EPRI ELECTRIC POWER RESEARCH INSTITUTE

EPRI Update

Trends in the Electric Power Industry

Southeast Area Tripartite Conference
Boilermakers
Destin, Florida
March 28, 2018

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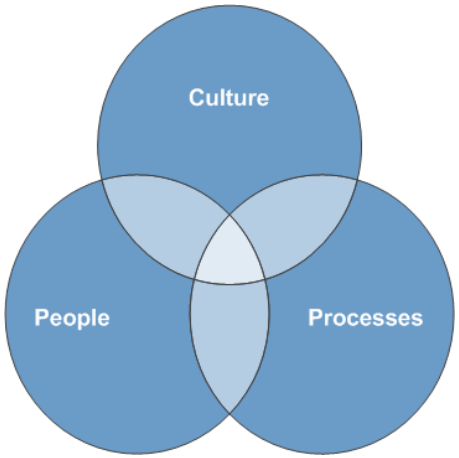
Principal Technical Executive

What is the Big Issue for the Electric Utility Industry

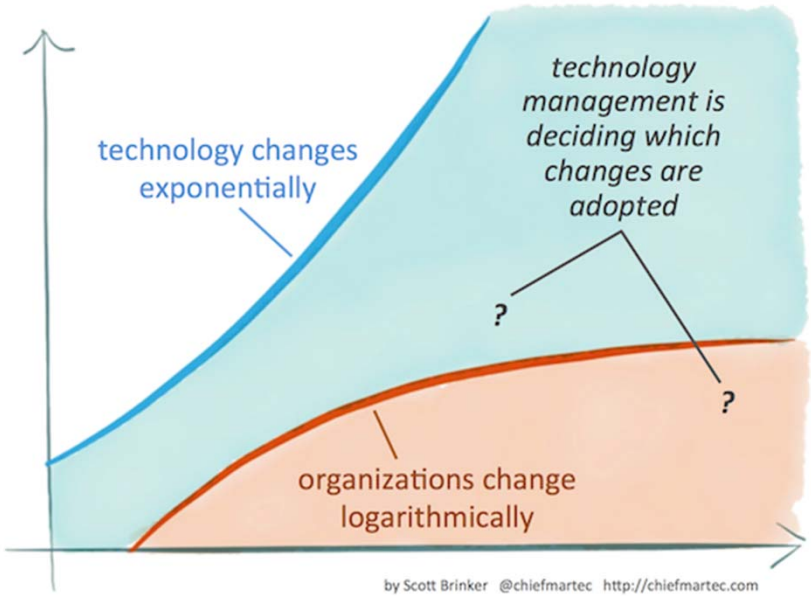
Where has all the Electric Consumption Growth Gone

- **The Electric Industry has been built on a history of expanding electric demand growth**
- **The Electric Industry has relied on technology advancement that allowed for a steady decrease in the cost of producing and delivering power from central generating resources**
- **Electricity Efficiency has reached the "Tipping Point"**
- **Traditional electrical consumption is disappearing**
- **Solar is now appearing and will likely be enhanced with the addition of Energy Storage thereby reducing the amount of power requested from electric utilities and shifting supply away from central station power**

What is Driving the Change



- Technology Innovation
- Third party Competition
- Environmental Movement
- Consumer Independence – the "Prosumer"
- Electricity Efficiency Adoption
- Declining Solar Costs



