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Capacity Building in the field of higher education

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Erasmus+ - Key Action 2

Capacity Building within the Field of Higher Education

eACCESS Project

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EU-Asia Collaboration for aCcessible Education in Smart Power Systems

WP7	**MANAGEMENT**
TASK	**T7.4 Project innovation monitoring**
LEAD PARTNER	**TUL**
PARTICIPATING PARTNERS	**UWS, AUTH, KEC, PU, RUB, ATM, SCU**

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EXECUTIVE SUMMARY

This deliverable summarises the continuous process of innovation monitoring and management on the improvements of the teaching methods, more effective management of the teaching and administration process, and more effective use of the teaching facilities and human resources.

All eACCESS partners have presented their capability of delivering eACCESS modules using eACCESS Teaching, Learning and Assessment platform. Student and staff feedback and performance of using eACCESS platform indicates teaching innovation delivered throughout this project.

The strong engineering component of the eACCESS project related to the development of advanced laboratory infrastructures at the partner universities resulted in additional genuine innovations concerning the development of practical skills during regular courses at partner universities and regularly organised professional courses related to renewable sources, green transformation of the power sector, smart grid implementation.

Moreover, the experience and skills gained in the developed laboratories have already resulted in tangible collaboration with industrial partners, communities, and scientific research.

With regular monitoring of the activities conducted at partner universities, which used developed infrastructures, eight major innovations in teaching and engineering have been discovered and briefly characterised in this deliverable.

The value of the innovations has been independently verified with several scientific publications and obtained research grants, further detailed in the deliverable D6.4 Preparation and submission in scientific journals.

1. Introduction

Innovation monitoring was conducted during regular General Management Meetings (GMM) and European project partners' technical visits and invited lectures at Asian partner universities, delivered by visiting European teachers.

Initially, the innovations reported were related to the new teaching methods developed and promoted by UWS, the leader of tasks T2.4 Development of new teaching techniques and assessment methods. The new teaching techniques have been extended with new audio-visual tools, including Extended Reality (XR), to increase the attractiveness of remote teaching during the first two years of the eACCESS project implementation. Research conducted by UWS and KEC teams proved that flipped class teaching is getting more efficient and effective, particularly in skill-based and competency-based teaching and learning. It also became more interesting for students when the classic classroomwas taken to a new virtual environment and new XR functionalities were applied.

In parallel, when working on the concepts for the advanced power engineering laboratories of practical skills teaching at partner universities, task T4.1 Preparation of the detailed technical specifications for the physical laboratories, the collaboration between TUL, the leader of the Pillar Three and KEC, RUB, ATM and SCU partner universities and their local industrial partners, four unique designs for configuration and functionalities of Industrial Automation laboratory at KEC, Nepal for Switchgear and Protection laboratory at RUB, Bhutan, as well as Renewable Energy laboratories at ATM and SCU, Indonesia, have been developed and implemented.

At least in one case, SCU implemented laboratory infrastructure and acquired skills in PV and storage installation and management, as well as experience in the operation and maintenance of modern power electronic devices, has become a springboard for starting new scientific projects, intensifying cooperation with industrial partners, and a source of ideas for new applications of renewable sources in agriculture and fisheries.

Finally, towards the end of the project, the classroom and lab virtualisation technique developed by UWS was used to share the developed laboratory infrastructures among partners to increase accessibility to these laboratories for disabled students and during online courses.

The most terrific examples of the innovations which emerged from the core activities conducted during the eACCESS project are characterised with more details in the following sections.

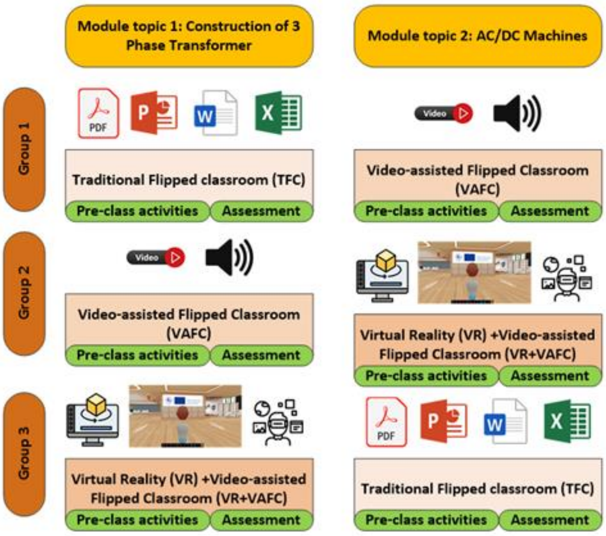
2. UWS -New teaching methods and tools

UWS partner led the second pillar of the eACCESS project dealing with implementing or modernising Moodle teaching platforms at partner universities and took responsibility for implementing the tasks T2.4 - Development of new teaching techniques and assessment methods.

These activities and collaboration with Asian partners resulted in two innovative tools:

- Developmentof a new state of art method: Traditional, Video, and Extended Reality (XR) assisted Flipped Classroom teaching,
- Implementation of eACCESS Teaching Learning and Assessment (TLA) platform.

UWS, together with KEC and with contributions from other Asian partners, investigated the comparative effectiveness of three Flipped Classroom (FC) teaching methods—Traditional Flipped Classroom (TFC), Video-Assisted Teaching Methods (VAFC), and Virtual Reality Flipped Classroom (VRFC)—in the context of Power and Electrical (PE) engineering education. Conducted at Kantipur Engineering College (KEC) in Nepal as part of the eACCESS Erasmus+ funded project, the study gathers feedback from students and teachers, evaluating perceptions and challenges associated with each FC method. The results are disseminated to other partners using workshops and dedicated training sessions.



