

General Instructions

GAIA tools manuals

Manuals are available for all GAIA tools on the project website in English, Greek and Italian.

Quantities and Units used

The quantities that are going to be used below are the electric **Current** (also referred to as **Current**), **Voltage**, electric **Power** and Electrical **Energy**. The quantity measured by the meters located in your school is the electric **Current** supplied to the three phases from the grid at the time of measurement.

- ☐ Electric **Current** is the flow of an electric charge and it is measured in **Ampere (A)**.
- ☐ **Voltage** is the difference in electric potential, it is measured in **Volt (V)** and in school building in Greece it can be considered constant at **230V**.
- ☐ **Energy** is the amount of work required for a system, such as an electric appliance, to change its state. It is measured in **Joule (J)** but in this context, it can also be measured in **kilowatt-hours (kWh)**. **1kWh** is equal to **3.600J**.
- ☐ **Power** is the transfer rate of **Energy** per second. It is proportional to the **Voltage** at the ends of the appliance and the **current** flowing through it. **Power** is measured in **Watt (W)**.

Out of these quantities, the most relevant for this document, are **Current** and **Energy**. **Current** is the quantity measured by the sensors installed in the electrical panels at your school. By using that measurement and assuming constant **Voltage** at **230V**, **Power** can be calculated using the formula

$$Power = Current \times Voltage$$

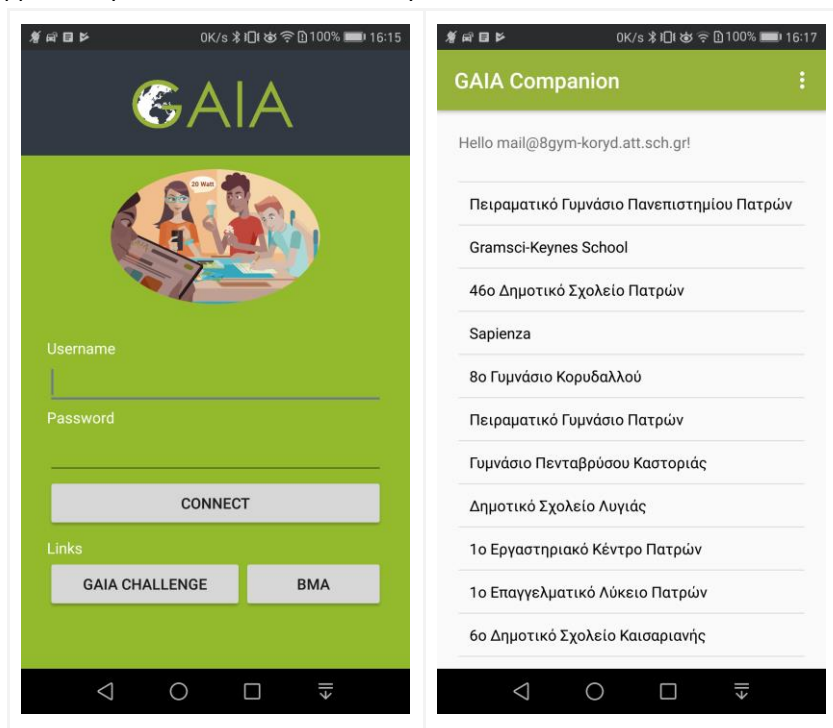
Power is used to calculate the **Energy** consumption for a given period by using the formula

$$Energy[J] = Power[W] \times Time[s]$$

The amount used to calculate the cost of **Energy** being consumed is **kilowatt-hours**, which is the **Energy** being consumed at a fixed rate of **1kW** for one hour.

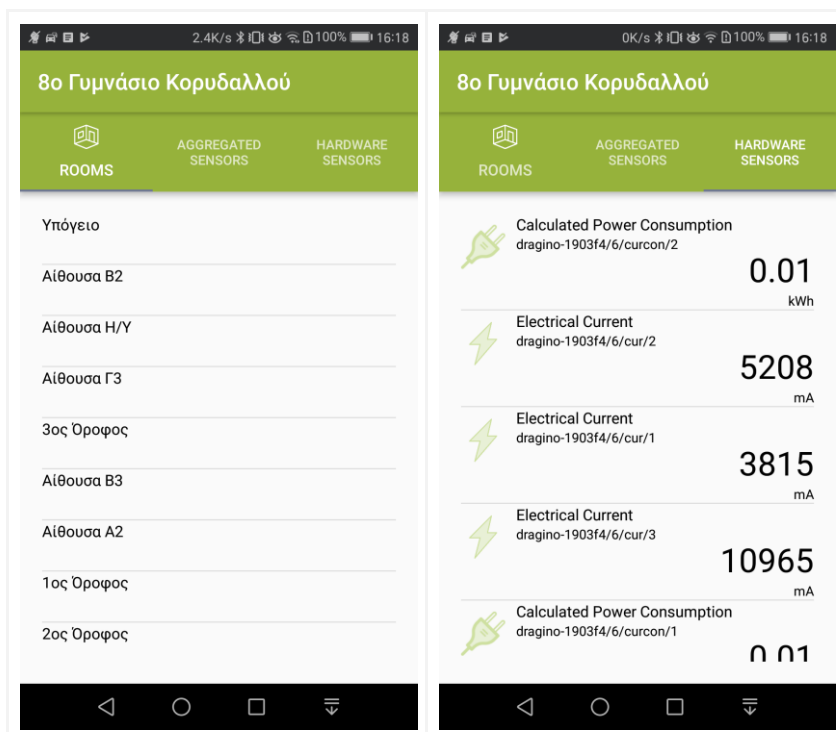
How to inspect the sensor measurements using the GAIA Companion Android app¹

