Proceedings Report on Training of Trainer Programmer

Technical Assistance for National Certification Scheme for Energy Auditors/Managers in Pakistan

Submitted to:

Climate Technology Centre and Network

United Nations Industrial Development Organization

Submitted by:

The Energy and Resources Institute

4th Main, 2nd Cross

Domlur 2 Stage,

Bangalore, Karnataka – 560071

January 2021

Acknowledgements

We are thankful to UNIDO and CTCN for giving us the opportunity to be involved in this very interesting and challenging project.

We are also extremely thankful to NEECA for providing complete support, guidance and cooperation in execution of this Technical Assistance program.

We will be happy to provide any further clarifications, if required.

Table of Contents

List of Figures

Executive Summary

The National Energy Efficiency and Conservation Act 2016, paves the way for energy conservation and efficient use of energy in Pakistan. The legislation has provided a legal basis to enforce necessary measures for efficient use and conservation of energy in the country in all sectors of the economy, in coordination with the relevant Provincial Departments.

As per the act, the National Energy Efficiency and Conservation Authority (NEECA) is mandated to carry out energy audits either by itself or by directing any certified or designated energy auditor for the designated consumers. In this context, NEECA, as the CTCN request proponent, had requested CTCN's support for developing the national certification scheme for energy auditors and managers including the preparation of draft rules and regulations required for making the certification scheme effective. The objectives of this technical assistance are:

1. Identification of designated consumers based on the definition and engagement of energy user classes for industries;
2. Guidelines on the eligibility and accreditation process;
3. Revision and finalization of draft guidelines, syllabus, and course modules including the development of model question banks for examination processes;
4. Organization and delivery of a two weeks Training of Trainer (ToT) programme; and
5. Review and finalization of draft regulations to support implementation roles as defined in National Certification Scheme.

It is estimated that savings of around US$ 5 billion per year and 42ktonnes per annum of carbon dioxide can be achieved through energy efficiency activities in Pakistan. The certification scheme will also create a pool of energy managers and auditors with relevant skill sets for identification of energy conservation opportunities.

Deliverable 5.1 provides details of the Training of Trainer Programme conducted from 14th to 19th of December 2021 along with the topics covered, details of resource persons and materials used for the training programme. The programme was aimed at establishing a pool of trained manpower for training of future energy auditors and managers.

1. Introduction

The National Energy Efficiency and Conservation Act 2016, paves the way for certification of Energy Auditors and Managers in Pakistan. For the successful implementation of this certification scheme, a perquisite is to have a pool of trained trainers, who in turn are able to provide capacity building training to future energy auditors and managers. To develop this pool of trainers, a Training of Trainer Programme was conducted as a series of webinars from 14th to 19th December 2020. Initially as per the Terms of Reference of the Technical Assistance programme, the Training of Trainer Programme was supposed to be conducted in Pakistan for up to 20 participants. However due to the geopolitical conditions in the region and the on-going Covid-19 pandemic, it was decided, in consultation with National Energy Efficiency and Conservation Authority (NEECA) to conduct the Training of Trainer Programme as a series of webinars.

To finalize modalities of the Training of Trainer programme multiple rounds of consultations were held with NEECA, local partner PITCO and CTCN. Minutes of the meetings are provided in Annexure 1A to 1C. From the consultations, it emerged that publishing advertisements in newspapers would be the most transparent manner for selection of participants. Moreover since the ToT was to be conducted as a series of webinars, the number of participants could be increased to 200 (the maximum number which could be accommodated in the online platform used for the ToT programme). Additionally, the ToT Programme being conducted online, recordings of the training are also available and will be shared with NEECA and CTCN. Newspaper advertisements were published in one leading Urdu daily and one English daily. Advertisement in English daily is provided in Annexure 2. A total of 96 applications were received by NEECA for the ToT programme.

In order to develop a business model for these trained trainers, NEECA decided to empanel the trainers with a three phase selection procedure. In phase 1, the participants would attend the online ToT programme and participate in end of day quizzes. The participants who successfully complete the end of day quizzes would move on to the second phase; **Offline Examination.** The offline examination will be conducted by NEECA in four centres, one each at Islamabad, Lahore, Peshawar and Karachi. TERI has developed and shared 5 sets of question papers and answer keys with NEECA for the offline examination. One set was shared by NEECA with all participants as a sample question paper. Participants qualifying in phase 2; offline examination move on to Phase 3 which is an **Online Interview** to evaluate the communication skills of the participants. The online interview panel will consist of representatives from NEECA and National and International experts. TERI has agreed to provide support to NEECA for the interview process by providing International resource persons. Participants successfully completing all 3 phases would be empanelled by NEECA as Trainers for the National Certification Scheme for Energy Auditors and Managers. NEECA is expected to complete the offline examination by end of January 2021 and interview phase is yet to be scheduled.

2. Online Platform and Agenda of Training of Trainer (ToT) Programme

Cisco WebEx Platform was used for the online training for 4 days; 14th, 15th, 17th and 19th December 2020 and Microsoft Teams was used for online training on 16th December 2020. Agenda for the Training of Trainer Programme is given below.

Day 1: 14.12.2020, Monday			
Time (Pakistan Standard Time)	**Topic**	**Speaker**	**Moderator**
9:30 - 10:45	Welcome address and Keynote Address	Dr. Sardar Mohazzam, MD NEECA and Mr Asad Mehmood, Technical Unit Head, NEECA	Ms Sabreen Ahmed, International Energy Efficiency Expert
10:45 - 11:00	Session Break		
11:00 - 12:15	Energy Management and Audit	Mr. K.K. Chakarvarti, Senior International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
12:15 - 13:30	Lunch Break		
13:30 - 14:45	Fuels and Combustion	Mr Atulkumar Auti, International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
14:45 - 15:00	Session Break		
15:00 - 16:15	Climate Change and Renewable Energy	Dr Irfan Yusuf, Consultant (RE) NEPRA Pakistan	Ms Sabreen Ahmed, International Energy Efficiency Expert
16:30 - 17:00	End of Day Quiz 1		Ms Sabreen Ahmed, International Energy Efficiency Expert
Day 2: 15.12.2020, Tuesday			
Time (Pakistan Standard Time)	**Topic**	**Speaker**	**Moderator**
9:30 - 10:45	Boilers (Including FBC Boilers)	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
10:45 - 11:00	Session Break		
11:00 - 12:15	Industrial Furnace	Mr D. Ramesh, Senior International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
12:15 - 13:30	Lunch Break		
13:30 - 14:45	Insulation and Refractories	Mr D. Ramesh, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert

14:45 - 15:00	Session Break		
15:00 - 16:15	Steam System	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
16:30 - 17:00	End of Day Quiz 2		Ms Sabreen Ahmed, International Energy Efficiency Expert
Day 3: 16.12.2020, Wednesday			
Time (Pakistan Standard Time)	**Topic**	**Speaker**	**Moderator**
9:30 - 10:45	Pumps, Pumping System and Cooling Towers	Mr Atulkumar Auti, International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
10:45 - 11:00	Session Break		
11:00 - 12:15	Waste Heat Recovery	Mr D. Ramesh, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
12:15 - 13:30	Lunch Break		
13:30 - 14:45	Cogeneration	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
14:45 - 15:00	Session Break		
15:00 - 16:15	Compressed Air System	Mr. Kashif Shaukat, Nation Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
16:30 - 17:00	End of Day Quiz 3		Ms Sabreen Ahmed, International Energy Efficiency Expert
Day 4: 17.12.2020, Thursday			
Time (Pakistan Standard Time)	**Topic**	**Speaker**	**Moderator**
9:30 - 10:45	Refrigeration and Air Conditioning	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
10:45 - 11:00	Session Break		
11:00 - 12:15	Fans and Blowers	Mr D. Ramesh, Senior International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
12:15 - 13:30	Lunch Break		
13:30 - 14:45	Electrical Systems	Mr. Kashif Shaukat, Nation Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert

14:45 - 15:00	Session Break		
15:00 - 16:15	Electric Motors and Lighting	Mr. Kashif Shaukat, Nation Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
16:30 - 17:00	End of Day Quiz 4		Ms Sabreen Ahmed, International Energy Efficiency Expert
Day 5, 18.12.2020, Friday: Weekly OFF			
Day 6: 19.12.2020, Saturday			
Time (Pakistan Standard Time)	**Topic**	**Speaker**	**Moderator**
9:30 - 10:45	Financial Management	Mr Atulkumar Auti, International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
10:45 - 11:00	Session Break		
11:00 - 12:15	Energy Performance Assessment in Cement Industry	Mr. K.K. Chakarvarti, Senior International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
12:15 - 13:30	Lunch Break		
13:30 - 14:45	Energy Performance Assessment in Thermal Power Plants	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert	Ms Sabreen Ahmed, International Energy Efficiency Expert
14:45 - 15:00	Session Break		
15:00 - 16:15	Energy Performance Assessment in Textile Plants	Mr D. Ramesh, Senior International Energy Efficiency Expert	Mr. C. Vijayakumar, Senior International Energy Efficiency Expert
16:30 - 17:00	Valedictory Session	Mr. Asad Mahmood, Technical Unit Head, NEECA, Mr Sambit Nayak, Climate Change and Mitigation Expert-Asia Pacific, CTCN and Ms. Sabreen Ahmed, International Energy Efficiency Expert	

3. Training of Trainer Programme Summary

An online Training of Trainer Programme was conducted by TERI in collaboration with PITCO and NEECA from 14th to 19th of December 2020. The training focused on capacity building of trainers in Pakistan for the successful implementation of the National Certification Scheme for Energy Auditors and Managers.

The platform provided an excellent opportunity for clarifying any queries about the energy audits, need for energy audits and how to carry out energy audit of various energy consuming equipment available in industries. In addition, case studies from several energy audit studies conducted by TERI and PITCO were also presented during the Training of Trainer Programme. The studies focused on identifying energy saving potentials and discussing best practices with respect to choice of right technologies and equipment operations.