FC implemetation methods and cross-over approach

Key contributions and novelty of this method consist of the following:

- Method Comparison: The study compares the effectiveness of TFC, VAFC, and VRFC in delivering PE engineering subjects. It employs a cross-over methodology and emphasises the importance of student feedback in the evaluation.
- Educational Landscape in Nepal: Highlights the transformation in the education sector in Nepal, specifically in fast-paced, privately catered undergraduate education. Addresses the challenges of adapting to non-conventional teaching methods in Asian countries.
- Flipped Classroom Approach: Advocates for the effectiveness of the flipped classroom approach in engineering education. Explores different FC methods, focusing on TFC, VAFC, and VRFC, to implement appropriate methods for Asian universities.
- Student and Teacher Perspectives: Presents students' perceptions of each FC method, emphasising their preferences and experiences. Discusses teachers' perceptions regarding operational feasibility, challenges, and benefits of implementing different FC methods.
- Operational Challenges: Identifies operational difficulties, particularly in procuring VR headsets, high-bandwidth internet requirements, and the time and resource-intensive nature of creating educational content for VR/XR.
- Virtual field trips: 3 virtual eACCESS power labs (DC machine, Renewable technology, and Transformers) were developed as a part of this project, which can be accessed from any web-based browser. Students can interact with the digital resources of these virtual labs as a part of the learning process.
- 360 Videos: All eACCESS physical laboratories at partner universities were captured with 360 Video technology. Virtual field trips can be taken anytime by visiting the eACCESS central website. An additional information layer is added to 360 videos detailing resource specifications.

The implementation work has been concluded by synthesising insights from student feedback and teacher perspectives on the three FC methods. It highlights VAFC as a preferred method, emphasising personalised pace, flexibility, and the ability to review pre-class learning resources. The study also outlines the challenges and complexities of implementing FC models in developing nations like Nepal, especially within privately established undergraduate education sectors striving for modernisation aligned with international education practices.

In total, 28 eACCESS modules have been developed and delivered by five partner universities using the eACCESS TLA platform. A summary of the novelty and contributions of each university:

ATM has contributed with five modules with extensive use of video-assisted teaching resources:

i. Implemented various assessment tools, including tests, quizzes and assignments.
ii. Demonstrated the utilisation of the eACCESS Photovoltage Laboratory and introduced Open-book exam assessment methods, a departure from traditional closed-book examinations.

KEC has contributedwith five modules, emphasising Flipped Classroom (FC) methods:

i. Conducted a pilot study on FC, incorporating video-assisted teaching resources and digital resources for Virtual and Extended Reality
ii. Investigated the feasibility of XR technology for delivering Engineering modules.
iii. Demonstrated effective use of eACCESS Moodle-based platform for non-eACCESS modules.

PU contributed with modules, showcasing fair use of eACCESS Moodle-based teaching, and learning platform:

i. Implemented various assessment tools, including Coursework assignments, Case studies, and tests or quizzes.
ii. Given challenging traditional assessment regimes, demonstrated a balanced approach in deploying various assessment methods.

RUB has contributed with six modules with a well-balanced teaching strategy:

i. Showcased a commitment to technical visits to power plants for hands-on learning.
ii. Implemented flipped classroom methodologies and diverse assessment methods, including self-reflection journals.
iii. Successfully integrated self-reflection journals to enhance reflective skills and contribute to individual and team performance.

SCU has contributed with four modules, primarily utilising Project work assessment:

i. Utilised both open and closed-book assessment methods.
ii. Adopted traditional teaching methods with lectures, labs, and tutorials.

The deliverable D2.4 provides an overview of the diverse methods employed by partner universities for delivering eACCESS Power Engineering modules. Partner universities successfully undertook module development and modernisation tasks, showcasing effective identification and implementation of suitable teaching and learning methods.

Despite limited or no prior experience with Virtual Learning Environments (VLE), the partner universities transformed initial assessment methods into Moodle-based activities.

The variety of assessment methods implemented by partner universities indicates the successful fulfilment of capacity-building objectives set by the eACCESS project.

3. KEC – Models of Industrial Automation Components

Under Pillar III, Infrastructure Development, KEC has installed an Automation Laboratory. Some of the components of the Automation Laboratory were purchased and assembled at KEC. This innovative task includes a Robotic arm, assembled VFD training kit and PLC DIY training kit with the design concept of some innovative ideas for the ease of student activity in the laboratory. The eACCESS project is a testament to implementing Nobel-worthy ideas in research and publication. This initiative reflects a dedication to advancing knowledge and disseminating valuable insights, thereby contributing to the broader intellectual and scientific community.

Furthermore, KEC has taken a significant step by integrating Moodle as a teaching and learning platform. This proactive move demonstrates leadership in virtualising educational activities in Nepal. The project's introduction of the flipped classroom concept can be seen as a local initiative to enhance the quality of teaching in Nepal. These innovative approaches are gaining traction within KEC andare expected to influence other institutes and universities across Nepal.

3.1 Robotic Arm

The Automation Laboratory at Kantipur Engineering College proudly houses a 6-DOF robot manipulator, showcasing innovation in the realm of automation. This versatile robotic arm is designed with six degrees of freedom, providing the capability to move in various directions within 3D space. It plays a pivotal role in industrial, research, and educational settings, demonstrating its adaptability in executing complex tasks.

The 6-DOF robot manipulator finds applications in various industries, including manufacturing, assembly, material handling, welding, painting, inspection, and research laboratories. It is widely used due to its flexibility and ability to automate repetitive and dangerous tasks. The major components used are:

a. **Base**: The base is the fixed part of the robot manipulator that serves as its foundation. It provides stability and supports all the other components. The base is securely mounted to the ground or a suitable structure.

b. **Joints**: The robot manipulator consists of several joints that enable the movement of individual segments. The common types of joints used are:

    i. Revolute Joint: Rotational movement about a single axis.
    ii. Prismatic Joint: Linear movement along a single axis.
    iii. Spherical Joint: Provides rotational movement about multiple axes.

c. **Links**: Links are rigid segments that connect adjacent joints and form the physical structure of the robotic arm.

d. **End Effectors (Gripper)**: The end effectors, also known as the gripper, are the tool or device attached to the last link of the robotic arm. It is responsible for interacting with objects and performing specific tasks, such as picking, placing, or manipulating objects.

e. **Actuators**: Actuators are the motors or mechanisms responsible for driving the motion of the robot's joints. They may be electric, pneumatic, hydraulic, or a combination; depending on the specific design, mainly servos and DC motors are used.

f. **Limit Switch**: It is generally used to get the desired control over the degree of rotation of the base by positing the minimum limit of 0 degrees and the maximum limit of 270 degrees, meaning it cuts off the power supply of the motor when it reaches those limits.

g. **Controller**: The controller is the brain of the robot manipulator, responsible for processing commands and controlling the actuators to execute desired movements.

