NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Valuing Response Products and Curtailment in U.S. Electricity Markets

Jessica Lau

Energy Studies Institute Workshop

Singapore, June 10, 2019

Outline

- Background
- Why do we have response products?
- U.S. Case Studies
  - Wholesale electricity markets
  - Distribution assets
  - Distribution markets

NREL at a Glance

2200

Employees, postdoctoral researchers, interns, visiting professionals

World-class facilities, renowned technology experts

nearly 820

Partnerships with industry, academia, and government

$410 million

Annual Budget

$1.1B annually

National economic impact

NREL at a Glance

Renewable Power

- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation

- Bioenergy
- Vehicle Technologies
- Hydrogen

Energy Efficiency

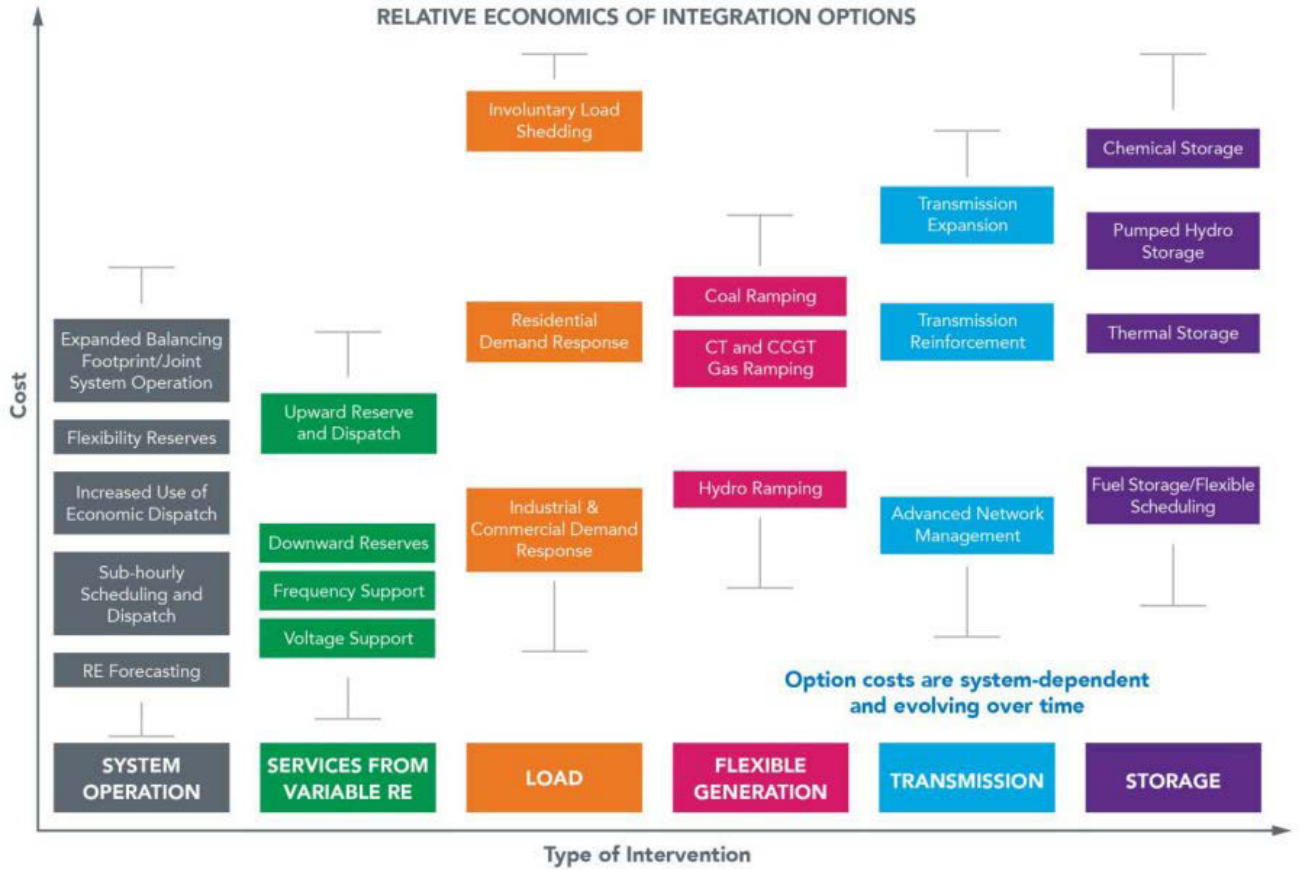
- Buildings
- Advanced Manufacturing
- Government Energy Management

Energy Systems Integration

- High-Performance Computing
- Data and Visualizations

Why do we need response products?

