



The Grid

Smart, Secure and Sustainable. . .

“ . . .The Future Ain't What it Used to Be”

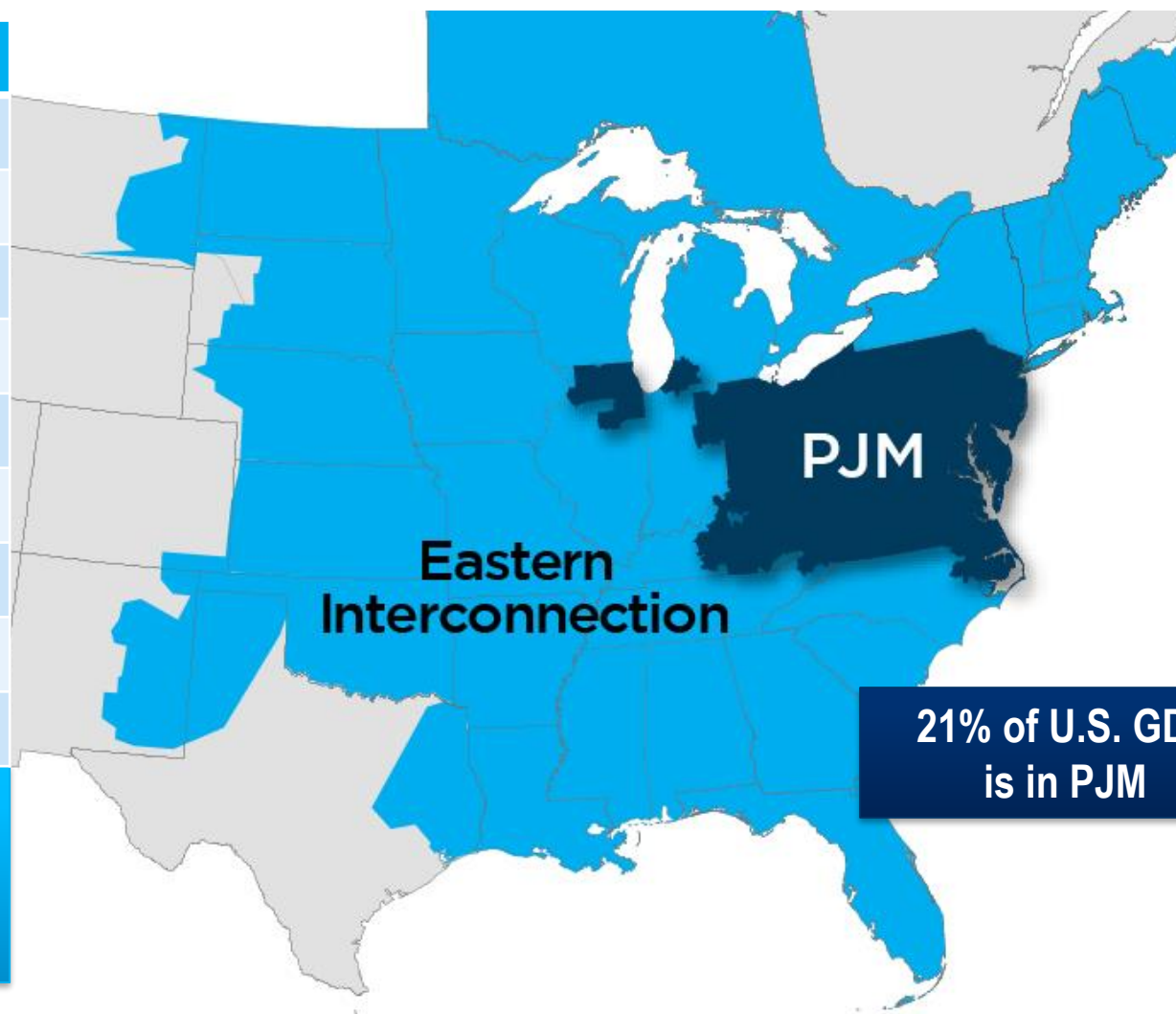
Terry Boston
Retired PJM President & CEO
SEEEI Eilat Israel Meeting
November 6, 2019

PJM as Part of the Eastern Interconnection

Key Statistics

Member companies	1,010+
Millions of people served	65
Peak load in megawatts	165,492
MW of generating capacity	180,086
Miles of transmission lines	84,236
2018 GWh of annual energy	806,546
Generation sources	1,379
Square miles of territory	369,089
States served	13 + DC

