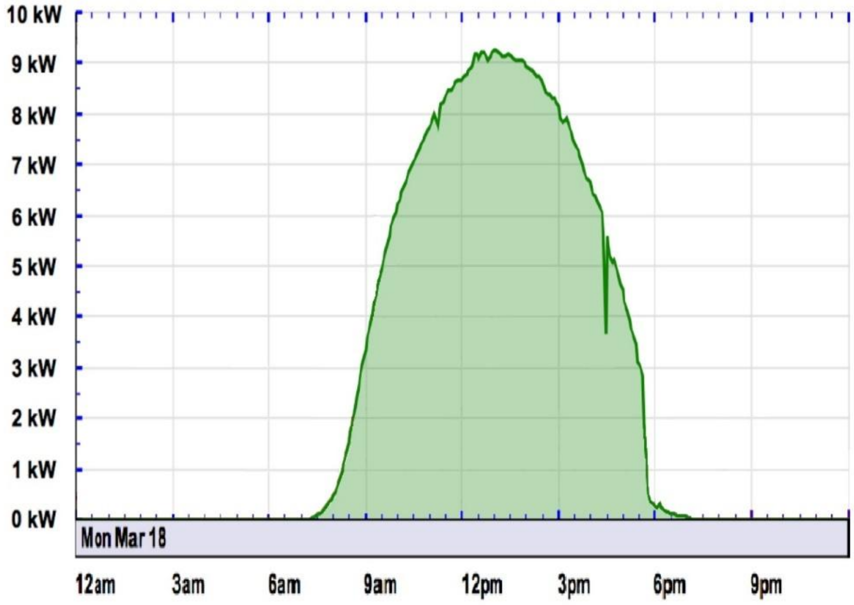
Funded by the European Union

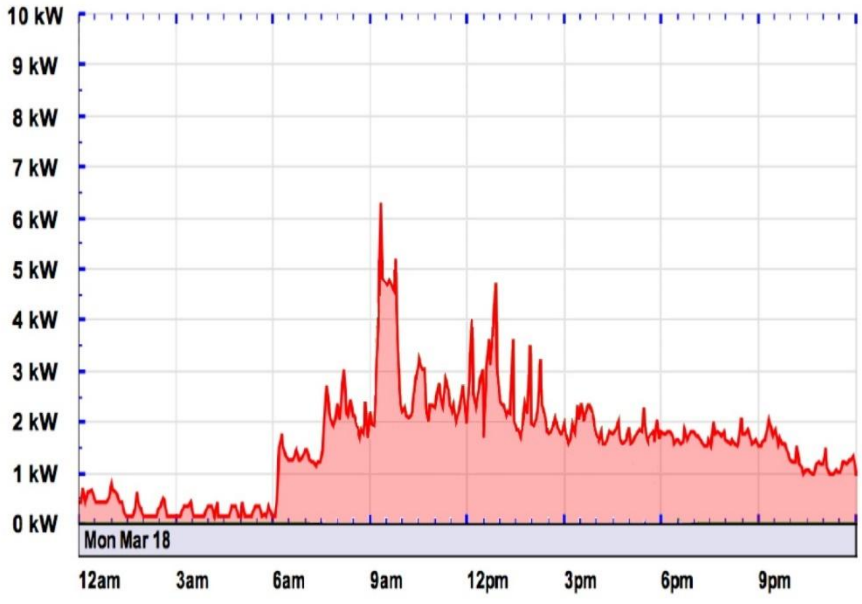
Teaching Guide for Teachers

Mini-PBL project	
Teacher data sheet: Teaching Guide	
Title	Generation and consumption of energy in a classroom at University of Life
SDG attended	Using this UN graphics, we mark such SDG which this project works. 
Content units	Derivatives and integrals
Sessions	3 sessions of 1h
Hours of autonomous work	1h
Competences to be developed	**Reasoning and modeling** ● Develop thinking strategies to solve real problems ● Explore, analyze, and apply mathematical ideas using reason and technology ● Estimate reasonably and demonstrate fluent, flexible, and strategic thinking about graphs ● Model with mathematics in situational contexts ● Think creatively and with curiosity and wonder when exploring problems **Understanding and solving** ● Develop, demonstrate, and apply conceptual understanding of mathematical ideas through play, story, inquiry, and problem solving ● Visualize to explore and illustrate mathematical concepts and relationships ● Apply flexible and strategic approaches to solve problems ● Solve problems with persistence and a positive disposition

