Solar PV's Impact Valuation
AC/DC Electric
Colorado Case Study

Applicant's Exercise

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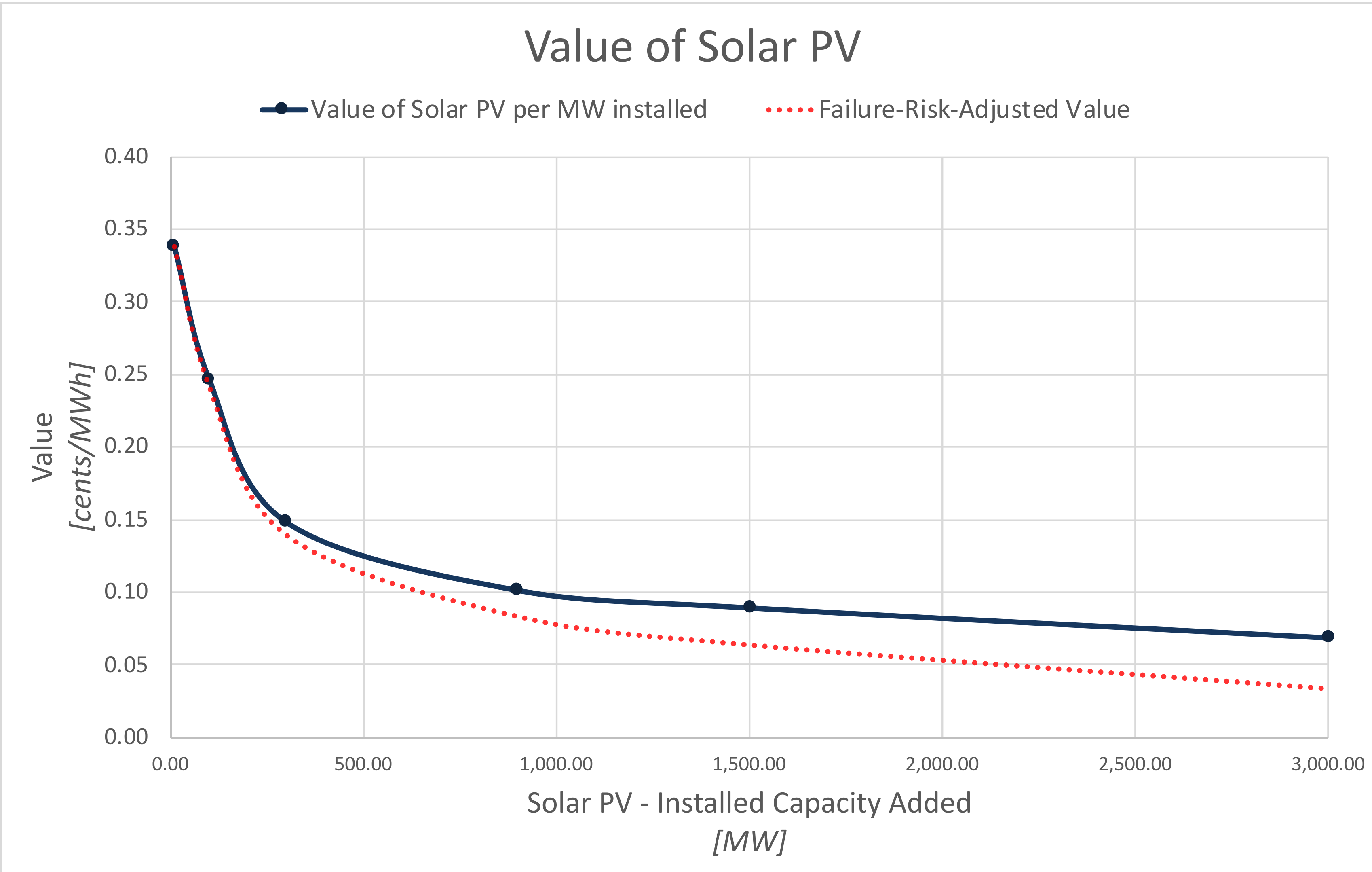
The marginal value of Solar PV decreases with the capacity installed



The value of the first Solar PV MW installed will be the highest

- For the current system conditions, the value of the first MW of Solar PV in AC/DC Electric’s system will be between ***0.25*** and ***0.35*** cents per MWh.
- As larger quantities of Solar PV are added onto the system, the marginal value of the addition will decrease. Intuitively, the first Solar MW will replace the most expensive MW currently in the system, so the next Solar MW will replace a less expensive MW and its marginal value will therefore be lower.
- The “Failure-Risk-Adjusted Value” line captures the idea that depending on how the new Solar PV were integrated into the system, the risk of facing a contingency (e.g. blackout) could increase with the quantity of Solar, which would further reduce its value.

