Erasmus+

Erasmus+ - Key Action 2

Capacity Building within the Field of Higher Education

eACCESS Project

Project number: 610041-EPP-1-2019-1-PL-EPPKA2-CBHE-JP

EU-Asia Collaboration for aCcessible Education in Smart Power Systems

WP 1	**PREPARATION**
TASK	T2.1 Development of the professional training courses
LEAD PARTNER	TUL
PARTICIPATING PARTNERS	AUTH, KEC, RUB, ATM, SCU

Document Status		
Date of Issue	18/10/2023	
Contributors	Tomasz Siewierski (TUL), Bishal Rimal (KEC), Manoj Sharma (RUB), Marsul Siregar (ATM), Florentinus Setiawan (SCU)	
Contact person	Tomasz Siewierski (TUL)	
E-mail address	t.siewierski@p.lodz.pl	
Organisation	Lodz University of Technology, Lodz, Poland (TUL)	
Approval Status	Draft ☐	Final ☒
Number of pages		
Keyword list		
Recipients	Only Partners ☐	Public ☒
Method of Distribution	Email ☒	Internet ☐
Confidentiality Status	Confidential ☐	Public ☐
Copyrights	**@TUL, @KEC, @RUB, @ATM,@SCU**	

Disclaimer

The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein:

DOCUMENT HISTORY

VERSION NO	DATE	Approved By	Revised By
1	18/10/2023	Tomasz Siewierski	Tomasz Siewierski
2	20/10/2023		Dimitrios Lampridis
3	28/10/2023	Tomasz Siewierski	Dimitrios Lampridis
4	**30/10/2023**	**Dimitrios Lampridis**	**Santiago Matalonga**

EXECUTIVE SUMMARY

The eACCESS project, leveraging its developed laboratory infrastructure, has successfully collaborated with four partner universities: KEC, RUB, ATM, and SCU. Together with EU partners, they have meticulously crafted curricula, proposed agendas, and comprehensive teaching materials for four specialised professional courses. These courses address critical aspects of industrial automation, switchgear and protection, photovoltaic (PV) installations, and microgrid systems.

The eACCESS project will drive excellence in renewable energy education, bridging theory and practice for a sustainable future.

The curriculum of the courses covers over 120 contact teaching hours, and they have been prepared. They will be delivered in close collaboration between outstanding academics from partner universities and experts from their local industrial partners.

The teaching material, tailored to the needs and expectations of professionals, technicians and engineers, includes almost 500 pages of presentations for face-to-face lecturing and over 130 pages of laboratory instructions and manuals for laboratory classes. What is more, many supporting reading materials developed under the eACCESS umbrella and support for regular courses and included in the deliverable D4.6 (Preparation of the final technical documentation and teacher and student laboratory instructions) will be made available for the participants of professional courses.

These courses position partner universities as leaders in specialised education. Industrial partners' collaboration fosters mutual learning and aligns with lifelong learning objectives. Bilateral and multilateral collaborations are expected to flourish, benefiting academia and industry.

TABLE OF CONTENT

1 Industrial automation training at KEC

1.1 Introduction

The demand for skilled professionals proficient in automation technologies such as Programmable Logic Controllers (PLCs) is rising in today's rapidly evolving industrial landscape. Recognising this trend, universities have a unique opportunity to collaborate with industry partners to offer professional courses in PLCs, attracting more students and ensuring graduates are well-prepared for the demands of the workforce. This essay explores the myriad benefits of such collaboration and outlines several strategies for implementation.

First and foremost, developing the curriculum for PLC courses in consultation with industry experts is paramount. By engaging with industry partners, universities can gain valuable insights into current industry needs and trends, ensuring the curriculum remains relevant and up-to-date. Real-world case studies, projects, and examples can be incorporated into the coursework, providing students with practical learning experiences that directly translate to the workplace.

Moreover, inviting industry professionals to deliver guest lectures and workshops adds a valuable dimension to the learning experience. These experts can share their insights and experiences, offering students valuable perspectives on PLC programming, applications, and best practices. Interacting with industry speakers allows students to ask questions, engage in discussions, and gain a deeper understanding of the practical aspects of working with PLCs.

Internships and co-op programs offer another avenue for collaboration between universities and industry partners. By establishing partnerships with companies in the automation and manufacturing sectors, universities can provide students with hands-on experience in industry settings. These programs allow students to apply their theoretical knowledge in real-world contexts, gaining valuable practical skills and insights into the day-to-day operations of PLC-based systems.

Furthermore, collaborative research projects sponsored by industry partners offer students the opportunity to contribute to cutting-edge advancements in PLC technology and automation. Engaging students in applied research activities enhances their technical skills and fosters innovation and creativity. By working on real-world problems, students gain a deeper understanding of the complexities of industrial automation and develop critical thinking and problem-solving abilities.

Professional development courses and certification programs in PLC programming and automation technologies further enhance students' employability and career prospects. By offering industry-recognized certifications, universities validate students' skills and expertise, increasing their competitiveness in the job market. These certifications testify to students' proficiency in PLC programming and automation, making them highly sought after by employers in the automation industry.

Forming industry advisory boards comprising representatives from leading automation companies, manufacturing firms, and engineering organisations ensures that university PLC courses align with industry needs and standards. Advisory board members provide valuable input and guidance on

program development, curriculum updates, and industry trends, ensuring that graduates are well-prepared to meet the demands of the workforce.

Access to state-of-the-art facilities, equipment, and software used in PLC programming and automation is essential for providing students with a comprehensive learning experience. By collaborating with industry partners, universities can access cutting-edge technology and resources, enabling students to gain practical experience and stay updated with the latest advancements in the field.

Finally, facilitating job placement opportunities and offering career services to students completing PLC courses ensures a smooth transition from academia to the workforce. By partnering with industry organisations, universities can connect students with potential employers, providing valuable networking opportunities and career guidance. Career counselling, resume writing workshops, and networking events further support students in their job search efforts, ensuring they are well-prepared to embark on successful careers in industrial automation.

In conclusion, offering university professional courses in Programmable Logic Controllers (PLCs) presents an excellent opportunity to collaborate with industry partners and attract more students. By leveraging industry collaboration, universities can enrich their PLC courses, provide students with valuable learning experiences, and enhance their competitiveness in the job market. This collaboration benefits students and industry stakeholders by bridging the gap between academic knowledge and industry practice, preparing students for successful careers in industrial automation.

PLC training benefits many professionals in industries that utilise automation and control systems. Here's a list of individuals who can benefit from attending PLC training:

Automation Engineers: Automation engineers responsible for designing, implementing, and maintaining automated systems in manufacturing plants, process industries, and other industrial settings can benefit from PLC training to enhance their programming skills and troubleshoot automation systems effectively.

Control Systems Engineers: Control systems engineers involved in designing and optimising control systems for industrial processes can benefit from PLC training to understand the integration of PLCs within control architectures and develop efficient control strategies.

Industrial Technicians and Electricians: Industrial technicians and electricians responsible for installing, configuring, and maintaining PLC-based control systems can benefit from PLC training to gain a deeper understanding of PLC hardware, programming, and troubleshooting techniques.

Maintenance Technicians: Maintenance technicians tasked with diagnosing and repairing faults in PLC-controlled machinery and equipment can benefit from PLC training to develop troubleshooting skills and reduce downtime in production facilities.

Process Engineers: Process engineers involved in optimising manufacturing processes and improving production efficiency can benefit from PLC training to implement advanced control algorithms and monitor process variables using PLC-based systems.

