

Does ground cover matter? A comparative analysis of solar farms

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Abstract

Over the last decade, large ground-mounted photovoltaic (PV) solar arrays have been installed, with larger arrays currently in the permitting and construction phases. As solar energy becomes more mainstream, the industry is being pressured to give better estimates on energy production potential during preliminary site assessments. Although there is evidence that surface cover may impact array efficiency, surface albedo is not currently taken into account when calculating array efficiency. To assess the impacts that ground cover has on PV array energy generation, temperature, light intensity, rainfall and overall energy generation were compared for two solar arrays with different surface cover. Significant differences in light intensity were found between the two sites. In contrast to the hypothesis, energy generation was not significantly different between locations. Results will not be conclusive until the effects of seasonality are determined after a full year of data collection. Energy generation estimates were up to 11% overestimated and 16% underestimated at the test sites in comparison to actual array performance. Therefore, any benefits of altering ground cover to increase energy generation should be weighed against the ecological costs associated with land use changes. Agrivoltaic systems and restoration of native plant species are two alternative ground cover usages that could be considered.

1. Introduction

“Since tens of thousands of acres of U.S. land are proposed for development into solar power in the upcoming years, the environmental impacts from the installation and operation phases deserve comprehensive research and understanding”(Turney, 2011)

True life cycle assessments done prior to installation cannot be performed until energy generation from solar modules can be more accurately estimated. This study will determine if ground cover (surface albedo) should be factored into energy estimations done prior to installation. Currently, surface albedo is only incorporated into PVWatts, a traditional modeling software used by industry to predict energy generation, in 40km² grid cells.

The literature suggests that diffuse irradiation stemming from the reflectivity of a surface may enhance crystalline silicon array performance (Andrews & Pearce, 2012). Until this study, this hypothesis has only been tested with snow conditions. As fine resolution modeling becomes standard, conditions like surface albedo can be factored in to allow industry to give better energy generation estimates if ground cover is found to effect module performance.

“Best estimates currently made on solar panel efficiency are anywhere from 5% underestimated to 3% overestimated” (Andrews et. al, 2012).

2. Methods

Two research locations Dynamic Solar, Wayne PA

(1)Sandyhill Camp-- 157kW polycrystalline solar array
Ground Cover- light tan woodchips, dispersed grasses

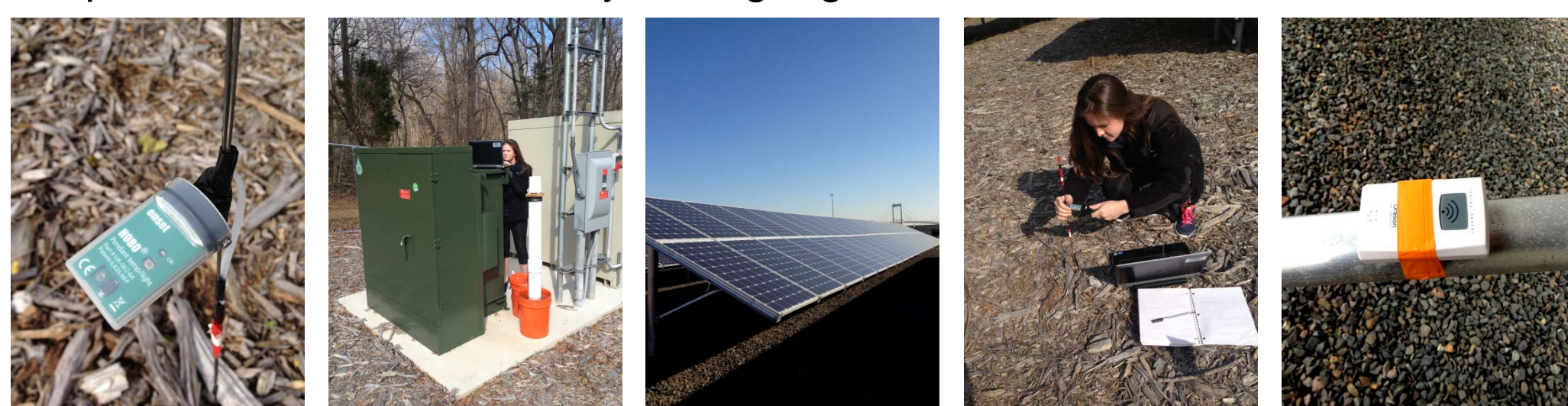
(2) PWD Southeast -- 248kW monocrystalline solar array
Ground Cover- dark grey/black gravel



