U.S. Electricity Generation Market Trends

IEA/METI Expert Workshop VIII

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June 15, 2018

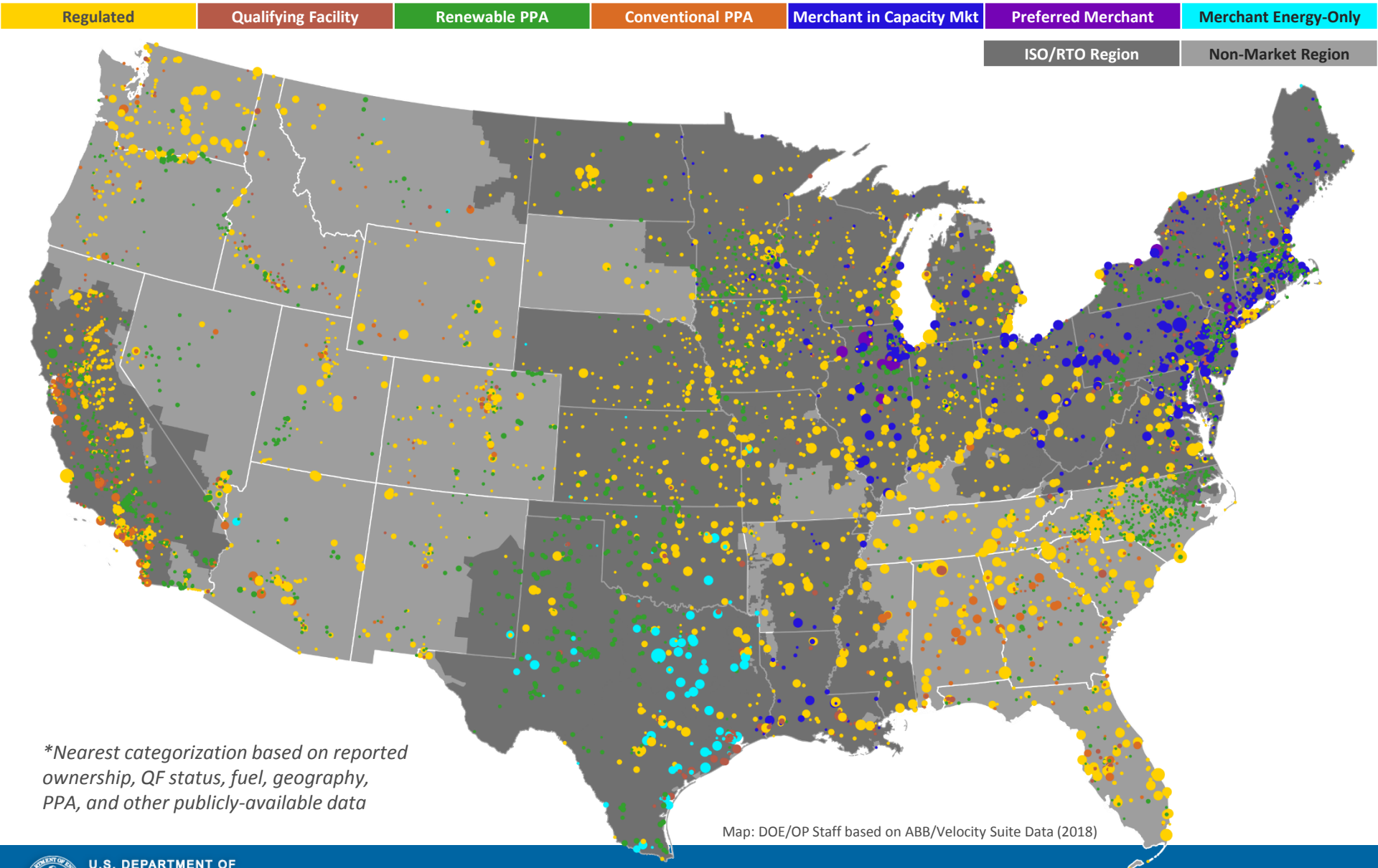
Generation investment trends: growing diversity

- Overview of generation procurement methods in the U.S.
- Examples of recent generation investment decisions
  - Regulated
  - Qualifying Facility/Power Purchase Agreement (PPA)
  - Capacity Merchant
  - Full Merchant
  - Preferred Merchant
- Macro market trends: more players, smaller projects
- The “art” of regulation

Risk Allocation of Generation Procurement Mechanisms

	←Cost-Based						Market-Based→
	Regulated	**Qualifying Facility (QF)**	**Renewable PPA**	**Conventional PPA**	**Merchant in Capacity Mkt**	**Preferred Merchant**	**Merchant Energy-Only**
CapEx (i.e. construction, land acquisition)	Ratepayers	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner
Interest	Ratepayers	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner
O&M	Ratepayers	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner
Fuel	Ratepayers	Ratepayers or Asset Owner	n/a	Ratepayers	Asset Owner	Asset Owner	Asset Owner
Taxes	Ratepayers	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner	Asset Owner
Capacity	Ratepayers	Ratepayers	Ratepayers	Ratepayers	Ratepayers	Ratepayers	Asset Owner
Energy	Ratepayers	Ratepayers	Ratepayers	Ratepayers	Asset Owner	Asset Owner	Asset Owner
Ancillary Services	Ratepayers	Ratepayers	Ratepayers	Ratepayers	Asset Owner	Asset Owner	Asset Owner
Policy Payment			Taxpayers			Taxpayers	
Approval (who can credibly commit to build)	Regulator	Congress, FERC	Regulator	Regulator	Asset Owner	Regulator, Legislature	Asset Owner

