THE GROWTH OF RENEWABLES AND DISTRIBUTED RESOURCES



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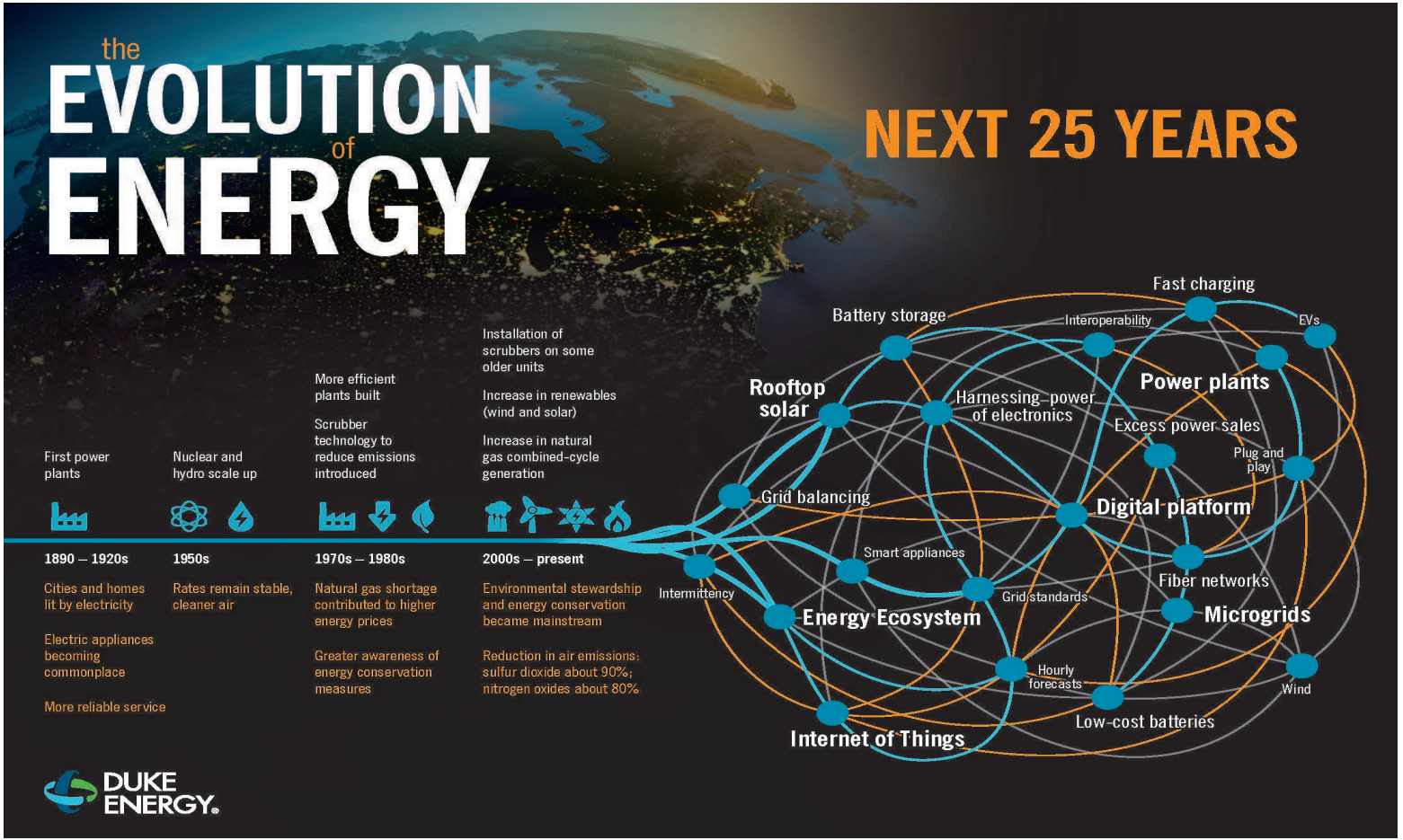
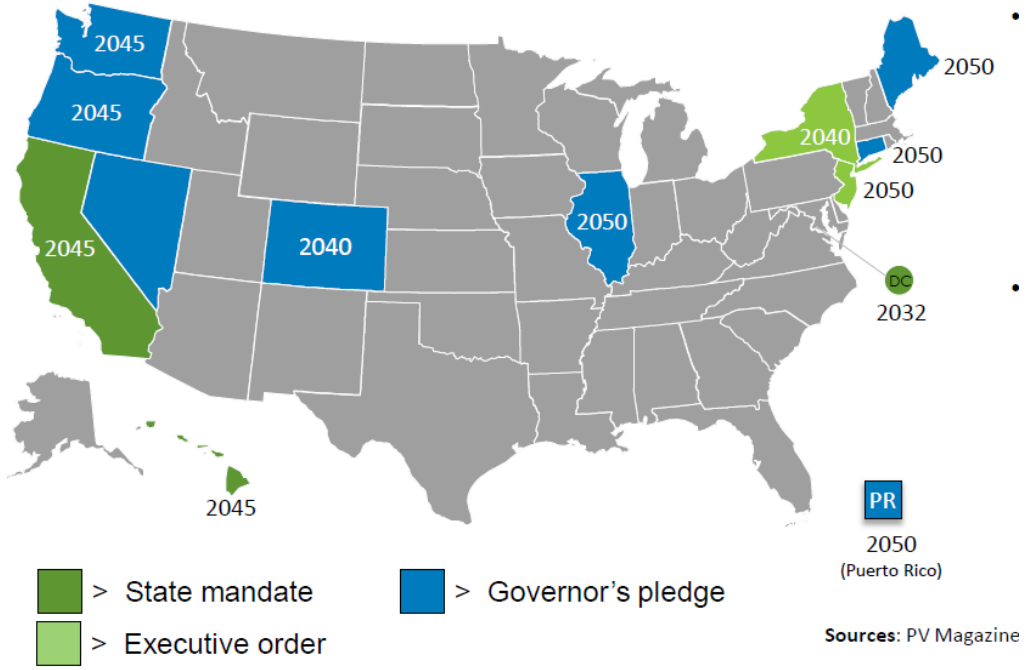
SUMMARY: 2018-2019

- By the end of 2018, Hawaii, California, the District of Columbia, 104 cities, 11 counties, and 51 American companies in the United States had made 100% clean power commitments.
- In 2018, renewables generated more electricity (41%) in Germany than coal (38%)—a first.
- The US Energy Information Administration (EIA) estimates 23% of all new electricity generating capacity in the United States came from solar installations in 2018—second to natural gas.
- Roughly 3 GW of new or refurbished U.S. PV manufacturing capacity is expected to come online in 2019.
- In January 2019, global module average selling price was reported to be $0.22/watt.
- 2018 global and U.S. solar investment were $132B and $21B respectively—the vast majority of which went to project deployment.

ENERGY IS BECOMING MORE DISTRIBUTED AND COMPLEX

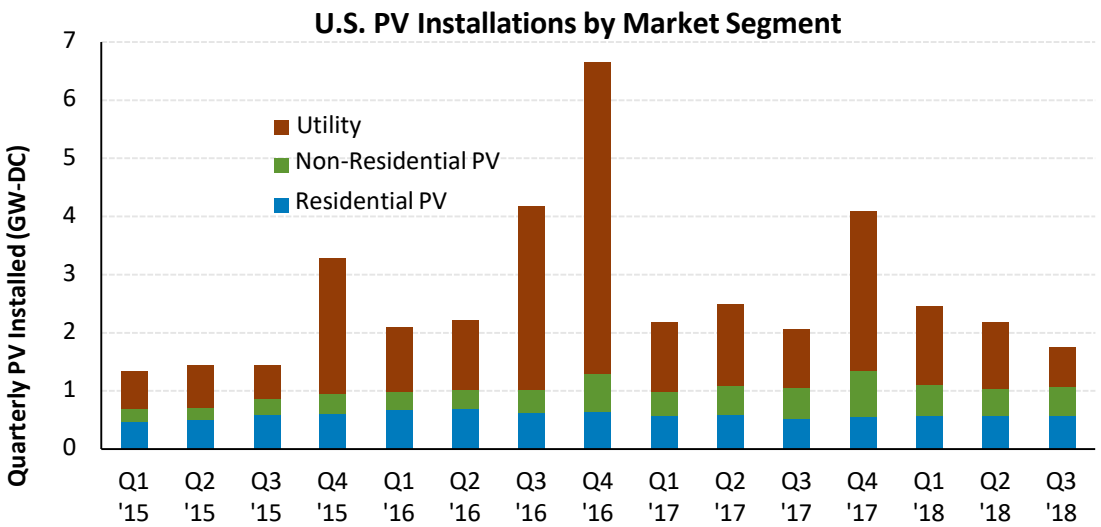


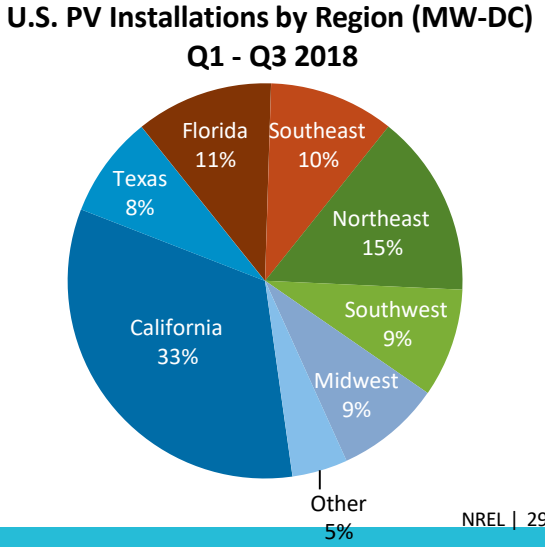
STATE COMMITMENTS TO 100% RENEWABLE ENERGY



