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# Renewable Energy Sources and the Processes of Renewable Energy Production

## Teacher's Guide

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September, 2025

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Project Partners





## CONTEXT

### The scope of this teacher's guide

This teacher's guide addresses four types of energy: solar, wind, hydroelectric, and biomass energy.

It presents lesson plans for each type of energy. These lesson plans are to be used together with the students' worksheets developed to support them.

Each lesson plan was prepared for a 60-minute class and is supported by one or more student's worksheets.

The target Group is secondary school students aged 15–17 years old

The duration of the topic is 9 classes of 60 minutes each

Some general information, followed by the lesson plans (including information on when and how to use the students' worksheets) is provided for each type of energy.

The subjects involved are Science, Physics, Chemistry, Geology, Geography, Computer Studies, Environmental Education / Environmental Studies, Technology, and English.

The number of lesson plans per type of energy is 3 for solar energy, 2 for wind energy, 2 for hydroelectric energy, and 2 for biomass energy

The keywords that describe the lessons are: renewable energy, solar energy, wind energy, hydropower, biomass, sustainable development, electricity production, environmental impact, green technology, clean energy, carbon footprint, energy sources, sustainability, global warming, eco-friendly solutions, green future, energy awareness, STEM education, energy literacy.

### Summary

This set of professional teaching plans is designed for students aged 15-17 and offers a comprehensive, interactive, and engaging educational experience aimed at raising awareness and fostering a deeper understanding of four key renewable energy sources. Through this hands-on workshop, students will explore solar, wind, hydroelectric, and biomass energy, discovering how they are produced and their importance for the future. The selection of these four types of renewable energies is based on the most representative renewable sources of energy found in the partner countries of the program – Turkey, Greece, Portugal, and North Macedonia.

### Aims of the learning sequence

By the end of the teaching and learning sequence, students are expected to show **knowledge** of renewable energy, namely to:

- Provide a clear and accurate definition of the selected renewable energies: solar, wind, hydroelectric, and biomass energy.



- Identify the energy sources of the four selected renewable energies — sun, wind, water, and biomass.
- Explain the principles underlying the production of the selected renewable energies.
- Compare the advantages, limitations, and potential applications of the diverse renewable sources of energy.
- Evaluate the environmental, economic, and social impacts of adopting renewable energy solutions.
- Design a high-quality, interactive final product (such as a digital presentation, visual poster, or physical model) that promotes awareness and understanding of renewable energy.
- Promote final product-based awareness campaigns for renewable energy use.
- Demonstrate effective teamwork abilities, including equitable task distribution and constructive communication within a group setting.

During the sequence, students will develop **21st-century** skills in the following areas:

- Creativity and innovation in problem-solving contexts
- Critical thinking and analytical reasoning
- Effective communication and collaboration skills
- Advanced information, media, and technology literacy
- Initiative, self-regulation, and a strong sense of environmental stewardship

## Methodological approach

The methodological approach relies on the following **strategies**:

- Collaborative and cooperative learning methodologies
- Experiential and inquiry-based learning
- Project-based learning with real-world applications
- STEM-integrated, interdisciplinary approach
- Sustainability-focused educational practices
- Development of media, digital, and visual literacy

The methodological approach acknowledges a **STEM orientation** by assuming:

- **Personalisation of learning:** Students select one of the four renewable energies (solar, wind, hydroelectric, biomass energy) to investigate in depth, based on their personal interests, curiosity, and career aspirations.
- **STEM topic integration:** The sequence integrates concepts from science (energy production and environmental impact), technology (innovative renewable energy systems), engineering (design of energy solutions and models), and mathematics (data analysis, energy efficiency calculations).



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- **Hands-on application:** Students engage in practical activities, experiments, and model-building to simulate energy generation processes and measure efficiency.
- **Real-world connections:** Case studies from the partner countries (Turkey, Greece, Portugal, and North Macedonia) illustrate the local application of renewable energy technologies and their socio-economic implications.
- **Assessment:** Continuous formative assessment through observation, reflective journals, and peer review, combined with a final summative evaluation of the group project.
- **Interdisciplinary links:** Incorporation of social studies, geography, and environmental ethics to contextualize the scientific and technological content.

## Assessment

Assessment is continuously done based on formative practices to personalize learning and enhance the overall teaching and learning experience.

Formative assessment is embedded in the lesson activities. It should be done during class discussions, brainstorming activities, group work, hands-on experiments, project work, etc. Students' worksheets include a variety of tasks to be performed by the students that allow the teacher to observe progression on knowledge, reasoning, behavior, communication skills, social-relational skills, creativity, etc. They also allow students to express their understanding in different ways, providing evidence of how deeply they understand and can use the content. Formative assessment should consider issues like accuracy of scientific content, creativity in presentation, collaboration and teamwork, critical thinking and clarity of reasoning, communication and argumentation, and engagement with the tasks.

To strengthen active participation, both self-assessment and peer assessment play a central role. Therefore, students are asked to reflect on their learning and contribution to the group, to evaluate their group's collaboration, and the performance of the different groups, etc. In addition to teachers' questions, worksheets include questions with this aim.

Together, these assessment practices provide a holistic view of each student's progress, enabling the teacher to adapt instruction to individual needs while helping students become reflective, self-directed participants in their own education.