Geography of Procurement Methods (In-Service Plants)*

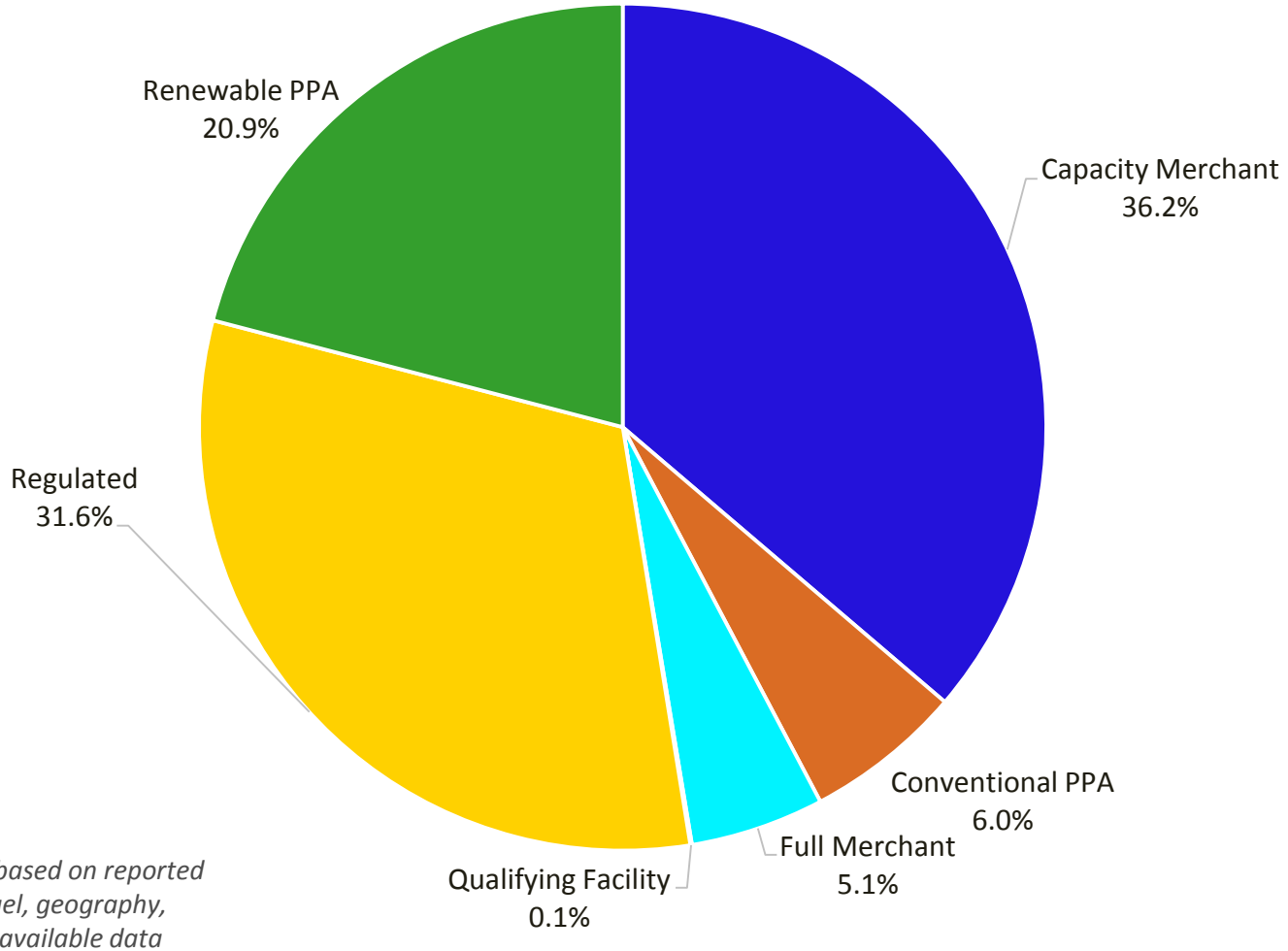


*Nearest categorization based on reported ownership, QF status, fuel, geography, PPA, and other publicly-available data

Map: DOE/OP Staff based on ABB/Velocity Suite Data (2018)

Recent Generator Procurement Methods

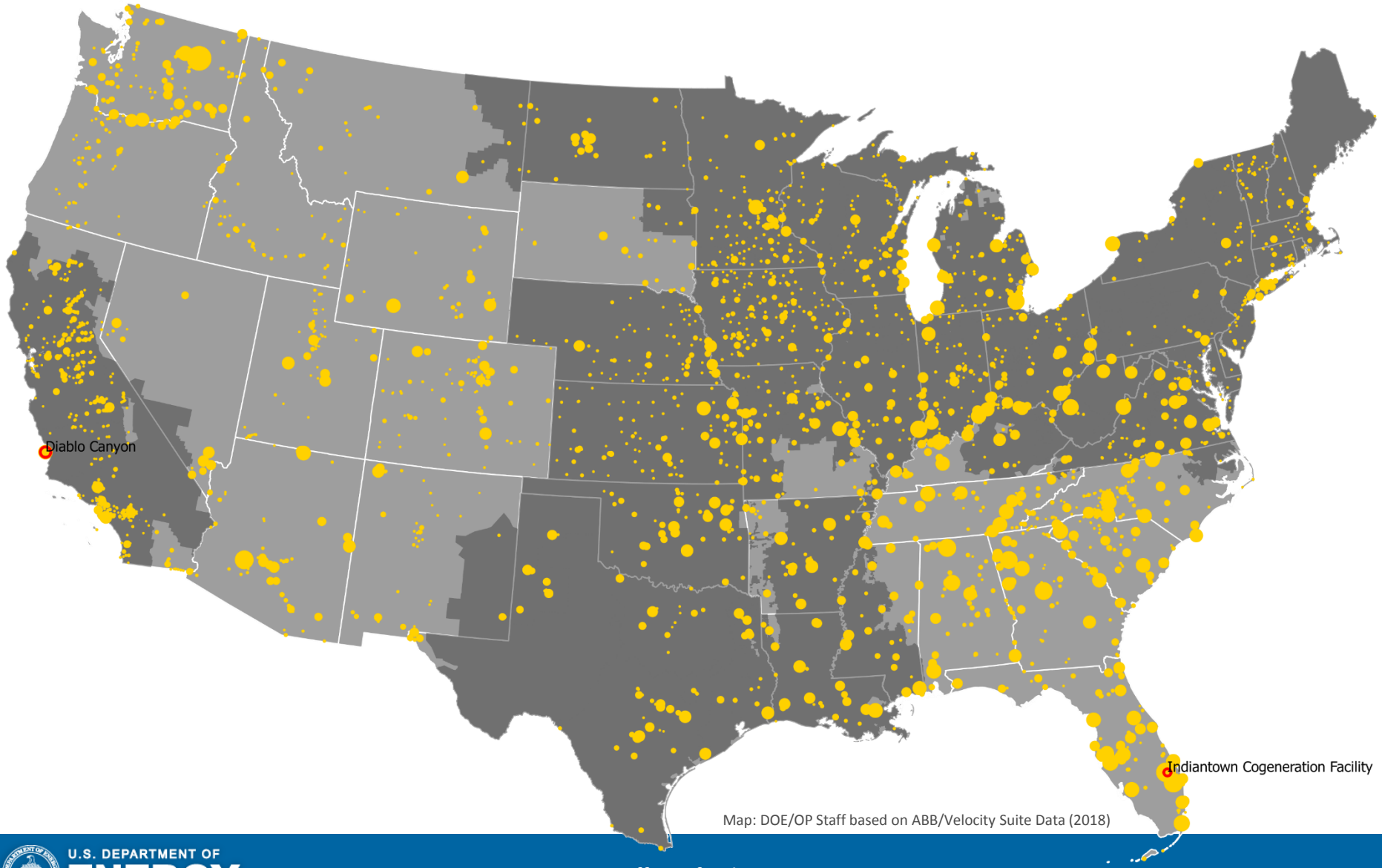
Procurement Type for Units Under Construction, 2018 Q2



