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The PV Heat Island Effect - What Is It? Is It A Problem For Horticulture and Dairy Farming?

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Background

In 2017 four PV farms applied for planning permission in the Municipality of the City of Greater Shepparton in Victoria. The proponents chose that area as it has a reasonable solar resource and it had sufficient grid capacity to accept the output from the solar farms. However, as the solar farms were proposed to be within an agricultural area there were some concerns by nearby farmers that the solar farm may adversely impact their operations due to the PV heat island effect.

The Greater Shepparton Solar Farm Planning Panel was held in Shepparton over five days between May 14 and May 28, 2018 (GSSF, 2018) to look at this and other potential impacts of the solar farm. A draft design and development guidelines have been published by the Victorian Government (DELWP 2018) that covers this effect amongst other aspects requiring consideration in the planning process.

What is the PV heat island effect?

The heat island effect is the term that is generally used to describe increased temperatures in urban areas compared to surrounding rural areas. The American Meteorological Society – Glossary of Meteorology defines the term Urban Heat Island (Or heat island.) as “Closed isotherms indicating an area of the surface that is relatively warm; most commonly associated with areas of human disturbance such as towns and cities. The physiographic analogy derives from the similarity between the pattern of isotherms and height contours of an island on a topographic map. Heat islands commonly also possess "cliffs" at the urban–rural fringe and a "peak" in the most built-up core of the city.”. This paper relates to whether there is a similar effect for PV farms, the photovoltaic heat island (PVHI) effect and whether it causes disturbance to temperatures in nearby agricultural properties.

Barron-Gafford et al (2016) monitored temperatures 2.5 m above the soil at three sites in Arizona at the same time. The sites represented a natural desert ecosystem, the traditional built environment (parking lot surrounded by commercial buildings), and within a PV power plant. They found that “temperatures over a PV plant were regularly 3–4 °C warmer than wildlands at night”. This effect was greater in warmer months than in cooler seasons. They claimed this to “…demonstrate that the PVHI effect is real and can significantly increase temperatures over PV power plant installations relative to nearby wildland”. They also postulated that the PVHI “may be due to heat trapping of re-radiated sensible heat flux under PV arrays at night”.

Liwei Yang et al (2017) measured temperatures within and outside a PV farm in Golmud, China in the Gobi Desert. “The results show that the air temperature at a height of 2 m at the two sites is essentially the same during winter daytime, but in the other seasons, the daytime air temperature at the PV farm is higher than that in the region without PV. The maximum difference appears during the summer daytime, with a value of 0.7°C (the summer daytime averaged value). …... The night time air temperature at a height of 2m during the four seasons at the solar farm was higher than that in the region without PV arrays, since the solar panels have a heat preservation effect near the ground. The differences in values between the two sites were 0.1, 0.3, 0.2, and 0.1°C in summer, autumn, winter and spring, respectively.” and “The results show that the daily range of soil temperature at a depth of 5–10 cm at the solar farm is lower than that in the region without PV farm.”

These two papers indicate that temperatures within the solar farm will be higher than in the surrounding areas for at least part of the time.

Will it impact nearby farms?

Whilst most measurements have occurred within solar farms, the impact will depend on what occurs at the edges of the solar array, the distance of the agricultural enterprise from the edge of the array and any means of blocking heat transfer from the array to surrounding areas.

Whilst decreasing heat build-up will be important to the operator of the solar farm, as PV output reduces as temperature of the panels increase, for neighbours the major issue will be to reduce the potential for heat transmission out of the solar farm into neighbouring properties.

Fthenakis and Yu (2013) measured temperatures at a height of 2.5 m at a solar farm in Canada within the PV field and at a number of points for a distance of up to 800m from the outside of the PV array. They found that "both the field data and the simulations show that the annual average of air temperatures in the center of PV field can reach up to 1.9°C above the ambient temperature, and that this thermal energy completely dissipates to the environment at heights of 5 to 18 m." …and… "analysis of 18 months of detailed data showed that in most days, the solar array was completely cooled at night, and, thus, it is unlikely that a heat island effect could occur."

Fthenakis and Yu also indicate that the PV farms exhibits another of the characteristics of a heat island, which is the temperature "cliffs" at the fringe of the PV farm where temperatures drop quickly into the surrounding area. Natural convection will take the warm air upward, so it will not spread heat into neighbouring properties. Forced convection could move heat from the PV farm to surrounding areas if there is no barrier to reduce air flow. In a mild breeze the influence of natural convection will quickly lift the warm plume upward and in a stronger wind the heat may be spread wider, but temperatures will dissipate quickly as the air is mixed more quickly, diluting the heated air with unheated air. A dense vegetation screen will effectively block air flowing from the solar farm to a neighbouring orchard, thereby reducing the temperature impact from the solar farm.

Radiation from one surface to a nearby area can be effectively eliminated by 'shading' the cooler area from the hotter one. The vegetation buffers or hedges, used in some PV farms, will, if higher than the panels, screen the warm panels from radiating to adjacent agricultural areas.

Heat build-up within the solar farm will be minimised by installation of efficient PV panels to transmit more of the incident solar energy out if the site as electricity and by tracking which will intercept more solar irradiation.

References

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