- 27% of generation in Eastern Interconnection
- 26% of load in Eastern Interconnection
- 20% of transmission assets in Eastern Interconnection



As of 1/2019

Greatest Engineering Achievements of the 20th Century

10. Air Conditioning/
Refrigeration

9. Telephone

8. Computers

7. Agricultural Mechanization

6. Radio and Television

5. Electronics

4. Water Supply and
Distribution

3. Airplane

2. Automobile
(PHEVs Someday)

1. The Grid/ Electrification

Source: National Academy of Engineering

Microgrids ... New York City After Superstorm Sandy



Power Engineering is not Rocket Science. . .

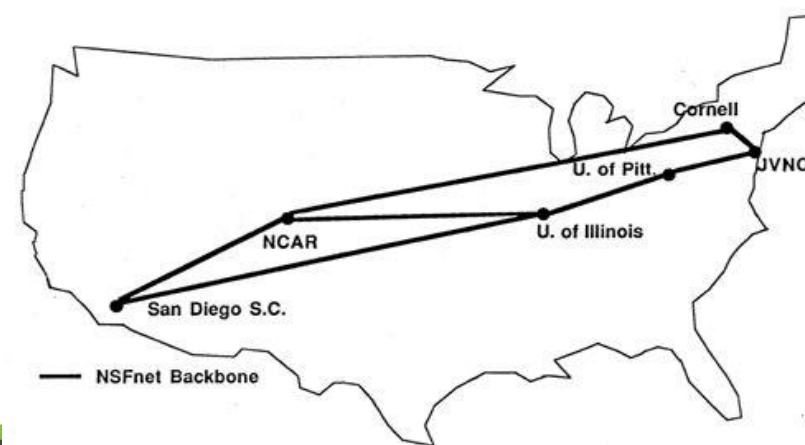


. . . It is much more important than that!

