Load Defection: How Solar+Storage Will Change The World

Thursday, August 20, 2015

Todd Olinsky-Paul
Project Director
Clean Energy Group
Housekeeping

All participants are in “Listen-Only” mode. Select “Use Mic & Speakers” to avoid toll charges and use your computer’s VOIP capabilities. Or select “Use Telephone” and enter your PIN onto your phone key pad.

Submit your questions at any time by typing in the Question Box and hitting Send.

This webinar is being recorded.

You will find a recording of this webinar, as well as previous Resilient Power Project webinars, online at:

www.cleanegroup.org/ceg-projects/resilient-power-project/webinars/

and at

vimeo.com/channels/resilientpower
Who We Are

RESILIENT POWER

Evolution of a New Clean Energy Strategy to Meet Severe Weather Threats
September 2014

www.resilient-power.org
www.cleanenergygroup.org

CleanEnergy Group
Innovation in Finance, Technology & Policy

Meridian Institute
Confronting People vs Nature Problems

CleanEnergy States Alliance

THE JPJ FOUNATION

THE KRESGE FOUNDATION

Surdna Foundation
Fostering sustainable communities in the United States
Resilient Power Project

• Goal: Significantly increase public/ private investment in clean, resilient power systems.
• Support state energy agencies in developing resilient power policy and programs.
• Engage city officials to develop resilient power policies/programs, link to state energy policies.
• Protect low-income and vulnerable communities; focus on affordable housing.
• Technical assistance & targeted support for pre-development costs to help agencies/project developers get deals done.
• See www.resilient-power.org for reports, newsletters, webinar recordings, and more.

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Today’s Guest Speakers

• Leia Guccione, Manager, Rocky Mountain Institute

• Jesse Morris, Manager, Rocky Mountain Institute
LOAD DEFECTION

HOW SOLAR-PLUS-BATTERY SYSTEMS ARE CHANGING THE WORLD

AUGUST 20, 2015, LEIA GUCCIONE & JESSE MORRIS
INTRODUCTION TO RMI

**OUR PURPOSE**

Rocky Mountain Institute transforms global energy use to create a clean, prosperous, and secure future.

**WHAT WE DO**

RMI advances market-based solutions that transform global energy use. We engage businesses, communities, and institutions to cost-effectively shift to efficiency and renewables, creating a clean, prosperous, and secure energy future.

**WHAT DIFFERENTIATES US**

- Our whole-systems expertise unlocks market-based solutions that can be replicated and implemented now.
- As an independent, non-partisan nonprofit, we convene and collaborate with diverse partners—business, government, academic, nonprofit, philanthropic, and military—to accelerate and scale solutions.
- We boldly tackle the toughest long-term problems—challenges often ignored by those held to short-term results.
- We’ve been a leader in energy efficiency and renewables for over 30 years.
TRENDS IN SOLAR PV AND BATTERY PRICE & ADOPTION – A DISRUPTIVE PAIRING

HISTORICAL SOLAR PV INSTALLED COSTS

LITHIUM-ION BATTERY PACK PRICES: HISTORICAL AND FORECASTED

SOLAR PV U.S. ANNUAL INSTALLED CAPACITY

Historical and near-term forecast

U.S. CUMULATIVE SALES OF PLUG-IN ELECTRIC VEHICLES

Can solar-plus-battery systems = grid defection?
THE CONVERSATION BEGAN WITH “GRID DEFECTION” IN FEBRUARY 2014

Key Messages

- Favorable defection economics exist for a small minority of customers today
  - Will expand to millions of customers by 2024 under conservative assumptions

- Grid parity arrives within the 30-year economic life of typical utility power assets

- The “traditional” utility business model is at risk today!
  - Utilities are making investments now for customers that may not exist in the future

- Defection is suboptimal
  - Economically, grid defected systems are an unnecessary over-investment/over-build
  - Socially, those unable to install these systems pay an increasing percentage of the cost for maintaining the grid

- Migrating to a grid-connected system that enables a two-way energy exchange can unlock value for customers, utilities, and installers alike

www.rmi.org/electricity_grid_defection
THE ECONOMICS OF GRID DEFECTION
WHEN AND WHERE DISTRIBUTED SOLAR GENERATION AND STORAGE COMPETES WITH TRADITIONAL RETAIL SERVICE

Commercial

Residential

LCOE Retail

- Louisville, KY
- Westchester, NY
- San Antonio, TX
- Los Angeles, CA
- Honolulu, HI

