Energy consumption solution through low cost energy conservation measures - training transfer impact check on IPMV protocol A

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ABSTRACT

Energy conservation measures are the practices to use less energy to reduce both costs and the environmental impact. They include using less electricity, gas, or any other form of energy that we get from our utility at a price. Training plays a critical role in educating energy users to practice conservation measures. The paper includes two case studies at two different facilities on air-conditioning applications to measure the impacts of low-cost energy conservation measures (LCECM) training transfer in actual operations. The impact was measured at both locations by reducing the air-conditioning running hours and increasing the set temperature without compromising the occupant's comfort level. As per international performance measurement and verification (IPMV) protocol A, data analysis was done using a formula to determine the quantum of savings. IPMVP outputt were checked further using a t-test using SPSS software. Results indicated a cumulative impact on energy conservation, environment, and cost of importing fossil fuel. Limitations include energy conservation measurements made with limited facilities and respondents' restrictions.

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1. INTRODUCTION

The finite fossil fuel resources available on our planet are depleting every day. Conserving energy whenever possible benefits individuals and our larger energy systems. By fine-tuning the controls and usage of software to manage energy at any facility, energy conservation activity is a low-cost measure [1]. Reducing energy consumption at home and increasing energy savings does not necessarily require purchasing energy-efficient products. Administrative and corrective measures have huge energy saving potential [2]. It has easy implementation with a small payback period, primarily administrative and remedial actions including training [3]. It will also impact demand side management and load curve [4]. Human energy usage behaviour can positively impact consumpotion of energy [5]. Reducing energy consumption is urgent priority in the building sector both domestic and commercial [5]. Improving energy efficiency by imparting behavioural training use of renewable energy and practicing low-cost measures for energy conservation [6], transparency of energy data, and digitalisation of the energy market will strengthen the energy conservation program [7]. The behaviour pattern of energy users has considerable potential adjustments for utility savings [7]. Heating and cooling costs contribute to an average home's utility bills [8]. Reducing the intensity and frequency of heating and cooling can result in considerable savings [3]. The paper includes two case studies undertaken at two different facilities on air-conditioning applications to measure the impacts of low-cost energy conservation measures low-cost energy conservation measures (LCECM) training transfer in actual operations [4].

2. LITERATURE REVIEW

If well-structured, tailor made LCECM training is given to the building occupants. Suppose the management provides a conducive working atmosphere. In that case, the building occupants can improve their energy usage behaviour by practising the learnt tips and guidelines, leading to efficient utilisation of energy as a whole for the building [9]. LCECM is something that most of us know but gets overlooked or ignored due to our preconceived mindset of thinking it to be insignificant [10]. However, it can easily be practised daily if it becomes a habit [11]. The government of India has initiated energy conservation building code (ECBC, 2016) [12] to improve the energy index of any building through such LCECMs, but it is left optional and not obligatory [13]. Suppose its implementation is mandated under ECBC as mandatory. It can help reduce energy usage daily in the Indian Commercial Building Sector, leading to saving cost and energy and the environment through operational excellence [14]. The impact of training transfer (T.T) on Energy Conservation: The effect of transfer of training can be done through some Dos and Don'ts instructions [15], [16]. The analysis was done after collecting feedback from the participants through questionnaires about their intentions of applying the instructions for energy conservation [16]. There is always a gap between choosing to do an action and action [17]. Therefore, the studies were done mainly indirectly, but there is a need for direct measurement in actual application to see the substantial impact [18]. Saving is daily at the consumer's end [17].

3. METHODOLOGY

Actual field data on air-conditioning (AC) applications were measured over 90 working days divided into three groups of 30 days each at two different facilities to assess the actual impact of LCECM training transfer on energy conservation. The electric meter readings were taken before and after LCECM training by IAEMP trainers on given to the participants during the same months but in subsequent years. Therefore, the temperature difference did not impact the measured readings. The temperature variation was 3^0C (30^0C to 33^0C) over these 90 working days for the readings before and after the LCECM training. Measurements were recorded in an excel sheet. Each of these groups had 30 working days of data. Data analysis was done as per international performance measurement and verification protocol – A ("IPMV Protocol A"), and the formula below used is to determine the quantum of savings.

