Seven Technology Disruptions Behind the Energy Transition

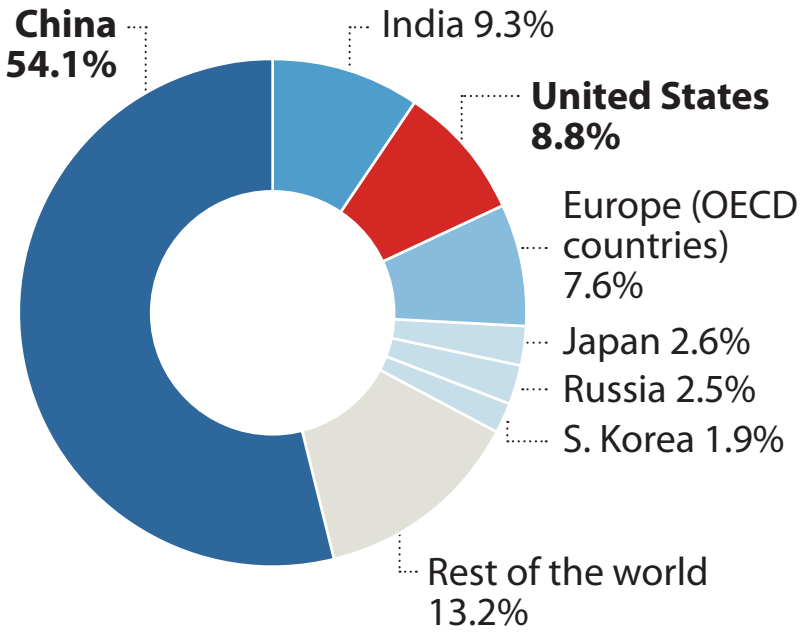
Understanding the Structural Decline of the U.S. Coal Industry

Seth Feaster, Energy Data Analyst, IEEFA

September 2018

World Consumption of Coal . . .

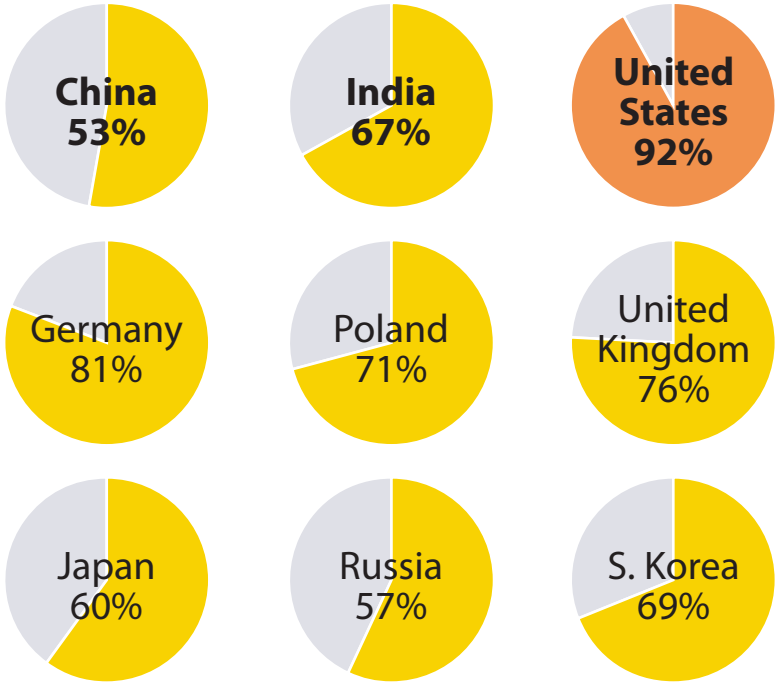
Last year, China consumed more than half of all the coal the world used. India, the United States, and Europe accounted for another quarter.



Estimates for 2017

. . . and Share Consumed for Electricity

Over 90 percent of the coal used in the United States was used to produce electricity; that share was far lower among the biggest consumers in Asia.