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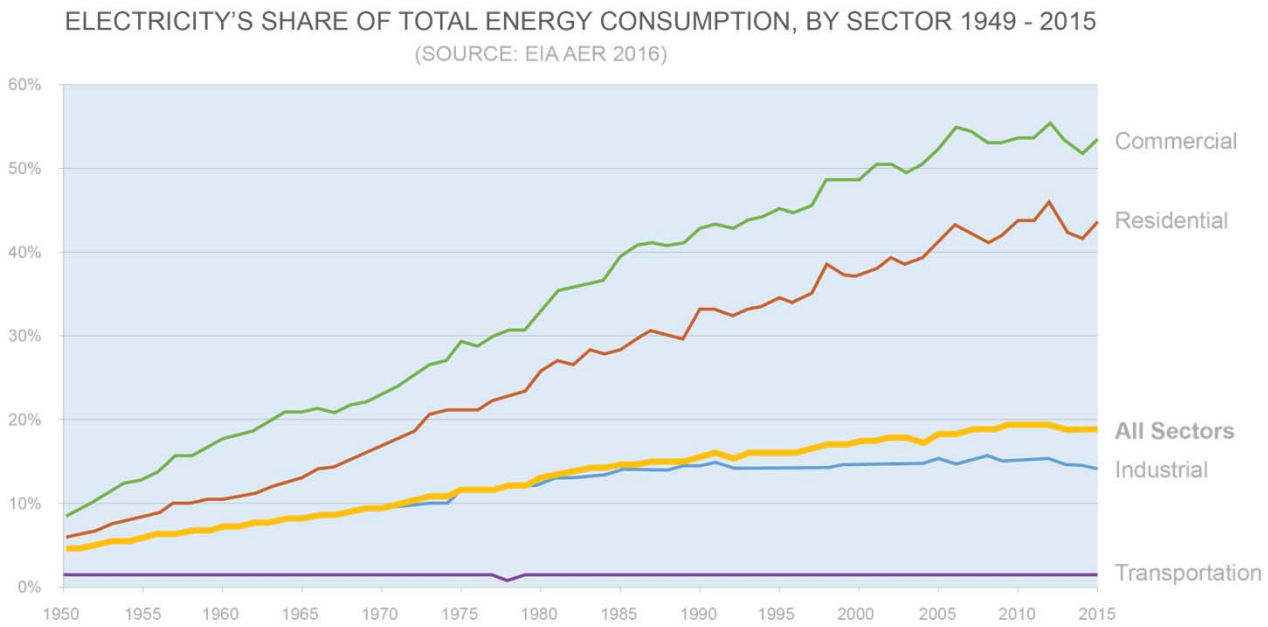
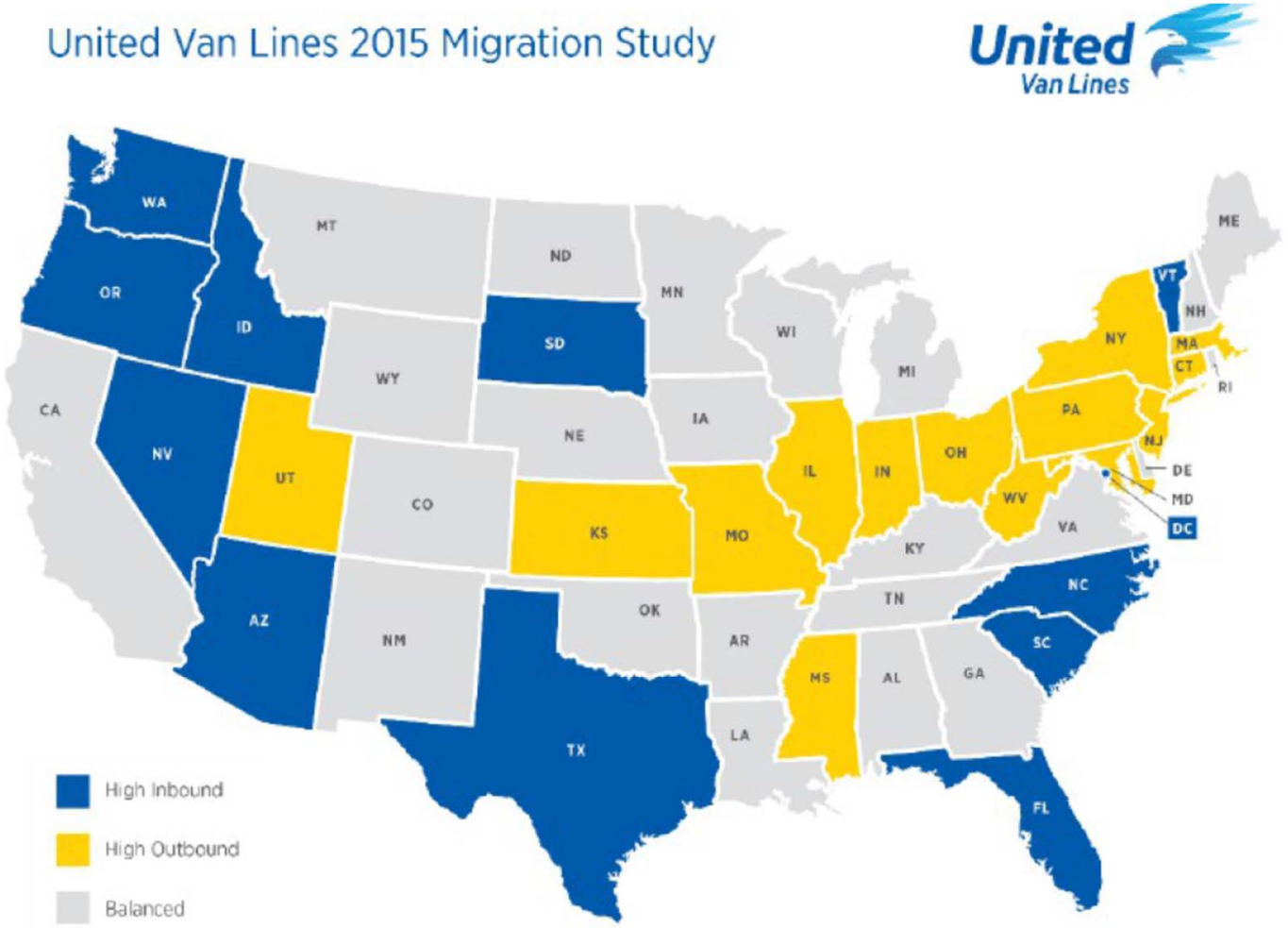
Electricity Use Has Grown Faster than Total Energy for More than A Century…What Will or Could Happen Next?