Dr. Sardar Mohazzam, Managing Director, National Energy Efficiency and Conservation Authority (NEECA), Pakistan initiated the session with his welcome remarks. Dr. Mohazzam highlighted the various activities taken up by NEECA since its formation. He further briefed the participants about the National Certification Scheme for Energy Auditors and Managers in Pakistan and also drew attention to NEECA's and the Government's efforts in developing energy efficiency market in Pakistan. Dr. Mohazzam's talk was followed by Mr Asad Mahmood, Technical Unit Head NEECA's presentation on the Technical Assistance project of CTCN for National Certification Scheme for Energy Auditors and Managers in Pakistan. Mr Mahmood stressed on the background work which has been completed as part of this technical assistance project; identification of major energy consuming sectors, finalization of associated rules and regulation and development of relevant course materials. The opening presentation by NEECA officials laid the ground for the successive sessions on energy audits and the technicalities of conducting a detailed energy audit.

3.1 Participation details

A total of 76 participants registered for the Training of Trainer Programme. The participants were from the academia, government organizations, energy consulting firms and industries. A break-up of the participant's background is given in figure 3.1.

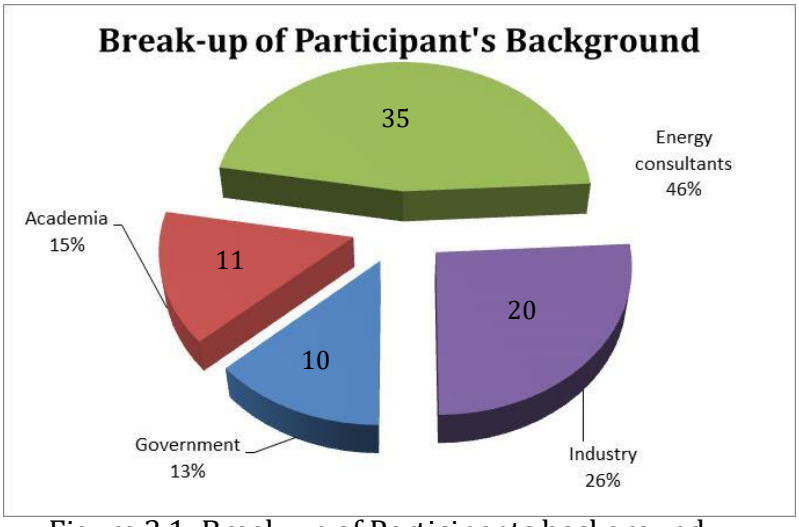


Figure 3.1: Break-up of Participants background

The industrial participants were mostly from thermal power plants, textile and cement sector, with a few from other industrial sectors as well. Table 3.1 provides breakup of industrial participants.

Table 3.1: Break-up of industrial participants

Industry	**No. of Participants**
Textile	2
Cement	2
TPP	7
Others	9
Total	**20**

Out of the 76 participants, 4 were female participants (5%). All 4 female candidates are from academia. As per the World Bank blog titled "Inspiring new generation Pakistani women leaders in STEM" published in "End poverty in Asia", only 4.9% women in Pakistan hold engineering supervisory roles. Thus, the percentage of female participation is in line with the above mentioned statistics.

4. Session Details

4.1 Day 1 Sessions

The first session of Day 1 was by Dr Sardar Mohazzam, MD NEECA and Mr Asad Mehmood, Technical Unit Head NEECA. Details of NEECA's sessions are provided in previous chapter.

Day 1 Session 2: Energy Audit and Management, presented by Mr K.K. Chakarvarti

This session covered in depth the basic principles of energy management along with the key activities of an energy manager. Energy audits, types of energy audits and the various aspects of conducting the field study for an energy audit were explained by Mr K.K. Chakarvarti along with examples from his own field experiences. He also explained in details about benchmarking and the methodologies for calculating energy performance index for any industry. Mr Chakarvarti also touched upon the different energy auditing equipment required for carrying out detailed performance analysis of various energy consuming equipment.

Day 1 Session 3: Fuels and Combustion, presented by Mr Atulkumar Auti

The fuels and combustion session covered the properties of solid, liquid and gaseous fuels. The chemical as well as physical properties of the fuels were discussed in details. In addition, Mr Atulkumar also explained in details about combustion and the various formulas and calculations associated with theoretical air requirement for complete combustion of fuel, excess air requirement and calculation for excess air percentage.

Day 1 Session 4: Climate Change and Renewable Energy, presented by Dr. Irfan Yusuf

Dr Irfan's session focussed on the various international treaties for mitigation of climate change and the various pathways adopted internationally. He then moved on to discuss about the renewable energy trends throughout the globe. Dr Irfan spoke about Pakistan's Nationally Determined Contributions (NDCs) and provided an overview of the energy consumption in various sectors along with the percentage share of carbon dioxide emission in those sectors. He shared the electricity generation breakup in Pakistan, which showed a higher dependence on coal in the coming years. Pakistan is committed to move towards renewable electricity generation and is expected to generate 30% electricity from renewable energy by 2030.

4.2 Day 2 Sessions

Day 2 Session 1: Boilers (including Fluidized Bed Combustion Boilers), presented by Mr C. Vijayakumar

Mr. Vijayakumar started with basics of boilers and selection of type of boilers based on applications. He then explained about Fluidized Bed Combustion (FBC) Boilers (Atmospheric and Circulating FBC type), importance of quality of water used for steam generation in assessment of boiler. This was followed by performance evaluation techniques of boilers. Mr Vijayakumar explained about the various methods of carrying out performance evaluation of boilers along with the instruments used for assessment

purpose and methodologies for conducting field measurements. He also shared a few case studies along with various energy conservation opportunities in boilers.

Day 2 Session 2: Industrial Furnaces, presented by Mr. D. Ramesh

Industrial furnace session covered details of various types of furnaces used in industries. Mr. Ramesh discussed about efficiency levels of various types of furnaces and explained the methodology for carrying out heat balance of industrial furnaces. He also shared a few practical case studies of heat balance in industries along with his field experience of conducting performance analysis of industrial furnaces. The session also covered basic thumb rules along with various energy conservation measures.

Day 2 Session 3: Insulation and refractories, presented by Mr. D. Ramesh

The industrial furnace session was followed by insulation and refractories. Mr. Ramesh explained that as surface losses form a major part of heat loss/gain in most heated/cooled surfaces, use of appropriate insulation material is of utmost importance from energy conservation view point. He described in details about the various types of insulating materials and refractories. Mr. Ramesh also touched upon the thermal coating materials available in market and their benefits in conservation of energy.

Day 2 Session 4: Steam System, presented by Mr. C. Vijayakumar

In most industries using boilers, substantial scope for energy conservation exists in the steam system. Mr. Vijayakumar discussed about the various components of a steam system with special emphasis on the layout and pipe sizing. He also explained about the benefit of using saturated steam for industrial process heating along with the associated calculations and case examples. The session dealt in depth about the various types of steam traps and their usage in industries. Mr. Vijayakumar shared his field experience of conducting analysis of steam traps as part of energy audit studies.

4.3 Day 3 Sessions

Day 3 Session 1: Pumps, Pumping System and Cooling Towers, presented by Mr. Atulkumar Auti

Day 3 session started off with pumps, pumping system and cooling towers. Mr. Atulkumar described the various types of pumps used in industries. He then moved on to the different flow control method employed by industries, the reasons behind use of such methods and the comparative efficiency of each method. Pump efficiency evaluation was also discussed in details and participants were provided with case study to evaluate the operating efficiency of pumps. The use of Variable Frequency Drives (VFDs) along with its governing law; the Affinity law was explained to participants. Mr. Atulkumar also shared a few case examples. Few of the participants requested for detailed calculations of energy savings achieved by various methods. Microsoft excel calculation sheets were also shared with all the participants for better understanding.

Day 3 Session 2: Waste Heat Recovery, presented by Mr D. Ramesh

Waste Hear Recovery was the second session for the day and it dealt with the typical heat recovery options available in industry. The type of waste heat available in industries was classified in 3 categories and each was explained with case examples. Mr.

Ramesh also touched upon the different methods of recovering waste heat and the applicability of each type in different industries.

Day 3 Session 3: Cogeneration, presented by Mr C. Vijayakumar

Mr. Vijayakumar's session on cogeneration focused on the definition, types and advantages of cogeneration. He touched upon the benefit of cogeneration over conventional system also with calculation and case examples. He discussed about the different cogeneration systems like gas based system, oil based or coal based. Participants were also informed about the types of turbines used in cogeneration systems viz. condensing turbines, extraction cum condensing turbine and back pressure turbines. The type of turbine used in different industrial sectors like cement, sugar etc. was shared with the participants.

Day 3 Session 4: Compressed air system, presented by Mr. Kashif Shaukat and Mr C. Vijayakumar

Compressed air systems are available in almost all industries and Mr Kashif gave an in depth information of the various components of a compressed air system. He explained about the working of air compressors, types of air compressors and the different parts and working principles of the air compressor. Mr Shaukat also described about the air driers and importance of air driers in the compressed air network. Mr Skaukat's presentation was followed by Mr Vijayakumar's presentation which focused on the energy performance evaluation of air compressors. He explained about the equipment used for carrying out field measurement, where the measurements are taken along with associated formulas for evaluating the free air delivery of an air compressor. Mr Vijayakumar informed he participants of the methodology adopted for calculating the among of leakages happening in a system.

4.4 Day 4 Sessions

Day 4 Session 1: Refrigeration and Air Conditioning, presented by Mr C. Vijayakumar

The refrigeration and air conditions session covered the basics of refrigeration system along with its various components. The Vapour compression system and vapour absorption systems were discussed and explained in details along with basic working principles. The air handling units along with others associated pumps were also covered. Mr. Vijayakumar went on to explain to the participants the methodology for carrying out performance analysis of the refrigeration system along with the instruments required for field measurements and associated formulas. The participants were given an exercise to evaluate the performance of a chiller which was successfully completed by most participants. Few benchmark values along with basic thumb rules were discussed during the session.

Day 4 Session 2: Fans and Blowers, presented by Mr D. Ramesh

Fans and blowers are important energy consuming component in most industries, especially large energy consuming sectors like cement, thermal power plants etc. Mr D. Ramesh provided a basic overview of the fans and blowers along with the various types available in industry. He shared with the participants the performance evaluation

methodology for fans and blowers and also the instruments required for carrying out field measurements. Mr. Ramesh used his own field experiences to explain to participants the hurdles in carrying out field measurements for fans in large cement and thermal power plants and means to overcome those hurdles. He highlighted the major energy conservation opportunities available in industries with respect to fans and blowers.