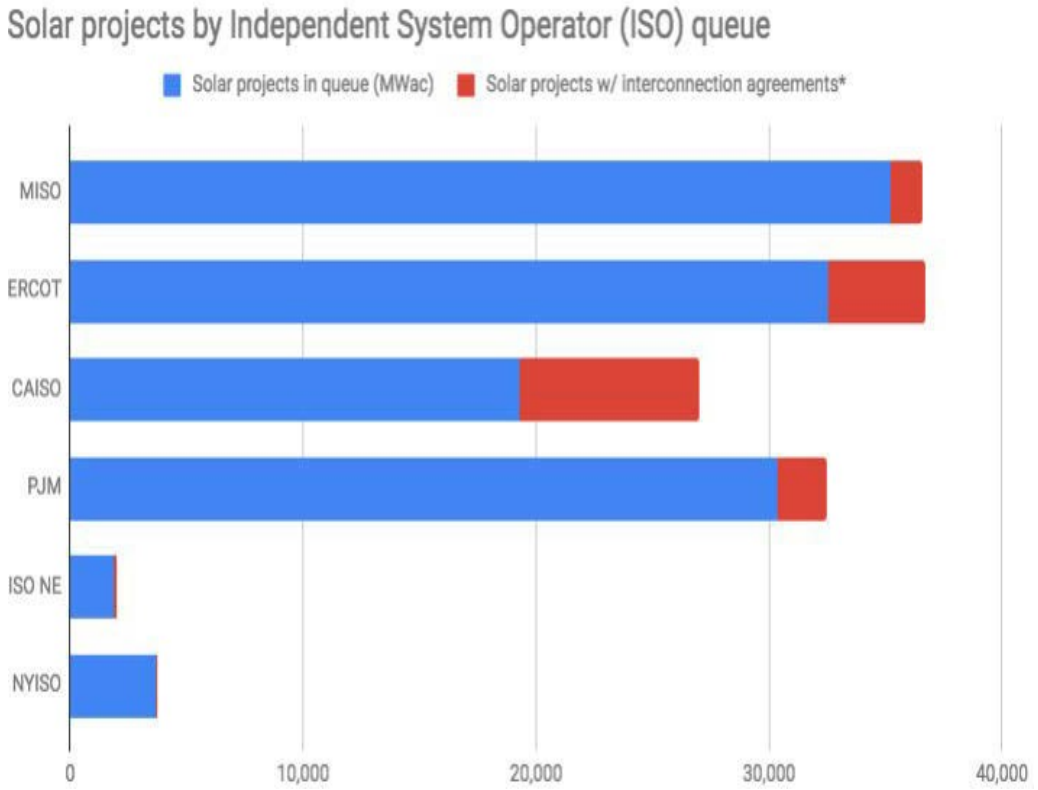
US SOLAR INSTALLATIONS

- In Q3 2018, the United States installed 1.8 GW-DC of PV, down 15% y/y.
  - Thirty-nine percent of capacity came from utility PV—the lowest level since Q1 2012.
  - Wood Mackenzie attributes the low level of utility-scale installation to uncertainty of the impacts of the Section 201 tariff in 2017.
  - Since late 2015, the United States has installed approximately 1 GW-DC of distributed PV each quarter.
  - More than 400 MW-DC of community solar was installed during the first nine months of 2018.

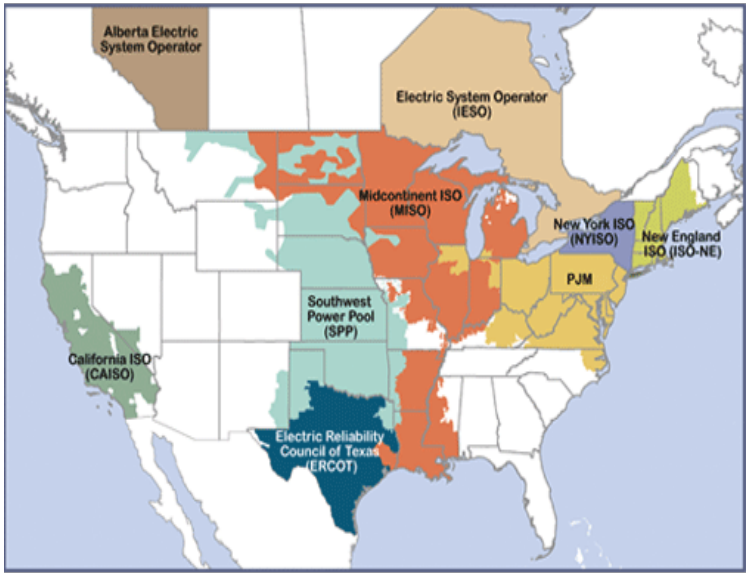




US UTILITY-SCALE SOLAR SET TO TAKE OFF



- PV Magazine reports that developers have applied to build 139 GW-AC of utility-scale PV systems in six grid-operating territories.
  - This figure does not include projects in most of the South, Mountain West, Pacific Northwest, and Plains States.

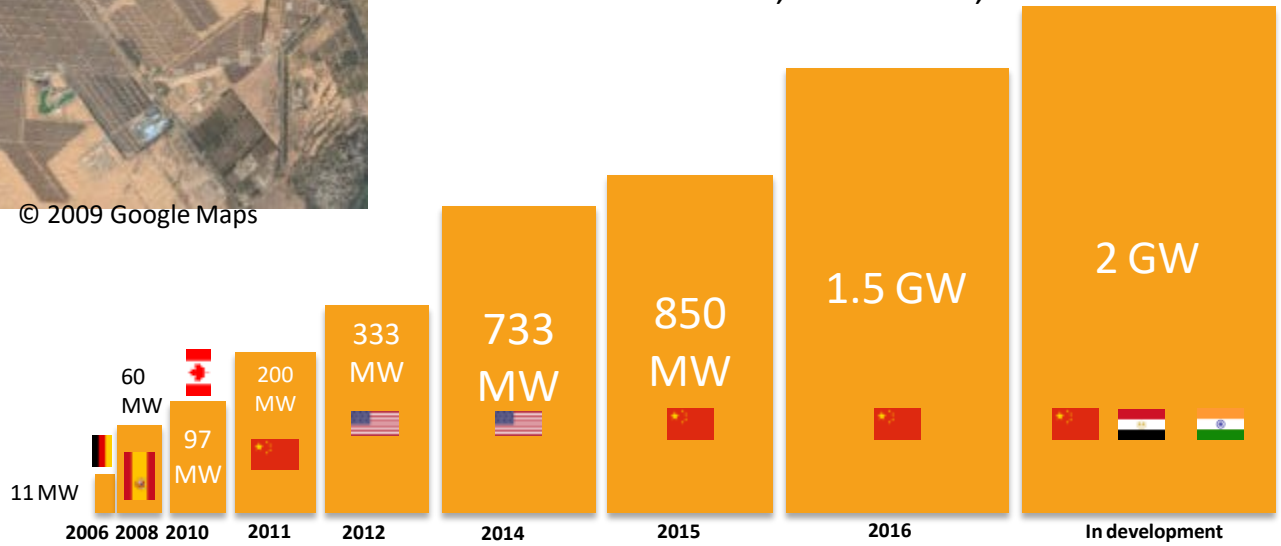


Source: https://pv-magazine-usa.com/2019/01/01/solar-tsunami/.

THE WORLD'S LARGEST PV SYSTEM – BUILT BY YEAR

© 2009 Google Maps

- In 2006, the largest PV system in the world was an 11-MW facility in Germany.
- Currently, the largest PV system in the world is a 1.5-GW facility in China; however, 2-GW projects (or parks) are in development in Egypt, India, and China.
- 1 MW = 5 acres; 2 GW = 10,000 acres



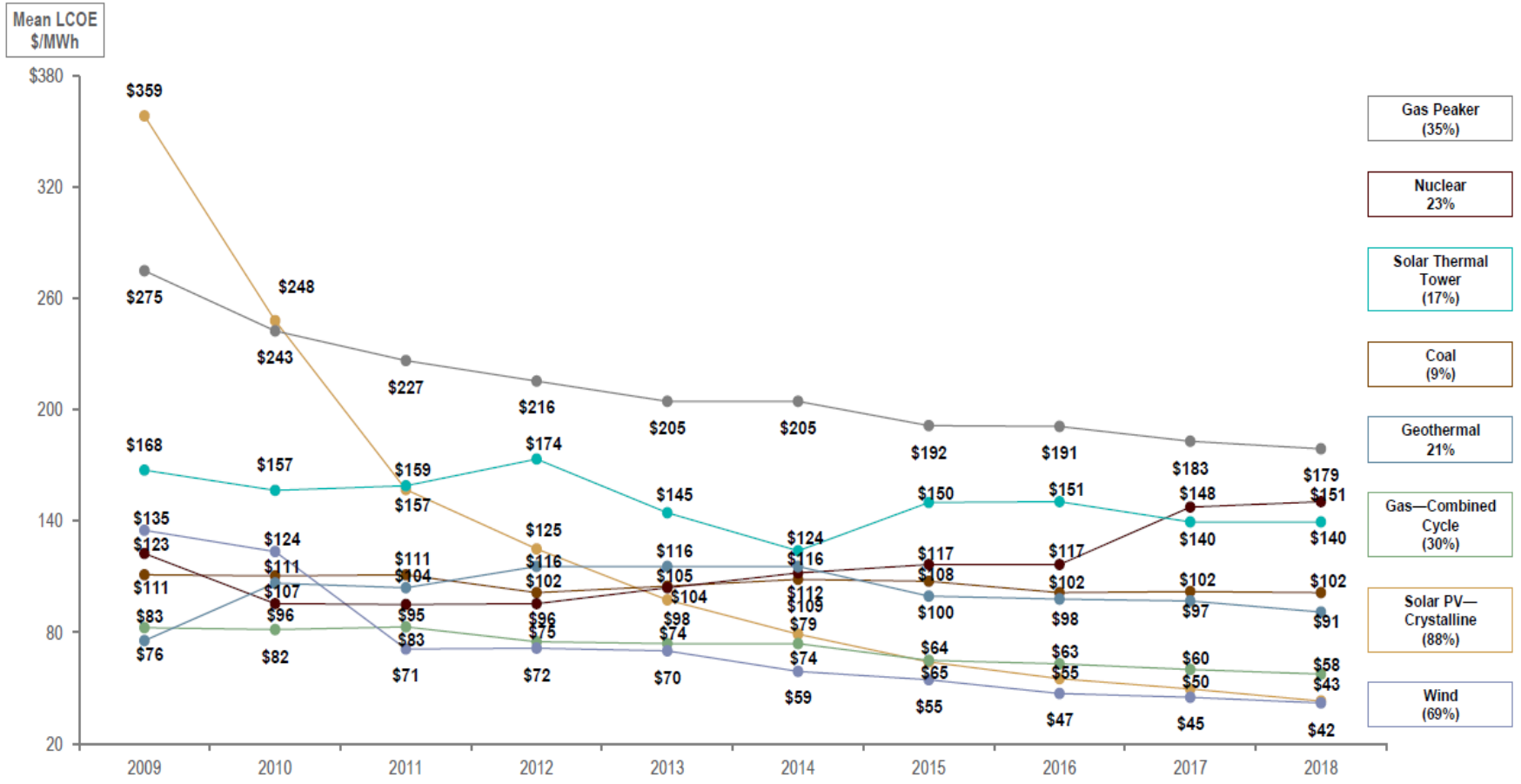
Sources: BBC (08/22/18); CleanTechnica (10/11/10); Energydigital.com; Engadget (03/08/17); Greentech Media (09/10/12); The Star (04/26/07); Google Maps, accessed 01/21/19.

