Curriculum Units by Fellows of the National Initiative
2013 Volume V: Energy Sciences

Math Equations of Energy

Curriculum Unit 13.05.06, published September 2013
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Introduction

With the amount of energy used worldwide, it is imperative to find a much cleaner option that will not compromise the security and health of our mother earth. Several possibilities such as natural gas, wind power and solar energy arouse, just to mention a few. It is just that there is not an assurance of a real clean solution. All the options that are being offered have a downside. We just need to balance the options and take the least damaging one. At the same time, we need to create a plan to minimize the damage to the earth or to replenish whatever was taken from it.

The over-use of natural resources and the emissions produced that would go into the air have created a problem for the ozone layer. Global warming has become an important issue of many political agendas.

Realistically, how much energy in the presentation of electricity is needed to live with the commodities we have in the US? Is it really necessary to use the amount that we are using? One might be surprised to receive the answer. In a comparison among other countries, the US is the one that uses the most. It seems that in reality we wouldn't need the amount used. However, businesses rely a lot on the fact that electricity will be a large part of their advertising. Lighted signs and media in the form of TV announcements use a lot of electric energy. If this electricity comes from the regular source that it has been coming from, such as coals, or from nuclear plants, the consumption will be found to be outrageous.

Currently, 60% of the electricity used in the US comes from coals and 20% from nuclear energy. One can imagine the amount of waste produced by either of these two options to obtain electricity. On one hand, mining the coal leaves the land unusable, and on the other hand, there is a lot of waste from the result of nuclear fission and nobody knows where to dispose it. Meanwhile, the nuclear waste is being "stored" in the same plant, which normally closes after a period of time.

Replacing current oil propelled vehicles with electric battery operated ones is a goal in which several companies are working. Using solar energy to recharge the batteries in these cars is another goal. Although the technology to accomplish their goals is not near their desires, the companies keep working looking for solutions.

This curriculum unit focuses on the benefits of using solar energy, but without ignoring the problems created by its production. Calculations related to efficiency including cost and usage of solar energy in comparison to the use of traditional electricity are as well included. The applied math in the energy problems is directly related to the curriculum studied in the courses of Algebra-1 and Algebra-2.

An Ancient use of Energy

Through history, different cultures show how important was the conservation of energy in their life. From the ancient empire of the Incas in South America to the North American tribes, the respect to the mother Earth was always present. An individual or a group of individuals will not take more from Earth than what they really need to subsist. There was a minor sense of commerce, but not with the intention of becoming rich. The only intention of commerce was to share fairly what it was given by the Earth.

In the Incan culture, the Sun was the main God, above the other minor ones. The Sun would provide the energy needed for a daily routine, such as the simple warm up of the water to take a bath. They also were very knowledgeable of geothermal resources, using what is known as "The thermal baths of the Inca," referring to the warm water coming up from the land. It is believed as well that those baths would provide a cure for several illnesses. The rich composition of sulfur in the water made it only for baths and obviously not to drink.

The respect for the sun is still shown in a ceremony called "The Inti Raymi." This ceremony is celebrated in Cuzco, near Machu Picchu, every June 24th . Colorful dresses and bodies full of jewelry made of gold and silver can be seen along with traditional dances that celebrate the resurrection of the sun.

A long time ago, even before the Incan empire, in the 4th century BC, the naturals living in the area of Ancash, in the coast of Peru, constructed "The thirteen towers of Chanquillo." It is believed by Peruvian descendants, that the pre-Inca culture that constructed those towers was the "Chavín culture" with the only intention of observing the behavior of the sun. This way, they could predict sunshine or rainy days, as well as how many hours of day light they would have.

The Incas had a very well maintained informational service. The "chasquis," messengers of the empire, would run for many miles carrying on a message to the emperor about the behavior of the sun or about other things. Later on, the Incas constructed a "solar clock," near Machu Picchu, using rocks, the sun light and the shadow created by the incidence of the solar rays.

Reservoirs to keep the water were constructed, among the famous "andenes," that were mini farms on the side of the mountains. All of these were done to take advantage of the energy of the sun to keep up with a healthy agriculture.

Another use of the solar energy in the Incan culture was the traditional "Pachamanca," which is still done now these days, but with some variations. Pachamanca has two roots, "pacha" means earth and "manca" means unearthed. It is a special preparation of food underground using the heat of stones. The stones are previously heated in a hole excavated just for this purpose. The energy of sun in sunny days is good enough to heat up the stones. In winter, they prefer to heat up the stones with fire to accelerate the process. Cooking their food, warming up the water, and placing their plants in andenes to receive the energy of the sun for photosynthesis, are good examples of the ancient use of solar energy.

