Co-funded by the European Union

Developing Competences of Pre-Service Teachers through STE(A)M-based Renewable Energy Curriculum

{RENEWTEACH}

PR1

Development of Curriculum and Training Program for Preservice Teachers

2021-1-TR01-KA220-HED-000027614

ABOUT

Overview

RENEWTEACH is an ERASMUS+ project with the title "Developing Competences of Pre-Service Teachers through STE(A)M-based Renewable Energy Curriculum" and project number 2021-1-TR01-KA220-HED-000027614. This document is designed to introduce PR1, one of the project results developed within the RENEWTEACH project.

What is the PR1?

PR1 covers the framework curriculum developed for renewable energy and STE(A)M fields within the scope of the RENEWTEACH project. In addition to unit outcomes, the curriculum includes suggestions for assessment and evaluation, teaching methods and strategies, and examples of STE(A)M activity designs based on common concepts. In this context, PR1 is the basis for all other PRs that follow it in terms of scope.

Aim of PR1

The aim of this project result is to lay the foundation for contents in which STEM skills are integrated into RE context. Thanks to this project, preservice teachers will gain knowledge, skills and attitudes towards RE and STE(A)M.

Implementation

Thanks to PR1 pre-service teachers;

- will have theoretical knowledge about renewable energy and STE(A)M.
- understand the nature of renewable energy sources.
- explore the working principles of renewable energy sources and their relationship with STE(A)M disciplines through common concepts.

In this context, PR1 is a framework for instructional designs in which STE(A)M approach is adopted in teaching topics related to renewable energy.

How to Access?

You can access the PR1 content via the RENEWTEACH project website (https://renewteach.org/) or by registering and logging in to the online learning platform developed within the RENEWTEACH project (https://guzemxonline.gazi.edu.tr/).

JUSTIFICATION OF THE CURRICULUM

- When the policies stated in the European Commission, Education and Training 2020 Working Group (WG) and Erasmus 2020 and the Council of Europe's 2019-2024 Strategic Agenda are examined, such as local and global challenges and resource saving, reducing energy use and waste, compensating carbon it is seen that the priorities for acquiring environmentally friendly behaviors are targeted.
- The development of environmental goals and STEAM skills were included in the priorities of higher education in the Erasmus Program Guide 2021 (EPG, 2021)
- Both in Turkey and European Countries is observed that the lack of a specific curriculum related to RE in higher education in the country. There isn't any project that addresses the embedded content of STE(A)M disciplines in the context of renewable energy (RE) in higher Education. Teachers and preservice teachers are therefore experiencing difficulties in developing sufficient knowledge, skills and attitudes towards RE. Therefore, this curriculum is an innovative feature in terms of eliminating this gap.

The European Qualifications Framework (EQF): an overview

The European Qualifications Framework (EQF) is a way of mapping qualifications across EU member countries. The EQF was officially adopted by the European Parliament and the Council in April 2008. It has two principal aims:

- To promote citizens' mobility between countries and
- To facilitate their lifelong learning.

Qualification Level

The learning outcomes are defined in terms of:

- Knowledge: in the context of EQF, knowledge is described as theoretical and/or factual.
- *Skills*: In the context of EQF, skills are described as cognitive (involving the use of logical, intuitive, and creative thinking) and practical (involving manual dexterity and the use of methods, materials, tools and instruments).

- Responsibility and autonomy: In the context of the EQF responsibility and autonomy is described as the ability of the learner to apply knowledge and skills autonomously and with responsibility.

The level indicates the difficulty and complexity of the knowledge and skills associated with any qualification. There are eight levels (Levels 1-8). This curriculum covers the EQF's level 6 competences.

Learning outcomes at EQF level 6

Knowledge: Advanced knowledge of a field of work or study, involving a critical understanding of theories and principles

Skills: Advanced skills, demonstrating mastery and innovation, required to solve complex and unpredictable problems in a specialised field of work or study

Responsibility and autonomy: Manage complex technical or professional activities or projects, taking responsibility for decision-making in unpredictable work or study contexts; take responsibility for managing professional development of individuals and groups

COURSE SUMMARY

With this curriculum...