To gain flexibility!
Comprehensive design approach is important!



Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies https://www.nrel.gov/docs/fy17osti/66854.pdf

ISO/RTOs cover two-thirds of generation & transmission

2016 Reserves Summary

	Spinning Reserves	Non-spinning Reserves	Regulation
CAISO	Spinning	Non-spinning	Regulation-up Regulation-down Regulation Mileage-up Regulation Mileage-down
ERCOT	Responsive	Non-spinning	Regulation-up Regulation-down
ISO-NE	Ten-minute Synchronized	Ten-minute Non-synchronized Thirty-minute Operating	Regulation
MISO	Spinning	Supplemental	Regulation
NYISO	Ten-minute Spinning Thirty-minute Spinning	Ten-minute Non-synchronized Thirty-minute Non-synchronized	Regulation
PJM	Synchronized	Primary	Regulation
SPP	Spinning	Supplemental	Regulation-up Regulation-down

Table 1-1 Overview of the ancillary services offered by each ISO/RTO

https://publications.anl.gov/anlpubs/2016/01/124217.pdf

PJM Reserve Markets Timeline

Before 2002

- Manual assignment by system operators
- Paid at cost-of-service

2002

- Introduced reserve markets
- Focused on procuring ancillary services to meet a defined requirement
- Not explicitly on maximizing operational efficiency or incentivizing flexibility

2012

- Implemented shortage pricing
- Targeted at enhancing rules for energy and reserve price formation during periods where PJM experienced reserve shortages

2018/2019 (Proposed)

- Combine synchronized reserve products
- Dynamic reserve sub-zones
- New Operating Reserve Demand Curve (ORDC)

https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/20181214/20181214-item-04-price-formation-paper.ashx

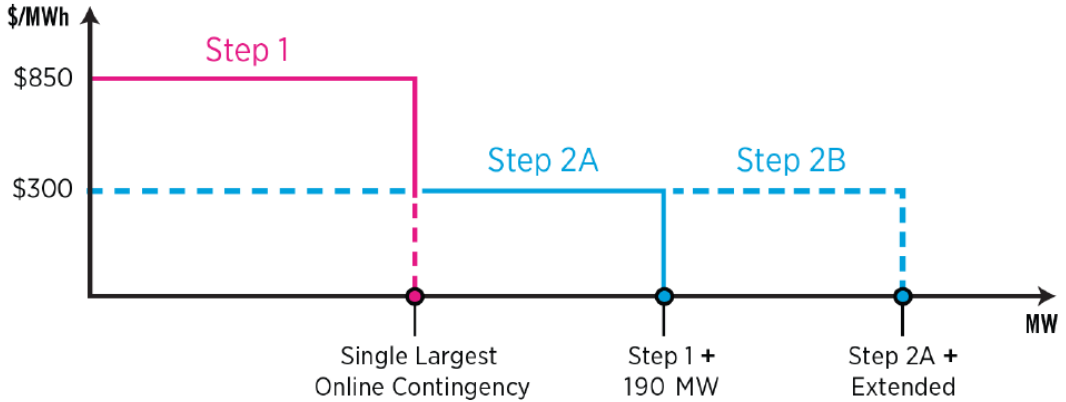
PJM Reserve Markets Timeline (Cont.)

2019 and beyond

- ORDC proposal filed. Stakeholder consensus could not be reached after more than 1 year
- Multi-period dispatch
- Zonal reserve market

Current

Figure 4. Current Synchronized Reserve Demand Curve



Drawbacks:

1) The curves do not value reserves highly enough
2) Reserves beyond the identified requirements are not accurately valued

https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/20181214/20181214-item-04-price-formation-paper.ashx

PJM Reserve Markets Timeline (Cont.)

