

Proceedings Report on

Practical Energy Audit Training Program

Organised on 16th and 17th January 2020, Bengaluru



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Suggested format for citation

TERI. 2020
“Practical Energy Audit Training Program 2020” organised during
16th and 17th January, 2020 at Bengaluru
Bangalore: The Energy and Resources Institute; 21 pp.
[Project Report No. 2019IB01]

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Mr. Yatharth Sharma	- Research Associate, TERI
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Mr. Arjun D Shetty	- Associate Fellow, TERI

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Dr. G.R. Narsimha Rao	- Director and AEA, Industrial Energy Efficiency, TERI
Mr. T Senthil Kumar	- Area Convenor and AEA, TERI
Mr. D Ramesh	- Senior Fellow and AEA, TERI
Mr. C Vijaya Kumar	- Fellow and AEA, TERI
Mr. T Siva Kumar	- Fellow and AEA, TERI
Mr. C S Kumaraswamy	- Fellow and AEA, TERI
Mr. S Satish Kumar	- Fellow and CEA, TERI
Mr. Rahul Raju Dusa	- Associate Fellow and CEA, TERI
Mr. Anish Antony	- Associate Fellow and CEA, TERI
Mr. R Vijay Mohan	- Associate Fellow and CEA, TERI
Ms. Sabreen Ahmed	- Associate Fellow and CEA, TERI

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Ms. Manjula	- Secretary, TERI
Mr. B Srikanth Chakravarthy	- Programme and Facility Coordinator, TERI
Ms. M Umamaheshwari	- Admin. & Accounts Officer, TERI
Mr. Shantha Murthy	- Lab-cum-Office Attendant, TERI
Mr M T Sunil Kumar	- Administrative Assistant, TERI
Mr. Varde Gowda	- Admin Attendant, TERI

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1.0 Introduction

1.1 Background

Energy efficiency and management has always been the first step in conserving energy which gives sizable environmental as well as economic benefits. Several nations have included energy conservation under their legislative acts and policy instruments mandating energy efficiency regulations to achieve their INDC mitigation targets. However, problems are arising due to dearth of in-house technical, financial capacities and human resources with relevant education and skillsets in national energy management, hence relying heavily on external resources. Furthermore, lack of information and data on energy consumption and energy –saving opportunities hinders the development of effective policy measures.

In the said context, several steps are being adopted by the government under the National Mission on Enhanced Energy Efficiency (NMEEE) for the industrial and commercial building sectors. The NMEEE is one of the eight identified mission under National Action Plan on Climate Change (NAPCC). One of the initiatives under NMEEE is Perform Achieve and Trade (PAT), which is a market based mechanism with the objective to enhance energy efficiency of identified energy intensive sectors by providing specific energy consumption targets.

Energy Efficiency (EE) improvement is a continuous process which involves energy management and energy auditing by following PLAN-DO-CHECK-ACT. The process starts with the review of the baseline to provide critical input to the energy policy for planning and developing energy management strategy. The key interventions entailing operational and technical measures identified in the plan are implemented. The EE improvements are checked with a monitoring and auditing system in place followed by a review to again provide feedback to the planning stage. The key resources in this whole process that continuously drives the technical, financial and operational aspects are the human resources- basically qualified energy managers and auditors. Hence, building in-house capacities at national and regional level for energy auditing and management expertise is critical. Due to several internal and external factors, facility personnel tend to practice inefficient operations which result in high energy bills

Energy and production efficiency has dramatically improved through capacity building and energy audits programs implemented either under external aided programs or by private energy consultants. Such programs have resulted in significant savings in energy and corresponding cost. In many countries, certification schemes at national level have been formulated and implemented. This has further led to successful market-based mechanisms in the field of energy efficiency in few cases. For example, the certification of energy auditors and managers in India has enabled successful implementation of Perform Achieve and Trade Mechanism (PAT) which resulted in 8.67 Mtoe/year savings which is 30% above the targeted savings from 8 energy intensive sectors in the PAT Cycle-I alone.

In the efforts to bridge the gap between the need for awareness on concrete energy efficiency practices by the industries, commercial buildings' workforce, and the available resources, TERI has re-initiated its Practical Energy Audit Training Program.