Field Work

HoboPendant 64k light/temp logger Oregon Scientific Rain gauge
Two per location-- under & adjacent One per location – next to inverter

Sites were visited once every fourteen days to download data to HOBOWare analysis site. Temperature and weather was recorded at each site visit as a comparison to ensure accuracy of all gauges.

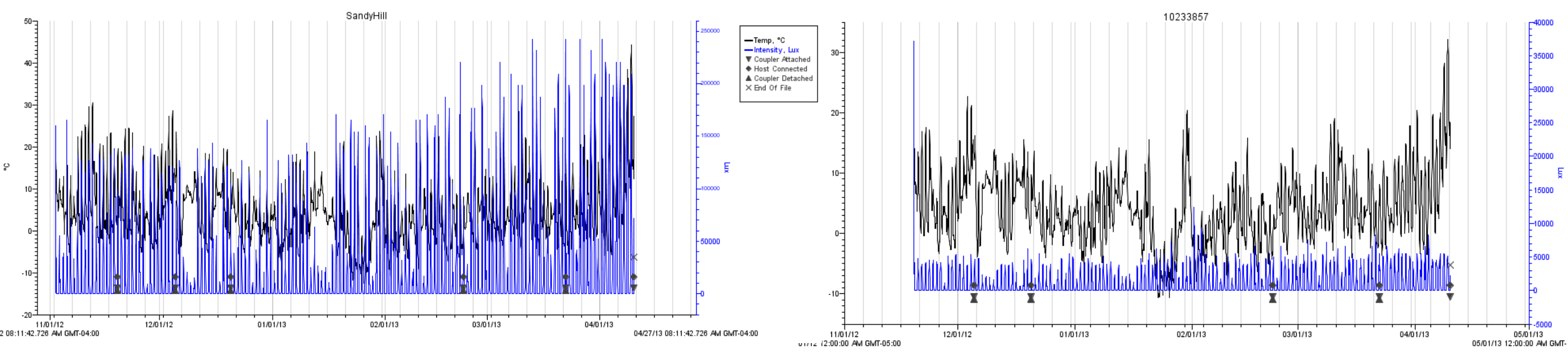
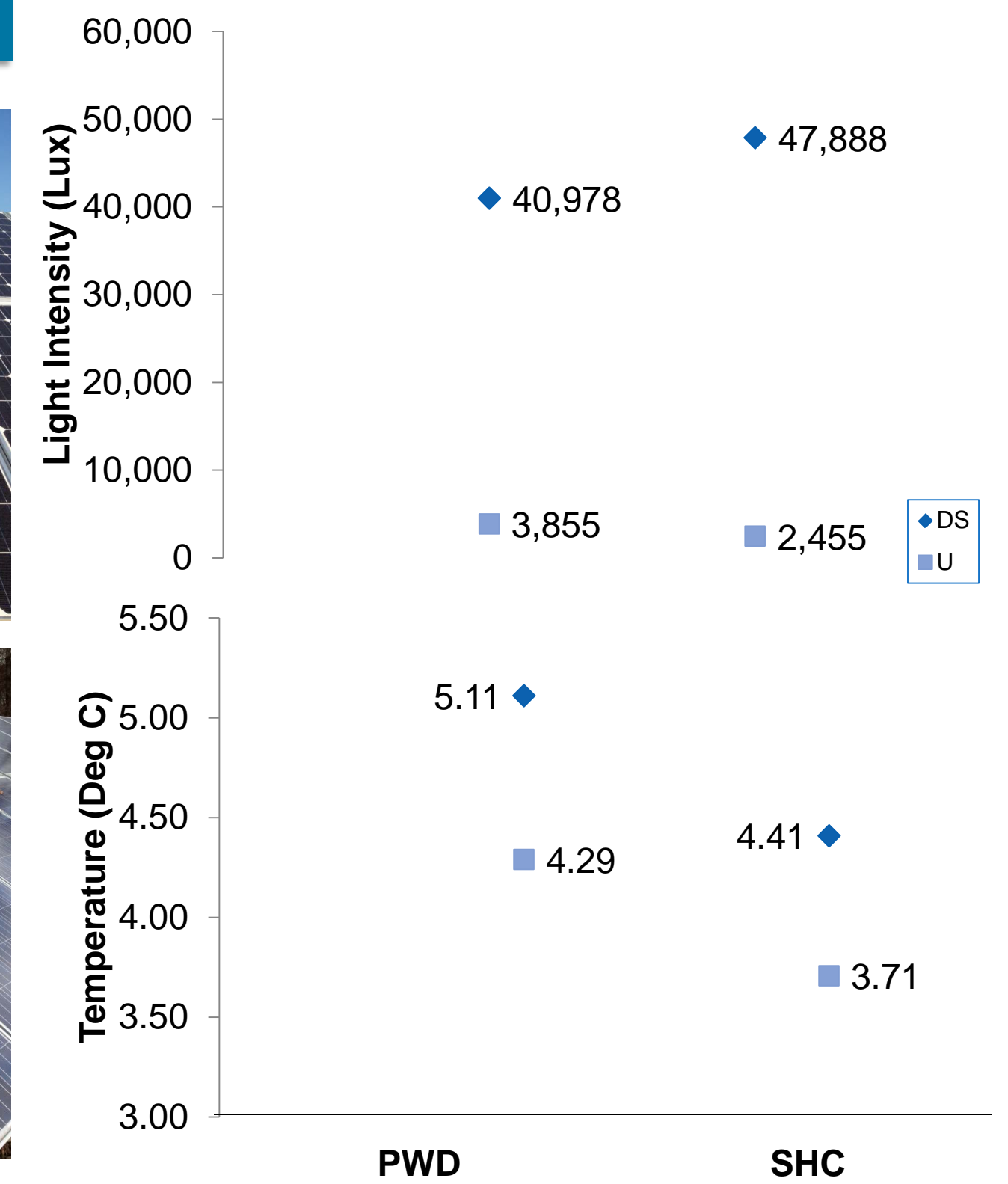


