

# **Innovation, disruption & transformation** at the grid's edge

## **8<sup>th</sup> Elecpor Conference**

4 November 2016

Lisbon, Portugal

**Fereidoon P. Sioshansi, Ph.D.**

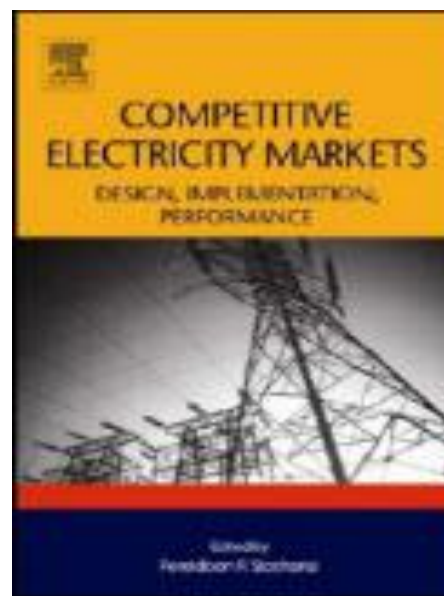
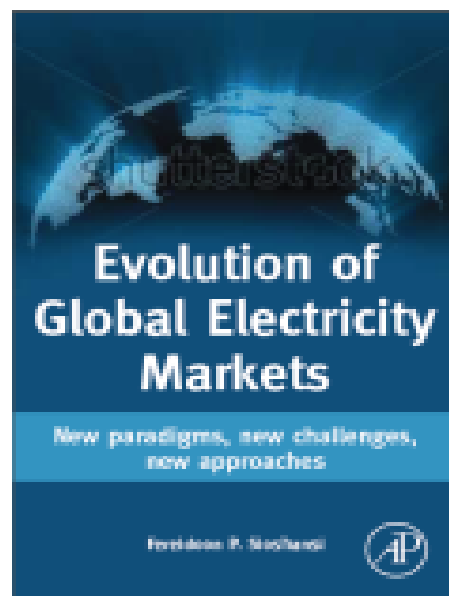
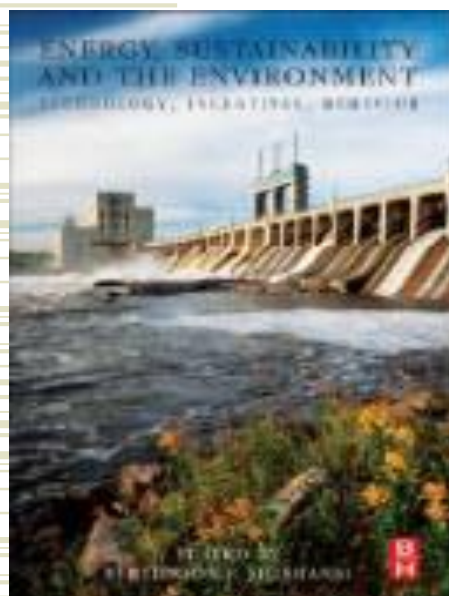
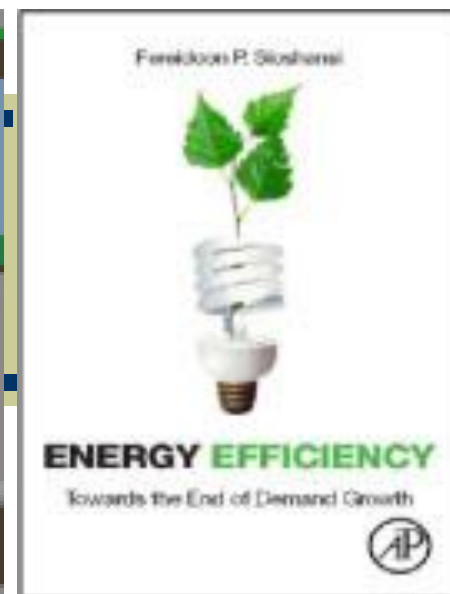
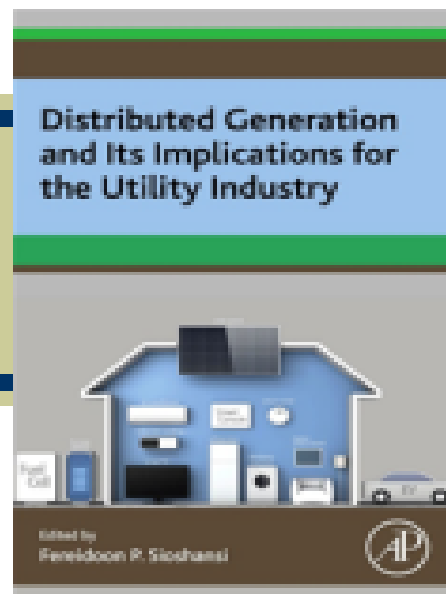
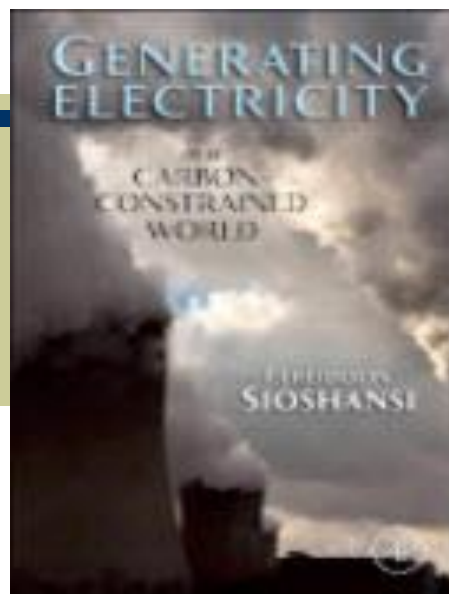
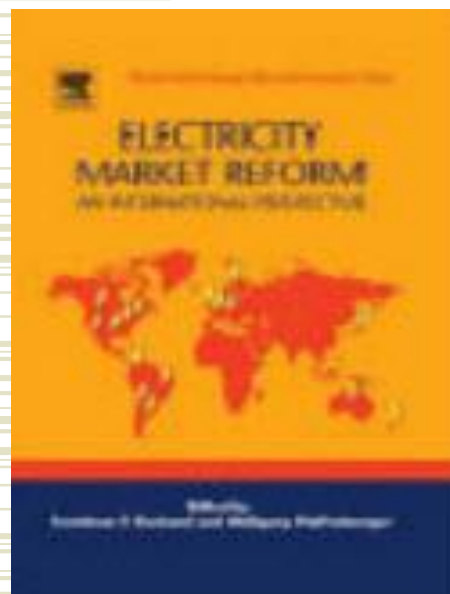
**Menlo Energy Economics**

San Francisco CA

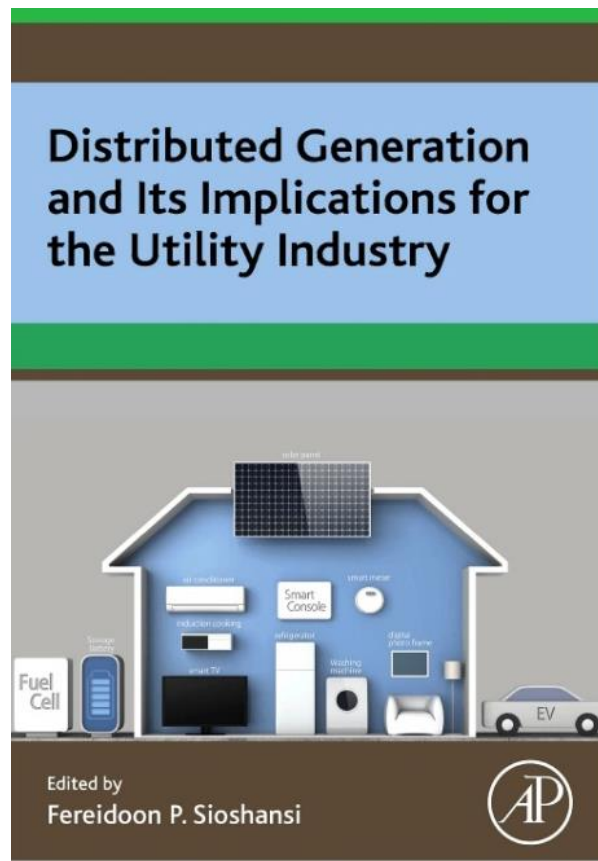
[www.menloenergy.com](http://www.menloenergy.com)

# Thank you Elecpor ...

- ◆ ... for invitation to speak ...
- ◆ My views are California-centric
  - Aim to be provocative ... to compare & contrast ...
  - ... but NOT to suggest that California has got it right ...
- ◆ Why “innovation, disruption & transformation?”
- ◆ Why “the grid’s edge?”
- ◆ Why important?
  - Serious implications for industry incumbents/regulators
  - Hopefully will fit the following presentation by EDP



# New business, new business model



# Outline

- ◆ Energy transformation
- ◆ Power sector mega trends
  - Demand
  - Prosumers
  - Prosumage
- ◆ Implications
- ◆ Relevance to Portugal?

