Massachusetts Department of Energy Resources

Panel 2: Considerations for Storage in the APS and Current Market Perspectives

Energy Storage Public Stakeholder Forum

May 30, 2018

Boston, MA

Energy Storage Support through Portfolio Standards: *General Considerations*

Bob Grace, President & Managing Director, Sustainable Energy Advantage, LLC

MA DOER
Energy Storage in the APS and Additional Program Support Mechanisms Forum
May 30, 2018

Sustainable Energy Advantage, LLC

Sustainable Energy Advantage, LLC

- Objective Analysis
- Modeling
- Forecasting
- Transaction Facilitation

- Tracking & Analysis
- Development
- Implementation
- Multi-Stakeholder Support

Markets | **Policies**

What We Do?

Strategy | **Projects**

- Insight
- Intelligence
- Negotiation Support
- Action

- Financial Models & Analysis
- Due Diligence & Feasibility
- Matchmaking

Since 1998, our consulting & advisory firm has helped clients build renewable energy business, markets, policies and projects through analysis, strategy & implementation.

Diverse client base with differing commercial interests =
Freedom to conduct objective analysis

Our Suite of Subscription Services

New England Renewable Energy Market Outlook (REMO)

- Detailed REC market fundamentals analysis, briefings, providing actionable information on New England's complex REC markets to support informed business decisions. Delivered 3x per year
- Since 2005

New England Eyes & Ears: Renewable Energy Regulatory Policy & Legislative Tracking & Analysis

- Comprehensive service enhancing users' government affairs and market intelligence functions
- Since 2007

Massachusetts Solar Market Study

- In-depth analyses of the Massachusetts solar markets since 2014, focusing on the solar renewable energy credit market and the new Solar Massachusetts Tariff (SMART) program

New in 2018: New York Renewable Energy Market Outlook (REMO) Suite

- Suite of services including topical webinars, periodic bulletins, detailed REC Market Fundamentals Analysis, and comprehensive regulatory, policy and legislative tracking and analysis, collectively providing subscribers with comprehensive & timely insight into New York's evolving renewables market.
- New York Eyes & Ears: Regulatory Policy & Legislative Tracking & Analysis

SEA's Market & Policy Analysis Resume

A Sample

- MA RPS Cost Study, Design & Implementation Support (2000-02)
- MA DOER Solar Policy Program and Post 400-MW Policy Analysis (2013)
- Developing a Post-1,600 MW Solar Incentive Program: Evaluating Needed Incentive Levels and Potential Policy Alternatives (2016)
- Crafting a Renewables Portfolio Standard for Rhode Island: Design Choices, Best Practices, and Recommendations (2002)
- RI Renewable Energy Standard model legislation (2002)
- NY RPS, RES Procurement, RES Tier 1 Obligation & Procurement design and implementation support
- Large-Scale Renewable Energy Development in New York: Options and Assessment (2015)
- Connecticut RPS Study (2013)
- Vermont RPS Study (2011)
- New York RPS Cost Study (2003, 2009, 2013)
- New York CES Cost Study (2016)
- *Analysis of MA CO_2 & Clean Energy Standard Regulations (2017)*
- *An Analysis of the Massachusetts Renewable Portfolio Standard (alternative futures) (2017)*
- *Massachusetts' Electricity Future: Reducing Reliance on Natural Gas Through Renewable Energy (2016)*
- Solar Market Development Volatility in NJ (2014)
- Potential Benefits of Long-Term Contracts for RPS Compliance in NJ (2015)
- Estimated Ratepayer Impact of Increasing the Maryland RPS (2013, 2014 & 2015)

Wiser, Ryan, Kevin Porter, Robert Grace, ***Evaluating Experience with Renewables Portfolio Standards in the United States***, Prepared for the Conference Proceedings of Global Windpower 2004 Chicago, Illinois: March 28-31, 2004, published as a Lawrence Berkeley National Laboratory report, March 2004.

Customized Energy Solutions, Alevo Analytics, Sustainable Energy Advantage, Daymark Energy Advisors & Strategen, ***State of Charge: Massachusetts Energy Storage Initiative*** (2016)

Today's acronym soup…

- APS = Alternative Portfolio Standard
- AECs = Alternative Energy Certificate (pronounced "aches", not to be associated with "pains")
- ACP = Alternative Compliance Payment (effectively, price cap)
- CHP = Combined Heat & Power
- ESS = Energy Storage System
- GIS = NEPOOL Generation Information System (certificate tracking system)
- REC = Renewable Energy Credit
- RPS = Renewable Portfolio Standards (a/k/a Renewable Energy Standards)

Overview

Objectives

- Help participants understand, if MA seeks to add ESS to APS:
  - issues, complexities
  - portfolio design considerations
  - Early insights
  - Opportunities, headaches
- Address the question:
  - What are considerations for MA DOER to add ESS to APS?

Outline

- Policy tools
- Key MA APS Features
- APS in ESS?
  - Why consider?
  - Objectives
  - Common Portfolio Standard design issues
  - Supply – Demand Balance
  - Compliance
  - Differentiating incentives btw. ESSs
- Take-aways

MA APS Key Features
Today

- Targets
  - 2018 = 4.50% of annual retail electricity sales ➔ 5.00% by 2020, increasing by 0.25%/yr indefinitely
  - Regs. require program review in 2020, incl. consideration of minimum standard
- Geographic Eligibility
  - Electricity: Must be in ISO-NE; “Off-grid” and behind-the-meter generation must be located in MA
  - Thermal: shall deliver Useful Thermal Energy to end-use load located in MA
- Technology Eligibility
  - CHP, flywheels, renewable thermal generation, waste-to-energy thermal, fuel cells (thermal or electric)
  - Liquid biofuel capped at 20% of total obligation
  - 50% greenhouse gas reduction requirement for emitting renewable thermal
  - Fuel cells must be more efficient than emitting locational marginal units
- One Alternative Energy Credit (“AEC”) =
  - Fuel cells: 1 MWh [elec + useful thermal equivalent] generated
  - Flywheel: 65% of MWh discharged
  - ‘MWh equivalent’ for thermal energy
  - CHP: elec. MWh/0.33 + Useful Thermal / 0.80 – energy content of fuel consumed
  - Compliance multipliers for fuel cells (1.5) & non-emitting renewable thermal (up to 5.0)
- Can ‘double-dip’ with RPS Class I & II (but can qualify as only 1 type of APS unit)
- 2018 ACP rate $22.64/MWh (vs. $68.95/MWh for Class I RPS), esc. @ CPI
- Key takeaway ➔ VERY flexible tool for DOER

RPS: all eligible supply gets 1 REC per MWh
APS: Requires relative valuation

MA APS as a tool to support Energy Storage Systems?

- *Selective references to: Wiser, Ryan, Kevin Porter, Robert Grace,* ***Evaluating Experience with Renewables Portfolio Standards in the United States*** *(2004)*

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Why consider APS to support ESS?

- Opportunity:
  - DOER has broad authority over APS targets and details
  - No new legislation required
  - ➔ Can be implemented relatively quickly
- APS designed to be flexible
  - Electric generators
  - Useful thermal
  - Etc.
  - *"The Island of Misfit Toys"*
- Already supporting ESS
  - Flywheels

Portfolio Requirement Design Considerations:
Objectives dictate design: What is the standard attempting to accomplish?

Common Objectives, Issues

- Stimulate market for eligible technologies
  - Attract financing to new investments
  - Support continued operation of existing resources (supplemental revenue stream)
- Create price signals
- Alter/encourage operating decisions, capabilities
- Misc. (less relevant to today's agenda), e.g.
  - GHG/other emissions reductions?
  - Energy security? Diversification?
  - Fish/water quality benefits?
  - Economic development

➔Objectives dictate design

➔Objectives may conflict / Design for one objective may fail at another

➔Tension btw goals vs. limiting ratepayer cost

➔*Lack of clear objectives sometimes hinders effective design*

APS + ESS

- What would be the objective?
  - Attract new investment?
  - Supplemental revenue stream of projects that can already achieve objectives?
  - Price signals?
  - Encourage certain design, or actual operation of equipment?

Selected 'Common Design Pitfalls'

- Poorly Balanced Supply-Demand Conditions
  - S>>D: low prices, can't increase supply, revenue shuts off (see most New England 'class 2' markets)
  - D>>S: high costs, undermines political support
- Policy Instability (duration, targets, eligibility) impedes commitment, investment
- Insufficient Duration and Stability of Targets
- Design Complexity

Portfolio Requirement Design Considerations:
Carefully Balanced Supply-Demand Conditions

Well-Defined & Stable Resource Eligibility Rules

- *"Ambiguity as to what resources are and are not eligible, or may become eligible, creates market uncertainty for both renewable developers and LSEs"*
- What competes head-to-head?
  - Technology/fuel
  - Geography
  - Vintage

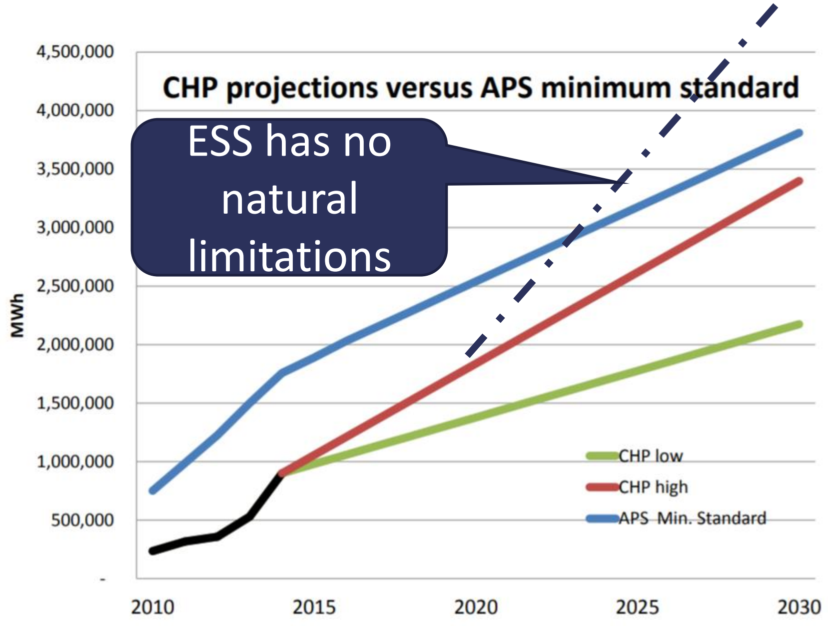
Sufficient Duration and Stability of Targets

- *"Are targets too unclear or of inadequate duration to provide sufficient certainty to renewable energy investors?"*

Reliability/predictability impacts generation investment/entry decisions, LSE purchase decisions, and more generally, the market's faith (regulatory stability) necessary to support investments

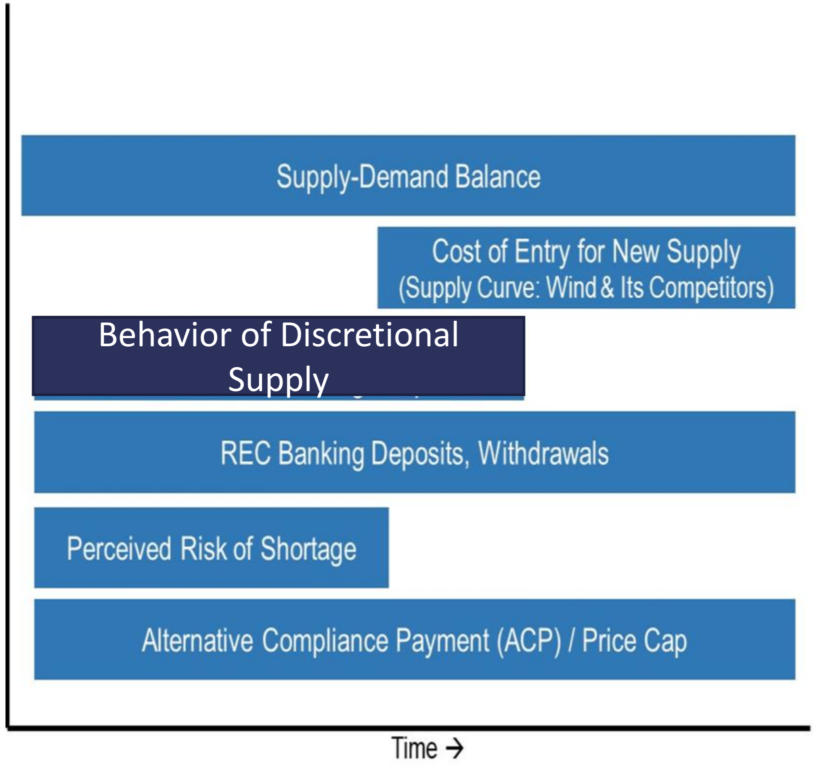
APS + ESS

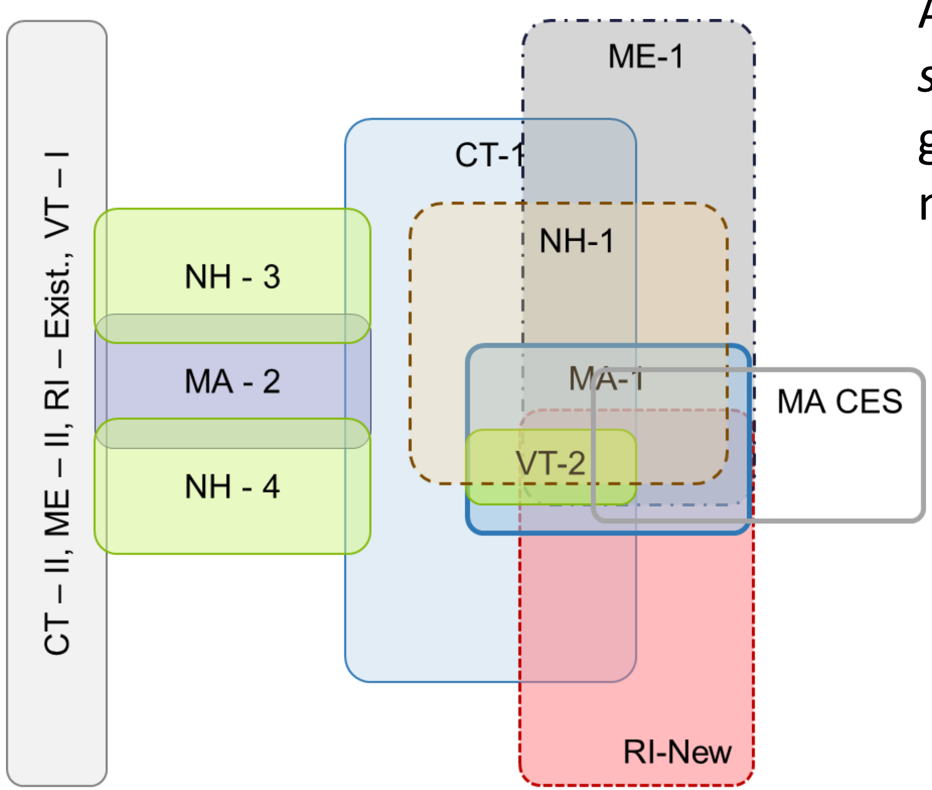
- Historically, as DOER has added technologies, market has ramped up generation
- How to maintain balance? (price tension)
  - Potential need for generation?
  - Target increase required?



From: MA DOER *Renewable Thermal Technologies in the Alternative Portfolio Standard,* Stakeholder Meeting Nov. 17, 2014 Boston, MA

Factors Influencing REC Price Outlook





APS + ESS

APS is an *isolated system*, resources don't generally trade in other markets

- ➔ no price-stabilizing *protection* from market backstops
- ➔ far more susceptible to disruption from eligibility changes than the RPS ecosystem

Portfolio Requirement Design Considerations: Compliance

Issues

- Units: AECs in MWh
- Unique for non-electric generation = unit conversion
- Tiers & multipliers for resources with materially different…
  - Costs
  - Resource potential
  - Supplemental revenue needs
- Tracking, Metering

ESS in APS

- If add unique/different technology… do they require carveout or tier to achieve objectives?
  - Or other options?
- Because ESS units not (necessarily) in MWh…
  - Not limited to 1:1,
  - Flexibility to use multipliers
  - (e.g., a TVR multiplier)
- If use different multipliers…
  - Basis for establishing the *relative* value of different supply sources?
- Ex: provide SMART participants with small multiplier to provide price signal incentivizing optimal performance
- Interval metering, if time-varying value?

