



scottmadden
MANAGEMENT CONSULTANTS

Smart. Focused. Done Right.®

Greening the Grid

An Overview of the Greening of the U.S.
Generation Fleet

Todd Williams, ScottMadden

GenForum Presentation

December 2016

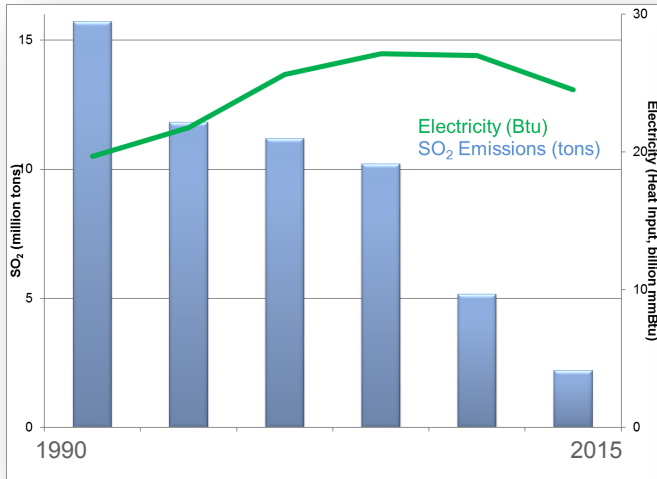
Agenda

- Greening has already been happening
- Three drivers for greening
- Lessons learned from Hawaii and Germany
- Three challenges posed by greening
- Conclusions

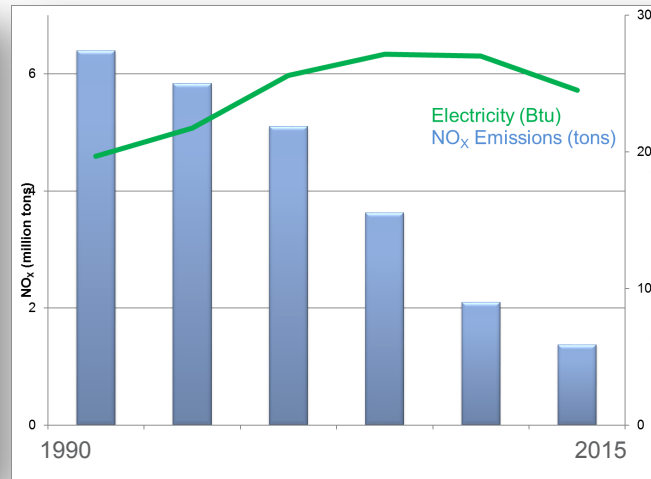
The Grid has become substantially greener in a short time. . .

Total emissions have fallen dramatically since 1990, even while total electricity generation has increased