GROWTH DRIVEN BY EFFICIENCY, CONVENIENCE, SAFETY, AND LOW COST

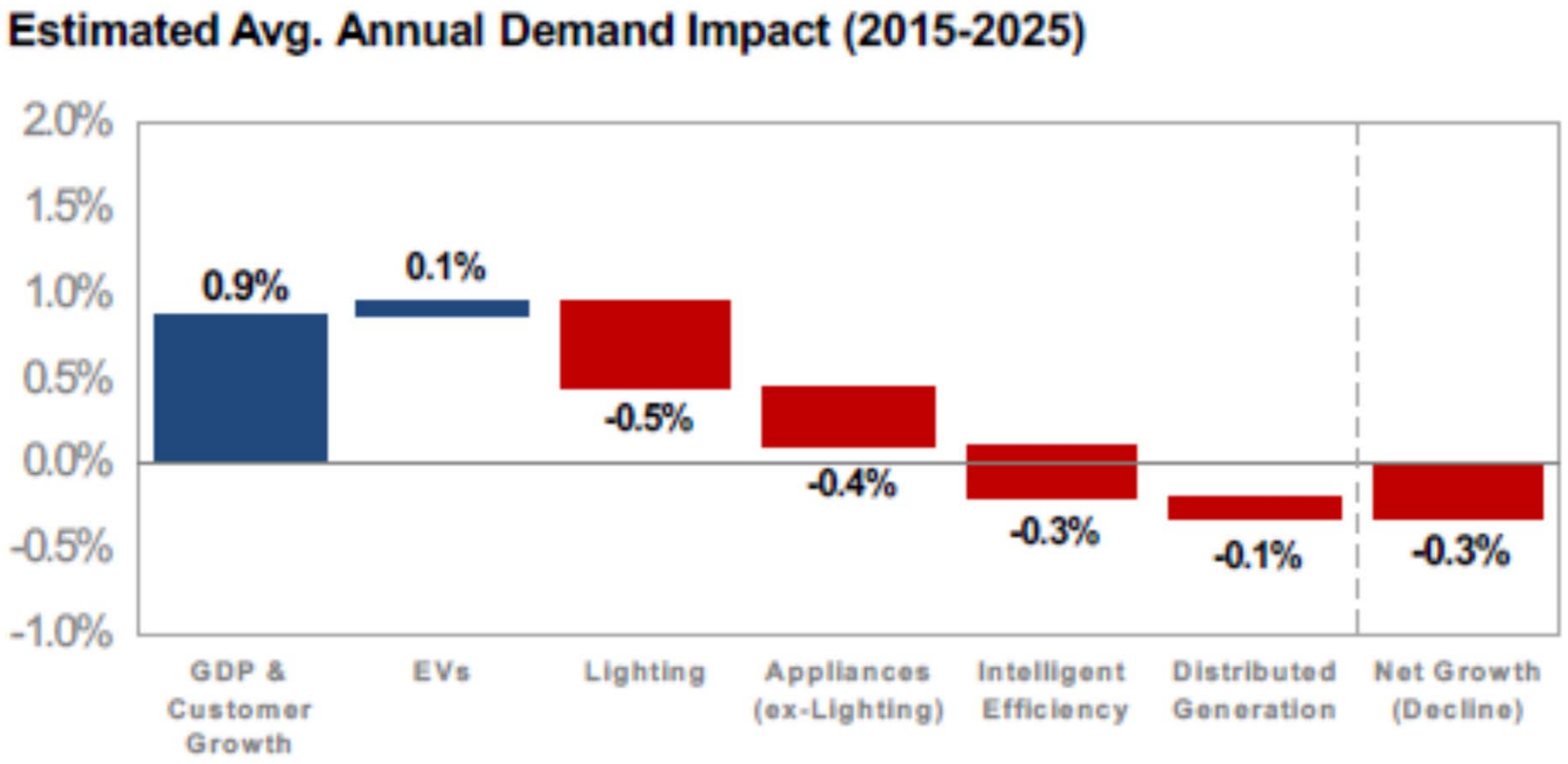
How might Electricity Growth Change by States



