Co-funded by the Erasmus+ Programme of the European Union

D2.5. Harmonization of the modernized curricula

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

Project number: 586087-EPP-1-2017-1-LV-EPPKA2-CBHE-JP (2017-3017/001-001)

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	21.05.2021	TPU — Anton Prokhorov	Detailed harmonization tables (appendix 1)
2v	15.09.2021	TPU — Anton Prokhorov INRTU, KSPEU, UrFU, HCMUTE, HUMG RTU – Diana Zalostiba	Introduction, Main part (structure) Description of programs Comments/remarks
3v	08.10.2021	TPU — Anton Prokhorov	Main part, conclusion

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	Institut 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

ESSENCE core curriculum offers 9 courses devoted to the different subjects in the field of Smart Energy Systems (47 ECTS) and practical training that shall provide a student with learning outcomes smoothing his/her integration into a company (4 ECTS):

- MicroGrids, SmartGrids and Supergrids (6 ECTS) developed by P4
- Digital Technologies for protection and communication (6 ECTS) developed by P5
- Technologies of energy conversion in SES (6 ECTS) developed by P6
- Artificial Intelligence and Machine Learning in SES (4 ECTS) developed by P6
- Economics in SES (4 ECTS) developed by P7
- Power System Analysis (5 ECTS) by P9
- Energy Management System (5 ECTS) developed by P6 (and partially by P9)
- Optimization in SES (5 ECTS) developed by P10
- ICT for SES (6 ECTS) developed by P10
- Practical Training (4 ECTS) developed by P4.

The overall content of core curriculum and practical training is intended to ensure the following program learning outcomes:

Table 1.1. Teaching techniques recommended to ensure proposed learning outcomes

Category of learning outcome	Program learning outcomes	Teaching techniques
Teamwork and leadership	**PLO1:** To be able to identify own role within a multidisciplinary team and explain the roles of the other team members; and be able to act both independently with a little supervision and cooperate with other team members; negotiate and manage conflicts.	**Crossover learning** **Role play**
Engagement and adaptability	**PLO2:** To be able to demonstrate high personal drive, result oriented and service minded work style, as well as the abilities of time and workload management, to act responsibly and account the interests of the larger community in mind; to work in a fast-paced and highly dynamic environment.	**Role play** **Case method**
Interdisciplinary and multicultural communication	**PLO3:** To be able to express ideas clearly and effectively in written and oral forms to the team members from different professional domains and of different cultures.	**eduScrum** **Gamification**
Lifelong learning	**PLO4:** To be able to identify own learning needs for professional or personal development; demonstrate an eagerness to take up opportunities for learning new things as well as the ability to learn effectively on their own.	**Flipped classrooms/learning** **Mobile learning**
Awareness of cutting-edge technologies	**PLO5:** To be able to identify and prioritize SES related problems and technologies.	**Inquiry-based learning** **Problem based learning**
Use of math intelligence,	**PLO6:** To justify a selection and apply appropriate mathematical models, algorithms, simulation techniques	**Spaced learning**

Category of learning outcome	Program learning outcomes	Teaching techniques
simulation and modern algorithms	for improvement of power system planning, operation and control.	**Simulation-based learning** **Design thinking approach**
System thinking	**PLO7:** To be able to design SES and analyse performance of SES while demonstrating the ability to explain each component and entire system behaviour.	**Case method** **Inquiry-based learning** **Simulation-based learning**
Digital readiness	**PLO8:** To be able to set up and apply specialized software, digital hardware and advanced ICTs to improve performance of SES.	**Experiential teaching** **Bite-sized learning** **Collaborative learning**

It is worth mentioning that formulations of Program learning outcomes (PLOs) defined within the ESSENCE project and the content through which they are assured are subject to flexibility. PLOs formulations can be adapted to the local conditions of implementation of educational programs (but shall be kept in line with their category) and assured through the content of individual courses which may differ (in part or fully) from the content suggested within ESSENCE project.

The example of such flexibility is intended learning outcomes (ILOs) formulated for individual courses by the developers and given in syllabi as deliverable D2.1. ILOs are formulated in respect to PLOs but can be adjusted in accordance with exact course content and activities that may evolve during the program lifetime. Moreover we encourage using the proposed program learning outcomes to modernize the content of the courses outside of ESSENCE core curriculum to make them consistent (harmonized) with it.

Taking this into account it is suggested that each partner is free to decide whether to implement all courses from ESSENCE core curriculum directly or, as considering local constraints and modernization strategies, use only selected parts of the core curriculum courses to modernize existing educational programs or to redesign content and way of teaching of existing courses to ensure proposed learning outcomes. The exact action plan taken by individual partner shall allow attaining the goal of the project - to create similarities of educational programs that enable and foster academic mobility between the partner universities and smooth recognition of study results obtained.

Thus the level of harmonization of modernized educational programs of the partner universities with ESSENCE core curriculum can be measured through the amount of ECTS granted for those elements of curriculum that ensure program learning outcomes proposed within the ESSENCE project.

The aggregated results of the harmonisation level measurement and brief analysis are provided by each partner in the Main part of this report and the details about PLOs and ECTS distribution among different components of all modernized educational programs are given in Appendix 2.

2. Methodology and criteria

To unify harmonisation of the partner's new or modernised program with the ESSENCE core curricula and to evaluate the level of harmonisation, the methodology has been developed. There are two main criteria to be assessed through the amount of ECTS granted for those elements of curriculum (courses, practical trainings, projects and master thesis), through which the program learning outcomes of the ESSENCE core curricula are achieved.

To calculate the criteria the following information is required (a template with the instructions is provided in Appendix 1):

- Full list of courses for a new or modernised program, including information about the type of course (compulsory/optional), ECTS of the course;
- For courses which based on the ESSENCE core curricula, the equivalent course of the ESSENCE core curriculum and total number of PLOs per this course need to be indicated;
- For each course (incl. ones outside of the ESSECE core curriculum), which ensures achievement of the ESSENCE PLO/s, the associated amount of ECTS and corresponding PLO status (formed (F) or assessed (A) or both (F-A)) shall be indicated.
- A brief analysis, explaining the purpose of curriculum modernization, how and when (if the process is step by step) the modernization is implemented, as well as the future plans on further modernization and implementation of the SES programs shall be provided.

Based on the above information the criteria are estimated as follows:

Share of the modernised content – which share of the educational program component is harmonized with ESSENCE core curriculum (this shows shares of the modernized parts of educational program that can be mutually recognized by the project partners):

$$\%, modernized\ content = (Number\ of\ ECTS\ gained\ for\ assessment\ of\ ESSENCE\ LO\ within\ the\ component / Number\ of\ ECTS\ per\ component) * 100\ \%$$

Share of the modernized content per core curriculum – how much the harmonized part of the educational program component weights in respect to the equivalent component of the core curriculum (this shows how much of the project results is currently used on continuous basis within modernized educational programs):

$$\%, per\ core\ curriculum = (Number\ of\ ECTS\ gained\ for\ assessment\ of\ ESSENCE\ LO\ within\ the\ component / Number\ of\ ECTS\ per\ component\ according\ to\ core\ curriculum) * 100\ \%$$

Since Projects and Master Thesis are usually devoted to an individual topic, ILOs obtained in results of these activities might have different weights in respect to the topic, thus we do not consider them for measuring modernization level.