PRE-2014
NY 2025
CA 2031
KY 2047
TX 2047

HI 2022
CA 2037
NY 2049
A BUILDING WAVE OF POTENTIAL DISRUPTION

BC - Base Case
ATI - Accelerated Technology Improvement
CI - Combined Improvement
DSI - Demand-Side Improvement

Parity is here already or coming in the next decade

Louisville, KY
Westchester, NY
Los Angeles, CA
Honolulu, HI
San Antonio, TX
Barclays, Utilities Credit Strategy Analyst Report [May 2014]
“We see near-term risks to credit from regulators and utilities falling behind the solar + storage adoption curve and long-term risks from a comprehensive re-imagining of the role utilities play in providing electric power.”

Morgan Stanley, Clean Tech, Utilities & Autos [March 2014]
“Our analysis suggests utility customers may be positioned to eliminate their use of the power grid.”

UBS, analyst note on EV and solar [August 2014]
“The expected rapid decline in battery cost by (more than) 50 per cent by 2020 should not just spur EV sales, but also lead to exponential growth in demand for stationary batteries to store excess power.”

Goldman Sachs, Analyst note on Tesla stock [March 2014]
“…decreased reliability from an aging distribution infrastructure, a broadening desire to reduce the carbon footprint, and perhaps most importantly, the reduction of solar panel and battery costs could also work together to make grid independence a reality for many customers one day”
Hypothesis - *Grid-connected* solar-plus-battery systems are:
- Optimally sized
- Less expensive
- More quickly adopted
- Able to provide value on both sides of the meter

**IF GRID DEFECTION IS A SUB-OPTIMAL AND UNLIKELY SCENARIO – WHAT IS MORE LIKELY?**

- On-grid/Conventional Consumer
- Grid-tied/DG Consumer
- Grid-tied/DG + Storage Consumer
- Off-grid/DG + Storage Consumer

**CONSUMER RELATIONSHIP WITH ELECTRIC SERVICE**

- Traditional
- Disruptive

- Battery as Backup
- Internal cost reduction
- Transactive System
- Grid as Backup
LOCATIONS WE STUDIED IN DETAIL

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<th>WESTCHESTER, NY</th>
<th>LOUISVILLE, KY</th>
<th>SAN ANTONIO, TX</th>
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<td><strong>2014 AVG RETAIL PRICE</strong></td>
<td>$0.17–$0.23</td>
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<td>$0.11–$0.18</td>
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<td><strong>INSTALLED PV BY STATE</strong></td>
<td>140 MW</td>
<td>3 MW</td>
<td>200 MW</td>
<td>1,900 MW</td>
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RATE STRUCTURES WE APPLIED

Residential
~2,500 square foot detached single-family home

Commercial
~43,000 square foot 4-story hotel

- Assumed no export compensation for solar – on-site consumption only

*Median load profiles studied for both customer types. Different load profiles impact economics similarly.

Energy Charge
kWh-based generation costs (e.g., fuel, wholesale electricity)

Customer Charge
Flat, monthly charge covering fixed costs of servicing customer regardless of use (e.g., billing, customer service)

Demand Charge
Costs of the generation, transmission, and distribution capacity to serve peak demand
HOW WE ARRIVED AT OUR RESULTS

2 Load Profiles
- Residential
- Commercial

Technical Specifications
- Solar PV
- Batteries
- Inverter

Cost Projections
- Solar PV
- Batteries
- Inverter

Financial Analysis Model

Financial Assumptions
- ITC Eligibility
- MACRS

HOMER® software

Modeling Results
- Net Present Cost
- Levelized Cost of Energy
- System Configuration
- Net Metering
EVOLVING ECONOMICALLY OPTIMAL SYSTEM CONFIGURATION

RESIDENTIAL

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<thead>
<tr>
<th>Location</th>
<th>2014</th>
<th>2016</th>
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EVOLVING ECONOMICALLY OPTIMAL GENERATION MIX

RESIDENTIAL

COMMERCIAL

WESTCHESTER, NY

LOUISVILLE, KY

SAN ANTONIO, TX

LOS ANGELES, CA

HONOLULU, HI

Grid Purchases
PV Contribution to Load

0%
20%
40%
60%
80%
100%

MAGNITUDE OF POTENTIAL LOAD DEFECTION IN THE NORTHEAST - RESIDENTIAL
MAGNITUDE OF POTENTIAL LOAD DEFECTION IN THE NORTHEAST - COMMERCIAL
DECLINING LITHIUM-ION BATTERY COSTS AND FORECASTS