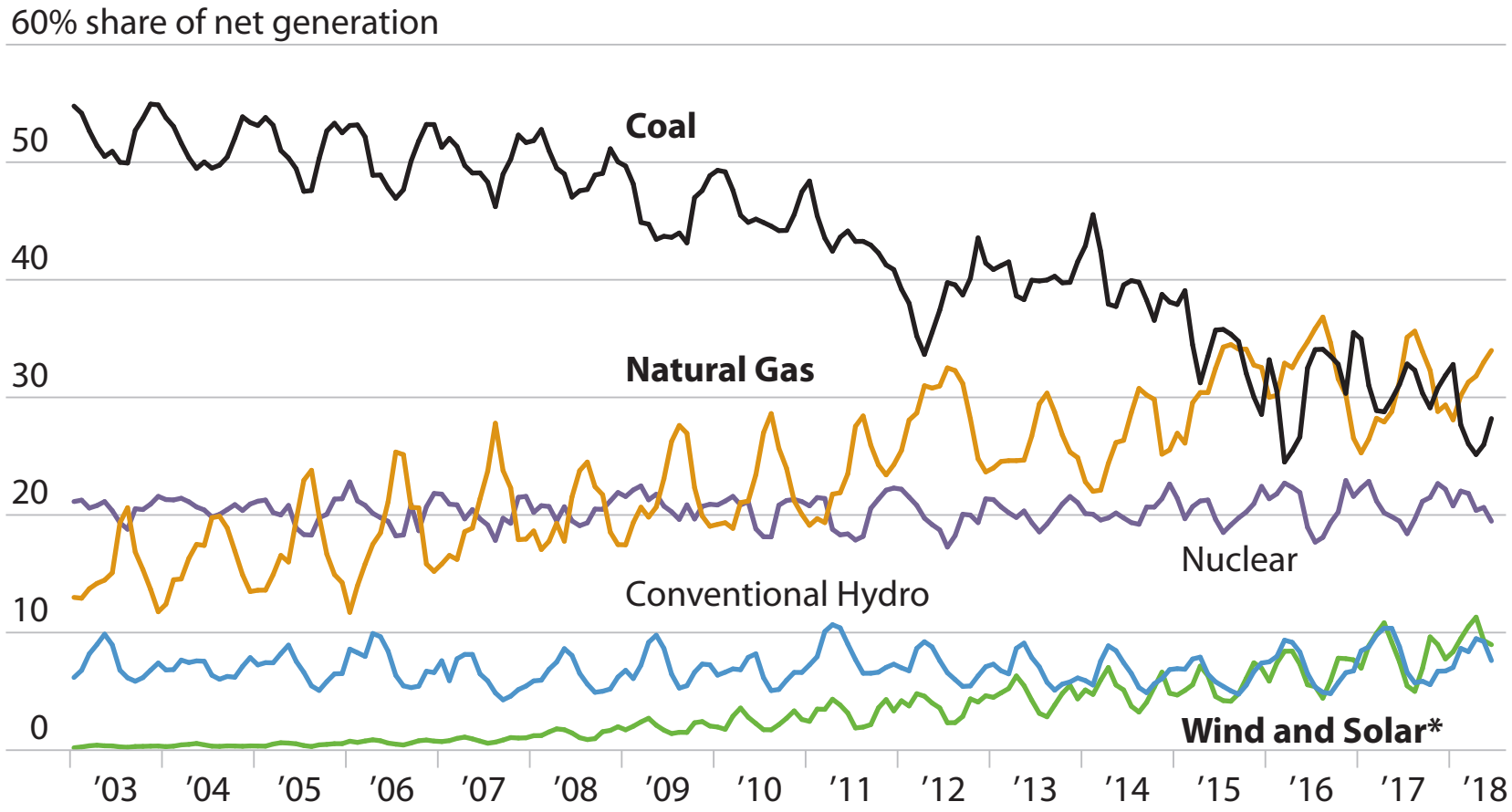


Figures for 2015

Sources: Energy Information Administration (consumption); International Energy Agency

Share of U.S. Electricity Generation, Electric Power Sector, by Fuel

Coal's share as a fuel for electricity generation has fallen sharply over the last 15 years as natural gas, wind, and solar have gained market share. Hydro and nuclear have remained relatively unchanged over the same period.



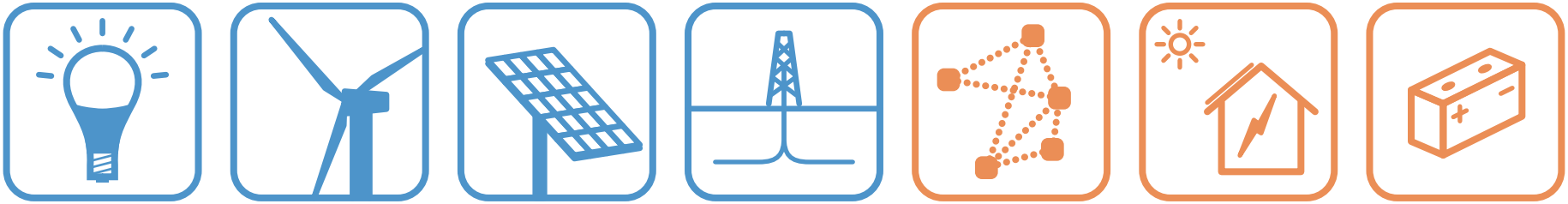
Source: Energy Information Administration

*Utility-scale only

The **Seven Disruptions** of the Energy Transition

GENERATION

GRID



Energy Efficiency

Policy/ Technology disruption

Wind

Mechanical/ Industrial Construction disruption

Solar

Semiconductor/ Manufacturing/ Construction disruption

Fracking

Mining Extraction/ Industrial Technology disruption

Grid Integration

Software/ Information Technology disruption

Grid Independence

Equipment Scale/ Business Model disruption

Energy Storage

Electrochemical Engineering/ Business Model disruption

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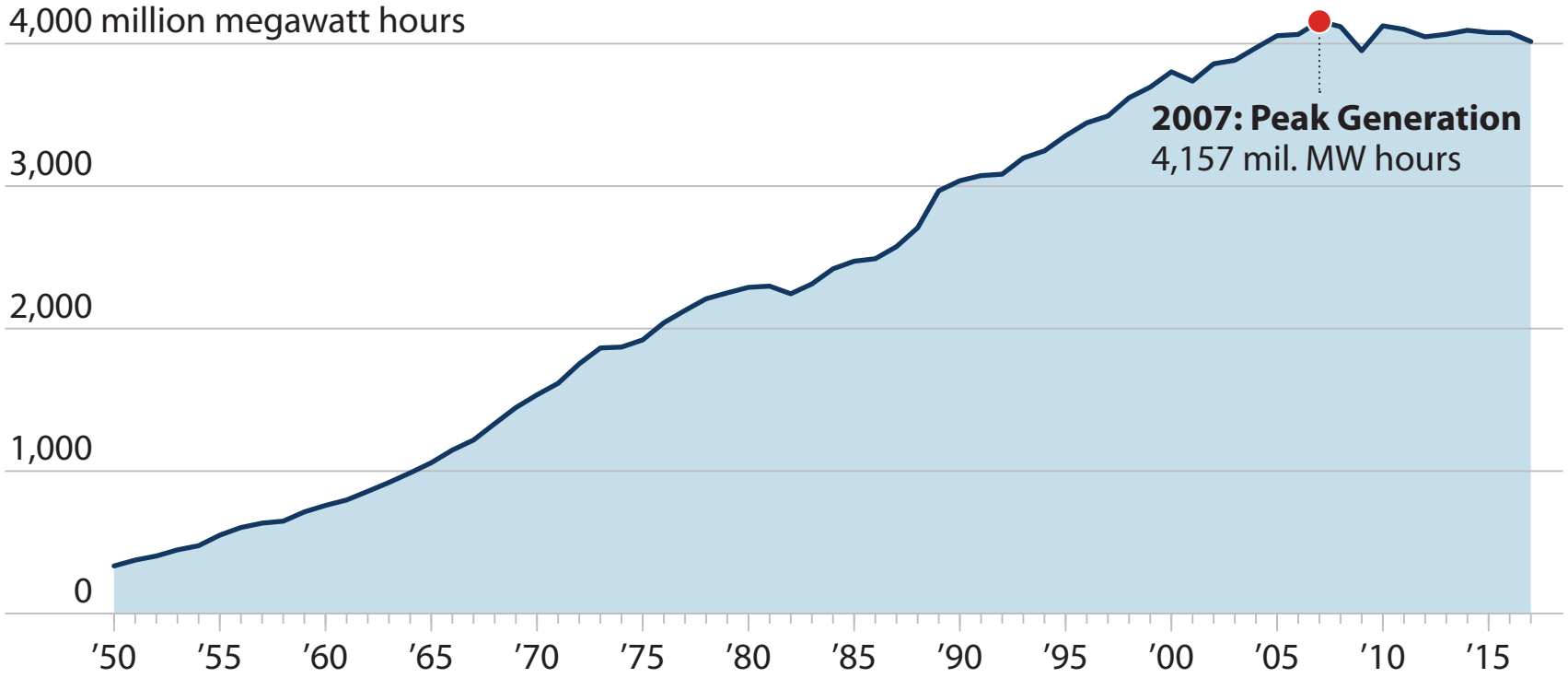
U.S. Net Generation of Electricity, 1950-2017

Decades of growth in electricity use ended in 2007, and demand has been flat to down ever since.