3. Harmonisation of the new or modernised programs within ESSENCE project

This section contains information about each RU and VN partner harmonization process and the achieved results, depending on the modernization strategies chosen by the partners in respect to the constraints.

The estimations of the given indicators for all the master level educational programs that have been modernized within the ESSENCE project are given below and contains the information about the size in ECTS of each of three components (courses, practical trainings, projects and master thesis) of modernized educational programs and the level of their harmonization with ESSENCE core curriculum measured based on data from Appendix 2.

Tomsk Polytechnic University (P4)

Brief characteristic of the modernized program(s):

TPU modernized two educational programs: Power Systems Operation and Control (2 years duration) and Information technologies for Electrical Power Industry (2.5 years duration). The particularity of these programs is that students can be simultaneously enrolled in both of them to obtain two diplomas (two majors). To acquire additional skills in digitalization Electrical engineering students can apply for a second degree in Applied informatics in the field of Power and Energy.

Industrial partners are involved in both programs in terms of practical training (industry internships), supervising master thesis, teaching individual topics of the courses, participating in assessment and master thesis defence.

Table 2.1. Results of harmonization of P4 master programs

Institution	Tomsk Polytechnic University			
Name of the program	Power Systems Operation and Control			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	57	25.5	44.7	54.3
Practical trainings	33	5.55	16.8	100
Projects and Master thesis	30	-	-	-
Overall	120	31.05	-	-

Institution	Tomsk Polytechnic University			
Name of the program	Information technologies for Electrical Power Industry			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	60	22.5	37.5	47.9
Practical trainings	30	7.8	26	100
Projects and Master thesis	30	-	-	-
Overall	120	30.3	-	-

Constraints revealed during modernization:

- Formulations of program learning outcomes are restricted by the frameworks of national educational standards. Increasing the number of program learning outcomes (in addition to those provided by national educational standards) changes the balance of a program since it requires redistribution of ECTS between all learning outcomes.
- There are institutional requirements to the minimum number of students enrolled into a master level educational program (12 students per program taught in Russian, 10 students per international program taught in English). Thus launching a new program requires an increased overall number of the students admitted to the university or termination of one of existing programs. Besides, a minimum number of students shall be assured every year which is critical for international programs in view of COVID-19 limitations. These constraints are not applied to academic mobility programs and they have a much shorter life cycle (1 year). Thus this makes them more attractive for international cooperation.
- The weight of innovative content devoted to Smart Energy Systems within each course and program in general is limited by the demand of the corresponding skills of graduates by industry (the evidence of limited demand is obtained within WP1 through industry surveys). As a result, for the programs with a large number of enrolled students the innovative content is added as special topics, chapters to existing courses. And only a few courses are mainly devoted to Smart Energy Systems.
- The experience of distant learning due to COVID-19 revealed the lack of computation resources and virtual teaching aids to effectively implement distant and blended learning activities of students. This constraint was overcome with the additional equipment purchased.

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To modernize the content of the courses of existing programs
- To modernize course and program learning outcomes of existing programs

- To develop and launch new courses within existing educational program

Brief summary on the results achieved within the project:

The modernization was implemented on a step-by-step basis. 15 courses of 2 existing educational programs got added value from 9 core curriculum courses through content supplement, enrichment of self-study process and teaching techniques, harmonization of descriptors, indicators and learning outcomes with core curriculum PLOs.

In addition, 1 semester (32 ECTS) academic mobility program for master level international students was modernized based on 6 core curriculum courses (20 ECTS in total), namely:

- MicroGrids, SmartGrids and Supergrids
- Power System Analysis
- Energy Management Systems
- Economics for SES
- Digital Technologies for protection and communication
- Artificial Intelligence and Machine Learning in SES.

Irkutsk National Research Technical University (P5)

Brief characteristic of the modernized program(s):

INRTU has opened a new master's program "Digital Power Engineering". A special feature is that it includes all the courses developed for the project. Thus, this made it possible to teach completely according to the developed courses.

Industrial partners participate in this program in terms of practical training (industrial internships), supervision of master's theses, teaching specific topics of courses, participation in attestation and defence of master's theses.

Table 2.2. Results of harmonization of P5 master program

Institution	**Irkutsk National Research Technical University**			
Name of the program	Digital Power Engineering			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	63	30	48	57
Practical trainings	48	11.25	23	100
Projects and Master thesis	9	-	-	-
Overall	120	41.25	-	-

Constraints revealed during modernization:

- The formulation of learning outcomes for the program is limited to the framework of national educational standards. Some of the competencies provided by the developed courses appeared in two or more courses due to the natural connection between them, but there was no coincidence or repetition of the material. The courses of the program were designed in such a way as to form a holistic competence for students.

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To launch new master programs

Brief summary on the results achieved within the project:

A new master's program was opened, which included all 9 courses from the core curriculum. The teaching process used courses developed by partners. There was only a minor adaptation to the specifics of training at INRTU and regional characteristics. But this did not in any way affect the content of the courses.

Ural Federal University (P6)

Brief characteristic of the modernized program(s):

The goal set up by the Ural Federal University at the piloting stage of the project was to integrate all the disciplines from the ESSENCE core curriculum into one existing master's curriculum at Automated Electrical Systems department. The program titled "Design and operation of power systems" was chosen by the department head for modernization. All the 9 disciplines and Practical Training were integrated into the educational plan of the curriculum with the similar names in order to ensure identity of the modernized program with the ESSENCE core curriculum. The only difference was the newly implemented discipline "Smart grids", incorporating the chapters from both – "Artificial intelligence in Smart Energy Systems" and "MicroGrids, SmartGrids and Supergrids" disciplines of the ESSENCE core curriculum, taught in the 2nd and 3rd semester (total 6 ECTS for the "Smart grids" discipline). The content of all the disciplines was either borrowed or enriched by the ESSENCE core curriculum disciplines.

As far as the master programs at Automated Electrical Systems department of Ural Power Engineering Institute have identical basis of the disciplines and only few fundamentally different special courses for each of the program, the majority of the modernized disciplines for "Design and operation of power systems" curriculum were taught simultaneously for the student groups of the other two master programs. Thus, the ESSENCE core curriculum has affected all three master programs at Automated Electrical Systems department, providing modernized content of the disciplines and enhancing the programs from the point of view of the skills and competences associated with Digital transformation of the power industry and Smart Energy Systems.

Industrial partners of Ural Federal University are actively involved in all three programs in terms of the Practical Training. The Practical Training covers the significant share of the existing master programs (37,5% of ECTS), demonstrating the importance of practical orientation of the

educational process and the share of time, when the students are mentored by both – the university representative and the industry expert. The industrial experts are also involved in supervising master thesis, teaching specific chapter and individual topics of the courses, participating the master thesis defence.