Notably, the 6-DOF Robot Manipulator's applications extend beyond conventional industrial uses, finding a place in educational settings where it is a powerful tool for hands-on learning in automation. The Automation Laboratory emphasises the importance of understanding the kinematics and workspace analysis of the robot, providing students with valuable insights into motion planning and control.

Furthermore, the robot operates in various control modes, adapting to specific task requirements and safety considerations. This ground-breaking technology enables users to delve into both forward and inverse kinematics, allowing precise control over the robot's position and orientation. The innovative task of implementing this 6-DOF Robot Manipulator in the laboratory highlights Kantipur Engineering College's commitment to fostering excellence in automation education and research.

In terms of safety, the laboratory ensures meticulous adherence to mechanical and electrical safety protocols, employing limit switches to control the robot's movements. Additionally, the implementation of safety measures, including regular maintenance, inspection, and the establishment of safety zones, underscores the institution's dedication to ensuring a secure and productive environment for both students and researchers.

In conclusion, the introduction of the 6-DOF Robot Manipulator at the Automation Laboratory is a testament to Kantipur Engineering College's dedication to staying at the forefront of technological innovation. This cutting-edge technology not only enhances the learning experience for students but also positions the institution as a hub for research and development in the field of automation.

3.2 VFD training kit

In the Automation Laboratory at Kantipur Engineering College, a Variable Frequency Drive (VFD) training kit takes centre stage, marking a significant stride in motor control and industrial automation. Variable Frequency Drives, also known as Variable Speed Drives or AC Drives, are electronic devices that redefine the control of electric motors by adjusting the frequency and voltage supplied to the motor. This innovative training kit, featuring the Delta Electronics VFD-EL series, goes beyond conventional education by providing hands-on experience with cutting-edge technology. The design and the components used are listed below.

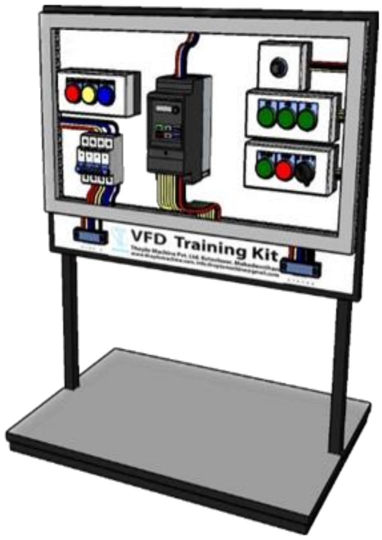


Figure 1 CAD visualisation of the designed VFD training kit (KEC)

1. **Delta VFD**: The Delta Electronics VFD-EL series is designed to offer reliable motor control with features that cater to various industrial applications. While the specific features and capabilities of the VFD-EL series can vary based on the model and version, here are some common characteristics and functionalities.

a. Built-in Control Modes: The VFD-EL series usually supports various control modes, such as V/F (Voltage/Frequency), Sensor-less Vector Control, and possibly more advanced control algorithms to suit different motor types and performance requirements.

b. Communication Interfaces: Many VFD-EL models come equipped with communication interfaces like RS-485 or other fieldbus protocols (Modbus, Profibus, etc.) to enable easy integration into automation systems and communication with other devices.

c. Programmable Inputs and Outputs (I/O): The drives usually have programmable digital inputs and outputs, allowing users to customise the drive's behaviour and interface with external sensors, switches, or control elements.

d. Protection and Safety Features: The VFD-EL series typically includes various protection mechanisms such as overcurrent protection, overvoltage protection, motor phase loss detection, and thermal protection to safeguard the motor and the drive from faults and failures.

e. User Interface: These VFDs often have a user-friendly interface with an LCD display, along with buttons or a keypad, to configure and monitor the drive parameters conveniently.

2. **MCB**: A 4-pole MCB (Miniature Circuit Breaker) is an electrical protection device that safeguards against overcurrent and short circuits. It has four independent switching mechanisms for controlling separate electrical phases in three-phase systems and a neutral pole. It trips when the current exceeds a threshold to prevent damage and fire hazards.

3. **Phase Indication:** In an electrical system with three different phases, you'll find three colour LEDs: RED, YELLOW, and BLUE. These LEDs are used to show the presence of each phase. They help check if the connections are correct and make sure things are safe in industrial places.

4. **Multifunction Switch:** A multifunction switch in a Variable Frequency Drive (VFD) is a feature that allows the user to select and change the operating mode or specific functionality of the VFD according to the application's requirements. In this kit, we are using six different multifunction switches. Five of these switches are push switches of the normally open (NO) type, and one is a selector switch. The multifunction switch is a convenient and accessible way for users to customise the VFD's behaviour without requiring complex programming or extensive parameter adjustments. This flexibility makes the VFD suitable for various industrial applications where motor control requirements vary significantly.

5. **Potentiometer:**A 10K potentiometer is also connected to VFD to vary the frequency of VFD.

In conclusion, the VFD training kit at Kantipur Engineering College's Automation Laboratory represents a pioneering initiative in providing students and researchers with a practical understanding of advanced motor control technology. By combining theoretical knowledge with hands-on experience, this innovative kit prepares individuals for the challenges of contemporary industrial automation and solidifies the college's commitment to excellence in technological education.

3.3 PLC DIY training kit

This kit is designed to simplify the understanding of PLC wiring, input/output connections, and their crucial role in industrial automation. Assembled with care at KEC, the kit includes all the necessary components, showcasing our commitment to making complex automation concepts easy to grasp in our innovative Automation Laboratory. The design of the DIY kit and the components are mentioned below.

