

D2.3. EQUIPMENT purchased for ESSENCE project implementation

ESSENCE: Establishing Smart Energy System Curriculum at Russian and Vietnamese Universities

Key Action 2: Cooperation for innovation and the exchange of good practices.
Capacity building in the field of higher education

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Document History

Version	Date	Contributor	Comments
1v	11.2019	P1 — Diana Zalostiba;	The first version drafted based on the self-assessment and validation forms
2v	09.2021	P4 — P10	Information about the equipment and its usage (incl. table)
3v	10.2021	P1 — Diana Zalostiba P4 — Anton Prokhorov	Final version

List of Abbreviations

Abbreviation	Definition
CBHE	Capacity building in the field of higher education
EACEA/ Agency	Education, Audiovisual & Culture Executive Agency
EC	European Commission
P1 / RTU	Riga Technical University; PIC 999920718
P2 / Grenoble INP	Institute Polytechnique de Grenoble; PIC 999875225
P3 / TUKE	Technical University of Košice; PIC 999839238
P4 / TPU	Tomsk Polytechnic University; PIC 997438488
P5 / INRTU	Irkutsk National Research Technical University; PIC 941879895
P6 / UrFU	Ural Federal University named after the first President of Russia B.N.Yeltsin; PIC 963580347
P7 / KSPEU	Kazan State Power Engineering University; PIC 916033857
P8 / NEFU	North-Eastern Federal University; PIC 967900436
P9 / HCMUTE	Ho Chi Minh City University of Technology and Education; PIC 923816846
P10 / HUMG	Hanoi University of Mining and Geology; PIC 922118085

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1. Introduction

This report summarizes information about the equipment purchased to implement the ESSENCE project activities.

In general, all purchased equipment can be split into three main groups:

- laboratory equipment (incl. lab benches, hardware, software, books) – to develop teaching materials, ensure teaching and learning process allowing students to reach the defined learning outcomes;
- auditorium equipment (incl. laptops for course developers, PCs, boards, etc.) – to support teaching and learning process allowing implementation of new teaching techniques;
- office equipment (incl. laptops, MFD) – to support management and administration processes.

Based on the needs of Russian and Vietnamese universities, the necessary equipment was identified (using the procedure described below), validated by EU partners and authorized by EACEA. After authorization almost all the purchases were made according to the individually authorized lists of equipment, however due to Covid-19 some deviations in terms occurred.

To maintain the educational process under the pandemic situation and the imposed restrictions the additional equipment was purchased (applying similar procedure for the equipment identification and authorization).

Laboratory and auditorium equipment was used for teaching and learning activities during piloting and implementation of the developed courses within the new or modernized programs. Overall, during the project piloting and implementation (in 2019/2020 and 2020/2021) the different laboratory and auditorium equipment were used by (not-unique) 1254 student users and 164 academic staff users. The following numbers of unique student/staff users are assumed for laboratory equipment by each partner (annually, unique student/staff users): P4 – piloting/implementation: 5-16 students/ 2-3 staff, after the project (in average): 37 students/5-9 staff; P5 – piloting/implementation: 16 students/1-3 staff, after the project: 30 students/1 staff; P6 – piloting/implementation: 7-24 students/2-4 staff, after the project: 50 students/4-8 staff; P7 – piloting/implementation: 10 students/3-4 staff, after the project: 15 students/3 staff; P9 – piloting/implementation: 19 students/3 staff, after the project xxx students/3 staff; P10 – piloting/implementation: 20 students/ 3 staff, after the project: 25 students/ 3 staff.

Total amount spent for the equipment is 173289.77 EUR, mainly spent for laboratory equipment (80.3%), then for auditorium equipment to support teaching process (16.3%) and office equipment (3.4%).

2. Procedure for the identification of the necessary equipment to purchase within the ESSENCE project

At the project proposal stage, it was impossible to identify what exact laboratory equipment (incl. hardware/ software/ books) will be required by each partner, a lump sum of 15000 EUR was allocated to each RU and VN partner. To identify the necessary laboratory equipment and to refine auditorium and office equipment, the following procedure was agreed and followed by the ESSENCE project partners:

- 1) Within the self-examination of the RU and VN universities and the assessment visits at RU and VN universities by the EU partners, the existing equipment and infrastructure of each RU and VN university were evaluated;
- 2) After selection and assignment of courses, the course syllabi were developed, including the lists of the recommended laboratory equipment (incl. hardware/ software/ books) for each course.
- 3) All syllabi (incl. equipment lists) were peer-reviewed by 3 experts; after finalising the syllabi, the final list of the recommended equipment was formed.
- 4) Each RU and VN partner selected the missing equipment to be purchased taking into account its needs, piloting and implementation plan.
- 5) The equipment lists were validated by the EU partners, which had conducted the assessment visits.
- 6) Along with the identification of the missing laboratory equipment, the RU and VN partners also revised the need for purchasing other planned items under the 'Equipment' heading; all the additions were included in the validation form for confirmation. The main goal was to spend the equipment budget to purchase mostly the items for teaching and learning needs.

To maintain the educational process under the pandemic situation and the imposed restrictions (e.g., social distancing, limitation of social contacts, segmentation, two-week quarantine for an infected student and his/her group, lockdown, etc.), the partner universities had to move their teaching and delivery of laboratory activities into online or blended mode. Regardless of the situation, the high academic standards have to be maintained, ensuring delivery of the learning outcomes associated with the curricula (or study course/-s). The piloting experience (under the Covid-19 situation) demonstrated that in some cases access to laboratory facilities, including switching to on-line mode and/or usage of alternative equipment/software, was limited or nearly impossible, and there was a need for additional laboratory and lecture-room equipment (incl. software). Since the consequences of Covid-19 and their impact on the teaching process (incl. implementation of the ESSENCE developed courses) are

long-term and available resources are different at different HEIs, the possibility to purchase additional equipment was considered within the project consortium. As a result, based on the individual needs of the partners, lists of additional laboratory and lecture-room equipment to be purchased were formed by the RU/VN partners and validated by the EU partners, who conducted the assessment visits, and authorized by EACEA.