Understanding and tackling day to day energy conservation aspects is a continuous process. The need for capacity building of engineers in energy efficiency and affordability concerns for full-fledged energy audits by several entities forms the genesis of this workshop. The training program builds on TERI's experience on more than 2500 energy auditing and energy management services. The program also emphasised on providing illustrated case studies along with detailed one to one participant – expert interaction that may result in

- Qualified and recognized workforce to drive the energy efficiency plans and policies of the nation.
- Economic benefits with reductions in energy intensity, lower operating costs and increased competitiveness of national production with improved product quality.
- Social benefits such as increased employment, behavioural changes towards energy.
- Energy and environmental benefits enabling the stakeholders to achieve their due contribution towards climate change mitigation

This would invite larger informed investment in the energy efficiency sector and providing the basis for reducing GHG emissions in the energy intensive sectors. Rightful identification of energy efficiency and conservation opportunities is need of the hour for national energy security and energy self-sufficiency in growing economies.

1.2 Objective

- a. To reach out to budding as well as established industries engineers and provide affordable training and knowledge sharing platform on Energy Auditing.
- b. To familiarize techniques, methodology and industry best practices on adopting energy conservation measures through case studies.

2.0 Agenda for Practical Energy Audit Training Program

- Day-1 (16/01/2020)

TIME	TOPIC	SPEAKER
9:00 – 9:30	Registration	Mr. Arjun D Shetty & Ms. Sabreen Ahmed
9:30 – 9:40	Welcome address	Dr. G. R. Narsimha Rao, Director & Senior Fellow, Industrial Energy Group, TERI, Bengaluru
9:40 – 10:00	Key Note Address by Chief Guest	Mr. G Venkateshwara Rao, Executive Director, FMD HAL
10:00 – 10:20	TERI Movie	
10:20 – 10:50	Energy Audit and Management	Dr. G. R. Narsimha Rao, Director & Senior Fellow
10:50 – 11:30	Electrical Systems	Mr. D Ramesh, Senior Fellow
11:30 – 11:50	Tea Break	
11:50 – 12:30	Electrical Drives	Mr. Anish Antony, Associate Fellow
12:30 – 13:00	Sponsor Presentation	WILO Mather and Platt Pumps Pvt. Ltd.
13:00 – 14:00	Lunch	
14:00 – 15:00	Compressed Air System	Mr. C Vijayakumar, Fellow
15:00 – 15:30	Lighting	Mr. T Sivakumar, Fellow
15:30 – 16:00	Sponsor Presentation	Eco Energime Engineers LLP
16:00 – 16:30	Tea Break & Group Photo	
16:30 – 17:00	Open Access Power Purchase	Mr. T Senthil Kumar, Area Convener & Senior Fellow
17:00 – 18:00	Energy Audit Instrument Demonstration	

- **Day-2 (17/01/2020)**

TIME	TOPIC	SPEAKER
9:30 – 10:15	Pumps, Fans and Blowers	Mr. C S Kumaraswamy, Fellow
10:15 – 11:15	HVAC	Mr. Rahul Raj Dusa, Associate Fellow
11:15 – 11:45	Tea Break	
11:45 – 12:30	Boiler and Steam	Mr. Satish Kumar, Fellow
12:30 – 13:00	Sponsor Presentation	Heatray Solar Pvt. Ltd.
13:00 – 14:00	Lunch	
14:00 – 14:45	Kiln and Furnaces	Mr. D Ramesh, Senior Fellow
14:45 – 15:15	Sponsor Presentation	Testo India Pvt. Ltd.
15:15 – 15:45	Renewable energy case studies by TERI (Solar PV)	Ms. Sabreen Ahmed, Associate Fellow
15:45 – 16:15	Tea Break	
16:15 – 17:00	Valedictory Session and Vote of Thanks	Mr. Rahul Raju Dusa, Associate Fellow
17:00	Networking & End of Day #2	