You can install the “GAIA Companion” Android application from the Google Play Store by searching using the term “GAIA Companion”. After installation, please launch the app and after you confirm the access requests being requested by the app, enter your credentials and select your school from the available list.

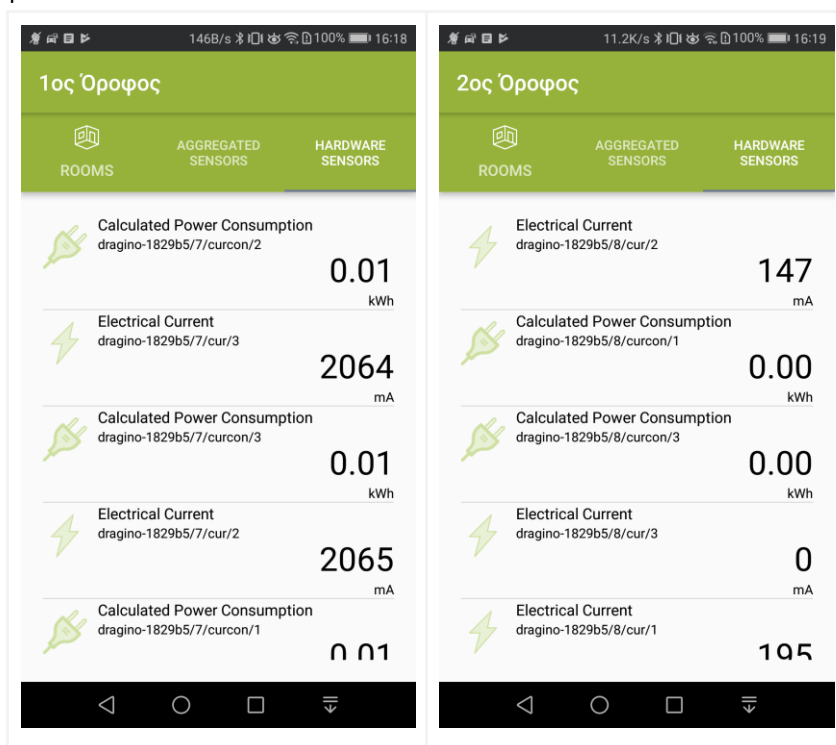


After selecting your school, from the home page you can access “HARDWARE SENSORS” to inspect the sensors in the school building. From the sensors titled “Electrical Current”, you can inspect the latest measurements in each of the three phases. The name of each sensor is shown directly below the title and denotes the phase, which it refers to. E.g., in the following pictures, the names of the sensors are dragino-1903f4/6/cur/1, dragino-1903f4/6/cur/2 and dragino-1903f4/6/cur/3. The last character in each name (1, 2 or 3) denotes the phase measured.

¹ <https://play.google.com/store/apps/details?id=eu.gaiaproject.android.companion>



In case your school has more than one sensor devices, the “HARDWARE SENSORS” starting page will be empty. In this case, you have to select the section that each sensor device monitors, e.g., “1st Floor” or “2nd Floor”, and then you can follow the procedure described above for each section.



An example on how to record the electric power of the appliances found in your school

During recording each appliance, the “state” of the school building should remain unchanged, i.e., there should be no appliances changing state (on/off) apart from the one being measured.

1. Turn on the appliance measured and wait for a few minutes. Inspect the measurements in the GAIA Companion App for each phase and write them down in line “Current with Appliances ON” into columns “Phase 1”, “Phase 2” and “Phase 3” respectively.
2. Turn off the appliance being measured again. Inspect the sensor readings in the app for each phase and write them down in line “Current with Appliances OFF” for Phase 1, Phase 2 and Phase 3 respectively.
Note: If the values between “Draft Measurement” and “Current with Appliances OFF” differ, you will have to repeat the procedure to verify your measurements. The state of the school might have changed during the experiment. Small differences of 100mA can safely be ignored.
3. For each line of the table, summarize the three phases and write down the result in column Phase Aggregate. Calculate the difference between the second the third measurements of the experiment using the formula *Phase Aggregate Diff = Current With Appliances – Current Without Appliances* for the column “Phase Aggregate” and write it down in “Phase Aggregate Diff”.
4. To calculate the electric power required by the appliance being measured you could use the following formula *Appliance Power = Phase Aggregate Diff × 230 ÷ 1000*.