Source: United Van Lines, Scana

Outlook for Energy Consumption

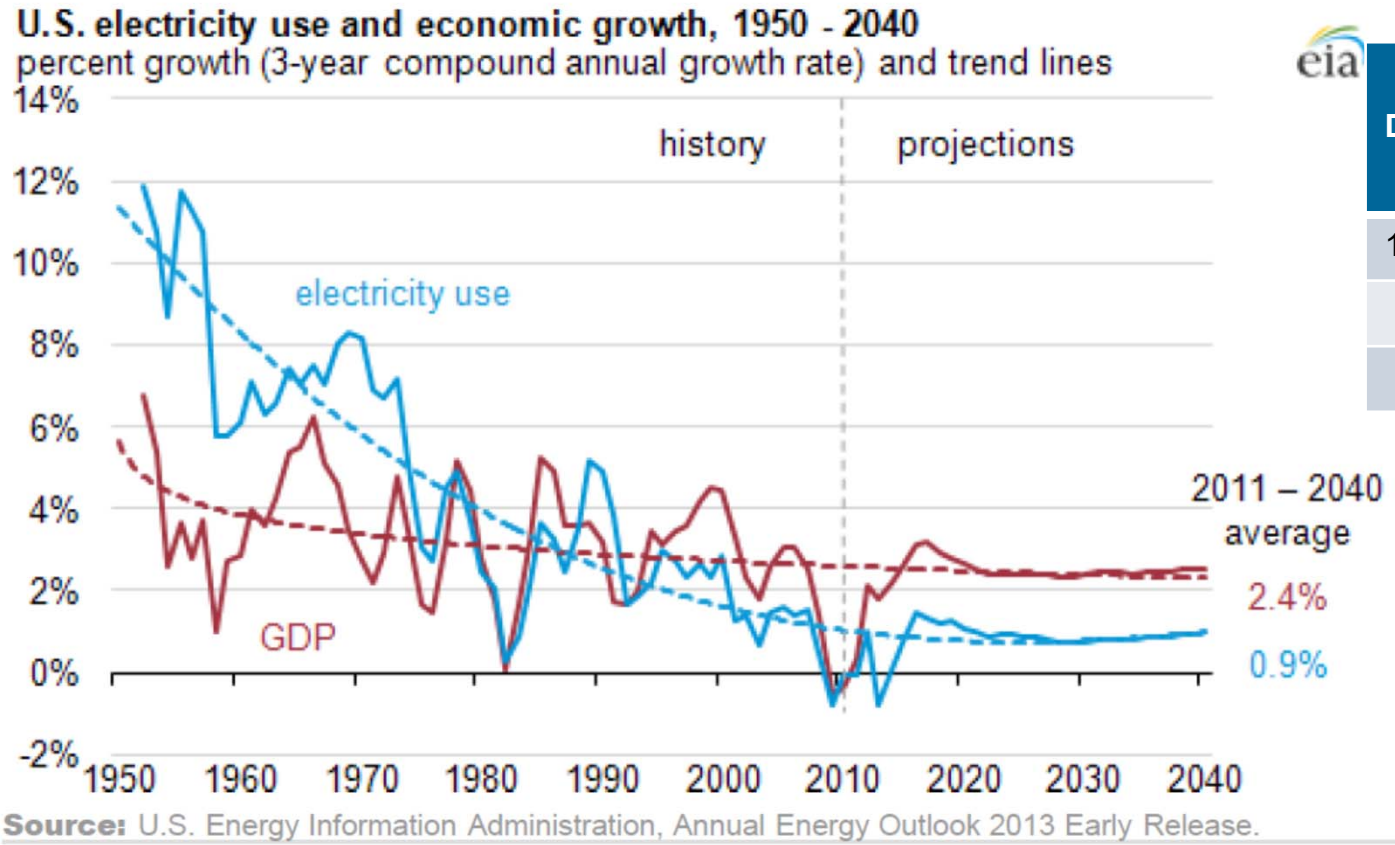
Supplied by Electric Utilities



Source: Morgan Stanley Research

Demand grew at an average rate of 1.6% CAGR from 1990-2010

The Effect of GDP on Consumption



Date	Electric/GDP
1950-1970	2.5
1990	1.0
Future	0.375

US PEV Sales to Date by Make – 703,230

800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0

Dec-10 Feb-11 Apr-11 Jun-11 Aug-11 Oct-11 Dec-11 Feb-12 Apr-12 Jun-12 Aug-12 Oct-12 Dec-12 Feb-13 Apr-13 Jun-13 Aug-13 Oct-13 Dec-13 Feb-14 Apr-14 Jun-14 Aug-14 Oct-14 Dec-14 Feb-15 Apr-15 Jun-15 Aug-15 Oct-15 Dec-15 Feb-16 Apr-16 Jun-16 Aug-16 Oct-16 Dec-16 Feb-17 Apr-17 Jun-17 Aug-17

Nissan GM Toyota Ford BMW
Tesla OTHER PHEV TOTAL BEV TOTAL

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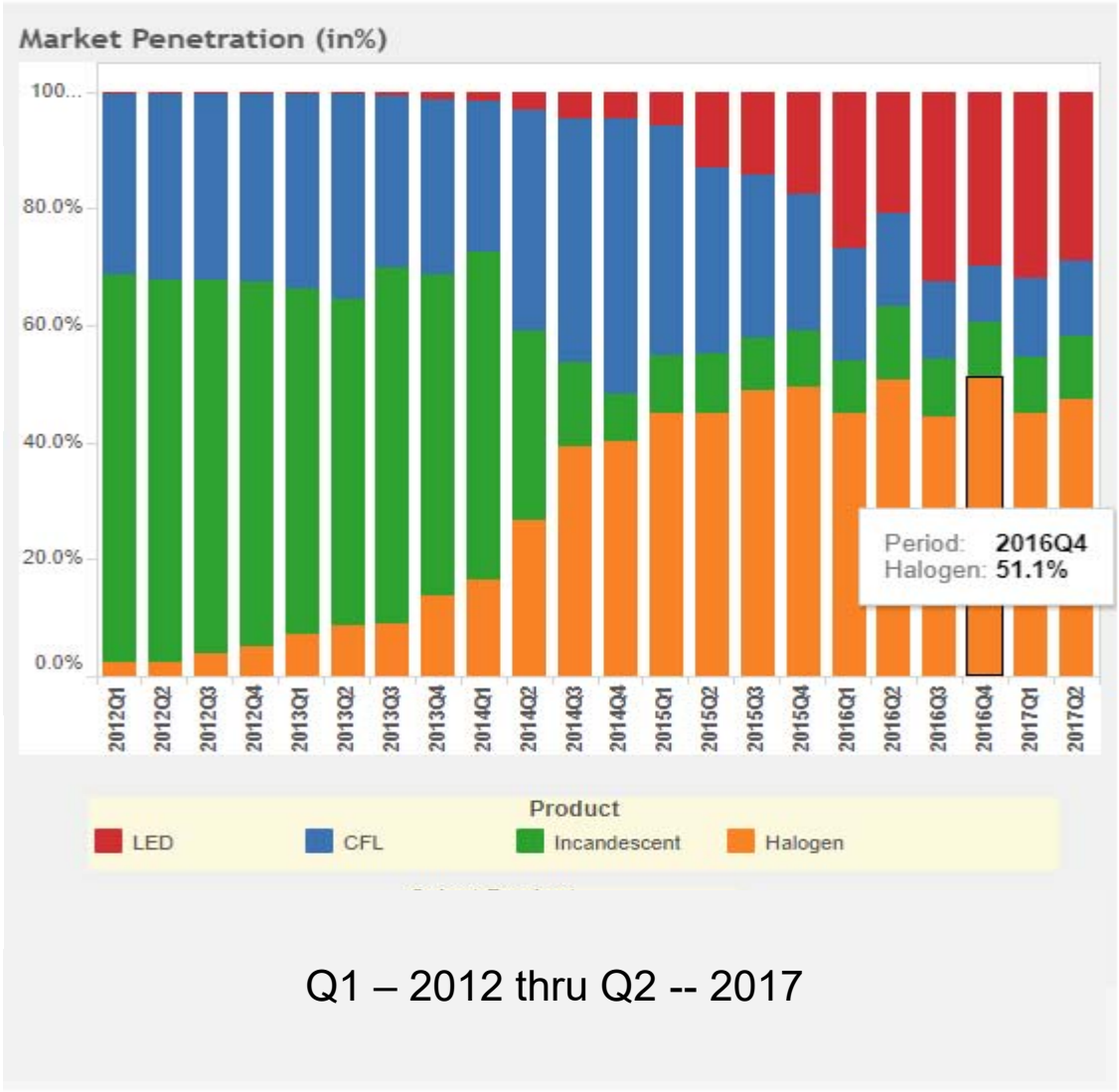
How the Market Distribution of Lighting Technology has Changed



