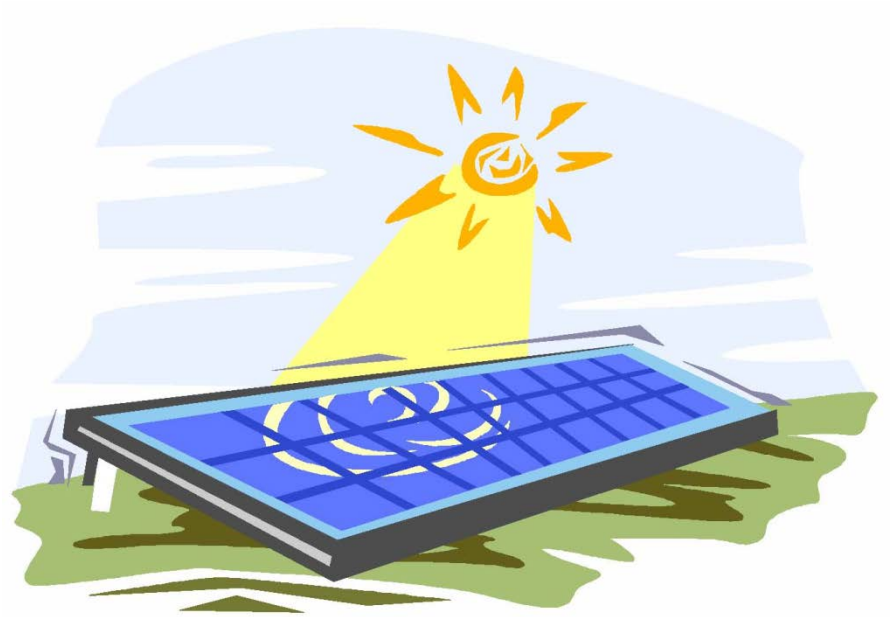

CURRICULUM

RESOR - **R**enewable **E**nergy **So**urces as a Chance for Development for the **R**ural Areas

Developed by

Bursa Uludağ University & Gürsu Municipality

May 2019

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RESOR - Renewable Energy Sources as a Chance for Development for the Rural Areas

Curriculum

Content

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RESOR - Renewable Energy Sources as a Chance for Development for the Rural Areas

Curriculum

Intellectual Output: IO1/A2

1 GENERAL

Program Title	**RENEWABLE ENERGY SOURCES FOR FARMERS CURRICULUM**
Aim	The training aims to • develop an attitude among farmers that affect their adoption of renewable energy activities, • increase the motivation of the farmers to apply renewable energy technologies, • raise awareness among farmers on the environmental impacts of energy use, • contribute to the agricultural sector to be a source of renewable energies. The agricultural sector can benefit from renewable energy sources, can produce renewable energy by using the associated technologies, and sell or incorporate this energy into the agricultural production processes. The main aim of the training is to provide information to the farmers on renewable energy sources and opportunities. This information would also help the farmers get a holistic understanding of the environmental impacts of traditional energy generation and environmental-friendly aspects of renewable energy use. The training will also cover the opportunities for renewable energy producers such as tax incentives. The environmental and economic costs and benefits of renewable energy sources compared to the traditional energy sources and fuels will also be discussed.
Target Group	The target groups of the training program are farmers, small and medium-sized enterprises in agricultural business, employees, municipal utilities, environmental foundations, rural development agents, and other interested stakeholders.

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Goals	The goals of the training program are: • Awareness- raising on the fact that the agricultural sector may contribute toward the production of renewable energies, • Awareness- raising on the fact that energy can be obtained from biomass, biogas, sun, wind, geothermal and water resources, and several technologies exist to obtain energy from these sources on small scales, • Awareness-raising on the negative economic and environmental impacts brought by the use of traditional energy forms and fuels, • Awareness-raising on the fact that the farmers' decisions may influence climate change and global warming positively or negatively.

