Electric energy markets

Before and after new energy technologies

24th MEM Congress

1 Nov 2018

Cartagena, Colombia

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Menlo Energy Economics

San Francisco CA

www.menloenergy.com

Thank you

- Pleased to be back to Cartagena
- Present latest developments
- Keen on your feedback

Premise

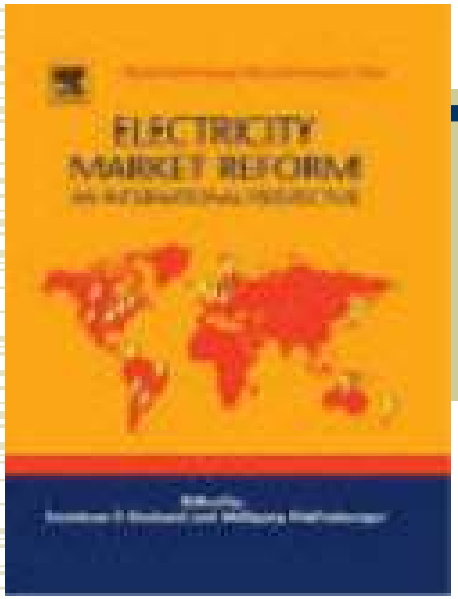
- Balance of power shifting to consumers
- Future of electricity is behind-the-meter
- Innovation & disruptions from new players
  - Intermediaries/orchestrators/aggregators
  - Platforms brining buyers & sellers together
    - Peer-to-peer (P2P) sharing & trading
  - Virtual power plants (VPPs)
    - Adding flexibility, integration of variable renewables
  - Blockchain
    - No need for an intermediary or clearinghouse?

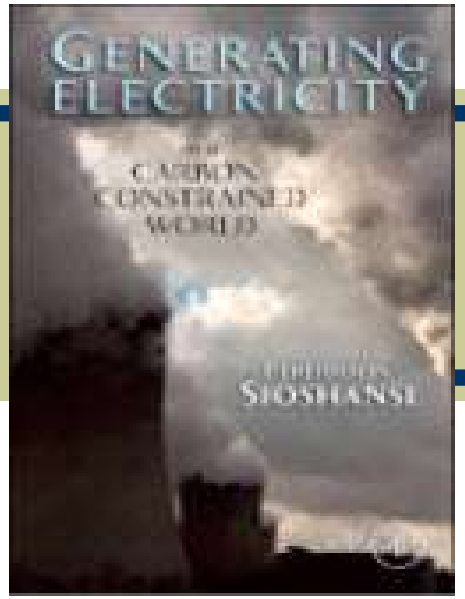
Questions

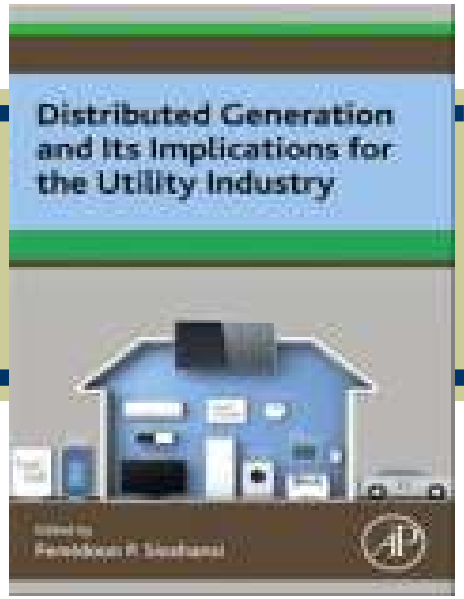
- What actually lies BTM?
- What is exciting about BTM?
- What can be done with BTM assets?
- How can individuals, groups, or communities of consumers be aggregated so that the entire portfolio of BTM assets can be better utilized?
- Critical for balancing load & demand in a future increasingly supplied by variable renewable resources

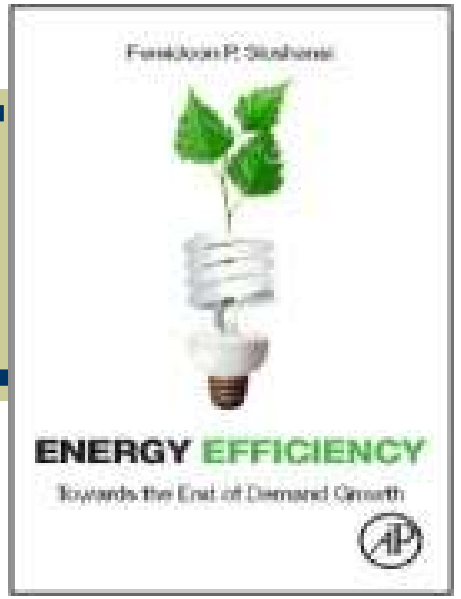
Context

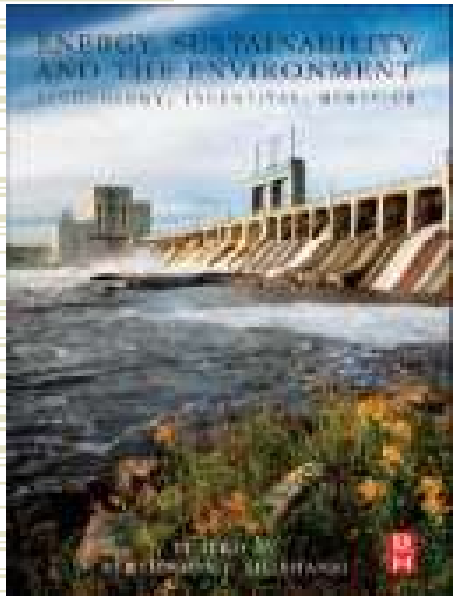
- Energy transition
  - 3Ds
- What's exciting?
  - Opportunities behind-the-meter (BTM)
  - The rise of aggregators, platforms, VPPs, P2P trading
- Future?
  - Storage => Better integration of supply & demand
  - Consumers => prosumers => prosumagers => nonsumers

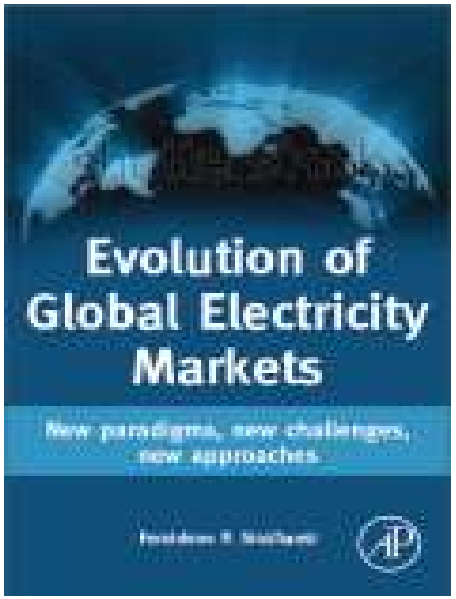

ELECTRICITY
MARKET REFORM

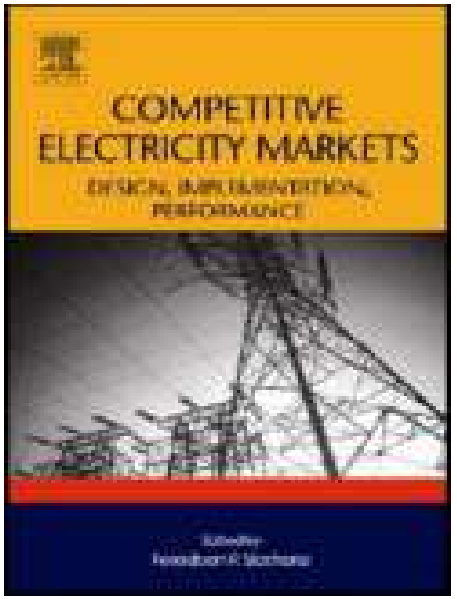

GENERATING
ELECTRICITY
SIOSHANSI

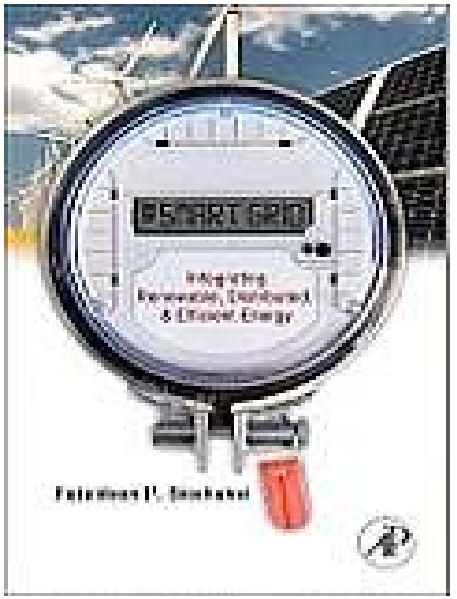

Distributed Generation
and Its Implications for
the Utility Industry


ENERGY EFFICIENCY



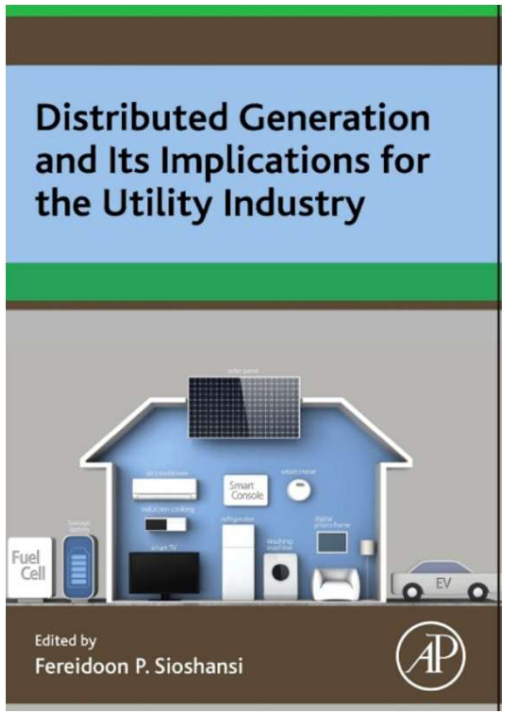

Evolution of
Global Electricity
Markets
New paradigms, new challenges,
new approaches