# Energy transformation?

- ◆ Uber, worth \$70 billion, offers driverless rides in Pittsburg, PA
- ◆ Ford to introduce driverless car in 2021
- ◆ RMI: US car ownership to peak in 2020
- ◆ 5 of top 10 global listed companies are virtual
- ◆ Renewables beat natural gas 70 to 1 in 1<sup>st</sup> Qtr. 2016 in US
- ◆ Record renewable investment despite low oil prices in 2015
- ◆ Renewables grow from 7 to 32% in 15 years in Germany
- ◆ Over 1 million solar roofs in Australia, 5 GW in CA
- ◆ Solar generation in 2016 to exceed coal in UK
- ◆ Coal consumption has peaked in China
- ◆ CA & NY 50% renewable by 2030, 100% in HI by 2045

# UberWorld



Source: The Economist, 17 Sept 2016

# Hard to believe but true

- ◆ ZNE: Buildings that need no energy
  - CA mandate for new residential in 2020, 2030 for commercial
  - Windows & roofs that produce energy!
- ◆ From buildings to communities
- ◆ Supercapacitors recharge in 90 seconds
- ◆ Peer-to peer electricity trading
- ◆ Solar power at 2.4 cents/kWh in UAE
- ◆ A world powered by “free” renewables
  - Plane flying around the world w/o fuel



# Zero Net Energy

CA 2020 mandate for new residential, 2030 commercial



# Solar roofs

Makes no sense to build a roof and add solar panels



# Solar windows & side panels

Sun shines not just on the roofs



Source: Lawrence Berkeley National Laboratory's FLEXLAB

# Queen Victoria era train station

Kings Cross, London





# PV panels integrated in roof

Future of buildings is BIPV



# ZNE Village

West Village, Univ. CA Davis





# Future is Zero Net Energy

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



Source: NREL

# Solar shading

Charge them from the sun







# Drivers of change?

- ◆ Millennials: An entirely different species
- ◆ Shared economy, virtual enterprise
- ◆ Digitization & “third wave”
- ◆ Rise of renewables
  - Free electrons
- ◆ Re-inventing mobility
  - No driver, no wheel, no brake or gas pedal and **no gas!**
- ◆ COP21: Paris agreement is ratified
  - Phase out of fossil fuels & “**ethical**” investing

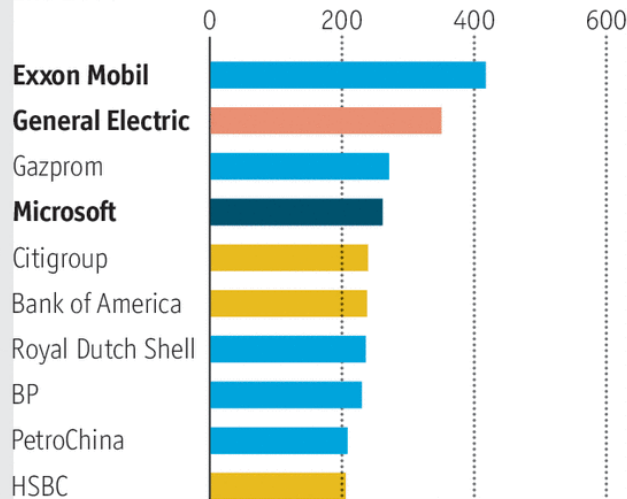
# A Virtual New World

## A virtually new world

World, largest listed companies by market capitalisation, \$bn

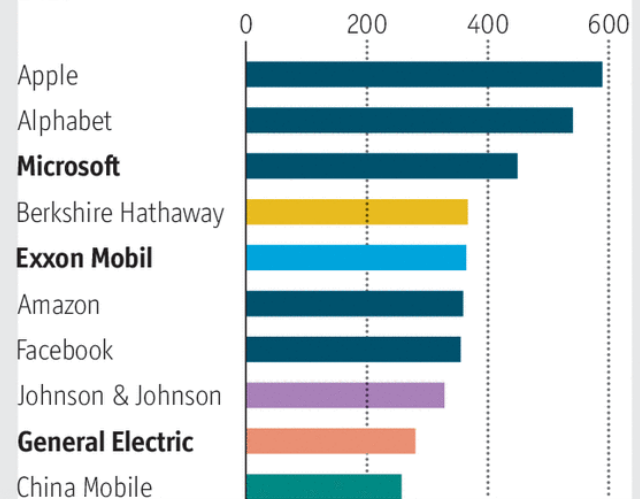
Sector: Energy Financials Health care Industrials IT Telecoms

End 2006



Source: Bloomberg

2016\*



\*At August 24th 2016

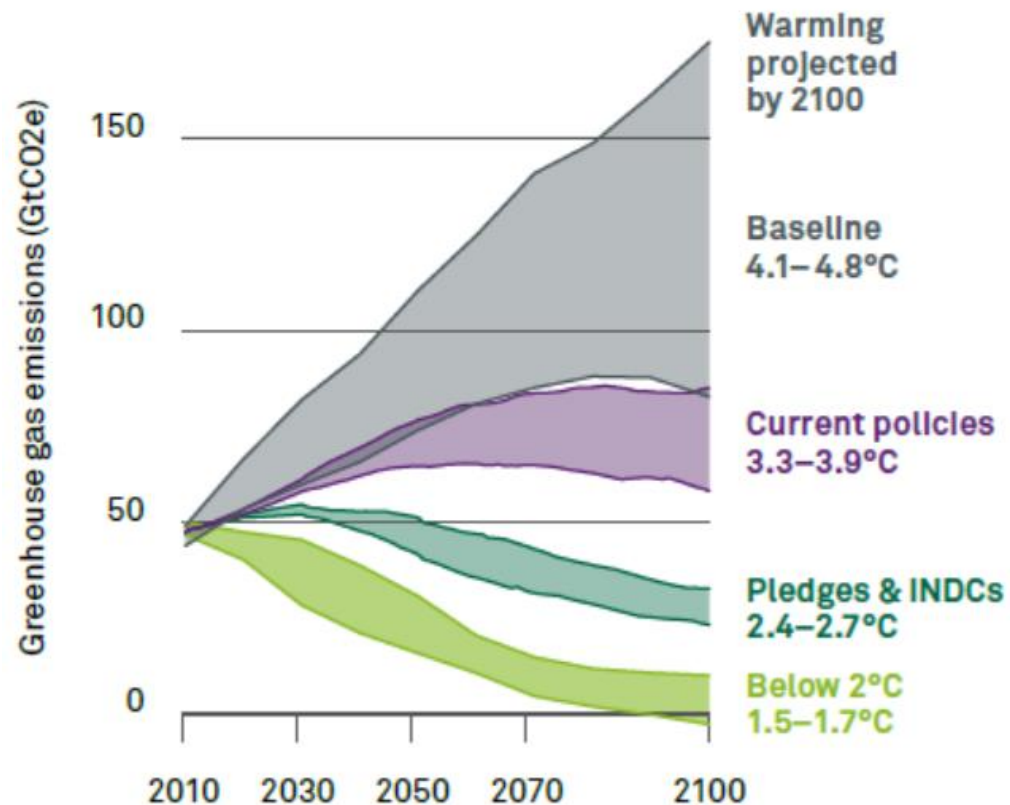
Economist.com

Source: The Economist, 17 Sept 2016

**No wheels, no brake, no gas  
pedal & no gas**



# Carbon diet



Source: Adapting portfolios to climate change, BlackRock, Sept 2016

# Power sector mega trends

Happening within OECD

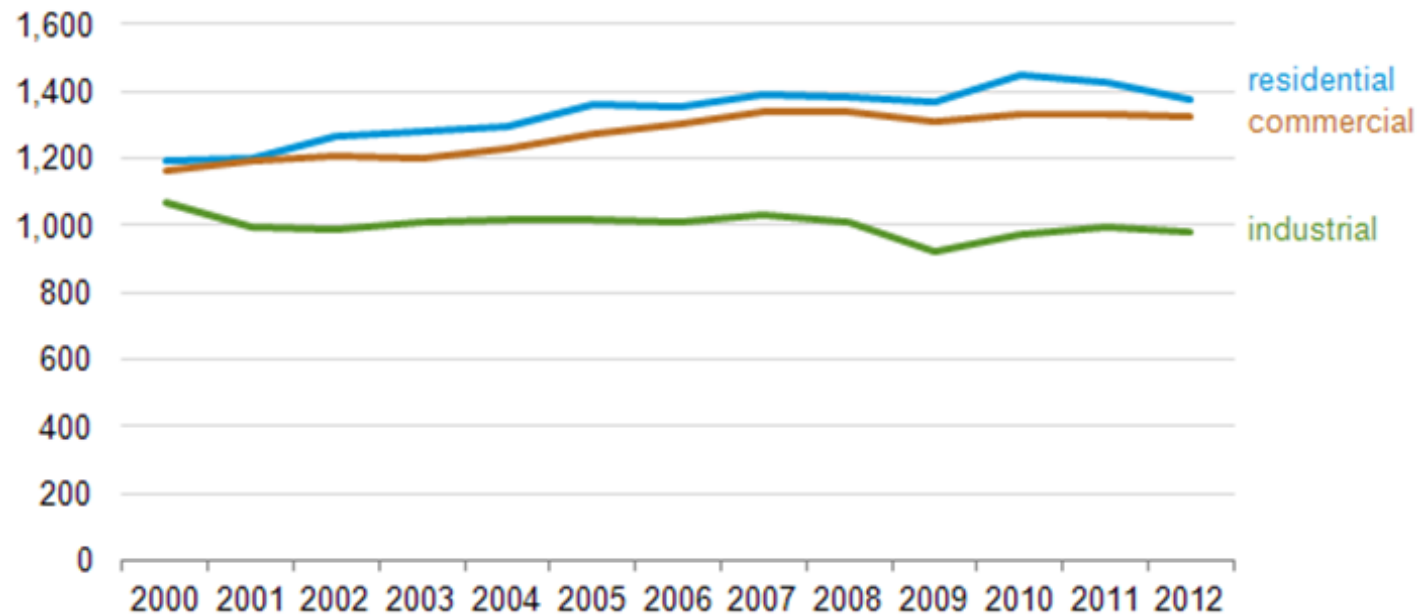
- ◆ End of demand growth
- ◆ Consumer => prosumer
- ◆ Prosumer + storage => “prosumage”

# First

## Forget demand growth

Annual retail electricity sales by sector (2000-12)

terawatthours



Source: Americans are buying less electricity. That's a big problem for utilities Brad Plumer, The Washington Post, 23 Dec 2013 based on data from EIA

# NY's experience typical

Period	Avg. sales growth for period
1966-76	3.8%
1976-86	1.5%
1986-96	1.4%
1996-2006	0.9%
2003-2013	0.3%
2014-2024	0.16%

