How Much Energy is a Kilowatt Hour?

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Table of Contents

I. Lesson: How much energy is a KWh?

California State Standards addressed:
Grade 9-12
Investigation and Experimentation
1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
    a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
    b. Formulate explanations by using logic and evidence.
    c. Distinguish between hypothesis and theory as scientific terms.
    d. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

Student background: An introduction to energy and the concept of work must have been covered previously.

Content: In this lesson, students are challenged to use personal energy output as a means to quantify the energy unit of 1 KWh. This will provide a knowledge base from which the student may evaluate the output of photovoltaic cells currently in use on the roof of their school.

Objectives: Students will be able to compare the energy generated by the school's photovoltaic system to the energy they generated climbing stairs.

Methodology:

Prior to the lesson the teacher must locate and measure (in meters) an appropriate set of stairs or steep incline for the students to walk or run up for this activity. The only measuring which counts is the elevation rise (be sure to explain that horizontal motion is not going directly against gravity, so is ignored in this activity).

Present the material in the prelab of the Lab: My Personal Power Plant

Prelab for "Lab: My Personal Power Plant"

10 minutes – I will place a transparency on the overhead projector and lead students through the majority of the front page of the lab. Along the way reminders of how work requires motion and inviting students to "choose their own rate (may choose to be a slower-walking power plant or a faster-running power plant) should

be thoroughly discussed along with the invitation to use "pseudo weights" if there are students with challenges here. I often invite the use of "round weights" like 150 pounds as a standard – or my own body weight if they want.

5 minutes – On the back of the lab solicit student volunteers to offer their information for the class to monitor. This allows a range of power data to be used and discussed in comparison work later.

15 minutes – Take students to your course and time them climbing the stairs (or running the hill).

10 minutes – Go back to class to finish calculations and place the rest of the information on the class table of data.

5 minutes – Lead the students through the analysis questions you feel need to be addressed at the end of the calculation time.

Offer the extra credit overnight (or over the weekend) to students to bring back and share their findings with the class.

Assessment: The completion of the analysis questions as well as their abilities to apply this background to the solar project they will be assigned after this task will serve as an appropriate assessment.

II. Lab: My Personal Power Plant

name: _____

period: __

Background Information:

* Weight is a force measured in _____

* Work is _____

    Work is measured in _____

    Work = _____

    Example: _____

* Power is _____

_____

    Power is measured in _____

    Power = _____

    Example: _____

Power generating (and use) is measured in _____

    Example: _____

Purpose: Understand power by _____

_____

_____

Hypothesis: I will generate _____ KW to climb the steps. This will be _____ than the power being generated by the photovoltaic system on the school roof right now.

Investigation:

Weight I will use: weight = _____ pounds (__)

    Weight = _____lb x _____ N/lb = _____N

My work =_____ x _____ = _____

My power = _____ / _____ = _____

    or Power = _____ W / _____ = _____

Person / action	Force (N)	distance (m)	Work (J)	time (s)	Power (W)	Power (KW)

Analyzing and interpreting data:

1. The person from the class data who generated the amount of power closest to what I generated was: _____. Our power was close because:

    _____

2. The person from the class data whose power generation differed the greatest from mine was _____. This difference happened because:

    _____

3. The equation to calculate how long it will take you to generate 1 KWh of energy with your personal power plant is: 1 KWh ÷ (kilowatts you generated) = _____ hour

    Class example: _____

    Use this equation to calculate the time it would take you to generate one KWh from the output of your personal power plant in this activity.

    _____

4. To put the feat of your personal power plant in some kind of perspective, let us do the calculation of how high of steps (or mountain) you will have to climb to completely generate your 1kWh you calculated in #3. The equation will look like this (since there is 3600 seconds in 1 hour and 1000 W in 1 KW) :

    3,600,000 Watt•seconds ÷ (your weight in Newtons) = _____ meters you must climb

    Class example: _____

    (* note – Mount Hood is 3429 m high and Mount Everest is 8,850 m high)

    Use this equation to calculate the distance you must climb to generate one KWh from the output of your personal power plant in this activity.

    _____

5. The KWh that can be generated by the school photovoltaic system is: _____

    So far this week the system has generated: _____.

    You may use the info sheet provided on page 9.

