

# Welcome to the EE/PV/ES/EV/DR Confluence: Navigating Choppy Waters Ahead

Chris Calwell



September 27, 2017

# Navigating through a Flurry of Acronyms:

- EE – energy efficiency
- PV – photovoltaics (solar power)
- ES – energy storage (often batteries)
- EV – electric vehicles
- DR – demand response

Do they come at us unexpectedly, like another unmapped rapids around the bend, making the journey that much more choppy and perilous?

Or do they blend with existing solutions into a coherent whole we might call a resource plan or a long term strategy?



First Frosts in the  
Mountain West  
(and Sharp  
Objects) Focus  
the Mind...



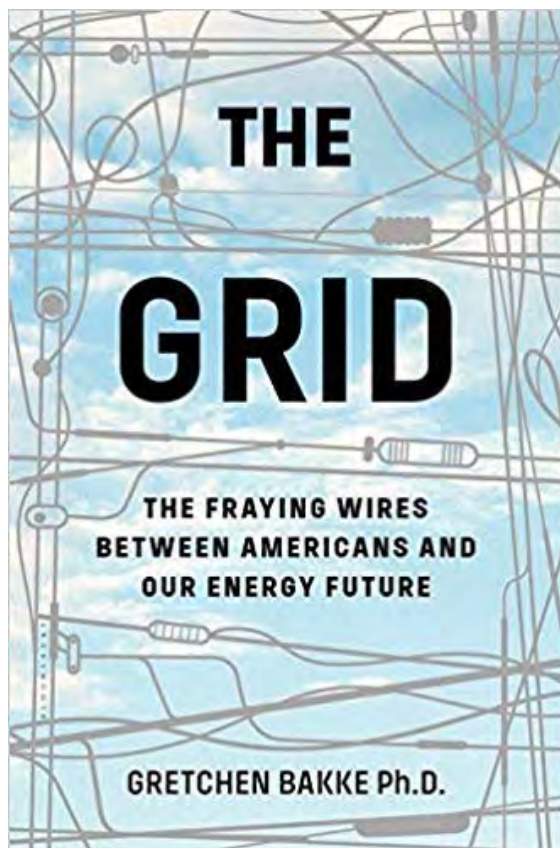


# Maybe We're Not Navigating Rough Waters at All -- We're Blending Disparate Ingredients Into a Coherent Whole





# Food for Thought...

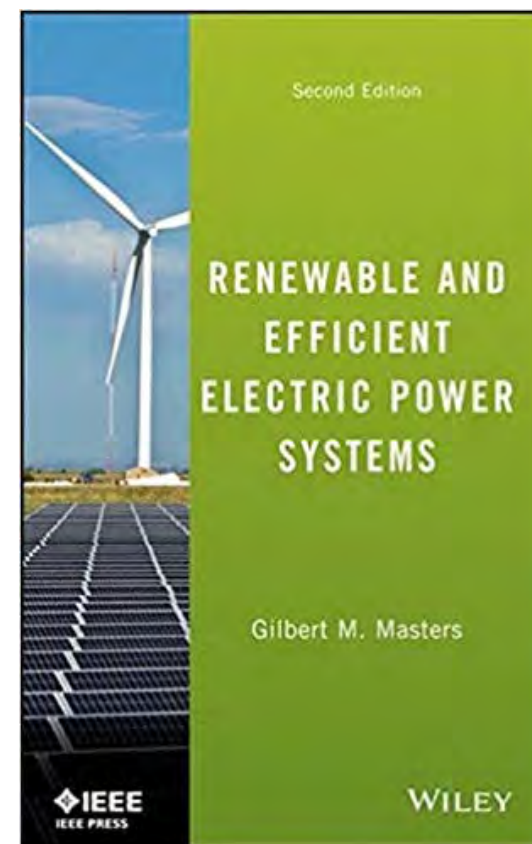


GET THE FACTS [www.bcse.org](http://www.bcse.org)

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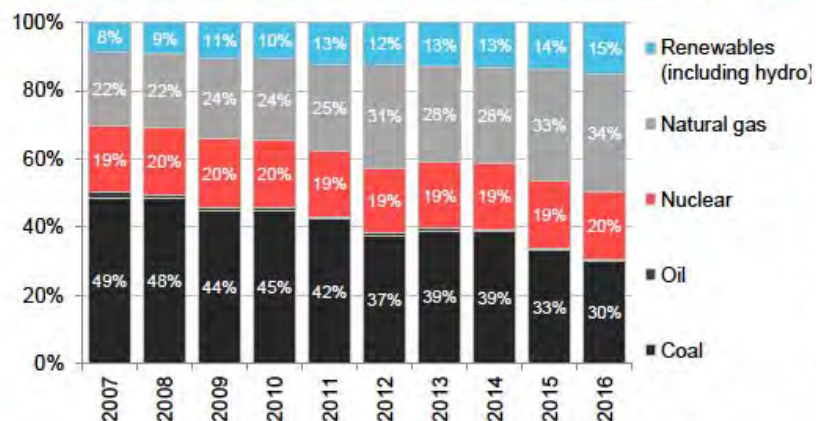




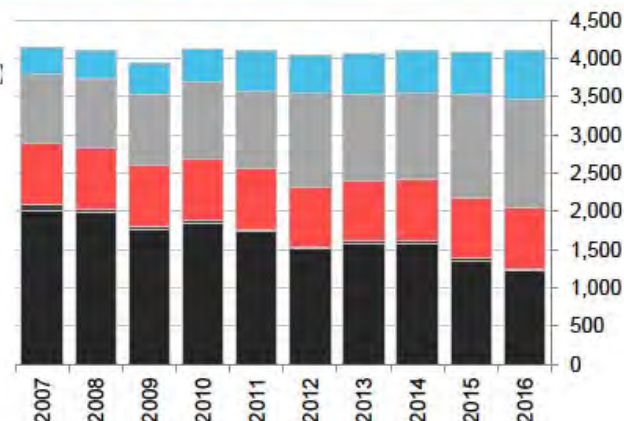
## US energy overview: Electricity generation mix

Bloomberg  
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US electricity generation by fuel type (%)



US electricity generation by fuel type (TWh)



- Natural gas has eclipsed coal as the largest contributor to the US electricity mix, hitting 34% in 2016, as aging coal-fired units retired and natural gas prices remained low. Coal sank to second place, providing 30% of the mix – its lowest share on record. Year-on-year, coal-fired power plants generated 10% less, slipping to 1,219TWh from 1,352TWh in 2015.
- Renewable generation topped 15% for the first time as the record-breaking drought in the West eased, boosting hydro generation, and as more solar and wind were connected to the grid.
- Since 2007, the US power sector has made large strides towards a decarbonized grid: coal's share plummeted from 49% to 30%, while natural gas's grew from 22% to 34% and renewables from 8% to 15%. On an absolute basis, coal generation sank 39% and natural gas generation rocketed 56% over the same timeframe.

Source: EIA

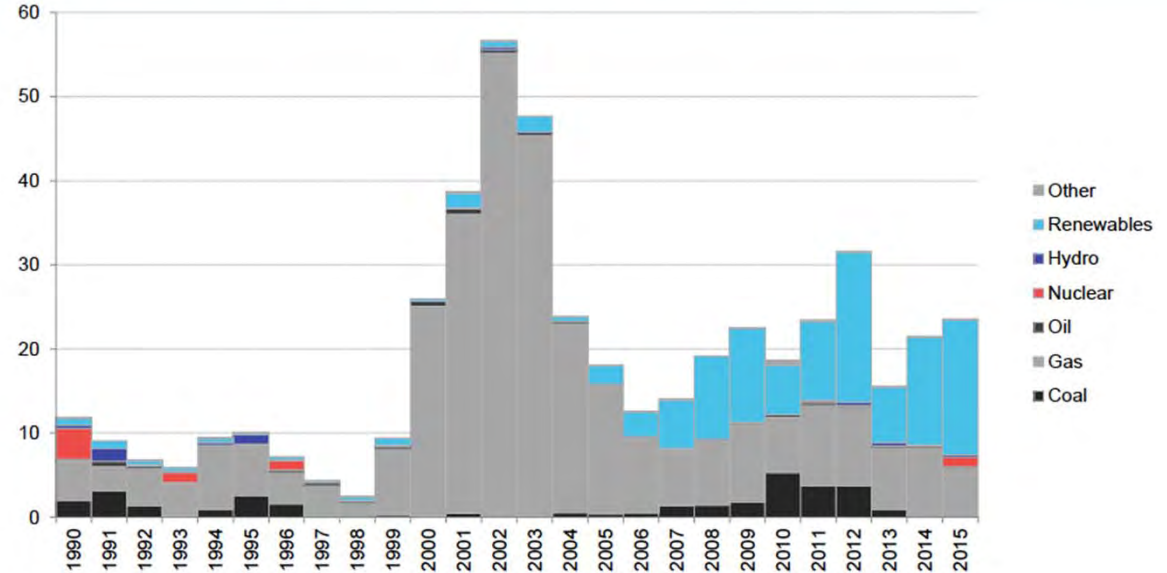
Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016). In chart at left, contribution from 'Other' is not shown; the amount is minimal and consists of miscellaneous technologies including hydrogen and non-renewable waste. The hydropower portion of 'Renewables' includes negative generation from pumped storage.

## We've Almost Stopped Building Baseload Generating Capacity

The overwhelming majority of new generating capacity in the last 20 years has been dispatchable natural gas and variable renewables.

### US energy overview: Electric generating capacity build by fuel type (GW)

Bloomberg  
NEW ENERGY FINANCE



- Since 2008, renewable energy projects have made up just over 50% of new capacity additions.
- Since 2000, 94% of new power capacity built in the US has been natural gas plants or renewable energy projects.
- In 2015, non-hydro renewables were the largest contributor to build for the second year in a row, providing over 16GW or 68% of total build. Gas made up another 25%. For the first time since the 1990s, there was also nuclear build of 1.1GW.

Source: EIA, Bloomberg New Energy Finance



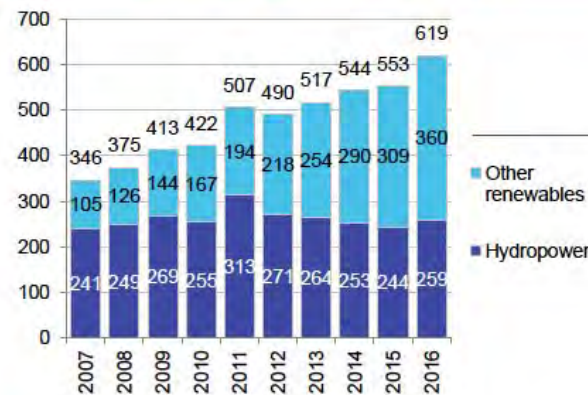
# Wind Continues to Be a Larger Contributor to Our National Mix than Solar – Why?

- Higher capacity factor
- Lower cost/kWh on average
- High quality resources more geographically dispersed around the US
- More electricity generated per acre of land utilized

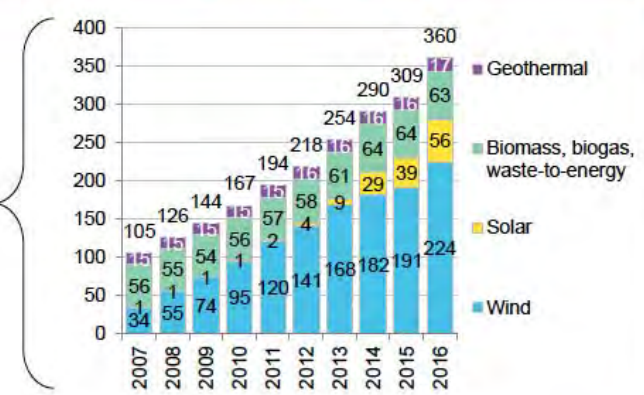
## US energy overview: Renewable energy generation by technology

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US renewable generation by technology (including hydropower) (TWh)



US non-hydropower renewable generation by technology (TWh)



- Total renewable generation swelled in 2016, increasing 12% over 2015 levels. Newly built wind and solar projects added 50TWh of incremental carbon-free generation, and at the same time, an easing drought out West boosted hydro output to its highest level in three years. Hydropower remains the largest single source of renewable generation (42%), but wind (36%) is catching up quickly.
- Non-hydro renewable generation has more than tripled over the past ten years. The largest growth was exhibited within the wind and solar sectors: wind generation has multiplied almost seven times over, while solar generation grew from virtually nothing to hit 56TWh in 2016.

Source: Bloomberg New Energy Finance, EIA

Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016). Includes net energy consumption by pumped hydropower storage facilities. Totals may not sum due to rounding. Beginning in 2014, numbers include estimated generation from distributed solar; generation from other distributed resources is not included.

