



How Does Vermont's Climate Cater to Solar Energy?

Project By: Jamie Hamilton and Sam Ligon



RACC
Research on Adaptation
to Climate Change
in the Lake Champlain Basin

Project Goals

The Green Mountain State is seeing an explosion of solar power, especially in Rutland County where the local power company hopes to make Rutland the "Solar Capital of New England." We want to learn about:

- What is the ideal climate for an efficient solar array?
- How does seasonality affect solar productivity?
- What makes Rutland a great solar location?
- What is the impact of solar irradiance on generated power?
- What is the impact of solar irradiance on panel temperature?
- How does panel temperature relate to air temperature?
- How does the time of year affect solar irradiance?
- How does Effective Cloud Transmissivity change throughout the year?
- How does the reflection by clouds change the daily climate?
- How does all this data come together to help produce an affective solar display?
- How can I use this data to determine whether solar is a worthwhile investment for a Vermont dairy farm?

How Does Solar Work?

- * Solar energy is created from sunlight using photovoltaic cells.
- * Photovoltaic cells exhibit the photoelectric effect because of the materials that they are made out of.
- * Most solar cells are made out of silicon crystals.
- * When light energy makes contact with the crystals, electrons break off of the silicon atoms, creating electrical current.
- * This electrical current is converted into electricity.



How is Solar Energy Converted to Electricity?

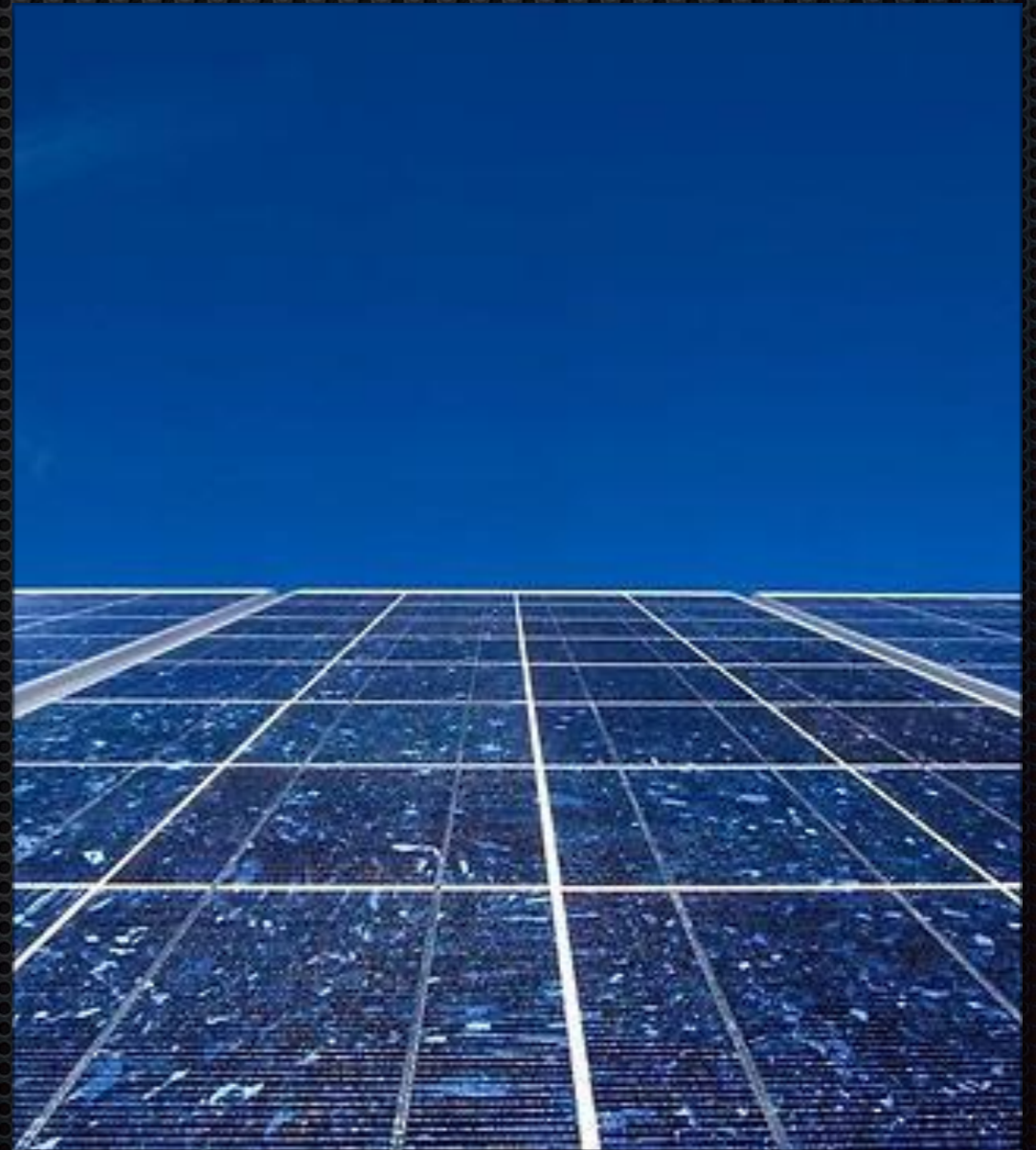
- DC power is converted to AC power for home use.
- An inverter performs this conversion.
- Meters on inverter and the side of the home monitor energy production and energy usage.