LITHIUM-ION BATTERY PACK PRICES: HISTORICAL AND FORECASTED

**Tesla Energy**
10 kWh Home Battery
$350/kWh

7 year acceleration
NET METERING’S EFFECT ON LOAD LOSS
NET GRID PURCHASES – WESTCHESTER, NY

COMMERCIAL - WESTCHESTER, NY

Without Net Metering

With Net Metering

Delay of Significant Load Defection
THE DIFFERENCE THE RATE MAKES

The availability of export pricing (i.e., net energy metering) significantly affects the economics for system configuration.
WE ARRIVED AT A FORK IN THE ROAD
TRAJECTORIES FOR ELECTRIC GRID EVOLUTION

**PATH 1 INTEGRATED GRID**
One path leads to grid-optimized smart solar, transactive solar-plus-battery systems, and ultimately, an integrated, optimized grid in which customer-sited DERs such as solar PV and batteries contribute value and services alongside traditional grid assets.

**PATH 2 GRID DEFECTION**
Another path favors non-exporting solar PV, behind-the-meter solar-plus-battery systems, and ultimately, actual grid defection resulting in an overbuilt system with excess sunk capital and stranded assets on both sides of the meter.
THREE LEVERS OF ACTION FOR AN INTEGRATED GRID

1. Evolved pricing and rate structures

2. New business models

3. New regulatory models

**Critical reform areas**
- Enhance fair and equal access to DERs
- Recognize, quantify, and monetize solar-plus-storage value
- Preserve equitable treatment of customers not invested in DERs

**Near Term Default or Opt-In Possibilities**
- Time-of-Use Pricing
- Energy + Capacity Pricing (i.e. Demand Charges)
- Distribution “Hot Spot” Credits

**Longer Term, More Sophisticated Possibilities**
- Real-Time Pricing
- Attributed-based Pricing
- Distribution Locational Marginal Pricing

**Electricity Integration, Control, Maintenance**

- **Access**
- **Value**
- **Equitable**
Behind-the-Meter Distribution

Backup power

Load Following / Arbitrage

Spinning / Non Spinning Reserve

Frequency Regulation

Voltage Support

Black Start

Transmission

Distribution

Behind-the-Meter

Service not possible

Transmission upgrade deferral

Distribution upgrade deferral

Time of Use Optimization

Self Consumption

Demand Charge Reduction

Load Following / Arbitrage

Spinning / Non Spinning Reserve

Frequency Regulation

Voltage Support

Black Start

Utility Services

Transmission

Distribution

Behind-the-Meter
THE ECONOMICS OF BATTERY STORAGE

Service Value [$/kW-year]

- $- $100 $200 $300 $400 $500

Utility Services

Energy Arbitrage
Load Following
Regulation
Spin / Non-Spin
Voltage Support
Black Start
Resource Adequacy
Distribution Upgrade Deferral
Transmission Congestion Relief
Transmission Upgrade Deferral

ISO / RTO Services

Time of Use
Self Consumption
Demand Charge Reduction

Customer Services

Wartsila
NYSERDA
RMI
Use Case I
RMI Use Case II
RMI Use Case III
RMI Use Case IV
RMI’s ‘Manual’ ES Dispatch Model

Using a simplified dispatch model we illustrate the net value of behind-the-meter energy storage systems centered on the delivery of a primary service supplemented by a stack of secondary services.

**Primary Storage Application**
- Each device is assigned a primary dispatch application
- The system is constrained to always be available to provide this service at a specified point in time

**Secondary Storage Dispatch**
- System is dispatched to a secondary service when not constrained by its primary application
- Not dispatched based on economic value, instead illustrates a suite of services
- Service value set by time-dependent historic market prices

**Diagrams**

**Distribution Deferral**

**Demand Charge Reduction**

**Self-Consumption**

**Ancillary Services**

**Resource Adequacy**

**TOU Management**

**Backup Power**
For these cases, we made the following high-level assumptions:

- We assumed no regulatory barriers to aggregated, behind the meter market participation or revenue generation
- We assign zero value to backup power as an extreme conservatism
- Predetermined dispatch strategy - For each case, we do not always dispatch the battery to the highest hourly valued service
- Batteries are dispatched for a minimum of one hour
- The cost of all power electronics falls on the battery systems
  - $500 per kWh and $1,100-$1,200 per kW
CASE 1: DISTRIBUTION UPGRADE DEFERRAL IN BROOKLYN / QUEENS

