Post Report of
On-line Training of Stakeholders on Digitizing Industrial Motor Systems for Energy Efficiency

Table Of Contents

Introduction

According to International Energy Agency (IEA), around half of the electricity used globally is consumed in electric motor systems. Industrial motor systems account for about 70% of manufacturing sector electricity consumption in different countries. United Nations Environmental Program (UNEP) has suggested that the motor systems have a potential of about 20% - 30% energy reduction through optimization and operational measures such as digitization. The digitization process is the incorporation of the latest technology including IoT into the industrial flow process for controlling, coordinating, and communicating industrial operations. However, awareness, familiarity, and higher skill levels should be ensured before proceeding to the digitization process.

In order to enhance the expertise of industry stakeholders in the Member States, SAARC Energy Centre conducted an Online Training of Stakeholders on Digitizing Industrial Motor Systems for Energy Efficiency from 6th December 2021 to 10th December 2021. Detailed agenda of the training is available at Annexure I Agenda. The training was based on a simulation/software platform along with presentations, lectures, training notes, videos, and interactive discussion. The training has been attended by industrial stakeholders from the majority of SAARC Member States. The training covered selection criteria of efficient electric motor systems, the basis energy savings in digitized motor systems, industrial flow process control, control, and communication strategy, application of the latest IoT tools etc. The training also focused on issues, challenges, and opportunities pertaining to digitization in the South Asian context.

The objective of this online training was to equip the stakeholders of the SAARC region with essential skill sets for the digitization of the motor systems. This training has become helpful for the participants to understand and apply smart technologies like variable frequency drives (VFD), IoT in the industrial process. Enhancement in the expertise of stakeholders will be supportive to transform the operations and energy footprint of industries in the South Asian Region.

In this training Top 10 China was invited as a team lead. Partnering with Impact Energy in Switzerland and other 6 well-versed trainers, the training has been successfully completed.

Participation

The training was attended by 86 industrial stakeholders representing various government organizations, private sector companies, industries, academia, and researchers from the SAARC Member States. The list of registered participants and their day of attendance is available in Annexure-II List of Participants.

Description

The training commenced with the introductory remarks by Programme Coordinator/Moderator, Mr. Tula Ram Poudel, Research Fellow, of SEC. The inaugural address was delivered by Dr. Tanvir Ahmad, Acting Deputy Director, of SAARC Energy Centre, Islamabad. He highlighted the importance of the digitalization of motor systems and energy efficiency for the South Asia region and showed his appreciation to the trainers and trainees. The briefing of the training including the breakdown of sessions was highlighted by Mr. Hu Bo, Director, Top 10 China.

The training comprised of five days interactive sessions including presentations by the trainers followed by Q&A sessions and a short self-assessment quiz for the participants (available at Annexure- VI MCQs for trainee evaluation). The training was focused on industrial motor systems efficiency and saving potential, motor system standardization, remote digital live training, demonstration of MEPSY online calculation, Industrial loT solutions, smart meters application, Industrial communication protocol, etc.

Technical Proceedings

The training was conducted for 5 days, with each day 1technical session comprising of 2 - 3 lectures by trainers followed by the Q&A. The sessions were moderated by Mr. Tula Ram Poudel (RFET). The technical sessions included quizzes for self-assessment of the participants, discussion on case studies, demonstration of the software, display of short videos, devices, and sensors, and open discussions to meet the learning objectives. The trainer's profiles along with their presentations are available at Annexure- Ill Trainers' profiles and contact details and Annexure -IV Technical presentations respectively. The list of suggested reading materials is available at Annexure- V List of suggested reading materials.

Training Sessions

From 6 December 2021, the training was conducted for 5 consecutive days until 10 December 2021 from 1400 hrs Pakistan Standard Time. Each day of training consists of two slots.

Day 1:

Slot 1: Mr. Conrad U. Brunner covered the title "Overview of motor system energy efficiency improvement. The aim of this slot was to provide information on motor system saving potential in the big overview and motor and system standardization. The trainees had the opportunity to have an extensive overview of the motor system energy efficiency and digitalization.