- Preservice Teachers will have theoretical knowledge about RE (what is RE, what is the scope)
- Comprehend the working principle of RE skills
- Understand the nature of the sources of RE, STEM disciplines operate together and comprehend the nature of what we call complex Science
- Understand how RE sources intersect with the principles of working (Science,Technology, Math and Eng) and what are the common ways of thinking

Unit Format

In each unit, learning outcomes are handled by considering EQF competencies and crosscutting concepts of NGSS. Procedural knowledge for renewable energy is provided with STEM integration.

Learning outcomes

Learning outcomes describe the knowledge, skills, or attitudes that learners need to know, do and apply in each unit. Learners must achieve the learning outcomes to pass the unit.

NGSS's Crosscutting Concepts

The following NGSS' crosscutting concepts are taken into account in the integration of STEM skills into renewable energy subject areas within the scope of this curriculum.

- *Scale, Proportion, and Quantity*: Learners must be able to recognize what is relevant at different sizes, times, and scales. They also need to recognize proportional relationships between categories, groups, or quantities.
- *Cause and Effect*: Learners are often interested in and attempt to identify causal relationships.
- *Patterns*: Learners use observed patterns in nature to guide organization and classification systems. They also attempt to understand the underlying cause of these patterns.
- *Systems and System Models*: Learners often need to define the system under study and then make a model of it to understand it. Models can be physical, conceptual, or mathematical.
- *Stability & Change*: Learners often need to understand what makes a system stable or unstable and what controls rates of change in a system.
- *Energy and Matter*: Learners often need to understand how energy and matter flow, into, out of, and within a system in order to understand it.
- *Structure and Function*: The structure of an object determines its function and places limits on what the object can and cannot do.

Entry Requirements:

- There are no entry requirements for this course

Qualification Target Group:

Our particular target groups to sharing and promotion project are below

- The project partners and their staff members in science education departments, as well as pre-service teachers studying in these departments.
- All teachers (especially STEAM teachers and science teachers) including candidate teacher and pre-service teachers
- Local public authorities in the field of education, regional education boards, administrations
- Education policy-makers -partners institutions in Higher education level across the EU
- Renewable Energy Associations and Agencies (World Wind Energy Association[DE], International Renewable Energy Agency , International Energy Agency [IEA] etc.)
- Other educational institutions (Higher Education Institutions, Research centers EU Level etc.)

Delivery Languages:

This qualification is available in English, Turkish, Romanian, Slovenian and Spanish.

Course Structre

Units	Title	Duration	Weeks
Unit 1	Introduction to the Subject Area of Renewable Energy Resources	6 lessons	2
Unit 2	STEM Thinking in The Context of Renewable Energy	6 lessons	2
Unit 3	Solar Energy	6 lessons	2
Unit 4	Bioenergy	6 lessons	2
Unit 5	Hydroelectric Energy and Wind Energy	6 lessons	2
Unit 6	Wave Energy and Geothermal Energy and Heat Pumps	6 lessons	2
Unit 7	Best Practices	6 lessons	2

UNIT 1	
Title	**Introduction to the subject area of renewable energy resources**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)

Unit purpose and aim(s): The aim of this unit is to enable pre-service teachers to understand fossil fuels and their role in global warming and to have basic knowledge about renewable energy sources.

Learning Outcomes	Assessment Criteria
❖ Know the fossil fuels and global climate change	1. Defines fossil fuels and their usage areas. 2. Defines the interactions between the structure of the atmosphere and combustion products. 3. Discusses the economic, political, social and environmental effects of the production, transportation and use of fossil fuels at the national and global level. 4. Discuss the effects of non-renewable energy sources on global warming and climate changes.
❖ Introduction to renewable energy sources	1. Knowing what Renewable Energy is. 2. Knowing Renewable Energy Sources and Types 3. Comprehending the importance of Renewable Energy Sources in terms of global warming and climate change. 4. Comparing the advantages and disadvantages of using renewable energy sources in relation with different contexts.

Pedagogy (Teaching methods and strategies)

The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.