Table 2.3. Results of harmonization of P6 master programs

Institution	Ural Federal University			
Name of the program	Design and operation of power systems			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	65	31.5	48.5	67.0
Practical trainings	45	10.4	23.1	100
Projects and Master thesis	10	1.5	15.0	-
Overall	120	43.4	-	-

Institution	Ural Federal University			
Name of the program	Power systems, grids, their operation modes, stability, reliability			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	65	28.0	43.1	59.6
Practical trainings	45	10.4	23.1	100
Projects and Master thesis	10	1.5	15.0	-
Overall	120	39.9	-	-

Institution	Ural Federal University			
Name of the program	Power systems digital control			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	64	29.0	45.3	61.7
Practical trainings	45	10.4	23.1	100
Projects and Master thesis	11	2.0	18.2	-
Overall	120	41.4	-	-

Constraints revealed during modernization:

- Within the framework of the ESSENCE project the courses were developed by the Partners from Russia and Vietnam. Due to the regional and national industrial background, the course developers had different best industrial practices and even material basis used for teaching materials development. Thus, the resulting teaching materials required considerable adaptation to the local industrial specific features of the educational and scientific school of the university. Even with similar material basis (equivalent software or laboratory benches) the share of the implemented results from the ESSENCE curriculum can never reach 100% if not redeveloped/redesigned by the home university' staff.
- Educational programs in the Russian Federation must comply with national educational standards that formulate the desired learning outcomes of program graduates and prescribe the share of program components. The standards are regularly undated and committed to fit the demand of the industrial sector. As also evidenced within the project, industrial companies in the fuel and energy sector stress the need for university graduates to have general engineering skills complemented with only a limited set of specific skills in the field of power engineering. Thus, the share of dedicated courses in the structure of smart energy programs required by the federal standards is limited. Therefore, the innovative content developed within the Essence project was often added as modules or chapters to existing courses.
- Another issue associated with strict limitations imposed by the federal education standards of the Russian Federation as well as by own education standards of Russian university is the burden of official recognition of newly formulated learning outcomes. The administrative procedure is complicated and time-consuming since it requires structural changes at the university level.

- The number of enrolments into state-funded programs is also prescribed by the federal government. This number cannot be increased unless duly rationalized at the ministry level. Otherwise, the new program can be implemented at the university level by terminating a previous program. Besides, at least 10 students must be enrolled into a master's program annually to keep the federal funding. However, the mentioned constrains do not apply to academic mobility and internship programs. After the COVID-19 pandemic hampered physical communication between countries and thus, placed on-site international programs as risk, new forms of cooperation including on-line educational and internship programs, as well as virtual mobility programs became attractive for partners.
- The COVID-19 pandemic also affected the teaching methodology since the program had to be moved online, which required that the constituent courses were redesigned. The major changes were needed in laboratory and practical courses that require lab equipment and provide for on-site internships by the University industrial partners.
- The developed ESSENCE core curriculum is highly multidisciplinary, incorporating the skills and competences from information technologies, mathematics and power industry. Thus, the implementation of the innovative content required considerable efforts of the teaching staff to get themselves involved in multidisciplinary content. During the project activities the course developers and the teaching staff responsible for developed courses implementation within the framework of the modernized master program completed relevant refresher courses and obtained necessary digital competences and skills.

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To launch new master programs, covering the core curriculum of the ESSENCE project.
- To modernize the content of the courses of existing programs.
- To modernize course and program learning outcomes of existing programs.

Brief summary on the results achieved within the project:

1. During the project time the modernization of the existing master's programs at Ural Federal University was implemented on a step-by-step basis. 19 courses including Practical Training of 3 existing educational programs got added value from 9 core curriculum courses and Practical Training through content supplement, enrichment of self-study process and teaching techniques, harmonization of descriptors, indicators and learning outcomes with core curriculum PLOs.

2. In 2021 it was agreed to launch new master programs, covering the core curriculum of the ESSENCE project. Four (4) master programs are now approved to be launched starting from September 2022 ("Energy for Smart Cities" – program in Russian and program in English (field of study – Power Engineering), "Artificial intelligence for Power Industry applications" – program in Russian and program in English (field of study – Applied mathematics). The programs are fully redesigned, ensuring the balance between digital competencies and engineering skills with the individual focus each – either on industrial issues or on the mathematics and informatics.

New programs contain enhanced share of project-learning activities based on real industry cases.

3. Two short-term online internship programs (“Machine Learning in Power Industry”, “Robotics in Power Industry”, 10 ECTS each) for master-level international students was developed and implemented based on 3 core curriculum courses:

- Artificial Intelligence and Machine Learning in Smart Energy Systems
- Energy Conversion Technologies in Smart Energy Systems
- Energy Management Systems

The internship programs proved to be a powerful tool for the project results dissemination and exploitation. Moreover, short-term programs are effective for establishing collaboration with international universities. The implemented programs are included into the extra-curriculum educational portfolio of UrFU and will be sustained in future.

4. Refresher courses for academic staff of the Russian universities were developed and piloted in order to provide digital competences for the teaching staff ensuring sustainable Smart Energy Systems curriculum scaling and development on the national basis. Refresher courses title: “Machine Learning in Power Industry” (3 ECTS).

5. During the project realization, two massive open online courses based on the corresponding ESSENCE discipline were created in order to sustain education during COVID-19 and after-pandemic time: “Machine Learning in Power Industry” in Russian and English languages. Development of “Cybersecurity in Energy Systems” massive open online course is planned in 2022. Cybersecurity was close to the top-list of the core curriculum disciplines within the framework of the WP1 surveying campaign.

Kazan state power engineering university (P7)

Brief characteristic of the modernized program(s):

KSPEU has opened a new master's program "Smart energy system". A special feature is that it includes all the courses developed for the project. The program lasts for 2 years. Thus, this made it possible to teach completely according to the developed courses. Students after completing the program, students could master and apply theoretical knowledge and practical skills in the field of smart energy systems. In the ways of developing technologies for the future of the concept of Smart Grid and Energy, introduce a system for automated and control of electrical substations ("digital substation"), power supply complexes used in both traditional and renewable energy.

Industrial partners participate in this program in terms of practical training (industry internships), supervision of master's theses, teaching specific topics of courses, participation in attestation and master thesis defence.

Table 2.4. Results of harmonization of P7 master program

Institution	Kazan State Power Engineering University			
Name of the program	Smart Energy System			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	60	29.8	49.7	63.4
Practical trainings	51	12.2	23.9	100
Projects and Master thesis	9	-	-	-
Overall	120	42	-	-

Constraints revealed during modernization:

-The formulation of learning outcomes for the program is limited to the framework of national educational standards. Some of the competencies provided by the developed courses appeared in two or more courses due to the natural connection between them, but there was no coincidence or repetition of the material. Thus, the implementation of the innovative content required considerable efforts of the teaching staff to get themselves involved in multidisciplinary content.

-In the ESSENCE project's boundaries, the courses were developed in English. In addition, they required adaptation to the local specifics of the educational and scientific school of the university and its current equipment. Some of the university teachers experienced difficulties while working with the educational material developed in English. In some courses, for example, Artificial Intelligence and Machine Learning, it was necessary to use special software tools, for the purchase of which the funds allocated within project's boundaries were not enough and it was necessary to change the developed materials to achieve the required indicators and learning outcomes with core curriculum PLOs.

-There is a limited number of seats distributed among all master level programs in Electrical Engineering at the institutional level. Thus it is impossible to lunch new program without reducing the number of seats within other programs. In order to preserve the number of students and do not terminate the existence of any of the programs, a small number of students were recruited to the modernized program.

-The program implementation was affected by COVID-19 pandemic, mainly in terms of the laboratory classes and practical training, which are usually implemented on-site either at KSPEU or at industrial partners of KSPEU.

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To launch new master programs, covering the core curriculum of the ESSENCE project.

