DC Microgrid for Penn State's College of Earth & Mineral Sciences

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Introduction

With Penn State's vision to reduce 80% (from 2005 levels) of its CO_2 emissions by 2050 (Penn State Office of the Physical Plant. N.d.), the university will have to be creative to drastically reduce its carbon emissions. Penn State has already implemented energy efficiency programs and solar power purchase agreements to reduce their carbon footprint. A solution that I am proposing is to start implementing building-level direct current (DC) microgrids to make outdated buildings into more energy efficient ones, contributing towards Penn State's 80% carbon reduction. Essentially "a microgrid is a localized group of interconnected loads and energy resources that normally operates connected to [a traditional centralized grid] and…can disconnect and function autonomously as physical and/or economic conditions dictate" (About Microgrids. N.d.).

An ideal place to test to see if DC microgrids are viable for the university is the College of Earth and Mineral Sciences' (EMS) Deike building. By choosing a relatively smaller building it would allow Penn State to determine if they want to install similar systems across campus. Also by choosing EMS, the college can utilize faculty that experts in the field and potentially advise of how DC microgrid is configured

Project Inspiration

The idea of a DC microgrid originated from visiting The Alliance Center in downtown Denver, Colorado. When we toured the building they discussed and showed us their DC microgrid setup and I was inspired to investigate the viability of a similar system at Penn State, University Park. I chose to analyze the Deike building since it is the hub of Penn State's College of Earth and Mineral Sciences, along with its good access to solar.

Project Overview

By having a DC microgrid in Deike, it would allow EMS to be powered in a clean and efficient matter through utilizing solar power and battery storage, while operating more efficiently through DC power, since it would minimize energy losses from solar and battery conversions.

Since the microgrid would be housed in Deike, EMS could both showcase the microgrid itself and the various design/research activities that are associated with the project (i.e. Microgrid Architecture, PV system design, etc.)

Solar Design

To design a practical PV system, a Helioscope analysis (figure 1) was performed in order to determine a realistic design and output of a PV system on the Deike Building

Module Specifications

- Model: Canadian Solar, CS3W-400
- Nominal Max. Power: 400 W
- Max. System Voltage: 1500 V
- Module Dimensions: 83.0 x 41.3 x 1.57 in

Rooftop Specifications

- Installed Capacity: 38.4 kW
- Module Qty: 96
- Racking: Fixed Tilt
- Azimuth: 244.6°
- Tilt: 22°

Carport Specifications

- Installed Capacity: 50.8 kW
- Module Qty: 127
- Racking: Carport
- Azimuth: 244.6°
- Tilt: 22°

Microgrid Design

For a DC microgrid to be incorporated into the Deike Building, it would require drastic changes to the electrical infrastructure in order to accommodate such a system.

The following infrastructure changes/additions would be required to switch over to a DC microgrid system:

- Electrical rewiring for DC power
- PV electrical infrastructure (PV panels, DC controllers, etc.)
- Utility Point of Common Coupling
  - Including AC/DC Inverters

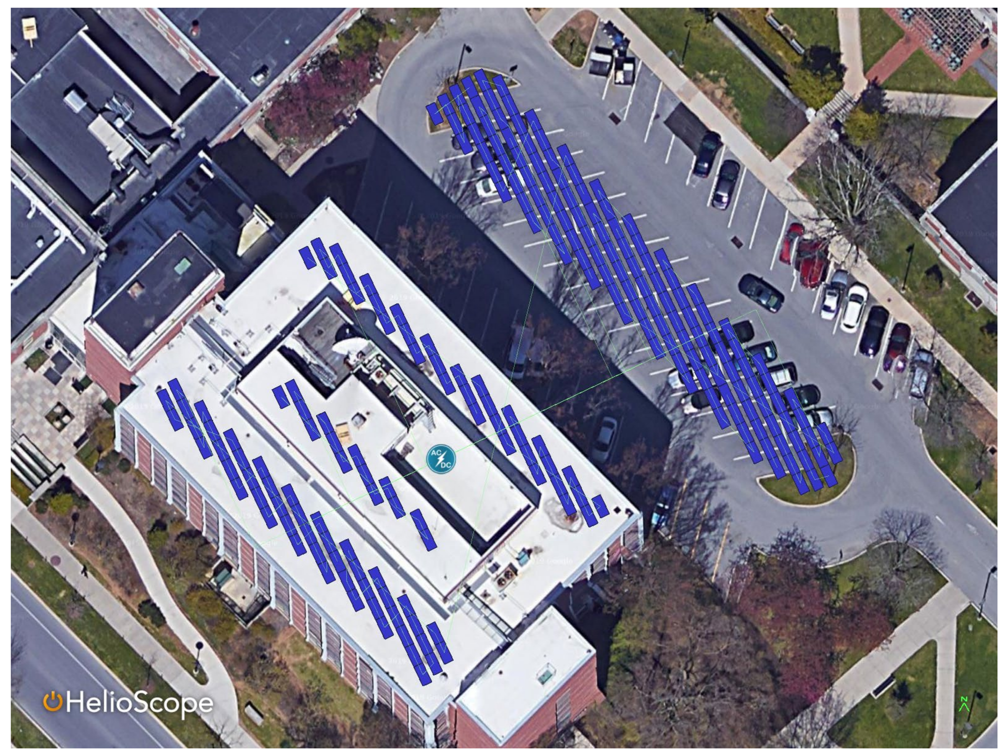

Figure 1. 89.2 kW PV system on Deike Rooftop with Carport Array (Source: Helioscope)

Sustainability Impacts

Environment

- Currently Deike Emits approximately 650 tons of CO_2e/yr
  Based on 1151.5245 lb CO_2e/MWh (US EPA. 2016)
  Deike Electric Usage: 1,137,593 kWh (EnergyCAP. 2019)
- Estimated CO_2e emissions with Rooftop Solar (89.2 kW): 635 tons CO_2e/yr
  - Emission Difference: -15 tons CO_2e/yr

Economic

- Creates greater energy security by reducing reliance from the grid
- Can operate during grid outages
- Operational Savings: $80/kW
  (Asmus et al. 2018)

Conclusions

If this project were to become reality more technical research and economic analysis would be required. In order to achieve this I would need to learn the technical side of microgrid. Since there is expertise within EMS that pertains to solar, I like to see their opinion of such a project. A cost analysis will also need to be performed in order to determine how much a DC microgrid would cost, including operational and maintenance costs.

References

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