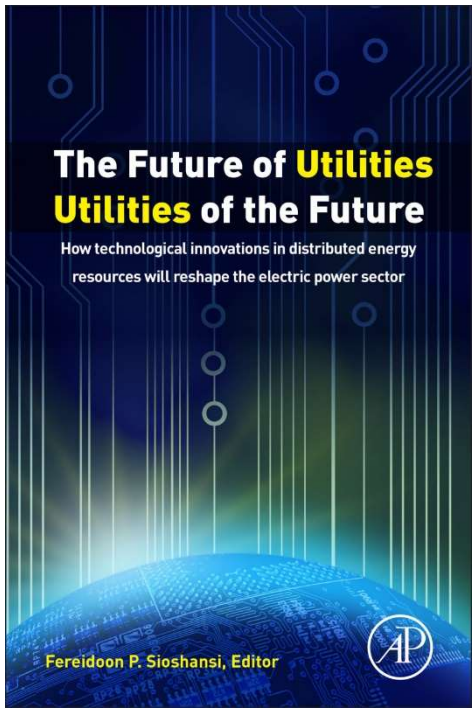

COMPETITIVE
ELECTRICITY MARKETS

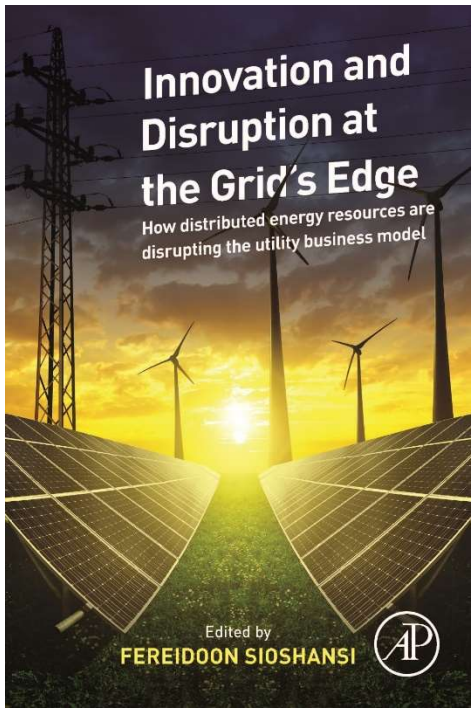

SMART GRID

Last 3 volumes

relevant to today's discussions







Consumer, Prosumer, Prosumager

How service innovations will disrupt the utility business model

Edited by
Fereidoon Sioshansi

Next?

- Behind & beyond the meter
- Organize symposia
  - Sydney/Melbourne — Feb 2019?
  - Berlin/Freiburg
  - London/Oxford — Mar 2019
  - Silicon Valley
  - Cambridge/Boston — May 2019
  - Florence

First
Energy transition

- 3Ds
  - De-carbonization — Low carbon energy future
  - Decentralization — Distributed generation & storage
  - Digitalization — Harnessing value of data

De-carbonization

- 179 countries have renewable “aspirations”
  - 57 have 100% renewable electricity targets
- 25% of EU budget devoted to climate
- Solar exceeds coal/gas/nuclear combined
  - $280 billion invested in renewables in 2017
- Renewables 20% of US generation
  - Wind output exceeded hydro for first time in 2017
- Germany totally renewable on some days
- California carbon-neutral by 2045

Carbon neutral California by 2045

Gov. Brown signing SB 100, 10 Sept 2018

Source: LA Times

Decentralization

700,000 solar homes in CA and counting

Decentralization is real

- Germany
  - Millions of small generators
- Australia
  - Over 1 million rooftop PVs
- California/Hawaii
  - Both going 100% renewable
- Puerto Rico
  - Pair solar PVs + storage
- Sub-Saharan Africa
  - No grid? No problem

Totally off grid

… where there is no grid

Source: Off Grid Electric

EV shading

Distributed, dis-connected & mostly self-sufficient

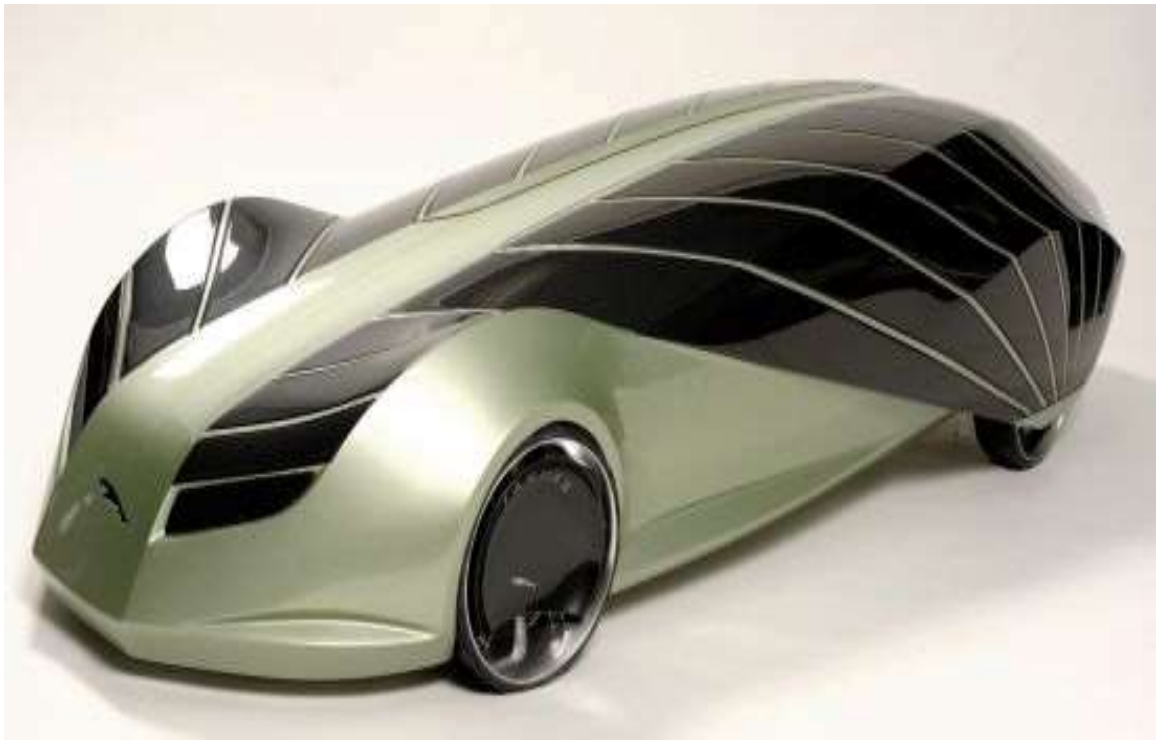
Cut the cord!

Source: SolarPad.com

Solar “augmentation”

Exterior surface as energy source

c



Jaguar solar concept car, *The Energy Post*, 26 Oct 2017

Digitalization

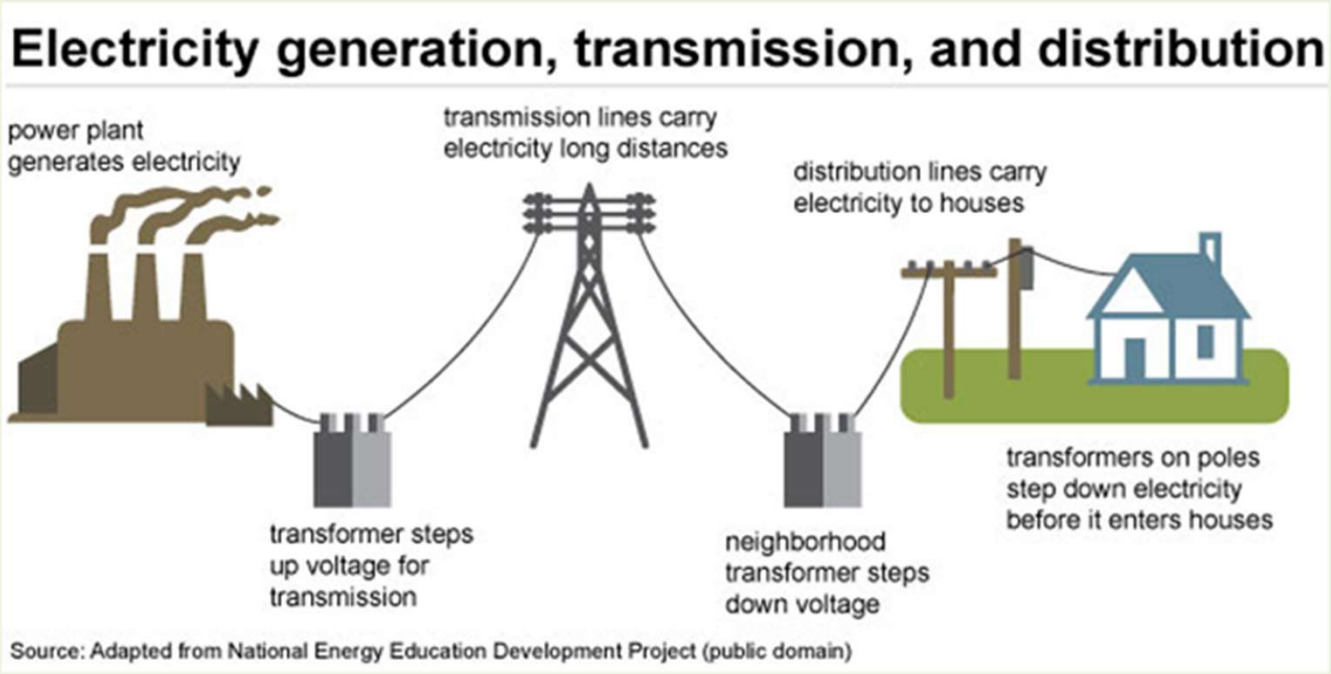
Remote monitoring & mgmt.: Compelling

Most exciting?