Day 4 Session 3: Electrical Systems, presented by Mr Kashif Shaukat

The session on electrical system focused on the different electrical equipment available within the boundary of the industries, starting from the power transformers, distribution transformers, distribution system, power control cubicles etc. Mr. Shaukat explained about the different instruments used for conducting the electrical systems audit along with how to use and connect the instruments in industries. The participants also raised various queries on the measurements and Mr. Shaukat explained all queries and cleared all doubts of the participants. He also highlighted few of the enegy conservation measures in electrical systems and touched upon the basics of DG generators used as captive/emergency backup systems in various industries.

Day 4 Session 4: Electric motors and Lighting Systems, presented by Mr Kashif Shaukat.

The last session on day four was on electric motors and lighting. Motors being the predominant electrical load in all industries, this session covered details about the types of motors and the field measurements to be carried out for the electrical motors. Mr. Shaukat explained about the different speed control methodologies employed in industries and also covered details of the variable frequency drives (VFD) along with methodology of carrying out measurements when VFDs are in use. He also shared few energy conservation measures used in industries for carrying out audits for electric motors.

Second part of session 4 was on lighting systems. Mr. Shaukat spoke about the different energy efficient lamps available in market with specific focus on the LED lamps.

4.5 Day 5 Sessions

Day 5 Session 1: Financial Management, presented by Mr Atulkumar Auti

The first session of last day of the training of Trainer programme was on financial management and our daily participants were joined by experts from banks and other financial institutions to get an overview of the Training of Trainer programme. The financial management session focused on the different financial calculations required to be carried out as part of energy audits. Since most recommendations during energy audits are associated with capital investment, it becomes imperative to analyze the financial viability of the projects. Mr Atulkumar explained the different financial calculations like simple payback period, return on investment, net present value and internal rate of return. The participants were appraised about the advantages and disadvantages of the various methods and also which method is most suitable in the energy audit context.

Day 5 Session 2: Energy performance evaluation in Cement Industry, presented by Mr. K.K. Chakarvarti

Cement being one of the largest energy consuming industrial sector in Pakistan, this session was entirely devoted to conducting energy audits in cement industries. Mr. Chakarvarti gave an overview of the cement manufacturing process explaining the various steps involved in the process of clinkerization and cement grinding. He then explained about the steps to be followed in conducting the audit and carrying out heat balance of the kiln. The various energy conservation opportunities available in most cement industries were highlighted through different case studies.

Day 5 Session 3: Energy performance evaluation in Thermal Power Plants, presented by Mr. C. Vijayakumar

Pakistan mostly comprises of gas and oil based power plants and this session was focused on performance evaluation of the gas and oil based plants. Mr Vijayakumar explained to the participants about the different components in gas/oil based power plants and spoke about the various energy conservation opportunities existing in such plants. Since performance evaluation of most of the equipment used in gas based thermal power plants were already explained in previous session, this session gave an overview of the approach to be adopted while carrying out the audit along with certain case examples.

Day 5 Session 4: Energy performance evaluation in Textile Plants, presented by Mr. D. Ramesh.

The last session of the Training of Trainer Programme was on Textile sector by Mr D. Ramesh. Mr Ramesh spoke about the importance of textile sector to Pakistan's GDP and he also highlighted the presence of a strong female workforce in the textile sector. He gave a brief overview of the major energy consuming equipment in textile mills and shared few case studies along with the energy conservation measures.

4.6 Valedictory Sessions

Mr. Asad Mehmood, Technical Unit Head of NEECA, started the valedictory session and congratulated all participants for successfully completing the training programme. He appraised the participants about the next two phases namely Offline examination and online interview. A few of the participants also came forward to provide their feedback on the Training of Trainer Programme. They congratulated NEECA and CTCN for organizing the training and providing a much needed platform for capacity building of all the stakeholders. Mr Sambit Nayak, Climate Change and Mitigation Expert-Asia Pacific, CTCN also joined the valedictory session. He appreciated the highly interactive participation and applauded NEECA for their continual efforts in developing the energy efficiency market in Pakistan.

The vote of thanks was delivered by Ms Sabreen Ahmed, who emphasized and acknowledged the efforts of the organizing team, along with PITCO and NEECA for successful completion of the training programme. She also thanked all the participants for their active involvement which ensured further knowledge and information sharing.

5. Details of End of Day Quiz

The Training of Trainer Programme was structured to have an online quiz at the end of each day. The quiz was based on the topic discussed during the sessions on that particular day. Each quiz was for 30 minutes and comprised of 21 questions amounting to a total of 30 marks. The first 20 question were of 1 mark each and the 21st question was a 10 mark question. The link for online quiz was shared with each participant at the end of the daily sessions and participants were instructed to complete the quiz within 7PM Pakistan time. The quiz question for all 4 days along with answer keys is provided in Annexure 3A to 3D.

An analysis of the results of the End of Day quiz was carried out and same is shown in Figures 5.1 to 5.4.