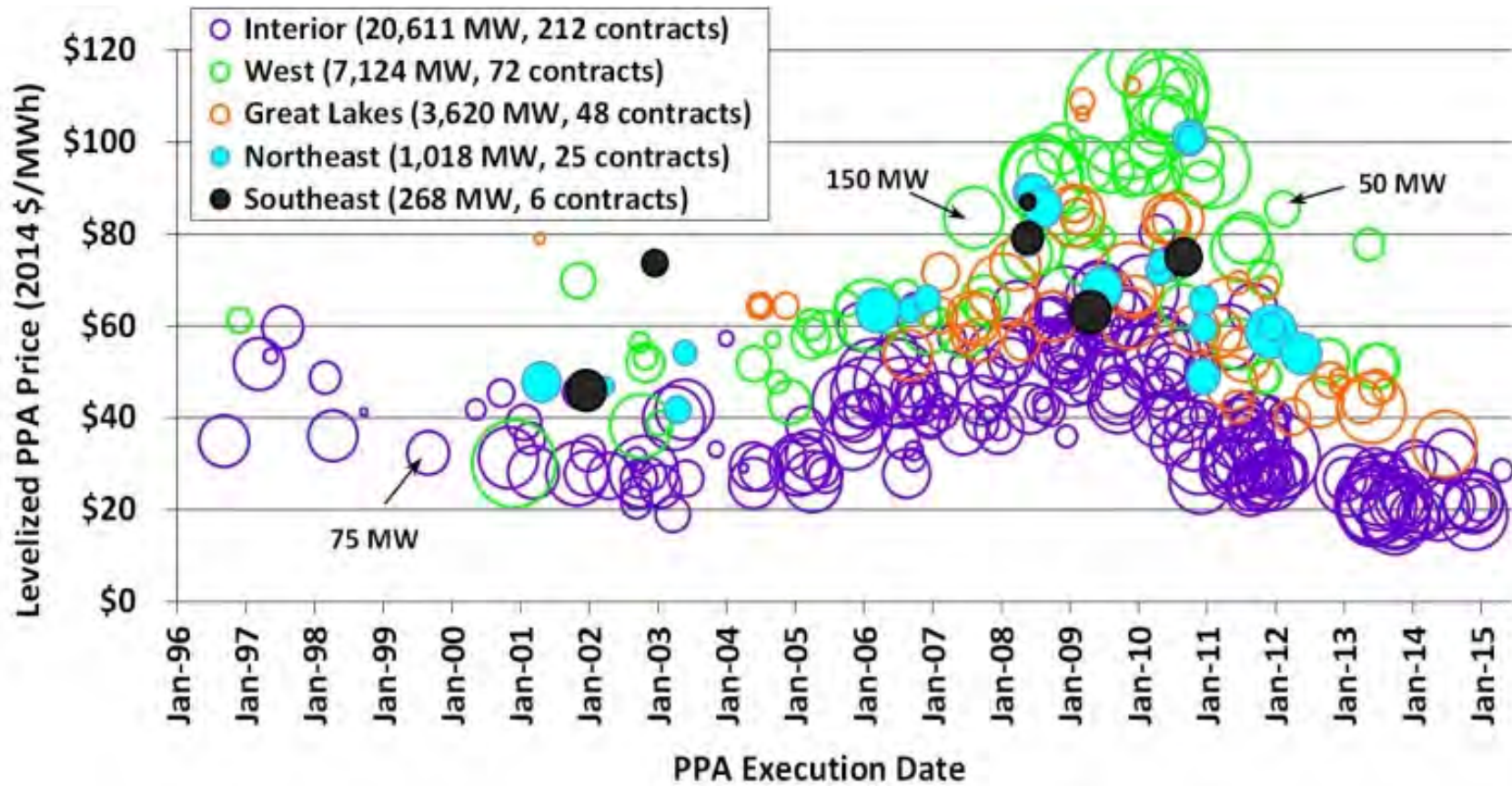




Photo credit: SSP Technology

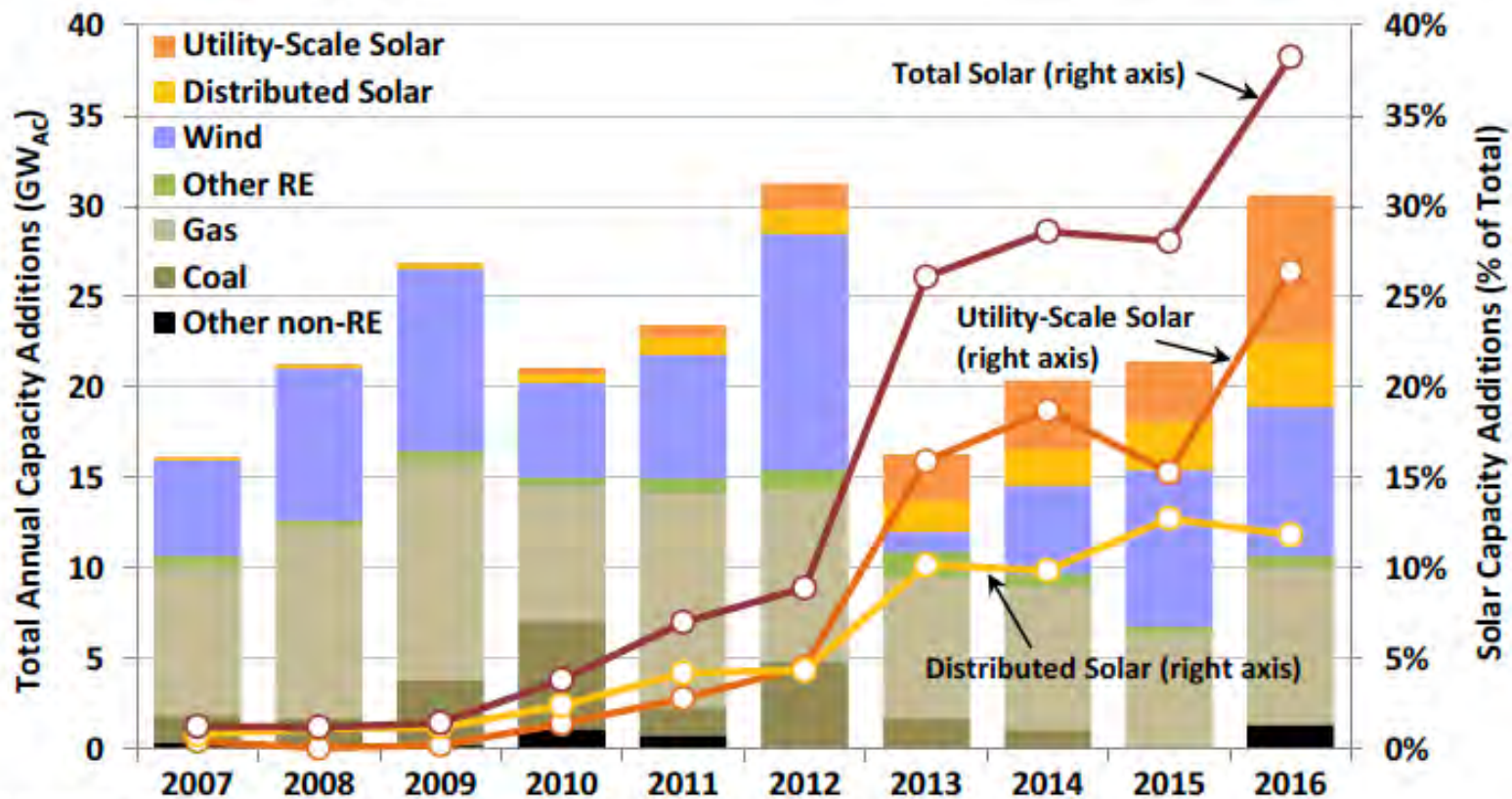
**Figure 5-4. Example of wind turbine blade transportation obstacles**

# Recent US Wind Project Locations and Costs



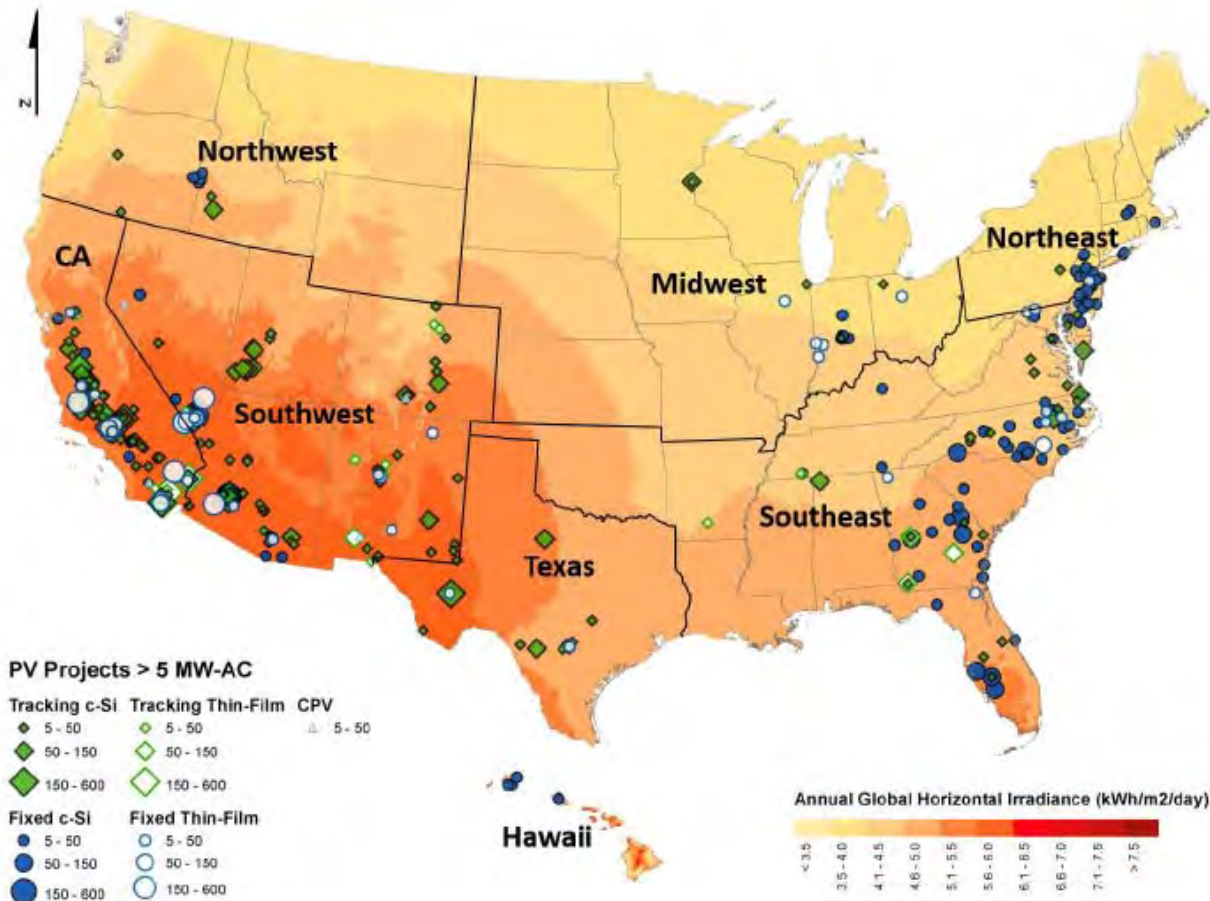


## Solar Growing Even Faster than Wind; Originally Mostly Distributed, But Now About 65% Utility-Scale



Source: ABB, AWEA, GTM/SEIA, Berkeley Lab





A Surprising Number of Utility Scale PV Projects Are Being Installed in Locations Far from the Best Sunshine Availability

Economics Now Attractive Enough to Drive Utility-Scale PV Investments in 29 States



# 3 to 4 Cents/kWh Is Now a Typical Price for Solar Power Purchase Agreements without Storage

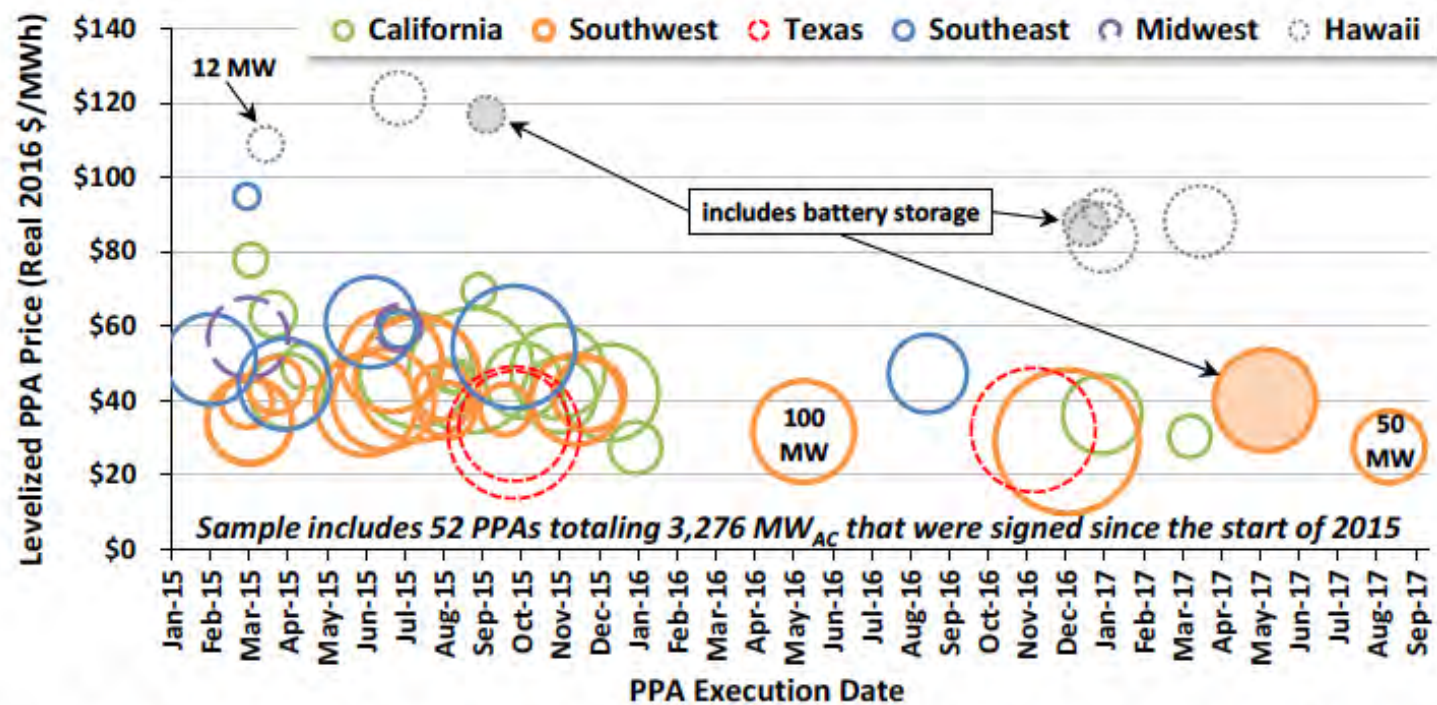


Figure 19. Levelized PPA Prices by Region, Contract Size, and PPA Execution Date: 2015-2017 (YTD) Contracts Only



Last year, solar in Chile set a record low global price for unsubsidized electricity by any technology. CREDIT: ACERA.

