RESILIENT

POWER

A Project of Clean Energy Group

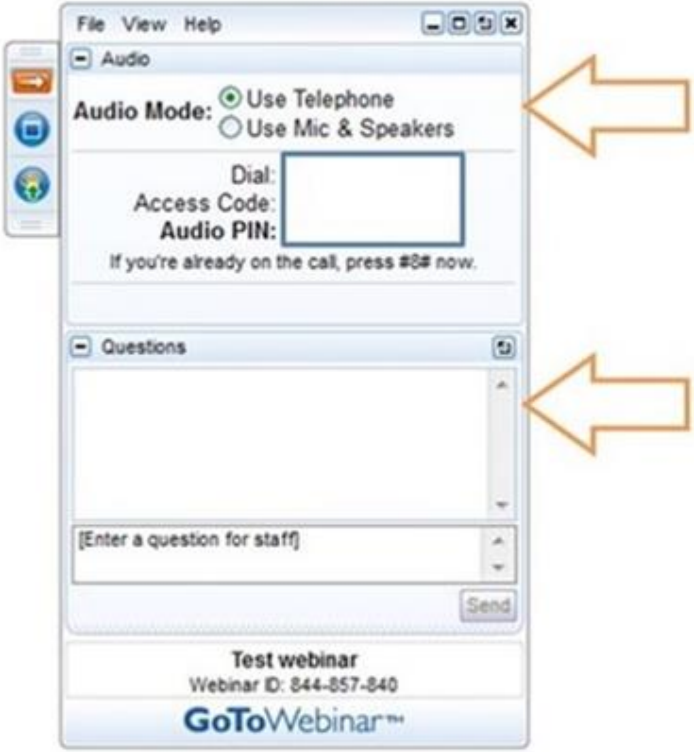
Load Defection: How Solar+Storage Will Change The World

Thursday, August 20, 2015

Todd Olinsky-Paul
Project Director
Clean Energy Group

CleanEnergyGroup
Innovation in Finance, Technology & Policy

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

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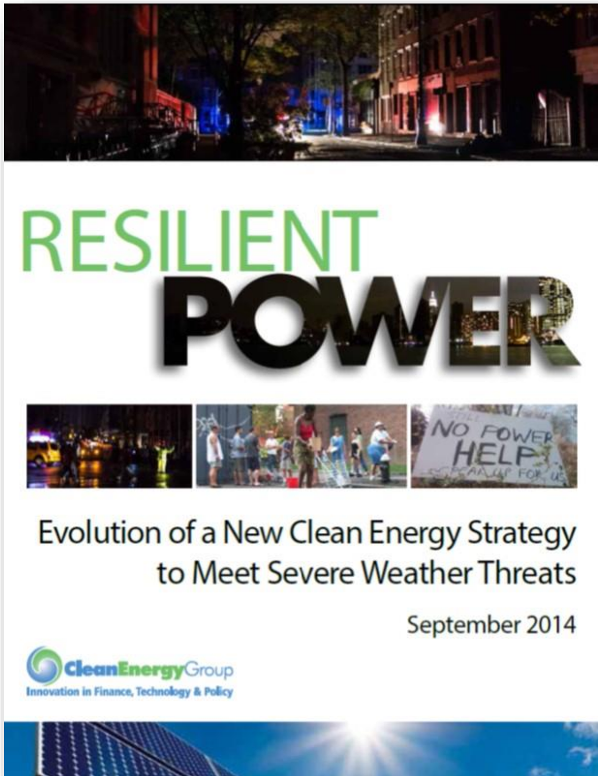
Innovation in Finance, Technology & Policy


RESILIENT POWER

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

September 2014

Clean Energy Group
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Meridian Institute
Connecting People to Solve Problems

Clean Energy States Alliance

THE JPB FOUNDATION

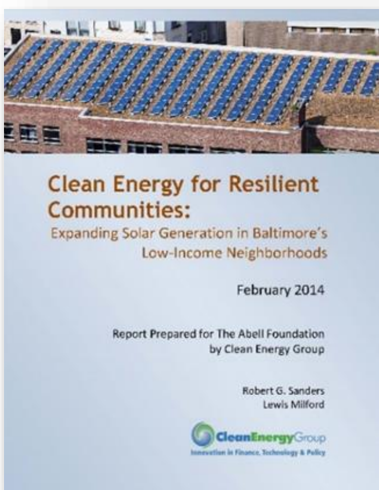
THE KRESGE FOUNDATION

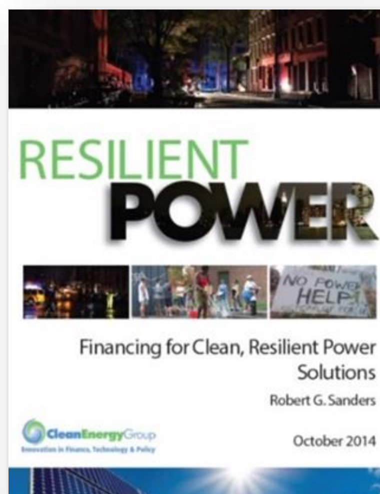
www.resilient-power.org
www.cleanegroup.org

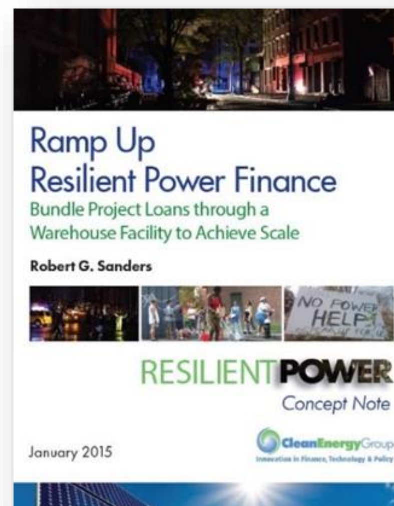
SURDNA FOUNDATION
Fostering sustainable communities in the United States

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.







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.

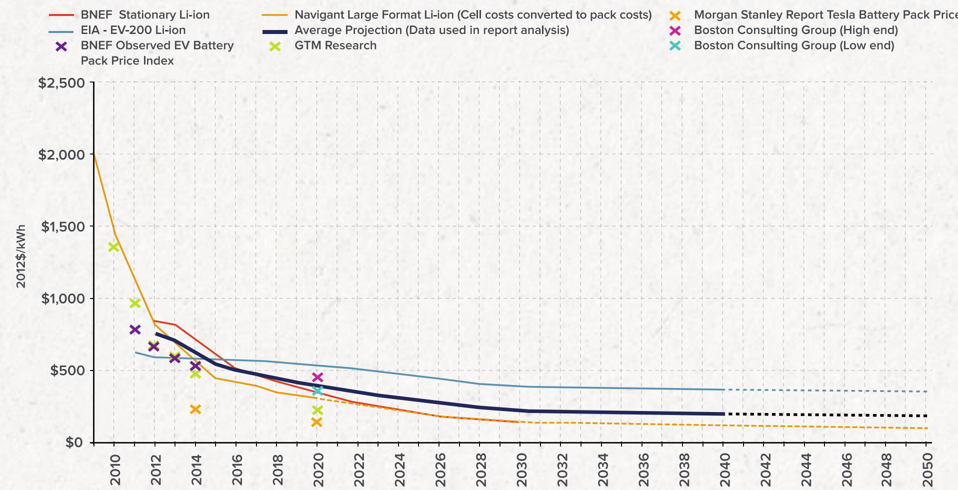
WHAT DIFFERENTIATES US

- 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

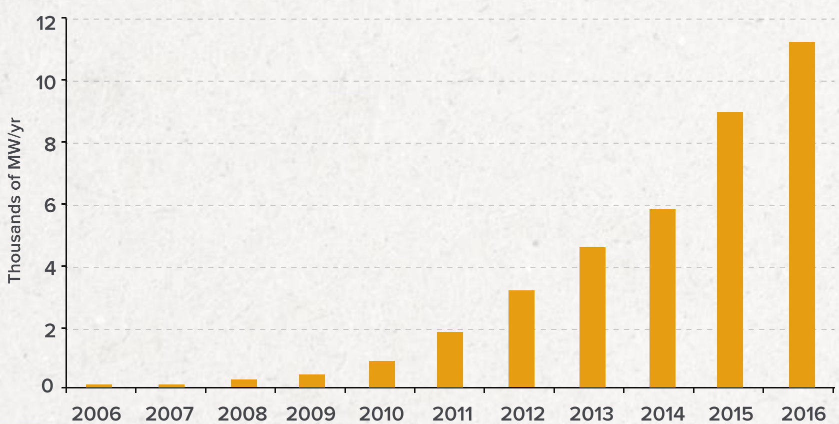
HISTORICAL SOLAR PV INSTALLED COSTS

LITHIUM-ION BATTERY PACK PRICES: HISTORICAL AND FORECASTED

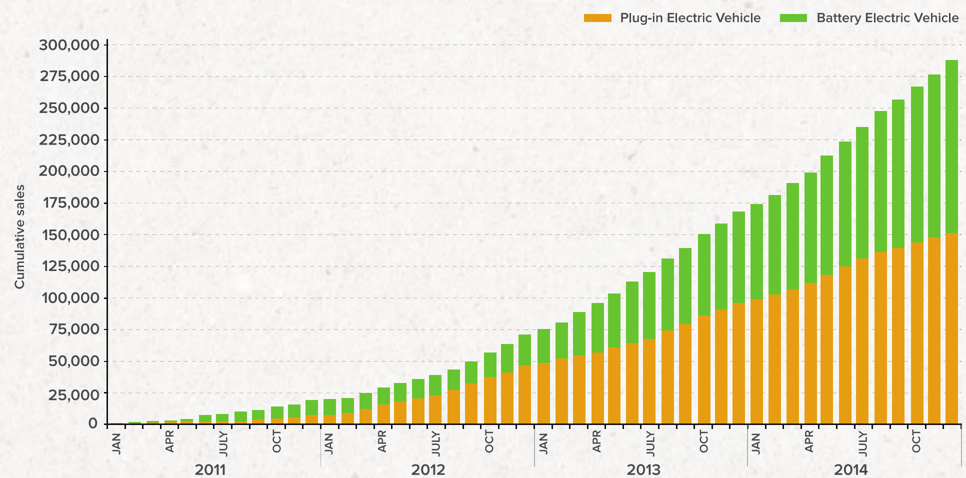


SOLAR PV U.S. ANNUAL INSTALLED CAPACITY

Historical and near-term forecast

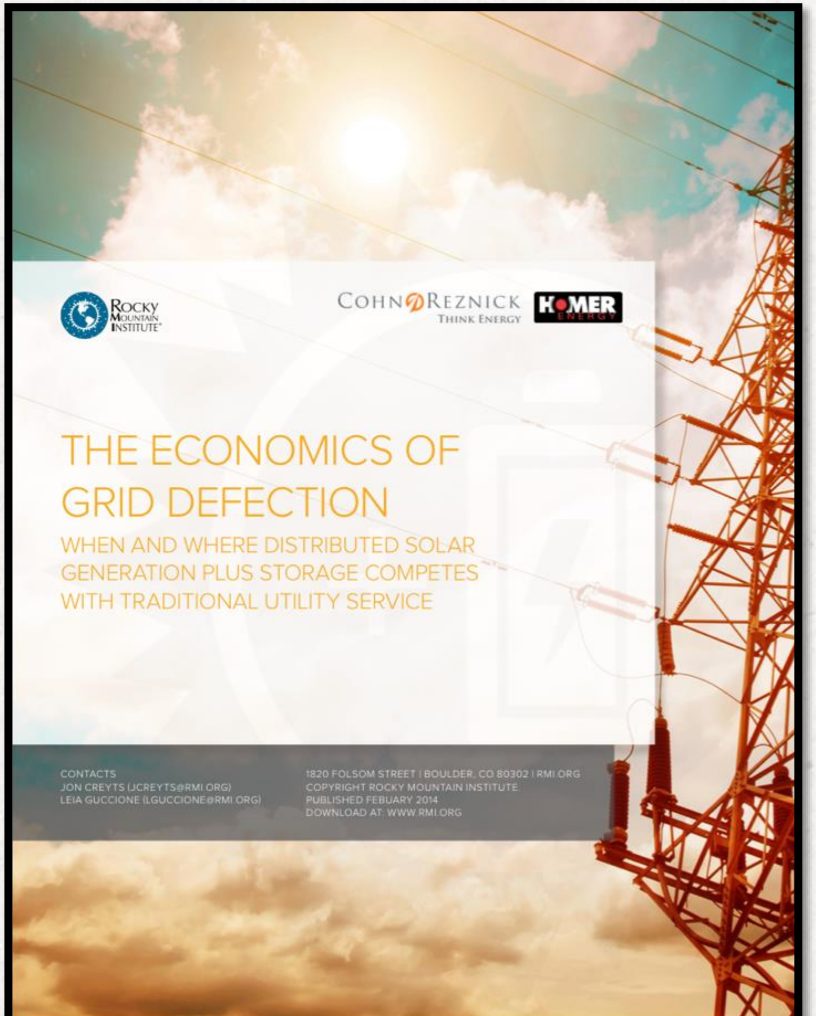


U.S. CUMULATIVE SALES OF PLUG-IN ELECTRIC VEHICLES



Can solar-plus-battery systems = grid defection?

