Electricity Markets

Rapid Conference

May 17, 2016

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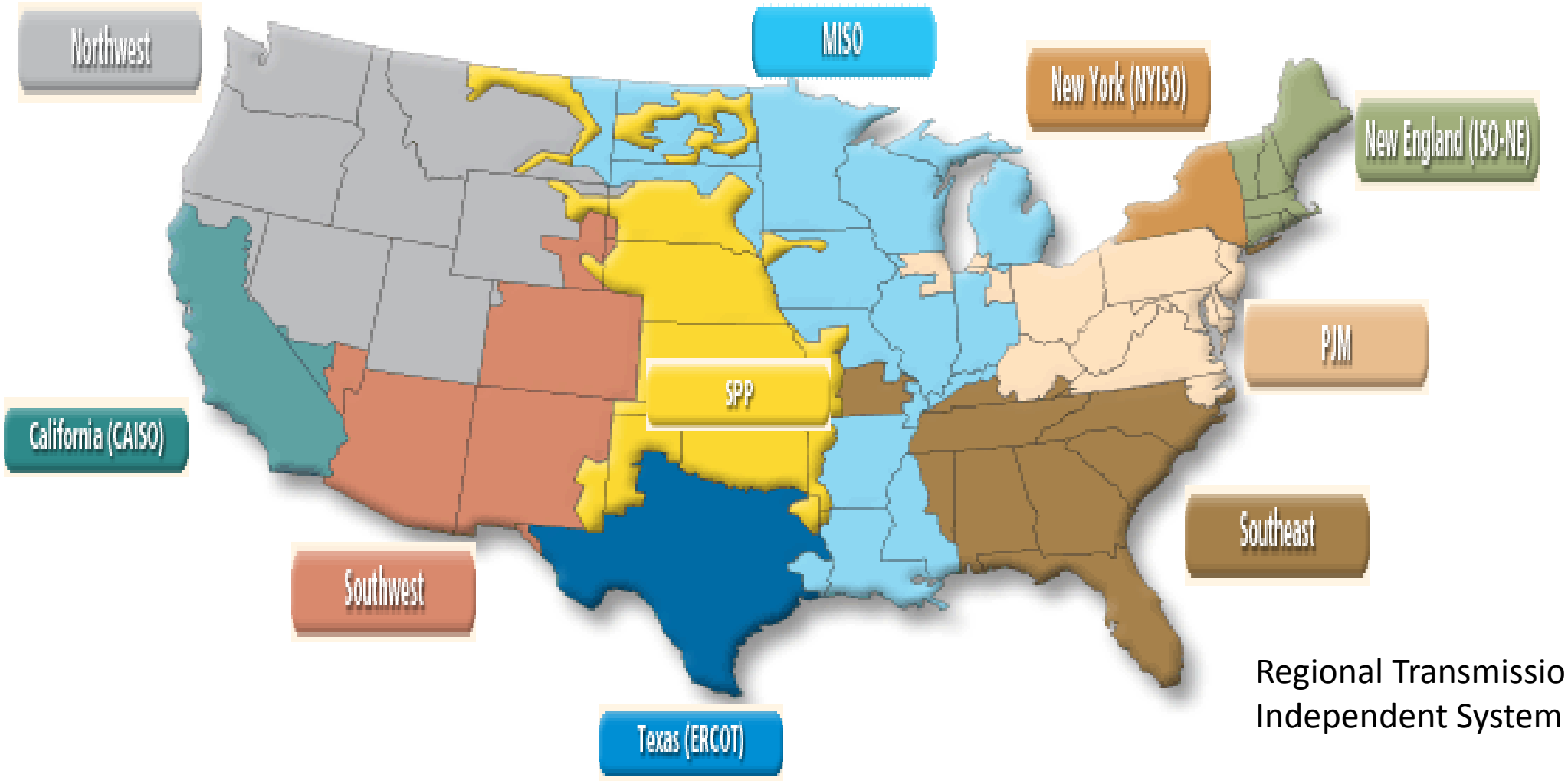
Topics

- Market Formation - Basics
- 2016 / 2017 Forecasts
- Natural Gas, Renewable Portfolio Standards, and Climate Change
- Shaping the Future - Transition to Low-Carbon
- Future Scenarios