**1980's Reliability. . .
. . .Lightning & squirrels**



**The future is not ours to see. . .
1986 NSF
Internet 56k**



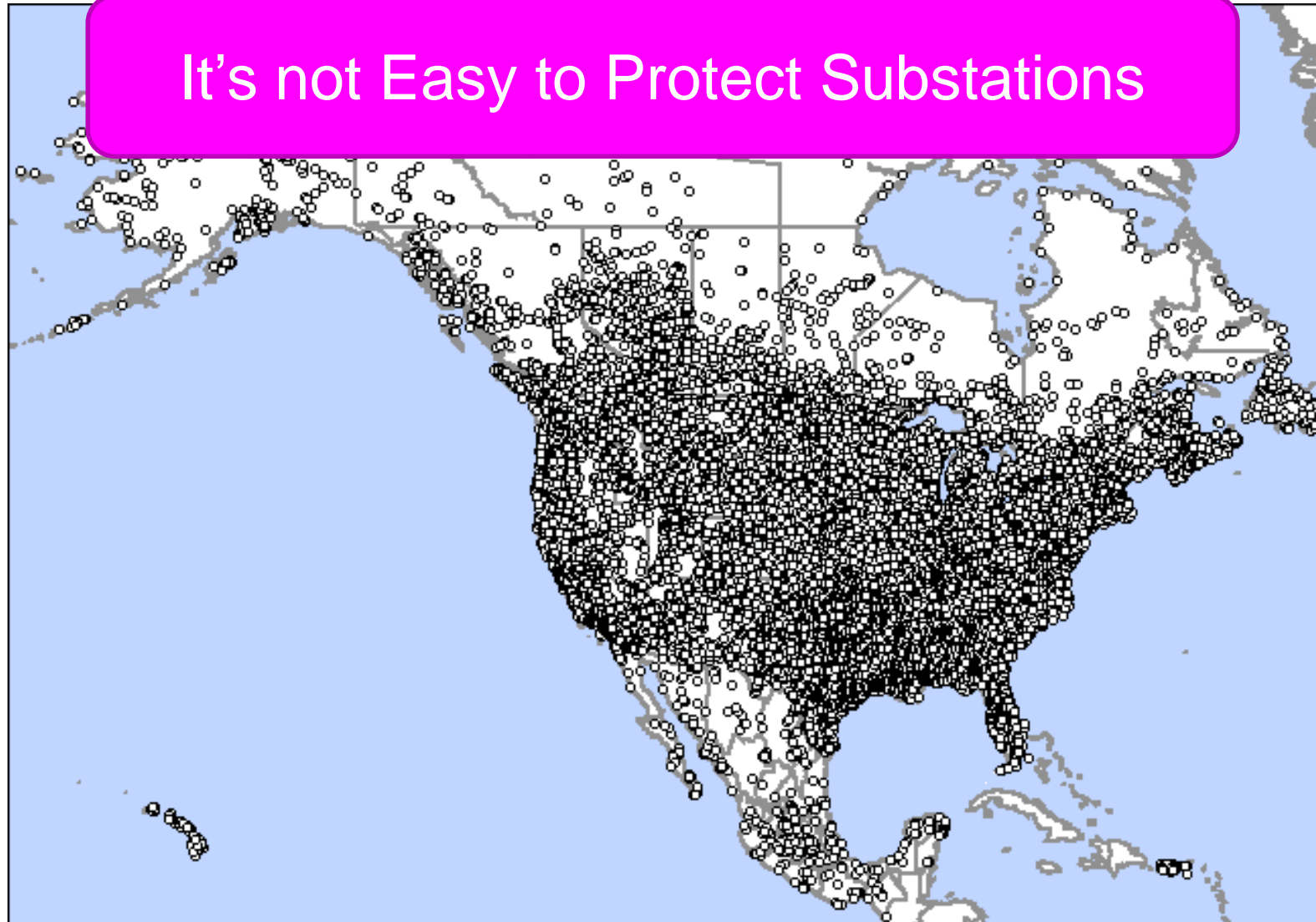
NSFnet Backbone Network

National Center For Atmospheric Research
March 19, 1996