PV projects in the best locations now coming in below 3 cents/kWh without tax credits or subsidies



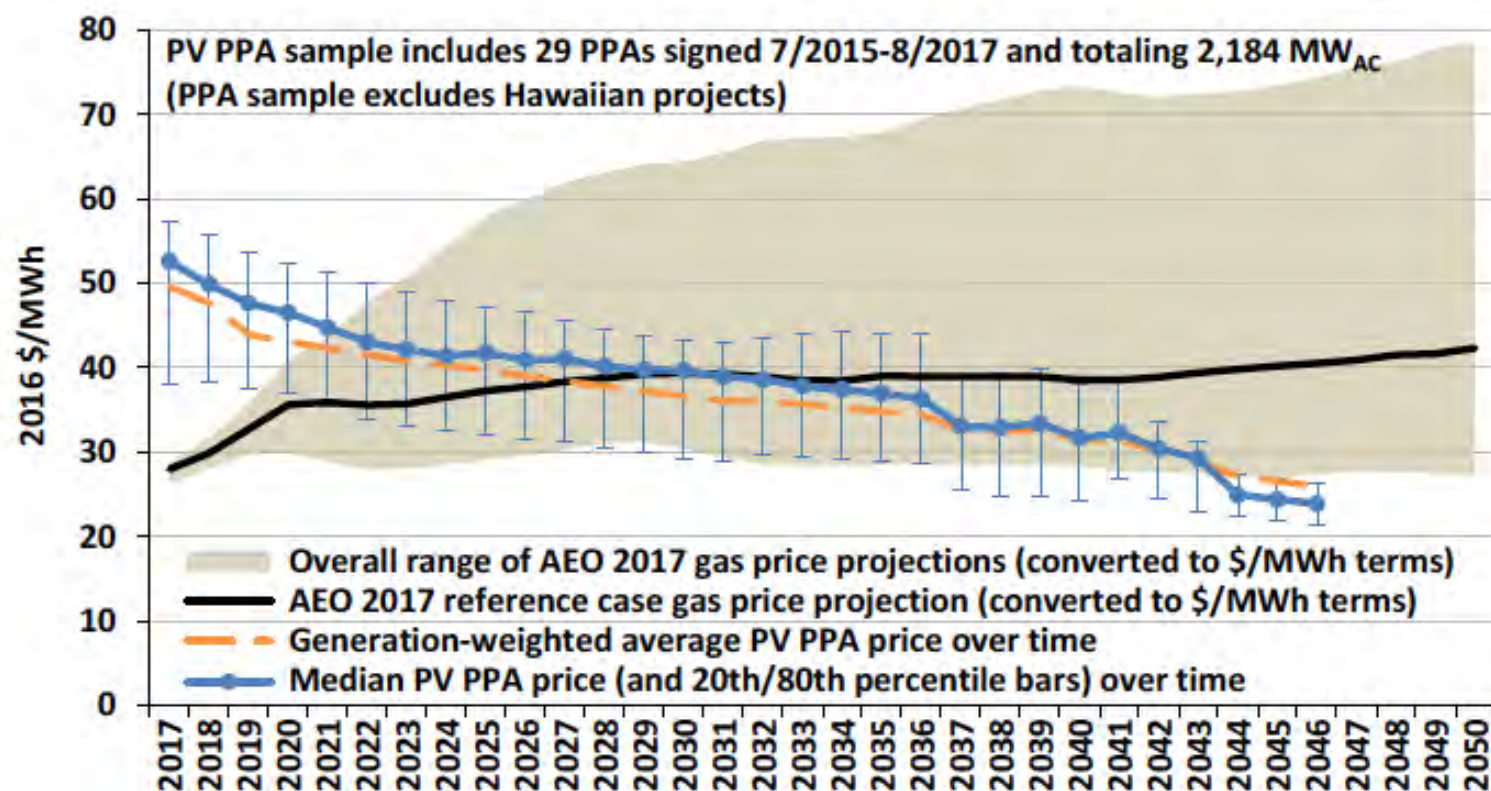




In 2016, India built a 648 MW solar power plant in 8 months (vs 4 years for typical baseload plants), and then signed a deal for a 750 MW solar plant a few months later for \$0.04/kWh. The results of this auction led the government to cancel four coal fired power plants and choose solar as its preferred new electricity source.

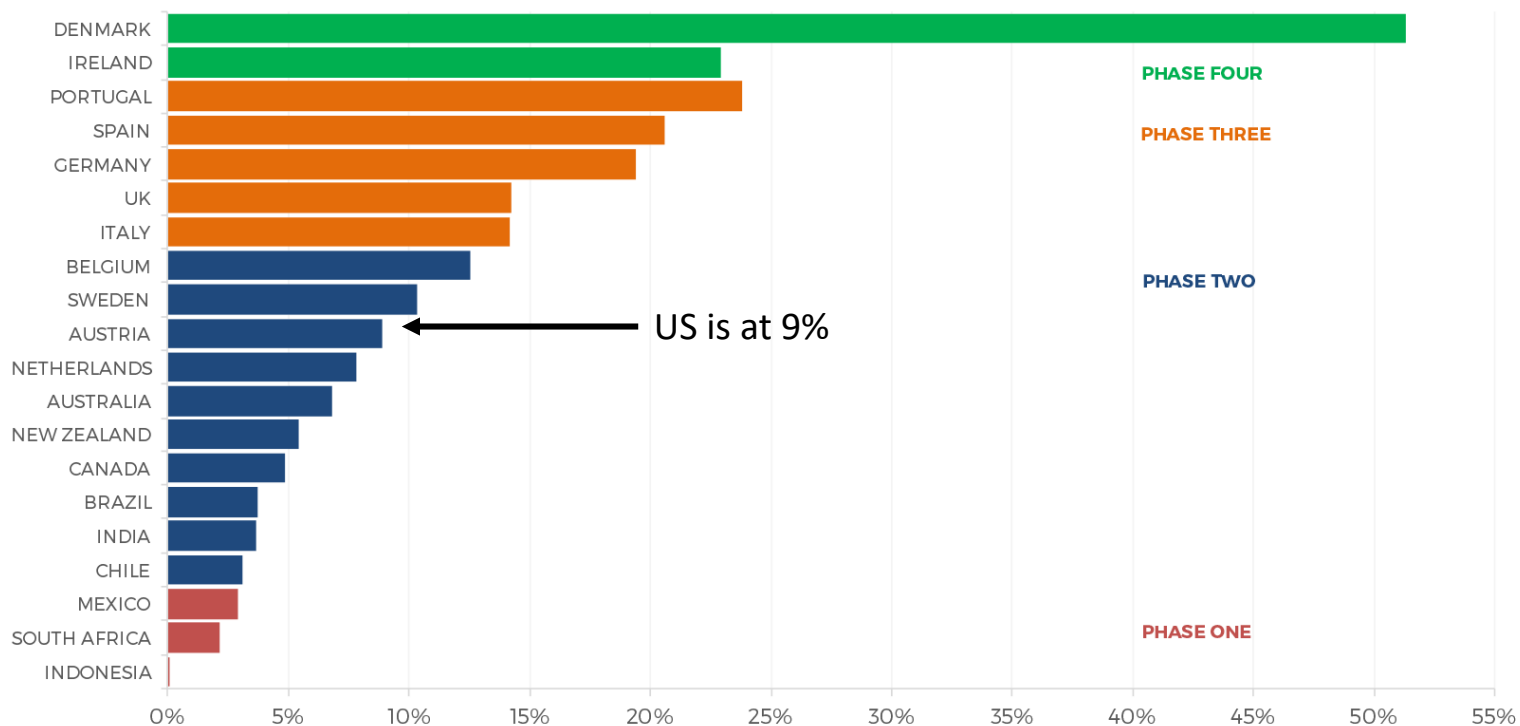


## Recently Signed Solar PPA's Have Sharply Declining Real Costs Over Time, While Natural Gas Prices Are Expected to Steadily Rise