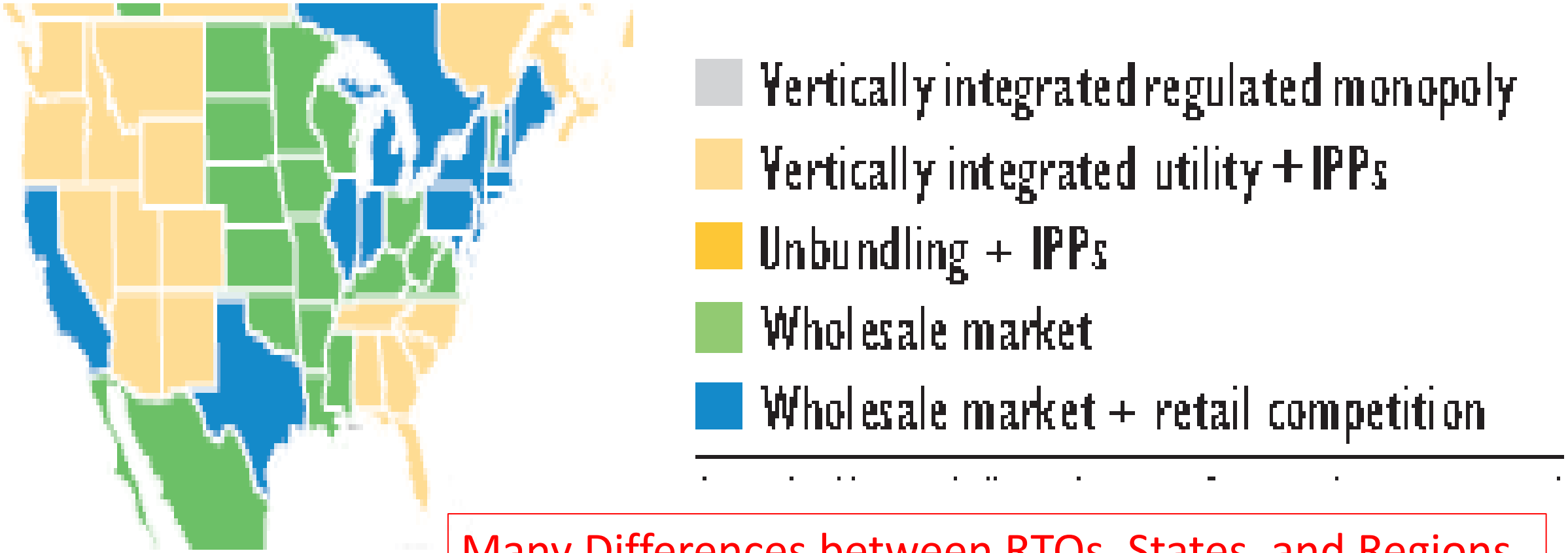
Market Formation – RTO / ISO



Regional Transmission Operators
Independent System Operators

Market Formation – States within the RTO /ISO

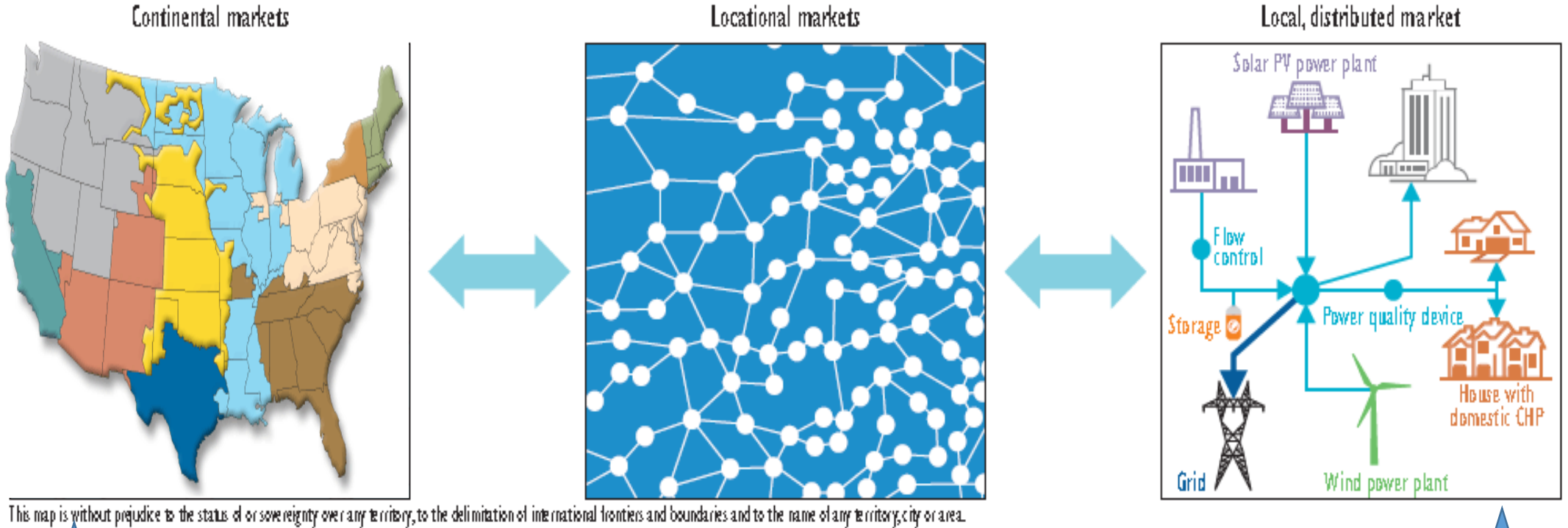
Whole Sale to Full Market Competition



Many Differences between RTOs, States, and Regions

Market Formation

Figure 1.7 • Regional, locational and local electricity markets

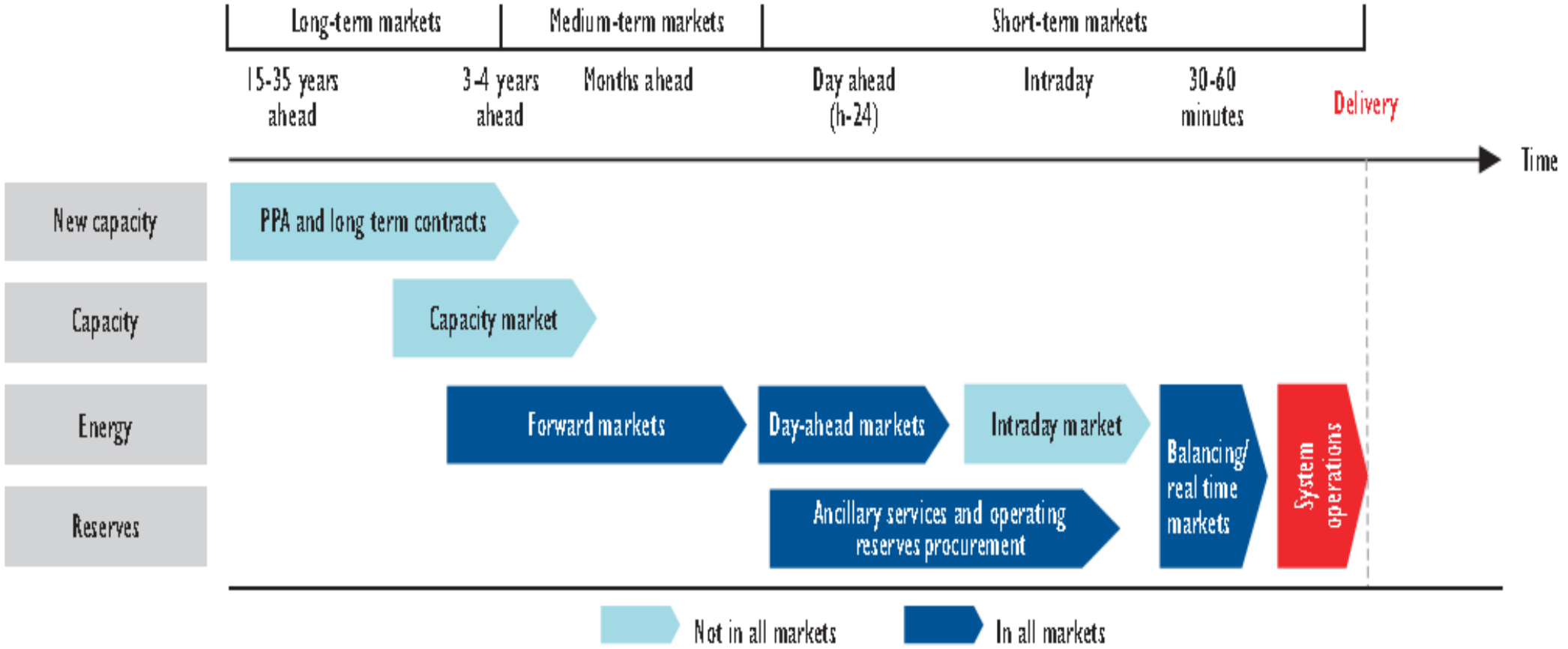


Zones can be multiple LMPs

***Key point** • Efficient co-ordination is needed, from the local level to the continental scale.*

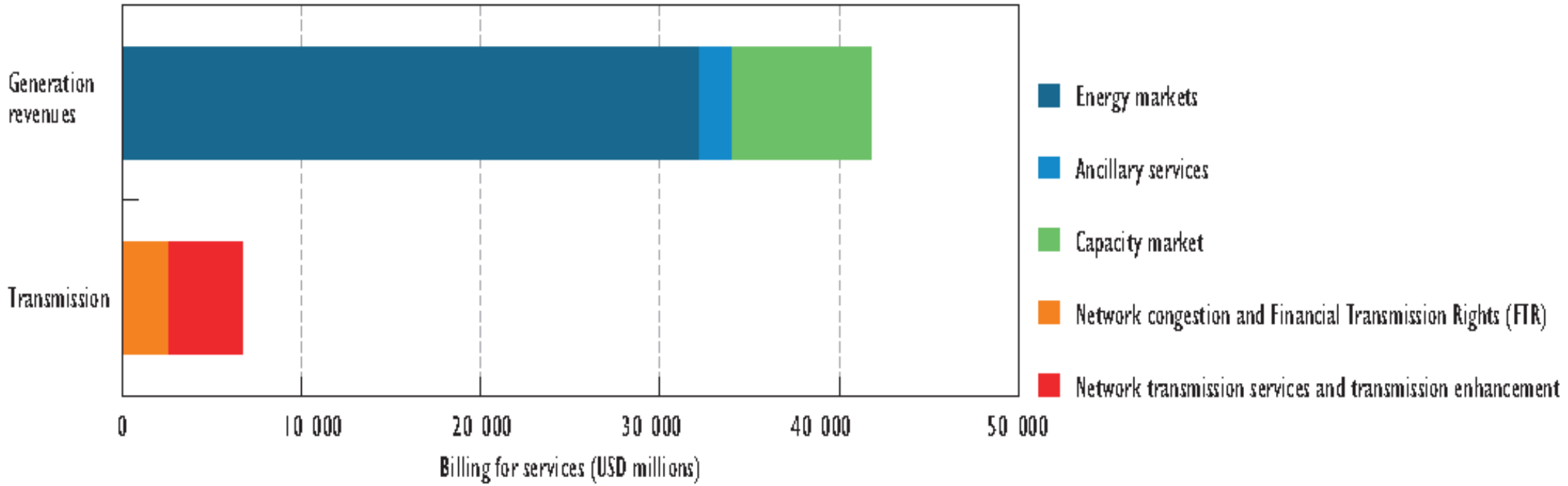
Market Formation

Figure 1.8 • Overview of different building blocks of electricity markets



Market Formation - Generator's Revenues PJM RTO Example

Figure 1.9 • PJM billing for services (2014)



Source : PJM (2015)

Key point: *Generators' revenues come mainly from the energy markets and, where they exist, capacity markets.*

Energy Pricing and Demand – PJM RTO Example

Energy Auction – **Revenue** for delivering energy into the market

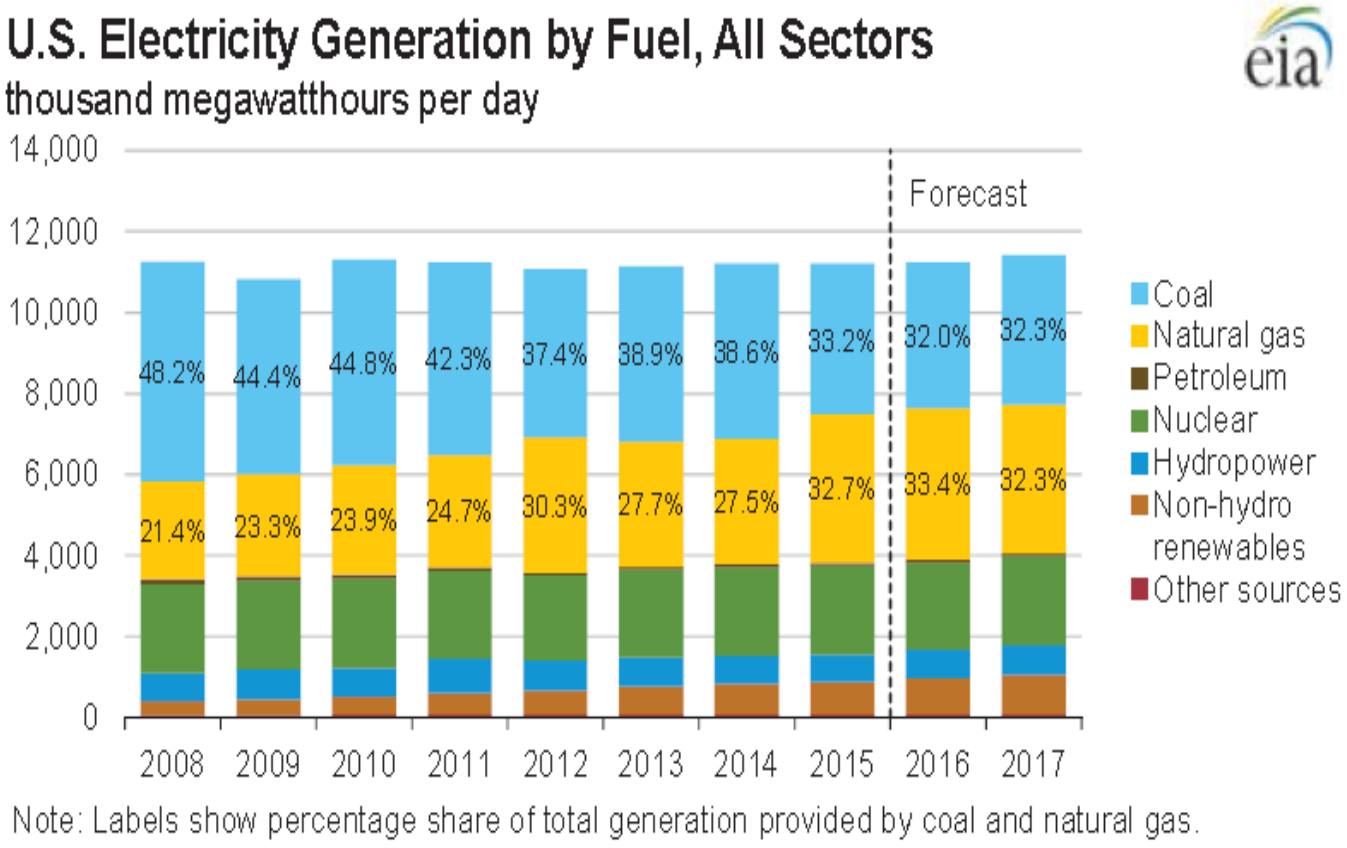
EXAMPLE: Excerpt Sat Apr 16 17:05:00 EDT 2016

Name	Type	5 Minute Weighted Avg. LMP	Hourly Integrated LMP for Hour Ending 17
AECO	ZONE	14.6	14.7
AEP	ZONE	24.6	26.7
APS	ZONE	25.0	27.2
ATSI	ZONE	24.0	26.0
BGE	ZONE	35.0	39.1
COMED	ZONE	22.1	24.3

Capacity Auction - **Future Revenue** for resources to maintain grid reliability whether needed to generate power or not.