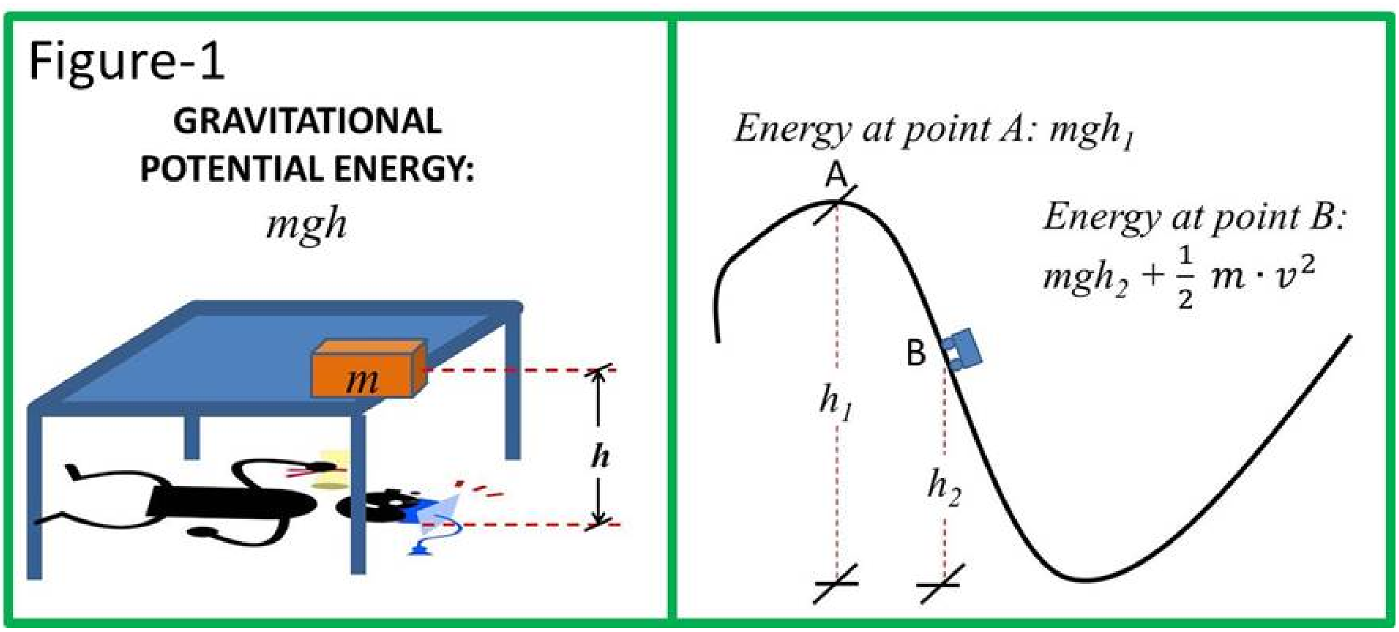
Two Types of Energy

From the physics point of view, energy is the ability to do work and it occurs in the form of chemical energy, thermal energy, electromagnetic radiation, gravitational energy, electric energy, elastic energy, nuclear energy, and rest energy. The energy can be stored in different forms, for which it receives the name of potential energy, or it can be a property of an object in motion, obtaining in this case the name of "kinetic energy." It is said that these are the only types of energy. Any other type of energy would fall in one of the two categories already mentioned. In addition to this idea, we can encounter a combination of both types of energy. In other words, the addition of potential and kinetic energy would give us what we call "total energy."

Potential Energy

As an example of potential energy, we can have a brick at the border of a table as it is shown in figure 1. The distance of the brick to the ground will influence the amount of potential energy. The amount of mass of the brick will also make a difference. One can easily understand that it will not be the same to have a brick as to have a pencil. It is obvious that the pencil is less probable to cause any damage to the floor, but it cannot be said the same about the brick. This type of potential energy is also known as "gravitational potential energy" because the energy depends on the mass located within a gravitational field.

The formula used to calculate the "gravitational potential energy E_p" is: $E_p = mgh$. In this formula, m represents the mass of the object, g is the acceleration of gravity and h is the height of the brick. Similarly, potential energies can be found within a magnetic field, an electric field, in the wet and dry batteries or inclusive in a system with a compressed spring. In this last case, the potential energy is present as soon as the spring is compressed.



Kinetic Energy

Kinetic energy is the result of an object with mass "***m***" that is traveling at a certain speed "***v***." This situation is as well found in the movement of our muscles when the glucose is broken to produce the amount of energy needed to move our body. The flow of water through a tube, the power produced by the wind and electrons moving around the nucleus of an atom, are also examples of kinetic energy. The formula to calculate the kinetic energy is:

$E_k = \frac{1}{2} m v^2$, where "***m***" is the mass and "***v***" is the speed of the object.

In the above formula for kinetic energy, the value of "***v***" is considered to be less than the speed of the light, which Albert Einstein used in his Relativity theory calculating the amount of energy as:

$E = mc^2$ where ***c*** represents the speed of the light.

On the left side of figure-1, if the brick would be falling, the height at a certain moment would produce an amount of potential energy. To calculate the total energy, the potential energy would need to be added to the kinetic energy that would appear because the brick will be now in motion. This "total energy" is:

$E = \frac{1}{2} m v^2 + mgh$.