Nearest categorization based on reported ownership, QF status, fuel, geography, PPA, and other publicly-available data

Chart: DOE/OP Staff based on S&P Global Data (2018)

Regulated



Map: DOE/OP Staff based on ABB/Velocity Suite Data (2018)

Regulated: Nuclear Retirement and Replacement

- Diablo Canyon
  - 2240 MW nuclear in California
  - Online 1985
  - License expiration in 2024-2025
- License extension scenario
  - 2025: $102/mwh-$211/mwh[1]
  - 2030: $107/mwh-$219/mwh[1]
  - NPV: ~$17b[2]
- Replacement energy scenario
  - 2025: proposed cost cap of $98/mwh[3]
  - 2025 NPV: $12b-$15b[2]
  - Energy efficiency, renewables, storage
  - Retain Helms Pumped Storage plant
- Support for labor and San Luis Obispo[4]
- CPUC approved retirement, Jan. 2018[4]

Image credit: flickr/dsearls (cc-by-sa-2.0)

1. Pacific Gas and Electric Company, "Diablo Canyon Power Plant Need Analysis," Page 2-22, August 6 2016
2. Caldwell, Marcus, White, Anthony, "A Cost Effective and Reliable Zero Carbon Replacement Strategy for Diablo Canyon Power Plant," 2015
3. Pacific Gas and Electric Company, "Replacement of Diablo Canyon Power Plant," Page 3-9, August 6 2016
4. CPUC, "Decision Approving Retirement of Diablo Canyon Nuclear Power Plant," A.16-08-006, January 11, 2018

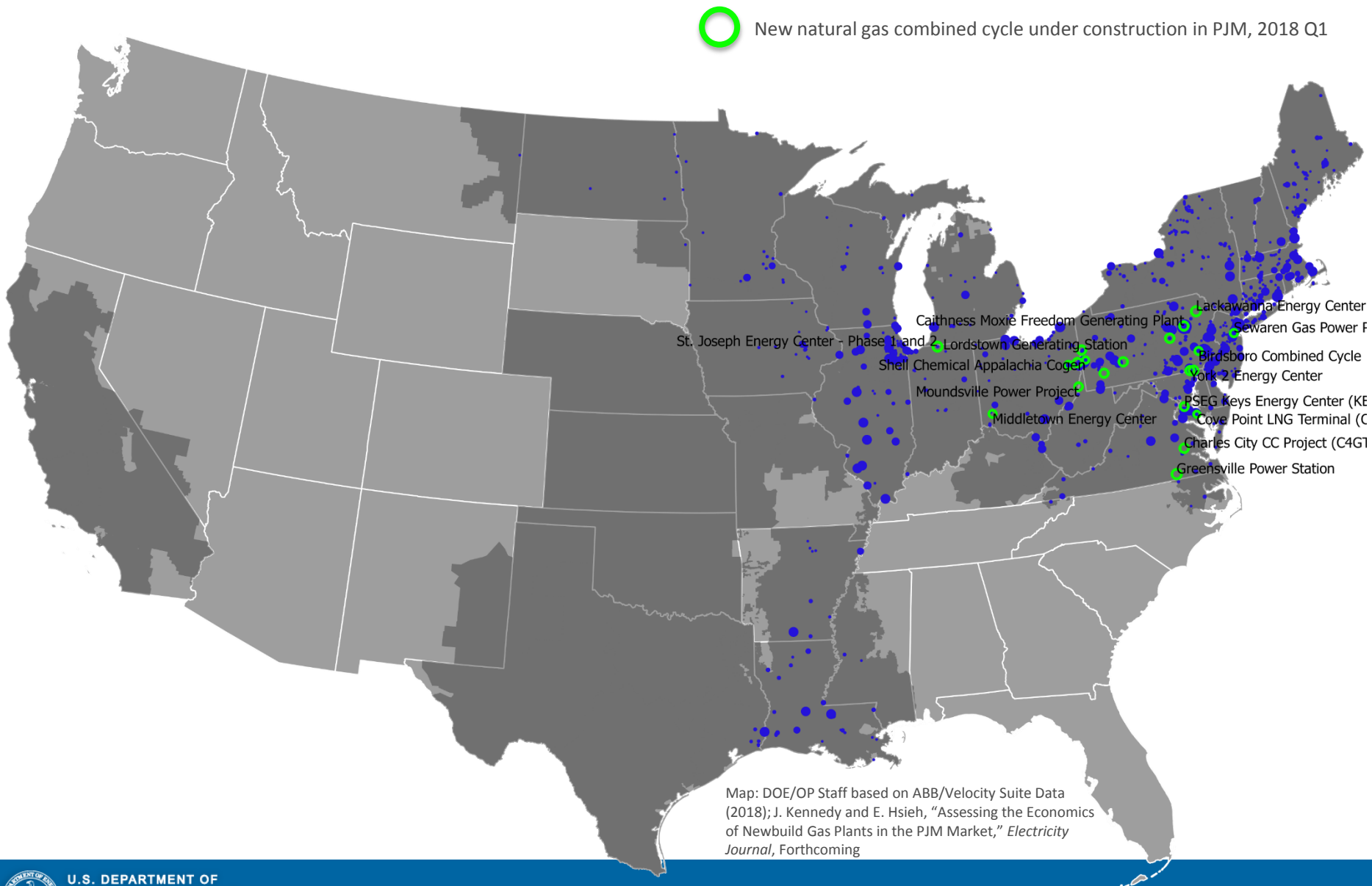
QF/Regulated: Coal Retirement and Replacement