3. Description of the purchased equipment

The identified and purchased equipment for the project implementation

To ensure successful project implementation the mentioned above procedure was used to identify necessary equipment based on each partner piloting and implementation plans, recommended equipment list developed by the course developers, self-assessment of the existing equipment.

Due to the Covid-19 the universities had to move their teaching and delivery of laboratory activities into online or blended mode. Regardless of the situation, the high academic standards have to be maintained, ensuring delivery of the learning outcomes associated with the curricula (or study course/-s). The piloting experience (under the Covid-19 situation) demonstrated that in some cases access to laboratory facilities, including switching to on-line mode and/or usage of alternative equipment/software, was limited or nearly impossible, and there was a need for additional laboratory and auditorium equipment (incl. software). In particular, the challenges of switching the laboratory activities of the course “Technologies of Energy Conversion in SES” into online mode were recognized (during the piloting by P5, P6, P7); the course was implemented on a regular basis by P4–P7 started from the autumn semester 2021. Initially, for the laboratory activities of this course, the physical laboratory benches were recommended by the course developers. Based on the piloting results and the student survey, as well as taking into account the necessity of delivering laboratory activities into online or blended mode, the existing lab benches were supplemented with virtual modules. As well as additional laboratory and auditorium equipment was purchased to support e-learning (P4, P6, P7, P10).

The following subsections and Table 3.1 summarize information about the purchased equipment by each RU and VN partner, its usage by the target groups during the project lifetime and after it.

P4: Tomsk Polytechnic University

The purchased RTDS cards and firmware were supplemented with media converter, necessary wiring (purchased with P4 own funds) and relay protection unit (provided by industrial partner) and connected with real-time digital simulator. The set-up laboratory bench allows students to learn both about hardware (physical interfaces, information channel) and software (protocols, standards like IEC 61850, IEEE C37) in interactive way since hardware can interact with digital model manipulated by students. The only limitation is that students shall be present in the room where the hardware is installed. This limitation became critical during covid-19 pandemic, since the students had limited access to the lab. So, mostly students doing their individual assignment were involved. However, starting fall semester 2021 we have two group of students 14 RU students and 4 foreign students that will be working with the equipment. And starting next academic year 2022/2023 we are going to increase the

number of students further by involving the equipment into Energy Management Systems course.



Figure 3.1. P4 laboratory equipment: real-time digital simulator, incl., bought RTDS cards and firmware

Since the mentioned technologies are core for emerging SES projects in Russia it is expected to involve industry to the teaching with the use of this equipment. During the project implementation we already had representative of industrial partner System Operator of United Power System delivering lectures about Digital Substations in 2019/2020 and 2020/2021 academic years. At the moment the other partner Ekra, Ltd is going to join us and help with further expansion of lab facilities.

The high-performance GPU server purchased in July 2021 has been tuned to serve 9 virtual machines (VM). Matlab, necessary Machine learning kits and virtual lab bench "Photovoltaic Power" have been installed on these VMs and access to the students has been granted. At the moment this equipment is very actual since regularly there are at least 2-3 students per group that cannot attend lab facilities due to covid-19 restrictions and there are much more of those who want to use VMs for doing home assignments. We estimated that under the current settings the server can host up to 20 students daily sequenced in time. So, if labs are wisely scheduled during semester, it can serve to about 40 students learning in blended form. The virtual lab bench "Photovoltaic Power" has been also installed in the classes and accessed by students following the course Processes and Operating Modes of Power Plants in fall semester 2021/2022.

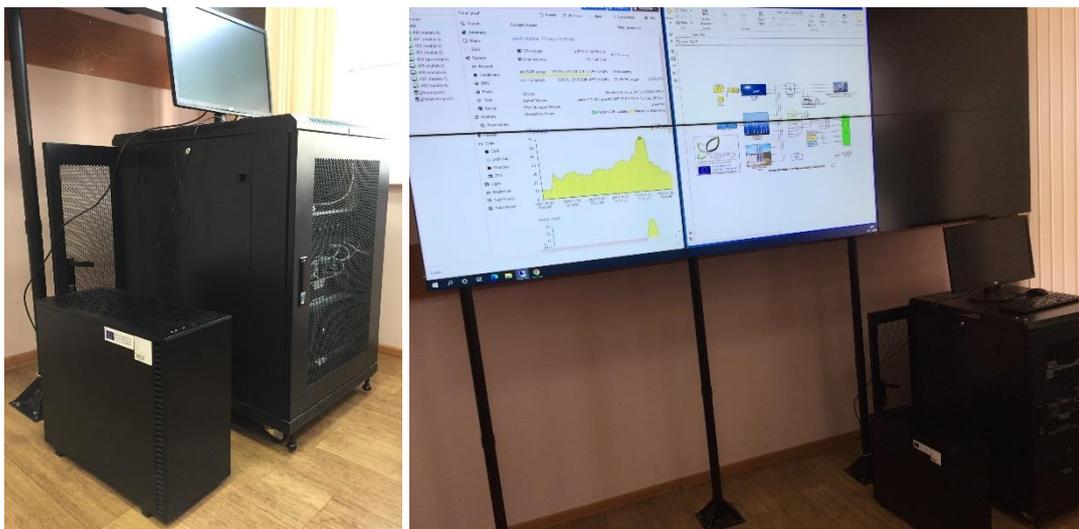


Figure 3.2. P4 laboratory equipment: virtual lab bench “Photovoltaic Power”

P5 INRTU: Irkutsk National Research Technical University

The laboratory complex consisting of the physical model, sensor for physical model, sensor for detecting faults on power lines, test device (primary test), mobile ground test device for fault detection is used to perform lab works for several courses developed and launched under ESSENCE master program “Digital power engineering” (for more information refer to table 3.1). The complex allows the students to master both the specialized hardware (physical interfaces, information channels) and software (protocols, standards such as IEC 61850). The purchased laboratory

equipment in a full scale emulates the real production processes and thus the students have a unique opportunity to solve real production tasks and cases, get to know the real working environment while in the laboratory. This is of special value for employers since the availability of such equipment and related labs decrease the time needed for graduates' adaptability to working conditions.