Teaching Method/Strategy	Definition	Recommended Content
Direct Instruction/ Didactic teaching	Presentation of academic content to learners directly by teachers	Conceptual information supported by demonstrations, animations and videos is conveyed to learners through presentations.

Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based simulation, or it can be described through scenarios.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate many ideas, and feel free to contribute ideas.
POE (Predict-Observe-Explain)	Learners test their predictions about a natural phenomenon with observations or experiments and have the opportunity to construct their knowledge.	In the conceptual learning process, conceptual change texts and vignettes can be used to control how learners construct knowledge and to eliminate misconceptions.

Assessment Guidance

The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.

• Test/Quiz • Writing Short /Narrative Stories	• Concept Maps • Questionnaires/Surveys

STEM Integration

- *In this unit, STEM integration is out of question as it is aimed to gain declarative knowledge on renewable energy.*

UNIT 2	
Title	**STEM thinking in the context of renewable energy**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)

Unit purpose and aim(s): The aim of this unit is to enable prospective teachers to understand the nature of STEM and to linking renewable energy applications and their underlying STEM practices.

Learning Outcomes	**Assessment Criteria**
❖ Identification of STEM	1. Explains the theoritical backgrounds and the nature of STEM Education 2. Uses appropriate concepts, ways of thinking (mathematical, scientific, and computational etc.) , or definitions about STEM 3. Develops a comprehension about interdisciplinarity of knowing. 4. Lists the characteristics of an individual with STEM thinking skills
❖ Relevance between renewable energy and STEM thinking dispositions	1. Explains the basis of renewable energy systems, as a design established with the intersection of different STEM content knowledge. 2. Clarifies how different STEM domain knowledge plays a role in the contexts of renewable energy. 3. Comprehends the standards in engineering applications and their reflections on renewable energy contexts.

Pedagogy (Teaching methods and strategies)

The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.

Teaching Method/Strategy	**Definition**	**Recommended Content**
Direct Instruction/ Didactic teaching	Presentation of academic content to learners directly by teachers	Conceptual information supported by demonstrations, animations and videos is conveyed to learners through presentations.
Problem-based learning	Learning concepts and principles through	The problem can be animated with a web-based simulation, or

	complex real-world problems	it can be described through scenarios.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the learners. The learner creates a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate a large number of ideas, and feel free to contribute ideas.

Assessment Guidance

The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.

• Formative Assessment • Test/Quiz • Self-evaluation	• Concept Maps • Questionnaires/Surveys • Peer Assessments

STEM Integration

In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.

Crosscutting Concepts:

- **Scale, Proportion, and Quantity:** Deciding on the type and capacity of the renewable energy plant to be established according to the energy needs.
- **Cause And Effect:** Establishes cause and effect relationships for the sources of sustainable energy problem and the global climate crisis and proposing STEM solutions to overcome.

• **Pattern:** Discovering that information about different STEM fields intersect and even integrate at certain points.
• **Systems and System Models:** Considering renewable energy power plants as a dynamic construction created by science and engineering.
• **Stability and Change:** Evaluation of renewable energy sources in terms of sustainability and efficiency.
• **Energy and Matter:** Comprehending the concepts of conservation and conversion of energy and the equivalent of these concepts in STEM practices.
• **Structure and Functions:** Analyzing renewable energy practices to understand how and to what extent STEM design is integrated into renewable energy contexts.

UNIT 3	
Title	**Solar Energy**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)

Unit purpose and aim(s): To enable prospective teachers to explore STEM integration in the context of solar energy by knowing solar energy and the ways it is produced.

Learning Outcomes	Assessment Criteria
❖ Introduction to solar energy	1. Defines solar energy. 2. Defines ways to benefit from solar energy 3. Explains the structure and functions of photovoltaic cells components. 4. Explains how solar energy is converted into electrical energy
❖ STEM integration to solar energy context	1. Understands how science, technology, mathematics and engineering disciplines are used in solar energy. 2. Comprehends how STEM integration takes place in the context of solar energy. 3. Comprehends the design and function of the parts/sectors that make up the solar panel.

Pedagogy (Teaching methods and strategies)

The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.