2019 and beyond

- ORDC proposal filed. Stakeholder consensus could not be reached after more than 1 year
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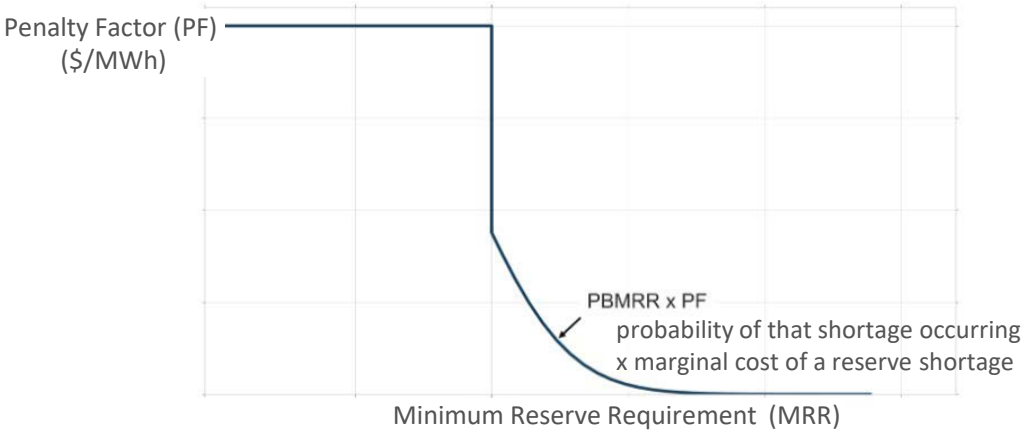
Proposed

Figure 8. Proposed ORDC Shape



Proposed Benefits:

1) Reserves in excess of minimum will be valued if beneficial
2) Additional reserves can be assigned when economically appropriate

https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/20181214/20181214-item-04-price-formation-paper.ashx

CAISO & MISO Ramp Products Timeline

2013

- MISO implemented Up Ramp Capability (URC) and Down Ramp Capability (DRC) products with market

2016

- CAISO Implemented flexible ramping product in RT market.
- Flexible Ramp Up and Ramp Down in both 5- and 15-minute market
- Requirement set by projections of the maximum 3-hr net load ramp during each month

2018

- Volatility year-to-year, net 2018 payment $7M, but $25M in 2017
- Load serving entities acquired more than requirement, mostly gas-fired gen
- Discovered unintended systematic bias in calculation

CAISO & MISO Ramp Products Timeline (Cont.)