THE CONVERSATION BEGAN WITH “GRID DEFECTION” IN FEBRUARY 2014



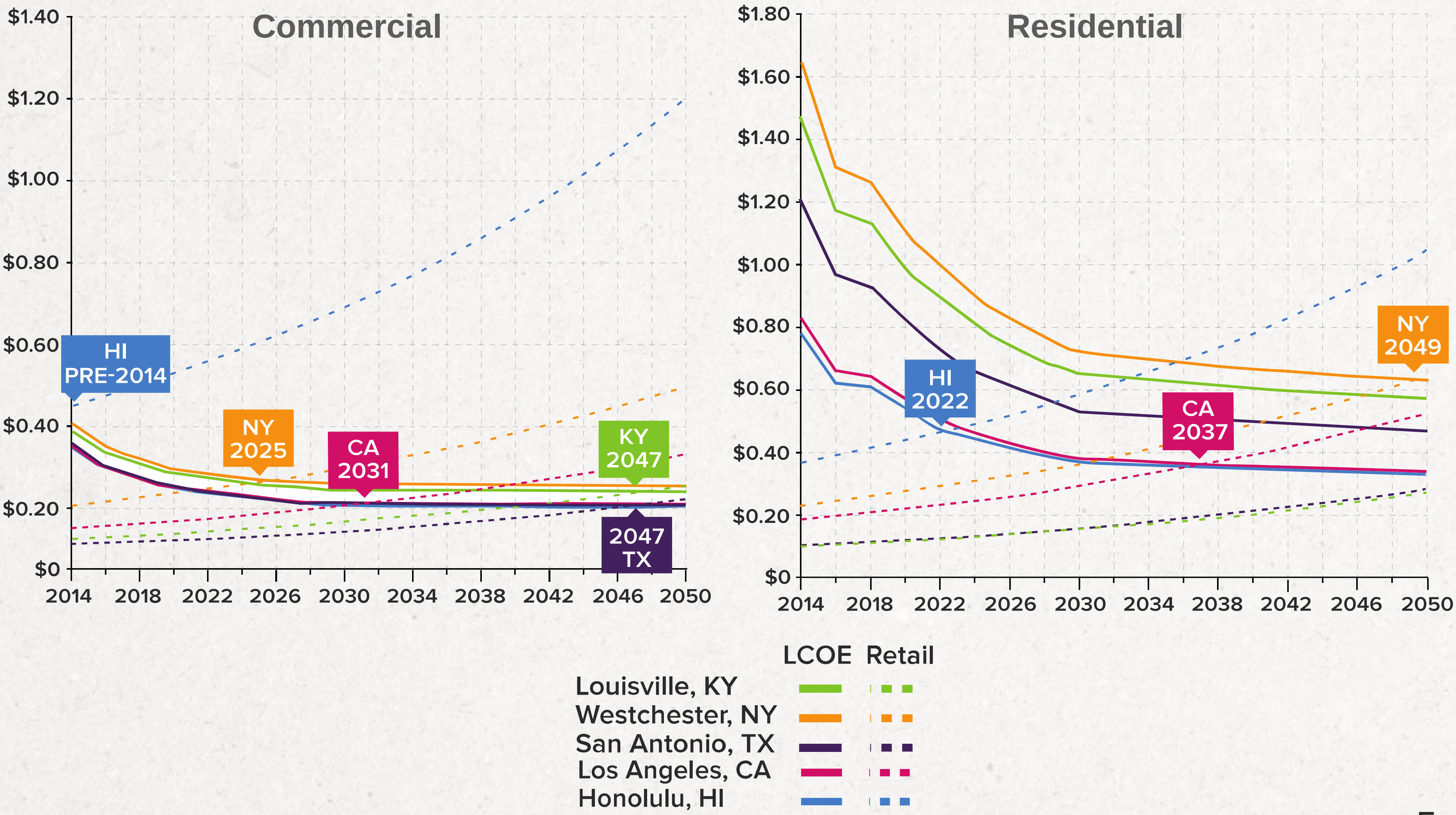
Key Messages

- 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

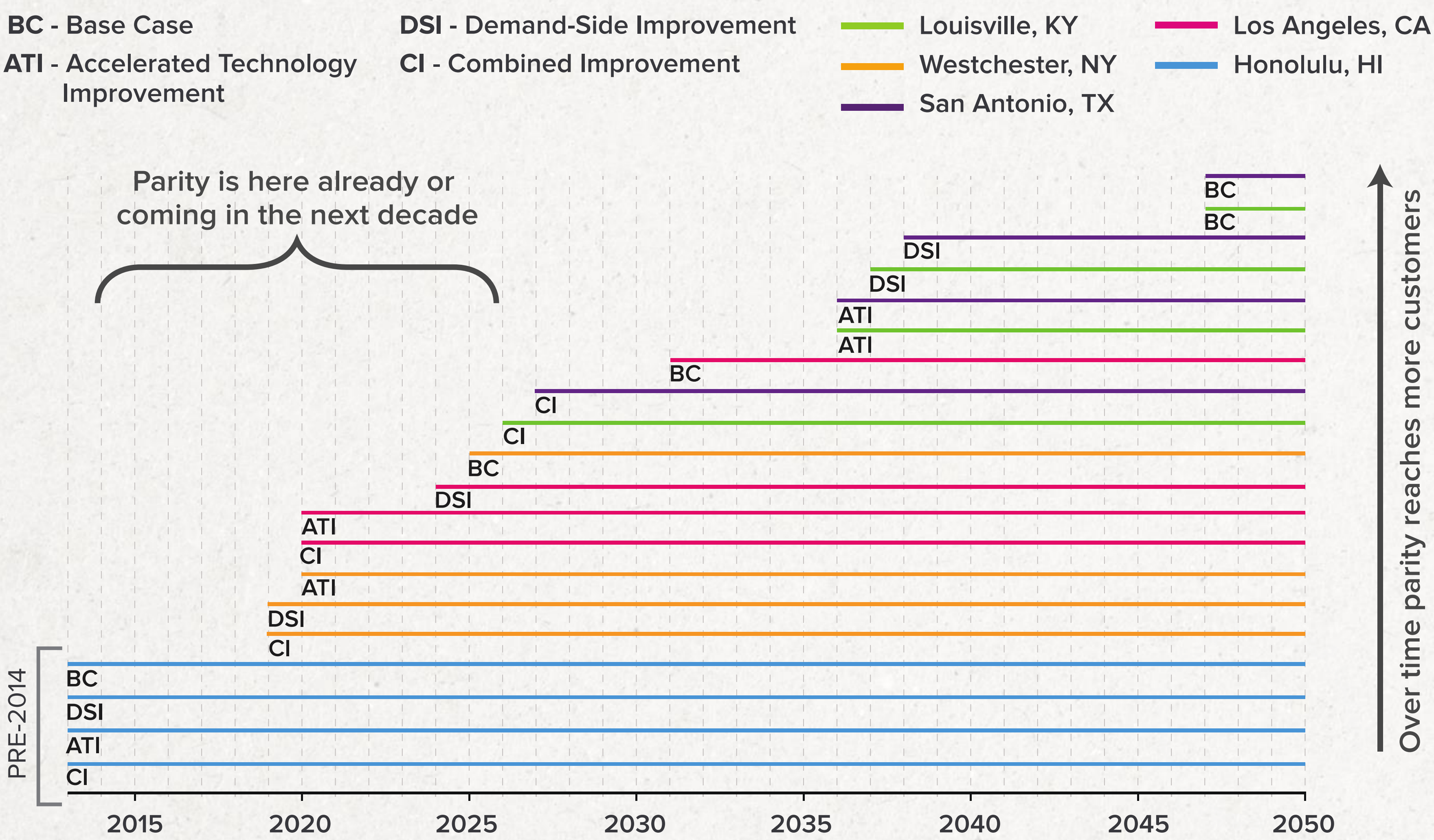
- www.rmi.org/electricity_grid_defection

THE ECONOMICS OF GRID DEFECTION

WHEN AND WHERE DISTRIBUTED SOLAR GENERATION AND STORAGE COMPETES WITH TRADITIONAL RETAIL SERVICE



A BUILDING WAVE OF POTENTIAL DISRUPTION



WHAT'S THE FUSS? THE FINANCE INDUSTRY WEIGHS IN

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]

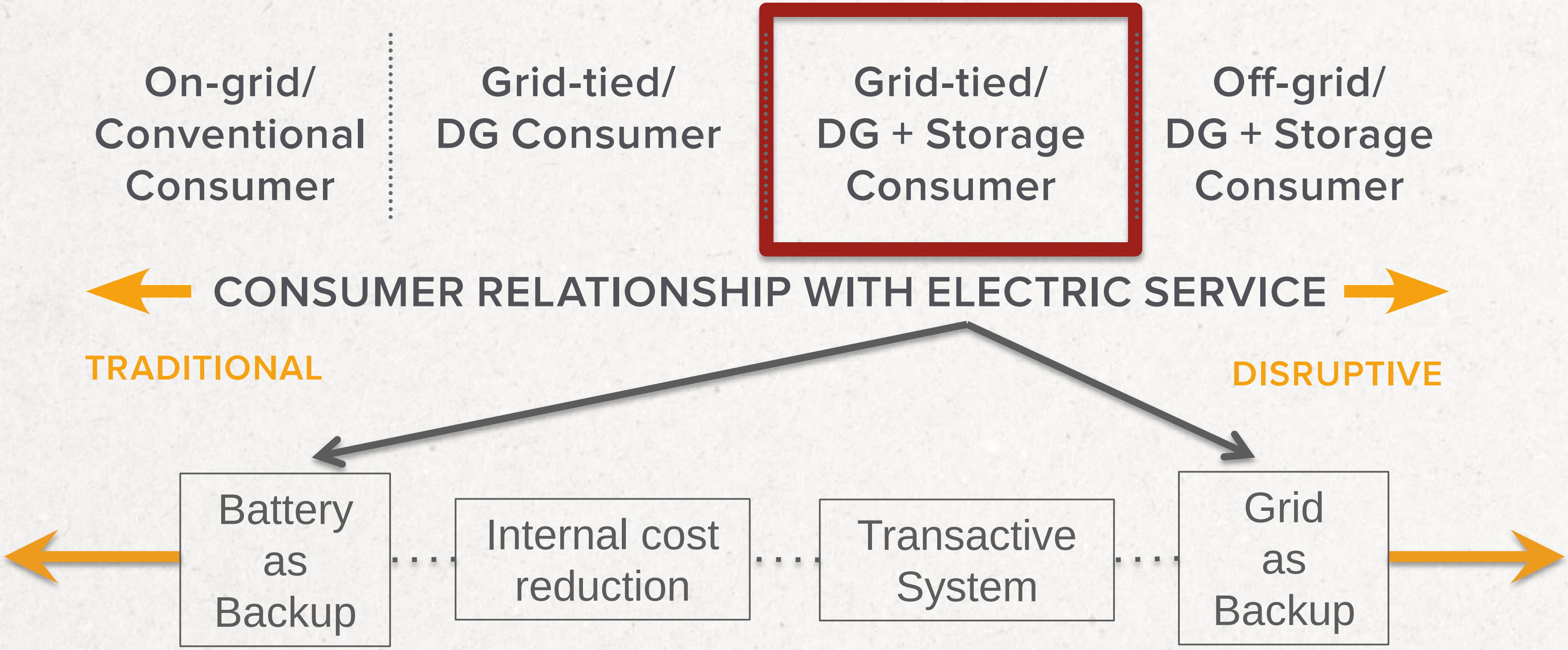
"The expected rapid decline in battery cost by (more than) 50 per cent by 2020 should not just spur EV sales, but also lead to exponential growth in demand for stationary batteries to store excess power."

