Photon vs. Carbon
The Global Impacts of Solar and Grid-tied Batteries

Li Ling Young
Sr Energy Consultant
Agenda

• Distributed Renewable Energy – What Is It Good For?
• Net Metering – How Does It Really Work?
• Your Utility – Part of a Larger Network
• Carbon impacts of distributed RE
Renewable Energy...

What Is It Good For?
Why Are You Interested in RE?

• Fill in the blank...

• What’s obscured with “Net” metering?
Net Metering
Not Just Accounting

1. Solar panels transform energy from the sun into electricity.

2. An inverter converts the electricity produced by the solar panels from direct current (DC) to alternating current (AC) for use in your home.

3. Energy is used to power your home.

4. A bi-directional utility meter measures energy used from the electric grid and excess energy produced from your solar panels.

Excess energy produced from your solar panels is distributed back into the electric grid.
• Gross production meter (feed-in tariff)
• Self-generation
• Rate for excess production
• Non-bypassable charges
• Time of Use
Green Mountain Power example

- Retail rate: $0.16446
- Efficiency charge: $.01413

- Avoided cost for electricity used before the meter:
  $0.16446 + $0.01413 = $0.17876

- Statewide blended rate: $0.15417

- Difference between RE used vs. purchased
  $.17876 - $0.15417 = $0.0246
Your Account
Bill Date: 05/13/19

Your Bill
Total Amount Due: $0.00

Bill Details

My Energy Use Snap Shot
Learn how your renewable energy habits contributed towards a sustainable energy future. For more details visit your account at greenmountainpower.com

My Net Meter Summary

- Total Solar Generated: 535 kWh
- Total Energy Used: 611 kWh
- 176 kWh used by your home
- 357 kWh Solar to the grid
- 433 kWh delivered to your home
- 176 kWh from generation

Continued on back

Message Center
Would you like to win an iPad or an electric bicycle? Make the switch to e-billing, and you’re entered to win! Paperless billing is a simple step you can take to reduce your carbon footprint while also cutting clutter and wasted paper. Now, every time we reach 5,000 more customers signed up for e-billing, we’re giving away an iPad. And when we reach 100,000 customers signed up, we’ll give away an electric bike. Get up to date on e-billing news at greenmountainpower.com, and you won’t miss the chance to win!
ISOs – Your local grid environment
ISO-New England

- Manages all the generation supply
- Provides all the power
- Responsible for reliability
- Controls the Forward Capacity Market
- Forecasts and plans for the next 10 years

*None of us is an island*
What's in store for summer?
Adequate electricity supplies are expected to meet peak consumer demand for electricity under both typical and extreme weather conditions. EE and BTM PV are forecasted to reduce the summer peak by 3,600 MW.

Today's Snapshot
AS OF 07/17/2019 08:20 AM

<table>
<thead>
<tr>
<th>Available Capacity (MW)</th>
<th>26,629</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecasted Peak Demand (MW)</td>
<td>22,110</td>
</tr>
<tr>
<td>Surplus Capacity (MW)</td>
<td>2,081</td>
</tr>
<tr>
<td>Yesterday's Peak Demand (MW)</td>
<td>20,951</td>
</tr>
</tbody>
</table>

Real-Time Data

System Demand

Fuel Mix

71% Natural Gas
20% Nuclear
6% Renewables
3% Hydro
<1% Other
<1% Oil

Internal Hub Price

- Energy: $32.90
- Congestion: $0.00
- Line Loss: $0.08

Total: $32.82

System Status
Normal

More Real-Time Data
We have received confirmation from BED that they are targeting a peak today **Wednesday, July 17th from 4:00 pm – 7:00 pm.** It does not look like a peak-day here in Vermont, but the New England system is peaking and southern NE is forecasted to experience much higher humidity and temperatures this afternoon. As such, we will be doing what we can to decrease demand during this time.

Today’s peak day plan of action:

- Unplug your laptops and run off battery power. Remember that a docked laptop with a second monitor in use draws ~50 watts.
- No printing – Commercial printers used in an office will draw 30 to 50 watts on standby and 300 to 500 watts when printing.
- No EV charging please. VEIC pays for the EV Charging (thanks for the perk). EV charging, if curtailed during peak periods, can have a huge impact on demand goals.
- To reduce water heating, water heaters in 4th floor hubs will be shut off. Hot water in the kitchen will remain on. If possible, try not to brew coffee during this time!
Net Metering and Carbon

Is it a winner?
Solar Production Monthly Average Loadshapes

Tilt: 17.5°
Azimuth: 197°
So ... you’re producing and consuming at different times. As long as the carbon footprint per unit of energy on the grid is pretty constant, who cares?
For every 15-minute period, I will calculate...

\[
\text{Emitted carbon (g)} = \text{ISO-NE footprint (g/kWh) } \times \text{my consumption (kWh)}
\]

\[
\text{Credited carbon (g)} = \text{ISO-NE footprint (g/kWh) } \times \text{my production (kWh)}
\]

At the day / month / year level, I will calculate...

\[
\text{Net carbon (g)} = \text{Emitted carbon (g)} - \text{Credited carbon (kWh)}
\]
December 2018

Solar production

Inverters Losses

Powerwall

Used for Climate Control

Used by House

Returned to Grid

In my house

New England
ISO Grid

Coal

Natural Gas

Solar

Nuclear

Wind

Hydro

Graph:

ISO/NE Grid Net Carbon Footprint (kg)

January: 200
February: 100
March: 0
April: -50
May: -100
June: -150
July: -200
August: -150
September: -100
October: -50
November: 0
December: 50
So... what was my overall footprint for electricity usage?

<table>
<thead>
<tr>
<th>Year</th>
<th>Carbon emissions (kg)</th>
<th>Carbon credits (kg)</th>
<th>Net carbon emissions (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>1,184</td>
<td>1,642</td>
<td>-457</td>
</tr>
<tr>
<td>2018</td>
<td>1,427</td>
<td>1,549</td>
<td>-122</td>
</tr>
</tbody>
</table>

Good... but there are two problems:

1) Your trend looks horrible – can you explain this?
2) Aren’t these numbers going to look worse once you electrify the rest of your heat and transportation?
Can’t I add a battery and suck up energy during the ‘clean’ times and discharge during the ‘dirty’ times and make my energy cleaner?

Let’s see if adding a GMP-controlled battery helps the carbon footprint and prices!
2017-2018 New England Carbon Footprint - mean: 286.0 g/kWh
Carbon Footprint during Powerwall Discharges - mean: 339.0 g/kWh

Carbon Footprint per Unit of Energy (grams CO₂ per kWh)
2017-2018 New England LMP - mean: $38.02/MWh
LMP during Powerwall Discharges - mean: $106.76/MWh

Real Time Vermont Locational Marginal Price ($)

Efficiency Vermont
February 9, 2017
Coincidence Factor: 0.8

House Demand (+) or Production (-) (KW)

Grid Peak Hour
My House Peak

2:00 AM  6:00 AM  10:00 AM  2:00 PM  6:00 PM  10:00 PM

Efficiency Vermont
July 2, 2018
Coincidence Factor: 0.33
Old GMP Powerwall Behavior – December 7, 2018

From Powerwall: **12.3 kWh**

New GMP Powerwall Behavior – April 9, 2019

From Powerwall: **15.9 kWh**
Thank You

Li Ling Young
Sr Energy Consultant
888-921-5990