Q1 – 2012 thru Q2 -- 2017

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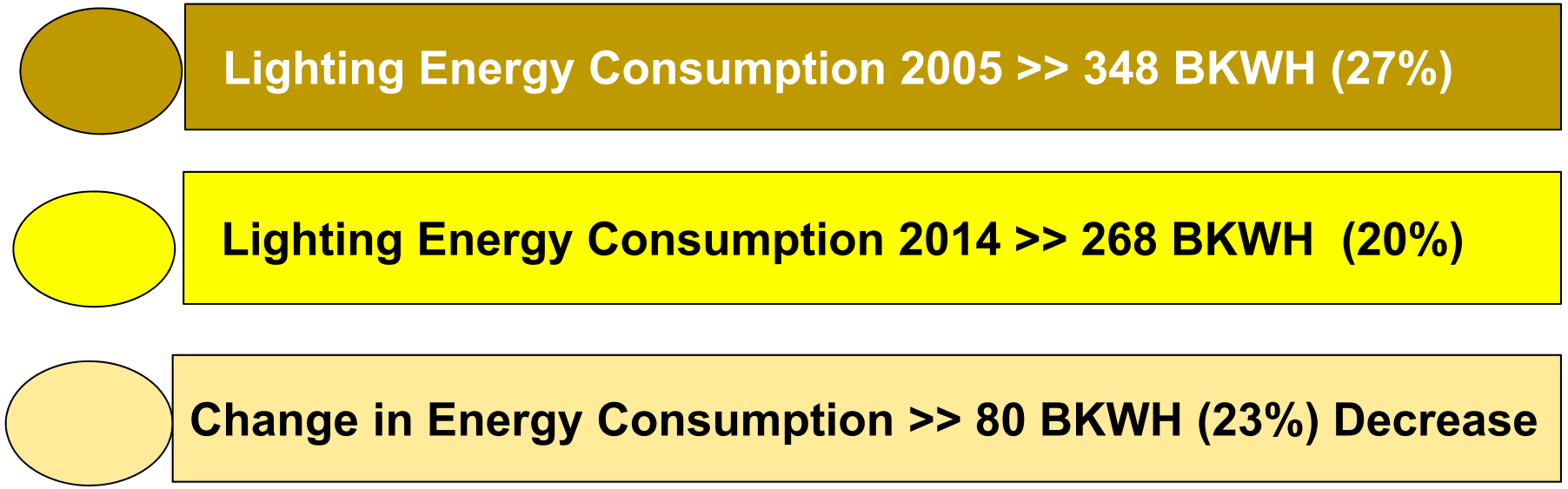
Summary of Lighting Impacts
Residential Annual Electricity Sales

- Lighting Energy Consumption 2005 >> 214 BKWH (16%)
- Lighting Energy Consumption 2014 >> 150 BKWH (11%)
- Change in Energy Consumption >> 64 BKWH (30% Decrease)

2005 to 2014 Annual Residential Energy Growth	%
All Residential Energy Growth	0.575
Residential Energy Growth Less Lighting Energy	1.250

What is the Story for Lighting in the commercial Sector

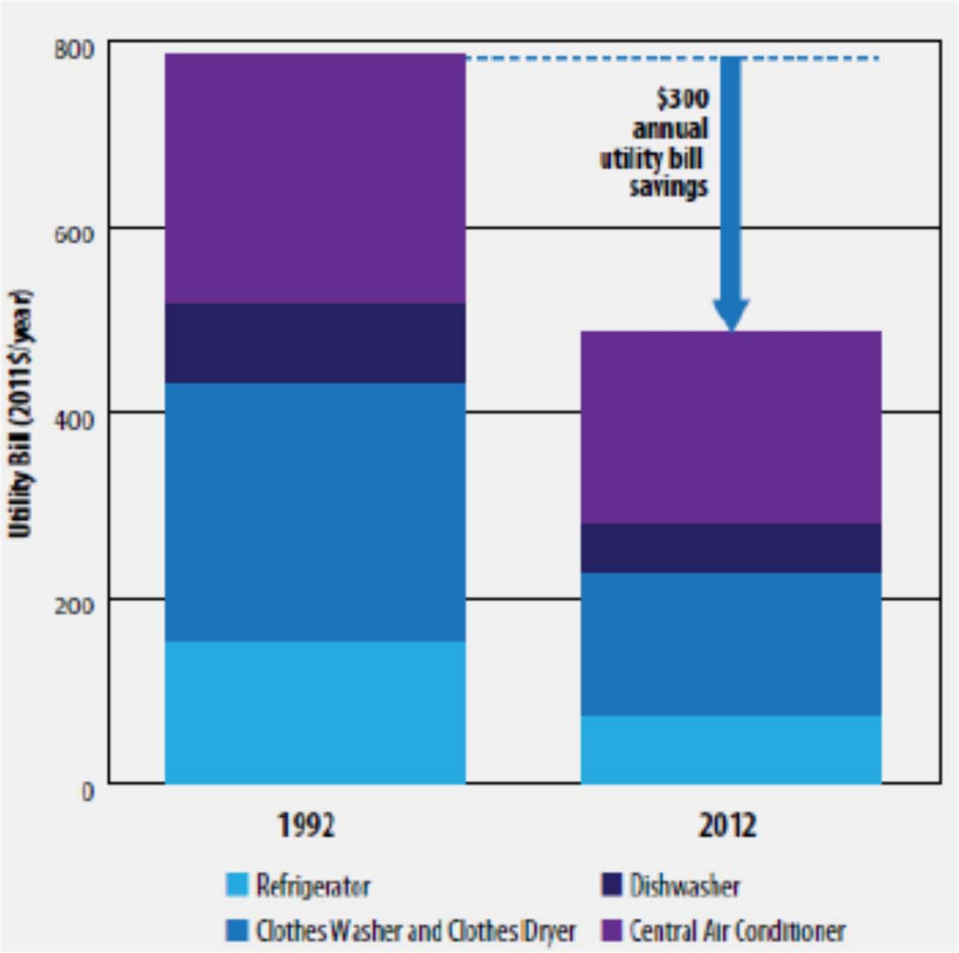
Similar Story to Residential – Except Larger!!