APS + ESS

How to fairly incentivize the many types of Energy Storage Systems?

- Different types of ESS doing different things
- Easier: different duration
  - (see SMART program… more value for more hours of storage)
- Different services
  - regulation/spinning reserve (flywheel) vs. moving large amounts of energy over time (e.g., flow battery)
  - What are you trying to accomplish?
  - Basis to *value* such different services, in absolute value, relative to other APS resources, and relative to each other??
  - *Cost* (gap) basis?
  - Other?
- Technology standard vs. performance standard
  - Ex: if storage hydro can provide same service, cheaper, than a battery…???

Key Takeaway: flexibility = unpredictability

Can ESS in APS attract investment?

Policymaker view:

- What is MA trying to accomplish?
  - Fund new build?
  - Price signal to change operations?
  - Encourage installation, or operation, through supplemental revenue streams
- Does the design align with objectives?

Resource perspective:

- APS potentially very unstable/unpredictable → adding ESS could exacerbate
- Is the APS market & regulatory construct…
  - Predictable enough to finance new investment?
  - Encourage or reward… whatever the objectives are?

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Intersection of Policy Tools
How do they fit?

Regional Portfolio Standards (RPS)	Procurements	DG Tariffs	Goals/targets	Other
• MA: 1, 2, 2-WTE, APS, CES, Solar Carveout • CT: 1,2,3 • RI: new, existing • NH: 1,2,3,4 • ME 1,2 • VT: 1,2,3 • **Objectives: vary** • **Targets: general to specific** • **Focus: create(short-term) demand** • **Method: Market** • **Tools: certificates (SREC: floor price auction)**	• Section 83 C (OSW) • Section 83D (Large Hydro / Class I RPS supply) • Other states conduct analogous events • Objectives: enable financing of **new** • Focus: reliable revenue • Method: Competitive RFPs • Tools: offtake contracts	• Solar Massachusetts Targets (**SMART**) • RI ReGrowth • CT LREC/ZREC • VT SPEED • Objectives: enable financing of **new** • Focus: reliable revenue • Competition (RFP) or standard offer (smaller) • Tools: EDC tariffs	• MA Energy storage targets • Objectives: set broad course of policy, but limited direct effect • Focus: technology deployment	• Grants (e.g. MassCEC's ACES) • Industry Support • Grid modification • Rate design

Resources

- Regulations
  - December 15, 2017, DOER filed the final Alternative Energy Portfolio Standard (APS) regulation with the Secretary of the Commonwealth to include renewable thermal, fuel cells, and waste-to-energy thermal as eligible technologies
    - https://www.mass.gov/files/documents/2017/12/14/225%20CMR%2016%20APS%20Regulation%20121517%20FINAL.pdf
- PPT from Renewable Thermal Technologies in the Alternative Portfolio Standard
  - https://www.mass.gov/files/documents/2016/08/tw/re-thermal-aps-regs-stakeholder-meeting.pdf
- Stats
  - https://www.mass.gov/service-details/compliance-information-for-retail-electric-suppliers

APS Compliance: Supply and Demand

Table Six
Aggregated Data from the APS Compliance Filings, 2010-2015 (MWh)

	2015	2014	2013	2012	2011	2010
CY Retail Sales (=Retail Load Obligation)	**48,009,723**	48,129,294	49,252,929	48,992,430	49,386,169	50,026,093
Exempt Load[85]	**34,578**	79,801	973,011	1,584,015	3,799,666	8,233,703
Net Load	**47,975,145**	48,049,493	48,279,918	47,408,416	45,586,504	41,792,390
Minimum Standard[86]	***3.75%***	*3.5%*	*3.0%*	*2.5%*	*2.0%*	*1.5%*
Aggregated APS obligation	**1,799,094**	1,681,759	1,448,421	1,185,236	911,748	626,902
Total AECs from CY Generation	**894,602**	831,080	531,781	351,179	324,922	227,134
minus CY total surplus AECs	**(2,869)**	(261)	(7,347)	(1,239)	(7,636)	(520)
Net CY AECs for CY obligation	**891,733**	830,819	524,434	349,940	317,286	226,614
plus banked from pre-CY surpluses	**261**	7,347	1,239	7,635	515	8,818
Total AECs used for CY obligation	**891,994**	838,166	525,673	357,575	317,801	235,432
plus total ACP credits	**902,605**	835,505	921,626	827,661	593,947	391,470
Total for compliance obligation[87]	**1,794,599**	1,673,671	1,447,299	1,185,236	911,748	626,902
Surplus APS Attributes banked forward	**2,869**	261	7,347	1,239	7,636	515
ACP proceeds (rounded)	**$19,875,362**	$18,147,169	$19,750,452	$17,397,429	$12,116,514	$7,829,400

Source: MA RPS & APS Annual Compliance Report for 2015

MARKET PERSPECTIVE: APS PROJECTIONS + CARBON IMPLICATIONS IN ENERGY STORAGE

May 2018

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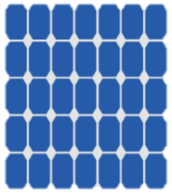
NEXT GRID MARKETS

ABOUT NEXT GRID MARKETS

- Energy Certificate Aggregator
- Client Base:
  - Hospitals, universities, manufacturers, and municipal and state entities (hold state-wide DCAMM contract).

- 30+ MA Cogen and other APS Customers
- ~90 MW



- 50+ MA Solar PV Customers
- 6.5 MW AC

- Services offered include:
  - Renewable attribute qualification and monetization
  - Development support and economic evaluation
  - Distributed generation operations support & performance reporting
  - DG optimization via software interface (via affiliate company, Icetec)

NEXT GRID MARKETS

ALTERNATIVE ENERGY PORTFOLIO STANDARD

- State program creates an obligation of Load Serving Entities (LSE) to acquire Alternate Energy Certificates (AECs) equal to a set percentage (Minimum Standard) of electric load served.
- For every MWh short of Minimum Standard – LSEs must pay Alternative Compliance Payment (ACP)
- 1 AEC = 1 MWh of generation from an eligible technology
  - Calculation of AEC varies by technology
- This strategy is to "green up" the ISO-NE grid and support creation of distributed generation
- Eligible Technologies:
  - Flywheel, CHP
  - Starting in 2017: Thermal technologies (ex. renewable thermal, energy from waste, and fuel cells)

NEXT GRID MARKETS

APS MARKET DRIVERS

1

Load Growth/Reduction

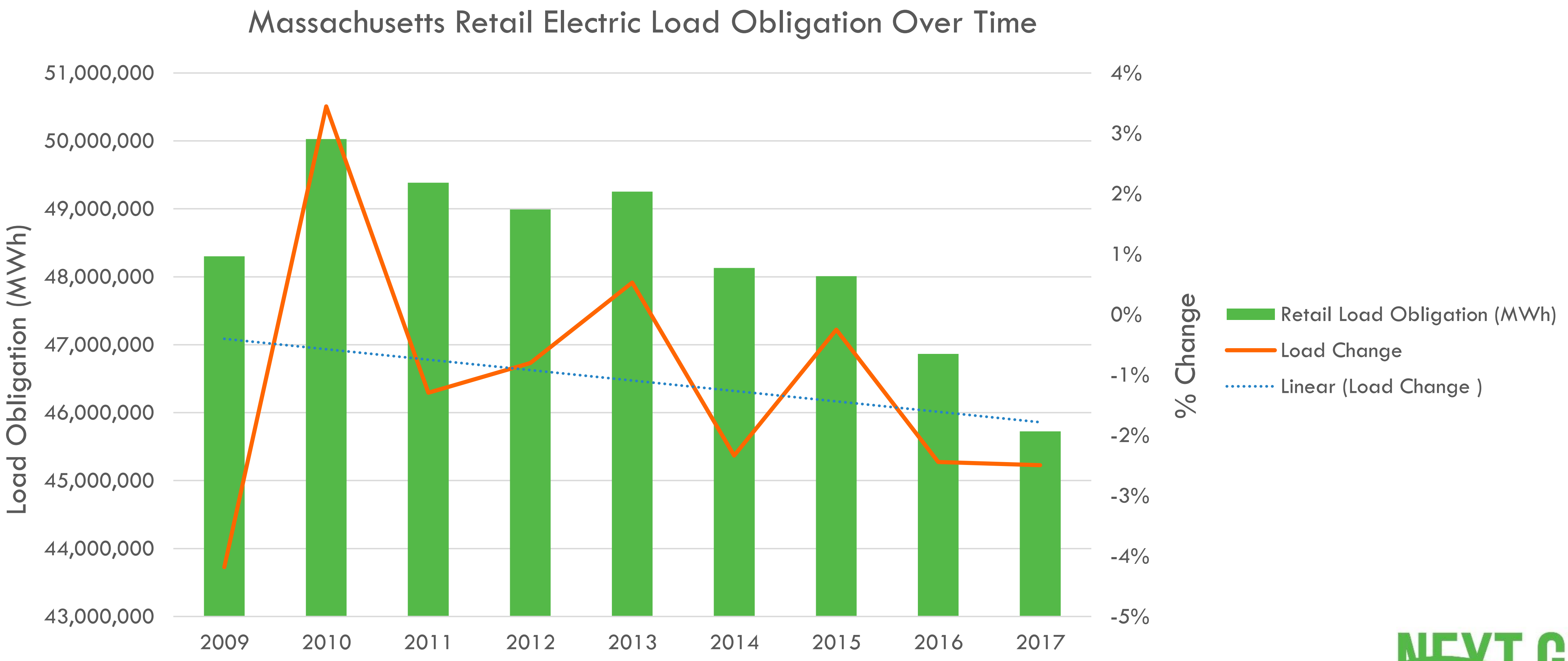
2

CHP Increased-Supply

3

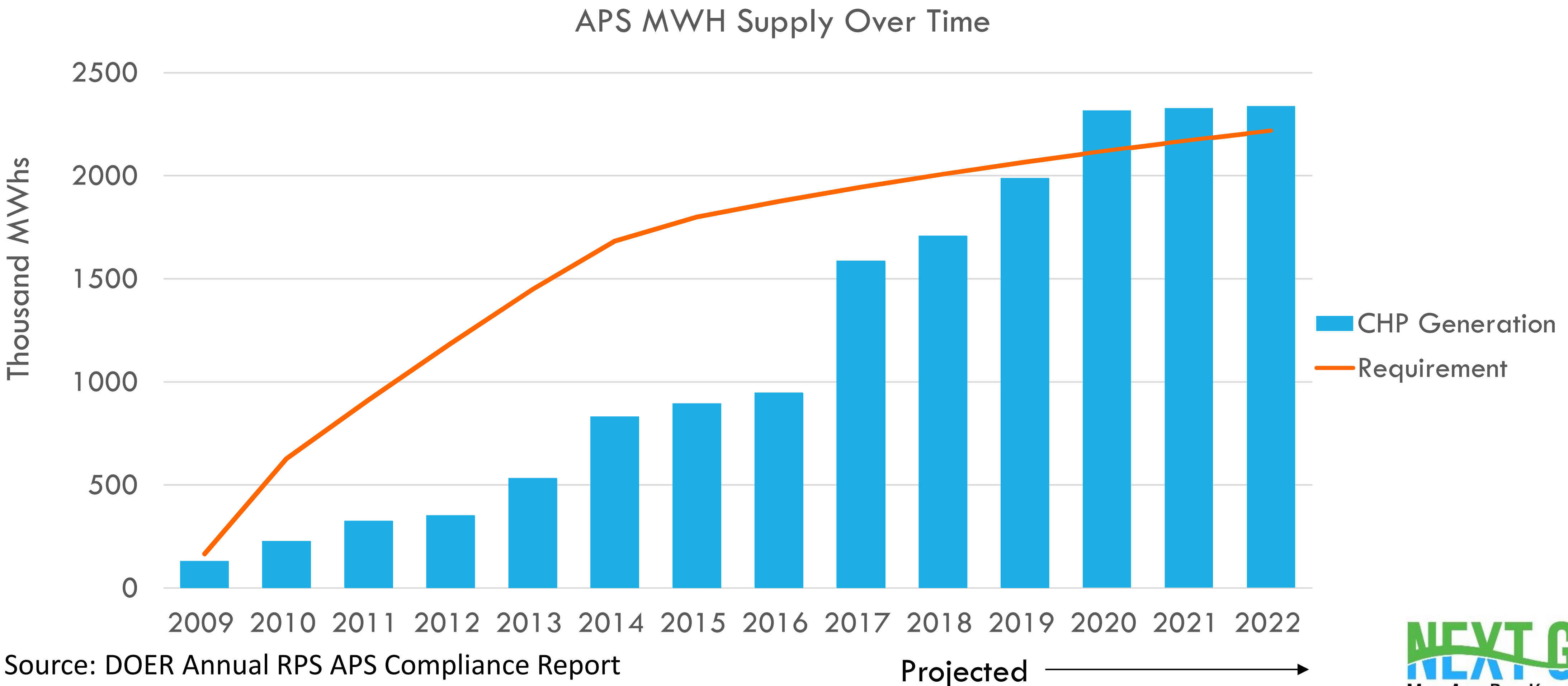
New Technologies-Increased Supply

MARKET DRIVER: LOAD GROWTH/REDUCTION



Source: DOER Compliance Total Load Obligation

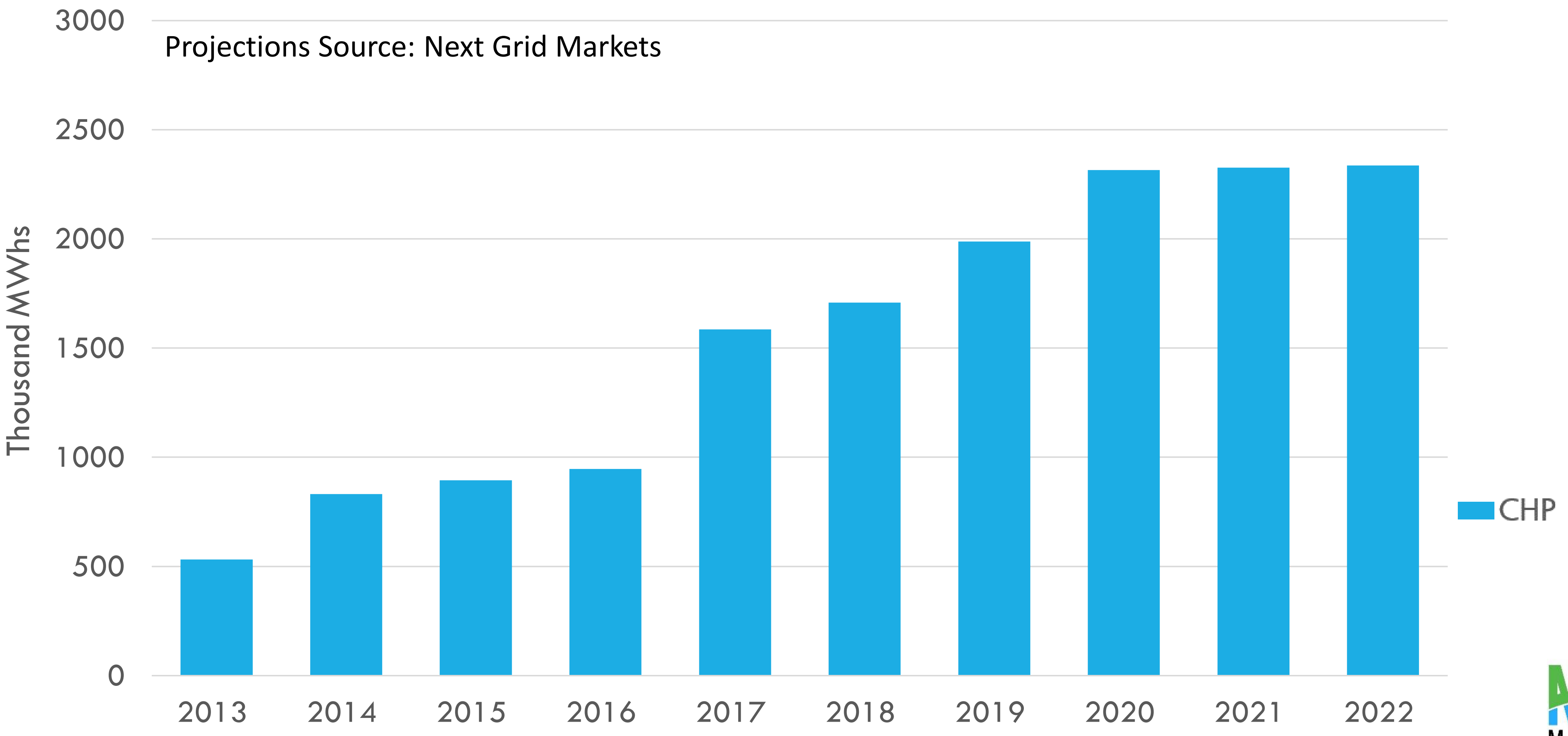
MARKET DRIVER: NEW CHP SUPPLY



Source: DOER Annual RPS APS Compliance Report and NEPOOL; Projections- Next Grid Markets