System Integrators: System integrators responsible for integrating PLCs with other automation components such as sensors, actuators, and human-machine interfaces (HMIs) can benefit from PLC training to ensure seamless communication and interoperability between different subsystems.

Plant Managers and Supervisors: Plant managers and supervisors overseeing production facilities can benefit from PLC training to understand the capabilities of PLCs, optimise production processes, and make informed decisions regarding automation investments.

Maintenance Managers: Maintenance managers responsible for overseeing the maintenance activities of PLC-based systems can benefit from PLC training to develop maintenance strategies, allocate resources effectively, and ensure the reliability of automation equipment.

The training will be based on the laboratory infrastructure developed in the eACCESS project (Pillar Three). The critical laboratory components, stand configuration, individual hardware and software components, and maintenance procedures are briefly described in **Annexe D2.1 KEC-1**. More on the laboratory infrastructure can be found in **the deliverables D4.1** and **D4.2**, available from the project website.

1.2 Training description

Professional training in Programmable Logic Controllers (PLCs) allows individuals to gain expertise in designing, programming, and troubleshooting automation systems widely used in industrial settings. The curriculum of the training will entail:

Fundamental Concepts:

- Introduction to automation: Understanding the importance of automation in modern industries.
- Basic electrical concepts: Familiarization with electrical components and circuits.
- Industrial control systems: Overview of control systems and their components.

PLC Basics:

- Introduction to PLCs: Understanding the purpose and functions of PLCs.
- Familiarisation with various PLC components such as CPU, I/O modules, and power supplies.
- Introduction to programming software used for PLCs.
- Input/output (I/O) modules: Understanding digital and analogue I/O modules and their configurations.

PLC Programming:

- Learning the fundamentals of ladder logic programming language.
- Understanding different types of PLC instructions such as timers, counters, and data manipulation instructions.
- Practical exercises to reinforce programming skills.
- Best practices for organising PLC programs for clarity and efficiency.

Advanced Topics:

- Understand communication protocols used for PLC networking.
- Introduction to HMI systems and their integration with PLCs.
- Motion control: Basics of motion control systems and their integration with PLCs.
- Safety PLCs: Overview of safety-related programming and standards for safety PLCs.

Troubleshooting and Maintenance:

- Learning systematic approaches to diagnose and solve PLC-related issues.
- Understanding preventive maintenance strategies to ensure the reliability of PLC systems.
- Hands-on experience in identifying and rectifying common PLC programming errors.

Application Projects:

- Apply PLC programming skills to solve practical industrial automation challenges.
- Project work -Collaborative projects to design and implement PLC-based control systems.
- Analyse real-life case studies of PLC applications in various industries.

Professional training in PLCs equips individuals with the skills and knowledge needed to excel in roles such as PLC programmer, automation engineer, control systems technician, and industrial maintenance technician. It provides a solid foundation for building a successful career in industrial automation.

1.3 Training agenda

The professional course on Automation Training will be held at the KEC campus at eACCESS Automation Laboratory, KEC, Dhapakhel, Lalitpur, Nepal.

The following preliminary agenda has been proposed for the 10-day intensive course.

Day 1	
Time	**Topics/Events**
9:30-10:00	Registration
10:00-11:00	Introduction to Automation and PLC
11:00-12:00	Introduction to Siemens S7 1200 PLC
12:00-1:00	Lunch Break
1:00-2:00	Introduction to Delta EX2 series
1:00-2:00	Introduction to Siemens TIA Portal
2:30-3:00	Coffee Break
3:00-3:30	Introduction to WPL Soft Delta software
3:30-4:00	Introduction to ladder Diagram

Day 2	
10:00-10:30	Understanding network and branches
10:30-12:00	Bit level Instruction

12:00-1:00	Lunch Break
1:00-2:30	Bit logic Operation and Project using different instruction
2:30-3:00	Coffee Break
3:00-4:00	Latching and unlatching

Day 3	
10:00-11:00	Positive and negative edge
11:00-12:00	Introduction to timers (Pulse timer, On-OFF timer, retentive timer)
12:00-1:00	Lunch Break
1:00-2:30	Timer continue
2:30-3:00	Coffee Break
3:00-4:00	Timer Parameter

Day 4	
10:00-12:00	Project using different types of timer
12:00-1:00	Lunch Break
1:00-2:30	Comparators operation
2:30-3:00	Coffee Break
3:00-4:00	Different types of math operation

Day 5	
10:00-11:00	Move operation
11:00-12:00	Program control operations(Jump label, Jump List, and switch)
12:00-1:00	Lunch Break
1:00-2:30	Project development using move, comparator and math instruction
2:30-3:00	Coffee Break
3:00-4:00	Project development cont:

Day 6	
10:00-11:00	Word Logic operation
11:00-12:00	Shift and rotate operation
12:00-1:00	Lunch Break
1:00-2:00	PLC safety circuits
2:00-2:30	Use of simulation in Siemens 17
2:30-3:00	Coffee Break
3:00-4:00	Delta PLC wiring

Day 7	
10:00-11:00	Project development in Delta PLC
11:00-12:00	Analog addressing and scaling
12:00-1:00	Lunch Break
1:00-2:30	Case studies and real field problem using Siemens training kit:
2:30-3:00	Coffee Break

3:00-4:00	Introduction to commonly used networking protocols-Profibus, Modbus, Ethernet

Day 8	
10:00-11:00	Master Slave Mode
11:00-12:00	Communication issues and troubleshooting
12:00-1:00	Lunch Break
1:00-2:00	Introduction to HMI and overview of delta HMI software
2:00-2:30	Tools and features for creating graphics, animations, etc:
2:30-3:00	Coffee Break
3:00-4:00	Types of switches and indicators and their usages

Day 9	
10:00-11:00	Animation and interlocking and their usages
11:00-12:00	Events, Alarms, Numeric display elements
12:00-1:00	Lunch Break
1:00-1:30	Different types of communication between PLC and HMI
1:30-2:30	Problem based worksheet
2:30-3:00	Coffee Break
3:00-4:00	Introduction and role of SCADA in Industrial Automation

Day 10	
10:00-11:00	Overview of SCADA software WinCC
11:00-12:00	Textual, Graphical and animation in SCADA
12:00-1:00	Lunch Break
1:00-2:00	Tagging, Trends Events and Alarms
2:00-2:30	Communication with PLC
2:30-3:00	Coffee Break
3:00-4:00	Problem based worksheets

1.4 Training material

For the theoretical (lecturing) part of the professional courses on Industrial Automation, KEC academic staff prepared 20 excellent quality presentations:

- Presentation 1: Introduction to automation, 20 slides,
- Presentation 2: Introduction to plc and ladder, 39 slides,
- Presentation 3: Introduction to Siemens TIA, 20 slides,
- Presentation 4: Networks and branches in TIA, 11 slides,
- Presentation 5: Understanding Bit Level Instructions, 24 slides,
- Presentation 6: Understanding set and reset, 28 slides,
- Presentation 7: Understanding Positive and Negative Edge Trigger, 16 slides,
- Presentation 8: Understanding Timer Pulse, 13 slides,
- Presentation 9: Understanding Timers On Delay, 10 slides,

- Presentation 10: Understanding Timers OFF Delay, 13 slides,
- Presentation 11: Retentive Timer, 9 slides,
- Presentation 12: Understanding Timer Parameters, 9 slides,
- Presentation 13: Understanding Counters, 9 slides,
- Presentation 14: Counters Operation, 9 slides,
- Presentation 15: Understanding Counters CTUD, 9 slides,
- Presentation 16: 17 Understanding Comparators, 6 slides,
- Presentation 17: Understanding Math Instructions, 28 slides,
- Presentation 18: Understanding Move Operations, 19 slides,
- Presentation 19: Understanding Jump switch, 15 slides,
- Presentation 20: Understanding Word Logic Operations, 26 slides.