- Calypso Indiantown
  - 330 MW coal cogenerator in Florida
  - Online 1995
- Qualifying Facility Power Purchase Agreement Terms (1991)
  - Energy indexed to coal price
  - Capacity fixed based on 1990 IGCC
  - 2015 operations:
    - 24% capacity factor (min gen floor)
    - All in cost: $264/mwh
    - FPL avoided cost: $18/mwh
- Buyout terms
  - FPL buys Indiantown for $451m
  - FPL avoids PPA payments: $594m through 2025
  - Indiantown closes after new NG pipeline is built
- FL PSC approved in 2016

Image credit: Google Maps (2018)

Source: FPL, "Petition for Approval of Arrangement to Mitigate Impact of Unfavorable Indiantown Cogeneration Power Purchase Obligation," June 20, 2016, FL PSC Docket 160154-EI

Capacity Merchant

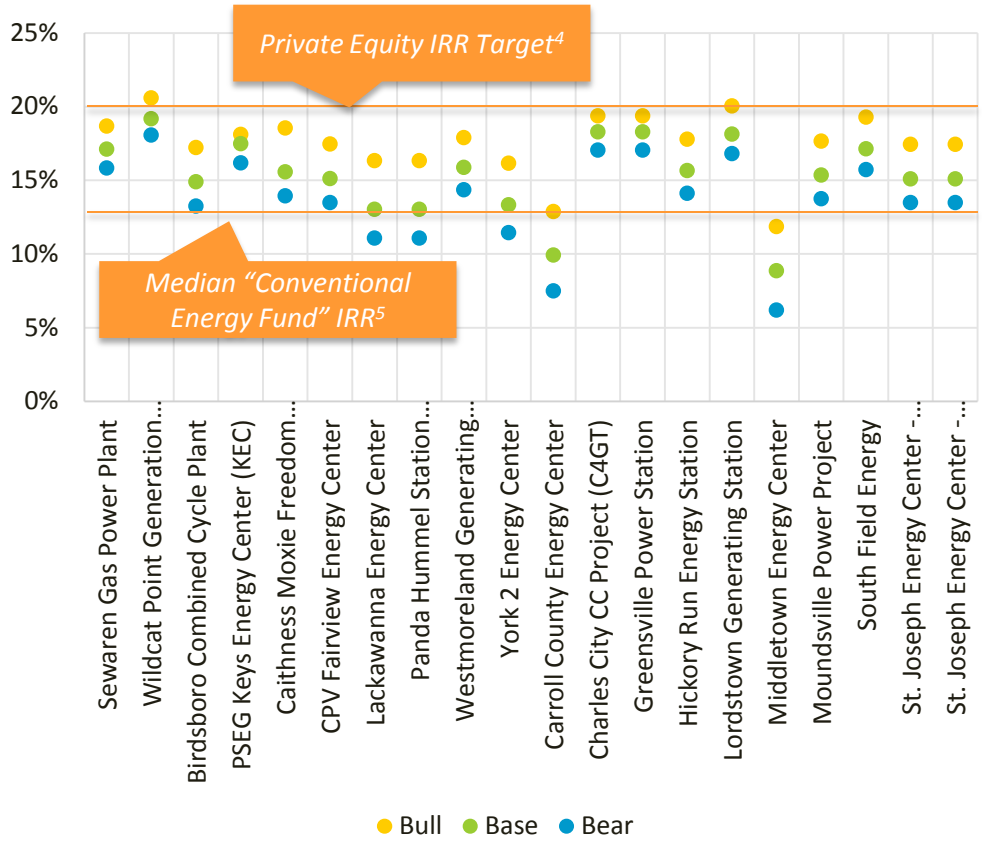


Map: DOE/OP Staff based on ABB/Velocity Suite Data (2018); J. Kennedy and E. Hsieh, "Assessing the Economics of Newbuild Gas Plants in the PJM Market," *Electricity Journal*, Forthcoming

Capacity Merchant: New Natural Gas Combined Cycle

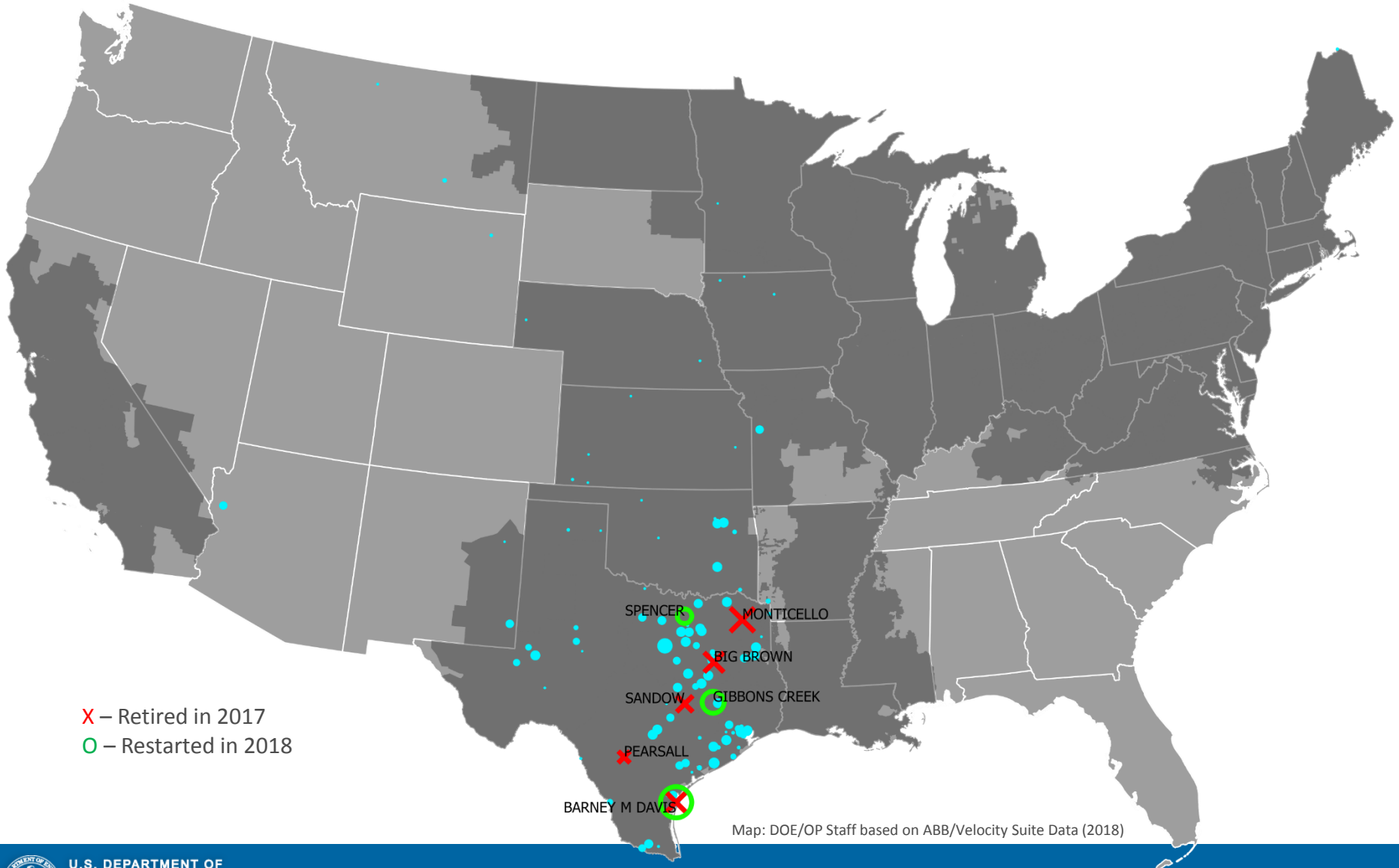
- 2018 PJM System
  - 2018 summer peak: 152 GW[1]
  - 2018 capacity: 189 GW[1]
  - 2018 reserve margin: 32.8%[1]
- 2018 PJM Queue
  - ~20 GW of NG CC categorized as "advanced development" or "construction begun"[2]
  - $20b total construction cost[2]
  - Estimated Equity IRR: 15.3% avg
    - 8.85% (min) to 20.05% (max) [2]
- Major Sensitivities
  - Gas/energy/capacity prices[2]
  - Debt/equity ratios and costs[2]