A series of solar inverters (brightergy.com)

Benefits of Solar

- Environmentally friendly.
- Users can make a profit from the energy they create.
- There are state grants/benefits to promote the installation of solar panels.
- Longterm investment.



Optimal Solar Locations

- Lots of sunlight!
- Brownfield areas
- Rooftops
- Open fields
- Roads/sidewalks?



Off-grid vs. Grid-tie Solar

- Off-grid solar arrays do not connect to the worldwide electrical grid.
- Grid-tie solar arrays have the capability to put solar-generated power back on the grid so that other parties can use the excess.
- If you are off-grid, you are on your own! Most off-grid setups have a backup battery that is also filled using the sun's energy.

Solar Power in Rutland, Vermont

- Green Mountain Power is spearheading the solar effort in Rutland, Vermont.
- Initial goal of at least 6,250 kW of solar capacity by the end of 2017. This goal has been extended to 10,000kW.
- Longterm goal: 90% of Vermont's energy will be renewable by 2050 making it the solar capital of New England.
- New sites are rapidly emerging.



Rutland's Solar Sites

- Rutland has many resources for potential solar sites.
- These include: Schools, fields, brownfield property, town land, and public sites.
- The most recent location for solar power in Rutland is the old Rutland Landfill Site.
- This site is the first project that establishes a micro-grid powered purely by solar and battery-backup, according to the U.S. Department of Energy.
- Contains 7700 panels that generates 4MW of battery storage.