	● Engage in problem-solving experiences connected with real-life examples. **Communicating and representing** ● Explain and justify mathematical ideas and decisions in many ways ● Represent mathematical ideas in concrete, pictorial, and symbolic forms ● Use mathematical vocabulary and language to contribute to discussions in the classroom ● Take risks when offering ideas in classroom discourse **Connecting and reflecting** ● Reflect on mathematical thinking ● Connect mathematical concepts with each other, other areas, and personal interests ● Use mistakes as opportunities to advance learning ● Incorporate First Peoples worldviews, perspectives, knowledge, and practices to make connections with mathematical concepts
ICT tools to be used	- Spreedsheets for calculation - DESMOS Graphic Calculator
Context: project statement	All of our energy, except the nuclear, comes from the sun. The sun can produce power directly with photovoltaic energy. As the earth spins and orbits the sun, seasons change and, as a result, there are temperature changes. These temperature changes are the drivers of weather and wind to produce wind power. Moreover, the sun evaporates moisture, lifting it high in the sky, which ultimately falls out in the form of rain and snow. On its way to the sea in liquid form, we have hydroelectric power plants. Lastly, we have organic matter consisting of Cs and Hs (carbon and hydrogen compounds) that can be burned to produce steam to generate electricity. Natural gas, coal, and biomass are examples. Production of organic matter is ultimately powered by the sun. It all seems in a perfect equilibrium. Nevertheless, this natural equilibrium is menaced by the rising demand for more energy, especially in developing economies, which increase the greenhouse gas emissions. Energy consumption and production account for about two-thirds of global emissions of these gases. Moreover, 81% of the global energy mix is still based on fossil fuels - a percentage that has not budged in decades. These gases are introducing climate changes, which affects the natural energy consumption and production equilibrium. A transition to a more inclusive, sustainable, affordable, and secure global energy system is imperative.
Tasks and problems	The slightly bell-shaped curve (the green color), $g(t)$, represents the power generated from solar panels installed at the University. The irregular curve (the red color in the graph), $c(t)$, represents the consumed power. The vertical axis is the power axis. The range is 0 to 10 kilowatts (kW). The horizontal axis is the time axis. The domain is from 12:00 noon on Monday, March 18 to 12:00 on Tuesday, March 19, 2015. Each of the

separators on the time axis represents half an hour (bold markers are spaced 3 hours apart).





Task 1:
Consider the green curve, $g(t)$. What does the approximate value of the area between any two points t= a and t= b (a<b) on the curve represent? Indicate the units. Justify.

Task 2:
Repeat exercise 1 for curve $c(t)$.

	Task 3: Draw, in two graphs, on the time axis, points equidistant by $\Delta t = 2$ hours. Apply Riemann sums to approximate $G(\mathrm{T})$, and $C(\mathrm{T})$, where $G(\mathrm{T})$ and $C(\mathrm{T})$ are the cumulative energy generated and consumed, respectively, between t = 0 and t = T. **Task 4:** Using the Riemann sums you drew for the previous exercise, fill out the table below, of (approximate) values of $g(T), G(T)$, $c(T), C(T)$. **Task 5:** Repeat tasks 3 and 4 for $\Delta t = 1\ h$. Compare the results with the ones obtained in Task 4. **Task 6**: Fill in the blanks: *The function G(T) above, representing energy generated, has something of an elongated "S" shape. On the other hand, the graph g(t) of generated power (see, again, the graph on the last page), which is the <u>derivative</u> of generated energy, has something of a <u>bell</u> shape.* *<u>Rmk</u>*: The derivative of an "S" curve is generically a bell curve. **Task 7:** Comment on the obtained results from a Sustainable point of view. Are the photovoltaic panels worth it? Can you save money? Are they useful for your university? Does your university have photovoltaic panels? **Task 8:** (ask for help from your Electronic Teacher) Build a motherboard to mimic a simple photovoltaic solar panel (8 cells, for example). Use easy and cheap electric parts.
Outcomes expected	- Graphics fitting the solution; - Tables of data used/obtained in solutions; - Numerical results explained and put in context; - Capture of ICT tools solutions used; - Sequence of steps followed; - Remark computations done by hand and done by ICT tools; - Provide complete answer to questions; - All the results must be presented in the context of the problem;
Guide for Learning	At the beginning of the course, the students need guides on new activities, and feel your support on a well-structured pack of suggestions on how to address the problems posted. Namely:

	- Read carefully the problem statement and the tasks posted. Always maintain a global view of all the projects. - Identify, or try to do a first draft match, the content units of your lecture notes involved in every task. - Take your lecture notes open and review before starting to solve the problems. - Match output expected with the tasks posted, at least as first draft approach. - Follow the order of the tasks, try to increase the knowledge of the problem while you are solving the activities. - Always think that maybe there are different ways to solve a problem. - Use ICT tools to avoid hard computations and check your solutions are correct in different ways if possible. - The solutions are always part of a context, expressing such a final solution totally integrated in the problem posted. - Be sure you answer the complete questions. - Always try to solve the questions by yourself. - If the project can be done in groups, discuss with the groups the proposed problem, to confirm and detect fails or weaknesses, confront strategies, discuss presentation format, etc. Working in groups doesn't mean work less but work better.
Guide for Teaching	Some hints needed to present and launch the mini-PBL to students - Do a small Introduction concerning Energy consumption, added to the Climate Change crisis we are currently living in. - Do a small introduction about the relations between power and energy, with the basic equations. - Students will form groups of 4 students and solve the mini-PBL using the eduScrum methodology. - The students should do each exercise in a sequential order, starting from Task 1. - The students should be able to thoroughly read and interpret the numerical results from a mathematical and the real-life example point of view. They should include also a discussion of the climate change crisis and enumerate some strategies they could apply at home or even at university to save resources, namely reduce energy consumption. They should also mention how this mini-PBL helps them identify the Sustainable Development Goals 4 And 7.
Assessment	- Final report; - Oral presentation; - Peer-assessment: students will apply peer-assessment for their periodic performance using online peer assessment tools, e. g. WebAVALIA (https://webavalia.wixsite.com/webavalia/home).

Others: References	[Active Learning Calculus I (colorado.edu)](#) https://eduscrum.org/about-us-and-how-we-try-to-make-it-happen/ More refs on active-learning tools: https://scholar.google.com/citations?hl=en&user=Aw39XwEAAAAJ&view_op=list_works&sortby=pubdate https://www.youtube.com/watch?v=mQ_mbDAB1us (there are more examples online)

Learning Guide for Students

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Student data sheet: Learning Guide	
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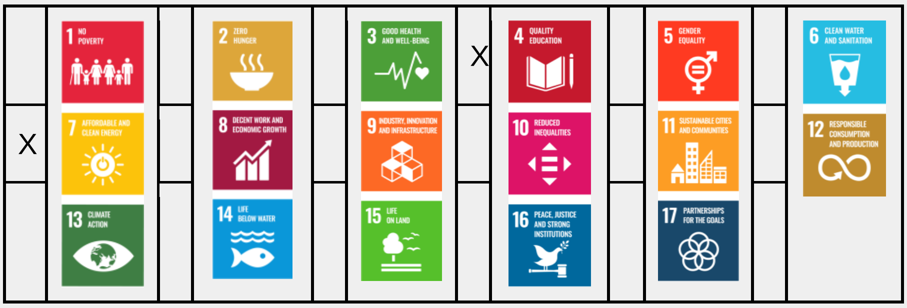
SDG attended	Using this UN graphic, we mark such SDG which this project works. 
Content units	Derivatives and integrals.
Sessions	3 sessions of 1h
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autonomous work	
ICT tools to be used	- Spreedsheets for calculation - DESMOS Graphic Calculator
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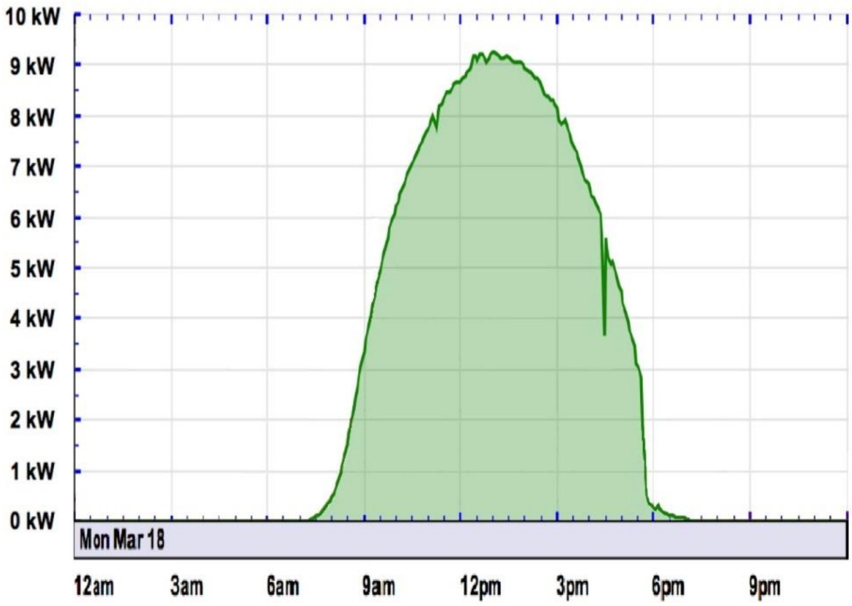