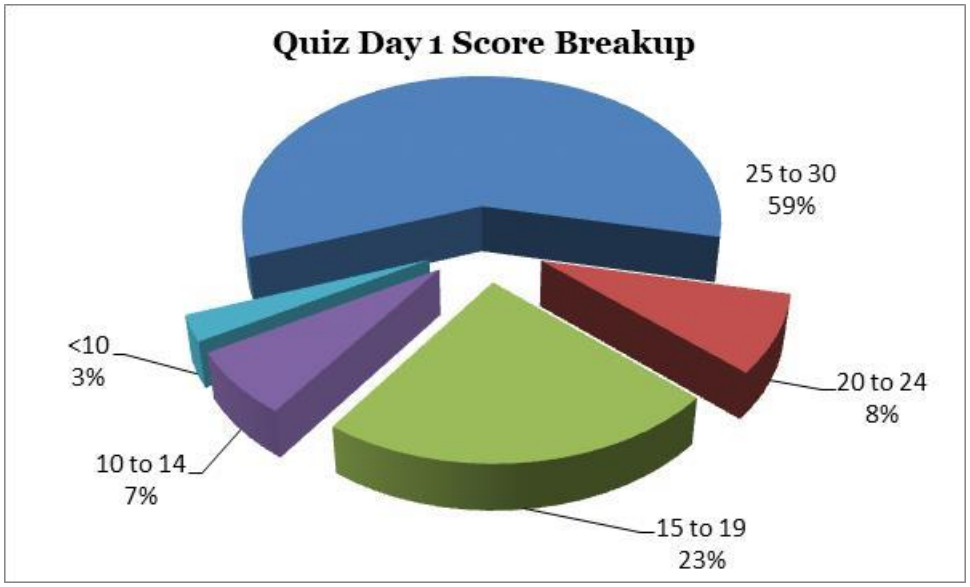


Figure 5.1: Analysis of End of Day 1 Quiz scores

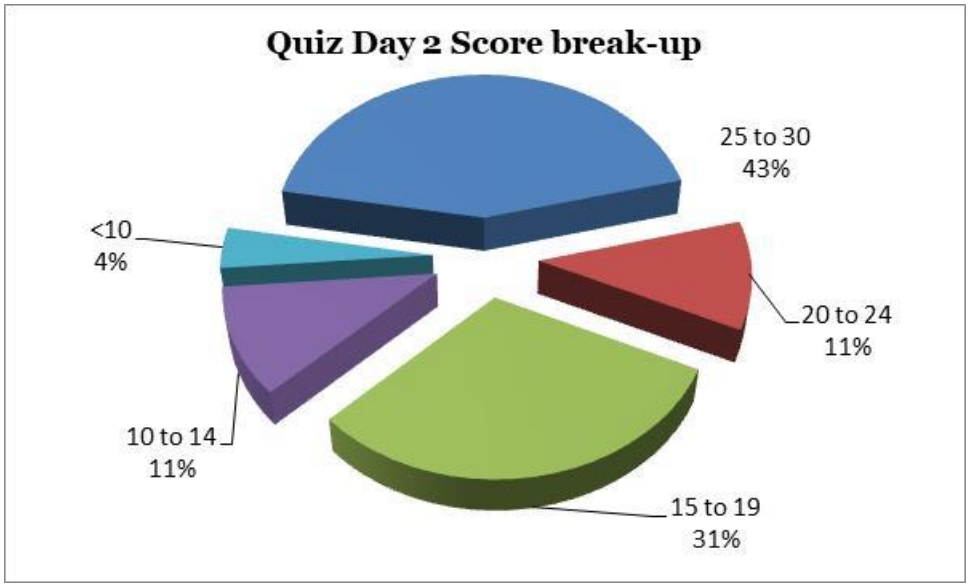


Figure 5.2: Analysis of End of Day 2 Quiz scores

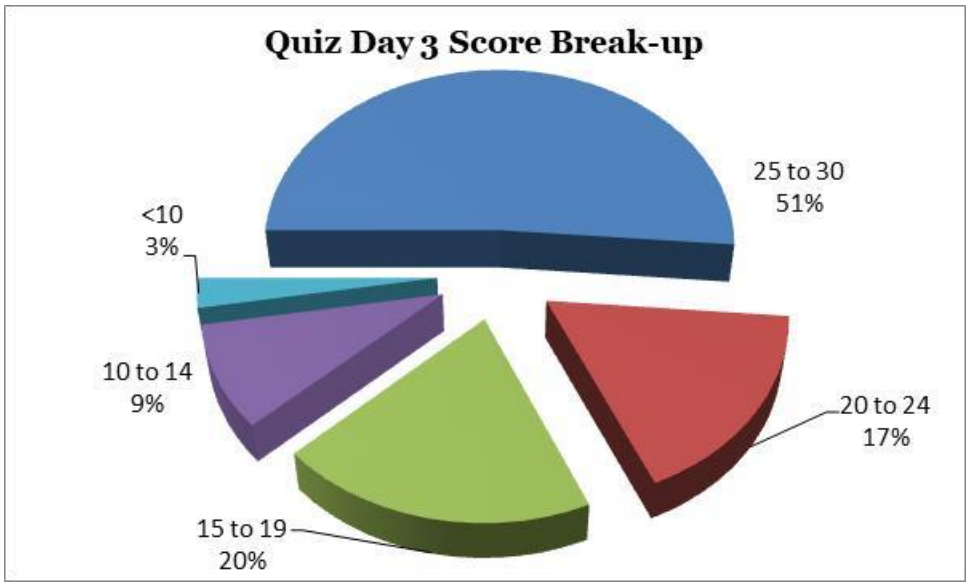


Figure 5.3: Analysis of End of Day 3 Quiz scores

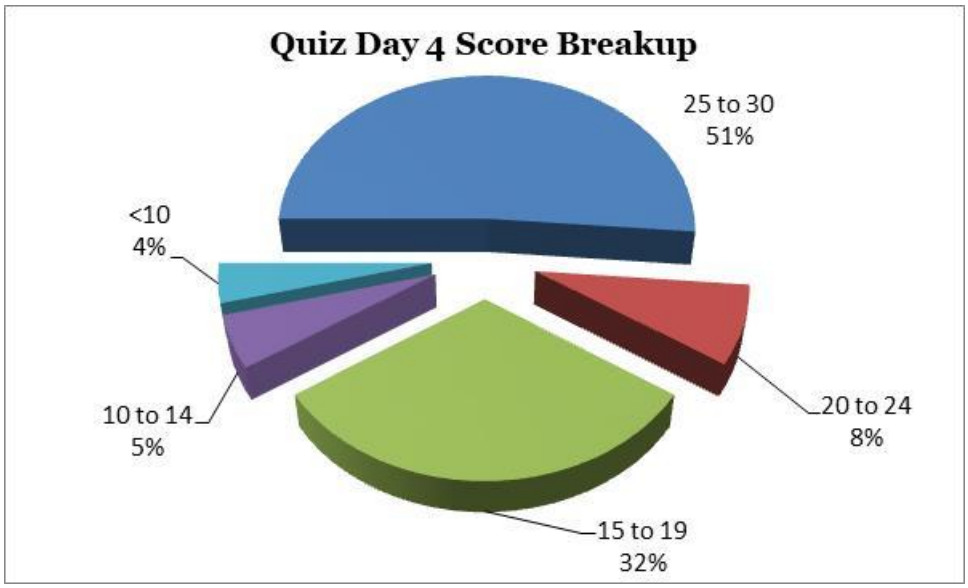


Figure 5.4: Analysis of End of Day 4 Quiz scores

The pass mark was 10 out of a total of 30 marks. From figures 5.1 to 5.4 above, it can be seen that 97% of participants cleared the quiz on day 1, 96% on day 2, 97% on day 3 and 96% cleared the quiz on Day 4.

Since the 21st question being a 10 mark question, which focused mainly testing the application of information shared during the training sessions and solving the problems, an analysis was carried out to identify the number of participants who managed to assess the question and answer it correctly. The results of analysis is given in Figure 5.5.

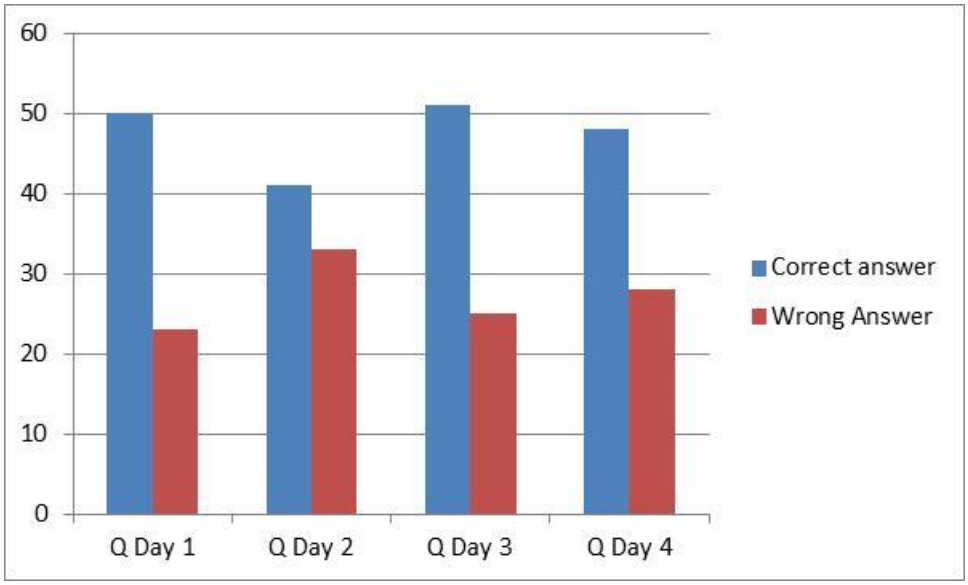


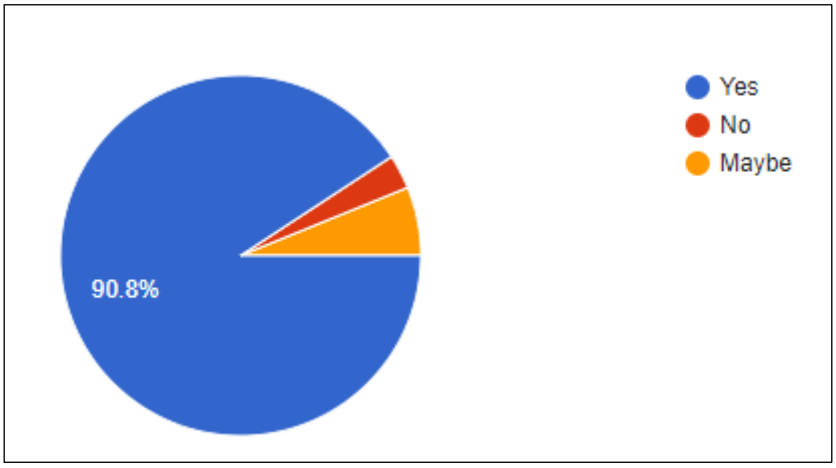
Figure 5.5: Analysis of long question answers

From figure 5.5, it can be seen that on an average 64% of the participants were able to answer the long question correctly.

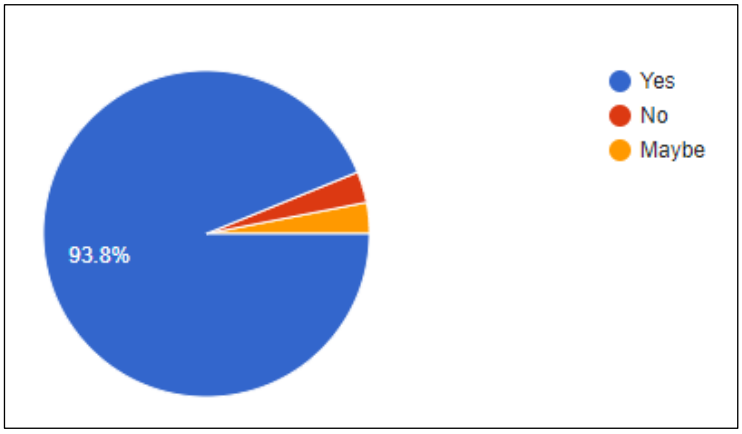
6. Participant Feedback

Feedbacks were collected from participants through online feedback forms for further assessment and necessary customization of future training of trainer (ToT) programmes. Summary of the participants is provided below:

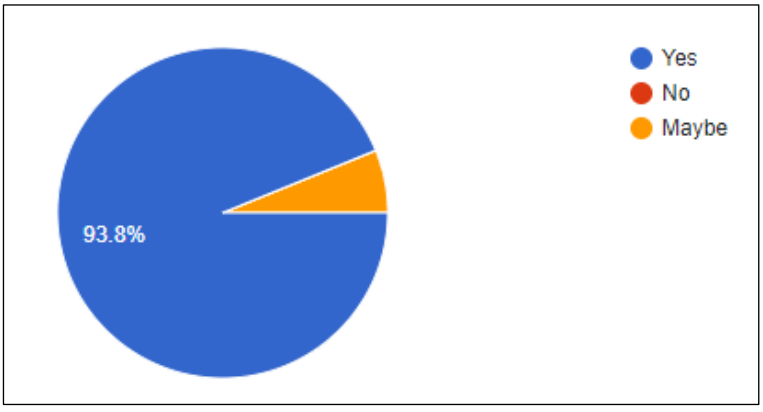
1. Has the ToT programme been able to contribute to capacity building of the participants



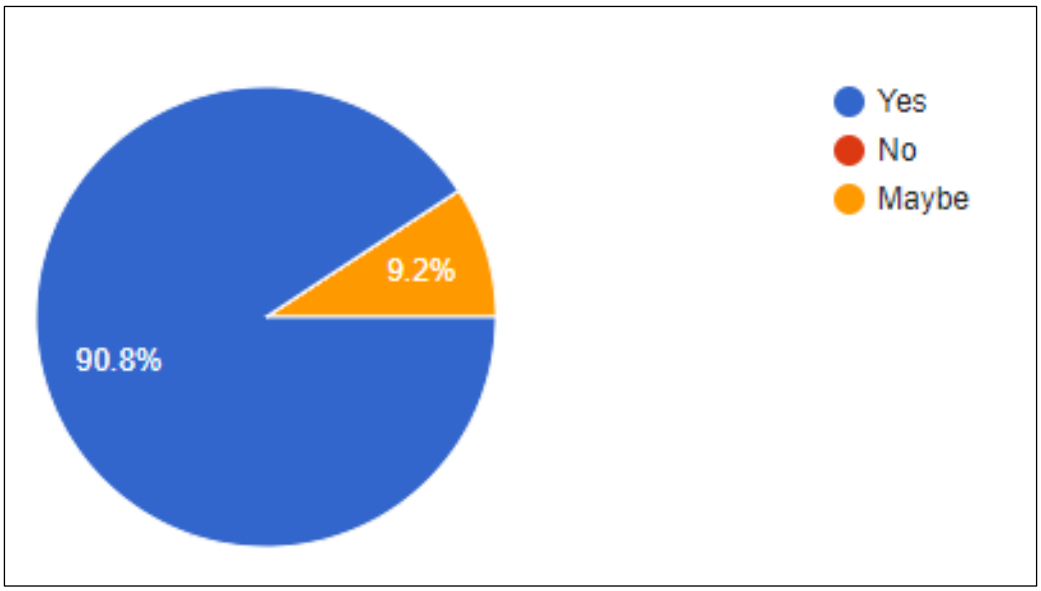
2. Has the ToT programme been able to increase awareness among participants about various energy efficiency techniques