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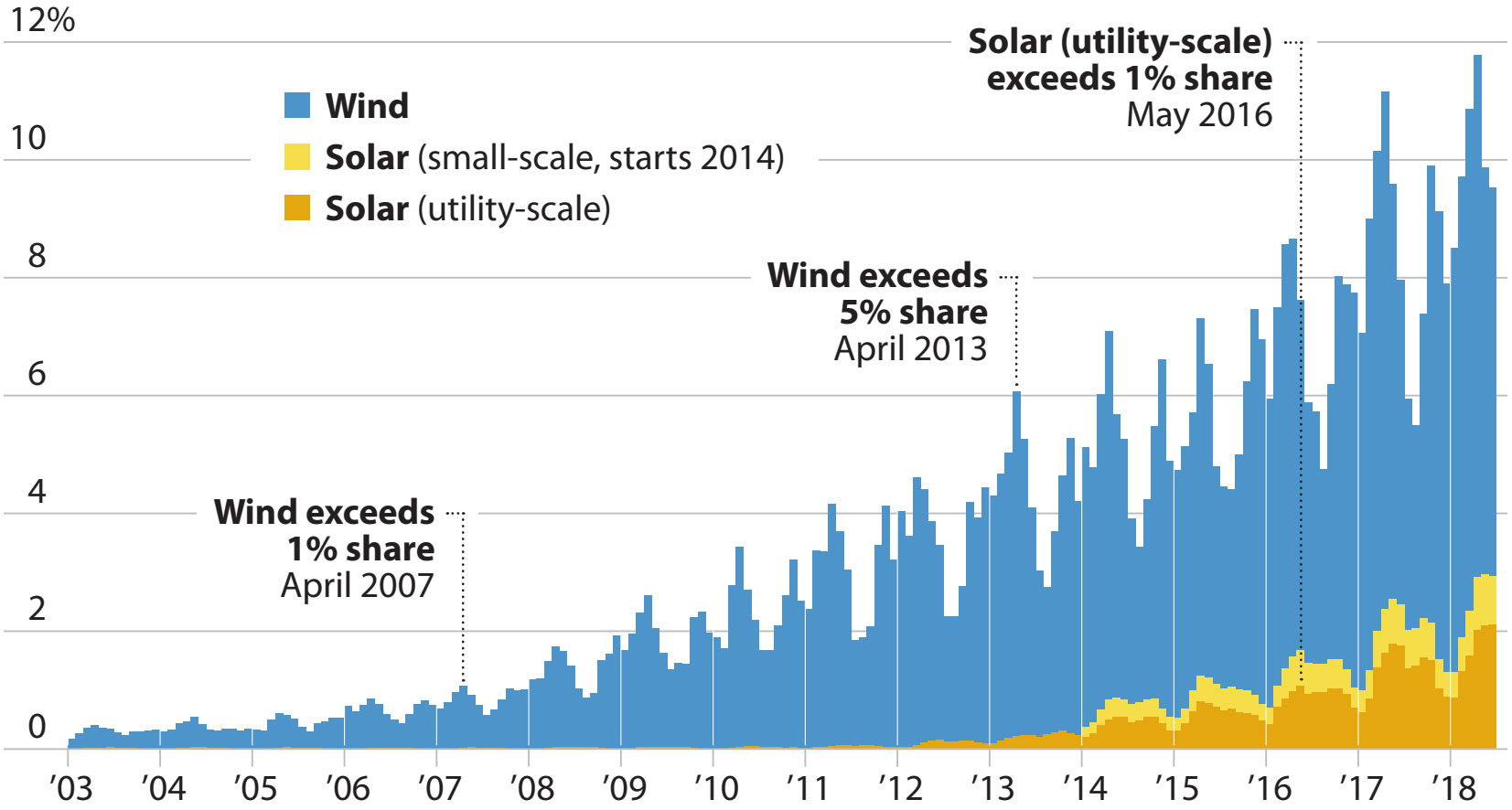
Wind and Solar Share of U.S. Electricity Generation

Wind and solar generation has been growing relentlessly as costs for these renwables have fallen sharply; grid operators have mastered integrating them; and utilities have increasingly embraced them.



Source: Energy Information Administration

Note: Share of generation for all sectors

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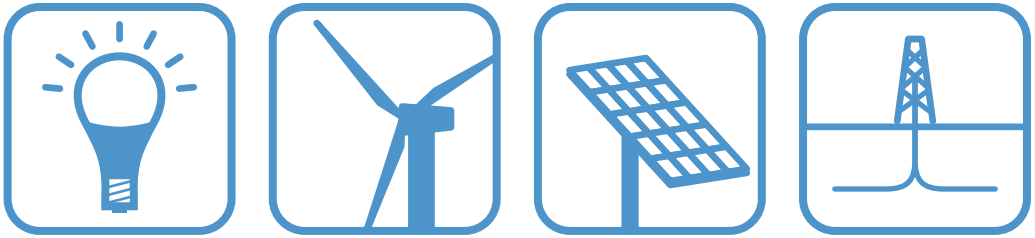