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"

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

- 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

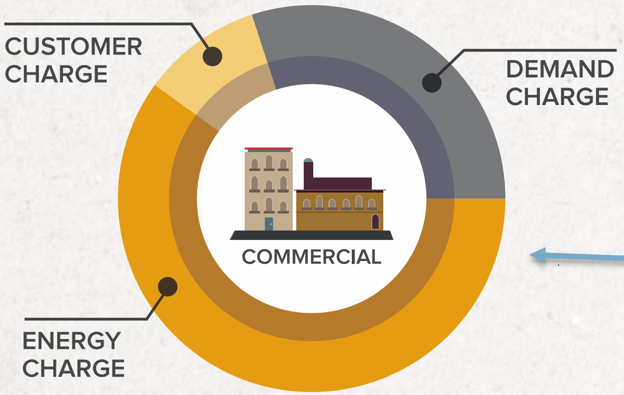


LOCATIONS WE STUDIED IN DETAIL




	WESTCHESTER, NY	LOUISVILLE, KY	SAN ANTONIO, TX	LOS ANGELES, CA	HONOLULU, HI
INSOLATION ($kWh/m^2/day$)	4.5 kWh	4.5 kWh	6 kWh	6 kWh	5.5 kWh
2014 AVG RETAIL PRICE ($/kWh)	$0.17–$0.23	$0.08–$0.09	$0.06–$0.10	$0.11–$0.18	$0.36–$0.42
INSTALLED PV BY STATE (MW)	140 MW	3 MW	200 MW	1,900 MW	27 MW
MARKET STRUCTURE	Restructured	Regulated	Restructured	Restructured	Regulated

RATE STRUCTURES WE APPLIED



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

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.