## Theoretical Background

Energy sources represent the foundation of modern societies, providing the power required for households, transportation, industries, and technological systems. They are generally divided into renewable and non-renewable sources. Renewable energy sources — such as sun, wind, water, and biomass — are naturally replenished, environmentally friendly, and essential for ensuring long-term sustainability. Non-renewable sources — including coal, oil, and natural gas — are finite and heavily associated with greenhouse gas emissions, environmental degradation, and global warming.

This teaching sequence focuses on four key types of renewable energies: solar, wind, hydroelectric, and biomass. Each of these types of energy plays a distinct role in shaping sustainable energy



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strategies. Sun's radiation (solar energy), air moving energy (wind energy), and water moving energy (hydroelectric energy) can be converted into electricity. Organic matter can also be transformed into usable energy (biomass energy). While each source of energy has unique benefits, they also present challenges - such as geographic dependence, cost of technology, and infrastructure needs. The process of biomass energy releases methane and CO<sub>2</sub>, which need to be used for biofuel production to prevent contributing to global warming.

Developing a deeper understanding of these renewable energy sources allows students not only to explore their scientific and technological principles but also to critically evaluate their environmental, economic, and social implications. This theoretical foundation prepares learners to engage actively in the transition towards a more sustainable future. More information is available as follows:

Solar energy: <https://www.projectgreenlighteu.com/Home/ePlatform?section=SolarEnergy>

Wind energy: <https://www.projectgreenlighteu.com/Home/ePlatform?section=Wind>

Hydroelectric energy: <https://www.projectgreenlighteu.com/Home/ePlatform?section=Hydraulic>

Biomass energy: <https://www.projectgreenlighteu.com/Home/ePlatform?section=BioMass>

More technical information on these types of energy can be found in an e-book available at:

<https://www.projectgreenlighteu.com/Home/Resources>

## LESSON PLANS ON SOLAR ENERGY (Sx)

Time: 180 minutes (3 x 60 minutes)

Teacher's materials: 3 lesson plans, including videos

Students' materials: 3 worksheets, including a list of materials for practical activities

### Lesson Plan S1 (60 minutes)

The first lesson introduces students to the concept of solar energy, sparks curiosity through multimedia, and engages them in collaborative classification activities.

1. **Motivation (10 minutes):** Show a short, engaging video presenting energy sources. A suggested video is available at: <https://www.youtube.com/watch?v=bPwvS5V5RW4&t=1s>

After watching the video, carry out a brainstorming activity by asking: "What comes to mind when you hear the word solar energy?"

2. **Introduction to solar energy (15 minutes):** Present a clear definition of solar energy—where and how it is produced, what it is used for, how much of it is currently used, and what its future looks like. You can get information on this from: <https://www.projectgreenlighteu.com/Home/Resources>

3. **Application (20 minutes):** Hand out Worksheet S1 to students and ask them to take the "True or False" Activity in small groups (question 1).



4. **Sharing (10 minutes):** Groups share their classifications and explain their answers, especially when they differ from group to group. The teacher summarizes and corrects any misconceptions. The solutions are given below.

5. **Reflection (5 minutes):** Students answer question 2 of [Worksheet S1](#), and share their reflections.

### **Solutions for the “True and false” activity (Worksheet S1)**

1. False - There are two types of solar panels. Thermal solar panels, which transform the energy from sun rays into heat that is used mainly to warm water; photovoltaic solar panels, which transform energy from sunlight into electricity. This activity focuses on the latter.
2. False – Photovoltaic solar panels work even with indirect sunlight, though efficiency is reduced.
3. True – Solar energy is renewable since the sun is not expected to finish (at a human time scale), and sunlight is continuously available.
4. False – Photovoltaic panels work in winter, as long as there is sunlight; they can be even more efficient in cooler temperatures.
5. True – Opposite to fossil fuels, the energy coming from the sun does not cost money. Technology for harnessing it (as it happens with technology for harnessing fossil fuels) costs some money, but, in the end, using solar energy still reduces electricity bills.
6. True – Electricity from solar energy can be stored in batteries for use at night or on cloudy days.
7. False – Photovoltaic solar panels need very little maintenance, usually just cleaning and occasional checks.
8. False – Manufacturing and recycling photovoltaic panels do cause some emissions, though far less than fossil fuels.
9. True – Large solar farms already power entire communities and cities.
10. False – Solar energy costs have dropped dramatically, making it cheaper than coal or natural gas in many regions.
11. True – Photovoltaic panels can be installed on rooftops, gardens, fields, deserts, and floating platforms.
12. True – Solar energy reduces reliance on fossil fuels and lowers greenhouse gas emissions.
13. False – Photovoltaic panels usually last 25–30 years, with efficiency gradually decreasing.
14. False – Photovoltaic panels lose efficiency in very hot conditions; they perform best in moderate temperatures with strong sunlight.
15. True – The sun is the fastest-growing renewable source of energy used worldwide, surpassing wind in new installations.
16. False– At night, photovoltaic panels cannot generate power because there is no sunlight. At night, the only way to use electricity produced from solar energy is to have it stored in batteries.

## **Lesson Plan S2 (60 minutes)**

The second lesson focuses on applying knowledge of solar energy through a paper-and-pencil scenario-based problem-solving.

1. **Motivation (10 minutes):** Introduce the scenario to the students; make sure they understand the task.



Scenario: “Your municipality aims to increase its use of solar energy to 40% of its energy mix within 10 years. You are invited to advise on how they can do that.”

2. Problem solving (20 minutes): Hand out Worksheet S2 and ask students to do questions 1 to 3, in small groups (3 to 5 students).
3. Sharing (15 minutes): ask the groups to share their proposals (3 minutes per group)
4. Class discussion (10 minutes): Conduct a class discussion of the presentations.
- 5- Reflection (5 minutes): Ask students to think about question 4 of Worksheet S2 and share their thoughts.