Source: NY Pub Service Commission, 26 Feb 2015

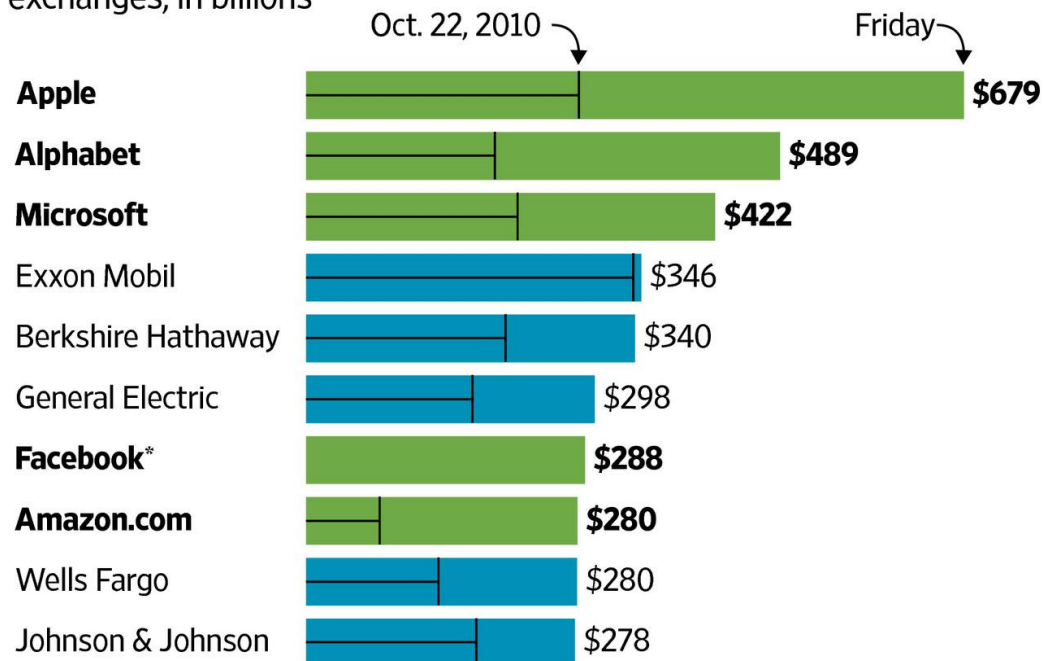


# America's top 10

Half are “virtual” & growing

## Tech Titans

Top 10 companies by market capitalization listed on U.S. exchanges, in billions

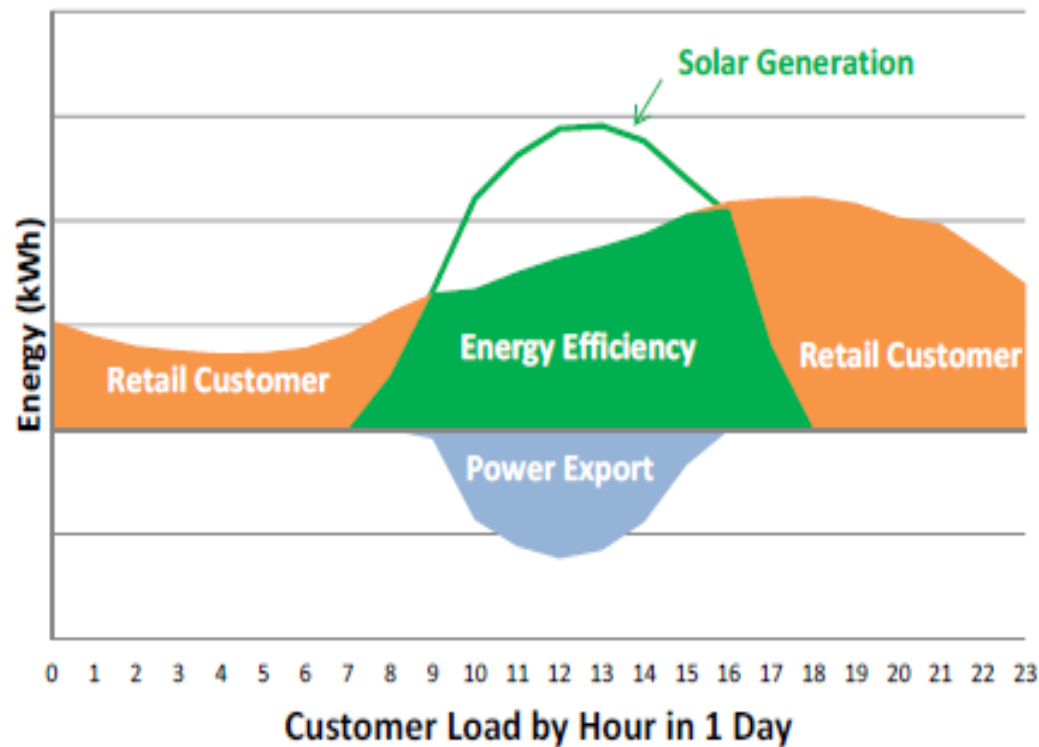


\*Facebook was not public 5 years ago Source: FactSet

THE WALL STREET JOURNAL.

# Second

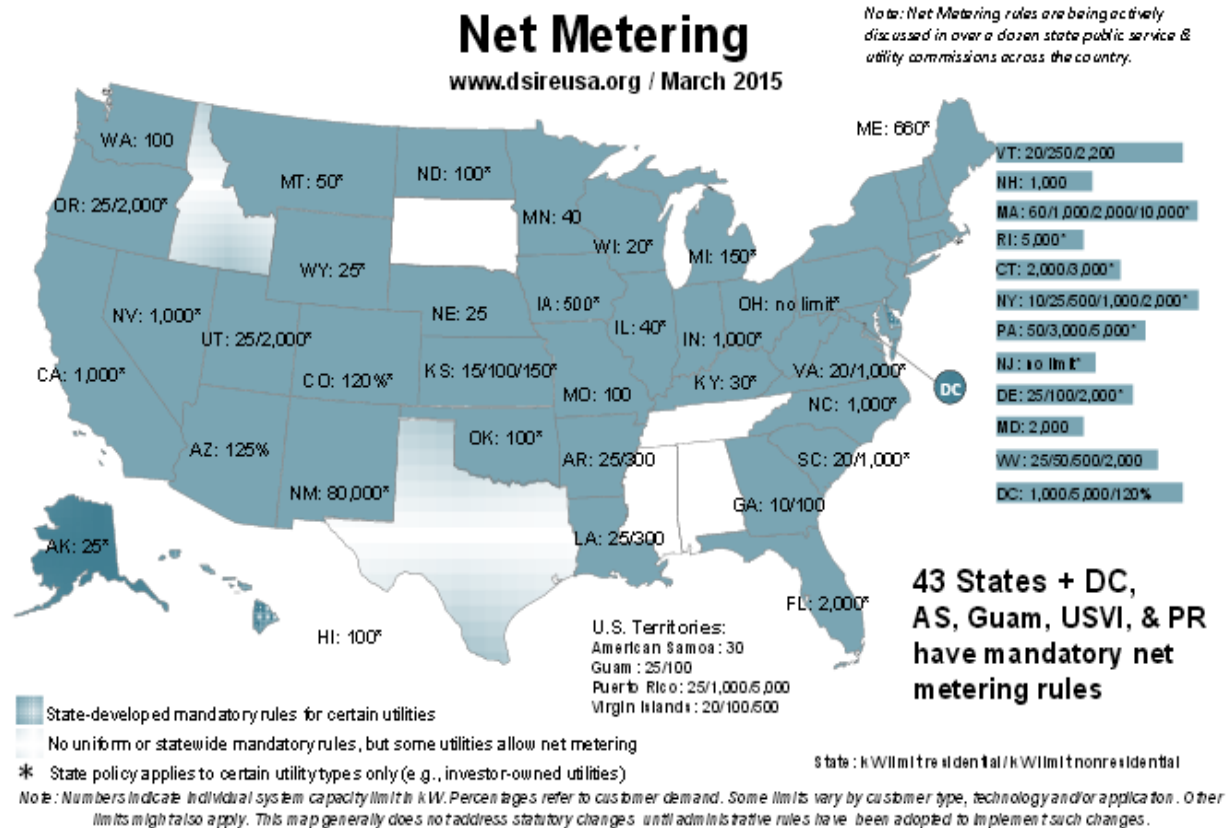
## Consumers => Prosumers



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

# Net Energy Metering (NEM)

Current net energy metering schemes, subject to change w/o notice



Source: Database of State Incentives for Renewables & Efficiency (DSIRE)

# Disruption: Solar leasing

An offer few customers can refuse

**Home Solar  
Rebates**

Lower Your Electric Bills By  
Going Solar!

Before	After
 <b>Account Summary</b> Bill for 09/16/15 -\$314.23 Payment Received 09/20/15 -\$314.23 Bill for 10/16/15 -\$303.91 Payment Received 10/19/15 -\$303.91 <b>Monthly Bill \$303.89</b>	 <b>Account Summary</b> Bill for 09/16/15 -\$30.15 Payment Received 09/20/15 -\$30.15 Bill for 10/16/15 -\$26.55 Payment Received 10/19/15 -\$26.55 <b>Monthly Bill \$69.10</b>

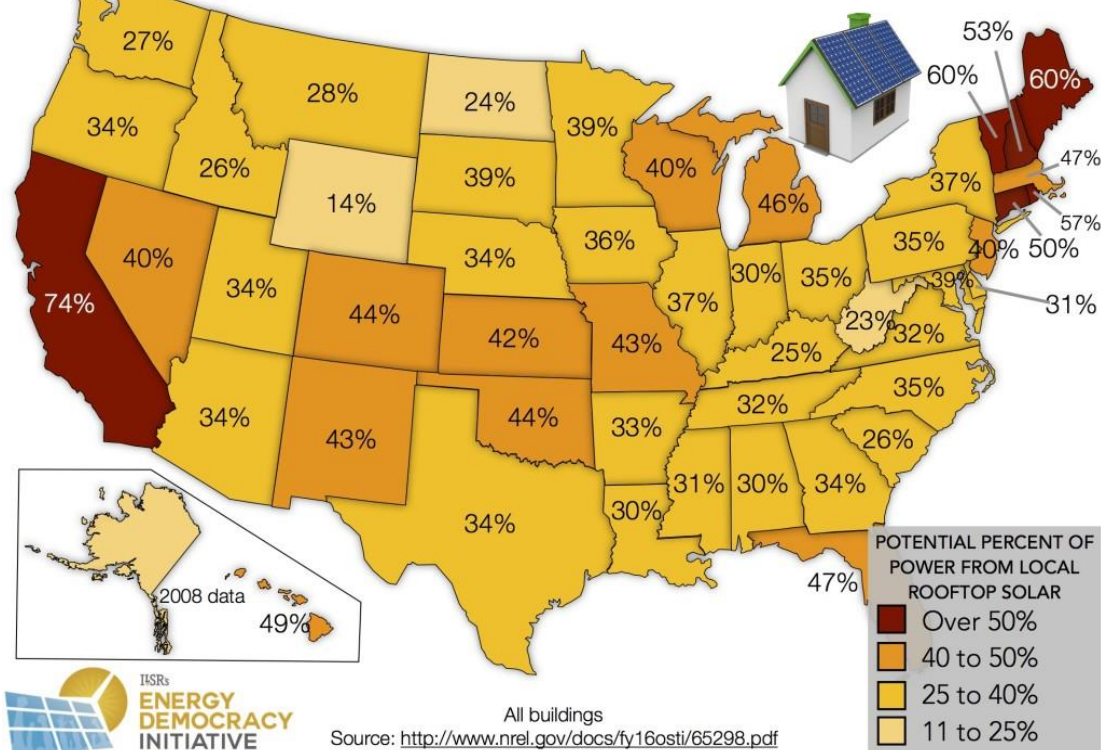
**Find out how much you can save today!**