2 CONTENT

2.1 Specific Topics

Topic	Duration
Module 0: Introduction to Renewable Energy Sources	**3 hours**
Module 1: Biomass Energy	**5 hours**
Module 2: Biogas Energy	**5 hours**
Module 3: Solar Energy	**5 hours**
Module 4: Photovoltaic Energy	**5 hours**
Module 5: Wind Energy	**5 hours**
Module 6: Geothermal Energy	**5 hours**
Module 7: Hydroelectric Energy	**5 hours**

2.2 Learning Outcomes

After the training program, attendees

- Will be able to explain the possible ways of producing energy from renewable energy sources which would help the farmers to become more self-sufficient
- Will be able to develop energy conservation practices,
- Will know that renewable energy can help farmers save money and also behave in a more environmental-friendly way by contributing to the efforts to combat climate change,

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- Will know that farmers can use biomass, geothermal, hydroelectric, solar, and wind energy and produce electricity for several purposes for sustainable farms,
- Will know that electricity can also be produced on-farm by methane digesters.

2.3 Learning materials and readings

All educative materials and reading lists will be available at www.resor-project.eu.

2.4 The organization of the educational process

This section is elaborated with the "training methodology-O1/A1" in detail.

The educational process will cover the delivery of the educative materials after pilot testing on the virtual environment based on the following principles:

- Educative materials will be delivered as e-learning material on the virtual environment,
- Text (Word) and presentation (PPT) documents of each module will be available to be downloaded,
- Self-test questions will be available for every module to facilitate the e-learning process.

Educational materials will be available to trainees in English, Turkish, Polish, Spanish, Slovak, and Hungarian languages.

2.5 Assessment of the Educative Material

A centralized pilot testing with skilled farmers and experts will be performed by all the partners. The test will be conducted on the e-learning platform including educative materials before definitive approval and translation into national languages by the partners. The evaluation methodology will be based on a questionnaire on internal satisfaction and discussion with skilled farmers and experts.

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3 MODULES

3.1 MODULE 0: INTRODUCTION

3.1.1 General

The topic of the Module	**Introduction to Renewable Energy Sources**
Duration	**3 hours**

3.1.2 Specific Topics

Topic
Global warming
Increase in the energy consumption, world production of oil and gas, energy generation in numbers
Coal, oil and gas formation
Potential sources of energy to reduce the negative effects of climate change/global warming, forward-looking solutions for sustainable energy, solutions for sustainable energy, tackling with global warming
Definition of renewable energy, renewable, and non-renewable energy resources
Introduction to biomass energy
Introduction to biogas energy
Introduction to solar energy & photovoltaic energy
Introduction to wind energy
Introduction to geothermal energy
Introduction to hydroelectric energy

3.1.3 Summary

With an introduction to the definition of energy, specific energy types and practical energy sources will be discussed in this module. The environmental impact of traditional energy production and fuel use will also be discussed. Attendees will be introduced to different types of renewable energy resources and associated technologies to convert renewable energy into electricity.

During the course attendees:

- Will discuss energy and energy sources.
- Will examine the power consumption in their farms and discuss the possible ways to conserve energy.
- Will know energy sources and discuss the difference between renewable and nonrenewable sources.

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- Will be introduced biomass, solar, photovoltaic, wind, geothermal, hydro, and biogas energies.

3.1.4 Learning Outcomes

After this course, attendees will

- Know different types of renewable energy sources,
- Be able to discuss the necessity to go towards renewable energy sources,
- Be able to discuss the traditional and renewable sources and uses of energy,
- Define the difference between renewable and non-renewable energy,
- Be able to give examples of common renewable and non-renewable energy resources,
- Know the benefits and disadvantages of using renewable resources.

3.1.5 Guiding Concepts

- Sun is the source of most of the Earth's energy,
- Each energy source and conversion technology has its environmental impacts,
- Technologies exist to transform renewable energy sources into usable energy in small units.
- A basic solution to cope with the energy problem is to substitute renewable energy with fossil fuels in agriculture.

3.1.6 Guiding Questions

1. How does the Sun provide most of the Earth's energy?
2. How do we generate the electricity used in our daily lives?
3. What are the environmental impacts associated with traditional energy sources?
4. Which energy sources do we use to fuel our vehicles?
5. Are there alternatives to traditional energy production that could be applied by the farmers?

3.1.7 Anchor Text(s)

It is a fact that fossil fuels are limited, cannot be sustained forever. It is possible to produce energy which is environmentally-friendly and more efficient than the traditional energy forms. A considerable amount of research has been conducted related to alternative fuels and energy sources. There is a considerable amount of evidence about pollution resulting from the use of fossil fuels and traditional energy production methods, which causes anthropogenic global warming. This impact will worsen due to continuously increasing energy demand and meeting this energy need by combustion of fossil fuels. It is necessary to

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learn how to conserve energy and use environmental-friendly energy sources that have low emissions to change this worsening trend.

