Innovation, disruption & transformation at the grid’s edge

8th Elecpor Conference
4 November 2016
Lisbon, Portugal

Fereidoon P. Sioshansi, Ph.D.
Menlo Energy Economics
San Francisco CA
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 1st 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
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 virtually new world

World, largest listed companies by market capitalisation, $bn

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<thead>
<tr>
<th>Sector</th>
<th>Energy</th>
<th>Financials</th>
<th>Health care</th>
<th>Industrials</th>
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Source: Bloomberg

*At August 24th 2016

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

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

<table>
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<th>Period</th>
<th>Avg. sales growth for period</th>
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<td>3.8%</td>
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<td>1976-86</td>
<td>1.5%</td>
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<td>1986-96</td>
<td>1.4%</td>
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<td>1996-2006</td>
<td>0.9%</td>
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<td>2003-2013</td>
<td>0.3%</td>
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<td>2014-2024</td>
<td>0.16%</td>
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Source: NY Pub Service Commission, 26 Feb 2015
America’s top 10
Half are “virtual” & growing

<table>
<thead>
<tr>
<th>Tech Titans</th>
<th>Nov. 8, 2010</th>
<th>Oct. 22, 2010</th>
<th>Friday</th>
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<td>Johnson &amp; Johnson</td>
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</table>

*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

Net Metering
www.dsireusa.org / March 2015

43 States + DC, AS, Guam, USVI, & PR have mandatory net metering rules

Source: Database of State Incentives for Renewables & Efficiency (DSIRE)
Disruption: Solar leasing
An offer few customers can refuse

Lower Your Electric Bills By Going Solar!

Before
Account Summary
- Bill for 09/14/15: $314.23
- Payment Received 09/20/15: $314.23
- Bill for 10/14/15: $303.81
- Payment Received 10/19/15: $303.81

Monthly Bill: $303.89

After
Account Summary
- Bill for 09/14/15: -$30.15
- Payment Received 09/20/15: -$30.15
- Bill for 10/14/15: -$26.55
- Payment Received 10/19/15: -$26.55

Monthly Bill: $69.10

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

Source: http://www.nrel.gov/docs/fy16osti/65296.pdf
Third
Prosumer + Storage = Prosumage
Virtual utilities
Germany’s Next Kraftwerke shows the future

Source: Next Kraftwerke
Implications?

- Assume disruption
- Variable supply $\Rightarrow$ 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
Peaky 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?

Tesla’s giga factory

<table>
<thead>
<tr>
<th>Gigafactory Projected Figures</th>
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<tbody>
<tr>
<td>2020 Tesla Vehicle Volume</td>
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<tr>
<td>2020 Gigafactory Cell Output</td>
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<tr>
<td>2020 Gigafactory Pack Output</td>
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<tr>
<td>Space Requirement</td>
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<tr>
<td>Total Land Area (acres)</td>
</tr>
<tr>
<td>Employees</td>
</tr>
</tbody>
</table>
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
Electric bus
Supercapacitors will revolutionize mass transit

Source: Solaris Urbino 12 electric from Braunschweiger Verkehrs-GmbH (Germany)
Variable supply $\Rightarrow$ 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
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

Hourly Average of Renewable Resources: Sunday, March 16, 2014
System Peak Demand (one minute average): 27,286 MW
(from the California Independent System Operator)

Instantaneous Peak Solar: 4,143 megawatts at 14:28

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

Flexible demand

Demand Side Management with Flexible Electricity Rate

Source: Next Kraftwerke
Outcome?
Confluence of 3 factors

Real

Constructed

Disruption
Biggest uncertainty?
Reading the regulator’s mind
Role of regulators?
NY or CA? Market-driven or micro-managed?

CPUC Commissioners:

President
Michael Picker

Commissioner
Mike Florio

Commissioner
Catherine J.K. Sandoval

Commissioner
Carla J. Peterman

Commissioner
Liane M. Randolph

Audrey Zibelman, Chair

Patricia L. Acampora

Gregg C. Sayre

Diane X. Burman
Thank you

- Questions?
Golden State
Major load centers along the coast

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.

- **Agriculture** | 7%
- **Transport, communications, utilities** | 5%
- **Mining** | 3%
- **Street lighting** | 1%


**Where It Goes in the Home**
California residential energy consumption by end use

- **Appliances, electronics, lighting** | 42%
- **Space heating** | 27%
- **Water heating** | 25%
- **Air conditioning** | 4%

Source: EIA Residential Fact Sheet, 2009

CAISO by the numbers

- 60,703 MW of power plant capacity (net dependable capacity)
- 50,270 MW record peak demand (July 24, 2006)
- 27,589 market transactions per day
- 26,024 circuit-miles of transmission lines
- 30 million people served
- 246 million megawatt-hours of electricity delivered annually

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

Average electricity rates ($/kWh) in US counties

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

Copyright, Joshua Rhodes. The University of Texas at Austin, 2016.
Solar insolation + retail price
Solar insolation, kWh/sq.m (left); retail prices, c/kWh (right)
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

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Reproduced from Giles Parkinson’s Renew Economy, 7 Feb 2016