1. **PLC** is an industrial digital computer designed to control and automate various manufacturing processes and machinery. It is widely used in industrial applications for tasks like controlling assembly lines, managing production processes, and automating factory machinery. The PLC used is DELTA EX2 with built-in eight high-speed input points (2 points for 100kHz, 6 points for 10kHz) and supports U/D, U/D Dir, and A/B counting modes with a program capacity of 16k Steps.
2. **HMI**: A Touch Panel HMI is a user interface that allows operators and users to interact graphically and intuitively with industrial machines, processes, or systems. It bridges humans and machines, enabling users to monitor the system's status, input commands, and receive real-time feedback. Touch Panel HMIs find widespread use in various industries, including manufacturing, automation, process control, and more.7’’ Colour touch Delta DOP-107BV with Cortex-A8 800MHz CPU is used in this kit.
3. **Input Section:** The input section has two boxes with three points connecting different devices. We can connect to six different things in total. These things can be switches like ON/NC switches or emergency switches. We can also connect special sensors like inductive or infrared (IR). It's like plugging things in to make the system work how you want it to. This allows you to use different devices based on what you need for your specific tasks.
4. **Output section**: The output section also has two boxes, each with three points connecting different colour LEDs. You can connect to six different LEDs in total. Users can use different types of relays or contractors to control loads. The output of PLC is +24 DC; thus, you must connect a 24V DC relay to connect the contactor or any high-power load.
5. **DIN Rail:**A "DIN rail" is a standardised metal rail that mounts and holds various electrical devices and components in industrial and commercial applications. DIN stands for "Deutsche Industrie Norm," the German Institute for Standardization. Due to its ease of installation, flexibility, and modular design, the DIN rail has become a widely accepted and utilised mounting solution in the electrical and electronics industry.DIN rails are typically made of metal, such as steel or aluminium, and come in various sizes, the most common being the standard width of 35mm. They have a standardised shape and mounting holes that allow for easy snap-on installation of devices. The primary purpose of DIN rails is to provide a

convenient and organised platform to mount various electrical components such as circuit breakers, terminal blocks, contactors, power supplies, relays, and other control devices.

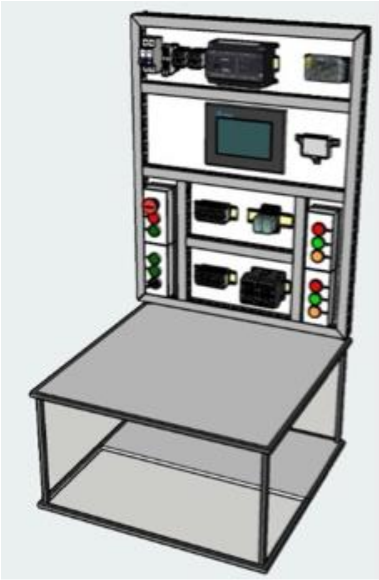


Figure 2 CAD visualisation of the PLC training kit (KEC)

In conclusion, PLC DIY Training Kit at Kantipur Engineering College pioneers a new era in PLC education, empowering students with practical skills in PLC wiring, operation, and troubleshooting. With hands-on experience, this kit prepares individuals for the challenges of the rapidly evolving industrial landscape and reinforces the college's commitment to excellence in technological education.

4. RUB – Smart Grid Protection Training Stations

This section highlights the innovative strides made by Bhutan Automation in designing and implementing the Switchgear and Protection Laboratory (SGPL). The laboratory is a tangible outcome of the EU-Asia Collaboration for Accessible Education in Smart Power Systems (eACCESS) project, generously funded by the European Union. Bhutan Automation has successfully delivered a fully functional laboratory with cutting-edge technology, including line, generator, bus bar, and transformer protection panels.

Figure 3 Omicron 356 test kit

Switchgear and Protection Laboratory (SGPL) is funded by the EU-Asia Collaboration for aCcessible Education in Smart Power Systems (eACCESS)" Project. The laboratory was completed in January 2023. This is the outcome of the eACCESS project and includes the deliverable of a fully functional laboratory consisting of a line, generator, bus bar, and transformer protection panels. The setup will expose the students to real-life power system protection applications and enable them to use the latest numerical relays with hands-on practice to enhance their knowledge and skill sets in the field of application. The setup will allow them to work on designing and implementing protection functions for key power system equipment such as generators, transmission lines, distribution lines and busbars. The laboratory also consists of an Omicron 356 test kit, the top choice among the power engineers for applications. With this state-of-the-art environment in power system protection, students will cement their classroom lessons in power system protection through practical experience without having to go outside the college campus.

Figure 4 Busbar protection panel designed and manufactured by Bhutan Automation in collaboration with RUB

The SGPL project is a significant achievement in smart power systems, contributing to accessible education and fostering innovation in the field. In collaboration with the EU, Bhutan Automation has developed a state-of-the-art laboratory that serves as a hub for research, learning, and experimentation in numerical relay switchgear and protection.

Key Features and Innovations:

1. Advanced Numerical Relay Technology: Bhutan Automation has incorporated the latest numerical relay technology into the laboratory's design. Numerical relays offer precise and reliable protection for power systems, and their integration into the SGPL enhances the educational experience for students and researchers.
2. Comprehensive Protection Panels: The laboratory encompasses protection panels for components such as lines, generators, bus bars, and transformers. Each panel is equipped with advanced numerical relays, providing hands-on experience in understanding, and implementing protection schemes for different elements of a power system.
3. Real-Time Simulation: An innovative feature of the SGPL is the inclusion of real-time simulation capabilities. This allows users to simulate different scenarios and fault conditions, providing a practical understanding of how protection systems respond in dynamic situations. This feature enhances the learning experience and prepares students for real-world challenges.
4. Interoperability and Integration: The SGPL focuses on interoperability, allowing seamless integration with other smart power system components. This ensures that students can gain insights into the holistic functioning of a modern power system and understand the interdependencies between various elements.
5. Accessibility and User-Friendly Interface: Bhutan Automation has prioritised accessibility in the laboratory design to cater to a diverse audience. The protection panels' user-friendly interface and simulation tools make it easier for students, educators, and researchers to navigate and derive meaningful insights.