In the table below, you can see an example of logging an experiment.

	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliances ON	2.000 mA	5.000 mA	7.000 mA	CurA = 14.000 mA	13:20
Current With Appliances OFF	2.000 mA	3.000 mA	7.000 mA	CurB = 12.000 mA	13:30
<u>Appliance Power =</u> <u>(CurA – CurB) × 230 ÷ 1000</u>			Appliance Power	460 W	

1st Step: Awareness and preparation

1. Measurement of Electrical Power in General Use Classrooms.

By utilizing the procedure described in the above example, you can measure the Electrical Power required by each classroom to operate. The two appliance groups most commonly found in a classroom are the lighting and the combination of a computer and a projector. Each group must be measured separately. In the following tables, you can fill in the readings of the sensors and calculate the electrical power of each appliance group in the respective table. After you complete the procedure for one of the classrooms, you could assume that each similar classroom has similar power requirements.

Name of classroom being measured:					
Number of similar classrooms:					
Lighting					
	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliance ON	mA	mA	mA	$CurA =$ mA	
Current With Appliance OFF	mA	mA	mA	$CurB =$ mA	
$\text{Appliance Power} =$ $(CurA - CurB) \times 230 \div 1000$			Appliance Power	W	
Computer and Projector					
	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliance ON	mA	mA	mA	$CurA =$ mA	
Current With Appliance OFF	mA	mA	mA	$CurB =$ mA	
$\text{Appliance Power} =$ $(CurA - CurB) \times 230 \div 1000$			Appliance Power	W	

2. Measurement of Electrical Power in the Computer Laboratory.

Utilize the procedure described in the example above to measure the power requirements of the Computer Laboratory. Initially measure and write down the sensor readings while everything is powered-OFF in the laboratory in the line named **Draft Measurement**. Do NOT turn OFF the always-on appliances that might be present in the laboratory, such as router or servers. Afterwards turn ON the lighting of the laboratory and write down the sensor readings in the line "Current with Appliance ON". To confirm your measurements, turn off the lighting again and

write down the sensor readings in the line “Current with Appliance OFF”. Repeat the procedure by turning ON the computers, monitor and any other appliances used during the lecture. It is preferable to emulate a smooth operation of the laboratory during a lecture, such as activating as many computers as usually used by students. You can calculate the electric power requirements of the laboratory as described in the “General Instructions” section.

Computer Laboratory					
Lighting					
	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliance ON	mA	mA	mA	$CurA =$ mA	
Current With Appliance OFF	mA	mA	mA	$CurB =$ mA	
$\underline{Appliance\ Power = (CurA - CurB) \times 230 \div 1000}$			Appliance Power	W	
Other appliances used during lectures					
Number of Computers and Monitors:					
	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliance ON	mA	mA	mA	$CurA =$ mA	
Current With Appliance OFF	mA	mA	mA	$CurB =$ mA	
$\underline{Appliance\ Power = (CurA - CurB) \times 230 \div 1000}$			Appliance Power	W	

3. Measurement of electric Power required by school lighting.

By following the procedure described in the example, turn OFF the lighting in the whole building and inspect the sensor readings. Write down the readings in the table below in **Draft Measurement** for each phase. Turn ON the lighting and write down the sensor readings in line “Current with Appliance ON”. The last step is to verify the measurement by turning OFF the lighting again and writing down the sensor readings in “Current with Appliance OFF”. You can calculate the electric Power requirements of the lighting of the school as described in General Instructions.

Lighting in corridors, staircases, halls and other public rooms					
	Phase 1 (cur/1)	Phase 2 (cur/2)	Phase 3 (cur/3)	Phase Aggregate	Time of Measurement
Current With Appliance ON	mA	mA	mA	$CurA =$ mA	
Current With Appliance OFF	mA	mA	mA	$CurB =$ mA	
$\text{Appliance Power} = \frac{(CurA - CurB) \times 230 \div 1000}$			Appliance Power	W	

4. Description of Teacher Hall

Describe what electrical appliances are in use in your teacher's hall and mention the nominal consumption as reported by the manufacturer in their labels.

5. Air Conditioners and electric Heaters

In the table below you can describe air conditioning or heating units per classroom as if they exist. You can also mention if there are any water heaters present in the school's water circuit. In column "Period of Operation", you can mention the period of the year in which each unit is in operation, preferably by noting the month each unit starts and ends its operations. In the column titled "Time of Operation", you can fill in the hours of the day each unit is being used. In the "Appliance Type" column, you can describe how each unit is being used, if it is an air conditioner or a heater as well as if it is being used for Cooling or Heating.