3.0 Training Program Summary

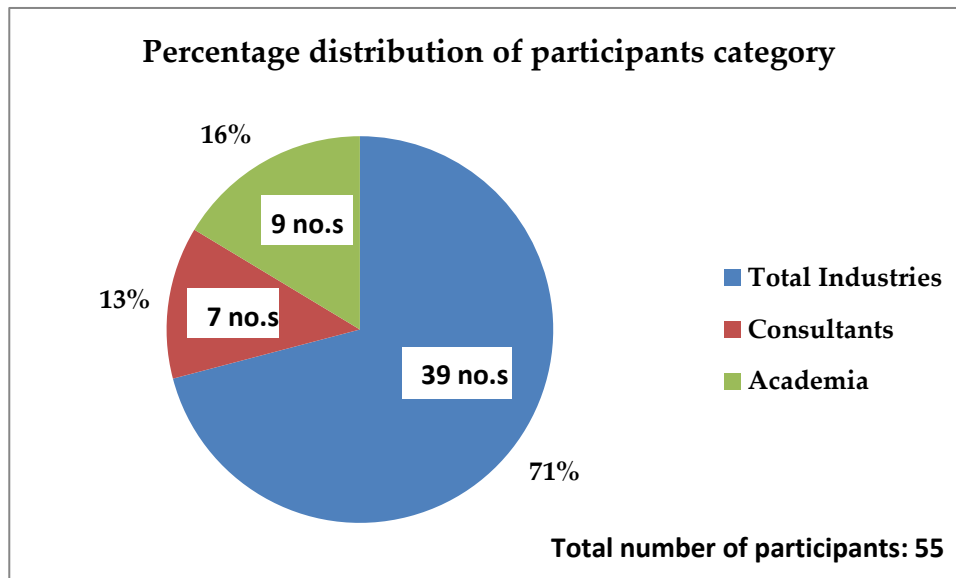
A Practical Energy Audit Training Program was conducted by TERI Industrial Energy Group at its TERI Southern Regional Centre, Bengaluru on 16th and 17th January 2020. Over 55 participants including delegates from the government, industry and academia participated in this event. The program focused on encouraging focussed discussion and sharing of knowledge among various stake holders such as industry representatives, energy and building consultants, instrument and equipment suppliers and domain experts with respect to energy auditing and energy management.

The platform provided an excellent opportunity for clarifying any queries about existing operational practices and adopting energy efficiency measures. In addition, case studies from several energy audit studies conducted by TERI were also presented during the Workshop. The studies focused on identifying energy saving potentials and following best practices with respect to choice of right technologies and equipment operations.

Mr. Garikipati Venkateswara Rao, Executive Director, Hindustan Aeronautics Limited (HAL) – Facility Management Division, Bengaluru initiated the session with his welcome remarks and talked about their exemplary work at HAL in the lines of energy efficiency and renewable energy. The context for the training program was later set by Dr. G. R. Narsimha Rao, Director – Industrial Energy Group, TERI Southern Regional Centre which was followed by technical sessions by Accredited Energy Auditors and Certified Energy Auditors from TERI. The program also provided platform for sponsor presentations and interactions.

The major objective of the training program was to present the new age findings, out of the box applications and updated technologies that are being used in the energy efficiency market and share TERI's experiences on ground realities for conducting energy audits at several industries and commercial buildings. The workshop presented all the stake holders a single platform for enquiring and addressing various strategies and issues regarding energy conservation measures. The training program also highlighted the overview of renewable energy integration and open access electricity procurement, thus presenting optimal and cost effective practices.

Participants from several industries such as Engineering, Cement, Glass, Pharma, Food and Packaging, Textiles, Chloro-Alkali and Chemical, Iron and Steel and Petroleum industries have attended the program. The training program also witnessed strong representation from the Academia and other consultants in the field. A brief representation of the participant background is illustrated below:



4.0 Session details

4.1 Inaugural Session

Welcome address and Context setting

Dr. G. R. Narsimha Rao, Director - IEE, TERI

Inaugural address

Chief Guest, Mr. Garikipati Venkateswara Rao, Executive Director, Hindustan Aeronautics Limited – FMD Bangalore.

Vote of Thanks

Mr. Rahul Raju Dusa, Associate Fellow and Certified Energy Auditor, TERI

The session began with a welcome address by Dr. G. R. Narsimha Rao, Director – IEE, TERI who welcomed the Chief Guest, participants and the sponsors.

The inaugural address was given by the Chief Guest **Mr. Garikipati Venkateswara Rao**. He appreciated the event organized by TERI. He briefed about in-house energy conservation efforts carried out across all HAL facilities in Bengaluru. He has also referred the state of art 3.5 MW solar power plant with single axis tracking, established under Developer model, which is first of its kind in India at an operational Airport. This plant is operating with a CUF of around 21% and has generated around 211 Lakh units till date. Roof top solar power plants have also been installed at our various Divisions. In total, about 31MW capacity is operational. He mentioned that through these initiatives, HAL is ahead of the energy targets provided by the Government of India to the Public Sector Undertaking (PSUs).

He valued TERI's long term association with HAL in planning and execution of several sustainable projects. TERI has provided consultation for two wind power plant projects with total capacity of 15 MW which has generated Rs. 34 crore of revenue in last three years. This revenue is being transferred to the HAL CSR Budget.

In continuation with use of TERI's technical assistance, he has also highlighted TERI's work on Sustainable Educational Institutions program where TERI has installed Solar Roof Top PV systems for over 47 government schools under HAL CSR initiative and the immense socio-economic benefits reaped by the schools and particularly the students. He further mentioned various sustainable activities taken up by HAL under energy efficiency, renewable energy, and social development activities such as water shed programs.