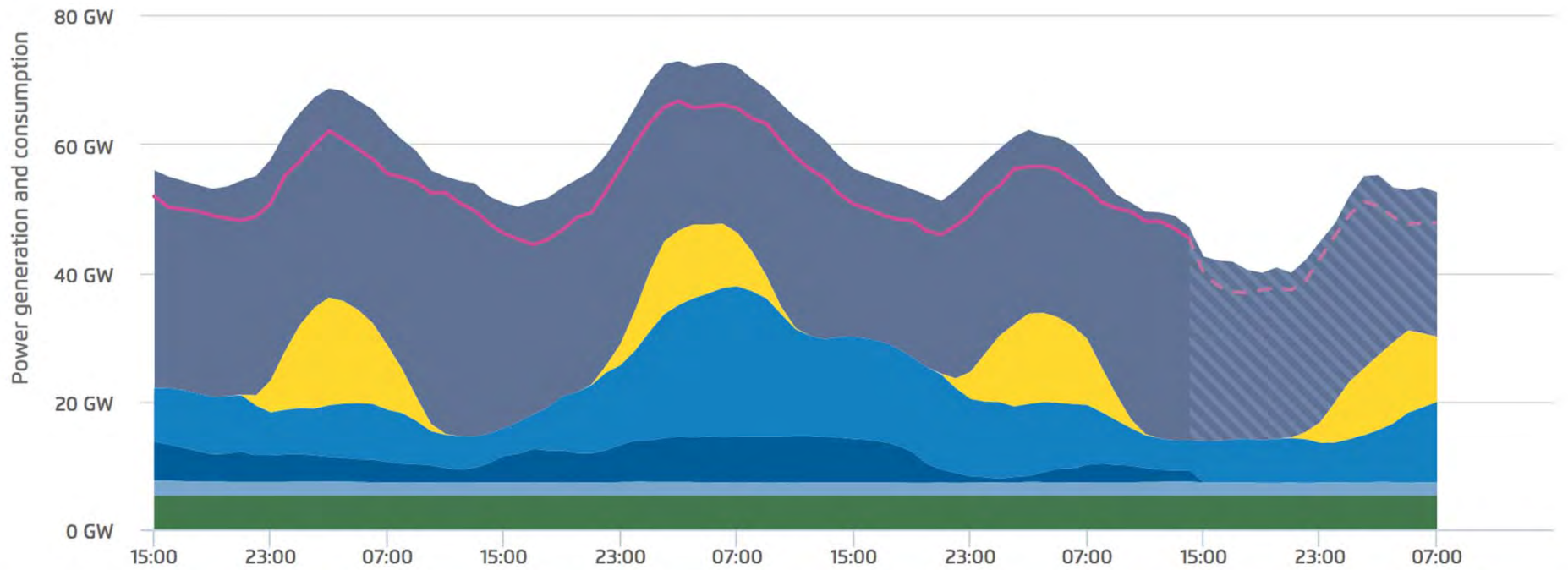




## Other Countries' Share of Variable Renewable Energy Is Already Much Higher than the Share on the US Grid



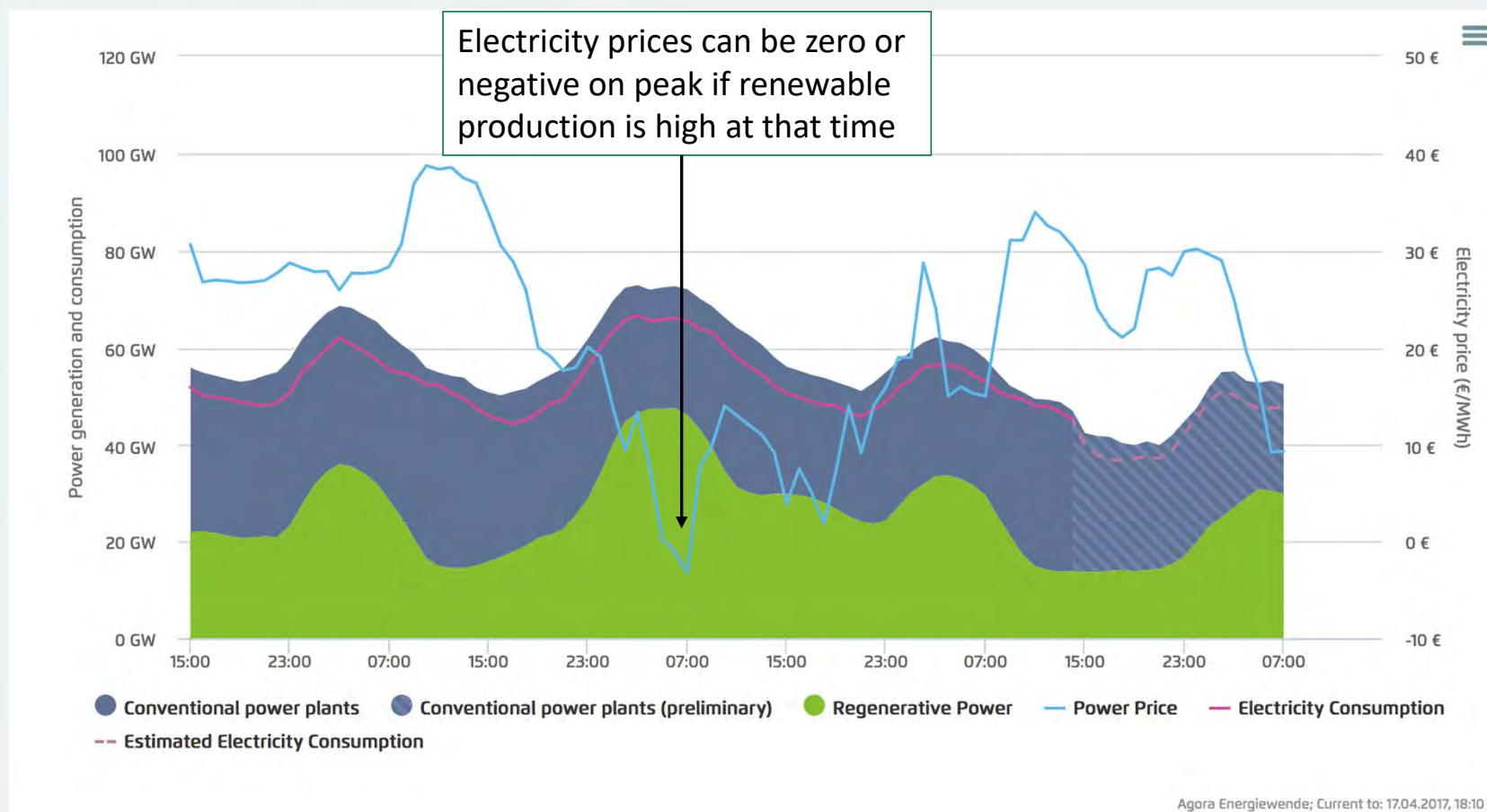
# Germany's Grid: A Postcard from the Future?



- Conventional power plants
- Conventional power plants (preliminary)
- Solar
- Wind Onshore
- Wind Offshore
- Hydro
- Biomass
- Electricity Consumption
- - - Estimated Electricity Consumption
- Hard coal
- Lignite
- Nuclear
- Pumped hydro
- Natural gas

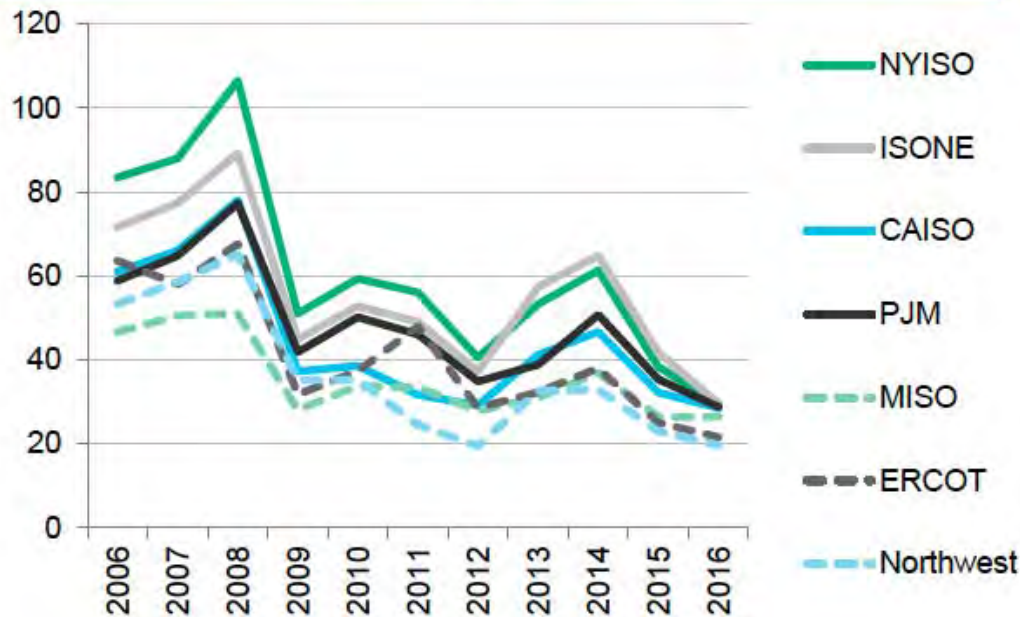


## Power Prices, Generation and Consumption



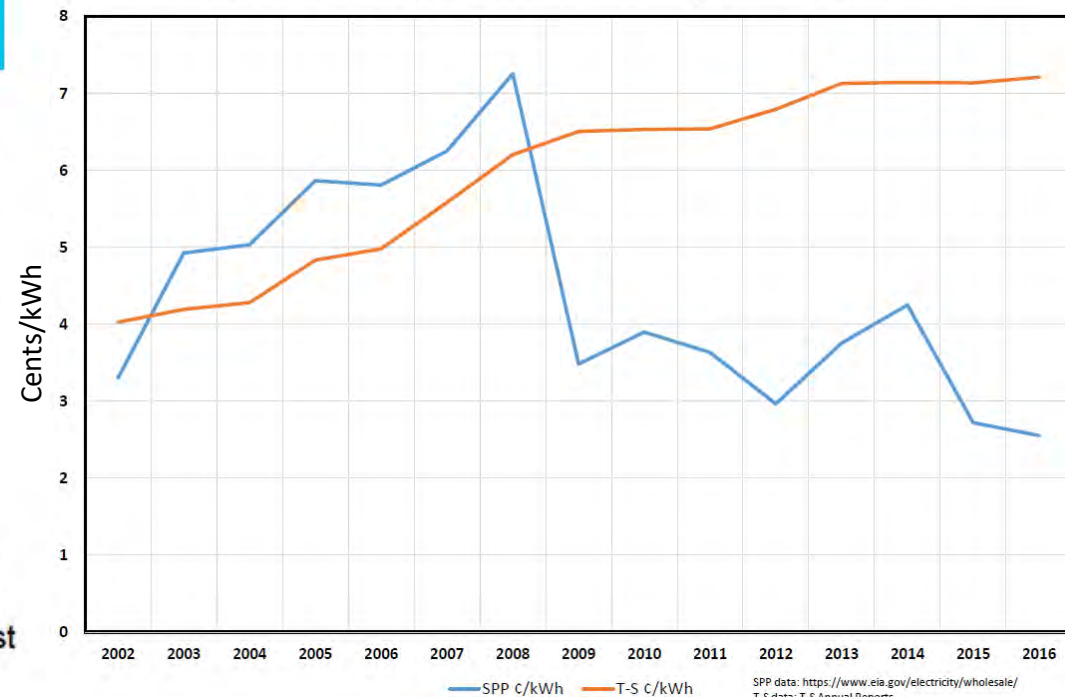
# Wholesale Power Prices are Dropping Nationally and in the Southwest, But G&T Utility Rates Are Rising

Wholesale power prices (2016 \$/MWh)



Bloomberg New Energy Finance

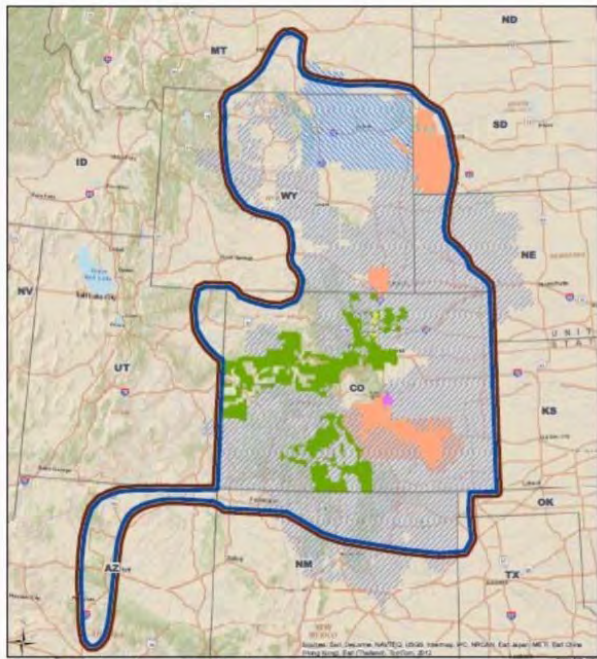
Southwest Power Pool (Palo Verde) and Tri-State Average Annual Wholesale Rates



Guinn Unger, "LPEA Long Term Strategy Discussion," 9/18/17



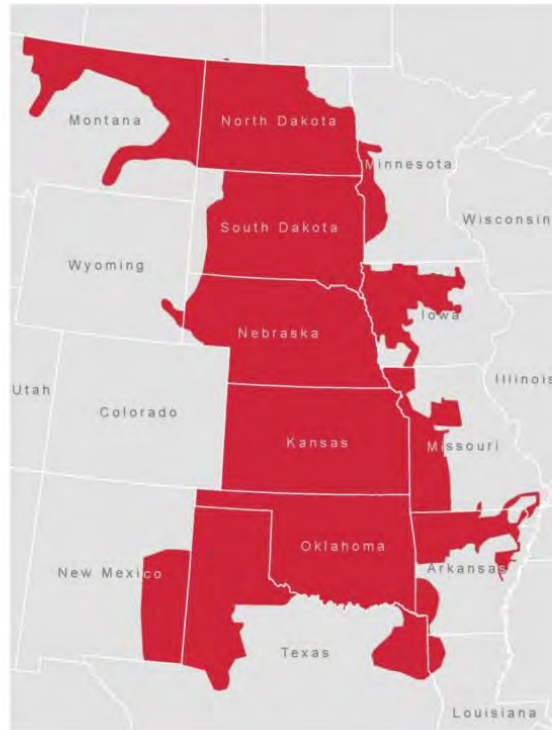
# Time to Join a Bigger Power Pool...



**Mountain West Transmission Group Membership Areas**

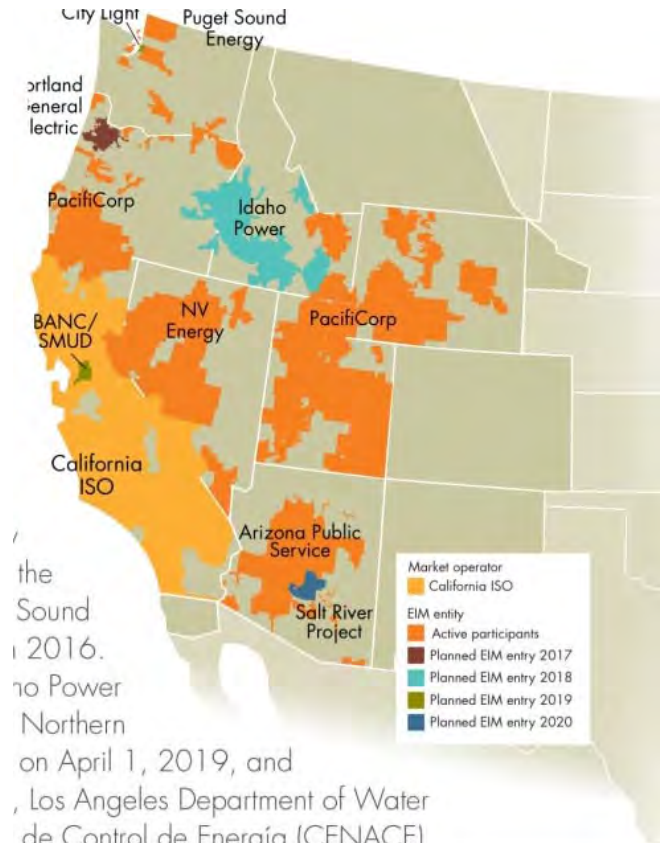
- MWTG Footprint
- MEMBER BY PLANNING AREA: Platte River Power Authority
- MEMBER BY MEMBERSHIP AREA: Borealis Electric Power Corp, Tri State Generation & Transmission Association Inc.
- MEMBER BY SERVICE AREA: Black Hills Companies, Colorado Springs Utilities, Public Service Co of Colorado
- WESTERN AREA POWER ADMINISTRATION: LAP and CRSP Transmission

Mountain West Transmission Group



Southwest Power Pool

The Southwest Power Pool serves utilities operating in 14 states.