Teaching Method/Strategy	Definition	Recommended Content
Hands-on/Minds-on	Engaging learners in a cognitive and mentally active manner. Learning by doing.	Learners can interact directly with learning materials through virtual reality activities, robotics and coding practices, models and miniatures.
Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based simulation, or it can be described through scenarios.

Project-based learning	Learners develop and present a Products or artifacts by working on an interdisciplinary problem or scenario individually or in groups.	Learners design models/miniatures using a variety of equipment, including simple tools and STEM kits. Prepares and presents a report by compiling the information obtained from various sources. Products or artifacts represent what the learners have understood about their field of study.
Inquiry-based learning	Learning process that engages learners by making real-world connections through exploration and high-level questioning.	Learners discuss with their peers the data and opinions they have obtained from scientific articles, vignettes, and other sources of evidence for a research question. Discussion continues until consensus is reached through small group discussion and/or class discussions.
Experimental Method	Experimental method involves manipulating one variable to determine if this causes changes in another variable	Learners collect data by using various experiment kits in the laboratory or by experimenting in a virtual laboratory environment.
Cooperative learning	Learners work on learning activities in small groups with each one of them having a particular role and receive rewards or recognition based on their group's performance	Groups are planned to be as heterogeneous as possible. There is competition between groups. Everyone in the group is encouraged to actively participate.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate many ideas, and feel free to contribute ideas.

Mastery learning	Each learner is given the amount and kind of instruction individually needed. Instruction varies according to need, and the end result is a uniformly high level of performance for all.	Learning environments can be supported by software and simulations where learners can follow their own learning. Abstract concepts can be embodied with animations and videos.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the learner. Learners create a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Outdoor learning	School trips are learning practices in which learning is carried from the classroom environment to real life and aiming to provide students with first-hand experience.	Learners may be asked to compile and report the observation notes they took during the field trip. In case of necessity, field trips can also be carried out in a virtual reality environment.

Assessment Guidance

The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.

• Portfolio of Evidence • Test/Quiz • Self-evaluation	• Coursework/Document Analysis • Concept Maps • Peer Assessments

STEM Integration
In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.
Crosscutting Concepts:
• **Scale, Proportion and Quantity:** Understanding how changes in scale, proportion and quantity affect the structure and performance of the solar energy systems.
• **Cause And Effect:** Establishing a cause-effect relationship on how solar energy is produced via comprehending the big idea of science and engineering disciplines.
• **Patterns:** Understands and explains the repetitive and serial events and concepts related to the science and engineering discipline in the context of solar energy production.
• **Systems and System Models:** Creating an explicit model of solar energy systems, by describing the structure of the system and identifying its boundaries.
• **Stability and Change:** Understanding the dynamic balance in the context of the stability of the solar energy generating system and comprehending how small changes in the system affect the stability.
• **Energy and Matter:** Comprehending the place of matter and energy in a system, the cycles, flow and transfer of matter and energy in the context of solar energy production.
• **Structure and Function:** Understanding the design and production of new systems according to the properties of the materials in the system (weight, hardness, etc.) via comprehending the structure and functions of the solar energy generating system.

UNIT 4	
Title	**Bioenergy**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)

Unit purpose and aim(s): To enable prospective teachers to explore STEM integration in the context of biogas energy by knowing biogas energy and the ways it is produced.

Learning Outcomes	Assessment Criteria
❖ Introduction to biogas energy/biomass	1. Defines biomass and bioenergy and its uses. 2. Explains how bioenergy is produced from biomass. 3. Distinguishes biofuel sources from other types of waste. 4. Lists the biomass energy sources. 5. Evaluates the advantages and limitations of biomass energy. 6. Evaluates the waste management policies and bioenergy potentials of countries.
❖ STEM integration to biogas energy/biomass	1. Comprehends how science, technology, mathematics and engineering disciplines are used in the production of biogas. 2. Comprehends how STEM integration takes place in the context of biogas energy. 3. Comprehends the design and function of the parts/sectors that make up the biogas plant.

Pedagogy (Teaching methods and strategies)

The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.