LAZARD LCOE: NEW TECH COMPETITIVE WITH CONVENTIONAL GEN.

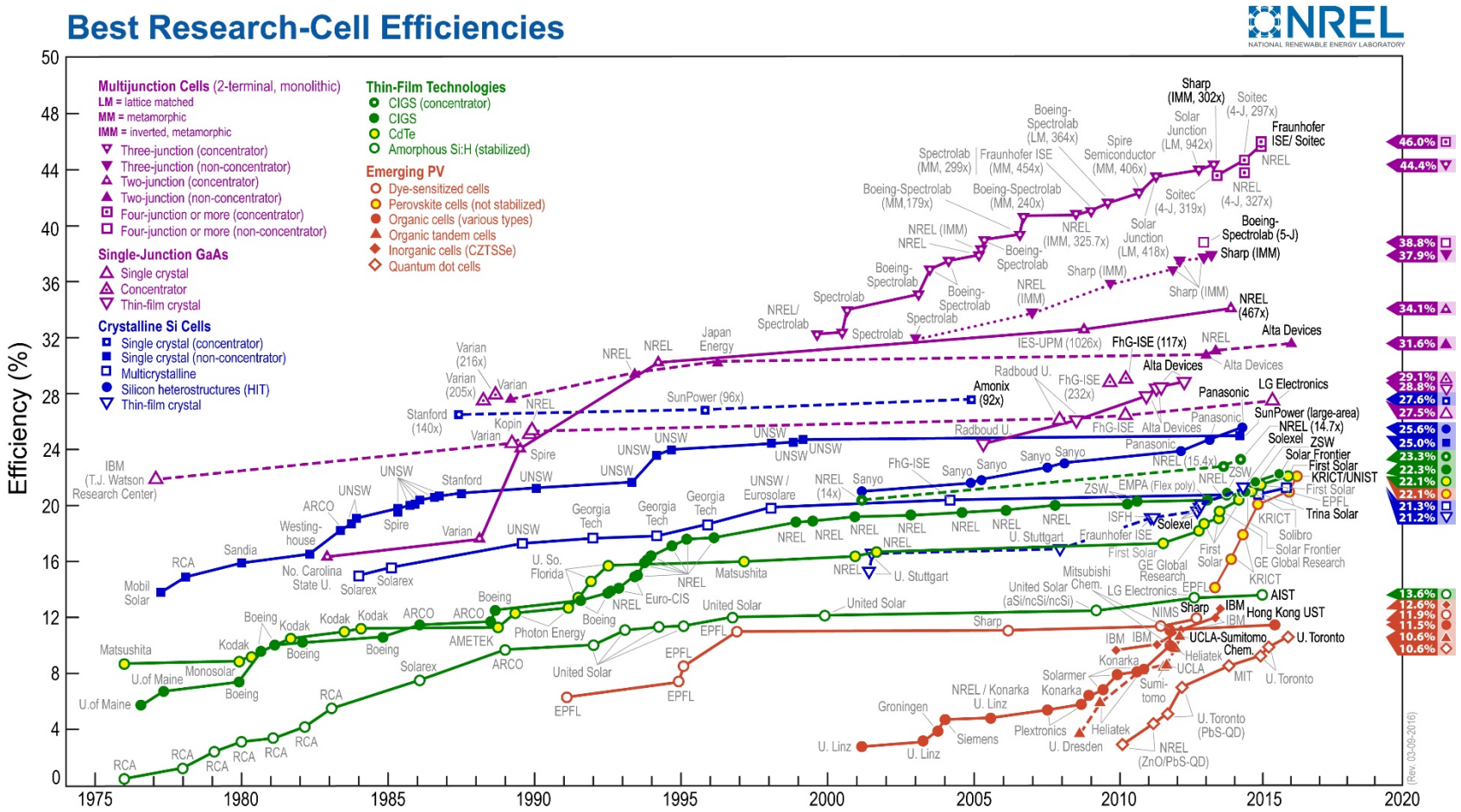
(3) Implied midpoint of offshore wind; (5) midpoints of fully-depreciated nuclear and coal units

Note: Unsubsidized

LAZARD LCOE: SELECTED HISTORICAL MEAN UNSUBSIDIZED VALUES



SOLAR PRODUCTION EFFICIENCY IS GETTING BETTER AND BETTER



DUKE ENERGY KENTUCKY SOLAR: WALTON I AND II

- The Walton projects occupies approximately 60 acres of property located at 352 York Road in Walton.
- 17,024 solar panels on the site.
- The facilities will generate more than 4 megawatts of electricity, which, at peak production, can provide electricity for more than 800 average-sized homes.
- All of the electricity created from the project is fed onto Duke Energy Kentucky's electric grid and delivered to homes, businesses, schools, places of worship and other customers in the area.


10.06.2017


10.10.2017

WALTON AERIAL 1

WALTON AERIAL 2

WALTON AERIAL 3

WALTON AERIAL 4

DEK SOLAR: CRITTENDEN

- The Crittenden project will occupies approximately 30 acres of property located at 922 Ruark Road in Dry Ridge
- 11,438 solar panels on the site
- The facility generates more than 2.7 megawatts of electricity, which, at peak production, can provide electricity for nearly 550 average-sized homes
- All of the electricity created from the project is fed onto Duke Energy Kentucky's electric grid and delivered to homes, businesses, schools, places of worship and other customers in the area

CRITTENDEN

CRITTENDEN AERIAL 1

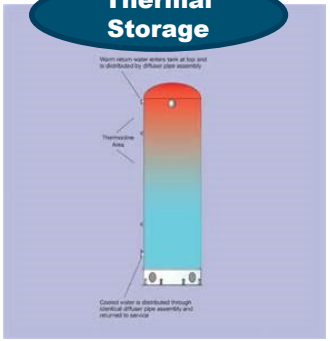
CRITTENDEN AERIAL 2

CRITTENDEN AERIAL 3

CRITTENDEN AERIAL 4

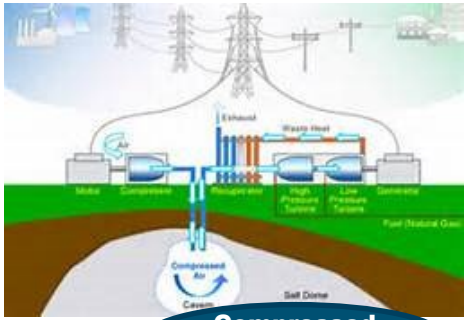
Energy storage is accomplished by devices or physical media that store energy to perform useful operation at a later time.

Thermal Storage



Energy Storage Will Be Transformative To The Utility

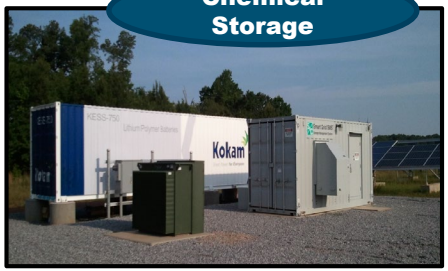
- Potential to eliminate real time need to balance generation with demand
- Enables variable generation to become mainstream
- Supports increased grid reliability and asset utilization
- Supports reliable distributed grid concepts
- Potential avoidance of future plant build for peaking needs
- Creates new customer products and services opportunities