- Opportunities behind-the-meter (BTM)
  - Historically ignored & under-appreciated
  - No incentive to go behind-the-meter
  - Nor could you do much even if you tried
- Aggregators, platforms, VPPs, P2P trading
  - New generation of players entering market
  - Enabled by technological innovations
  - Monitoring & managing BTM assets

Add BTM to picture

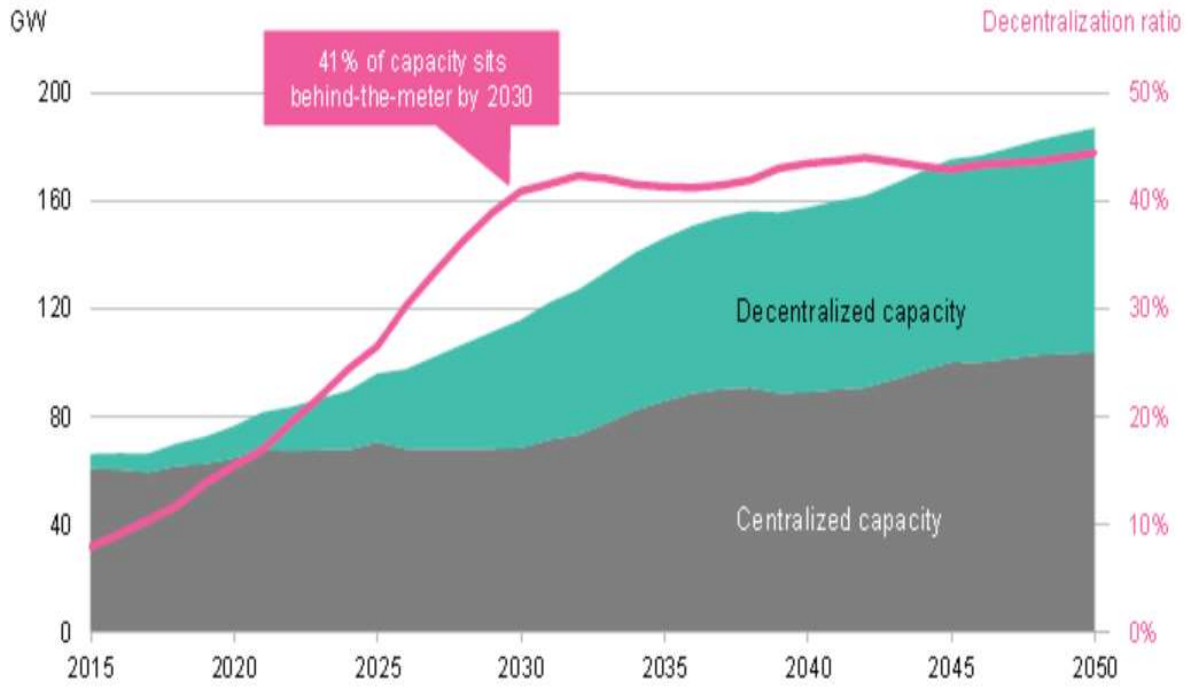
Historical business model stopped at the “meter”



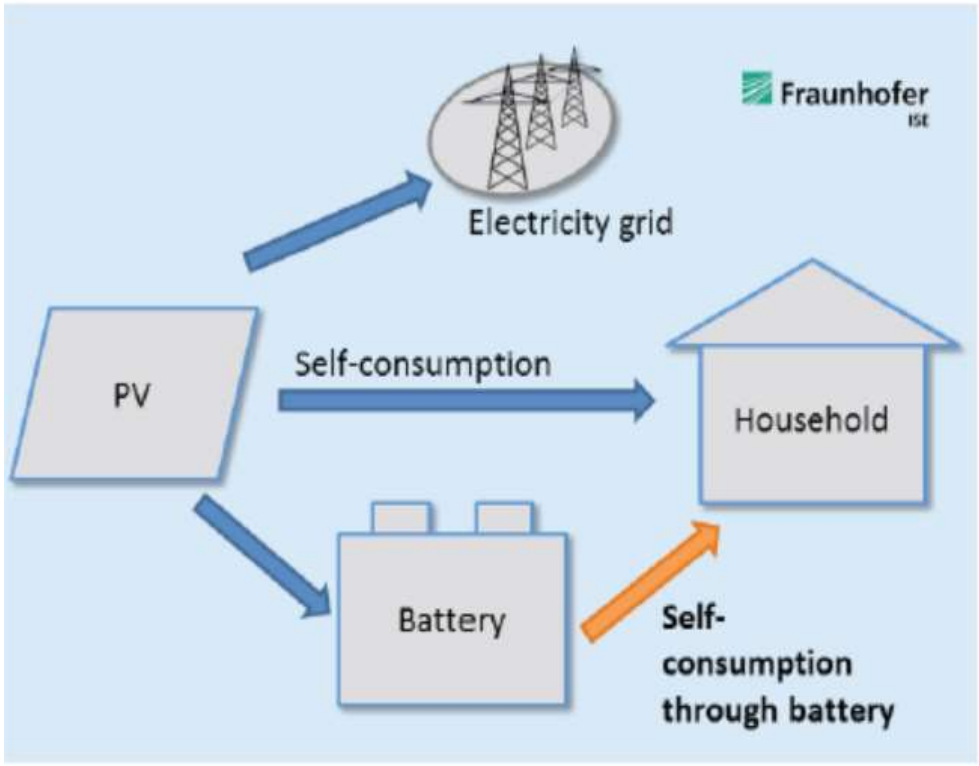
What is BTM?

- Electricity using devices
  - Lights, HVAC washers/dryers, TVs/electronics, pumps, motors
- Distributed generation
  - Rooftop solar PVs
- EVs
  - Expected to take off
- Distributed storage
  - Batteries, hot/cold water tanks, other storage media

BTM is big & getting bigger

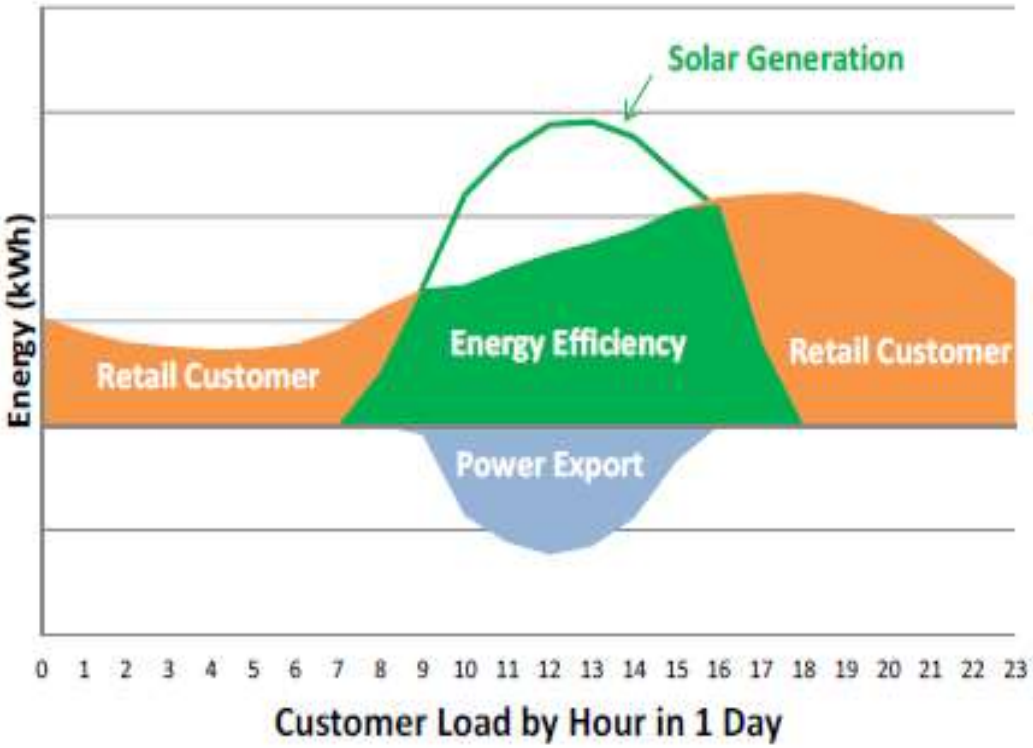


Source: Annabel Wilton, BNEF, presented at Australian Clean Energy Summit, Sydney, July 2018



Source: LCOE: Renewable energy technologies, Fraunhofer Inst., Mar 2018

Consumer => Prosumer



Source: Evaluating the benefits and costs of NEM laws in California, prepared for Vote Solar, Jan 2013

EVs
End of ICE?