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

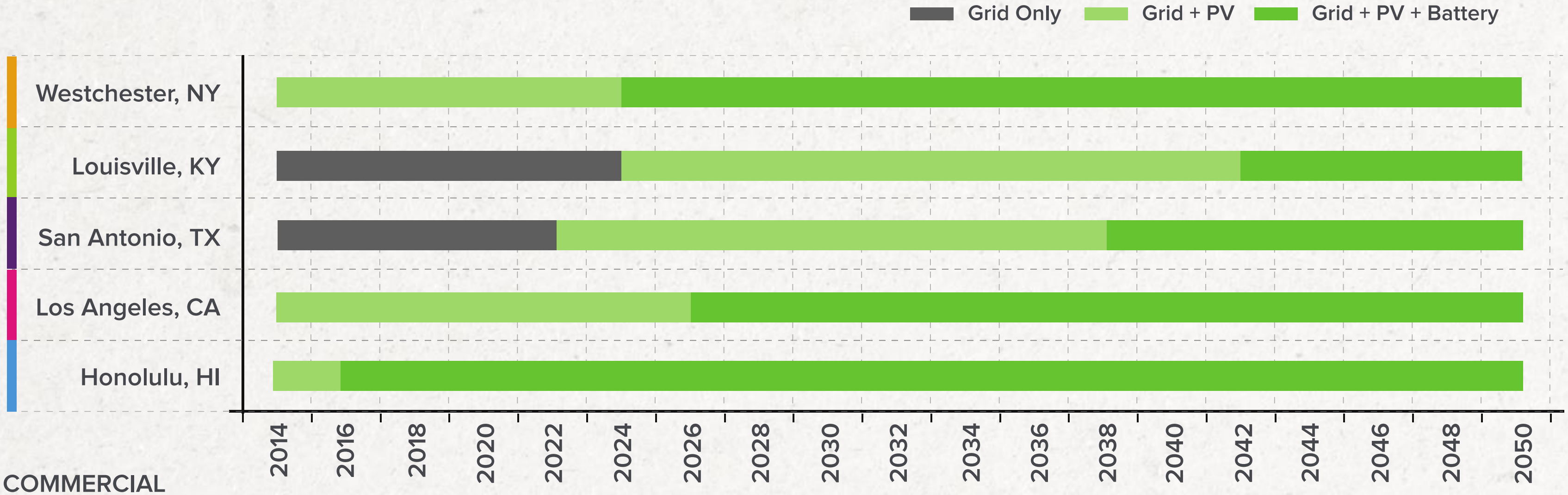
Levelized Cost of Energy

System Configuration

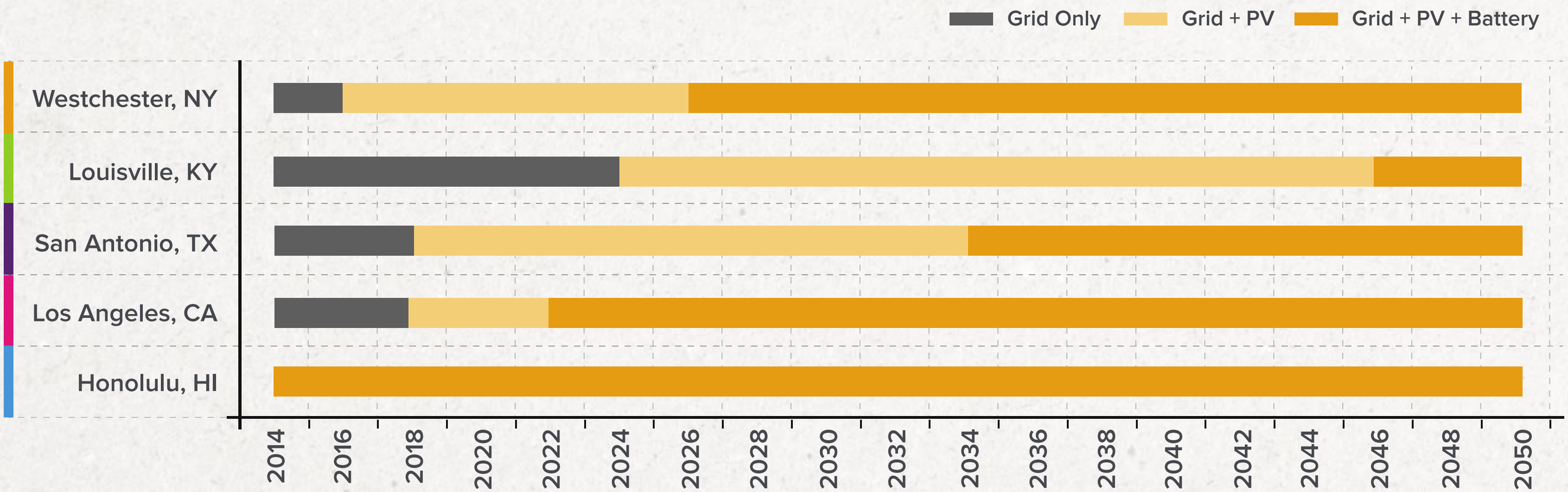
Net Metering

EVOLVING ECONOMICALLY OPTIMAL SYSTEM CONFIGURATION

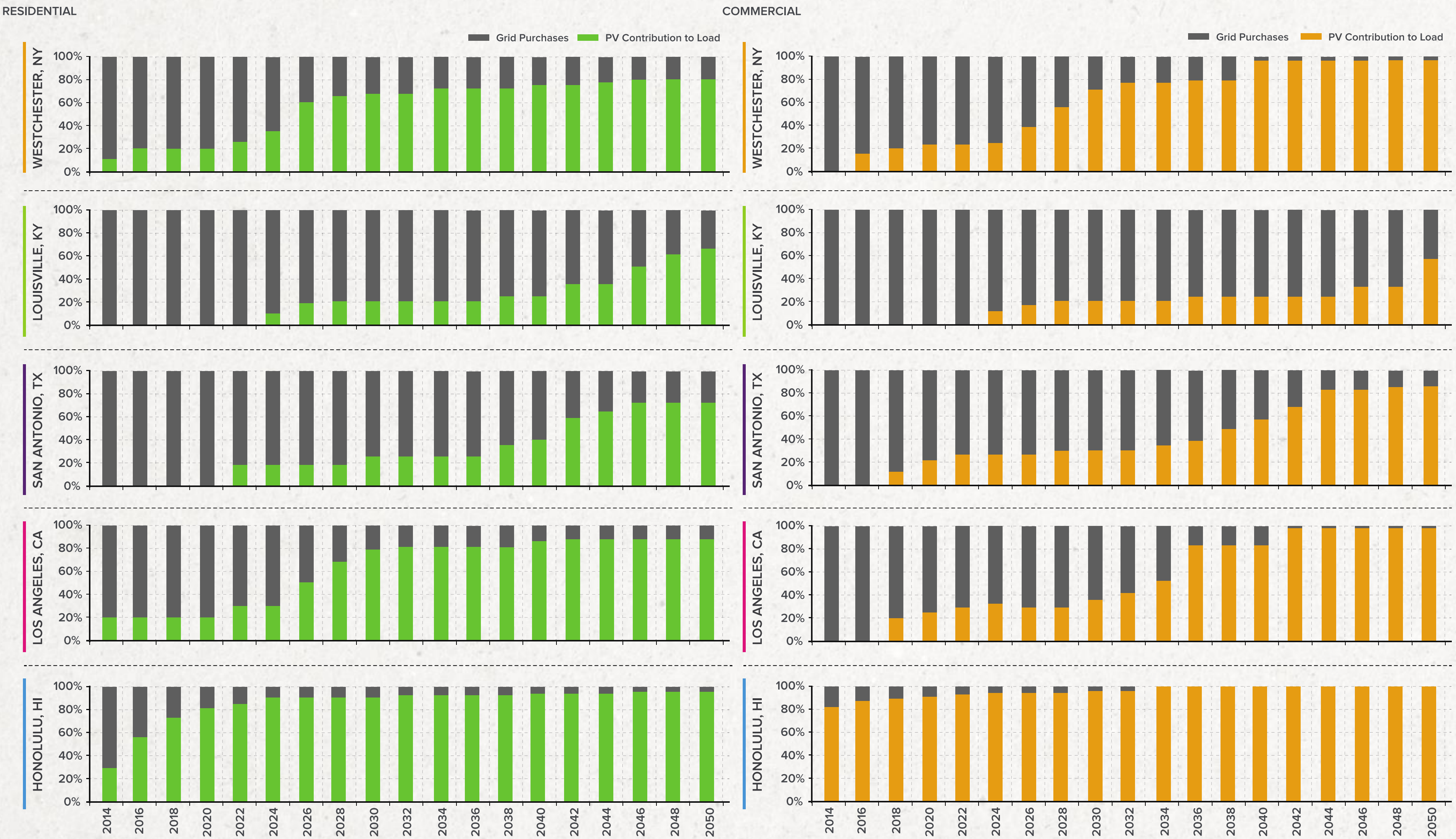
RESIDENTIAL



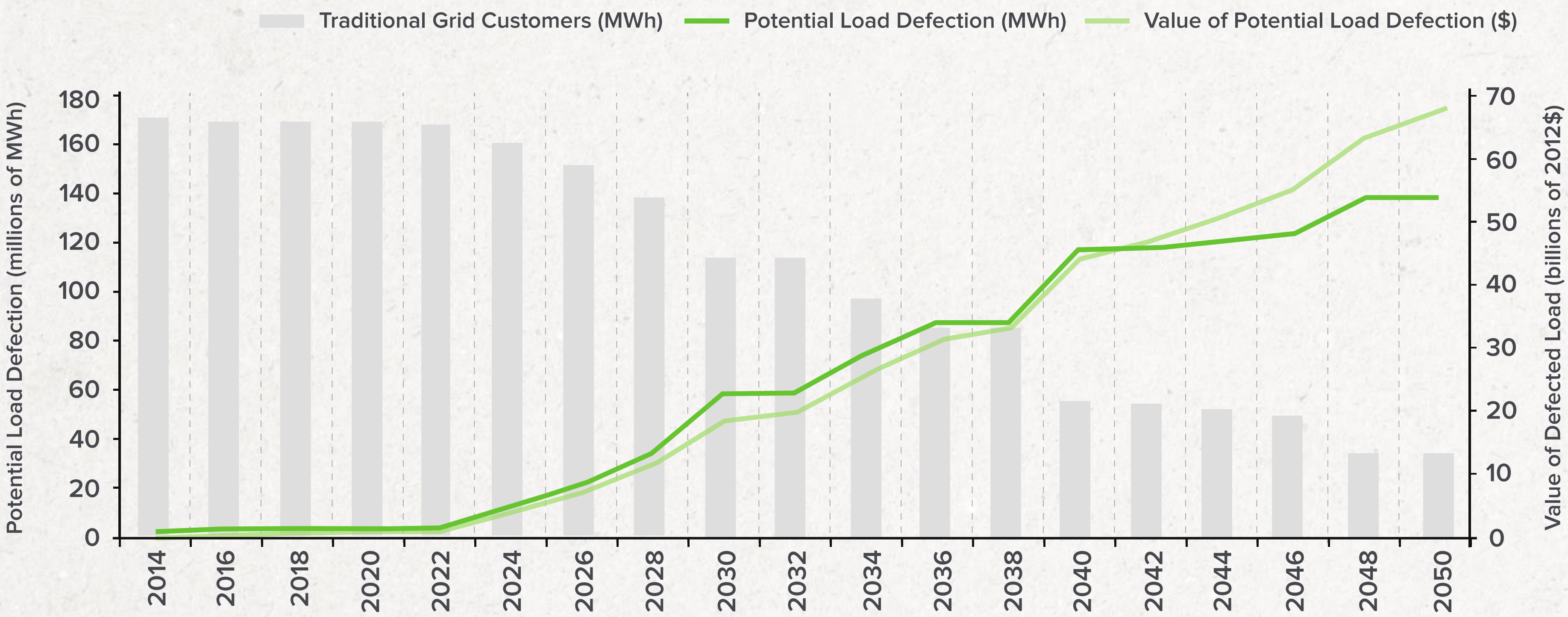
COMMERCIAL



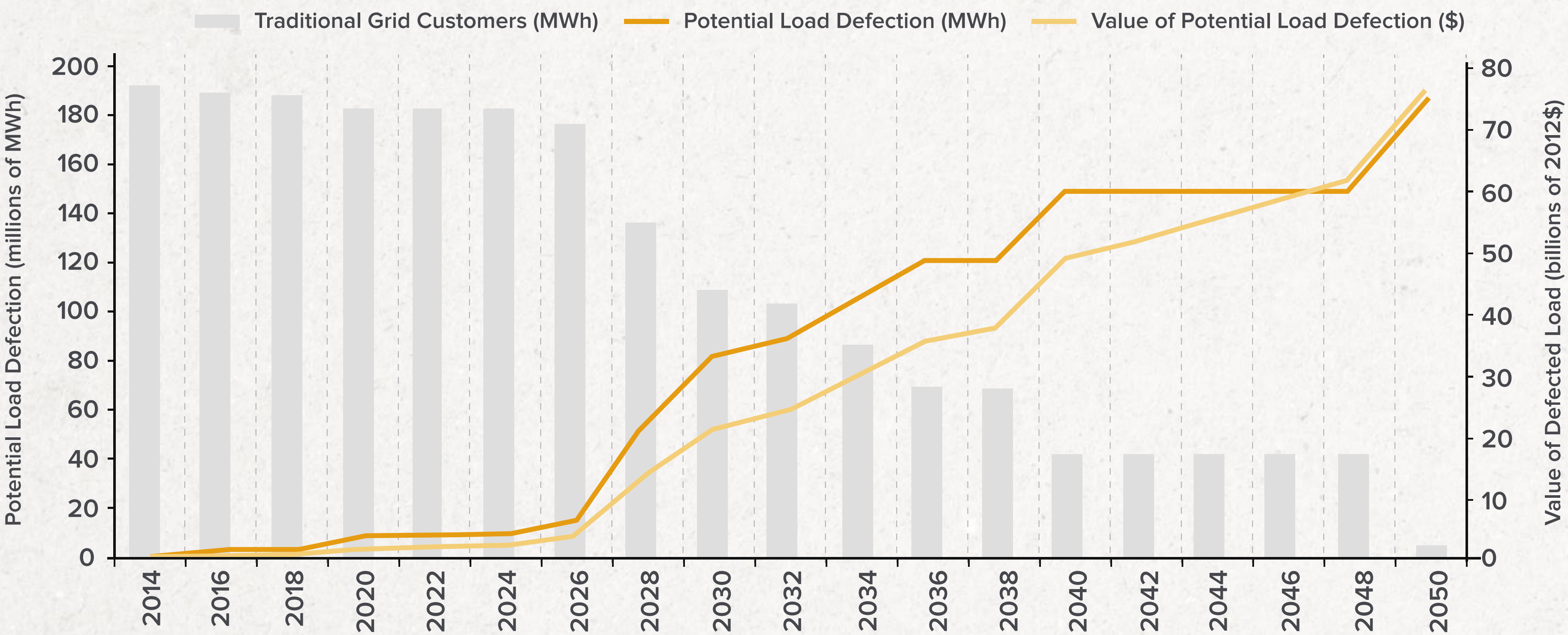
EVOLVING ECONOMICALLY OPTIMAL GENERATION MIX