## Lesson Plan S3 (60 minutes)

The third lesson focuses on applying knowledge of solar energy through a hands-on activity based on a scenario.

1. Motivation (5 minutes): Introduce the scenario in Worksheet S3 to the students.

Scenario: “At your home, you use electricity, gas, or coal to cook your meals. Have you ever thought about using the sun to cook? Do you think it would be possible? If so, how would it work?”

Ask students to answer the questions of the scenario (question 1 of Worksheet S3), in small groups (3 to 5 students). If you feel you do not have time to do it in groups, do it in class.

2. Experiment (30 minutes): Ask students to proceed according to Worksheet S3, from question 2 to 7, in small groups (3 to 5 students). Do not tell them what device they are going to build. Monitor the groups so that they can succeed in building their device and collect and register data in the table provided in worksheet S3. Let them conclude that their device is a solar oven.
3. Sharing and conclusion (15 minutes): ask the groups to share their conclusions.
4. Reflection (5 minutes): Ask students to think about question 8 and share their thoughts.

### Alternative experiment to the one in Worksheet S3

If the school has a digital lab that includes solar energy equipment, the teacher can experiment to demonstrate how solar panels work and what key variables affect the panel's efficiency. Students should be cognitively actively engaged in the experiment and analyze the findings obtained.

5. Self-assessment (5 minutes): Invite students to play the games available at <https://www.projectgreenlighteu.com/Home/ePlatform?section=SEGames>



## Assessment in the Solar Energy lessons

Assessment in the solar energy lessons is continuous and integrates both formative and summative elements, aiming at personalizing learning and enhancing the overall teaching and learning experience.

Suggested reflective prompts include:

- What did you already know about solar energy, and which new facts surprised you?
- How effectively did your team collaborate during the experiment?
- Which part of your solar oven design worked best, and what would you improve?
- In which situations do you learn most effectively—through experiments, discussions, or independent research?

Formative teacher-led assessment is conducted through interactive strategies such as:

- *Fist-to-Five*: Students indicate how confident they feel about solar energy concepts.
- *Agree/Disagree Circles*: Used during the *True/False* activity.
- *Think-Pair-Share*: Applied after the video and during scenario discussions.

The final (summative) assessment focuses on the quality and depth of the end products: the *True/False* task and the experiment outcomes. Evaluation criteria include:

- Accuracy of scientific content
- Creativity in presentation
- Collaboration and teamwork
- Critical thinking and clarity of reasoning

Together, these assessment practices provide a holistic view of each student's progress, enabling the teacher to adapt instruction to individual needs while helping students become reflective, self-directed participants in their own education.



## LESSON PLANS ON WIND ENERGY (W<sub>x</sub>)

Time: 120 minutes (2 x 60 minutes)

Teacher's materials: 2 lesson plans, including videos

Students' materials: 3 worksheets, including lists of materials for practical activities, and wind energy domino cards.

### Lesson Plan W1 (60 minutes)

The first lesson introduces students to wind energy, sparks curiosity with multimedia, and activates understanding through a sequencing game.

1. Opening (15 minutes): Tell students that they are going to watch a video and have to jot down 2–3 observations while watching

The video suggested is: “How do Wind Turbines Work?”, which is available from [https://www.youtube.com/watch?v=niZ\\_cvu9Fts](https://www.youtube.com/watch?v=niZ_cvu9Fts) If appropriate, they can watch the following one too: [https://www.youtube.com/watch?v=QcxT\\_pv80v8](https://www.youtube.com/watch?v=QcxT_pv80v8)

Afterwards, promote a class brainstorm using the following prompt: “Where are wind turbines most effective and why?” → Record the answers (students' previous ideas) on the board (mountains, coastal areas, offshore) without commenting on them.

2. Introduction to wind energy (15 minutes): Use simple visuals (e.g., Canva slides) to explain the energy conversion chain: wind → kinetic energy → mechanical rotation in turbine → electrical energy via generator. Show and compare pictures of onshore vs offshore turbines. Then, ask students what they think now about what is written on the board, that is, “Where turbines are more efficient and why?” It is time to discuss and correct students' previous ideas.

3. “Energy Domino Game” Activity (20 minutes): Provide each group with laminated domino-style cards (Wind, Turbine, Generator, Grid, Homes, Storage, etc.) and hand out worksheet W1. Ask students to play the game and the tasks given in Worksheet W1.

Students should at least reach Homes/Schools to complete the main task. The Storage card can be used as a bonus or extension for groups that finish quickly. Encourage groups to justify their sequencing in 2–3 sentences, focusing on how energy transforms at each stage.

Alternatively, you can ask students to take the quiz available online from: <https://projectgreenlighteu.com/Home/ePlatform?section=WEGames>

4. Reflection (10 minutes): Ask students to do the exercises in Worksheet W2.

Students' answers should be corrected, paying special attention to misconceptions.



End with a question: “Thinking of wind energy, what happens when the wind doesn’t blow?” Let students conclude that when the wind does not blow, the blades cannot rotate, and the wind turbines do not produce electricity.