NEXT GRID MARKETS

MARKET DRIVER: NEW TECHNOLOGIES



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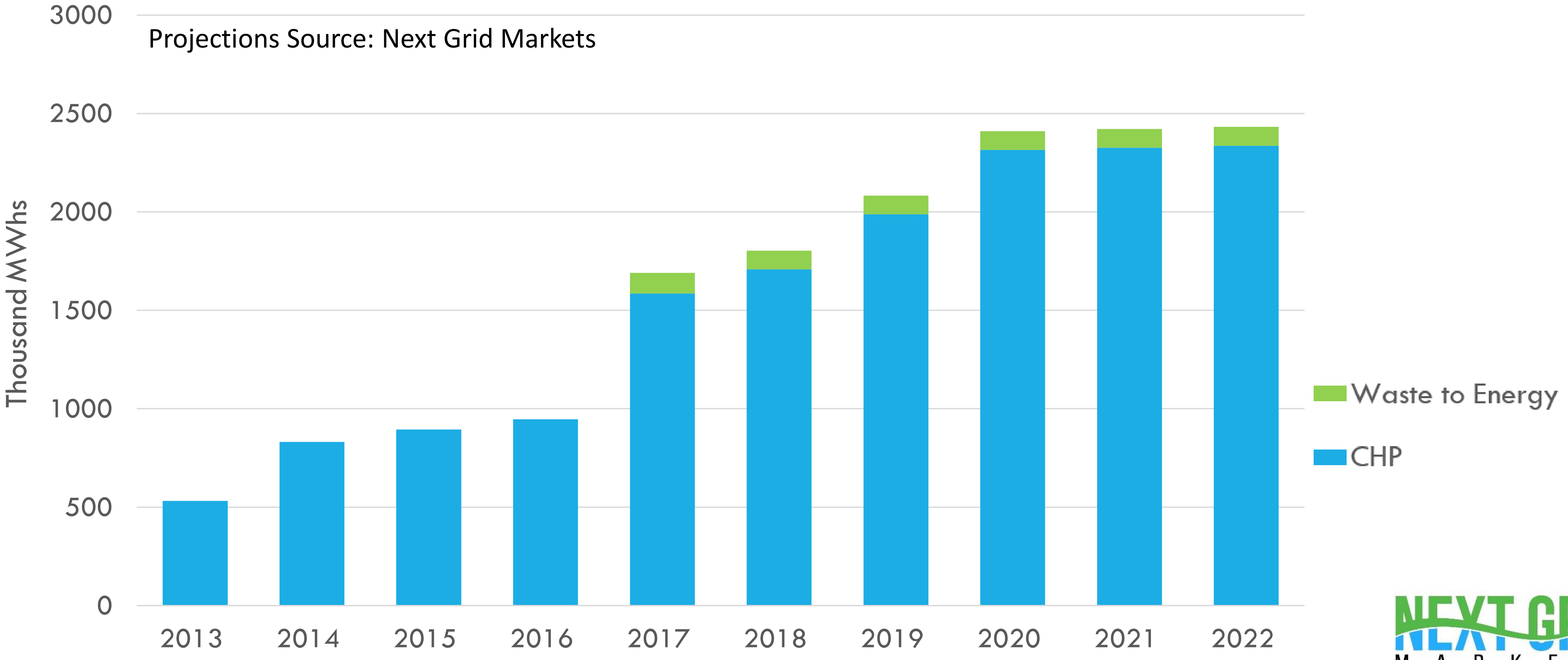

NEXT GRID MARKETS

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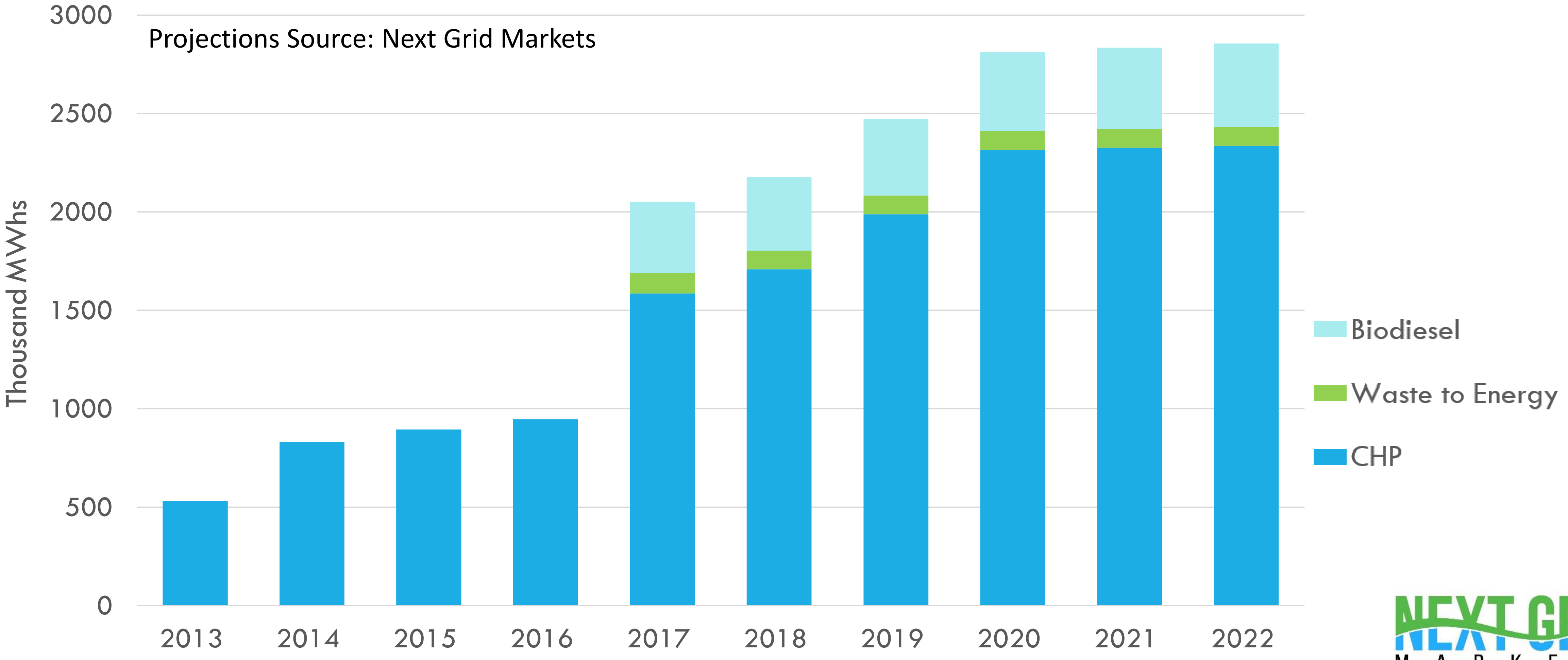

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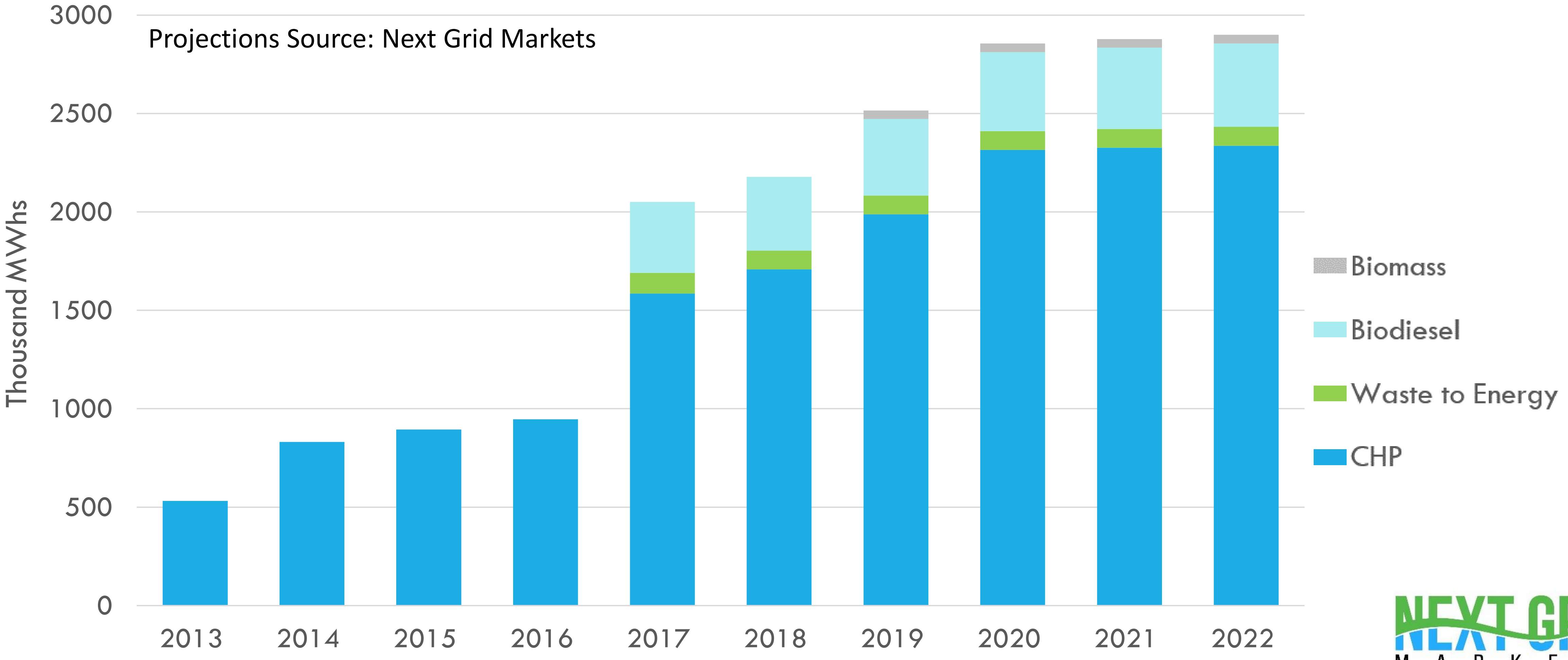

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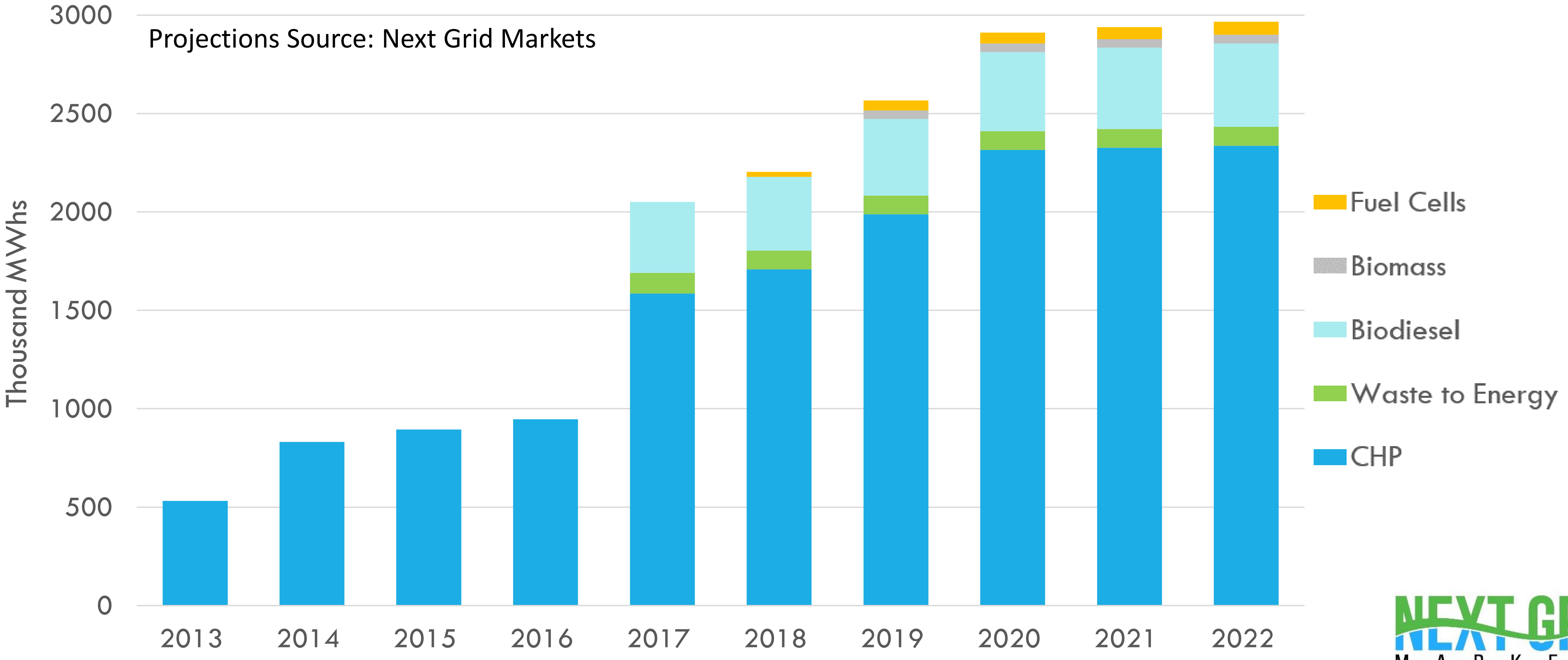