2005 to 2014 Annual Commecial Energy Growth	%
All Commercial Energy Growth	**0.509**
Commercial Energy Growth Less Lighting Energy	**1.564**

Appliance Energy Usage Patterns

Bill Impacts Down over 35%



20-year Period

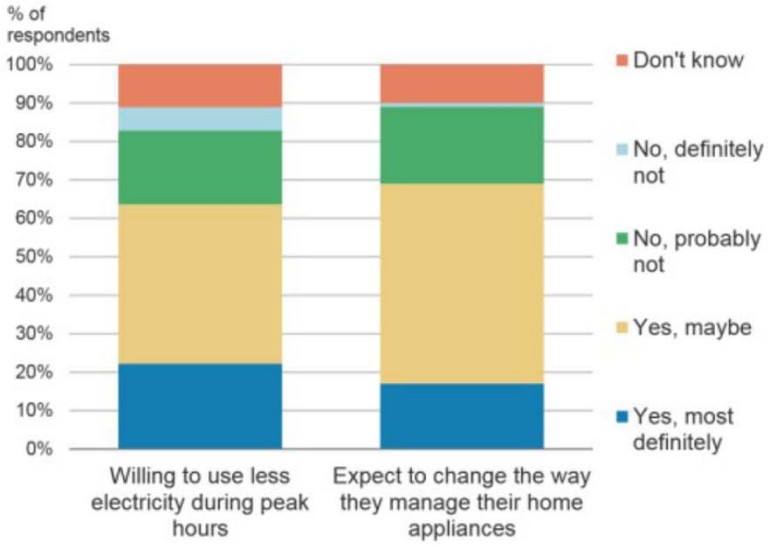
Energy Consumption is down about 2,500 kwh per year @12 cents/kwh

Source: ASAP, NRDC

Role of Smart Devices

Source: Nest

A potential reduction in energy use of up to 15% via thermostat



Source: Morgan Stanley Research, AlphaWise (as of March 2015)

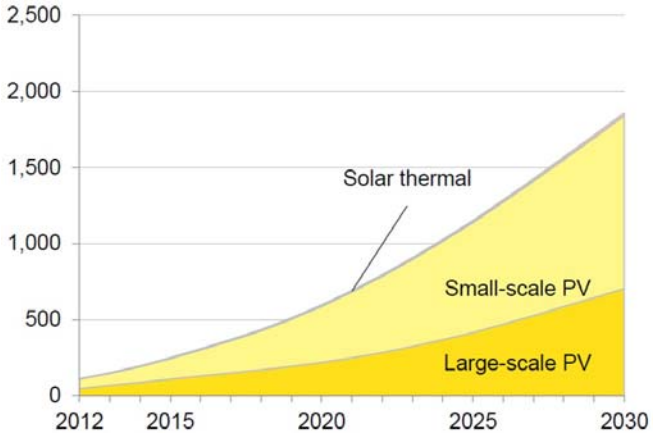
Source: ABB

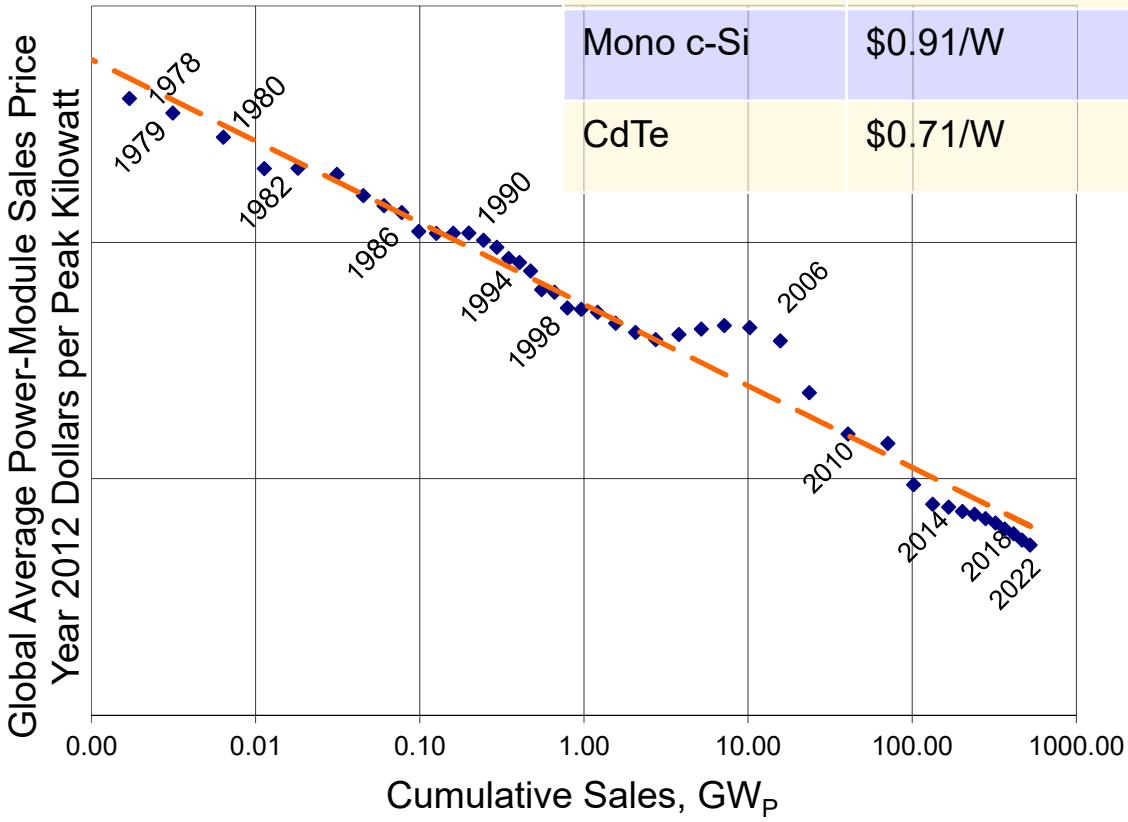
Average PV Module Price Trajectory

Global Solar Market Overview

Module Tech.	Avg. Price (Mar 2014)
Multi c-Si	$0.84/W
Mono c-Si	$0.91/W
CdTe	$0.71/W

Installed Solar Capacity by Technology (GW)





The historical average module selling price (ASP) has declined by ~20% with each doubling of sales over several decades. The recent slowdown in module price reductions is not expected to alter the long-term pricing decline.

