

Watt's It All About?

OVERVIEW

Students complete a worksheet to familiarize themselves with various electric terms such as current, amps, voltage, power, watts, kilowatts, watt-hours, and electrical energy. With their knowledge of these terms, they practice using the mathematical relationships between energy, power, and efficiency.

PRIOR KNOWLEDGE

This worksheet is designed to supplement the reading about electricity in the NEED publication, *Schools Going Solar*.

TIME

One 45-minute class period

MATERIALS

- *Schools Going Solar* (NEED publication) - one copy for each student/student group
- “Watt’s It All About?” worksheets – one for each student
- Calculators

PREPARATION

- Review Procedures and readings.
- Make copies of the reading from “Schools Going Solar,” as needed.
- Make copies of “Watt’s It All About?” worksheets of this lesson.

PROCEDURES

- Distribute reading from *Schools Going Solar* (suggestion – assign this as homework reading the night before).
- Answer any questions students have about the reading from *Schools Going Solar*.
- Explain that they will be applying these new concepts in a worksheet.
- Distribute “What’s It All About?” worksheets to students.
- As students work individually or in groups, circulate and provide assistance as needed.
- When students have completed worksheets, go over them as a class or collect for grading.

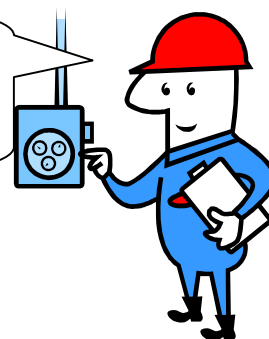
Watt's It All About?

This is a worksheet to practice calculating power, energy, and inverter efficiency of the PV Array (as well as electricity in general). This worksheet is designed to supplement the reading about electricity in the NEED publication, *Schools Going Solar*, pages 19-21.



Volts? Amps? Watts? Kilowatts? Electrical Energy? Power? Efficiency? My head is spinning with all these new words and ideas! Somebody help me!

Never fear – Captain Kilowatt is here! Use my handy toolkit below to sort out just what all these terms mean. With a little bit of practice, you'll be calculating power, finding energy usages, and comparing efficiencies like a pro!



First, review these definitions from the reading. Whoops! Captain Kilowatt seems to have gotten them a little scrambled. Match the correct term with its definition.

Term	Definition
1. _____ Voltage	A. The unit for measuring electrical current.
2. _____ Electrical Current	B. A “pressure” that pushes electrons in a circuit to make them move.
3. _____ Electrical Power	C. Units used for measuring electrical energy.
4. _____ Electrical Energy	D. Electrons flowing between two points having a difference in voltage.
5. _____ Volts (V)	E. The unit for measuring voltage.
6. _____ Amps (A)	F. The rate at which electricity is produced or consumed.
7. _____ Watts (W)	G. The energy of moving electrons.
8. _____ Watt-hour (Wh) and Kilowatt-hour (kWh)	H. The units used to measure electrical power.

Now that we've gotten the vocabulary straightened out, let's put it to use and practice some calculations. We'll talk about **POWER**, **ENERGY**, and **INVERTER EFFICIENCY**.

★ **Power** – Most of the Ohio Solar Schools PV arrays can produce up to 1 Kilowatt of electric power. We can calculate the power produced by a PV array using the equation:

$$\mathbf{POWER} \text{ (in Watts)} = \mathbf{VOLTAGE} \text{ (in Volts)} \times \mathbf{CURRENT} \text{ (in Amps)}$$

$$1000 \text{ watts} = 1 \text{ kilowatt}$$

Conversion from Kilowatt to Watt: multiply by 1000

Conversion from Watt to Kilowatt: divide by 1000

- A photovoltaic array with a voltage of 48 V that produces a current of 15 A has a power of _____ watts or _____ kilowatts.
- If you take a reading and find that your system is operating at 50 V and 20 A, how much power is the system producing in watts? _____ In kilowatts? _____
- A solar array with a power rating of 2 kW and a maximum voltage of 80 V will produce _____ Amps of current under ideal conditions.