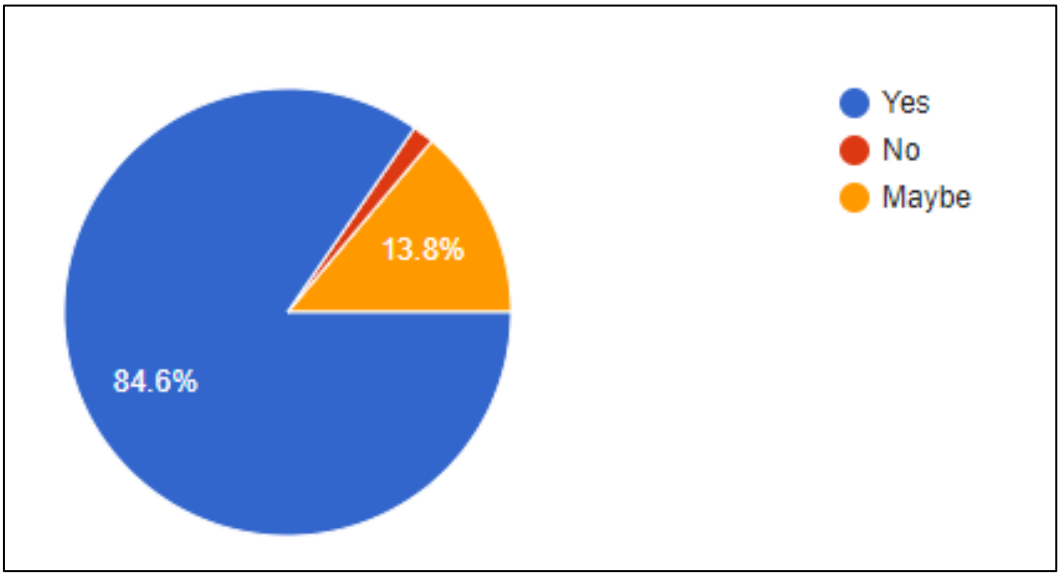
3. Has the ToT been able to increase knowledge of energy efficiency and its benefits



4. Has the ToT been able to increase knowledge of methods and tools for energy efficiency



5. Has the ToT Programme been able to increase knowledge of methods and tools for carrying out performance evaluation of various energy consuming equipment in industry



6. Suggestions and comments on meeting the overall objectives of the Training of Trainer Programme
    a. Request for phase 4 involving field visit to industries for audits
    b. More emphasis on real life example and case studies
    c. More emphasis on data collection and reporting

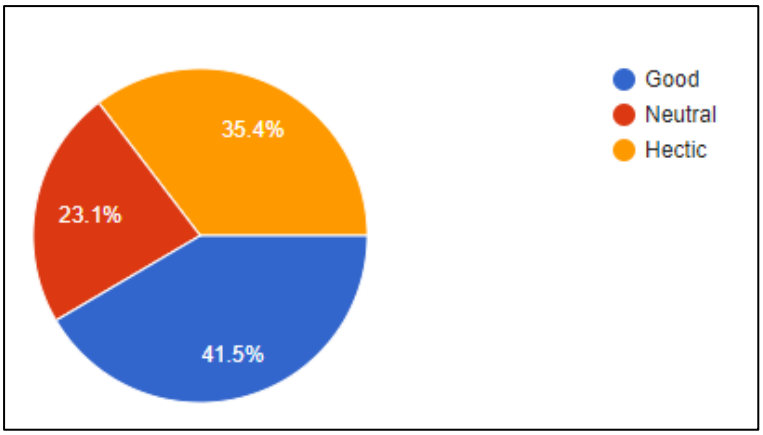
7. How would you rate the importance of the various sessions of the ToT Programme

Topic	Score				
	1	2	3	4	5
Climate change and renewable energy	2	6	14	27	16
Energy audit and management	1	1	6	16	41
Fuels and combustion	0	2	8	25	30
Boilers (Including FBC)	0	1	5	27	32
Industrial furnaces	0	3	11	25	26
Insulation and refractories	0	1	12	29	23
Steam system	0	1	7	23	34
Pumps, pumping system and cooling towers	0	0	8	27	30
Waste heat recovery	0	1	3	24	37
Cogeneration	0	2	7	26	30
Compressed air system	0	4	10	25	26
Refrigeration and air conditioning	0	1	9	26	29
Fans and blowers	0	0	10	27	28
Electrical systems	1	3	6	22	33
Electric drives and lighting	0	3	9	22	31

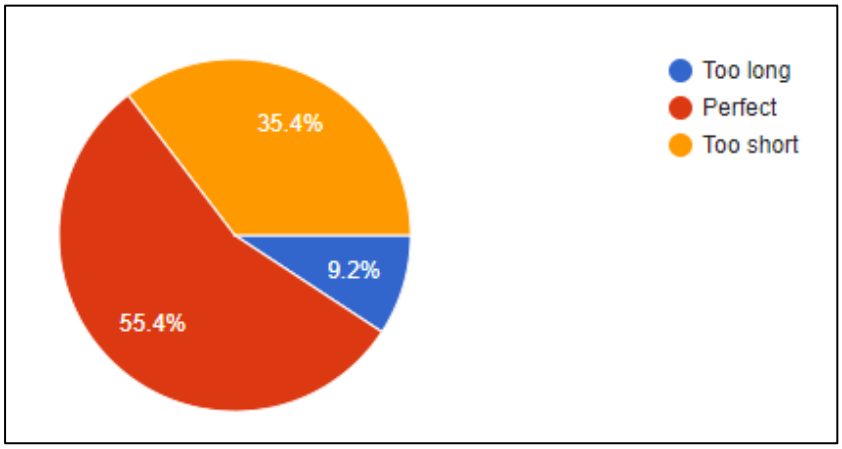
8. How would you rate the performance of various sessions of the ToT Programme

Topic	Score				
	1	**2**	**3**	**4**	**5**
Climate change and renewable energy	3	5	22	25	10
Energy audit and management	0	2	8	32	23
Fuels and combustion	0	2	10	32	21
Boilers (Including FBC)	0	1	12	28	24
Industrial furnaces	1	2	23	24	15
Insulation and refractories	1	3	13	30	18
Steam system	0	2	12	31	20
Pumps, pumping system and cooling towers	0	3	10	31	21
Waste heat recovery	0	2	9	36	18
Cogeneration	1	1	14	27	22
Compressed air system	4	8	18	21	14
Refrigeration and air conditioning	1	1	8	36	19
Fans and blowers	2	2	11	38	12
Electrical systems	2	8	18	24	13
Electric drives and lighting	4	7	19	22	13

9. How do you consider the daily schedule?



10. What is your opinion of the total duration of this ToT programme?



11. Subjects not adequately covered during the ToT Programme

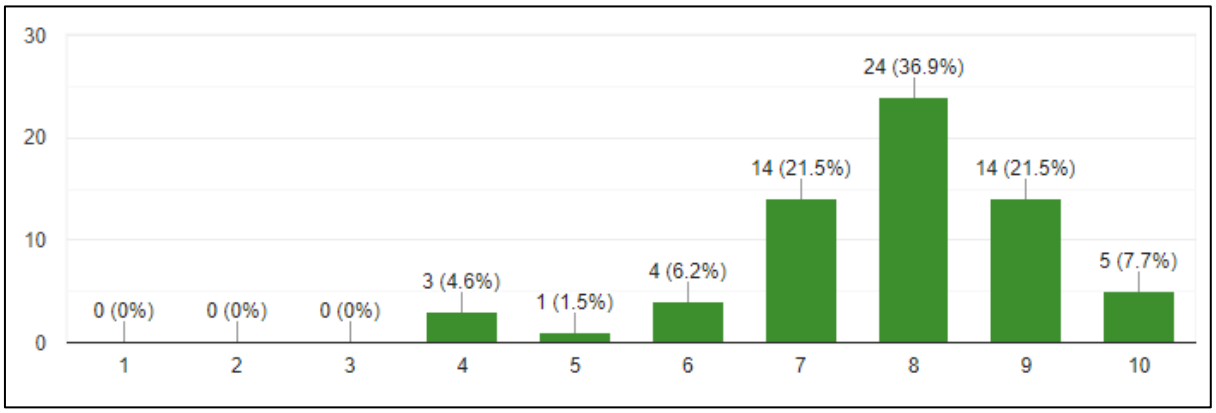
    a. Less emphasis on renewable energy technologies
    b. Electrical systems with reference to electrical grid, transmission and distribution
    c. Data collection and reporting

12. What difficulties, if any, have you encountered?

    a. Network connectivity issues
    b. Difficulty in attending webinar sessions and continuing office work
    c. Short duration, more time required for few topics
    d. Inherent issues with online session, such as lack of physical classroom environment

13. Do you have any other suggestions on changes in the contents and composition of the programme?
    a. Presentation material to be shared before the sessions
    b. Maximum 2 sessions per day
    c. Videos to be added to the presentation

14. Overall rating of the Training of Trainer Programme



As seen from graph above, 66% of the participants gave an overall rating of 8 and above and almost 94% gave an overall rating of 6 and above.

Annexure

1A: Minutes of meeting held on 10.08.2020
1B: Minutes of meeting held on 21.09.2020
2: Advertisement for Training of Trainer Programme in English Daily
3A: Quiz Day 1 Question set with answer key
3B: Quiz Day 2 Question set with answer key
3C: Quiz Day 3 Question set with answer key
3D: Quiz Day 4 Question set with answer key
4: List of Participants
5: Links for training slides and training materials

1A: Minutes of meeting held on 10.08.2020

Minutes of Meeting

Date: 10.08.2020

Participants:

TERI:	**NEECA:**	**PITCO**
Mr. K. K. Chakarvarti	Mr. Sardar Mohazzam	Mr. Qazi Sabir
Mr. D. Ramesh	Mr. Asad Mahmood	
Mr. C. Vijayakumar		
Ms. Sabreen Ahmed		

Agenda: Discussion on modalities of conducting Training of Trainer programme under the National Certification Scheme for Energy Auditors and Managers.

Start time: 2:00 PM Pakistan time (2:30PM India Time)

TERI team updated MD NEECA about the status of the project. Till date, deliverables 1,2,3,4 and 6 have been completed. Only deliverable 5, i.e. Training of Trainer programme is pending due to Covid-19. All the course materials have been submitted and NEECA's feedback has also been obtained. TERI is working on the suggested changes / modifications and will share the finalized books at the earliest.

Considering the ongoing Covid-19 pandemic situation, TERI team mentioned that conducting the training programme in a third location as planned initially doesn't seem feasible till 2021 and thus proposed to conduct the Training of Trainer programme as a webinar series. All participants will be joining in online for the training. Mr. Qazi from PITCO also agreed that webinar series is the best option for the training of trainer programme.