Driverless: Sooner or later

Source: Google's Waymo self-driving car

Prosumer => Prosumager

Just add storage

Source: The Wall Street Journal 2 May 2015

Distributed storage

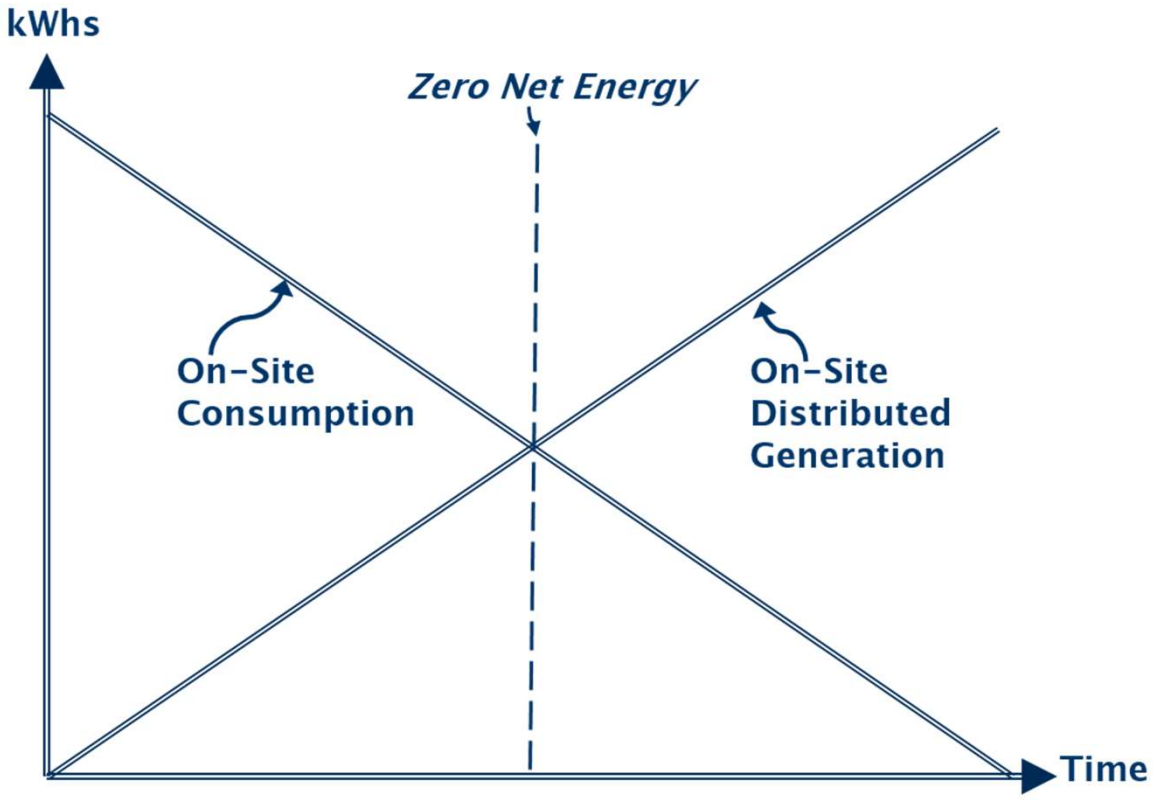
Tesla's $5 billion gigafactory near Reno, NV

New electric company: Your home

Wall Street Journal 21 Jan 2015

Zero Net Energy

New CA building code starting 2020



ZNE office

Apple’s new headquarter going beyond ZNE

ZNE campus: Why not?

Office parks, shopping malls, hospitals, universities, whole cities

Source: NREL

BIPVs

Turning exteriors of buildings into powerhouses

Source: Onyx

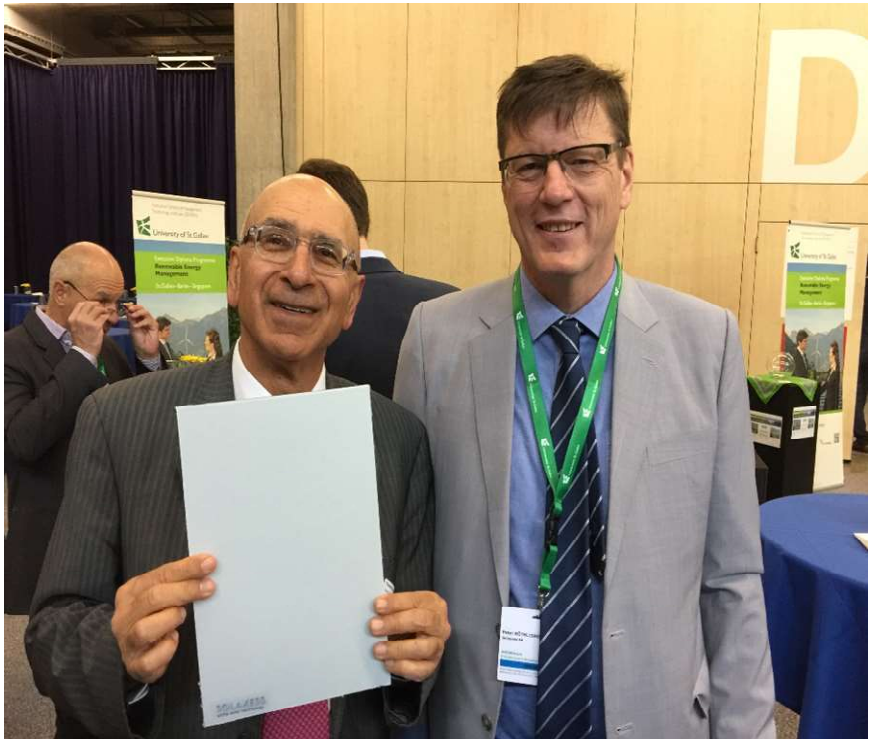
CBD as powerhouse

Entire surface of buildings generates power

Source: Skanska

Solar tiles

In any color you like



Solar window

”Clearly electric”

Source: solarwindow.com

Solar block, solar sidewalk

Source: Univ. of Exeter

Integrated energy services

Tesla energy: PVs, EVs & storage

Source: Tesla unveils residential solar roof and new Powerwall battery, Utility Dive, 28 Oct 2016