Compressed Air Storage

Inertia / Flywheel Storage

Chemical Storage



Hydro Storage

DUKE ENERGY IS A LEADER IN ELECTROCHEMICAL ENERGY STORAGE

36 MW / 24 MWh
Advanced Lead Acid / Li Ion - West Texas

**402 kW / 282 kWh
Sodium Nickel Chloride - Mt. Holly, NC

75 kW / 42 kWh
Lithium Titanate - Indianapolis, IN

250 kW / 750 kWh
Lithium Polymer - Charlotte, NC

25 kW / 25 kWh
Lithium Ion - Charlotte, NC

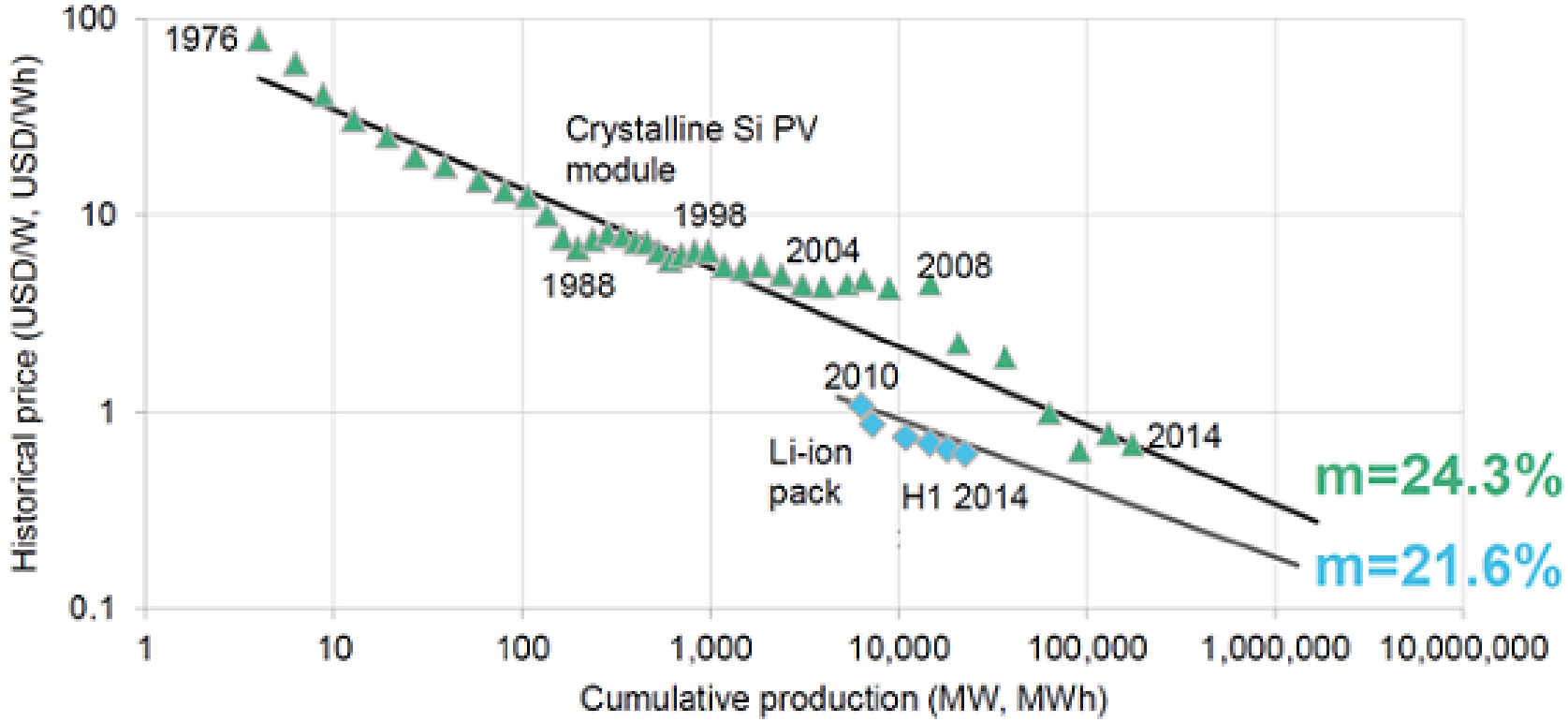
200 kW / 500 kWh
Lithium Iron Phosphate - Charlotte, NC

4 MW / 1.5 MWh
Beckjord Station - New Richmond, OH

200 kW / 400kWh
Lithium Ion - St. Petersburg, FL

Residential Product Testing
TBD

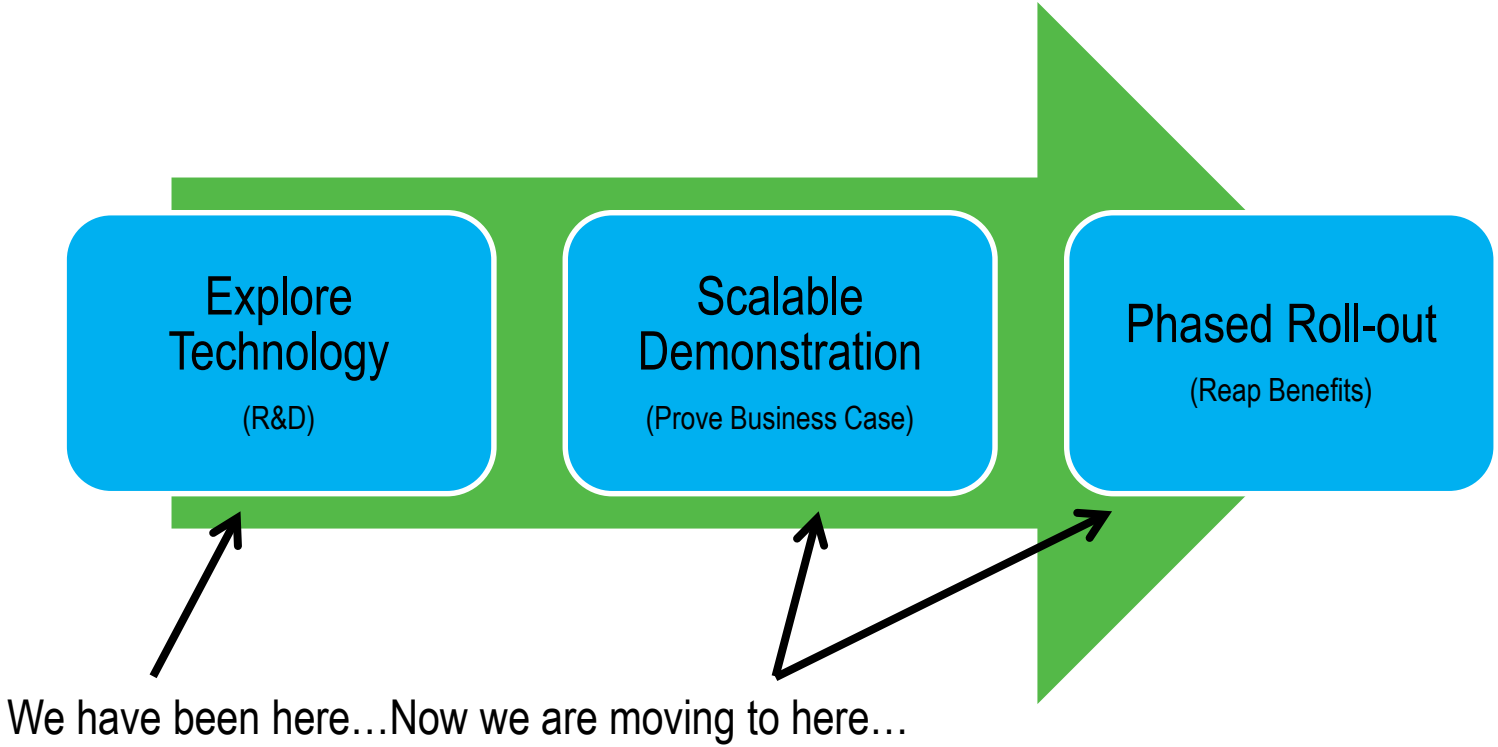
ENERGY STORAGE EXPERIENCE CURVE VS. SOLAR EXPERIENCE CURVE



Note: Prices are in real (2014) USD.

Source: Bloomberg New Energy Finance, Maycock, Battery University, MIIT

ENERGY STORAGE DEPLOYMENT LIFECYCLE



IT'S AN INTERESTING TIME TO BE AN ELECTRIC UTILITY….

- Robust economy with low interest rates
- Aging infrastructure
- Low natural gas prices driving the switch from coal
- New competitors
- Emerging technologies
- Changing customer preferences and behaviors
- Evolving regulatory landscape
- Cyber and physical security threats

Appendix

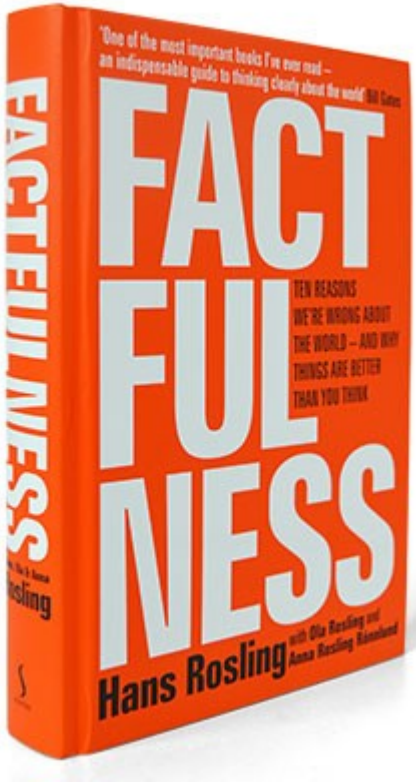
SUMMER READING (1): *FACTFULNESS*, Hans Rosling