Classroom Name	Appliance Type	Number of Units	Period of Operation	Time of Operation

6. Description of school cafeteria

Describe what electrical appliances are in use in your school's cafeteria and mention the nominal consumption as reported by the manufacturer in their labels. Also, mention the operating hours of the cafeteria.

7. Registry of school schedule

Please register your school's schedule during the week. You can also mention which classrooms are being used beyond the regular school schedule, such as in the afternoon or in the weekend for different uses, for example, various clubs or remedial teaching.

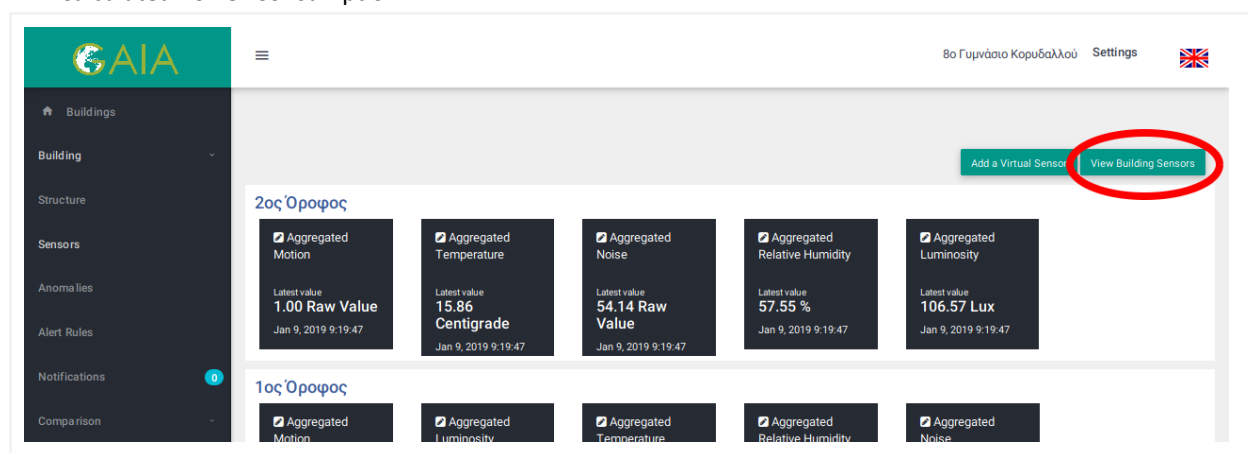
2nd Step: Observation and Recording of Base Energy Consumption

How to calculate the Base Energy Consumption of your school

The term **Base Energy Consumption** in this context is being used to convey the energy consumption in your school during a typical day from always-on appliances, or from activities/appliances that cannot be “deactivated”. Essentially, this part refers to processes in the building that consume energy, and which cannot be altered without having an effect on the daily operation of the school. If you calculate this type of energy consumption, it is then easier to detect the parts of energy consumption inside a school that can be effectively targeted by students and teachers.

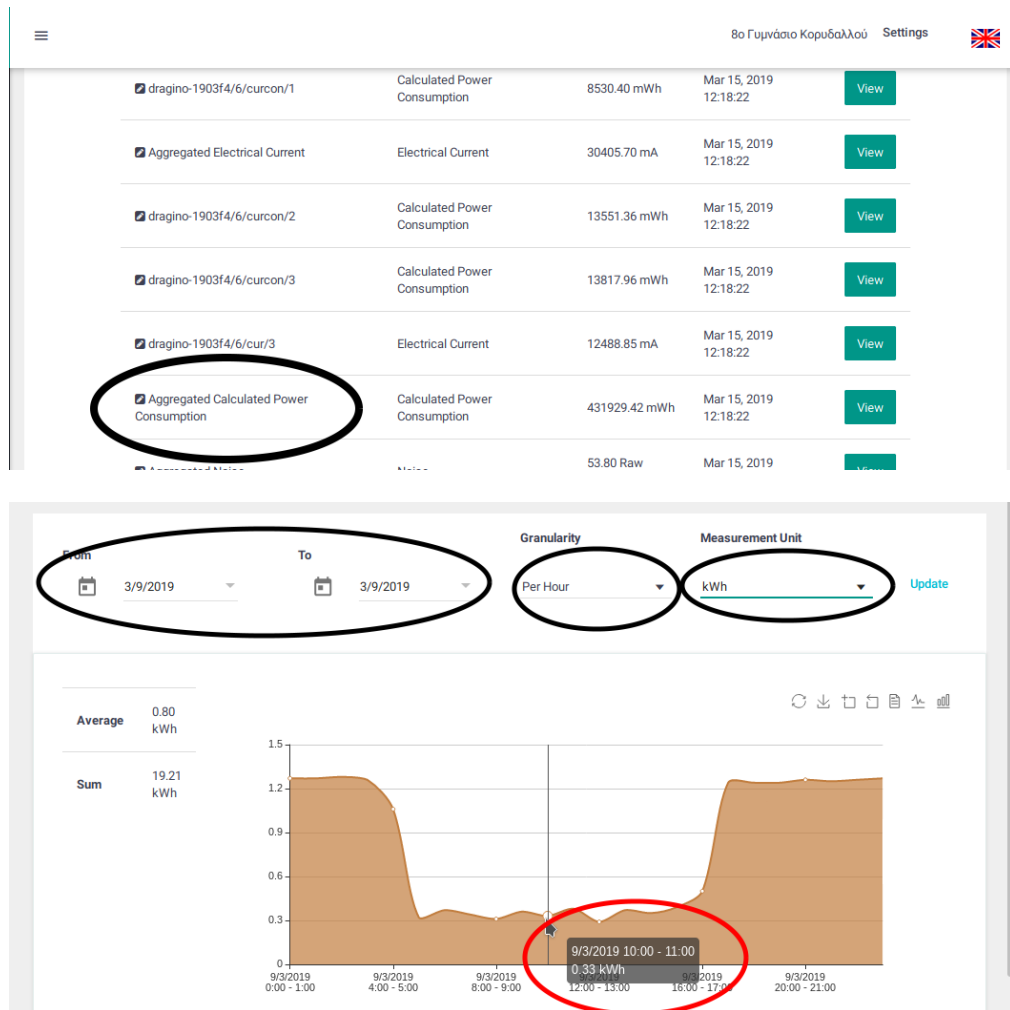
To calculate the **Base Energy Consumption** you can use the following procedure.