Source: SPV Market Strategies (adapted by EPRI)

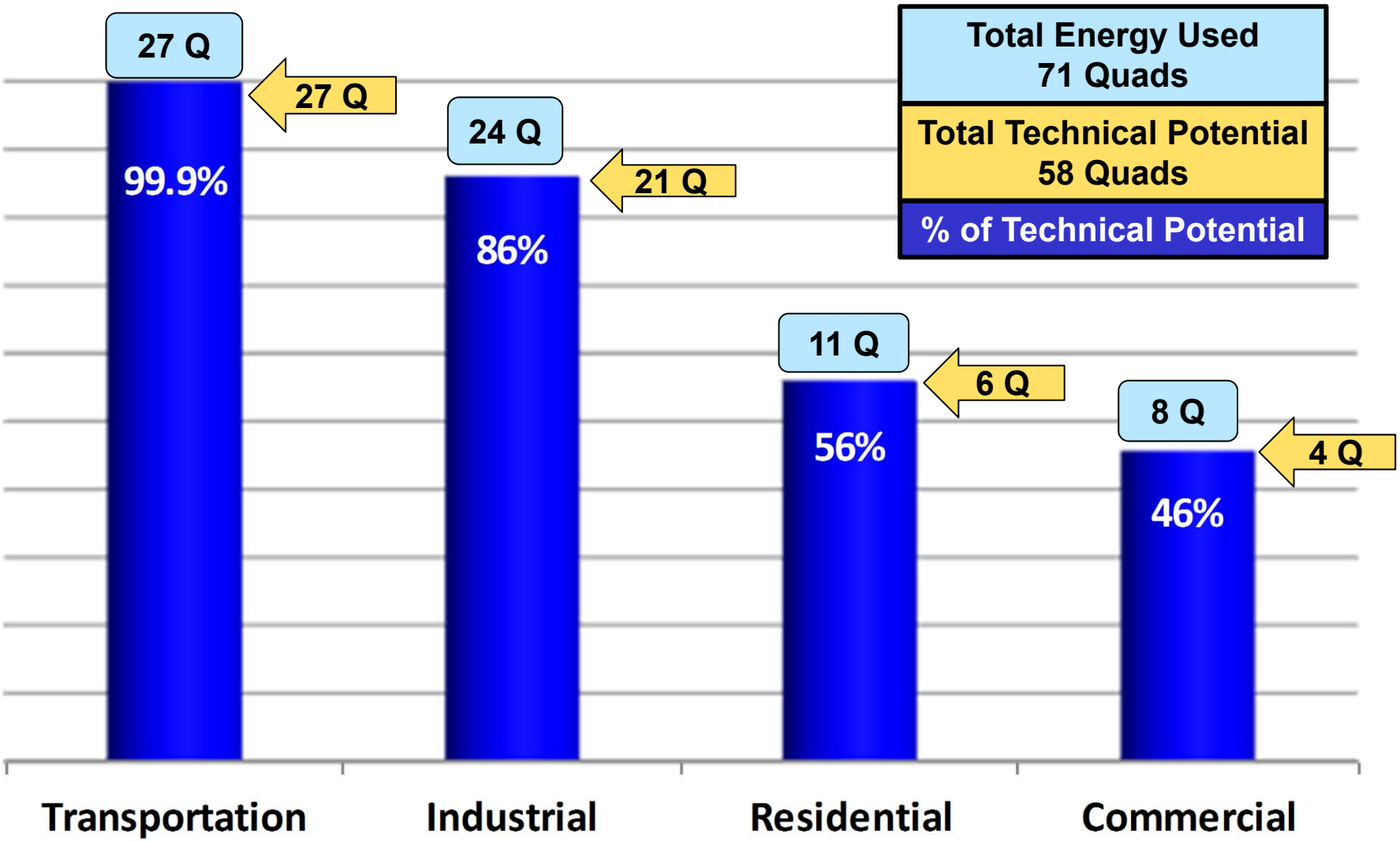
Is There Hope for Electric Utilities?

OR

What is Electrification?

Applying efficient electric technologies as an alternative to existing choices, while increasing customer benefit.

National Technical Potential for Electrification



Source: DOE/EIA Annual Energy Outlook 2013, 13 Q Electricity rounds to Total Energy of 71 Q.

Defining the Technology Pipeline

HEATING AND COOLING

Advanced Heat Pumps

Heating/Drying Technologies

Thermal Storage

Waste Heat Recovery

TRANSPORTATION

Advanced Energy Storage

High Power DC Charging

Heavy Duty, C&I Applications

Low Cost Hydrogen Fueling

Autonomous and Other Advanced Mobility Technologies

ALTERNATIVE PROCESSES

Agriculture

Additive and Advanced Manufacturing Techniques

Chemical Refining

Material Production

Join EPRI for a Global Forum on Electrification

What Else is Changing

The Role Combined Cycle Power (CCP) plants

- Natural Gas-fired powered generation is expected to grow at 3.1% per year through 2038 adding 348GW of capacity with most coming from CCP
- By 2038, CCP will rise to over 50% of electric energy supply while compared with 25% in 2014
- By 2038, coal will only occupy 21% of the electric energy supply falling from 39% in 2014.
- Efficiency of CCP plants is typically 60% or greater

How does it work?