In cooperation with industrial partners, 333 pages of teaching material for the theoretical part have been prepared by the KEC academic staff. The presentation files for these practicals are included in **Annexe D2.1 KEC - 2**.

Figure 1 The first page of the presentation from the teaching materials prepared for KEC professional training on Industrial Automation

For the practical part, the KEC team also prepared four practical exercises based on the eACCESS laboratory infrastructure for the professional course participants, accompanied by illustrative presentations. They will be used to develop or improve. PLC programming skills. They include the following exercises:

- Project 1: Box sorting application, 14 slides.
- Project 2: Time application, 13 slides.

- Project 3: Counter application, 11 slides.
- Project 4: Monitoring and control of water level, 13 slides

Together, 51 pages of teaching material for laboratory practicals have been delivered. The presentation files for these practicals are included in **Annexe D2.1 KEC - 3**.

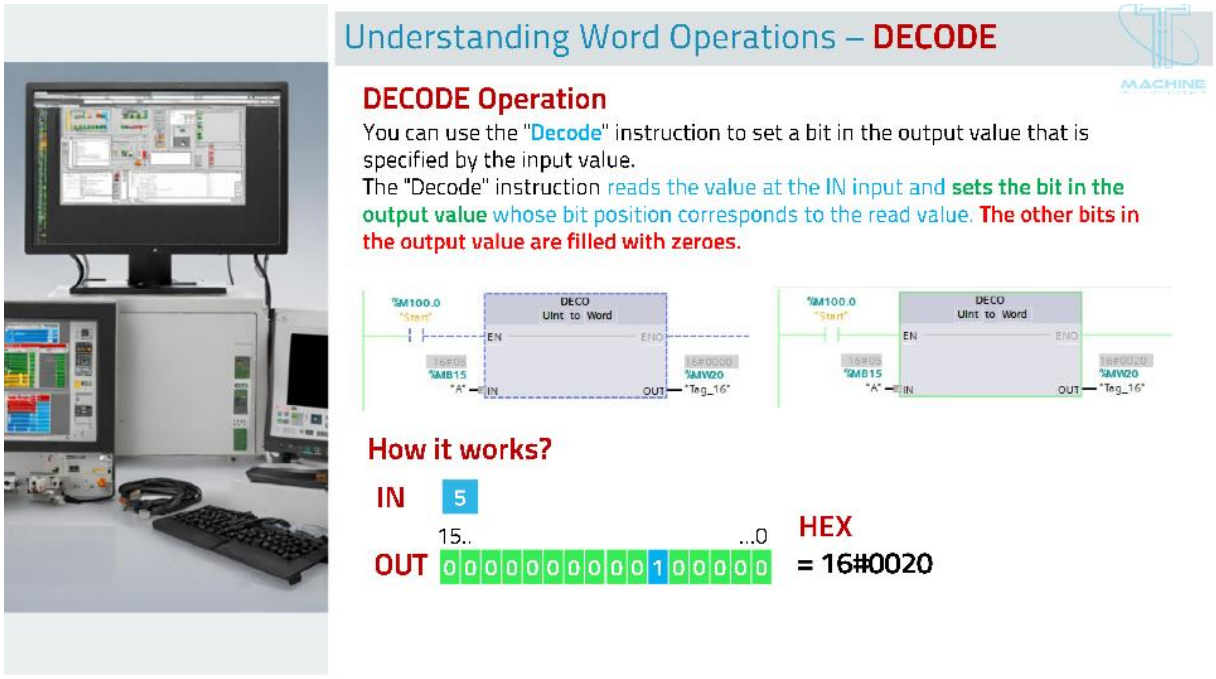


Figure 2 Example of the quality of the presentations prepared for the Industrial Automation training at KEC partner university.

1.5 Feedback form

To improve the quality of courses, meet expectations and address the needs of the attendees, the feedback questionnaires will be collected in the form of Google online feedback forms with the following points covered:

1.	Teaching Approaches	Strongly Agree	Agree	Neutral	Disagree
1.1	The instructor stimulated my interest in the subject.	6	0	0	0
1.2	The instructor managed classroom time and pace well.	5	1	0	0
1.3	The instructor was organized and prepared for every class.	3	3	0	0
1.4	The instructor encouraged discussions and responded to questions.	5	1	0	0
1.5	The instructor demonstrated in-depth knowledge of the subject.	5	1	0	0
1.6	The instructor appeared enthusiastic and interested.	5	1	0	0
1.7	The instructor used a variety of instructional methods to reach the course objectives (e.g. group discussions, student presentations, etc.)	4	2	0	0
1.8	The instructor motivated participants to do their best work.	5	1	0	0
1.9	The instructor was punctual in the class.	4	0	2	0

2.	Assignments and Project	Strongly Agree	Agree	Neutral	Disagree
2.1	Assignments/Projects were useful to enhance self-learning.	2	4	0	0
2.2	Information about the projects was communicated clearly.	5	1	0	0
2.3	Feedback was provided within the stated timeframe.	0	4	2	0
2.4	Feedback showed how to improve my work (e .g. corrections including comments).	3	3	0	0

3.	Resources and Administration	Strongly Agree	Agree	Neutral	Disagree
3.1	The course was supported by adequate resources.	3	3	0	0
3.2	Training Resources and slides for the course were useful.	4	2	0	0
3.3	Instructor gave guidance on where to find resources.	2	4	0	0

4.	Additional Feedback	Strongly Agree	Agree	Neutral	Disagree
4.1	The objectives and syllabus were explained at the beginning of the training.	3	3	0	0
4.2	The training was delivered as outlined in the syllabus.	4	2	0	0
4.3	Projects/ assignments related to the course learning outcomes.	3	3	0	0

5.	Participant Self Evaluation	Strongly Agree	Agree	Neutral	Disagree
5.1	I am satisfied regarding experience of the training.	5	1	0	0
5.2	I participated and contributed constructively during in-class activities.	4	2	0	0
5.3	I feel I am achieving the learning outcomes.	5	1	0	0
5.4	I will implement this learning in my research work.	3	3	0	0
5.5	I will implement this learning in my teaching/project work.	4	2	0	0

6.	Comments on Strengths and ways of Improvement
(a)	What did you like best about Automation Training?
	The Lecturer, Lesson and every tools on the automation lab
	the detail teaching from the lecture very helpful to understand and the lecture very friendly
	I like every component automation training, especially for HMI and Scada for automation training.
	I like doing the practical session, especially when trying the VFD because I've never tried adjusting the frequency before, only the voltages.
	Detailed explanation of each component
	Well equipped lab and proper guidance.
(b)	What did you like least about Automation Training?
	Nothing
	-
	Nothing
	I like all the sessions, because it was an new experience and a new lesson for me.
	-
	N/A
(c)	What can be done to improve standard of such training?
	I suggest to add more practical tools and improve the PLC
	-
	I hope many more people can be train or study about industrial automation.
	Perhaps providing more training and collaborating with other to increase knowledge about about electricity.
	More detail, but more updated topics
	Conducting Regular training can help to improve the standard of such training
(d)	Any further, constructive comment:
	Nice experience
	-
	-
	-
	Keep the spirit on.
	N/A

Figure 3: An example of the online questionnaire used to collect feedback from the participants of the professional courses on industrial automation.