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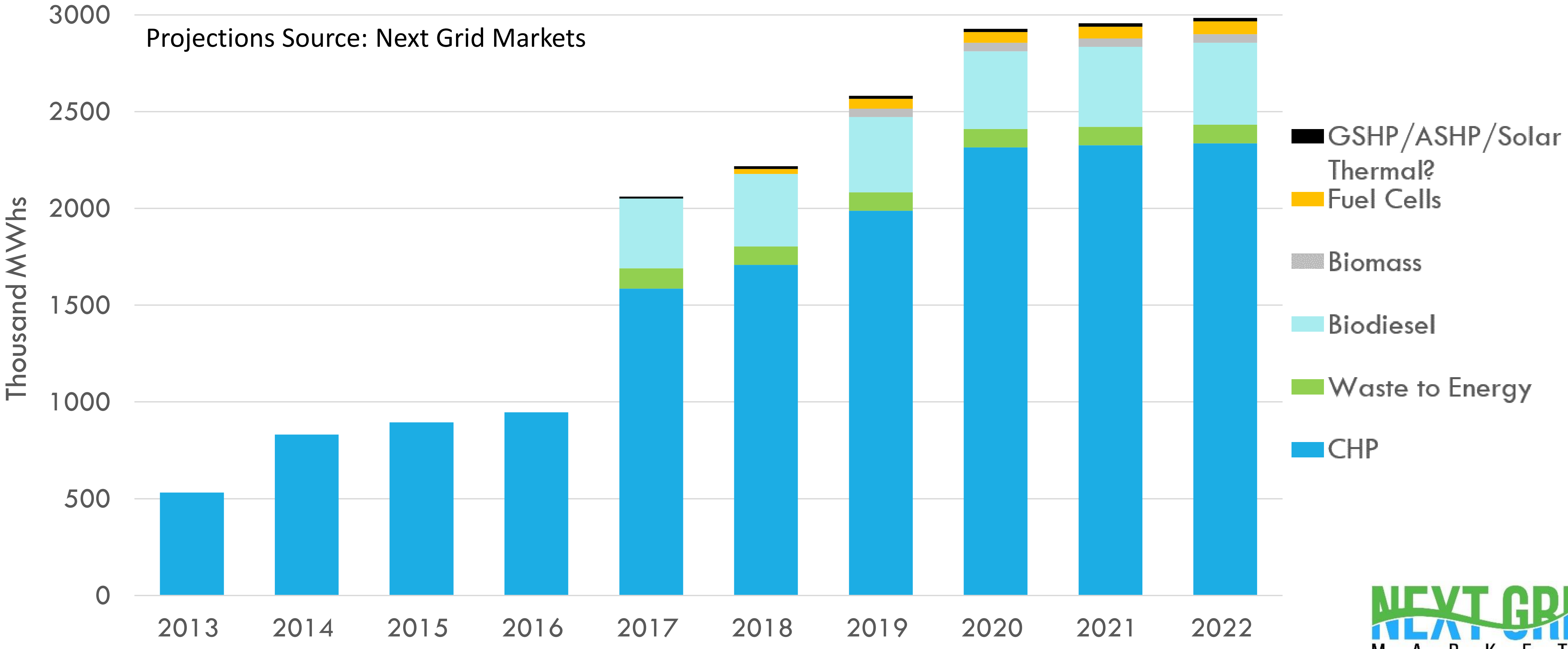

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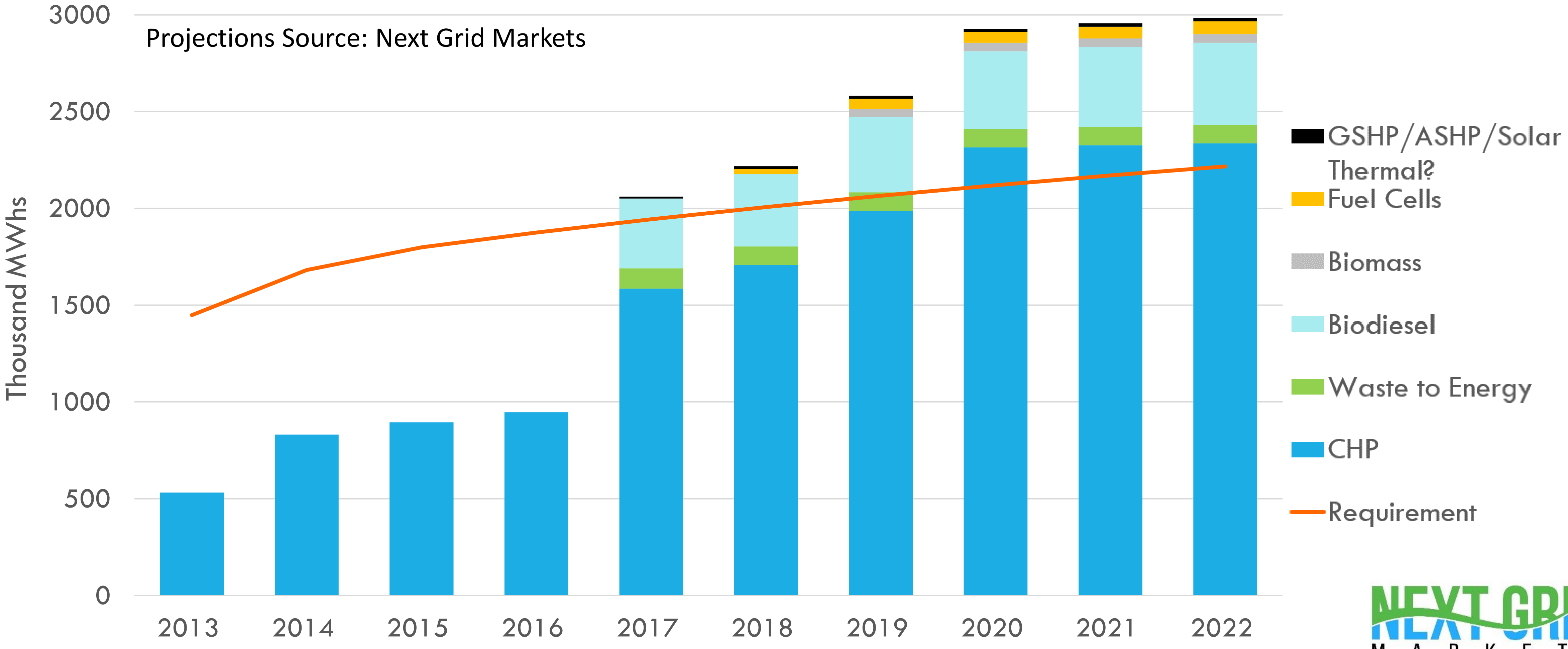


CARBON IMPLICATIONS IN ENERGY STORAGE

SHIFTING CO_2 LANDSCAPE

Sources of Electricity Production

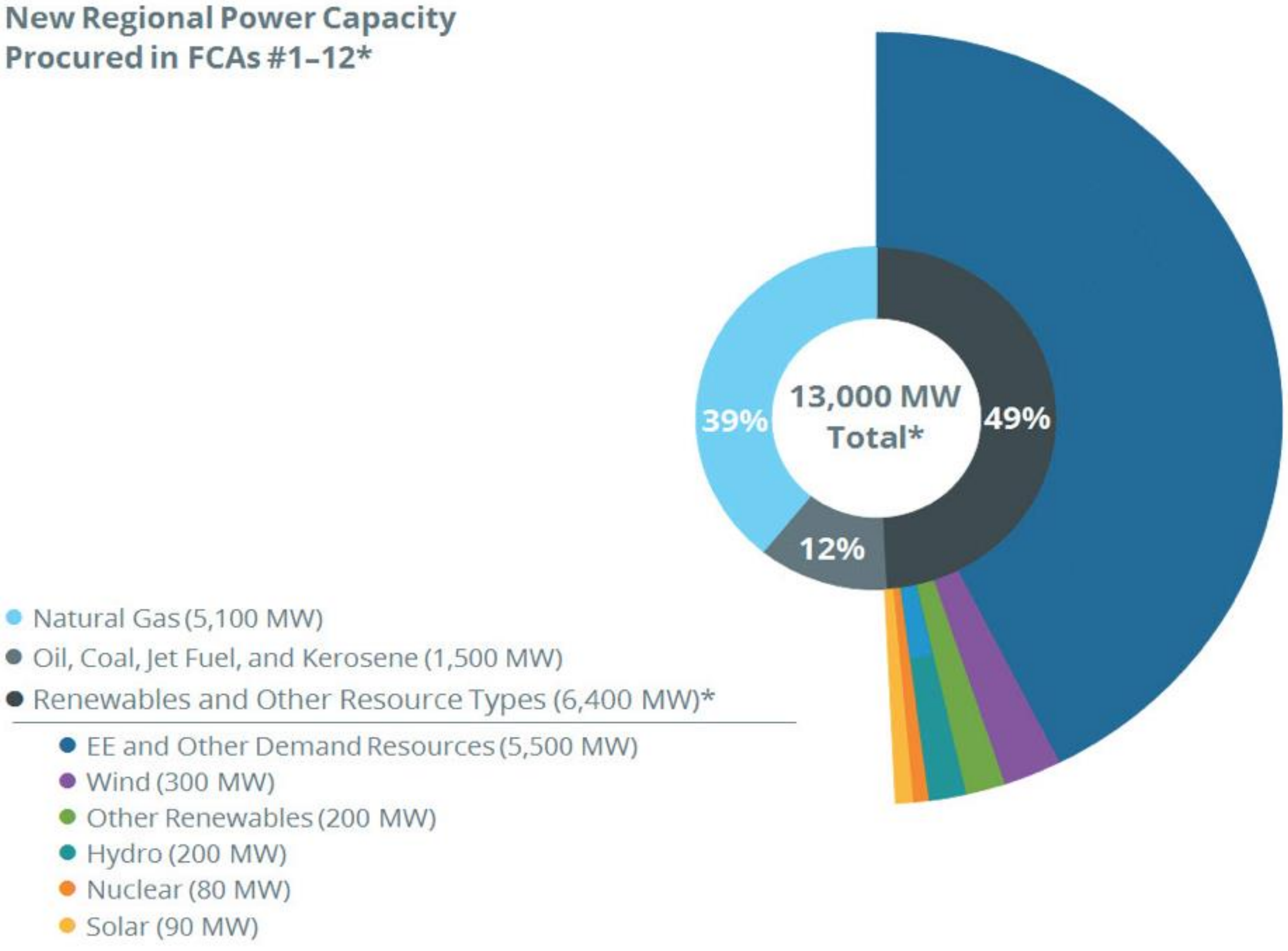
Major shift from oil and coal to natural gas over the past 17 years

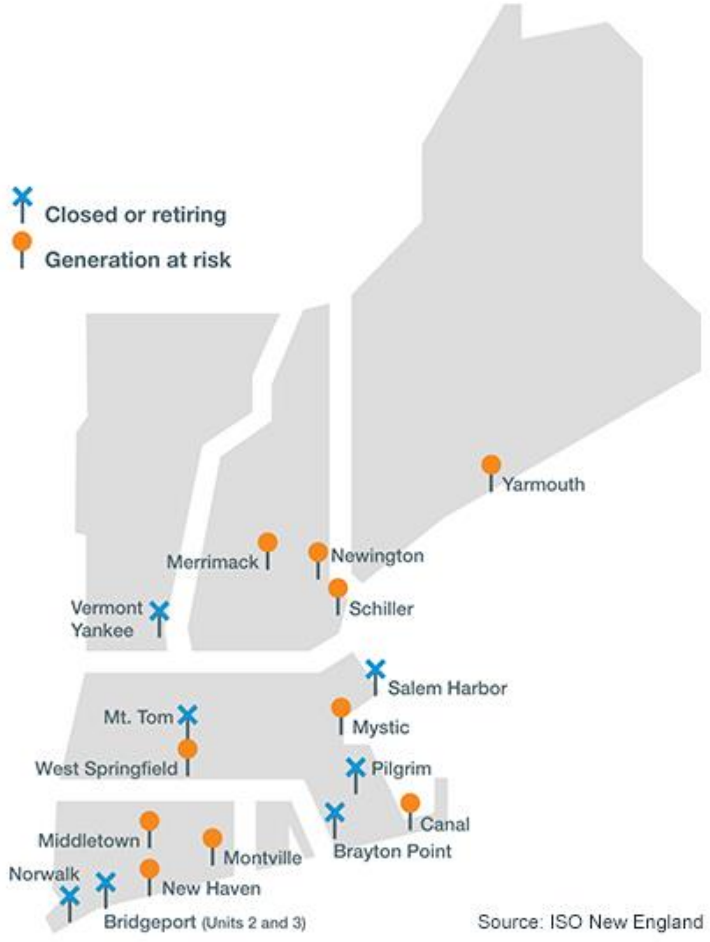
View the real-time fuel mix at **iso-ne.com**	Natural Gas	Nuclear	Renewables	Hydro	Coal	Oil
2000	**15%**	31%	8%	7%	**18%**	**22%**
2017	**48%**	31%	11%	8%	**2%**	**1%**

Source: ISO NE

NEXT GRID MARKETS

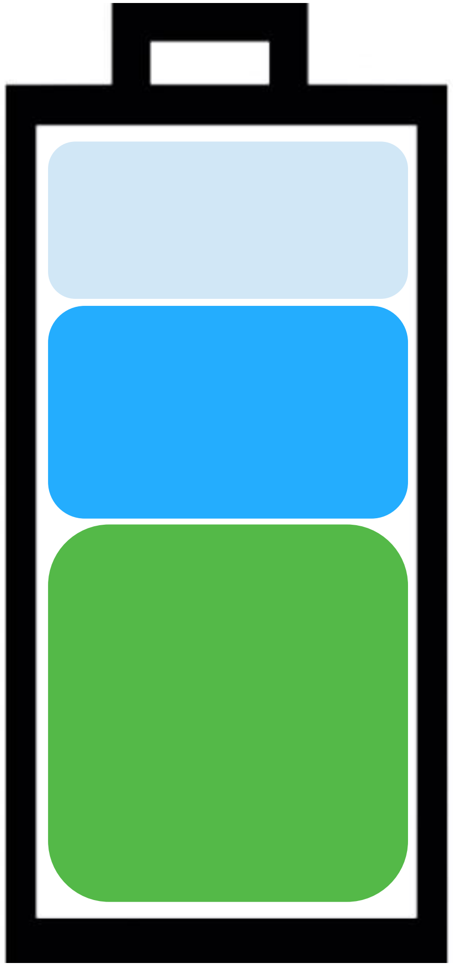
LOOKING AHEAD





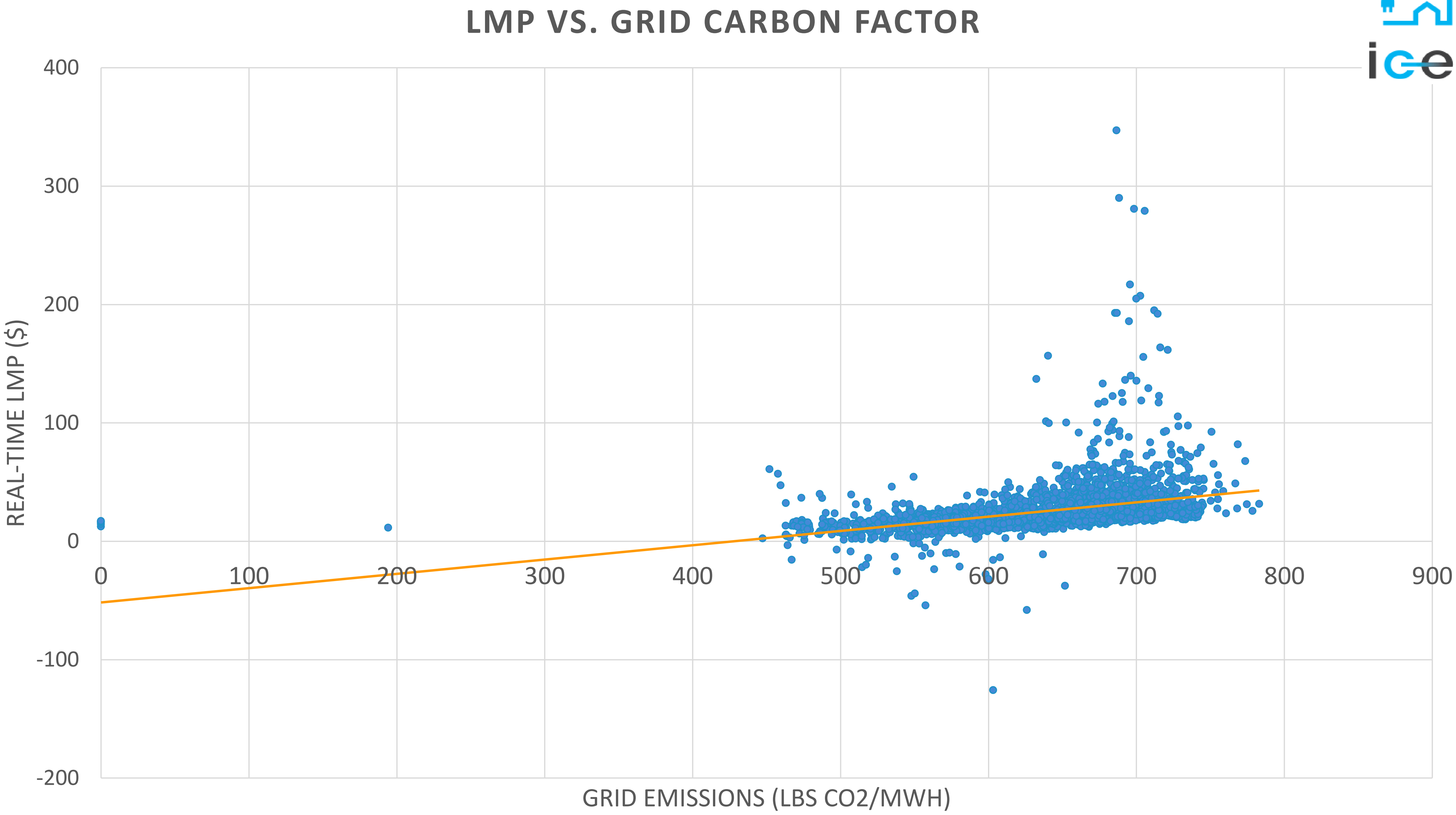
Source: ISO NE

ENERGY STORAGE AS A CO_2 GAME CHANGER



- Storage operators can manage the CO_2 footprint of their energy discharge by:
  - Managing and tracking charging from co-collected DERS (Storage, CHP) or:
  - Biasing Grid charging to take place during intervals of min CO_2 levels
- Market and policy incentives could ensure that discharge that occurs during peaks is associated with significant CO_2 delta