Slot 2: This slot with the title of "Motor Systems efficiency and check with model tools"

was presented by Mr. Rolf Tieben. This aimed at providing information on motor system energy conservation projects management in factories, assessing factory motor saving potential with the SOTEA tool, managing factory motor systems with ILI+ tool and calculating motor system efficiency with the motor system tool. The trainees were familiar with how to calculate energy efficiency, what are barriers for efficiency improvement and how to use the tools of SOTEA and ILI+

Day 2:

Slot 1: it was presented by Hu Bo with the title of "Pump System Energy Efficiency and Smart Pump Demonstrator". It aimed at providing information on conducting remote digital live training via a pump demonstrator training facility and pump system operation and energy-saving cases with pump demonstrator. The trainees could understand international technology transfer, the pump system energy efficiency facts, the digital pump demonstrator operation and cases to avoid the low-efficiency operation of the pumps.

Slot 2: This slot entitle Q "Condition Monitoring for Motors and Powertrain" was presented by Teijo Karna. The purpose of this slot was to provide information on digitalization, condition monitoring, the importance of motor and powertrain monitoring and ABB's technical solutions for condition monitoring. The trainees are familiar with the benefits of motor condition monitoring, conduct the condition monitoring and ABB's solution in motor and powertrain condition monitoring

Day 3:

Slot 1: It was presented by Andrea Vezzini. He took the audience through VFD and motor system saving potentials. It aimed at providing information on VFD application in system energy conservation and efficiency, VFD and Motor efficiency, and motor system transmission efficiency. The trainees know how to improve motor and VFD efficiency and save energy for pump systems by VFD and Pump.

Slot 2: It was presented by two experts. Mr. Liu Ren presented on "Development and Implementation of Energy Efficiency Standards & Labeling Programs for Motor in China", and Colin Taylor presented "Mepsy: The Appliance & Equipment Climate Impact Calculator ". Those presentations aimed to provide information about the introduction and demonstration of the MEPSY online calculation tool for policy development and China motor and related system energy efficiency standardization and best practices. The trainees knew how the MEPS standards can promote energy efficiency development national wide. The MEPSY calculation tools show the energy-saving potential in SA countries. This tool is used to stimulate policy changes.

Day4:

Slot 1: It was presented by Mr. Hu Bo explained on Digitalization and Electricity

Monitoring. It aimed at providing information on smart meters application in motor systems and electricity monitoring meters and technical solutions. The trainees are taught on the technologies behind the innovative pump demonstrator, digitalization by various cases, and live demonstration.

Slot 2: This slot was also presented by Mr. Hu Bo. He discussed Industrial communication protocol training 1: Modbus. It aimed to provide information on the Modbus protocol introduction demonstration and application. The trainees could know in-depth knowledge of Modbus industrial equipment communication protocol and debug tools and software to communicate and control the Modbus devices.

Day 5:

Slot 1: It was covered by Mr. Lokesh B.M. He presented on "IEC Low voltage motors: VFD Applications & Motor Technologies". It aimed at providing information on VFD duty motor, types of loads, and VSD Efficiency & savings. The trainees knew the motor performance characteristics in-depth, the motor load types, VFD duty motor, how to apply VSD for different type loads, problems in preventing and the saving potentials from VSD application.

Slot 2: It was presented by Mr. Hu Bo. He presented on Industrial communication protocol training II: OPC UA". It aims at providing information on OPC UA protocol introduction, OPC UA protocol modeling, and OPC UA protocol programming and application. The audience knew the benefits of OPC UA loT communication protocol, the history and introduction of OPC UA, how to research OPC UA, and several cases that apply the OPC UA technologies.