1.6 Communication and promotion

To disseminate information about the professional courses dealing with Industrial Automation based on eACCESS-developed laboratory infrastructure and promote the courses among relevant stakeholders, a wide range of broadcasting channels has been used:

- Online Advertising: Advertisements published on the university websites.
- Email Marketing: an email list of professionals, students, and organisations interested in renewable energy or related topics and highlighting the benefits and features of the courses, including session topics, speakers, and registration details.
- Partnerships and Collaborations: Collaborate with industry organisations, universities, and professional associations to promote the courses to their members and students. Offer special discounts or incentives for members of partner organisations to encourage enrolment.
- Content Marketing: Creating high-quality content such as blog posts, articles, videos, or webinars related to photovoltaic technology, renewable energy trends, or career opportunities in the solar industry. Share this content on your website, social media channels, and industry forums to establish your expertise and attract potential participants. An example of such a banner is included below (for the first professional course scheduled for October 2023).
- Networking Events and Workshops: Organize networking events, workshops, or webinars focused on photovoltaic technology and invite industry professionals, researchers, and students to participate. Use these events to promote your courses and engage with potential participants.

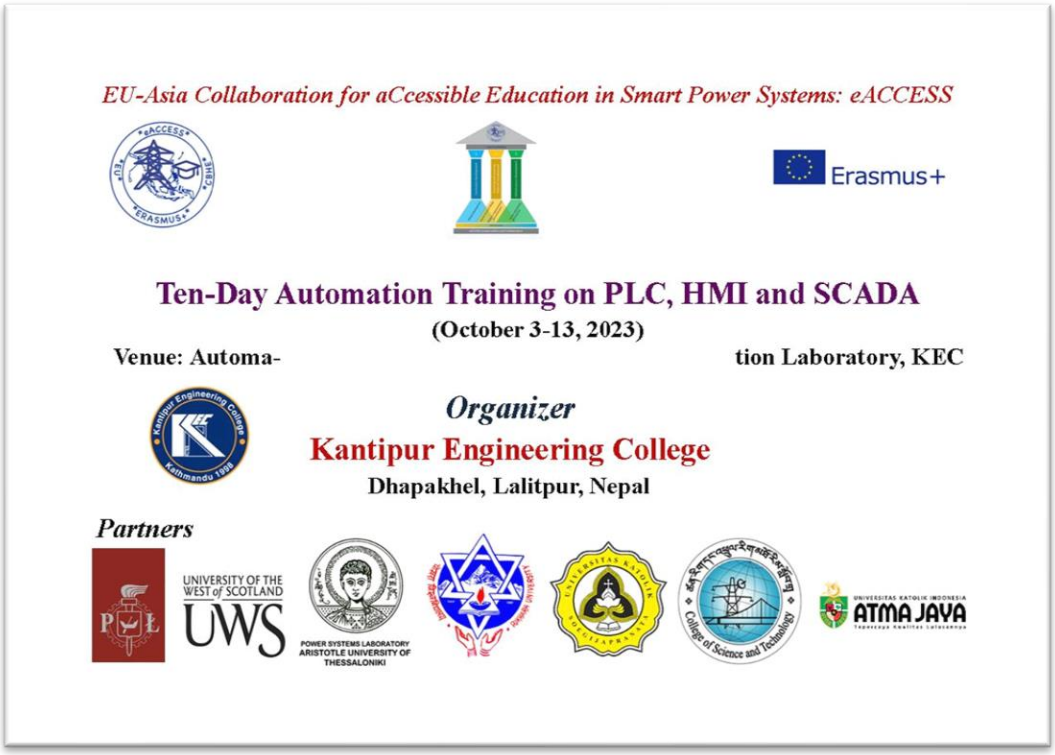


Figure 4 Promotional poster prepared by the KEC team for Industrial Automation professional training.

2 Switchgear and protection training at RUB

2.1 Introduction

In the dynamic landscape of modern energy systems, the demand for skilled professionals in power system protection and automation has never been greater. With the rapid evolution of technology and the increasing complexity of power grids, there is a growing need for individuals equipped with specialised knowledge and expertise to ensure electrical networks' reliability, safety, and efficiency. Professional courses in power system protection and automation play a vital role in meeting this demand by providing professionals with the necessary skills and qualifications to excel in this critical field.

One of the pillars of the eACCESS project was the development of laboratory infrastructures at partner universities. RUB, College of Science and Technology, Royal University of Bhutan proposed a laboratory focused on Switchgear and Protection. The developed, commissioned, and validated laboratory involves the most important HV protection units (generator protection relays, distance protection relays, transformer protection relays, feeder protection relays) and a relay test kit. This configuration allows the implementation of practical exercises covering set-up and operation testing of Distance Protection, Directional and non-directional Overcurrent, Under voltage protection, Transformer Differential Protection, Directional/non-directional Earth fault, Directional and non-directional Overcurrent, Reverse Power Protection, Generator Differential Protection, Bus bar protection. The development of this lab is essential as most of the graduates join Power companies where protection is vital to have a reliable power supply. More information about the developed eACCESS laboratory infrastructure can be found in the **deliverables D4.1 and D4.3** from the project website.

Building upon the developed SGPL (Switchgear and Protection Laboratory) laboratory, on top of the regular undergraduate courses in Power System Protection and Automation with laboratory practice included in the curriculum, the CST RUB team prepared advanced professional courses.

Scope of the course: The course will cover many topics, including relay operation principles, fault analysis, protection schemes, and advanced automation techniques. By delving into these subjects, professionals understand the challenges and opportunities in power system protection and automation, empowering them to make informed decisions and implement effective solutions in their respective roles.

Benefits: professional courses in power system protection and automation will offer hands-on learning experiences that allow professionals to apply theoretical knowledge to real-world scenarios. Participants will develop practical skills and problem-solving abilities essential for success in the field. These hands-on learning opportunities reinforce theoretical concepts and provide professionals with the confidence and competence to tackle complex power system protection and automation challenges with proficiency and precision.

Another significant advantage of professional power system protection and automation courses is the exposure to expert instruction and guidance from experienced industry professionals and academic experts. By learning from individuals with a wealth of practical experience and domain expertise, professionals gain valuable insights, best practices, and industry perspectives that are invaluable for

their professional development. Moreover, interacting with instructors and peers facilitates knowledge sharing, collaboration, and networking, creating a supportive learning environment conducive to growth and learning.

Professional courses in power system protection and automation also play a crucial role in advancing career prospects and unlocking new opportunities for professionals in the energy sector. Upon completing these courses, participants receive industry-recognized certifications that validate their skills and expertise, enhancing their credibility and marketability in the job market. Whether seeking career advancement within their current organisations or exploring new opportunities in power engineering, automation, or related fields, professionals with specialised training in power system protection and automation are well-positioned to succeed in various roles and industries.

Target audience: The course will be paramount and a professional career development opportunity for the following potential attendees: power engineers, electrical engineers, automation engineers, control systems engineers, and energy sector professionals. In the case of Bhutan, the potential participants will include electrical engineers from Druk Green Power Corporation, Bhutan Power Corporation Limited, Industries, and Bhutan Automation. Ultimately, the power system protection and automation courses might also be open to academics from RUB, partner universities, and CST visiting staff and students.

2.2 Training description

This professional training program will provide a holistic understanding of switchgear and protection systems, equipping you with the knowledge and skills needed to excel in power system protection and automation. Join us and take the first step towards mastering the complexities of protecting critical power infrastructure. The course curriculum will cover the following topics:

Fundamentals of Switchgear and Protection: Understand the backbone of electrical safety and reliability; Explore the crucial role of switchgear in power transmission and distribution systems; get hands-on with the operation principles of various switchgear types.