Teaching Method/Strategy	Definition	Recommended Content
Hands-on/Minds-on	Engaging learners in a cognitive and mentally active manner. Learning by doing.	Learners can interact directly with learning materials through virtual reality activities, robotics and coding practices, models and miniatures.
Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based

		simulation, or it can be described through scenarios.
Project-based learning	Learners develop and present a Products or artifacts by working on an interdisciplinary problem or scenario individually or in groups.	Learners design models/miniatures using a variety of equipment, including simple tools and STEM kits. Prepares and presents a report by compiling the information obtained from various sources. Products or artifacts represent what the learners have understood about their particular field of study.
Inquiry-based learning	Learning process that engages learners by making real-world connections through exploration and high-level questioning.	Learners discuss with their peers the data and opinions they have obtained from scientific articles, vignettes, and other sources of evidence for a research question. Discussion continues until consensus is reached through small group discussion and/or class discussions.
Experimental Method	Experimental method involves manipulating one variable to determine if this causes changes in another variable	Learners collect data by using various experiment kits in the laboratory or by experimenting in a virtual laboratory environment.
Cooperative learning	Learners work on learning activities in small groups with each one of them having a particular role and receive rewards or recognition based on their group's performance	Groups are planned to be as heterogeneous as possible. There is competition between groups. Everyone in the group is encouraged to actively participate.
Brainstorming	Sharing ideas spontaneously with other	Group members are encouraged to express their opinions, not criticize any

	members to find solutions to practical problems.	ideas, generate many ideas, and feel free to contribute ideas.
Mastery learning	Each learner is given the amount and kind of instruction individually needed. Instruction varies according to need, and the result is a uniformly high level of performance for all.	Learning environments can be supported by software and simulations where learners can follow their own learning. Abstract concepts can be embodied with animations and videos.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the learner. Learners create a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Outdoor learning	School trips are learning practices in which learning is carried from the classroom environment to real life and aiming to provide students with first-hand experience.	Learners may be asked to compile and report the observation notes they took during the field trip. In case of necessity, field trips can also be carried out in a virtual reality environment.

Assessment Guidance

The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.

• Portfolio of Evidence • Test/Quiz • Self-evaluation	• Coursework/Document Analysis • Concept Maps • Peer Assessments

STEM Integration
In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.
Crosscutting Concepts:
• **Scale, Proportion and Quantity:** Understanding how changes in scale, proportion and quantity affect the structure and performance of the bioenergy power plants.
• **Cause And Effect:** Establishing a cause-effect relationship on how bioenergy is produced via comprehending the big idea of science and engineering disciplines.
• **Patterns:** Understands and explains the repetitive and serial events and concepts related to the science and engineering discipline in the context of bioenergy production.
• **Systems and System Models:** Creating an explicit model of bioenergy systems, by describing the structure of the system and identifying its boundaries.
• **Stability and Change:** Understanding the dynamic balance in the context of the stability of the bioenergy generation and comprehending how small changes in the system affect the stability.
• **Energy and Matter:** Comprehending the place of matter and energy in a system, the cycles, flow, and transfer of matter and energy in the context of bioenergy production.
• **Structure and Function:** Understanding the design and production of new systems according to the properties of the materials in the system (weight, hardness, etc.) via comprehending the structure and functions of the bioenergy power plants.

UNIT 5	
Title	**Hydroelectric Energy and Wind Energy**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)
Unit purpose and aim(s): To enable pre-service teachers to explore the STEM integration in the context of hydroelectric energy and wind energy by knowing the production ways of hydroelectric energy and wind energy.	
Learning Outcomes	**Assessment Criteria**
❖ Introduction to Hydroelectric Energy	1. Defines hydroelectric energy. 2. Explains how electrical energy is produced in hydroelectric power plants. 3. Defines the factors affecting the energy production capacity of hydroelectric power plants.
❖ STEM integration to Hydroelectric Energy	1. Understands how science, technology, mathematics, and engineering disciplines are used in hydroelectric energy. 2. Comprehends how STEM integration takes place in the context of hydroelectric energy. 3. Comprehends the design and function of the parts/sectors that make up the hydroelectric power plant.
❖ Introduction to Wind Energy	1. Defines wind energy and its uses. 2. Explains wind energy and how electrical energy is produced in wind turbines. 3. Explains how to interpret wind maps and their usage areas. 4. Evaluates the performance curves,maintenance costs and energy production graphs of different types of wind turbines under similar conditions.
❖ STEM integration to Wind Energy	1. Understands how science, technology, mathematics, and engineering disciplines are used in wind energy production. 2. Understands STEM integration in the context of wind energy. 3. Comprehends the design and function of the parts/sectors that make up the wind turbine.