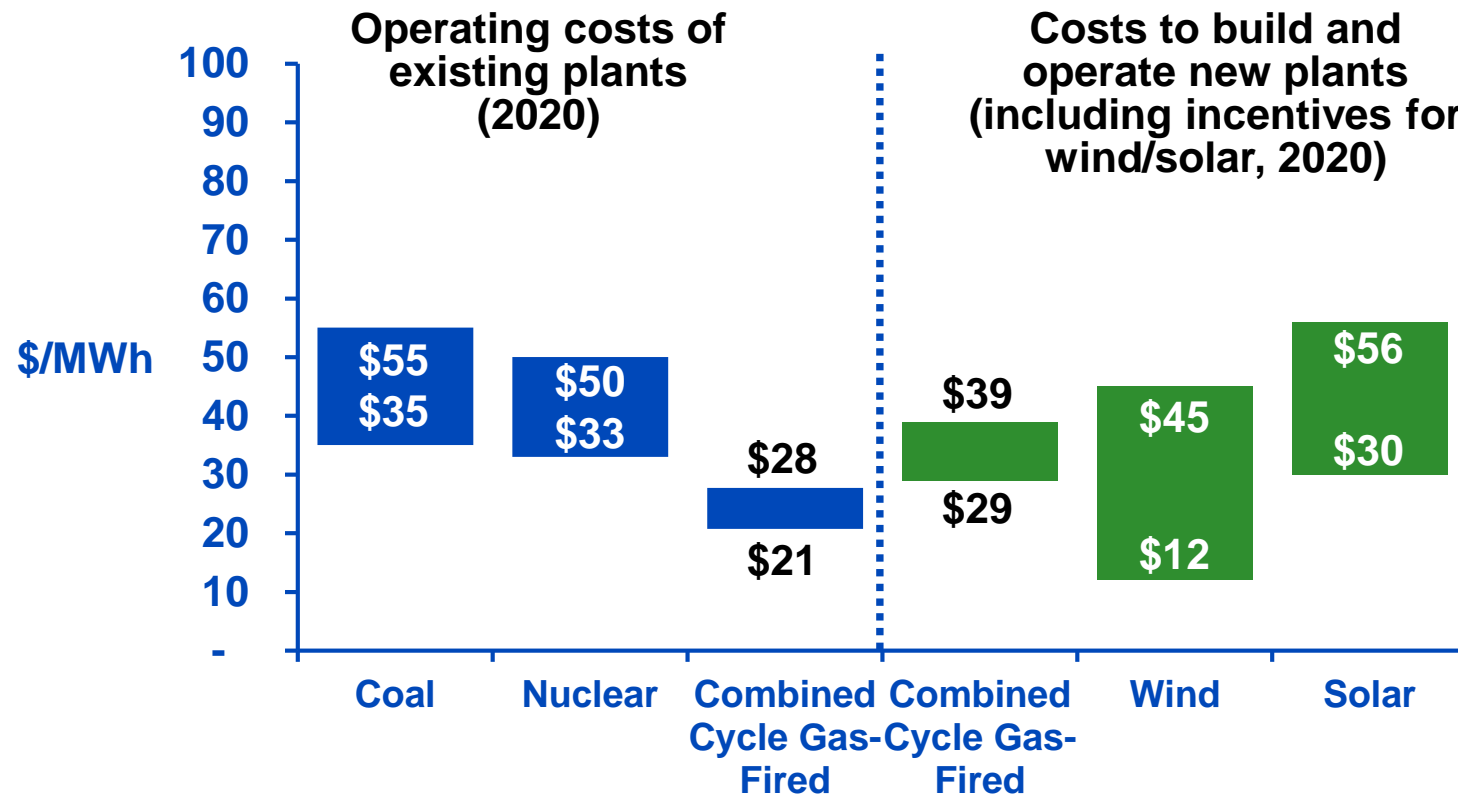
The Internet of Things (IoT) c. 2019



It's not Easy to Protect Substations



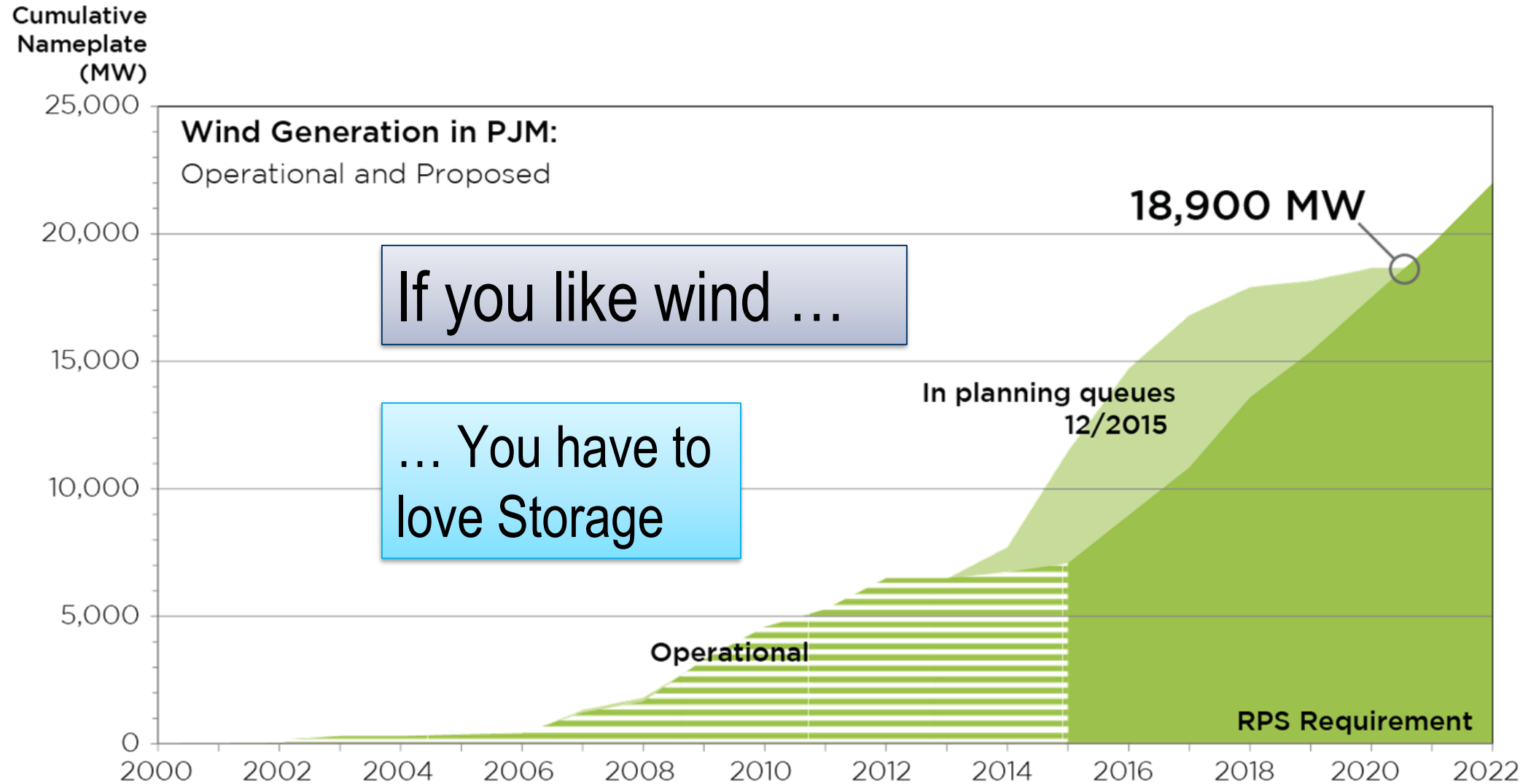
The cost to build and operate new gas, wind and solar power is challenging existing generation resources