Brief summary on the results achieved within the project:

A new master program was opened, which included all 9 courses from the core curriculum. The courses developed by partners are used in teaching process. There was an adaptation of courses developed by foreign partners to national characteristics. Most of the course content has been retained.

In addition, the 3 courses of the Industry Skills Development Program (professional development program) have benefited from the 3 core curriculum courses through content supplement, enrichment of self-study process and teaching techniques, harmonization of descriptors, indicators and learning outcomes with core curriculum PLOs.

Ho Chi Minh City University of Technology and Education (P9)

Brief characteristic of the modernized program(s):

Out of the available Master degree programs in HCMUTE, the university has a Master degree training program in Electrical Engineering which has been running for years and has the most suitability with the courses developed in the ESSENCE project. The program lasts in 1.5 years with a required total number of credits of 36 credits which is equivalent to 90 ECTs. After completing the program, students could master and apply the theoretical knowledge and practical skills in Electrical Power Systems in order to analyze, evaluate, renovate, develop or put modern technologies into application in the systems. Students are given opportunities to investigate and solve the existing industrial problems through the support from industrial partners who have also contributed opinions to the curriculum design process. Students are to complete the Master program by defending their final theses in front of a Judge committee including HCMUTE professors, off-campus professors and industrial representative(s).

Table 2.5. Results of harmonization of P9 master program

Institution	Ho Chi Minh City University of Technology and Education (P9)			
Name of the program	Electrical Engineering			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	70	18.20	26	N/A
Practical trainings	10	3.15	31.5	N/A
Projects and Master thesis	20	-	-	-
Overall	90	25.35	-	-

Constraints revealed during modernization:

- HCMUTE must maintain the core courses (approved by Vietnam Ministry of Education and Training) while the list of Elective courses could be extended.

- For some courses, teaching contents could be partially modified (usually under 30%) to adapt with students' learning interest and performance.

- A piece of knowledge could appear in two or more courses due to the natural linkage between (among) them but overlap or repeat should not exist. Instead, the courses join together to form a holistic competence for students.

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To modernize the content of the courses of existing programs
- To modernize course and program learning outcomes of existing programs
- To develop and launch new educational program basing on the 10 core courses of ESSENCE project when possible

Brief summary on the results achieved within the project:

The course Power System Analysis of ESSENCE project has been inserted into the modernized Master program in Electrical Engineering program as a compulsory course. The other 9 courses of ESSENCE project are added to the list of elective courses for students to select.

Hanoi University of Mining and Geology (P10)

Brief characteristic of the modernized program(s):

Master of Electrical Engineering is one of the most traditional master level programmes in Hanoi University of Mining and Geology (HUMG). The program is designed for lasting in 1.5 years with a required total number of credits of 60 credits which is equivalent to 90 ECTs. Being trained with theoretical knowledge and practical skills in Electrical engineering which is involved strongly with electric power systems and grid, the graduation students could be mastered and be able to utilize the most updated modern and advanced technologies for analyzing, designing or developing the entire systems (including HV, EHV or UHV grids). They also have chances to join deeply into the practical projects/tasks from industrial partners who are majoring with power engineering, automation, robotic technique. The final theses of the students are mostly concerned with practical issues which are defended in front of a Judge committee including HUMG professors, off-campus experts and industrial representative(s).

Table 2.6. Results of harmonization of P10 master program

Institution	Hanoi University of Mining and Geology			
Name of the program	Electrical Engineering			
Education level	Master			
	Total per component, ECTS	Modernized part, ECTS	%, modernized content	%, per core curriculum
Courses	73	13	17,8	14,8
Practical trainings	6		50	100
Projects and Master thesis	12		-	-
Overall	91	13	-	-

Constraints revealed during modernization:

- Conversion of national credits and ECTS in some terms is not easy and it wrongly reflects the modernization aspect of the program. Some learning outcomes are not fully reached because of a particular pandemic.
- Covid 19 makes the practical training and Labworks really hard. The timetable of the semester changed frequently, making the training activities unstable. Distance learning/teaching/examining prevents quality accreditation from being finished well. By purchasing new additional equipment for the Lab, this constraint was overcome

Taking into account above mentioned constraints the following modernization strategies are accepted:

Modernization (harmonization with project results) strategies:

- To modernize the content of the courses of existing programs by updating and translating the courses verified by the project
- To modernize the content of the courses of existing programs
- To modernize course and program learning outcomes of existing programs
- To develop and sustain short-term educational programs (mobility, internships) ensuring effective international and national collaboration (Internship programs developed and piloted during the ESSENCE project lifetime).

Brief summary on the results achieved within the project:

A modernization of master level program has been done. All 3 courses implemented by P10 (which are Power system analysis, Optimization for Smart energy system and Digital Technologies for protection and communication) are valuable for the modernization of MEE in HUMG. The lab facilities and equipment purchased by project budget will certainly contribute significantly to the education procedure of both undergraduate and master level training programs. All of the course content has been retained.

4. Conclusion

The proposed methodology and criteria are suitable for harmonization of a program/s with the ESSENCE core curriculum and assessment of its harmonization level.

By measuring the harmonization level we can make sure that modernized programs provide the same level of qualification and degree can be recognizable. Besides, by measuring harmonization level per course or semester and indicating the correspondence with courses from ESSENCE core curriculum we can easier agree curricula for academic mobility and design joint programs in the future.

APPENDIX 1. The template of the table illustrating distribution of PLOs and ECTS among of courses of modernized programs

1. Provide full list of courses for modernized program. For the courses modernized based on the ESSENCE results indicate if corresponding PLO is formed (F) or assessed (A) or both (F-A). The courses shall be properly sequenced to make sure that targeted PLOs are formed before assessment and assessed (measured) if they are formed. Note that ILOs formulated for ESSENCE courses may be reformulated for the courses within modernized program due to the national specifics, program profile (minor) and vision of a teacher. PLOs may also have a non identical wording but shall be consistent with ESSENCE PLOs to make sure that curricula of different HEI are haronized in terms of targeted PLOs.

2. Please note that if a course allows students to attain several PLOs of a modernized curriculum but not all of them comes from the ESSENCE core curriculum you shall define a fair share of ESSENCE's PLOs in ECTS. Note that an amount of ECTS per PLO depends on how much of the course materials supports this PLO or/and the amount of grading points associated with exact PLO assessment. Different PLO can be weighted in different way based on the teacher's vision. Example: A course of 3 ECTS targets 4 PLOs an only one of them is from ESSENCE core curriculum, 50 % of a course content support ESSENCE PLO and one PLO outside of ESENCE curriculum thus ESSENCE PLO can be weighted as: 3 ECTS * 0.5/2= 0.75 ECTS.

3. Some of the courses outside of ESSENCE core curriculum can also target ESSENCE's PLOs, please indicate ECTS per ESSENCE PLO for them also.

4. The level of curriculum modernization can be estimated as: *TOTAL amount of ECTS granted for attainment of ESSENCE PLOs / TOTAL amount of ECTS for courses and practical training*

5. Optional course can be extracurriculum (obtained ECTS goes additionaly to the standart amount of program ECTS (120) or it may be one of several courses and student shall choose between them. In both cases there is no 100% guarantee that student complete this course within program curriculum. Thus, please, indicate such courses but do not account them in the total.