Combines gas turbine with a steam turbine to produce electricity.

Gas is fed to the gas turbine that generates electricity.

Waste heat is gathered from the gas turbine and is used to form steam for the steam turbine.

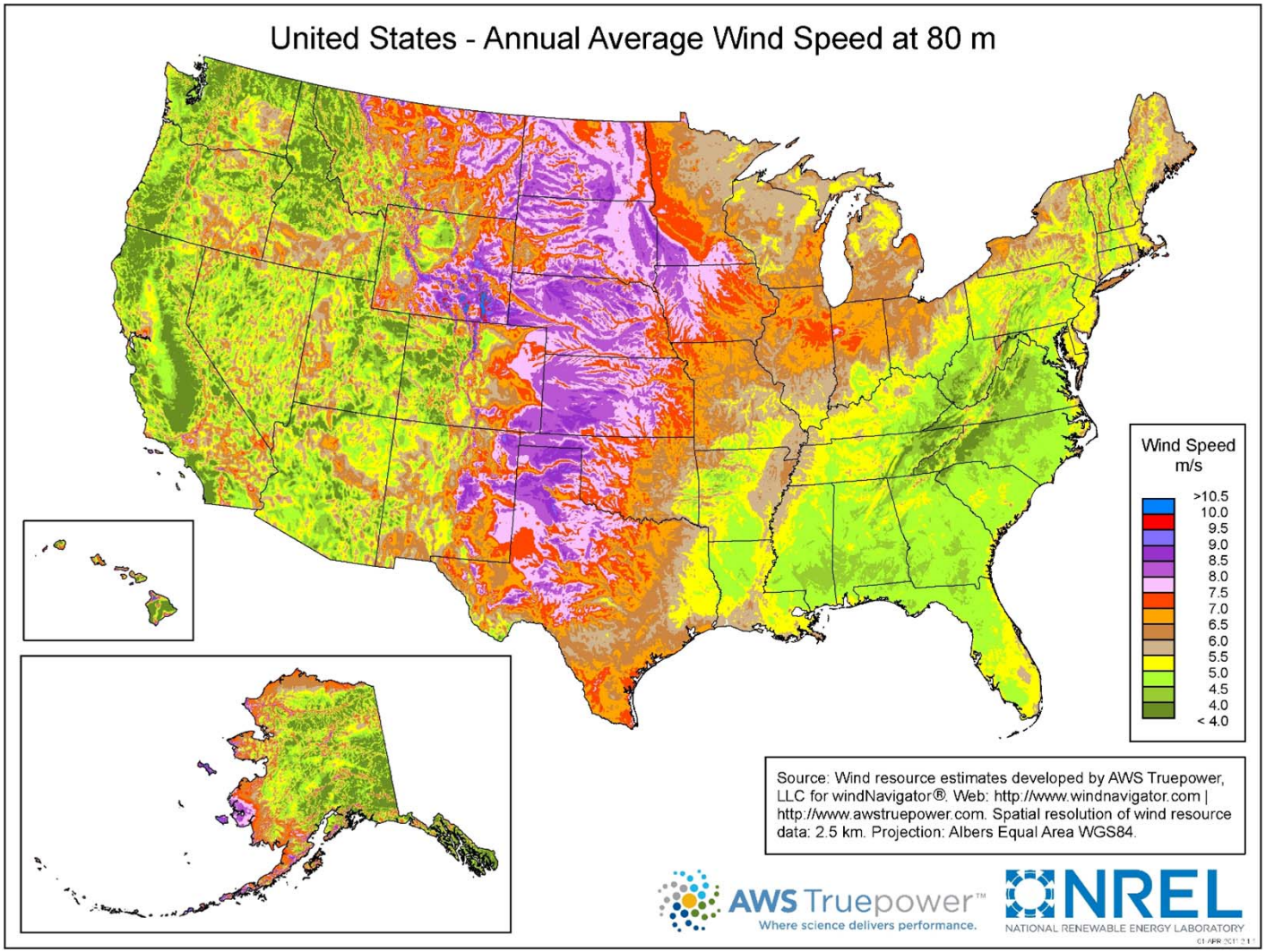
What are the Drivers on the adoption of CCP Technology

- Low natural gas prices and an abundant gas supply
- Stricter rules for coal in terms of meeting environmental regulations
- Increasing deployments of renewable energy as solar and wind requires power plants that can cycle including quick start and shutdown

Cape Canaveral 1200 MW FPL

H.F. Lee Energy Complex 920 MW Duke

Wind Energy is a Large Resource as Well



The Role Transmission in Future Electric Systems

- Transporting renewable energy – wind and solar from remote sites to load centers
- Providing stabilization to electric systems as inertialess devices substitute for the inertia of large rotating equipment. Traditionally, inertia provided for small system frequency changes and reduced power surge issues
- Increasing roles for Flexible AC Transmission System (FACTS) devices

Major Barrier: Securing right-of-ways for construction of new lines

Problems for PV Systems

New Field of Opportunity

Module Soiling

Module Shading

Healthy Vegetation

Maintaining Electric Vehicle Systems

New Field of Opportunity

https://www.epri.com/#/pages/product/3002011125/

Workforce Training & Education Requirements

Replacing an "Old Technology" Workforce

- Replacing Retirements
- Filling Training Gaps
- Cross Training
- Recruiting new people

Developing a "New Technology" Workforce

- CCP Technology
- Wind Turbine Technology
- Solar & Storage Systems
- Digital Technology

Together…Shaping the Future of Electricity