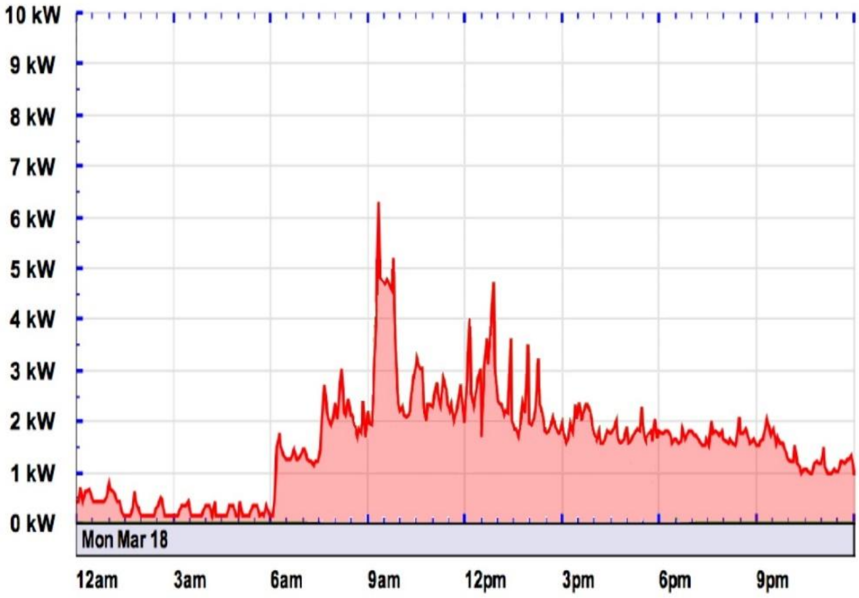

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Others: References	Active Learning Calculus I (colorado.edu) https://eduscrum.org/about-us-and-how-we-try-to-make-it-happen/ More refs on active-learning tools: https://scholar.google.com/citations?hl=en&user=Aw39XwEAAAAJ&view_op=list_works&sortby=pubdate https://www.youtube.com/watch?v=mQ_mbDAB1us (there are more examples online)

ANNEX 1: RUBRIC

Category	4=Excellent	3=Good	2=Low	1=Poor
Mathematical Concepts	Explanation shows complete understan- ding of the mathe- matical concepts used to solve the problem(s).	Explanation shows substantial understan- ding of the mathema- tical concepts used to solve the problem(s).	Explanation shows some understan- ding of the mathe- matical concepts needed to solve the problem(s).	Explanation shows very limited unders- tanding of the underlying concepts needed to solve the problem(s) OR is not written.
Mathematical Terminology and Notation	Correct terminology and notation are always used, making it easy to understand what was done.	Correct terminology and notation are usually used, making it fairly easy to understand what was done.	Correct terminolo- gy and notation are used, but it is sometimes not easy to understand what was done.	There is little use, or a lot of inappropriate use, of terminology and notation.
Strategy/Procedure	Typically, uses an efficient and effective strategy to solve the problem(s).	Typically, uses an effective strategy to solve the problem(s).	Sometimes uses an effective strategy to solve problems, but does not do it consistently.	Rarely uses an effective strategy to solve problems.
Completion	All problems are completed.	All but one of the problems are completed.	All but two of the problems are completed.	Several of the problems are not completed.
Mathematical Errors	90-100% of the steps and solutions have no mathematical errors.	Almost all (85-89%) of the steps and solu- tions have no mathematical errors.	Most (75-84%) of the steps and solu- tions have no mathematical errors.	More than 75% of the steps and solu- tions have mathe- matical errors.