Savings = (Baseline Period Energy – Reporting Period Energy) ± Adjustments."

The analysis result was further analysed by t-Test using SPSS software.

Field data in the air-conditioning application were measured at two facilities: one in a food court and another at the dining hall. The facility owners allowed the researchers to collect the data with the restriction of only the existing measuring mechanism. Data were measured for 90 working days. Data were recorded in three groups, each consisting of 30 working days. Actual energy consumption data were recorded before and after the LCECM training by facility engineers in consultation with the researcher. Data before the training is considered as the baseline period energy. Data after the training was recorded with the increased air-conditioning set temperature and reduced operating time without compromising the occupants' comfort level and considered as reporting period energy. The deviation in time and temperature was done so that there were no complaints from the facility users about any compromise with their comfort level. The comfort level is not compromised by placing a complaint box with sufficient visibility and announcement. Moreover, there were no complaints about both the facilities. The study ensured that climatic conditions on air-conditioning concerning ambient temperature had no adverse impact on meter reading see Table 1. The ambient temperature varied from 33^0C to 30^0C from September to January.

Table 1. Details of buildings and meter readings

Site/building under study	SNP complex (site 1)	CSSR Corp (site 2)
Location	Food court	Dining hall
Area (Sq. Ft)	8000	600
Capacity of AC (TR)	358	25
Duration of readings	3 Sept 2017 - 10 Jan 2018 3 Sept 2018 - 10 Jan 2019	
Average Ambient Temp.	33^0 C to 30^0 C	
Running Hours	6.30 AM to 9 PM	12.30 PM to 2.30 PM
Condition for Meter Reading	Before LCECM Training After LCECM Training	Before LCECM Training After LCECM Training
Calculation basis	Average of 30 Days	Average of 30 Days

4. RESULTS AND DISCUSSION

To study the impact of off-setting the air-conditioning set temperature and optimising the air-conditioning running hours, without compromising the occupants' comfort level, on energy consumption is done at two sites. The air-condition running hour was optimised and reduced by 30 minutes in 14.30 hours. The air-conditioning set temperature was optimised by increasing the set temperature by 1^0C. Energy consumption data before and after LCECM training was compared for energy saving. The air-condition running hour was optimised and reduced by 20 minutes in 2 hours operation, and the air-conditioning set temperature was optimised by increasing the set temperature by 2^0C. Ten ceiling fans that were not used earlier were also kept ON during the post LCECM training meter reading Table 2. Before and after LCECM training, energy consumption data was compared for energy saving [Savings = (Baseline Period Energy – Reporting Period Energy) ± Adjustments, Ref: IPMVP – A, Table 3].

Table 2. t-Test on LCECM-A outcome

		Paired sample statistics			
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SNP_Before	3.2152	90	.19223	.02026
	SNP_After	2.5786	90	.16936	.01785
Pair 2	CSSRP_Before	14.7006	90	.04656	.00491
	CSSRP_After	11.6524	90	.10449	.01101

Table 3. Savings as per IPMVP-A

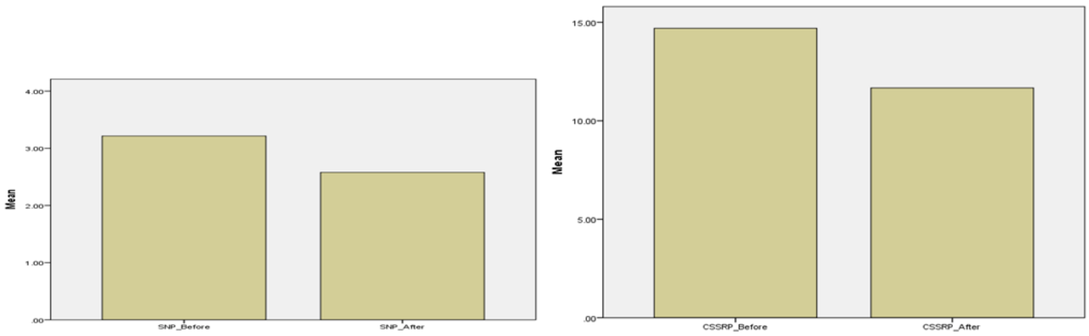
Average daily power consumption before training			
Study site number	First 30 days	Second 30 days	Third 30 days
1 (MWh)	3.24	3.21	3.24
2 (KWh)	14.72	14.7	14.68
Average daily power consumption after training (MWh)			
Study Site Number	First 30 days	Second 30 days	Third 30 days
1 (MWh)	2.68	2.57	2.5
2 (KWh)	11.72	11.68	11.55
Daily Average Savings (MWh)			
1 (MWh)	0.55	0.64	0.7
2 (KWh)	3	3.02	3.12
Daily Average Savings %			
1 (MWh)	17.1	19.9	21.7
2 (KWh)	20.4	20.6	21.3