Setting the context for the training program Dr. G. R. Narsimha Rao expressed that TERI was pleased to see a massive response from the participants. He talked about the global energy demand and mentioned how energy efficiency has significant opportunity in global CO2 emission reductions. He briefly discussed about India's commitments and suitable efforts taken to comply with the INDCs pledged. Dr. Rao also shared TERI's contribution in this regard and the positive impact achieved through last 5 years of its energy auditing services.

4.2 Technical Session

Day 1: 16th January 2020

The technical session began with presentation on Electrical Systems by **Mr. D Ramesh**, Senior Fellow and Accredited Energy Auditor. Mr. D Ramesh touched upon basics of electricity billing and dwelled into the intrinsic factors of electrical load management. He mentioned the need to have maximum demand control steps in place and the benefits of maintaining improved power factor. He engaged the participants with deeper discussions on several possible system losses and how to tackle them followed by industry cases studies.

Mr. Anish Antony, Associate Fellow and Certified Energy Auditor presented on Electrical Motors. Electrical drives being the essential part of any utility and process systems, he gave an overview about their usage, different types that are available in the market and the importance of having the right type of motor for a given application. He also talked about different types of energy losses and how best they can be mitigated. Mr. Anish emphasised the need for regular performance monitoring and maintenance activities and suitable instruments that the engineers should keep in handy. He extensively discussed about several measures to avoid energy losses and to ensure quality power supply.

Mr. Vijayakumar, Fellow and Accredited energy Auditor presented about compressed air systems. He explained about general details and features of air compressors. He shared about steps followed before conducting a compressed air audit and also explained about various tests to be conducted. He then presented case studies of compressed air audits carried out in different types of industries / sectors and explained how schemes for energy conservation was identified and also briefed about cost benefits realised after implementation of identified schemes.

The Lighting Systems was delivered by **Mr. T Siva Kumar**, Fellow and Accredited Energy Auditor. He introduced to the participants about the latest technologies available in the market, their applications and suitable benefits. Luminous performance characteristics of different types of lighting systems were presented. The participants expressed their curiosity over plasma and laser lighting technology which further developed into an intensive discussion. Mr. T Siva Kumar further explained the nuances of conducting a lighting audit, showcased energy conservation case studies. He emphasised that optimal lighting systems in place are beneficial not only for energy conservation but also a healthy work environment.

An expert session on Open Access Power Purchase was delivered by **Mr. T Senthil Kumar**, Senior Fellow and Accredited Energy Auditor. He defined the traditional electrical power structure and explained what open access is in power sector is. Covering the chronology of policy events and divulging into overview of EC Act, he described past and present scenario power trading. The participants got the opportunity to discuss the nature of contracts and the types of tariff structures, relating to optimal options available for their industries. Healthy interactions between the participants also took place during the session where they were exchanging the challenges and advantages of procuring power through open access. Lastly, Mr. T Senthil Kumar concluded the presentation by explaining a sample calculation with and without open access power purchase which the participants found very useful.

Day 2: 17 January 2020

Day 2 directly dived into the technical session on Pumps, Fans and Blowers by **Mr. C S Kumaraswamy**, Fellow and Accredited Energy Auditor. He started his presentation with basic definitions and classifications of pumps. Since centrifugal pumps are widely used in industries, his discussion further focused on centrifugal pumps working principal and types. He also explained the relation between Pump Volume, Head and power with Speed (Affinity law/ Law of Pump). During the presentation he emphasised the philosophy and use of pump curve, system curve, pump operating /duty points, pump curve with throttled valve with graphical representation. After explaining about the type of portable energy audit instruments used for measurements and evaluation of pump operating efficiency with examples, he moved on to talk about fans and blowers systems. The implemented practical case studies on the pumps, fans and blower systems were very well received by the participants.

Mr. Rahul Raju Dusa, Associate Fellow and Certified Energy Auditor presented HVAC Systems. Mr. Rahul gave a brief introduction on different types and applications of HVAC systems in place. After explaining the overview of the system, he has compared the pros and cons of the systems with respect to applications, efficiencies and cost of operations. The participants showed interest in Vapour Absorption Machines (VAM), over which detailed discussions have taken place varying from applicability to their industries to the operational economics. The participants were presented with successfully implemented and verified unconventional case studies which triggered deeper understandings of operating existing installed efficient technologies in more efficient manner.