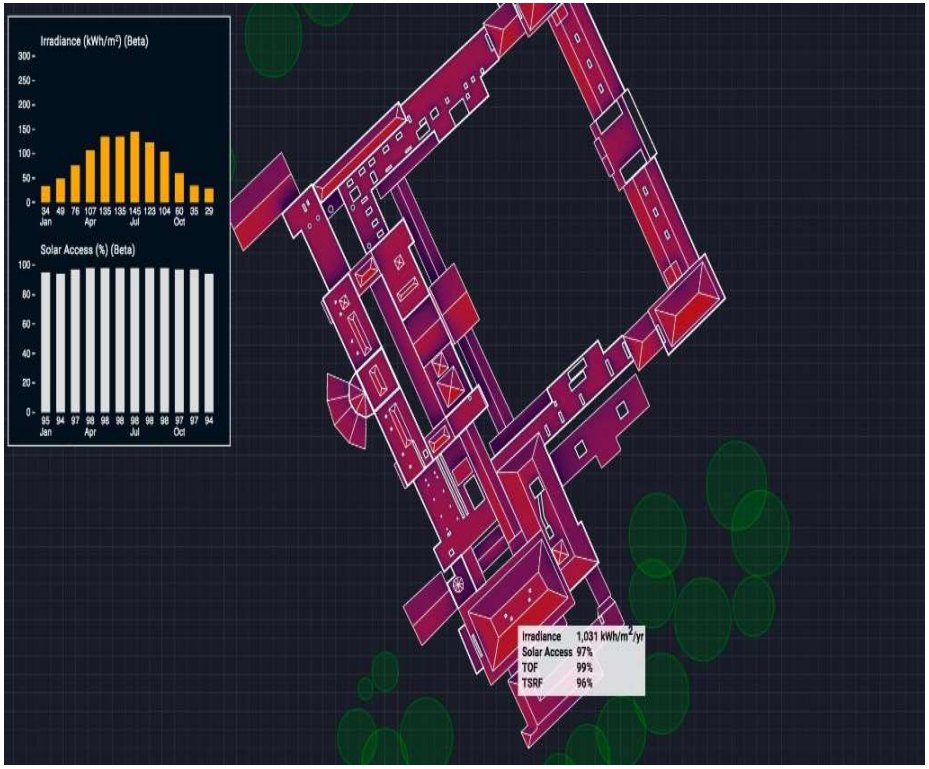
Buckingham Palace

Source: Aurora Solar

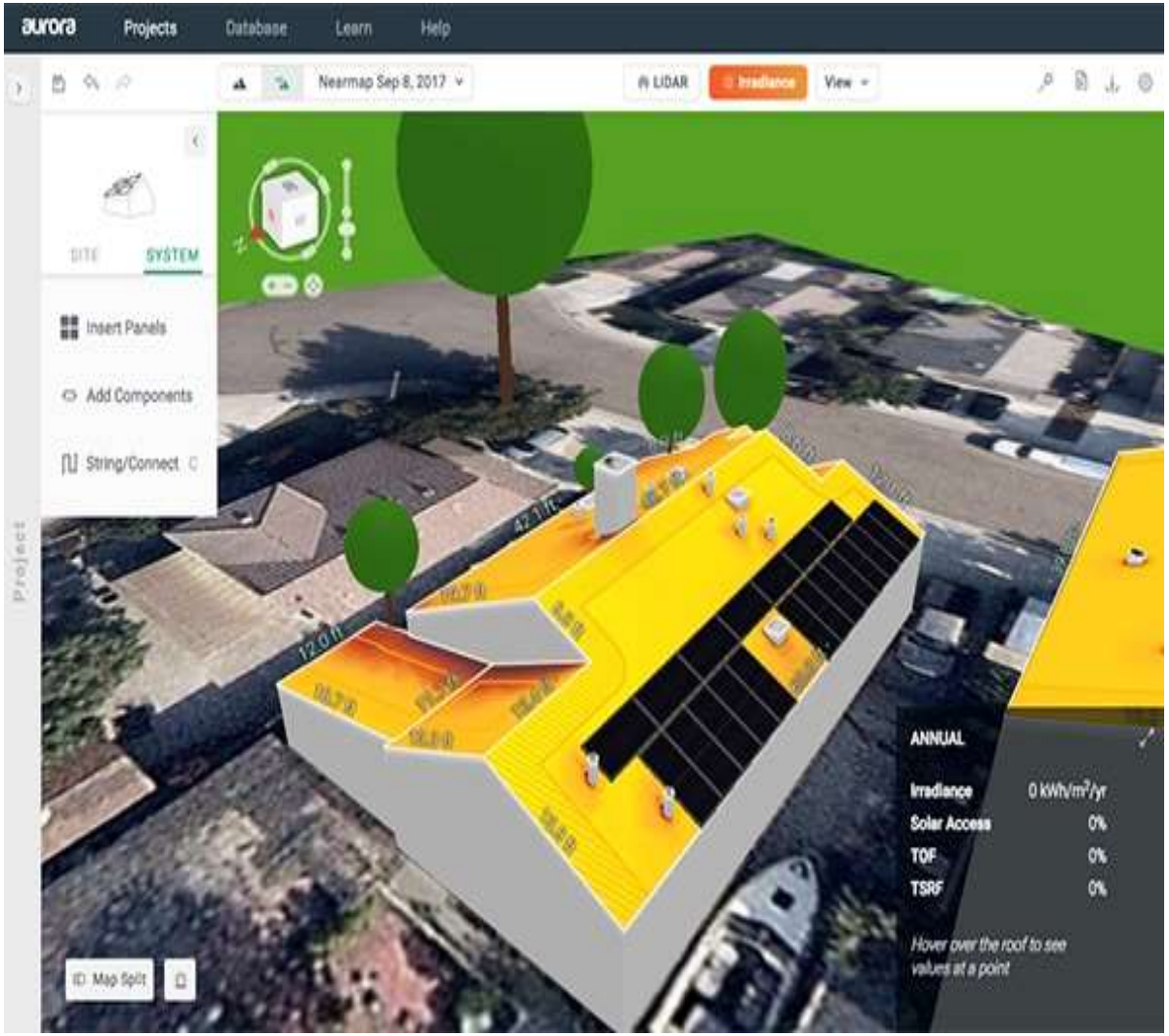
Solar fit for the queen

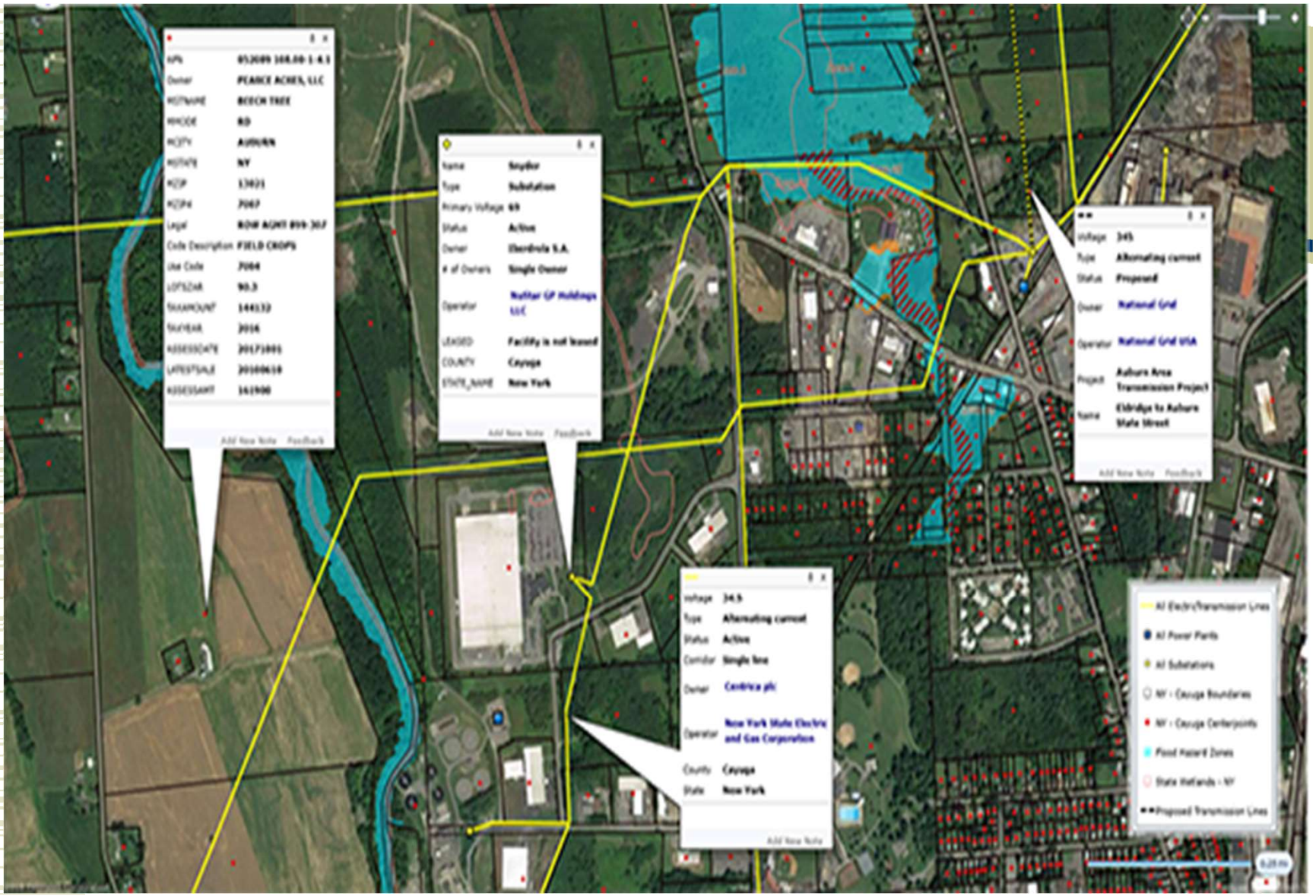
Source: Aurora Solar

Optimally designed



Source: Aurora Solar


aurora
Projects
Database
Learn
Help
Nearmap Sep 8, 2017
LIDAR
Irradiance
View
SITE
SYSTEM
Insert Panels
Add Components
String/Connect
Project
Map Split
ANNUAL
Irradiance
0 kWh/m²/yr
Solar Access
0%
TOF
0%
TSRF
0%
Hover over the roof to see values at a point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Owner PEARCE ACRES, LLC
FOOTNAME BEECH TREE
RHCODE RD
RCITY AUBURN
RSTATE NY
RZIP 13021
RZIP4 7067
Legal ROW AGMT 899-307
Code Description FIELD CROPS
Use Code 7104
LOTSIZE 90.3
TAXAMOUNT 144132
TAXYEAR 2016
ASSESSDATE 20171001
LATESTSALE 20160616
ASSESSAMT 161900
Add New Note Feedback
Name Stryker
Type Substation
Primary Voltage 69
Status Active
Owner Iberdrola S.A.
# of Owners Single Owner
Operator Nutter GP Holdings LLC
LEASED Facility is not leased
COUNTY Cayuga
STATE_NAME New York
Add New Note Feedback
Voltage 345
Type Alternating current
Status Proposed
Owner National Grid
Operator National Grid USA
Project Auburn Area Transmission Project
Name Eldridge to Auburn State Street
Add New Note Feedback
Voltage 34.5
Type Alternating current
Status Active
Corridor Single line
Owner Centrica plc
Operator New York State Electric and Gas Corporation
County Cayuga
State New York
Add New Note
All Electric Transmission Lines
All Power Plants
All Substations
NY - Cayuga Boundaries
NY - Cayuga Centerpoints
Flood Hazard Zones
State Wetlands - NY
Proposed Transmission Lines

Beyond ZNE: Solar ordinance

City of Lancaster, CA: 2 W per sq. ft. living space

Next?

Innovations in aggregation, platforms, VPPs

- Why now?
  - Technological advancements
  - Compelling business case
- What makes them exciting?
  - Service innovation
  - Ability to scale up at speed
  - Disruptive as in Uber, Airbnb or worse


Kodak

Disruptors hard at work

Or hardly working?

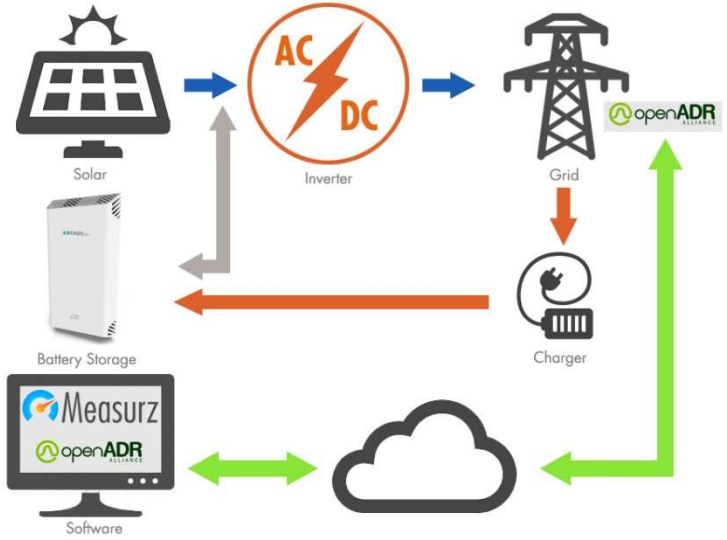
Source: http://www.yeloha.com/about

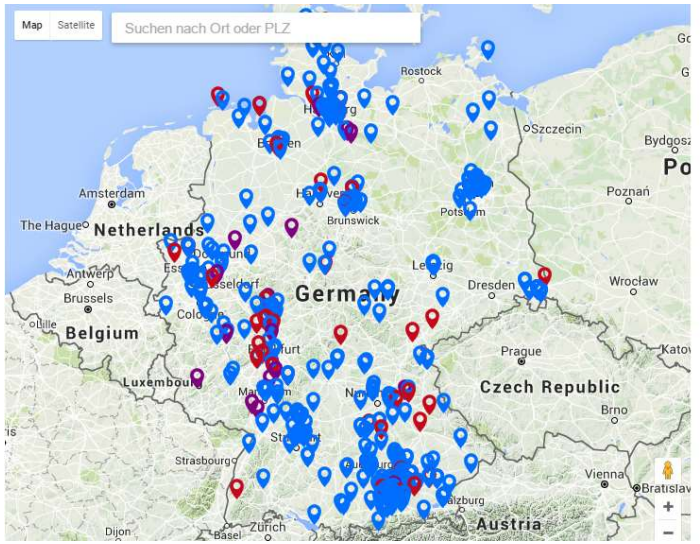
BTM technologies

- Zero Net Energy (ZNE) buildings
- Energy Storage Systems (ESS)
- EVs/electrified transport
- Trading platforms
- Virtual Power Plants (VPPs)
- Micro-grids, grid-parallel, grid-assisted
- Integrated energy services
- Aggregation, intermediation, optimization

