Due: Oct 29, 2025

Energy: Science, Technology, and Society

Project

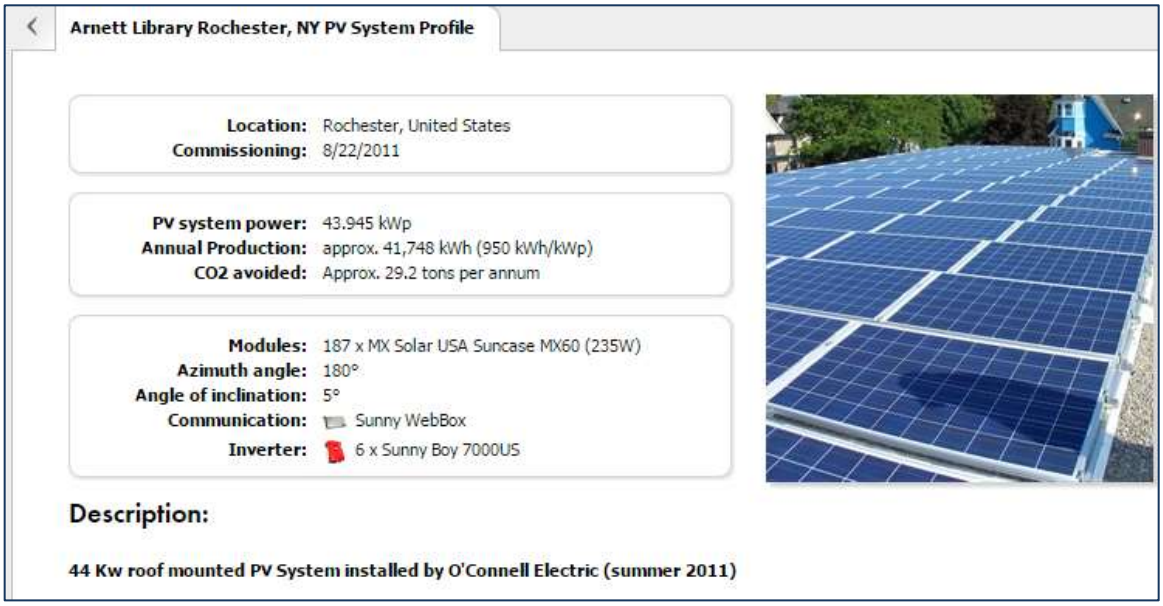
Case Study of 2024 Solar Power Generation in Rochester

The main goal of the project is to evaluate and illustrate the utility of solar power generation in the North-Western New York area. Actual data for the performance of a medium-sized solar PV array will be gathered and analyzed in terms of seasonal and overall yearly efficiency (capacity factor, CF), as well as in terms of the cost of delivered electricity and the savings in avoided carbon emissions.

Array Description

In 2011, the City of Rochester had a solar PV array of 44 kW nominal power output installed on the rooftop of the Arnett branch of the Rochester Public Library. A PV cell is a semiconductor device that produces electricity when irradiated with light.

The specifications of the array are listed in the table and can be obtained from the URL given above. The cost of the PV panels (see enclosed data sheet), plus installation (BOS), was $3.15/W in 2011. The estimated total system prices for small rooftop arrays have not changed very much recently). The estimated lifetime of the array is of



https://www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=f766fcda-84c3-4e9f-aecb-52f8ef9087ef&plant=405ee5cd-1beb-4f75-b59f-35bcbecfcb94&splang=en-US

the order of 20 years. Operational costs include cost for the rental of an DC-AC inverter and a smart (two-way) switch connection to the electrical grid run by RG&E utility. Cleaning and maintenance for the PV array incurs a monthly fee. The nominal Arnett array power has been customized such that the array can serve the entire operational power requirements by the library, averaging at 18kW during public hours. During off hours, the residual power requirements decrease to 5 kW. Surplus power produced by the array can be fed back into the electrical grid and is credited as "reimbursement" at regular utility commercial price.