★ **Energy** – Power and energy are related by time. Electrical power is rate at which electricity is produced or consumed. The following equation describes this relationship mathematically:

$$\mathbf{ENERGY} \text{ (in kilowatt-hours)} = \mathbf{POWER} \text{ (in kilowatts)} \times \mathbf{TIME} \text{ (in hours)}$$

For practice, use the energy equation to calculate the energy produced or consumed in the following examples.

- If your PV array has been operating at 750 Watts for 4 hours, how many kilowatt-hours of energy has it produced? _____ (Hint: remember to convert watts to kilowatts).
- If your computer (including printer and monitor) needs 200 Watts of power, and you are looking on the internet for 3 hours, how many kilowatt-hours (kWh) of energy have you used? _____
- Toaster or Microwave? To reheat a piece of cold pizza, you can either heat it in a typical toaster oven (1150 Watts) for 6 minutes (0.1 hours) or put it in the microwave (1300 Watts) for 1 minute (0.0167 hours). Which uses less energy?
- Create your own example. Find an appliance, look on the back to find its power requirements (listed as Watts or a combination of DC Volts and Amps), estimate the number of hours you use it each day, and calculate the energy consumed.

Note to Teacher: The Soltrex monitoring system does not provide any DC data (only AC). As a result, you will not be able to do any actual efficiency calculations of the PV array.

★ **Inverter Efficiency** – As the inverter changes the DC electricity produced by the PV array into AC electricity suitable for use in the school, some of the power is lost. The efficiency is a ratio between the power that goes into the inverter P_{in} (from the solar panels) and the power that comes out, P_{out} (and enters the school). You can calculate the inverter efficiency using this equation:

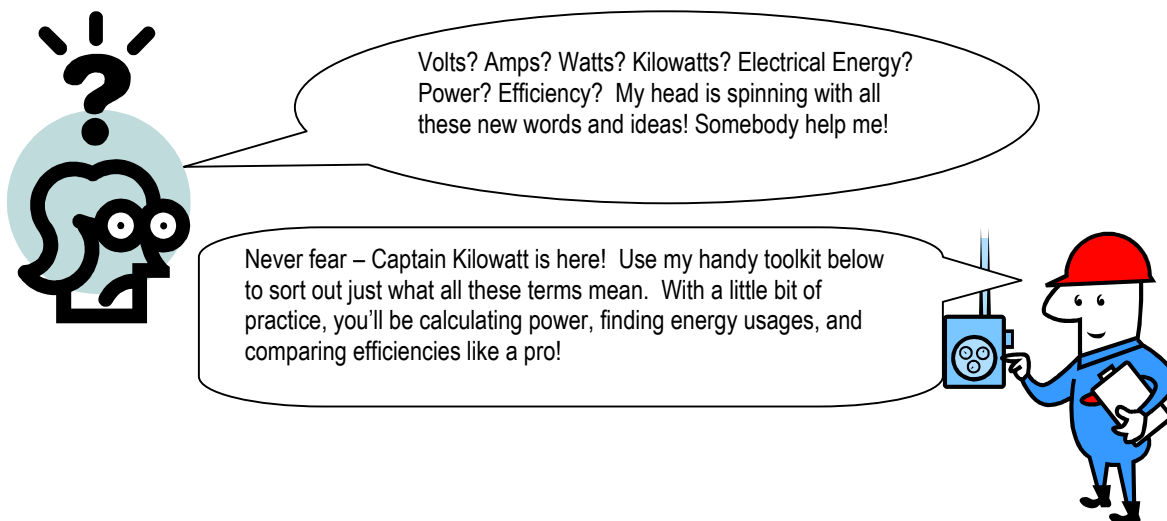
$$\% \text{ Efficiency} = (P_{out} / P_{in}) \times 100$$

For practice, use the efficiency equation to answer the following examples.