### Solutions for the questions in Worksheet W2

- 1.1. False: A turbine generator converts kinetic energy into electricity.
- 1.2. False: Wind turbines convert kinetic energy from the wind into kinetic energy of the blades and also into sound energy (noise) and thermal energy (or heat, which is dissipated).
- 1.3. True: Offshore wind farms are located in the sea.
- 1.4. False: Wind energy does not produce greenhouse gas emissions while generating electricity.
- 1.5. True: The blades move first and transmit motion to the rotor, which in turn sends it to the generator that will convert kinetic energy into electricity
- 1.6. True: A turbine generator converts rotational kinetic energy into electricity
- 1.7. False: Offshore areas are the locations that generally have more consistent winds for turbines
- 1.8. False: Wind turbines generate some thermal energy (or heat, which is dissipated).

## Lesson Plan W2 (60 minutes)

The second lesson promotes transforming knowledge into creation and testing, combining a visual design sprint with a simple turbine experiment.

1. Creative Activity (10 minutes): Ask small groups of students (3 to 5 per group) to create a mini-poster (in paper or canvas) titled: “Wind Energy: Powering the Future”. They should follow the instructions on Worksheet W3.

Encourage creativity: colors, icons, short captions, and clear layout. Ensure that each mini-poster includes all required elements: a statistic, a benefit, a challenge, and visuals.

2. Hands-on Experiment (25 minutes): Ask small groups of students (3 to 5 students) to carry out the windmill experiment, to investigate how wind (from a fan) can make a pinwheel spin and how different distances and angles affect its rotation. Students should follow the procedure described in Worksheet W4 and answer the questions provided.

For students to learn how to make and operate a pinwheel, you ask them to watch a video at the following link: <https://www.youtube.com/watch?v=HN0GxOQMzME>

Encourage students to predict before testing and compare results.

Emphasize careful measurement of distance and angle.

If available, students can take photos or videos to support their observations.



3. Presentation & Feedback (15 minutes): Each group shares 1–2 findings. Peers respond with Fist-to-Five (fist = disagree, five fingers = strongly agree with their interpretation).

4. Reflection (5 minutes): Ask students to answer questions in Worksheet W5.

They should write down one advantage (e.g., is renewable, reduces carbon emissions) of wind energy and one siting challenge (e.g., noise, space use, visual impact) of installing wind turbines in a city or rural area.

Finally, encourage students to think critically about what they learned about wind energy and to share one personal thought or idea, keeping answers concise.

5. Self-assessment (5 minutes): Invite students to play the games available at <https://www.projectgreenlighteu.com/Home/ePlatform?section=WEGames>

## Assessment

To enhance active participation, self-assessment and peer assessment are emphasized. In the first lesson, students reflect on their reasoning during the “Energy Domino Game” activity and evaluate how their group collaborated to justify their classifications. In the second lesson, students assess their teamwork during the pinwheel experiment and provide peer feedback after the short debate presentations using techniques like Fist-to-Five.

Suggested reflective prompts include:

- What new information did you learn about wind energy that challenged your prior understanding?
- How did your group collaborate during the windmill experiment?
- What design adjustments improved the performance of your pinwheel model?
- How easy did you find it to learn through debate, experimentation, or multimedia exploration? Why?

Formative teacher-led assessment is conducted through interactive strategies such as:

- **Fist-to-Five**: Students rate their confidence in understanding wind energy concepts.
- **Think-Pair-Share**: Used after the introductory video
- **Traffic Lights**: Students self-assess their confidence after the windmill experiment by marking green (understood), yellow (partially understood), or red (need help).

The summative assessment focuses on the quality and depth of the group products and activities, the debate outcomes, and the experimental windmill results. Evaluation criteria include:

- Accuracy of scientific content
- Creativity in problem-solving and experimentation
- Collaboration and effective teamwork
- Critical thinking and clarity in argumentation



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Together, these assessment practices provide a holistic understanding of each student's progress. They allow the teacher to adapt instruction to individual needs while helping students become reflective, self-directed learners who can engage critically with renewable energy issues.



## LESSON PLANS ON HYDROELECTRIC ENERGY (Hx)

Time: 120 minutes (2 x 60 minutes)

Teacher's materials: 2 lesson plans, including videos

Students' Materials: 2 worksheets, including materials for a puzzle and a list of roles for a role-playing activity

### Lesson Plan H1 (60 minutes)

The first lesson unpacks how moving water generates hydroelectric energy, that is, electricity, and engages students in systems thinking with a process puzzle.

1. Opening (10 minutes): Ask small groups of students to discuss how electricity is generated from water. Ask them to share their thoughts.
2. Introduction to Hydroelectric Energy (20 minutes): Ask students to watch a video on hydroelectric energy generation and take notes while watching. The video, "How Hydroelectric Power Works", is available from: <https://www.youtube.com/watch?v=q8HmRLCgDAI>.

Ask students to compare what they watched with their previous ideas. Conduct a discussion so that students can understand how hydroelectric energy is generated from water.

Conduct a brainstorm, asking students, "Where does water have the most usable energy?" (e.g., waterfalls, mountains, rivers).

Show a quick world snapshot of countries with large hydropower (China, Brazil, Norway). As homework, students research the potential for hydroelectric energy in their country. They should identify major rivers, existing dams, and regions suitable for hydroelectric energy development.

3. Application (20 minutes): Ask students to do the "Hydroelectric Energy Process Puzzle", as described in Worksheets H1.

The groups place the cards (reservoir, penstock, turbine, generator, transmission lines) in the correct order of energy flow and write what happens at each step. The teacher circulates to help students overcome their difficulties.