Figure 5 Line protection panel designed and manufactured by BhutanAutomation in collaboration with RUB.

The successful implementation of the SGPL has far-reaching implications for education and research in smart power systems. The laboratory serves as a valuable resource for students to gain practical knowledge and skills, aligning with the objectives of the eACCESS project. Additionally, the SGPL contributes to the overall advancement of smart power systems by fostering innovation and collaboration.

Automation's achievement in designing and implementing the Switchgear and Protection Laboratory is a testament to the collaborative efforts of the EU-Asia eACCESS project. The innovative features, advanced technology, and comprehensive protection panels make the SGPL a pioneering smart power systems education initiative. The laboratory's impact extends beyond Bhutan, influencing the landscape of accessible education and technological advancements in the broader region.

5. SCU – Unconventional Application of PV and Power Electronics

5.1 Solar Power Plant for Shrimp Farm

The Erasmus + program inspired a team of researchers from the Department of Electrical Engineering at Soegijapranata Catholic University to develop renewable energy, one of which is a solar power plant. The research team consists of Dr. Leonardus Heru Pratomo. MT, Professor Slamet Riyadi, Arifin Wibisono. MT and Dr. Florentinus Budi Setiawan. MT applied for a Kedaireka grant related to solar power plants from the Indonesian Ministry of Research and Technology. This applied research is in partnership with CV Riz Samudra, which is engaged in cultivating Vaname shrimp, which has problems related to energy to rotate the waterwheel to supply oxygen intake in Vaname shrimp ponds. CV Riz Samudra is in Teluk Awur, Jepara District, Central Java.

Figure 6 Vaname shrimp ponds in Teluk Awur, Jepara District, Central Java

The system developed is a hybrid solar power plant, as the master and slave sections are equipped with an on-grid inverter. The installed system is 5.5 kWp, with power distribution in the hybrid system at 3.3 kWp and in the on-grid system at 3.2 kWp. The working principle applied: During the day, the hybrid inverter converts sunlight energy into electricity and stores it in the battery, while the on-grid inverter turns the waterwheel using an induction motor through the inverter. At night, the energy stored in the battery is used to supply electricity to the waterwheel. The single-line diagram of the implemented system is as follows:

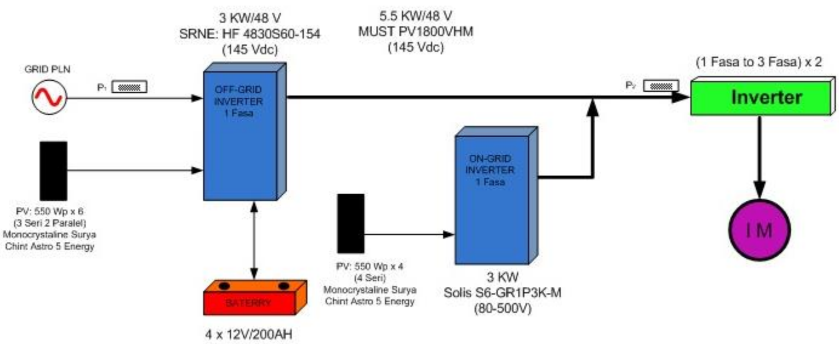


Figure 7 The design of PV installation designed by SCU team for shrimp farm green electricity supply.

This system is a development of the laboratory provided by Erasmus + at Soegijapranata Catholic University so that actual application in the industrial environment of shrimp ponds can be seen realistically. This applied research resulted in an outdoor laboratory used by the Electrical Engineering department for students and others who want to learn about solar power generation. Several training sessions have also been conducted there for students of Soegijapranata Catholic University, Atma Jaya University Jakarta, De La Salle Catholic University Manado, and Pokhara University, Nepal.

Figure 8 ATM partner university student visiting SCU and participating in PV training at shrimp farm PV installation.

5.2 Innovative Three-Phase Inverter

An inverter is an electronic power device that converts DC voltage to AC voltage. The inverter consists of several static switches arranged in a certain configuration. Inverters have been widely applied in various applications. Department of Electrical Engineering, Soegijapranata Catholic University, has taught the students how to design an inverter. One of these inverters is a three-phase inverter with standard topology to drive an induction motor. The inverter consists of three legs,each with two static switches implemented by IGBTs SKM22GD123. The driver circuit needs a voltage level that matches the static switches to turn the switches on and off. Driver circuits can be implemented by IC TLP250 or IR 2132. In operating the three-phase inverter to generate sinusoidal current, digital control is required, and it is implemented by a 16-bit microcontroller dsPIC30F4012. When operating static switches in one leg, dead time must be considered. At the time of transition, when two static switches in one leg start to turn on and off, there will be an interval of time where the voltage and current of both switches are not equal to zero. Such a condition will result in dissipated power in the switches, so this situation must be avoided by giving dead time. After the prototype was designed, experimental tests were done in the laboratory to drive the three-phase induction motor.