MAGNITUDE OF POTENTIAL LOAD DEFECTION IN THE NORTHEAST - RESIDENTIAL

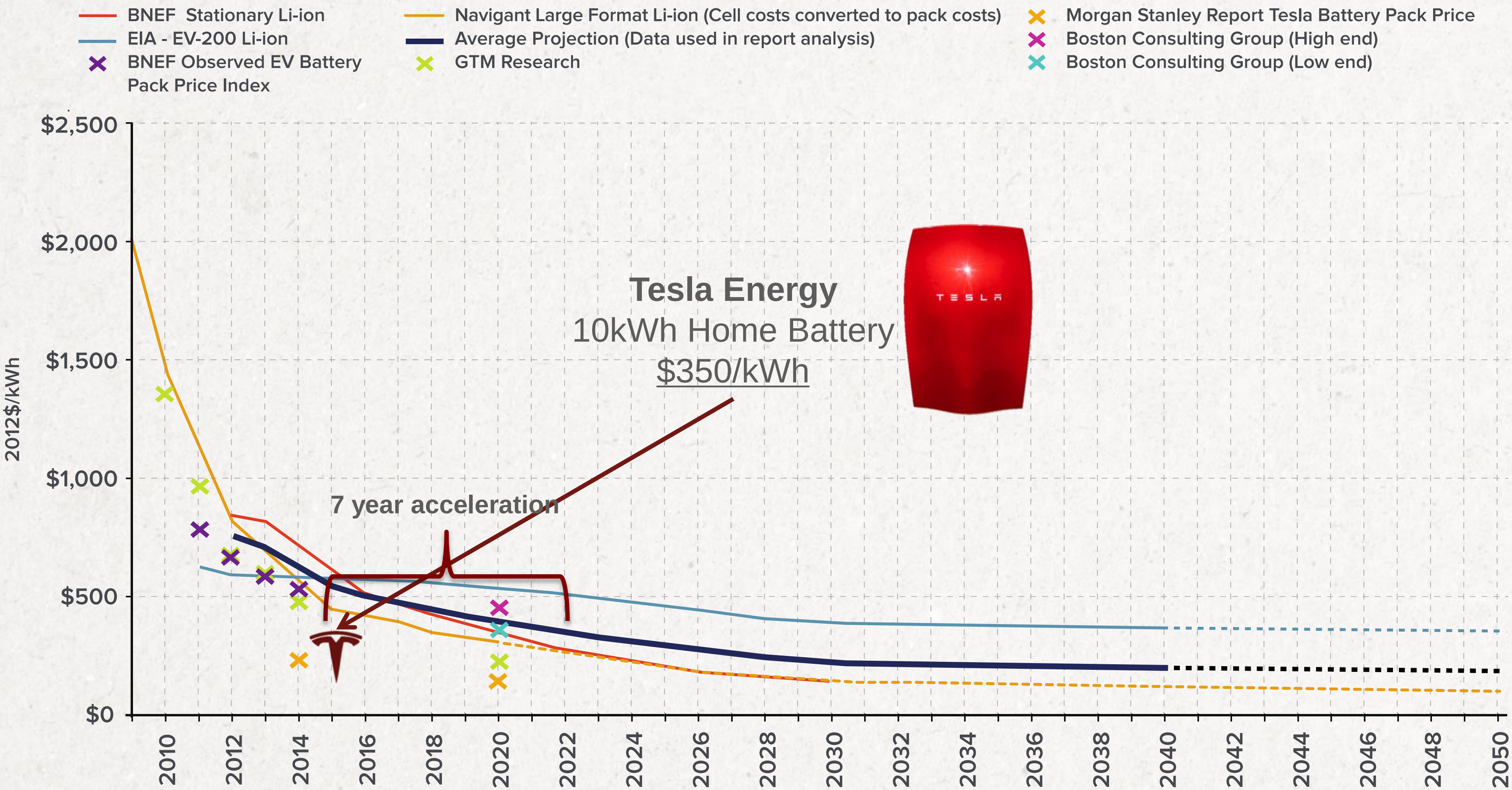


MAGNITUDE OF POTENTIAL LOAD DEFECTION IN THE NORTHEAST - COMMERCIAL

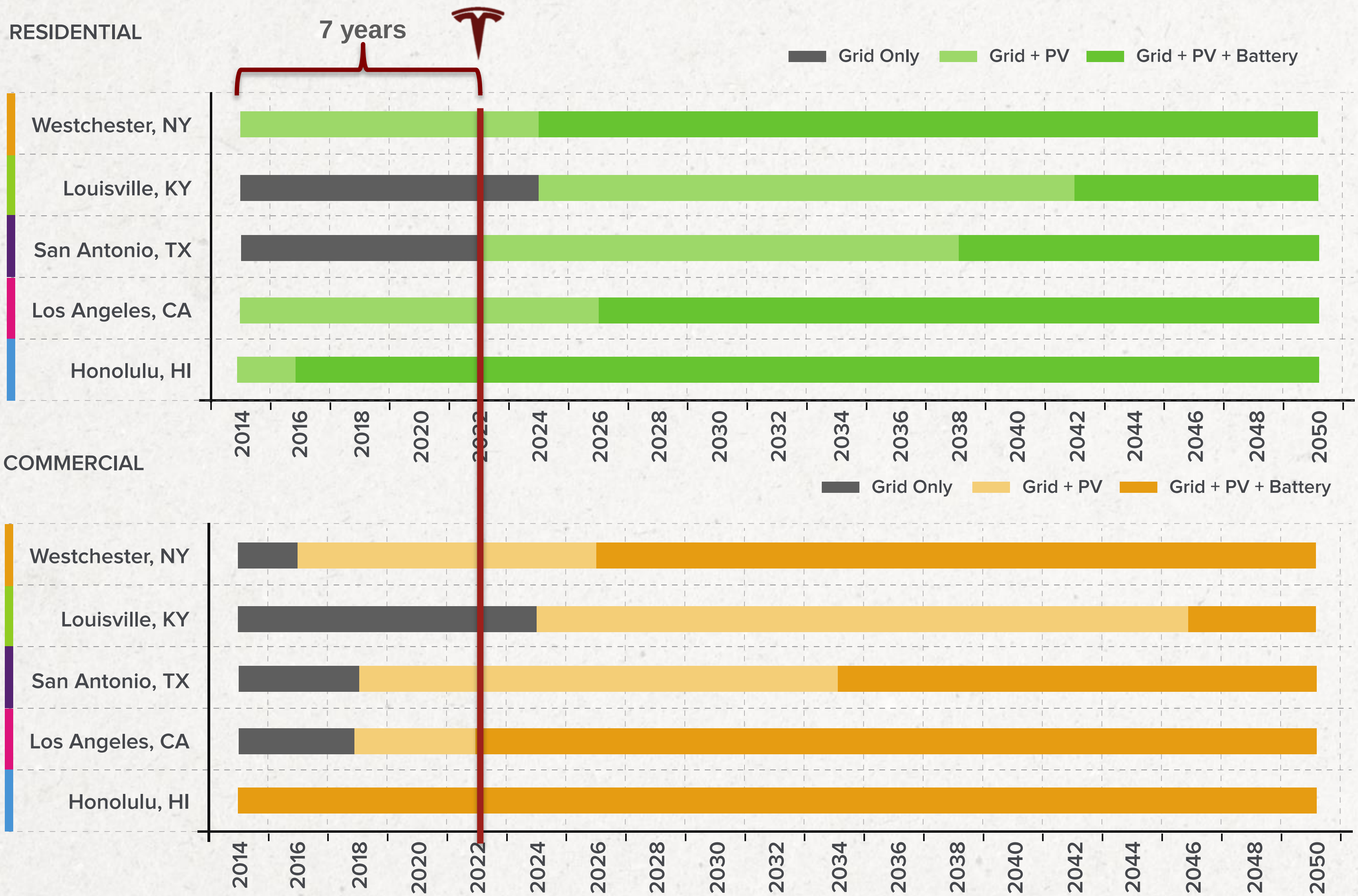


DECLINING LITHIUM-ION BATTERY COSTS AND FORECASTS

LITHIUM-ION BATTERY PACK PRICES: HISTORICAL AND FORECASTED

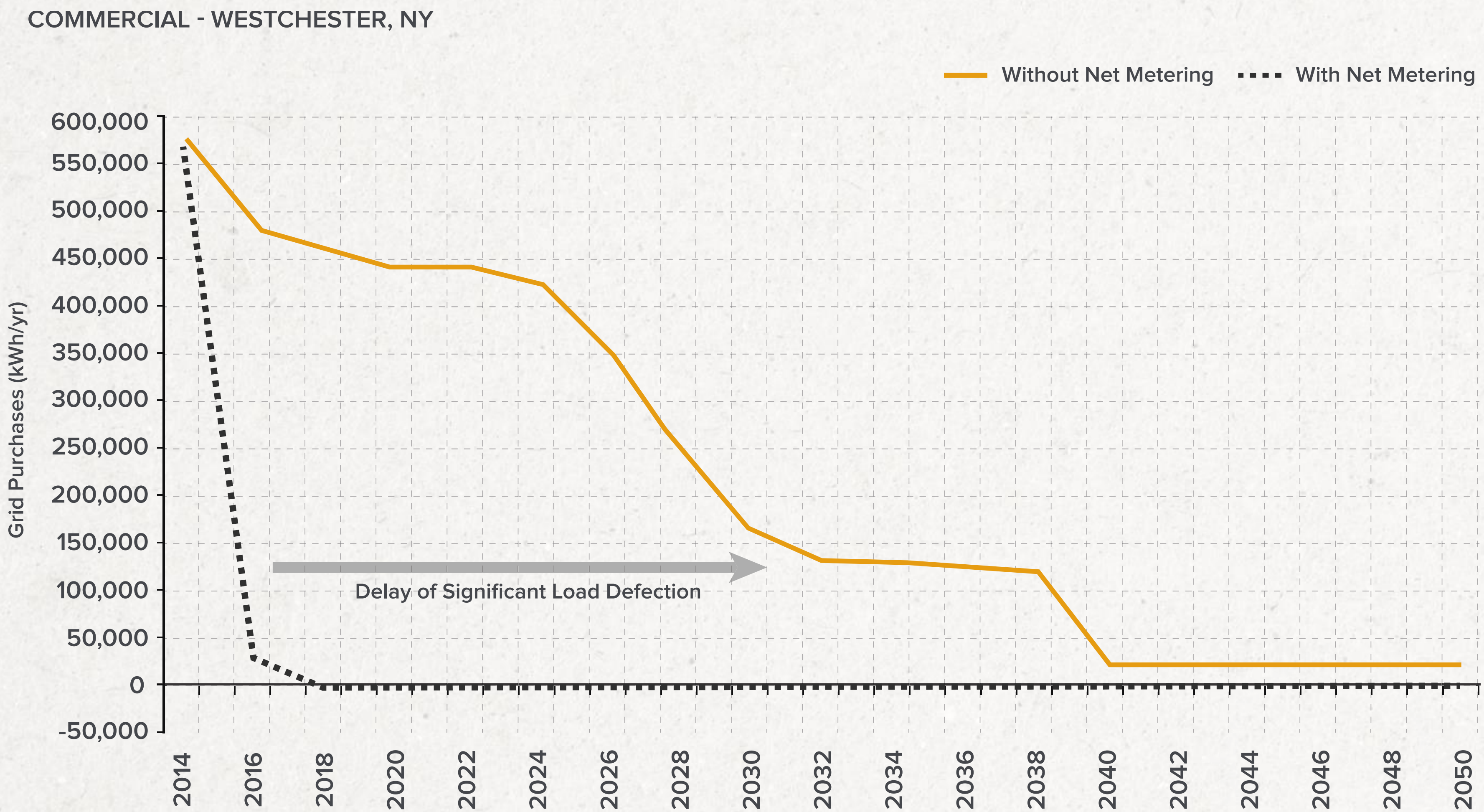


EVOLVING ECONOMICALLY OPTIMAL SYSTEM CONFIGURATION



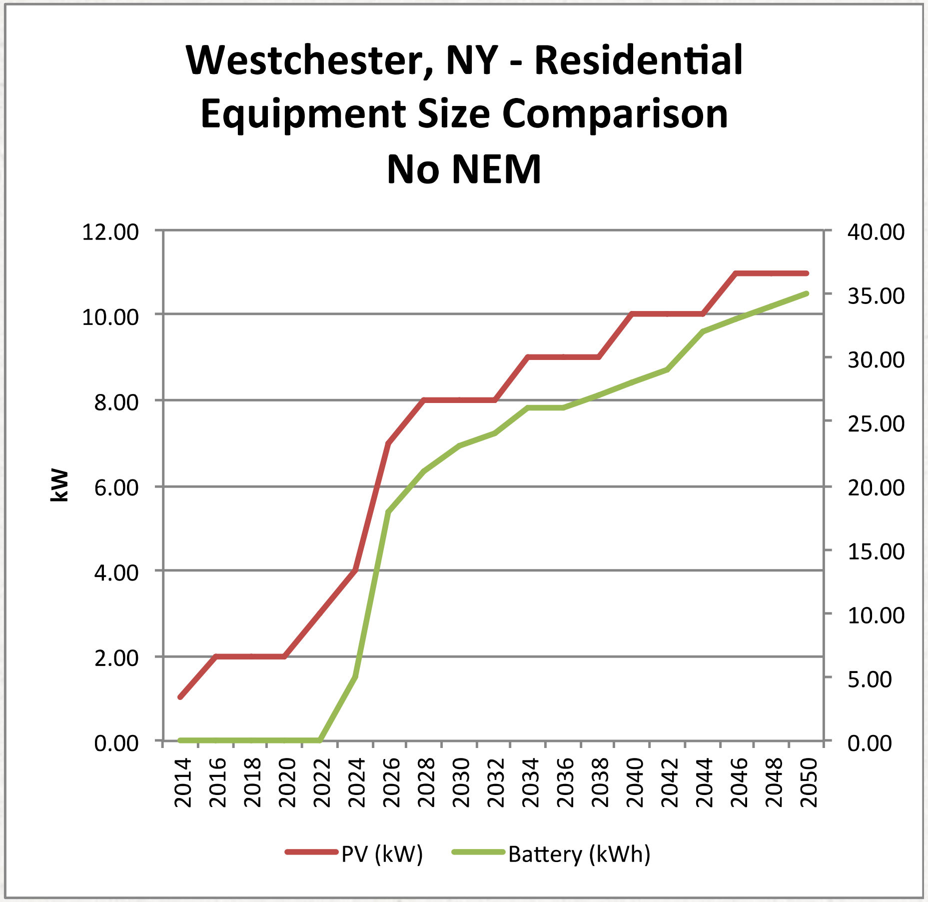
NET METERING'S EFFECT ON LOAD LOSS

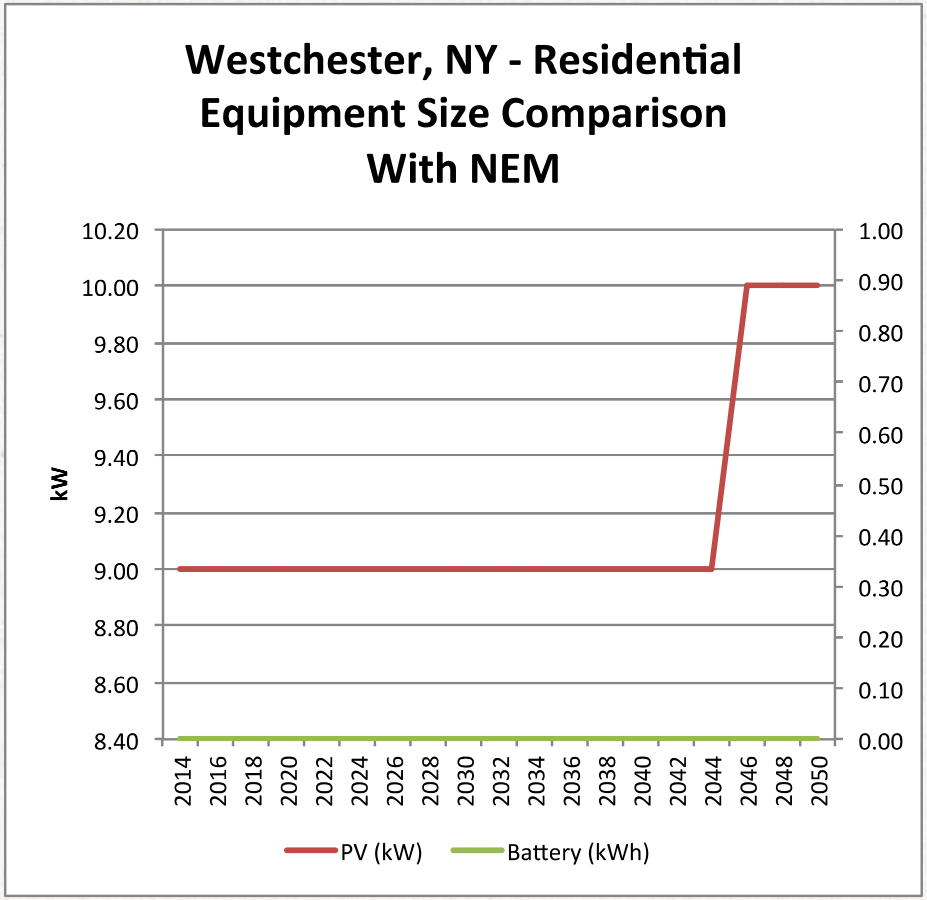
NET GRID PURCHASES – WESTCHESTER, NY



THE DIFFERENCE THE RATE MAKES

The availability of export pricing (i.e., net energy metering) significantly affects the economics for system configuration.