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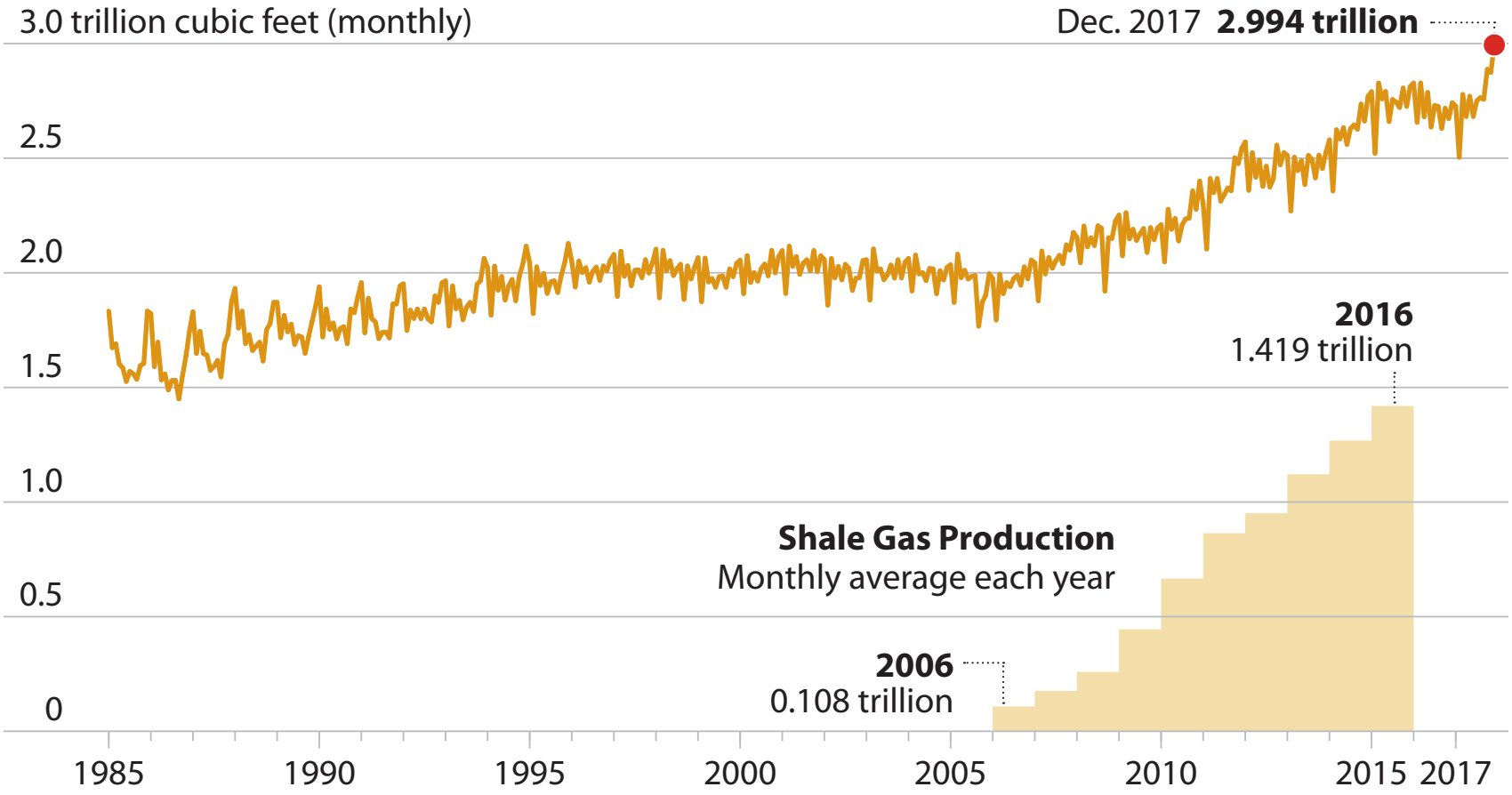
U.S. Natural Gas Production, 1985-2017

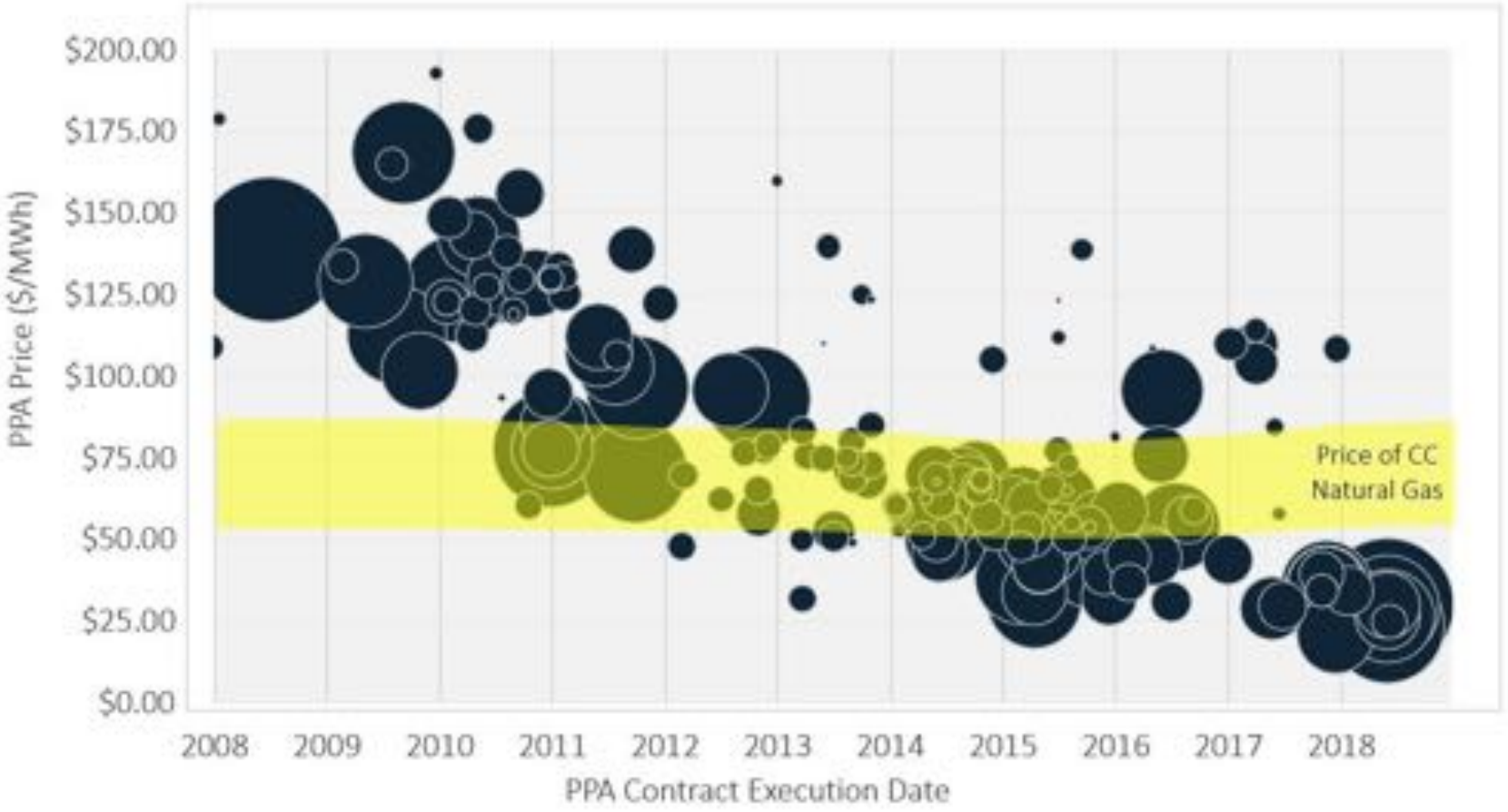
After about a decade of flat natural gas production (1995-2005), rapid adoption and technical advances in the use of hydraulic fracturing in shale formations led to a surge in supply and low prices.