Statistical Analysis

T-tests with equal variances were run to compare locations in direct sunlight and locations underneath the panels. A t-test to test for significant difference in temperature in direct sunlight between the two sites was run and a t-test for light in direct sunlight. Two t-tests-- to comparing both locations underneath the panels. Significant differences in temperature and light intensity was tested for. Two factor ANOVA- to determine if there was a significant difference in light, temperature and rainfall between the two sites. By running a two factor ANOVA, biases that occur with t-test replication was eliminated. T-test-- differences in energy generation between both sites.

3. Results

- Significant differences in **light** availability under the panels and adjacent to the panels (both locations)
- Significant differences in **temperature** under the panels and adjacent to the panels (both locations)
- Significant differences in **light** availability in direct sunlight between both locations
- No significant difference in **temperature** in direct sunlight between both locations
- No significant difference in **energy** generation between solar arrays after standardization



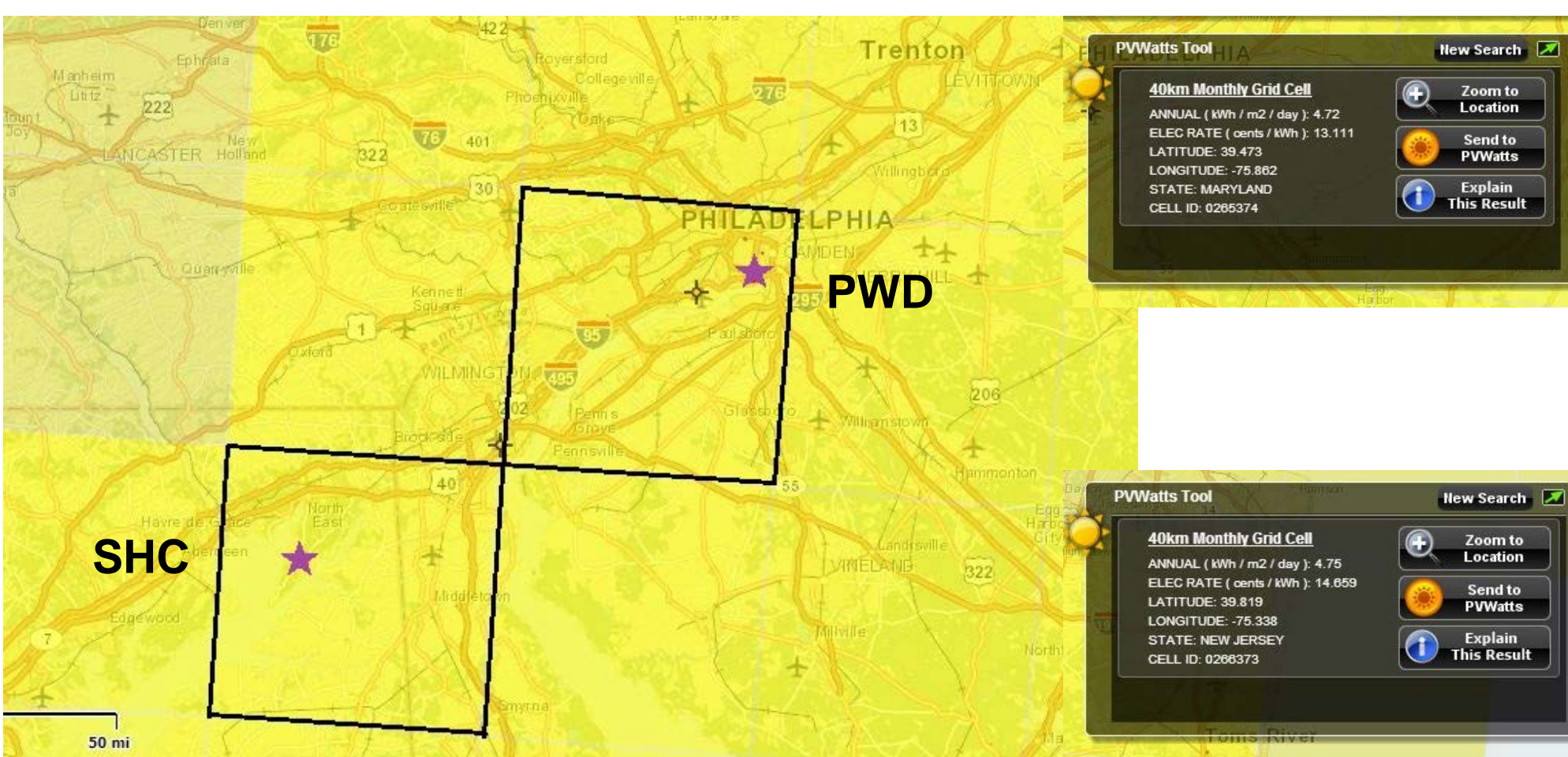
4. Conclusions

Although results indicate that ground cover **does not** significantly affect energy generation from the arrays, there are a few factors that may be biasing the results:

- Seasonal cycles not taken into account
- Solar farms used in this research are small scale
- Effects from albedo could be misinterpreted as white noise



Restoring native vegetation /converting traditional PV to agrivoltaic systems Environmental AND Economic Benefits



It is crucial to refine PV energy estimating programs to account for site differences at specific geographic locations. Currently, solar radiation and albedo are averaged at 40km² cell resolution. As seen on the left, both research sites are incorporated into neighboring grid cells.

As shown in the photographs, both locations are very different geographically, but are given almost identical variables in energy estimates.

5. Future Research

- Continue this study until **November 2013**
 - Eliminate seasonal biases
 - Albedo variations
- Second study at a **single location- 2mW**
- Half black surface, half full vegetation cover
- Each sending to a different inverter (2)



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