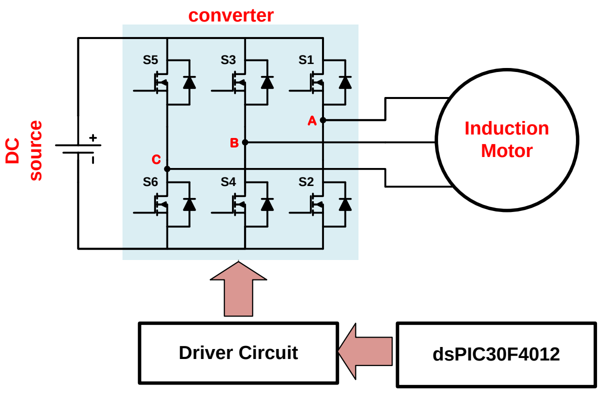


Figure 9 General layout of moder three phase power converter

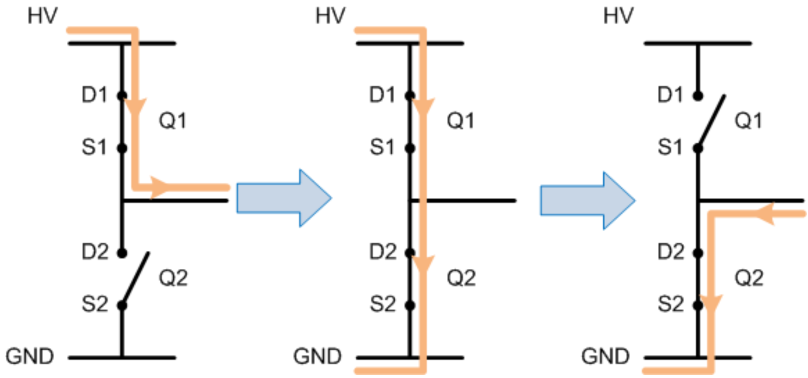


Figure 10 Static switches in one leg under transition without dead-time

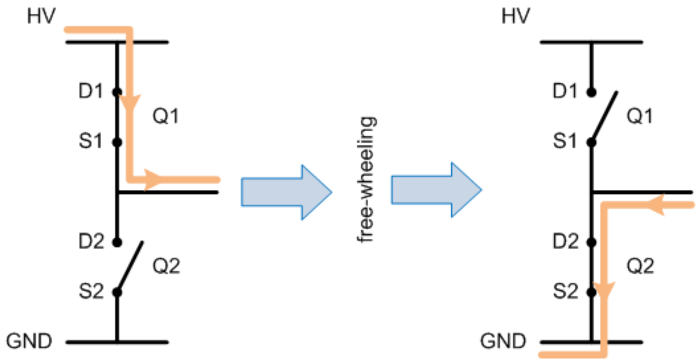


Figure 11 Static switches in one leg under transition with dead-time

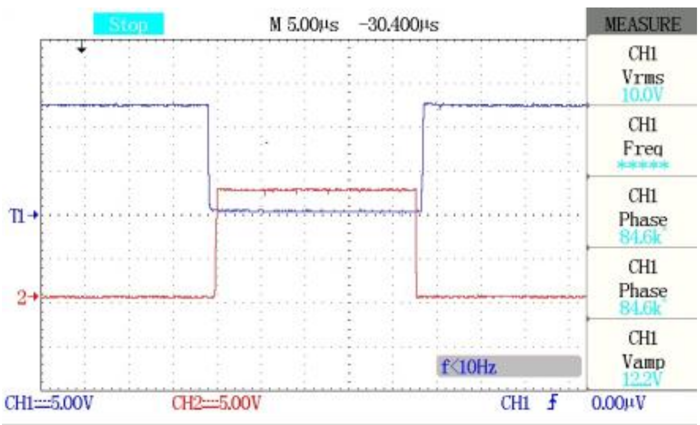


Figure 12 Laboratory tests of the microcontroller for static switches on the upper and lower side of one leg

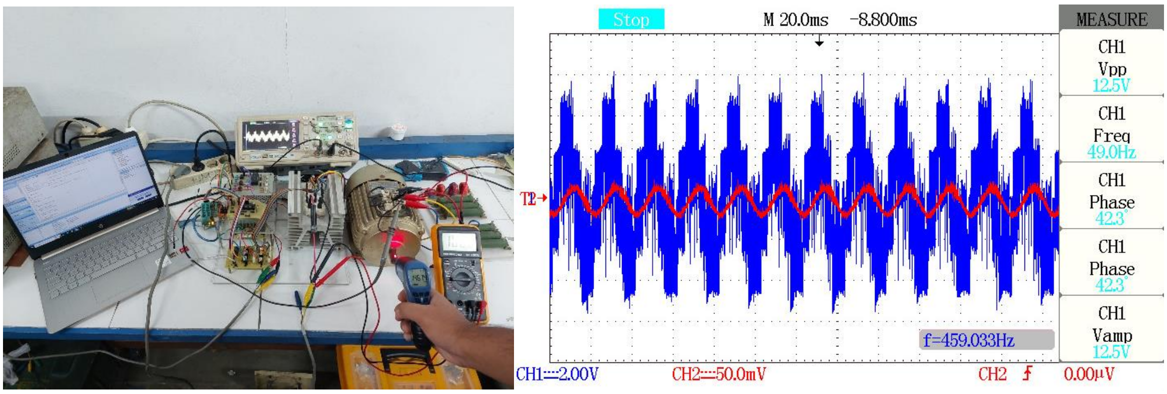


Figure 13 Laboratory test bench for three-phase inverters and registered current and voltage waveforms of phase A

5.3 Solar Power System for Fishing Boats

Nowadays, the need for electrical energy is increasingly becoming a primary need. This causes the addition of electrical energy generating centres to become a top priority to meet electricity needs. Housing, offices, and industry development is rapid, and much electrical energy is needed to facilitate this development. What's worse is that many remote places do not have electricity and may not be able to have electricity well. So electrical energy is considered very important as an energy source for converting physical quantities into electrical quantities that are transmitted to be known over long distances. The increasing use of electrical energy causes energy problems, especially in the electricity supply sector; even worse, suppliers of electrical energy use fossil fuels as primary energy. This type of energy runs out over time. Energy conversion using fossil fuels hurts the environment, namely air pollution, noise, increasing earth temperature effects, high carbon levels in the air and the greenhouse effect. Nowadays, many technologies have the motto "Go Green with Green Technology". To overcome electrical problems, a solution with environmentally friendly technology is needed.

Figure 14 Final preparations for "green boat" field test

Solar modules or solar cells are devices that produce electrical energy by utilising sunlight energy. This type of energy is available in large quantities, is environmentally friendly, is obtained free of charge and can be continuously renewed. The system for converting sunlight energy to electrical energy requires special handling so that the energy conversion can be maximised according to its characteristic curve. With this tool, the electrical energy needed can be produced by yourself and with a simple control system, this system can be available at a low price. This gives rise to the concept that where there is a load (electricity demand), there is a generating centre.