TEN REASONS WE'RE WRONG ABOUT THE WORLD - AND WHY THINGS ARE BETTER THAN YOU THINK

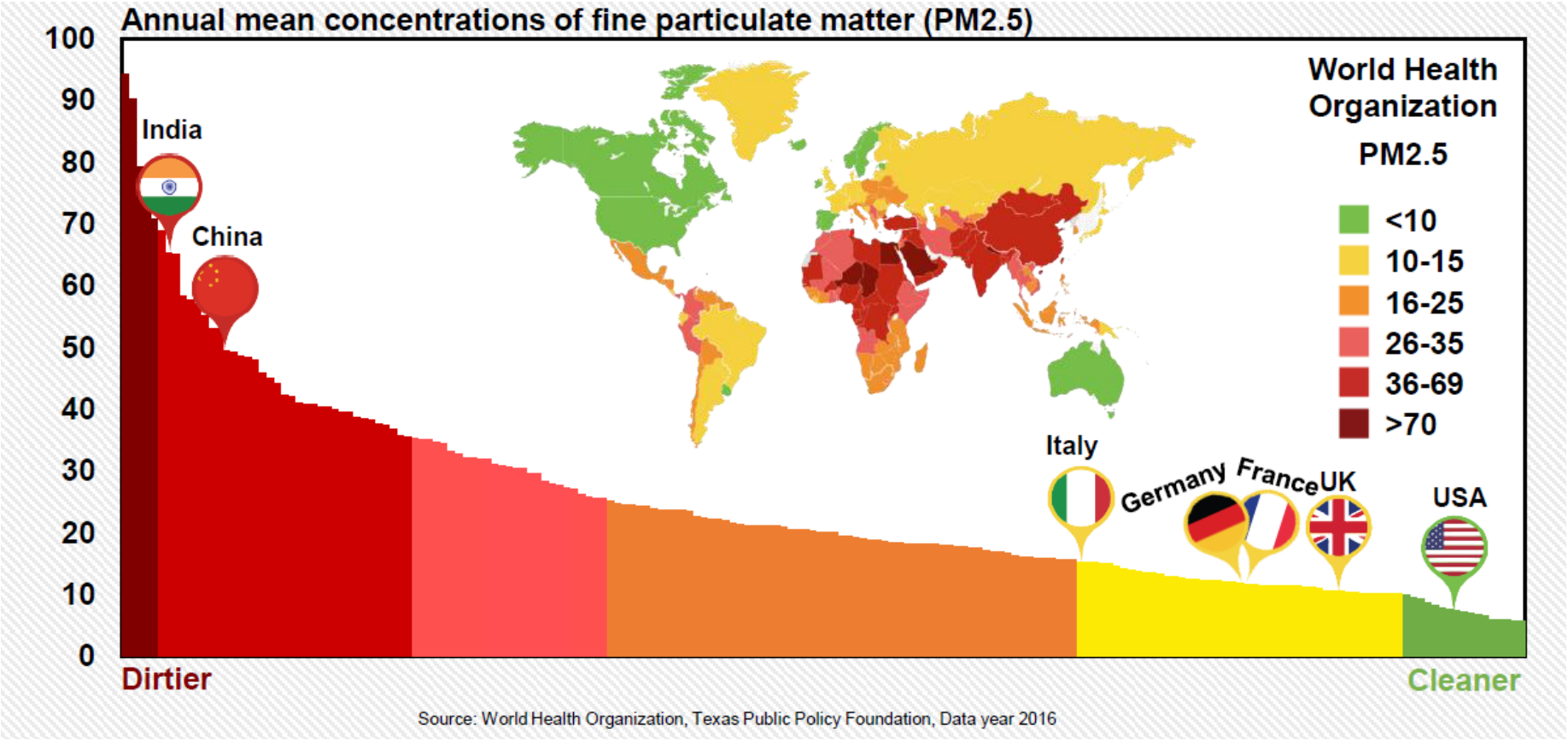
The 10 Dramatic Instincts:

- **The Gap Instinct:** Dividing into groups and imagining a gap between them.
- **The Negativity Instinct**: We tend to instinctively notice the bad more than the good.
- **The Straight Line Instinct**: When we see a line going up steadily, we assume it will keep going.
- **The Fear Instinct:** We tend to perceive the world to be scarier than it really is.
- **The Size Instinct:** We tend to see things out of proportion, over-estimating both importance and scale
- **The Generalization Instinct:** We tend to wrongly assume that everything or everyone in a category is similar.
- **The Destiny Instinct:** We tend to assume that destinies are fixed.
- **The Single Perspective Instinct:** We tend to focus on single causes or solutions, which are easier to grasp and make our problems seem easier to solve.
- **The Blame Instinct:** When something goes wrong, we instinctively blame it on someone or something.
- **The Urgency Instinct:** We tend to rush into a problem or opportunity for fear that there's no time and we may be too late.

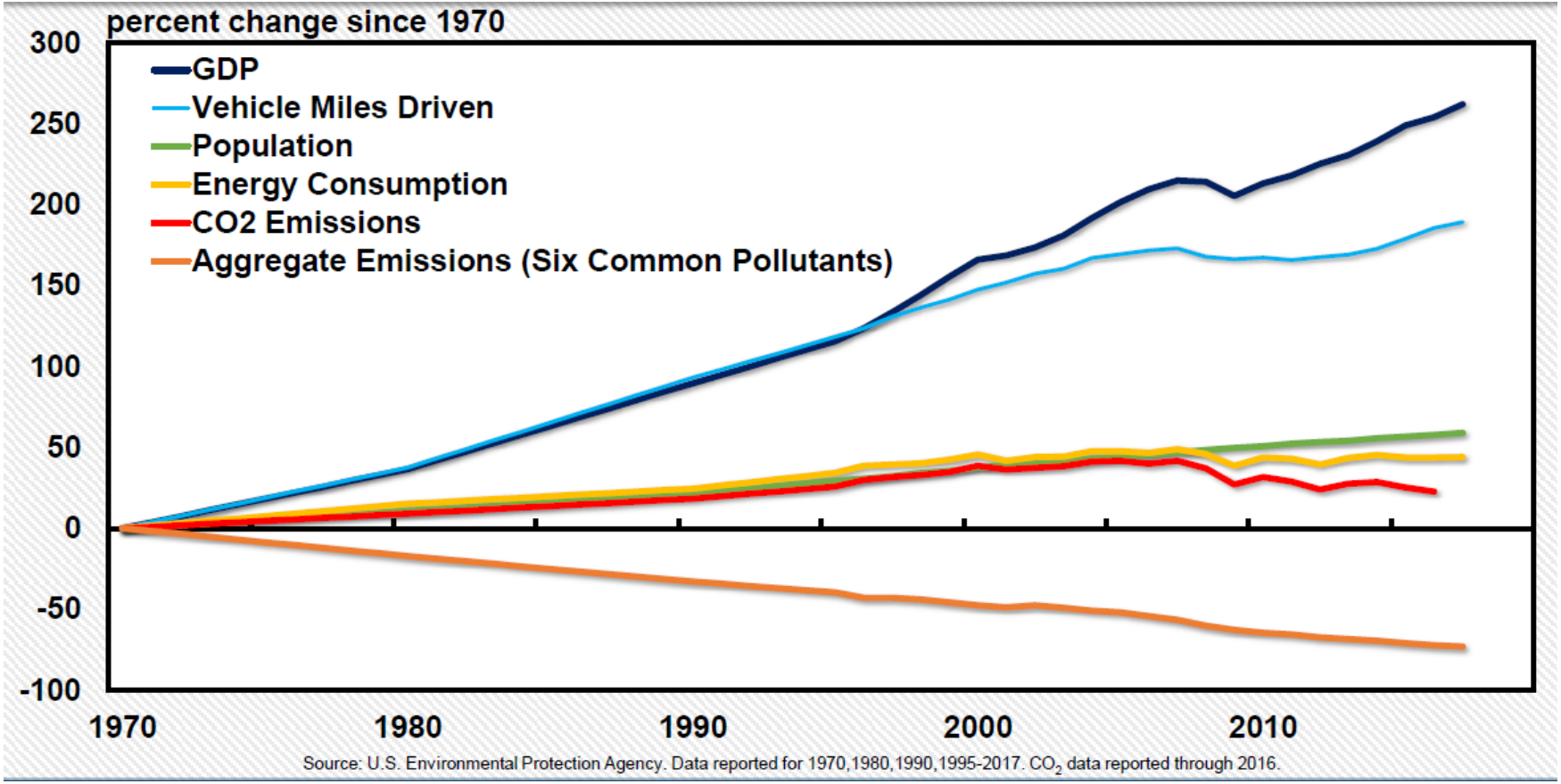
http://www.factfulnessquiz.com



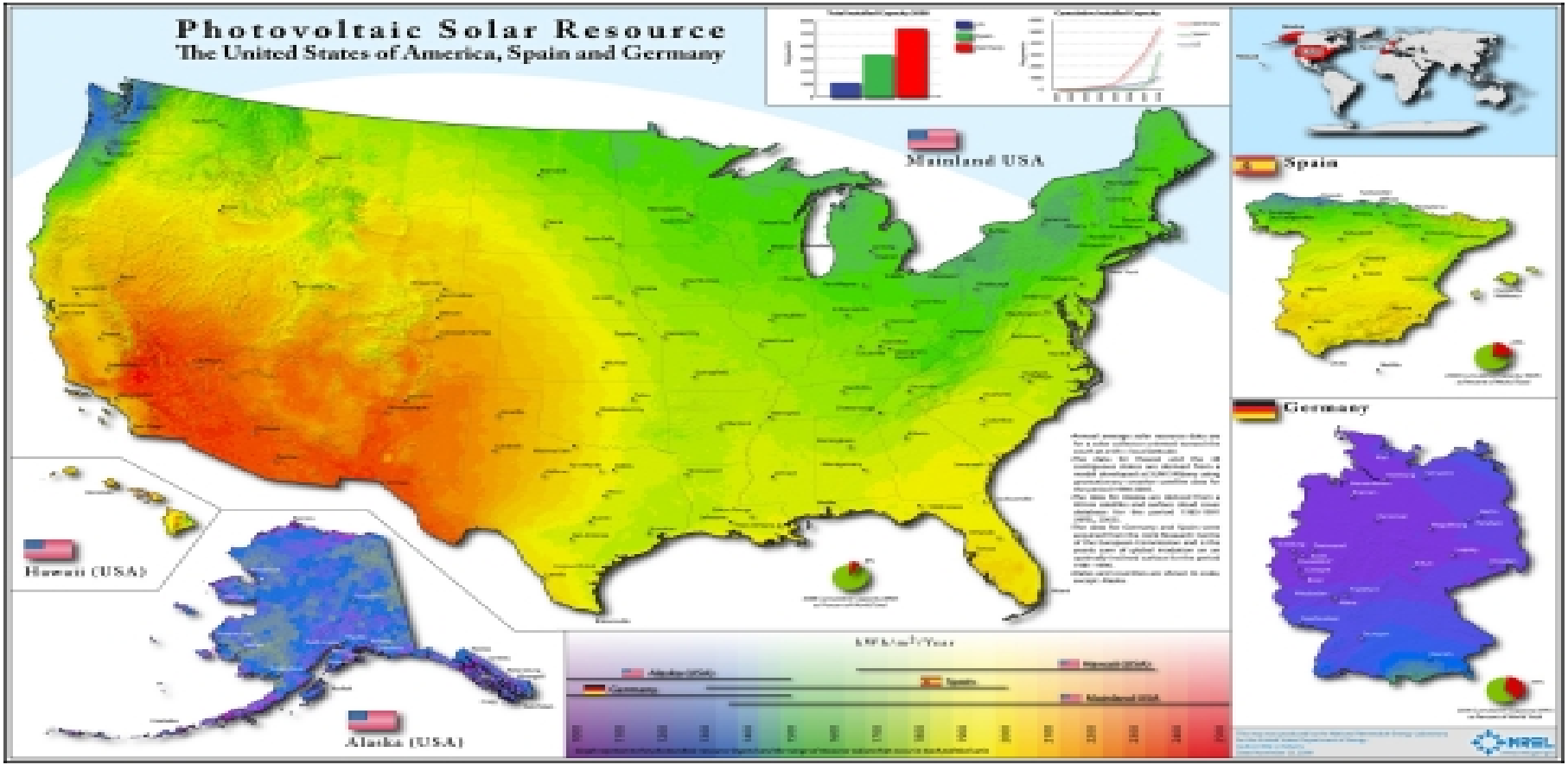
THE NEWS ISN'T ALL BAD, PART 1 - CLEANER AIR IN THE US