- 2016/2017 –
- Capacity =169,160 MW, base price $59.37, down 56 percent from 2015/2016.
- All-time peak demand 163,848 MW

2016 / 2017 Forecast – Generation by Fuel



Note: Labels show percentage share of total generation provided by coal and natural gas.

Source: Short-Term Energy Outlook, March 2016.

Summary

	2016	2017
Natural Gas	33	32
Coal	32	32
Nuclear	20	20
Renewables		
Hydro	6	7
Other renewables	8	9 (Solar – 1.1%, Wind – 5.6%)
Other sources		

2016 / 2017 Forecast - Natural Gas and Coal

Natural Gas (EIA)

Futures - March 2015 - June 2015

- **avg $2.83/MMBtu**
- $1.92/MMBtu -$4.18/MMBtu
  - 95% confidence interval

Futures - March 2016 - June 2016

- **avg $1.91/MMBtu**
- $1.27/MMBtu - $2.88/MMBtu
  - 95% confidence interval

Coal Prices (EIA)

- 2015 Delivered
  - avg **$2.23/MMBtu**
- 2016 / 2017 Forecast
  - **$2.18/MMBtu**
  - **$2.20/MMBtu**

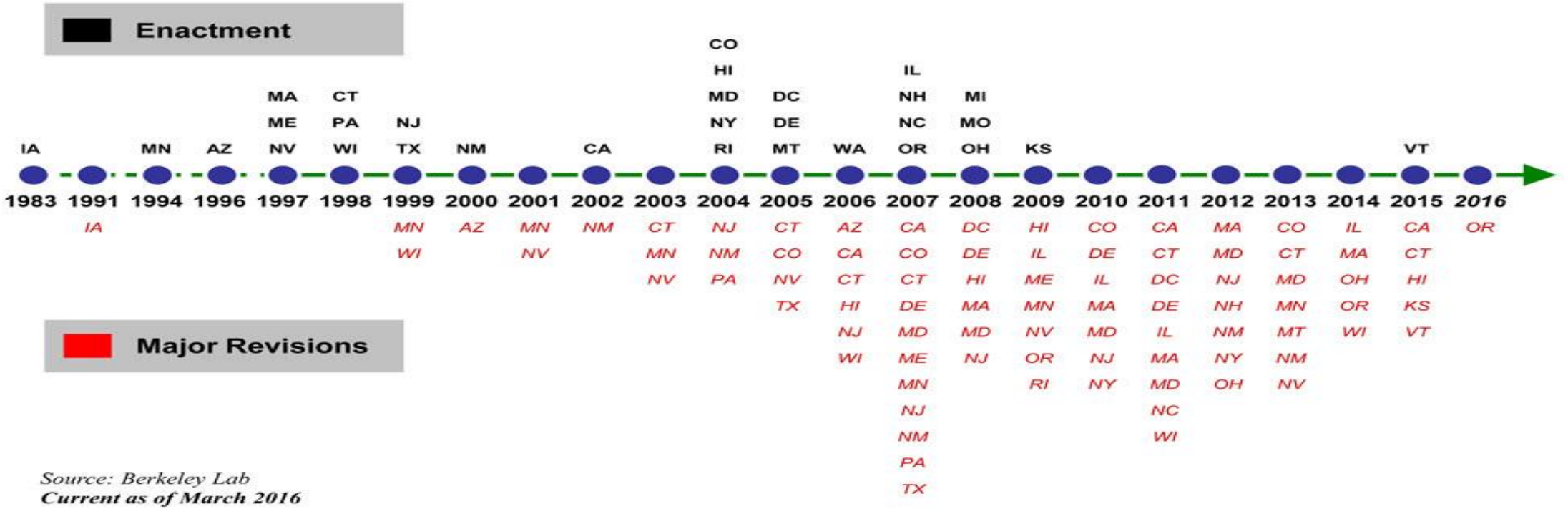
Dispatch Bid into Energy Market

CCGT - 7000HR x $1.91 = $13.37/MWh

Coal Plt- 9500HR x $2.18 = $20.71/MWh

2016 / 2017 Forecast
Policy – Renewable Portfolio Standards

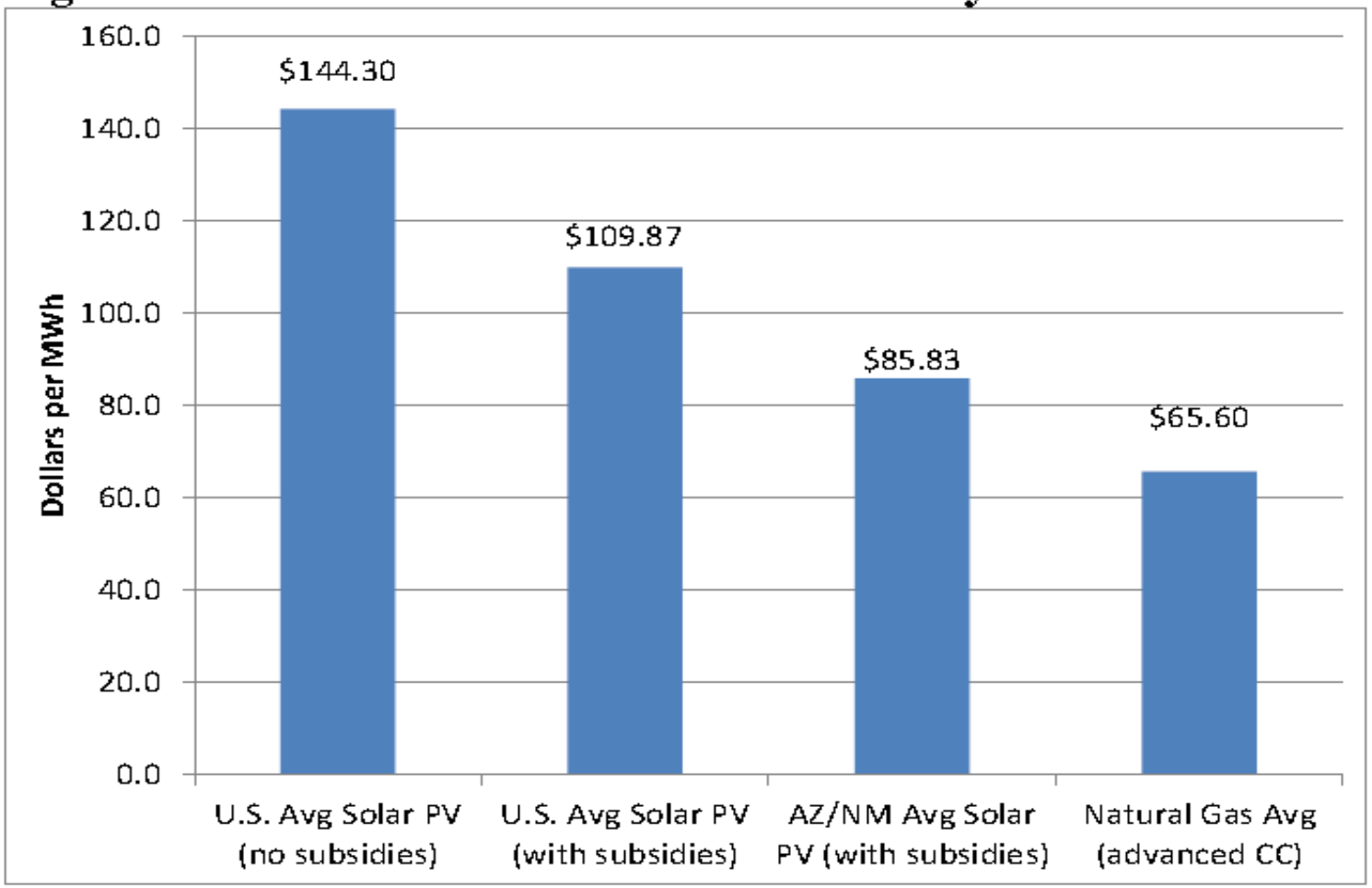
Enactment of New RPS Policies Has Waned, but States Continue to Hone Existing Policies



Source: Berkeley Lab
Current as of March 2016

2016 / 2017 – New Generation LCOE

Figure 4: Current Levelized Cost of Electricity for New Generation Resources ($/MWh)



Note: Per EIA, current new generation costs are for facilities installed in 2018; "with subsidies" cases assume tax credits at current levels.
Source: EIA (2013a)