Alternative energy technologies, such as biomass, solar, photovoltaic, wind, geothermal, hydroelectric, biogas have been well researched and developed. Solar cells use the Sun's energy to generate electricity, the kinetic energy of the wind is converted into electricity with turbines, bioenergy can be extracted from biomass, and biogas can be obtained from any organic material. Each of these alternative energy sources can be applied by the farmers depending on several conditions.

Energy sources that can be replenished are called renewable sources. These sources can be used to produce electricity, heat, and hydrogen, etc.

3.1.8 Vocabulary

Solar Energy
Biomass Energy
Geothermal Energy
Fossil Fuels
Hydropower
Wind Energy
Electrical energy
Nonrenewable energy
Renewable energy
Active solar system
Photovoltaic system

3.1.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.1.10 Questions for Self-Evaluation

Ten multiple choice questions (including answers) will be available to trainees in this section to help the trainees evaluate themselves on their understanding of the specific topics of each module.

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3.2 MODULE 1: BIOMASS ENERGY MODULE

3.2.1 General

Specific topic	**Biomass Energy Education**
Duration	**5 hours**

3.2.2 Specific Topics

Topic
Biomass: Definition and Types
Photosynthesis
Utilization of Biomass
Biomass Resources
Feedstock Supply, Harvesting, and Handling
Biomass Conversion Technologies
Advantages and Disadvantages
Biomass and the environment
Using biomass to produce electricity
Using biomass to produce biofuels (ethanol, biodiesel, etc.)
Technical Impediments
Environmental impacts of using biomass energy
Economics of the small-scale biomass energy systems

3.2.3 Summary

This module aims to inform the attendees of the fact that it is possible to convert energy from biomass, which is abundant in the agricultural sector. This alternative energy would help to combat climate change, bring economic input, and achieve energy independence of the farmers. The module will start with an introduction to the biomass concept, and cover topics such as biomass resources, conversion technologies, biofuels, etc.

3.2.4 Learning Outcomes

After this course, attendees will

- Be able to define biomass
- Be able to discuss the production of biomass energy
- Know the technical impediments to biomass energy and be able to discuss how these impediments can be overcome

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- Be able to discuss the sustainability aspects of biomass
- Be able to understand concepts and principles related to biomass energy
- Identify examples of biomass energy

3.2.5 Guiding Concepts

- Plants capture solar energy through photosynthesis to make food.
- The term "biomass" is used as a name for plant and animal waste used as an energy source or fuel. Biomass is related to biological material, not organic material like coal.
- Energy can be derived from biomass, which can be used to generate electricity or to produce heat.
- Thermal energy can be obtained from biomass with combustion, torrefaction, pyrolysis, and gasification technologies.
- Biomass can be chemically converted to bio-fuel, which can be used for transportation, heat, and electricity.
- Plants can be replenished, unlike oil, coal, and gasoline.
- Plant sugar, starch, and cellulose can be turned into ethyl alcohol (ethanol).
- Microorganisms eat the sugars and starch to produce alcohol. Alcohol can be used as gasoline.
- Vegetable oil and animal fat can be used to make biodiesel (diesel from plants).
- Biodiesel is made through a chemical change, reacting oil or fat with alcohol.

3.2.6 Guiding Questions

1. What is biomass?
2. Where does the energy of biomass come from?
3. Is biomass energy renewable source?
4. What are the types of biomass?
5. What are the possible uses of biomass energy?
6. How can the biofuels be produced?

3.2.7 Anchor Text(s)

Biological matter such as wood, crops, animal wastes, are called biomass that can be used as an energy source. Biomass gets its energy from the sun through photosynthesis. Plants (biomass) use the sunlight energy to convert water and carbon dioxide into oxygen and sugars. These sugars, called carbohydrates, provide energy to the plants. Foods rich in carbohydrates are good sources of energy.

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Biomass is a renewable energy source; trees and crops can always grow, and waste will always be generated. Sugar cane, sweet corn, potatoes, celery, cellulose, sunflower seeds, and soybean oils can not only be used as food but as biomass to produce electricity or heat homes as well. Biomass can be converted directly into liquid fuels, called biofuels Ethanol and biodiesel are the most common types of biofuels. Ethanol is made by fermenting biomass that is high in carbohydrates such as starches and sugars.