In designing a solar-powered boat system, several data are needed for engineering considerations, including solar radiation level, electric motor capacity, battery storage capacity, and solar panel capacity.

If the motor used is around 1000 Watts, the minimum rating of the inverter used is 1000 Watts/inverter efficiency. If the inverter efficiency is 80%, then the minimum rating of the inverter used is 1000 Watts/0.8 = 1250 Watts.

Battery: If the boat's operation duration without sunlight = 2 hours (afternoon, night or morning), then the energy required is 1000-Watt x 2 h = 2000 Wh. Assuming the energy is taken from 60% of the battery capacity, the battery required is 2000 Wh/0.6 = 3300 Wh. A 12 Volt 50 Ah battery has a stored energy of 12 V x 50 A h = 600 Wh, so to provide 3300 Wh of energy, you only need 6 50 Ah batteries or another combination to reach 3300 Wh.

Solar Panels: To determine the size of solar panels, the following understanding is needed if the effective time for sunlight to be available is 4 hours (10.00 to 14.00), assuming:

a. The motorbike can be operated for 2 hours without solar energy (via battery), so a total energy requirement of 1000 Watts x 2 h = 2000 Wh/day is required,
b. 2000 Wh of energy must be produced from solar panel energy conversion for 4 hours so that each hour 2000/4 = 500 Wh of energy is needed per hour or the equivalent of 500 Watts of power,
c. If the solar panel efficiency is assumed to be 50%, a solar panel with a rating of 500/0.5 = 1000 Wp is required.

The configuration of a solar-powered boat is as follows:

i. Solar panels are placed on the boat's top and function as a heat shield for fishermen.
ii. The electric motor is placed at the back of the boat and is connected to the propeller and rudder.
iii. The controller and battery are placed in the boat body.

6. ATM- Innovation and Development of Solar Power Plants

Ledongara, an area located in Karuni village, Loura District, has a geographical position at coordinates 9°18'-10°20' South Latitude (LS) and 118°55'-120°23' East Longitude (BT). Despite its considerable potential, the area still faces severe challenges in gaining access to electricity. Located in Southwest Sumba Regency, Ledongara is included in the frontier, remote, and underdeveloped regions (3T) based on Presidential Regulation (Perpres) Number 63 of 2020. This situation reflects underdevelopment, especially in the economic sector. To overcome these problems, the 3T Regional based on Renewable Energy was initiated in Ledongara, focusing on procuring solar power plants (PLTS) and empowering local communities. This program is a response to underdeveloped conditions in 3T areas, aimed at providing sustainable solutions and improving the community's quality of life. This program starts in January and runs until April 2022. During this period, the activity plan was successfully carried out well, covering the fields of engineering and community empowerment. The results of the implementation of this program are expected to have a significant positive impact on overcoming electricity challenges and advancing the Ledongara area.

The decision to implement solar power plants (PLTS) is based on sustainability, efficiency, and positive environmental impact considerations. Renewable energy was chosen as an environmentally friendly and sustainable solution to meet electricity needs in Ledongara, in line with the global commitment to reduce greenhouse gas emissions. This program aims to provide better access to electricity in Ledongara and simultaneously improve the economic conditions and welfare of the local community. Until now, the program has achieved its objectives in engineering and empowerment. The existence of the 3T Regional Community Empowerment Program based on Renewable Energy in Ledongara is expected to be a concrete step in overcoming the challenges of underdevelopment, especially in terms of electricity access and community economic development.

The design of the solar power plant is based on the identified electrical energy needs through site surveys, considering the allocated funds. With a capacity of 5.6 kWp, the PLTS can provide energy to the power grid. The energy distribution process starts by channeling energy from the PLTS to the power grid, while excess energy is stored in 6 batteries, each with a storage capacity of 51.2 kWh. The DC current generated by the solar cells is then converted into AC through two inverters connected to the display panel. This function enables the solar cells to supply energy to the power grid.

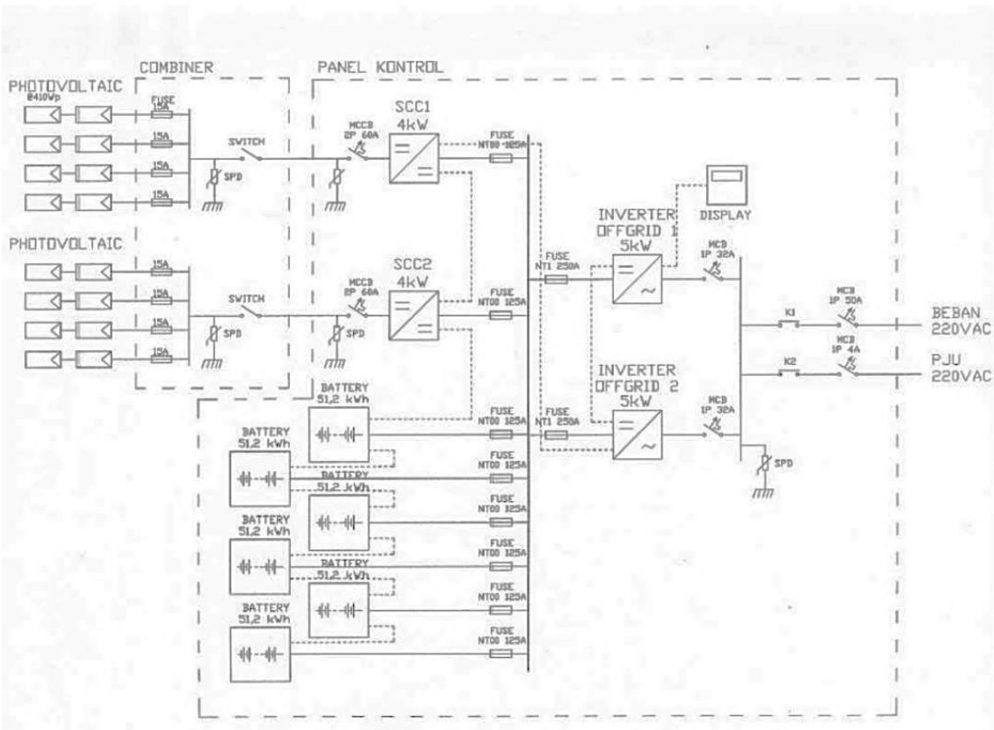


Figure15 Single Line Diagram of the System

The sufficient battery storage capacity allows stored energy to be used at night to supply electricity to residential homes directly. This process ensures the continuity of electricity services without solely relying on direct solar cell production. As a result, the solar power plant in Karuni village provides better access to electricity and demonstrates sustainability in providing energy for the needs of the local community.