- ✓ Limited-Time 2015 Solar Rebates Available Now
- ✓ \$0 Down Leasing for Qualified Homeowners
- ✓ Protect Against Rising Energy Costs

**Click Here For FREE Quotes**

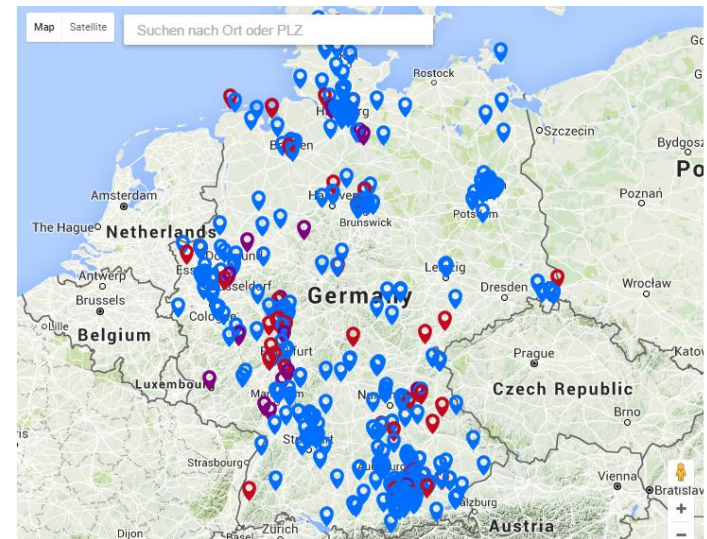
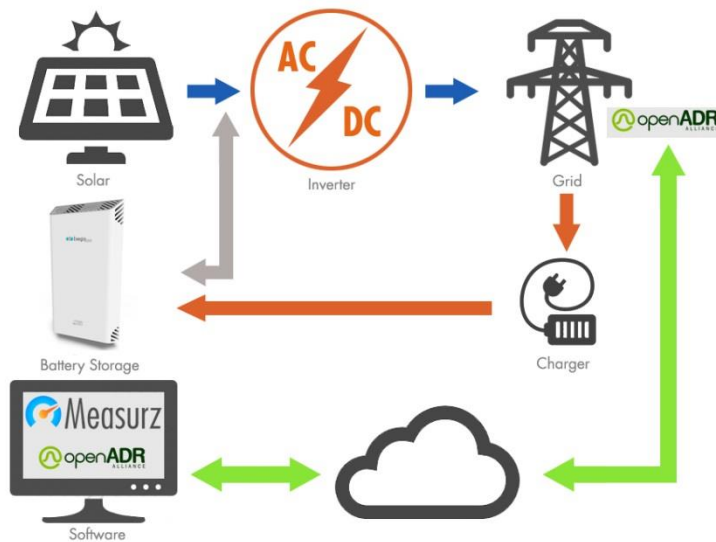
# Rooftop energy

## ROOFTOP SOLAR POTENTIAL 2016



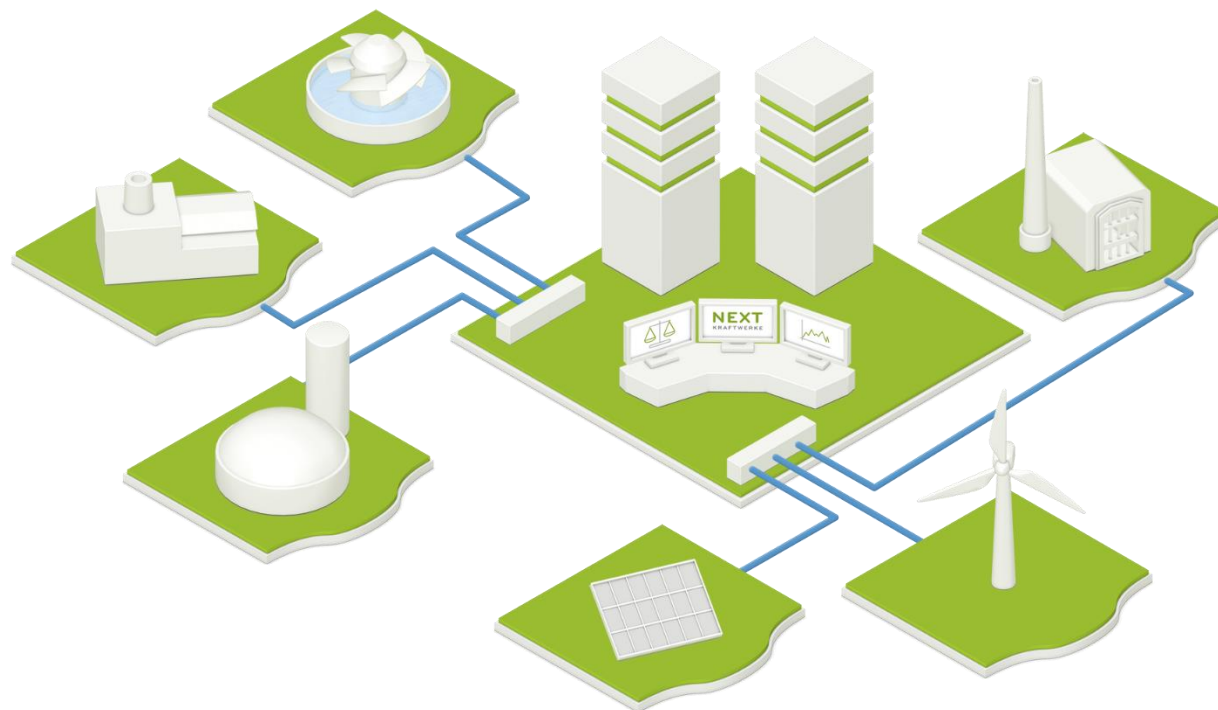
Source: John Farrell, Institute for Local Self-Reliance

# Third Prosumer + Storage = Prosumage



# Virtual utilities

## Germany's Next Kraftwerke shows the future



Source: Next Kraftwerke

# Implications?

- ◆ Assume disruption
- ◆ Variable supply => Flexible demand
- ◆ Rethink strategy



# Questions

- ◆ How are US utilities reacting to lost revenues?
- ◆ Are US utilities “unbundled?”
- ◆ What about *consumers* subsidizing *prosumers*?
- ◆ Role of regulators?
- ◆ Status of net energy metering?
- ◆ Retail price vs. credit for feeding the grid?
- ◆ Peer-to-peer energy trading?
- ◆ Who pays for the grid?
- ◆ Smart meter penetration?

# Strategy?

- ◆ Let's start from the bottom of list
- ◆ What is the future of utilities ...
- ◆ ... or utilities of the future?

# New electric company: Your home

Wall Street Journal 21 Jan 2015



# Big customer, no revenues

Apple's new office building under construction in Cupertino, CA



# What future?

Different strokes for different folks

- ♦ Utility as “service integrator”
  - Edison Energy focused on “energy as a service”
- ♦ Solar leasing: AGL Australia
- ♦ Battery leasing: Green Mountain Power
- ♦ EV charging infrastructure: California IOUs
- ♦ Demand Response: Next Kraftwerke
- ♦ Home Energy Management: Nest
- ♦ P2P trading among prosumers: Open Utility

# **The Future of Utilities** **Utilities of the Future**

How technological innovations in distributed energy  
resources will reshape the electric power sector

Fereidoon P. Sioshansi, Editor



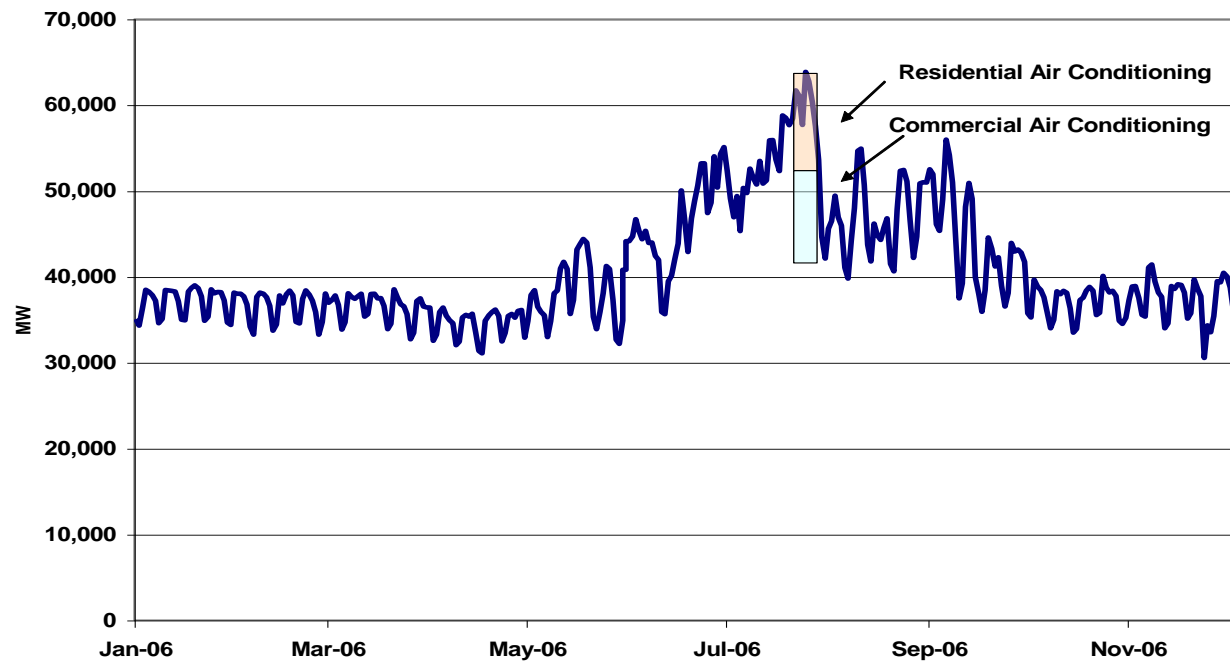


# Innovation & disruption?

- ◆ No longer **if**, but when & how
- ◆ Why?
- ◆ Power sector ripe for “disruption”
- ◆ Vast, under-utilized infrastructure
- ◆ Business model fit for Thomas Edison

# Peak load in CA

summer peaks are aggravated by AC load



Source: David Hungerford, CEC

# Tesla Car



Source: CAISO Discussion of Markets, Mark Rothleder, 3 June 2014

# Google



# Face of disruption

Will Tesla's Powerwall usher in prosumage?