6. The completed web form shall be accompanied with the analysis explainig the purpose of curriculum modernization, how and when (if the process is step by step) the modernization is implemented (for instance some partners lunched new curriculum before the TMs development was finished, in this case structure and PLOs of the program were modernized first, after that a content has been updated step by step and with the growth of the ESSENCE provided content in the modernized curriculum, the weights of ESSENCE PLOs (in ECTS) has been increased. Besides the future plans on further modernization and implementation of the SES programs shall be provided and scheduled in time.

PLO1: To be able to identify own role within a multidisciplinary team and explain the roles of the other team members; and be able to act both independently with a little supervision and cooperate with other team members; negotiate and manage conflicts.

PLO2: To be able to demonstrate high personal drive, result oriented and service minded work style, as well as the abilities of time and workload management, to act responsibly and account the interests of the larger community in mind; to work in a fast-paced and highly dynamic environment.

PLO3: To be able to express ideas clearly and effectively in written and oral forms to the team members from different professional domains and of different cultures.

PLO4: To be able to identify own learning needs for professional or personal development; demonstrate an eagerness to take up opportunities for learning new things as well as the ability to learn effectively on their own

PLO5: To be able to indentify and prioritize SES related problems and technologies

PLO6: To justify a selection and apply appropriate mathematical models, algorithms, simulation techniques for improvement of power system planning, operation and control

PLO7: To be able to design SES and analyze performance of SES while demonstrating the ability to explain each component and entire system behavior

PLO8: To be able to set up and apply specialized software, digital hardware and advanced ICTs to improve performance of SES

Program name: *Power Systems Operation and Control*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed and assessed. Provide amount ECTS associated with a particular PLOs within a course**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum (!including practical training!)	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Computer, network and information technologies	Information and Communication Technologies for SES	Compulsory	3	4							F-A	0.75								
Add rows if necessary																				
Semester 2																				
Add rows if necessary																				
Semester 3																				
Add rows if necessary																				
Semester 4																				
Add rows if necessary																				
TOTAL																				

This project has been funded with support from the European Commission. This publication / communication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

APPENDIX 2. Distribution of PLOs and ECTS among of courses of modernized programs

Table A.1. Tomsk Polytechnic University (P4) – program 1.

Program name: *Power Systems Operation and Control*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Professional English Training	MicroGrids, SmartGrids and Supergrids	Compulsory	3	4	F-A	0,5			F-A	0,5										
Computer, Network and Information Technologies	Information and Communication Technologies for SES	Compulsory	3	2	F-A	2					F-A	1								
Advanced Chapters of Mathematics	Optimization in SES	Compulsory	6	5			F-A	1												
Operating Modes and Stability of Electric Power Systems	Power System Analysis Energy Management Systems (State estimation)	Compulsory	3	4			F-A	1,4	F-A	1,2	F-A	0,4								
Automatic Control Systems Theory		Compulsory	3																	
Processes and Operating Modes of Power Plants	Technologies of energy conversion in SES	Compulsory	3	2	F-A	0,5			F-A	1,5										
Research (Project) Work in the Semester		Compulsory	6																	
Semester 2																				
Professional English Training		Compulsory	3	4	F-A	1											F-A	0,5	F-A	0,5
Project Management		Compulsory	3																	
Characteristics of Electric Equipment for Power Plants and Substations		Compulsory	3																	
Methods and Tools for Power Electronics based control of Power Systems	MicroGrids, SmartGrids and Supergrids	Compulsory	3	5					F-A	1,5	F-A	1								
Automatic Control of Electric Power Systems		Compulsory	3																	
Software and Hardware for Monitoring and Control of Electric Power Systems	Energy Management Systems	Compulsory	3	2	F-A	1					F-A	3								
Emergency Control in Power Systems		Compulsory	3																	
Research (Project) Work in the Semester		Compulsory	6																	
Practical training for obtaning primary professional skills		Compulsory	6	9									F-A	0,3	F-A	0,3	F-A	1,2	F-A	0,6
Semester 3																				
Electricity and Power Markets	Economics for SES	Compulsory	3	3	F-A	2	F-A	0,6					F-A	0,4						
Emergency Control in Power Systems		Compulsory	3																	
Power system operation and expansion planning	Optimization in SES	Compulsory	3				F-A	1	F-A	0,5										
Power System Relay Protection Coordination and Setting	Digital Technologies for protection and communication	Compulsory	3	4			F-A	1	F-A	1	F-A	0,5								
Dispatch control of power systems		Compulsory	3																	
Research (Project) Work in the Semester		Compulsory	12																	
Semester 4																				
Technological Practical Training		Compulsory	9	9									F-A	0,45	F-A	0,45	F-A	0,45	F-A	0,45
Pre-Graduation Practical Training		Compulsory	18	9													F-A	0,45	F-A	0,9
Master thesis		Compulsory	6																	
TOTAL			**120**			7		5		6,2		5,9		1,15		0,75		2,6		2,45
TOTAL harmonized			**31,05**																	

Table A.2. Tomsk Polytechnic University (P4) – program 2.

Program name: *Information technologies for Electrical Power Industry*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Professional English Training		Compulsory	3		F-A	0,5			F-A	0,5										
Computer, Network and Information Technologies	Information and Communication Technologies for SES	Compulsory	3	2	F-A	2					F-A	1								
System and Application Software		Compulsory	3																	
Research (Project) Work in the Semester		Compulsory	3																	
Semester 2																				
Professional English Training	MicroGrids, SmartGrids and Supergrids	Compulsory	3	4	F-A	1											F-A	0,5	F-A	0,5
Project Management		Compulsory	3																	
Advanced Chapters of Mathematics	Optimization in SES	Compulsory	6	5			F-A	1												
Automatic Control Systems Theory		Compulsory	3																	
Databases		Compulsory	3																	
Information and Control Systems		Compulsory	3																	
Research (Project) Work in the Semester		Compulsory	6																	
Technological Practical Training		Compulsory	9	9							F-A	0,9	F-A	0,45	F-A	0,45	F-A	0,45	F-A	0,9
Semester 3																				
Information Networks and Telecommunications	Information and Communication Technologies for SES	Compulsory	3	3							F-A	3								
Introduction to Programming and Algorithms		Compulsory	3																	
Industrial networks, interfaces and data transfer protocols for electric power industry	Information and Communication Technologies for SES Digital Technologies for protection and communication	Compulsory	3	2							F-A	3								
Research (Project) Work in the Semester		Compulsory	6																	
Semester 4																				
Object-Oriented Programming Concepts		Compulsory	3																	
Information models of the technical systems	Information and Communication Technologies for SES	Compulsory	6	2	F-A	1			F-A	2,5	F-A	2,5								
Datawarehouse	Artificial Intelligence and Machine Learning in SES (Data mining)	Compulsory	3	2			F-A	0,25			F-A	0,25								
Research (Project) Work in the Semester		Compulsory	6																	
Technological Practical Training		Compulsory	9	9							F-A	0,9	F-A	0,45	F-A	0,45	F-A	0,45	F-A	1,8
Semester 5																				
Information Security and Data Protection		Compulsory	3																	
Machine Learning	Artificial Intelligence and Machine Learning in SES	Compulsory	3	2			F-A	2			F-A	1								
Information System Design		Compulsory	3																	
Pre-Graduation Practical Training		Compulsory	12																F-A	0,6
Master thesis		Compulsory	9																	
TOTAL			**120**			4,5		3,25		3		12,55		0,9		0,9		1,4		3,8
TOTAL harmonized			**30,3**																	