1. Using the **BMA** (bms.gaia-project.eu) platform, navigate to the page of your school and select the “Sensors” option. Select “View Building Sensors” in the top right corner and locate the sensor named “Aggregated Calculated Power Consumption”.



2. Select the “Aggregated Calculated Power Consumption” sensor to open its page, then select a day (“From” and “To” in the same day) during which the school didn’t host any activity, for example in the weekend, with Granularity “Per Hour”, Measurement Unit “kWh” and press Update. To calculate the Base Energy Consumption during one day with relative precision, hover the graph with your mouse pointer over an hour between 8:00 and 16:00. Multiply the measurement appearing in the pop-up box next to the cursor with the 24 hours of the day, to calculate the **Base Energy Consumption** for the whole day. If during the weekend your school hosts extracurricular activities, you can select a different day, for example a holiday. Preferably, select the day with the least non-zero energy consumption.

$$\text{Basic Energy Consumption (per day)} = \text{Basic Energy Consumption (per hour)} \times 24$$



3. In the right top corner above each graph there is a "Save as Image" icon (downwards arrow). You can use it to download each graph to be used in a report logging energy saving activities.

3rd Step: Experimenting & Monitoring Energy Consumption

In GAIA, we use the term **controllable energy consumption** to refer to the percentage of energy consumption, which can be manipulated by the school's users: it is the part of energy consumption that you can affect. To calculate it you will have to measure the **Regular Energy Consumption per day** of your school during a day of normal operation, and subtract from that the **Base Energy Consumption per day**, which was calculated in the previous step.

1. Using the **BMA** (bms.gaia-project.eu) platform, navigate to the page of your school and select the "Sensors" option. Select "View Building Sensors" in the top right corner and locate the sensor named "Aggregated Calculated Power Consumption".
2. Select the "Aggregated Calculated Power Consumption" sensor to open its page, select a day ("From" and "To" in the same day) during which the school was operating normally, with Granularity "Per Hour", Measurement Unit "kWh" and press Update. You can find the Summary on the left of the graph being shown.