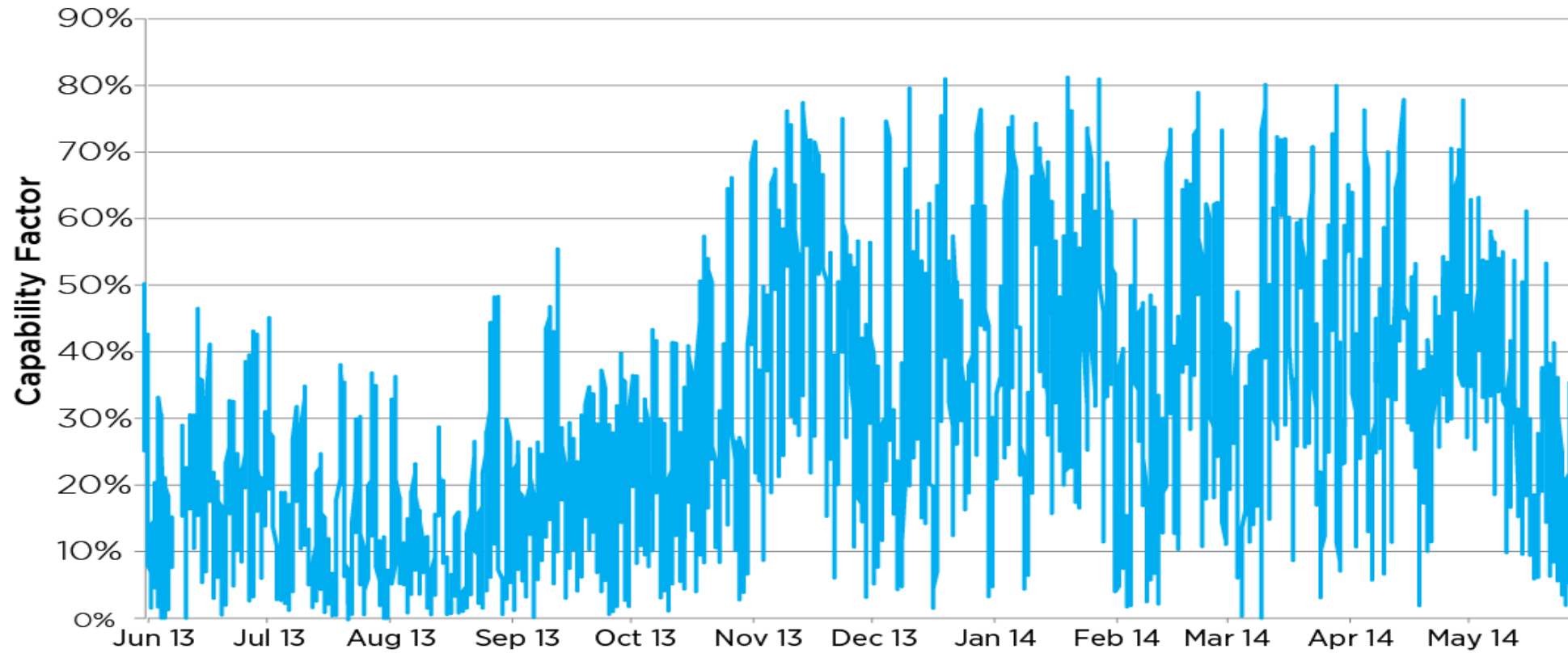
Falling wind and solar costs, and lower gas prices have been accelerating the retirement of coal and nuclear plants

1) Source: Source: Lazard. Assumes \$3/MMBtu natural gas. Midwest wind and solar resource