Pedagogy (Teaching methods and strategies)		
The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.		
Teaching Method/Strategy	**Definition**	**Recommended Content**
Hands-on/Minds-on	Engaging learners in a cognitive and mentally active manner. Learning by doing.	Learners can interact directly with learning materials through virtual reality activities, robotics and coding practices, models and miniatures.
Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based simulation, or it can be described through scenarios.
Project-based learning	Learners develop and present a Products or artifacts by working on an interdisciplinary problem or scenario individually or in groups.	Learners design models/miniatures using a variety of equipment, including simple tools and STEM kits. Prepares and presents a report by compiling the information obtained from various sources. Products or artifacts represent what the learners have understood about their particular field of study.
Inquiry-based learning	Learning process that engages learners by making real-world connections through exploration and high-level questioning.	Learners discuss with their peers the data and opinions they have obtained from scientific articles, vignettes, and other sources of evidence for a research question. Discussion continues until consensus is reached through small group discussion and/or class discussions.
Experimental Method	Experimental method involves manipulating one variable to determine if this causes changes in another variable	Learners collect data by using various experiment kits in the laboratory or by experimenting in a virtual laboratory environment.

Cooperative learning	Learners work on learning activities in small groups with each one of them having a particular role and receive rewards or recognition based on their group's performance	Groups are planned to be as heterogeneous as possible. There is competition between groups. Everyone in the group is encouraged to actively participate.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate a large number of ideas, and feel free to contribute ideas.
Mastery learning	Each learner is given the amount and kind of instruction individually needed. Instruction varies according to need, and the result is a uniformly high level of performance for all.	Learning environments can be supported by software and simulations where learners can follow their own learning. Abstract concepts can be embodied with animations and videos.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the learner. Learners create a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Outdoor learning	School trips are learning practices in which learning is carried from	Learners may be asked to compile and report the observation notes they took

	the classroom environment to real life and aiming to provide students with first-hand experience.	during the field trip. In case of necessity, field trips can also be carried out in a virtual reality environment.

Assessment Guidance

The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.

• Portfolio of Evidence • Test/Quiz • Self-evaluation	• Coursework/Document Analysis • Concept Maps • Peer Assessments

STEM Integration

In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.

Crosscutting Concepts

- **Scale, Proportion and Quantity:** Understanding how changes in scale, proportion and quantity affect the structure and performance of the hydroelectric power plants/wind turbines.
- **Cause And Effect:** Establishing a cause-effect relationship on how hydroelectric energy/wind energy is produced via comprehending the big idea of science and engineering disciplines.
- **Patterns:** Understands and explains the repetitive and serial events and concepts related to the science and engineering discipline in the context of hydroelectric energy/wind energy production.
- **Systems and System Models:** Creating an explicit model of hydroelectric energy power plants/wind turbines, by describing the structure of the system and identifying its boundaries.
- **Stability and Change:** Understanding the dynamic balance in the context of the stability of the hydroelectric energy/wind energy generation and comprehending how small changes in the system affect the stability.
- **Energy and Matter:** Comprehending the place of matter and energy in a system, the cycles, flow, and transfer of matter and energy in the context of hydroelectric energy/wind energy production.
- **Structure and Function:** Understanding the design and production of new systems according to the properties of the materials in the system (weight, hardness, etc.) via comprehending the structure and functions of the hydroelectric power plants/wind turbines.