Source: The Wall Street Journal 2 May 2015

# Tesla's giga factory





# Batteries made under solar roof

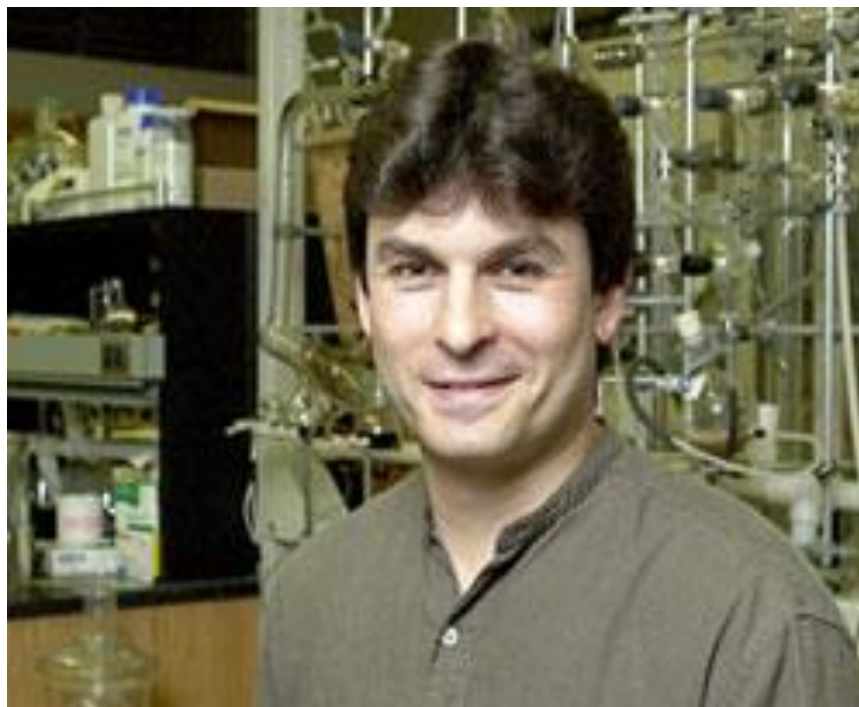
Recently completed in Reno. NV



Tesla Gigafactory under construction, by Bob Tregilus (CC BY-NC-SA 4.0)

# Next: Supercapacitors

UCLA Prof. Richard Kaner



Source: [www.chem.ucla.edu/dept/Faculty/kaner/images](http://www.chem.ucla.edu/dept/Faculty/kaner/images)

# Electric bus

Supercapacitors will revolutionize mass transit



Source: [Solaris Urbino 12](#) electric from Braunschweiger Verkehrs-GmbH (Germany)

# **Variable supply => Flexible demand**

- ◆ Requires new mindset

# 550 MW

Topaz Solar Farm, San Luis Obispo, CA





# BrightSource

392 MW Ivanpah CSP



Source: California Energy Commission (CEC)



# Rooftop power generators

5 GW in CA and counting

**Residential Retrofit**



**New Production Homes**



**Commercial & Public**



**Power Plants**



# Walking around neighborhood

One in 3 homes are solar in sunny suburbs of CA





# Not just for self-consumption

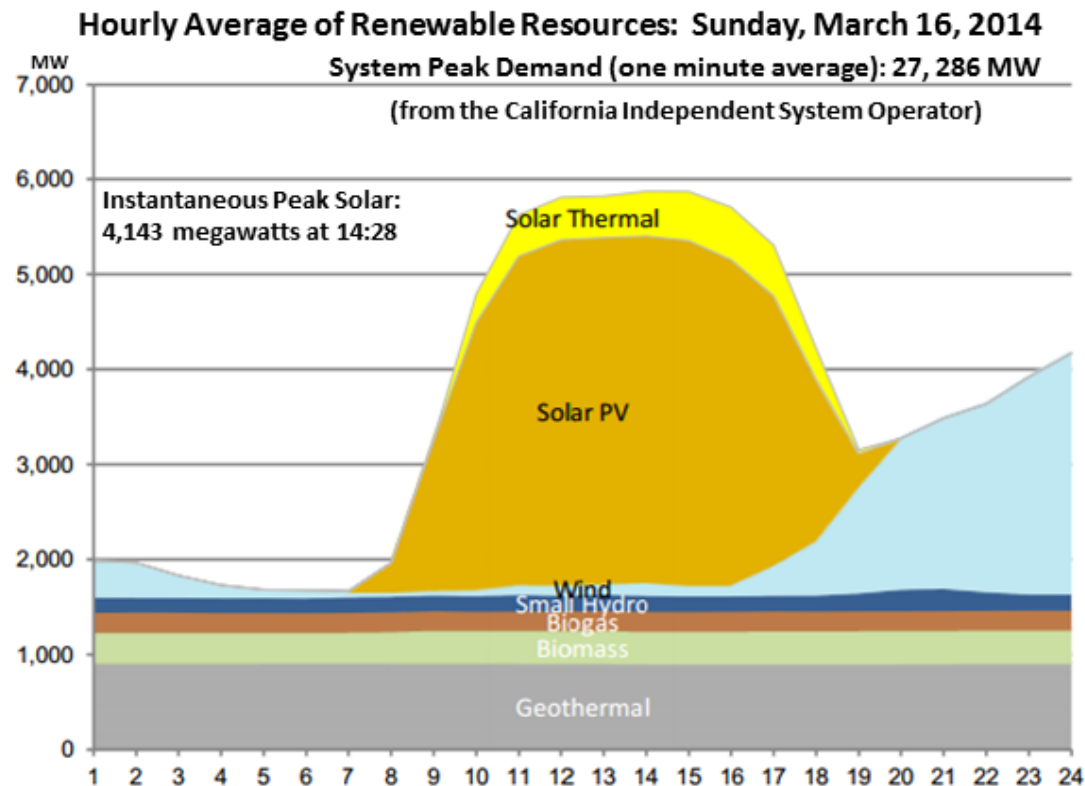


**Add solar hot water too**



# Mid-day sun = “over-generation”

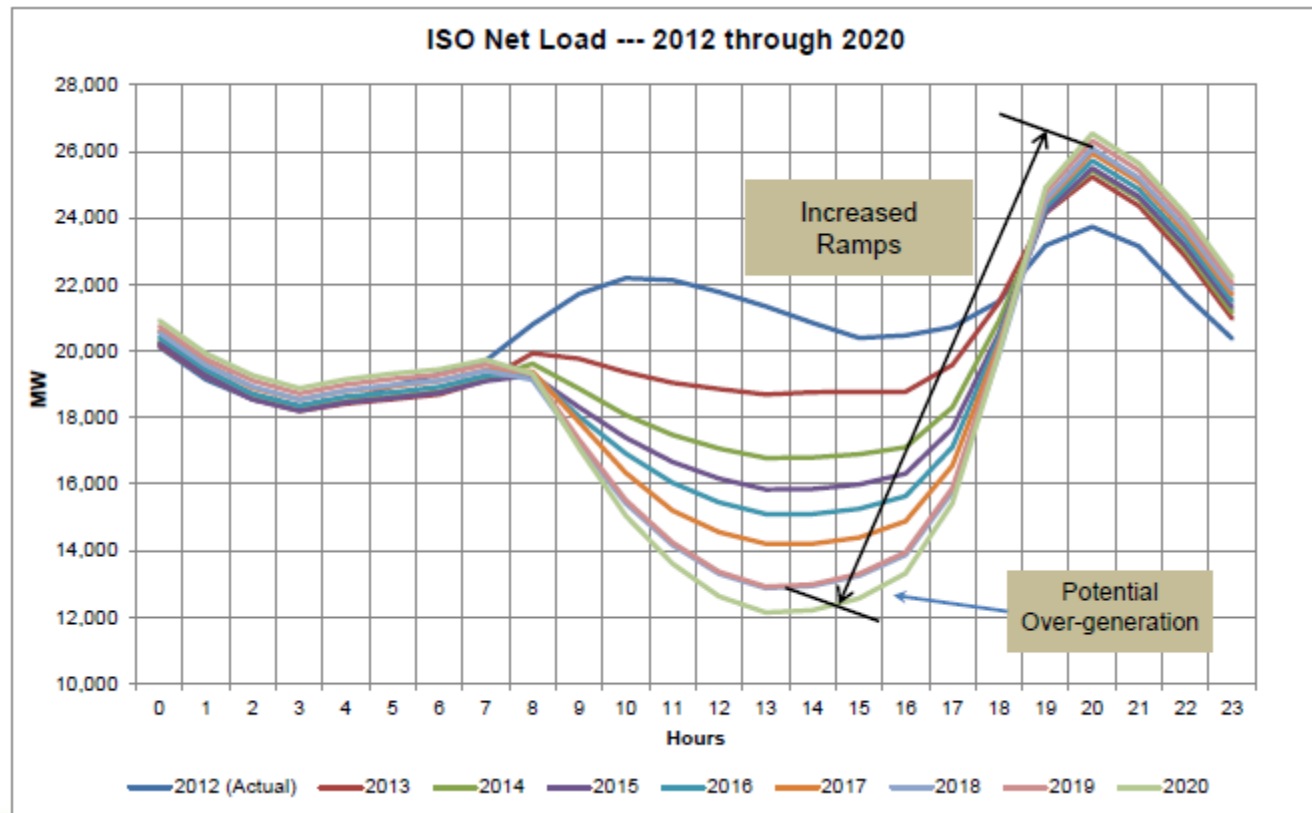
In many networks mid-day peaks have disappeared