A good example of where the total energy can be calculated is a roller coaster going down and in the middle of the hill as it is shown on the right side of figure-1.

Nuclear Power – Nuclear Energy

The splitting of Uranium atoms, in a process called fission, originates nuclear energy. This process releases energy used to make steam that consequently will produce electricity. Twenty percent of the electricity produced in the US comes from nuclear energy. There are currently more than 100 nuclear generating plants in the US.

Pollution Created by Nuclear Plants

Once the Uranium has been used, there are several things that are considered "nuclear waste." The containers, the machinery, the tools, the infrastructure inclusive, the radioactive materials left over, are all in the list of nuclear waste. How it is currently being disposed is a major problem for many countries. Although we know that eventually, the radioactivity will stop at some point, due to the decay of radioactive materials, it is impossible to avoid how to properly dispose the waste.

The United States Nuclear Regulatory Commission (USNRC) has a classification for the waste as low level, incidental, high level and Uranium mill tailings. Protective clothing, tools, rags, filters, medical tubes and other items that have been exposed to radioactivity in the nuclear plant are considered as low-level waste.

Incidental waste refers to the byproducts obtained by processing spent nuclear fuel, solid and liquid waste byproducts containing significant amount of fission products. Irradiated or used nuclear reactor fuel is under the category of high level waste, while the residues left after the processing to extract Uranium are called Uranium mill tailing.

Although there is a tendency to do the appropriate disposal under the regulations managed by the USNRC, still the amount of nuclear waste keeps increasing. Cumulated waste keeps being stored without really knowing what to do with it. Meanwhile, environmentalists are looking for cleaner options of energy trying to minimize the impact in our environment.

Solar Energy

The high cost of oil has induced several countries to look for other much cleaner and more affordable options. The dependability on foreign petroleum has created a set of increasingly prices for those countries who buy their oil. Therefore, the idea of solar energy started to be part of the agendas in many energy meetings around the planet.

It seems very easy and simple to start using solar energy. The propaganda about the rebate options and the economic incentives given by local governments is creating a large group of consumers who rely on the arguments of the companies offering the product, the installation and the service. There is, however, the other side of the story about the construction of solar cells that would store the solar energy. Toxic materials are used to produce photovoltaic cells for solar panels and, therefore, the "ghost" of pollution comes again. In any case, the impact in Mother Nature for the production of solar cells is much less damaging than the one obtained with the waste produced with nuclear energy.

Solar energy is currently being used as a solar heating, solar photovoltaic, solar thermal electricity and artificial photosynthesis. Hot water heaters powered by solar energy are very friendly to install and with easy technology, but the common households are not taking advantage of this or there are not incentives to installing solar water heaters. The other reason could be just plain ignorance of the matter.

Our school district has recently installed solar panels in all the schools within their jurisdiction. Therefore, our school, Jefferson High School in Daly City, uses only electricity converted from solar power. It is also well known that there is a possibility of "selling back" the amount of electricity produced from solar power that is not used. Obviously, this will help me to present a case to the school authorities and in general to the population interested in saving energy and, therefore, saving money as well.

This curriculum unit will serve as the ignition of the project to analyze the amount of energy used per hour, per square foot, particularly in the lower gym of our school, and the cost of this consumption. I see a problem that can be corrected if my students and I can show the amount of money that the school could save. The problem that I am presenting here is that the lights of the lower gym are on continuously after school hours and on Saturdays and Sundays. Even now, during summer break, the lights of the gym are on. This means that the lights are on 24-7. Although I have already mentioned this to the school administration, the answer is "there should be a timer," and no action is taken. On my part, the action I am taking is to educate the students in the subject and together find a solution to avoid wasting energy. As an integrated project among other subjects, students will write letters to PG&E and to the Principal to buy a switch or a timer. Either of these items will be paid by saving energy anyway over the time.

Passive and Active Solar Technology

There are two categories for solar technology, passive and active. Passive technology uses the light and the heat directly from the sun by simple exposure. Certain structures are specifically constructed in a way that their orientation can capture as much of the solar energy as possible.

The active solar technology uses the solar photovoltaic (PV) or the solar thermal systems. The PV technology uses the properties of semiconductors to produce electricity. A semiconductor produces an electrical charge when is hit by the sun and this electrical charge can be transferred through a circuit to anything that uses electricity. The solar thermal technology is classified as low, medium or high temperature collectors. Low temperature collectors use plates generally to heat swimming pools. Medium temperature collectors use also plates to capture the heat and are used to heat water in residential or commercial buildings. High temperature collectors use lenses or mirrors and inclusive parabolic shaped devices to concentrate the heat in one point with the purpose of producing electricity.

Solar thermal energy is very different from and much more efficient than photovoltaic energy, which converts direct sun light into electricity. In 2009, the worldwide production of solar thermal power was only 600 megawatts, but projects for concentrated solar thermal to power up to an additional amount of 14,000 megawatts are on their way.

