MODULE VI

Lesson Plan 1

Summary

Title

Introduction to energy storage

Duration	90 minutes
The age range of students	10 to 14 years.

Summary of the theme

This topic aims to give a general introduction to energy storage. A little more emphasis will be placed on electrical energy storage, as this is what we are most used to seeing in, for example, batteries in electronic devices.

Learning outcomes

Aim/Learning Objectives

- Understand the difference between power and energy.
- To learn about different forms of electricity production.
- Understand the concept of energy storage.
- Learn the main types of energy that can be stored.

Cross-cutting objectives

- Develop environmental awareness and ecological responsibility.
- Promote energy storage.
- Promote the use of clean and sustainable energies.

Connection with Sustainable Development Goals

This theme is aligned with SDG 7 "Ensure access to affordable, secure, sustainable and modern energy" - Target 7.2 By 2030, significantly increase the share of renewable energy in the energy mix; and Target 7.3 By 2030, double the global rate of improvement in energy efficiency.
This theme is aligned with SDG 11 "Make cities more inclusive, safe, resilient and sustainable" Target 11.3 By 2030, increase inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

This theme is aligned with SDG 12 "Ensure sustainable consumption and production patterns" - Target 12.2 By 2030, achieve sustainable management and efficient use of natural resources.

Implementation

Facilitation

- Make sure all resources are ready before the class.
- Make sure you always use recyclable or recycled materials.
- Promote an atmosphere of collaboration and respect for the environment.

Resources / Materials needed

No resources/materials are needed for this topic.

Ideas to continue

As a continuation of this topic, it is proposed to delve deeper into the storage of electrical energy in electric batteries.

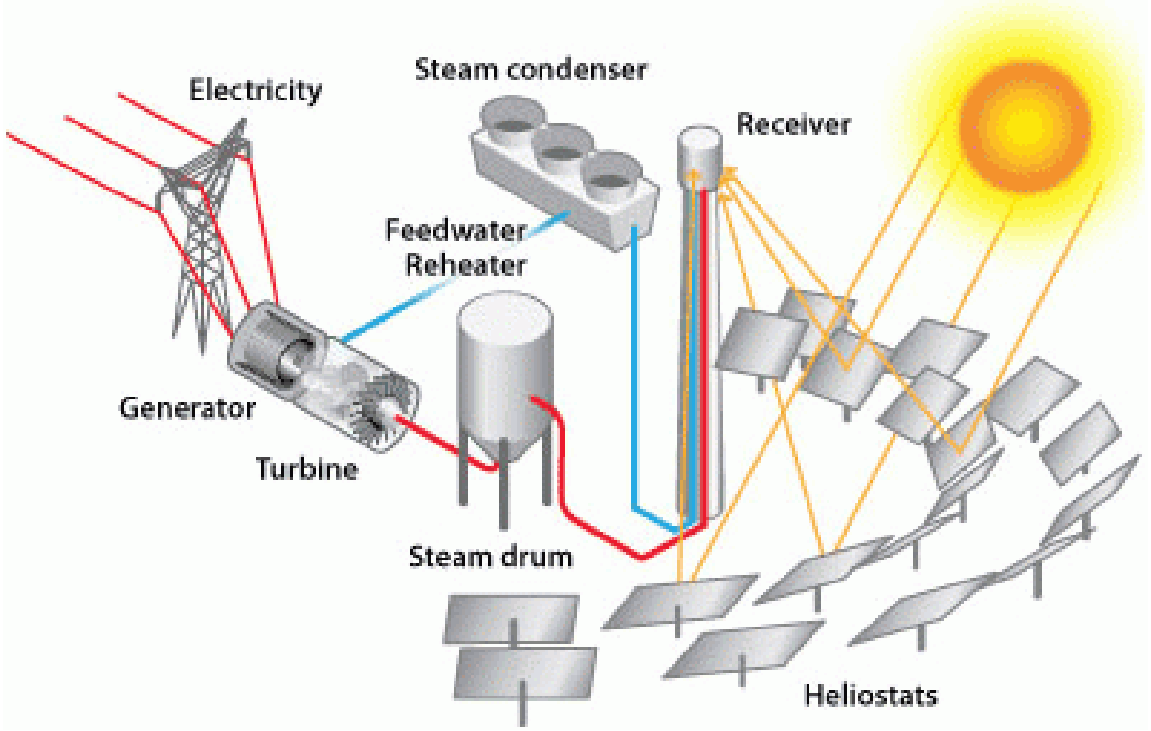
Source / Classroom materials and preparation

Real-time electricity demand website:
https://demanda.ree.es/visiona/home
Global Energy and Climate Network, Statistical Yearbook:
https://datos.enerdata.net/electricidad/estadisticas-mundiales-produccion-electricidad.html
Basic videos on energy production:
https://www.youtube.com/watch?v=0PpO-2mEO_0

Topic outline

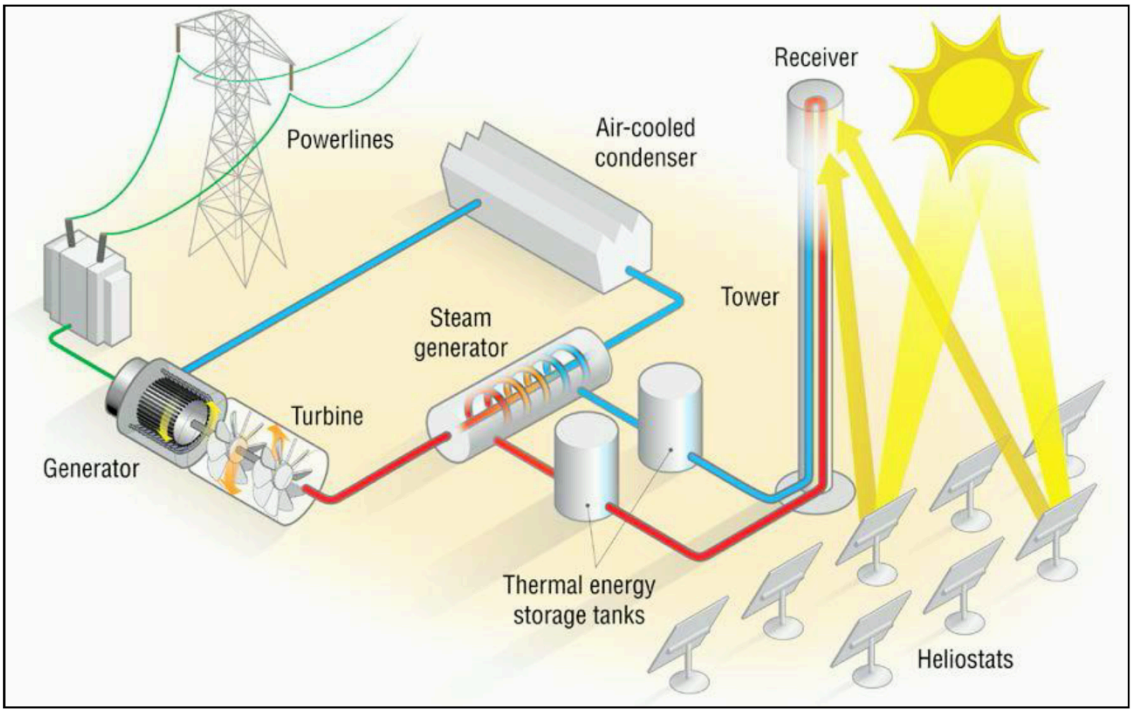
Timing	Step-by-step instructions
10 min.	Introduction to the subject: Present the objectives of the topic, emphasising the importance of being able to store energy because there are times when it is "leftover" and can be used later before turning on other power plants that generate energy at a higher cost. Talk about energy surpluses (more production than necessary) and the solar surplus, which should be the most well-known. Domestic solar installations generally generate more energy than they consume, but using this energy is not rewarded because the system's control becomes more complicated. The production of a power plant is very controlled, but the excess production of solar energy in homes depends entirely on the consumption of the home at any time.
10 min.	Difference between power and energy: Explain the main difference between power (instantaneous) and energy (cumulative). Power is the amount of work done per unit of time. It is typically measured in Watts but is also widely used in Steam Horsepower (1 hp = 736 W). Energy is the capacity to do work. It is typically measured in watt-hours, which is the sum of the powers produced (if the power is constant, it would be P-t); for comparison, the *ton of oil equivalent* (toe) is also used, which is the energy that one ton of oil is capable of generating (1 toe = 11,630 kWh). This can be understood more clearly in a car: the engine can have a fixed power of 150 HP, but the time it is in operation depends on the fuel tank we have (the energy stored to feed the engine). View a real demand curve (https://demanda.ree.es/visiona/home), focusing only on real power (yellow curve). The curve is formed by the power demanded at each instant; the energy would be the area under the curve (a kind of accumulated power).
20 min.	Forms of electricity production: Explain the importance of electrical energy today (https://datos.enerdata.net/electricidad/estadisticas-mundiales-produccion-electricidad.html) and see how it has evolved over the years. You can see the data for a specific country on the website, which allows us to compare the differences between cultures, development, and so on.