Estimated IRRs for New Natural Gas Combined Cycle Generators in PJM



1. NERC "2018 Summer Reliability Assessment," June 1, 2018
2. J. Kennedy and E. Hsieh, "Assessing the Economics of Newbuild Gas Plants in the PJM Market," *Electricity Journal*, June 2018, https://doi.org/10.1016/j.tej.2018.05.001
3. Chart: DOE/OP Staff based on S&P Global Data (2018)
4. Goldman Sachs, "Historical Distributions of IRR," Vol. 11 (2001)
5. Preqin, "Preqin Special Report: Conventional and Renewable Energy," New York (2017)

Merchant Energy-Only



Map: DOE/OP Staff based on ABB/Velocity Suite Data (2018)

Merchant: ERCOT Retirements and Restarts

2017 Low wholesale prices[1]

PPA Terminations

2017 Q4 4.6 GW in announced retirements[2]

2018 Q2 900 MW in restarted capacity[3]

728 MW in new capacity[4]

2018 Summer Forecasted Peak: 72.8 GW[4]

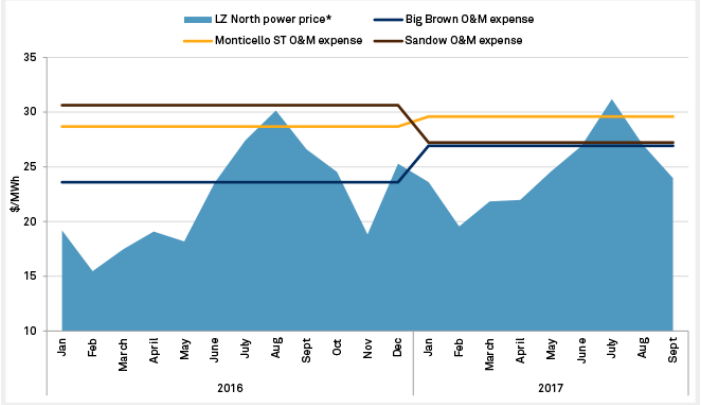
Forecasted Capacity: 78.2 GW[4]

S&P Global

ERCOT summer power prices dip after plant restart announcements

Thursday, April 19, 2018 1:05 PM ET

Luminant plants O&M expenses vs. ERCOT LZ North power price ($/MWh)



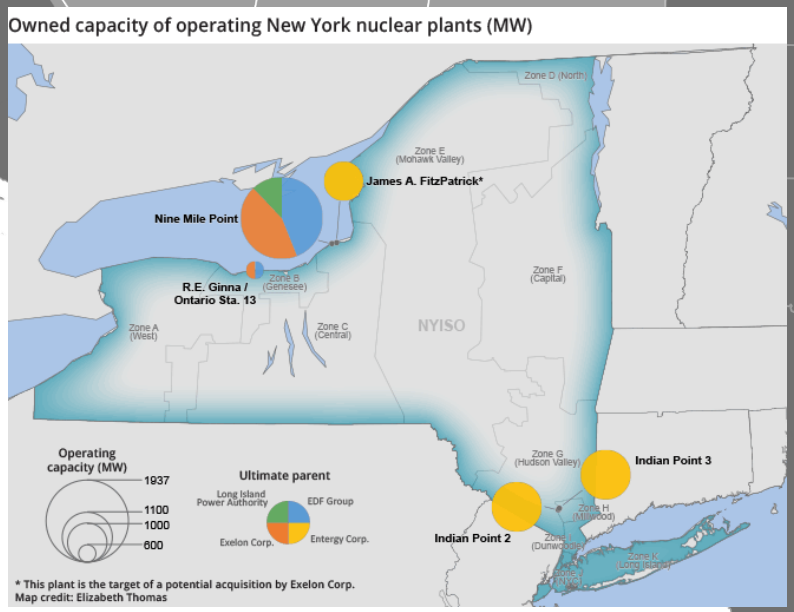
As of Oct. 13, 2017.
* These are ISO day-ahead around the clock monthly average prices.
Operating and maintenance expenses are modeled from S&P Global Market Intelligence's Generation Supply Curve.
Sandow's O&M expenses are the sum of Sandow and Sandow (Unit 5) expenses.
Source: S&P Global Market Intelligence

[A]nticipated record demand, combined with recent plant retirements…is expected to result in tight reserves that could trigger the need for… contracted Emergency Response Service[.]