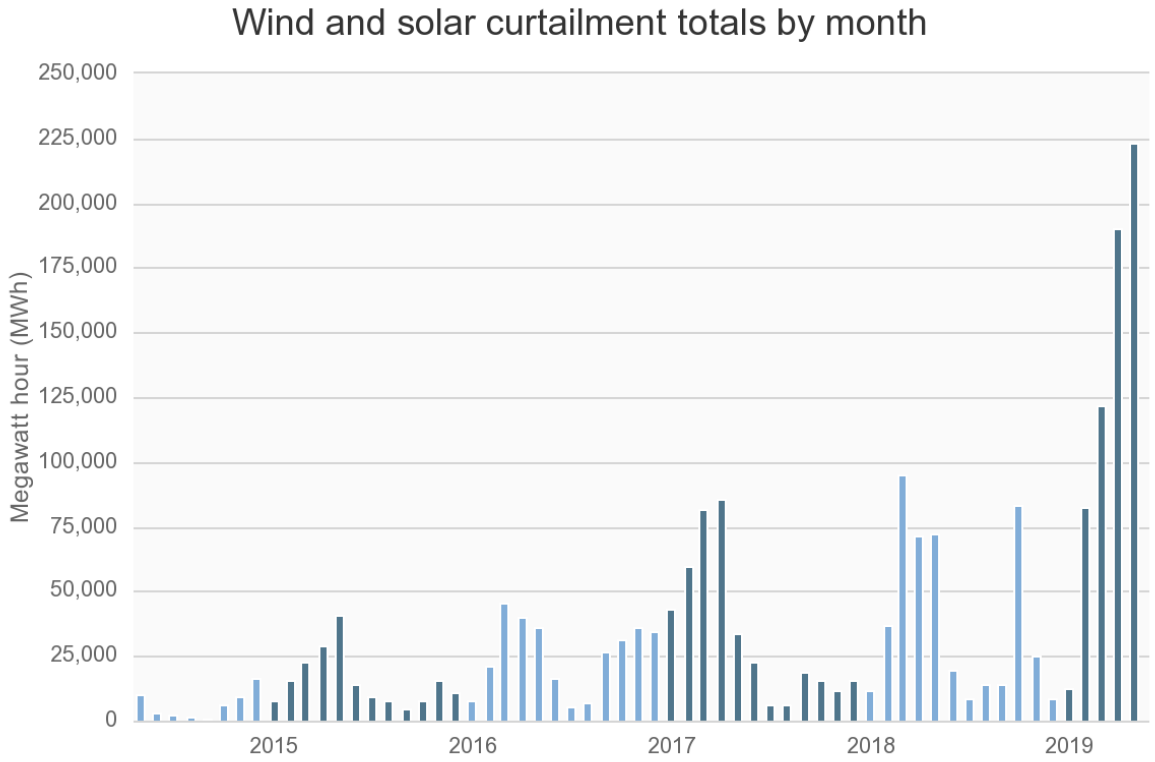
2019 & beyond

- CAISO Day-Ahead Ramp product development to address 2 uncertainties
  - locational: may not be deliverable in real-time due to transmission constraints
  - Time horizon: bridge past the 5- and 15-minute markets to reach longer timeframes
- CAISO Resource Adequacy-based full process and market review
- MISO AGC Enhancement for Fast Ramping Resource (to attract new resources, like storage)
- MISO to consider allowing dispatchable intermittent resources to provide regulation
  - Concerns with deliverability

CAISO Curtailment

Another flexibility option!

- Curtailment is when actual production is less than what is available
- Reasons for curtailment
  - **Market-based**
    - 1) Economic
  - **Manual**
    - 2) Self-scheduled cuts
    - 3) Operator exceptional dispatch



http://www.caiso.com/informed/Pages/ManagingOversupply.aspx

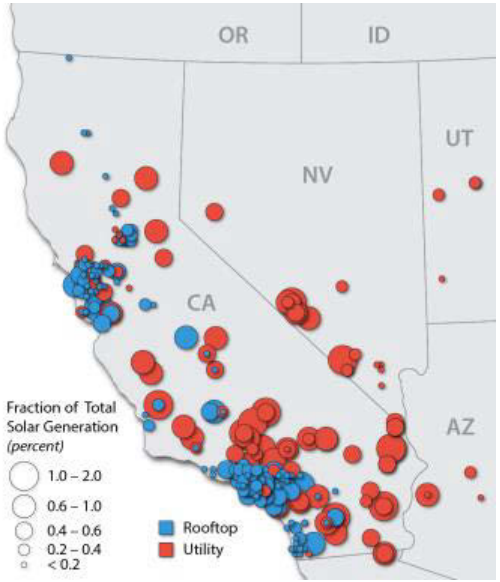
Flexibility and Increasing Variable Generation

Case Studies

Case Study: California (Includes CAISO + Munis)

Flexibility Options for Increasing PV

- Change Operating Practices (includes allowing VG to provide reserves)
- Demand Response
- Exports
- Battery Storage
- DR + Storage



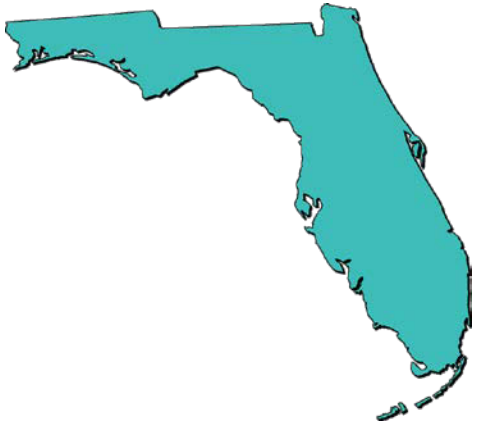
PV Scenarios:
7.5% to 37% PV in ~4% Increments

Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies
https://www.nrel.gov/docs/fy17osti/66854.pdf

Case Study: Florida Reliability Coordinating Council (FRCC)

Flexibility Options for Increasing PV

- Allow PV to Provide Reserves
- Combined-Cycle Minimum Generation Level
- Enhanced Balancing Area Cooperation
- Battery Storage
- Increased Transmission Capacity between SERC and FRCC



PV Scenarios:
5% to 30% PV in 5% Increments
Up to about 39 GW of PV capacity

Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies
https://www.nrel.gov/docs/fy17osti/66854.pdf

Case Study: Southwest Power Pool (SPP)

Wind Scenarios:
12% to 51% wind in 3% Increments
Up to about 42 GW of wind capacity