Sources Checking				
Working with Others	Student was an engaged partner, listening to suggestions of others and working cooperatively throughout lesson.	Student was an engaged partner but had trouble listening to others and/or working cooperatively.	Student cooperated with others, but needed prompting to stay on-task.	Student did not work effectively with others.
Neatness and Organization	The work is presented in a neat, clear, organized fashion that is easy to read.	The work is presented in a neat and organized fashion that is usually easy to read.	The work is presented in an organized fashion but may be hard to read at times.	The work appears sloppy and unorganized. It is hard to know what information goes together.
Diagrams and Sketches	Diagrams and/or sketches are clear and greatly add to the reader's understanding of the procedure(s).	Diagrams and/or sketches are clear and easy to understand.	The work is presented in an organized fashion but may be hard to read at times.	Diagrams and/or sketches are difficult to understand or are not used.
ICT tools used				

Sources of examples

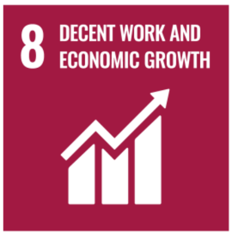
Special interest for any teacher is to have access to a high variety of sources for examples and problems to supply the mini-PBL projects. In fact, it is enough to give a basic applied problem to generate a bigger list of activities based on that.

Every course, in all universities around the world, graduate students present thousands of degree, master and PhD thesis where you can find for sure a list of examples/applications where a graphic or dataset can be the start point for constructing a mini-PBL project.

We encourage you to find your own sources, ask colleagues from your university for precise use of mathematics in any scientific area. Then connect such applications with SDG and construct your mini-PBL.

For help in such searching, in the following table we group basic scientific areas with the SDG to provide a list of suggestions for search math applications with SDG's interest label. Obviously, this is not a closed list, the items are interchangeable, and anyone can find an application of interest in the thousands of research papers and reports published every year all round the world.

SUSTAINABLE DEVELOPMENT GOALS	**Scientific areas or studies**
1 NO POVERTY	❖ Population studies and databases ❖ Incomes & Costs reduction ❖ Logistic & Transportation ❖ Equality studies
2 ZERO HUNGER	❖ Agriculture ❖ Nutrition ❖ Plagues ❖ Pollution
3 GOOD HEALTH AND WELL-BEING	❖ Medical databases ❖ Epidemiology ❖ Pharmacokinetic ❖ Microbiology ❖ Genetic ❖ Sports ❖ Aging

	❖ Education databases ❖ Psychology ❖ Neuroscience ❖ Human & childhood behavior ❖ Economy of Education ❖
	❖ Incomes inequalities ❖ Population proportion on labor sectors ❖
	❖ Water supply databases ❖ Pollution ❖ Microbiology ❖ Engineering ❖
	❖ Energy production and consume databases ❖ Engineering ❖ Consume ❖ Optimization of resources ❖ Penetration of renewable energies
	❖ Labor databases ❖ Social studies ❖ Share market ❖ Bank products ❖ Economy and enterprise ❖ Tourism ❖ Digital business
	❖ Industry and production databases ❖ Engineering ❖ Mobility ❖ Artificial Intelligence ❖ New Materials ❖ Nanotechnology ❖ Connectivity ❖ Logistic & Transportation ❖ 4^{th} Industrial Revolution: Industry 4.0

10 REDUCED INEQUALITIES	❖ Social lacks and gaps databases ❖ Social studies ❖ Population studies ❖ Incomes/costs reduction ❖ Digital access
11 SUSTAINABLE CITIES AND COMMUNITIES	❖ Quality living databases ❖ Population studies ❖ Optimization ❖ Logistic & Transportation ❖ Civil Engineering ❖ Architecture ❖ Baggage management ❖ Energy ❖ New materials for urban furniture: maintenance, cleaning, preventing damage,... ❖ Electric and autonomous mobility ❖ Air pollution ❖ Noise reduction ❖ Mobility ❖
12 RESPONSIBLE CONSUMPTION AND PRODUCTION	❖ Consume and human behavior databases ❖ Marketing ❖ Social networks ❖ Raw and new materials ❖ Energy ❖ Engineering
13 CLIMATE ACTION	❖ Climate change databases ❖ Deforestation ❖ Desertification ❖ Atmospheric physics ❖ Overheating ❖ CO_2 reduction ❖ Carbon footprint
14 LIFE BELOW WATER	❖ Climate change and oceans ❖ Acidification of oceans ❖ Sustainable fishing ❖ Microbiology on oceans ❖ Microplastic and oceans ❖ Waste and biodegradable materials
15 LIFE ON LAND	❖ Climate change and land sustainability ❖ Sustainable farming ❖ Residues and waste processing ❖ Waste and biodegradable materials

16 PEACE, JUSTICE AND STRONG INSTITUTIONS	❖ Social studies databases ❖ Economy ❖ Cooperation for development ❖
17 PARTNERSHIPS FOR THE GOALS	❖ Social studies ❖ Social networks ❖ Civil movements ❖

References

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