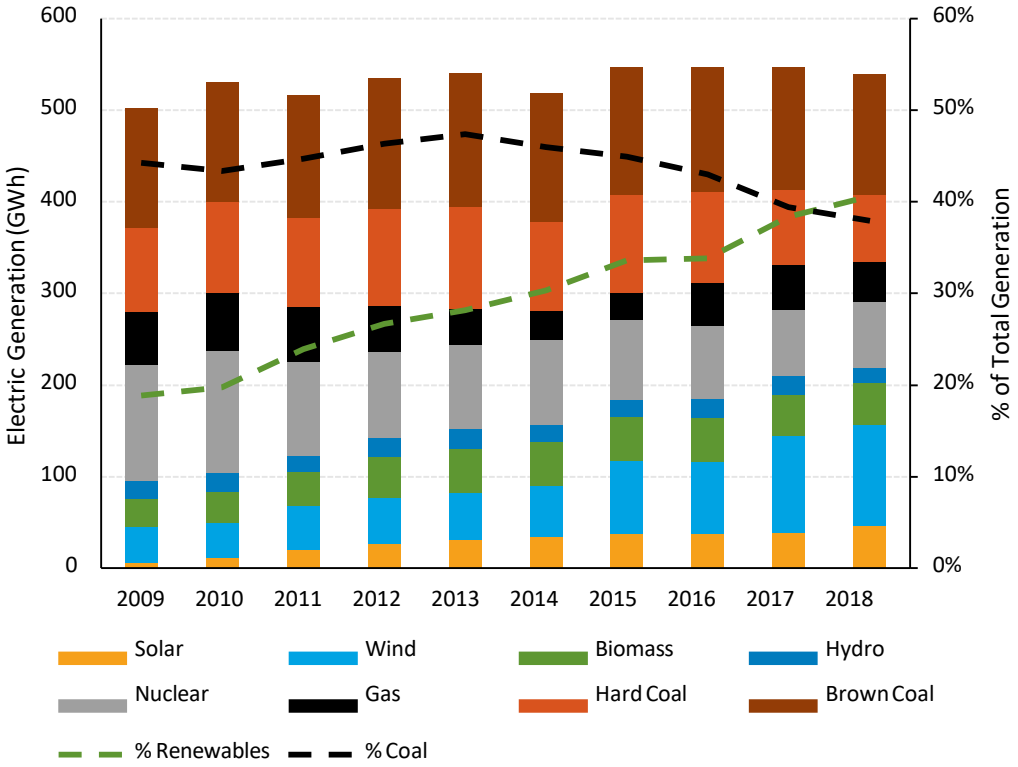
PART 2 - ECONOMIC GROWTH, DECLINING EMISSIONS



U.S. SOLAR RESOURCES RELATIVE TO GERMANY AND SPAIN



GERMAN ELECTRIC GENERATION, BY SOURCE



Source: The Fraunhofer Institute.

- In Germany in 2018, renewables generated more electricity (41%) than coal (38%)—a first in history.
- In comparison, from November 2017 to October 2018, the United States generated 18% from renewables and 27% from coal.
- From 2014 to 2018 in Germany, wind and solar generation increased by 55 GWh and 11 GWh, respectively, while coal and nuclear generation decreased by 34 GWh and 20 GWh, respectively.
- Average residential rate = EUR 0.31/kWh ($0.35/kWh); DEK ~ $0/11/kWh

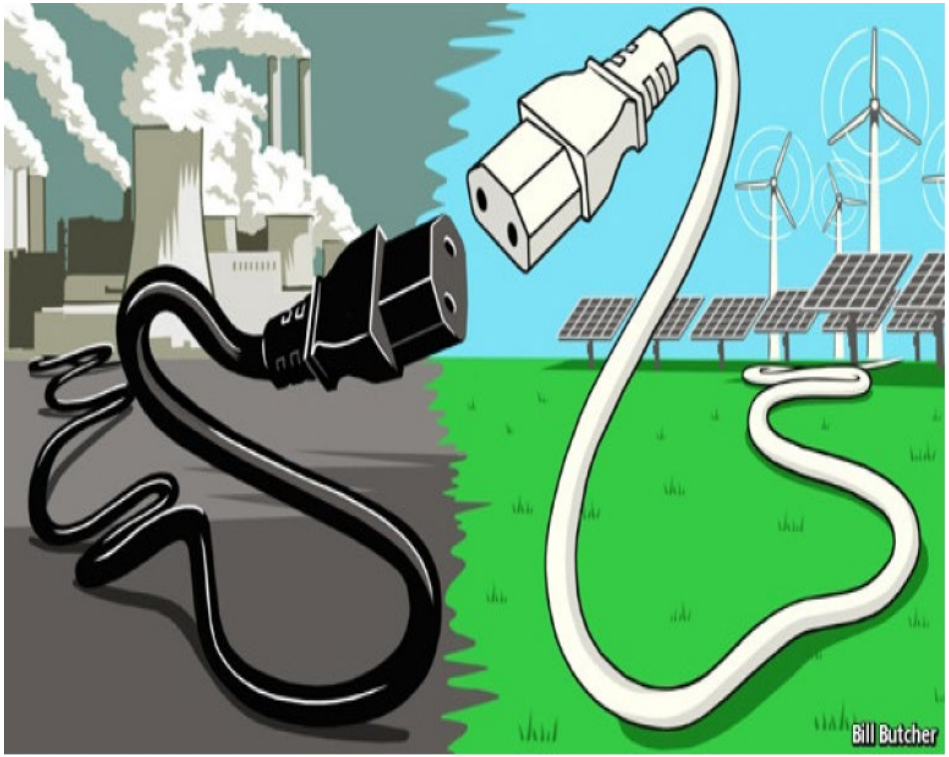
SUMMER READING (2): *How to Lose Half a Trillion Euros*