After each slot presentation, the trainee's queries were addressed by the trainer

The MCQs for each day's training were conducted to evaluate the trainee's understanding of the knowledge shared by trainers. These MCQs are provided at Annexure - VI MCQs for trainee evaluation

Closing

The closing of the training was conducted after the last slot of day 5 training. Mr. Conrad Brunner a former IEC motor technical committee member gave highly impressive summary remarks on motor system energy efficiency and digitalization and expressed his willingness to support the related works in the South Asia region in the future Mr. Conard's remarks was followed by Mr. Hu Bo. He appreciated the participants for joining and SAARC Energy Centre for the oppo rt unity. Finally, on behalf of the director of SEC, Communications Specialist Ms. Mehnaz Khurshid Gardezi gave the final closing speech, and the event ended.

Annexure- I Agenda

SAARC Energy Center, Islamabad

On-line Training of Stakeholders on Digitizing Industrial Motor Systems for Energy Efficiency

December 6 – 10, 2021

Timetable for online training

Day	Time (Pakistan Standard Time)	Titles and Speakers	Description
Session 01: Inauguration & Efficient motor systems approach			
Day-1, Dec-6,	2:00 – 2:05 PM	Welcome and Introduction ***by Tula Ram Poudel, Research Fellow (Energy Trade), SEC***	
	2:05-2:15 PM	Inaugural address by **Director SAARC Energy Centre**	
	2:15 – 2:25 PM	Overview of training program By ***Mr. Hu Bo, Top10 China***	
	2:25 – 3:10 PM	**Slot 1:** Overview of motor system energy efficiency improvement By ***Mr. Conard. U. Brunner, CUB, Switzerland***	• Motor system energy saving potential overview • Motor and motor system standardization
	3:10 – 3:30 PM	**Q&A session and Break**	
	3:30 – 5:00 PM	**Slot-2:** Motor Systems efficiency and check with model tools By ***Mr. Rolf Tieben, Impact Energy, Germany*** *and* ***Mrs. Rita Werle, Impact Energy, Hungary***	• Motor system energy conservation projects management in factories • Assess factory motor saving potential with SOTEA tool • Manage factory motor systems with ILI+Tool • Calculate motor system efficiency with motor system tool
	4:50 – 5:00 PM	**Q & A Session and day's wrap up**	
Session 02: Digital pump system and smart solutions			
Day-2 Dec-7	2:00 – 3:15 PM	**Slot-1**: Pump system with pump demonstrator By ***Mr. Hu Bo, Top10, China***	• Conduct remote digital live training via pump demonstrator training facility • Pump system operation and energy saving cases with pump demonstrator
	3:15 – 3:30 PM	**Q&A session and Break**	
	3:30 – 4:50 PM	**Slot 2:** ABB Ability Industrial Internet of Things (IoT) for smart motors and digital powertrain By ***Mr. Teijo Karna, Product manager, ABB motion Service division, Finland***	• ABB Ability Industrial IoT solutions • ABB motor system application cases
	4:50 – 5:00 PM	**Q & A Session and day's wrap up**	