	To present the different types of large-scale electricity production: Hydro, Wind, Thermal, Thermal, Nuclear, Solar... In the videos you can see a brief overview of how energy is generated; the logical steps would be: Power is generated in an electric generator. The generator must be turned to produce electricity. Hydropower, like wind power, can turn the generator directly using the turbine (hydro or wind). Thermal power generally uses steam to turn a steam turbine, and depending on how we heat the water, we can find different types of power plants (coal-fired, geothermal, nuclear, etc.). Gas turbines are a particular type of engine that does not use steam to turn the generator. They are heat engines similar to conventional car engines (with higher efficiency). Nuclear power plants use the heat from a decay reaction of atoms to heat water. Solar farms (with photovoltaic panels) are different; they generate direct current and have to be switched to alternating current. They have no moving parts like the generators of the other types of power plants.
30 min.	Explain the concept of energy storage: See some actual consumption curves (https://demanda.ree.es/visiona/home) and the associated cumulative generation curve (e.g. https://demanda.ree.es/visiona/peninsula/demandaqh/acumulada/2024-9-2). In the cumulative curve, energy types can be removed to see the variability of the different types. Nuclear: Constant (cannot be varied for safety reasons). Cogeneration and waste: dependent on one industry. Wind and solar photovoltaic: weather-dependent. Hydro and Combined Cycle: demand-driven (they adjust). Solar thermal: This depends on the weather, but it is produced at night. ... Explain how beneficial it would be to have constant production, with variations being taken over by energy storage systems. The more constant the production, the lower the cost. Returning to the previous example, it could be said that cars consume more if we accelerate and brake frequently than if we maintain a constant speed. Focusing only on solar thermal from the previous website, explain how these plants work based on the following image. These power plants, like thermal power plants, use a steam turbine to move the electric generator, but solar energy is used to generate steam. Water cannot be evaporated simply by "exposing" it to the sun, so what is done in these power plants is to concentrate the sun's rays on a single point through mirrors, and at that point, temperatures of over 250ºC are reached, sufficient to generate the steam that will move the turbine.

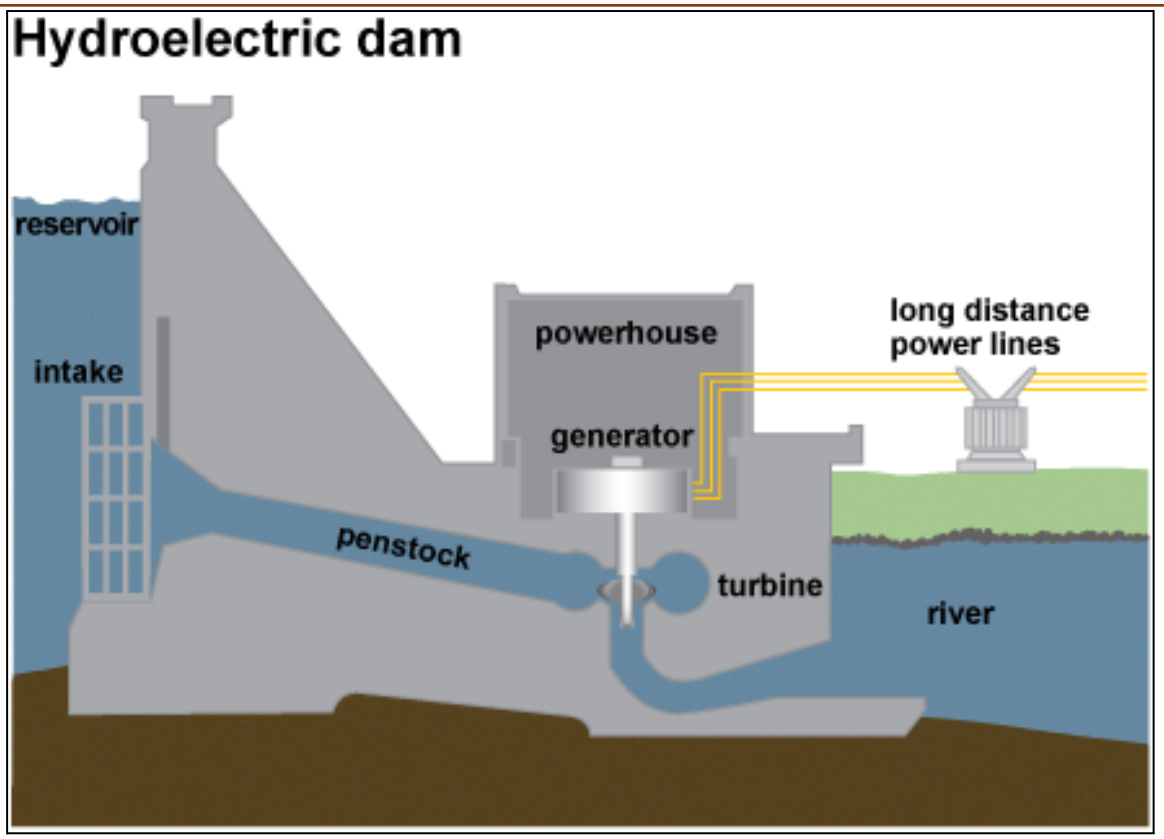


https://www.energy.gov/sites/default/files/styles/full_article_width/public/power_tower.gif?itok=v5ubFiZ3

The most modern plants of this type already incorporate an energy storage system, in this case, thermal energy storage. What is done is to heat specific substances (sodium salts as a general rule), which is used to generate steam; not directly the sun's rays. These substances allow only the energy needed to produce steam, and the rest is stored (by increasing the temperature of these sodium salts) to be used and continue generating steam even when there is no solar energy. The idea can be seen in the following image, which allows the production of electrical energy during the first hours of the night (until the energy accumulated during the day is used up).



	https://pub.mdpi-res.com/sustainability/sustainability-12-00127/article_deploy/html/images/sustainability-12-00127-g001.png?1577089148 The following image shows a power plant of this type (with storage), where the two thermal energy storage tanks can be seen, as well as the field of mirrors that are oriented at all times to the receiver, located at the top of the tower.  https://www.powermag.com/wp-content/uploads/2015/06/solar-storage-figure-2.jpg
20 min.	Extrapolate to other types of energy other than electricity: Describe the types of energy that can be stored and used (potential, kinetic…). Potential and kinetic energy are the other two main types of energy stored for later use. The first can be seen directly in reservoirs, where water is stored at a height greater than the turbine's (a simple image is shown in the following image). This water at height has potential energy, which will later be transformed into electrical energy when the turbine spins.



https://www.eia.gov/energyexplained/hydropower/images/hydro-dam.png

Kinetic energy, on the other hand, is stored in flywheels, and one of the "devices" where we can see it is in spinning tops, like the one in the following image. Spinning tops must keep spinning to stay "upright," and when we spin them, we provide them with kinetic energy. As this energy is used up by friction with the ground and air, the top loses speed until it falls again.



https://upload.wikimedia.org/wikipedia/commons/thumb/9/90/A_tough_gang_of_Spinning_Tops.jpg/640px-A_tough_gang_of_Spinning_Tops.jpg

Formative evaluation

For this theme, essentially a single formative assessment tool is proposed:

- Group discussion:
  Description: Divide students into groups to discuss specific topics and then share their findings with the class.
  Example: Ask each group to develop an idea on how to apply energy storage in their daily lives. The easiest example would be the electric water heater, which stores thermal energy so that it does not have to be heated when consumed, or the heating accumulators, which accumulate energy at night (for example) to use throughout the day.

Feedback

This example is proposed (you can adapt/modify it):

Net Promoter Score (NPS) is a widely used tool to measure the loyalty and satisfaction of customers or, in an educational context, students. It measures the likelihood that students will recommend the subject or course to others.
How to analyse and apply NPS is explained below:

Development of the NPS question:

- Main question: "On a scale of 0 to 10, how likely are you to recommend this topic to other students?
- Follow-up questions: "Why did you select this score?" and "How can we improve this issue?

Collection of responses:

- Digital surveys: Use online tools such as Google Forms, SurveyMonkey, or Typeform to collect student responses.
- Paper surveys: Paper questionnaires are distributed at the end of the lesson for students to complete. A template for collecting responses with paper surveys is shown in the Annex.
- Interactive applications: Interactive applications such as Quizziz, Mentimeter, or Kahoot! are used to collect answers in real-time.

Classification of responses:

- Promoters (Score 9-10): Students are very satisfied and likely to recommend the subject.
- Passive (score 7-8): Satisfied, but not enthusiastic students; they could easily change their minds.
- Detractors (Score 0-6): Dissatisfied students who are unlikely to recommend the subject; they could provide constructive criticism.