Ethanol can be produced with gasification technology, in a low-oxygen environment with high temperature. Biomass is converted into syngas, which is a mixture of hydrogen and carbon monoxide in the gasification process. The syngas obtained can then converted into ethanol and other fuels. Ethanol is commonly blended with gasoline to increase octane ratio and decrease carbon monoxide and other emissions.

Biodiesel is the product of a combination of alcohol with vegetable oil, animal fat, or cooking grease recycled. Biodiesel can be used as an additive to reduce vehicle emissions or as an alternative fuel for diesel engines. There is an emerging interest in research into the production of biodiesel from algae.

3.2.8 Vocabulary

Bioenergy
Biochemical conversion
Biofuel
Biogas
Fermentation
Anaerobic digestion
Gasification
Ethanol
Syngas
Biodiesel

3.2.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.2.10 Case Study

This section will contain a case study on the same scale application of biomass energy. The topics within the table below will be covered during the presentation of the case study.

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Case study title	
Case study content	
Summary	
Images for the case study	

3.2.11 Questions for Self-Evaluation

Ten multiple choice questions (including answers) will be available to trainees in this section to help the trainees evaluate themselves on their understanding of the specific topics of each module.

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3.3 MODULE 2: BIOGAS ENERGY MODULE

3.3.1 General

Specific topic	**Biogas energy education**
Duration	**5 hours**

3.3.2 Specific Topics

Topic
Definition of biogas
Sources of biogas
Anaerobic digestion, the process
Bio-digesters
Biogas producing wastes
The energy content of biogas
Basic designs of the digester
End uses of biogas
Environmental impacts of using biogas energy
Economics of the small-scale biogas energy systems

3.3.3 Summary

The generation and possible uses of biogas energy will be discussed in this course. Information on the basic design of an anaerobic bio-digester will be given.

3.3.4 Learning Outcomes

After the completion of the course, attendees will be able to

- Explain how biogas can be generated,
- Describe the sources of biogas
- Define the basic components of a biogas system

3.3.5 Guiding Concepts

- Biogas consists mainly of methane (CH4) and carbon dioxide (CO2). It is a product of anaerobic decomposition of organic compounds.
- If the waste material mainly consists of carbohydrates, such as glucose and other simple sugars and high-molecular compounds (polymers) such as cellulose and hemicellulose, methane production is low.

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- If the fat content is high, the methane production becomes high.

3.3.6 Guiding Questions

- What is biogas energy?
- How is electricity produced from biogas?
- How can we improve the quality of biogas?
- How does home biogas work?
- How long does it take to produce biogas?
- What can speed up anaerobic digestion?

3.3.7 Anchor Text(s)

Biogas is naturally produced from the anaerobic decomposition of organic waste. When organic matter, such as food scraps and animal waste, break down in an anaerobic environment they release biogas, primarily methane and carbon dioxide. Biogas production is also known as anaerobic digestion.

Animal manure, food scraps, wastewater, and sewage are examples of organic matter that can produce biogas by anaerobic digestion. Due to the high content of methane, biogas can be used as an energy source.

Organic matter decomposes in a digestion chamber or reactor. The digestion chamber is fully submerged in water. The anaerobic environment allows for microorganisms to decompose organic material and convert it into biogas.

Nutrients present in the waste dissolve into the water and create a nutrient-rich sludge in the liquid environment of the digestion chamber. The by-product sludge is typically used as fertilizer for plants.

Anaerobic decomposition has four stages from the initial composition of organic matter through their biogas state. The first stage is the hydrolysis stage. Insoluble organic polymers (such as carbohydrates) are broken down in this stage. Now the organic matter will be accessible to the next stage of bacteria, which are called acidogenic bacteria. At the second stage, the acidogenic bacteria convert sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. At the third stage, the acetogenic bacteria convert the organic acids into acetic acid, hydrogen, ammonia, and carbon dioxide. At the fourth stage, the methanogen bacteria convert the final components of the fourth stage into methane and carbon dioxide, which is called as biogas and can then be used to generate energy.

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3.3.8 Vocabulary

Anaerobic bacteria
Fermentation
Digestion
Hydrolysis
Fermentation
Biochemical Conversion
Bioreactor
Co-generation
Digestate
Methane
pH

3.3.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.3.10 Case Study

This section will contain a case study on the same scale application of biomass energy. The topics within the table below will be covered during the presentation of the case study.