1. Substation overload of 52 MW in 2018
2. Assumed DR and EE reduce peak by 26 MW and shorten overload to 6 hours
3. 4000 Res systems [5kW/10kWh and 1500 Com systems [30kW/90kWh]
4. $120 million dollar deferral value

Projected Brooklyn-Queens Load Pocket During Peak Summer Overload

Load Pocket Summer 2018 Load [MW]

Time of day

Energy Storage Load Management
Substation Capacity
Substation BAU Load
Load after ES/EE/LF
CASE 1: DISTRIBUTION UPGRADE DEFERRAL IN BROOKLYN / QUEENS

Revenue and Cost

% of Hours Storage is Dispatched to Each Service

- Load Following, 23%
- Regulation, 50%
- Regulation, 50%
- Charging/Idle, 10%
- Dist Upgrade, 1%
- Resource Adequacy, 3%
- Non Spinning Reserve, 10%
- Spinning Reserve, 4%
- Non Spinning Reserve, 10%
- Load Following, 23%
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CASE 2: DEMAND CHARGE REDUCTION IN SAN FRANCISCO

1. The building’s original load exceeded 500 kW, bumping the customer into the PGE E19 tariff schedule.

2. Properly sized storage can ensure the 15 minute peak building load never exceeds 500 kW, resulting in significantly reduced demand charges.

3. Hourly simulation with a perfect load forecast resulted in a system size of:
   - 140 kW
   - 560 kWh
**CASE 2: DEMAND CHARGE REDUCTION IN SAN FRANCISCO**

### Revenue and Cost

- **Revenue**
  - Customer Services: $600K
  - Utility Services: $200K
  - ISO / RTO Services: $100K

- **Cost**
  - Total Cost: $700K
  - CapEX: $600K
  - Tax: $400K
  - O&M & Charging: $300K
  - Tax Benefits: $200K
  - Demand Charge Reduction: $100K
  - Resource Adequacy: $50K
  - Spinning Reserve: $10K

### % of Hours Storage is Dispatched to Each Service

- Demad Charge Reduction: 48%
- Load Following: 11%
- Regulation: 26%
- Charging/Idle: 10%
- Resource Adequacy: 3%
- Spinning Reserve: 2%
RECOMMENDATIONS FOR:

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<th>Regulators</th>
<th>Utilities</th>
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<td>❖ Enact regulatory change that incent utilities to incorporate storage and other DER’s to provide a full stack of services to the electricity system</td>
<td>❖ Restructure business models and rates to reflect the value of storage via temporal, locational, and attribute-based functionality</td>
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<td>❖ Require utilities to disaggregate the cost of electricity service across multiple categories (eg ISO / RTO services and grid services) and make the information publicly available</td>
<td>❖ Educate across departments to illustrate how services can stack on a single energy storage system in order for distribution planners, grid operators, and rate designers to understand storage’s full suite of capabilities</td>
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<td>❖ Weigh potentially increased costs of downstream energy storage placement against the additional values and flexibility created by these assets</td>
<td>❖ Implement pilot projects to demonstrate the ability of storage to be reliably used as an alternative to traditional assets</td>
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<td>❖ Screen BTM developers using specific criteria prior to awarding contracts</td>
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**Recommendations for:**

**Developers / Third Party**

- Pursue cost reduction efforts for all power-focused elements of energy storage systems (all $/kW components)

- Collaborate with utilities and regulators to help them understand what values energy storage can provide and what new business models will be needed to scale them

- Under rate structures or regulations where energy storage can enhance or protect the value proposition of solar PV through increased self-consumption, develop new lease or power purchase agreement products that integrate small batteries

**Research Community**

- Develop a widely recognized modeling tool or consistent methodology and approach capable of comparing, on an equal basis, the net cost of stacked services provided by energy storage and other distributed energy resources compared to other incumbent technologies

- Develop a detailed roadmap on a state-by-state basis that specifically identifies policy and regulatory changes that must be adapted or revised to enable widespread integration of energy storage
e-Lab Accelerator
A Boot Camp for Electricity Innovation
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Upcoming Webinars

- **Electricity Markets and the Economics of Energy Storage** Thursday, August 27, 1-2:30 pm ET

- **Fuel Cells for Wastewater Treatment Plants**
  Wednesday, September 9, 2-3 pm ET

- **Energy Storage Market Updates** (first in a series)
  Wednesday, September 30, 1-2 pm ET

More information about the Resilient Power Project, its reports, webinar recordings, and other resources can be found at www.resilient-power.org.
Thank you for attending our webinar

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