Platforms

Millions of proactive prosumers with complex interactions

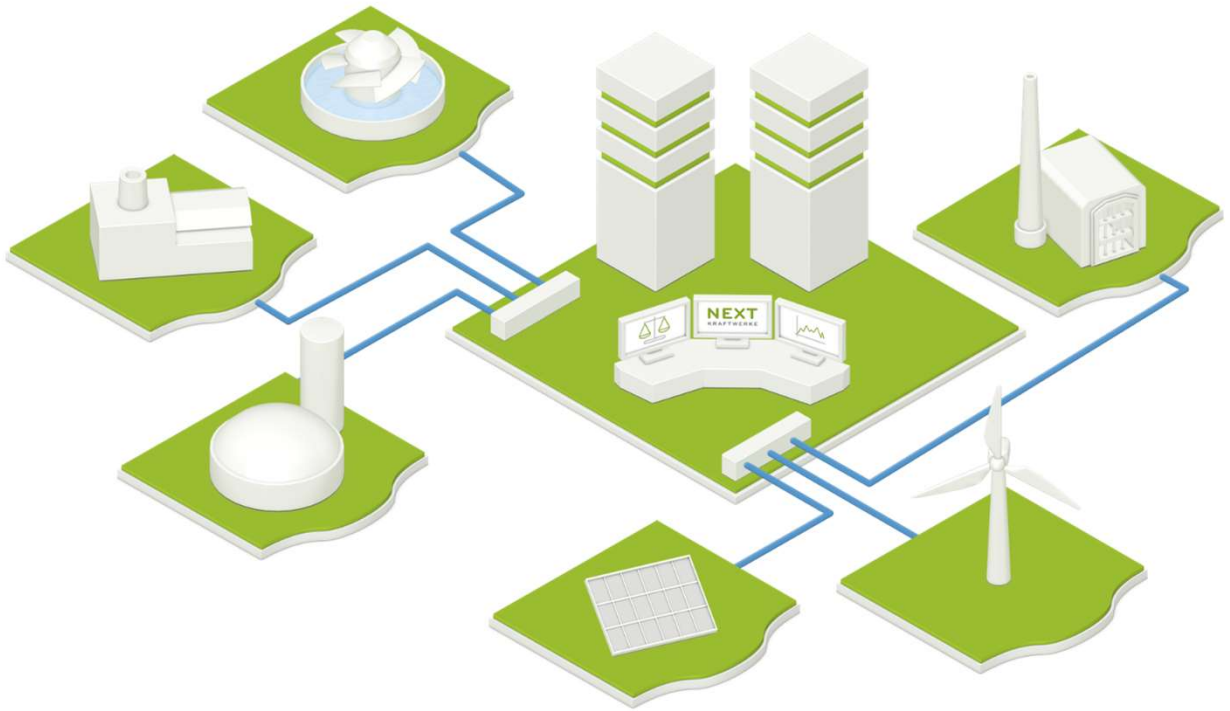




Value is in the platform

Virtual power plants

Germany's Next Kraftwerke: 4.5 GW, 5,400 participants

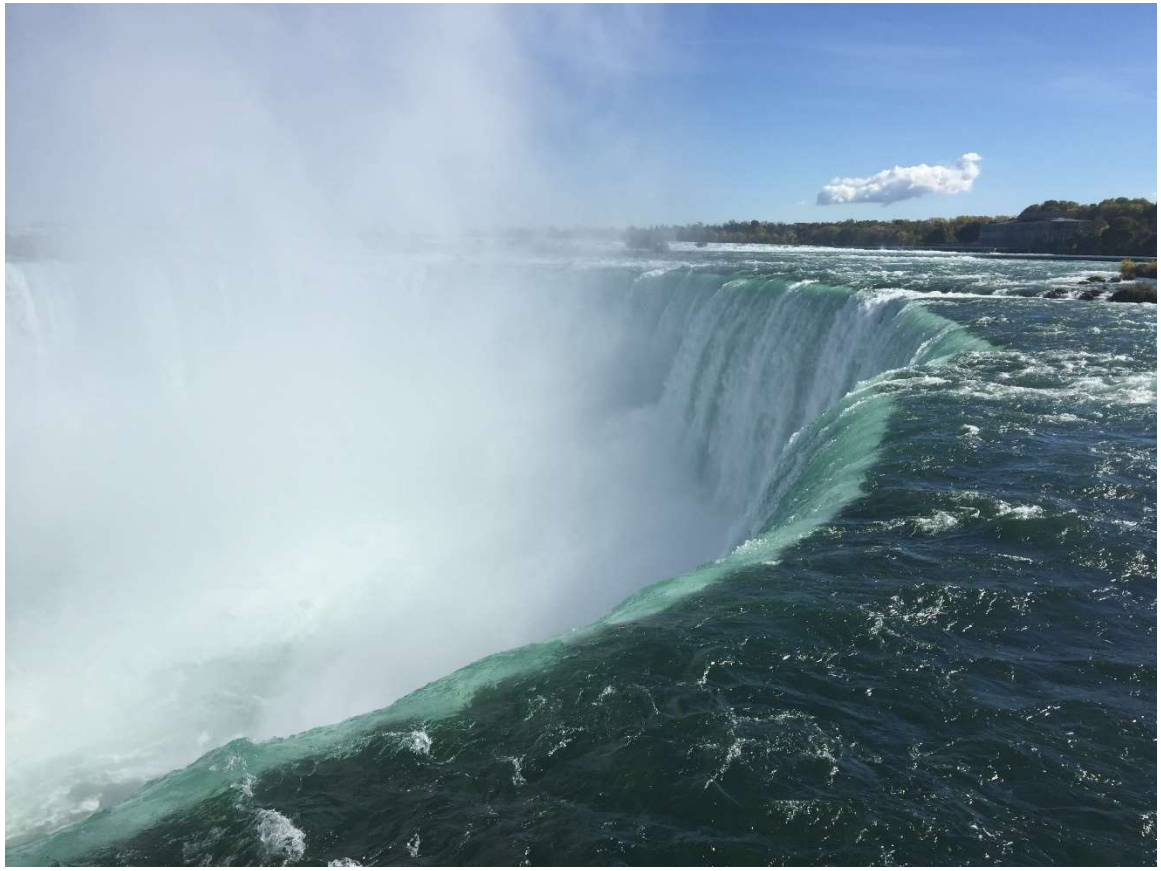


Source: Next Kraftwerke

Micro-grids

Where grid is unreliable as in Puerto Rico

Storage value proposition? Use it or lose it!



550 MW

Topaz Solar Farm, San Luis Obispo, CA

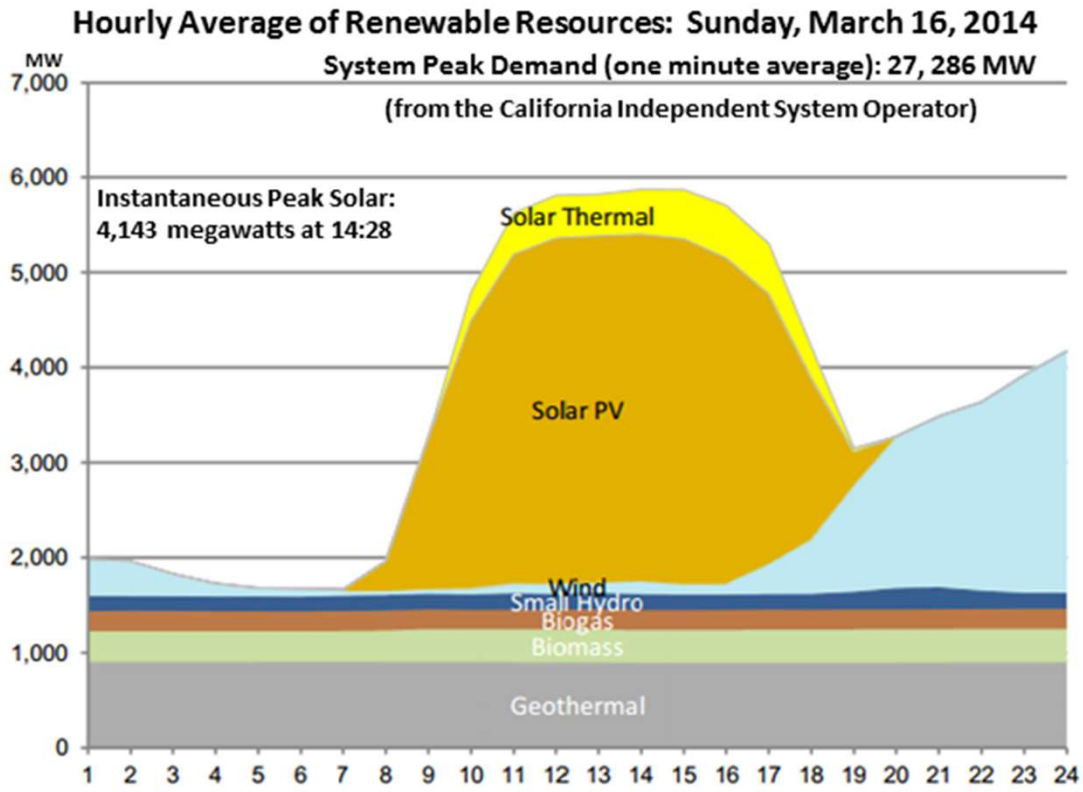
Proposed 2 GW CSP

Storage, not generation, makes it attractive

Source: SolarReserve

Mid-day sun = “over-generation”