Calculation of NPS:

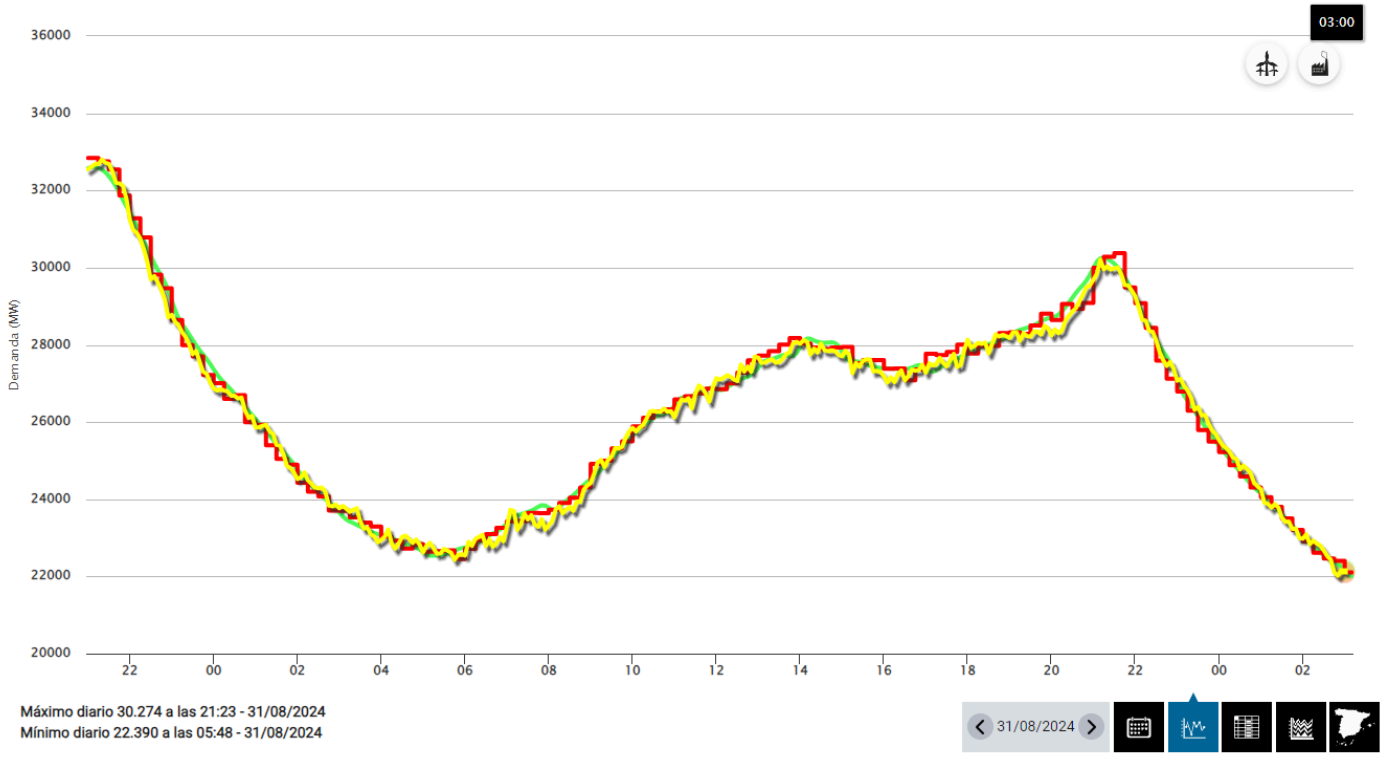
- Formula: NPS = % of promoters - % of detractors.
- Score interpretation: NPS ranges from -100 to +100. A positive score (above 0) is generally good, and a score above 50 is excellent.

Analysing and using comments:

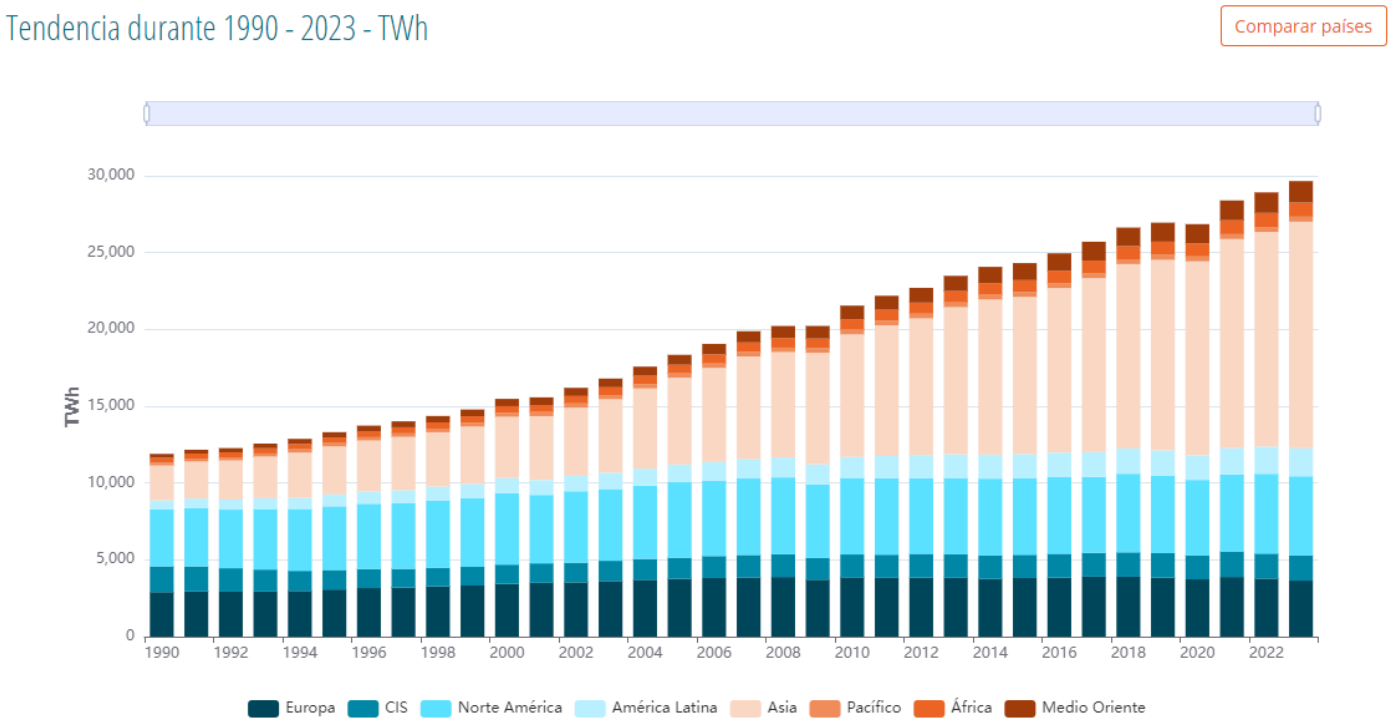
- Review the comments to understand the reasons behind the scores.
- Identifies patterns and specific areas for improvement among detractors and passives.
- Use the promoters' positive comments to reinforce the positive aspects of the issue.

Annexes

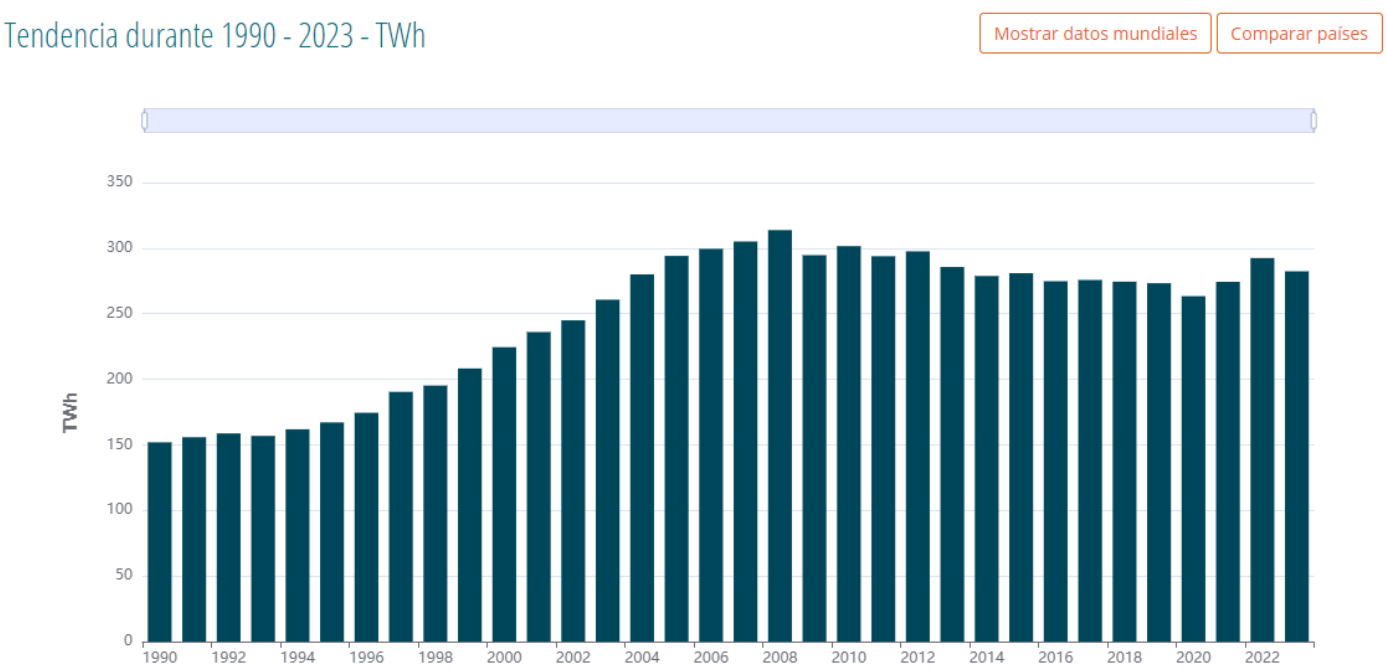
Example of a demand curve:



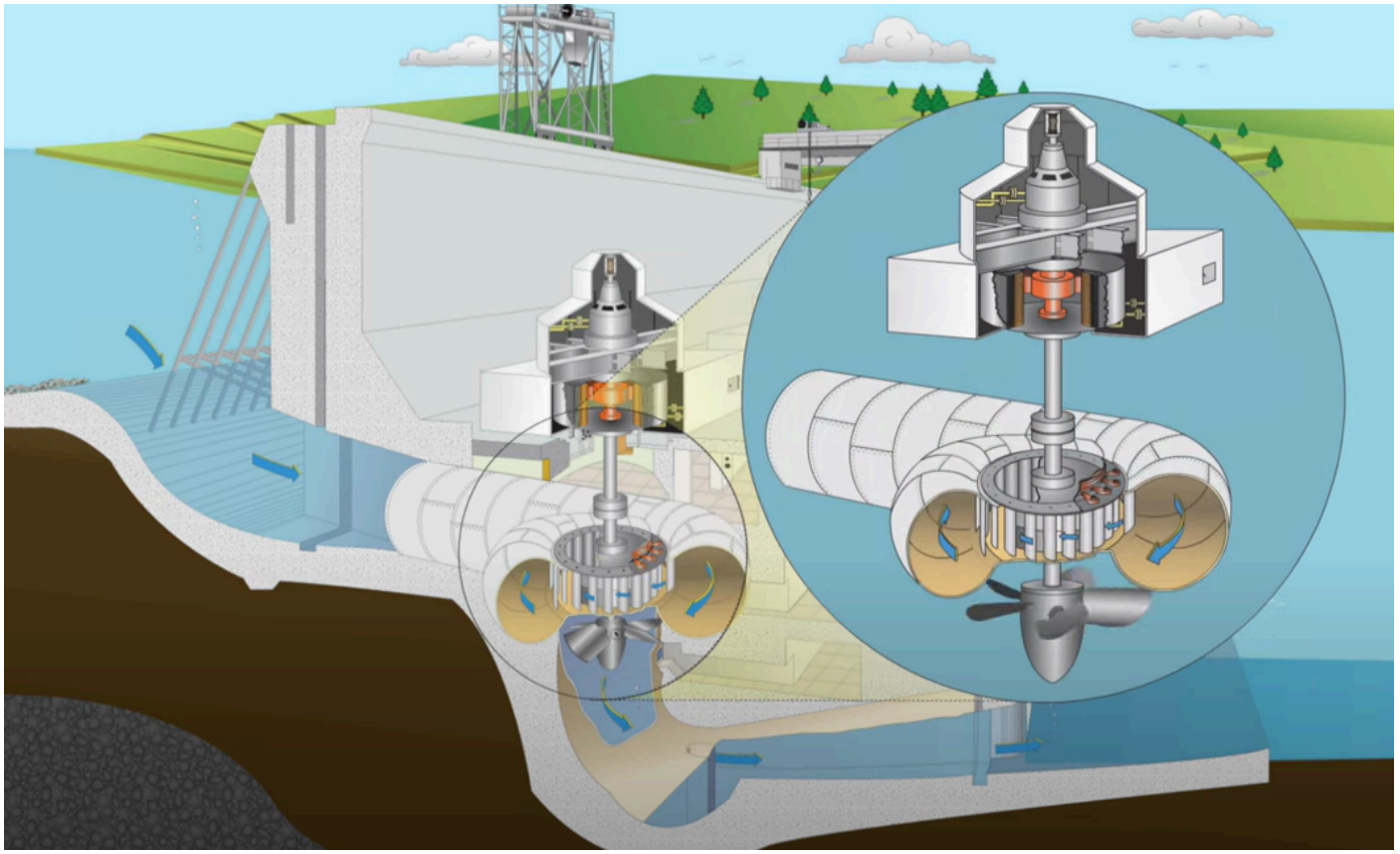
Example of the evolution of electricity consumption worldwide:



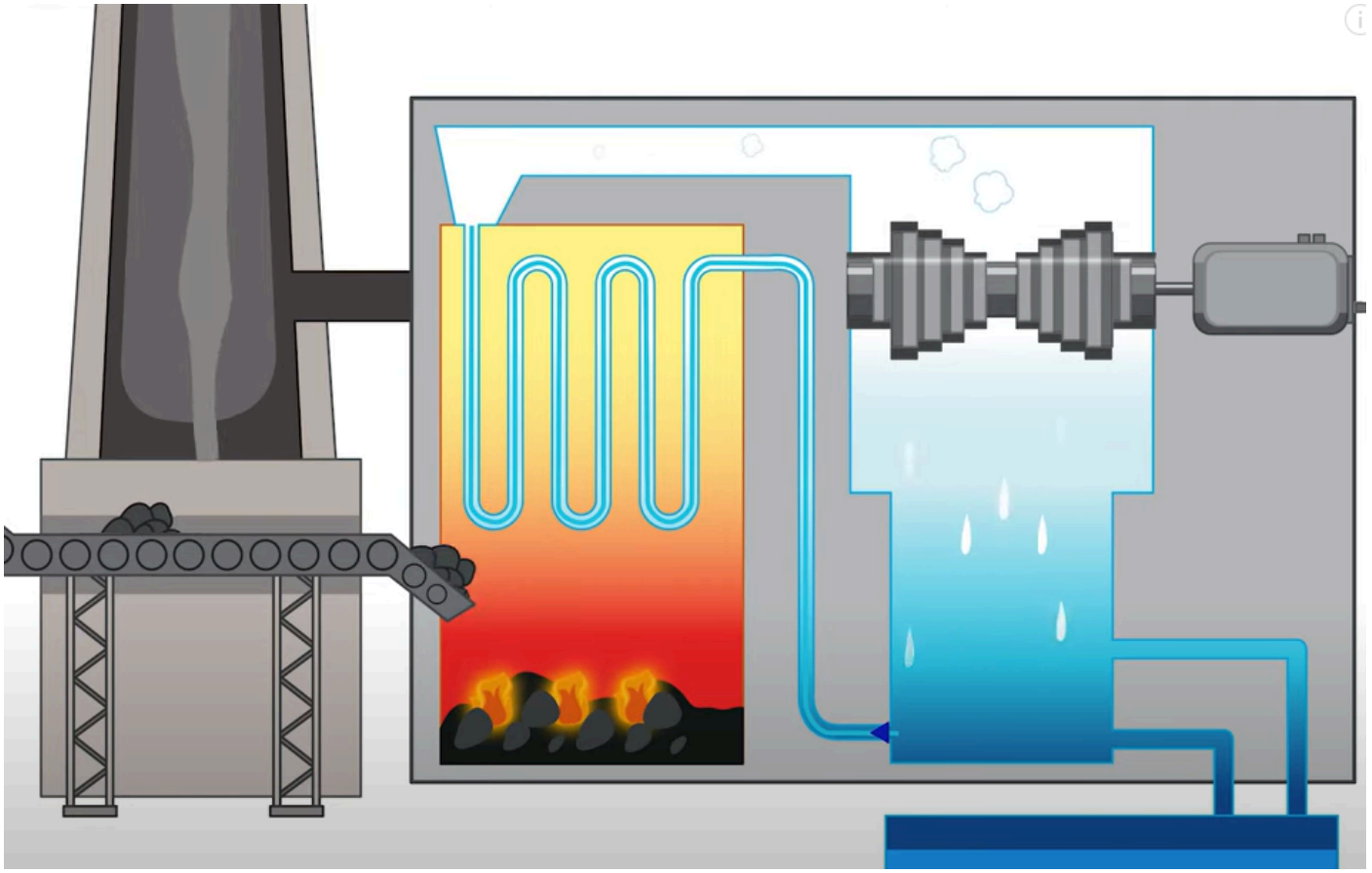
Example of the evolution of electricity consumption in Spain:



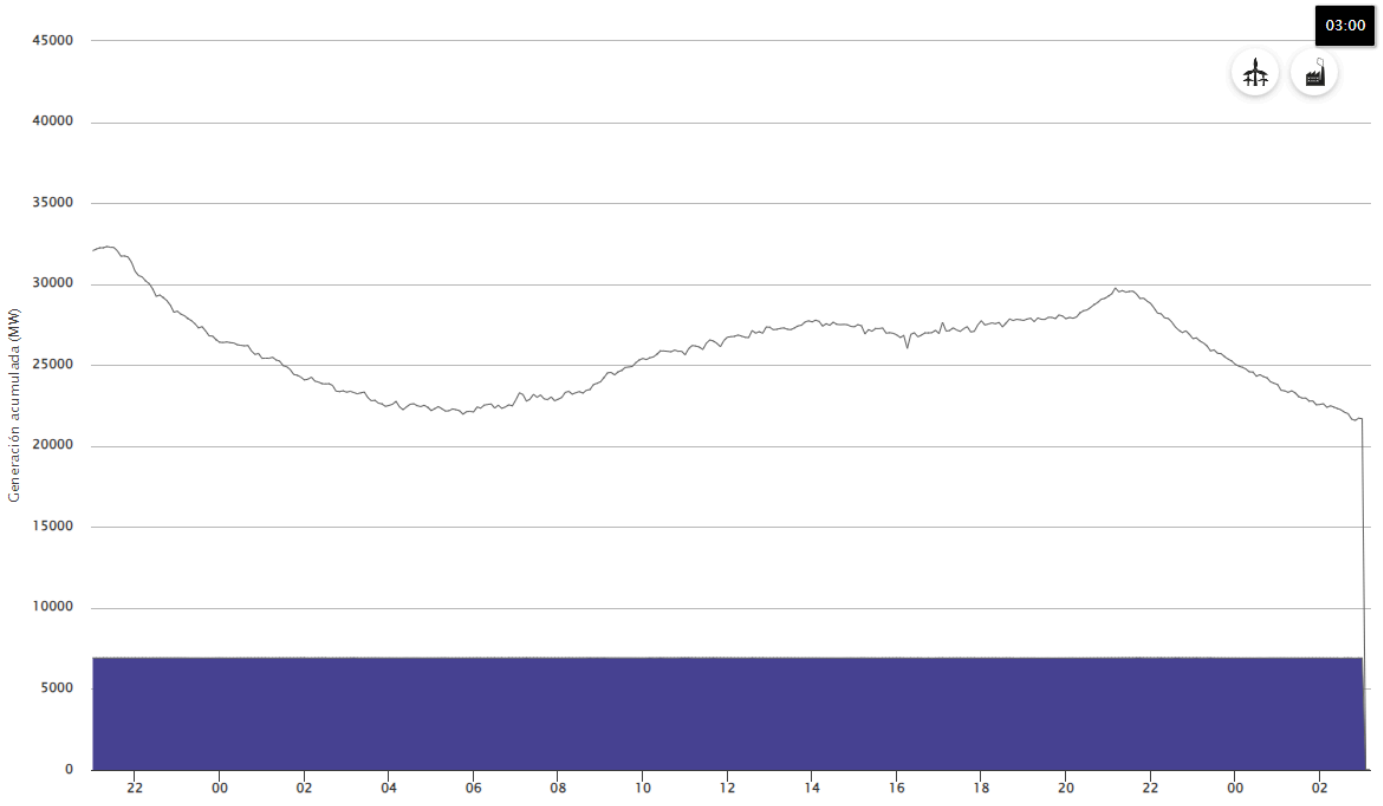
Example of a hydroelectric power plant:



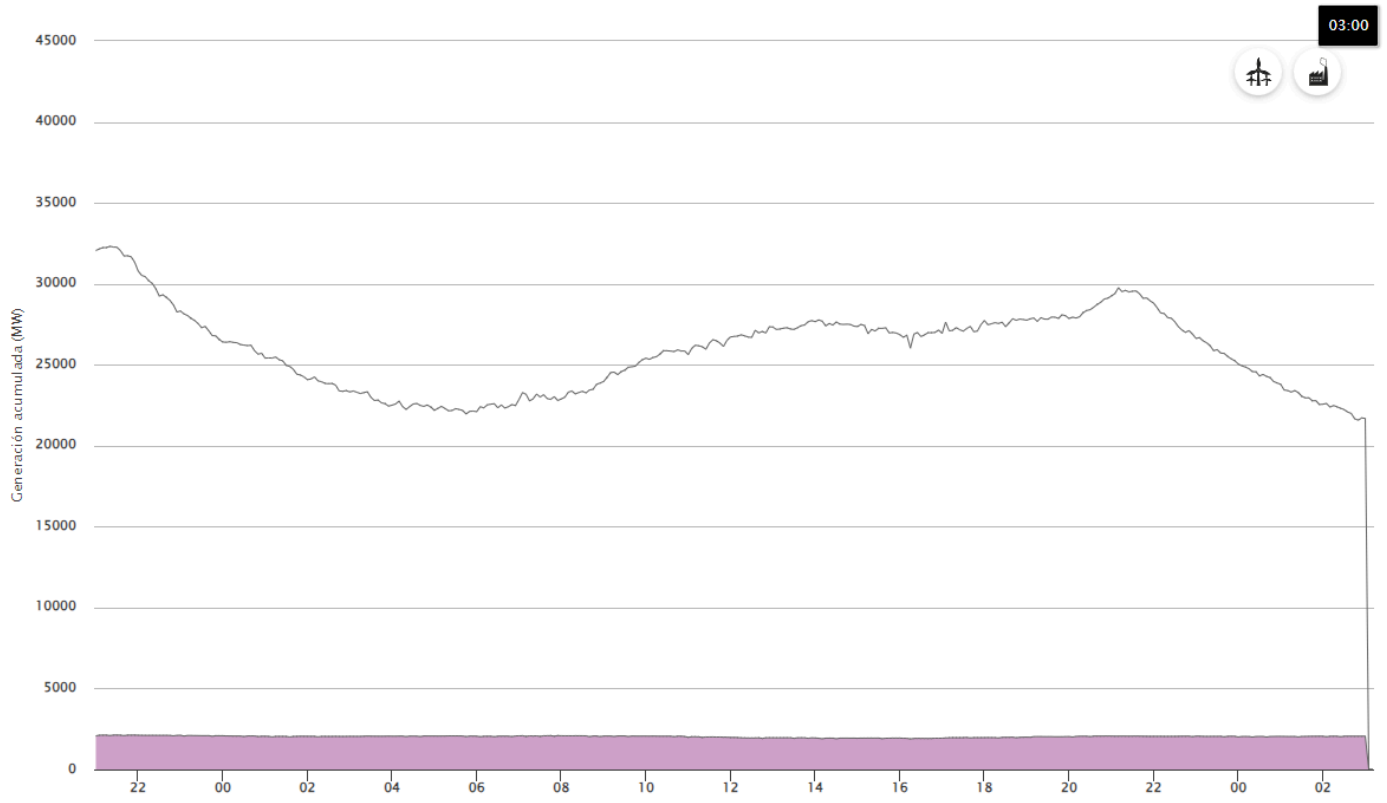
Example of steam generation with fuels:



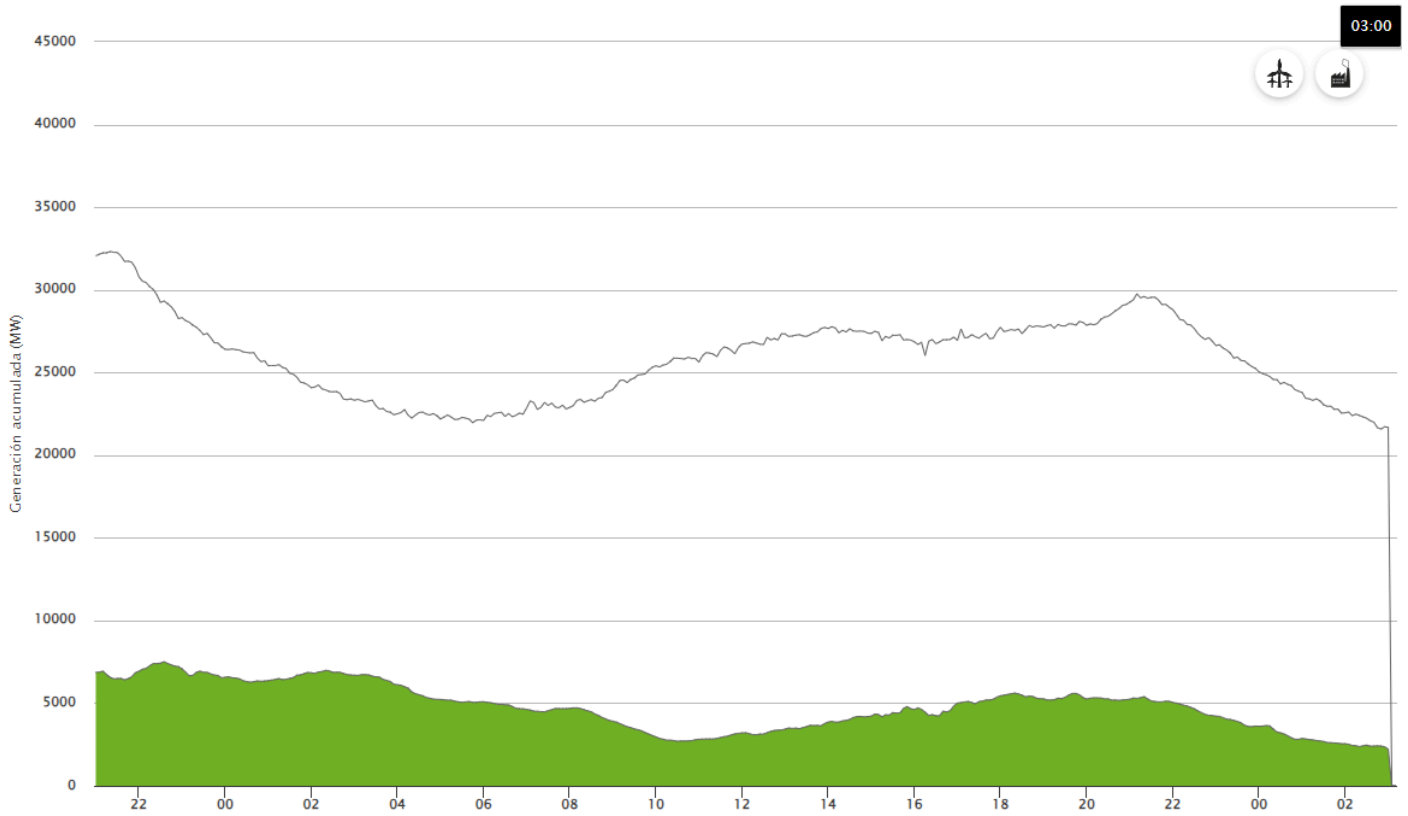
Example of cumulative Nuclear generation:



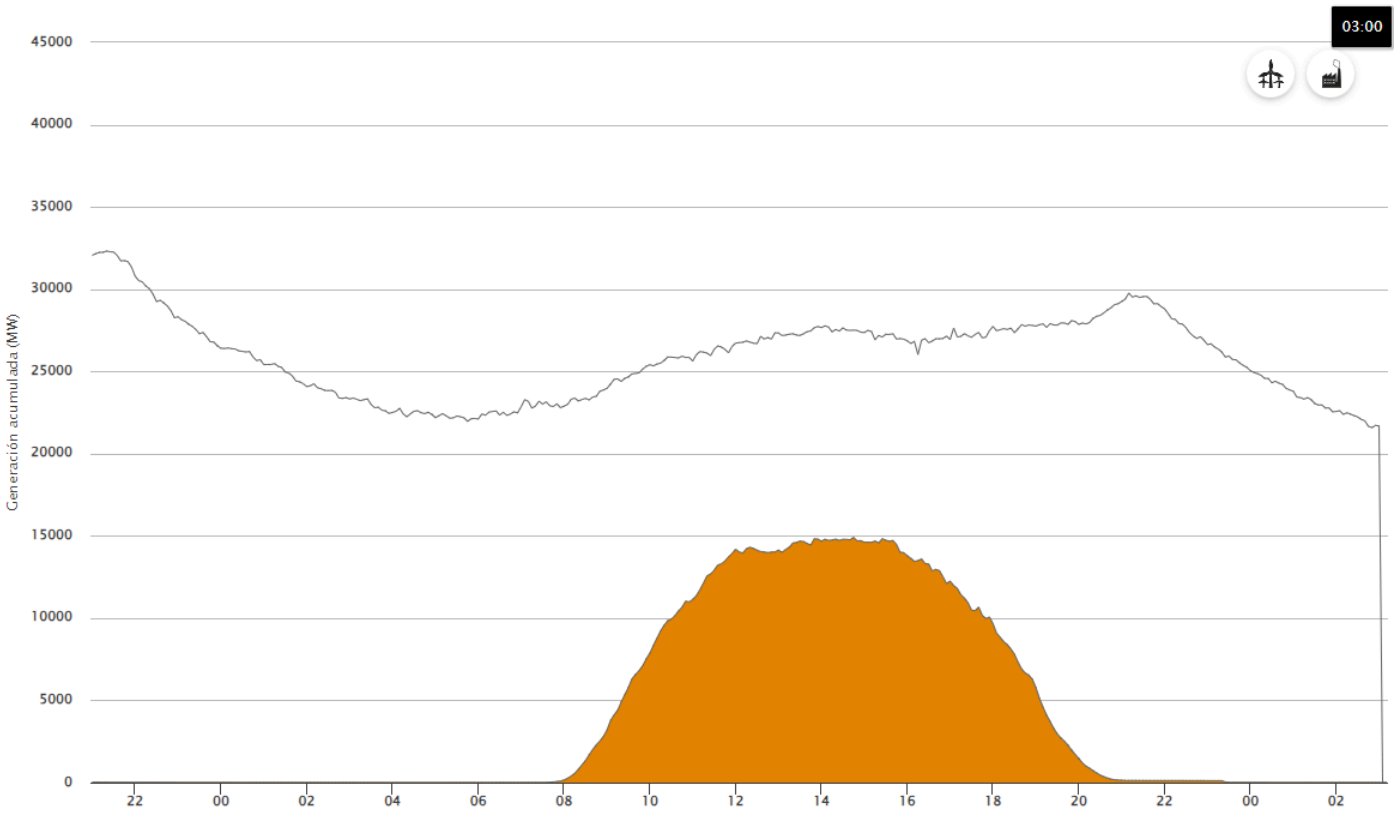
Example of cumulative generation, Cogeneration and waste:



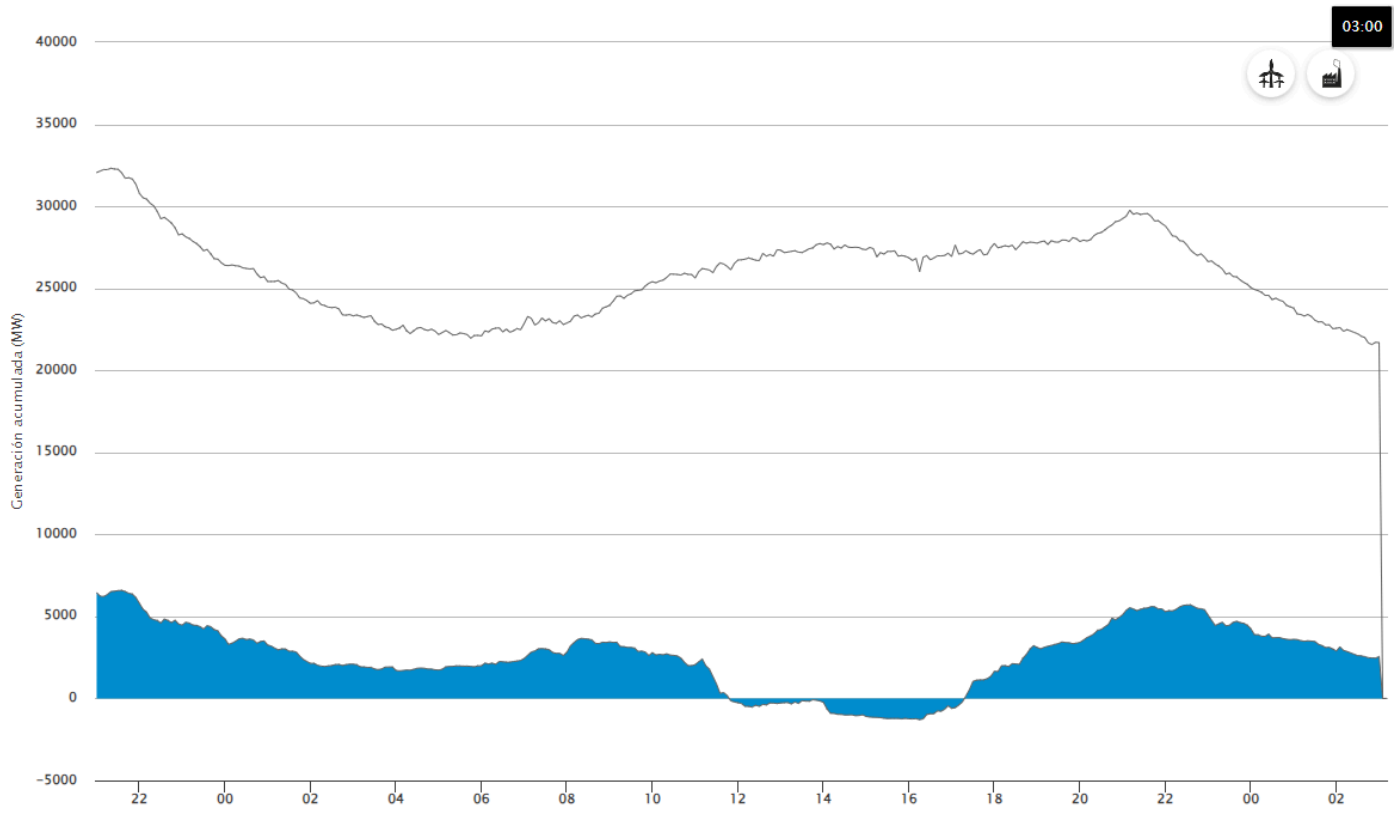
Example of cumulative wind power generation:



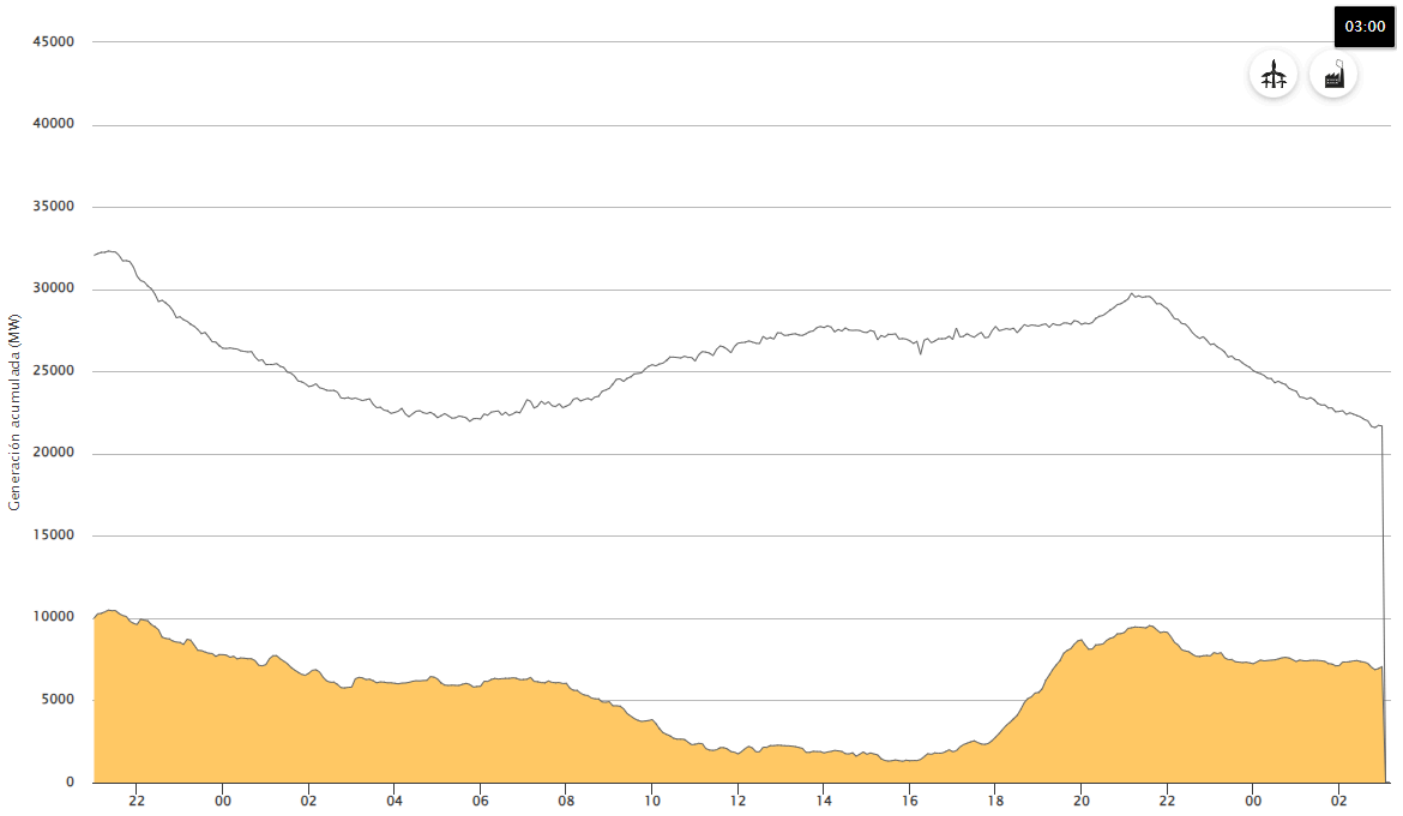
Example of cumulative generation Solar photovoltaic:



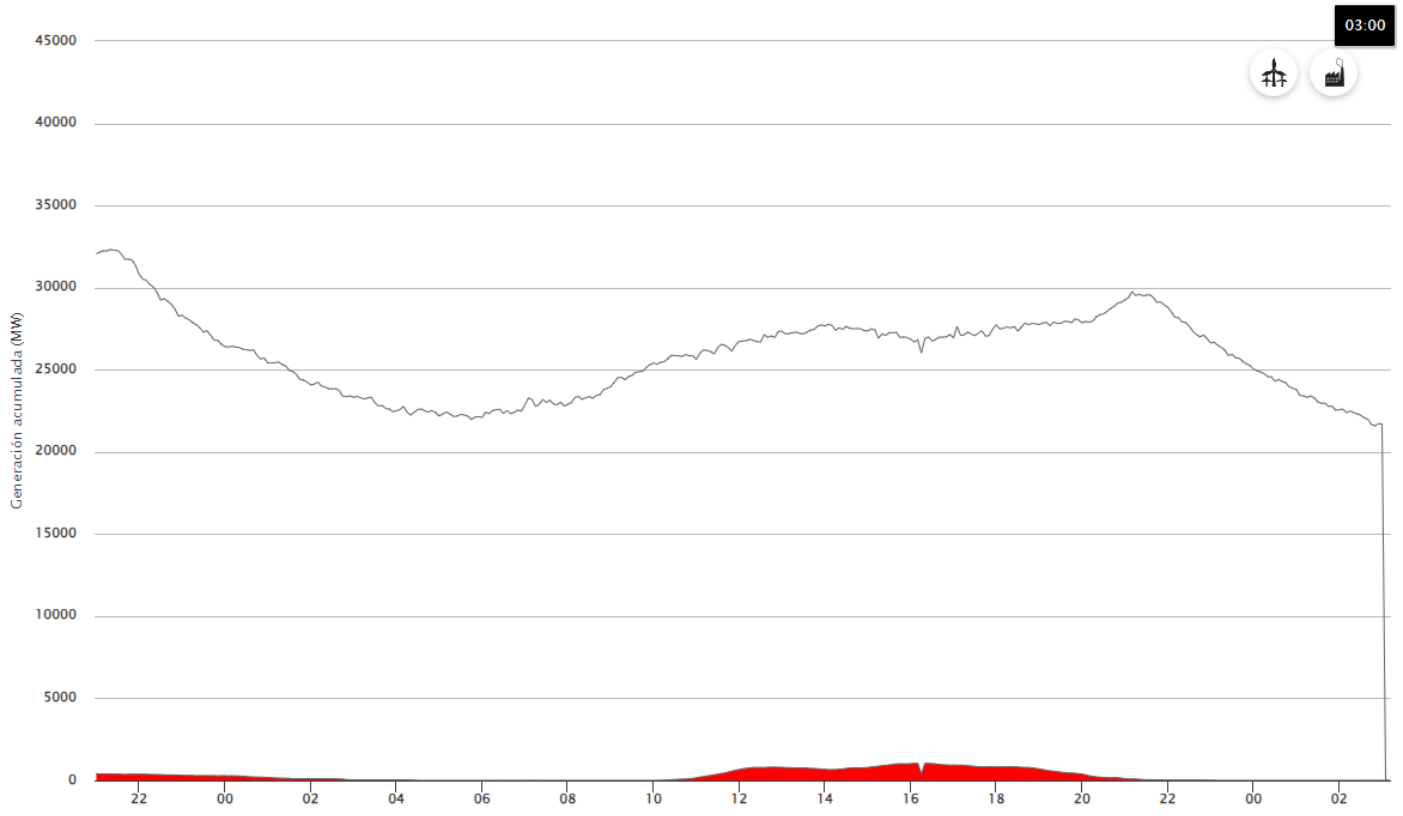
Example of cumulative generation Hydro:



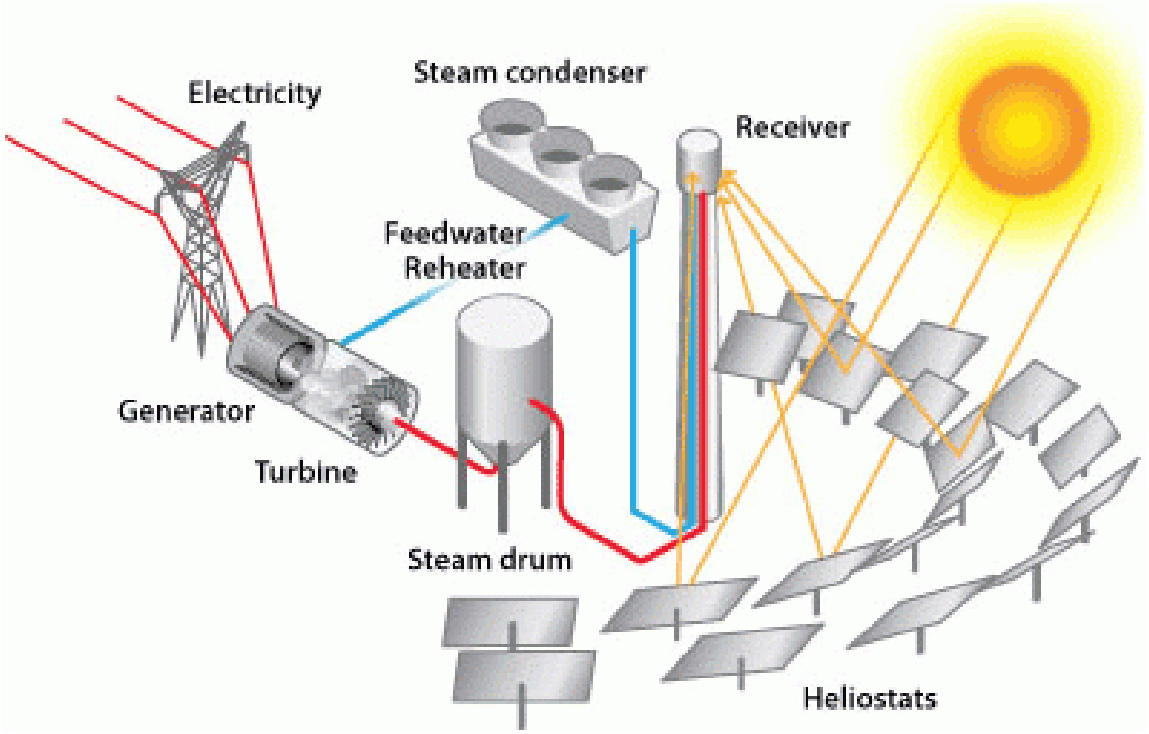
Example of cumulative generation combined cycle:



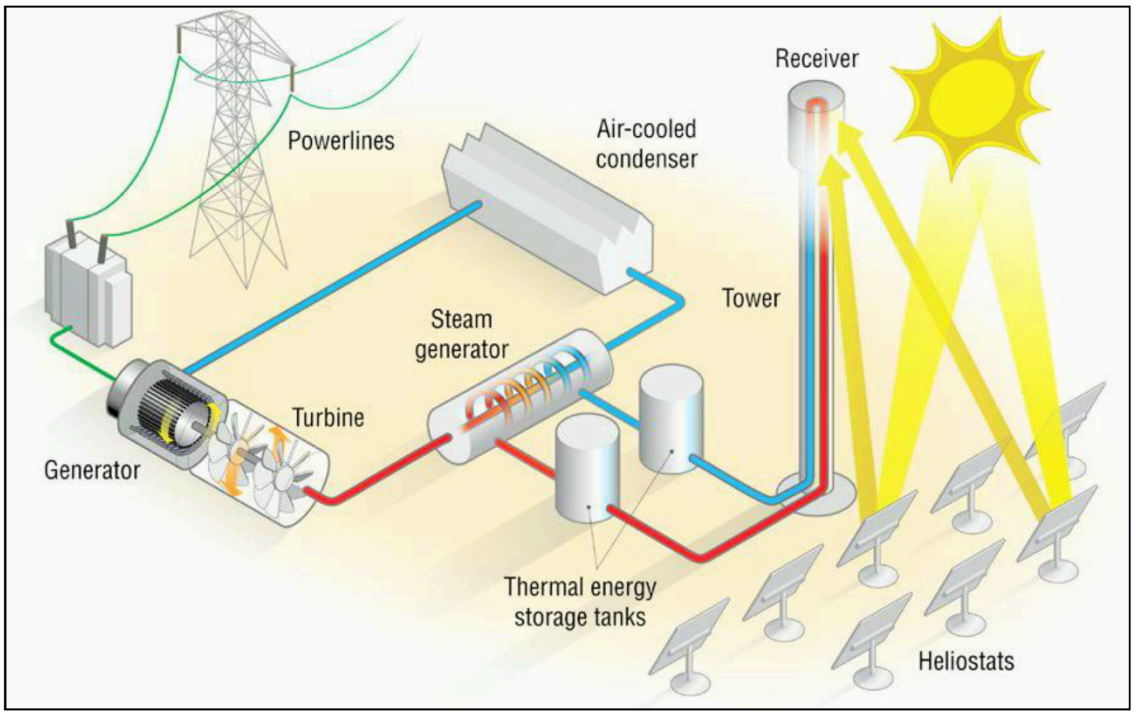
Example of cumulative generation Solar thermal:



Example of the basic operation of a solar thermal system:



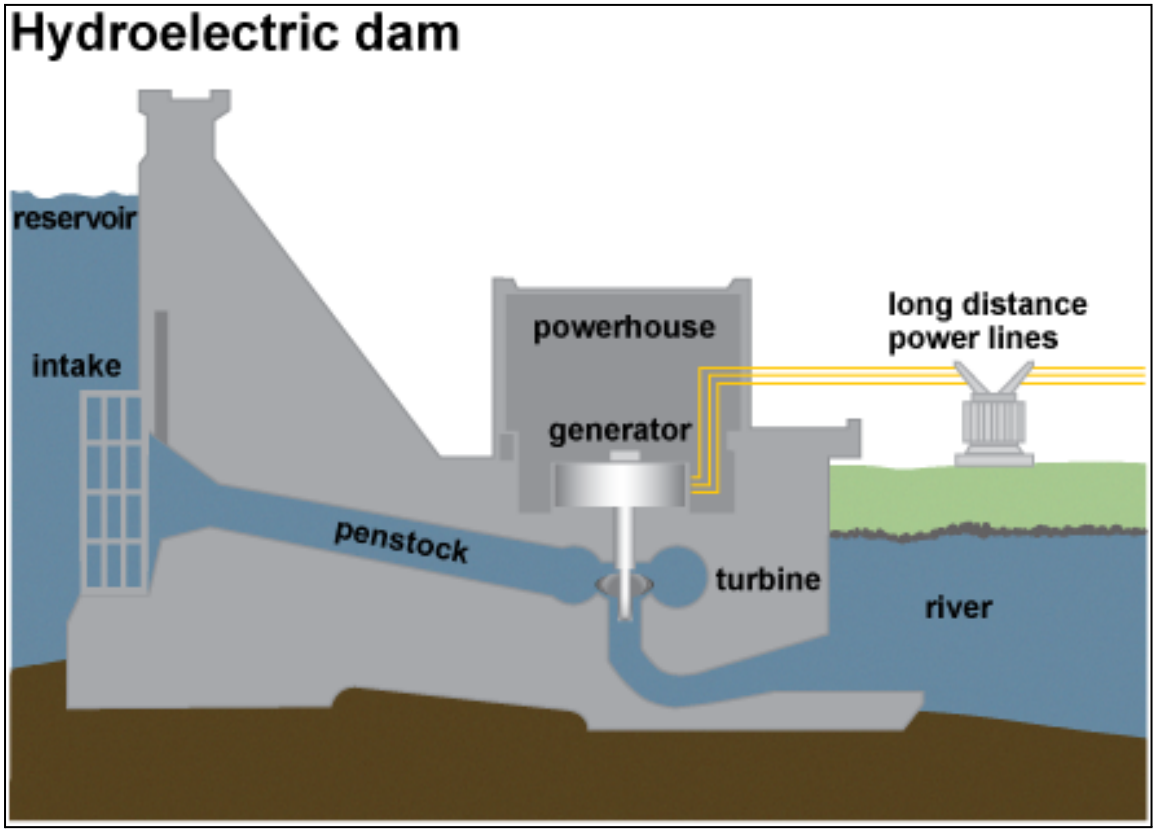
Example of a solar thermal system with storage:



Example of a real solar thermal system with storage:



Example of potential energy storage:



Example of kinetic energy storage:



QUESTIONNAIRE TO COLLECT FEEDBACK ON THE TOPIC

On a scale of 0 to 10, how likely would you recommend this subject to other students?

0	1	2	3	4	5	6	7	8	9	10

Not likely at all — Extremely likely

Why did you choose that score?

How could this issue be improved?