The Boiler and Steam systems were presented by **Mr. Satish Kumar**, Fellow and Certified Energy Auditor. Mr. Satish started with basics of boilers and selection of type of boilers based on applications. In addition to the technical aspects, he has also focused upon policy change overs, regulations and their impacts on industries belonging to several regions in the country. A particular case of the Delhi NCR region was taken up where petcoke was being fired in the boilers and thermic fluid heaters earlier and is presently banned. In the process of adopting cleaner fuels such as Natural Gas, he indicated that cost effective retrofits should be adopted to increase the power generation efficiency as well as the overall cogeneration efficiency with additional heat recovery (thermic fluid heating / packaged steam generators) from the flue gas. A set of participants enquired for inputs on their industry flue gas temperature at stack which was higher above 190°C for the solid fuel fired in their boiler even after the boiler loading and pressure was less than 80% of the rated capacity. Preliminary inputs were given covering possible best operation options and was further planned to take up detailed evaluation.

Mr. D Ramesh, Senior Fellow and Accredited Energy Auditor also presented on Furnace and Kilns. This was a special session conducted particularly tailored for the participants from cement, glass, forging and other industries using furnaces in their day to day operations. He has covered different types of furnaces and presented case studies post which a long healthy discussion with the participants took place. The participants found the session helpful as they were able to assess their performance indicators as compared to the best operating indicators.

An expert session on Renewable Energy Case studies was delivered by **Ms. Sabreen Ahmed**, Associate Fellow and Certified Energy Auditor. She discussed briefly on Indian Solar PV scenario, National Solar Mission and further proceeded to discuss about various rooftop Solar PV connection schemes. A video about successfully implemented Sustainable Educational Institutions program under HAL-CSR initiative was played which explained the overview of the socio economic developments that has taken place for the government schools and students under this program. Ms. Sabreen Ahmed also illustrated several industry adopted case studies and how different benefactors have availed the benefits of Solar PV in their day to day facility operations.

Demonstration of energy audit instruments were carried out during the training program. In addition to the in-hand experience of these portable instruments, real time measurements were using specific instruments such as power analyser and water flow meter were shown to the interested participants. In addition, participants also made use of the opportunity to explore different materials, equipment and instruments that were on display at the sponsor's stalls.

4.3 Sponsor presentations

TERI appreciates and acknowledges the support of

- a. Karnataka Renewable Energy Development Limited.
- b. Eco Energime Engineers LLP,
- c. Conergy Energy Systems India Pvt. Ltd.
- d. Testo India Pvt. Ltd.
- e. WILO Mather and Platt Pumps Pvt. Ltd.
- f. Heatray Solar Pvt. Ltd.

The training program was successfully conducted with kind support from many established and reputed companies. The idea was to provide a platform where regulatory officials, different equipment and instrument suppliers, service providers may share their experiences and present the latest frameworks and technologies in the field of energy efficiency and renewable energy. In turn, the participants may relate the suitable applications and upgradations for their day to day operational requirements.

Dr. H.B. Budeppa, Managing Director, KREDL was invited to grace the inaugural session. KREDL being the State Designated Agency (SDA) supporting the Bureau of Energy Efficiency (BEE), Ministry of Power, the idea was to provide an opportunity to the participants to understand the government perspective on formulation, implementation and monitoring of energy efficiency and renewable energy projects. However, due to last minute engagements, the MD, KREDL was unable to attend the training program and has conveyed his greetings and support.

Mr. A Govindaraj representing **Eco Energime Engineers LLP and Conergy Energy Systems India Pvt. Ltd.** brought in the perspective of ESCO project consultants. He explained the benefits of opting for an ESCO model and further detailed on the process of conducting assessments and identifying right projects.

Mr. Vimal Chavda from **Testo India Pvt. Ltd.** conducted a lively session presenting the different types of advanced and sophisticated instruments used for measurements of different parameters. They brought in state of the art wireless data monitoring systems by which the industrial and building facilities can monitor the performance of different energy systems.

Mr. Anil Ghorpade representing **WILO Mather and Platt Pumps Pvt. Ltd.** talked a brief about the origins of the company and went on to explain different products associated to pumping systems and their use in the energy conservation projects. The participants found their “One Stop Water Solutions” service concept interesting. He has showcased case studies, particularly highlighting some of the projects from UAE which were executed along with TERI.

Mr. Ajay Pendse representing **Heatray Solar Pvt. Ltd.** presented about advantages of solar thermal energy for industry and building applications. He displayed a demonstration model of a concentrated solar water heater. He mainly focuses on application of solar concentrators for mild and moderate heating need in industries. Few industrial heating applications where solar concentrators can be used are Industrial process heating, Boiler feed preheating, E.T.P. & R.O. plant feed preheating, R.O. reject evaporation, Desalination, Industrial air drying and Industrial space heating & cooling. He also explain different benefits of solar concentrator projects like Reduce carbon footprint of industries, Industries will get 30% subsidy from MNRE, Life of project is 15 years and IRR/ROI of project is within 2-3 years.