- ERCOT[4]

1. S&P Global, "Operating costs of Luminant coal plants run generally higher than ERCOT prices," October 17, 2017
2. S&P Global, "With recent retirements, new scrutiny on ERCOT supply," October 30, 2017
3. RTO Insider, "ERCOT Board of Directors Briefs," April 10, 2018" S&P Global, "ERCOT summer power prices dip after plant restart announcements," Thursday, April 19, 2018
4. ERCOT, "Final Seasonal Assessment of Resource Adequacy for the ERCOT Region (SARA) Summer 2018", April 20, 2018

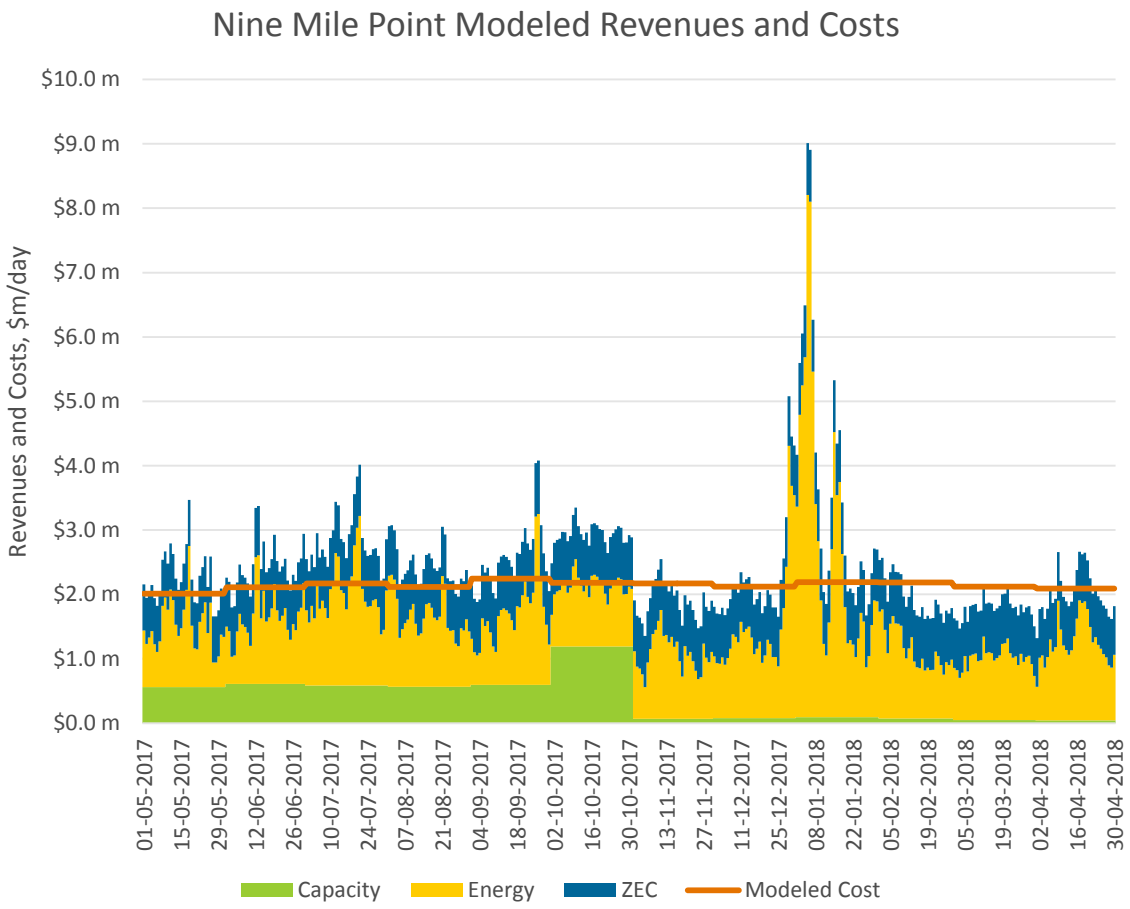
Preferred Merchant



Large Map: DOE/OP Staff based on ABB/Velocity Suite Data (2018)
Inset Map: S&P Global, "NY nuclear credits boost upstate nuclear plants," August 19, 2016

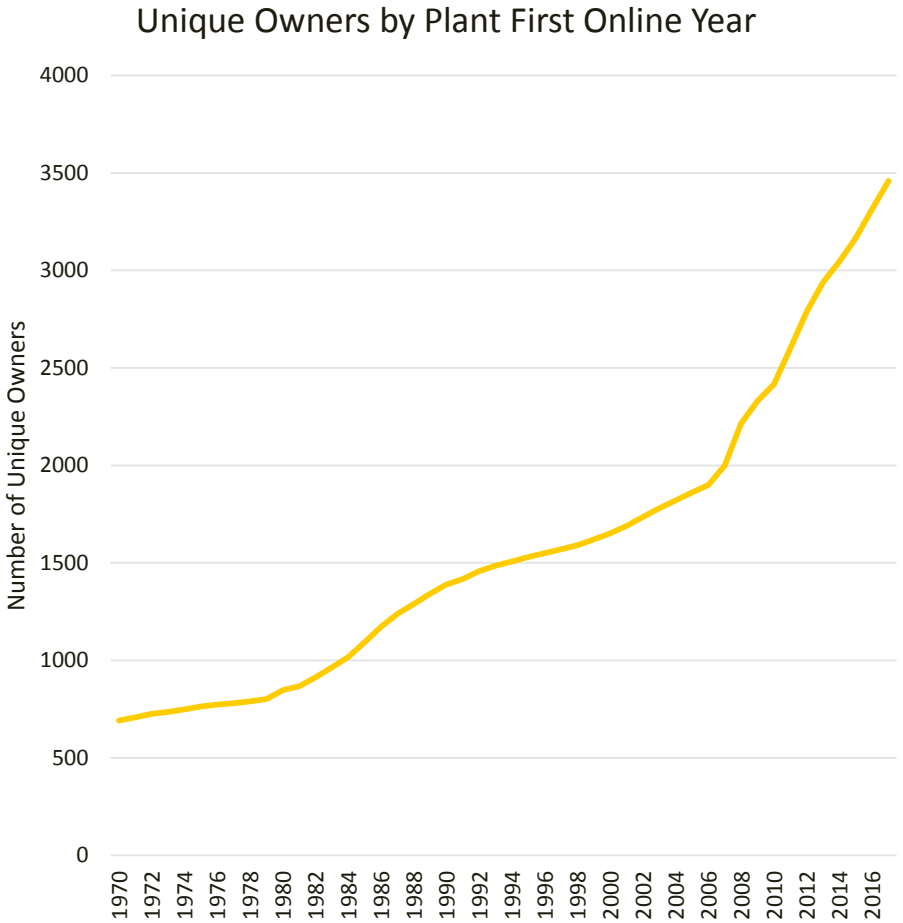
Preferred Merchant: Greenhouse Gas Attribute Payment