Table A.3. Irkutsk National Research Technical University (P5)

Program name: Digital Power Engineering					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Technologies of energy conversion in Smart Energy Systems	Technologies of energy conversion in Smart Energy Systems	Compulsory	3	2	F/A	1														
Economics for Smart Energy Systems	Economics for Smart Energy Systems	Compulsory	4	3	F/A	1	F/A	1												
Power system analysis	Power system analysis	Compulsory	3	2			F/A	0,5	F/A	1	F/A	0,5								
Research Work Practical Training	Practical training	Compulsory	4	7	F/A	1							F-A	0,5					F-A	0,5
Philosophy of Science		Compulsory	2	3																
Modern problems of electric power and electrical engineering		Compulsory	4	1																
Problems of development and functioning of electric power systems in modern conditions		Compulsory	3	1																
Foreign language		Compulsory	1	1																
Organization of the educational process and research work in higher education at the departments of technical profile		Compulsory	3	3																
Semester 2																				
Energy Management System	Energy Management System	Optional	1	2					F/A	0,25	F/A	0,25								
Artificial Intelligence and Machine Learning in Smart Energy Systems	Artificial Intelligence and Machine Learning in Smart Energy Systems	Compulsory	4	2			F/A	0,5			F/A	1								
ICT for SES	ICT for SES	Compulsory	4	2			F/A	0,5	F/A	1	F/A	1								
Practical Training in Obtaining Primary Skills in Research work	Practical training	Compulsory	2	1	F/A	0,5							F-A	0,25					F-A	0,5
Project Practical Training	Practical training	Compulsory	4	6	F/A	0,5	F/A	0,5	F/A	1	F/A	0,5	F-A	0,5					F-A	0,5
Research Work Practical Training	Practical training	Compulsory	2	7	F/A	1							F-A	0,5					F-A	0,5
Methodology for creating smart energy systems		Compulsory	3	1																
Computer, network and information technologies		Compulsory	3	1																
Trends in the development of electrical equipment in the power industry		Compulsory	3	1																
Automated energy metering systems		Optional	1	2																
Power electronics		Optional	2	1																
Foreign language		Compulsory	1	1																
Semester 3																				
Optimization in Smart Energy Systems	Optimization in Smart Energy Systems	Compulsory	5	2			F/A	0,5			F/A	1								
Micro Grids, Smart Grids and Super Grids	Micro Grids, Smart Grids and Super Grids	Compulsory	5	2					F/A	1,5	F/A	1								
Digital Technologies for protection and communication	Digital Technologies for protection and communication	Compulsory	5	2	F/A	0,5	F/A	1	F/A	1	F/A	2								
Energy Management System	Energy Management System	Optional	2	2					F/A	0,5	F/A	0,5								
Research Work Practical Training	Practical training	Compulsory	4	7	F/A	1											F-A	1		
Foreign language		Compulsory	1	1																
Special issues of reliability of power supply systems		Optional	3	2																
Reliability of Intelligent Power Supply Systems		Optional	3	2																
Automated Energy Metering Systems		Optional	2	2																
Selected questions of theoretical electrical engineering		Optional	2	1																
Semester 4																				
Project Practical Training	Practical training	Compulsory	12	6	F-A	1	F-A	0,5	F-A	0,5	F-A	0,5	F/A	1	F/A	0,5	F/A	0,5	F/A	1
Teaching Practical Training	Practical training	Compulsory	6	3									F-A	0,5					F-A	0,5
Pre-Graduation Practical Training	Practical training	Compulsory	6	6	F-A	1	F-A	1	F-A	1	F-A	1								
Master thesis		Compulsory	9	7																
TOTAL			**120**			**8,5**		**6**		**8,75**		**9,25**		**3,25**		**0,5**		**1,5**		**3,5**
TOTAL harmonized			**41,25**																	

Table A.4. Ural Federal University (P6)– program 1.

Program name: *Design and operation of power systems*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Philosophical problems of science and technology		compulsory	3	2													F-A	1,0		
Mathematical methods and algorithms in power industry	Power System Analysis	compulsory	3	6			F-A	1,0			F-A	0,5								
Automatic control theory in power industry		compulsory	3	2			F-A	0,5												
Power system automation		compulsory	3	5	F-A	0,5														
Practical training: obtaining primary research skills, research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Optimization in smart energy systems	Optimization in Smart Energy Systems, Energy Managem	optional	3	3	F-A	0,5	F-A	1,0												
Mathematical modelling of power system operation modes	Power System Analysis	optional	3	6			F-A	1,5	F-A	0,5										
Information and communication technologies in power systems	ICT in Smart Energy Systems, Digital Technologies for Pro	optional	3	3	F-A	1,0					F-A	1,0								
Power system analysis	Power System Analysis	optional	4	6			F-A	2,0	F-A	1,0	F-A	1,0								
Semester 2																				
Information technologies in power industry	ICT in Smart Energy Systems, Digital Technologies for Pro	compulsory	3	4							F-A	1,0								
Energy conversion technologies in smart energy systems	Energy conversion technologies in Smart Energy Systems	compulsory	3	5	F-A	2,0	F-A	0,5												
Industry-focused practical training: research work	Practical training	compulsory	3	8									F-A	0,5	F-A	0,5				
Industry-focused practical training: project-based learning		compulsory	6	8													F-A	1,0	F-A	1,0
Information technologies for power system control	Energy Management Systems	optional	3	5	F-A	0,5	F-A	1,0												
Digital technologies for protection and communication	Digital technologies for Protection and Communication	optional	3	3					F-A	0,5	F-A	1,0								
Economics in smart energy systems	Economics in Smart Energy Systems	optional	3	6	F-A	0,5	F-A	0,5												
Long-distant energy transmission of extra-high voltage	Micro Grid, Smart Grid and Supergrids	optional	3	4	F-A	0,5	F-A	0,5												
Smart grids	Artificial intelligence and machine learning in Smart Energy	optional	2	5			F-A	1,0			F-A	0,5								
Semester 3																				
Information technologies in power industry	ICT in Smart Energy Systems, Digital Technologies for Pro	compulsory	3	4							F-A	1,0								
Industry-focused practical training: research work	Practical training	compulsory	9	8													F-A	1,0	F-A	1,0
Module project "Economics and development of smart energy systems"		optional	1	3			F-A	0,5												
Power system development optimization	Optimization in Smart Energy Systems, Energy Managem	optional	4	6	F-A	0,5	F-A	1,5												
Ecology and energy security	Energy conversion technologies in Smart Energy Systems	optional	3	6	F-A	1,0														
Reliability of power equipment operation		optional	3	5			F-A	1,0												
Energy quality assurance		optional	3	5					F-A	1,0										
Smart grids	Micro Grid, Smart Grid and Supergrids, Artificial intelligenc	optional	4	5	F-A	0,5	F-A	0,5	F-A	1,0	F-A	0,5								
Semester 4																				
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: pre-graduation training	Practical training	compulsory	18	8									F-A	1,0	F-A	1,0	F-A	0,5	F-A	0,5
Preparation and defence of graduation work		compulsory	8														F-A	0,5		
Preparation and passing state examination		compulsory	1																F-A	0,5
TOTAL			**120**			7,5		13		4		6,5		1,5		1,5		5,2		4,2
TOTAL harmonized			**43,4**																	

Table A.5. Ural Federal University (P6)– program 2.