Daily savings for the first, second and third 30 days were 0.55 MWh, 0.64 MWh and 0.7 MWh, respectively. This corresponds to 17.1%, 19.9%, and 21.7% energy savings on the first Site. While on the second Site, the daily savings for the first, second and third 30 days were 3 KWh, 3.02 kWh and 3.12 kWh, respectively. This corresponds to 20.4%, 20.6%, and 21.3% energy savings. To identify the energy-saving impact on the output by using IMPV protocol through meter reading, the researcher checked it statistically by applying t-Test and analysing it using SPSS software. The result as shown in Table 4 is highly significant, which justifies the analysis report of IPMVP -A. Savings at both Sites understudy as highlighted in Figure 1.

Energy consumption data before and after LCECM training was compared for energy saving on both sites. On the first Site, the air-condition running hour was optimised and reduced by 30 minutes in 14.30 hours operation. In addition, the air-conditioning set temperature was optimised by increasing the set temperature by 1^0C. Daily savings for the first, second and third set of 30 days were 0.55 MWh, 0.64 MWh and 0.7 MWh, respectively. This corresponds to 17.1%, 19.9%, and 21.7% energy savings. On the second Site, the air-condition running hour was optimised and reduced by 20 minutes in 2 hours operation. The air-conditioning set temperature was optimised by increasing the set temperature by 2^0 C. Ten numbers of ceiling fans that were not used earlier were also kept ON during the post LCECM training meter reading. Daily savings for the first, second and third 30 days were 3 KWh, 3.02 kWh and 3.12 kWh, respectively. Resulting in 20.4%, 20.6%, and 21.3% energy savings. Direct Meter readings show 17.1% – 21.7% highlighting monthly energy savings in an air-conditioning application. The energy-saving is on two counts. Firstly, by increasing the air-conditioner set temperature by 1°C. Secondly, by reducing the air-conditioner 'Switch ON' duration by 20 minutes, without any compromise to the comfort level of the occupants. Field measurements were first analysed using IPMVP Protocol – A and then t-Test to confirm the actual savings.

Table 4. Paired Samples Test

		Paired Differences					t	df	Sig. (2 tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	SNP_Before - SNP_After	.63667	.24468	.02579	.58542	.68791	24.685	89	.000
Pair 2	CSSRP_Before - CSSRP_After	3.04818	.09893	.01043	.3.02746	3.06890	292.289	89	.000



Comparison of After over Before meter reading at site 1

Comparison of After over Before meter reading at site 2

Figure 1. Comparison of after over before meter reading

5. CONCLUSION

LCECM training, if designed and executed in-house by the organisation, then does not cost any money to the organisation, but if the same is done by engaging an expert from the industry, then it costs a negligible amount of money which can be recovered from the savings in organisation's monthly energy bill in few months. Therefore, the monetary burden to implement such energy conservation measures is minimal and affordable by any organisation. The more significant impact is building a work culture that will impact the organisation. The same will be carried out, practised, and encouraged by the employees wherever they go after working hours, like public places and their residents. The cumulative impact will be a change in energy usage behaviour in the country at large in a few years' time, leading to energy conservation and a positive impact on the environment and government exchequer for a reduction in energy import bills.

LIMITATIONS

The present study follows the training provided by IAEMP. The energy conservation measurement is made with limited facilities and restrictions imposed by the respondents.

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