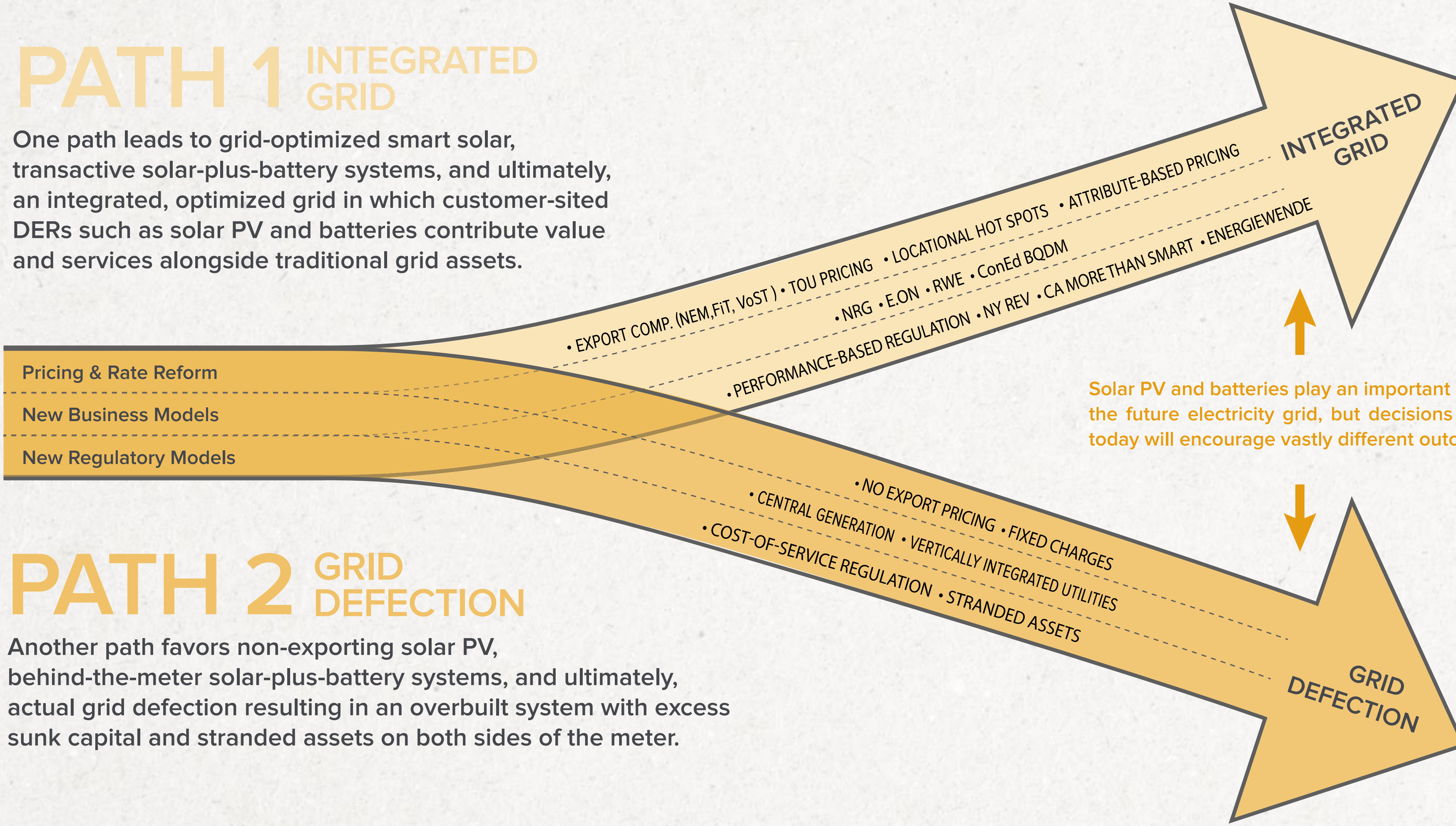


WE ARRIVED AT A FORK IN THE ROAD

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.



Solar PV and batteries play an important role in the future electricity grid, but decisions made today will encourage vastly different outcomes.

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.

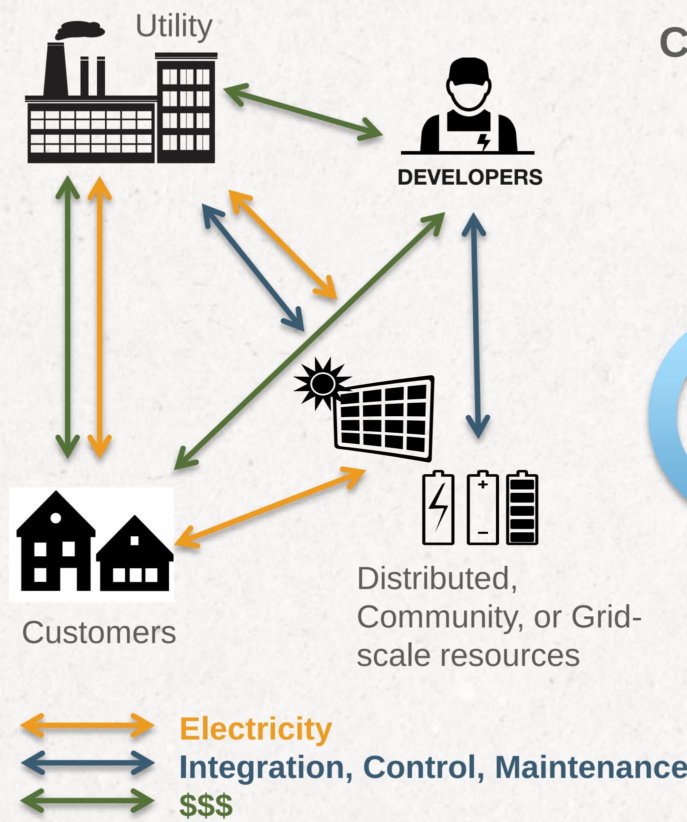
THREE LEVERS OF ACTION FOR AN INTEGRATED GRID

1. Evolved pricing and rate structures

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

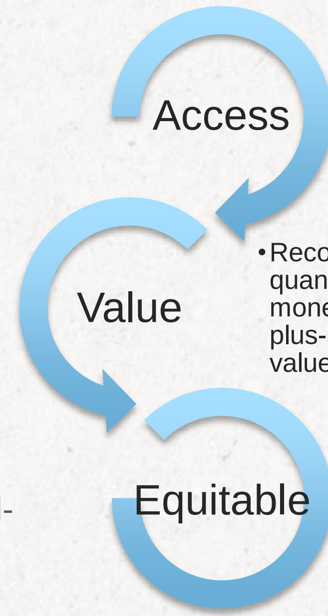
Longer Term, More Sophisticated Possibilities
Real-Time Pricing
Attributed-based Pricing
Distribution Locational Marginal Pricing