4. Reflection (10 minutes): Ask small groups to think about the challenges of using hydropower energy and present their results in 1 minute each. Teacher clarifies ecological issues (e.g., fish migration, sediment build-up, seasonal water flow changes).



## Lesson Plan H2 (60 minutes)

The second lesson builds argumentation and design thinking through a debate on a dam and impact-aware infographic creation.

1. Scenario Discussion (5 minutes): Present the scenario provided in Worksheet H2 to the students.

### Scenario

“Imagine that your local authorities want to increase the mix of hydroelectric energy. One possibility of achieving that goal is to build a dam. Should our region build a medium dam?”

1. Motivation (10 minutes): Ask students to work in small groups and answer questions 1 and 2 of Worksheet H2, as preparation for the role-playing activity.

2. Role-playing (20 minutes):

This activity combines role-playing and structured debate, allowing students to explore multiple viewpoints and practice evidence-based argumentation.

Start by selecting a student from each group to represent one of the following roles: government, environmental groups, energy companies, tourism agents, or safety agents.

The rest of the class is divided into two teams—Pros and Cons-

Students have to argue for or against the project (to build a dam) by incorporating the perspectives of their assigned stakeholders.

The debate consists of opening statements (2 minutes per side) followed by rebuttals (1 minute per side), while the teacher moderates to ensure equal participation and clarifies any inaccurate ideas.

3. Peer Feedback (10 minutes): After the debate, ask each student to write down one key argument or strong point put forward by a different stakeholder and explain why it was chosen. And to answer question 3 of Worksheet H2.
4. Conclusion (15 minutes): The teacher then leads a quick class summary, highlighting the main arguments from both the Pro and Cons teams and the different stakeholder viewpoints, ensuring students understand the variety of perspectives and the complexity of balancing energy, social, and environmental considerations.

### Clues for Pro and Con arguments

Possible Benefits: clean renewable energy, flood control, irrigation, job creation, and energy independence.

Possible Risks: relocation of people, impact on fish and ecosystems, cost, long construction time, and visual landscape changes.

5. Self-assessment (5 minutes): Invite students to play the games available at <https://www.projectgreenlighteu.com/Home/ePlatform?section=HEGames>



## Assessment

In the lessons on hydroelectric energy, formative assessment is embedded in both lessons—during video-based discussions, brainstorming, puzzle tasks, and the role-playing activity.

To strengthen active participation, both self-assessment and peer assessment are consistently applied during small group work, class discussion, and role-playing. Peer feedback methods such as the *Fist-to-Five* technique enable students to develop awareness of evaluation criteria and foster responsibility for their own learning journey.

Suggested reflective prompts include:

- Which new facts about hydroelectric energy surprised you the most?
- How well did your team collaborate during the debate?
- Which task helped you understand hydroelectric energy more effectively?

Formative teacher-led assessment is carried out through interactive strategies such as:

- *Fist-to-Five*: Students quickly indicate their confidence level in understanding hydroelectric energy concepts.
- *Think-Pair-Share*: Used after the video and during the role-playing activity preparation phase.

Summative assessment focuses on the quality and depth of student outcomes in both lessons: the classification task in Lesson 1 and the debate arguments in Lesson 2. Evaluation criteria include:

- Accuracy of scientific content
- Critical thinking and clarity of reasoning
- Creativity in designing and explaining arguments/solutions
- Collaboration and teamwork

Together, these formative and summative strategies provide a holistic picture of each student's progress, while also allowing the teacher to adapt instruction to individual needs and encouraging students to become reflective, responsible, and active participants in their own learning.



## LESSON PLANS ON BIOMASS ENERGY (Bx)

Time: 120 minutes (2 x 60 minutes)

Teacher's materials: 2 lesson plans, including videos

Students' materials: 2 worksheets, including a list of materials for practical activities

### Lesson Plan B1 (60 minutes)

The first lesson explores what counts as biomass and how energy can be obtained from biomass, using an experiment and a playful classification game to solidify concepts.

- Opening (10 minutes):** Ask students to watch the video: "What Is Biomass?" [https://www.youtube.com/watch?v=nV117JLn\\_u0](https://www.youtube.com/watch?v=nV117JLn_u0)  
Promote brainstorming by asking students, "Which household wastes could be useful to produce energy?". This question is expected to lead to an answer mentioning food scraps and garden waste.
- Introduction to biomass energy (15 minutes):** Based on the video, promote a discussion on what biomass energy is, where it comes from, mentioning the main sources such as wood, crop residues, manure, and food waste.  
Emphasize the processes of obtaining energy from these materials, including direct combustion (leading to thermal energy or electricity), and composting (leading to biogas). Ask for examples of everyday uses of biomass energy, such as heating, cooking, and electricity generation, to help students connect the processes to real-life applications.
- Experiment (20 minutes):** Ask small groups of students (3 to 5 students) to conduct an experiment described in Worksheet B1: inflating a balloon with Biomass. Do not tell them what will happen. Let them feel the sense of discovery.  
With this experiment, students explore anaerobic digestion, a process where microorganisms break down organic matter in the absence of air to produce biogas, such as methane, which can be used to generate electricity.
- Conclusion (15 minutes):** When the experiment is completed, ask students to answer questions 2 to 6 of worksheet B1, to analyze data, and conclude from the experiment.  
This hands-on activity demonstrates the basic principles of biomass conversion and fermentation, showing how microorganisms convert organic matter into energy, and allows students to analyze the roles of sugar, water, and yeast, as well as the environmental conditions that maximize gas production.
- Reflection (Homework):** Ask students to write down the most important thing they learned and one question they still have.