MD, NEECA mentioned that the training programme will be more effective if participants can engage better with the presenters. Mr. K.K. Chakarvarti suggested that the training can be designed as 90 minutes of theoretical training, followed by 45 to 60 minutes of Q&A and case study discussions.

MD NEECA also insisted on the participants being informed about few of the best operating practices for the different industrial sectors. TERI team shared their experience of conducting a training programme for energy auditors and managers in India and the case studies which were shared as part of the programme. TERI mentioned that both international and national (shared by PITCO) case studies can be included for the training of trainer programme. MD, NEECA suggested that Mr. Asad along with PITCO can contact the potential participants and get their feedback about conducting training of trainer programme as webinar series. TERI requested the consultation to be completed by Monday, 17th of August 2020, to arrive at a consensus.

Mr. Asad, NEECA enquired about the question banks for the course material and TERI informed that all question banks will be share by 12/13th of August. MD, NEECA enquired whether the question banks can be designed in the web based format. TERI will be sharing across the question banks in PDF and editable format and same can be used by NEECA to prepare web based format as a separate project. NEECA mentioned that they have an upcoming meeting with CTCN and the modalities of conducting the training programme will be discussed.

The meeting ended at 3:30 PM Pakistan time (4:00 PM India time).

1B: Minutes of meeting held on 21.09.2020

Minutes of Meeting

Date: 21.09.2020

Participants:

TERI:	**NEECA:**	**PITCO**	**CTCN**
Mr. K. K. Chakarvarti	Mr. Sardar Mohazzam	Mr. Qazi Sabir	Mr. Sambit Nayak
Mr. D. Ramesh	Mr. Asad Mahmood		
Mr. C. Vijayakumar			
Ms. Sabreen Ahmed			

Agenda: Discussion on modalities of conducting Training of Trainer programme under the National Certification Scheme for Energy Auditors and Managers.

Start time: 2:00 PM Pakistan time (2:30PM India Time)

TERI team discussed the idea of conducting a launch for the training programme in Islamabad for 50 participants, following which the training programme would be started online basis and participants will attend from their personal locations.

MD NEECA highlighted the major challenge of online sessions; which is the inability of participants to follow the training. Moreover he mentioned that NEECA wants industry to consider energy audits as a business model. In this regard, it was felt that the participants in the training programme should pay for the training and make all necessary arrangements for attending the programme. Since the training programme will assist the participants in realizing further business opportunities, the expenses of the training programme can be considered as an investment by the participants. He felt that it would be beneficial if the participants attended the training programme from designated locations. It was proposed to hold the training at 4/5 locations. Mostly educational institutions/chamber of commerce can be approached for conducting the online training at their premises. The participants will assemble at their closest venue and attend the training programme. All expenses and arrangements for stay and travel is to be borne by the participants. TERI and PITCO will be responsible for expenses related to venue.

Mr Sambit, CTCN accepted the idea proposed by MD NEECA and requested NEECA to share a list of centres where the training will be conducted via online mode.

For transparency in selection of candidates, NEECA felt that it is best to advertise in newspaper regarding the training programme. The candidates will be provided around 2 weeks' time period to respond to the advertisement. For creation of a set of competent trainers, MD NEECA suggested that

50% of the participants should be engineers. Remaining could be from financial background and individuals from engineering colleges and poly technique institutes.

TERI also accepted the proposal and requested NEECA to formulate selection methodology for participants. While selecting participants from the list of applicants, inclusion of women professionals needs to be emphasized. Mr K.K. Chakarvarti said that since the training programme is online mode, it will be conducted simultaneously at all locations. He also mentioned that the regulation for certification procedure of energy auditor and managers needs to be notified by NEECA, along with the rules for minimum qualification for energy auditors and managers.

MD NEECA mentioned that NEECA is exploring ways of connecting financial audits with energy audits and were looking at having participation of professionals from the Big 4 consulting firms based out of Pakistan in the energy auditing market.

Mr Asad mentioned that participants will be required to carry their own laptops as the training programme will also consist of online evaluations. He also requested for possible field visit to industries for the participants.

TERI mentioned that considering the present scenario, it is a bit challenging from project perspective to conduct field visits to industries.

The meeting concluded at 3:15PM Pakistan time (3:45PM India time)

2: Advertisement for ToT in English Daily

APPLICATIONS INVITED FOR PARTICIPATION IN TRAINING OF TRAINERS (ToT) PROGRAM

NEECA has recently initiated number of activities to promote energy efficiency and conservation across all sectors of economy. It has been observed that there is an immense demand for trained human resource to conduct activities related to EE&C. However, there is a shortage of trained human resource and to meet this demand, NEECA intends to conduct ToT Program in collaboration with the Climate Technology Center Network (CTCN) under UNFCCC across Pakistan in November 2020. The aim of ToT is to develop a pool of trainers to train future workforce for Energy Management and Audits.

For more information, interested candidates can visit the **trainings tab** on NEECA website (**www.neeca.gov.pk**) to fill online application forms. The applicants can also send the filled application form in hard copies with an initial application processing fee of Pak Rs. 1000/ in the form of a nonrefundable Payee Account Demand Draft in favor of "Energy Conservation Fund" within the 15 days of this advertisement at the address given below. Please note that due to limited seats only shortlisted candidates meeting the general eligibility criteria will be approached and would be required to submit the final fee of Pak Rs. 25,000/ to attend the course to be conducted by the International & National experts at designated locations in Pakistan.

Research Associate-ECF

NEECA Building, G-5/2, Islamabad.

Ph: 051-2272649, Email: trainings@neeca.gov.pk

3A: Quiz Day 1 Question Set and Answer Key

Energy Audit and Management:

1. The objective of energy management includes
   a) Minimising energy costs b) minimising waste c) Minimising environmental degradation d) all the above
2. The ratio of current year's production to the reference year's production is called as
   a) demand factor b) production factor c) utilisation factor d) load factor
3. Replacement of steam based hot water generation by solar system is an example of
   a) matching energy usage to the requirement b) maximising system efficiency c) Energy substitution d) Performance improvement
4. Which instrument is used to monitor O2, CO in flue gas?
   a) Combustion analyzer b) Power analyzer c) Pyrometer d) Fyrite
5. The percentage of energy saved at the current rate of use, compared to the reference year rate of use, is called
   a) Energy Utilization b) Energy Performance c) Energy Efficiency d) None
6. Non-contact speed measurements can be carried out by
   a) Tachometer b) Stroboscope c) Oscilloscope d) Speedometer
7. The tool used for performance assessment and logical evaluation of avenues for improvement in Energy management and audit is
   a) Fuel substitution b) Monitoring and verification c) Energy pricing d) Bench marking
8. Find out the 'odd' among the following choices for fuel substitution for industrial sector
   a) LDO with LSHS b) coal with rice husk c) natural gas for fertilizer plant d) LPG for soft coke
9. Air velocity in ducts can be measured by using ___ and manometer
   a) Orifice meter b) Borden gauge c) Pitot tube d) Anemometer
10. "The judicious and effective use of energy to maximise profits and enhance competitive positions". This can be the definition of:
    a) Energy Benchmarking b) Energy management c) Energy policy d) Energy Audit

Fuels and Combustion:

1. SI unit of density is:
   a) kg/m2 b) kg/m3 c)m3/kg d) m2/kg
2. For fuel oils, which of the following statements correctly describes the relation between "specific heat" and "specific gravity"
   a) lighter oils have higher specific heat b) heavier oils have lower specific heat c) lighter oils have lower specific heat d) none of the above
3. Viscosity of a fluid is dependent on :
   a) pressure b) pipe size c) temperature d) colour
4. Presence of sulphur in boiler fuel can lead to
   a) erosion b) corrosion c) increased heat transfer d) none of the above
5. To calculate theoretical air requirement for a fuel, we need
   a) proximate analysis b)ultimate analysis c)calorific value d)volatile matter percentage
6. Moisture content is highest in
   a) Coconut shell b)de-boiled bran c)Saw dust d) Paddy husk

7. Hydrogen content is highest in
   a) Coal b) Fuel oil c)Natural gas d) Saw dust
8. Quantity of oxygen required for complete combustion of 12kg of carbon:
   a)32kg b)44kg c)96kg d)108kg
9. High excess air levels result in
   a) dilution of flue gases b) reduction in flue gas temperature and heat transfer c) increase in flue gas losses and reduced combustion efficiency d)All the above
10. Excess air requirement is highest for
    a) Natural gas b) Light oil c) Heavy oil D) Coal

Long Question – 10 Marks

Q. For combustion of 500 kg/hr of natural gas containing 100% methane, calculate the air fuel ratio while 15% excess air is supplied.

Solution:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$

1 mole of methane requires 2 moles of oxygen

16kg of methane requires, 64kg of oxygen

16 kg of methane produces 44kg of carbon dioxide

Therefore, 500kg/h of methane would require 2000kg/h of oxygen and produce 1375kg/h of carbon dioxide.