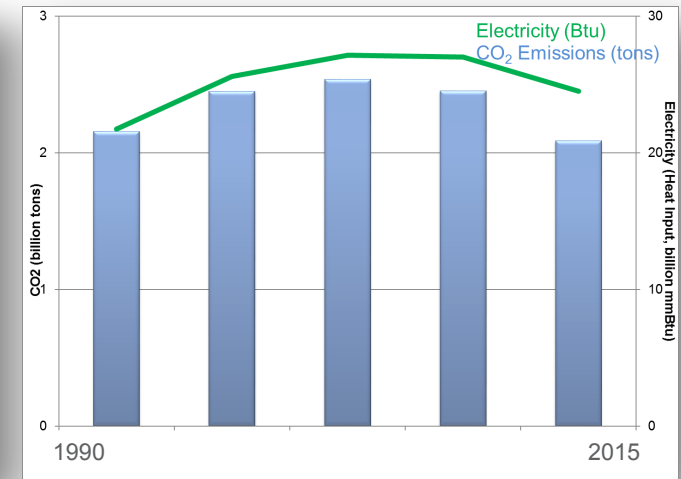
SO₂



NO_x



CO₂



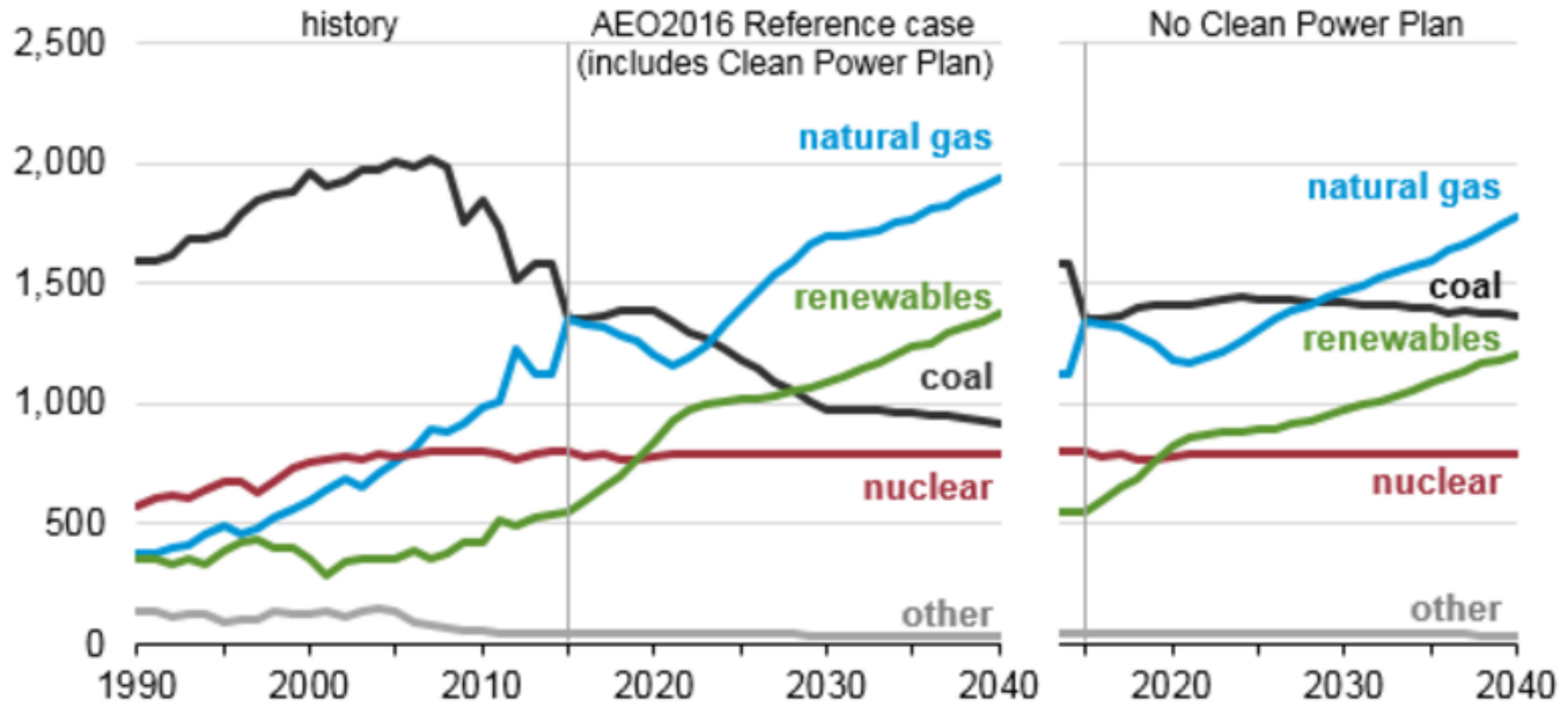
Source: EPA, <https://www3.epa.gov/airmarkets/progress/datatrends/index.html>

And is projected to become greener

Going green is a combination of three trends:

↑ Natural gas ↑ Renewables ↓ Coal

U.S. net electricity generation by fuel (1990-2040)
billion kilowatthours



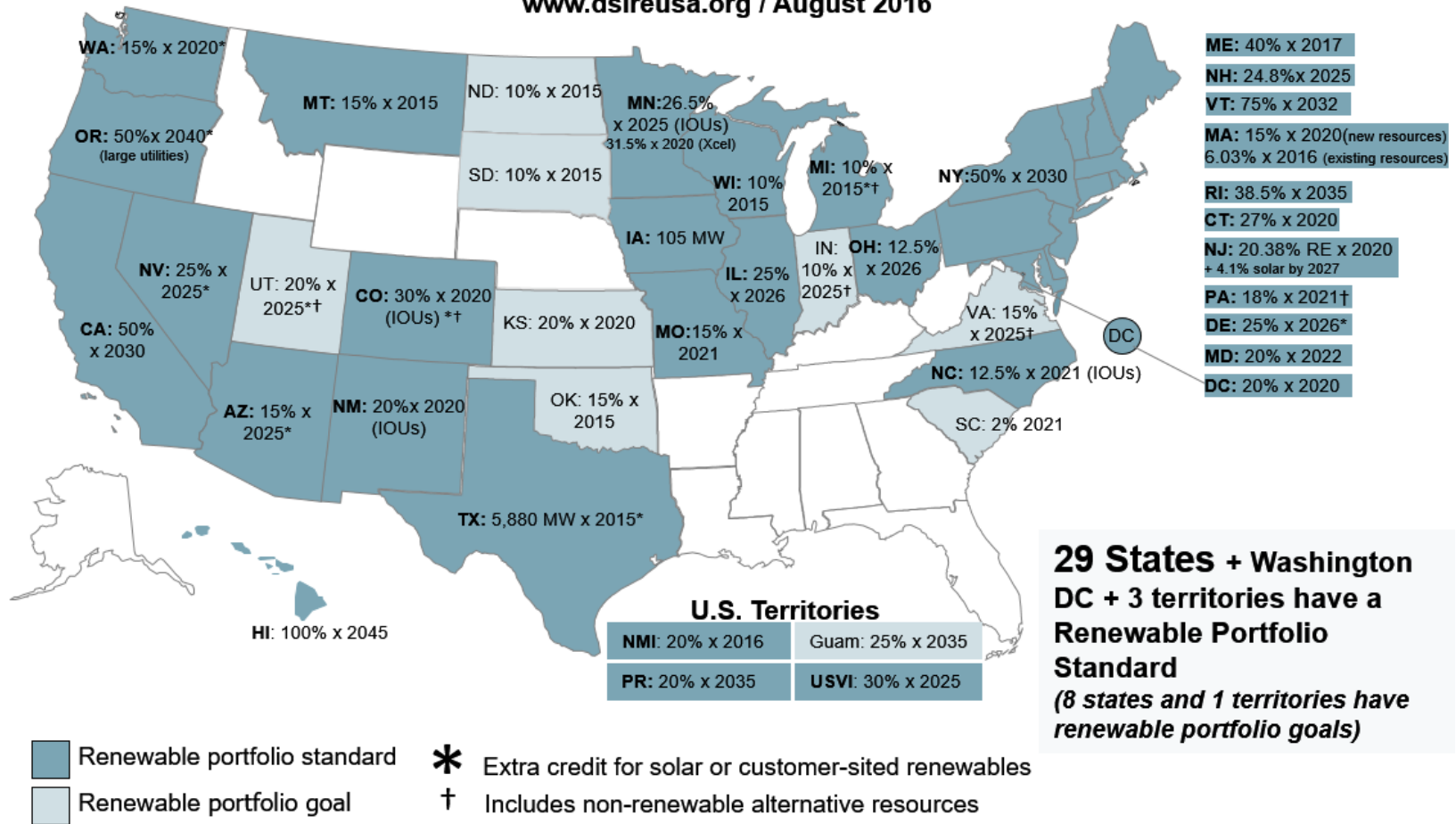
Source: EIA, <http://www.eia.gov/todayinenergy/detail.php?id=26712>

Green Driver #1: Regulations and mandates

State and federal mandates and regulations have driven early growth of renewable generation