## Lesson Plan B2 (60 minutes)

The second lesson channels creativity into designing a feasible biogas production system and evaluating real-world trade-offs.

1. Warm up Biomass Bingo game (10 minutes): Invite students to play the Biomass Bingo game, using worksheet B2.

Distribute the cards (annex to worksheet B2) among the students.

Read items one by one, in random order.

Correct answers must be confirmed by a quick class discussion, and students' understanding reinforced.

### Correct classification of the items in the cards

Suitable for Biomass energy	Not Suitable for Biomass energy
Corn husks	Plastic bottles
Manure	Coal
Olive pits	Natural gas
Wood chips	Gasoline
Food waste	Glass
Straw	Aluminum cans
Sawdust	Steel scrap
Sugarcane bagasse	Oil

2. Creative design of a mini biogas system (25 minutes): Students are asked to plan, on a A3 paper, a mini biogas (production and use) system following instructions in Worksheet B3, questions 1 and 2.

The design must include: inputs (waste types), digester, gas output, fertilizer byproduct, storage, and possible uses.

Encourage students to draw arrows, icons, and labels, and Canva icons (optional). Circulate and ask them guiding questions (e.g., "What happens if there's too much food waste at once?").

3. Presentation of the design (10 minutes): After completing the design, each group gives a 60-second pitch of their design. One question from peers per group should be encouraged. Comment on students' designs to correct them if necessary.

4. Reflection (10 minutes): Ask students to get the "Exit ticket", by answering question 3 of Worksheet B3.

Students should complete the sentence using ideas like the ones below.



“Biomass energy production works best when [utilizing sustainable and efficient supply chains that avoid competition with food crops and minimize negative environmental impacts] but we must watch out for [air pollution and emissions, soil degradation and loss of biodiversity, and carbon neutrality concerns, as biomass burning can still produce significant greenhouse gases and may require unsustainable land use changes]”.

5. Self-assessment (5 minutes): Invite students to play the games available at <https://www.projectgreenlighteu.com/Home/ePlatform?section=BMgames>

## Assessment

Assessment in the biomass energy lessons is continuous and combines formative and summative approaches, aiming to support differentiated learning and maximize student engagement.

Formative assessment is embedded in both lessons—during the introductory video, group brainstorming, classification activities and the biomass energy experiment. Students understanding is actively monitored through worksheets, guided discussions, reflective tasks, and observation of group dynamics. These strategies allow the teacher to identify misconceptions early and help students consolidate their knowledge step by step.

Suggested reflective prompts include:

- What did you already know about biomass, and what new facts did you learn?
- How well did your team collaborate during the classification activity?
- What was the most surprising finding from the biomass energy production experiment?
- If you had to convince a community to use—or not to use—biomass to produce energy, which arguments would you choose?

Teacher-led formative assessment is carried out through interactive techniques such as:

- *Think–Pair–Share*: Used after the introductory video to guide students from personal reflection to group exchange.
- *True /false*: Applied during the “Bingo game” activity to spark dialogue around misconceptions.
- *Traffic Lights*: Used after the experiment to gauge students’ level of understanding.
- *One-Minute Paper*: At the end of each lesson, students write down the most important thing they learned and one question they still have.

Together, these assessment methods provide the teacher with a comprehensive understanding of student progress and enable learners to take responsibility for their own learning, while developing critical thinking, creativity and teamwork skills.



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## Interdisciplinary Connections of the Topic

The lessons have connections with several subjects, as follows:

- Science: Analysis, classification, and comparison of Solar, Wind, Hydroelectric, and Biomass energy sources.
- Geography: Influence of location, climate, and natural resources on energy production and efficiency.
- Economics: Exploration of costs, benefits, and sustainability of different energy technologies.
- Technology/Art: Creation of visual materials and digital presentations using tools like Canva, Genially, and Google Forms.



## ANNEXES

### Annex 1: Glossary

- **Energy:** The ability to do work or cause change.
- **Types of energy:** have to do with the different ways energy manifests itself: thermal, light, mechanical, and chemical energy.
- **Forms of energy:** are broad classifications of energy which encompass kinetic energy, the energy of motion, and potential energy, due to position or state. Examples include the energy of a moving car (kinetic) and the energy of water stored in a high dam (potential).
- **Renewable Energy:** Energy derived from natural sources that are constantly replenished, such as sunlight, wind, flowing water, and biomass.
- **Non-renewable Energy:** Energy obtained from sources that cannot be replenished on a human time scale, such as fossil fuels.
- **Fossil Fuels:** Energy sources formed from the remains of ancient plants and animals, including coal, oil, and natural gas.
- **Solar Energy:** Energy harnessed from the sun's rays, often captured using solar panels or solar thermal systems.
- **Wind Energy:** Energy generated by converting the kinetic energy of wind into electrical power using turbines.
- **Hydroelectric energy:** Energy produced by using the flow of water to generate electricity, usually through dams or small-scale river turbines.
- **Biomass Energy:** Energy produced from organic materials such as wood, agricultural residues, or animal waste, through burning or composting processes.
- **Sustainability:** Using resources in a way that meets current needs without compromising the ability of future generations to meet theirs.
- **Energy Efficiency:** Using less energy to perform the same task, reducing waste and environmental impact.
- **Energy Saving:** Reducing overall energy consumption by changing habits, using energy-efficient technologies, or improving existing processes.