The Eloquence of the Numbers

Approximately, the amount of solar energy in the form of solar irradiation that our planet receives is 5.5×10^{24} joules per year. [1] Just to have an idea of the amount of energy from the Sun, the solar energy received by the Earth in 2002 was more in one hour than the energy used by the world in one year. [1a] Another comparison is that the amount of solar energy received by the planet in one year doubles the amount of energy that will ever be obtained from all the other sources combined, including coal, oil, natural gas and mined uranium. [2] The unit used for energy in these cases is the joule, which is presented in another section with equivalences and conversions.

Photosynthesis

Approximately, the very large amount of 3×10^{21} joules per year of solar energy is used by plants and other photosynthetic organisms to "fix" the CO_2 in the atmosphere. As it is known, plants receive CO_2 from the air and after receiving water and sun light energy, it transforms it into sugars and O_2. This is one of the reasons that it is suggested to plant trees in urban zones to "oxygenate" the air. What percent of the total solar energy received by the planet is used for photosynthesis? In terms of percent, and numerically expressing the same question, we can write: What percent of 5.5×10^{24} is 3×10^{21} ? This question will be addressed and solved in the lesson plans and activities section.

I never thought that photosynthesis could be as important as it is in the search of a clean option as a source of energy. After reading several articles where energy and photosynthesis are linked, I started researching more about it, finding information that will show once again, that solar energy is a good option.

Scientists Niek van Hulst, professor at the Institute of Photonic Sciences in Barcelona, Spain and Richard Hildner, professor at University of Bayreuth in Germany, have found that the high efficiency transportation of energy in plants is connected to a quantum-mechanical phenomenon. The transportation of energy during photosynthesis is done at a molecular level and it is very fast, for which, capturing this phenomenon has been very difficult. To accomplish their task, they came up with ultrafast spectroscopy (taking pictures) techniques. [3]

To capture a very fast sequence of pictures, Niek van Hulst and Richard Hildner sent femtoseconds of light flashes during the photosynthetic process. [4] A femtosecond is the time that the light travels a distance of one hundredth of the diameter of a human hair. This sequence of pictures helped them to understand how solar energy is transported through proteins. The findings of the efficiency in the transportation of energy in plants through photosynthesis, is opening the possibility of creating a new more efficient solar cell.

Solar Panels

There are different types of solar panels, such as rigid thin-film and flexible thin-film modules, where the material used is mainly glass made of cadmium telluride or silicon. However, here I will refer only to the crystalline and the multi-crystalline silicon module types.

Currently, the biggest problems are to minimize the cost of production of solar panels and to make panels with solar cells with high efficiency. A photovoltaic system contains normally a set of several panels, because a single panel can only produce a very limited amount of power. In addition to the panels, the system contains an electrical inverter, a battery and wiring. Each panel has its DC output approximately between a minimum of 100 to a maximum of 320 watts. An electric inverter is a converter that changes direct current (DC) to alternating current (AC).

Electricity is a type of energy where electrons move through a conductor. In the conductor, generally a wire, the movement of electrons can occur only in one direction or both directions through the wire. If it goes only in one direction, it is called direct current (DC). If it goes in both directions, one, and then, the other one, it is called alternating current (AC). The electricity coming from a battery is an example of direct current DC, while the electricity we use at home when we plug in our household appliances is a good example of alternating current AC.

Efficiency of a Solar Panel

Given a same amount of DC output, the efficiency of a panel is inversely proportional to the area of the panel. In other words, if the same DC output is given, the smaller the panel, the larger efficiency we will obtain. For example, a 20% – efficient 200 watt panel has half the area of a 10% – efficient 200 watt panel.

Very much of the incident light on a panel is wasted, because it cannot cover (process) the entire frequency range of the solar light. If the panels were to be illuminated only with mono-chromatic light, the efficiency would increase by 50%. Therefore, there is another idea to construct a photovoltaic panel where the light would be split in different wavelength ranges, directing the splits onto different cells adjusted for each range.

