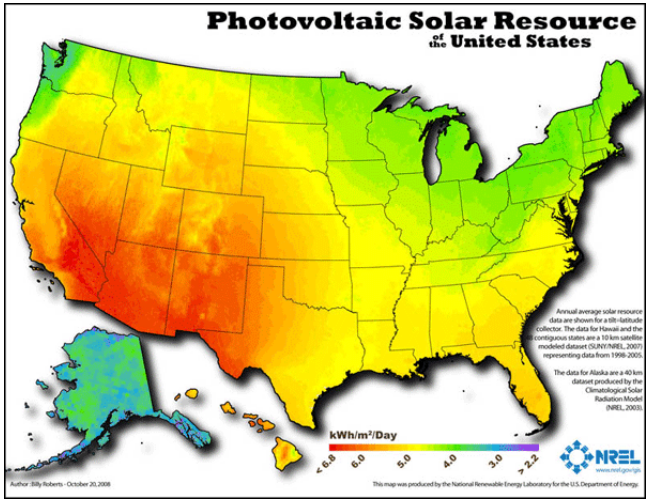
Rhode Island Renewable Energy Growth Program

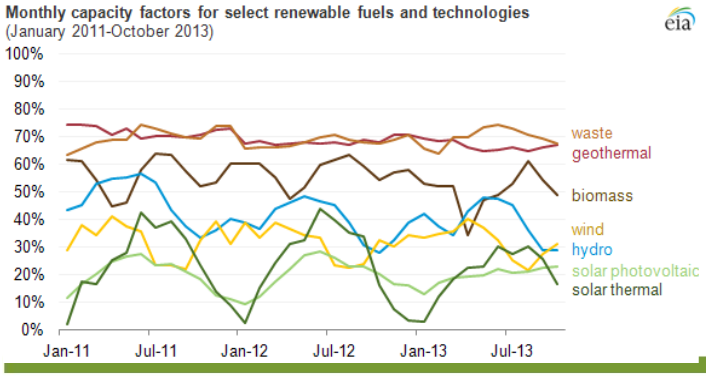
nationalgrid
HERE WITH YOU. HERE FOR YOU.

Overview of Solar PV Capacity Factor And System Sizing Issues
July 24, 2017

What is Capacity Factor for Solar PV?

nationalgrid
HERE WITH YOU. HERE FOR YOU.





- Capacity factor is a measure of the percentage of time a system can operate at its peak nameplate rating over a period of time on average
- Solar PV capacity factor is the result of system losses and solar insolation, driven by latitude, cloud and snow cover, shading, and orientation of any tilt
- Capacity factor varies by hour, day and month, and averages out to an annual number
- The peak rating and efficiency of a panel has more to do with power density (kWp/ sq. meter)
- An easy measure of capacity factor is kWh AC/kW-DC per year divided by total hours
  - 1226 kWh AC / 1 kW DC / 8760 = 14%

RE Growth System Sizing Highlights

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- To receive bill credits, RE Growth systems must be sized like Net Metering systems to not produce more than the 3-year annual average use of the customer
- Net Metered systems are measured in Alternating Current (AC)
- RE Growth Systems are measured by Direct Current (DC)
- Capacity factor between DC and AC accounts for losses in the system and inverter efficiency, and inverter sizes are typically smaller than the DC rating of the panels
  - RE Growth average is 115% DC/AC ratio, or an 87% derate

- **An average Rhode Island capacity factor for DC nameplate is 14%**
- **The AC capacity factor is this rate divided by the derate (.14/.87) or 16.1%**

Class Qualification and Sizing

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- The RE Growth program classes for solar are all measured in peak power DC, and include all fractions up to the next kW of total DC nameplate
  - Systems in the 1-10 kW class include 10.9 kW DC; systems in 26-250 kW class include 250.9 kW DC; etc.
- Sizing of maximum allowed system is calculated to the DC nameplate using 14% capacity factor. The following example illustrates:
  - 9,000 kWh avg. 3-yr annual use / 14% capacity factor / 8,760 hours/year = 7.34 kW DC (round to 1/100th)

Net Metering Application

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- Sizing of maximum allowed system for Net Metering uses the AC nameplate of the inverter, for which we now use a 16.1% capacity factor. The following example illustrates:
  - 9,000 kWh avg. 3-yr annual use / 16.1% capacity factor / 8,760 hours/year = 6.38 kW AC (round to 1/100th)
  - This maximum AC inverter size would be serving panels totaling approximately 7.34 kW DC at the 115% DC/AC average ratio

Former Sizing by Comparison

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- PV Watts shows for a 20% tilt, 180 degrees south 1 kW DC array an average annual output of 1,332 kWh AC, or 15.2% capacity factor
- Previously to the recent change, the Company had been using 13.5% for Net Metered systems on the AC rating of the inverter:
  - 9,000 kWh avg. 3-yr annual use / 13.5% capacity factor / 8,760 hours/year = 7.61 kW AC (round to 1/100th)
  - If this system had panels of 115% AC rating, or 8.44 DC, its output would be 10,350 kWh, or even 11,238 kWh at the PV Watts rate, which is greater than 3-year avg.
  - This old CF was underestimating how much a typical residential system actually produces, and allowed customers to oversize their systems
  - 13.5% was an acceptable DC capacity factor before recent improvements in inverter and system efficiency, but should not have been applied to the AC inverter rating

Review of Suggested Method

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- Consideration of a more detailed capacity factor calculation for RE Growth and Net Metering, as suggested by Newport Solar, is ongoing
- Would take into account system tilt and azimuth, and perhaps DC/AC ratio, all of which have an impact on the output and capacity factor
- Need to review integration of PV Watts or similar sizing tool into our process (version control, underlying data, input control, etc.)
- Process will undergo some changes with release of online application and interconnection portal, and we are reviewing the coordination of this potential process change with that release

Other Sizing Issues

nationalgrid
HERE WITH YOU. HERE FOR YOU.

- Appreciate comments on consistent approach to estimation of use when three year history is not available
- New construction load at an existing residence is allowable if 1) construction is complete, and 2) modeled load estimate is available and provided
- We will launch a process improvement effort to determine a better way to estimate the usage of a customer when load history is not available or meaningful, and a streamlined process for customers to obtain their own usage history
  - We will explore a consistent means to providing permission for a vendor to obtain customer usage history as part of this