NEXT GRID MARKETS

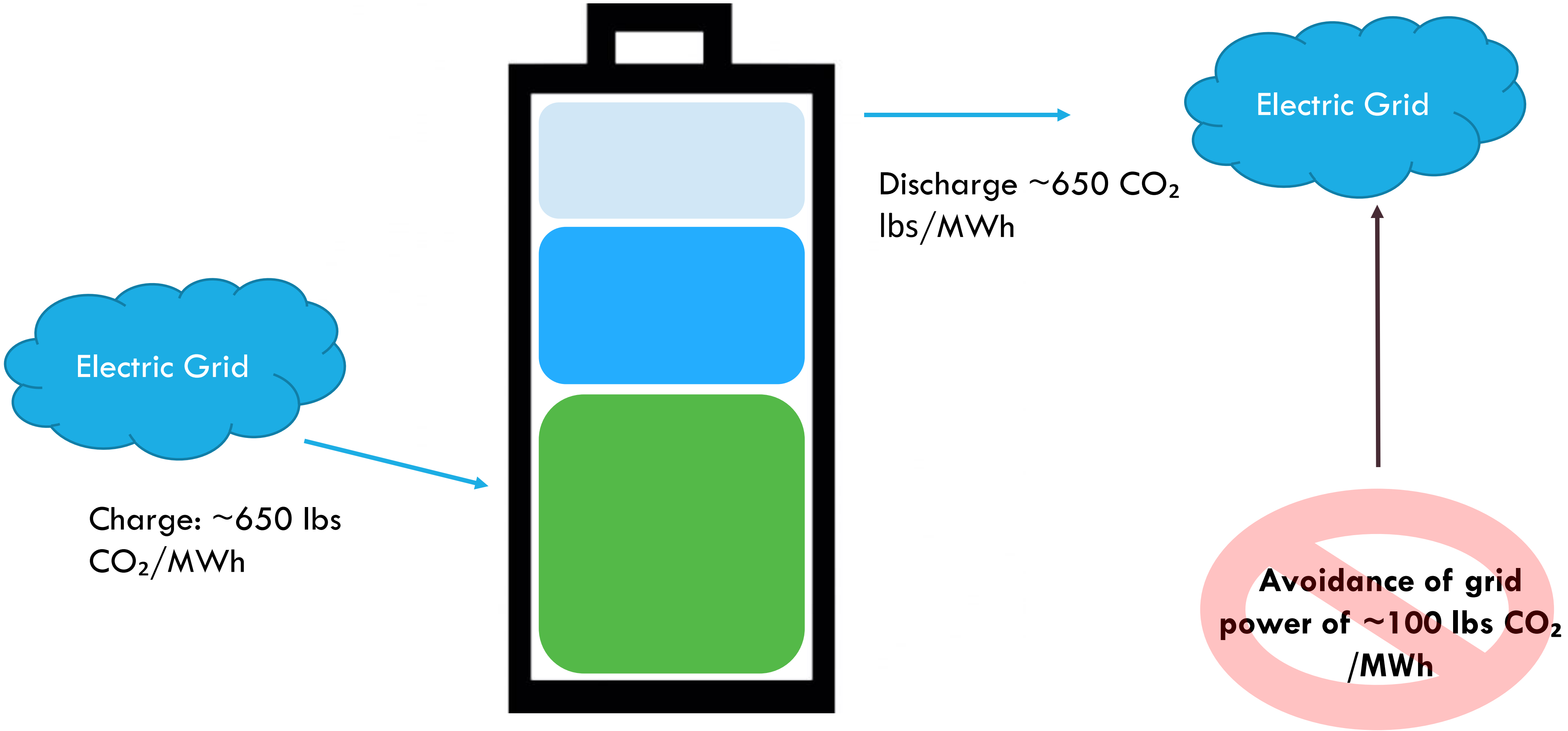


Source: ISO NE

Peak Day Grid CO_2 Factor and Price

Source: ISO NE, Icetec

ENERGY STORAGE AS A CO_2 GAME CHANGER



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QUESTIONS?

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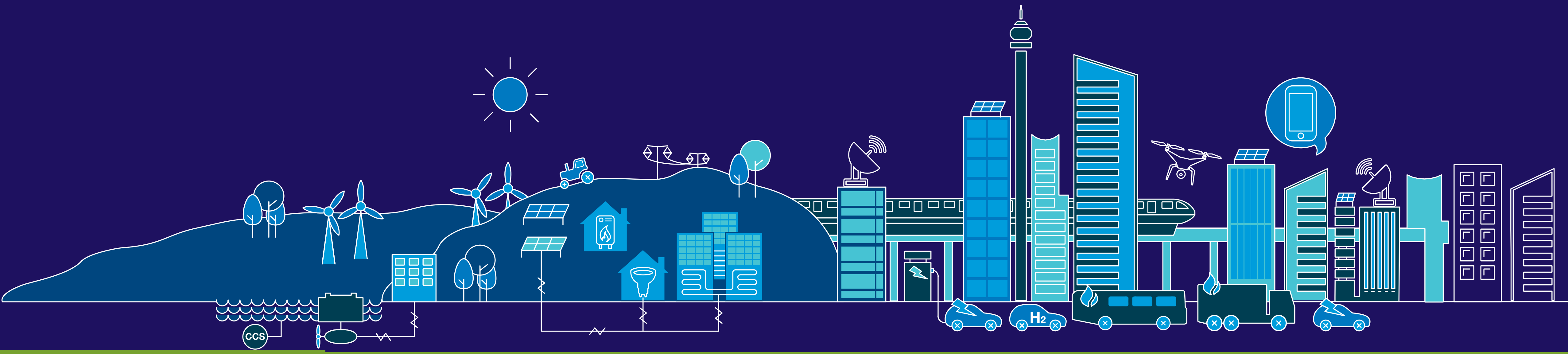
nationalgrid

Energy Storage and the Alternative Portfolio Standard in Massachusetts

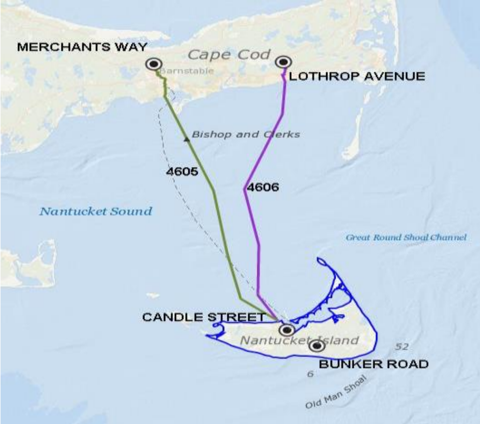
A Distribution Utility Perspective



MA Storage Projects & Pipeline

nationalgrid

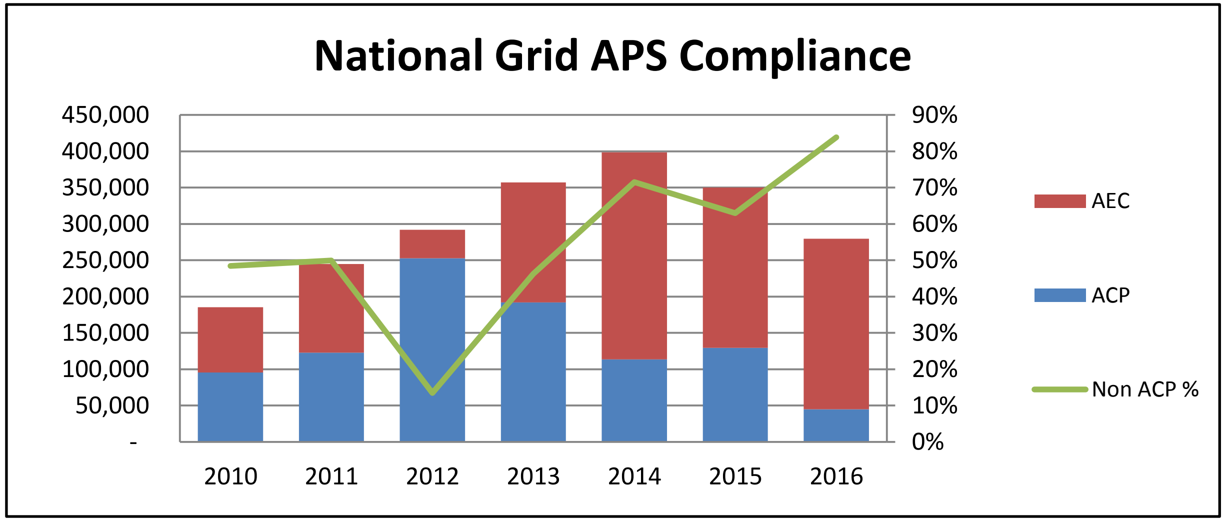
- Under Solar Phase II and III programs, National Grid is installing 7.1 MWh/ 4.5 MW of lithium-ion battery systems near company-owned solar PV
- Under earlier funding from DOE, National Grid has installed two Vionix vanadium redox flow batteries, at 3 MWh / 500 kW each, both near renewable DG installations
- On Nantucket, New England Power Co., National Grid's transmission subsidiary, is deploying a 48 MWh/ 6 MW Tesla battery system for reliability, along with potential demand reduction and market participation benefits
- Multiple third-party owned systems selected in the ACES and Peak Demand Reduction programs now in process, for additional 23 MWh
- Ability to rate base ESS while <u>reducing</u> net revenue requirement with ISO-NE market participation has been in question, but may be allowed due to Order 841and ISO-NE compliance changes



4605 (40.2 MVA) & 4606 (38.7 MVA) Supply Line Routes

APS Compliance Dynamics

- The Alternative Energy Portfolio Standard has in past been difficult to meet with purchased certificates, leading to certificate prices at the Alternative Compliance Payment level and substantial ACP payments
- New supply plus recent changes to the APS qualifications for thermal energy sources has expanded availability of AECs, and reduced prices into the mid-teens
- National Grid's served load (Basic Service) has declined significantly in recent years, reducing overall compliance needs
- Looking ahead, additional supply from storage devices would help meet increased APS demand levels and moderate cost even more
  - Compliance demand increases by 0.25% of load each year to 5% in 2020
  - DOER to review rate of increase and cost/benefit in 2019



Market Impacts from Energy Storage with On-Peak Dispatch

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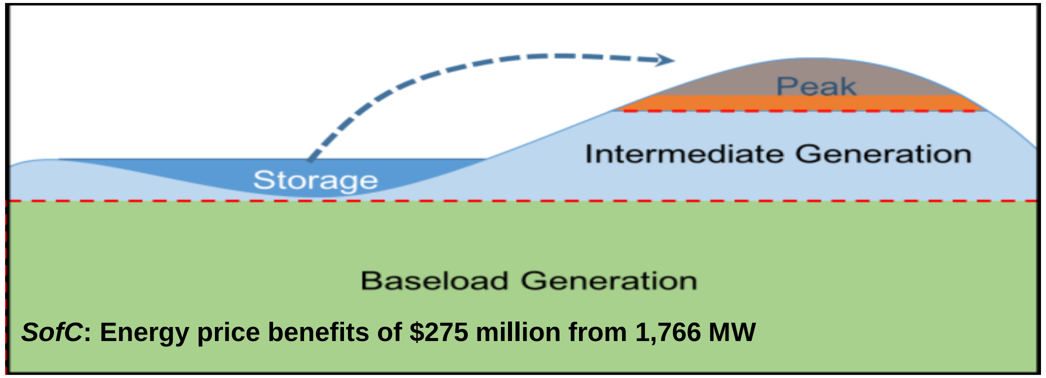
- *State of Charge* report highlighted how Energy Storage Systems (ESS) could provide energy market benefits:
  - Energy price suppression
  - Increased load factor/utilization
- Energy storage would not likely reduce GHG emissions in the region under RGGI without mitigation measures
  - Storage dispatch on-peak will likely lower RGGI prices without offsetting overall emissions
  - Could be offset by RGGI retirements either at auction or by ESS owners
- Storage will likely have modest FCM price impact due to CASPR and its “substitution auction” process and already declining clearing price in the recent FCM auctions



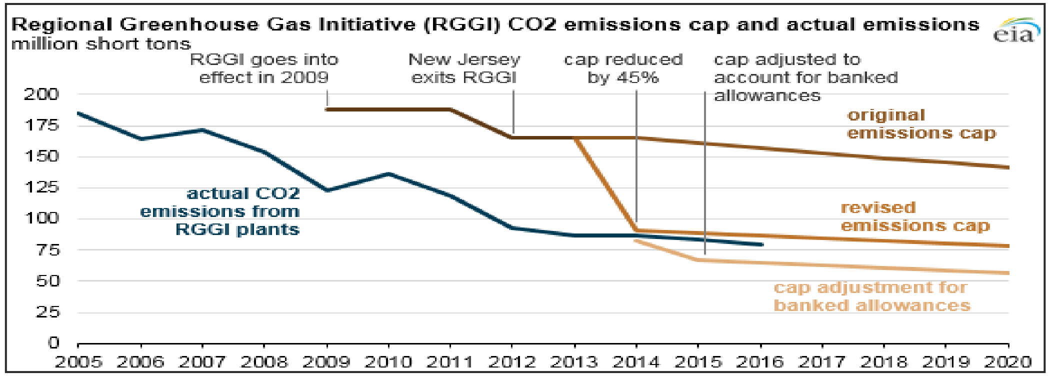
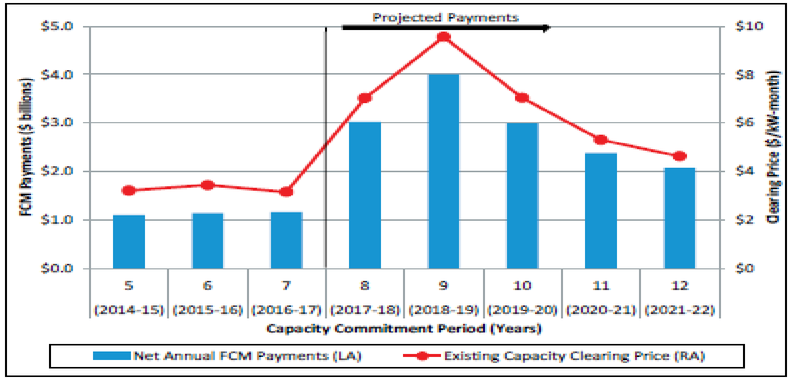