The participants interacted with the sponsor company representatives during their presentations and also during pre and post sessions at the stalls arranged in the TERI Bangalore lawn.

4.3 Concluding session

The training program was accepted and appreciated by all the stakeholders. Most importantly the participants have expressed their satisfaction and also requested for more focused area specific training program in future.

Post evening high tea break, certificates were distributed to all the participants for their successful completion of the training program. Memento were handed over to the Chief Guest and sponsors acknowledging them for their immense support.

MR. Rahul Raju Dusa concluded the session by thanking

- Chief Guest Mr. Garikipati Venkateswara Rao, Executive Director, Hindustan Aeronautics Limited – FMD Bangalore for his time.
- Sponsors - Karnataka Renewable Energy Development Limited (KREDL), Eco Energime Engineers LLP, Conergy Energy Systems India Pvt. Ltd., Testo India Pvt. Ltd., WILO Mather and Platt Pumps Pvt. Ltd. and Heatray Solar Pvt. Ltd for their support.
- The participants from various organizations for attending the training program, and
- TERI colleagues and resource persons for successfully organizing the program.

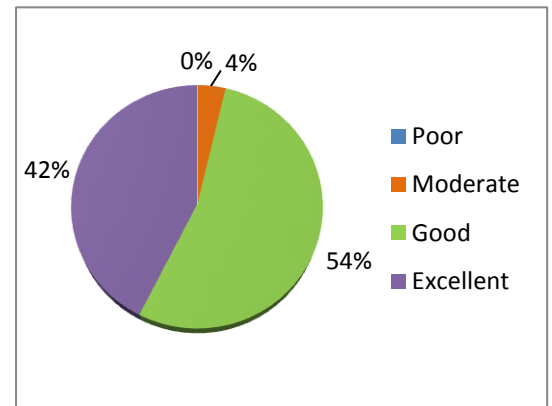
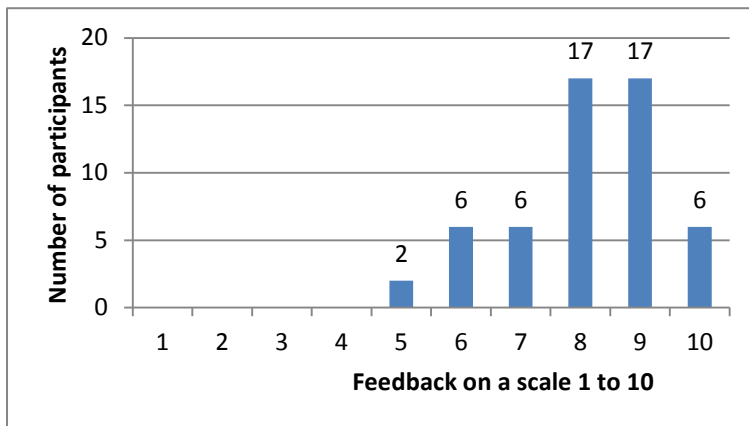
5.0 Participant feedback

Filled feedback forms from the participants were collected for further assessments and necessary customization as per participant's requirements in upcoming training programs. The rating system was grouped as per the following scale:

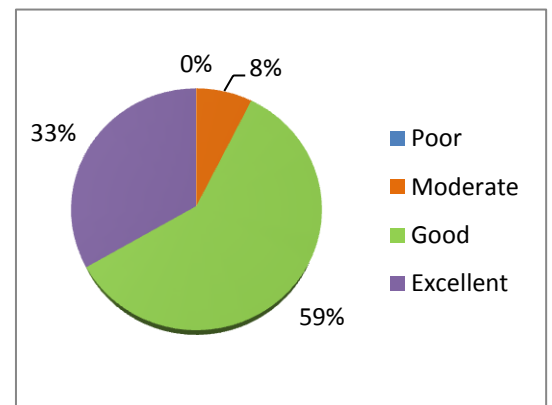
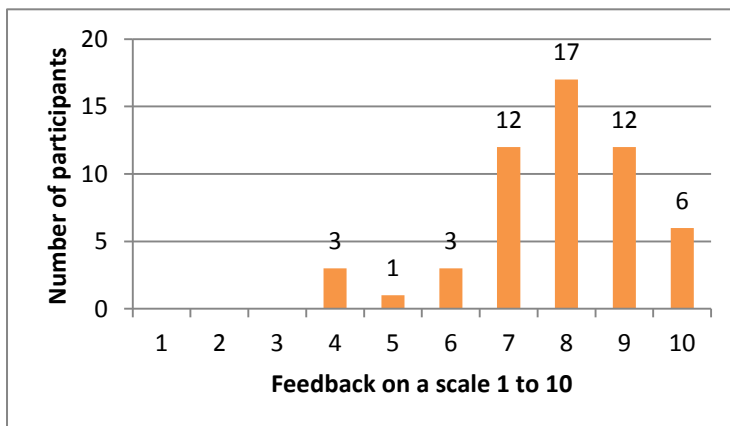
Score		Category
9 to 10	:	Excellent
6 to 8	:	Good
3 to 5	:	Moderate
1 to 2	:	Poor