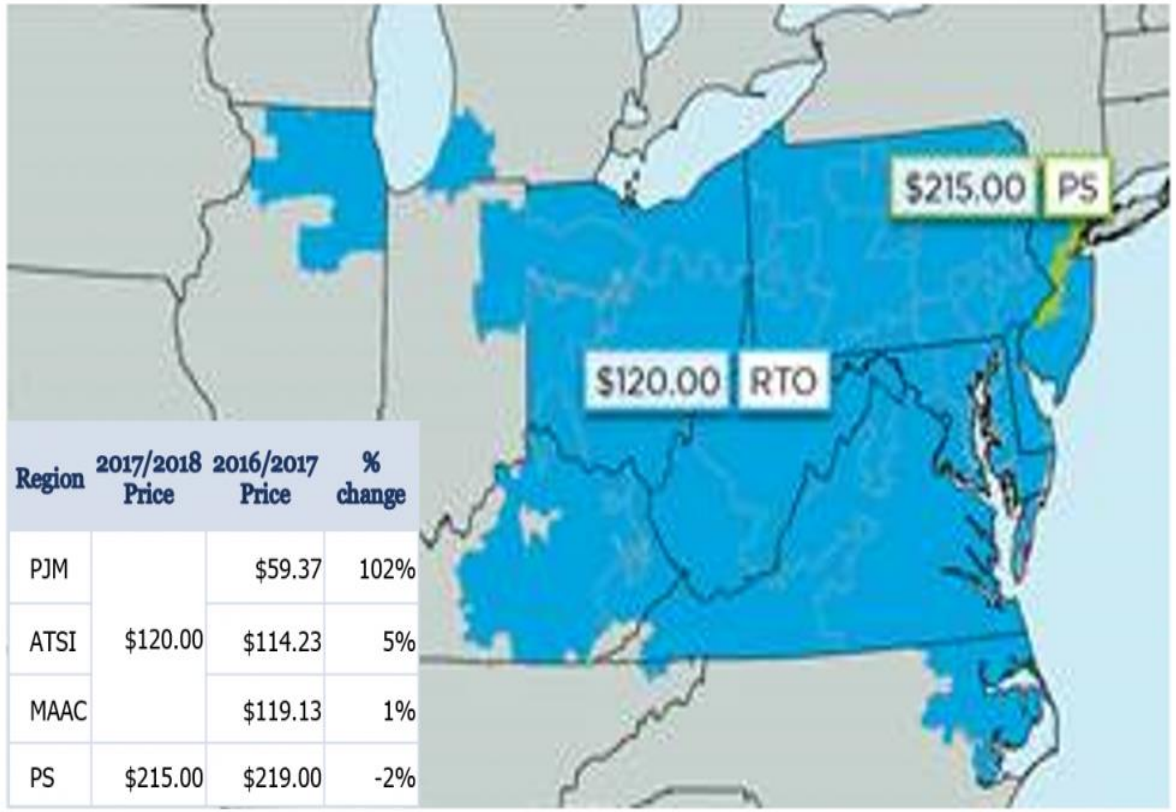
2016 /2017 Forecast
Policy – FERC Regulation / RTO Rules

2017/2018 Capacity Auction

- $120/MW-day in most of PJM
- RTO rule changes - limited demand response and generation imports
- Nearly doubled from $59/MW-day 2016/2017 auction.

Policy changes Influences pricing and financial viability of Base Load Capacity

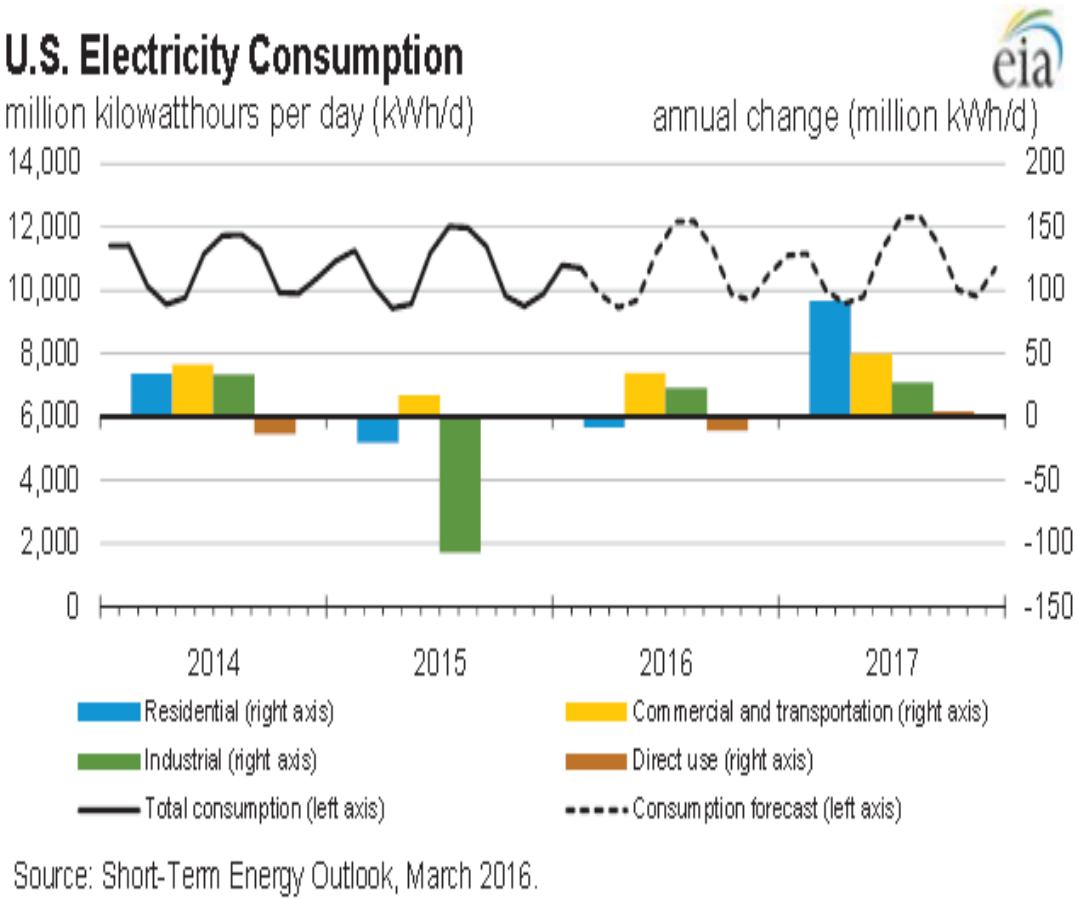
Capacity Auction Clearing Prices 2017/2018



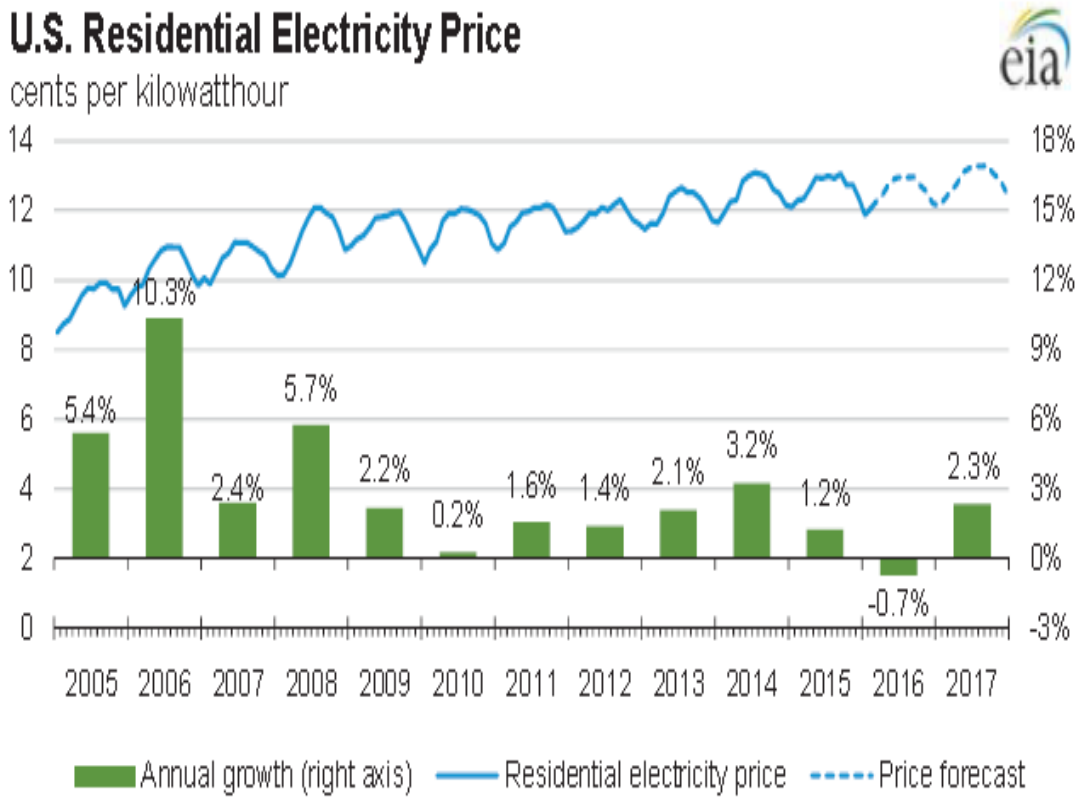
Region	2017/2018 Price	2016/2017 Price	% change
PJM	$120.00	$59.37	102%
ATSI		$114.23	5%
MAAC		$119.13	1%
PS	$215.00	$219.00	-2%

Prices in MW-day (Source: PJM Interconnection, LLC)

2016 / 2017 – Consumption and Price



Source: Short-Term Energy Outlook, March 2016.



Source: Short-Term Energy Outlook, March 2016.

Contrast: Industrial rates aligned to wholesale markets stable and declining

Shaping the Future – Transition to Low-Carbon

U.N. Framework Convention on Climate Change Paris 2015

- **Goal of limiting global temperature increase well below 2 degrees Celsius, while urging efforts to limit the increase to 1.5 degrees;**
- **Binding commitments by all parties to make "nationally determined contributions" (NDCs), and to pursue domestic measures aimed at achieving them;**
- **Commit all countries to submit new NDCs every five years,**
- **Support the efforts of developing countries,**
- **Extend the current goal of mobilizing $100 billion a year in support by 2020 through 2025,**
- **Call for a new mechanism, similar to the Clean Development Mechanism under the Kyoto Protocol, enabling emission reductions in one country to be counted toward another country's NDC.**

Shaping the Future – Transition to Low-Carbon Legislation and Regulation

Omnibus Appropriations Tax Extenders Bill

Investment Tax Credit (ITC) - **Solar commercial and residential projects**

- 2021, gradual phase down, based on start time
- commercial - Start construction by 12/31/ 2019 - 30 percent credit, 2020 -26 percent, 2021 - 22 percent. 10 percent in perpetuity.
- Residential - phase down for years 2020 and 2021 same as commercial, Expires

Production Tax Credits (PTC) – Wind projects through 2019 and retroactively 2015.

- 80% 2017, 60% 2018, and 40% 2019.
- 2020 Expires permanently.