Figure 6-1: FCM Payments by Commitment Period

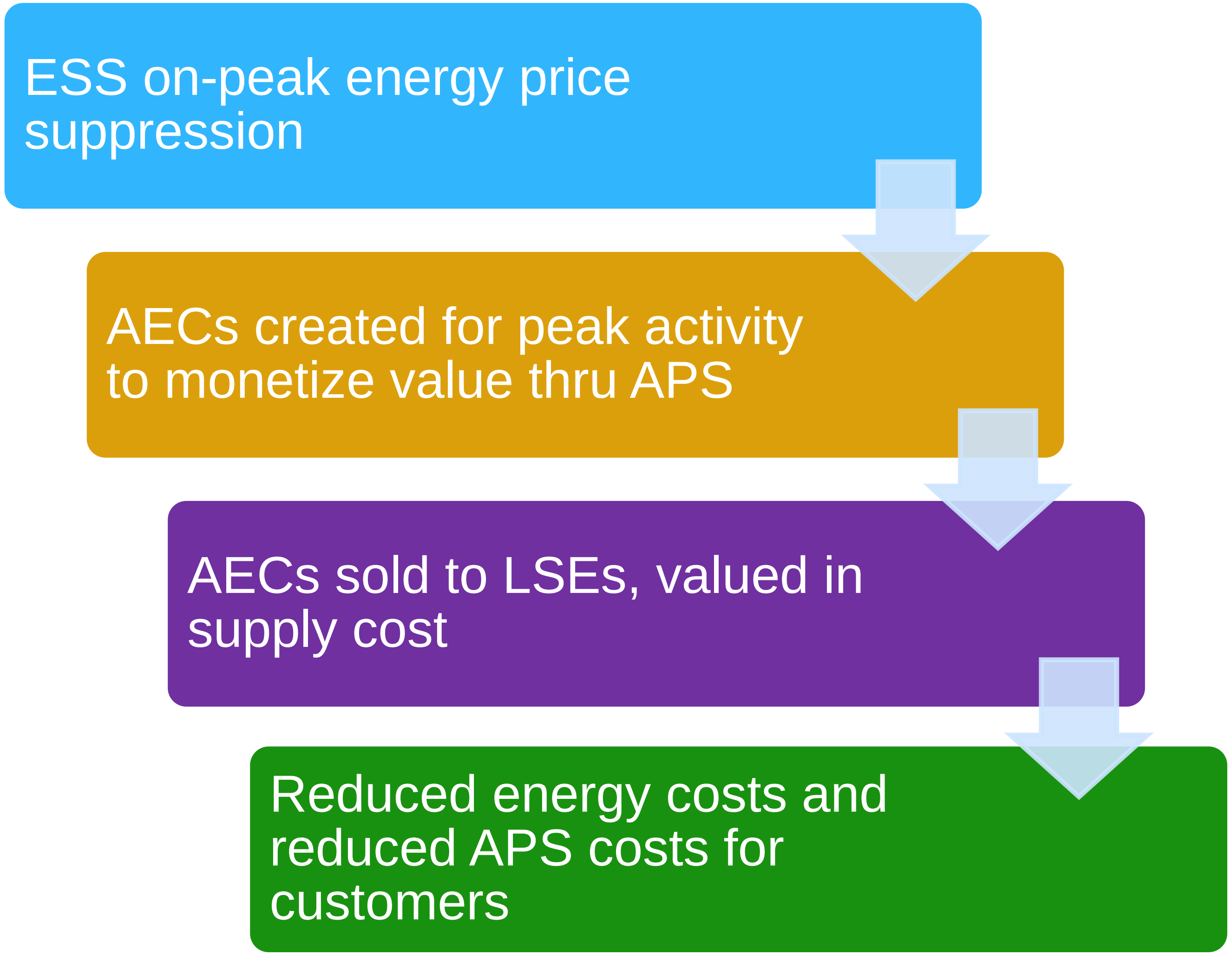


ISO-NE 2017 Annual Markets Report, May 2018

APS Could Monetize Energy Benefits for ESS Owners and Lower Customer Costs

nationalgrid

- Performance requirements for inclusion in the MA APS could focus ESS to perform at periods of peak energy demand and cost
- AECs could be created to monetize a portion of the price suppression benefits for ESS participants
- More AECs are then sold to load serving entities across the state, lowering APS cost, which is then reflected in commodity supply costs
- Potential 4X win:
  - Lower energy costs
  - Lower APS costs
  - Funding for ESS deployment
  - Offset to revenue requirement for EDC-owned ESS
- DOER should conduct study to assess these impacts and consider dynamics of market entry on effects diminishing over time



Time Varying Design Considerations for the APS

May 30, 2018

Lon Huber

About Strategen

Certified WBENC Women's Business Enterprise
WOMEN OWNED™

Strategies for clean energy

Strategen provides insight to global corporations, utilities and public sector leaders, helping them to develop impactful and sustainable clean energy strategies

CLIENTS

We work with governments, utilities, research institutions, technology providers, project developers, and large energy users seeking to evaluate and implement next generation grid and clean energy technologies.

MARKETS

Our exclusive focus on clean energy and advanced grid technologies means we bring our clients a sophisticated understanding of industry trends, market drivers and regulatory policy.

SERVICES

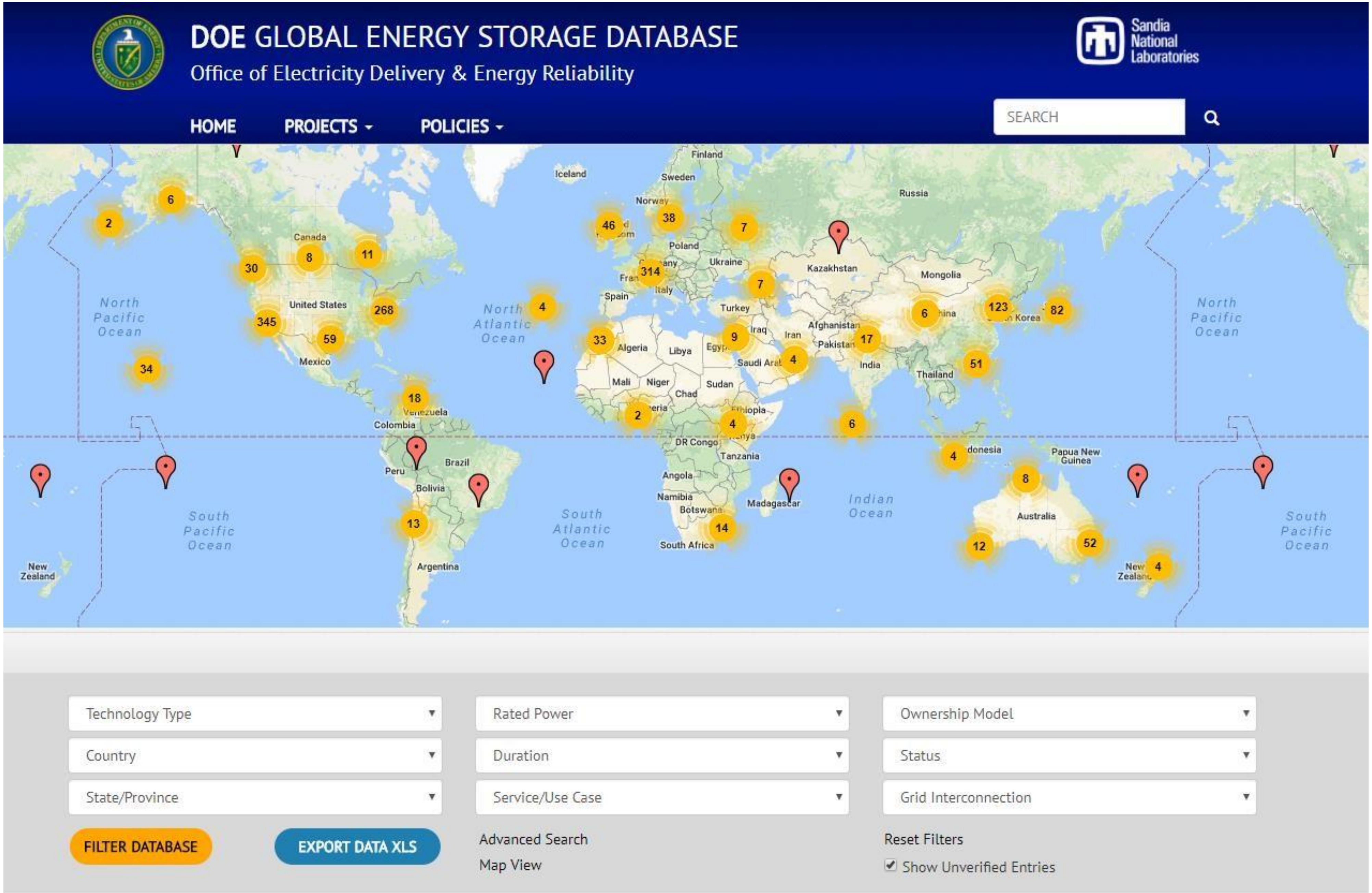
Our clients come to us for our expertise in developing business models, commercial strategies, financing tools and regulatory support that empower them to create sustainable value and long-term solutions.

TEAM

Our team is comprised of well-respected thought leaders and industry experts who have played instrumental roles in shaping the power sector's transformation in the 21st century.

We are experts in power sector strategy. Our track record and networks are unmatched in the business.

- Cost/benefit analysis
- Market entry
- Public proceeding support
- Regulatory strategy
- Product development
- Grid resource planning and procurement
- Stakeholder engagement and education
- Mergers and acquisitions


DOE GLOBAL ENERGY STORAGE DATABASE
Office of Electricity Delivery & Energy Reliability
Sandia National Laboratories
HOME
PROJECTS
POLICIES
SEARCH
North Pacific Ocean
North Atlantic Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Canada
United States
Mexico
Colombia
Venezuela
Peru
Brazil
Bolivia
Argentina
Iceland
Finland
Sweden
Norway
Poland
Ukraine
Spain
Italy
Turkey
Russia
Kazakhstan
Mongolia
Afghanistan
Pakistan
Iran
Iraq
India
Thailand
Algeria
Libya
Mali
Niger
Chad
Sudan
DR Congo
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Angola
Namibia
Botswana
South Africa
Madagascar
Australia
Papua New Guinea
New Zealand
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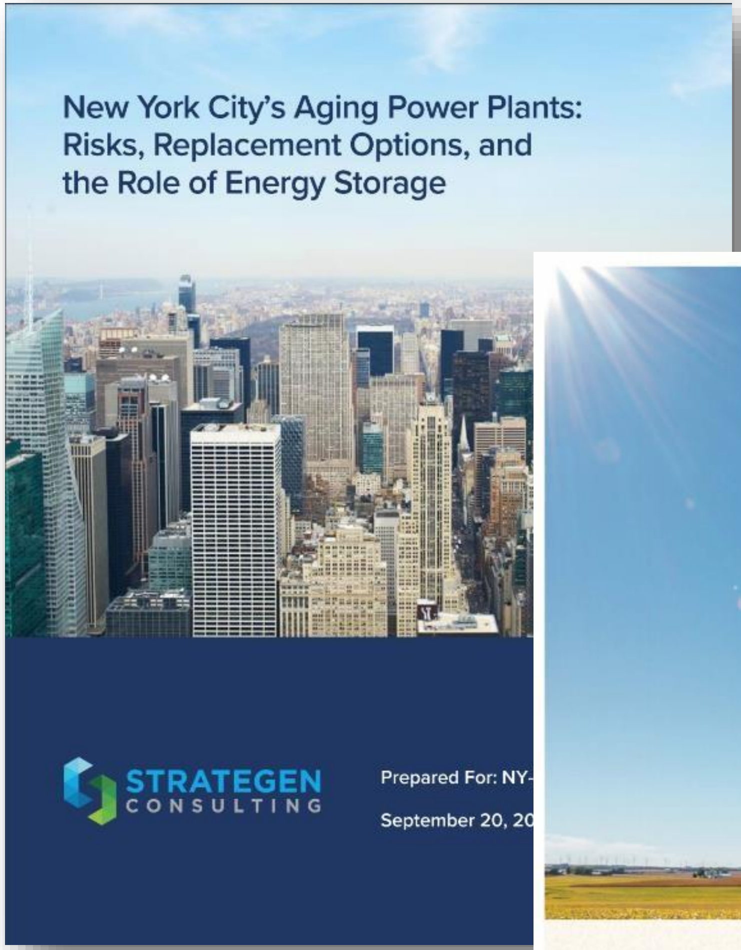
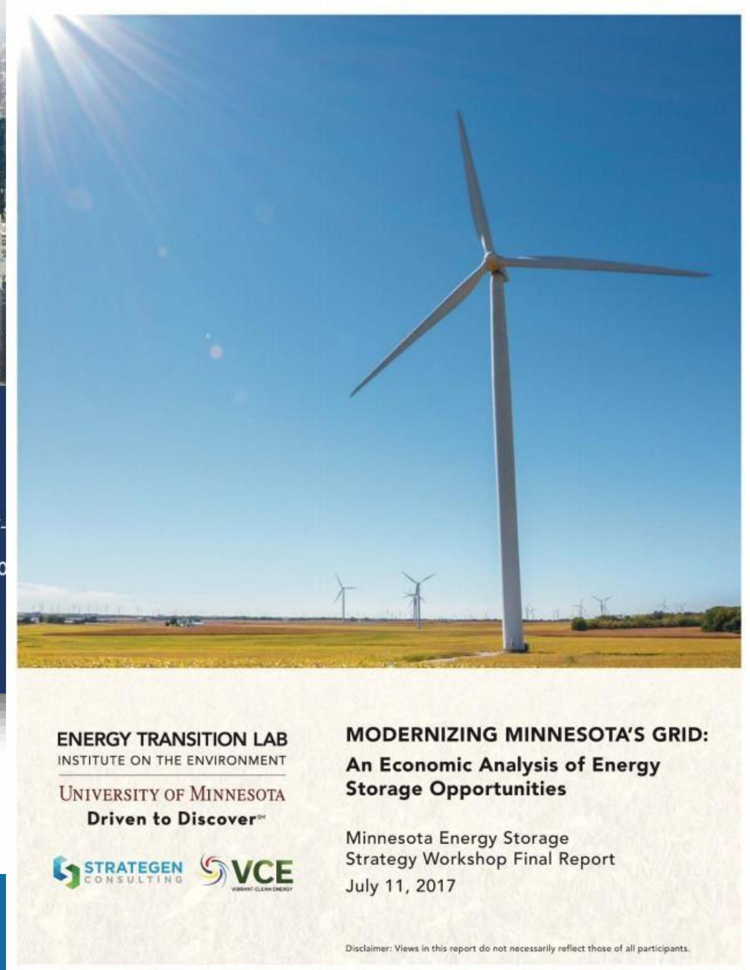
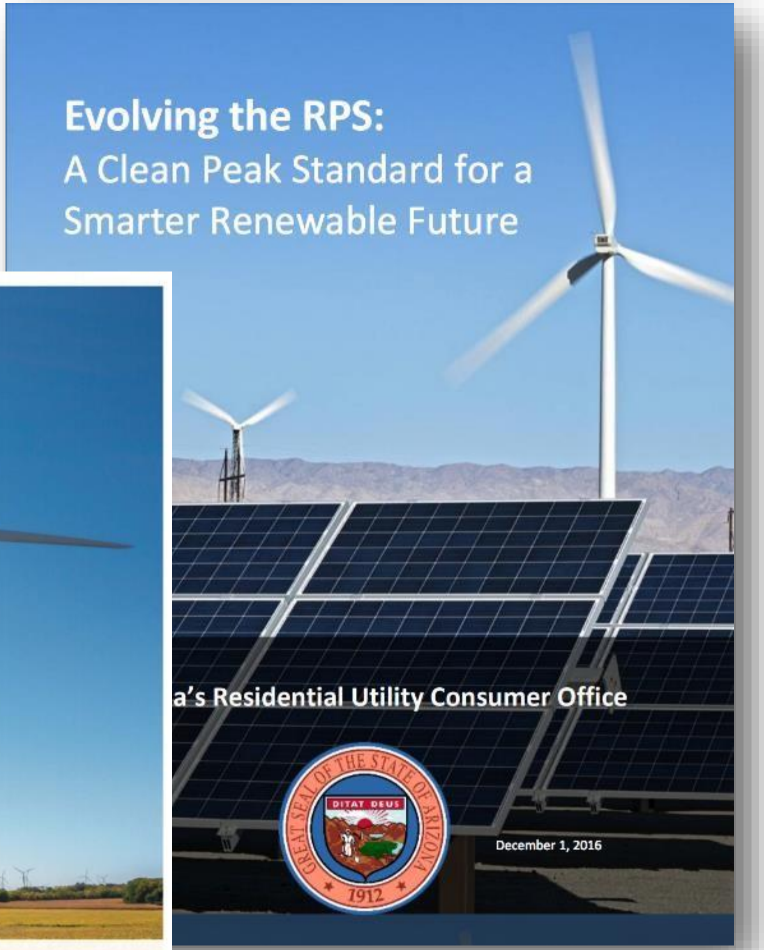
Technology Type
Country
State/Province
Rated Power
Duration
Service/Use Case
Ownership Model
Status
Grid Interconnection
FILTER DATABASE
EXPORT DATA XLS
Advanced Search
Map View
Reset Filters
Show Unverified Entries