Figure 3.3. P5 laboratory complex

Another set of lab equipment – virtual lab benches “Photovoltaic power”, “Hydro power” and “Storage devices” - are used to deliver ESSENCE course “Technologies of energy conversion”. The virtual complexes allow students to perform laboratory works in a remote mode which is very timely under the conditions of restricted access to lab facilities due to COVID-19 pandemic. Purchased and installed in summer 2021, the equipment is being used starting from September 2021 (fall semester) when occasionally students get sick and the whole group has to stay isolated for 2 weeks. The software ensures the implementation of all tasks prescribed by the course syllabus remotely and reaching the desired learning outcomes. Having been bought specifically for distance learning, the virtual lab benches can be however used directly

in the class to provide the students with the demonstration of power equipment characteristics and operation process.

Along with the students enrolled in ESSENCE master program “Digital power engineering”, the students of adjoining master programs such as “Renewable energy”, “Smart power supply systems”, “Optimization of power supply systems”, “Energy efficiency, audit, and energy sector management” use the equipment – both hardware and software – for the implementation of laboratory works under a selected number of courses which were partly modernized using teaching materials developed under ESSENCE project (for example, “Analogue and digital measurement systems”, “Distributed generation protection and control”, “Advanced technology in electrical power generation”, “Renewable energy sources”, “Water power plants”, Decentralized energy sources” and others). On a yearly basis, there are about 90 such students and 10 teaching staff benefitting from equipment use.



Figure 3.4. P5 virtual lab bench

P6 UrFU: Ural Federal University

As it was demonstrated in Harmonization report, the master programs at Ural Federal University, Ural Power Engineering Institute have very similar basis of disciplines. From ESSENCE core curriculum 8 of 10 disciplines were taught for 3 (three) groups together, so the analysis of the equipment usage is provided for all 3 (three) groups.

In 2019, P6 has purchased two physical and one virtual laboratory bench in order to support the learning process within the framework of “Technologies of Energy Conversion in SES” discipline from the ESSENCE core curriculum. In 2020 UrFU was locked down due to the COVID-19 starting from March till December 2020, which limited the access of the students to physical laboratory facilities of the university. In 2020 in total 4 students (including 1 MSc ESSENCE student) and 2 professors had the access to the aforementioned lab facilities in individual mode for graduation work physical experiments and practical training at UrFU. Starting from 2021, all the

students have got access to the physical laboratory facilities: three groups of MSc students – 24 MSc students in total.

Virtual laboratory bench “Energy storage” purchased and installed in 2019 was used on regular basis in 2020 by means of providing the remote access to the computer with installed licensed software. The virtual lab bench purchased in summer 2021 “Hydro Power” has the same access opportunities, so it is used on regular basis to ensure the master’s program learning outcomes. The corresponding laboratory classes are being held in October-November 2021 for the 2020 intake group of MSc students. Another advantage of virtual laboratory benches is that they can be used both for in-class and out-of-class teaching, which expands their application area.

The purchase of laboratory benches (both virtual and physical) has expanded the collaboration links of UrFU with industrial partners both in education and research. In 2021 UrFU has signed the agreement with RTSoft company (partner of the ESSENCE Summer School). Within the framework of the agreement, UrFU started exploitation of A-Platform of RTSoft, allowing connection of UrFU SES devices (lab benches) and models to a virtual platform, expanding the opportunities of teaching and research.

The purchased computers in 2020 were used by the MSc students of 2019 intake within the framework of “Artificial intelligence and machine learning in SES” (AI&ML) discipline. The whole MSc group of students was allowed to attend the AI&ML classes due to sufficient social distance (2,0 m) between the working places. In 2021 the computers were used on regular basis by the 2020 intake MSc students for different disciplines, including those, developed within the framework of the ESSENCE project. UrFU has co-funded the installation of the educational and research software on these computers in order to expand their application for other courses and MSc programs.

The ultrabooks purchased in December 2019 were used by the course developers in full-time mode in 2020-2021 for online lecturing, communication and conducting of extra-curriculum activities, including short-term online internships for foreign students.

Powerful multimedia (tablet with e-learning supporting equipment) allowing “mobile” and “remote” teaching was purchased and installed in ESSENCE classroom in 2021, expanding the opportunities of the academic staff to deliver classes both on-site and online. The equipment was used starting from the ESSENCE Summer School in 2021 for video-lecturing, consultations, communication with Partners. The MSc students of 2020 intake are benefitting from using this equipment in 2021 on regular basis.

Power Factory was purchased to support the educational activities of the following disciplines: “Power System Analysis”, “Optimization in Smart Energy Systems”. The students have started using the software in autumn semester. Power Factory ensures transition of the best European practice into Russian Universities, ensures future sustainability and provides collaboration link with European and international partners. Power Factory purchased by UrFU was used within the framework of the internship with French students in 2021. RTSoft, industrial partner of UrFU, has provided free webinars on Power Factory usage for UrFU academic staff.

Considering the other target groups, the ESSENCE equipment was also available for school pupils. Within the joint educational project “Perspective Ural 2021” a group of school pupils joined project learning activities at Ural Power Engineering Institute, using the ESSENCE equipment. This increases the visibility of the University, the project, and supports entrees recruiting for the future.