Research

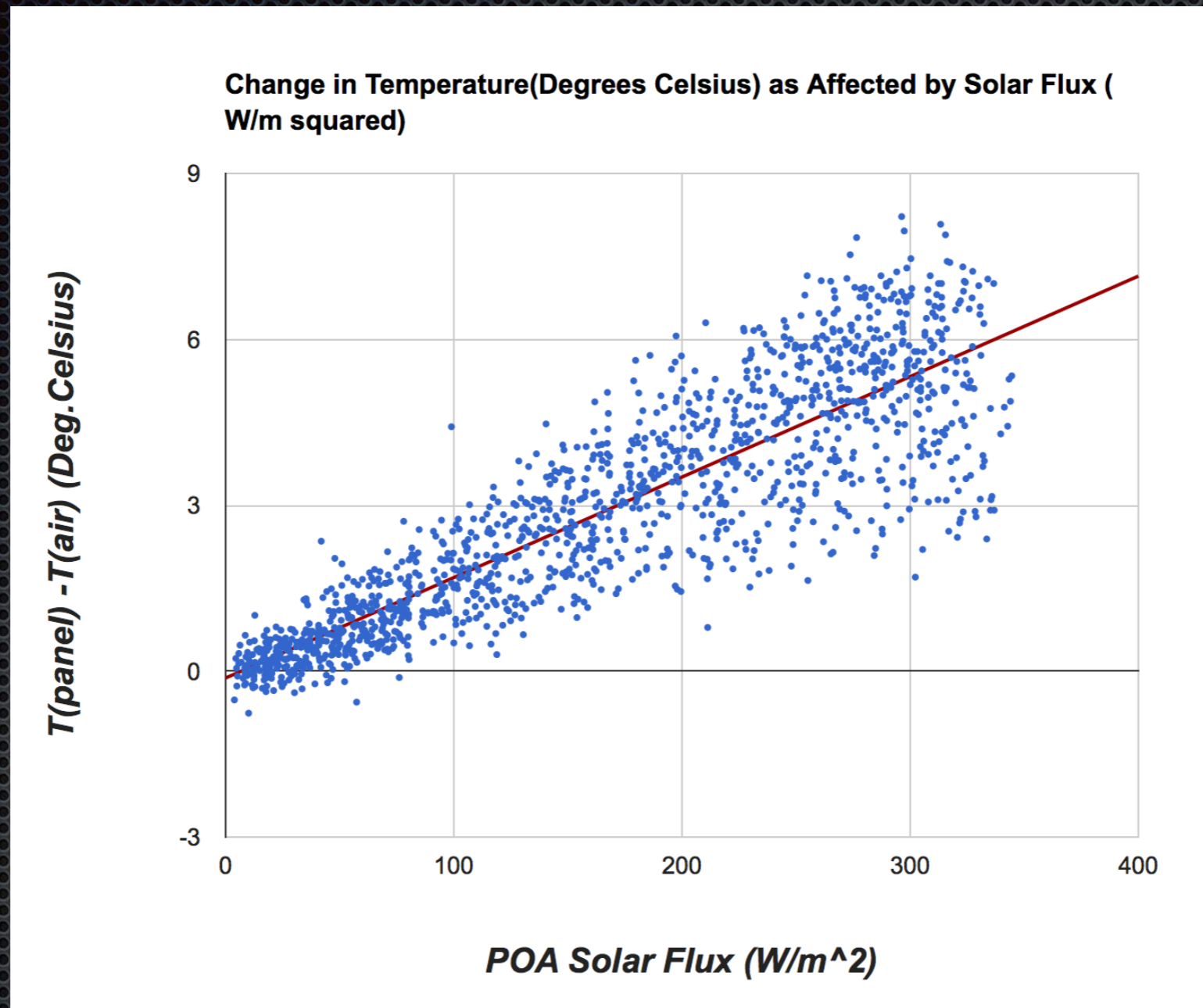
- Analyzing Rutland's solar sites for productivity using graphical analysis
- Creating awareness of solar efficiency and or inefficiency