5. A. Calculate how long you would need to "run/walk" to generate that much power?

6. Use what you have learned about generating 1 KWh to evaluate how useful the electricity generated by the school's photovoltaic system is.

_____

_____

_____

_____

_____

Extra credit investigations:

Take this lesson a few steps further by checking a home electric bill and compare the power from the school roof system (access the system information through http://view2.fatspaniel.net/FST/Portal/) with what your family used in a month. You may choose to do a month to month comparison of the school roof system generation and your family usage. Evaluate the impact the system would have on your family electric bill (use specific numbers). Write your findings below or attach a separate paper.

Choose your favorite exercise and show your work as you calculate how long of a workout you will need to use 1 KWh of energy. A resource you will need will be an exercise calorie charge or you might enter 1 hour and your information to the site: http://primusweb.com/fitnesspartner/jumpsite/calculat.htm. You will most likely need the conversion factor: 1 kWh = 15,072 kilocalories (food calories). 1 cal =0.001 kcal.

III. Lab: My Personal Power Plant – Key for Background Information

Background Information:

    * Weight is a force measured <u>in pounds (lb) or Newtons (N)</u>

    * Work is force applied through a distance

        Work is measured in <u>Joules</u>

        Work = <u>Force x Distance</u>

        Example: <u>20 N x 3 m = 60 J</u>

    * Power is the rate at which work is done

        Power is <u>measured in Watts (W) or Kilowatts (KW)</u>

        Power = <u>Work ÷ Time</u>

        Example: <u>60 J ÷ 5 seconds = 12 W</u>

        Power generating (and use) is measured in Kilowatt hours (KWh)

        Example: <u>0.5 KWh x 3 hours = 1.5 KWh</u>

Purpose: <u>Understand power generation by using my body as a power plant and calculate its output to compare to our school photovoltaic system.</u>

Hypothesis: I will generate _____ KW to climb the steps. This will be _____ than the power being generated by the photovoltaic system on the school roof right now.
Investigation: (this will be shown with weight of 150 lb and a stair height of 4.0m)

    Weight I will use – weight = <u>150</u> pounds <u>(lb)</u>

        Weight = <u>150</u> lb x<u> 4.45 N/lb = 667.5 N</u>

    My work = <u>667.5 N x 4.0 m = 2670 J</u>

Now I will use a time of <u>5.23 seconds</u> for how long it took this person to run up the stairs

    My power = <u>2670 J / 5.23 s = 511 W</u>

    or Power = <u>511 W / 1000 W/KW = .511 KW</u>

I have had students capable of generating in excess of 1 KW of power (over this short course)

Analyzing and interpreting data: "Sample data"

1. The person from the class data who generated the amount of power closest to what I generated was: <u>Joe</u> . Our power was close because: <u>even though he is lighter than me (did less work) he used the same power because he did his work in less time (went up stairs faster)</u>

2. The person from the class data whose power generation differed the greatest from mine was <u>Bill</u>. This difference happened because: <u>Bill did more work (is heavier) in less time than I did.</u>

3. The equation to calculate how long it will take you to generate 1 KWh of energy with your personal power plant is: 1 KWh ÷ (kilowatts you generated) = _____ hour

   Class example: 1 KWh ÷ .511 KW= 1.96 hours of climbing stairs at my rate
   Use this equation to calculate the time it would take you to generate one KWh from the output of your personal power plant in this activity.

4. To put the feat of your personal power plant in some kind of perspective, let us do the calculation of how high of steps (or mountain) you will have to climb to completely generate your 1kWh you calculated in #3. The equation will look like this (since there is 3600 seconds in 1 hour and 1000 W in 1 KW) :

   3,600,000 Watt • seconds ÷ (your weight in Newtons) = _____ meters you must climb

   Class example: 3,600,000 W • s ÷ 667.5 N = 5393 m

   (* note – Mount Hood is 3429 m high and Mount Everest is 8,850 m high)
   Use this equation to calculate the distance you must climb to generate one KWh from the output of your personal power plant in this activity.

5. Go to <u>UCSD Gilman Solar Grove</u> and <u>UCSD Hopkins Solar Grove</u> to get information on how much kWh these parking structures can generate in a year.

You may also go to this link: http://www.solarschoolhouse.org/ then click live data online. PV power generation information is available for some school around the U.S.