Source: ISO

# CA Duck curve

ISO's net load projection for 2012 through 2020

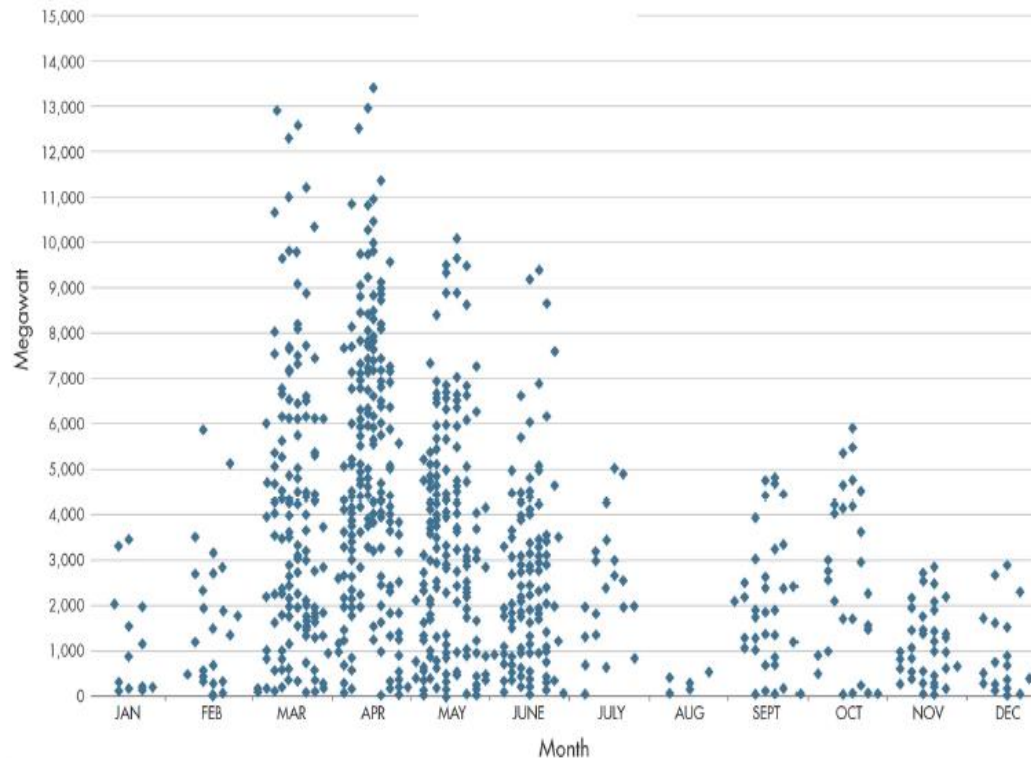


Source: CAISO Discussion of Markets, Mark Rothleder, 3 June 2014



# 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

# CAISO

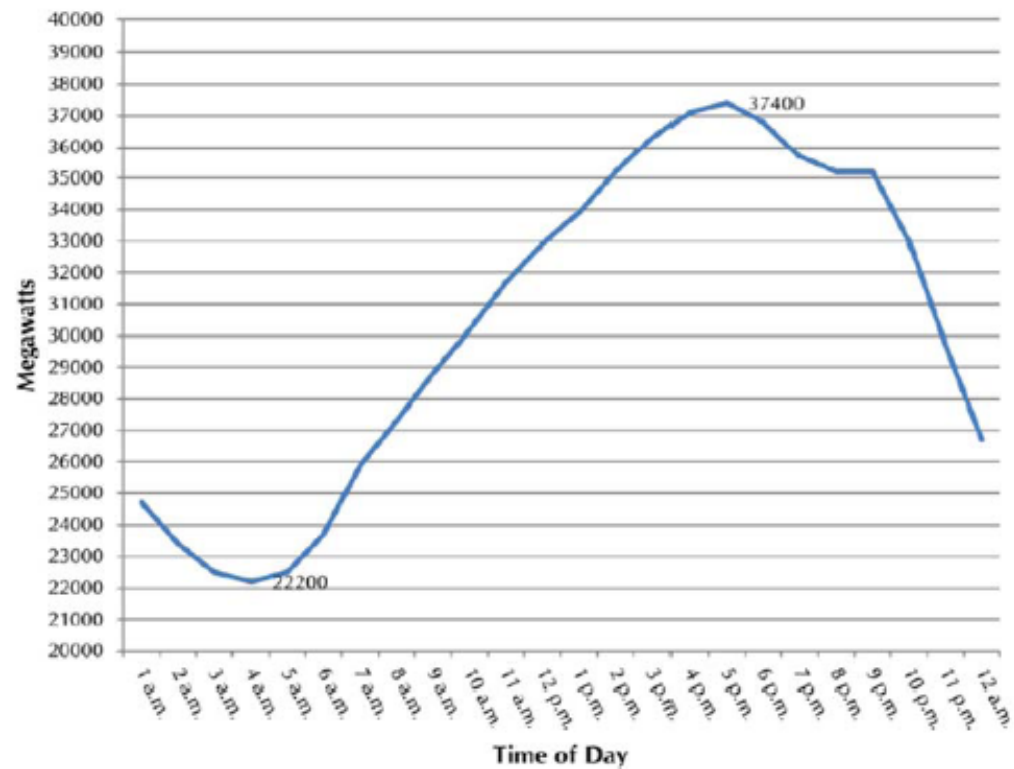
Is this a dispatch center or weather forecasting station?



Source: CAISO

# Demand

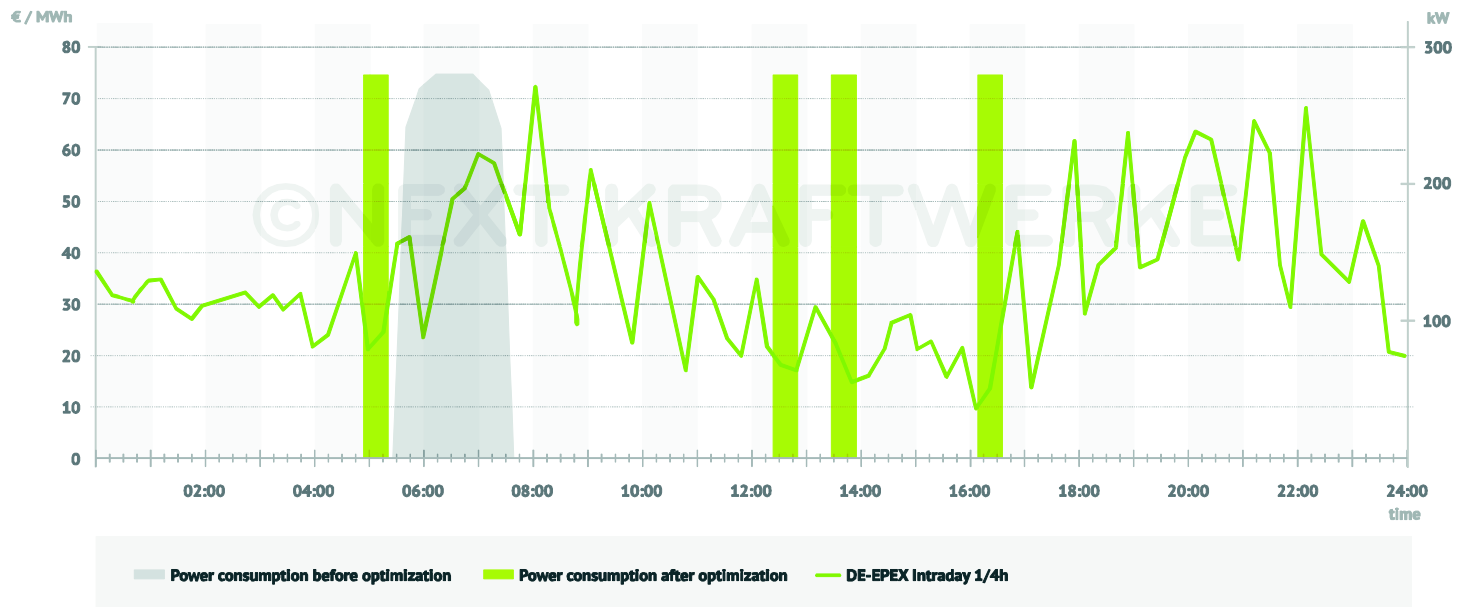
Historical CA demand pattern



Source: Rewiring California: Integrating agendas for energy reform, Little Hoover Commission, Dec 2012

# Flexible demand

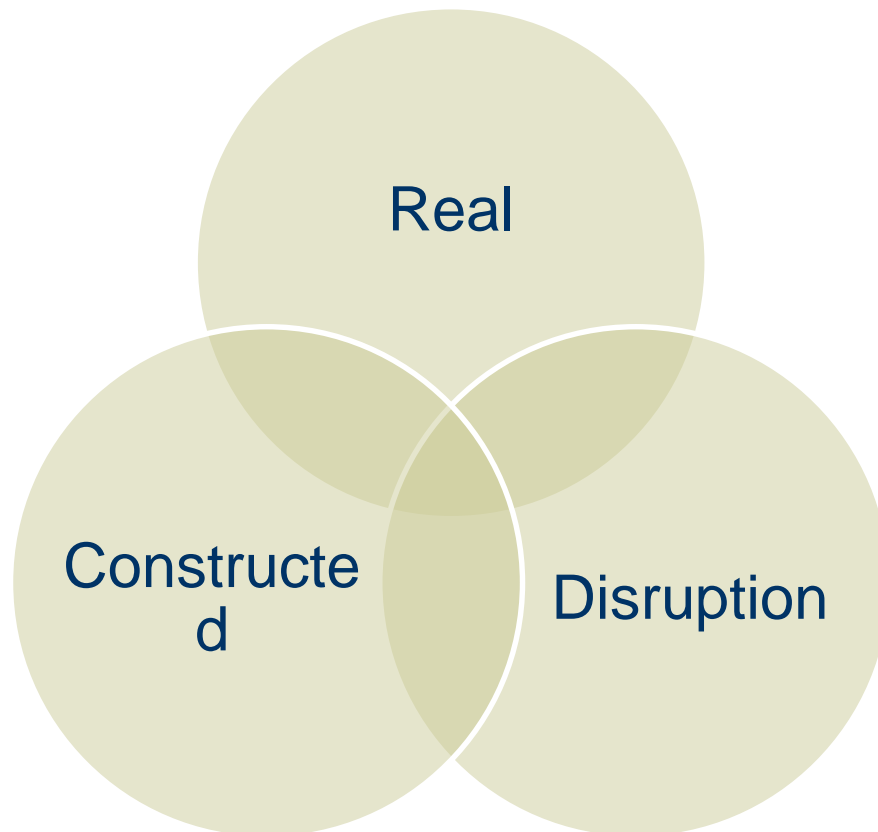
## Demand Side Management with Flexible Electricity Rate



Source: Next Kraftwerke

# Outcome?

Confluence of 3 factors



# Biggest uncertainty?

Reading the regulator's mind





# Role of regulators?

NY or CA? Market-driven or micro-managed?