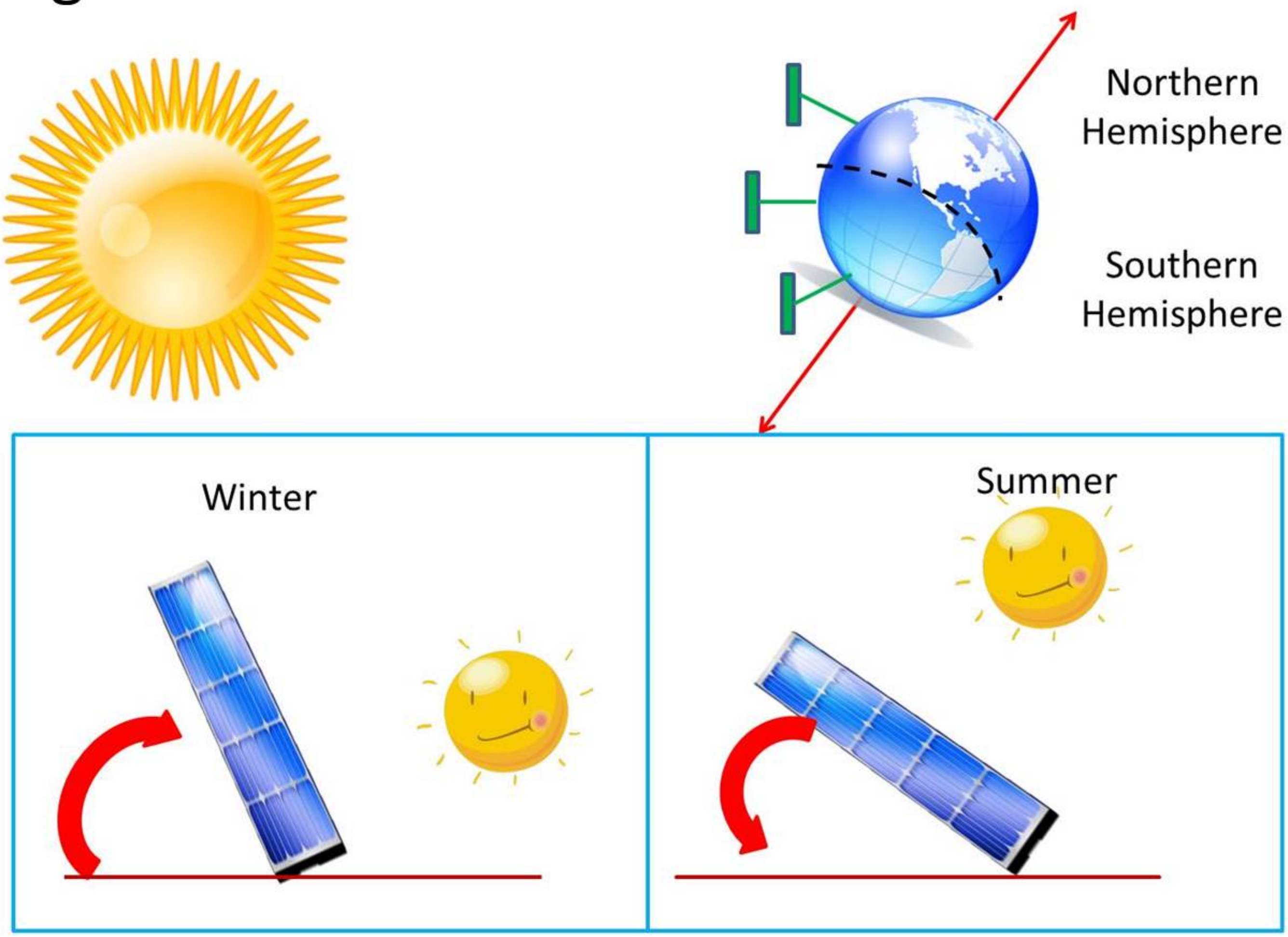
The best up to date efficiency of a commercial solar panel is around 20.1%, which is much lower than the efficiency of isolated individual solar cells. With this number, the most efficient energy value that a solar panel produces is up to 16.22 watt per square foot or 175 watt per square meter.

The position of the panels when installation takes place is as well very important to obtain the maximum efficiency of the solar panels. The inclination of the panels that can be seen on the roofs of certain houses and buildings is done exclusively to try to receive as much as direct sun-light as possible. The perfect situation would be to have the sun rays at a 90 ° angle of incidence on the panels all the time, but the reality is that the sun moves and the Earth moves too. Therefore, there is a certain angle that provides the best range of incidence to obtain the maximum amount of sun over the period of time of a day. There will be not a perfect situation on a continuous basis because of the movement of the sun, but the efficiency will have the tendency to be maximized. [5]

At a professional level of installation, the zip code determines the angle of inclination. Installers receive from their companies a set-table with the angles of inclination of the panels. At a "do-it-yourself-level," the zip code is used on a map from the Internet to locate the latitude and longitude of the place where the panels are going to be installed.

A general example of the position of the panels is given in figure-2.

Figure-2 Solar Panels Orientation



The panel tilt angle for our school with zip code 94014 is calculated in the winter by adding 15 ° to the latitude and subtracting 15 ° in summer. This is a general rule applicable for all cases. There are newer models that use a photo-tracking device that locates the sunlight and directs the solar panel/s towards the light, adjusting the angle automatically.

Photovoltaic Cells

Photovoltaic cells are also called solar cells, although the light being used to make it function does not necessarily have to come from the sun. In any case, these cells are electronic devices that receive the light, process it and convert it into electricity. The current, voltage or resistance varies, depending on the incidence of light.

The term photovoltaic is compound of two roots, "photos," which means light in Greek and "voltaic," that comes from the Italian Alessandro Volta, who invented the electrochemical cell, called now "battery."