Program name: *Power systems, grids, their operation modes, stability, reliability*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Philosophical problems of science and technology		compulsory	3	2													F-A	1,0		
Mathematical methods and algorithms in power industry	Power System Analysis	compulsory	3	6			F-A	1,0			F-A	0,5								
Automatic control theory in power industry		compulsory	3	2			F-A	0,5												
Power system automation		compulsory	3	5	F-A	0,5														
Power system control and optimization	Optimization in Smart Energy Syste	compulsory	3	3	F-A	0,5	F-A	1,0												
Mathematical modelling of power system operation modes	Power System Analysis	compulsory	3	6			F-A	1,5	F-A	0,5										
Digital substation	ICT in Smart Energy Systems, Digita	compulsory	3	3	F-A	1,0					F-A	1,0								
Practical training: obtaining primary research skills, research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Special issues of power system operation		optional	4	5			F-A	0,5												
Semester 2																				
Information technologies in power industry	ICT in Smart Energy Systems, Digita	compulsory	3	4							F-A	1,0								
Energy conversion technologies in smart energy systems	Energy conversion technologies in S	compulsory	3	5	F-A	2,0	F-A	0,5												
Information technologies for power system control	Energy Management Systems	compulsory	3	5	F-A	0,5	F-A	1,0												
Digital substation	Digital technologies for Protection ar	compulsory	3	3					F-A	0,5	F-A	1,0								
Wholesale and Retail Electricity Markets Fundamentals	Economics in Smart Energy System	compulsory	3	6	F-A	0,5	F-A	0,5												
Means of power system control in normal and emergency operation modes	Power System Analysis	compulsory	2	6			F-A	0,5	F-A	0,5	F-A	0,5								
Industry-focused practical training: research work	Practical training	compulsory	3	8									F-A	0,5	F-A	0,5				
Industry-focused practical training: project-based learning		compulsory	6	8													F-A	1,0	F-A	1,0
Long-distant energy transmission of extra-high voltage	Micro Grid, Smart Grid and Supergri	optional	3	4	F-A	0,5	F-A	0,5												
Semester 3																				
Information technologies in power industry	ICT in Smart Energy Systems, Digita	compulsory	3	4							F-A	1,0								
Module project "Sustainable development of power systems"		compulsory	1	3			F-A	0,5												
Mathematical basics of power system development optimization	Optimization in Smart Energy Syste	compulsory	4	6	F-A	0,5	F-A	1,5												
Ecology and energy security	Energy conversion technologies in S	compulsory	3	6	F-A	1,0														
Means of power system control in normal and emergency operation modes	Power System Analysis	compulsory	4	6			F-A	1,0	F-A	0,5	F-A	1,0								
Industry-focused practical training: research work	Practical training	compulsory	9	8													F-A	1,0	F-A	1,0
Power systems reliability		optional	3	5			F-A	1,0												
Energy quality assurance		optional	3	5					F-A	1,0										
Semester 4																				
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: pre-graduation training	Practical training	compulsory	18	8									F-A	1,0	F-A	1,0	F-A	0,5	F-A	0,5
Preparation and defence of graduation work		compulsory	8														F-A	0,5		
Preparation and passing state examination		compulsory	1																F-A	0,5
TOTAL			**120**			7		11,5		3		6		1,5		1,5		5,2		4,2
TOTAL harmonized			**39,9**																	

Table A.6. Ural Federal University (P6)– program 3.

Program name: *Power systems digital control*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Philosophical problems of science and technology		compulsory	3	2													F-A	1,0		
Mathematical methods and algorithms in power industry	Power System Analysis	compulsory	3	6			F-A	1,0			F-A	0,5								
Automatic control theory in power industry		compulsory	3	2			F-A	0,5												
Power system automation		compulsory	3	5	F-A	0,5														
Power system control and optimization	Optimization in Smart Energy Systems, Energy Management Systems	compulsory	3	3	F-A	0,5	F-A	1,0												
Mathematical modelling of power system operation modes	Power System Analysis	compulsory	3	6			F-A	1,5	F-A	0,5										
Digital substation	ICT in Smart Energy Systems, Digital Technologies for Protection and Communication	compulsory	3	3	F-A	1,0					F-A	1,0								
Practical training: obtaining primary research skills, research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Technologies of microcontrollers programming	Digital Technologies for Protection and Communication	optional	3	3							F-A	1,0								
Semester 2																				
Information technologies in power industry	ICT in Smart Energy Systems, Digital Technologies for Protection and Communication	compulsory	3	4							F-A	1,0								
Information technologies for power system control	Energy Management Systems	compulsory	3	5	F-A	0,5	F-A	1,0												
Energy conversion technologies in smart energy systems	Energy conversion technologies in Smart Energy Systems	compulsory	3	5	F-A	2,0	F-A	0,5												
Digital substation	Digital technologies for Protection and Communication	compulsory	3	3					F-A	0,5	F-A	1,0								
Wholesale and Retail Electricity Markets Fundamentals	Economics in Smart Energy Systems	compulsory	3	6	F-A	0,5	F-A	0,5												
Hardware and software for power system protection and automation	Digital technologies for Protection and Communication	compulsory	3	3							F-A	2,0								
Industry-focused practical training: research work	Practical training	compulsory	3	8									F-A	0,5	F-A	0,5				
Industry-focused practical training: project-based learning		compulsory	6	8													F-A	1,0	F-A	1,0
Digital signal processing	Digital technologies for Protection and Communication	optional	3	3			F-A	1,0			F-A	0,5								
Semester 3																				
Information technologies in power industry	ICT in Smart Energy Systems, Digital Technologies for Protection and Communication	compulsory	3	4							F-A	1,0								
Module project "Sustainable development of power systems"		compulsory	1	3			F-A	0,5												
Mathematical basics of power system development optimization	Optimization in Smart Energy Systems, Energy Management Systems	compulsory	4	6	F-A	0,5	F-A	1,5												
Ecology and energy security	Energy conversion technologies in Smart Energy Systems	compulsory	3	6	F-A	1,0														
Frequency control in steady-state and transient operation modes of power systems	Power System Analysis	compulsory	3	7			F-A	1,0	F-A	1,0										
Power systems reliability		compulsory	3	5			F-A	1,0												
Module project "Hardware and software for power system protection and automation"	Digital technologies for Protection and Communication	compulsory	1	3							F-A	0,5								
Hardware and software for power system protection and automation	Digital technologies for Protection and Communication	compulsory	3	3							F-A	1,0								
Industry-focused practical training: research work	Practical training	compulsory	9	8													F-A	1,0	F-A	1,0
Semester 4																				
Industry-focused practical training: research work		compulsory	3	8													F-A	0,4	F-A	0,4
Industry-focused practical training: pre-graduation training	Practical training	compulsory	18	8									F-A	1,0	F-A	1,0	F-A	0,5	F-A	0,5
Preparation and defence of graduation work		compulsory	8														F-A	0,5		
Preparation and passing state examination		compulsory	1																F-A	0,5
TOTAL			**120**			6,5		11		2		9,5		1,5		1,5		5,2		4,2
TOTAL harmonized			**41,4**																	

Table A.7. Kazan state power engineering university (P7).