Case study title	
Case study content	
Summary	
Images for the case study	

3.3.11 Questions for Self-Evaluation

Ten multiple choice questions (including answers) will be available to trainees in this section to help the trainees evaluate themselves on their understanding of the specific topics of each module.

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3.4 MODULE 3: SOLAR THERMAL ENERGY MODULE

3.4.1 General

Specific topic	**Solar Thermal Energy Education**
Duration	**5 hours**

3.4.2 Specific Topics

Topic
The sun and solar energy
History of solar energy
Use of solar thermal energy
The greenhouse effect
Solar collectors
Solar space heating
Passive solar design
Active solar design
Solar water heating
Benefits of using solar thermal energy
Challenges of using solar thermal energy
Environmental impacts of using solar thermal energy
Economics of the small-scale solar thermal energy systems

3.4.3 Summary

In this module, attendees will learn about solar thermal energy and its possible uses. The importance of the amount of solar energy available at a given location and time of day will also be discussed. The importance of determining incoming solar energy for solar devices will be discussed. The module will also cover several opportunities for the farmers to use the solar system in their activities.

3.4.4 Learning Outcomes

After this course, attendees will

- Be able to describe solar thermal energy and the importance of time and location to benefit from solar energy.
- Be able to explain how solar thermal energy can be used in large and small applications.
- Be able to explain the benefits and challenges of using solar thermal energy.

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3.4.5 Guiding Concepts

- Radiant energy (light) from the Sun travels through space to the Earth.
- Sun's energy is spread out; it is not concentrated in any one area.
- Solar collectors can convert solar energy into heat.
- Photovoltaic cells convert radiant energy into electricity.

3.4.6 Guiding Questions

- How would life on earth be if there were no greenhouse effect?
- How can we concentrate the energy of the Sun in one area?
- How can we capture the sun's energy?
- How can we convert radiant energy directly into electricity?

3.4.7 Anchor Text(s)

Solar energy can be used directly or indirectly as the energy source in our daily lives. The amount of energy from the sun that falls on the earth in one hour is more than the amount is used by everyone in the world in one year. Several technologies can convert sunlight into usable energy for buildings. The most common solar technologies for buildings and small applications can be listed as solar water heating, passive solar design for space heating and cooling, and solar photovoltaics for electricity.

Solar heating can be passive or active. The passive system concentrates solar energy within a structure to provide low-temperature heat. In the active heating system, collectors are used to capture solar energy; pumps are used to circulate the heated fluid. The available solar energy in a given location is important for the efficiency of a solar device.

3.4.8 Vocabulary

Solar radiation
Collectors
Heat energy
Irradiance
Active system
Passive system

3.4.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

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3.4.10 Case Study

This section will contain a case study on the same scale application of biomass energy. The topics within the table below will be covered during the presentation of the case study.

Case study title	
Case study content	
Summary	
Images for the case study	

3.4.11 Questions for Self-Evaluation

Ten multiple choice questions (including answers) will be available to trainees in this section to help the trainees evaluate themselves on their understanding of the specific topics of each module.

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3.5 MODULE 4: PHOTOVOLTAIC ENERGY MODULE

3.5.1 General

Specific topic	**Photovoltaic Energy Education**
Duration	**5 hours**

3.5.2 Specific Topics

Topic
Photovoltaic systems
A short history of photovoltaic systems
Photovoltaic effect
Photovoltaic cells
A traditional photovoltaic cell
PV system components
The scale of photovoltaic systems
Benefits and limitations
Measuring electricity
Environmental impacts of using photovoltaic systems
Economics of the small-scale photovoltaic energy systems

3.5.3 Summary

In this course, attendees will learn how photovoltaic cells transform solar energy into electricity. The opportunities to integrate photovoltaic cells into small-scale systems such as farms will be discussed.

3.5.4 Learning Outcomes

After this course, attendees will be able to,

- Define the technology terms photovoltaic, photovoltaic (solar) cell, solar energy, and solar panel,
- Discuss if photovoltaic cells can be used in small scale applications,
- Discuss the limitations and benefits of using photovoltaic solar cells.

3.5.5 Guiding Concepts

- Photovoltaic systems convert solar energy directly into electricity.
- Photovoltaics means light–electricity.

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- Many small calculators, wrist watches, and outdoor lights use simple examples of photovoltaic systems.
- Large photovoltaic systems generate electricity for factories and many types of equipment, as well as lighting homes.