Renewable Portfolio Standard Policies

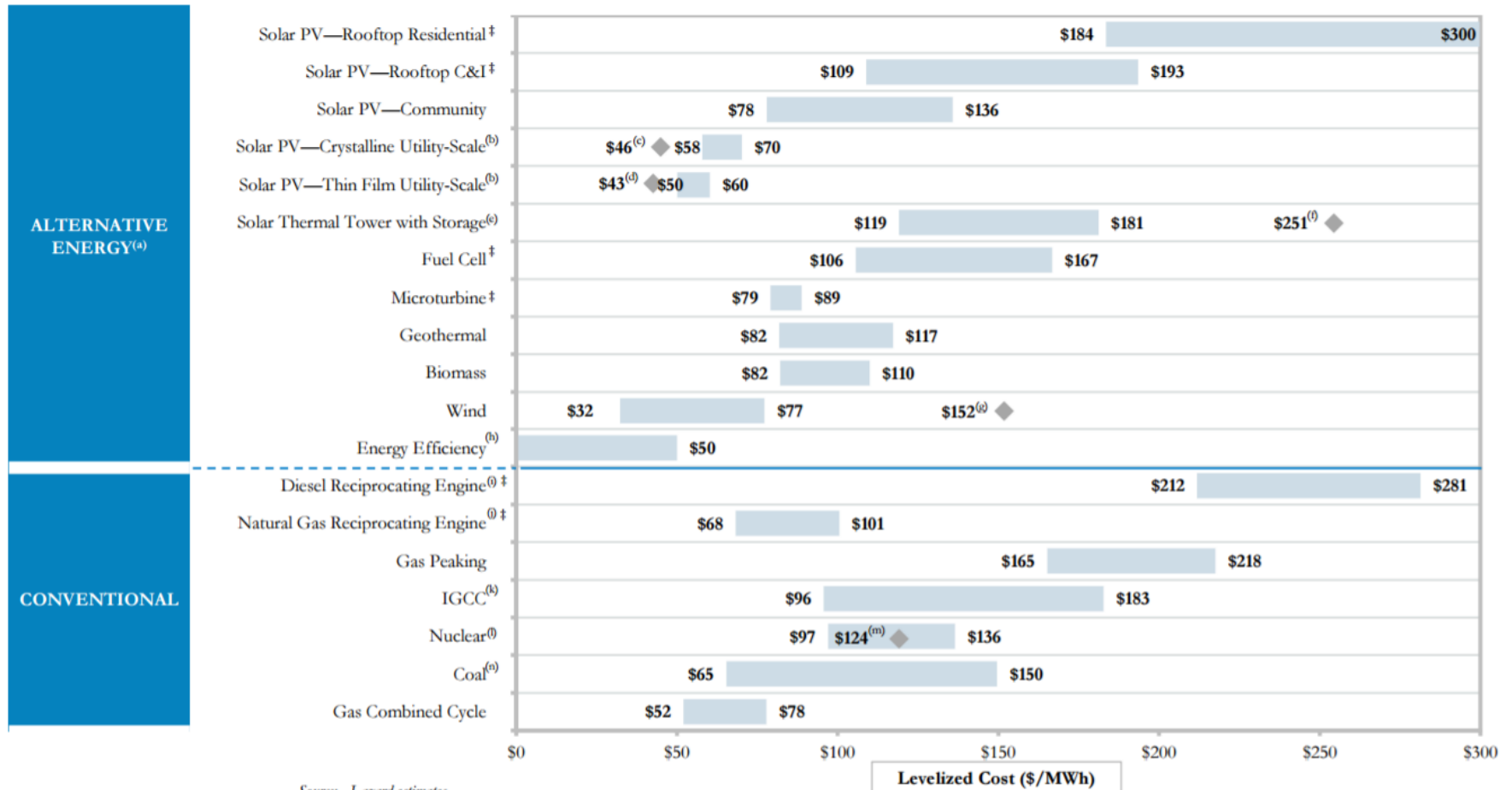
www.dsireusa.org / August 2016



DSIRE database, 2016

Green Driver #2: Economics

Renewable generation sources are becoming more economic, even without subsidies



Source: Lazard estimates.