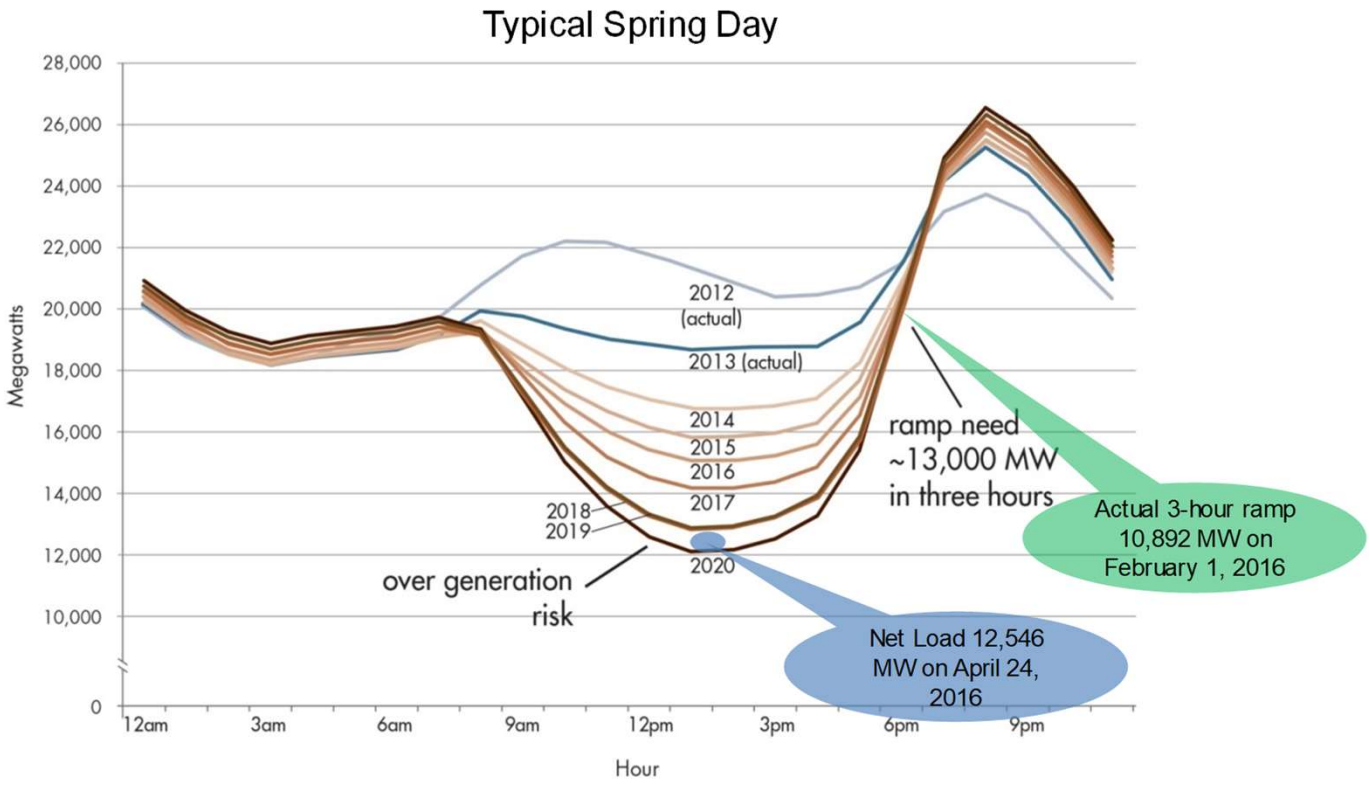
In many networks mid-day peaks have turned into troughs