Storage of Energy: The Energy Grid

An energy grid is the interconnected power network to transfer energy. Therefore, an electric grid is a network of coordinated power-providers and power-consumers that are connected by transmission and distribution lines and operated by one or more control centers.

Units of Energy

The most significant measures for the purpose of solar energy are the intensity and the energy delivered. One of these measures relates to "At point in time," while the other one is related to "Over a period of time." Irradiance in Watts per square meter and power in Watts represents the intensity at a point in time. Over a period of time, energy per unit area, Kilowatt-hour per square meter, represents the energy.

The unit that is commonly used to measure the amount of energy is the same as the one used to measure the amount of work. In the international system (SI), this unit is the joule, in honor of the English physicist James Prescott Joule for his work on the mechanical equivalent of heat. Joule's work led to the theory of conservation of energy: "Energy cannot be created or destroyed, it can only be transformed."

A joule

Previous to defining what a joule is, I will define what a newton is. The name of the unit is given to honor Sir Isaac Newton for his studies in classic mechanics. It is important to mention that the unit is spelled in English starting with a lower case "n." A newton is the amount of force used to move an object with a mass of 1 Kg, a distance of 1 meter, in one second, reaching a speed of 1 m/second, starting from rest.

A joule is the amount of energy needed to move one meter of distance an object with a mass of 1 Kg, in one second, reaching the speed of 1 m/second, starting from rest. For electricity, one joule is the amount of energy used in passing an electric current of one ampere through a resistance of one ohm for one second.

1 joule is equal to the following:

1×10^{7} ergs (exactly), 6.24150974×10^{18} eV (electron volts), 0.2390cal (thermochemical gram calories or small calories), 2.3901×10^{-4} kcal (thermochemical kilocalories, kilogram calories, large calories or food calories), 9.4782×10^{-4} BTU (British thermal unit), 0.7376ft-lb (foot-pounds), 2.7778×10^{-7} kilowatt-hour, 2.7778×10^{-4} watt-hour, 9.8692×10^{-3} liter-atmosphere, 11.1265 femtograms (mass-energy equivalence), 1×10^{-44} foe (exactly). One femtogram is equal to 1.0×10^{-18} Kg.

Units defined exactly in terms of the joule are:

1 kilowatt hour = 3.6×10 ^{6} j (or 3.6 Mj), 1 watt second = 1j, 1 watt hour = 3600 j, 1 ton TNT = 4.184 Gj, 1 thermochemical calorie = 4.184 j

Thermodynamic Limit on Efficiency of a Heat Engine

Efficiency equation = 1 – T_{cold}/T_{hot}

Lesson Plans and Activities

There is a fine line between certain topics taught in Algebra-1 and Algebra-2, which is the reason I will create lesson plans for both. The introductory part of the curriculum unit can be easily directed to the population of students in Algebra-1, due to the calculations, formulas and transformations to be applied. Also, given the analysis of area within the consumption and the efficiency contexts, the lessons can be applied as well to geometry.

The use of trigonometric functions and the angles of inclination for the panels in the installation process are very important. Skew angles, angles of inclination and other similar concepts will be defined and taught prior to the curriculum unit development. These numbers will vary depending on the zip code of the city, meaning that the sun directs its rays in different angles, depending on the location of the city and on the position of the solar panels. The calculations coming out of these data are directly related to the efficiency of the solar panels and are relevant to Algebra-1, Algebra-2 and Trigonometry.

Graphing equations based on the analysis of given information are very useful not only in math, but as well in science and other subjects; therefore, lessons on graphing equations with data obtained from our calculations from this curriculum unit are included too.

Lesson Plan-1: Solar Panels and Analysis of the Areas

Objectives: The objective of this hands-on lesson is to compare the influence of the changing areas of the solar panels in the calculation of power output and efficiency.

Materials: Solar panels of different sizes, multi meter /voltmeter, metal hanger or items to maintain the panels steady, table-chart to record measurements, graph paper, pen and pencil.

Procedure: Students calculate the area of each solar panel and record these data in their chart. There are 4 different panels in each group; therefore, each student in a group should have recorded 4 different results, one per each panel.

Students place their solar panels in a position facing the sun or another source of light. The angles of inclination of all the panels should be the same without any change. This demonstration is done maintaining the angle of inclination constant.

One at a time, the multi-meter is connected to the terminals of the solar panel to measure the voltage. The current as well needs to be measured, changing the units of reading in the multi-meter.

Students analyze their data and predict a relationship between area and current measured. The voltage may not show a significant change, with the tendency to stay constant but the amperes will show a change as a function of the area.

After writing their conclusions, students will move their solar panels to different points, distant from their original location and away from the light. Once again, the data observed need to be recorded in the chart. This information will serve students to analyze if the amperage varies with the distance from the source of light.