Introduction to the protection unit test kit: Overview of the components and features of the test kit; Understanding the capabilities and limitations of the test kit; Hands-on demonstration of the essential operation of the test kit, OMICRON CMC 356 and PC interface; Navigation through the user interface and menu options; Setup of test scenarios to simulate various fault conditions; Analysis of test results and interpretation of findings; Generation of test reports and documentation.

Faults in Transformers, Transmission, and Distribution Lines: Learn to spot and mitigate common faults in transformers and lines, Grasp the causes and implications of faults on system performance, and ensure equipment reliability with advanced fault analysis techniques.

Introduction to Transformer Protection: Get acquainted with the cutting-edge protection unit for HV transformer protection and understand configuration codes and hardware modules for smooth setup and optimal performance with expert configuration techniques and protection settings with MiCOM P642.

Introduction to Easergy Studio Engineering and Logic Settings: Dive into the capabilities of Easergy Studio Engineering software and customise protection settings with precision for specific fault scenarios.

Introduction to Busbar and Line Protection: Expand your knowledge to include busbar and line protection panels; ensure comprehensive protection coverage with expert configuration and testing.

Introduction to Generator Protection: Tackle the unique challenges of generator protection head-on, Configure MiCOM P343 effectively and validate system performance with testing.

2.3 Training agenda

The lectures will be delivered, and laboratory exercises will be guided and moderated by the Electrical Engineering Department faculty staff with relevant field knowledge and expertise from Bhutan Automation.

The course will be held at the College of Science and Technology, Rinchending, P/Ling. The following preliminary agenda for the five-day course has been proposed.

Day 1			
Time	**Topics/Events**	**Duration**	**Venue**
8:30-10:30	Registration and pre-training survey	0:5	Training Hall
	Introduction to training objectives	0:5	
	Introduction to basics of switchgear and protection, faults in transformers, transmission and distribution lines, busbar and generators:	1	
10:30-11:00	**Recess Time**	**0:5**	
11:00-12:30	Introduction to transformer protection panel (MiCOM P642) including technical features, configuration code, available hardware modules for interfaces:	0:5	SGP laboratory
	Decoding of transformer protection wiring diagram	0:5	
	Introduction to Easergy Studio Engineering and logic settings for different types of faults	0:5	
12:30-13:30	**Lunch Break**	**1**	**Canteen**
13:30-15:00	Configuration and setting of transformer protection setting	0:5	SGP laboratory
	Fault parameters calculation for MiCOM P642 configuration	0:5	
	Setting of OMICRON CMC 356 and PC interface	0:5	
15:00-15:30	**Recess time**	**0:5**	
15:30-17:00	The differential pick up test	1	SGP laboratory
	Differential slop test	0:5	

Day 2

Time	Topics/Events	Duration	Venue
9:00-10:30	Overcurrent Protection testing (IDMT test and IDMT characteristics test)	1:5	SGP laboratory
10:30-11:00	**Recess Time**	**0:5**	
11:00-12:30	Over fluxing protection test	0:5	SGP laboratory
	Transformer Restricted earth fault (REF) protection (both LV and HV REF)	1	
12:30-13:30	**Lunch Break**	**1**	**Canteen**
13:30-15:00	Transformer Restricted earth fault (REF) protection (both LV and HV REF)	0:5	SGP laboratory
	Transformer sensitive earth fault (un-restricted REF) protection test)	1	
15:00-15:30	**Recess Time**	**0:5**	
15:30-17:00	Introduction to Busbar protection panel (MiCOM P746)	1	SGP laboratory
	Decoding of Busbar protection wiring diagram	0:5	

Day 3			
Time	**Topics/Events**	**Duration**	**Venue**
9:00-10:30	Configuration and setting of MiCOM P746 using Easergy Studio:	0:5	SGP laboratory
	Explain the theory and fault calculation to align with MiCOM configuration	1	
10:30-11:00	**Recess Time**	**0:5**	
11:00-12:30	Busbar protection testing	0:5	SGP laboratory
	R-Phase differential protection testing	1	
12:30-13:30	**Lunch Break**	**1**	**Canteen**
13:30-15:00	Y and B-phase differential protection testing	0:5	SGP laboratory
	Bus configuration with different loads in station	1	
15:00-15:30	**Recess time**	**0:5**	
15:30-17:00	Introduction to line protection panel (MiCOM P443)	1	SGP laboratory
	Decoding of line protection wiring diagram	0:5	

Day 4			
Time	**Topics/Events**	**Duration**	**Venue**
9:00-10:30	Configuration and setting of MiCOM P443 using Easergy Studio:	0:5	SGP laboratory
	Explain the theory and fault calculation to align with MiCOM configuration:	1	
10:30-11:00	**Recess Time**	**0:5**	
11:00-12:30	Line impedance protection testing	1:5	SGP laboratory
	Over current protection testing		
12:30-13:30	**Lunch Break**	**1**	**Canteen**
13:30-15:00	Voltage based protection testing	1:5	SGP laboratory
	Synchronization check testing		

15:00-15:30	**Recess time**	**0:5**	
15:30-17:00	Introduction to generator protection panel (MiCOM P343)	1	SGP laboratory
	Decoding of generator protection wiring diagram	0:5	

Day 5			
Time	**Topics/Events**	**Duration**	**Venue**
9:00-10:30	Configuration and setting of MiCOM P443 using Easergy Studio:	0:5	SGP laboratory
	Explain the theory and fault calculation to align with MiCOM configuration:	1	
10:30-11:00	**Recess Time**	**0:5**	
11:00-12:30	Overcurrent protection testing	1:5	SGP laboratory
	Impedance based protection testing		
	Voltage based protection testing		
12:30-13:30	**Lunch Break**	**1**	**Canteen**
13:30-15:00	Generator earth fault overcurrent protection testing	1:5	SGP laboratory
	Generator 95% stator earth fault protection testing		
15:00-15:30	**Recess time**	**0:5**	
15:30-17:00	Question and answer session	1	Training Hall
	Post training and feedback	0:5	

2.4 Training material

The training material has been prepared as a PowerPoint presentation, and it includes **89 slides** covering both theoretical topics and an introduction to practical exercises. The teaching material is included in **Annexe D2.1 RUB - 1**.

Capacity Development Training on Switchgear and Protection
(5 days duration) Course Manual

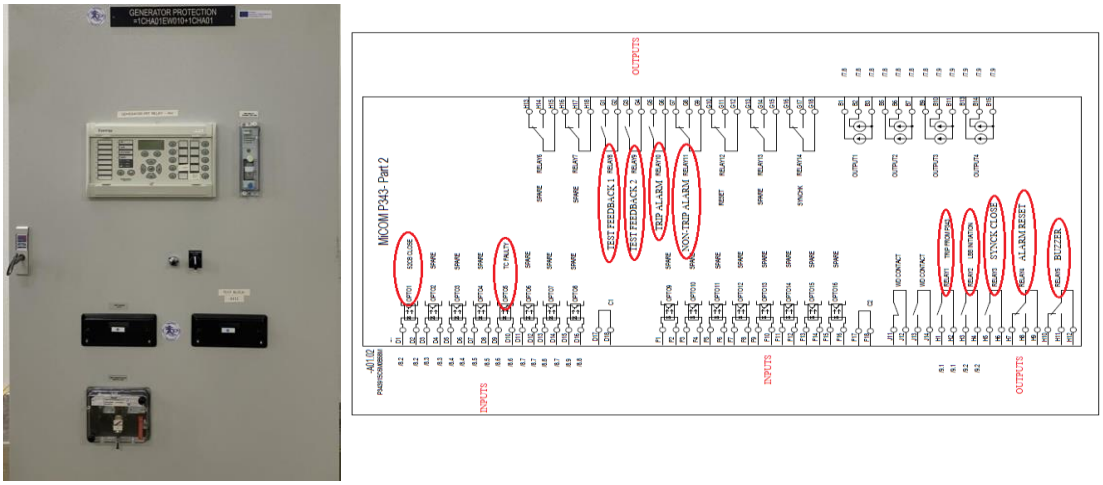

Generator Protection panel | Line Protection Panel | Transformer Protection panel | Busbar Protection Panel