Note: Here and throughout this presentation, unless otherwise indicated, analysis assumes 60% debt at 8% interest rate and 40% equity at 12% cost for both conventional and Alternative Energy generation technologies. Assumes diesel price of ~\$2.50 per gallon, Northern Appalachian bituminous coal price of ~\$2.00 per MMBtu and a natural gas price of ~\$3.50 per MMBtu for all applicable technologies other than Natural Gas Reciprocating Engine, which assumes ~\$5.50 per MMBtu. Analysis does not reflect potential impact of evolving regulations/rules promulgated pursuant to the EPA's Clean Power Plan. See following page for footnotes.

‡ Denotes distributed generation technology.

2 | LAZARD ‡

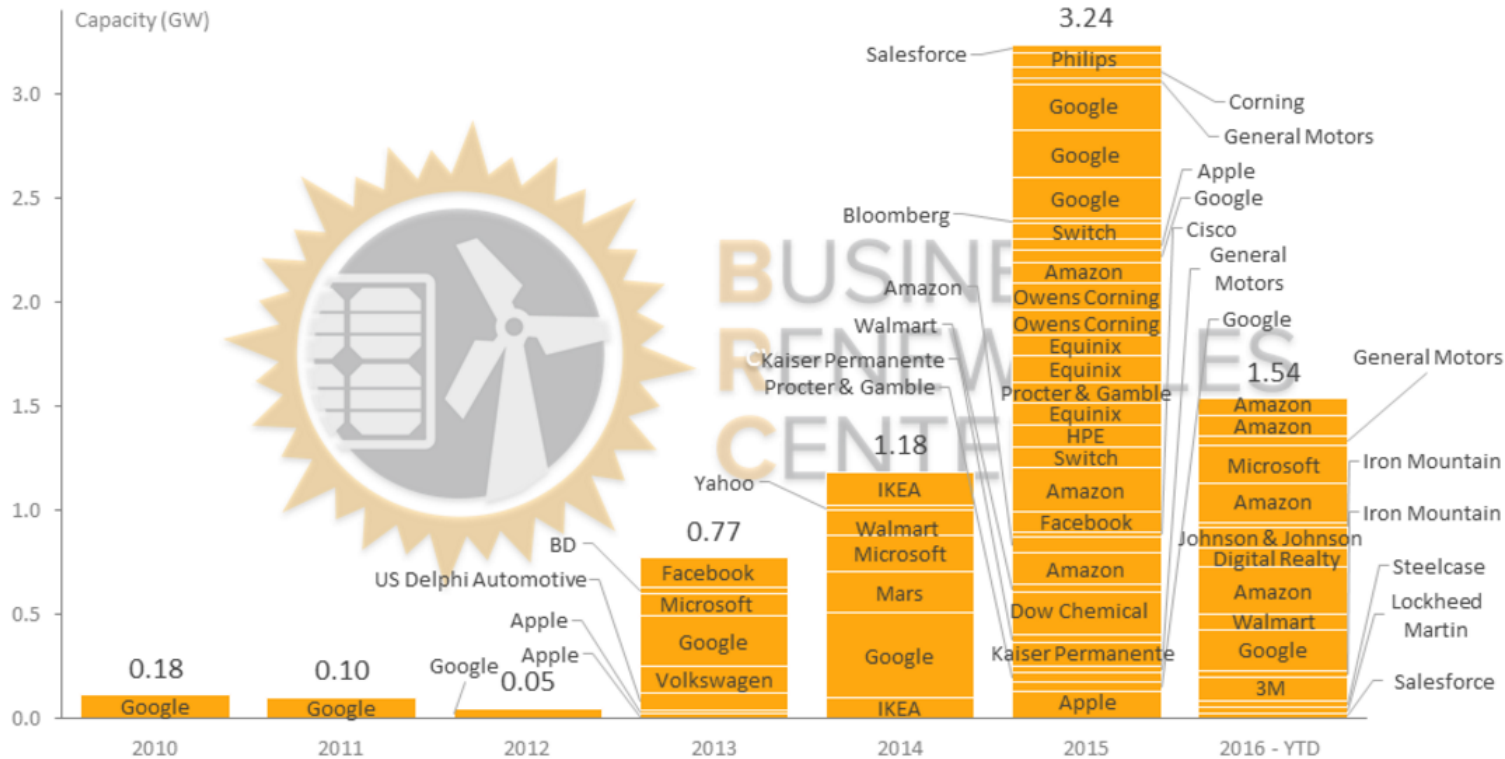
Copyright 2015 Lazard.