	Session 03: VFD and motor system saving potentials		
Day-3 Dec-8	2:00 – 3:20 PM	**Slot-1**: Complete drive Systems – motors & VFD By ***Mr. Andrea Vezzini, IEC TC member, Switzerland***	• VFD application in system energy conservation and efficiency • VFD and motor efficiency • Motor system transmission efficiency, belt/gears
	3:20 – 3:40 PM	**Q&A Session and Break**	
	3:40 – 4:50 PM	**Slot 2:** Motor system energy-saving best practices from China ***By China National Institute of Standardization, China*** MEPSY – motor saving potentials in different scenarios By ***Mr. Colin Taylor, CLASP, USA***	• Introduction and demonstration of MEPSY online calculation tool for policy development • China motor and related system energy efficiency standardization and best practices • Motor system energy performance contracting
	4:50 – 5:00 PM	**Q & A Session and day's wrap up**	
	Session 04: Digitalization of motor and energy systems		
Day-4 Dec-9	2:00 – 3:00 PM	Slot-1: Electricity monitoring and digitalization By ***Mr. Hu Bo, Top10, China***	• Smart meters application in motor systems • Electricity monitoring meters and technical solutions
	3:00 – 4:00 PM	**Slot-2: Industrial communication protocol training I: Modbus** By ***Mr. Hu Bo, Top10, China***	• Modbus protocol introduction • Modbus protocol demonstration and application
	4:00 – 4:20 PM	**Q&A Session and Break**	
	4:20 – 4:50 PM	**Slot-3:** Industrial communication protocol training II: OPC UA By ***Mr. Hu Bo, Top10, China***	• OPC UA protocol introduction • OPC UA protocol modeling • OPC UA protocol programming and application
	4:50 – 5:00 PM	**Q & A Session and day's wrap up**	
	Session 05: Digitalization of motor systems and closing ceremony		
Day-5 Dec-10	2:00 – 2:50 PM	**Slot 1:** ABB motor efficiency improvement applications matching with motor technologies and different case studies By ***Mr. Lokesh B.M, R&D Hub Manager India, ABB Motion IEC motor division, India***	• ABB Ability Industrial IoT solutions • ABB motor system application cases
	2:50 – 3:00 PM	**Q & A Session**	
	3:00 – 4:00 PM	**Slot-2:** Industrial communication protocol training II: OPC UA II By ***Mr. Hu Bo, Top10, China***	• OPC UA protocol introduction • OPC UA protocol modeling • OPC UA protocol programming and application
	4:00 – 5:00 PM	**Valedictory session**	Closing Remarks by Director SEC and Mr. Conrad U. Brunner

Annexure- II List of Participants

S.N.	Last Name	First Name	Email Address	Days attended
1	Wahab	Abdul	abdulwahab2334@outlook .com	0
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8	Naufal	Ahmed	ahmed.naufal@ura .gov.mv	5
9	Vasser	Ahmed Ammar	ammar312@gmail .com	0
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78	Qureshi	Muhammad Ali	rfpower@saarcenergy.org	1
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Annexure – IV Trainers' profiles and contact details

Conrad U. Brunner: cub@cub.ch

Conrad U. Brunner got his diploma at the ETH in Zurich in 1966 and completed a Master degree at the University of Pennsylvania. He has been working since 1974 in energy efficiency. He was involved in launching the Swiss Agency for Efficient Use of Energy (S.A.F.E.) and of the international Topten program for efficient appliances. Since 2004 he has been engaged in energy efficiency project, research and policy work in industry. He has been an expert for the development of Ecodesign regulations of motors, pumps and fans. In 2014, he founded together with Rita Werle and Rolf Tieben the international consultancy Impact Energy in Zurich and is its president of the board. He is responsible for the Task International Standards in IEA 4E Electric Motor Systems Annex. He is active in IEC TC2 motors and SC 22G converters as well in the IEC Advisory Committee of Energy Efficiency (ACEE) and involved in a variety of national Swiss and international efficiency projects in China and India around efficient electric motor systems.

Rolf Tieben: rolf.tieben@impact-energy.ch

In 2010 Rolf Tieben has received his diploma as a Mechatronic Engineer at the Technical College Willhelmshaven (D). In 2012 he joined S.A.F.E., the Swiss Agency for Efficient Energy Use, focusing on electric energy efficiency in industry. In 2014 Rolf Tieben and his colleagues Rita Werle and Conrad U. Brunner established the company Impact Energy (www.impact-energy.ch), of which he is a member of the board. Impact Energy is an independent consultancy, concentrating its field of work on energy efficiency in the industry, commercial and agricultural sectors in Switzerland, but also engaging in projects worldwide.

Hu Bo: hu.bo@top10.cn

Hu Bo started his career by working for China Standard Certification Center in the field of energy efficient product certification, standardization, labeling, green government procurement and sustainable consumption and production. From November 2009, he moved to Top10 China as technical manager until now. He took in charge of top energy efficient products study for household appliances, office equipment and cars. His work covers testing, standardization and market research. He started his motor work at CSC from a market transformation project for higher efficient motor in 2007. He continues his motor work by introducing Topmotors from Switzerland to China. He works for Topmotors Zhenjiang pilot project from 2014. He transferred Swiss motor training facility PumpDemonstrator to China and develop an innovative digitalized China version. He also localize Topmotors training

materials with the support of SDC.