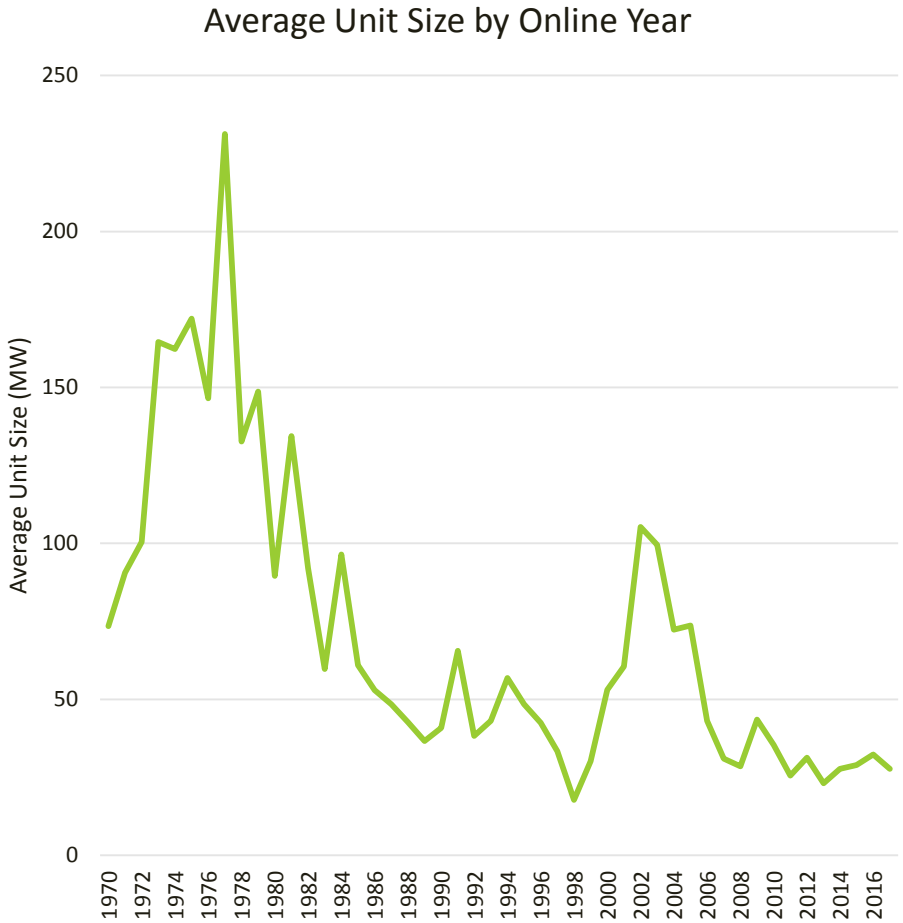
- NY Zero Emissions Credit
  - "…ensure the proper valuation of carbon-free power from nuclear plants."[1]
  - A "bridge to a renewable future"[1]
  - Eligible resources: nuclear generators in upstate NY
  - 6 tranches, two years each, through 2029
- ZEC Payments
  - Calculation: subtract RGGI effect and market revenue index from carbon
  - 2017-2018 Tranche 1: $17.48/mwh
- Active legal challenges



1. NY PSC, "Order Adopting a Clean Energy Standard," August 1, 2016
2. S&P Global, "NY nuclear credits boost upstate nuclear plants," August 19, 2016
3. Chart: DOE/OP Staff based on S&P Global Data (2018)

Macro Market Trends: More Owners, Smaller Units





Charts: DOE/OP Staff based on S&P Global Data (2018) and ABB/Velocity Suite Data (2018)

Conclusion

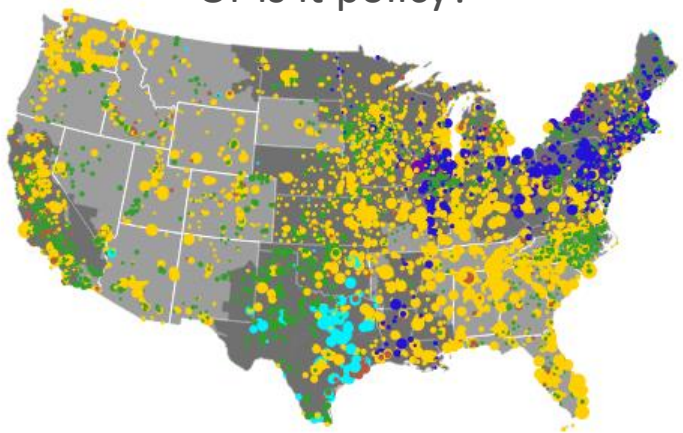
- Diverse methods for generation capacity decisions in the U.S.
  - Overseen by a regulator (risks allocated to ratepayers)
  - Mixed structures
  - Medium-term capacity markets
  - Short-term energy markets (risks allocated to asset owners)
- Increasing variety of approaches

Is it art?

Image via flickr/Alan Teo (CC BY-NC-SA 2.0)