- On a bright, sunny day, the PV array produces 950 Watts of power. The inverter then converts this to 900 Watts to contribute to the schools electricity. What is the inverter efficiency?
- On a partly cloudy day in September, the following readings were taken. $P_{out}=535W$ and $P_{in}=636W$. What was the inverter efficiency that day?
- If your inverter is only 50% efficient and P_{out} is measured at 400 Watts, how much power was the PV array producing as P_{in} ?

Watt's It All About? – KEY

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First, review these definitions from the reading. Whoops! Captain Kilowatt seems to have gotten them a little scrambled. Match the correct term with its definition.

Term	Definition
1. <u>B</u> Voltage	A. The unit for measuring electrical current.
2. <u>D</u> Electrical Current	B. A “pressure” that pushes electrons in a circuit to make them move.
3. <u>F</u> Electrical Power	C. Units used for measuring electrical energy.
4. <u>G</u> Electrical Energy	D. Electrons flowing between two points having a difference in voltage.
5. <u>E</u> Volts (V)	E. The unit for measuring voltage.
6. <u>A</u> Amps (A)	F. The rate at which electricity is produced or consumed.
7. <u>H</u> Watts (W)	G. The energy of moving electrons.
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Now that we've gotten the vocabulary straightened out, let's put it to use and practice some calculations. We'll talk about POWER, ENERGY, and INVERTER EFFICIENCY.

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$$\text{POWER (in Watts)} = \text{VOLTAGE (in Volts)} \times \text{CURRENT (in Amps)}$$

- A photovoltaic array with a voltage of 48 V that produces a current of 15 A has a power of 720 watts or 0.720 kilowatts.
- If you take a reading and find that your system is operating at 50 V and 20 A, how much power is the system producing in watts? 1000 W. In kilowatts? 1 kW
- A solar array with a power rating of 2 kW and a maximum voltage of 80 V will produce 25 Amps of current under ideal conditions.

★ **Energy** – Power and energy are related by time. Electrical power is rate at which electricity is produced or consumed. The following equation describes this relationship mathematically:

$$\text{ENERGY (in kilowatt-hours)} = \text{POWER (in kilowatts)} \times \text{TIME (in hours)}$$

For practice, use the energy equation to calculate the energy produced or consumed in the following examples.

- If your PV array has been operating at 750 Watts for 4 hours, how many kilowatt-hours of energy has it produced? 3 kWh (hint: remember to convert watts to kilowatts).
- If your computer (including printer and monitor) needs 200 Watts of power, and you are looking on the internet for 3 hours, how many kilowatt-hours (kWh) of energy have you used? 0.6 kWh
- Toaster or Microwave? To reheat a piece of cold pizza, you can either heat it in a typical toaster oven (1150 Watts) for 6 minutes (0.1 hours) or put it in the microwave (1300 Watts) for 1 minute (0.0167 hours). Which uses less energy? The microwave (0.022 kWh) uses less than the toaster (0.115.kWh).
- Create your own example. Find an appliance, look on the back to find its power requirements (listed as Watts or a combination of DC Volts and Amps), estimate the number of hours you use it each day, and calculate the energy consumed.

Answers will vary. For a listing of the wattage and typical usage of some common household appliances, see:

<http://www.city.ames.ia.us/ElectricWeb/energyguy/appliances.htm>

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$$\% \text{ Efficiency} = (P_{out}/P_{in}) \times 100$$

For practice, use the efficiency equation to answer the following examples.

- On a bright, sunny day, the PV array produces 950 Watts of power. The inverter then converts this to 900 Watts to contribute to the schools electricity. What is the inverter efficiency?

$$(900/950) \times 100 = 94.7\%$$

- On a partly cloudy day in September, the following readings were taken. $P_{out}=535W$ and $P_{in}=636W$. What was the inverter efficiency that day?

$$(535/636) \times 100 = 84.1\%$$

- If your inverter is only 50% efficient and the PV array is producing 800 Watts, how much power is entering the school as P_{out} ?

$$\begin{aligned} P_{out} &= (\% \text{ Efficiency}/100) \times P_{in} \\ &= (50/100) \times 800 \\ &= 400 \text{ Watts} \end{aligned}$$