The Economist

European utilities

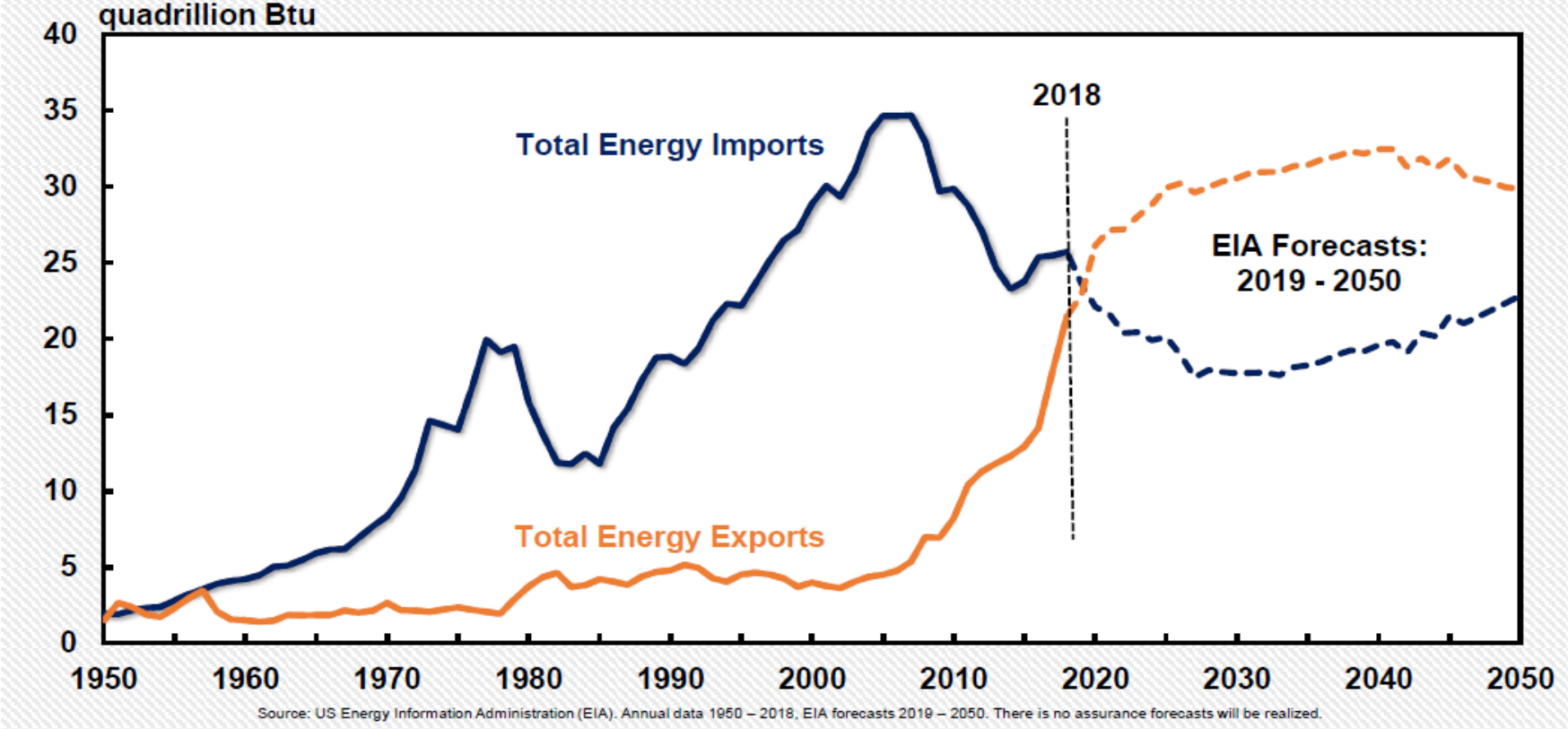
How to lose half a trillion euros

Europe's electricity providers face an existential threat

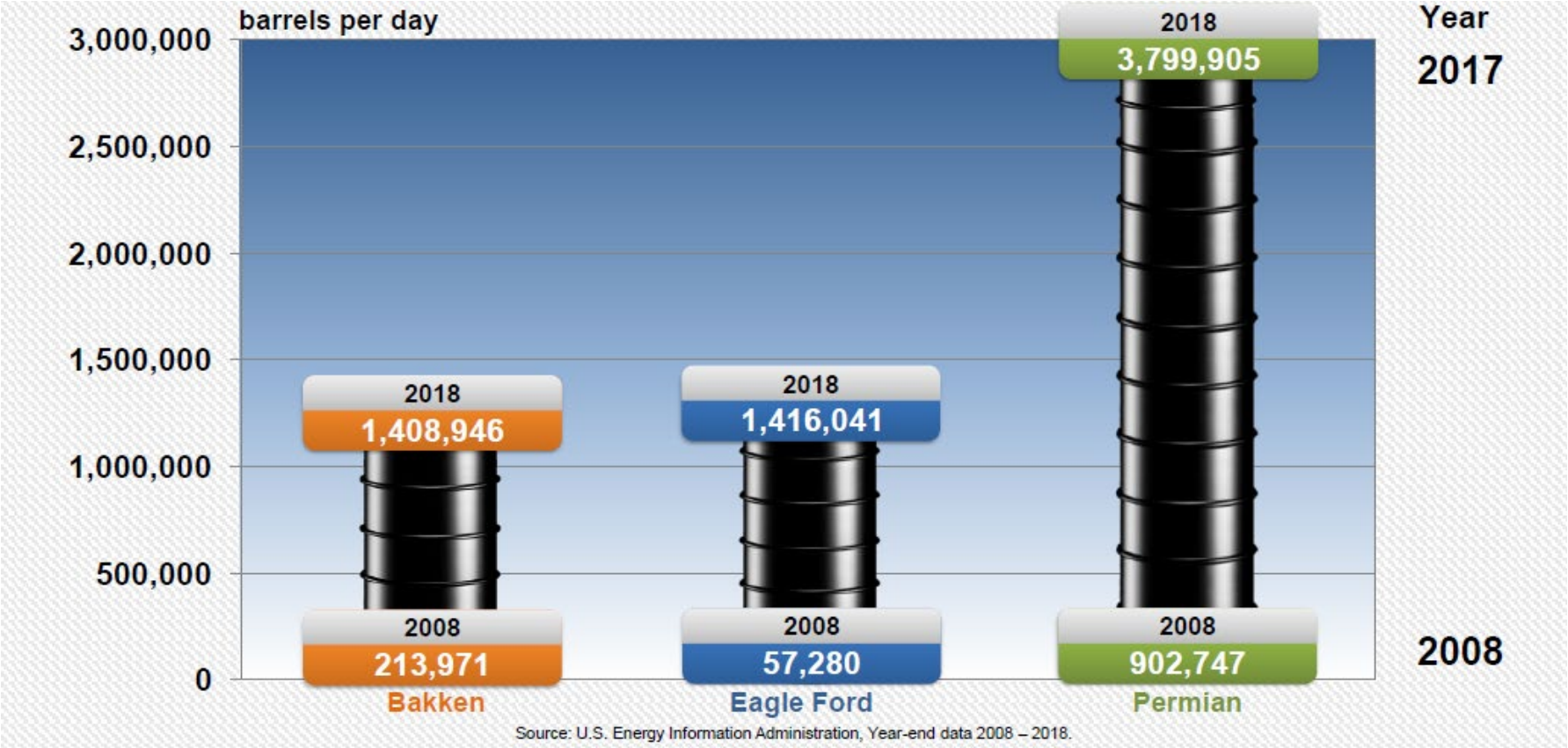


NOT RENEWABLE, BUT STILL INTERESTING

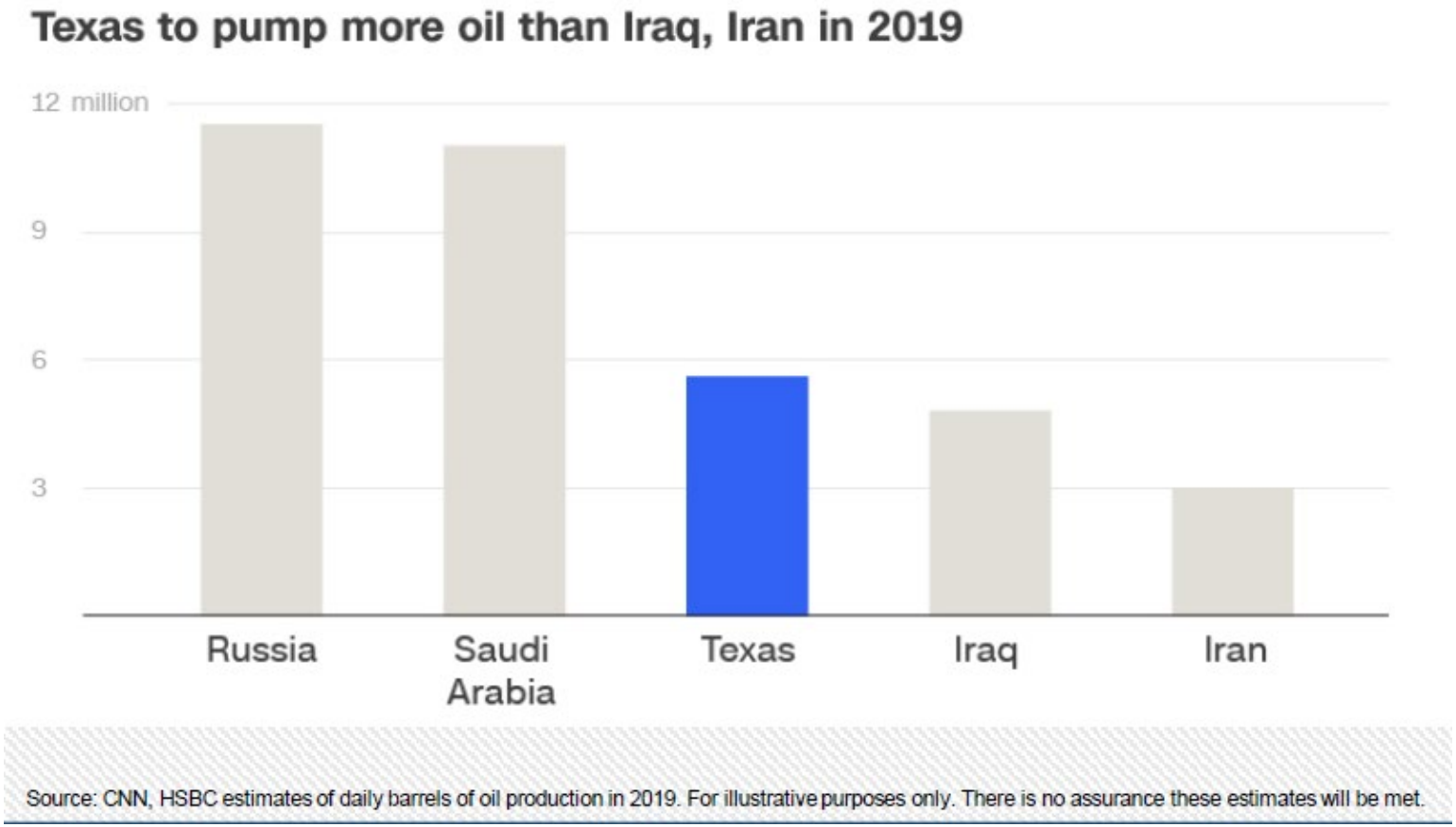
The U.S. is on track to be a net energy exporter in 2020 – next year!