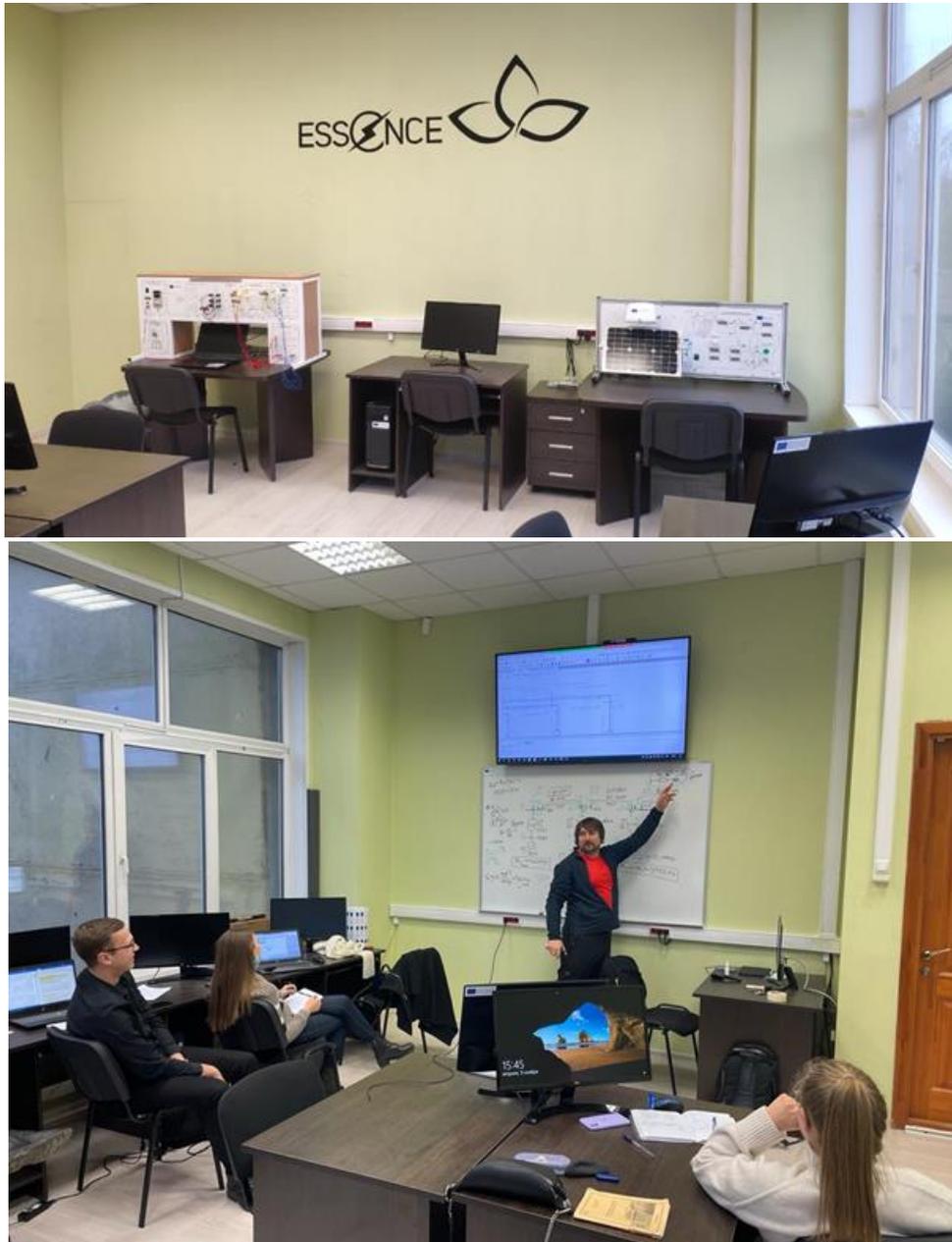


Figure 3.5. P6 laboratory and auditorium equipment

Starting from 2022/2023 academic year, Ural Federal University opens 4 new Master programs based on ESSENCE core curriculum: 2 programs in Russian language and 2 programs in English language titled: “Artificial intelligence for Power Industry Applications” (RU, ENG), “Energy for Smart Cities” (RU,ENG). Each of the programs will have at least 7-10 students, so the total amount of MSc students, having access to the EU-funded lab equipment will be increased up to 50 in 2022/2023 academic year and up to 70-80 in subsequent years, resulting from targeted PR activities.

In total, during the project lifetime, the equipment was used by almost 100 students and lecturers.

P7 KSPEU, Kazan

In July 2019, P7 purchased three laboratory stands, which are designed to train students in the discipline "Technologies of Energy Conversion in SES". Laboratory bench, wind power is needed to create air flow and transmit it to a synchronous wind generator. Laboratory bench, solar power includes a dimmable light source and a dimmable photovoltaic module. This helps to explore the modes of its operation. Laboratory bench, storage helps to study the design, principle of operation and characteristics of electrical energy storage devices.



Figure 3.6. P7 laboratory benches

The limitation to the use of the equipment was online training due to Covid-2019. That is why Virtual Lab Bench Photovoltaic Power was purchased in July 2021. This equipment made it possible to conduct laboratory work in an online format. A specialized hardware and software complex was purchased. This complex made it possible with the help of graphics to study models of mini (micro) Hydro Power equipment of various types, the principle of operation. P7 did not have Virtual Lab Bench Hydro Power. This equipment helped students learn how Hydro Power works in P7 buildings and remotely accessed during quarantine. P7 purchased Software Power Factory, which is required to perform complex calculations and analysis of electrical power systems. Multimedia equipment was purchased for the teachers to ensure the high quality of the lessons.



Figure 3.7. P7 laboratory (virtual) benches and auditorium equipment

It is important to note that the equipment, purchased under the grant is used not only for students of the new ESSENCE master's program, but also for students of other specializations. The disciplines that student's study was created by the teachers of the department on the basis of materials developed within the framework of the ESSENCE grant. 187 students of other specializations improved their knowledge by working on the equipment of the grant.