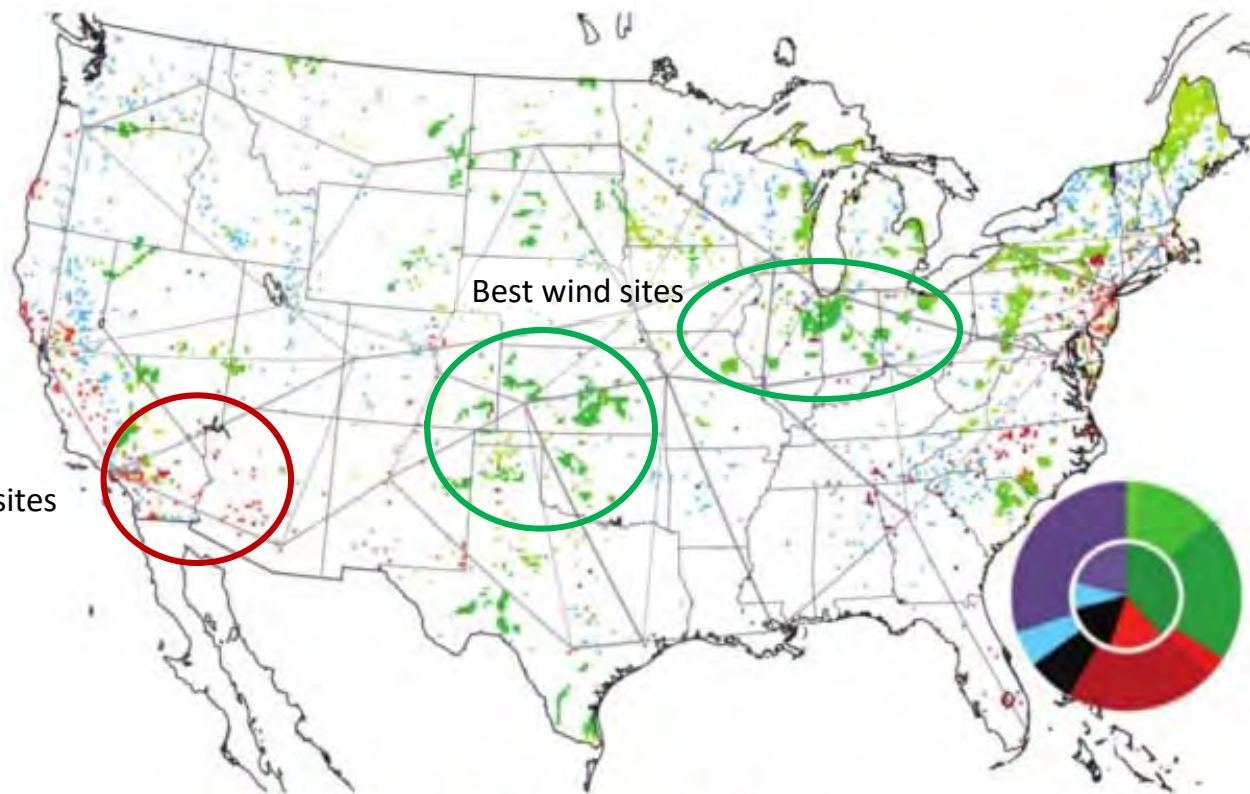


the Sound  
2016.  
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Northern  
on April 1, 2019, and  
, Los Angeles Department of Water  
de Control de Energía (CENACE)

Prevailing winds

Best solar sites

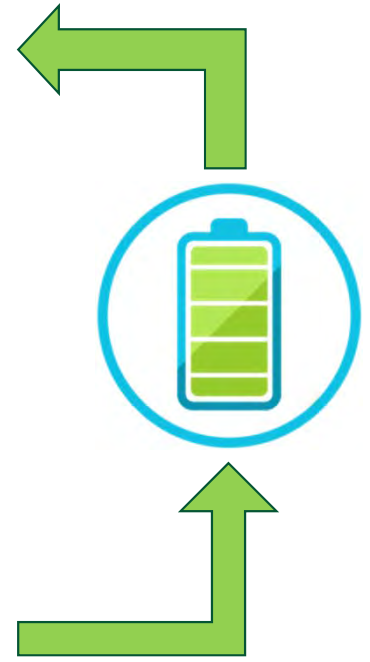
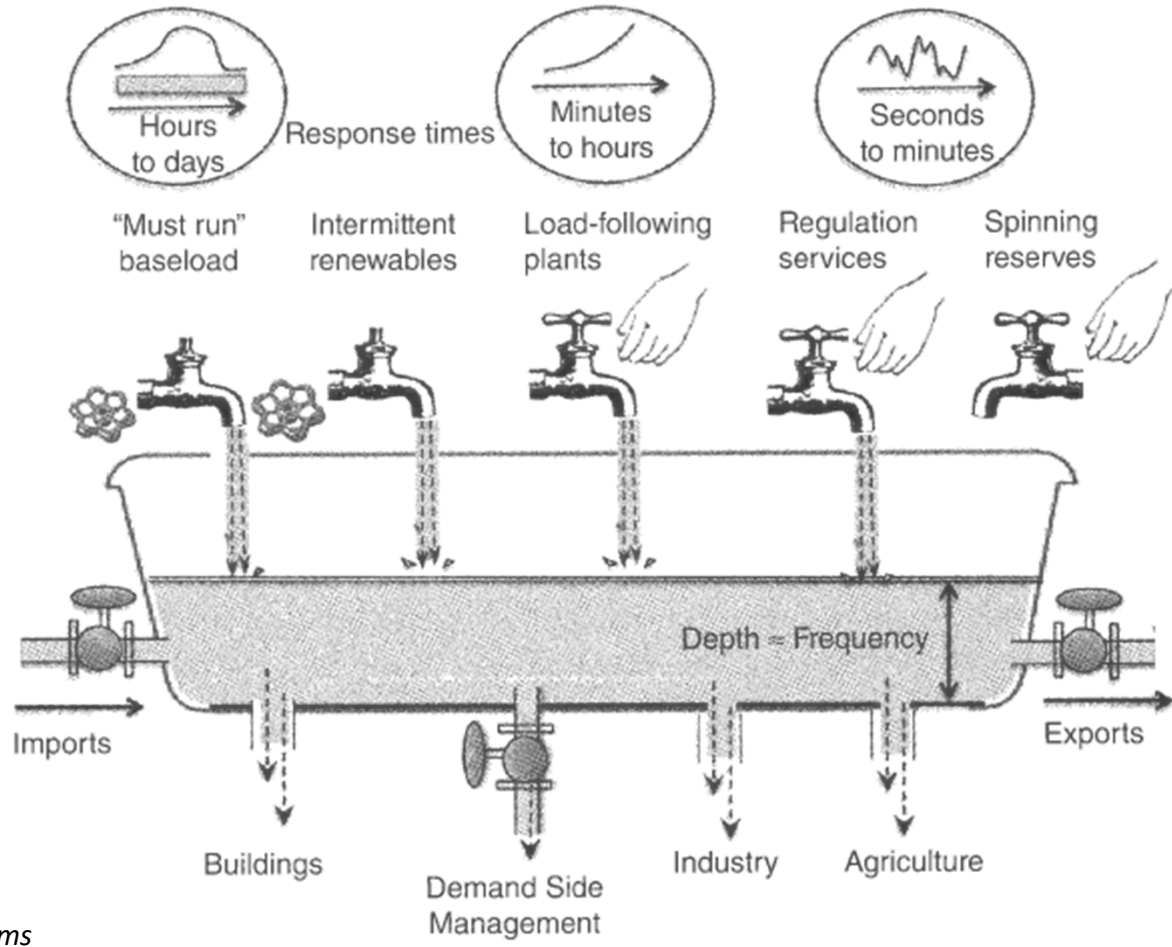
Setting sun



Continent-sized  
DC high voltage  
grids help  
greatly with  
integrating large  
amounts of wind  
and solar



# Grid as Bathtub...



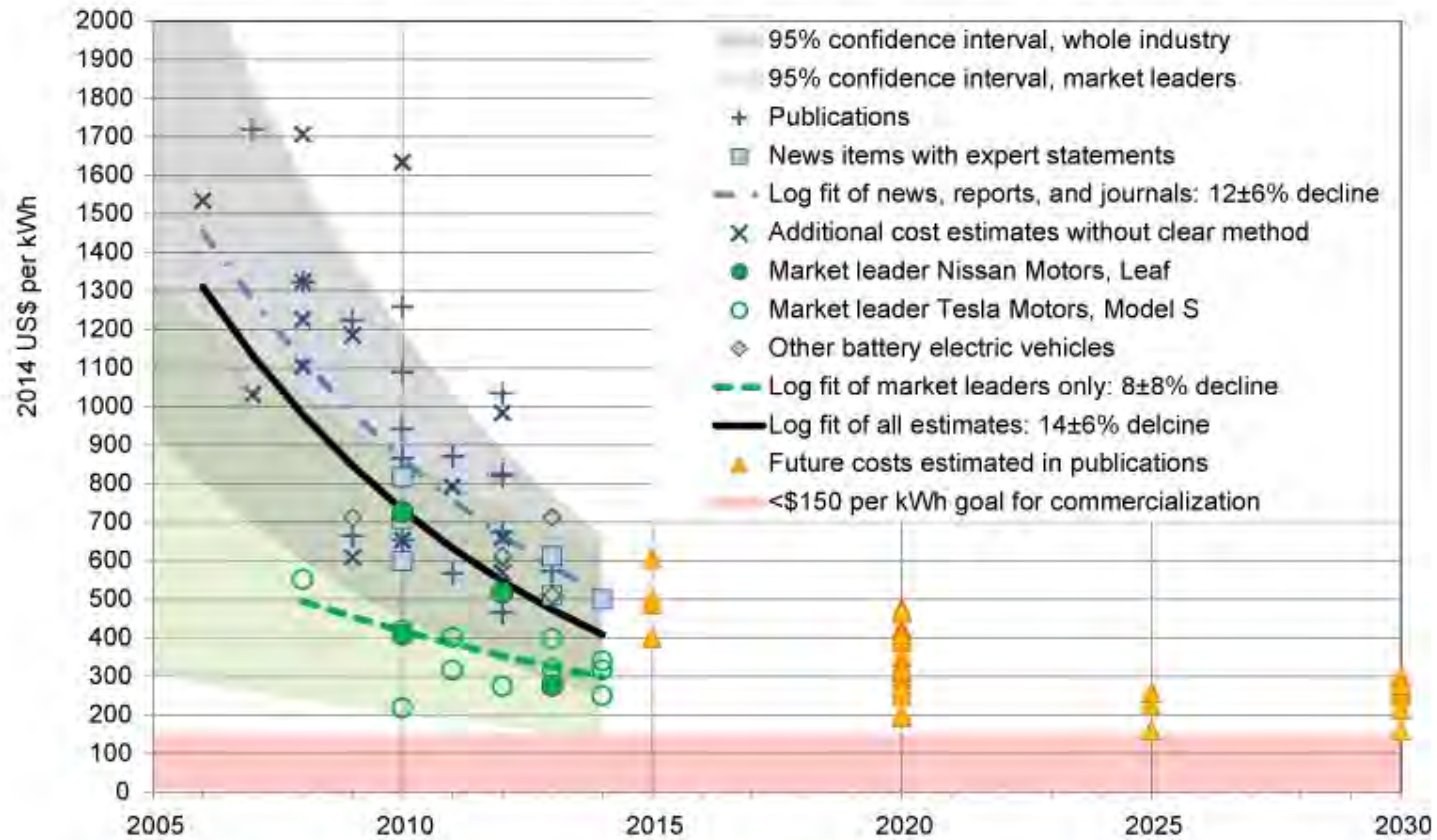
# Included Energy Storage Will Be Increasingly Common (and Affordable) in New PV Projects

State	Project		Capacity (MW-AC)		Battery Storage		PPA Date	Expected COD	PPA Term (years)	PV Mount	Expected Capacity Factor	Levelized PPA Price (2016 \$/MWh)	% of PV used to charge
	Sponsor	Offtaker	PV	Battery	Duration	MWh							
HI	Tesla	KIUC	13	13	4 hours	52	Sep-15	Apr-17	20	Fixed	~20%	~\$117	>80%
HI	AES	KIUC	20	20	5 hours	100	Dec-16	Oct-18	25	Tracking	~29%	~\$88	>70%
AZ	NextEra	SRP	20	10	4 hours	40	Apr-17	Mar-18	20	Tracking	~33%	N/A	~25%
AZ	NextEra	TEP	100	30	4 hours	120	May-17	Dec-19	20	Tracking	~33%	~\$40	~15%

On the mainland, there is only one publicly available PPA price data point at present: Tucson Electric Power's (TEP's) announcement that its all-in cost will be "significantly less than" \$45/MWh, and that the solar component is less than \$30/MWh on its own (Maloney 2017), implying an adder of ~\$15/MWh for 4 hours of storage at 30% of PV nameplate. This implied adder is consistent with NextEra's recent projection of a battery storage adder (for 4 hours at 40% of solar nameplate) of \$19-29/MWh in 2016, dropping to \$12-22/MWh in 2020 (NextEra Energy 2017). In the wake of the TEP announcement, ViZn Energy (a zinc-iron flow battery manufacturer) heralded its own ability to build a similar project for under \$40/MWh, with a storage adder (for 4 hours at 30% of solar nameplate) of ~\$14/MWh (ViZn Energy 2017).