3.5.6 Guiding Questions

- How does photovoltaic technology generate electricity?
- What is a semiconductor?
- Which types of materials are used to make photovoltaic cells?
- Which parameters influence the amount of electricity that a photovoltaic cell produces?
- What are the types of photovoltaic cells?
- How is a traditional photovoltaic cell made?
- What are the components of a photovoltaic system?
- Where can we install photovoltaic systems?
- What are the practical limitations to photovoltaic systems?

3.5.7 Anchor Text(s)

Sunlight is converted into electricity with the help of photovoltaic cells. Photovoltaic means obtaining electricity (voltage) from sunlight (photons). Solar cells have been used not only for pace satellites but for smaller items such as calculators and watches as wells for years. Currently, it is possible to equip homes and businesses with individual solar photovoltaic systems.

In buildings, solar cells are typically combined as modules of approximately 40 cells. A typical home uses approximately 10-20 solar panels to meet its energy needs. Solar panels are usually mounted at certain locations to collect the sunlight. Many solar panels are combined to create one system that is called solar array. Hundreds of solar arrays can be interconnected for large industrial applications.

Silicon is the fundamental material that has been used to make the traditional solar cells, which are usually flat-plate type. Amorphous silicon or non-silicon materials such as cadmium telluride are being used by second generation solar cells, which are thin-film solar cells. Thin film solar cells are flexible and contain layers of semiconductor materials. They can be used as rooftop shingles, tiles, etc. New materials besides silicon, such as solar inks with conventional printing press technologies, solar dyes, and conductive plastics are used to

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produce third-generation solar cells. Plastic lenses or mirrors are also used to concentrate sunlight onto photovoltaic material.

Photons of the sunlight contain various amounts of energy corresponding to the different wavelengths of the solar spectrum. Photons that strike a photovoltaic cell may be reflected, pass through, or be absorbed. Only the absorbed photons provide energy to generate electricity. Electrons of the material's atoms start to leave their position when enough sunlight is absorbed by the material (a semiconductor), and holes are formed.

When negatively charged electrons travel towards the front surface of the cell, a charge imbalance is formed between the cell's front and back surfaces, which creates a voltage. Electricity flows when the two surfaces are connected through an appliance.

3.5.8 Vocabulary

Photovoltaic cell
Solar panel
Albedo
Semiconductor
Voltage
Current
Resistance
Photon
Solar cell

3.5.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.5.10 Case Study

This section will contain a case study on the same scale application of biomass energy. The topics within the table below will be covered during the presentation of the case study.

Case study title	
Case study content	
Summary	

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Images for the case study	

3.5.11 Questions for Self-Evaluation

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3.6 MODULE 5: WIND ENERGY MODULE

3.6.1 General

Specific topic	**Wind energy education**
Duration	**5 hours**

3.6.2 Specific Topics

Topic
What is wind?
What is wind energy?
Using the power of the wind, small-scale wind energy systems
Wind turbine
Limitations and advantages of wind turbines
Electricity from turbines
Siting a wind turbine
Environmental impacts of using wind energy
Economics of the small-scale wind energy systems

3.6.3 Summary

During the course, renewable aspects of wind energy will be discussed. The benefits and adverse impacts of wind turbines and wind farms will be explored. Effectiveness of wind turbines in varying weather conditions and effective ways to create wind power will be discussed.

3.6.4 Learning Outcomes

After this course, attendees will be able to;

- Discuss the reason to define wind energy as a renewable energy source,
- Discuss wind turbine and wind farm,
- Describe how wind turbines transfer the energy of the wind into electricity,
- List some advantages and disadvantages of wind turbines.
- Discuss the technologies that harness energy from the wind.

3.6.5 Guiding Concepts

- The wind is produced by the unequal heating of Earth's surface by the Sun.
- Wind energy can be used to generate electricity.

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- Wind speed increases above Earth's surface, so wind turbines are mounted on tall towers.

3.6.6 Guiding Questions

- What is a wind turbine?
- What is a wind farm?
- How can it be possible to collect wind energy?
- What are the disadvantages of a wind turbine?
- Where is the best location for a wind farm?

3.6.7 Anchor Text(s)

The movement of the air relative to the surface of the Earth can be defined as the wind. Atmospheric pressure differences caused by uneven heating of the atmosphere by the sun cause air to flow as winds. Earth's terrain, water bodies, and vegetative cover cause changes in the direction and strength of the wind. Strong winds are experienced consistently in several regions in a particular direction, while the situation is reversed in other locations.

