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The Math-Science Connection….Two Examples for Your Gifted Classroom

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Throughout my many interactions with G&T classroom teachers, we always seem to get down to the topic of how to constructively present meaningful math and science application examples to students. As a retired engineer and inventor, math and science seem to me to be virtually two sides of the same coin. They are important tools I use to inquire about my world, and the wonderful processes that go on within.

Shown below are two examples I like to use with students to show how math and science are related, examples you might want to try on your gifted students. One deals with the topic of solar energy and using the sun's energy. The other is a classic way to use math and science to learn about how we use electric energy in the home. Look for other examples of the math-science connection for your gifted classroom. There are lots of great real-world examples I know you can find. Why not challenge your gifted students to look for examples as well, or maybe create their own!

Usable Energy from the Sun

The sun does not shine with equal intensity over the face of the planet. Some places have greater amounts and more cloudless days, which make it more economic to use the sun than those places where cloud cover is common. For instance, in the United States, the southwestern part of the country receives about 1.5-1.7 times as much solar energy as the northeast where cloud cover is prevalent about 50% of the daytime period. The table below shows this for a variety of American cities.

Variation of Sunlight—United States Cities

City	Solar Radiation (kWh/square meter)
Seattle	3.32
Boston	3.60
New York City	3.90
Chicago	4.16
Washington, DC	4.16
Nashville	4.43
Miami	4.71
Bismarck	4.71
Fort Worth	4.99
Honolulu	5.32
Denver	5.82
Phoenix	6.64

These figures represent the amount of energy available from the sun over a square meter of surface area per day. Now shall we use some math to think about what this means? We shall work the math around New York City whose radiation is 3.9 kWh/sq. meter. Since it takes about 30 square meters of photovoltaic solar panels for a typical 3-4 kW system for a home, this means:

3.9 kWh/sq. meter/day X 30 sq. meters = 117 kWh/day of potential energy coming down from the sun.

Experience this for 365 days and the total potential available energy from sunlight would be……117 kWh/day X 365 days/yr. = 42,705 kWh /yr. This is actually a huge number compared to what a typical home in the New York City area might use, which is about 7300 kWh; however, our calculation is not yet complete. How much of all this potential energy can be actually captured and used?

Today, solar systems can convert about 10-15% of the incoming sunlight (42,705 kWh/yr.) into useful electrical energy, which means between 4271 to 6406 kWh can be collected…but one must convert this DC solar produced electricity to AC for use in the home; and there is an efficiency of conversion here of about 80% – so we are now at 3417-5125 kWh of useful AC energy per year. This means a photovoltaic system, on an annual average basis, might be able to supply 47-70% of a New York City area home's annual electricity needs. It could be as a much as 90-100% (or more) in the summer when the sun's energy is very strong for a long portion of the day to 15-20% during the winter when the sun is weak and low in the sky. A similar analysis for other cities can also be done as long as you know the typical electric loads in the homes of those cities. These calculations show how important it is to increase the conversion efficiency of solar systems. There is a great deal of free available solar energy out there not being put to good use.

Sunlight normally can vary quite a bit with season and year. In fact, a swing of 15-30% either way is not unusual. One good volcanic blast like Mount St. Helens in 1980, or Mount Pinatubo in the Philippines in the mid-90s did in fact all by themselves, reduce ambient world solar radiation for that year by 15%. It even varies on a state basis. Here in New Jersey, the southern half of the state receives about 13% more energy than the northern portion.

When you design a solar system, you must know both the maximum power needs of your application and how energy is used throughout the daytime hours. A complete energy audit of the energy consumption of the application is the first crucial step to sizing the solar system, which ultimately determines how many solar panels will be needed.

The Important Difference between Power and Energy

While solar panels are rated in their power output capability, how long they operate delivering this power output is their energy capability. Consider this discussion below explaining the crucial difference between power and energy.

A kWh is a unit of **energy**, and a kW is a unit of **power**, the rate at which energy is consumed or generated. The relationship between them is:

ENERGY = POWER X TIME

KWh = kW X hours

The fundamental unit of electric energy consumption per unit time is the watt, in which we express the power rating of an electric appliance. For example: your color TV set might use 200 watts; a kitchen can opener, maybe 180 watts; the frost-free refrigerator, perhaps 400 watts; your dishwasher – 1,300 watts; and, that deluxe, super hair dryer, the one your daughter dims the room lights with, can use a whopping 2,000 watts.

A kilowatt (kW) is 1000 watts, so that monster hair dryer consumes power at the rate of 2 kW. <u>Power is simply the rate of consumption</u>.

Think of your car. If your speed is 60 mph, this is your rate of travel. Keep that rate of travel up for one hour and you will have traveled 60 miles. Run that dryer continuously for 1 hour and you will have consumed 2 kWh of energy. <u>Energy is power summed over time</u>. Run your TV set for 1 hour and you end up using 0.200 kWh of energy.

Here is a simple equation to help you understand:

Power Draw Of Appliance (in watts) X Time of Operation (in hours) X Cost of Electricity ($/kWh)
1000 (conversion of watts to kilowatts)
= Estimated Operating Cost ($)

Let's do some math. Run your TV set for 6 hours a day for an entire month, and your energy bill for that usage will be:

<u>200 watts X 180 hrs. (30 days times 6 hours per day) X $0.10 /kWh</u> = $3.60
1000

In this example, we assume our cost for electricity is an average value of a dime a kWh. Certainly with higher electricity costs, higher operating costs result; the same with greater hours of usage. Now for the super hair dryer: Let's say your daughter/sister uses it for 15 minutes every day for one month, so 30 days times 0.25 hours per day is 7.5 hours of usage for the month. Here we go….

<u>2000 watts X 7.5 hours X $0.10</u> = $ 1.50
1000

As you can see, just because an appliance uses more power, does not mean it will use more energy, unless you know how long the appliance operates. The TV costs more to operate, yet it is ten times less in power consumption than the super hair dryer; but the TV set is on many hours more than the hair dryer.