The results are based on an estimated Solar PV output profile and simulated market runs

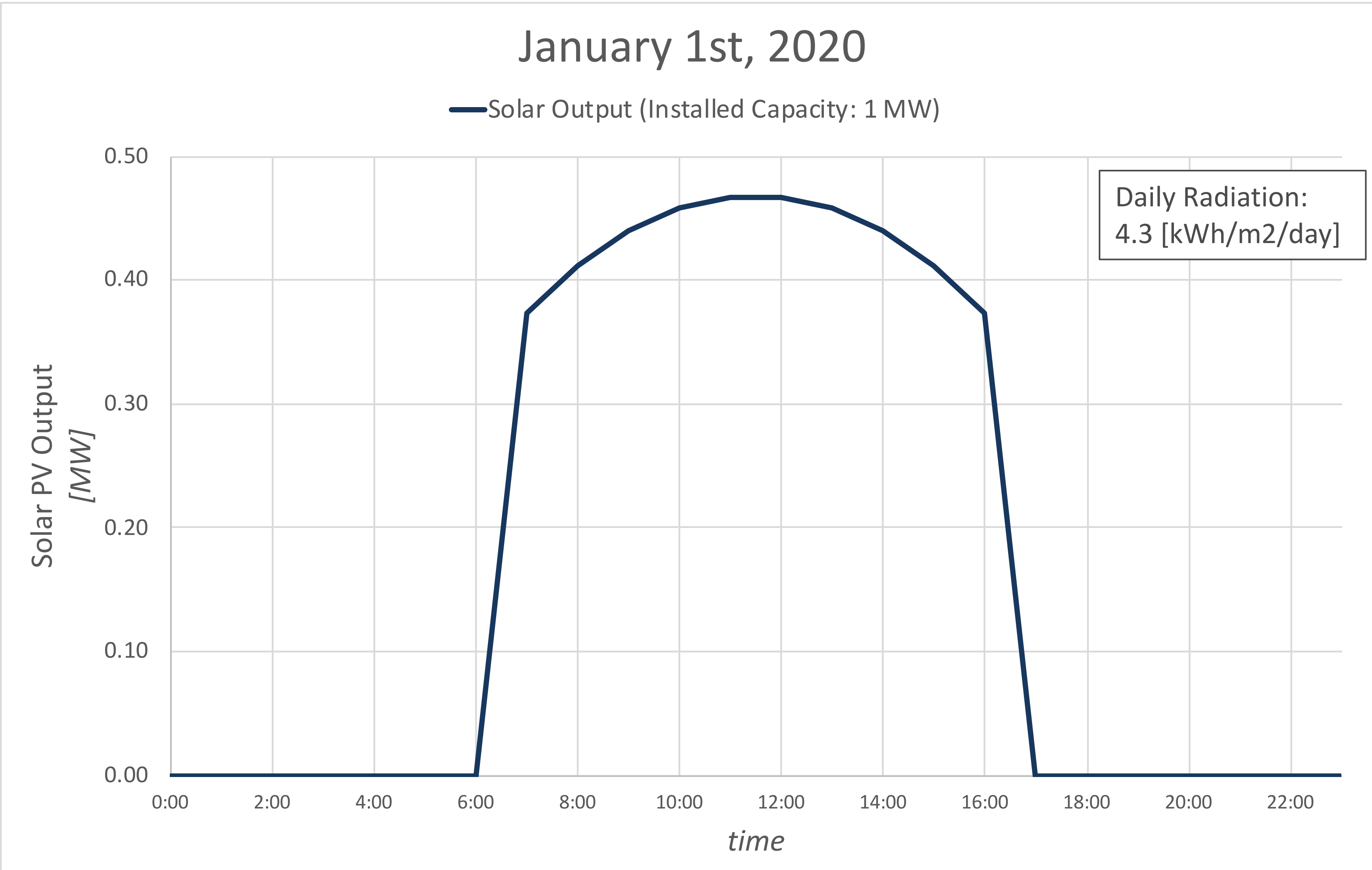
- The first step was to estimate the hourly Solar output profile.

$$Solar\ Output_{hr} = Normalized\ Weight_{hr} * MW_{Installed} * \left(\frac{Actual_{[Day]}}{Ideal_{\left[1000\,\frac{W}{m^2}\right]}}\right)_{Radiation}$$

- Assumptions:
  - Daily daylight durations are constant through each month, and monthly values are for Denver, CO from weather-us.com.
  - The daily Solar Radiation coefficient is constant through the month, and values were recovered for Colorado from pvwatts.nrel.com.
  - Only hours within the daylight period produce output, but hours farther from noon receive a lower proportion of the daily radiation value. Assumed weight (to achieve a bell-shaped profile):

$$Weight_{hr} = 1 - \left(\frac{Noon - hr}{Daylight\ Duration}\right)^2$$

A Solar PV output profile looks like this



The hourly market runs minimized production cost while honoring resources' constraints

- For each hour, the simulation minimized the total cost to meet load while honoring resources' constraints.
- Assumptions:
  - Each generator's adjusted "dependable" capacity and costs are:

$$Dependable\ Capacity = PMax\ * (1 - Forced\ Outage\ Rate)$$

$$Generator\ Cost = Heat\ Rate * Fuel\ Cost$$

  - The optimization considers the status of generators and constraints (e.g. cumulative time on or off, and minimum runtimes and downtimes), but does not consider future hours (i.e. look-aheads). A fully optimized solution is attainable but computationally expensive.
  - Customers pay, and generators receive, the marginal cost of electricity.
- Market runs were simulated in python and the code, as well as all the files used, can be found here.