Power vs. POA Solar Irradiance



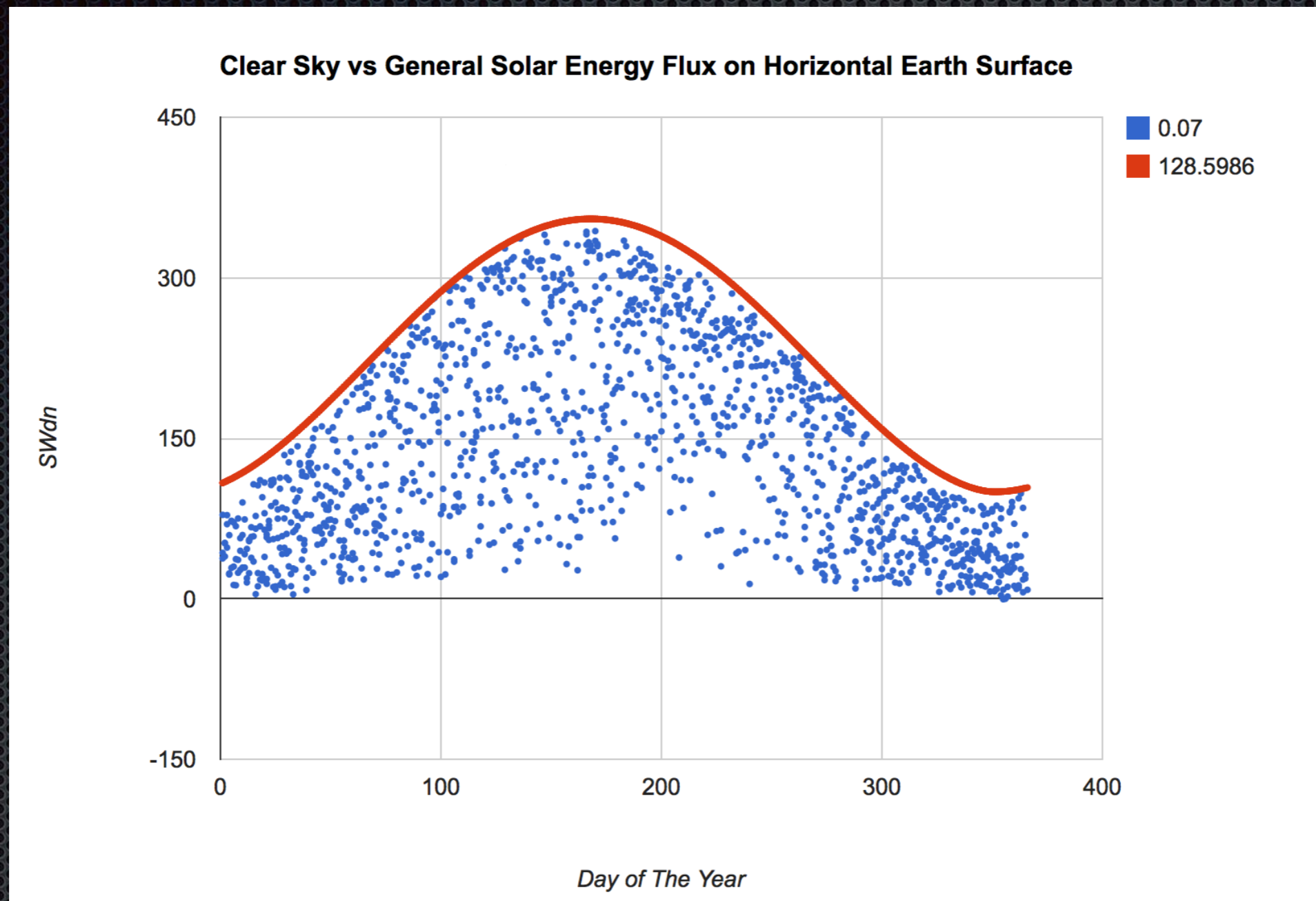
As POA Solar Irradiance (amount of light that hits the panels) increases, the power produced by the panels increases as a linear relationship.