Theoretical air required for combustion = 2000/0.23 kg/h = 8695.6kg/h

Considering 15% excess air,

Actual air supplied for combustion = 8695.6x1.15kg/h = 10,000kg/h

Air to fuel ratio = 10,000/500 = 20

3B: Quiz Day 2 Question Set and Answer Key

Day 2 Quiz

Boilers

Considering efficiency parameters in mind, which of the boiler can be considered as most efficient? a) fluidised bed combustion boiler b) lanchashire boiler c) Stoker fired boiler d) chain grate boiler
The water supplied to the boiler that is converted into steam is called as: a) make-up water b) condensate water c) feed water d) blow-down water
A rise in conductivity of boiler feed water indicates ___ . a) drop in the contamination of feed water b) greater purity of feed water c) rise in the contamination of feed water d) it has got no relation with the contamination of feed water
For higher boiler efficiencies, the feed water is heated by ___ . a. air pre-heater b. convective heater c. super heater d. economiser
Internal water treatment for steam boiler is done to:. a) remove suspended soils b) prevent formation of scales c) help improve combustion efficiency d) reduce stack temperature

Industrial Furnace

For optimum fuel consumption, furnaces should be operated at a) slightly negative b) slightly positive c) neutral d) any of the above
Pick up the wrong statement: The thermal efficiency of the furnace increases by a) increasing the furnace loading b) increasing the air flow rate c) reducing the surface heat loss d) minimising the CO loss

The axis of the burner in a furnace should be kept: a. slightly inclined towards the roof b. more inclined towards roof c. slightly inclined towards the stock d. parallel to stock
Higher excess air in an oil fired furnace would result in: a. increased furnace temperature b. increased heating rate c. reduced flame temperature d. none of the above
Instrumentation used for measuring billet temperature in a reheating furnace a. flue gas analyser b. infrared pyrometer c. Pt/Pt-Rh thermocouple with indicator d. chrome alumnel thermocouple with indicator

Steam System

1.	The best quality of steam for industrial process heating is: a) dry saturated steam b) superheated steam c) wet steam d) high pressure steam
2.	Which among the following steam traps has the principle of operation "Difference in temperature between steam and condensate" a) thermodynamic trap b) thermostatic trap c) orifice type trap d) float trap
3.	Velocity of steam in steam pipe is directly proportional to: a) number of bends in pipe b) specific volume of steam c) length of pipe d) none of the above
4.	Proper sizing of steam pipeline helps in minimising a) steam requirement b) condensate c) insulation thickness d) pressure drop
5.	The equipment used to remove dirt from steam lines before steam trap is:

	a) vent	b) drain	c) strainer	d) by pass line

Insulation and Refractories

1.	'Ceramic fibre insulation' suitable up to ___ temperature. a) 90 °C b) 105 °C c) 350 °C d) 250 °C
2.	Which Insulation material is suitable for low temperature application? a) Asbestos b) Fibre glass c) Silica d) polyurethane
5.	The refractory material should have ___ heat conductivity. – a) low b) High c) Medium c) None of the above
7.	Which of the following need not be considered while determining the economic thickness of insulation: (a) Surface temperature (b)Boiler efficiency (c) Fuel cost (d) Quantity of makeup water
11.	While positioning the furnace wall using various type of insulation like, fire bricks, calcium silicate blocks and insulation bricks are used. Can you suggest the sequence of placement of their temperature tolerance for each of them? a) hot face, cold faces and intermediates b) cold face, intermediates and hot face c) hot face, intermediate and cold face d) All the above

Long Question

A beverage industry uses a steam jacketed kettle, in which liquid product is batch-processed at atmospheric pressure. The kettle has a 500 kg per batch capacity. Liquid product is heated from a temperature of 30°C to 100°C, where 20% of its mass is then driven off as vapor. The industry processes 3 batches per day. Determine the amount of 1 kg/cm2 (g) steam required per day, not including the heating of the kettle itself. (Specific heat of milk is 0.90 kCal/kg°C). The latent heat of steam at 1 kg/cm^2 is 525kCal/kg.

Solution:

Quantity of water evaporated from liquid product = 500x0.2kg

= 100kg/batch

Heat required for raising temperature of liquid product from 30 to 100°C

= 500x0.9x(100-30)

= 31,500 kCal/batch

Amount of heat required to evaporate 100kg of water = 100x540

= 54000 kCal/batch

Total heat required = (31500+54000) kCal/batch

= 85500 kCal/batch

Quantity of steam required = 85500/525

= 163kg per batch

Total steam required per day = 489 kg per day

3C: Quiz Day 3 Question Set and Answer Key

Cogeneration

1.	In the context of cogeneration turbine, thermodynamic process takes place a) contraction b) <u>expansion</u> c) condensation d) all the above
2.	In a combined cycle power plant consisting of gas turbine and waste heat boiler, the exhaust gas temperature is ___ . a) <u>around 150 °C</u> b) around 250 °C c) around 300 °C d) around 400 °C
3.	In a glass industry, exhaust gas from the glass melting furnace has potential to go for power generation by installing steam boiler and turbine. Which type of co-generation can be applied there: a) gas turbine b) diesel generator c) topping cycle d) <u>bottom cycle</u>
4.	The type of cogeneration which has the maximum overall efficiency is: a) extraction and condensing steam turbine b) diesel engine c) gas turbine <u>d) back pressure steam turbine</u>
5.	Which of the following industry will not use cogeneration concept? a) sugar b) paper & pulp c) refinery d) <u>refractory</u>

Waste Heat Recovery

1.	Economizer is provided to utilize the flue gas heat for ___ a<u>) preheating the boiler feed water</u> b) preheating the stock c) preheating the combustion air d) preheating fuel
2.	Low grade heat ranges from: a) 200 - 600°C b) 600 - 800°C c) 100 - 200°C d) Above 1000°C
3.	In sugar industry, recovery of waste heat from low pressure steam is done using: a<u>) thermo compressor</u> b) waste heat recovery boiler
4.	Which of the following is FALSE for waste heat recovery a) Higher the temperature, greater the potential for heat recovery from flue gas b) Latent heat of condensation can be recovered while extracting heat from vapour streams c) Heat recovery potential does not depend upon the quantity of waste heat available d) Heat can be recovered from 200 deg Celsius waste heat
5.	Example of liquid to liquid heat exchanger is a<u>) plate heat exchanger</u> b) recuperator

	c) economizer	d) regenerator

Pumps and Pumping System

1.	What is the impact on flow and pressure when the impeller of a pump is trimmed? a) Flow decreases with increased pressure b) Both flow and pressure increases c) Both pressure and flow decreases d) None of the above
2.	For high flow requirement, pumps are generally operated in a) parallel b) series c) any of the above d) none of the above
3.	For large capacity centrifugal pumps, design efficiencies are in the range of a) around 70% b) around 85% c) around 95% d) any of above
4.	If the speed of a centrifugal pump is doubled, its power consumption increases by------- times. a) two b) four c) eight d) no change
5.	Small by-pass lines are installed some times to ____. a) control flow rate b) control pump delivery head c) prevent pump running at zero flow d) reduce pump power consumption

Compressed Air System

1.	Over the life of compressor, approximately ___ of the total cost is electricity a) 80% b) 50% c)10% d)25%
2.	The basic function of air dryer in a compressor is: a. prevent dust from entering compressor b. storage and smoothening pulsating air output c. reduce the temperature of the air before it enters the next state to increase efficiency d. to remove remaining traces of moisture after after-cooler
3.	For every 5.5°C raise in air inlet temperature of an air compressor, the power consumption will increases by____ a) 2% b) 1% c) 3% d) 4%
4.	Every 0.14 bar or 2psig reduction in pressure, reduces electric power consumption by a) 1 % b) 2% c) 4 % d) None of the above
5.	From the point of lower specific energy consumption, which of the following compressors are suitable for part load operation? a) Single stage reciprocating compressors b) Centrifugal compressors

	c) Two stage screw compressor	d) Single stage screw compressor

Long Question:

In an energy audit study of a cement plants following measurements were noted.

Rated parameters:

Rated flow, m^3/h	Rated head, m
150	40

Operating parameters:

Measured flow, m^3/h	Measured , kW	Suction head, m	Discharge head, m
110	22	-5	30

Note: Motor efficiency is considered as 92%

Evaluate the operating efficiency of the pump.

Pump efficiency: $= \frac{Flow\left(\frac{m}{s}\right) \times Head\ developed(m) \times 9.81}{(Motor\ Input\ Power \frac{kW}{Motor} efficiency)} \times 100$

Q: m^3/s

W: 1000

H: in meters of fluid column

Typically for pump no. 1

Efficiency η_p : $\frac{\frac{110}{3600} \times (30-(-5)) \times 9.81}{22/0.92} \times 100$

$= 51.8\%$

3D: Quiz Day 4 Question Set and Answer Key

Quiz Day 4

HVAC

1.	The essential parameters to estimate cooling load from air side across air handling unit (AHU) / Fan Coil Unit (FCU) are_____. a) Flow rate b) dry bulb temperature c) RH% or wet bulb temperature d) all
2.	In water cooled refrigeration systems, condenser cooling water temperature should be close to: a) dry bulb temperature b) wet bulb temperature c) dew-point temperature d) any of the above
3.	Higher COP can be achieved with____. a) Lower evaporator temperature and higher condenser temperature b) Higher evaporator temperature and Lower condenser temperature c) Higher evaporator temperature and higher condenser temperature d) Lower evaporator temperature and Lower condenser temperature
4.	The specific energy for a centrifugal chiller producing chilled water at 5.5 °C and condenser water temperature around 30 °C is the order of: a) 0.65 – 0.8 kW / TR b) 1.0 kW / TR c) 1.15 – 1.25 kW/ TR d) 0.45 – 0.55 kW/ TR
5.	The efficiency of screw compressor at part load compared to centrifugal compressor is __. a) higher b) lower c) Same d) None
6.	The device used to cool the refrigerant in vapour absorption chiller is: a) vacuum pump b) condenser c) vacuum condenser d) none of the above

Fans and Blowers:

1.	Which of the following is not a centrifugal fan type? a) Vane axial b) Radial c) Airfoil, backward d) Forward curved
2.	Capacity control for axial fans can be carried out by the which method? (a)damper control (b)Inlet Vane control (c)Blade angle control (d)None of the above

3.	For a centrifugal fan, the speed was reduced by 10%, what will be the corresponding reduction in power? a)10% b)19% c)22% d)<u>27%</u>
4.	The pressure to be considered for calculating the power required for centrifugal fans is: a) Discharge static pressure b) Static + dynamic pressure c) <u>Total static pressure</u> d) Static + ambient air pressure
5.	The pressure along the line of the flow that results from the air flowing through the duct is _____ a) Static pressure b) <u>velocity pressure</u> c) Total pressure d) Dynamic pressure

Electrical System:

1.	If distribution of power is raised from 11 kV to 66 kV, the voltage drop would lower by a) 6 times b) <u>1/6 times</u> c) 36 times d) 1/36 times
2.	If the distribution voltage is raised from 11 kV to 33 kV, the line loss would be: a) <u>Less by 1/9</u> b) More by 9 times c) No change d) None of the above
3.	The maximum demand of an industry, if trivector meter records 3600 KVA for 15 minutes and 3000 kVA for next 15 minutes over a recording cycle of 30 minutes is____. a) 3600 kVA b) 3000 kVA c) <u>3300 kVA</u> d) 600 kVA
4.	The loading of a 1MVA distribution transformer was found to be 40%. Transformer no load loss: 1kW, Full Load Loss: 10kW. Calculate the annual energy losses of the transformer. (Assume 8760 hours of operation per annum) a) <u>22,776kWh</u> b) 21,765kWh c) 8760kWh d) 14,016kWh
5.	The 5th and 7th harmonic in a 50 Hz power environment will have: a) voltage and current distortions with 55 Hz & 57 Hz b) voltage and current distortions with 500 Hz & 700 Hz c) <u>voltage and current distortions with 250 Hz & 350 Hz</u> d) no voltage and current distortion at all

Electric Motors

1.	The efficiency figures for energy efficient motors (in comparison with standard efficiency motor) can be generally higher by___%. a) 1% b) 3-7% c) 10% and above d) 8-10%
2.	Unbalance in voltages at motor terminals is caused by ___. a) Supplying single phase loads disproportionately b) Use of different sizes of cables c) Both (a) & (b) d) None of the above
3.	With decrease in speed of the motor, the required capacitive kVAr: a) Increases b) Decreases c) Does not change d) None of the above
4.	Which of the following are ill suited for energy efficient motors application? a) Pumps b) Fans c) Punch Presses d) All the above
5.	The inexpensive way to improving energy efficiency of a motor which operates consistently at below 40% of rated capacity is by ____. a) Operating in Star mode b) Replacing with correct sized motor c) Operating in delta mode d) None

Long Question:

L1. Estimate tonne of refrigeration from the data given below for two AHUs?