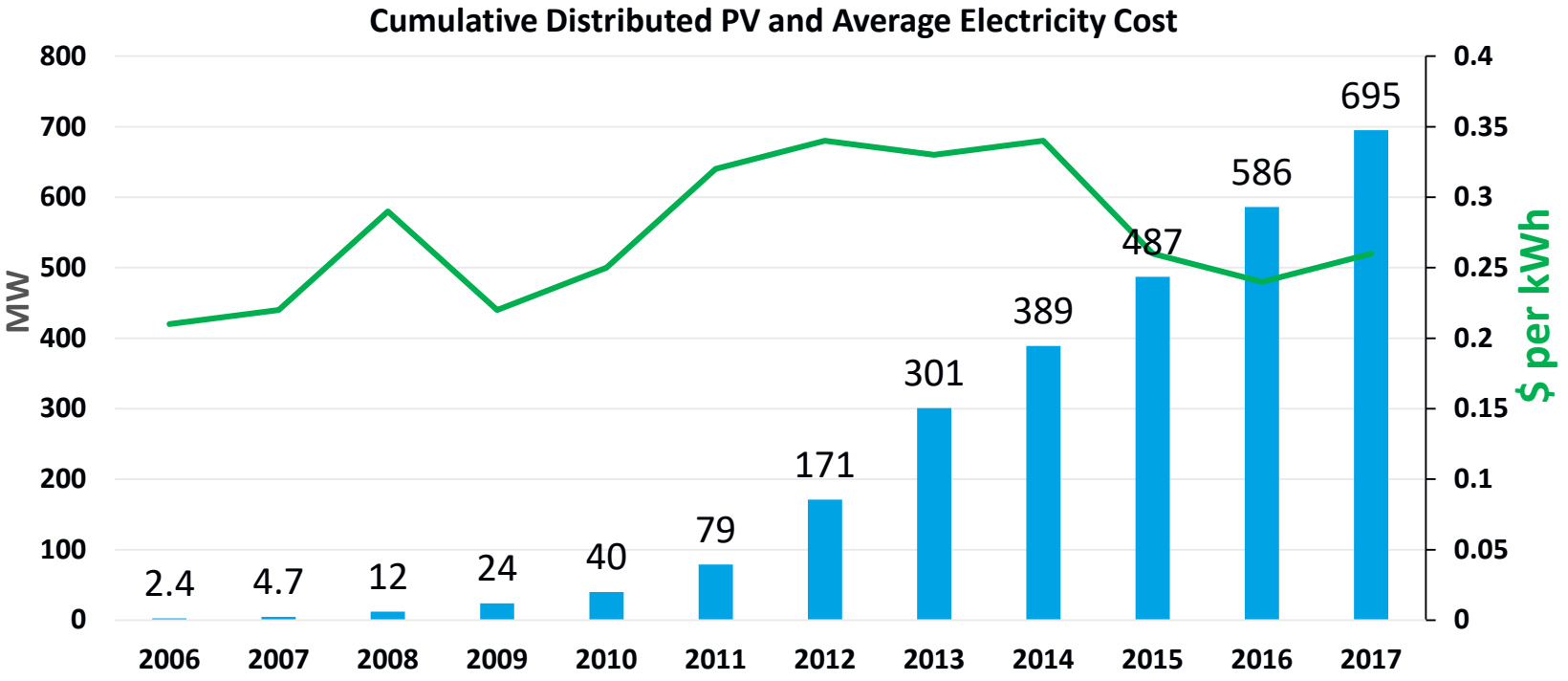
Flexibility Options for Increasing Wind

- Allow Wind to Provide Reserves
- Combined-Cycle and Coal Minimum Generation Level
- Increased Interface Flow Limits
- Battery Storage
- Increased Operation between SPP, MISO, and Canadian Regions

Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies
https://www.nrel.gov/docs/fy17osti/66854.pdf