Storage analytics and cost/benefit







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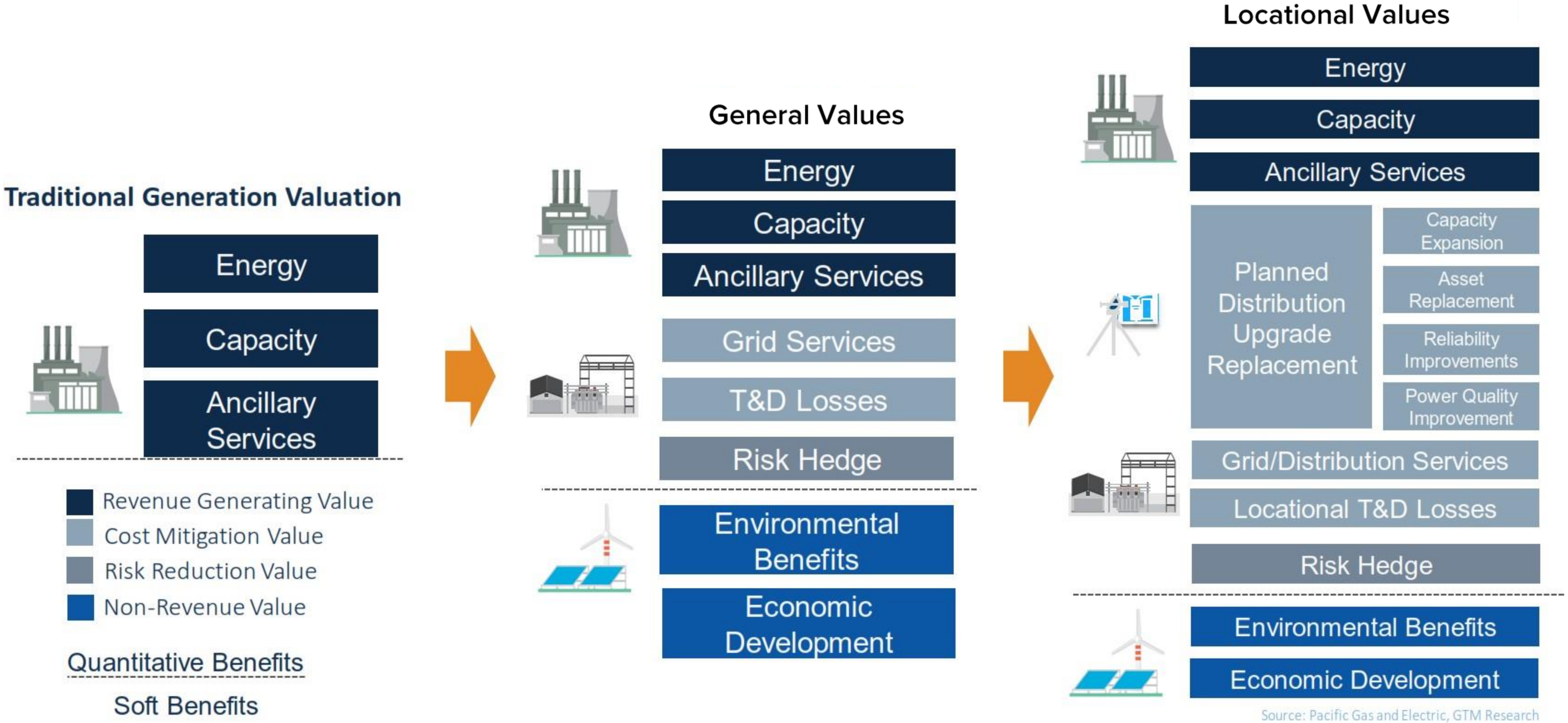
Market segment

- Distribution or transmission connected resources
- Market participant

Possible services and benefits



Source: Pacific Gas and Electric, GTM Research

Flexible Capacity Multiplier for Non-emitting Resources

- **Flexible Capacity Credit (FleCC)** - FleCC payment is designed to compensate for non-market benefits provided by fast acting dispatchable resources and provide revenue visibility for developers.
  - Additional revenue stream independent of wholesale markets
  - Revenue accounts for public benefits provided that are not reflected in existing market based mechanisms (grid and non-grid benefits)
  - Competitive procurement
    - Price setting: Yearly competitive bid procurement for transmission connected procurement annually, step downs for distribution connected market segments
    - Payment terms would be predetermined for a set contract term of 15 years

Key enabling feature: new fixed revenue stream based on administrative calculation of non-market benefits

Eligibility

- Technology must be dispatchable and non-emitting with a fast ramp rate (e.g. must reach full continuous capacity rating within 5 minutes)
- Distribution connected non-emitting resources
  - BTM – Must be used for demand charge mitigation or enrolled in a load reduction program
- Front of meter non-emitting resources
  - Must be participating as a capacity resource in NE-ISO
- Renewable plus FleCC resources are also eligible for FleCCs (and RECs).
  - If charged from RE the FleCC resource would have a clean capacity adder

Potential Methodology to Calculate Starting FLECC Value

A methodology is needed to determine starting FLECC prices.

Proposed Methodology:

Total FLECC Price ($/kW-mo) =

- *+ Avoided Local Criteria Pollutant Emissions*
- *+ Avoided Generator Startup Costs*
- *+ Avoided Incremental Transmission Costs*
- *+ Avoided Flexible Capacity Costs*
- *+ Avoided Natural Gas Pipeline Constraints*
- *+ Avoided GHG Emissions*
- *+ Avoided RE Curtailment*
- *+ Avoided Hosting Capacity Costs (if applicable and in distribution system)*
- *+ Policy Goals (Market learning, soft cost reduction, environmental justice, capacity diversity, optionality (improved property values, industry building, etc.)*

FLECC payment is designed to compensate for non-market benefits provided by storage and provide revenue visibility for storage.

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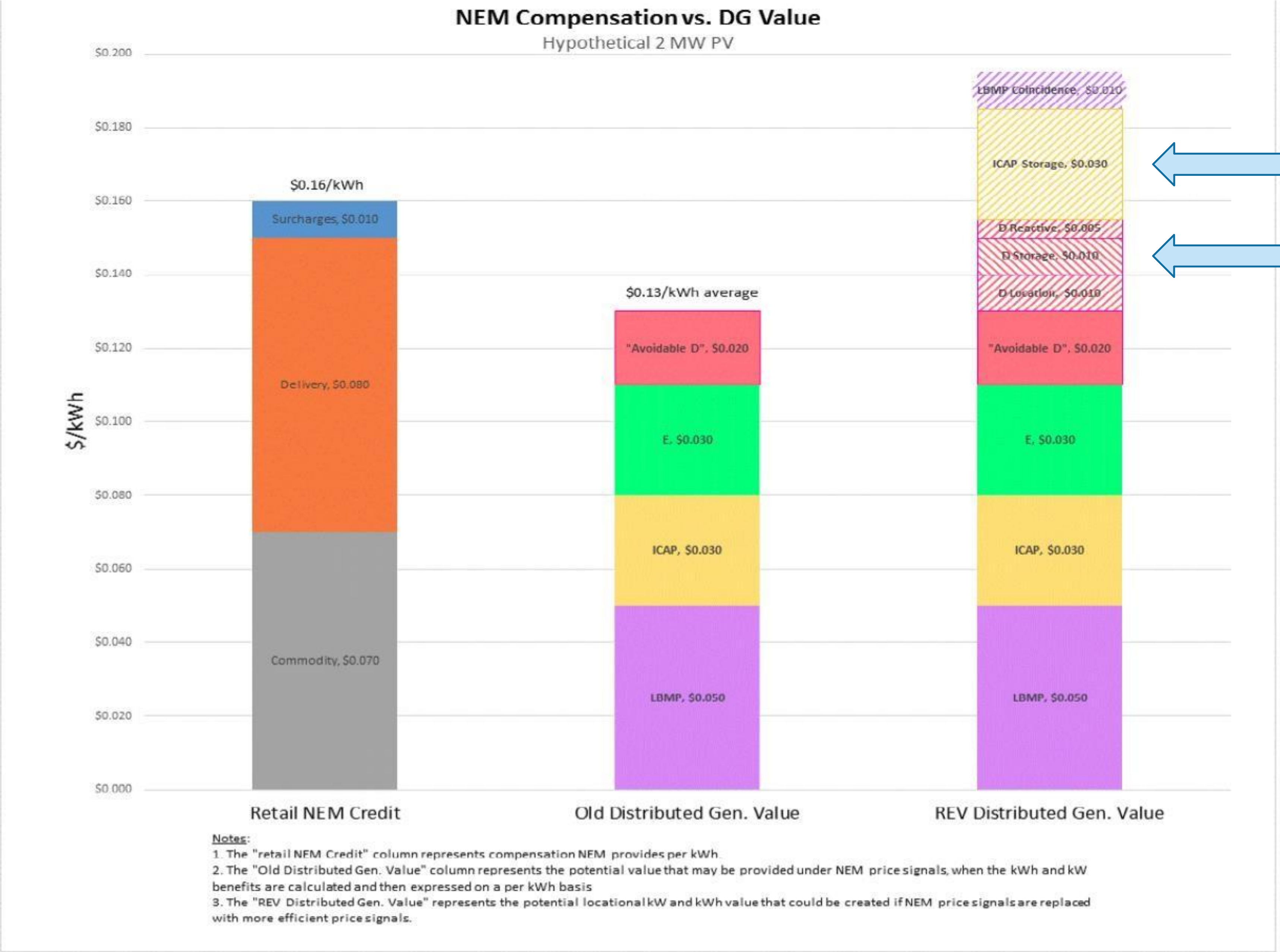
Load Modifier/Value Stack Approach

Market segment

- Distribution connected resources
- Non-market participant

New York: VDER Stack

Environmental Value	• Value of environmental attributes of the generation. • Based on higher of the latest CES Tier 1 Renewable Energy Certificates (RECs) in New York Market or the Societal Cost of Carbon.
Delivery Value ("D")	• Value of avoided delivery system costs due to demand reduction • Basic "Demand Reduction Value" linked to $/kW-year determined from utility Marginal Cost of Service (MCOS) studies • Can be enhanced with "Locational System Relief Value" in specific high-value locations
Capacity Value ("ICAP")	• Value of avoided capacity costs • Dispatchable (e.g. storage) and intermittent (e.g. PV) technologies treated differently Dispatchable Technologies: MW production (ex-post during peak hour) X ICAP Spot Price (month) • Intermittent Technologies: Alternative 1 - (default) spread across all hours of year • Alternative 2 - Higher rate but paid only on injection during 60 summer hours 2-7pm June- • Aug
Energy Value ("LBMP")	• Reflects the avoided cost of energy purchases (and avoided line losses). • Based on actual Day Ahead NYISO LBMP Energy Prices (varies by hour and location).



Storage provides added value to basic PV system

Source: Staff Report and Recommendations in the Value of Distributed Energy Resources Proceeding, October 27, 2016, 15-E-0751

Load Modifier (VDER) Approach for New England ISO

Environmental Value	▪ Value of environmental attributes of the generation ▪ "Shaped value" of RECs to meet RPS requirements
Transmission Value	▪ Value of avoided transmission system costs due to demand reduction ▪ ISO-NE transmission regional network system (RNS) charges and LNS ▪ 12 CP
Distribution Value	▪ Discussed later
Capacity Value	▪ Value of avoided capacity costs ▪ ISO-NE net regional clearing price * DER's prior year coincident peak ▪ Demand reduction induced price effects (DRIPE)
Energy Value	▪ Reflects the avoided cost of energy purchases (and avoided line losses) ▪ ISO-NE real-time Nodal LMP Energy Prices (5 min intervals) ▪ Demand reduction induced price effects (DRIPE)
Ancillary Service Value	▪ Reflects the avoided cost of ancillary service purchases ▪ ISO-NE ancillary market charge * DER's prior year output

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Distribution Valuation Strategies

- Through rate cases distribution companies know their average marginal system cost
- Locational granular values aren't typically available
- Traditional solutions (eg. Transformers, lines) have a known cost and capabilities. The following details are well established:
  - Timing
    - Load forecast and work backward with known lead times
  - Location
    - Controllable, install equipment in area required
  - Amount/Capacity
    - Size and rating of equipment known
  - Availability
    - Generally understood but system planning does utilize redundancy for failures

Various methods to value grid have been considered in the past

Marginal Costing Method	Description	Comments
Total Investment Method - TIM	Discounted capital budget cash flow divided by additional peak demand.	Longer time horizon appears less expensive. Cannot compare areas with different timing.
Discounted Total Investment Method – DTIM	Discounted capital budget cash flow divided by discounted additional peak demand.	Equivalent to constant $/kW payment needed to match cash flow. Does not capture avoided cost of a kW saved.
Present Worth – PW	Deferment value from shifting optimal capital plan in time due to change in peak demand from base case.	Captures avoided cost of a kW saved.
Regression Method (NERA) – RM	Slope of linear regression based on historical and forward-looking cost vs. demand.	Historical costs skew results. Does not capture avoided cost of a kW saved.
Replacement Cost New – RCN	Average cost based on cost to replace. Marginal cost based on "engineering elasticity" derived from simulation.	Does not reflect actual costs.

Similar to New York DRV process → TIM, DTIM

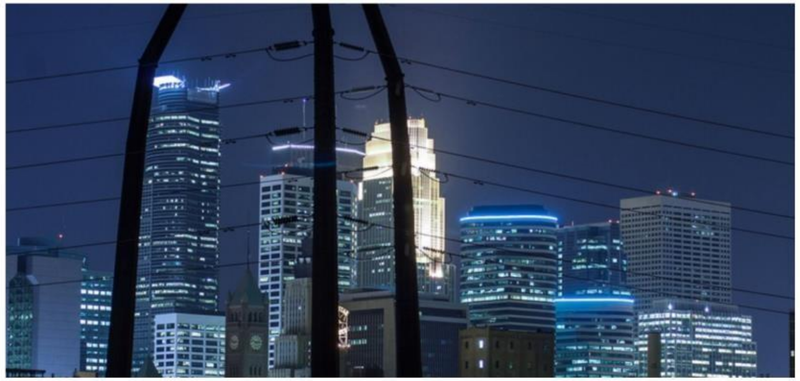
Central Hudson & LNBA → PW

General value vs. locational value

Figure source: E3 California LNBA Update

Cost Duration Method

Hour (Rank)	Load	Allocated Cost, % of Rev Req (Lauriol Method)	Cumulative
1	2591	4.11%	4.11%
2	2527	1.65%	5.76%
3	2515	1.42%	7.19%
4	2515	1.41%	8.60%
...	...	...	...
8757	483.4	0.002%	99.994%
8758	482.9	0.002%	99.996%
8759	480.2	0.002%	99.998%
8760	479.8	0.002%	100%



DEEP DIVE

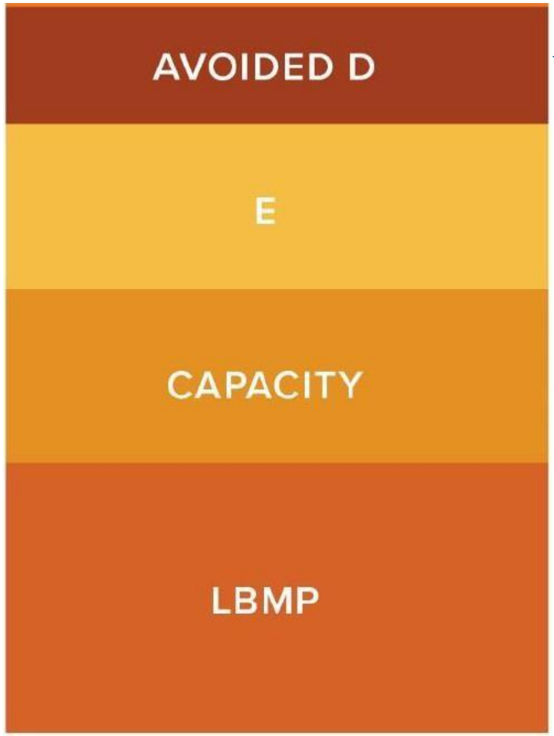
Has Xcel Minnesota designed the ideal residential time-of-use rate?

