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Photovoltaic Systems and their Dependency on Sunlight

Overview

Comparing the amount of electricity generated by the PV systems of different Schoolgen schools reveals frequently varied results. One explanation is that PV cell electricity generation is dependent on the intensity of incoming light. In a solar generation system this light is sunlight and its intensity will change throughout the day; the fluctuation will depend on time of day, season, and latitude. Paradoxically, during winter when evening power demand is highest, the generating daylight hours are shortest.

Solar Flux

The sun is a steady source of a continuous spectrum of electromagnetic radiation (EMR). This radiation is referred to as the solar flux. As this EMR passes through the earth's atmosphere, some is reflected, absorbed and scattered, resulting in a reduction in the amount that actually reaches the surface.

Daily (diurnal) Solar Cycle

During a cloudless day the solar flux will begin to increase from sunrise to midday then decline until sunset. This change will be related to how high in the sky the sun appears. Early after sunrise and again near sunset 'beams' from the sun are spread over a larger area of the earth, and have to pass through more of the atmosphere. The result is that early morning and late afternoon sun is not as bright or intense. Around midday sun beams have the smallest angle of incidence to the earth and are spread over the smallest area. They also have to pass through the least amount of atmosphere, so there is less reflection and the sky is brighter (see figure 1.).

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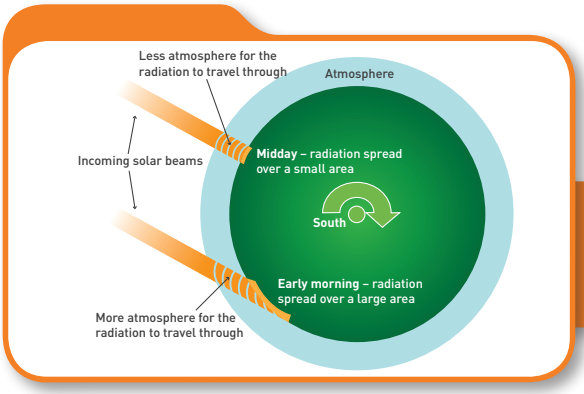

Figure 1: Solar beams at different times of the day.

Seasonal Changes in the Solar Cycle

The seasonal changes (in temperature, insolation and daylight hours) are mainly due to the tilt of the earth's axis of rotation relative to the plane of the ecliptic (our plane of orbit) (see figure 2.). When New Zealand is tilted towards the sun, the sun appears higher in the midday sky, and the day length is longer. The converse is true for winter (see figure 3.).

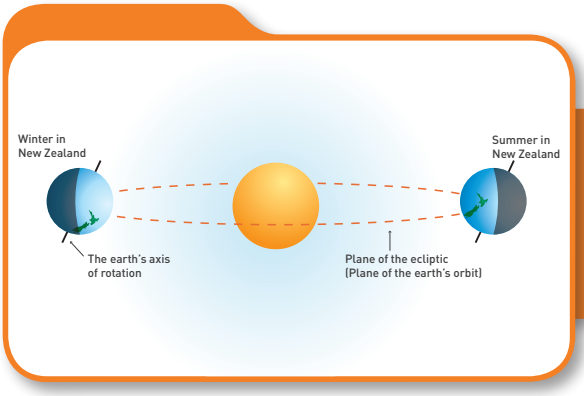

Figure 2: At different times of the year, the earth is tilted on different angles as it spins around the sun.

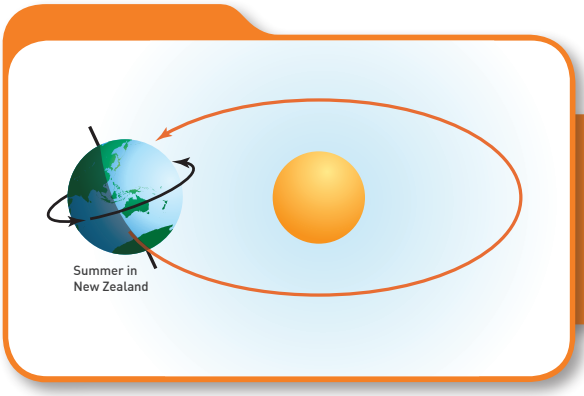

Figure 3: It is Summer in New Zealand when the New Zealand-side of the earth is tilted towards the sun.

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Latitudinal Influences on the Solar Cycle

Latitude affects both daylight hours and the sun's altitude on any given date and at any given time. Proximity to the polar latitudes in summer gives longer daylight times than at equatorial locations. At the extreme (inside the Arctic or Antarctic circles) there will be 24 hours of daylight per day for part of the summer. However, the sun appears lower in the sky closer to the poles than in equatorial latitudes. Also the incident light must pass through a great distance of atmosphere before reaching the surface, further reducing its intensity.

Other Factors that May Affect School Comparability

The Size of the Photovoltaic Array:

The capacity of the schools photovoltaic array will affect total daily electricity output, though not the output per cell.

Orientation and Inclination of the Photovoltaic Array:

In most cases the photovoltaic cell panels are roof mounted. The roof inclination and orientation will differ between schools resulting in a variation of effectiveness

Climatic Parameters:

Weather conditions, notably sunshine hours, and cloud cover, will affect the quality of light. These factors are measured at a range of official weather stations and the data is collected by NIWA in a national database.