OMICRON TEST KIT CMC356

Electrical Engineering Department
College of Science and Technology
Royal University of Bhutan

Figure 5 The first page of the RUB teaching material for the Switchgear and Protection professional training

Generator Protection Panel MiCOM P343



10/4/2023 Capacity Development Training on Switchgear and Protection 73

Figure 6 Presentation page from RUB teaching material on generator protection unit terminal configuration

2.5 Feedback form

The RUB team has proposed the following questions for RUB professional course feedback collection:

Pre-training survey form

Question 1: What is your level of expertise on switchgear and protection testing? (Ratings from 1-5)
Question 2: Have you taken any courses on this topic before? (Yes/No)
Question 3: What would you like to know from this course? (Opinion)
Question 4: What are the expected topics from this course (Opinion)

Post-training survey form:

Question 5: The training was relevant to my profession (1-5 rating)
Question 6: Was the training course a mix of presentations and activities suitable? (1-5 ratings)
Question 7: The facilitator was resourceful and knowledgeable (1-5 ratings)
Question 8: What is your proficiency in using protection panels after the training? (1-5 rating, bad to good)
Question 9: How likely are you to recommend this course to your colleagues? (1-5 ratings)
Question 10: Did the training meet your expectations? (1-5 ratings)
Question 11: How would you rate the quality and content of the training? (1-5 ratings)

2.6 Communication and promotion

Promoting professional courses concerning Switchgear and Protection and the modules developed in this eACCESS project requires a targeted approach to reach potential participants interested in advancing their knowledge and skills in Power system and switchgear and protection. The dissemination of information about the professional course concerning the operation, simulations and testing of protection panels will be implemented using various broadcasting channels, including:

- Online Advertising: Advertisements published on the university websites.
- Email Marketing: an email list of professionals, students, and organisations interested in renewable energy, switchgear and protection or related topics and highlighting the benefits and features of the courses, including session topics, speakers, and registration details.
- Social Media Marketing: Using LinkedIn, Twitter, and Instagram to share course announcements.
- Partnerships and Collaborations: Collaborate with industry organisations, universities, and professional associations to promote the courses to their members and students. Offer special discounts or incentives for members of partner organisations to encourage enrolment.
- Content Marketing: Creating high-quality content such as blog posts, articles, videos, or webinars related to Switchgear and protection, power systems, renewable energy trends, or career opportunities in the power industries.
- Networking Events and Workshops: Organize networking events, workshops, or webinars focused on photovoltaic technology and invite industry professionals, researchers, and students to participate. Use these events to promote your courses and engage with potential participants.
  Example of a poster is attached.

Figure 7 Promotional poster for RUB professional courses

3 PV installation training at ATM

3.1 Introduction

Amidst the global shift towards more sustainable and environmentally friendly energy sources, solar energy has become a primary focus in efforts to create a cleaner energy future. Photovoltaic technology, commonly known as PV (Photovoltaic), plays a key role in this transformation. PV converts solar energy into electricity, potentially reducing the negative impacts of fossil-based energy.

The expansion of photovoltaic technology encompasses not only the installation of solar panels on residential rooftops but also much larger projects, such as large-scale solar power plants and the development of grid-connected electrical systems with distributed energy resources. This creates significant career opportunities in the renewable energy industry.

However, to understand and implement solar energy technology, a firm grasp of fundamental concepts, the functioning of photovoltaic systems, and aspects of design, installation, operation, maintenance, and troubleshooting in PV systems is required. The Professional Training in Photovoltaics at Atma Jaya Catholic University of Indonesia, Jakarta, must provide participants with an in-depth understanding and practical training on solar energy and photovoltaic technology.

This training will provide valuable insights to participants, preparing them to actively address global energy challenges and continue pursuing a better environment. This training combines in-depth theoretical instruction with hands-on practice, allowing participants to experience solar energy's boundless potential directly. This report is expected to offer a clear overview of the event's success and encourage participants to make solar energy an integral part of the future of energy and sustainability.

The training will be based on the laboratory infrastructure, ATM PV Lab developed in Pillar Three of the eACCESS project. More on the laboratory infrastructure can be found in **the deliverables D4.1** and **D4.5**, available from the project website.

3.2 Training description

In this photovoltaic training, participants will have a unique opportunity to delve into renewable energy, particularly solar power, through courses and practical sessions. In addition to an in-depth theoretical understanding, participants will have a valuable opportunity to engage in hands-on practice in the photovoltaic laboratory (PV Lab) equipped with modern facilities.

The training aims to provide participants with a comprehensive understanding of photovoltaic technology and equip them with the practical skills to manage PV systems. As a result, participants are expected to be prepared to actively contribute to the renewable energy industry and promote the broader and sustainable use of solar energy.

The training will be divided into six sessions:

1. Solar Energy Sources and Photovoltaic Systems. This session, led by Dr. Ir. Marsul Siregar, Meng (ATM), should help understand the fundamental principles of solar energy and photovoltaic (PV) technology. Participants will learn how the sun produces energy and how PV technology converts solar energy into usable electricity. This session also includes an explanation of the key components of PV systems.
2. Introduction to the Renewable Energy Skills Board (DKET). This session, led by Mr. Sim Budiman (ST. MM), should familiarise participants with the Renewable Energy Skills Board (DKET) and its role in supporting the development of expertise in renewable energy. Mr. Budiman will introduce participants to the initiatives and objectives of DKET in supporting the transition to Net Zero Emission.
3. Design and Installation, Operation, Maintenance, and Troubleshooting in PV Systems. This session, led by Ir. Suryo Widodo & Marsul Siregar (ATM), will focus on technical aspects of PV technology, from system design and correct installation to efficient operation and maintenance of PV systems. In addition, this session will discuss common problems that may arise in PV systems and strategies to overcome them.
4. Introduction to the Photovoltaic Laboratory. This session, led by Cristoni Hasiholan Pardosi (S.T.), aims to introduce the Photovoltaic Laboratory (PV Lab) and the facilities available. Participants will be given an overview of the laboratory's operating system, monitoring, and control.
5. Visits and Practice in the Photovoltaic Laboratory, to be prepared and delivered by Ir. Suryo Widodo and Cristoni Hasiholan Pardosi (S.T), will allow participants to gain practical experience in the Photovoltaic Laboratory. They will understand the basic principles of solar energy, perform solar panel installation, operate PV systems, and understand maintenance and troubleshooting. The safety of participants is a top priority during this practice.
6. Advanced Practice and Introduction to Operating Photovoltaic Systems (PV), led by Marsul Siregar and Andrew Januar Wilyanto, (ATM) Cristoni Hasiholan Pardosi, (S.T), is an advanced stage that allows participants to dive deep into the operational practices of PV systems and understand the importance of monitoring and control in maintaining optimal performance. They will engage in the operational practices of PV systems, including remote operation, disconnection, and testing of several key components. The instructor will guide participants on how to run PLC, SCADA, and Website-based systems efficiently and securely.