Summary of the participant feedback is illustrated below:

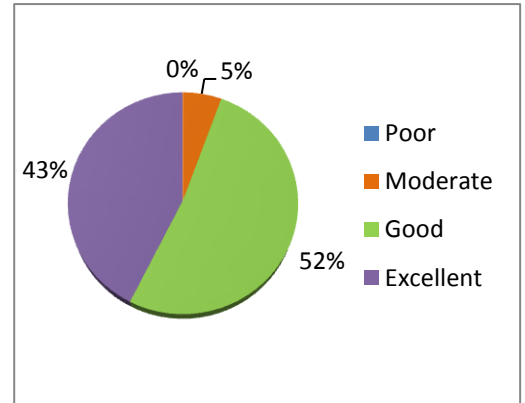
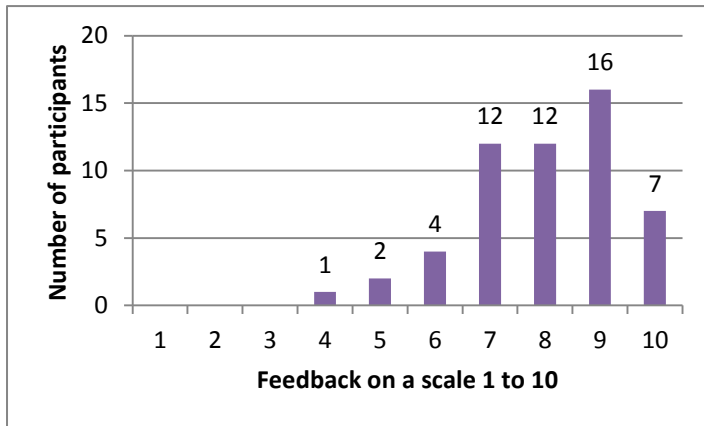
Q1: How the training program was conducted and presented?



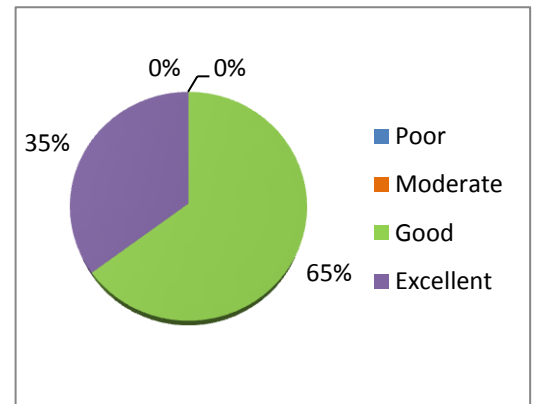
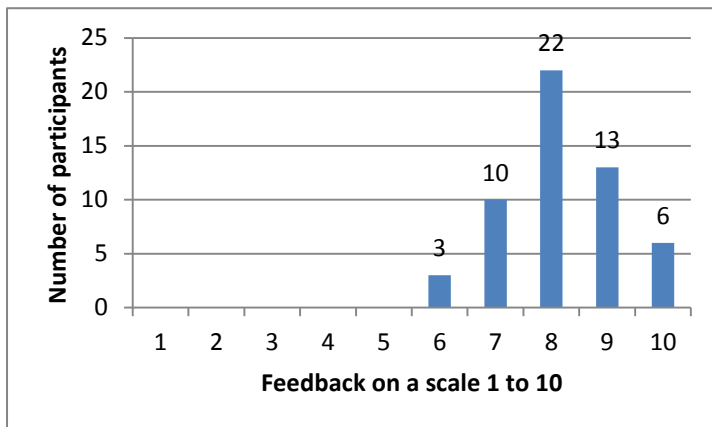
Q2: Whether the curriculum of the program is meeting the defined objectives?