Energy Efficiency

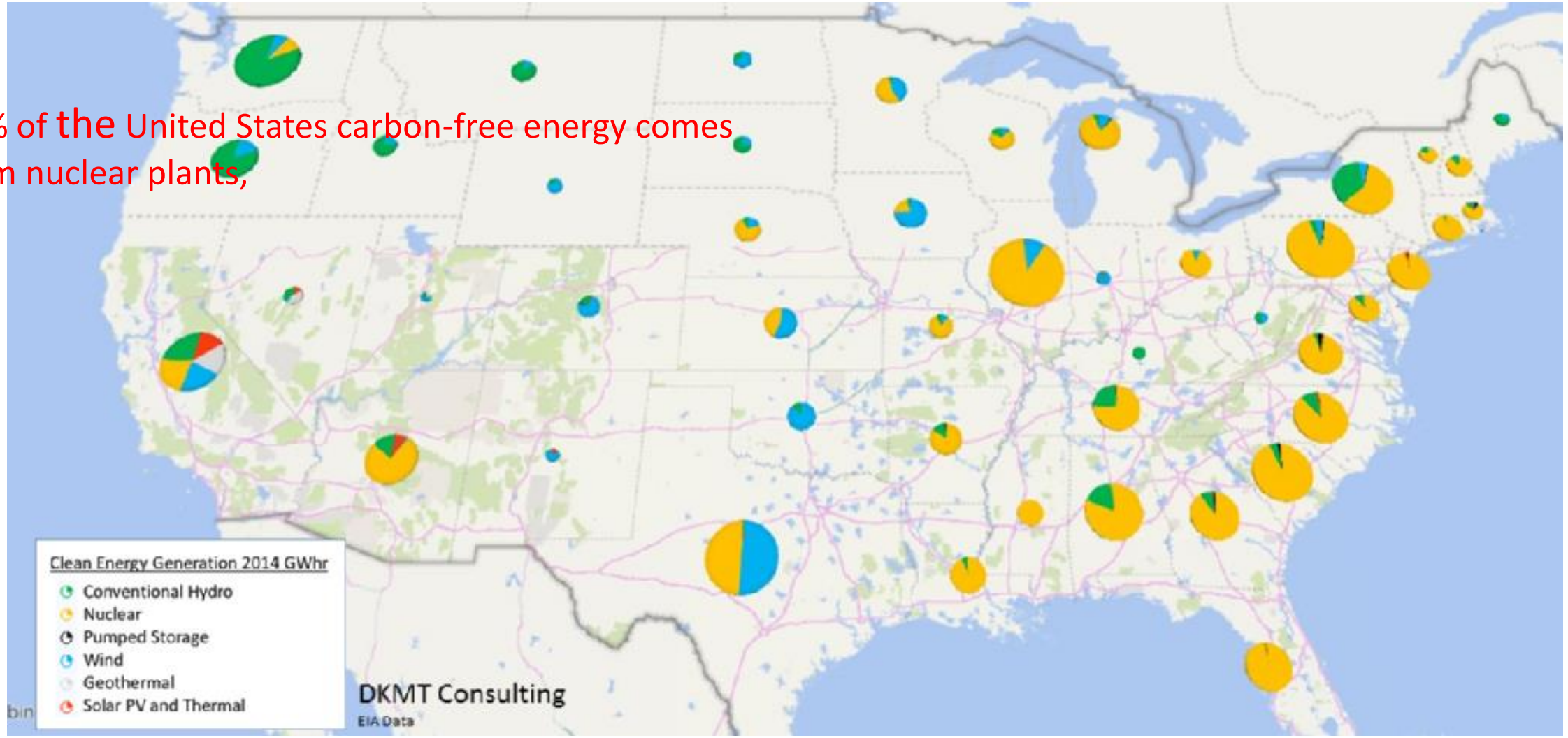
- Extended through 2016 and, retroactively, for 2015

EPA: Clean Power Plan

- rule's goals could be achieved by replacing 476 million MWh of carbon-based energy with carbon-free electricity – roughly the energy used by 37% of U.S. homes.
- Stayed by the Courts – Under Review

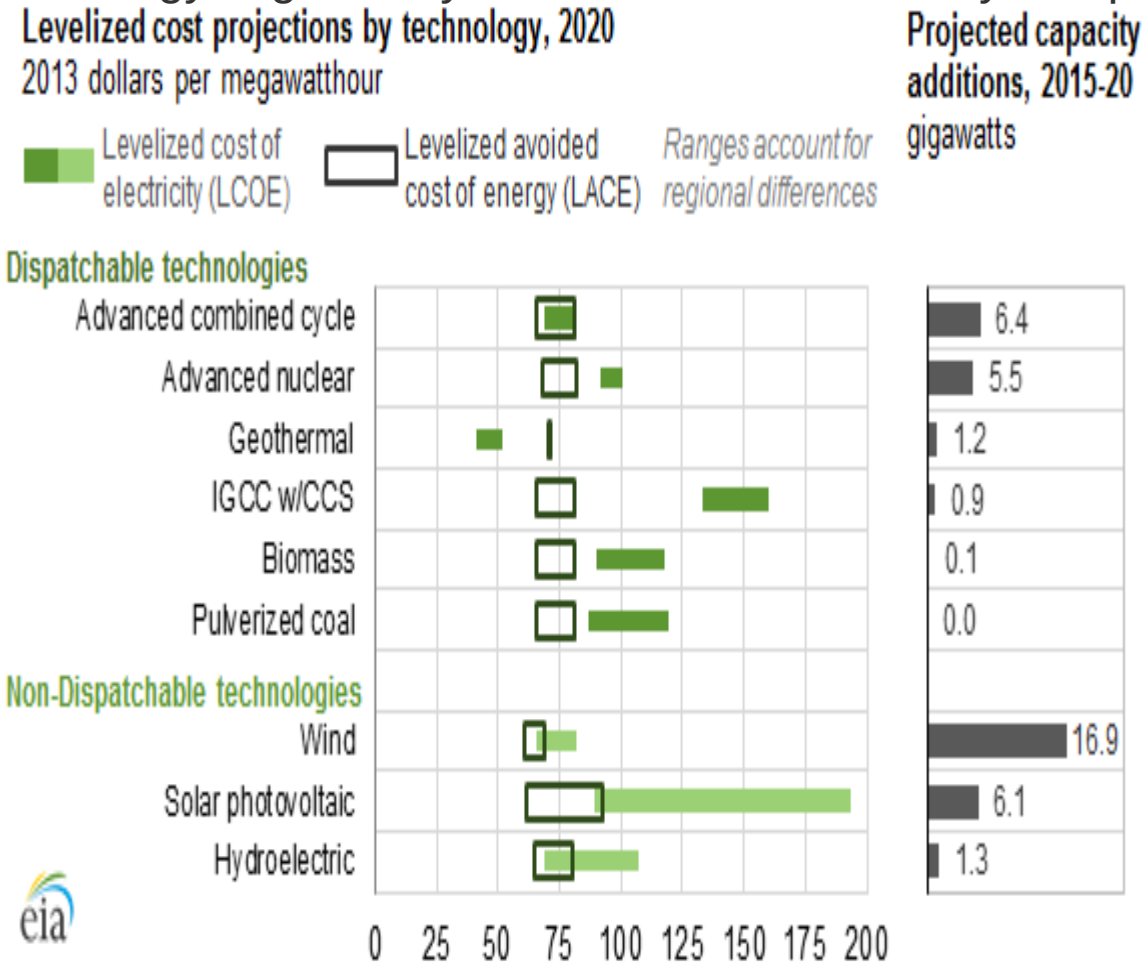
Transition to Low-Carbon
- Policy / Regulatory Framework

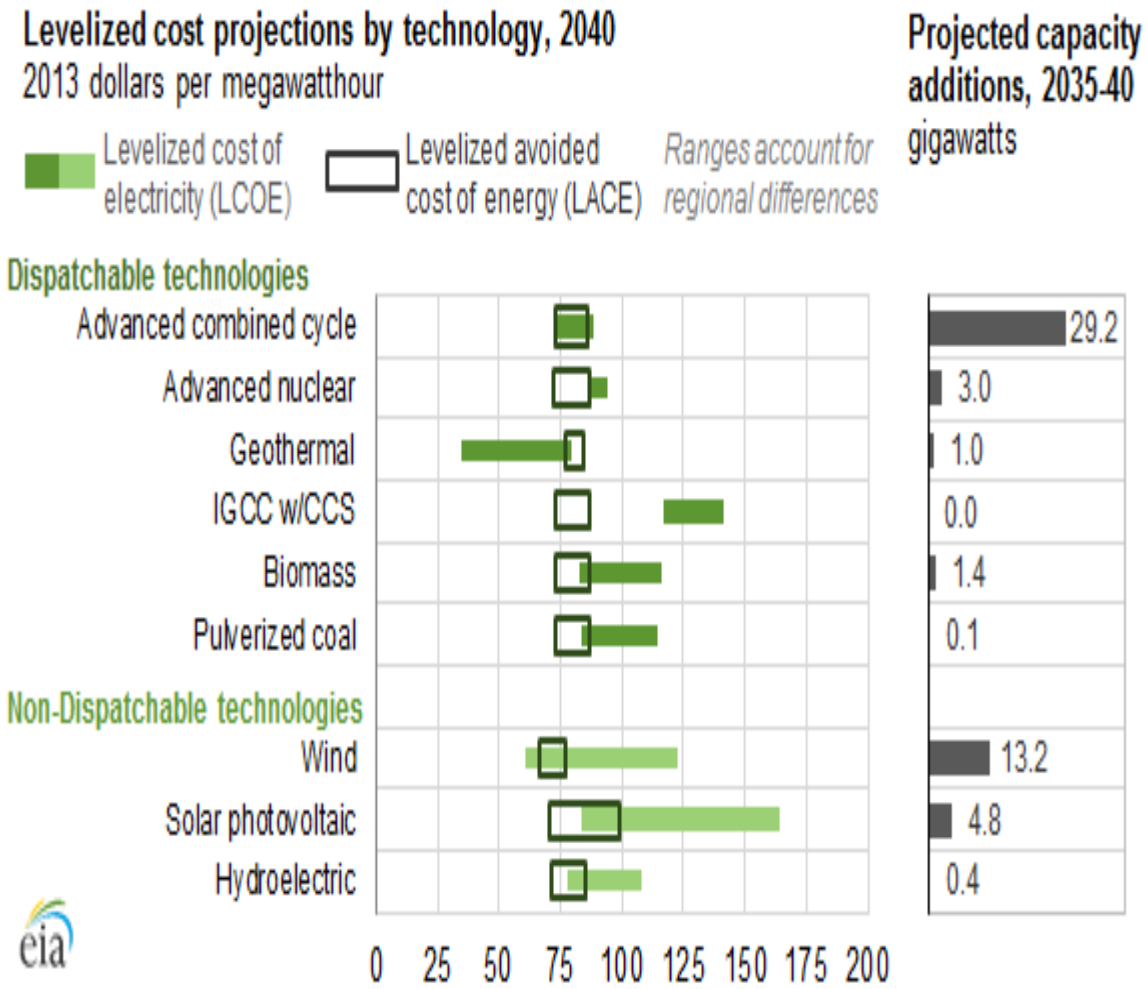
63% of the United States carbon-free energy comes from nuclear plants,