Teijo Karna: teijo.karna@fi.abb.com

Mr. Teijo Karna is a Product Manager at ABB Motion Service Division, Finland. He has completed BSc in mechanical engineering. He has 25 years of experience in ABB. His areas of expertise include Electrical Motors and Frequency Converters in different Sales, Project and Service management roles. He also long experience in Wind power and other Renewable energy segments.

Andrea Vezzini: andrea.vezzini@bfh.ch

Prof. Andrea Vezzini received 1996 a PhD in Electrical Engineering from ETH Zürich, Switzerland and successfully completed in 2002 the program for Mastering Technology Enterprises (MTE) at IMD Lausanne. He is Professor for Industrial Power Electronics at Bern University of Applied Sciences since 1996 and was visiting Professor at GM Advanced Technology Centre in 2003 and Distinguished Visiting Scientist at CSIRO Australia (Commonwealth Science and Industrial Research Organization) in 2007. Currently Prof. Dr. Andrea Vezzini holds the position of Head of the BFH-CSEM Energy Storage Research Center and Deputy Head of the Swiss Competence Center for Energy Research (SCCER) Mobility. Since Beginning of 2015 he is member of the Federal Energy Research Commission (CORE). Since 2017 he is a member of the 4E Electric Motor Systems Annex for Switzerland

Liu Ren: liuren@cnis.ac.cn

Liu Ren is an associate researcher from the China National Institute of Standardization (CNIS). His research covers mandatory and voluntary industrial equipment energy efficiency standards, public quality inspection projects, and national infrastructure projects. He is deeply involved in energy management, technical consulting projects, and R&D projects supported by national funds. He takes the lead and participates in developing more than 10 national mandatory energy efficiency standards for industry equipment and energy monitoring and management. He is also active in international collaboration initiatives, such as APEC EGEEC secretary and G20 EE Hub secretary. Before joining CNIS, he worked as the China Quality Certification Centre engineer in various subjects, including testing, reporting, research, and certification. Liu Ren got his doctoral degree from the Beijing Institute of Technology, and he studied as a post-doctor at Tsinghua University.

Colin Taylor: ctaylor@clasp.ngo

Colin is a Manager on the Climate team, leading impacts modeling and financial mechanisms to support market transformation for cooling and beyond. He brings over seven years of energy efficiency and finance experience. Prior to joining CLASP, Colin lived in Jamaica

where he co-founded a consulting business focused on clean energy policies and projects. He holds a B.A. in International Politics & Economics from Middlebury College and an M.A. in International Economics and Energy, Resources, and Environment from Johns Hopkins University's School of Advanced International Studies. Outside of work, Colin enjoys traveling to find the best hiking trails and camping spots.

Lokesh B.M: lokesh.b.m@in.abb.com

Mr. Lokesh BM is Vice President of R&D Hub & Engineering Manager in ABB India Ltd. Bangalore. He has Completed BE in Electrical & Electronics Engineering from Mangalore University. He has over all 23 Years of experience in Design & Development of 3 Phase Induction Motors. He Started his career in Kirloskar Electric company as a management trainee & served in Design & Engineering of 3 Phase induction motors for 6 Years. He Joined ABB Bangalore in 2005 for new Low Voltage motor plant project & now as on date heading R&D and Engineering team for IEC low Voltage Motors, India based in Bangalore.