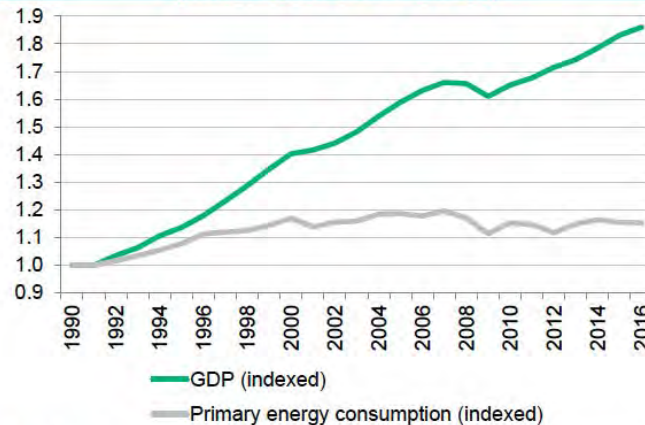
### Estimates of costs of lithium-ion batteries for use in electric vehicles



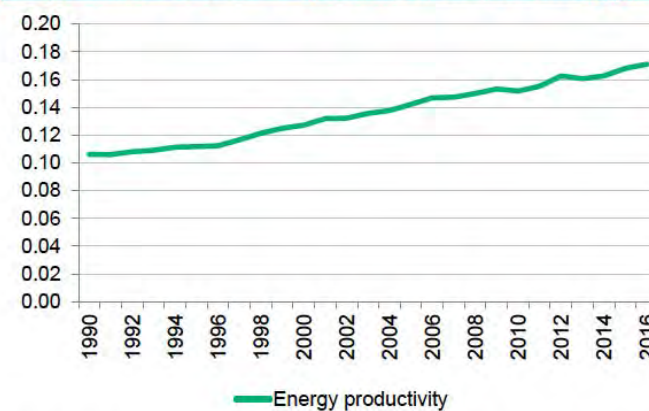
## US energy overview: Economy's energy productivity

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US GDP and primary energy consumption  
(indexed to 1990 levels)



US energy productivity  
(\$ trillion of GDP / quadrillion Btu of energy)



- The US economy continues to become more energy productive, as total energy consumption plateaus while GDP advances. Over the past 25 years, real GDP has accelerated by 80%, while primary energy consumption has risen by only 14%. Within the past 10 years, this decoupling is even more evident: GDP has grown by 12%, while energy consumption has declined 3.6%.
- By another measure (US GDP per unit of energy consumed), productivity has soared 58% since 1992, 16% since 2007, and 1.8% since 2015. While the shifting composition of the US economy is a key driver, estimates put forward by the American Council for an Energy Efficient Economy in 2015 indicate that efficiency gains are responsible for as much as 60% of the energy intensity improvements seen since 1980.

Source: US Energy Information Administration (EIA), Bureau of Economic Analysis, Bloomberg Terminal

Notes: Values for 2016 energy consumption are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016). GDP is real and chained (2009 dollars); annual growth rate for GDP for 2016 is based on consensus of economic forecasts gathered on the Bloomberg Terminal as of January 2017.



# Regional Electric Load Growth Is Slow

Figure 1 | Average Annual Percent Change in Electricity Sales in All Southwestern States by Sector<sup>ii</sup>

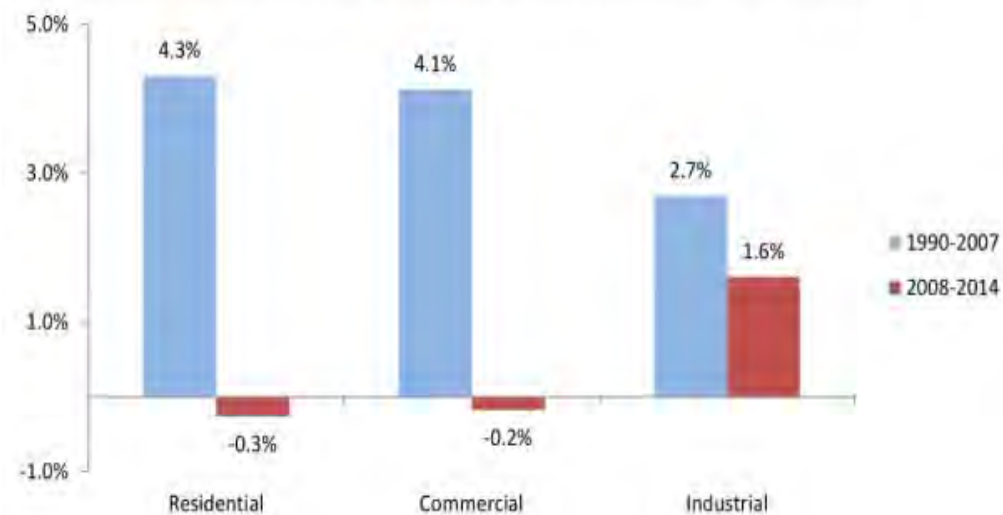
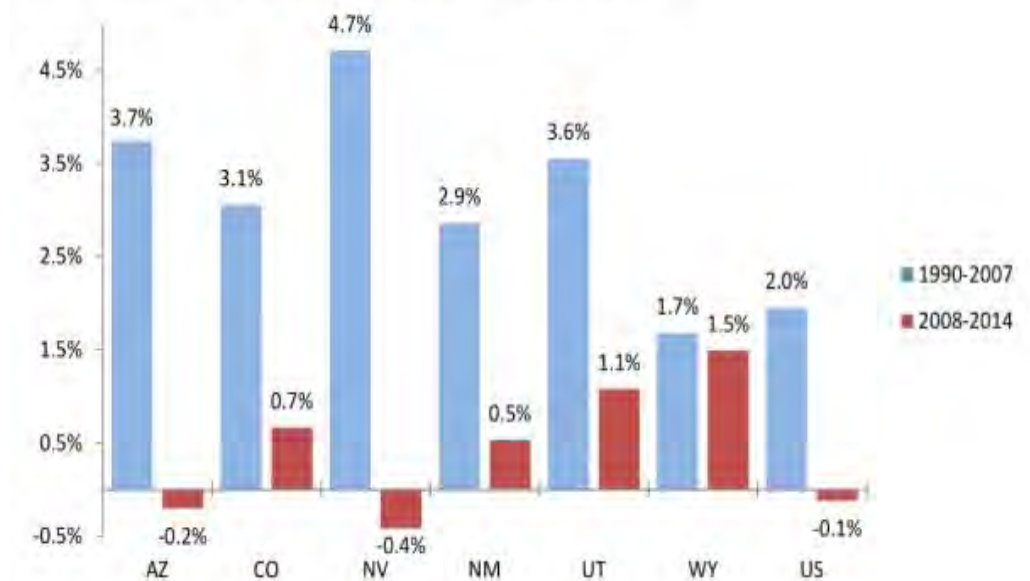
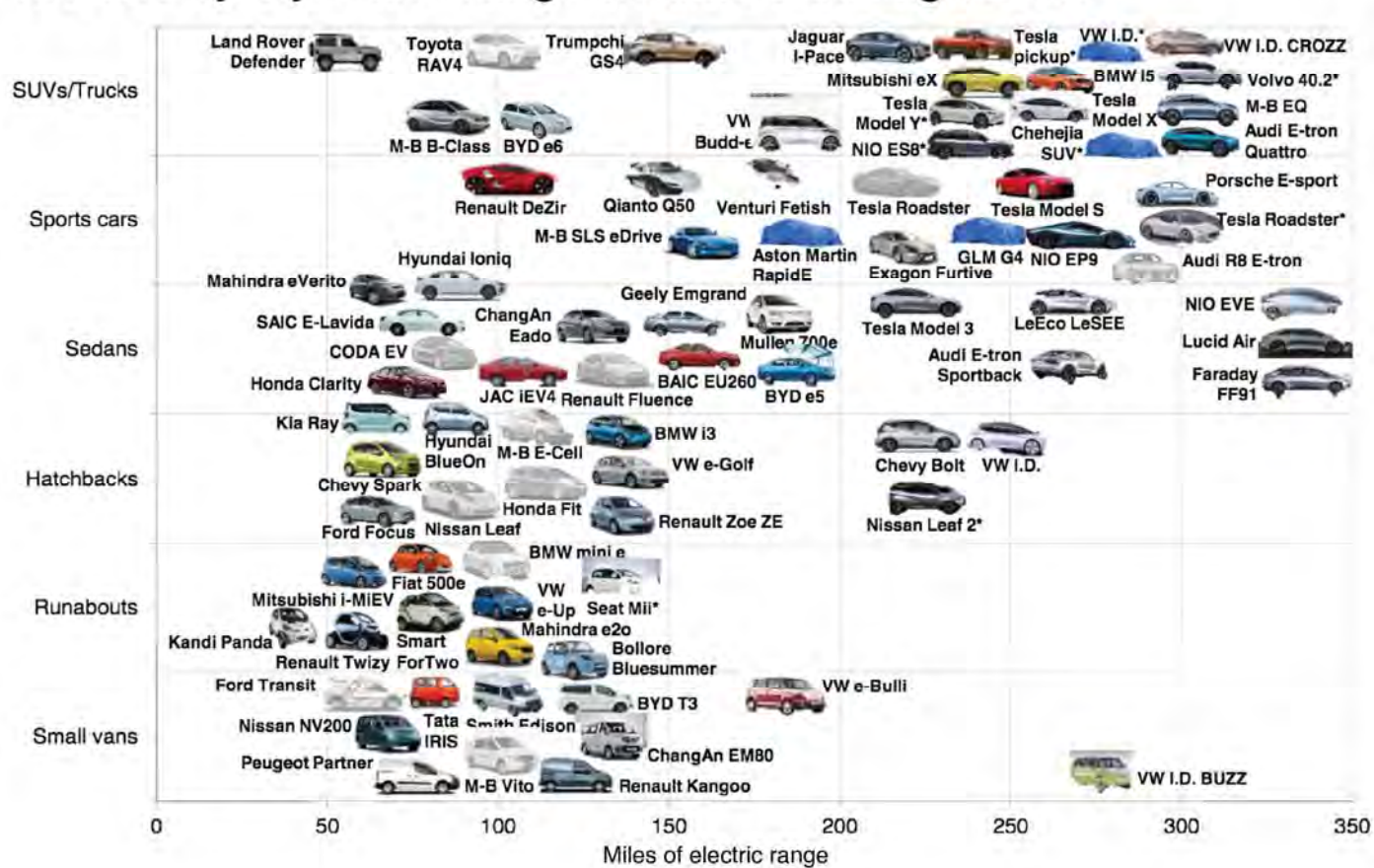


Figure 2 | Average Annual Percent Change in All Electricity Sales by State<sup>iii</sup>



# Electric-Car Boom

Models by style and range available through 2020

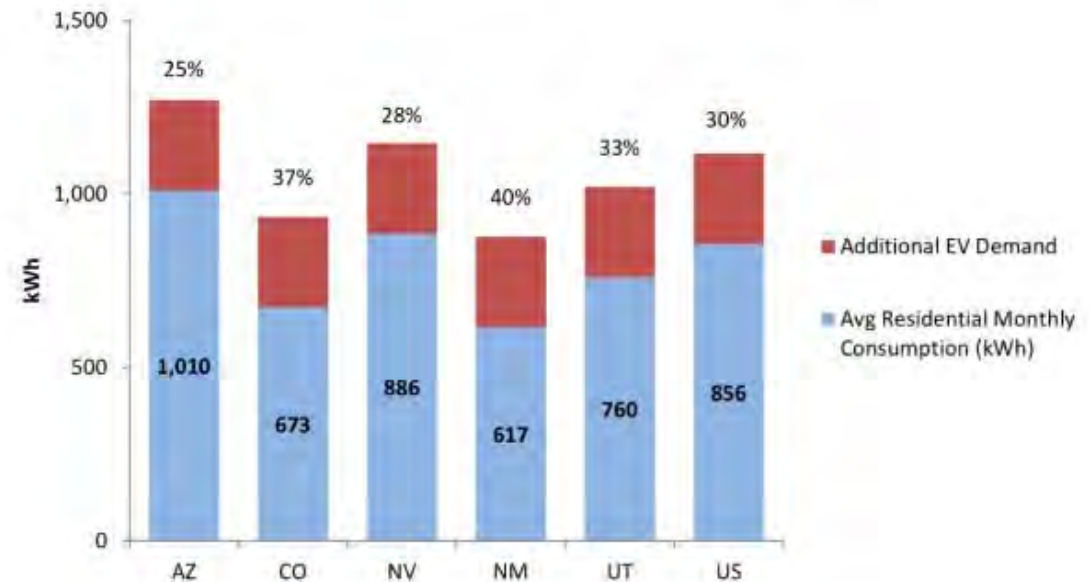




# Key Quotes from SWEEP's Electric Vehicle Report

- “Much higher levels of EV penetration will be necessary to make up for the decreases in demand due to energy efficiency and solar PV.”
- “An average EV consumes 3,100 kWh/year.”
- “In the Southwest, EVs currently make up approximately 0.5% of all new light duty vehicle sales and it is estimated that by the end of 2015 there were around 30,000 EVs in this region.”
- “The active involvement of utilities now could play an important role in increasing adoption rates above this baseline.”