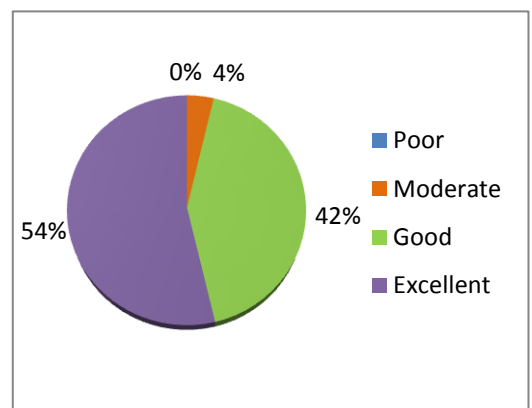
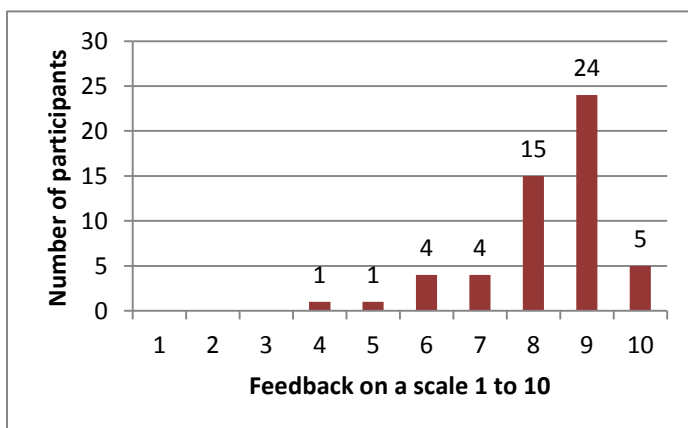
Q3: Whether all topics covered are relevant?



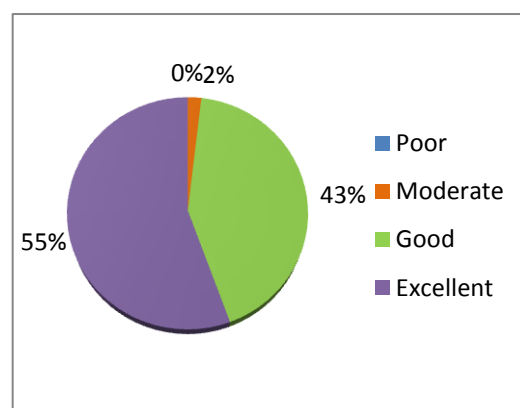
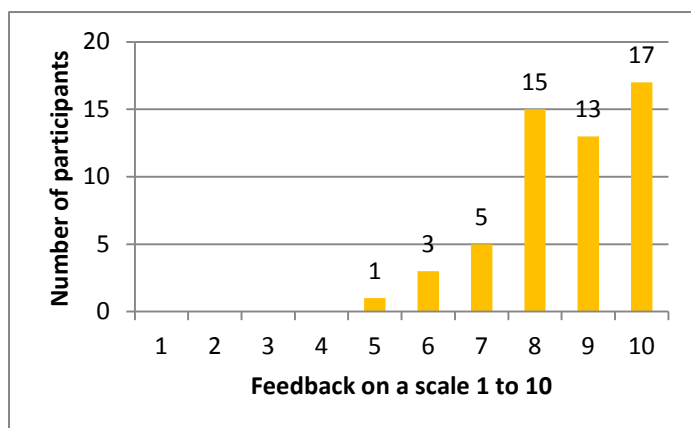
Q4: Participation and interaction were encouraged during the program



Q5: The training information will be useful to generate ideas specific to your industry



Q6: The training hall and the facilities were adequate and comfortable



Overall 96.3 % of the participants have found the training program good or excellent.

Some of the areas which the participants majorly liked, as mentioned in the feedback forms were

- Variety of topics covered and their Interactive sessions
- Case studies, Practical insights and the methodology of presentations.
- Hands on Energy audit instruments
- Electrical drives, Boiler, HVAC, Lighting systems, Compressed air, Pumps fans blowers Open Access, RE integration and CSR activities presented.
- Participants being encouraged to discuss their doubts about their industry applications.
- Excellent arrangements, interaction and clarity.
- Sponsor presentations
- Good hospitality and opportunity for networking

Participants also share productive aspects about which the training could be further improved, majorly

- Requesting for Focused training program with respect individual topics and also the target audience.
- Present more animated case studies and concepts
- Collaborating with TERI and conducting workshops on energy efficiency and renewable energy, as particularly requested by the students, professors and research scholars in the program.

All the inputs from the participants have been considered and shall be taken into consideration for upcoming training programs.

Also about **28% of the total participants have conveyed their interest in taking up energy audit services from TERI.** TERI will be happy to take this forward to serve their best in helping the respective organizations in optimizing energy consumption.

6.0 Photographs of the Forum

Few selected photographs of the Conference are given below.