## Annex 2: Checklist for Lesson Activities

- **Definition & Understanding:** Has the student understood and can clearly explain what this specific type of energy is (Solar/Wind/Hydroelectric/Biomass energy)?
- **Classification:** Was the correct categorization made (renewable/non-renewable) and were key characteristics of each category identified?
- **Key Concepts:** Are essential details included (method of production, technologies, current levels of use, prospects)?
- **Pros & Cons:** Are at least two advantages and two disadvantages identified for each energy source use?
- **Environmental Impacts:** Are the positive/negative impacts on the environment accurately described?
- **Real-world Examples:** Are there concrete examples from students' countries/Europe/the world showing practical application?
  - Solar: e.g., Portugal – Solar farm of Amareleja ; Greece – Chronus Kozani Solar PV Park, Turkey – Karapınar Solar Power Plant.
  - Wind: e.g., Wind farm in Mani offshore wind turbines (general example: North Sea); Turkey – Balıkesir Bandırma Wind Farm.
  - Hydropower: e.g., Kremasta Hydroelectric Plant small “run-of-river” facilities.
  - Biomass: e.g., Biomass units in Western Macedonia use of agricultural residues, Turkey – Konya Biomass Power Plant, using agricultural waste.
- **Collaboration:** Was there effective teamwork (role distribution, time management, conflict resolution)?
- **Creativity:** Was creativity incorporated (poster/infographic, role-play, original solutions to scenarios)?
- **Critical Thinking:** Were positions supported with evidence? Were options compared and justified?
- **Use of Digital Tools:** Were Canva/Genially/Kahoot/Google Forms effectively used for research, organization, and presentation?
- **Presentation Skills:** Were the presentations clear, well-structured, and adapted to the audience?
- **Reflection:** Was self- and peer-assessment carried out (e.g., Fist-to-Five, short reflective responses) with clear next steps for improvement?
- **Visual & Communication Clarity:** In visual work, were appropriate images/icons/layouts used to ensure readability and an engaging outcome?



## Annex 3: Selected Excerpts from Scientific Articles for Discussion

### Excerpt 1

The year 2024 marked a historic turning point for Europe, as solar energy for the first time generated more electricity than coal. Photovoltaic systems supplied around 11% of the EU's total electricity, surpassing the 10% produced by coal. This achievement was not the result of exceptionally sunny weather—in fact, sunshine levels in 2024 were lower than average—but rather the outcome of record-breaking new solar installations across the continent.

At the same time, reliance on natural gas continued to decline, accounting for only 16% of the EU's energy mix, marking the fifth consecutive year of reduction. This trend demonstrates that the transition toward renewable energy can happen faster than expected when technological innovation, political commitment, and strong investment align.

The rapid growth of solar energy also carries broader social and environmental implications. On the one hand, it significantly reduces carbon dioxide emissions and contributes to mitigating climate change. On the other, it strengthens Europe's energy independence by reducing the need for fossil fuel imports. These developments highlight the potential for the EU to move closer to the ambitious targets of the European Green Deal and achieve climate neutrality by 2050.

The example of solar power in 2024 can be used as a case study for classroom discussion, helping students explore not only the benefits but also the challenges of renewable energy. Alongside the advantages, the challenges include energy storage, grid integration, and ensuring that the transition remains fair and inclusive for all.

(adapted from: The Guardian – Rising star: Europe made more electricity from solar than coal in 2024-<https://www.theguardian.com/world/2025/jan/22/rising-star-europe-made-more-electricity-from-solar-than-coal-in-2024>)

### Excerpt 2

The year 2024 marked a significant expansion of wind energy capacity in Europe, with 16.4 GW of new installations, of which 12.9 GW were added within the EU-27. The majority of this growth came from onshore projects (84%), while offshore accounted for 2.6 GW. Altogether, Europe's wind capacity has now reached 285 GW, with the EU holding 231 GW (210 GW onshore and 21 GW offshore).

Looking ahead to 2025–2030, projections indicate the addition of 187 GW of new capacity across Europe, including 140 GW within the EU. This implies an annual growth rate of approximately 23 GW, raising Europe's total wind capacity close to 450 GW and the EU-27's to around 351 GW by 2030. Such growth plays a crucial role in meeting the EU's target of at least 42.5% renewable energy share in the overall energy mix.

These figures highlight not only the rapid technological and market developments but also the importance of policy support, infrastructure upgrades, and permitting processes in driving the



continent’s energy transition. Discussing these numbers in the classroom helps students connect real-world data with the challenges and opportunities of shifting towards a sustainable energy future.

(adapted from: WindEurope – Wind energy in Europe: 2024 Statistics and the outlook for 2025-2030 – [https://www.dnv.com/energy-transition-outlook/download/?utm\\_source=googlecpc&utm\\_medium=search&utm\\_campaign=eto\\_2024\\_download&gad\\_source=1&gad\\_campaignid=21616551769&gbraid=0AAAAA09W8r3DHPYYI0bVThnDhrFD-IDo&gclid=Cj0KCQjwLFBhDmARIsAltqgt5dk05yBPEf0DPVULyFv6s5NOWdAJga3TkXFmcFIBGtSnEq1WNI7HgaAjiHEALw\\_wcB](https://www.dnv.com/energy-transition-outlook/download/?utm_source=googlecpc&utm_medium=search&utm_campaign=eto_2024_download&gad_source=1&gad_campaignid=21616551769&gbraid=0AAAAA09W8r3DHPYYI0bVThnDhrFD-IDo&gclid=Cj0KCQjwLFBhDmARIsAltqgt5dk05yBPEf0DPVULyFv6s5NOWdAJga3TkXFmcFIBGtSnEq1WNI7HgaAjiHEALw_wcB) )

**Excerpt 3**

Based on the Eurostat article on renewable energy statistics, hydroelectric energy continues to provide a significant contribution to electricity production in the EU. In 2024, hydroelectric energy accounted for approximately 29.9% of the total electricity generated from renewable sources in the EU.