Program name: Smart energy systems					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Technologies of energy conversion in Smart Energy Systems	Technologies of energy conversion in Smart Energy Systems	Compulsory	3	2			F-A	1			F-A	1								
Economics for Smart Energy Systems	Economics for Smart Energy Systems	Compulsory	6	1	F-A	3	F-A	3												
Power system analysis	Power system analysis	Compulsory	3	1			F-A	1	F-A	1										
Mathematical methods of modeling and forecasting		Compulsory	3				F-A	0,75												
Philosophy of Science and Technology		Compulsory	3																	
Technogenic safety		Compulsory	3																	
Theory and practice of self-development		Compulsory	3																	
Theory and practice of scientific research in the electric power industry		Compulsory	3												F-A	0,5			F-A	0,5
Professional English Training		Compulsory	3	2	F-A	0,25											F-A	0,3	F-A	0,5
Energy policy		Compulsory	3	5										F-A	0,5					
Semester 2																				
ICT for SES	ICT for SES	optional	3	1					F-A	0,75										
Optimization in Smart Energy Systems	Optimization in Smart Energy Systems	Compulsory	6	2			F-A	2	F-A	2	F-A	2								
Technological Practical Training	Practical training	Compulsory	6	6																
Practical training for obtaning primary professional skills	Practical training	Compulsory	9	2									F-A	0,2	F-A	0,4	F-A	1	F-A	0,5
Energy project management		Compulsory	3										F-A	1	F-A	0,2	F-A	1	F-A	1
Educational practical training	Practical training	Compulsory	3																	
Semester 3																				
Energy Management System	Energy Management System	Compulsory	3	4	F-A	1	F-A	2												
Artificial Intelligence and Machine Learning in Smart Energy Systems	Artificial Intelligence and Machine Learning in Smart Energy Systems	Compulsory	3	2	F-A	1	F-A	1,5	F-A	1										
Micro Grids, Smart Grids and Super Grids	Micro Grids, Smart Grids and Super Grids	Compulsory	6	3	F-A	1,5			F-A	1	F-A	1								
Digital Technologies for protection and communication	Digital Technologies for protection and communication	Optional	4	2	F/A	2	F/A	0,2	F/A	1	F/A	1								
Operational Practical Training	Practical training	Compulsory	13	5									F-A	1	F-A	0,3	F-A	0,5	F-A	0,6
Teamwork to control the modes of the main electrical equipment		Compulsory	2	1			F-A	1					F-A	1						
Semester 4																				
Operational Practical Training	Practical training	Compulsory	14	5									F-A	1	F-A	0,3	F-A	0,5	F-A	0,6
Pre-Graduation Practical Training	Practical training	Compulsory	6	5											F-A	1	F-A	0,5	F-A	0,6
Master thesis		Compulsory	6																	
TOTAL			**120**			**7**		**10**		**6**		**5**		**4,2**		**2,2**		**3,8**		**3,8**
TOTAL harmonized			**42**																	

Table A.8. Ho Chi Minh City University of Technology and Education (P9).

Program name: *Master of Electrical Engineering*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Electric Power Quality	Energy Management System	Elective	5	3			F-A	0,2	F-A	0,2	F-A	0,2	F	0,5			F	0,3		
Electric Drives		Elective	5	4	F-A	0,5	F-A	0,75	F-A	0,5	F-A	0,25			F	0,5				
Energy Audit	Energy Management System	Elective	5	3					F-A	0,6			F	0,5			F	0,3	F	0,5
Power System Modeling anh Simulation	Power System Analysis	Compulsory	5	3			F-A	0,75			F-A	0,5								
Power System Planning		Elective	5	4	F-A	0,75	F-A	0,5	F-A		F-A	0,5			F	0,5			F	0,5
Power Electronic devices in Power Systems	Micro Grids, Smart Grids and Super	Elective	5	2			F-A	0,75			F-A	0,75								
Optimization of Power System Operation and Control	Optimization in SES	Elective	5	2	F-A	0,75	F-A	0,75									F	0,5		
Semester 2																				
Power System Analysis	Power System Analysis	Compulsory	5	4	F-A	0,5	F-A	0,75	F-A	0,5	F-A	0,25					F	0,3		
Powerplant Technology		Elective	5	2	F-A	0,75			F-A	0,75			F	0,5						
Renewable Energy	Technologies of energy conversion in	Elective	5	3	F-A	0,75	F-A	0,75												
Relay Protection and Automation in Power System	Digital Technologies for protection an	Elective	5	4	F-A	0,75			F-A	0,5					F	0,5				
Communication Networks for Smart Grids	ICT for SES	Elective	5	3	F-A	0,5			F-A	0,75										
Electricity Markets and Power System Economics	Economics for Smart Energy Systen	Elective	5	2	F-A	0,75	F-A	0,75					F	0,75			F	0,5	F	0,5
Transience and Stability in Power System	Power System Analysis	Elective	5	4	F-A	0,5	F-A	1			F-A	0,5								
Semester 3																				
Final Thesis		Compulsory	20																	
TOTAL			**90**			**6**		**5,95**		**3,8**		**2,45**		**2,25**		**1,5**		**1,9**		**1,5**
TOTAL harmonized			**25,35**																	

Table A.9. Hanoi University of Mining and Geology (P10)

Program name: Master of *Electrical Engineering*					**Indicate if PLOs recommended by ESSENCE core curiculum is: F-formed, A- assessed or both F-A - formed**															
					PLO5		**PLO6**		**PLO7**		**PLO8**		**PLO1**		**PLO2**		**PLO3**		**PLO4**	
The courses of modernized curriculum	**Equivalent course from ESSENCE core curriculum**	**Type of course (compulsory/optional)**	**ECTS of the course (according to the modernized curriculum)**	**Total number of PLOs per course**	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS	F/A	ECTS
Semester 1																				
Measurement methods and Data processing applied for the insulation parameters of the mining electric system		Compulsory	5																	
Power System Analysis	Power System Analysis	Compulsory	5	5			F-A	1	F-A	3	F-A	1								
Using the transformative equipment in power system		Compulsory	5																	
Electric power supply structuring		Compulsory	5																	
Numeric protective relays in power system	Digital Technologies for protection and communication	Compulsory	5	4	F-A	1	F-A	1	F-A	1	F-A	1								
Semester 2																				
Optimization for Electric Power System	Optimization in SES	Compulsory	5	3			F-A	1	F-A	1,5	F-A	1,5								
FACTS equipments in alternating current transmission		Compulsory	5																	
Advanced Industrial PLC application		Optional	3																	
Simulation model for power supply system		Compulsory	5																	
Advanced safety techniques for preventing electrical shock and explosion-proof		Optional	5																	
Semester 3																				
Switching Voltage Stabilizing Power Supply		Optional	5																	
Automatic Elements In the Power System		Optional	5																	
Power Grid Planing and Managing		Compulsory	5																	
Over voltage and grounding in the electrical system		Optional	5																	
Power system electric quality		Optional	5																	
Practical training	*Practical training*	Compulsory	6																	
Semester 4																				
Graduation thesis	Practical Training and Graduation thesis	Compulsory	12																	
Add rows if necessary																				
TOTAL			**91**			1		3		5,5		3,5								
TOTAL harmonized			**13**																	