Parameter	AHU-A	AHU-B
Evaporator area (m^2)	8.75	0.39
Inlet velocity (m/s)	1.81	11.50
Inlet air DBT (°C)	21.5	24.5
RH (%)	75.0	73.5
Enthalpy (kJ/kg)	53.0	59.3
Out let air DBT (°C)	17.4	19.5
RH (%)	90.0	83.0
Enthalpy (kJ/kg)	46.4	53.0
Density of air (kg/m^3)	1.14	1.05

AHU refrigeration load =

$$\frac{Air\ \ flow\ rate\,(m^3h)\ x\ Density\ of\ \ air\,(kg/m^3)\ x\ Difference\ in\ enthalpy}{3024\ \ x\,4.18}$$

	AHU-A	$= \frac{(8.75\,x\,1.81\,x\,3600)\,x\,(1.1.4)\,(53-46.4)}{3024\,x\,4.18} =$ 33.9 TR
	AHU-B	$= \frac{(0.39\,x\,11.5\,x\,3600)\,x\,(1.05)\,x\,(59.3-53)}{3024} =$ 8.4 TR

4: List of Participants

S. No	Name:	Cell:	Emails:	City:
1	Sardar Mohazzam		sardar.mohazzam@gmail.com	Islamabad
2	Asad Mahmood	0333-5501855	asadm_46@yahoo.com	Islamabad
3	Muhammad Umar	0345-8691989	muhmad.umar@gmail.com	Islamabad
4	Tanzeel ur Rehman Khan	0333-5650011	tanzeelkhan164@gmail.com	Islamabad
5	Sher Shah Hasan	0343-3550578	shershah@neeca.gov.pk	Islamabad
6	Syed Zohaib Abbas	0334-7005613	syedzohaib@neeca.gov.pk	Islamabad
7	Rida Abbas	0332-2141472	ridaabbas28@yahoo.com	Islamabad
8	Muhammad Kashaf	0331-3613092	kashaf.ssuet15@gmail.com	Islamabad
9	M Omar Qasmi	0300-9756516	momarqasmi@hotmail.com	Islamabad
10	Irfan Ahmad Gondal	0333-5398944	drirfanagondal@gmail.com	Islamabad
11	Hafiz M Kamran	0334-8831443	kamran.dcma.bannu@gmail.com	Islamabad
12	Usman Afzal	0321-5357177	usmanok@gmail.com	Islamabad
13	M. Naveed Khan	0304-9041429	muhammadnaveedk786@gmail.com	Islamabad
14	Farhan Khan	0312-5139035	farhan.kn86@gmail.com	Islamabad
15	Faheem Akhtar	0333-2892202	faheem.akhtar@iba-suk.edu.pk	Islamabad
16	Azhar ulhaq	0315-4149253	azhar.ulhaq@ceme.nust.edu.pk	Islamabad
17	Muhammad Ramzan	0300-0664656	m.ramzan@nepra.org.pk	Islamabad
18	Dr. M. Imran Ahmad	0344-9020774	imran.ahmad@uetPeshawar.edu.pk	Peshawar
19	Dr. M. A. Irfan	0346-9304648	mairfan@uetPeshawar.edu.pk	Peshawar
20	Muhammad Rizwan	0345-5853555	rizwan_191@hotmail.com	Peshawar
21	Irum Shehzadi	0340-1931271	iramrvc@gmail.com	Peshawar
22	Faizullah Khan	0332-9245711	faizikhan917@yahoo.com	Peshawar
23	Zaeem Ahmed	0346-9849299	zaeemuet14@gmail.com	Peshawar
24	Naveed ahmed	0333-9298191	engrnavid99@gmail.com	Peshawar
25	Alamgir Khan	0345-8385866	alamgirkhan1466@gmail.com	Peshawar
26	Syed Shafiq Aziz	0345-9459908	shafiqpesco@gmail.com	Peshawar
27	Atif Khan	0333-2136288	atif@arch.com.pk	Karachi
28	Atif Naeem	0333-6315958	atif.naeem@hubpower.com, atifnaeem_878@yahoo.com	Karachi

S. No	Name:	Cell:	Emails:	City:
29	Dr. Ahmed Ali Shah	0334-3545092	ahmedali.shah@iba-suk.edu.pk	Karachi
30	Ali Zia Naqvi	0316-2315616	alizia.engr@gmail.com	Karachi
31	Fahad Juma	0300-2334465	imperial.energysolution@outlook.com	Karachi
32	Uzair Jamil	0332-2037764	uzair.jamil@hotmail.com	Karachi
33	Mujtaba Qadri	0322-2224702	mujtabaqadri91@gmail.com	Karachi
34	Farhan Malik	0333-2484236	farhan-malik@hotmail.com	Karachi
35	Syed Farhan Ali	0331-2004802	syed.farhan@sgs.com	Karachi
36	Muhammad Ali Imran	0344-5529414	ali.imran@sgs.com	Karachi
37	Arif Mehmood	0333-6054058	arif.mehmood@omsltd.net	Karachi
38	Bilal Hasan	0321-8959191	bilal.hasan@hubpower.com	Karachi
39	Adnan Ibad	0322-3811014	adnan.ibad@sgs.com	Karachi
40	Mehdia Naqvi	0332-8212838	mehdianaqvi93@gmail.com	Karachi
41	Salman Shamim	0343-2536254	msalman.dcet@gmail.com	Karachi
42	Tariq Jamal	0322-8187004	tjamal44@gmail.com	Karachi
43	Lalarukh Memon	0332-2825558	lalarukhmemon@gmail.com	Karachi
44	Shabee Husnain	0333-3872566	shabee.husnain@envirogreen.co	Karachi
45	Rehan Fareed Khan	0321-8753558	rehan.khan@lucky-cement.com	Karachi
46	Syed Qambar Ahmed Rizvi	0313-2290258	qambar_riz@hotmail.com	Karachi
47	Rohail Aftab Siddiqui	0331-2792691	rohail.aftab@toyota-indus.com	Karachi
48	Amer Mehmood	0333-6599113	amer.mehmood@energyfuturesconsulting.com	Lahore
49	Faisal Hameed	0300-2015135	faisal.hameed@synsol.pk	Lahore
50	Fahad Akhtar	0300-7798248	fahad52engr@gmail.com	Lahore
51	Ahrar Ahmed	0334-4546747	ahrarahmad@hotmail.com	Lahore
52	Aitsam Hassan	0331-4964452	eatisam@hotmail.com	Lahore
53	Sobia Baig	0321-9697148	drsobia@cuiLahore.edu.pk	Lahore
54	Kaleem ullah Khan	0300-8486590	kaleemkhan@hubpower.com	Lahore
55	Rashid Bhatti	0300-0206379	rashid.bhatti@hubpower.com	Lahore
56	Amir Mehmood	0301-8262599	amir.mahmood@hubpower.com	Lahore
57	Hussnain Nadeem	0301-8110773	hussnain.nadeem@hubpower.com	Lahore
58	Fahad Zaman	0331-4061601	fahad.zaman@mayfair.com.pk	Lahore

S. No	Name:	Cell:	Emails:	City:
59	Fawad Azeem	0334-3545106	fawad.azeem1@gmail.com	Lahore
60	Syed Faizan Ali	0334-4783115	faizan_alishah@hotmail.com	Lahore
61	Amir Zahoor	0321-4012358	amir.zahoor@nu.edu.pk,	Lahore
62	Muhammad Shahzaib	0308-0942182	consultant.shahzaib@gmail.com	Lahore
63	Saqib Waheed	0333-4400667	sakibwaheed@yahoo.com	Lahore
64	Wasif Nawab	0321-7567273	wasif.nawab@omsltd.net	Lahore
65	Raza Hussain	0322-4473903	raza.hussain@omsltd.net	Lahore
66	Mahmood Ahmed	0300-7834336	mahmood691@live.com	Lahore
67	Waqar Ahmed	0335-4675668	engr.waqar018@gmail.com	Lahore
68	Sameer M Tahir	0333-4343756	sameer.muhammad42@gmail.com	Lahore
69	Talha Fareed Hashmi	0334-9949659	tfhashmi@hotmail.com	Lahore
70	Samir Ahmad	0341-2082000	samir.ahmad@energyfuturesconsulting.com	Lahore
71	Ahsan Abbas	0333-4209448	m.ahsanabbas@gmail.com	Lahore
72	Hafiz Zaheer Ahmad	0321-4702048	engrzaheer87@gmail.com	Lahore
73	Nauman Sheikh	0344-7202994	naumansheikh16@hotmail.com	Lahore
74	Rabia Kalsoom	0318-3991722	rabiakalsoom11@gmail.com	Lahore
75	Ahmad Faizan	0345-4501094	mohd.ahmad.faizan@gmail.com	Lahore
76	Hammad Mushtaq	0333-6730583	mhammadpannu@gmail.com	Lahore
77	Abdullah Khattak	0345-5086114	akhattak@lmkr.com	Islamabad
78	Faheem Ashraf	0300-5359877	mfa1410@gmail.com	Islamabad
79	Mustafa M haji	0322-2313255	mustafa@keystonesocks.com	Karachi
80	Nadeem Ahmed	0300-2829767	110keystone@gmail.com	Karachi

5: Link for training slides and training materials

Link for training slides in pdf format:

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Link for training materials (Video recordings):

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