Flexibility comes from T&D
Hawaii & New York Case Studies

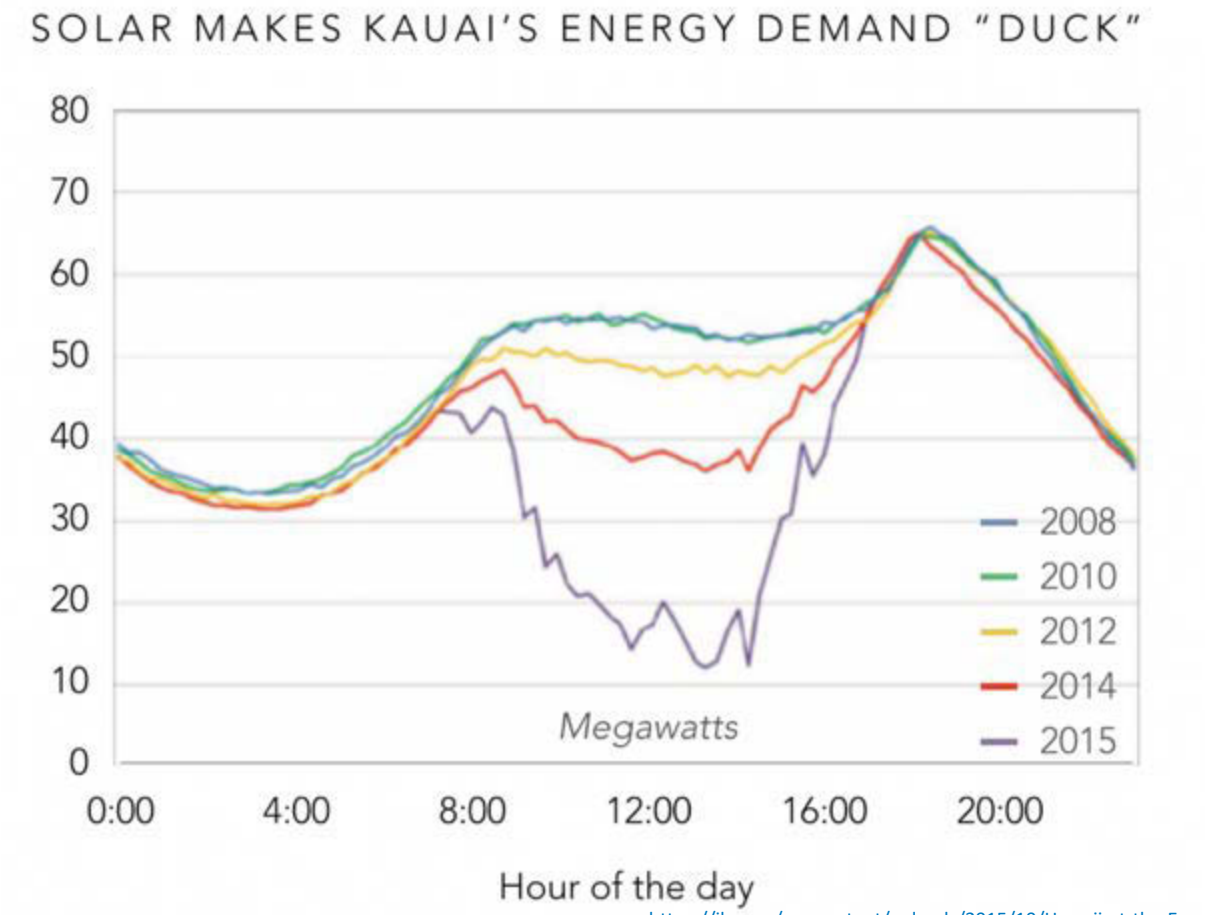
On-going Energy Transition in Hawaii



DER PV has grown 290x since 2006

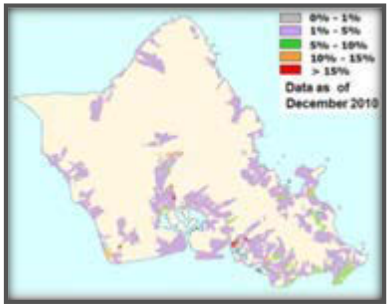
https://pv-magazine-usa.com/2018/01/26/heco-sees-109-mw-of-new-hawaii-solar-2017/

The Duck Curve



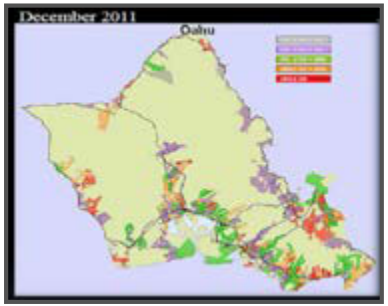
https://ilsr.org/wp-content/uploads/2015/10/Hawaii-at-the-Energy-Crossroads-ILSR-2015.pdf

Distributed Energy in Hawaii



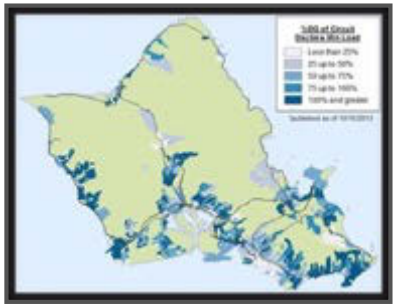
2010

Many Feeders
> **1%**
daily
minimum
load (DML)