The energy of the wind has been in use for hundreds of years. For example, windmills have been used for pumping water or grinding grain for years. Windmills convert the kinetic energy of the wind into mechanical energy. Similar to the windmills, wind turbines convert the wind's energy into electricity. Wind turbines have generators that convert mechanical energy into electricity. Wind turbines are generally mounted on high levels to efficiently capture the wind energy. Faster and less turbulent wind exist at high levels above the ground. Blades of the wind turbines help to capture the wind's energy. Three blades are usually mounted on a shaft to form a rotor of a wind turbine. Wind turbines are comprised of a tower, a rotor, a speed control system, and an electrical generator.

Wind turbines can be installed as stand-alone applications. They can also be connected to a grid. A large number of wind turbines can be built closely to form a wind plant or wind farm. Homeowners, farmers, and ranchers in windy areas can use wind turbines as a way of being self-sufficient in terms of energy.

Aerodynamics principles are used in turbine blade design, such as lift and drag. The energy generated by the wind turbines is related to the diameter of the blades. The wider the blades, the higher the amount of the energy generated.

Wind energy is a continuously renewable energy source since it is indirectly derived from the continually supplying solar radiation reaching Earth's surface.

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3.6.8 Vocabulary

Anemometer
Generator
Kinetic energy
Rotor
Wind turbine
Wind energy
Wind farm
Generator

3.6.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.6.10 Case Study

This section will contain a case study on the same scale application of biomass energy. The topics within the table below will be covered during the presentation of the case study.

Case study title	
Case study content	
Summary	
Images for the case study	

3.6.11 Questions for Self-Evaluation

Ten multiple choice questions (including answers) will be available to trainees in this section to help the trainees evaluate themselves on their understanding of the specific topics of each module.

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3.7 MODULE 6: GEOTHERMAL ENERGY MODULE

3.7.1 General

Specific topic	**Geothermal Energy Education**
Duration	**5 hours**

3.7.2 Specific Topics

Topic
Geothermal energy: Definition and generation
Sources and uses of geothermal energy
Availability of geothermal energy
Exploration and drilling
Direct use of geothermal energy
Energy conversion
Geothermal power plants
Dry steam power plants
Flash steam power plants
Binary cycle power plants
Geothermal heat pumps
Advantages & disadvantages
Risks associated with the use of geothermal energy
Environmental impacts of using geothermal energy
Economics of the small-scale Geothermal energy systems

3.7.3 Summary

The principles of heat transfer will be discussed in this module. Information will be given on the technology to use geothermal energy to generate electricity. Advantages & disadvantages will also be discussed.

3.7.4 Learning Outcomes

After the course,

- The attendees will know and understand the existence and sources of geothermal energy,
- The attendees will understand thermal energy can be conducted from one liquid to another,
- The attendees understand that the thermal energy in steam can be converted into mechanical energy, which can be used to generate electricity with a turbine,

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- The attendees will know the disadvantages and advantages of geothermal energy.

3.7.5 Guiding Concepts

- Geothermal energy is the heat energy which originates from the underground layers of the Earth.
- Shallow ground sources (low temperature), hot waters, steam and rock formations below the Earth's surface (high temperature) are geothermal energy sources.
- Low-temperature geothermal resources use the constant temperature of the soil or surface water.
- High-temperature geothermal resources use underground reservoirs of hot water or steam.

3.7.6 Guiding Questions

- How is geothermal energy generated?
- Where is geothermal energy found?
- How does energy is transferred between fluids in a geothermal power plant?
- How does salinity affect the boiling point of water?
- What are the environmental impacts of a geothermal power plant?
- What is the importance of turbine blades and steam jets in geothermal energy generation?

3.7.7 Anchor Text(s)

Geothermal refers to the heat from the inside of the Earth. Natural temperatures of the soil or water are used in geothermal energy applications. Geothermal energy can be directly used for heating, or electricity generation, or indirectly used by heat pumps.

Direct use for heating: Elevated temperature of groundwater is used. This technology is limited to areas that have naturally occurring hot springs or easy access to elevated temperature groundwater in the 38–120°C range. Spas, greenhouses, or heating systems of buildings use this water.