The equipment, purchased in the spring 2021 semester will help strengthen the knowledge not only of ESSENCE students, but also almost 200 students of other specializations.

Communication module compatible with Sepam are used in laboratory work in the following disciplines: "Digital Technologies for Protection and Communication" (new master's program) and "Microprocessor Relay Protection Devices" (profile "Power Systems Automation"- 18 students). These modules are installed in the laboratory racks of the Sepam 60 and Sepam 80 microprocessor relay terminals.

P9 HCMUTE

The equipment tendering process started from 2019 and it was planned that the equipment would be installed and put into usage by December 2019. However, due to the serious spread of Covid-19 pandemic in Vietnam continuously from the end of 2019 till almost the end of 2020, the equipment could only be installed in December 2020 in the auditorium that HCMUTE had already prepared for ESSENCE project lab.



Figure 3.8. P9 laboratory equipment installation and handing-over

Right after the installation, within the first 09 months of 2021, the equipment was put into usage for practical training for both Master level and undergraduate level students. As the first priority, it was used for 17 Master students to practice lab works on the piloted ESSENCE course Energy Management System (EMS). Also, 2 Master students utilized the equipment (both hardware and software) for their Master theses development which focused on improvement of Photovoltaic system performance.



Figure 3.9. P9 Teaching and learning on the ESSENCE project equipment

Not only master level students had the chance to work with the purchased equipment, 280 undergraduate level students were assigned to use the equipment for their practice of related courses in undergraduate program, such as Power supply systems, Power relay protection systems, Power quality and Renewable energy. The equipment was also utilized by 10 undergraduate students to fulfill their final graduation theses on ETAP-realtime applications, simulating renewable power resources, monitoring Microgrid systems, Power SCADA systems, and so on). In order to prepare further practical laboratory assignments for junior students, 10 senior students were assigned to explore the competence and applications of the ETAP-realtime kit.

The equipment selection and proposal in which HCMUTE chose to buy ETAP-Realtime software and supportive hardware at the first half of the project turned out to be a good decision for students' practice. Although the social distance rules prevented students from coming to school, it was still possible that the teacher provided them with online lectures and virtual lab works on the software. Therefore, students found clearer for the transferred knowledge.

In general, the licensed software and equipment have been efficiently exploited since their installation in HCMUTE. It is planned that the equipment will be inserted into lab works of students in EMS course (Master level), Power SCADA systems, in which students will practice and discover software – hardware connection protocols, applications of ETAP in power flow calculation for Microgrid control and energy management, and so on in HCMUTE, at the total number of about 20 master students and 300-350 undergraduate students per year. Although there are not yet good matches between ESSENCE courses and the existing undergraduate courses in Electrical Engineering programs, HCMUTE plans to gradually harmonize the courses, starting from the inclusion of the sponsored ETAP-Realtime system into related courses.

P10 HUMG, Hanoi

The first purchase of equipment for P10 was done in Nov 2019. The purchased equipment was ETAP software and 8 personal desktop computers for software installation. The software was used for piloting of the course of “Optimization of Smart Energy System” within the framework of the ESSENCE Project. There were 20 master students used the ETAP system optimization model for a course-work project for calculating the intelligent load flow solutions to minimize system operating costs and maximize system performance while maximizing the value. The software was also used for lab works in for the courses such as “Energy Management System” and “Power System Analysis” in the modernized master program on power engineering of P10. Additionally, the personal desktop computers were also used for teaching and lab works of students at different levels from undergraduate to doctoral degrees. There have been a number of students to use these computers for their experiment works for the courses related to Artificial Intelligence and Machine Learning in power engineering, Technologies of Energy Conversion, Economics for power engineering and so on. Although these courses have not been piloted yet during the project time, some new contents from the corresponded courses in ESSENCE project were added to them and the software, desktop computers were very useful.

From 2020, due to the COVID-19 pandemic, most of the teaching in HUMG were implemented online and blended. Fortunately, the auditorium equipment (laptop, projector) was purchased and equipped to HUMG, especially the Electrification Department of HUMG, at very right time to help the lecturers and students in studying and even theses defending.

To further support for online teaching, especially for the summer school event, P10 requested and approved for purchasing the smart board and laptop computer in 2021. These are for completion of the auditorium system in Electrification Departments, HUMG. The smart board was especially useful for group online discussion and presentation for P10’s summer school students. The whole system was also used for teaching of the Power System Analysis and Optimization in Smart Energy System in

summer semester and the total number of students benefited from this newly purchased equipment are 50 students in the courses delivered by 06 teaching faculty members. Therefore, the new equipment purchased in the June 2021 semester are used not only of ESSENCE students, but also the students in the other programs.

It is estimated that there will be 100 students use ETAP and 250 students benefited from the auditorium system in P10 every year from 2021.



Figure 3.10. P10 Lab-work instruction using ETAP and personal computers



Figure 3.11. P10 Auditorium and Computer Room

Table 3.1. Summary of the purchased equipment and its usage by each partner

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P4	March 2020 Room 243, 7, Usov str., 634034, Tomsk, Russia	Laboratory equipment: Interface cards for RTDS, firmware	Teaching and learning, adaptation of the developed course “Digital Technologies for Protection and Communication”	During the piloting/implementation (on a yearly basis): 5 students 3 academic staff After the project (planned on a yearly basis): 37 students 4 academic staff
P4	June 2021 Room 243, 7, Usov str., 634034, Tomsk, Russia	Laboratory equipment: GPU server	9 high-performance virtual machines are set up and available for students learning needs. Teaching and learning of: “Artificial Intelligence and Machine Learning in SES” “Micro Grids, Smart Grids and Supergrids”	During the piloting/implementation (on a yearly basis): 16 students 2 academic staff After the project (planned on a yearly basis): 37 students 3 academic staff
P4	July 2021 Room 221, 249, 7, Usov str., 634034, Tomsk, Russia	Laboratory equipment: virtual lab bench “Photovoltaic Power”	Teaching and learning of: “Technologies of energy conversion in SES”	During the piloting/implementation (on a yearly basis): 13 students 1 academic staff After the project (planned on a yearly basis): 30 students 2 academic staff
P4	July 2019 Room 246, 7, Usov str., 634034, Tomsk, Russia	Laboratory equipment: Books	Development of the course: “MicroGrids, SmartGrids and Supergrid” Teaching and learning of: “Artificial Intelligence and Machine Learning in SES”	During the piloting/implementation (on a yearly basis): 7 students 4 academic staff After the project (planned on a yearly basis): 37 students 5 academic staff