## CPUC Commissioners:

President

**Michael Picker**

[More](#)



Commissioner

**Mike Florio**

[More](#)



Commissioner

**Catherine J.K. Sandoval**

[More](#)



Commissioner

**Carla J. Peterman**

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Commissioner

**Liane M. Randolph**

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**Department of  
Public Service**



Audrey Zibelman, Chair



Patricia L. Acampora

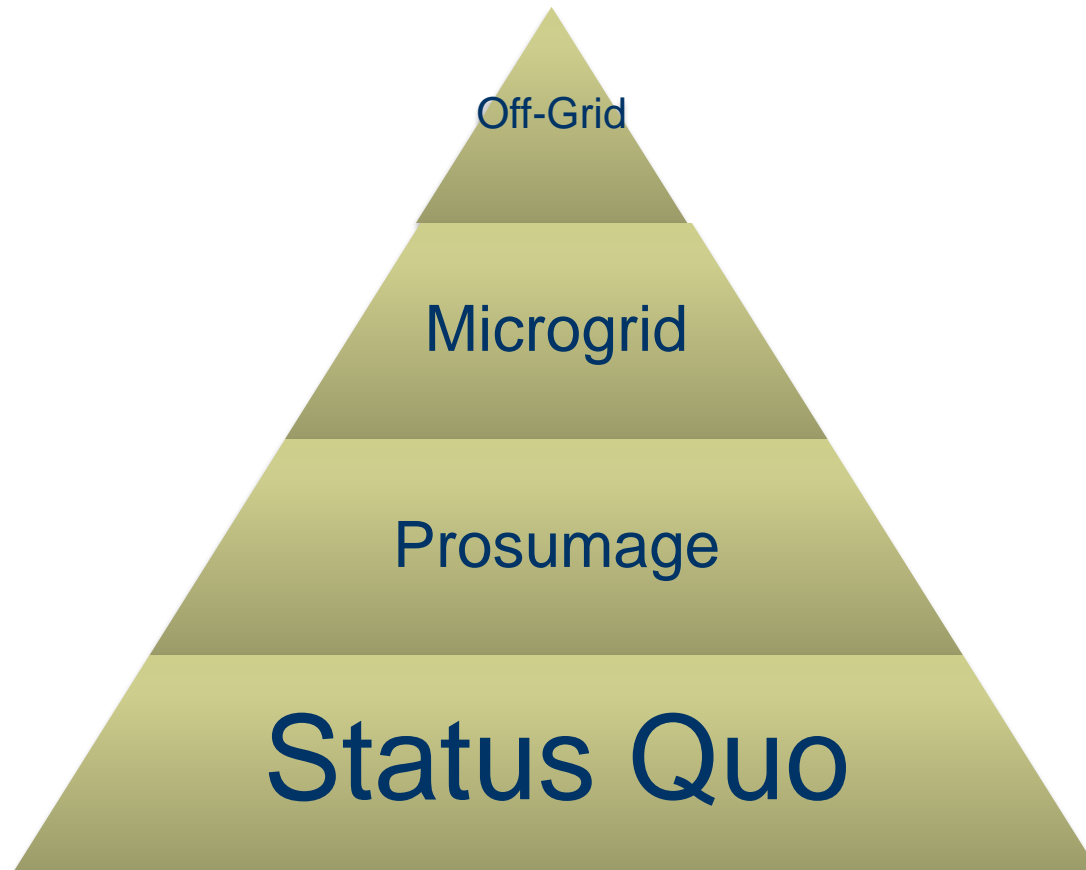


Gregg C. Sayre



Diane X. Burman

# Customer pyramid



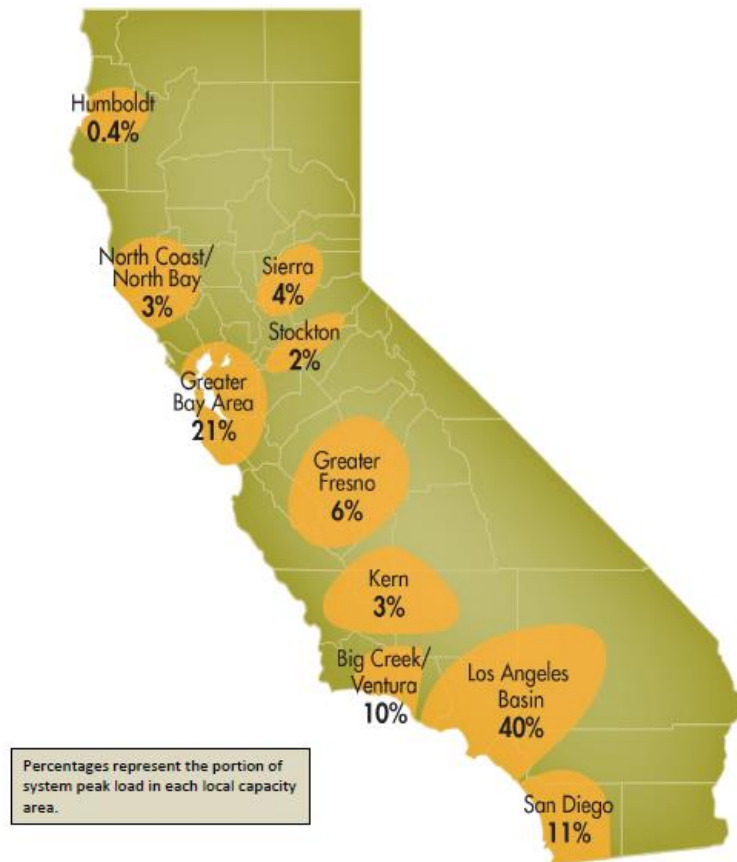


# Thank you

- ◆ Questions?

# Golden State

## Major load centers along the coast



Source: CAISO 2013 Annual Report On Market Issues & Performance

# The Golden State

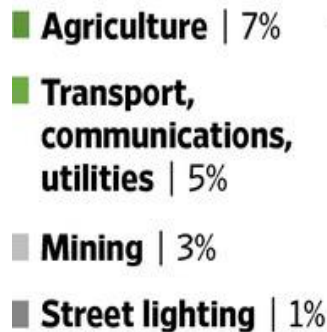
- ◆ Population: 39 m US: 320 m
- ◆ Median family income \$70K US: 54K
- ◆ Little heavy industry; no coal generation
- ◆ Biggest employer: Univ. of Calif. System
- ◆ Biggest companies: Apple, Google, Facebook, Uber, Tesla, SolarCity
- ◆ VC capital of world: Menlo Park
- ◆ Hub of innovation & disruption: Silicon Valley
- ◆ ½ of US EVs
- ◆ ½ of rooftop solar PVs



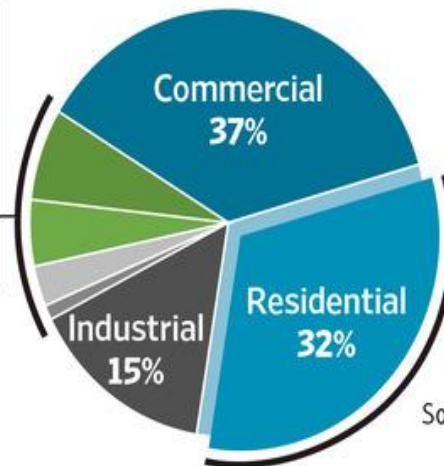
# CA's electricity consumption

## Power Users

California electricity consumption by sector.  
Residential is the No. 2 user of power.

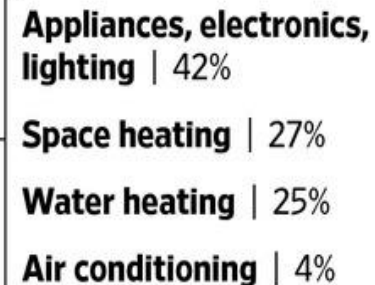


Source: California Energy Commission, Integrated Energy Policy Report, 2008



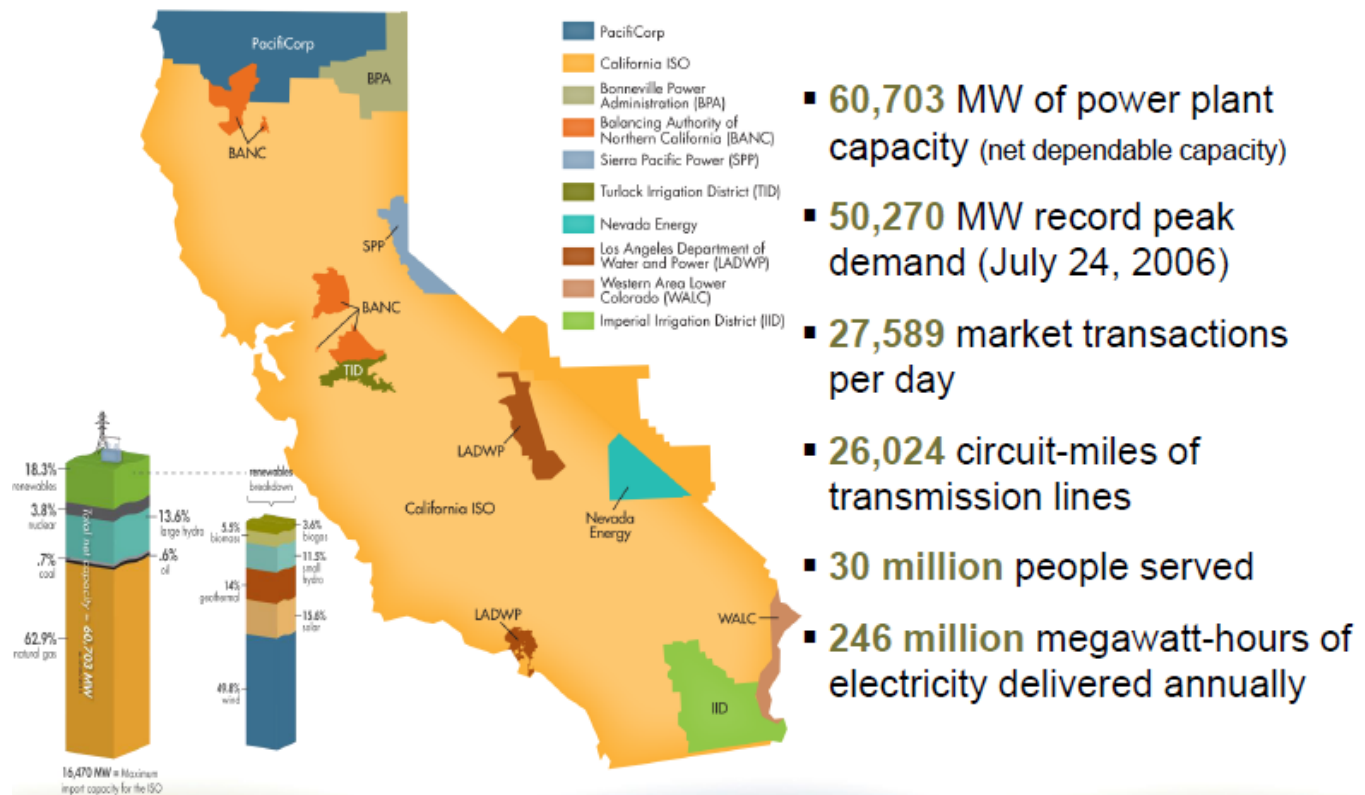
## Where It Goes in the Home

California residential energy consumption by end use



Source: EIA Residential Fact Sheet, 2009  
THE WALL STREET JOURNAL.