Figure 3 | Growth of Electricity Consumption per Household When an EV is Added



# Good TOU Rate Design Is Key to Ensuring EVs Charge at Times Favorable to the Utility

Figure 4 | Average Demand for Xcel Energy and Distribution of EV Load<sup>25</sup>

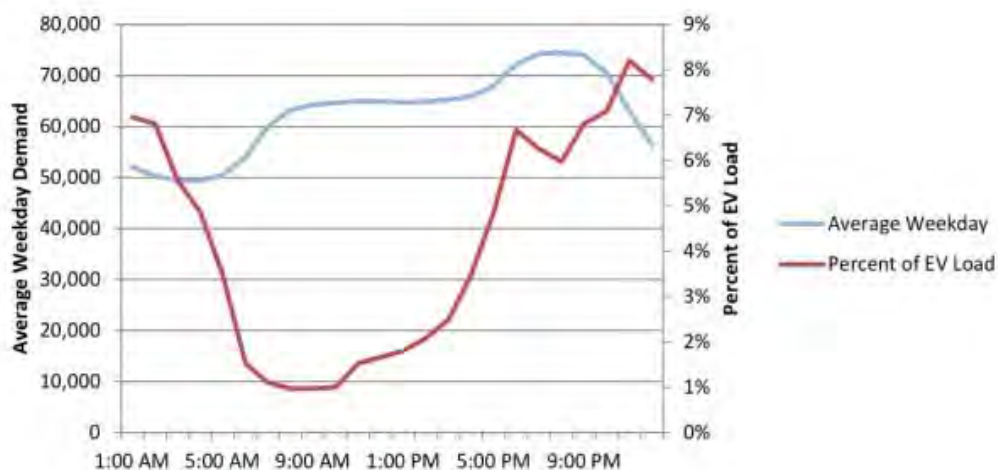
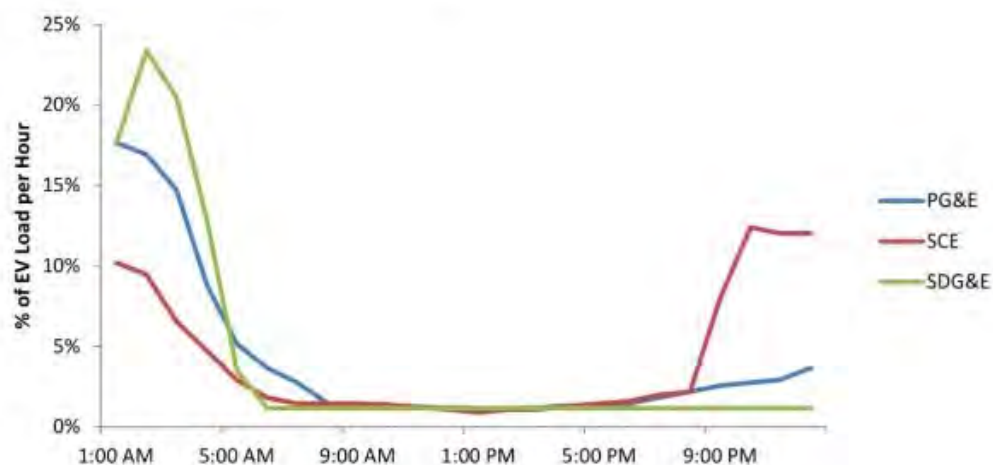


Figure 5 | Daily EV Load for Major California Utilities<sup>26</sup>





## Many Utilities Offering EV Charger and Vehicle Incentives

Most common approach is to contribute \$500 to \$1500 toward cost of residential charging stations or fully fund upfront and recover on customer bill over time.

Commercial charging station incentives are all over the board. Initially focused on Level 2 stations, but increasingly driving DC Fast Charge (Level 3) installations as more vehicles are released with that capability.

Utility incentives for the vehicles themselves are more rare, but federal and CO state tax credits already strongly encourage their purchase.

SWEEP, *How Leading Utilities Are Embracing Electric Vehicles*, 2015

Current Utility Incentives	Residential Charging Stations	Commercial Charging Stations	Vehicle
Alabama Power		\$500	\$750
Austin Energy <sup>55</sup>	\$1,500		
Central Maine Power		\$2,500	
Georgia Power	\$250	\$500/\$10,000	
Glendale Water & Power <sup>56</sup>	\$200		
Great River Energy <sup>57</sup>	\$500		
Indiana-Michigan Power <sup>58</sup>	\$2,500		
Jacksonville Energy Authority (JEA)		Free and up to \$7,500 installation costs	\$500/\$1,000
Lansing Board of Water and Light <sup>59</sup>	\$1,000		
Los Angeles Dept. of Water and Power (LADWP)	\$750	\$750/\$1,000/\$15,000	
Northern Indiana Public Service Company (NIPSCO)	\$1,650	Free Level 2 \$3,000/\$37,500	
NV Energy		\$30,000 (DCFC)	
Orlando Utilities Commission (OUC)		\$500	
PECO <sup>60</sup>	\$50		
Puget Sound Energy	\$500		
San Miguel Power Authority <sup>61</sup>			\$250/\$750
<b>Expired Incentives</b>			
Central Maine Power		\$2,500	
Consumers Energy	\$2,500		
NV Energy		\$5,000-\$7,000	

# V2G (Vehicle to Grid) Offers Intriguing Simplicity and Affordability

Charger  
(two-way eventually?)

Sub-panels  
& controls

Inverters  
& conduit

Battery packs  
& conduit





Nissan is now testing its “Leaf to Home” two-way power flow concept in 4000 households in Japan, and hundred more in Denmark, the UK and US.



Only about 15 kWh of car’s battery capacity needed to run a typical home after the sun sets and until it rises. Peak discharge rates are much lower than when driving, minimizing wear on battery.

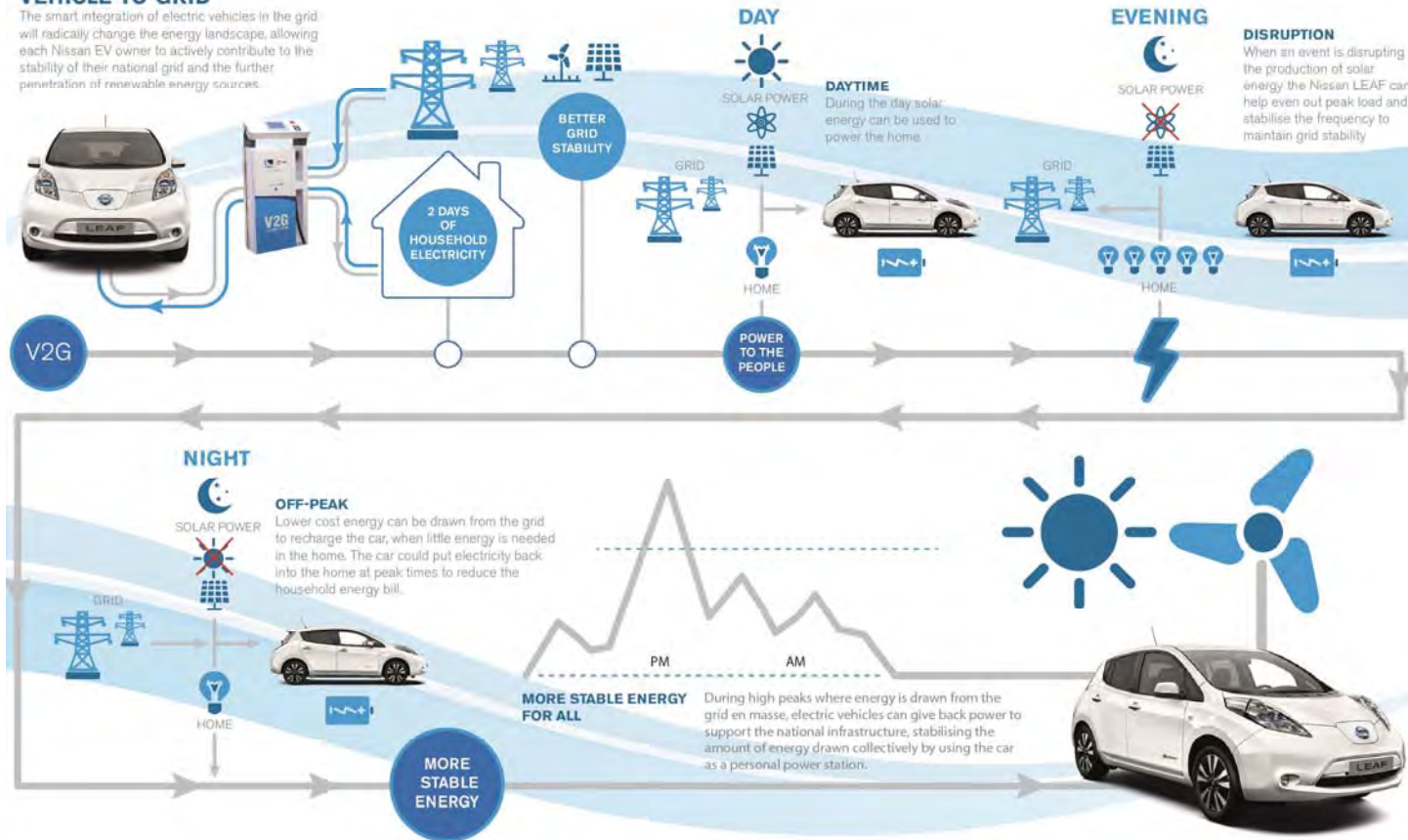


## POWER TO THE PEOPLE

NISSAN'S VISION FOR THE ENERGY GRID PUTS THE POWER IN YOUR HANDS

### VEHICLE-TO-GRID

The smart integration of electric vehicles in the grid will radically change the energy landscape, allowing each Nissan EV owner to actively contribute to the stability of their national grid and the further penetration of renewable energy sources.



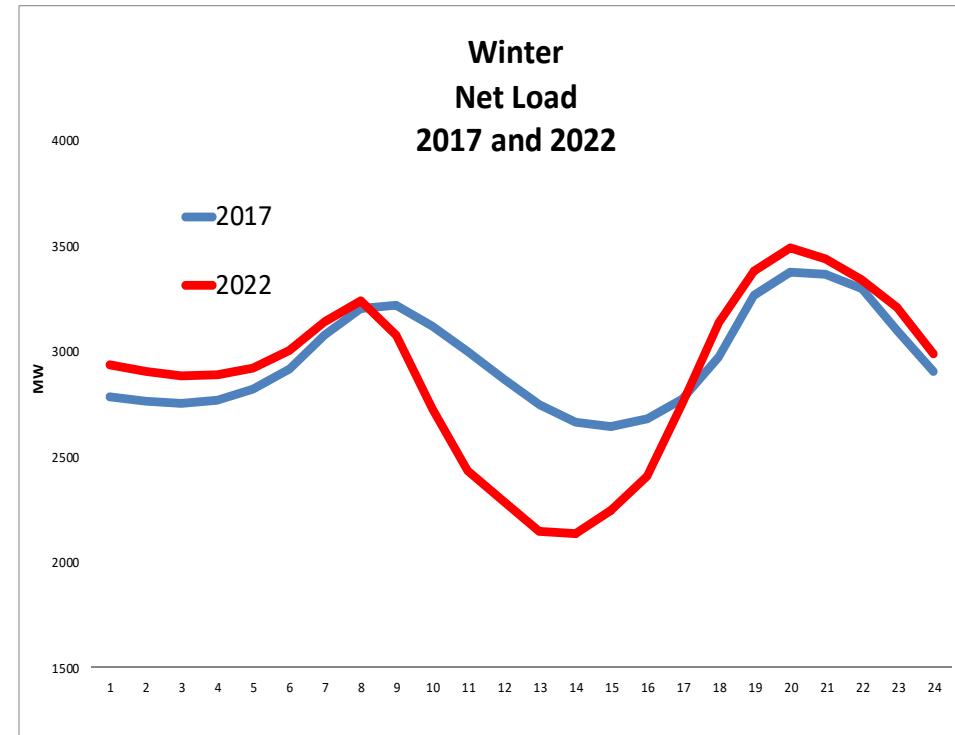
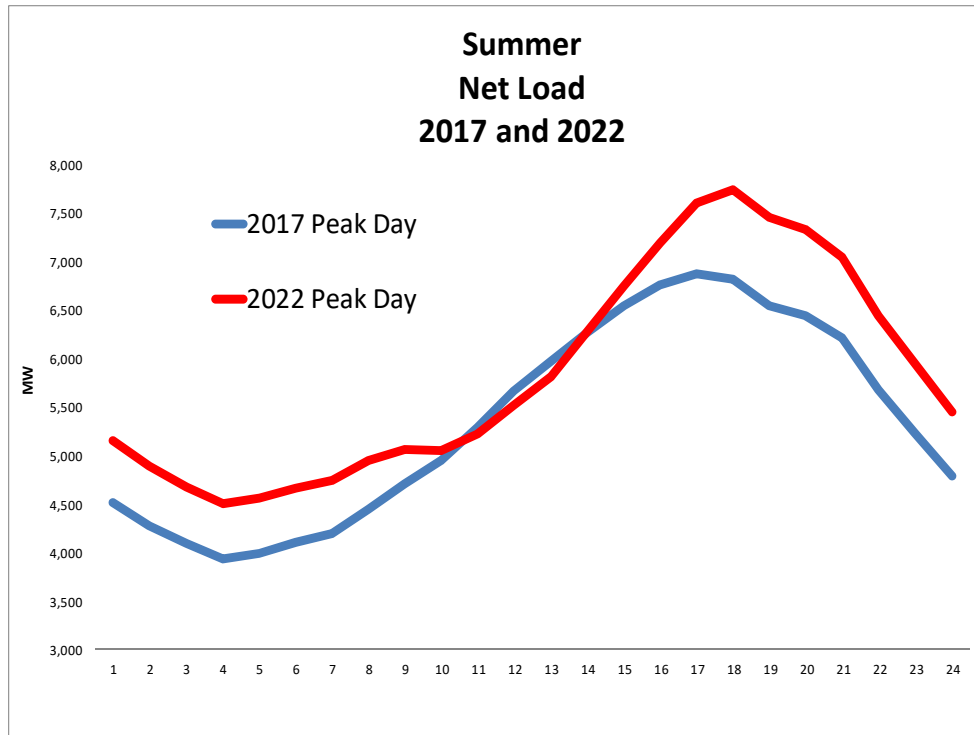
## Themes from the Most Innovative Efficiency Program Approaches