2. New business models

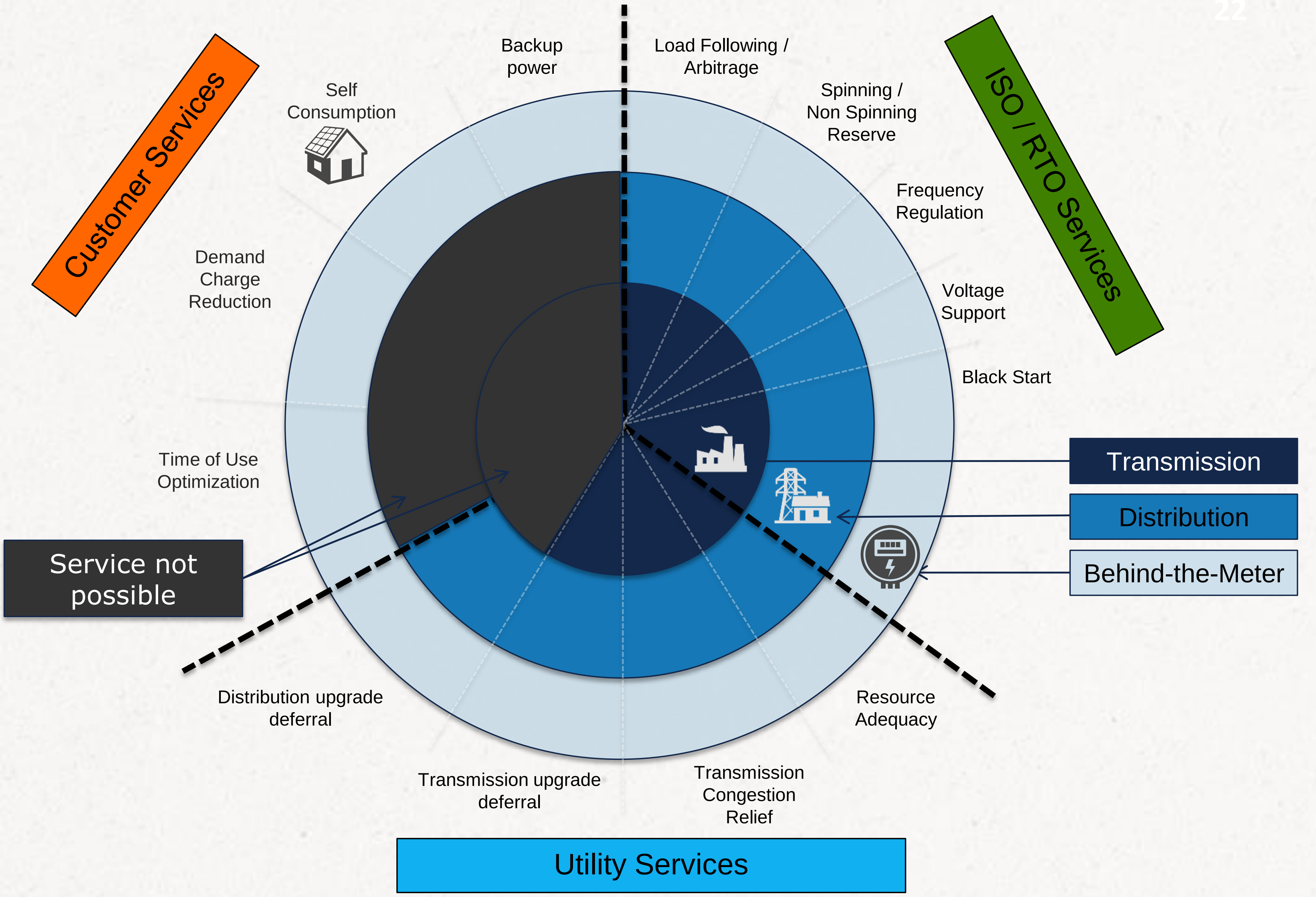


3. New regulatory models

Critical reform areas

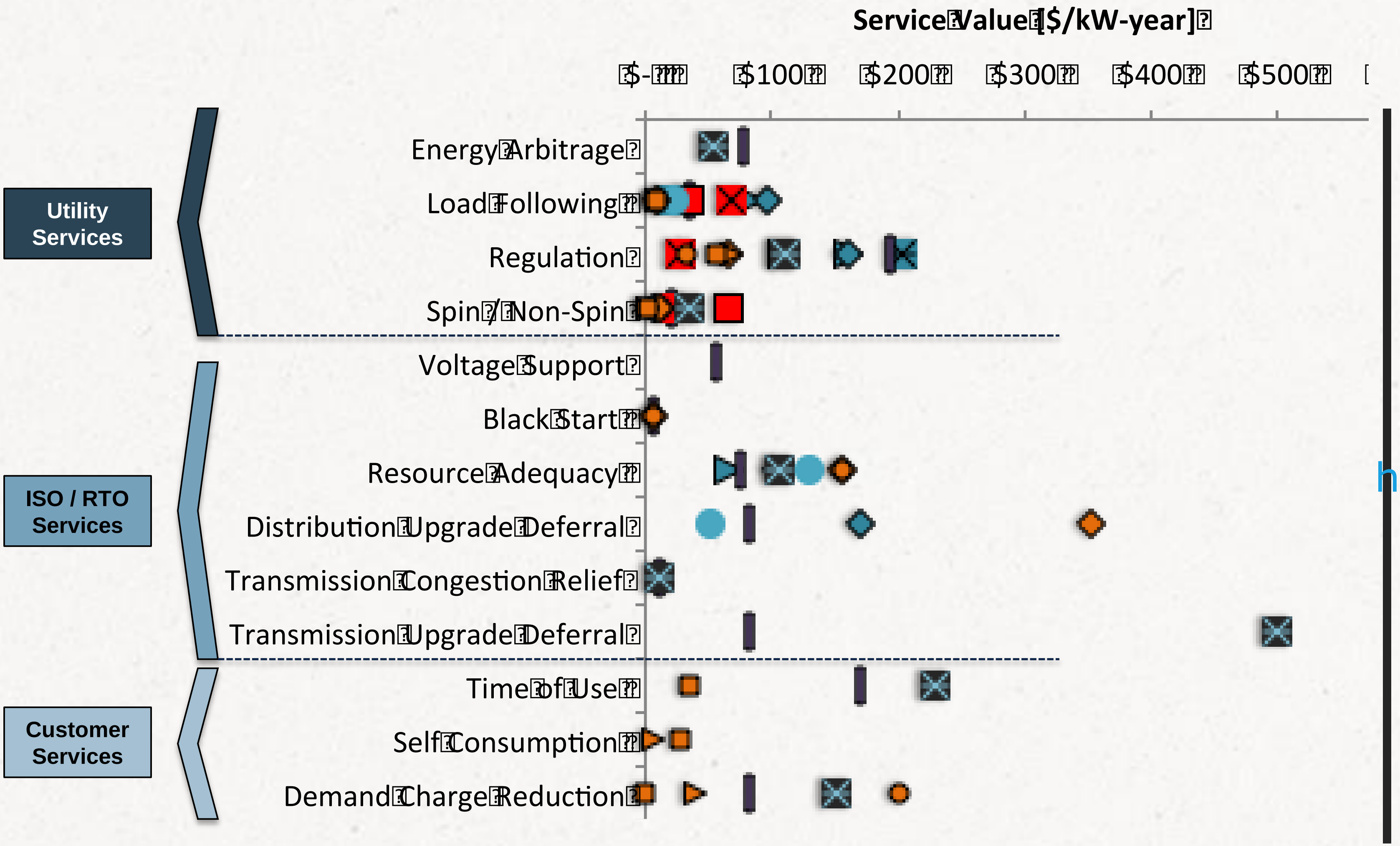


- Enhance fair and equal access to DERs
- Recognize, quantify, and monetize solar-plus-storage value
- Preserve equitable treatment of customers not invested in DERs



Customer Services
ISO / RTO Services
Utility Services
Backup power
Self Consumption
Demand Charge Reduction
Time of Use Optimization
Load Following / Arbitrage
Spinning / Non Spinning Reserve
Frequency Regulation
Voltage Support
Black Start
Resource Adequacy
Transmission Congestion Relief
Transmission upgrade deferral
Distribution upgrade deferral
Transmission
Distribution
Behind-the-Meter
Service not possible

THE ECONOMICS OF BATTERY STORAGE

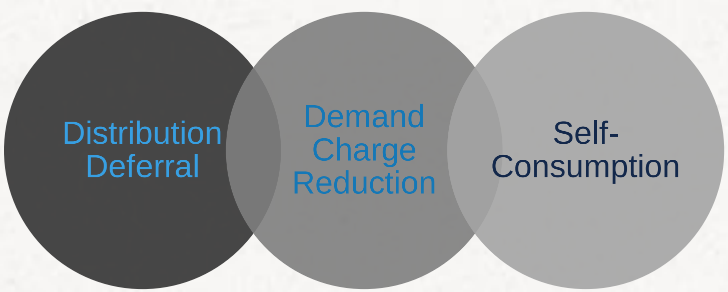


RMI's 'Manual' ES Dispatch Model

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.

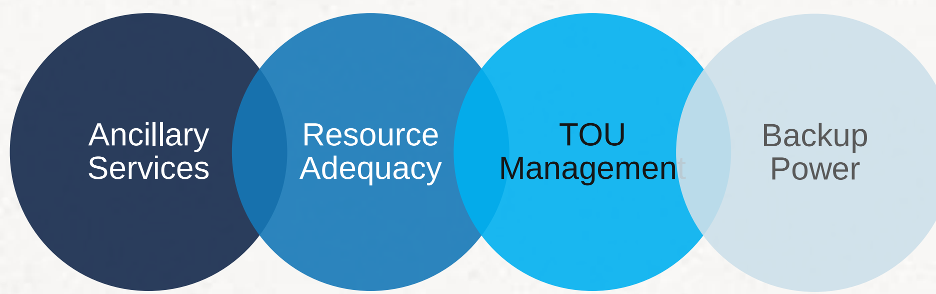
Primary Storage Application

- 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

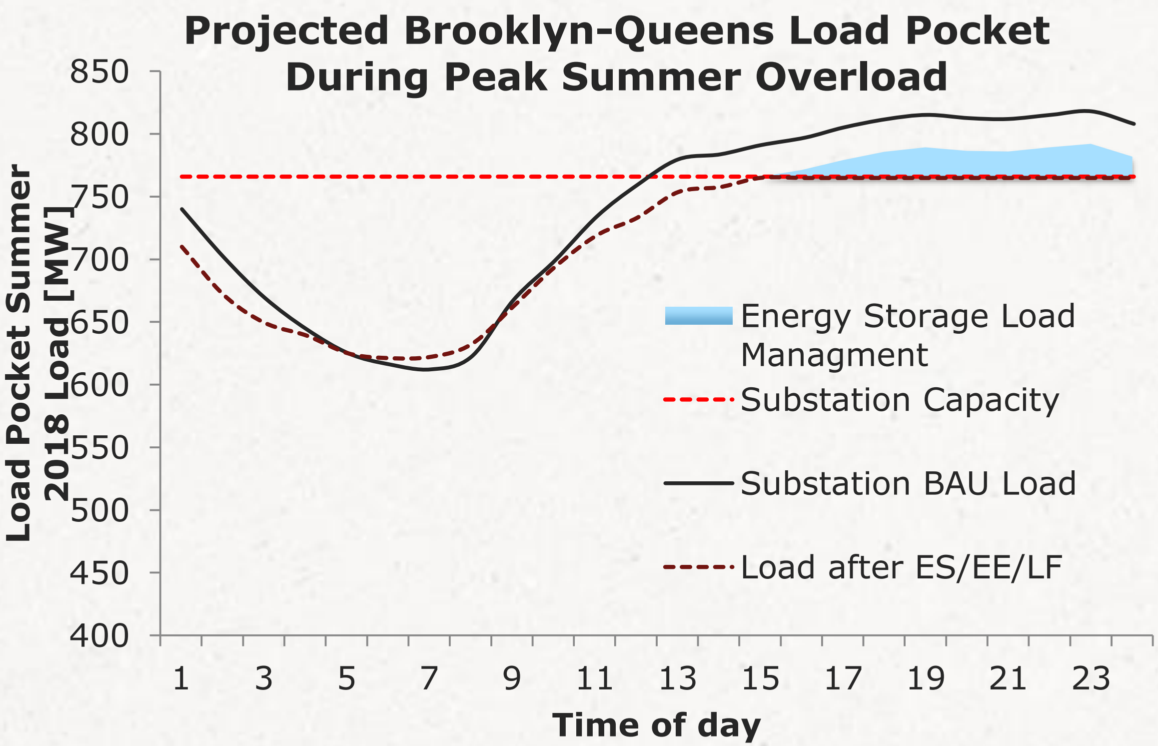
- System is dispatched to a secondary service when not constrained by is primary application
- Not dispatched based on economic value, instead illustrates a suite of services
- Service value set by time-dependent historic market prices



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

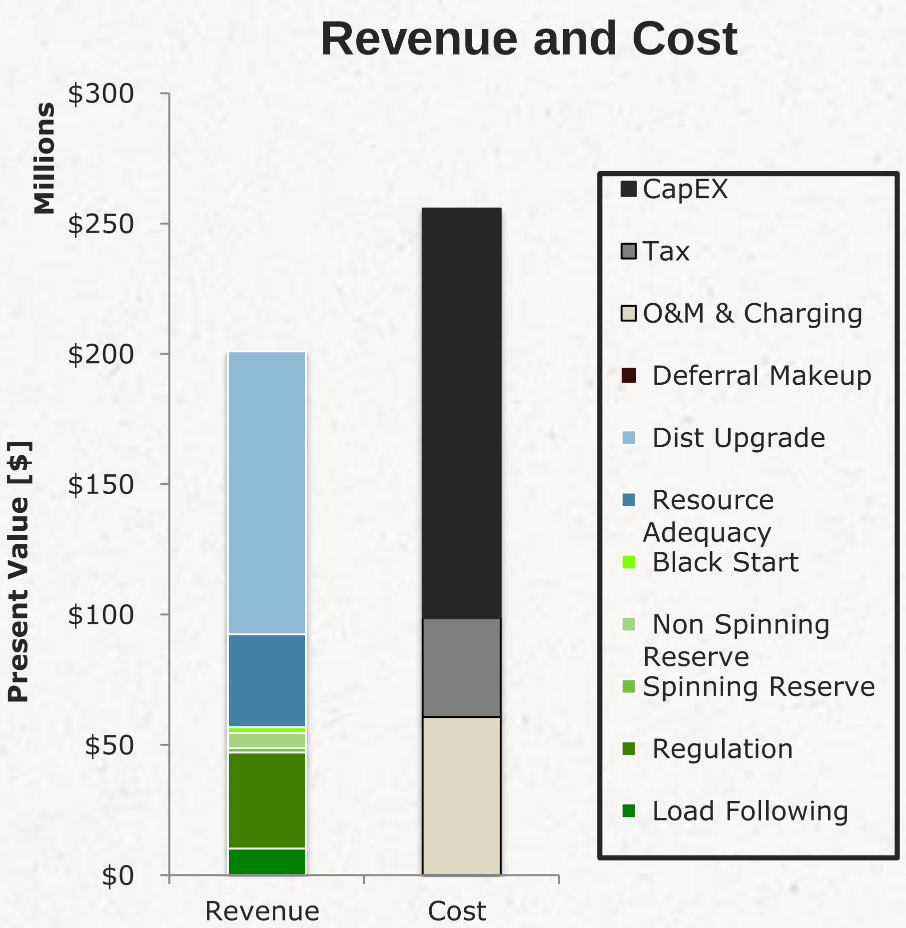
- We assumed **no regulatory barriers to aggregated, behind the meter** market participation or revenue generation
- **We assign zero value to backup power** as an extreme conservatism
- **Predetermined dispatch strategy** - For each case, we do not always dispatch the battery to the highest hourly valued 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