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
			"Micro Grids, Smart Grids and Supergrids"	
P4	July 2019 Room 246, 7, Usov str., 634034, Tomsk, Russia	Office equipment: Laptop	Management, administration	During the piloting/implementation (on a yearly basis): 1 management staff After the project (planned on a yearly basis): 1 management staff
P4	July 2019 Room 246, 7, Usov str., 634034, Tomsk, Russia	Office equipment: MFD	Management, administration	During the piloting/implementation (on a yearly basis): 3 administrative staff After the project (planned on a yearly basis): 3 administrative staff
P5	February 2020 Room 307, 1a, Igoshin street, 664074 Irkutsk, Russia	Laboratory equipment set: - Physical model (demonstration signal box); - Test device (mobile ground fault detection); - Sensor (device for detecting faults on power lines); - Test device; - Sensor for physical model (overhead line fault indication device).	Teaching and learning: Course "ICT for SES"	During the piloting/implementation (on a yearly basis): 16 students 3 academic staff After the project (planned on a yearly basis): 30 students 1 academic staff
			Teaching and learning: Course "Digital technologies for protection and communication"	During the piloting/implementation (on a yearly basis): 16 students 3 academic staff After the project (planned on a yearly basis): 30 students 1 academic staff
			Teaching and learning: Course "MicroGrids, SmartGrids and Supergrid"	During the piloting/implementation (on a yearly basis): 16 students 3 academic staff After the project (planned on a yearly basis):

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
				30 students 1 academic staff
P5	July 2021 Room 307, 1a, Igoshin street, 664074 Irkutsk, Russia	Laboratory equipment: virtual lab bench “Photovoltaic Power”	Teaching and learning: Course “Technologies of energy conversion in SES”	During the piloting/implementation (on a yearly basis): 16 students 1 academic staff After the project (planned on a yearly basis): 30 students 1 academic staff
P5	July 2021 Room 307, 1a, Igoshin street, 664074 Irkutsk, Russia	Laboratory equipment: virtual lab bench “Hydro Power”	Teaching and learning: Course “Technologies of energy conversion in SES”	During the piloting/implementation (on a yearly basis): 16 students 1 academic staff After the project (planned on a yearly basis): 30 students 1 academic staff
P5	July 2021 Room 307, 1a, Igoshin street, 664074 Irkutsk, Russia	Laboratory equipment: virtual lab bench “Storage devices”	Teaching and learning: Course “Technologies of energy conversion in SES”	During the piloting/implementation (on a yearly basis): 16 students 1 academic staff After the project (planned on a yearly basis): 30 students 1 academic staff
P5	February 2019 Room 307, 1, Igoshin street, 664074 Irkutsk, Russia	Auditorium equipment: Laptop	Development of the course “Digital technologies for protection and communication” Piloting/Implementation of all courses developed under the project	During the piloting/implementation (on a yearly basis): 7 academic staff After the project (planned on a yearly basis): 8 academic staff

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P5	February 2019 Room A-305, 83, Lermontov street, 664074 Irkutsk, Russia	Office equipment: Laptop	Management, administration	During the piloting/implementation (on a yearly basis): 1 management staff After the project (planned on a yearly basis): 1 management staff
P5	June 2019 Room A-305, 83, Lermontov street, 664074 Irkutsk, Russia	Office equipment: MFD	Management, administration	During the piloting/implementation (on a yearly basis): 5 administrative staff After the project (planned on a yearly basis): 3 administrative staff
P6	November 2019, Ural Power Engineering Institute, classroom	Laboratory equipment: laboratory bench "Solar power"	Teaching and learning, new curricula implementation (<i>Tech</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 1 MSc student from 2019 intake (practice at UrFU) - 2 academic staff <i>2021 year:</i> - 24 students from 2020 intake (regular MSc groups) - 2 academic staff After the project (planned on a yearly basis): - 50 students (new programs start in 2022) - 4 academic staff (new programs start in 2022)
P6	November 2019, Ural Power Engineering Institute, classroom	Laboratory equipment: laboratory bench "Wind power"	Teaching and learning, new curricula implementation (<i>Tech</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 1 MSc student from 2019 intake (practice at UrFU) - 2 academic staff <i>2021 year:</i> - 24 students from 2020 intake (regular MSc groups) - 2 academic staff