Figure 16 Solar Power Plant in Karuni Village.

Figure 17 Community Houses and Public Elementary School 1 Loura That Have Received Electricity Supply from PLTS

The Regional Community Empowerment Project in Ledongara has yielded significant impacts and demonstrated sustainability in several key areas:

a) Impact on Electricity Access: Implementing Solar Power Plants (PLTS) has significantly improved electricity access in Ledongara. By providing affordable and reliable energy solutions, the project has enhanced the quality of life for residents, enabling them to engage in productive activities and access essential services.

b) Economic Empowerment: The project's emphasis on community involvement and capacity building has economically empowered the residents. Through training programs and skill development initiatives, individuals have gained valuable energy management and maintenance expertise, creating opportunities for entrepreneurship and income generation.

c) Environmental Sustainability: By harnessing renewable energy sources, particularly solar energy, the project has contributed to environmental sustainability. Reducing dependence on fossil fuels has minimized carbon emissions and reduced environmental degradation, promoting a cleaner and healthier ecosystem for present and future generations.

d) Social Cohesion and Empowerment: The participatory approach adopted in project implementation has fostered social cohesion and community empowerment. Through collaborative decision-making and active involvement, residents have developed a sense of ownership of the project, leading to increased social capital and collective action.

e) Long-Term Sustainability: The sustainability of this project is further reinforced by an integrated approach to capacity building and infrastructure development. Ongoing training and support ensure the effective operation and maintenance of PLTS, maximizing the lifespan and efficiency of energy infrastructure.

f) Replicability and Scalability: The success of the Regional Community Empowerment Project serves as a model for similar initiatives in other underserved communities. Its innovative strategies and collaborative framework can be replicated and enhanced to address energy challenges and promote sustainable development on a broader scale.

In conclusion, the project has significantly improved electricity access, fostered economic empowerment, and promoted environmental sustainability in Ledongara. The project has laid the foundation for sustainable positive change through a multi-faceted approach and commitment to community engagement. It serves as a beacon of hope for sustainable development initiatives in the region.

7. Final Remarks and Project Performance Indicators

With regular monitoring of the activities conducted at partner universities during the implementation of the eACCESS project,a few concrete innovations related to teaching methods, renewable energy sources, and smart grids have been discovered further. One genuine eACCESS innovation created a new teaching technique, a flipped classroom using XR functionalities, developed in collaboration between UWS and KEC. Four original laboratory designs have been developed, implemented and validated in practical teaching and professional courses due to collaboration between TUL, KEC, RUB, ATM and SCU.

Two innovations have been developed by the SCU team in collaboration with industrial partners concerning the unconventional use of PV installations in the farming and fishing industry and the new construction of three-phase inverters with improved parameters.

The genuine values of the aforementioned innovations have been confirmed with several scientific publications in academic journals and conferences, including joint papers. The list of relevant publications is provided at the end of this deliverable.

8. Scientific publications related to eACCESS innovations.

[1] P. Vichare, M. Cano, K. Dahal, T. Siewierski and M. Gilardi, “Incorporating Extended Reality Technology for Delivering Computer Aided Design and Visualisation Modules,” 2022 14th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), Phnom Penh, Cambodia, 2022, pp. 114-119, doi: 10.1109/SKIMA57145.2022.10029398.

[2] F. B. Setiawan, S. Riyadi, L. H. Pratomo and A. Wibisono, “A 5.4 kWp Microgrid Laboratory Development for Higher Education and Industrial Workshop,” 2022 14th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), Phnom Penh, Cambodia, 2022, pp. 89-94, doi: 10.1109/SKIMA57145.2022.10029640.

[3] Vichare, P., Paudel, S., Rimal, B., Adhikari, S., Panchenko, V., Rijal, R., & Dahal, K.P. (2023). Traditional, Video and Extended Reality (XR) Assisted Flipped Classroom Teaching Methods:

An Approach and Comparison. 2023 15th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), 298-305.

[4] Aresh, B., Vichare, P., Dahal, K., Leslie, T., Gilardi, M., Lovska, A., Vatulia, G., 2023. Integration of Extended Reality (XR) in Non-Native Undergraduate Programmes, in: 15th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), https://doi.org/10.1109/skima59232.2023.10387333

[5] Setiawan, F. B., Riyadi, S., Pratomo, L. H., & Wibisono, A.. (2023). Design of Electric Resource for Solar Tunnel Dryer for Night and Cloudy Condition. https://doi.org/10.1109/skima59232.2023.10387302

[6] Wibisono, A., Riyadi, S., & Yanuardi, D. R.. (2023). The Influence of Partial Shading on the Active Power Output of Solar Grid-Tied Inverter. https://doi.org/10.1109/skima59232.2023.10387340

[7] Riyadi, S., Wibisono, A., Pratomo, L. H., Setiawan, F. B., & Rimal, B.. (2023). Switched Reluctance Generator : An Alternative Source for Microgrid. https://doi.org/10.1109/skima59232.2023.10387305.

[8] Rimal, B.,Paudel, N. and Bhattarai, A. (*2022)* Optimal Placement of Phasor Measurement Units Ensuring Power System Observability. *14th International Conference on Software, Knowledge, Information Management and Applications (SKIMA)*, Phnom Penh, Cambodia, 2022, pp. 7-12, doi: 10.1109/SKIMA57145.2022.10029514.