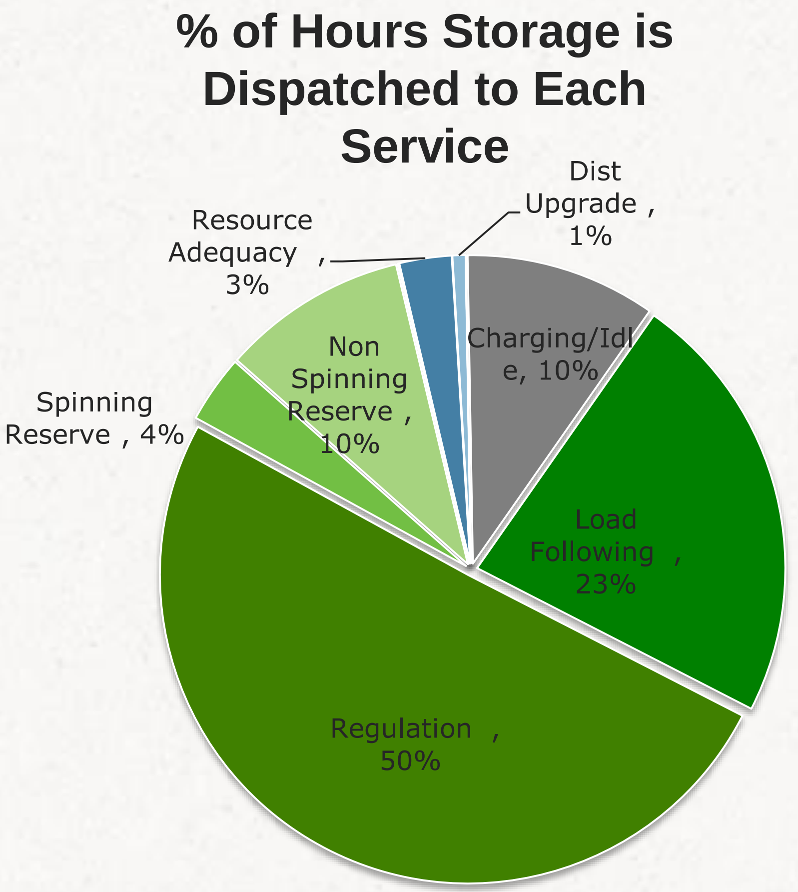
CASE 1: DISTRIBUTION UPGRADE DEFERRAL IN BROOKLYN / QUEENS



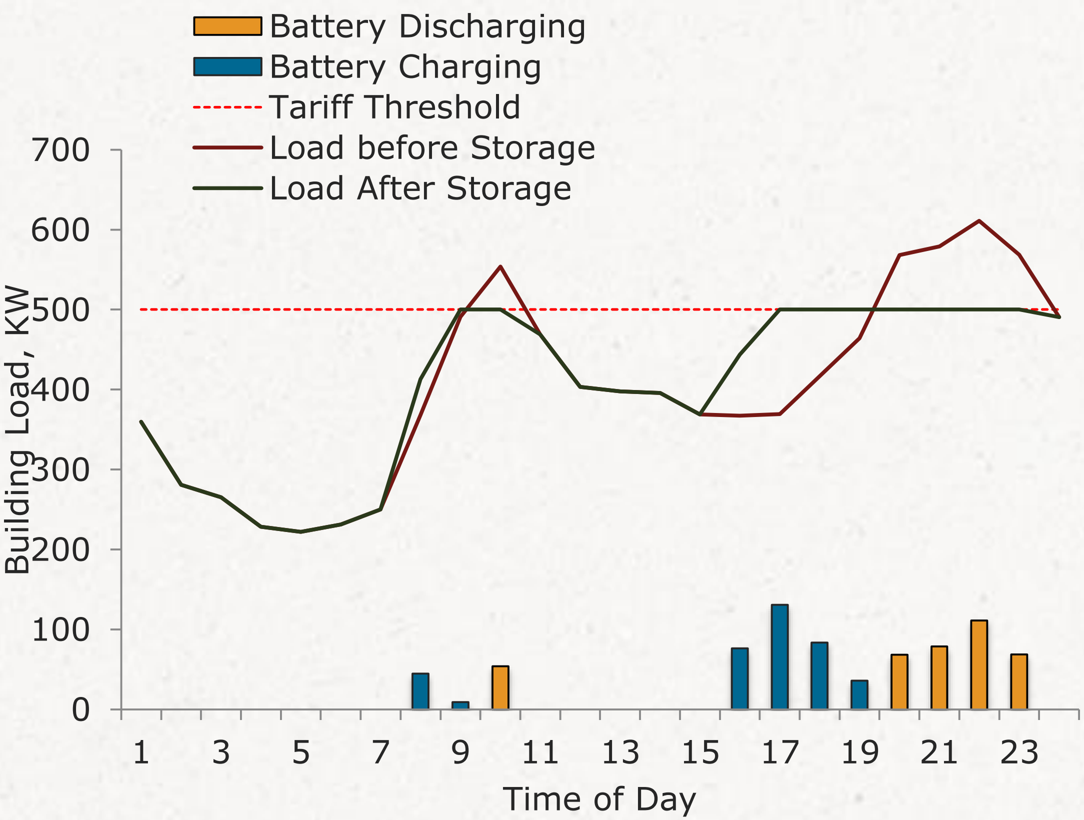
1. Substation overload of 52 MW in 2018
2. Assumed DR and EE reduce peak by 26 MW and shorten overload to 6 hours
3. 4000 Res systems [5kW/10kWh and 1500 Com systems [30kW/90kWh]
4. $120 million dollar deferal value

CASE 1: DISTRIBUTION UPGRADE DEFERRAL IN BROOKLYN / QUEENS





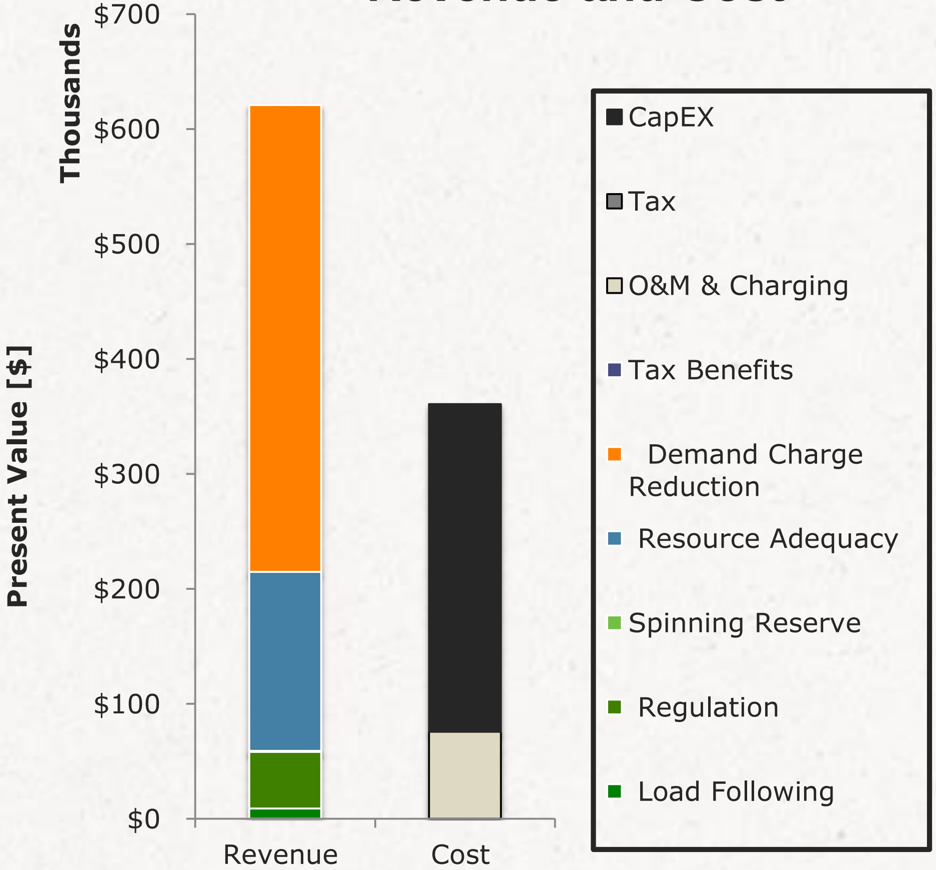
CASE 2: DEMAND CHARGE REDUCTION IN SAN FRANCISCO



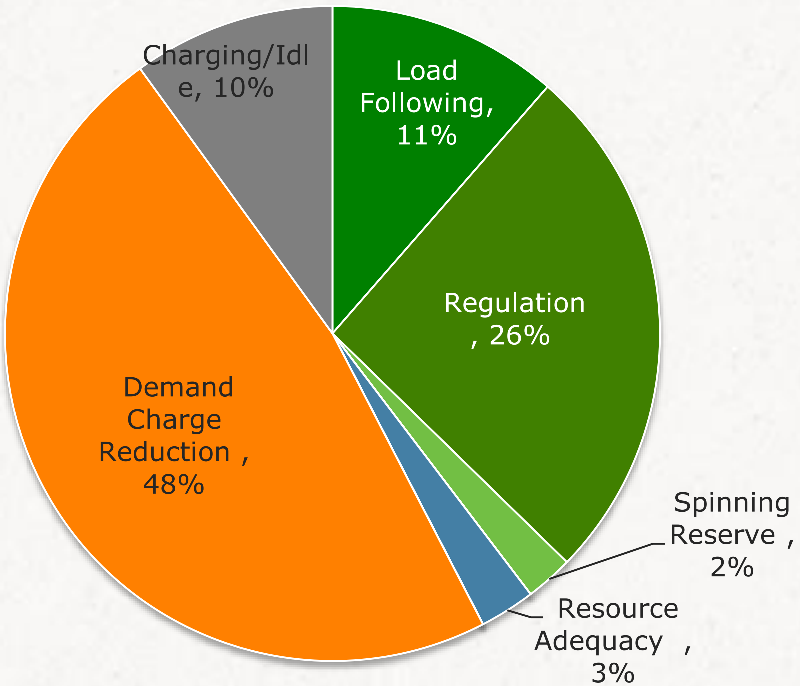
1. The building's original load exceeded 500 kW, bumping the customer into the PGE E19 tariff schedule
2. Properly sized storage can ensure the 15 minute peak building load never exceeds 500 kW, resulting in significantly reduced demand charges
3. Hourly simulation with a perfect load forecast resulted in a system size of:
   - 140 kW
   - 560 kWh

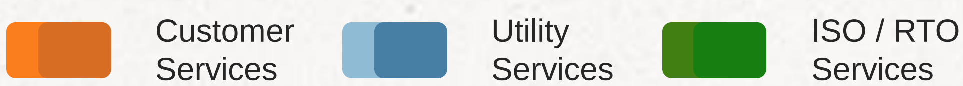
CASE 2: DEMAND CHARGE REDUCTION IN SAN FRANCISCO

Revenue and Cost



% of Hours Storage is Dispatched to Each Service





Recommendations for:

Regulators

- Enact regulatory change that incents utilities to incorporate storage and other DER's to provide a full stack of services to the electricity system
- 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
- Weigh potentially increased costs of downstream energy storage placement against the additional values and flexibility created by these assets

Utilities

- Restructure business models and rates to reflect the value of storage via temporal, locational, and attribute-based functionality
- 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
- Implement pilot projects to demonstrate the ability of storage to be reliably used as an alternative to traditional assets
- Screen BTM developers using specific criteria prior to awarding contracts

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

Sundance Mountain Resort, Utah

April 24-27, 2016

www.rmi.org/elab_accelerator

Creating a clean, prosperous, and secure energy future

www.rmi.org

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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

Sign up for the RPP e-Distribution List to get notices of future webinars and the monthly *Resilient Power Project Newsletter*: http://bit.ly/RPPNews-Sign-UP

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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