Air Temperature vs. POA Solar Irradiance



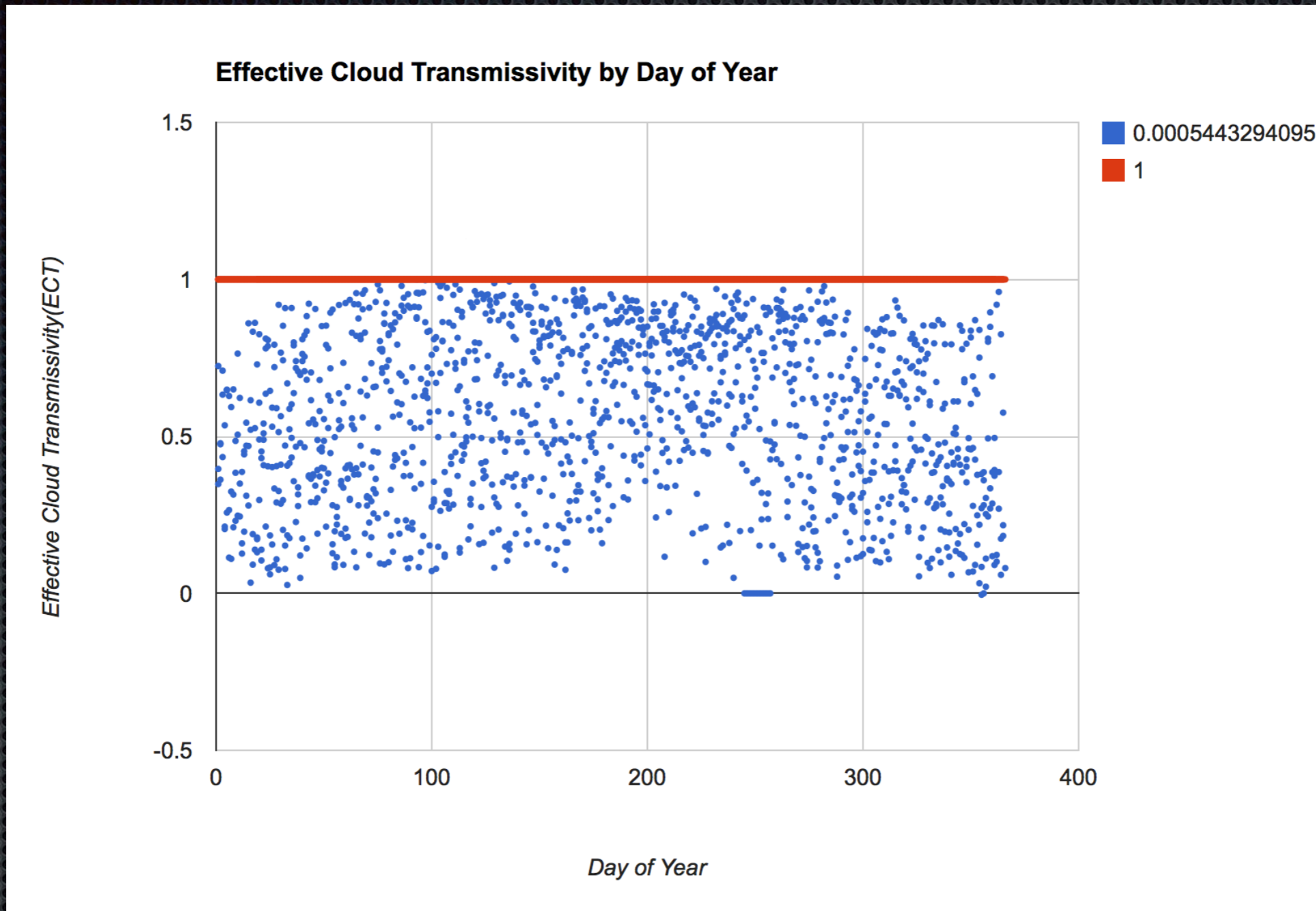
As the POA Solar Irradiance (Flux) increases, the solar panel temperature increases in relation to the air (linear but spread).