Source: Energy Information Administration

U.S. solar projects:

Cost of power-purchase agreements vs. natural gas combined cycle



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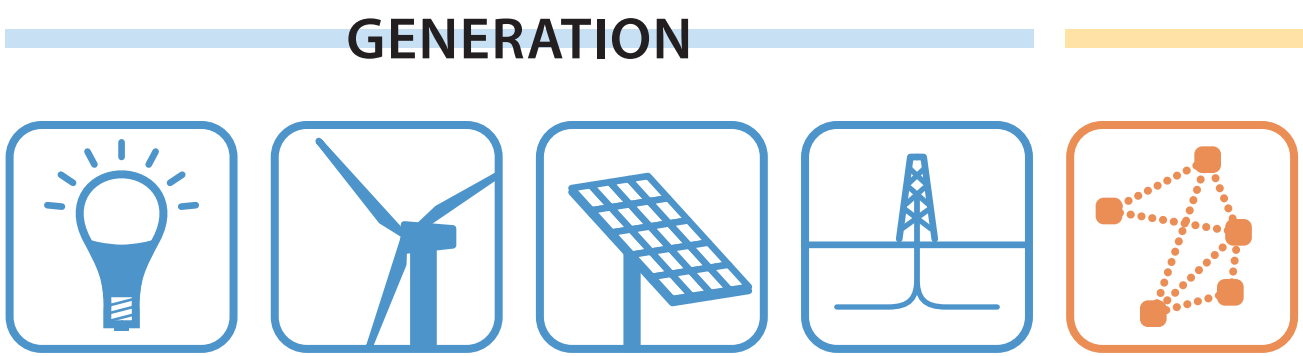
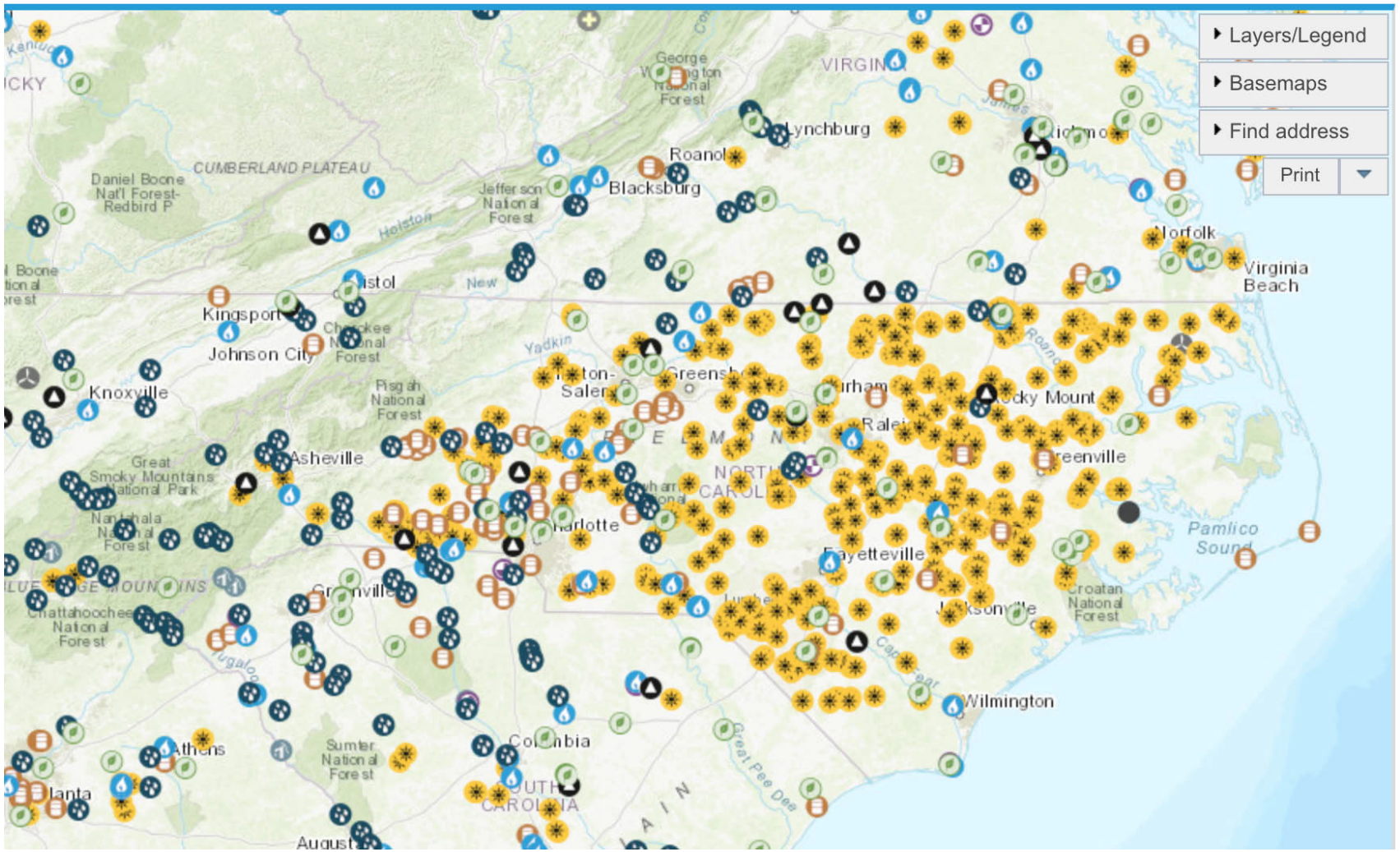