UNIT 6	
Title	**Wave Energy, Geothermal Energy and Heat Pumps**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)
Unit purpose and aim(s): The aim is to enable pre-service teachers to explore the STEM integration in the context of wave energy and geothermal energy by knowing the production ways of wave energy and geothermal energy.	
Learning Outcomes	**Assessment Criteria**
❖ Introduction to Wave Energy	1. Defines wave energy and its uses. 2. Explains how wave energy is converted into electrical energy. 3. Explains the working principle of Wave Energy plants 4. Discuss the advantages and limitations of wave energy.
❖ STEM integration to Wave Energy	5. Understands how science, technology, mathematics and engineering disciplines are used in wave energy. 6. Comprehends how STEM integration takes place in the context of wave energy. 7. Comprehends the design and function of the parts/sectors that make up the wave energy generator.
❖ Introduction to Geothermal Energy and Heat Pumps	1. Defines geothermal energy and heat pumps. 2. Implements the first law of thermodynamics to geothermal systems. 3. Explains the working principle of geothermal power plants and heat pumps 4. Discuss the advantages and limitations of geothermal energy sources.
❖ STEM integration to Geothermal Energy and Heat Pumps	1. Understands how science, technology, mathematics and engineering disciplines are used in geothermal energy. 2. Comprehends how STEM integration takes place in the context of geothermal energy. 3. Comprehends the design and function of the parts/sectors that make up the geothermal energy power plants and heat pumps.

Pedagogy (Teaching methods and strategies)		
The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.		
Teaching Method/Strategy	**Definition**	**Recommended Content**
Hands-on/Minds-on	Engaging learners in a cognitive and mentally active manner. Learning by doing.	Learners can interact directly with learning materials through virtual reality activities, robotics and coding practices, models and miniatures.
Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based simulation, or it can be described through scenarios.
Project-based learning	Learners develop and present a Products or artifacts by working on an interdisciplinary problem or scenario individually or in groups.	Learners design models/miniatures using a variety of equipment, including simple tools and STEM kits. Prepares and presents a report by compiling the information obtained from various sources. Products or artifacts represent what the learners have understood about their field of study.
Inquiry-based learning	Learning process that engages learners by making real-world connections through exploration and high-level questioning.	Learners discuss with their peers the data and opinions they have obtained from scientific articles, vignettes, and other sources of evidence for a research question. Discussion continues until consensus is reached through small group discussion and/or class discussions.
Experimental Method	Experimental method involves manipulating one variable to determine if this	Learners collect data by using various experiment kits in the laboratory or by

	causes changes in another variable	experimenting in a virtual laboratory environment.
Cooperative learning	Learners work on learning activities in small groups with each one of them having a particular role and receive rewards or recognition based on their group's performance	Groups are planned to be as heterogeneous as possible. There is competition between groups. Everyone in the group is encouraged to actively participate.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate many ideas, and feel free to contribute ideas.
Mastery learning	Each learner is given the amount and kind of instruction individually needed. Instruction varies according to need, and the result is a uniformly high level of performance for all.	Learning environments can be supported by software and simulations where learners can follow their own learning. Abstract concepts can be embodied with animations and videos.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the learner. Learners create a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Outdoor learning	School trips are learning practices in which learning	Learners may be asked to compile and report the

	is carried from the classroom environment to real life and aiming to provide students with first-hand experience.	observation notes they took during the field trip. In case of necessity, field trips can also be carried out in a virtual reality environment.

Assessment Guidance	
The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.	
• Portfolio of Evidence • Test/Quiz • Self-evaluation	• Coursework/Document Analysis • Concept Maps • Peer Assessments

STEM Integration
In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.
Crosscutting Concepts
• **Scale, Proportion and Quantity:** Understanding how changes in scale, proportion, and quantity affect the structure and performance of the wave energy generators/geothermal power plants and heat pumps.
• **Cause And Effect:** Establishing a cause-effect relationship on how wave energy/geothermal energy is produced via comprehending the big idea of science and engineering disciplines.
• **Patterns:** Understands and explains the repetitive and serial events and concepts related to the science and engineering discipline in the context of wave energy/geothermal energy production.
• **Systems and System Models:** Creating an explicit model of wave energy generators/geothermal power plants and heat pumps, by describing the structure of the system and identifying its boundaries.
• **Stability and Change:** Understanding the dynamic balance in the context of the stability of the wave energy/geothermal energy generation and comprehending how small changes in the system affect the stability.
• **Energy and Matter:** Comprehending the place of matter and energy in a system, the cycles, flow, and transfer of matter and energy in the context of wave energy production.
• **Structure and Function:** Understanding the design and production of new systems according to the properties of the materials in the system (weight, hardness, etc.) via comprehending the structure and functions of the wave energy generators/geothermal power plants and heat pumps.