Obliteration Room, Yayoi Kusuma

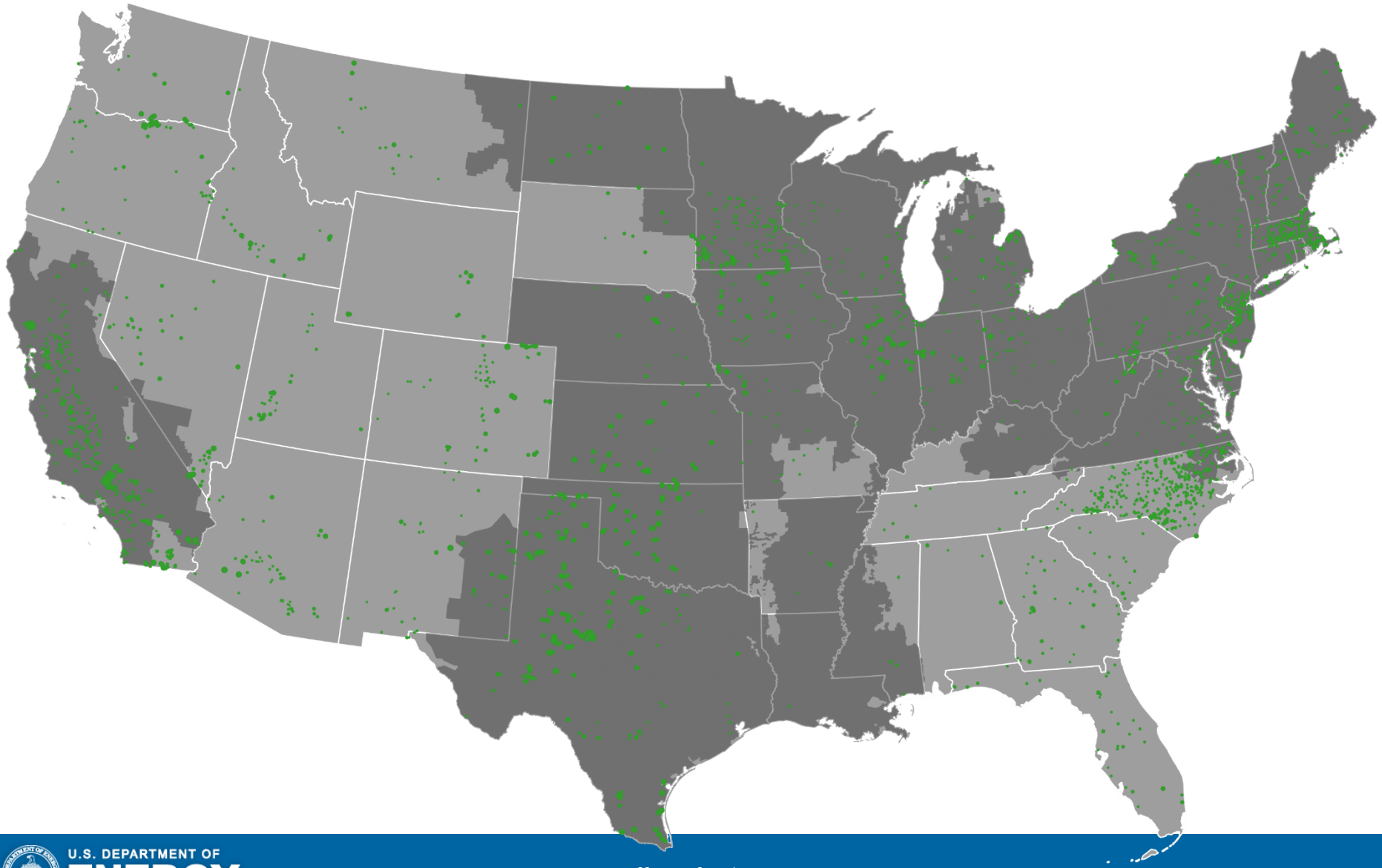
Or is it policy?



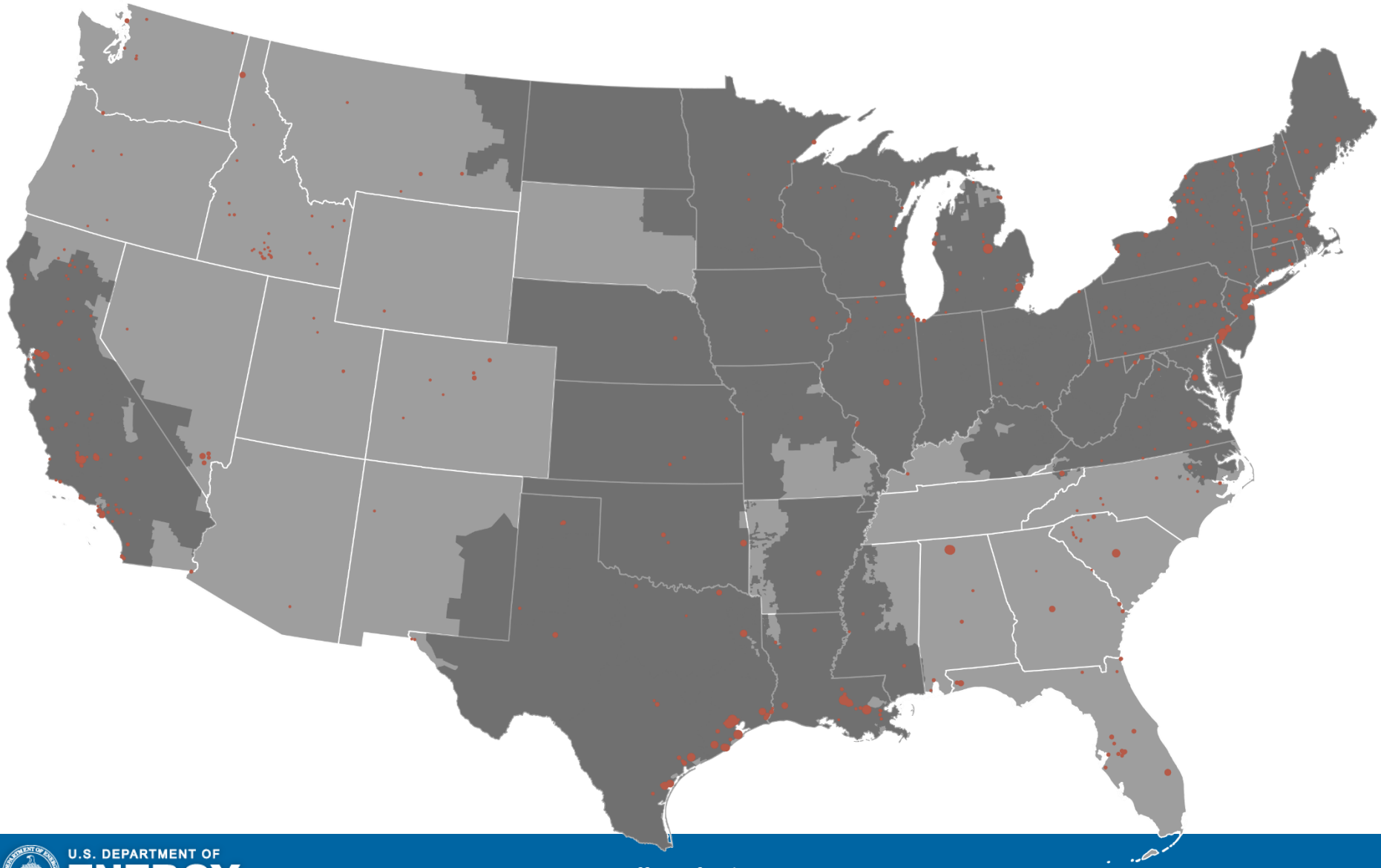
U.S. Generator Procurement, USDOE

Appendix

Renewable PPA



Qualifying Facility



Conventional PPA