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
				<p>After the project (planned on a yearly basis):</p> <ul style="list-style-type: none"> - 50 students (new programs start in 2022) - 4 academic staff (new programs start in 2022)
P6	July 2019, Ural Power Engineering Institute, virtual license	Laboratory equipment: laboratory bench "Storage" (virtual)	Teaching and learning, new curricula implementation (<i>Tech</i>)	<p>During the piloting/implementation (on a yearly basis):</p> <p>2020 year (<i>COVID-19 lockdown</i>):</p> <ul style="list-style-type: none"> - 25 MSc students from 2019 intake (regular MSc groups) - 2 academic staff <p>2021 year:</p> <ul style="list-style-type: none"> - 24 MSc students from 2020 intake (regular MSc groups) - 2 academic staff <p>After the project (planned on a yearly basis):</p> <ul style="list-style-type: none"> 50 students (new programs start in 2022) 4 academic staff (new programs start in 2022)
P6	July 2021, Ural Power Engineering Institute, virtual license	Laboratory equipment: virtual lab bench "Hydro Power"	Teaching and learning, new curricula implementation (<i>Tech</i>)	<p>During the piloting/implementation (on a yearly basis):</p> <p>2021 year:</p> <ul style="list-style-type: none"> - 24 MSc students from 2020 intake (regular MSc groups) - 2 academic staff <p>After the project (planned on a yearly basis):</p> <ul style="list-style-type: none"> - 50 students (new programs start in 2022) - 4 academic staff (new programs start in 2022)
P6	May 2021, Ural Power Engineering Institute, virtual license	Laboratory equipment: software (Power factory), network licence	Teaching and learning (<i>PSA, Opt</i>)	<p>During the piloting/implementation (on a yearly basis):</p> <p>2021 year:</p> <ul style="list-style-type: none"> - 9 students, internship - 2 academic staff (on regular basis) <p>After the project (planned on a yearly basis):</p> <ul style="list-style-type: none"> - 50 students (new programs start in 2022) - 4 academic staff (new programs start in 2022)

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P6	December 2019, Ural Power Engineering Institute (on the person, course developers)	Auditorium equipment: Ultrabook (2 pcs)	Course/s development, piloting/ implementation (<i>AIML, Tech, EMS</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 4 academic staff (on regular basis) <i>2021 year:</i> - 4 academic staff (on regular basis) After the project (planned on a yearly basis): - 4 academic staff
P6	November 2019, Ural Power Engineering Institute, classroom	Auditorium equipment: PCs (11 pcs)	Teaching and learning, new curricula implementation (<i>AIML, Tech, Grids, Opt, EMS, PSA</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 7 students from 2019 intake (regular MSc group) - 4 academic staff <i>2021 year :</i> - 24 students from 2020 intake (regular MSc groups) - 4 academic staff After the project (planned on a yearly basis): - 50 students (new programs start in 2022) - 6-8 academic staff (new programs start in 2022)
P6	November 2019, Ural Power Engineering Institute, classroom	Auditorium equipment: Marker board	Teaching and learning, visualization (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 7 students from 2019 intake (regular MSc group) - 4 academic staff <i>2021 year:</i> - 24 students from 2020 intake (regular MSc groups) - 4 academic staff After the project (planned on a yearly basis): - 50 students (new programs start in 2022) - 6-8 academic staff (new programs start in 2022)

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P6	December 2019, Ural Power Engineering Institute, classroom	Auditorium equipment: TV set 65'	Teaching and learning, visualization (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>)	During the piloting/implementation (on a yearly basis): <i>2020 year (COVID-19 lockdown):</i> - 7 students from 2019 intake (regular MSc group) - 4 academic staff <i>2021 year:</i> - 24 students from 2020 intake (regular MSc groups) - 4 academic staff After the project (planned on a yearly basis): - 50 students (new programs start in 2022) - 6-8 academic staff (new programs start in 2022)
P6	June 2021, Ural Power Engineering Institute, classroom	Auditorium equipment: tablet with e-learning supporting equipment	Teaching and learning, visualization (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>)	During the piloting/implementation (on a yearly basis): <i>2021 year:</i> - 24 students from 2020 intake (regular MSc groups) - 9+10 students, internship - 4 academic staff After the project (planned on a yearly basis): - 50 students (new programs start in 2022) - 6-8 academic staff (new programs start in 2022)
P6	December 2019, Ural Power Engineering Institute (on the person, P6 coordinator)	Office equipment: Notebook	Management, administration	During the piloting/implementation (on a yearly basis): 1 management staff After the project (planned on a yearly basis): 1 management staff
P6	November 2019, Ural Power Engineering Institute (P6 ESSENCE paper keeping office)	Office equipment: MFD	Management, administration	During the piloting/implementation (on a yearly basis): 5 administrative staff After the project (planned on a yearly basis): 3 administrative staff

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P7	November 2019, KSPEU Krasnoselskaya,51 Room B-304	Laboratory equipment: laboratory bench "Solar power"	Teaching and learning (Technologies of Energy Conversion in SES)	During the piloting/implementation (on a yearly basis): 10 students (new master prog) 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	November 2019, KSPEU Krasnoselskaya,51 Room B-304	Laboratory equipment: laboratory bench "Wind power"	Teaching and learning (Technologies of Energy Conversion in SES)	During the piloting/implementation (on a yearly basis): 10 students (new master prog) 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	November 2019, KSPEU Krasnoselskaya,51 Room B-304	Laboratory equipment: laboratory bench "Storage" (virtual)	Teaching and learning (Technologies of Energy Conversion in SES)	During the piloting/implementation (on a yearly basis): 10 students (new master prog) 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	February 2020 KSPEU Krasnoselskaya,51 Room D-214	Laboratory equipment: Communication module	Teaching and learning Digita ITechnologies for protection and communication	During the piloting/implementation (on a yearly basis): 10 students (new master prog) 10 2021 year students (new master prog) 1 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 1 academic staff

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
P7	July 2021 KSPEU Krasnoselskaya,51 Room B-305	Laboratory equipment: virtual lab bench "Photovoltaic Power"	Teaching and learning (Technologies of Energy Conversion in SES)	During the piloting/implementation (on a yearly basis): 10 students from another educational prog 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	July 2021 KSPEU Krasnoselskaya,51 Room B-305	Laboratory equipment: virtual lab bench "Hydro Power"	Teaching and learning (Technologies of Energy Conversion in SES)	During the piloting/implementation (on a yearly basis): 10 students from another educational prog 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	July 2021 KSPEU Krasnoselskaya,51 Room B-305	Laboratory equipment: software (Power factory)	Teaching and learning (PSA, Opt,)	During the piloting/implementation (on a yearly basis): 10 students from another educational prog 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	September 2019, KSPEU Krasnoselskaya,51 Room V-713	Laboratory equipment: Books	Teaching and learning, new curricula implementation	During the piloting/implementation (on a yearly basis): 10 students (new master prog) 10 2021 year students (new master prog) 4academic staff After the project (planned on a yearly basis): 15 students (new master prog)