Time Period	Regular Energy Consumption per day in kWh

3. To calculate the percentage you can manipulate, use the following formula

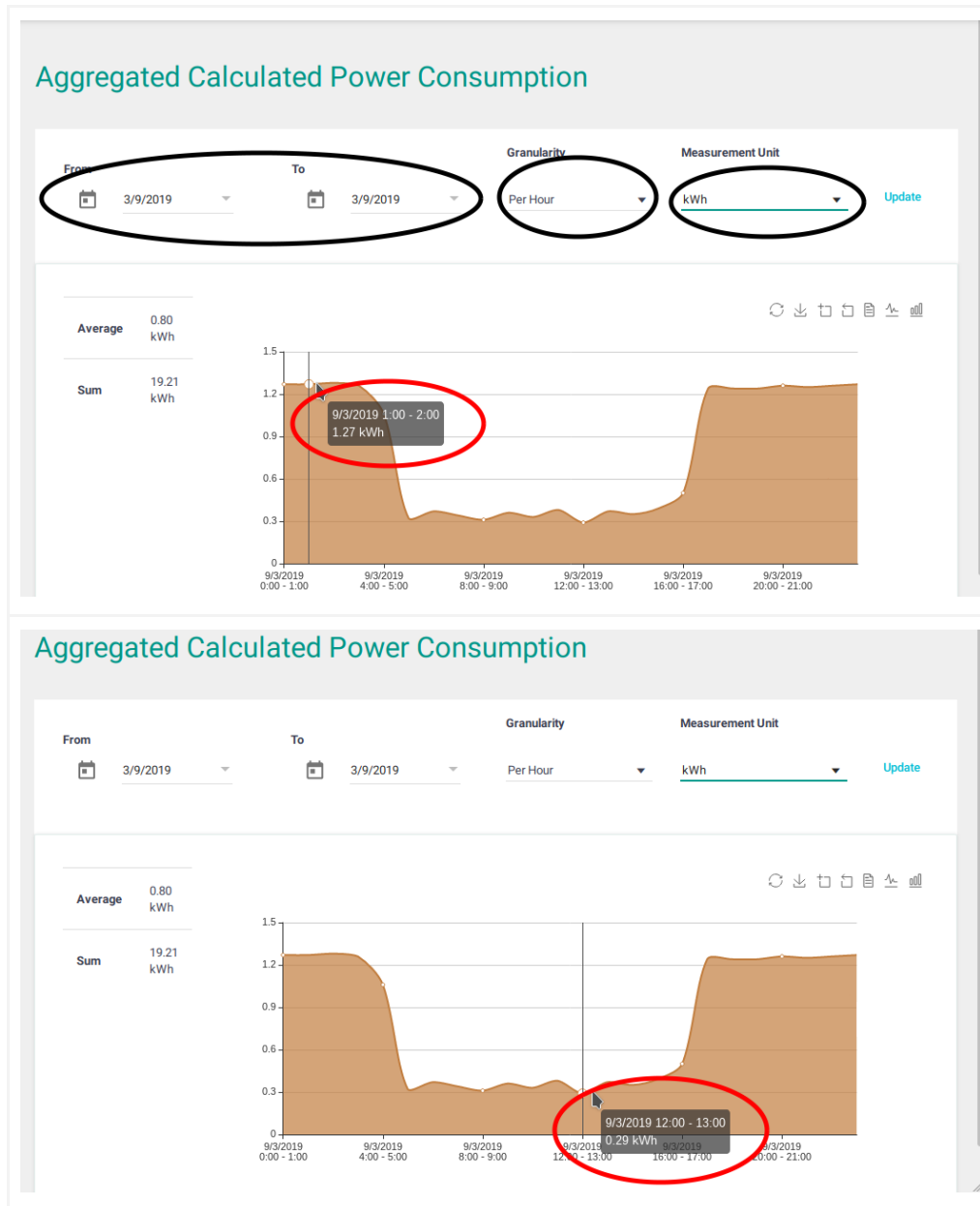
$$\text{Controlled Energy Consumption (\%)} = 100 \times (\text{Regular E.C.} - \text{Base E.C.}) \div \text{Regular E.C.}$$