Green Driver #3: Consumer preference

Given a choice, many electricity consumers simply prefer green generation. For example, the growth in C&I direct purchase of renewables



Corporate Renewable Deals 2010 – 2016



Likely some acceleration of deals into 2015 due to PTC expirations

<http://www.businessrenewables.org/corporate-transactions/>

Publicly announced contracted capacity of corporate Power Purchase Agreements, Green Power Purchases, Green Tariffs, and Outright Project Ownership in the US and Mexico, 2012 – 2016. Excludes on-site generation (e.g., rooftop solar PV) and deals with operating plants. Last updated: December 2, 2016.

Copyright 2016 by Rocky Mountain Institute

For more information, please visit <http://www.businessrenewables.org/> or contact BRC@RMI.org

Hawaii and Germany – Bellwethers for the rest of us?

A world apart but similar experiences



Hawaii Renewables	2007	2014
Generation (GWhs)	945	1,989
% of total demand	9.2%	21.3%
Res. price ¢/kWh	24	37
US avg. res. price	11	13

- Despite the high penetration of renewables, the system is not in collapse

Germany Renewables	2007	2014
Generation (TWhs)	88.3	194.0
% of total demand	14.3%	32.5%
Res. price ¢/kWh	30	36

1.34 and 1.33 \$ per €, 2007 and 2014

- Even though grid management has increased, supply disruptions have only marginally increased and are not attributed to the energy policy turnaround and associated increase in decentralized power generation

Green Challenge A: Dispatchability

Figure 2: Lowest March Daytime Net Load, 2011–2016

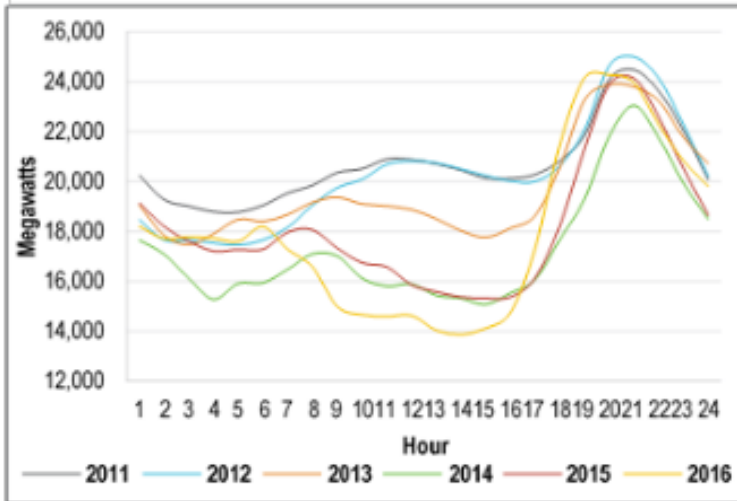
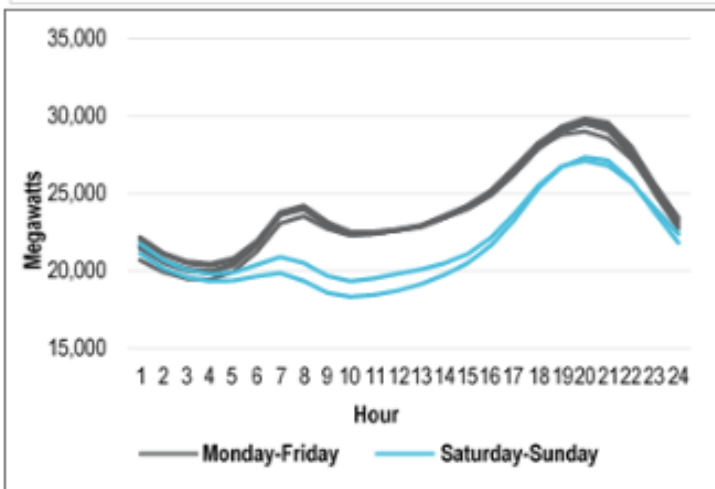