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
				4 academic staff
P7	December 2019, KSPEU Krasnoselskaya,51 Room B-304	Auditorium equipment: Ultrabook	Development of the course “Economics for SES”	During the piloting/implementation (on a yearly basis): 3 academic staff After the project (planned on a yearly basis): 4 academic staff
P7	June 2021 KSPEU Krasnoselskaya,51 Room B-305	Auditorium equipment: tablet with e-learning supporting equipment	All disciplines of the curriculum	During the piloting/implementation (on a yearly basis): 10 students from another educational prog 10 2021 year students (new master prog) 3 academic staff After the project (planned on a yearly basis): 15 students (new master prog) 3 academic staff
P7	December 2019, KSPEU Krasnoselskaya,51 Room V-312	Office equipment: Notebook	Management, administration	During the piloting/implementation (on a yearly basis): 2 academic staff After the project (planned on a yearly basis): 2 academic staff
P7	December 2019, KSPEU Krasnoselskaya,51 Room V-312	Office equipment: MFD	Management, administration	During the piloting/implementation (on a yearly basis): 4 academic staff After the project (planned on a yearly basis): 5 academic staff
P9	December 2020	Laboratory equipment: software, hardware (ETAP)	Teaching and learning in EMS piloting course of ESSENCE project and also partially for undergraduate students' practice in related existing courses of HCMUTE.	During the piloting/implementation (on a yearly basis): 19 Master students 280 Undergraduate students 03 academic staff After the project (planned on a yearly basis):

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
				300 students 03 academic staff
P10	November 2019, HUMG, Department of Electrification Laboratory	Laboratory equipment: software, hardware (ETAP)	Teaching and learning (<i>Opt, EMS, PSA</i>)	During the piloting/implementation (on a yearly basis): 20 students 03 academic staff After the project (planned on a yearly basis): 25 students 03 academic staff
P10	November 2019, HUMG, Department of Electrification Laboratory	Auditorium equipment: PC (8 pcs)	Teaching and learning (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>) Used for teaching and learning for ESSENCE project and other students in Electrical Engineering in P10	During the piloting/implementation (on a yearly basis): 50 students 05 academic staff After the project (planned on a yearly basis): 150 students 05 academic staff
P10	November 2019, HUMG, Department of Electrification Laboratory	Auditorium equipment: Laptop	Course development, piloting/implementation (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>) Used for course development document editing Used for teaching and learning for ESSENCE project and other students in Electrical Engineering in P10	During the piloting/implementation (on a yearly basis): 50 students 06 academic staff After the project (planned on a yearly basis): 100 students 06 academic staff
P10	November 2019, HUMG, Department of Electrification Laboratory	Auditorium equipment: Smart board	Teaching and learning, visualization (<i>AIML, Tech, Grids, Opt, EMS, Econ, PSA, Dig, ICT</i>) Used for course development document meeting and discussion	During the piloting/implementation (on a yearly basis): 50 students 06 academic staff After the project (planned on a yearly basis): 100 students

#	Installed (date, address)	Equipment	Used for	Target group (students/staff; yearly)
			Used for teaching and learning for ESSENCE project and other students in Electrical Engineering in P10	06 academic staff
P10	June 2021, HUMG Department of Electrification Laboratory,	Auditorium equipment: projector compatible with smart board and a backup laptop for mentor	Teaching and learning, visualization (<i>Opt, PSA, ?</i>) Used for course development document meeting and discussion Used for teaching and learning for ESSENCE project and other students in Electrical Engineering in P10	During the piloting/implementation (on a yearly basis): 50 students 06 academic staff After the project (planned on a yearly basis): 100 students 06 academic staff
P10	June, 2021, HUMG, Department of Electrification Laboratory	Office equipment: Laptop	Management, administration Used for presentation in summer school event Used for meeting and discussion in course development process In the future, it will be used for students meeting and presentation in seminars and workshops	During the piloting/implementation (on a yearly basis): 150 students 06 academic staff After the project (planned on a yearly basis): 250 students 06 academic staff

* ESSENCE developed courses within SES core curricula: AIML — Tech Artificial Intelligence and Machine Learning (P6), Tech — Technologies of Energy Conversion (P6), Grids — Micro Grid, Smart Grid, Supergrids (P4), Opt — Optimization in SES (P10), EMS — EMS (P6), Econ — Economics for SES (P7), PSA — Power System Analysis (P9), Dig — Digital Technologies for Protection (P5), ICT — ICT for SES (P10)

4. Conclusion

The defined procedure for necessary equipment identification and validation allowed to distribute funding and purchase equipment in reasonable and valuable way considering each partner university needs, existing equipment and funding.

The purchased equipment was installed and used for the project implementation activities. As a result, the ESSENCE developed core curricula “Smart Energy Systems” and its courses were successfully piloted and integrated in the new or modernized programs at RU and VN universities. The laboratory and auditorium equipment has been used not only to deliver regular lectures but also during the ESSENCE summer school. The office equipment has been used to ensure day-to-day coordination, technical and administration activities.

Based on the feedback, the staff and students of the partner universities have highly appreciated the functionality and opportunities provided by the purchased equipment. The smart sequencing in time is used to increase the number of users and loading of equipment. Besides the access to equipment to students of adjoining master program (e.g, Renewable energy, Smart power supply systems, Power relay protection systems, etc) or PhD students have been and will be provided. Since during the selection the compliance with the existing equipment and options to connect additional modules/items have been foreseen, it will be possible to expand functionality and maximise usage of the purchased equipment in the future, e.g., by adding new modules, new licences/users, etc..

The partners co-funded and are ready to co-fund the purchasing of the necessary (not purchased) equipment step by step along with implementing the core curricula at their HEIs.