3.3 Training agenda

The lecture (theoretical background) and laboratory (practical skills) training will be held at Universitas Katolik Indonesia Atma Jaya, BSD Campus, CISAUK, where the eACCESS PVLab infrastructure has been developed.

The following preliminary agenda for the first training has been prepared:

Time	Topics/Events	Venue
08:30-09:00	Registration	Hall 8th Floor BSD
09:00-09:30	Session I: Solar Resources	Hall 8th Floor BSD
09:30-10:30	Session II: PV Systems	Hall 8th Floor BSD
10:30-11:00	Session III: Coffee Break	Hall 8th Floor BSD

11:00-11:30	Session IV: Design and Installation	Hall 8th Floor BSD
11:30-12:00	Session V: Maintenance and Trouble Shooting	Hall 8th Floor BSD
12:00-13:00	Lunch break	
13:00-13:30	Session VI - part A: Introduction to PV Lab	eACCESS PV Lab
13:30-15:00	Session VI – part B: Practice	eACCESS PV Lab
15:00-16:00	Session VI – part C: Practice & System Monitoring	3rd Floor BSD

3.4 Training material

The training material has been prepared as MS PowerPoint slides. Together, 37 slides have been prepared for the theoretical (introductory) part.

A copy of the presentation is included in **Annexe 2.1 ATM - 1**

Figure 8 First page of the ATM lecture material on PV installations

3.5 Feedback form

A short feedback form has been prepared for attendees of the professional training at ATM to improve the course contents and the quality of course organisation, lecturing, and developing practical skills.

Question 1: How beneficial did you find the first session on solar energy sources and photovoltaic systems for your understanding?

Question 2: Did the session on the introduction to the Renewable Energy Skills Council (DKET) provide a clear understanding of DKET's role in renewable energy development?

Question 3: What is your opinion about the session on Design and Installation, Operation, Maintenance and Troubleshooting in PV systems?
Question 4: How was your experience during the visit and practice session in the Photovoltaic Laboratory (PV Lab)?
Question 5: Did you feel that the field practice helped you understand the theoretical concepts taught earlier?
Question 6: How do you rate the language and presentation of the speakers/instructors?
Question 7: Would you recommend the Photovoltaic Professional Training prepared and provided by ATM to others?

The questionnaire will be handled online.

3.6 Communication and promotion

Promoting professional courses concerning PV installations requires a targeted approach to reach potential participants interested in advancing their knowledge and skills in photovoltaics. The dissemination of information about the professional course concerning the operation and maintenance of PV installations has been implemented using various broadcasting channels, including:

- Online Advertising: Advertisements published on the university websites.
- Email Marketing: an email list of professionals, students, and organisations interested in renewable energy or related topics and highlighting the benefits and features of the courses, including session topics, speakers, and registration details.
- Social Media Marketing: Using LinkedIn, Twitter, and Instagram to share course announcements.
- Partnerships and Collaborations: Collaborate with industry organisations, universities, and professional associations to promote the courses to their members and students. Offer special discounts or incentives for members of partner organisations to encourage enrolment.
- Content Marketing: Creating high-quality content such as blog posts, articles, videos, or webinars related to photovoltaic technology, renewable energy trends, or career opportunities in the solar industry. Share this content on your website, social media channels, and industry forums to establish your expertise and attract potential participants. Posters and billboards were placed at the ATM campus. An example of such a poster is included below.
- Networking Events and Workshops: Organize networking events, workshops, or webinars focused on photovoltaic technology and invite industry professionals, researchers, and students to participate. Use these events to promote your courses and engage with potential participants.

Figure 9 Promotional poster for ATM professional courses.

4 Microgrid training at SCU

4.1 Introduction

Microgrids, powered by renewables, are transforming Indonesia's energy landscape. They enhance energy access, reduce emissions, and empower island communities. As Indonesia continues its green transformation, microgrids will play a pivotal role in achieving a sustainable and resilient energy future.

With its vast archipelago of over 17,000 islands, Indonesia faces unique challenges in providing reliable and sustainable electricity to its remote communities. The isolation of these islands often results in limited access to centralised power grids. However, innovative solutions such as microgrids and renewable energy sources transform the energy landscape, ensuring a cleaner and more resilient power supply.

Microgrids are localised energy systems operating independently or in conjunction with the main grid. They offer several advantages, especially for isolated regions:

- **Energy Independence**: Microgrids reduce dependence on distant power plants and transmission lines. They generate electricity locally, enhancing energy security.
- **Resilience**: In the face of natural disasters or grid failures, microgrids can continue supplying power to critical facilities like hospitals, schools, and community centres.
- **Integration of Renewables**: Microgrids facilitate the integration of renewable energy sources, such as solar, wind, and hydropower, into the energy mix.

Indonesia has abundant renewable energy resources, including sunlight, wind, and geothermal heat. Leveraging these resources is crucial for achieving a sustainable energy transition. Here are some notable examples:

- **Nusa Penida Microgrid**: Hitachi Energy successfully deployed a microgrid in Nusa Penida, an adjacent island to Bali. This 4MWp/3MW/3MWh microgrid met the 20% surge in electricity demand during the recent G20 Summit in Bali. It supports local customers and contributes to Indonesia's commitment to clean energy.
- **Maluku Province**: The New Zealand-Maluku Access to Renewable Energy Support (NZMATES) team is working tirelessly to establish clean, sustainable power throughout Maluku Province. Their efforts bring renewable energy to remote island communities, improving livelihoods and reducing carbon emissions2.
- **De-Dieselization Program**: Indonesia's state-owned utility, PT PLN (Persero), aims to replace diesel power plants with greener alternatives. By deploying microgrids with battery energy storage systems (BESS), they reduce carbon emissions and accelerate the shift to renewables1.

While microgrids offer immense potential, challenges remain:

- **Technical Integration**: Integrating diverse renewable sources into microgrids requires advanced control systems and grid management.
- **Financial Viability**: Initial setup costs can be high, but long-term benefits justify the investment.

- **Community Engagement**: Educating local communities about microgrids and involving them in decision-making is crucial.

To implement and explore the concept of smart microgrids for the green transformation of the Indonesian power system and toward enhanced environmental sustainability of small communities, it is necessary to educate and train many technicians and engineers with advanced skills. The eACCESS project has been developed at SCU partner university's cutting-edge microgrid laboratory infrastructure for teaching engineering skills concerning microgrid design, implementation, operation, and maintenance. More details about the technical specifications of the eACCESS laboratory can be found **in deliverables D4.1 and D4.5**, available from the project website.

Using this infrastructure, SCU academic staff has prepared a concept for the two-day professional course dealing with PV installation-based microgrids.

4.2 Training description

This comprehensive professional course delves into the intricate world of photovoltaic (PV) systems and renewable energy. Designed for engineers, installers, and industry professionals, the course covers various topics, from international standards to the practical aspects of PV installation and operation. Participants will gain essential knowledge to navigate the evolving landscape of clean energy solutions.

The course lectures and laboratory exercises will address the following areas and specific topics:

A. International Standards and National Regulations

Legal Basis and Certification of Installers: The legal framework governing PV systems, the purpose and significance of introducing a certification system for installers, rights, obligations, and conditions for obtaining, renewing, and maintaining certification.

B. Health, Safety, and Environmental Provisions

Hazard Identification: Study international standards related to PV installation and electricity storage components; examine national regulations, grid codes, and installation standards specific to Indonesia; Address safety, fire protection, and environmental considerations during installation.

C. Basic Physical Properties and Principles of PV Systems

Solar Cells -Structure and Operation: Photovoltaic Conversion - Grasp the physical basis of photovoltaic conversion; Explore the structure and technical characteristics of photovoltaic cells; Understand the principles behind solar energy conversion.