Students will come up with an empirical formula that relates the amperage with the area of the panel and with the distance from the source of energy. The outcome should show an inverse squared distance dependence. As an additional outcome, an empirical formula for efficiency as a function of the area of the panel and the distance from the source of light can be included. Finally, students will be directed to compare if there is a co-relation between the amperage and the efficiency.

There is time for a discussion about the data found and the empirical formulas. This is the first of two lessons about solar panels.

Lesson Plan-2: Solar Panels and Analysis of the Angle Tilted

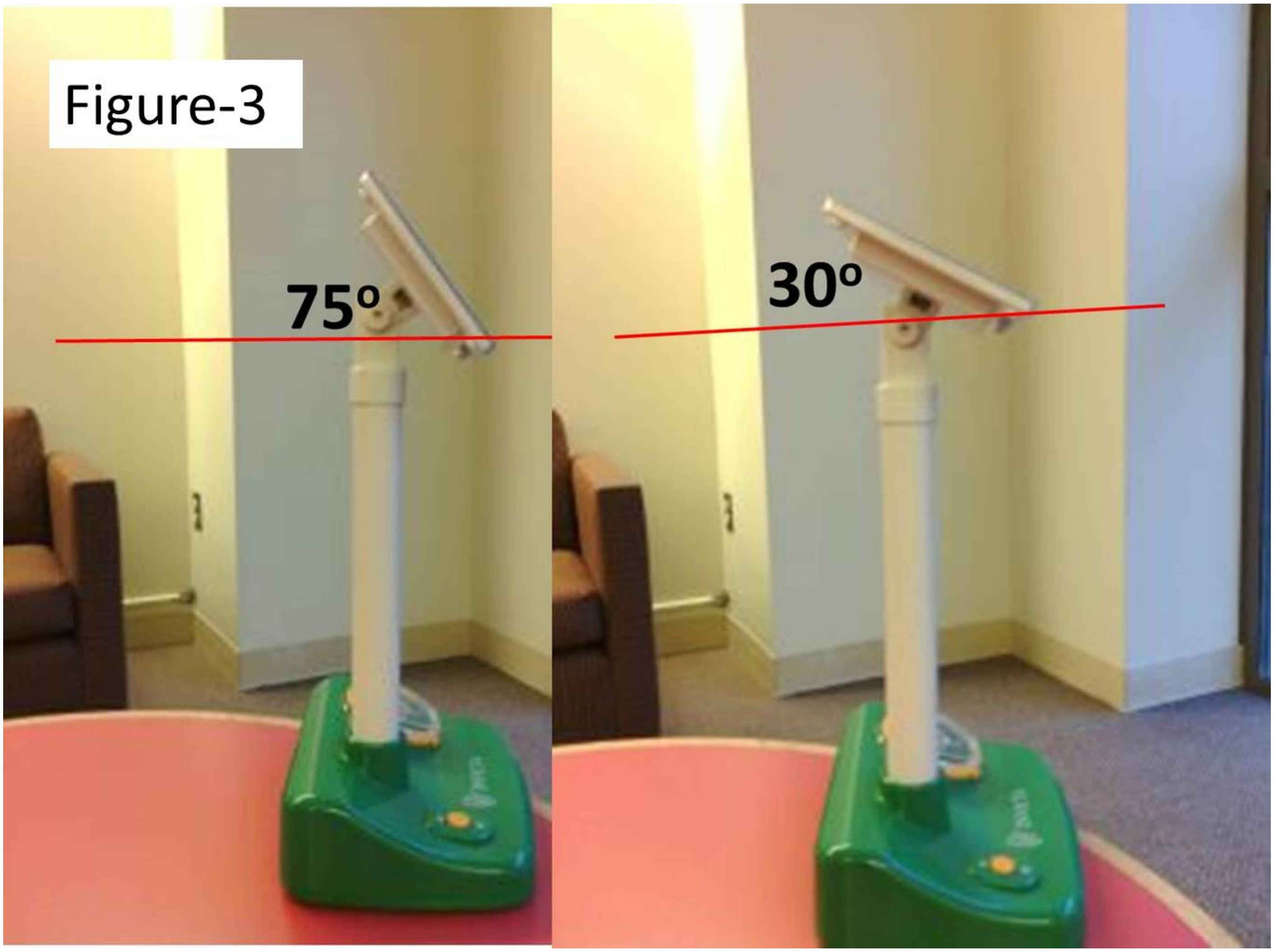
Objective: Analysis of efficiency as a function of the angle of inclination of the panel.

Objectives: The objective of this hands-on lesson is to compare the influence of the tilted angle changes of the solar panels in the calculation of power output and efficiency.

Materials: Solar panels of different sizes, multi meter /voltmeter, metal hanger or items to maintain the panels steady, table-chart to record measurements, graph paper, protractor, pen and pencil.

Procedure: From the previous lesson, students will continue recording the information.

Students will keep the solar panel in a steady position without changing its location. The only change will be the angle of inclination. With a protractor, students will measure several angles between the panel and the horizon. The horizon is defined as a horizontal line coinciding with the bottom portion of the panel as it is shown in red color in figure-3.