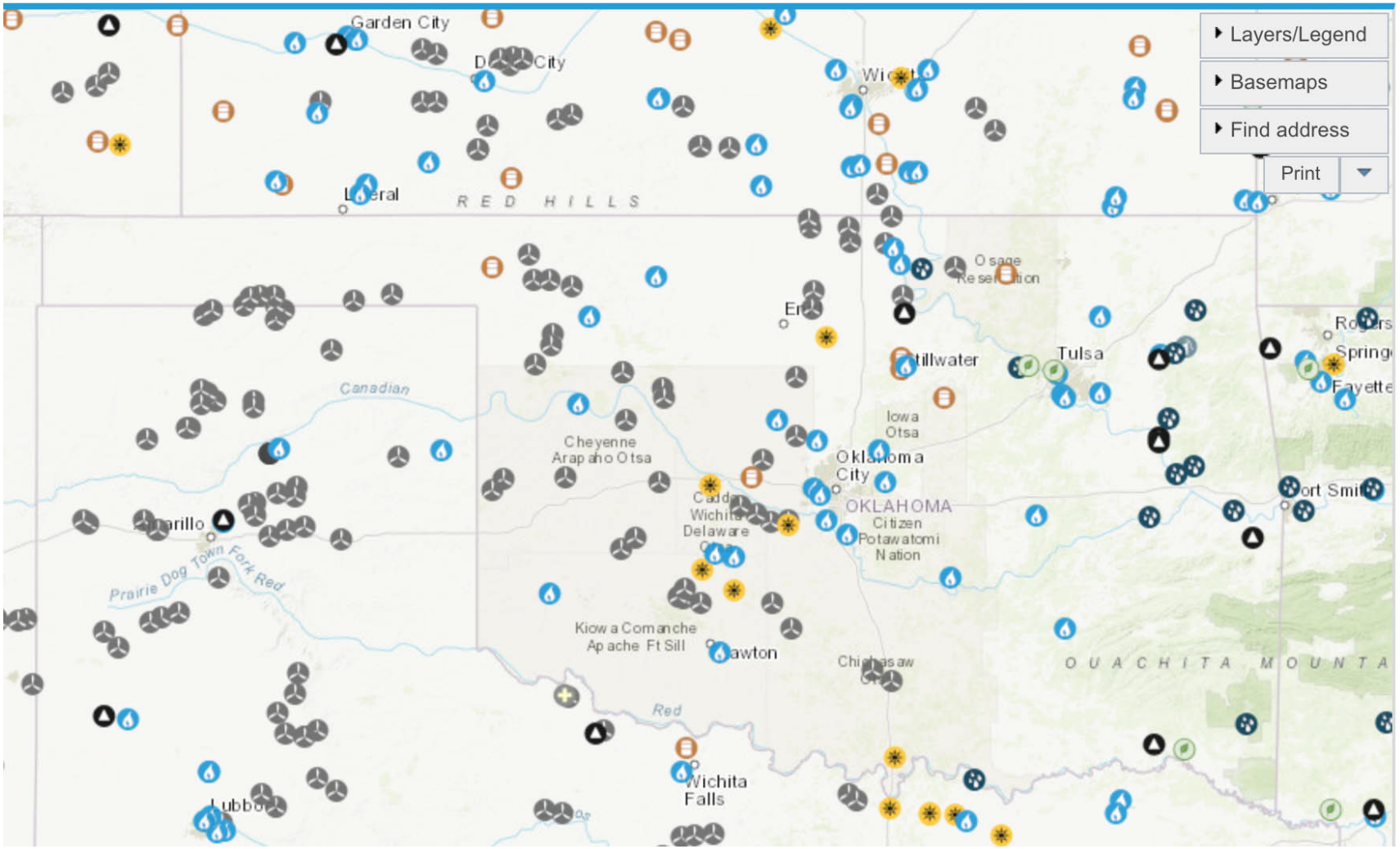
Utility-scale solar plant

North Carolina, August 2018



Wind farm

Texas-Oklahoma, August 2018



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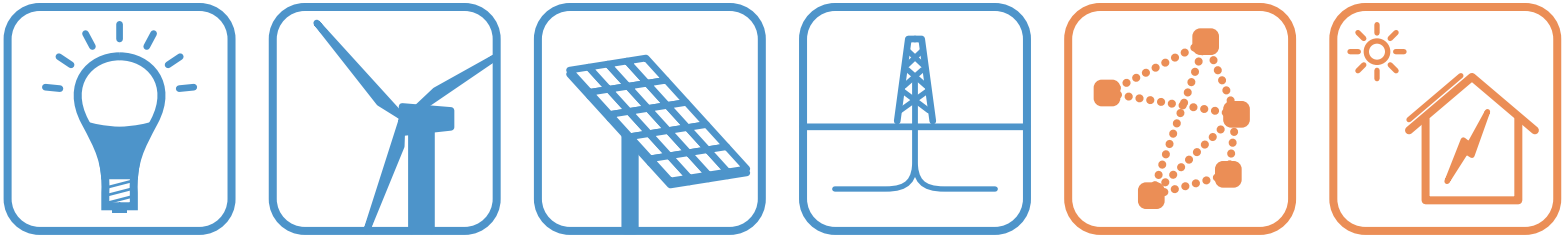

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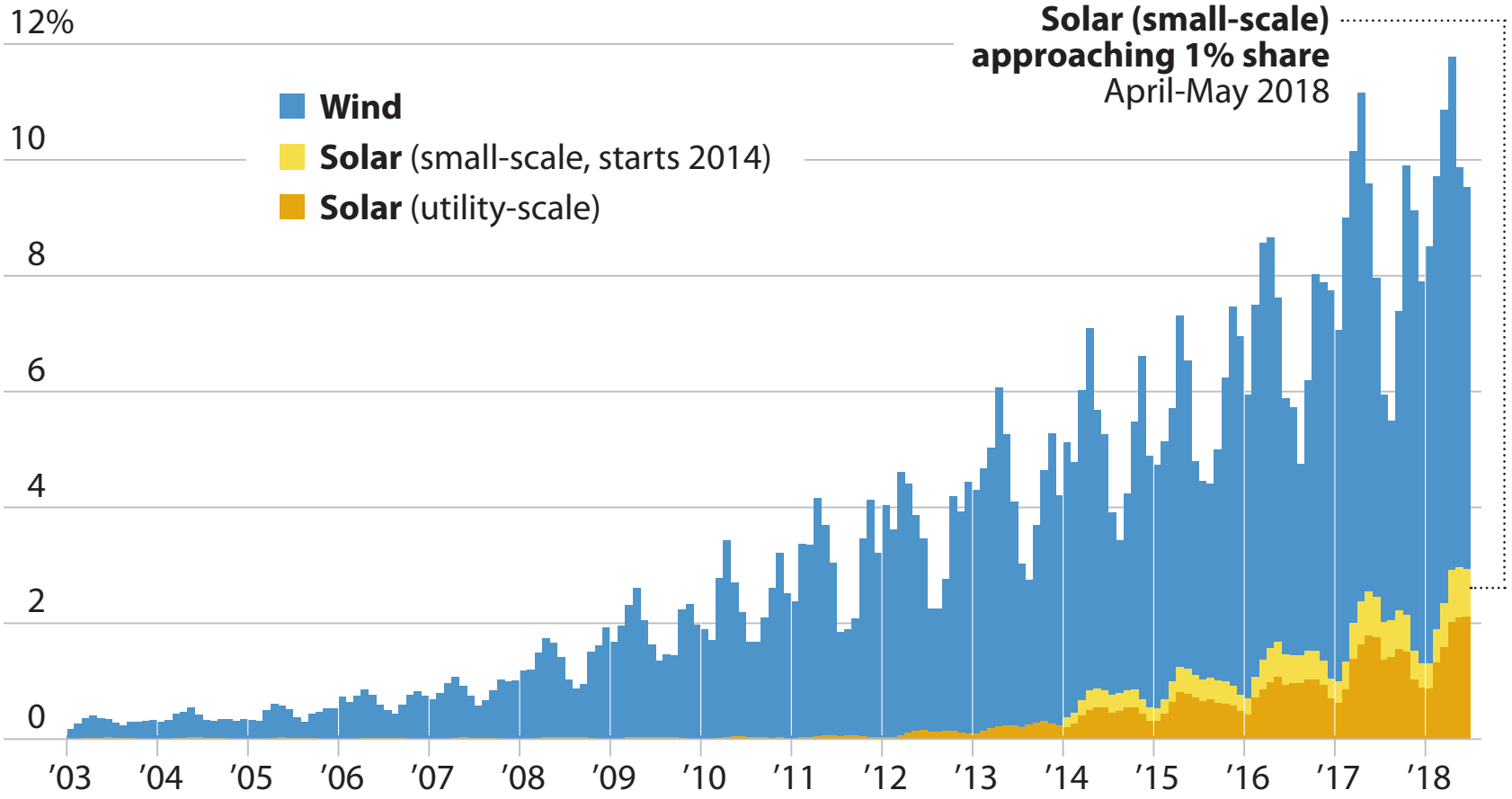