- When?**
- Create 8760-hour load profiles for all the most important commercial and residential loads in your territory, then design programs to save that electricity at the most opportune times of day and months of the year, including pre-cooling or pre-heating of buildings or water when possible.
- Whom?**
- Build customer-centric, tailored energy savings offerings for specific commercial customers, rather than trying to nudge them to participate in one-size-fits-all standard efficiency programs.
- Where?**
- Geographically target energy savings (and/or distributed generation and storage) to places in your service territory that are the most costly to serve
    - Isolated loads at the end of long, difficult-to-maintain feeders
    - Neighborhoods with overloaded substations and distribution infrastructure
    - Any location where a costly powerline upgrade or new installation is being considered

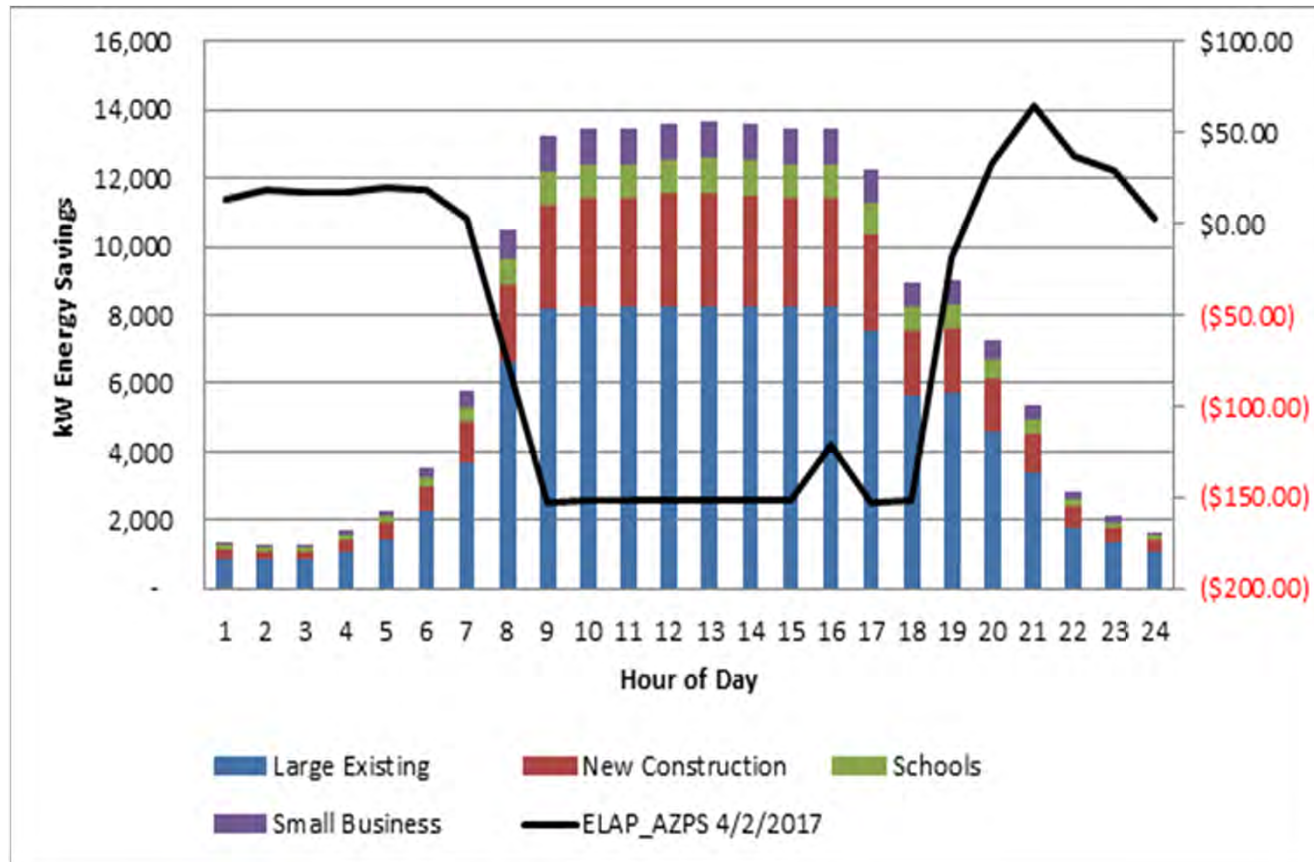


# Arizona Resource Needs Are Changing

Value of energy saved not the same for all hours of the year

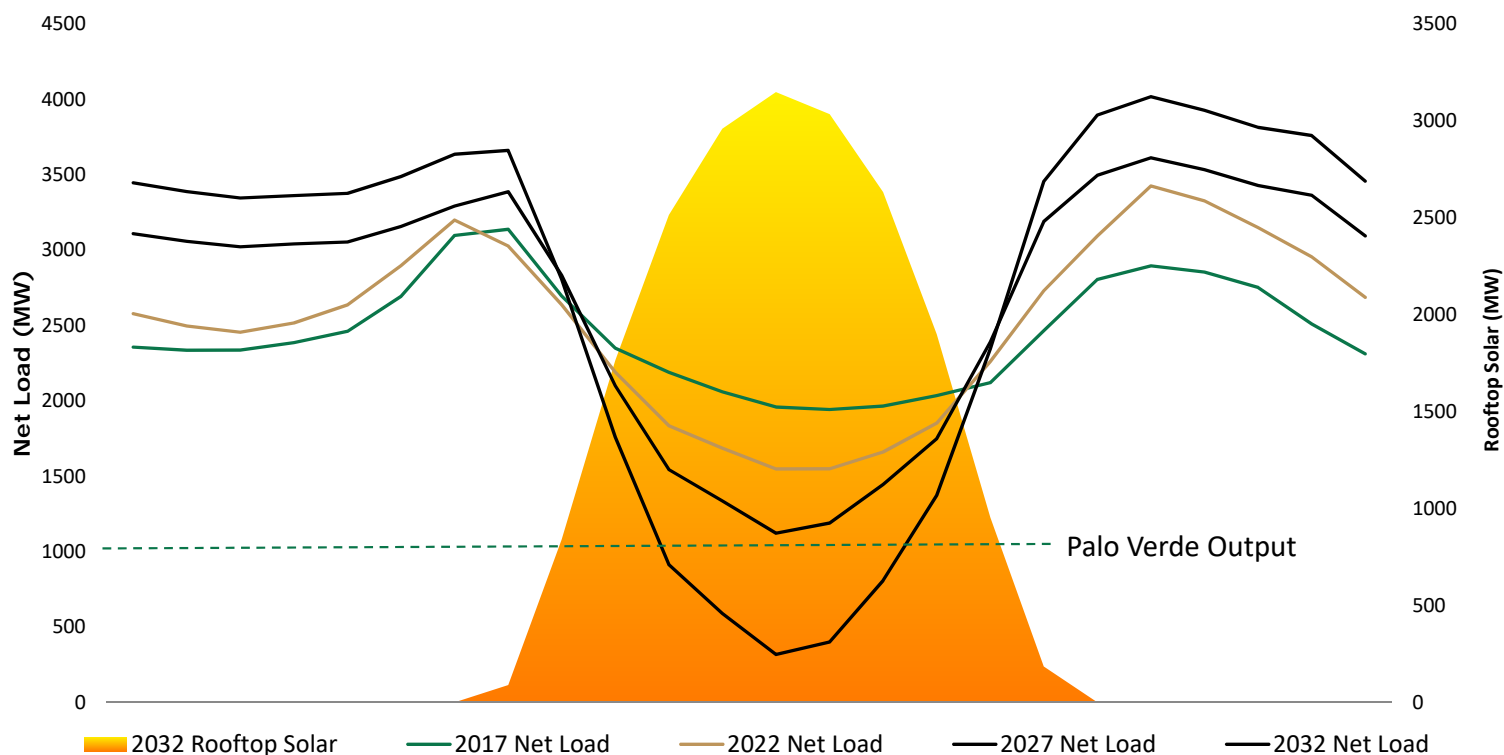


## Savings from Arizona Commercial Lighting Efficiency Programs No Longer Financially Attractive





APS Evolving Load Shape  
Non-Summer Illustration

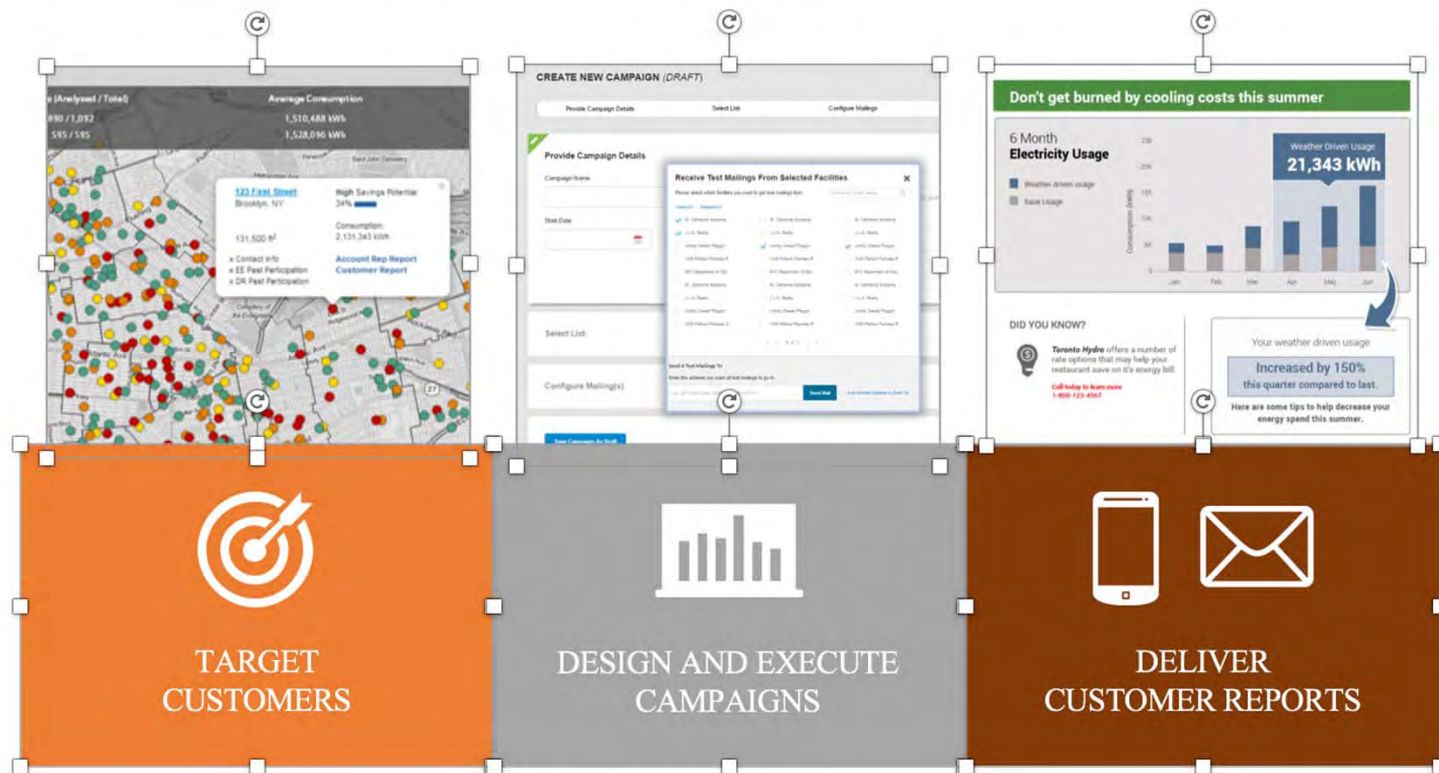


Resulting program changes:

- Shifting incentives away from lighting, pool pumps and commercial refrigeration
- Res programs focusing on smart thermostats and water heaters rather than showerheads and LEDs
- Encouraging connected water heaters, smart thermostats and pre-wiring for EV charging in new homes

# One Promising Approach (Ecova's) to Commercial Customer Targeting

- TARGET AND ENGAGE ACROSS MULTIPLE CHANNELS





## Summing It All Up...

- Energy efficiency improvements and distributed PV will keep natural load growth modest, flat, or even declining for the foreseeable future.
- Utility scale and distributed PV and wind will play an ever-larger role in the regional generation mix, continuing to take share from coal, but create challenges around the timing of electricity availability.
- Ongoing transmission upgrades and bigger power pools critical to enabling balanced resource mixes of primarily of wind, natural gas and PV in our region.
- Energy efficiency and demand response solutions are morphing to provide more targeted savings to the right customers, at optimal times of the day and year, and in optimal locations in the service territory.
- Electric vehicles are the most promising near-term source of offsetting load, and utilities have natural allies in promoting their rapid adoption.
- Stationary energy storage will increase dramatically at utility and industrial scale in the next few years, but V2G looks more promising and cheaper at residential and small commercial scales in the near term.

# Thank You!



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