Hydroelectric energy is generated by the impact of moving water on turning turbines. This technology is one of the oldest forms of renewable energy, with historical applications dating back to pre-industrial times, such as water mills. Beyond supplying substantial amounts of renewable electricity, hydroelectric energy can also provide key system services for the European electricity grid, including flexibility and energy storage. These services are essential for maintaining grid stability and integrating an increasingly variable renewable generation mix, such as solar and wind energy.

Hydroelectric energy also contributes to the EU’s energy security by reducing dependence on imported fossil fuels and supporting energy autonomy. However, the development of new hydroelectric energy projects can face environmental and social challenges, including ecosystem management and the impacts on local communities.

Overall, hydroelectric energy remains a critical renewable energy in the EU, playing a major role in achieving CO<sub>2</sub> reduction targets and advancing a sustainable energy transition.

(adapted from: [https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Renewable\\_energy\\_statistics](https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Renewable_energy_statistics))

**Excerpt 4**

Based on the IEA Bioenergy report on biomass deployment in the EU in 2024, biomass remains the largest renewable energy source in the European Union. In 2022, biomass accounted for approximately 60% of the total renewable energy in the EU, with production of energy from biomass reaching 6.1 exajoules (EJ). This significant contribution places biomass at the forefront of renewable energy sources in the region.

Biomass energy production is utilized across multiple sectors, including electricity generation, heating, and transportation. In electricity production, biomass contributes around 6% of total EU generation. In heating, biomass covers roughly 18% of thermal energy use, mainly through direct use



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in residential and industrial applications. In the transport sector, biofuels (that is gases obtained from biomass composting) such as biodiesel and bioethanol, serve as important energy sources, with biodiesel representing 7.2% of diesel consumption and bioethanol 4.7% of gasoline consumption in the EU.

Biomass is primarily composed of wood residues, agricultural and forestry residues, and organic waste. This energy source benefits from high domestic production, with the EU having low dependence on biomass imports, unlike fossil fuels. Specifically, dependence on biomass and waste imports for energy use is below 5%, while for fossil fuels, dependence exceeds 70%.

However, the expansion of bioenergy (that is energy obtained from biomass), that is energy obtained from biomass, faces challenges, such as the need for sustainable cultivation practices, ecosystem management, and social acceptance. It is essential to ensure that biomass production does not lead to deforestation or negatively affect biodiversity. The EU has established strict sustainability criteria for biofuels to ensure that bioenergy development positively contributes to the energy transition and the achievement of CO<sub>2</sub> emission reduction targets.

(adapted from: [https://www.ieabioenergy.com/wp-content/uploads/2025/01/CountryReport2024\\_EU27\\_final\\_v2.pdf](https://www.ieabioenergy.com/wp-content/uploads/2025/01/CountryReport2024_EU27_final_v2.pdf))

## Annex 4: Annexes of students' worksheets

### Annex to Worksheet W1 - Cards for the Domino Game

1		Generator → Converts mechanical energy into electricity
2		Kinetic Energy → Energy of moving air (wind)
3		Wind → Natural moving air
4		Blades → “Capture” the wind’s kinetic energy
5		Homes → Electricity for families
6		Electric Grid → Distribution network
7		Storage Batteries → Store excess of electricity for later use

Annex to Worksheet H1 - Cards for the puzzle on the hydroelectric energy generation process

<p>1</p> 	<p>Turbine</p>	
<p>2</p> 	<p>Transmission Lines</p>	
<p>3</p> 	<p>Penstock</p>	
<p>4</p> 	<p>Reservoir</p>	
<p>5</p> 	<p>Generator</p>	



**Annex to Worksheet B2 - The «Biomass Bingo» Cards**

**Card 1**

Corn Husks	Plastic Bottles	Manure	Coal
Olive Pits	Wood Chips	Natural Gas	Food Waste
Straw	Gasoline	Glass	Sawdust
Sugarcane Bagasse	Aluminum Cans	Steel Scrap	Oil

**Card 2**

Manure	Aluminum Cans	Corn Husks	Oil
Food Waste	Glass	Olive Pits	Coal
Steel Scrap	Wood Chips	Straw	Natural Gas
Gasoline	Sugarcane Bagasse	Sawdust	Plastic Bottles

**Card 3**

Straw	Oil	Plastic Bottles	Food Waste
Sugarcane Bagasse	Aluminum Cans	Corn Husks	Sawdust
Coal	Olive Pits	Glass	Gasoline
Steel Scrap	Manure	Wood Chips	Natural Gas

**Card 4**

Wood Chips	Gasoline	Food Waste	Plastic Bottles
Manure	Sugarcane Bagasse	Aluminum Cans	Straw
Natural Gas	Olive Pits	Oil	Glass
Sawdust	Coal	Corn Husks	Steel Scrap

**Card 5**

Olive Pits	Sawdust	Plastic Bottles	Corn Husks
Coal	Manure	Glass	Wood Chips
Aluminum Cans	Food Waste	Gasoline	Steel Scrap
Oil	Straw	Sugarcane Bagasse	Natural Gas