Project Tasks

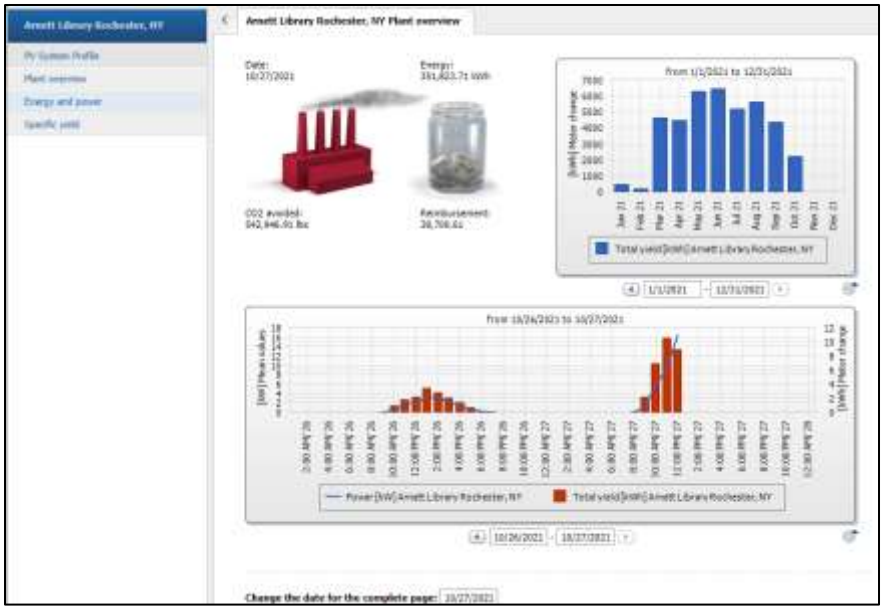
1. Obtain solar isolation data for Rochester **for the year 2024** (most recent). Explore and then use the National Solar Radiation Database (NSRDB) to access data of hourly and half-hourly values of most common measurements of solar radiation: global horizontal, direct normal, and diffuse horizontal irradiance, in addition to meteorological data. The "Download Wizard" at the link https://maps.nrel.gov/nsrdb-viewer/?aL=x8CI3i%255Bv%255D%3Dt%26Jea8x6%255Bv%255D%3Dt%26Jea8x6%255Bd%255D%3D1%26VRLt_G%255Bv%255D%3Dt%26VRLt_G%255Bd%255D%3D3%26VRLt_G%255Br%255D%3Dt%26mcQtmw%255Bv%255D%3Dt%26mcQtmw%255Bd%255D%3D2%26mcQtmw%255Br%255D%3Dt&bL=clight&cE=0&lR=0&mC=43.1430821780996%2C-76.67633056640625&zL=8 will direct you to a world map. Focus on the US and the Rochester area. A menu item "**Direct Normal Irradiance**" provides current and historical data relevant for the Arnett location.

Clear sky DHI	Watt/m^2	
Clear sky DNI	Watt/m^2	
Clear sky GHI	Watt/m^2	
Cloud Type	Unitless	
Dew Point	Degree C	
DHI	Watt/m^2	
DNI	Watt/m^2	
GHI	Watt/m^2	

2. Consider the types of radiation power listed in the table above and briefly discuss their expected qualitative effect on any solar array and then refer specifically to the Arnett solar array for the month of August 2024.

The following tasks refer to actual Arnett Array data posted for 2024.

3. Analyze the 2024 data and calculate the average daily percentage of the incident solar radiation power received by Rochester. (For historic comparison, in 2014 Rochester received on average 51% of the incident radiation, according to NOAA.)



4. Access and retrieve the published monthly Arnett power data for 2024. Note seasonally different times of operation of the library. Obtain and report the hours in a table of your project report. Sample 2024 data such as shown in the above image about the electric power generated by this array (in another year) can also be found published on the Web URL: https://www.sunnyportal.com/Templates/PublicPageOverview.aspx?page=f766fcda-84c3-4e9f-aecb-52f8ef9087ef&plant=405ee5cd-1beb-4f75-b59f-35bcbecfcb94&splang=en-US

5. Describe qualitatively and quantitatively the observed daily, monthly and seasonal patterns of power generation by the Arnett solar array. For example, compare the power output in one week, in March of 2024, to one week in July and one week in October of that year. Calculate the corresponding means and standard deviations for the power outputs. Generate plots for illustrating your discussion of observations.