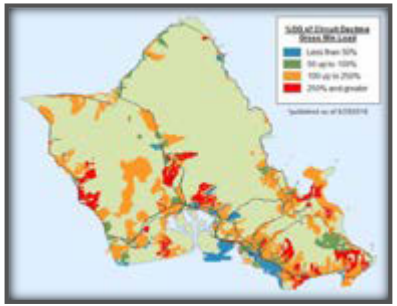
2011

Many Feeders
> **15%**
daily
minimum
load (DML)



2013

Many Feeders
> **100%**
daily
minimum
load (DML)



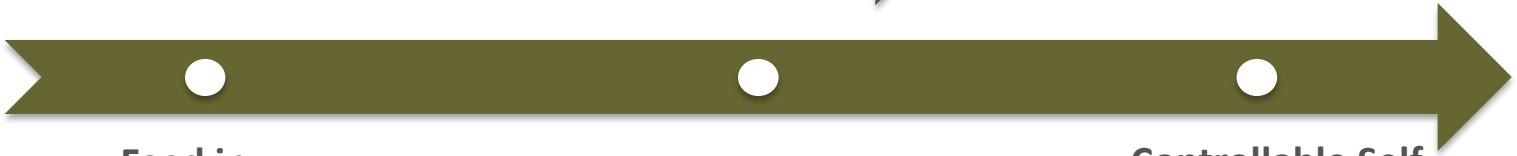
2016

Many Feeders
> **250%**
daily
minimum
load (DML)

https://www.hawaiianelectric.com/clean-energy-hawaii/integration-tools-and-resources/locational-value-maps

Hawaii DER Policy

Stream-lined Permitting and Interconnection Processes



Feed in Tariff

- Customers receive a credit at or above retail rates.

Net Energy Metering

- Customers receive a credit at retail rate for electricity exported to the grid.
- If the customer produces excess electricity, the customer pays a minimum bill (ex., $17).

Controllable Self Supply or Smart Export

Self Supply (no export, $25 minimum)

or

Smart Export (4 pm – 9 am) at wholesale rates

NY Reforming the Energy Vision (REV)

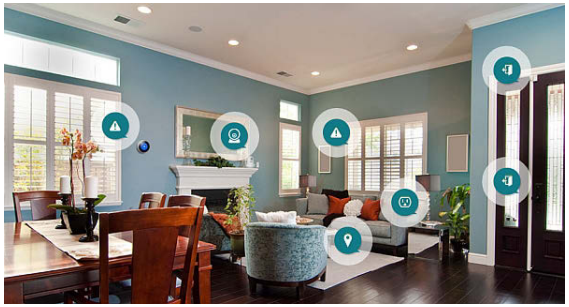
- REV is a strategy to build a clean, resilient, and affordable energy system for all New Yorkers.

Cutting greenhouse gas emissions 80% by 2050

50% electricity will come from renewable energy sources by 2030

Solutions for System Upgrades

Traditional (“wires”) solutions



Non-Wire Alternatives (NWA)

Grid investment that uses non-traditional (“wires”) solution to defer or replace need for specific equipment upgrades

Reconductoring
Transformer Cooling
Increasing transformer size
New Substation

Energy efficiency
Distributed Generation
Demand Response
Storage

Simplified NWA Assessment Process

- Utilities are increasingly considering NWAs
- More states are requiring utilities to include NWAs
- Depending on retail structure, a utility may own and operate, or contract with 3rd party

https://www.scottmadden.com/wp-content/uploads/2019/05/ScottMadden_Energy_Industry_Update_V19_I1_2019.pdf#page=17

NWA Findings (so far)

- Successful delays and deferrals of infrastructure upgrades
- Provides **flexibility**
- Cost Savings and Allocations