Clear Sky and Actual Solar Flux Throughout the Year



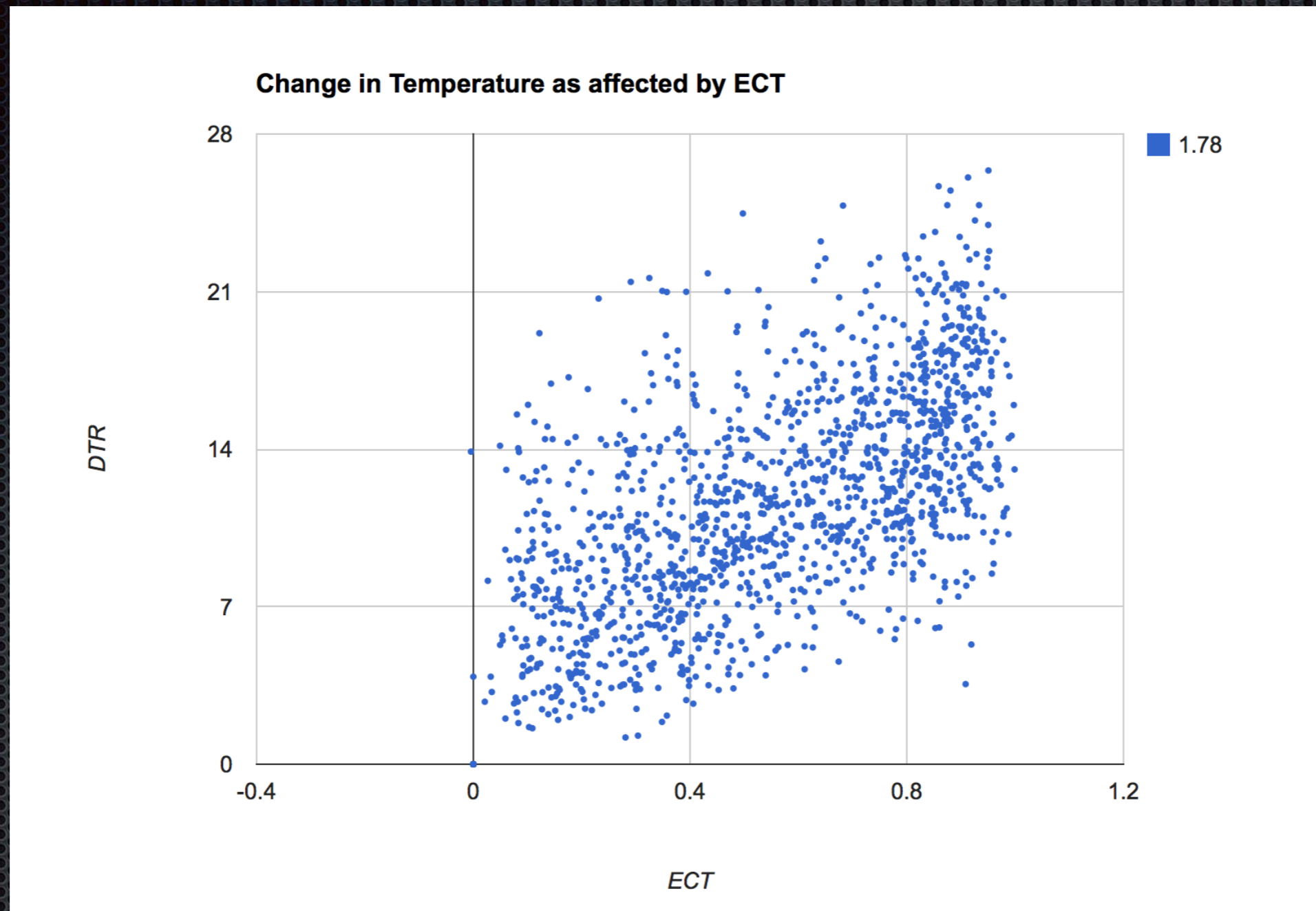
The bell curve represents the clear sky solar flux throughout the year (more flux in the summer months). The blue dots are actual values taken throughout the year.

ECT (Effective Cloud Transmissivity)



The red line is the ideal ECT (100% or no clouds), while the blue dots are the values throughout the year that vary depending on cloud cover.

Change in Temperature (DTR) as affected by ECT



As the ECT gets closer to 1 (100% effectiveness), the temperature range tends to increase. However, there is no true trend. This means that on sunnier days, there is a greater change in temperature.

The Action Plan

- Present our findings to Green Mountain Power and the Vermont EPSCoR Summit.
- Extend research to incorporate solar power on dairy farms.



Solar Panels on Farms

- Is it worth it?
 - **YES!**
- 800-1200 kilowatt-hours/cwt annually
- Electricity is everywhere on a dairy farm
- Potential locations - fields or barn roofs
- McKnight Farm - East Montpelier, VT
 - Generating profit from panels in 6 years.



Solar Panel Storage on Rooftops

- Maximize space and efficiency
- Investment pays itself off
- No longer an eyesore
- Fewer obstacles to block sunlight



Special Thanks

- Dr. Alan K. Betts - Atmospheric Researcher
- Green Mountain Power

Questions?

Website

<http://jhamiltoncapstone.weebly.com>

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