UNIT 7	
Title	**Best Practices and Social Impacts of Renewable Energy**
Level	Higher Education
Guided Learning Hours (GLH)	2 Weeks (2T + 4P)

Unit purpose and aim(s): Develop awareness of the future and potential of renewable energy sources

Learning Outcomes	Assessment Criteria
❖ Renewable energy and self-awareness for sustainability	1. Develops awareness of energy security and environmental protection. 2. Evaluates the renewable energy policies and renewable energy potentials of the countries. 3. Develops the foresight to evaluate potential renewable energy sources in the surrounding area. 4. Discusses the ideas and case scenarios about how to use renewable energy in the future.

Pedagogy (Teaching methods and strategies)

The following Teaching methods/strategies may be used to ensure all learning outcomes and assessment criteria are fully covered.

Teaching Method/Strategy	Definition	Recommended Content
Direct Instruction/ Didactic teaching	Presentation of academic content to students directly by teachers	Conceptual information supported by demonstrations, animations and videos is conveyed to students through presentations.
Problem-based learning	Learning concepts and principles through complex real-world problems	The problem can be animated with a web-based simulation, or it can be described through scenarios.
Mastery learning	Each learner is given the amount and kind of instruction individually needed. Instruction varies according to need, and the result is a	Learning environments can be supported by software and simulations where students can follow their own learning. Abstract concepts can be

	uniformly high level of performance for all.	embodied with animations and videos.
Flipped Learning	Identifies as an individualized gradual process in which learners take responsibility for their own learning by deciding on the subject matters in learning environments that are flexible, highly diverse, and where groups can be independent from each other to a certain extent. The teacher acts as a guide in this process.	The information package, which consists of various materials such as scientific articles, scenarios, animations, and videos, is presented to the student. The student creates a synthesis by combining the ones that are suitable for them among the resources presented to them with the information from the resources they have obtained. Then, the control and enrichment of learning is provided in the classroom environment.
Brainstorming	Sharing ideas spontaneously with other members to find solutions to practical problems.	Group members are encouraged to express their opinions, not criticize any ideas, generate many ideas, and feel free to contribute ideas.
POE (Predict-Observe-Explain)	Learners test their predictions about a natural phenomenon with observations or experiments and have the opportunity to construct their knowledge.	In the conceptual learning process, conceptual change texts and vignettes can be used to control how learners construct knowledge and to eliminate misconceptions.
Outdoor learning	School trips are learning practices in which learning is carried from the classroom environment to real life and aiming to provide students with first-hand experience.	Learners may be asked to compile and report the observation notes they took during the field trip. In case of necessity, field trips can also be carried out in a virtual reality environment.

Assessment Guidance	
The following assessment method/s may be used to ensure all learning outcomes and assessment criteria are fully covered.	
• Writing Short /Narrative Stories • Self-evaluation	• Questionnaires/Surveys • Peer Assessments

STEM Integration
In this unit, STEM integration will be provided by using one or more of the following crosscutting concepts.
Crosscutting Concepts
• **Scale, Proportion and Quantity:** Determining how much of the renewable energy sources meet the total energy supply.
• **Cause And Effect:** Comprehends why and how planned changes/interventions in alternative model proposals for increasing the efficiency of renewable energy sources may have affected energy efficiency.
• **Patterns:** Realizing that designs in nature inspire best practices to increase the efficiency of renewable power plants.
• **Systems and System Models:** Comparing the design of existing renewable energy systems with their past counterparts and planning alternative system updates for future applications.
• **Stability and Change:** Developing proposals to increase the efficiency of renewable energy sources.
• **Energy and Matter:** Evaluating the best practices of renewable energy in terms of energy security and energy efficiency.
• **Structure and Function:** Evaluation of renewable energy systems in terms of system integrity and functionality.