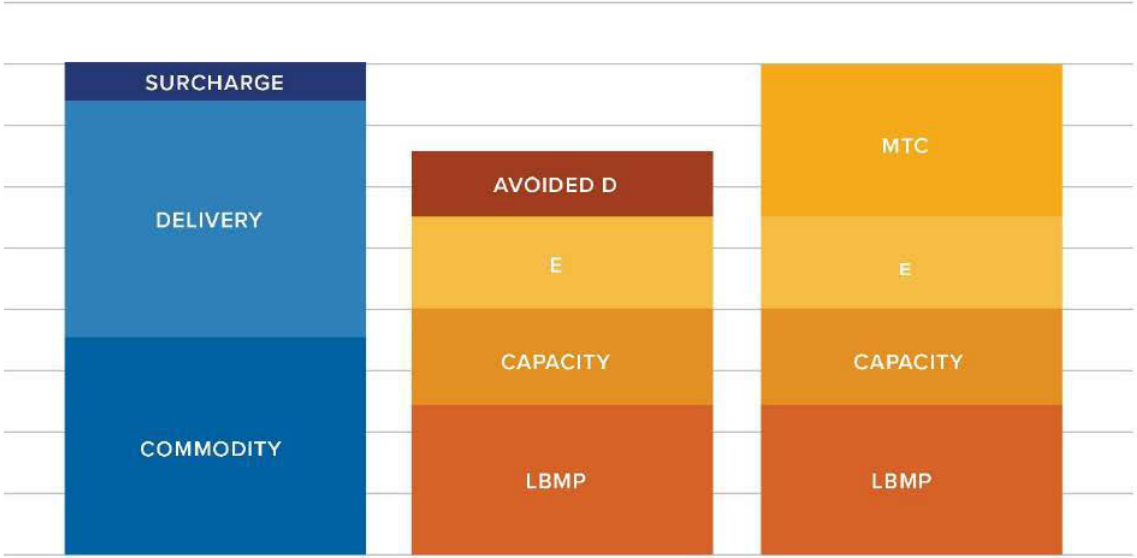
Further research needed:

- Ownership and control
- Sourcing best practices and utility contracting benchmarks
- Navigating multiple value streams of, and cost recovery approaches for, DERs serving as NWAs

https://sepapower.org/resource/non-wires-alternatives-case-studies-from-leading-u-s-projects/thank-you/

Net-Metering to Value Stack

The evolution to a T&D market



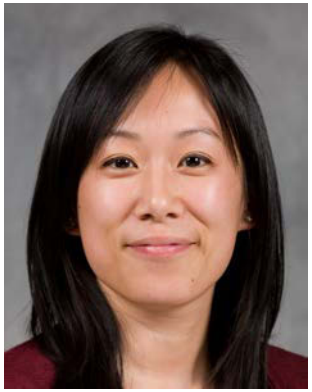
- Avoided D – avoided demand
- E – environmental benefit
- Capacity – ICAP
- LBMP – energy commodity
- MTC – market transition credit for CDG

NEW YORK STATE OF OPPORTUNITY. NYSERDA

Source: Value of DER

Summary

- Comprehensive market design can capture the flexibility elements that the system needs to acquire.
  - Including price formation, market products, curtailment dispatch, and forecasting practices)
- Flexibility can be leveraged from all resources, including transmission and distribution level resources
- Technical challenges to variable RE integration are real, but the limit of RE penetration is primarily economic, driven by factors that include transmission availability and operational flexibility.
- PV is more dependent on grid flexibility, including transmission and energy storage.



Jessica.Lau@nrel.gov
Sr. Technical Project Manager
Strategic Energy Analysis Center

Thank you

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More materials

- CAISO Flexible Ramping Product http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/FlexibleRampingProduct.aspx
- CAISO 2018 Review of Flex Ramp Product https://www.caiso.com/Documents/Presentation-FlexibleRampingProductPerformanceDiscussionFeb22018.pdf
- CAISO 2019 Policy Initiatives Roadmap http://www.caiso.com/Documents/2019FinalPolicyInitiativesRoadmap.pdf
- MISO 2019 Market Roadmap https://cdn.misoenergy.org/MISO%20Market%20Roadmap194258.pdf
- PJM 2018 Reserves Price Formation https://www.pjm.com/-/media/committees-groups/task-forces/epfstf/20181214/20181214-item-04-price-formation-paper.ashx
- ISO-NE Do-not-exceed dispatch http://isonewswire.com/updates/2019/6/4/wind-and-hydro-resources-incorporated-into-the-day-ahead-ene.html
- NREL Impact of Flexibility Options on Grid Economic Carrying Capacity of Solar and Wind: Three Case Studies https://www.nrel.gov/docs/fy17osti/66854.pdf

- 2016 U.S. Ancillary Services Summary https://publications.anl.gov/anlpubs/2016/01/124217.pdf