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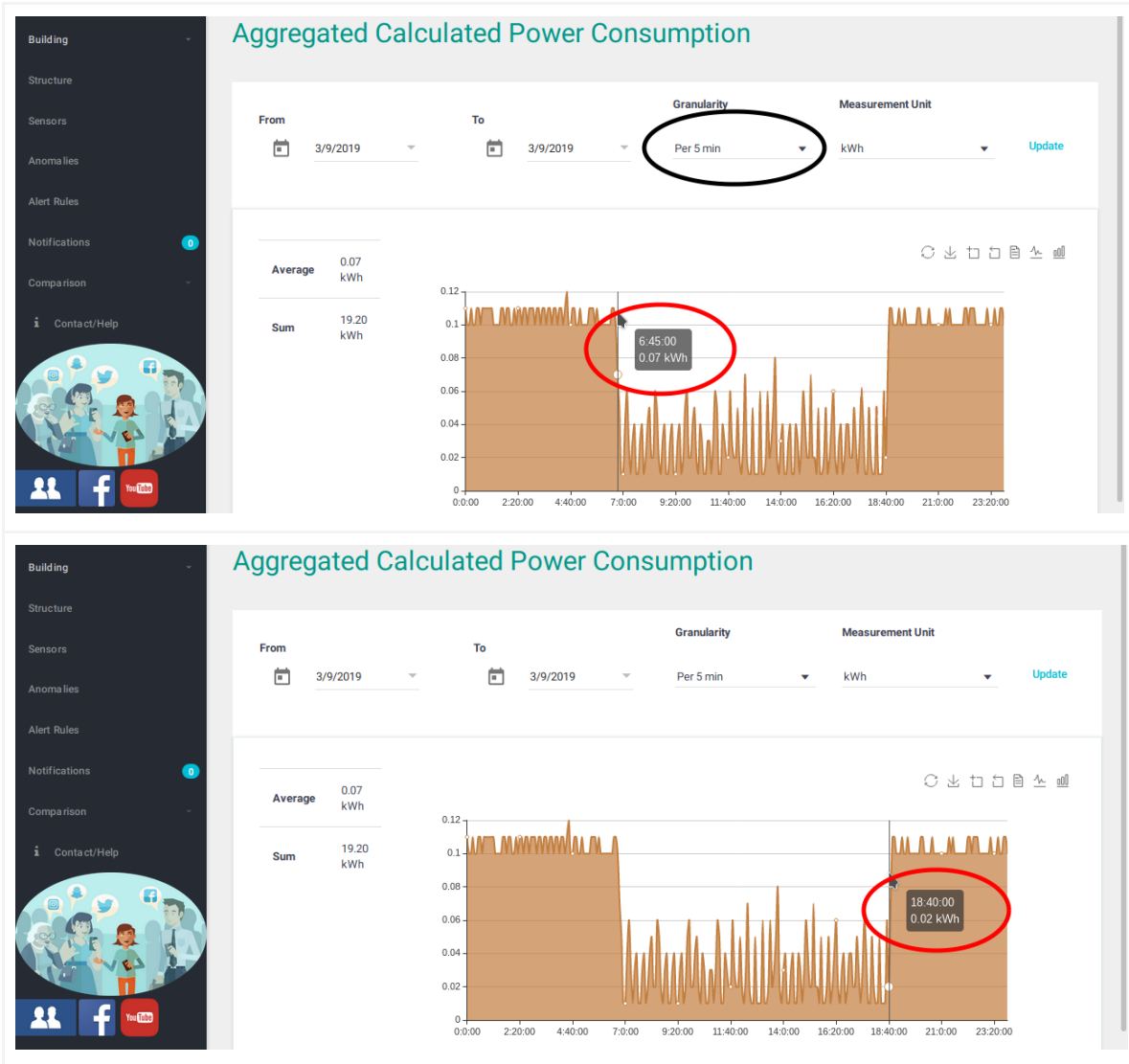
Determination of External Lighting Energy Consumption

In case there is External Lighting operating in your school during the night, you can approximate its energy consumption by using the BMA platform.

1. Using the BMA (bms.gaia-project.eu) platform, navigate to the page of your school and select the "Sensors" option. Select "View Building Sensors" in the top right corner and locate the sensor named "Aggregated Calculated Power Consumption".
2. Select the "Aggregated Calculated Power Consumption" sensor to open its page, select a day ("From" and "To" in the same day) during which the school didn't host any activity, for example in the weekend, with Granularity "Per Hour", Measurement Unit "kWh" and press "Update". If during the weekend your school hosted extracurricular activities, you can select another day such as a holiday. Preferably, select the day with the least non-zero energy consumption. In case your school does not have, does not utilize or the sensors does not measure the external lighting, the graph will not have any differences between Day and Night. In this case, you can ignore the following procedure.
3. To calculate their energy consumption, find an indicative value during the night by hovering your mouse cursor over the graph. Afterwards, find an indicative value during the day.



4. To approximate the period of operation for the external lighting during the day, change the granularity to "Per 5 min" and press Update. Using your mouse cursor, hover over the edge of High to Low consumption in the morning and the Low to High edge in the evening. From the pop-up next to the cursor, you can find out the time that the change in the energy consumption was measured.



5. Calculate the difference between the Night Indicative Value and the Day Indicative Value and multiply it with their operating hours to approximate their energy consumption.

$$\text{Energy Consumption} = (\text{Night Indicative Value} - \text{Day Indicative Value}) \times \text{Operating Hours}$$

Experimentation on energy savings in case the classroom lighting is turned off during a break/recess

In this experiment, you can calculate the energy consumed by lighting in classrooms in case it remains turned on during a break. Based on that you can determine how much energy can be saved if the lighting is being turned off.

1. Using the information you collected in the step **Awareness and Preparation**, calculate the electric power required by the lighting in all general education classrooms by multiplying the result in the 1st Step (*Classroom Lighting Electric Power*[W]) with the number of classrooms (*Number of Classrooms*).