Photovoltaic Modules: Investigate the design and technical features of photovoltaic modules; Learn how modules contribute to overall system performance.

Types of Photovoltaic Systems: Isolated and Autonomous Systems; Stand-alone PV systems for remote locations; Understand their design, components, and energy storage solutions.

Grid-Connected Systems: Learn about grid-tied PV systems with or without electricity storage, Grid codes, and synchronisation requirements.

Mixed (Hybrid) Systems: Investigate hybrid PV systems that combine renewable sources with conventional grids.

Building-Integrated Photovoltaics (BIPV): PV integration into building structures (roofs, facades, glass roofs).

D. Photovoltaic Equipment and Components:

Inverters, Charge Controllers, and Batteries: Understand the role of inverters in converting DC to AC power; Explore charge controllers for optimal battery management; Learn about battery technologies and their impact on system performance.

4.3 Training agenda

The detailed, hour-by-hour agenda for the two-day course has not yet been developed. The core SCU staff will deliver the training for the eACCESS project. Prof. Dr. Ir. Slamet Riyadi, MT, will provide the theoretical part, while Arifin Wibisono, ST, will oversee the laboratory practice.

The training will be organised at the SCU campus, Semarang.

The training programme includes the following laboratory exercises:

i. Study of the microgrid operation, grid-connected, without battery mode for $P_{PV} < P_{Load}$
ii. Study of the microgrid operation, grid-connected, without battery mode for $P_{PV} > P_{Load}$
iii. Study of the microgrid operation, grid-connected, in battery discharging mode for $P_{PV} < P_{Load}$
iv. Study of the microgrid operation, grid-connected, in battery charging mode for $P_{PV} > P_{Load}$
v. Study of the microgrid operation in the islanding mode for $P_{PV} < P_{Load}$

4.4 Training material

Two laboratory manuals have been prepared by SCU academic staff for the participants of the professional course on microgrids and PV installations. One teacher instruction has also been created. These documents included in **Annexe D2.1 SCU -1** are mainly based on regular undergraduate course laboratory manuals (presented in more detail in the **deliverable D4.6** and available from the project website) and included in **Annexe D4.6.5 SCU -1.**

The participant's manual for the first day of laboratory activity consists of 21 pages, and for the second day includes 18 pages. The teacher's instruction consists of 16 pages. Both documents are of acceptable quality and explain well the structure of the microgrid and its components, five exercises dealing with different operation modes of the microgrid, including the coordination of control of the PV installation and battery storage.

More to the prepared participant and teacher manuals and instructions explaining step-by-step how to conduct five practical exercises, SCU will offer access to additional reading material prepared by Prof. Prof. Dr. Ir. Slamet Riyadi for regular student courses. The same safety and maintenance instructions prepared for routine undergraduate laboratory classes will also be used for professional courses. More details about these complementary but essential documents can be found in the **deliverable D4.6.5 and Annexes D4.6.5 2-5**.

4.5 Feedback form

A simple feedback form has been prepared to collect participants' opinions about the course curriculum, time slot allocation, quality of the teaching material, and the available laboratory infrastructure. The feedback forms will be distributed in paper versions.

	Very Poor	Poor	Fair	Good	Very Good
Course Material					
Resources					
Course Facility					
Method					
Time					
Understanding					
Preparation					
Facilitator					
Coach					

4.6 Communication and promotion

Figure 10: Promotional poster for the SCU professional course on August 2nd and 3rd, 2022.

Figure 11: Promotional poster for the SCU professional course on September 13th, 2022.

5 Final remarks, recommendations, and project performance indicators

Using eACCESS developed laboratory infrastructure, four project partners, KEC, RUB, ATM and SCU, have prepared curricula, proposed agenda, and core teaching material covering theory and practice and offered eACCESS-supported additional reading materials for four professional courses:

a) Industrial Automation at KEC partner university, the duration is ten whole days, approximately 60 hours,
b) Switchgear and Protection at RUB partner university, the duration is five full days, approximately 40 hours,
c) PV Installations at ATM partner university, the duration is one full day, 6 hours,
d) Microgrid and PV Systems at SCU partner university, the duration two full days, 16 hours.

All the professional courses have been developed in close collaboration with industrial partners, primarily suppliers of laboratory hardware and software equipment:

a) Thoplo Machine Pvt.Ltd, Nepal, https://thoplomachine.com
b) Bhutan Automation, Bhutan, https://bhutanautomation.com
c) PT Syntek Otomasi Indonesia, Energy & Control, Indonesia, https://syntek.co.id
d) PT Surya Utama Putra, Indonesia, https://suryautamaputra.co.id/

All submitted materials meet a standard of good quality, relevance, thoroughness, and comprehensiveness. The implementation of this deliverable has resulted in collective output, including **presentations (KEC - 20 presentations, 333 slides; RUB – one presentation, 89 slides; ATM – one presentation, 37 slides), laboratory manuals (KEC - 5 manuals, 77 pages; SCU - 3 manuals, 55 pages), and the development of four special laboratory projects aimed at enhancing advanced PLC programming and design skills (KEC, 51 slides)**.

The developed courses will become an opportunity for the partner universities to attract more attention and recognition among industrial partners. It will trigger bilateral and multilateral collaboration with industrial partners. The close partnership will help to learn about industrial partners' objectives and expectations concerning the life-long learning process of their employees. It will also create an opportunity to extend the eACCESS-funded laboratory infrastructure further, which can be used for teaching regular courses and conducting advanced research.

It is of paramount importance in the case of professional courses to keep the content alive and agile and react to the continuously changing needs of industrial partners regarding the graduates' knowledge and practical skills.

6 List of annexes and references

Annexes:

1. Annexe D2.1 KEC - 1.pdf, presentation of training laboratory infrastructure at KEC.
2. Annexe D2.1 KEC - 2.pdf, lecturing material prepared by KEC team with contribution from industrial partners for Industrial Automation training.
3. Annexe D2.1 KEC - 3.pdf, practical exercises prepared by KEC team for Industrial Automation training.
4. Annexe D2.1 RUB - 1.pdf, presentation prepared by RUB team for Capacity Development Training on Switchgear and Protection
5. Annexe D2.1 ATM - 1.pdf, presentation prepared by ATM team with contribution from industrial partners for Professional Training on Photovoltaic
6. Annexe D2.1 SCU - 1.pdf, practical exercises prepared by SCU team for Microgrid Professional training.

References:

1. Deliverable D4.1 - the description of the detailed technical concept of the advanced laboratory infrastructures at partner universities (KEC, RUB, ATM, SCU) developed by the eACCESS project.
2. Deliverable D4.2 - the detailed technical specification of the hardware and software components of the Industrial Automation and Power Electronics Laboratories implemented at KEC by the eACCESS project.
3. Deliverable D4.3 - the detailed technical specification of the hardware and software components of the Switchgear and Protection Laboratory implemented at RUB by the eACCESS project.
4. Deliverable D4.4 - the detailed technical specifications of the hardware and software components of the Microgrid and Photovoltaic Laboratory implemented at SCU by the eACCESS project.
5. Deliverable D4.5 - the detailed technical specifications of the hardware and software components of the Photovoltaic Laboratory implemented at ATM by the eACCESS project.
6. Deliverable D4.6, the consolidated deliverable summarising laboratory students' and teachers' manuals prepared at partner universities for the developed laboratory infrastructures (KEC, RUB, ATM and SCU)
7. Annexes D4.6.5, 1-5, annexes to deliverable D4.6 with the developed student instructions, laboratory maintenance manuals, safety instructions, etc.