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SCHOOLGEN ACTIVITIES **LEVELS 7-8**

PHOTOVOLTAIC SYSTEM DATA ANALYSIS

Teacher-led Activity

In this activity, the students will interpret photovoltaic system data from the Schoolgen website. After retrieving hourly photovoltaic system data, weather data [especially sunshine hours], and solar altitudes, the students will then process this data statistically or graphically, analyse it for trends and, if possible, quantify these trends.

PHOTOVOLTAIC SYSTEM DATA ANALYSIS

1. LEARNING AREAS: Physics

2. CURRICULUM LEVELS: 7–8

3. AIM OF THE ACTIVITY

In this activity, students will interpret photovoltaic system data from the Schoolgen website (http://www.schoolgen.co.nz/ss/default.aspx). After asking the students to set research questions and a framework, they will retrieve hourly photovoltaic system data, weather data (especially sunshine hours), and solar altitudes for the period under study, process it statistically or graphically, analyse for trends, and, if possible, quantify them. It will involve applying basic physics principles to the explanation of any trends observed in the data.

The patterns and trends the students will explore are the:

- Daily changes in solar flux
- Influence of orientation and inclination of the solar panels on electricity generation
- Influence of seasonal effects on the duration and intensity of solar energy.

By selecting data from Schoolgen schools in the same region (for example, Auckland), they data from each school could be treated as individual sample points and so statistical work could be done. With access to Australian data (http://www.solarschools.net), the investigation could be widened to investigate latitudinal influences.

For further information on key concepts and terms, go to the student fact sheet Photovoltaic Systems and their Dependency on Sunlight

4. INTENDED LEARNING OUTCOMES

The students will be able to:

- Retrieve comparable data from several sources and collate using a spreadsheet
- Analyse data graphically or statistically to identify imbedded patterns, correlations, and anomalies
- Use the concepts of insolation (solar flux density reaching the Earth's surface), angle of incidence, energy conversion, and the diurnal solar cycle to explain patterns in the data.

5. WHAT YOU NEED

- A computer with a spreadsheet program and an internet connection
- Skyglobe software (free to download from http://www.sidewalkastronomy.com/skyglobe.html) or a simpler solar position calculator might be easier to use, for example, http://www.srrb.noaa.gov/highlights/sunrise/azel.html
- Free registration of your school at the National Climate Database (http://cliflo.niwa.co.nz/), to be able to access data on climate and weather.

6. FOCUS

Ask the students questions like:

- Under what conditions is solar energy a viable alternative for electricity generation in New Zealand? Students may take into account factors such as: sunlight hours, electricity needs, comparative cost of grid supply electricity and grid connection fees for remote areas[1], the impact of drought on the supply/cost of hydro electricity, the introduction of government rebates and incentive schemes for the purchase and installation of PV systems, and the environmental impact of electricity generated from burning fossil fuels.

- What is solar flux and how can it be measured?
- How could daily fluctuations in sunlight affect the output of photovoltaic arrays?
- How predictable is the sun's position at any given time?
- Is there a predictable pattern linking photovoltaic array output to the sun's altitude, and can we represent it as a mathematical model?
- How could the output of a photovoltaic array be optimised?
- To what extent does weather affect the output of photovoltaic arrays? What specific components of 'weather' are most likely to influence a photovoltaic array?
- How does the latitude of an installation influence solar generation there?

7. MANAGING THE ACTIVITIES

Ask the students to:

(i) Devise a suitable research question. The question must be able to be answered from the data available, for example, "Does the photovoltaic array output increase with solar altitude?" or "Does increased summer daylight length compensate for reduced solar altitude at higher latitudes?"

(ii) Decide on a sampling regime – to be statistically significant, how many sample schools might be needed, what spread of localities is needed, and what variables need to be considered that may have the potential to influence results? How can these variables be controlled or monitored?

(iii) Gather photovoltaic array data from each selected school and enter the data into a spreadsheet. Include hourly, daily, photovoltaic array output (taken from Schoolgen http://www.schoolgen.co.nz/ss/default.aspx), latitude of the school, and photovoltaic panel installation information – orientation, inclination, panel size, array size, etc.

(iv) Gather weather data for each school area from the National Climate Database (http://cliflo.niwa.co.nz), and enter the data into a spreadsheet. Include relevant daily weather data (for example, sunshine hours, cloud cover) for the school region and the period of time under investigation.

(v) Gather solar data for each school area using Skyglobe or by using a solar position calculator, and enter the data into a spreadsheet. Include astronomical data, such as sunrise/set times, and solar altitude.

(vi) Graph the data. Present the photovoltaic array and site data separately in time-related graphical format, and use spreadsheet functions to produce the most appropriate graph(s) for the type of data

(vii) Visually analyse the graphs to seek recognisable patterns

(viii) Where possible, statistically analyse the data. Is there an apparent mathematical relationship that might predict maximum photovoltaic array performance at any given time of year or location?

(ix) Suggest theoretical causes for any correlations noted. Does this suggest a causal relationship?

8. REFLECTION

- To what extent was the data sufficient to answer the research question?
- Does any correlation noted suggest a possible causal relationship?
- What is needed for a correlation in data to be interpreted as causation?
- To what extent does the ability to use a model to predict future events add to the credibility of that model?

9. EXTENSION

- To what extent does latitude affect the annual output of photovoltaic arrays?
- Do long summer daylight hours in higher latitudes mitigate the effect of lower solar altitude on total daily photovoltaic array generation compared to lower latitudes?
- What sized photovoltaic array would be needed to generate 2kW.hr of electricity per (cloudless) day in Southland on 21st December 2008 (summer solstice)? How about close to 21st June 2008 (winter solstice)?

10. SAFETY GUIDE

There are no safety guides for this activity.

11. RESOURCES

- Student fact sheet Photovoltaic Systems and their Dependency on Sunlight
- Global energy cycle notes http://www.ess.uci.edu/~yu/class/ess55/lecture.3.energy.pdf
- Light intensity and angle notes http://nova.stanford.edu/projects/mod-x/ad-flashangle.html
- Solar module information http://www.ecovantageenergy.com/sizing.html

[1]For estimates of prices to purchase and install PV systems in New Zealand, go to the Energy Efficiency and Conservation Authority web site and download the PDF document "Photovoltaic Fact Sheet" (http://www.energywise.govt.nz/node/3400)