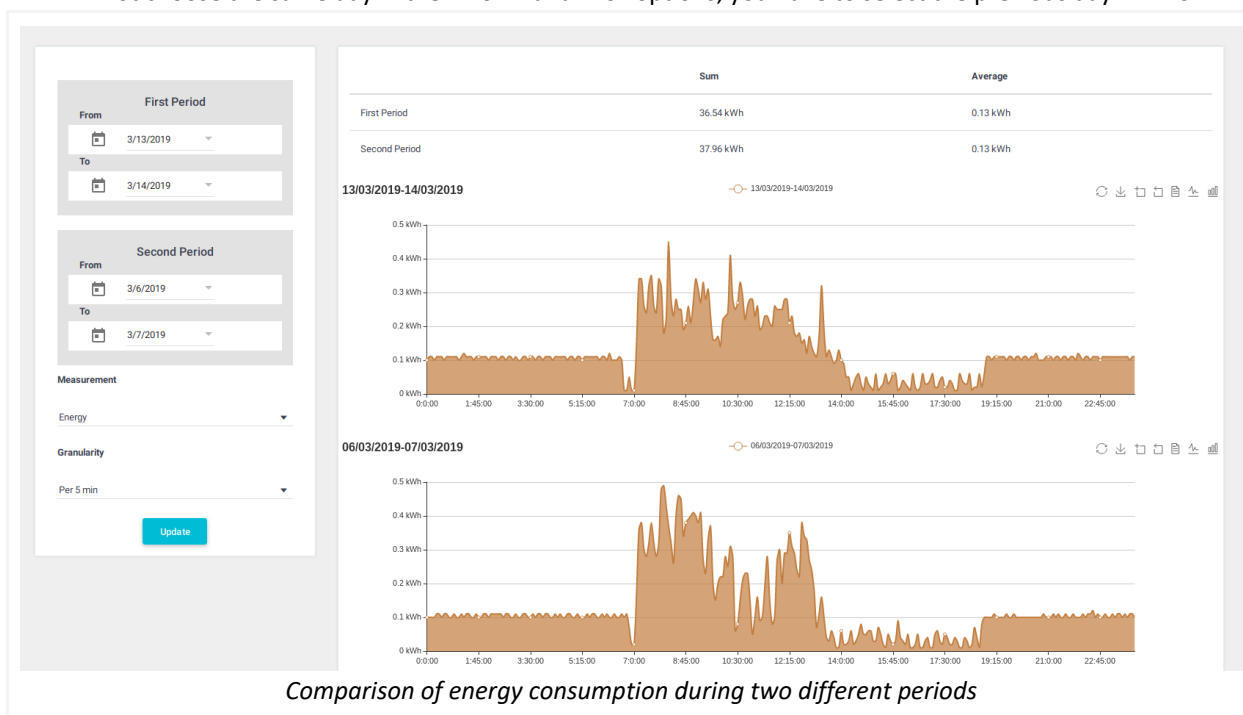
$$\text{Cumulative Lighting Electric Power}[W] = \text{Classroom Lighting Electric Power}[W] \times \text{Number of Classrooms}$$
2. You can approximate the energy consumption due to lighting with the following formula

$$\text{Energy Consumption}[kWh] = \text{Cumulative Lighting Electric Power}[W] \div 60000 \times \text{Recess Duration}[\text{minutes}]$$

4th Step: Monitoring the Progress of Energy-Saving Actions

The BMA platform offers a “Comparison” tool, which enables the user to compare the aggregated sensor readings of a building for the measurements Energy, Luminosity, Relative Humidity, Temperature, Noise and Movement in the same or different buildings. It can also compare sensor readings in different periods.

1. Using the BMA (bms.gaia-project.eu) platform, navigate to the page of your school and select the Comparison option. From the drop-down menu select “In your school”.
2. In the presented page, under the “First Period box”, select a day of the week during which you did not implement any energy-saving action. In the box “Second Period”, select the same day but in a week during which you implemented such actions. Under “Measurement”, select “Energy” and for “Granularity” select “Per 5 min”. Please pay attention to the selection of days: if you wish to observe a specific day, you should not choose the same day in the “From” and “To” options, you have to select the previous day in “From”.



3. In the following table, you can record a “Summary” of both periods. In the “Improvement-Energy” column, you can calculate the difference in total energy consumption (Summary) between the two periods. In the “Improvement-Percentage” column, calculate the percentage of energy savings using the formula

$$\text{Percentage} = (\text{Summary w/o Actions} - \text{Summary with Actions}) \div \text{Summary w/o Actions} \times 100$$
4. In the “Cumulative Improvement” row, you can calculate the respective values for a whole week.

	Date		Summary		Improvement	
	Without Actions	With Actions	Without Actions	With Actions	Energy	Percentage
Monday			kWh	kWh	kWh	%
Tuesday			kWh	kWh	kWh	%
Wednesday			kWh	kWh	kWh	%
Thursday			kWh	kWh	kWh	%
Friday			kWh	kWh	kWh	%
Saturday			kWh	kWh	kWh	%
Sunday			kWh	kWh	kWh	%
Cumulative Improvement			kWh	kWh	kWh	%

A useful practice is to “log” the implemented actions in a few paragraphs of text every few days, after you complete any of the suggested steps. To enhance your reports, you can use images from the BMA platform and pictures from your implementation of the actions, such as graphs and motivational/promotional material made by the students.