Annexure – V Technical presentations

Please refer to the SAARC Energy Centre training web portal page:
https://www.saarcenergy.org/on-line-training-on-dims-ef/

Annexure – VI List of suggested reading materials

Please refer to the SAARC Energy Centre training web portal page:
https://www.saarcenergy.org/on-line-training-on-dims-ef/

Annexure - VII MCQs for trainee evaluation

Day 1:

1. Motor system consumes about % of global electricity?
    a) 53%
    b) 45%
    c) 75%
    d) 30%

Answer is: A

2. Which 3 motor systems consume most electricity?
    a) Pump
    b) Conveyor
    c) Transport
    d) Pan
    e) Air compressor
    f) Lift

Answer is: A, D, E

3. What is the range of IEC 60034 standards motor energy efficiency classification?
    a) IE0 – IE5
    b) IE1 – IE5
    c) IE0 – IE4
    d) IE1 – IE4

Answer is: D

4. Which international organization is responsible for motor energy efficiency?
    a) ISO
    b) IEC
    c) ICCT
    d) 3GPP

Answer is: B

5. Which belt has lowest energy efficiency?
    a) Flat-Belt
    b) Toothed-Belt
    c) V-Belt
    d) Direct transmission

Answer is: C

6. What is the rated efficiency of a 7.5 kW motor with following parameter: voltage – 400V, current – 13.4A, power factor: 0.92?
    a) 90%
    b) 88%
    c) 86%
    d) 84%

Answer is: B

Day 2:

1. What's the rotating speed of 4 poles motor at the input electricity of frequency 50 HZ?
    a) 3000 RPM
    b) 1500 RPM
    c) 1000 RPM
    d) 800 RPM

Answer is: B

2. The output power of pump is proportional to the? of the speed of the motor?
    a) Linear
    b) Square
    c) Cubic
    d) 4 times

Answer is: C

3. What's increasing rate of power when the rotating speed of motor increased by 4% for a pump system?
    a) 4%
    b) 8%
    c) 12%
    d) 16%

Answer is: C

4. When the flow is reduced to ZERO by the valve, will the output power of the pump be reduced to ZERO too?
    a) Yes
    b) No

Answer is A

Day 3:

1. The electricity cost takes? % of life cycle costs components for industrial electric motors
    a) More than 90%
    b) 80%
    c) 70%
    d) 60%

Answer is: A

2. A VFD makes an additional loss of about 3-4% at the nominal point but allows to control the driven equipment over a large torque and speed range. Is this correct?
    a) No
    b) Yes

Answer is: B

3. The Mepsy can model all of the following except:
    a) National electricity consumption reductions
    b) Lifecycle cost savings for consumers
    c) Peak demand reductions
    d) National CO2 emissions reductions

Answer is: C

4. Which of the following is needed for conducting custom Mepsy analysis?
    a) Number of manufacturers in your country

b) Natural gas prices
c) Average annual motor electricity consumption
d) Uptake of motor replacement programs

Answer is: C

Day 4:

1. Modbus was published in which year?
   a) 1975
   b) 1978
   c) 1979
   d) 1982

Answer is: C

2. The maximum number of slave devices supported by Modbus is?
   a) 240
   b) 247
   c) 250
   d) 255

Answer is: B

3. The function code of “write single coil is”?
   a) 03
   b) 04
   c) 05
   d) 06

Answer is: C

4. The function code of “write single hold register is”?
   a) 03
   b) 04
   c) 05
   d) 06

Answer is: D

5. The function code of “read single hold register is”?
   a) 03
   b) 04
   c) 05
   d) 06

Answer is: A

Day 5:

1. What are the advantage of VFD?
   a) Soft start of Induction motor
   b) Precise control
   c) To increase the efficiency of system
   d) All of the above

Answer is: D

2. What are type of loads?
    a) Quadratic Torque
    b) Constant torque
    c) Constant power
    d) Constant power/Torque
    e) All of the above

Answer is: E

3. Example of Quadratic Load?
    a) Conveyor
    b) Rollers
    c) Pumps & Fan
    d) None of the above

Answer is: C

4. The function code of “write single hold register is”?
    a) For Speed variation
    b) Reduce mechanical components
    c) To improve the system efficiency
    d) All of the above

Answer is: D

5. The function code of “read single hold register is”?
    a) Induction Motor
    b) Shaded pole motor
    c) Ferrite Assisted Synchronous Reluctance motor
    d) None of the above

Answer is: C