Figure 5: Average Net Load by Day of the Week, 2015

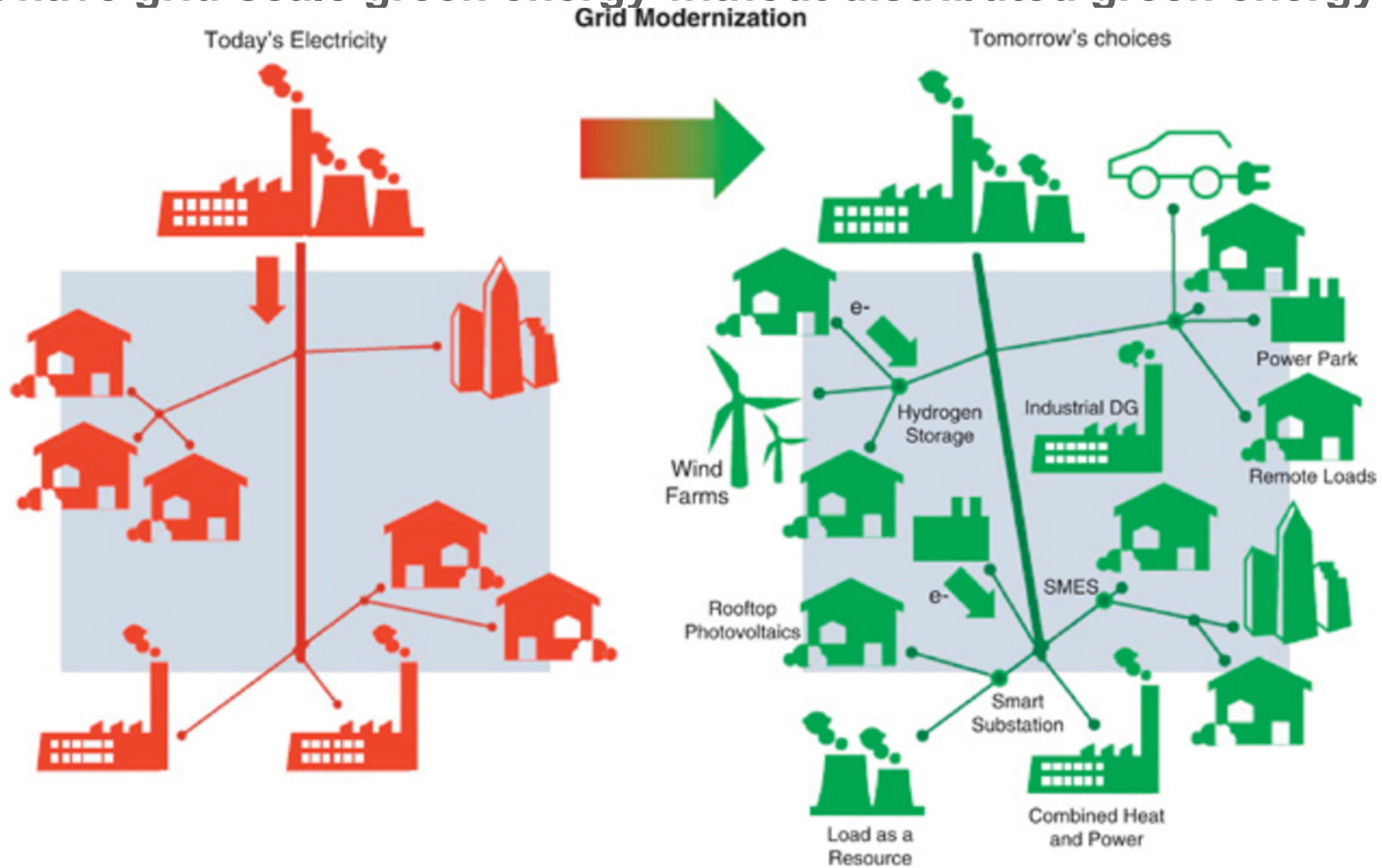


The duck curve is:

- Producing net loads lower than forecast
- Increasing ramps throughout the year
- Most severe on the weekends
- Occurring in multiple seasons, not just spring months
- Driven by utility-scale solar in California, not distributed resources

Green Challenge B: Consumer choice

A little like peaceful atomic power and military atomic power, you really cannot have grid-scale green energy without distributed green energy



Source: <http://www.netanir.ir/upload/image/distributed-generation.jpg>

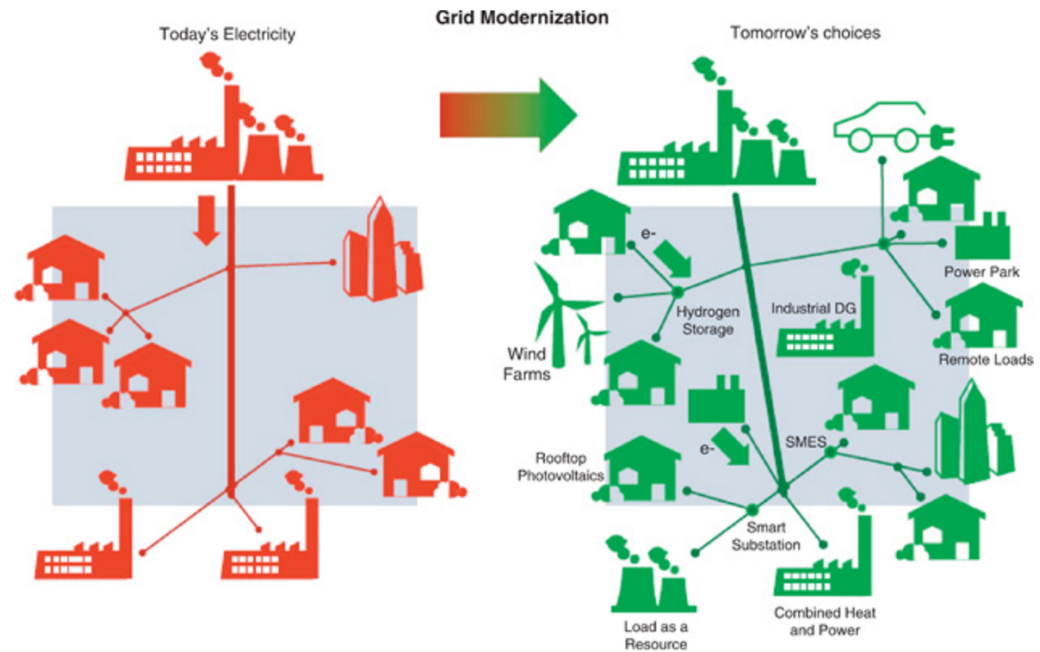


Green Challenge C: A darker side of green

If the greening of the grid means both utility-scale and distributed generation, then how much is our grid today like the telephone network in the late 1980s?

“Telephone networks, it was often said, had an intelligent core — the switches that ran everything — and “dumb” edges, meaning the handsets in nearly every home and business in the nation.

The Internet, by contrast, would have a “dumb” core — all the network did was carry data — with intelligent -edges, meaning the individual computers controlled by users.”



Conclusion

- Generation will continue its path toward green
- Key signposts that signal the speed include:
 - Capital cost reductions
 - Price of natural gas
 - Policy driven mandates and incentives

Questions?

Todd Williams

Partner

ScottMadden, Inc.
3495 Piedmont Road
Building 10, Suite 805
Atlanta, GA 30305
toddwilliams@scottmadden.com
O: 404-814-0020



Smart. Focused. Done Right.

POWER GENERATION WEEK 2016

#PowerGenWeek