The pilot program, to determine if price signals can get customers to shift energy usage away from peak times, has garnered wide acclaim.

Distribution Valuation Strategies - NY

*Central Hudson has specific LSRV values from their study rather than a blanket MCOS x 150% multiplier.

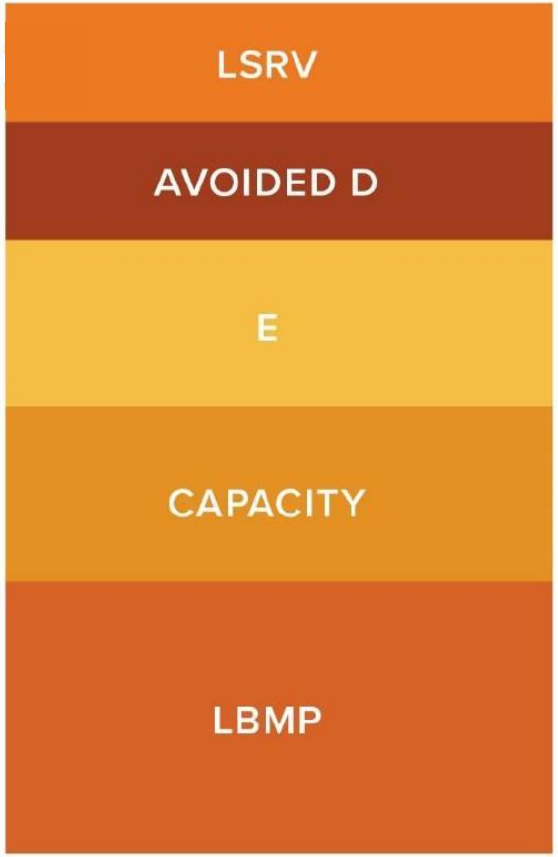
(MCOS x 150%) – DRV*



x 100%

Utility	DRV rate ($/kW-year)
NYSEG	$29.67
National Grid	$61.44
Con Edison - Westchester	$199.40
Con Edison - New York City	$199.40
Orange & Rockland	$64.29
RGE	$31.92
Central Hudson	$14.55

Central Hudson's MCOS=DRV. The remaining area's DRV are adjusted down from their MSOC to compensate for the higher LSRV areas with a value of 150% MCOS, so the system wide MCOS remains the same.



Source: NYSERDA VDER Stack Calculator

Distribution Valuation Strategies - NY

Table 1. Initial LSRV Areas with MW Available for LSRV Compensation

Type	Name	Borough or County	MW Available for LSRV (As of May 1, 2017)	CSRP Zone
Sub-transmission	Plymouth	Brooklyn	14.3 MW	2 PM to 6 PM: Borough Hall network
Sub-transmission	Water St.	Brooklyn	30.1 MW	7 PM to 11 PM: Williamsburg and Prospect Park networks
Sub-transmission	Glendale, Newtown	Queens	8.1 MW	11 AM to 3 PM: Borden network 4 PM to 8 PM: Sunnyside network 7 PM to 11 PM: Maspeth network
Area Station	E. 179th St.	Bronx	7.9 MW	7 PM to 11 PM: Fordham network
Area Station	Parkchester No. 2	Bronx	2.8 MW	4 PM to 8 PM: Northeast Bronx network
Area Station	Parkchester No. 1	Bronx	0.7 MW	7 PM to 11 PM: Southeast Bronx network
Area Station	W. 42nd St. No. 1	Manhattan	6.5 MW	11 AM to 3 PM: Pennsylvania network
Area Station	W. 65th St. No. 1	Manhattan	1.5 MW	11 AM to 3 PM: Plaza network
Area Station	Wainwright	Staten Island	7.2 MW	4 PM to 8 PM: Wainwright load area

High value locations have capacity limits

Distribution Valuation Strategies – Central Hudson

- Central Hudson was the only area to develop location specific values through probabilistic load forecasting methods
- Central Hudson Methodology:
  - Probabilistic load forecasting methodology for granular transmission areas and substations
  - Analyze load patterns, excess capacity, load growth rates, and the magnitude of expected infrastructure investments at a local level
  - Develop location specific forecasts of growth with uncertainty
  - Quantify the probability of any need for infrastructure upgrades at specific locations
  - Calculate local avoided T&D costs by year and location using probabilistic methods
  - Identify beneficial locations for DERs

Source: Joint Utilities Presentation, (5th April 2017) *Value of Distributed Energy Resources Technical Conference*

Distribution Valuation Strategies – Central Hudson

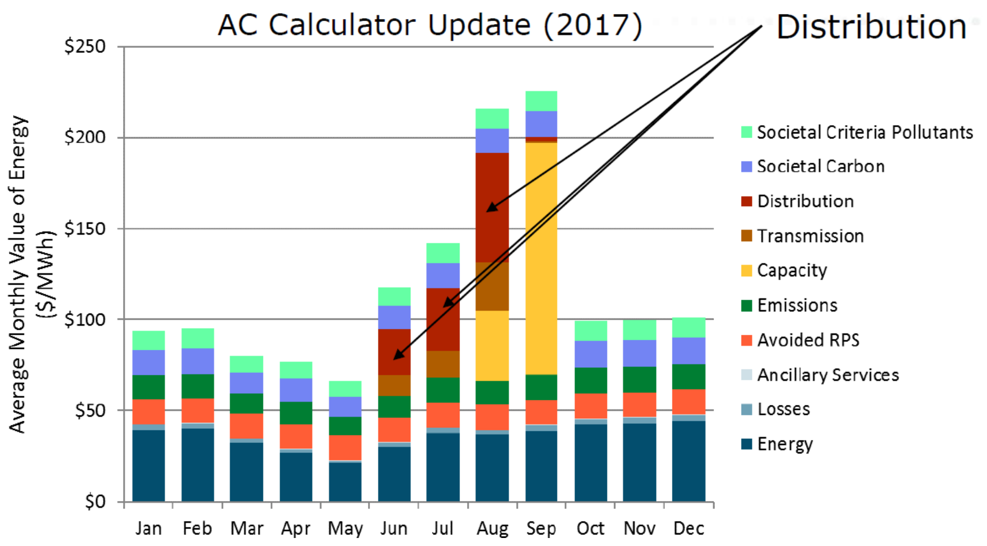
- DRV for CH based on most recent MCOS = $14.55
- 5 Areas – two transmission/3 distribution or substation growth areas
- Preliminary Locational Values based on MCOS study
  - RD-RJ Line $58.05 kW-year (transmission)
  - WM Line $102.11 kW-year (transmission)
  - Hunter $31.46 kW-year (Substation) (Winter Peaking)
  - Lawrenceville $275.34 kW-year (Substation) (Winter Peaking)
  - Coldenham $119.91 kW-year (Substation)
  - 8 transmission areas $0 kW-year
  - 50 substations areas $0 kW-year

LSRV values for Central Hudson

Source: Joint Utilities Presentation, (5th April 2017) *Value of Distributed Energy Resources Technical Conference*

Distribution Valuation Strategies - CA

- Local Net Benefits Analysis (LNBA)
- Builds on the DERAC model, DERAC model lacked granular distribution data
- Many values are fixed over the year but distribution and transmission deferral and capacity are only valuable during summer where they can defer infrastructure

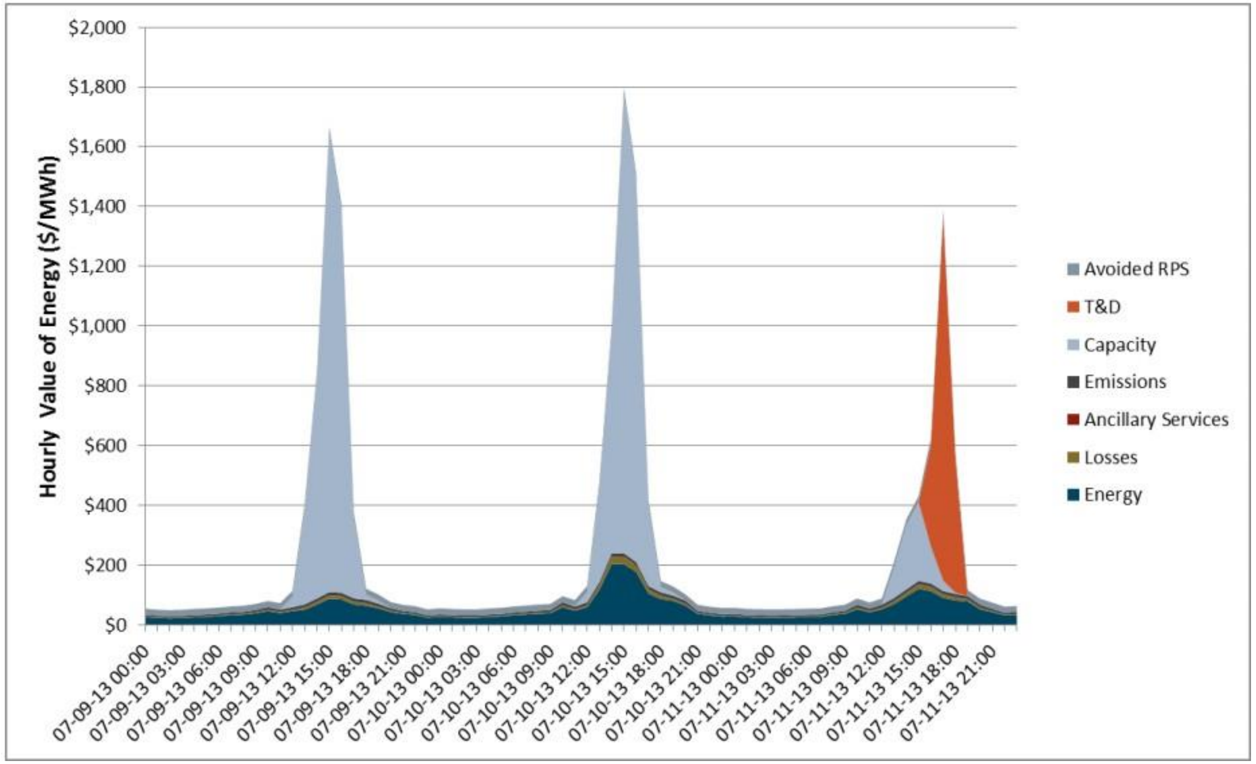


DRP LNBA Components
Generation Energy
Losses
Generation Capacity
Ancillary Services
Transmission Capacity
Distribution Capacity
Environment
Avoided Renewable Portfolio Standard energy requirement
Additional Components

Table source: SCE Valuation and Integration of Distributed Energy Resources presentation
Figure source: E3 California LNBA Update

California : VOS Component Methodology

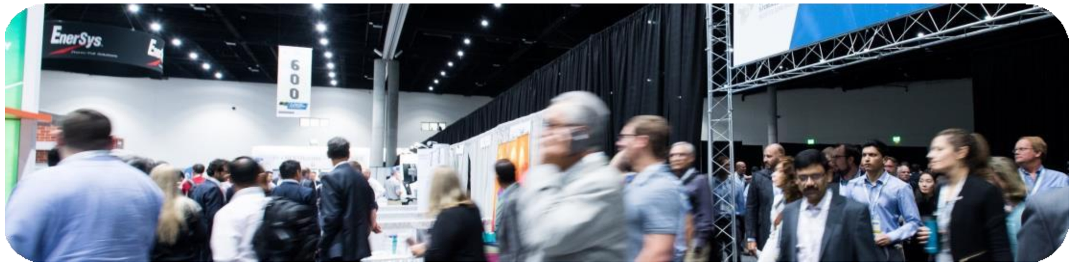
Figure 6: Three-Day Snapshot of Energy Values in CZ2



- E3 developed hourly avoided cost curves
- E3 used hourly solar production profiles for the different climate zones in CA
- By multiplying those curves together, the result is the solar avoided cost, i.e., the VOS

Solar could produce more value if generating during high value of energy hours

Figure source: E3 – 2013 California NEM Impact Evaluation



6th Energy Storage North America (ESNA) Conference + Expo: November 6-8, Pasadena, CA

Largest grid-connected energy storage conference in North America, covering all applications including EV charging
(www.esnaexpo.com)

Questions?

STRATEGEN CONSULTING

Thank You!

Lon Huber

Vice President

Strategen Consulting, LLC

lhuber@strategen.com

Appendix

Environmental Value

Environmental Value

- Renewable Energy Credits (RECs)
  - ACP
- Regional Greenhouse Gas Initiative (RGGI)
- Shape the value over high emitting hours

Transmission Value

Transmission Value

- ISO-NE Regional Network Load (RNL) Charge
  - Infrastructure: RNS rate (based on annual infrastructure revenue requirement) * IOU's monthly coincident peak (12-CP)
  - Reliability: Total ISO-NE payments to resources / RNL monthly peak * IOU's monthly CP
  - Administrative: Tariffed rate (based on annual administrative revenue requirement) * IOU's monthly CP
- DER Transmission Value determined by monthly coincident peak * total RNL rate (sum of infrastructure, reliability, & administrative)
  - Adjusted for IOU-specific line losses

Note: Local Network System (LNS) charges are a component of the RNS rate, which is broken into charges for pre-97 (LNS) and post-96 transmission infrastructure

Capacity Value

Capacity Value

- ISO-NE Forward Capacity Market (FCM) Charge
  - Net Regional Clearing Price (NRCP) = Payments made to Capacity Supply Obligations (CSO) / Sum of Capacity Load Obligations (CLO)
  - FCM Charge = NRCP * IOU's previous year's CP
    DER Capacity Value = DER reduction of IOU's CP * NRCP
  - Note that this value lags a year because of its dependence on the
    - previous year's CP

DRIPE Capacity Value

- DER Capacity DRIPE Value is determined by the reduction in the FCA's clearing price due to DERs multiplied by amount capacity called in the
  - FCM
    - This value is difficult to determine because while the change in the FCA's clearing price due to DERs can be estimated using the FCA's supply and demand curves, the amount of capacity called in the FCM will not be determined for 3 years

Energy Value

Energy Value

- ISO-NE Energy Locational Marginal Price (LMP)
  - Real-time (RT) Nodal LMPs (5 min intervals) adjusted by IOU-specific line-losses
- ISO-NE Net Commitment Period Compensation Charge
  - Compensates resources for deviations between day-ahead and real-time prices
- DRIPE Energy Value
  - Due to the fact that LMPs are derived incorporating the demand reductions caused by DERs, LMPs are lower than they would be without the presence of DERs
  - DER Energy DRIPE Value estimated based on average of DRIPE impacts in latest reports on Avoided Energy Supply Costs (AESC) in New England

Ancillary Service (AS) Value

Ancillary Service Value

- ISO-NE Ancillary Market Charge
  - Regulation Market
    - Total hourly cost of resource regional compensation / Region's RT Load Obligation (RTLO)
  - Forward Zonal Reserves (only during peak hours)
    - Total hourly cost of zonal resource compensation / Zonal RTLO
  - RT Zonal Reserves (all hours)
    - Total hourly cost of zonal resource compensation / Zonal RTLO
  - Transitional Demand Response (DR)
    - Total cost of regional resource compensation / Regional RTLO
- DER AS Value is estimated by summing the AS rates above (AS Market Charge) and multiplying by output