Students will record in their data sheet the angle of inclination and the corresponding voltage measured with the voltmeter. In addition, the current, measured in amperes will be measured. The areas of their solar panels were already recorded the day before.

After 5 different inclinations, students will switch panels and record their results, using the same angles, but this time, the area of the panel will be different. The switch of the panels should end when every student has received the all different panels in their groups.

The final conclusion for the two days for each group should involve an analysis and discussion on:

What happens when the area increases?

What happens when the angle of inclination increases?

What happens when the distance from the source of energy varies?

Lesson Plan-3: Solar Energy at Jefferson High School

Objective: To determine the amount of energy wasted when lights in the empty lower gym are on.

Materials: Paper, PG&E invoice, calculator, pen or pencil.

Procedure: Letters to the administration and to the superintendent will be sent requesting permission to analyze an invoice for the month of May, 2013. The data obtained from the invoice will be our "control." In addition, a letter to PG&E will be sent, to enter in their educational project. PG&E provides training for teachers through workshops and webinars. A technician is sent to the class to help students to understand the facts of solar energy and how the solar panels work. If a technician is not available, I will provide the information.

The most important part in this lesson is to obtain the data from the PG&E invoice. With these data, the cost of the energy used can be calculated. The information needed is the amount of energy used in a period of time. In figure-4, an invoice similar to the one provided by PG&E is shown. The amount of energy used from April 13 to May 12 was 756 Kwh. In this invoice, the real cost of the energy used in a period of time of 30 days was $87.61. However, some local governments provide incentives for reducing the energy used in comparison with the previous year. For the purpose of our calculations, we will use 756 Kwh and $87.61 to find the cost of 1 Kwh by simple division. The answer in this case is 11.58 cents per 1 Kwh. This is just an example, but it is very close to the 2011 average price [6] in US, of 1 Kwh at 10.75 cents.

Working in groups, students will count the number and wattage of incandescent bulbs and/or fluorescent bulbs per classroom, offices, gym and any other part lighted in the school. Students will also survey the classrooms to see the amount of electronic devices such as computers, monitors, microwaves, coffee-makers, water heaters, photocopy machines, telephones and loud speaker system. Students will create a list of household appliances with their respective energy usage. The goal with the above count is to isolate the amount of energy used in lighting up the entire school in a month. Then, dividing this amount by the number of bulbs, we can obtain the energy used per bulb per month. It is important to understand that we will find different types of bulbs, which it has to be accounted for accuracy. This last number obtained is very important to show how much energy is used in the gym that I am referring in the objective of this lesson.

Figure-4 **PG&E SAMPLE INVOICE**

Customer Name	PG&E Account Number	Service to:	Total PG&E Charges
LUIS MAGALLANES	**17716-100-233089**	**5/12/2013**	**$42.65**

SUMMARY OF PG&E CHARGES:

Electric Service:	$41.05
Utility Tax 3.9%	$1.60
TOTAL PG&E CHARGES	$42.65

ELECTRIC ACCOUNT DETAIL:

From 04/13/13	To 05/12/13	Billing days: 30	Meter #:	J233089
Prior Meter Read	Current Meter Read	Difference	Constant	Usage
27062	27818	756	1	756 Kw h

Total Electric Charges		$87.61
Legislated Rate Reduction		8.76-
Direct Access Energy Credit	$0.0500/Kwh	37.80-
Net Electric Charges		$41.05

The net electric charges shown above include the following components:

Transmission	$ 5.00
Distribution	$ 2.00
Public Purpose Programs	$15.00
Nuclear Decommissioning	$ 5.00
Competition Transition Charge (CTC)	$ 1.84
Trust Transfer Amount (TTA)	$12.21

Notes

[1] Renewable Energy Seminar July 10th, 2013 Power Point

[1a] The Eloquence of Numbers

http://www.nature.com/nature/journal/v443/n7107/full/443019a.html

[2] The Eloquence of Numbers

http://www.umassd.edu/sustainability/research/solarpower/

[3] Photosynthesis: The Future of Solar Energy

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Appendix on Implementing District Standards

Appendix A

Common Core Standards (CCS), are currently in the process of being implemented in our district. Training has been scheduled prior to the beginning of the school year. Meanwhile, the CCS from Algebra-1 applicable to this curriculum unit is A1 (4), which says:

> Building upon their prior experiences with data, students explore a more formal means of assessing how a model fits data. Students use regression techniques to describe approximately linear relationships between quantities. They use graphical representations and knowledge of context to make judgments about the appropriateness of linear models. With linear models, they look at residuals to analyze the goodness of fit.

Creating equations and using functions are also part of this curriculum unit, as well as it is embedded in the CCS for both Algebra-1 and Algebra-2. Using the data obtained in the hands-on experiences will help to obtain the information needed to create the equations. The equations will become the empirical formulas.