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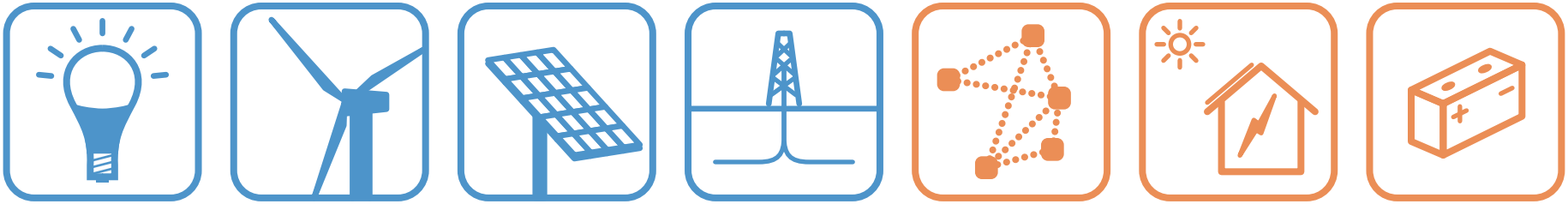

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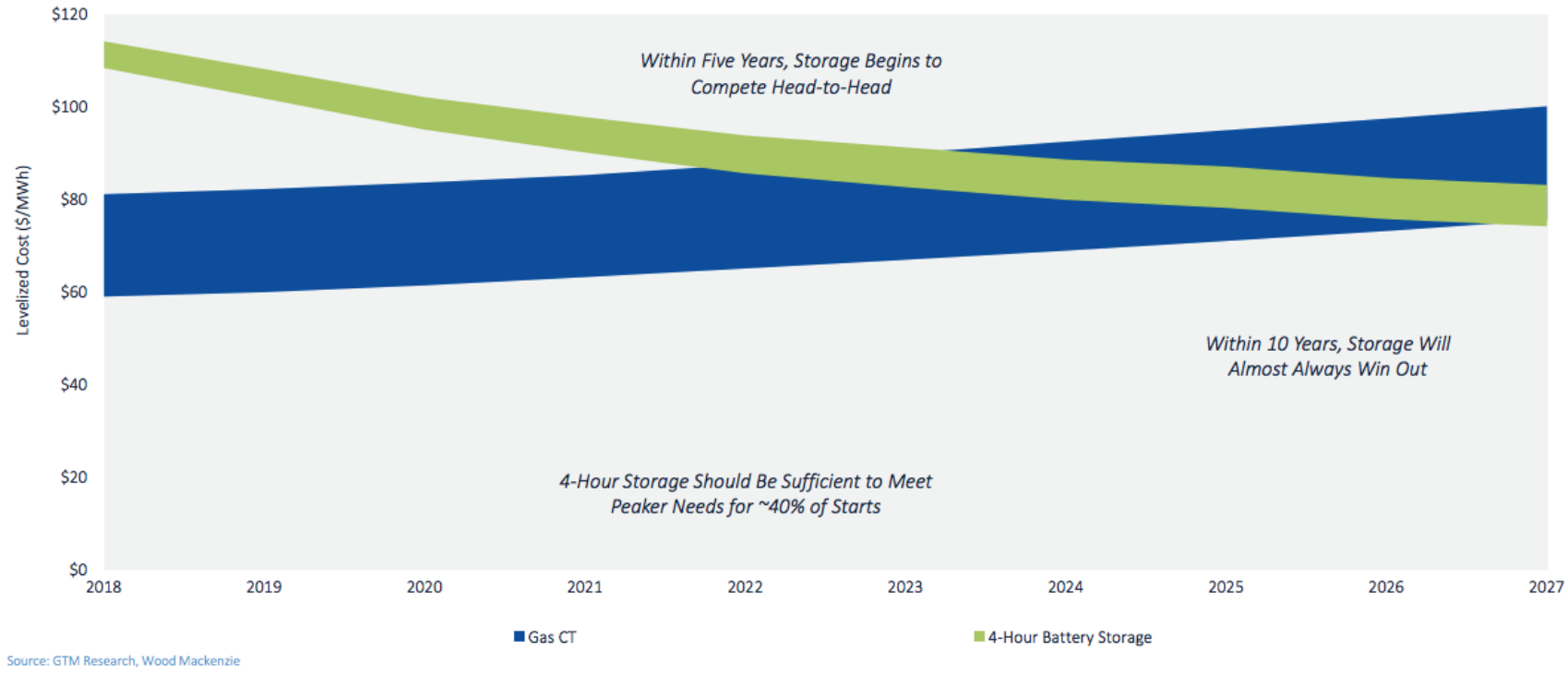
Peaking Gas Combustion Turbine vs. 4-Hour Li-Ion Battery Storage ($/MWh)



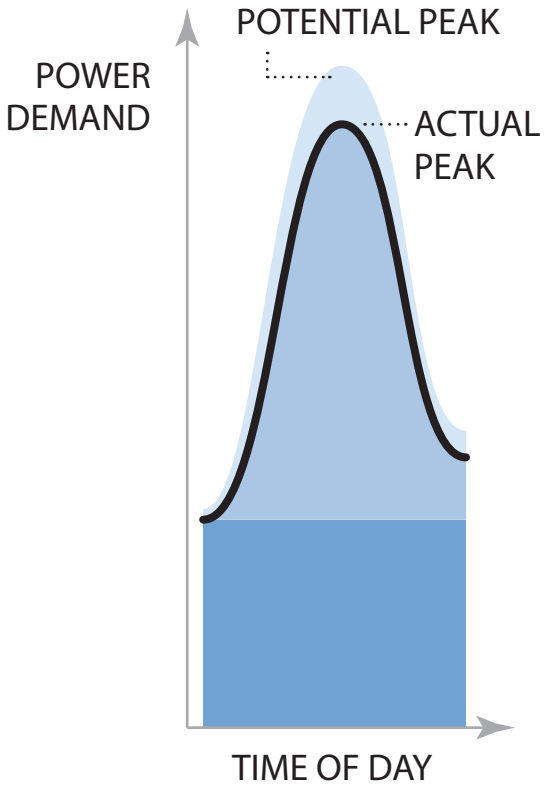
Source: GTM Research, Wood Mackenzie

General grid-operator rules:

1. No blackouts

2. "Cost effective" operation

Demand curve



Types of generation

RESERVES

VARIABLE LOAD

BASE LOAD

Traditional dispatch stack

HIGHEST COST

Diesel, Oil
Oldest Coal

Natural gas
Coal

Coal
Nuclear
Hydro

LOWEST COST

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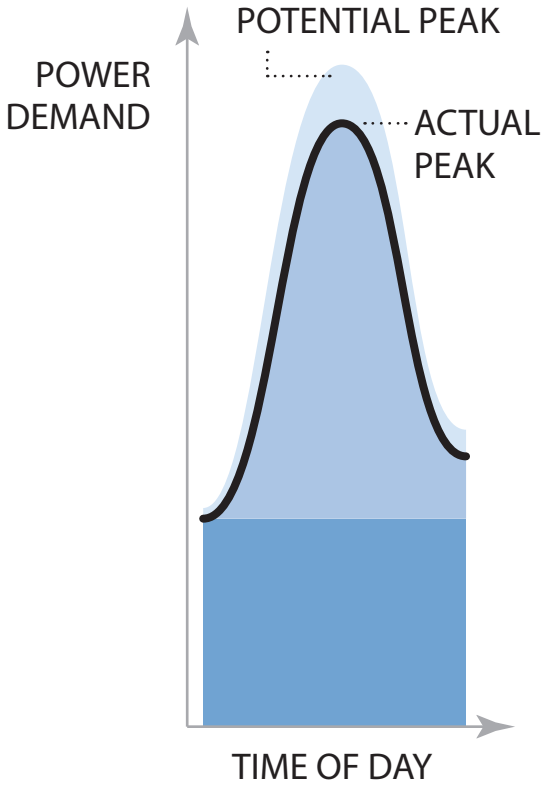


Cost range

UP TO $9,000 MEGAWATT HOUR (TEXAS)

GENERALLY $20 – $50 MEGAWATT HOUR

$0 DURING MAXIMUM SOLAR GENERATION (CALIFORNIA)

Disrupted dispatch stack

HIGHEST COST

Solar or wind + batteries

Coal

Nuclear

Natural gas

Wind

Solar

LOWEST COST

Hydro

Implications for the U.S. Coal Industry

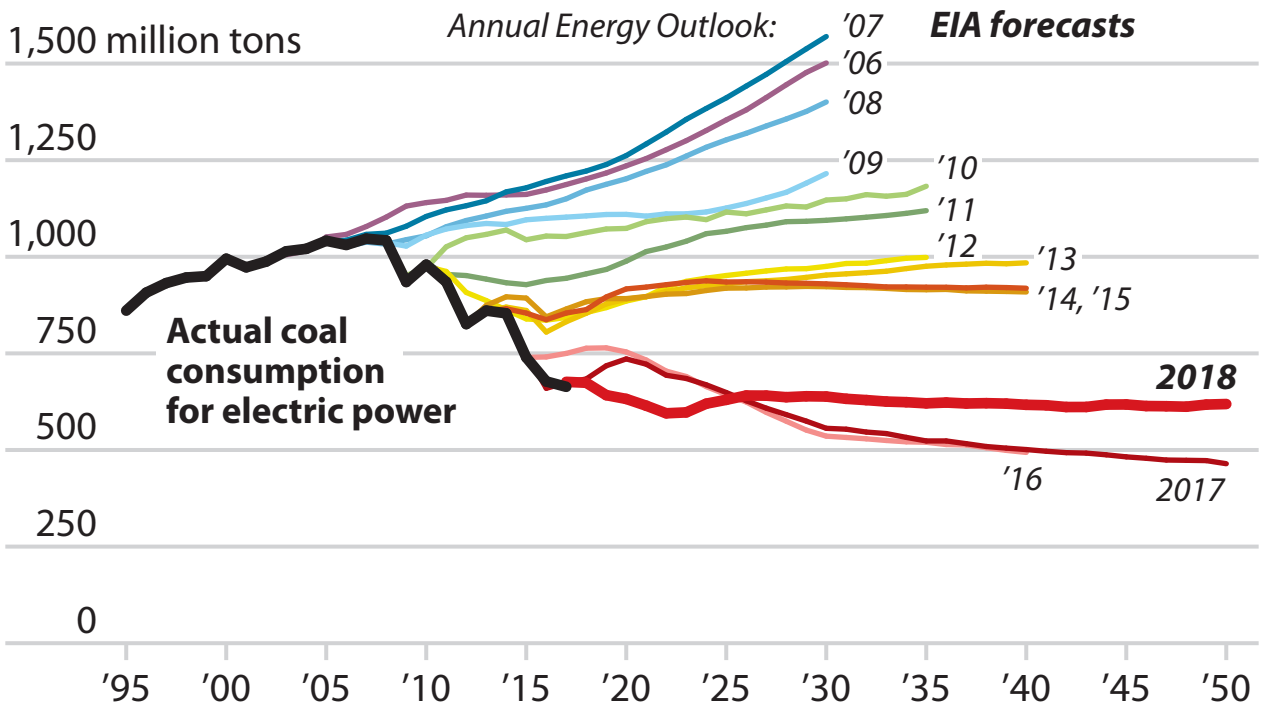
1. Technology-driven, disruptive economics arrayed against coal are broad and long-term
2. Coal industry innovations are limited, with some notable recent failures
3. Intellectual and financial capital avoiding coal
4. Competitive intensity accelerating, compounded by social and business embrace of new technologies

Outcomes for the U.S. Coal Industry

1. No new coal plants
2. Existing plants see accelerated retirements due to age and economic competition
3. Federal policy changes have minimal impact on pace of closures and long-term planning by utilities
4. Non-export mining companies face relentless financial distress and financial extraction
5. Mine closures coming

EIA Coal Consumption Forecasts, 2006-2018

Each year, the Energy Information Administration releases its Annual Energy Outlook, which includes a long-term forecast for U.S. coal consumption for electric power generation. However, the forecasts have been wildly inaccurate, even in the near term.



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