Source: ISO

CA Duck Curve

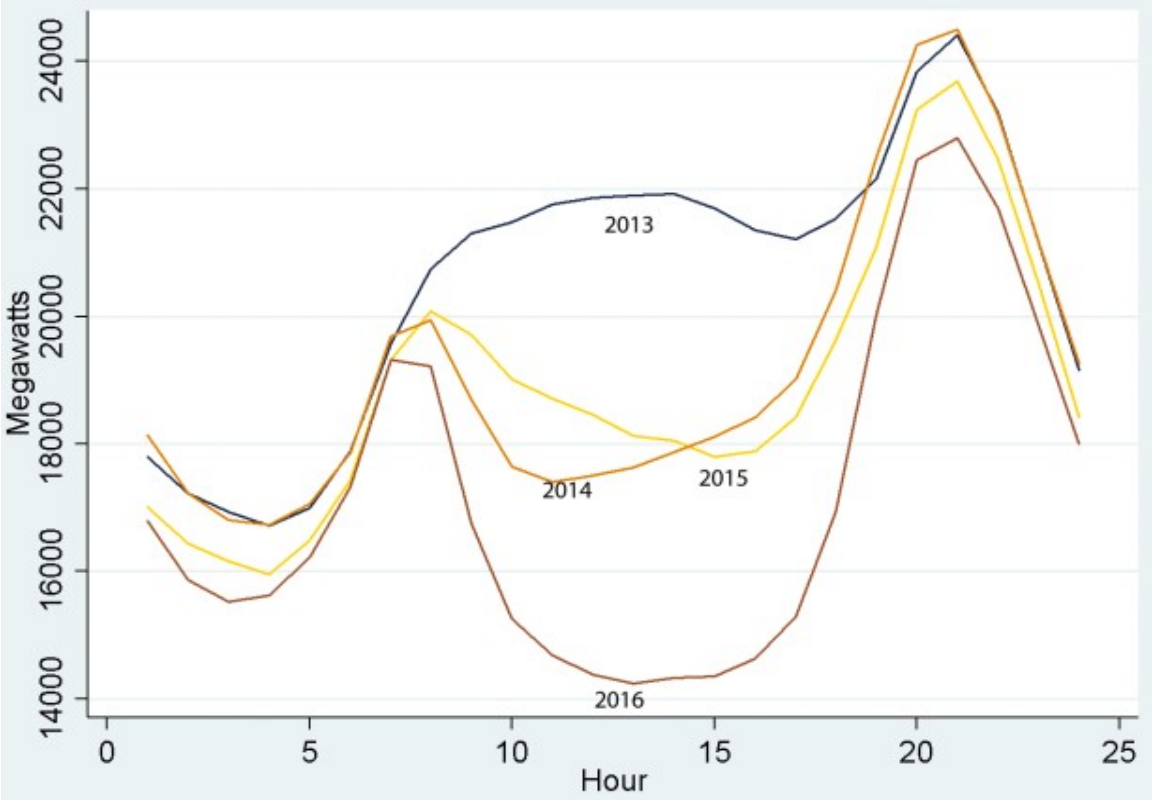
Mid-day dip instead of peak



Source: CAISO

“California Duck” arrived early

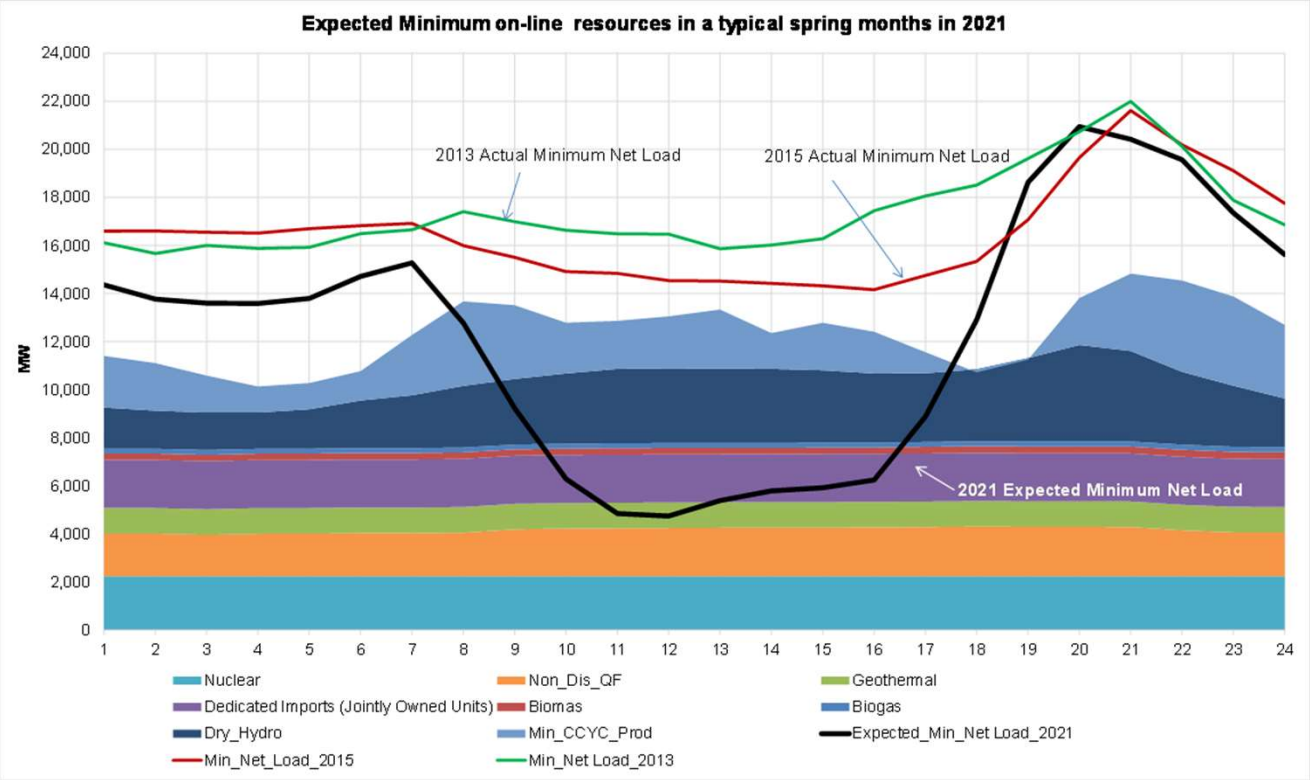
2020 projections realized in 2016



Data taken from CAISO website. Graph summarizes hourly data, 28 March – 3 April, 2013-16
Source: Blog posted by M. Fowlie, 2 May 2016

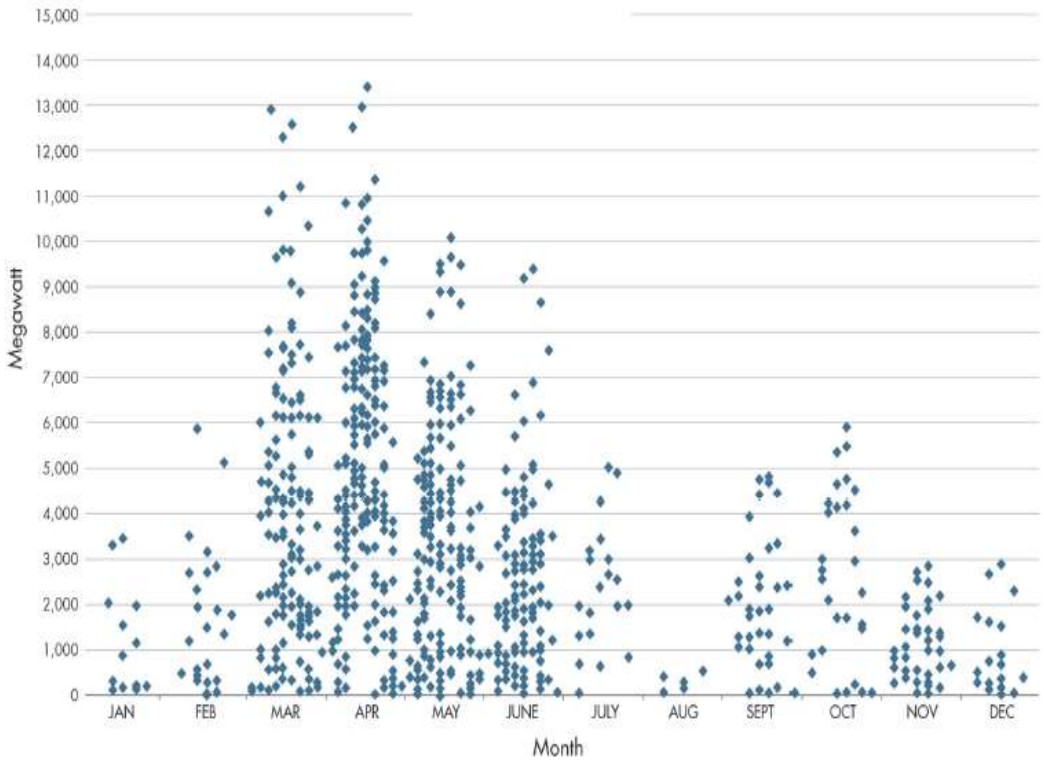
Baseload becomes a problem

Variable generation makes baseload a “nuisance”



California over-generation

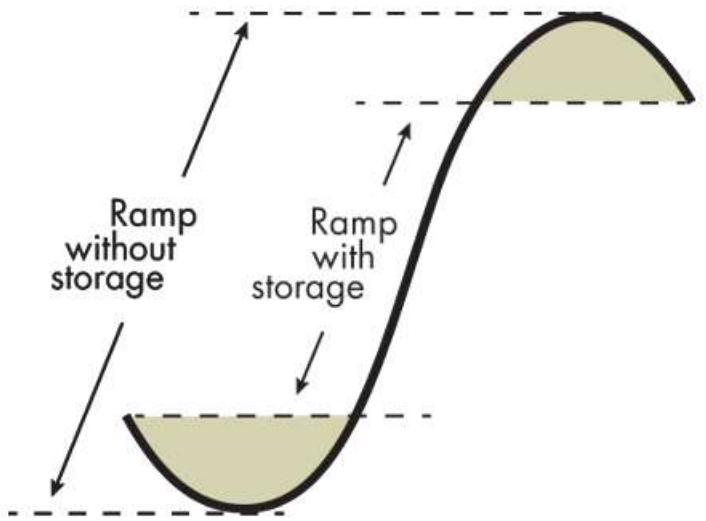
RPS Curtailment in 2024 under a hypothetical 40% RPS Scenario



Source: Notice of ex parte communication by CAISO, CPUC, 3 Dec 2014

Storage
Shave the peak, fill the valley

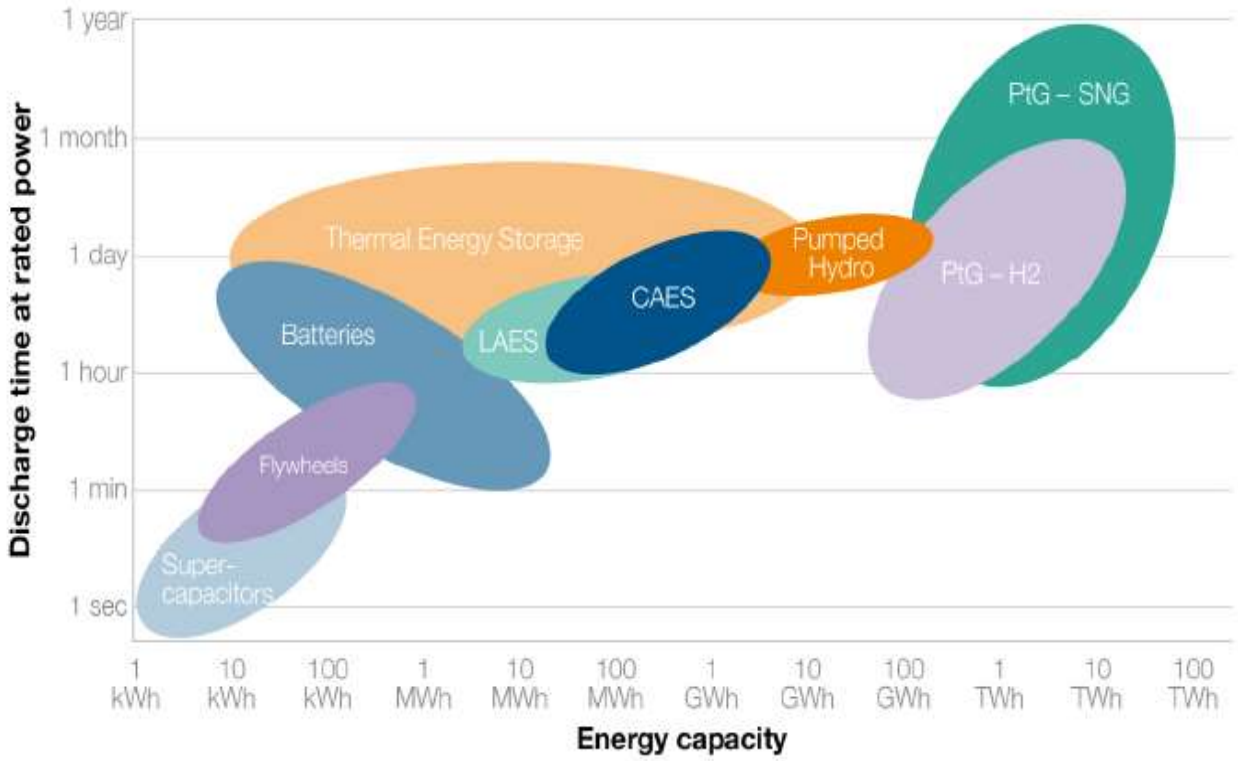
- California mandates utilities procure 1,325 MW of storage by 2020
- Ramping from trough to peak poses two challenges:
  - Having sufficient flexible ramping capacity
  - Potential over-generation at trough due to minimum output of generation needed to meet net load ramp
- Storage is a valuable ramping resource:
  - Reduces the net load ramp other resources must meet
  - Reduces over-generation because less generation needed on-line



Source: CAISO

Storage is more than batteries

From MWs & multiple MWhrs to kW & milliseconds



Source: World Energy Council, E-Storage: Shifting from cost to value, 2016

Observations?

- What actually lies BTM?
  - Billions of devices
  - Worth trillions of dollars
  - Infrequently & poorly utilized, not integrated
- What can be done with these assets?
  - Enabled to play a proactive role in balancing load/demand
- How?
  - With great deal of difficulty
  - Daunting scale, razor thin margins
  - “Transaction costs will eat you alive”

Customer stratification

Over time, consumers will self-select what works best