Direct use for electricity: This technology historically has used water temperatures above 150°C. Modern technology started to make it possible to generate electricity with water temperatures lower than 150°C. Flash power plants, dry steam plants, binary plants, and flash/binary combined plants are the technologies for electricity generation from geothermal resources.

Flash power plants separate geothermal waters into steam and hot water. The pressurized waters from the ground "flashes" as it reaches the surface and produces steam along with

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hot water. The hot water is re-injected back into the geothermal reservoir. The steam is utilized to operate a turbine that generates electricity.

Dry steam plants use steam to power the turbines. The wells are dry wells that only produce steam. Therefore re-injection is not required.

Binary power plants use geothermal water that is lower than 150^{o}C to generate electricity. These power plants use hot water to heat another liquid. The water transfers its heat to a liquid such as isobutene, pentafluoropropane, or another organic fluid that boils at a lower temperature, in a heat exchanger. The vapor formed from the other liquid is used to power the turbine that generates electricity.

Flash/binary systems use both the flash of the water and the steam of the binary system. The initial steam is used to run turbines. The hot water is then used in a binary system, where the heat is transferred to the organic fluid. Organic fluid would produce vapors that operate the turbine.

3.7.8 Vocabulary

Binary cycle
Co-production
Dry steam
Flash steam
Ground source heat pumps
Heat capacity
Heat exchanger
Heat flow
Hydrothermal fluid

3.7.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate the specific topics of the module.

3.7.10 Case Study

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Images for the case study	

3.7.11 Questions for Self-Evaluation

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3.8 MODULE 7: HYDROELECTRIC ENERGY MODULE

3.8.1 General

Specific topic	**Hydroelectric energy education**
Duration	**5 hours**

3.8.2 Specific Topics

Topic
Hydroelectric power: Definition
Potential sources
Hydropower plants
Hydroelectric energy & dams
Water wheels
High-speed commercial turbines
Head and flow
Storing energy
Power plant efficiency
A home-made water turbine
Advantages & disadvantages
Environmental impacts of using hydroelectric energy
Economics of the small-scale hydroelectric energy systems

3.8.3 Summary

In this module, the hydropower generation will be introduced to attendees. Kinetic and potential energy will be discussed, and attendees will understand how electricity is produced with the power of water.

3.8.4 Learning Outcomes

After this lesson, attendees will be able to

- Describe how a dam on a river produces electricity,
- Explain the environmental impacts of hydroelectric energy generation,
- Describe the basic components of a hydroelectric generation system.

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3.8.5 Guiding Concepts

- The kinetic energy generated by the falling water is the source for hydropower.
- The flow and fall of the water determine the amount of available hydroelectric energy.
- Hydropower plants collect the kinetic energy of the water.
- Energy is captured by damming a river, creating an artificial reservoir, or channeling a portion of a river through a generating facility.

3.8.6 Guiding Questions

- What makes hydropower an attractive energy source?
- How does hydropower work?
- What are the basic components of a hydropower plan?
- Which factors influence the amount of energy generated by a hydropower plant?

3.8.7 Anchor Text(s)

Hydropower plants contain a dam, intake, turbine, generator, transformer, power lines, and outflow. Large dams are used for large-scale hydropower generation. Dams are also used for flood control, water storage, and irrigation.

When the gates on the dam are open, the intake water is pulled through the penstock with gravity. The penstock is a pipeline that leads to the turbine. The pressure of the water increases as it flows through this pipe. The water strikes and turns the large blades of a turbine, which is attached to a generator. As the blades of the turbine turn, a series of magnets inside a generator turn. These magnets produce alternating current. A transformer takes the alternating current and converts it to the higher-voltage current.

The amount of hydroelectric electricity generated is affected by several factors, such as the volume of water flow and the amount of hydraulic head. The hydraulic head refers to the distance between the water surface of the reservoir and the turbines. It is dependent upon the amount of water in the reservoir. As the head and flow increase, the amount of electricity generated increases.

Micro-hydropower plants can also capture the energy of moving water on a small scale. Small to mid-sized generators are placed in rivers and streams to provide electricity for smaller applications.

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3.8.8 Vocabulary

Hydropower
Hydroelectricity
Kinetic energy
Mechanical energy
Potential energy
Turbine

3.8.9 Resources & Links

Resources and links will be provided to the trainees in this section who want to elaborate on the specific topics of the module.

3.8.10 Case Study

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Case study title	
Case study content	
Summary	
Images for the case study	

3.8.11 Questions for Self-Evaluation

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