Generation Technology

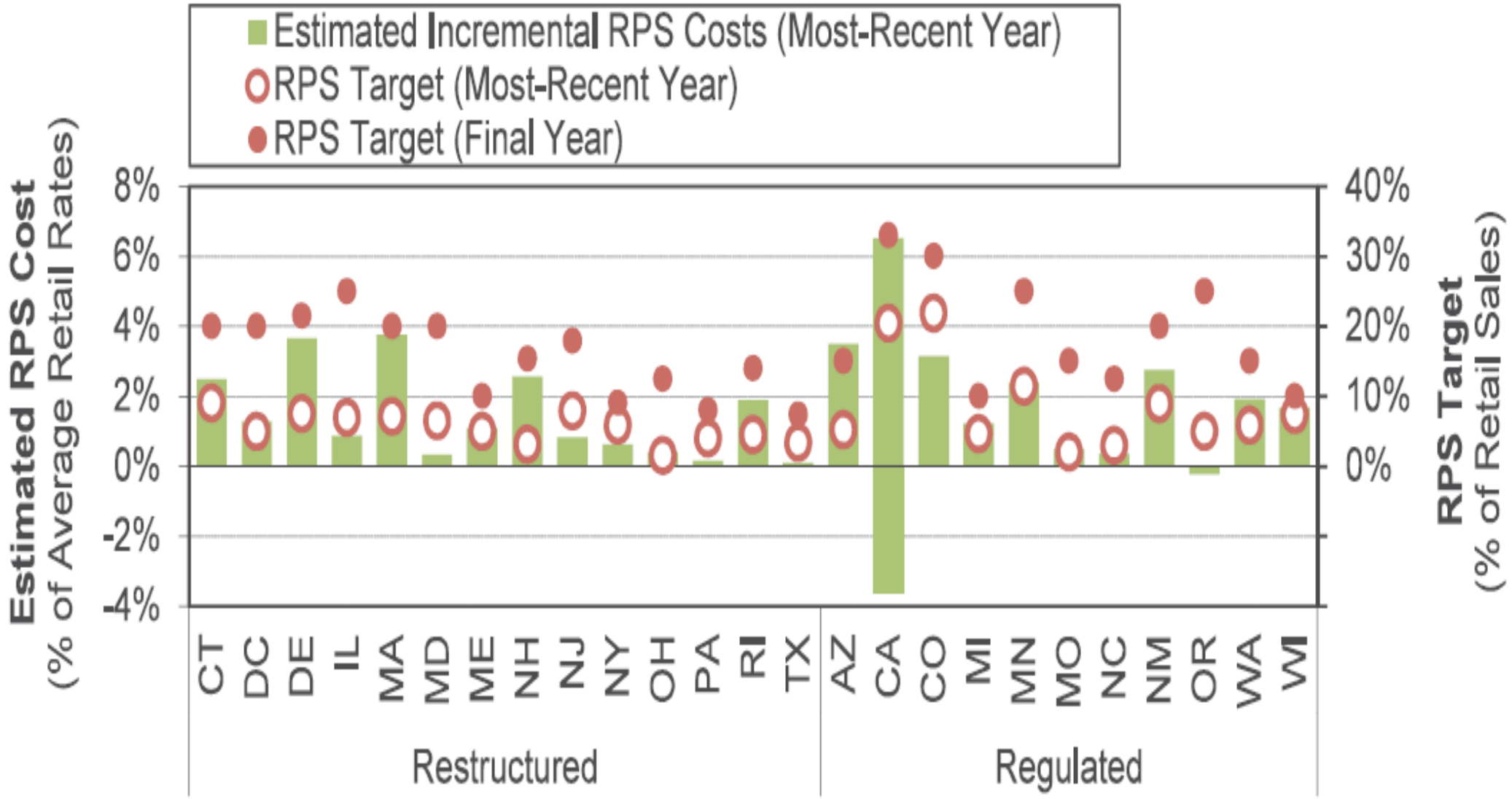
A technology is generally considered economically competitive when its LACE exceeds its LCOE.





Costs reflect utility-scale systems and include federal tax incentives for renewables as applicable in 2020 under current law.

Renewable Portfolio Standards



Future Scenarios – Regulation and Markets

Table 1.0 • Overview of the key dimensions of market frameworks for decarbonisation

Objective	*Policy*	Type of regulation	Competitive markets
Low-carbon investments	*Carbon pricing*	○ Carbon regulation	○ Carbon price (trading scheme) ○ Long-term contracts
	Additional policy: Support schemes	○ Low-C long-term support	○ Auctions set support level ○ Integration in markets
Operational efficiency / Reliability and adequacy	*Short-term energy markets*	○ Market rules ○ Scarcity pricing ○ Reliability standards	○ Energy prices with a high geographical resolution ○ Energy prices with a high temporal resolution ○ Dynamic pricing offers
	Additional policy: Capacity markets	○ Capacity requirements ○ Demand response product definition	○ Capacity prices ○ Demand response participation
Network efficiency	*Regulation*	○ Regional planning ○ Network cost allocation	○ Congestion revenues ○ Transmission auctions
Consumption	*Retail pricing*	○ Network tariff structure ○ Taxation and levies	○ Retail competitive prices ○ Distributed resources

Transition to Low-Carbon - Policy / Regulatory Framework, Markets

Policy and Markets

- Policy proliferation - Unintended consequences - interaction
  - Renewables and Energy Efficiency **Policy** – causing reduced wholesale electricity prices
  - **Markets** unable to incentivize other low-carbon investment in nuclear or CCS, or even renewables
- Renewable support policies
  - Successful in deploying renewables, but
  - Significantly increased electricity bills
- Rapid deployment of wind and solar power
  - Limited contribution to meet peak demand, relying on conventional fossil-fired capacity.

Increases the complexity of an already complex set of markets

Regulation and Markets

- Renewables deployment increases low-carbon generation to meet limits
  - dispatch natural gas power – cheap gas
  - Closure of baseload nuclear and older coal plants

Paradoxical situation where growth in renewables does not reduce CO2 emissions.

Regulation Shaping Markets – Emissions Limits

Transition to Low-Carbon - Policy / Regulatory Framework, Markets

Carbon Markets

Carbon price reflected in short-term, and futures prices

- promote energy efficiency, renewables and nuclear and CCS.

Experience Carbon and Emissions Trading System Exchanges

- collapse after economic crisis, renewable subsidies, and inflows of international carbon credits.

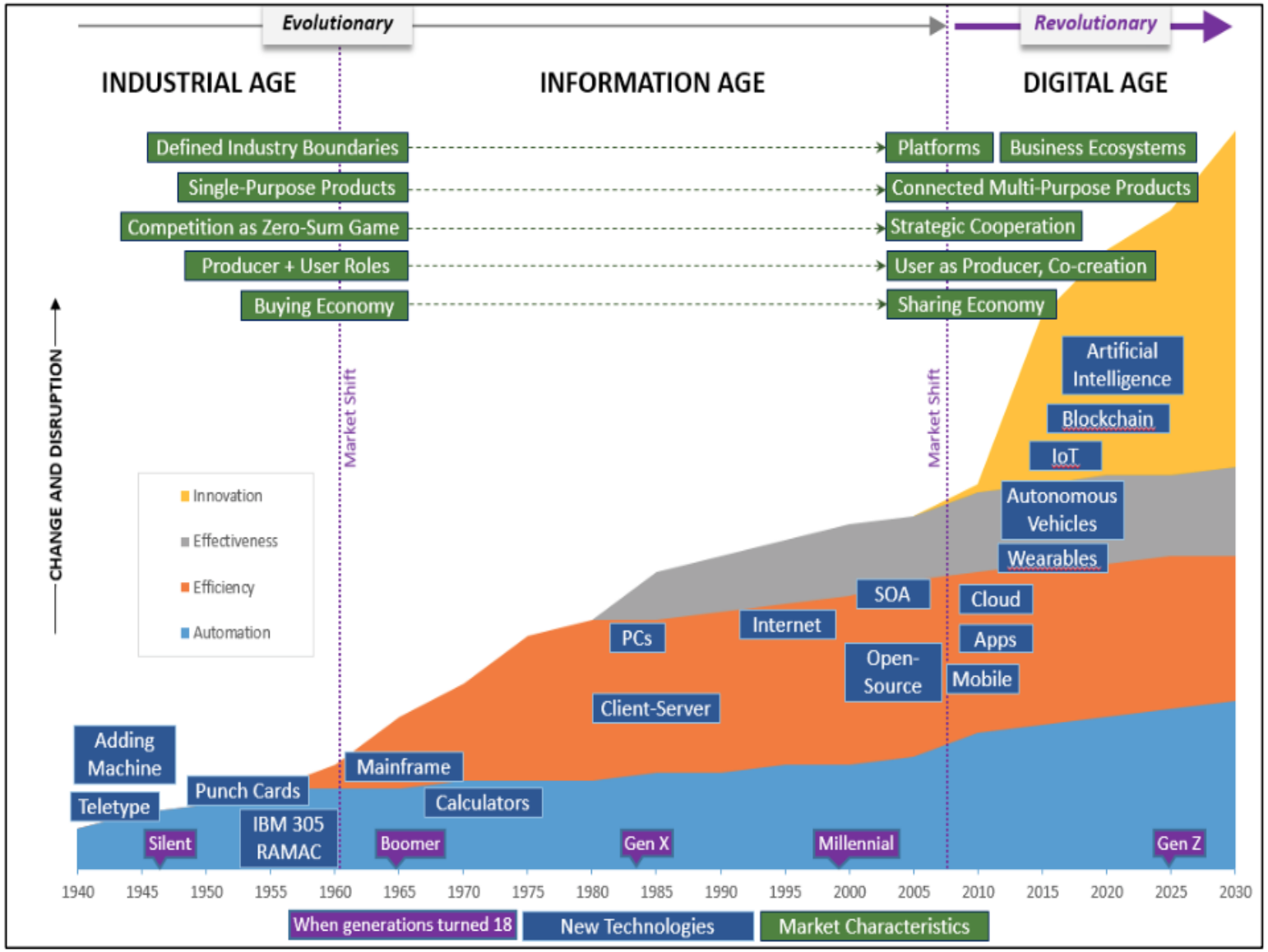
Carbon market design - address these risks:

- Market Stability
- Exogenous events and of policy interactions

Reliability

- Justification for Capacity Markets
- Need for Capacity markets due to potential misalignment between different mechanisms.
  - Signal and revenue for new generation
  - Incentivize other clean technologies such as CCS and nuclear
  - Cheap gas – most new additions are CCGT – CO2 emissions

Opportunity – Innovation, Technology, Investment



- Upgrading a 100 yr. old business model
- Leadership, Communications, Customers
- Error Free Performance by Design(PII)
- Artificial Intelligence
- Autonomous and Automation
- Cyber Security

Conclusion

- Policies, Regulations, and Markets to de-carbonize “are interacting with one another, sometimes in unexpected ways that are not always aligned with the intended transformation of the power sector (OECD, 2015).”
- “While the CPP was not really incentivizing new nuclear development and leaned instead on existing plants, it came at a time when plants are being challenged by cheap natural gas and high operating costs, which has led some utilities to shutter some facilities prematurely or mull that possibility, and so sends a mixed message”
- "Keeping existing nuclear energy facilities online is critical to reducing greenhouse gas emissions. States like Illinois, Michigan, Pennsylvania and Georgia face a significant carbon-free electricity shortfalls if existing nuclear energy facilities were to close.
- Third Way, reports, nuclear generation is needed to meet new regulations and a move away from the clean generation could spike emissions levels.

References and Backup Slides

- FERC Market Oversight – Natural Gas Trading
- FERC – State of Markets 2015
- Federal Bank – US Economic Activity
- US EIA - Levelized Cost Compliance Helps Explain Value of Various Electric Generation Technologies
- US EIA – Short Term Energy Outlook 2016
- IEA – Re-powering Markets
- PJM – Daily Market Offer Data
- US EPA – Clean Power Plan Fact Sheet
- EPRI – Comments on EPA 40 cfr part 60 Carbon Pollution Emission Guidelines for Existing Stationary Source Electric Utility Generating Units
- EPRI – The Clean Power Plan EPRI Perspectives
- NREL – A Survey of State Level Cost and Benefit Estimates of Renewable Portfolio Standards
- DKMT Consulting – CPP without Nuclear
- Institute for Policy Integrity – Annual Energy Outlook Projections and the Future of Solar PV Electricity
- Climate Central – Is Nuclear Power Our Energy Future, Or in a Death Spiral?
- RTO Insider – Prices Double in West PJM, Flat in East
- RTO Insider – Capacity Price Jump Following Rules Change
- Triple Pundit- Investment Tax Credit Extension Makes Commercial Solar Profitable
- Utility Dive – As RPS Importance Declines, 3 Factors Help Drive Growth for Utility Scale Solar
- Utility Dive – Report: Without Nuclear, US States Face Struggle to Meet Carbon Goals
- American Bird Conservancy – 10 of the Worst Sited Wind Energy Projects for Birds

U.S. Average Levelized Costs (2012 $/MWh) for Plants Entering Service in 2019

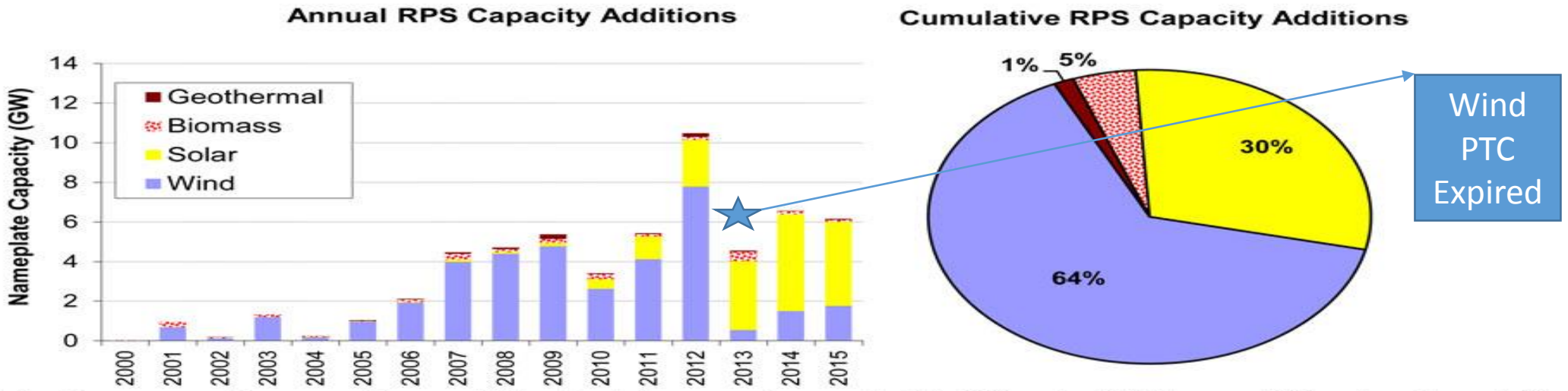
Plant Type	Capacity Factor (%)	Levelized Capital Cost	Fixed O&M	Variable O&M (Including fuel)	Transmission Investment	Total System Levelized Cost
Dispatchable Technologies						
Conventional Coal	85	60.0	4.2	30.3	1.2	95.6
Integrated Coal-Gasification Combined Cycle (IGCC)	85	76.1	6.9	31.7	1.2	115.9
IGCC with Carbon Capture & Storage (CCS)	85	97.8	9.8	38.6	1.2	147.4
Natural Gas-Fired						
Conventional Combined Cycle (CC)	87	14.3	1.7	49.1	1.2	66.3
Advanced CC	87	15.7	2.0	45.5	1.2	64.4
Advanced CC with CCS	87	30.3	4.2	55.6	1.2	91.3
Conventional Combustion Turbine (CT)	30	40.2	2.8	82.0	3.4	128.4
Advanced CT	30	27.3	2.7	70.3	3.4	103.8
Advanced Nuclear	90	71.4	11.8	11.8	1.1	96.1
Geothermal	92	34.2	12.2	0	1.4	47.9
Biomass	83	47.4	14.5	39.5	1.2	102.6
Non-Dispatchable Technologies						
Wind	35	64.1	13.0	0	3.2	80.3
Wind-Offshore	37	175.4	22.8	0	5.8	204.1
Solar PV	25	114.5	11.4	0	4.1	130.0
Solar Thermal	20	195.0	42.1	0	6.0	243.1
Hydro	53	72.0	4.1	6.4	2.0	84.5

Source: U.S. Energy Information Agency Annual Energy Outlook. April 2014

2016 / 2017 Forecast
Renewable Portfolio Standards

Wind Was Historically the Dominant New-Build for RPS, But Solar Has Come to the Fore

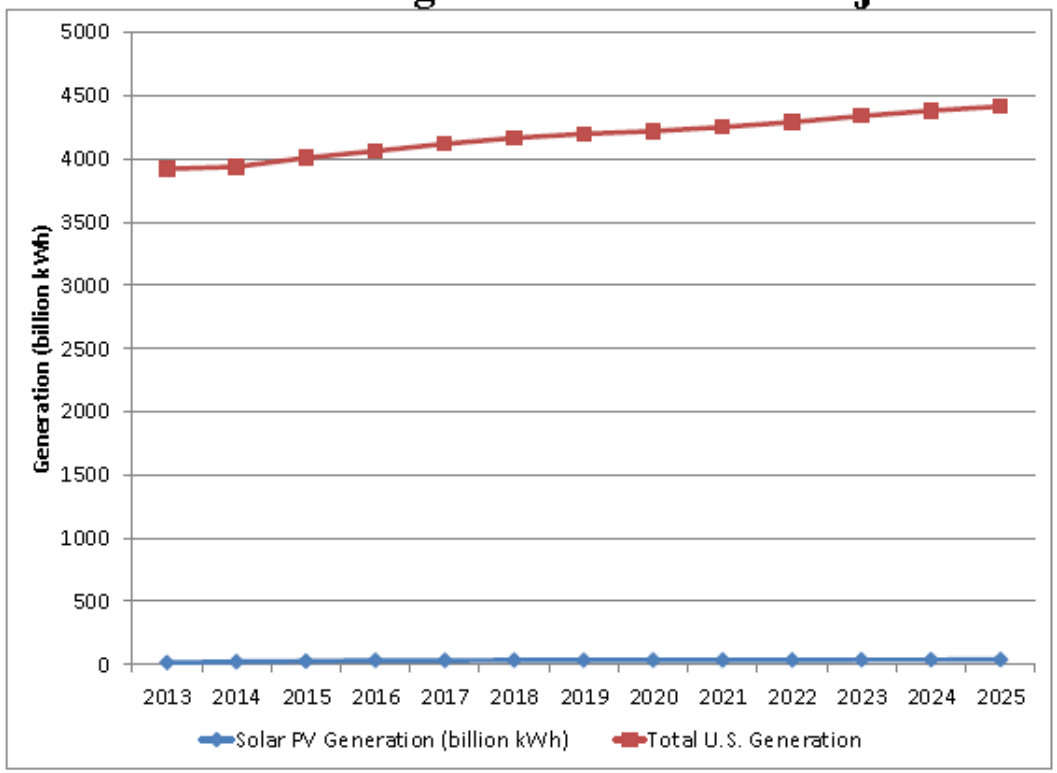
RPS Capacity Additions by Technology Type