6. Deduce how many "dark days" the Arnett solar array experienced in 2024, where the power output was below 10% of the nominal ("nameplate") power during the hours of operation of the library? Produce a table and a plot of the distribution of the number of dark periods vs. the duration of a period in daylight hours. How many "dark periods" in 2024 had more than 1 dark day in a row? How long was the longest dark period?

7. Calculate the amount of CO_2 avoided by utilizing the electricity generated by the array, as compared to the same energy produced by a natural gas power plant with 42% efficiency.

(Useful info: Nat gas contains an energy of 127 kWh per Mcf (1,000 cubic feet) and burns 8,039 Btu/kWh of electricity, produces 50.3kg CO_2/GJ.)

8. Use the actual mean solar insolation in 2024 Rochester and the mean power output of the array to deduce the mean conversion efficiency $\varepsilon = kWh/\left(A \cdot Wh/m^2\right)$ of the array.

9. Estimate the direct cost per kWh delivered by the Arnett Array in 2024. Prorate the acquisition and installation costs.

10. Calculate the LCOE for the Arnett array in 2024, using Operation & Maintenance costs of about $770 per typical year — $350/yr scheduled maintenance plus $35/mo ($420/yr) for inverter and smart-switch/monitoring and connection service. Include additional 2024 costs, if any.

11. The Arnett public library needs on average 18kW of electrical power to operate. To what extent did the output of the array match this actual need?

12. What additional baseload electricity (or stored battery) energy would have been required to bridge the average dark time in 2024?

Note that baseload (dispatchable) power stations (gas, coal, nuclear stations) must idle at some non-zero power level, to be able to ramp up quickly as required. Assume as standby a natural gas power station idling at 15% of maximum power.

13. Design and cost the operation of a scaled-up, large solar farm in NW NY capable of replacing on average 25% of the power of the local Ginna nuclear power plant. Base your scaling on the actual 2024 solar data for the NW NY area.

14. Summarize the main findings of your study and provide data-based arguments for your conclusions about the prospects of solar power in Western NY as replacement for conventional power sources.

Write up the study as an informal hand-written report with separate type set data and figure sections. Start the narrative with Title, Bylines, Abstract, Introduction, discussion of Tasks 1-14, referring in the text to data by Table # or Figure #, followed by Summary/Conclusions. Reproduce all data used in table format, e.g., as MS-Excel worksheets or MS-Word tables, label and number data tables and figures.

MX Solar USA MX60-230 (230W) Solar Panel

This page contains information about the MX Solar USA MX60-230 (230W) solar panel. To compare this to other PV modules, click here.

- **Manufacturer Data Sheet**
- **Installation Manual**

- STC Power Rating 230W
- PTC Power Rating 205W [1]
- STC Power per unit of area 12.8W/ft^2 (137.5W/m^2)
- Peak Efficiency 13.75%
- Power Tolerances 0%/+2%
- Number of Cells 60
- Nominal Voltage not applicable
- Imp 7.84A
- Vmp 29.3V
- Isc 8.36A
- Voc 36.8V
- NOCT 44.7°C
- Temp. Coefficient of Power -0.54%/K
- Temp. Coefficient of Voltage -0.138V/K
- Series Fuse Rating 15A
- Maximum System Voltage 600V

- Type Polycrystalline Silicon
- Output Terminal Type Multicontact Connector Type 4
- Frame Color Clear
- Backsheet Color data not available
- Length 65.6in (1,665mm)
- Width 39.6in (1,005mm)
- Depth 1.7in (43mm)
- Weight 48.5lb (22kg)
- Installation Method Rack-Mounted

- 80% Power Output Warranty Period 25yrs
- 90% Power Output Warranty Period 10yrs
- Workmanship Warranty Period 10yrs
- UL Fire Classification data not available
- Compliances UL 1703
- CSI Listed Yes (California Solar Initiative (CSI) list of Eligible Modules)