# CAISO by the numbers

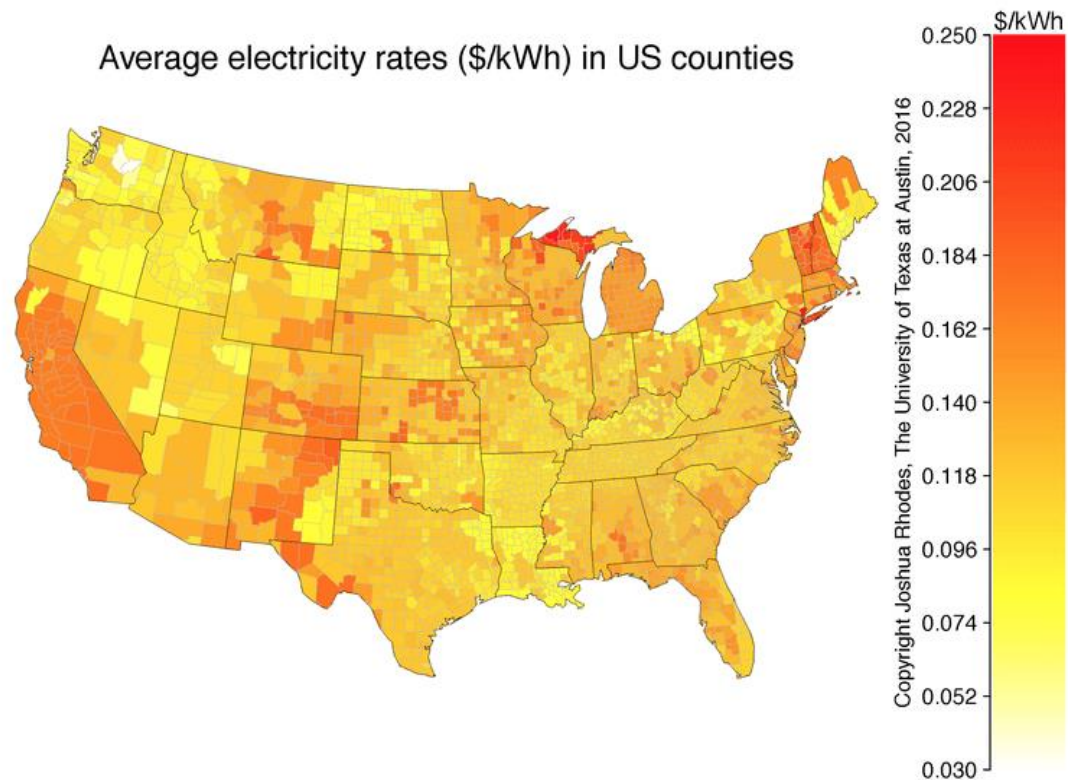


# Firing on too many cylinders

- ◆ Climate bill first passed in 2006
  - Reduce emissions to 1990 level by 2020
  - Reduce 40% below 1990 level by 2030
  - 80% below 1990 level by 2050
- ◆ Renewable mandate
  - 33% by 2020; 50% by 2030
- ◆ Zero net energy buildings
  - New residential by 2020; commercial by 2030
- ◆ Energy efficiency
  - Flat per capita electricity consumption since 1978
- ◆ And many more ...

# High tariffs => self generation

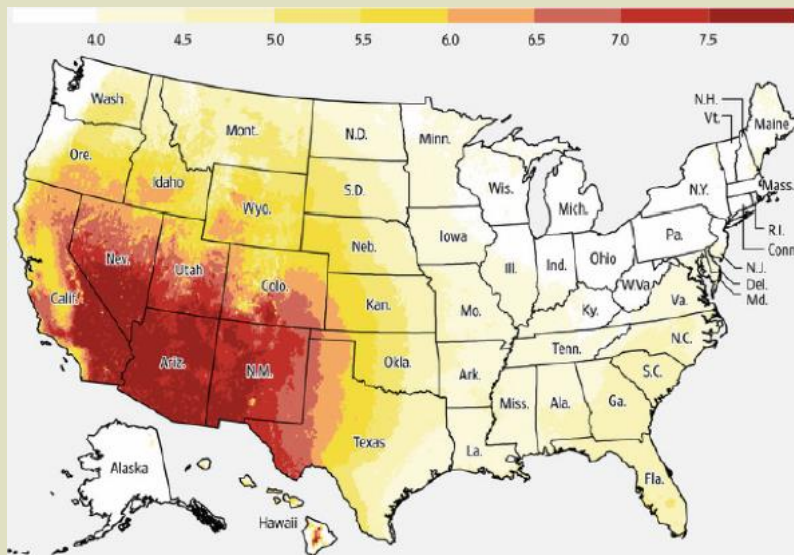
Rise of prosumers



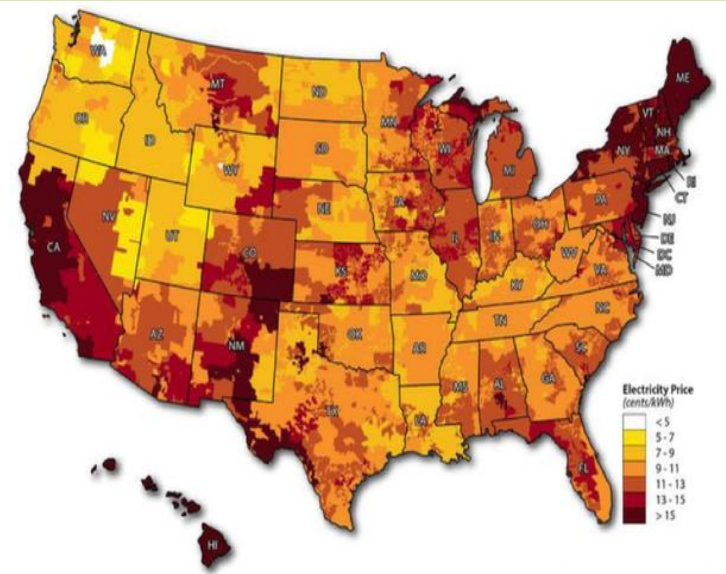
Map of average electricity rates across the U.S. EIA.

# Solar insolation + retail price

Solar insolation, kWh/sq.m (left); retail prices, c/kWh (right)



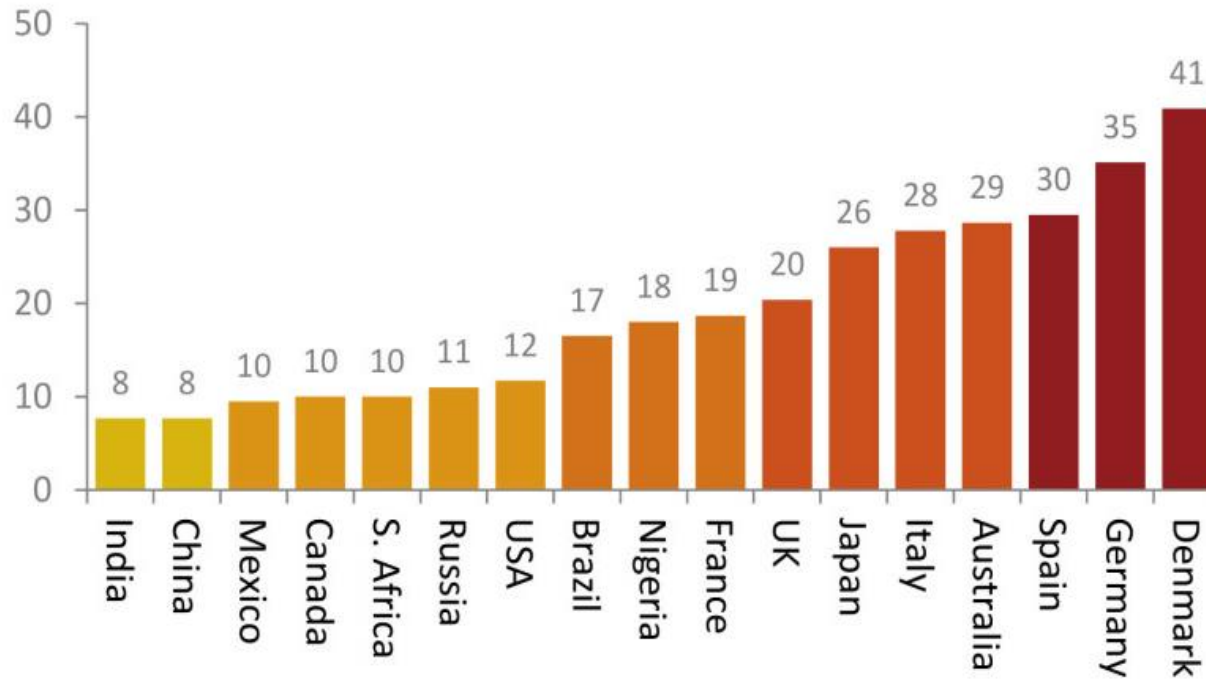
The Wall Street Journal





# Who will buy from the grid?

High retail tariffs are driving DG revolution



Data: average prices from 2011 converted at mean exchange rate for that year

Source: ESAA based on data from IEA, EIA, etc.

# Real

1 every 3 minutes