BAKKEN, EAGLE FORD AND PERMIAN BASINS OIL PRODUCTION

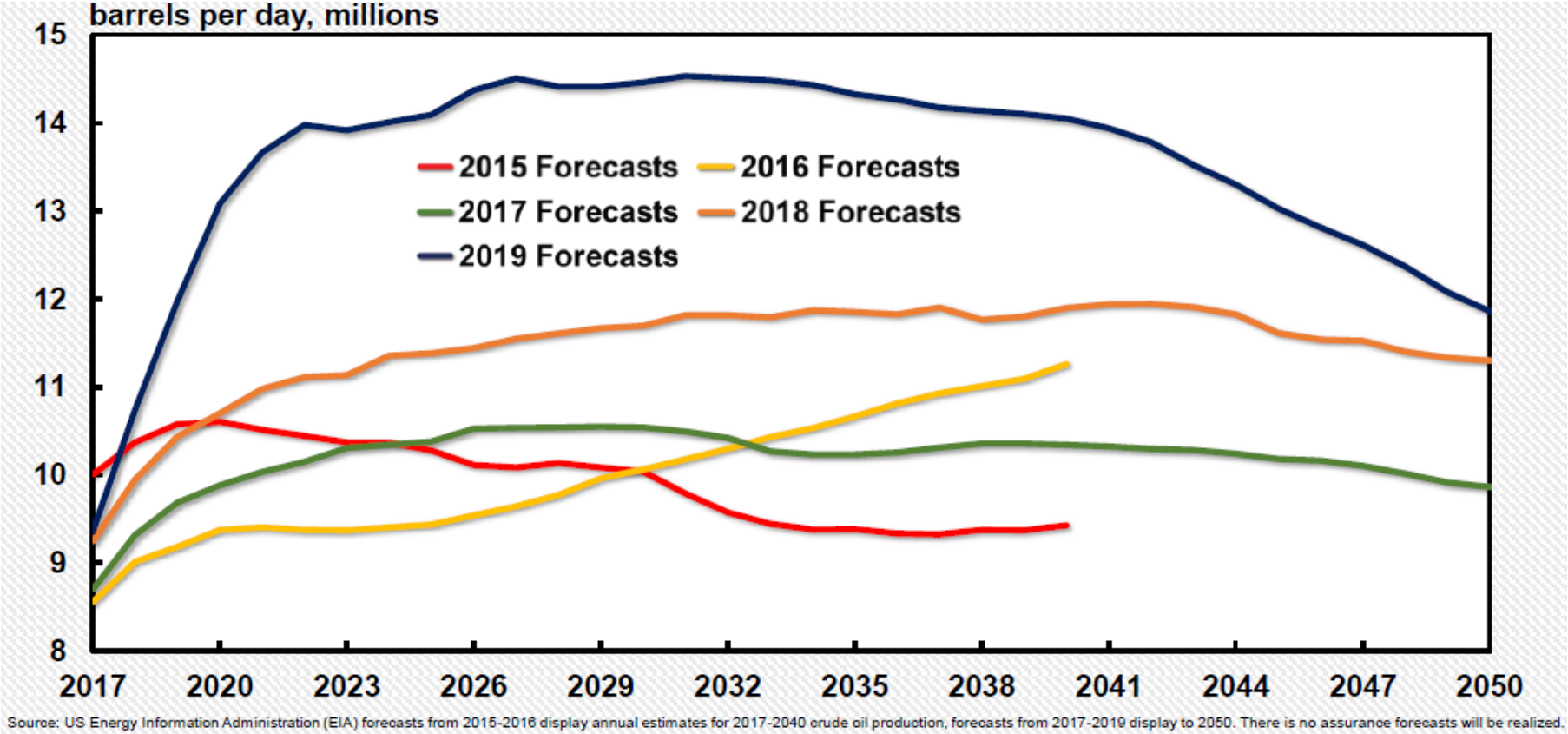


DON'T MESS WITH TEXAS



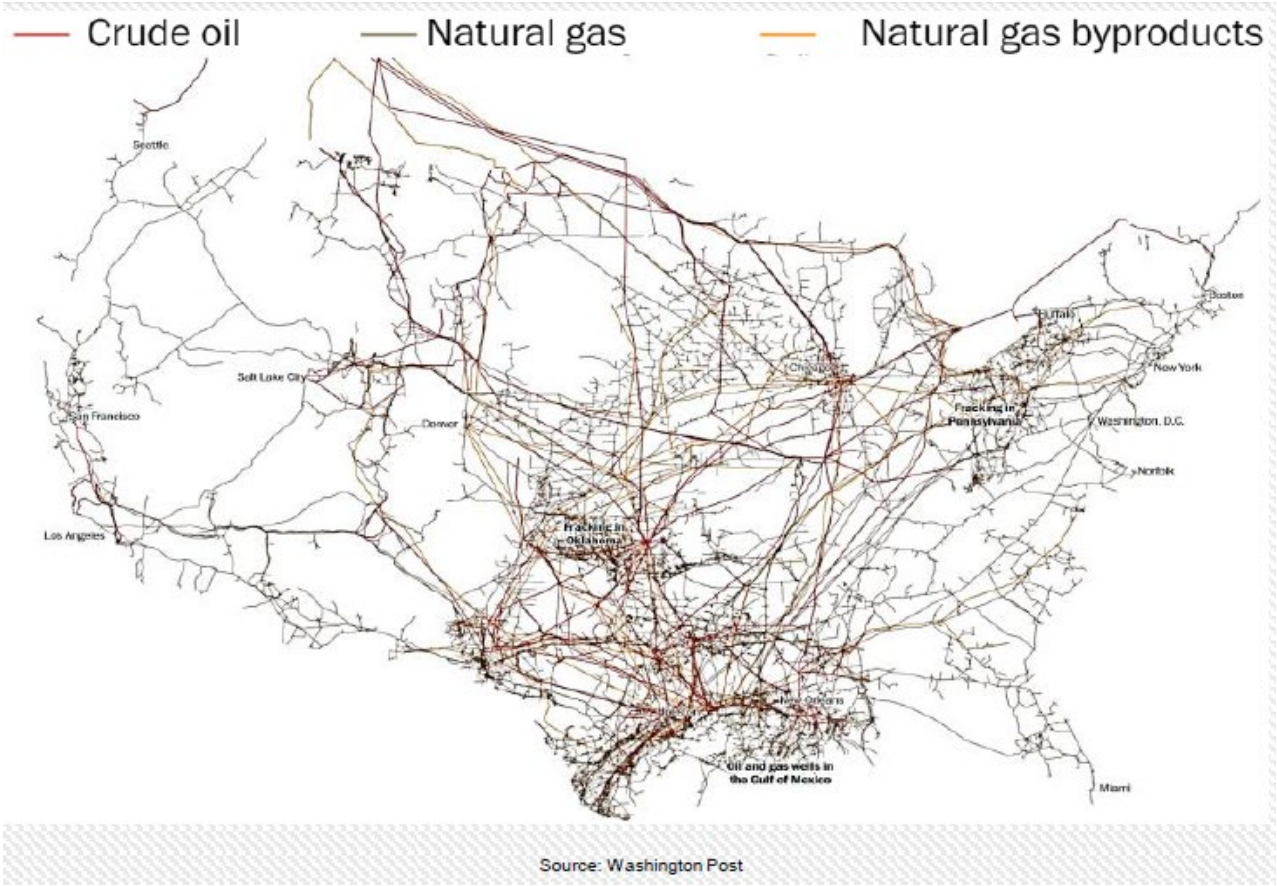
Source: CNN, HSBC estimates of daily barrels of oil production in 2019. For illustrative purposes only. There is no assurance these estimates will be met.

EIA U.S. CRUDE OIL PRODUCTION FORECASTS



Source: US Energy Information Administration (EIA) forecasts from 2015-2016 display annual estimates for 2017-2040 crude oil production, forecasts from 2017-2019 display to 2050. There is no assurance forecasts will be realized.

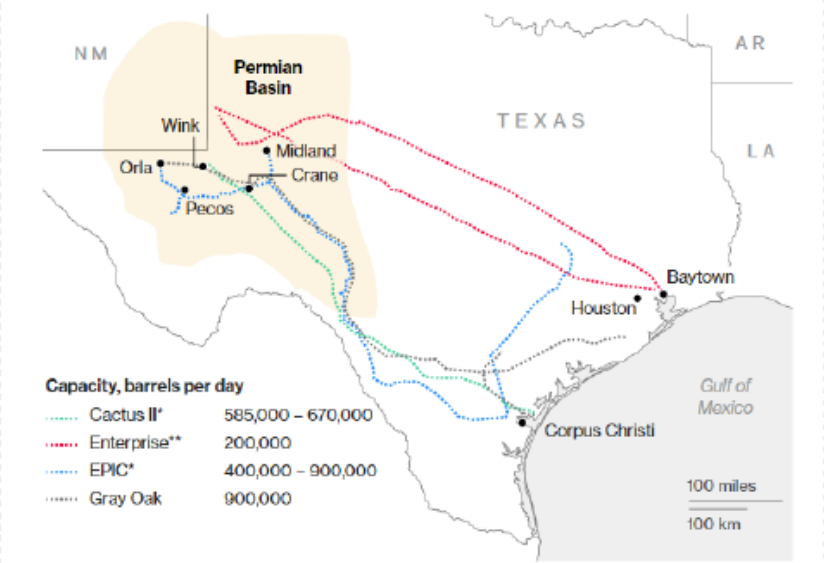
U.S. PIPELINE INFRASTRUCTURE - EXISTING



Source: Washington Post

BAD NEWS FOR OPEC

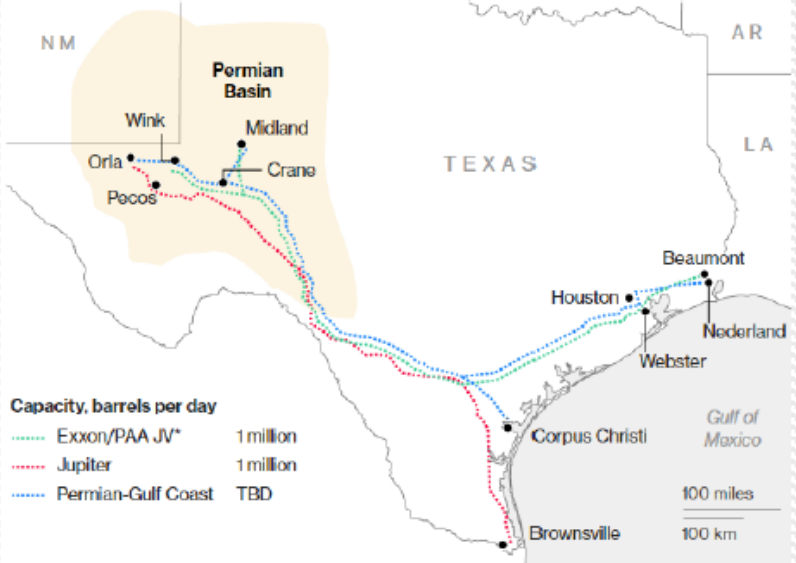
Scheduled for 2019



Source: Pipeline companies

* Early flows to start in 2019, with full service planned for 2020.
** Enterprise Products Partners plans to convert one of the NGL pipes in those two routes

Scheduled for 2020



Source: Pipeline companies

* Exxon Plains All American joint venture pipeline path is notional. No route has been announced

Source: Bloomberg News, Pipeline companies.