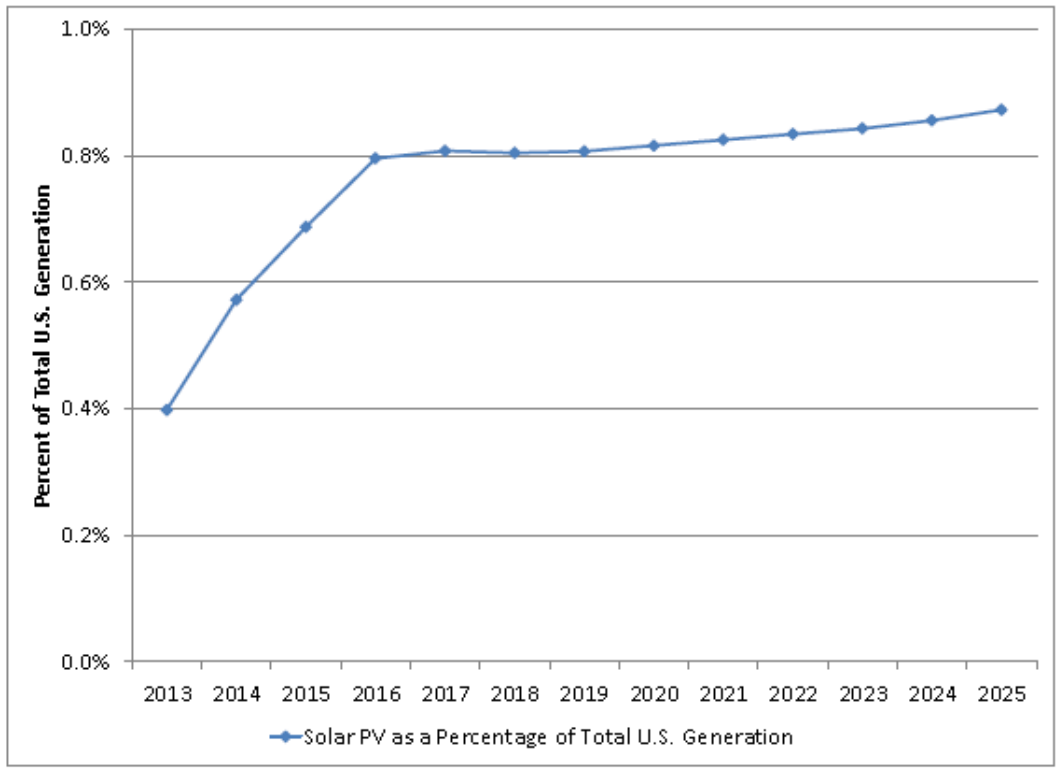


Notes: On an energy (as opposed to capacity) basis, wind represents approximately 68%, solar 16%, biomass 12%, and geothermal 4% of RPS-related renewable energy growth. See Supplementary Notes for data sources and methodological details.

Trends partly reflect that recent wind additions have been built primarily outside of RPS requirements, while solar is relatively more-concentrated in RPS states

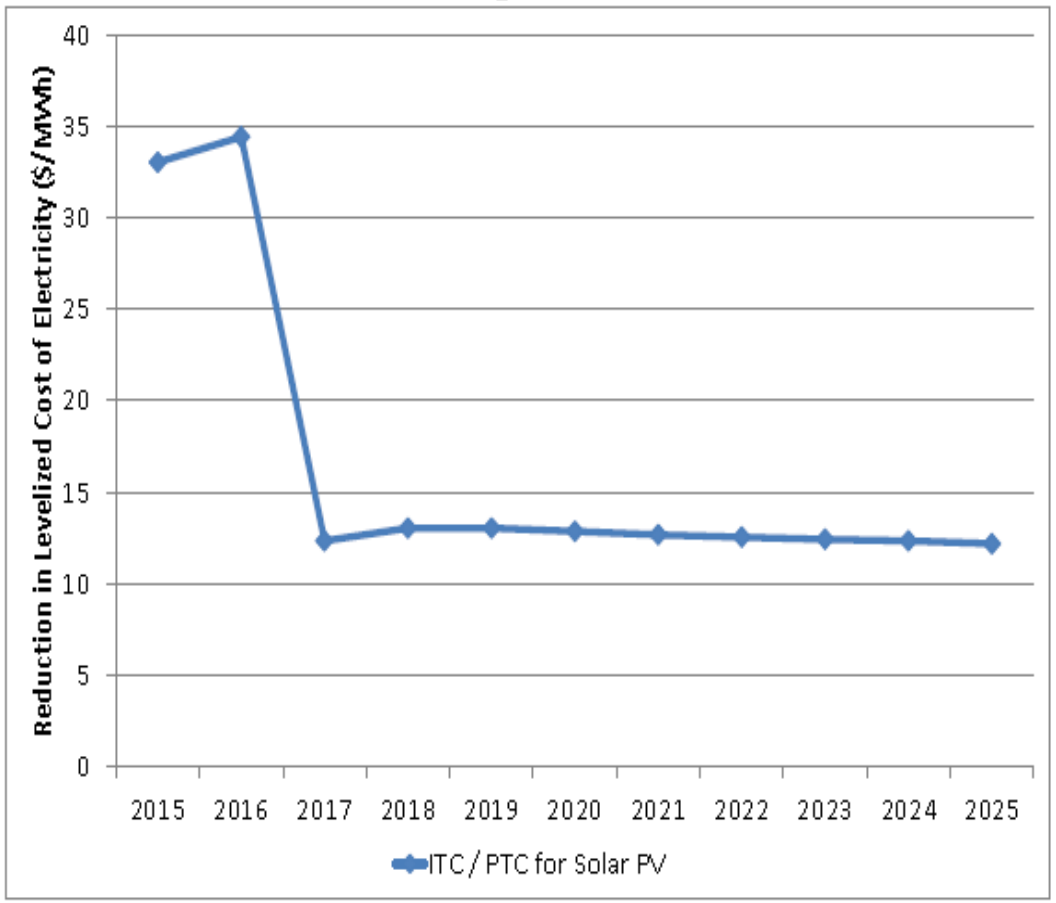
Figure 5: AEO 2014 Projections of Solar PV and Total U.S. Generation

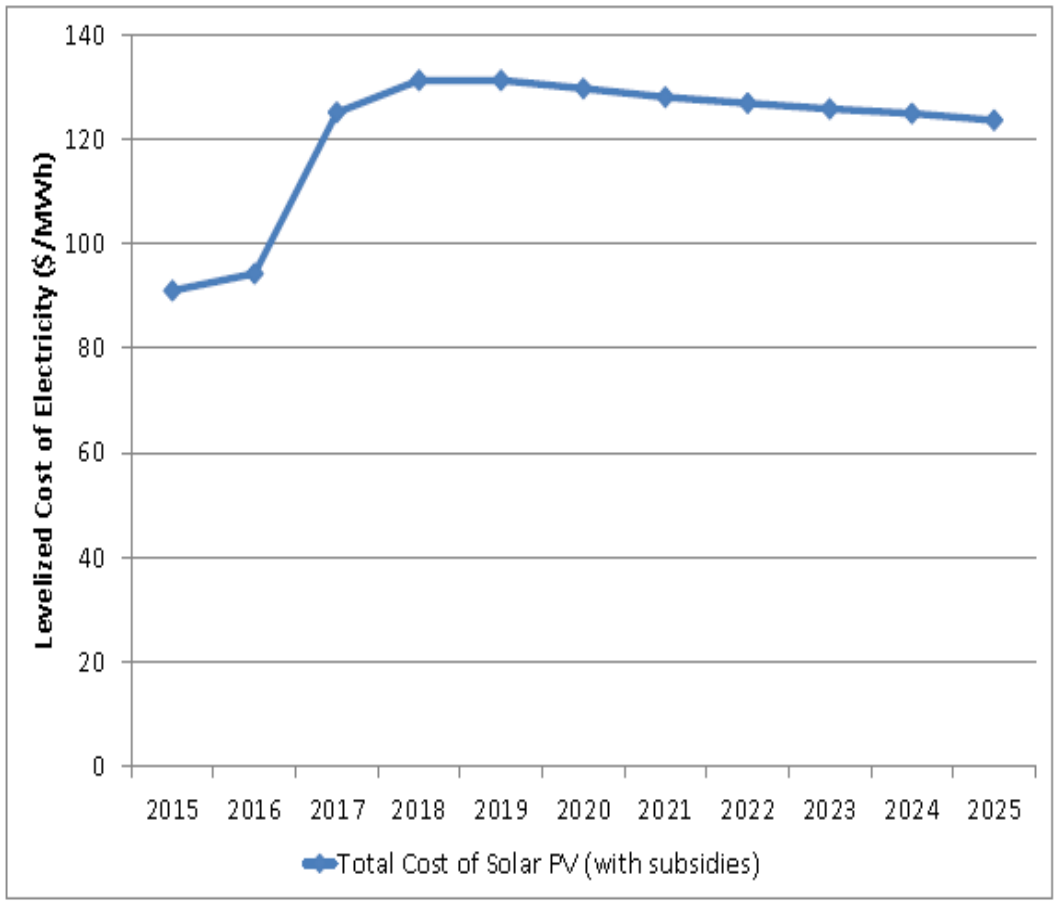




Source: EIA (2013b)

Figure 7: Subsides and Total Cost of Solar PV from AEO 2013





Source: EIA (2013a)