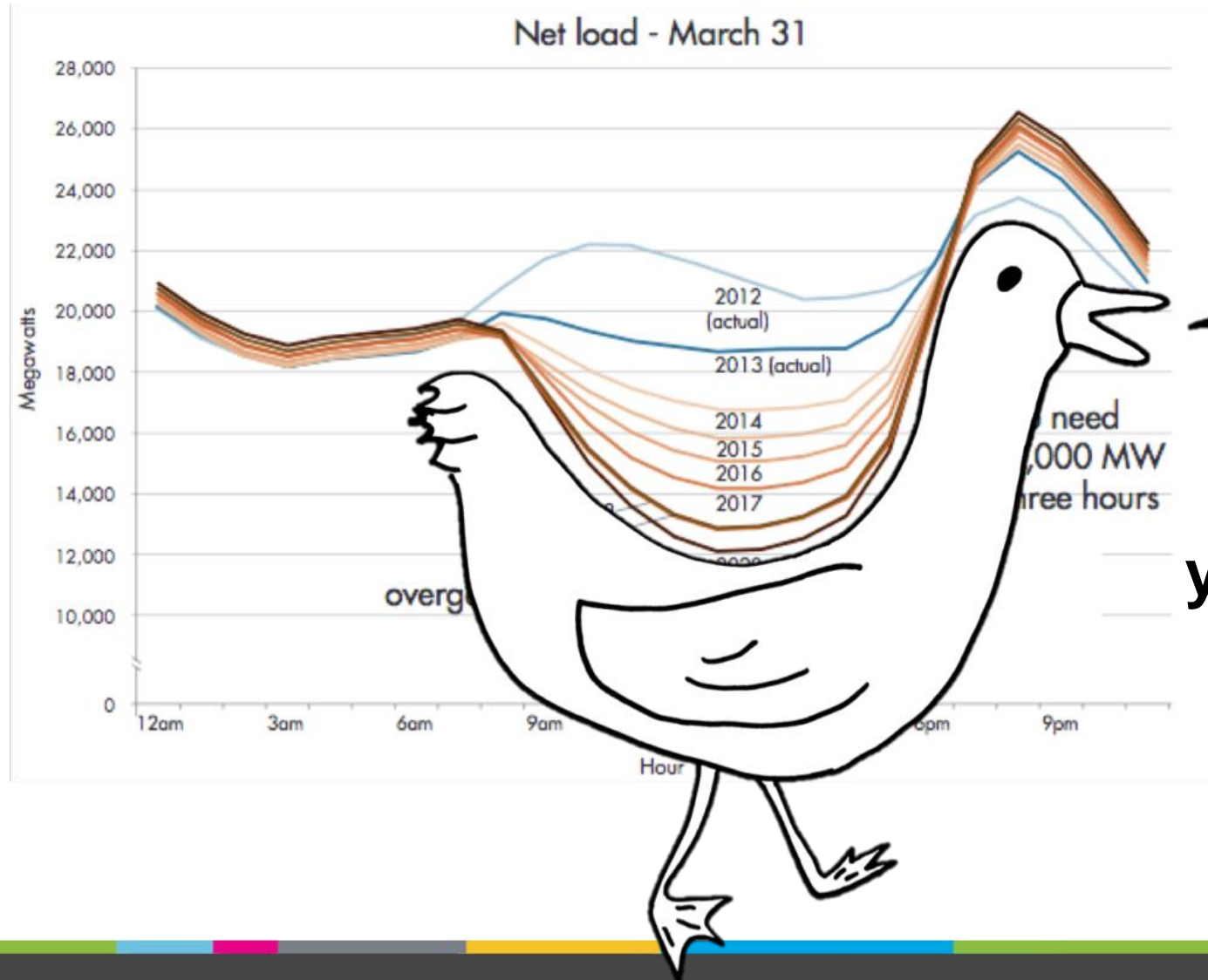
Wind Generation in PJM



Hourly Average Wind Capacity Factor 28.6%



Solar --The Infamous “California Duck Curve”



**“If you can’t store
you’ll have no electricity
after 4”**

Grid-Scale Energy Storage --- 296+ MW in PJM

U.S. Patent Dec. 8, 2015 Sheet 8 of 15 US 9,109,458 B2

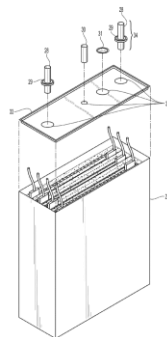


Fig. 9



**Innolith's
Advanced Battery
Inflammable electrolyte**

Twice the energy density

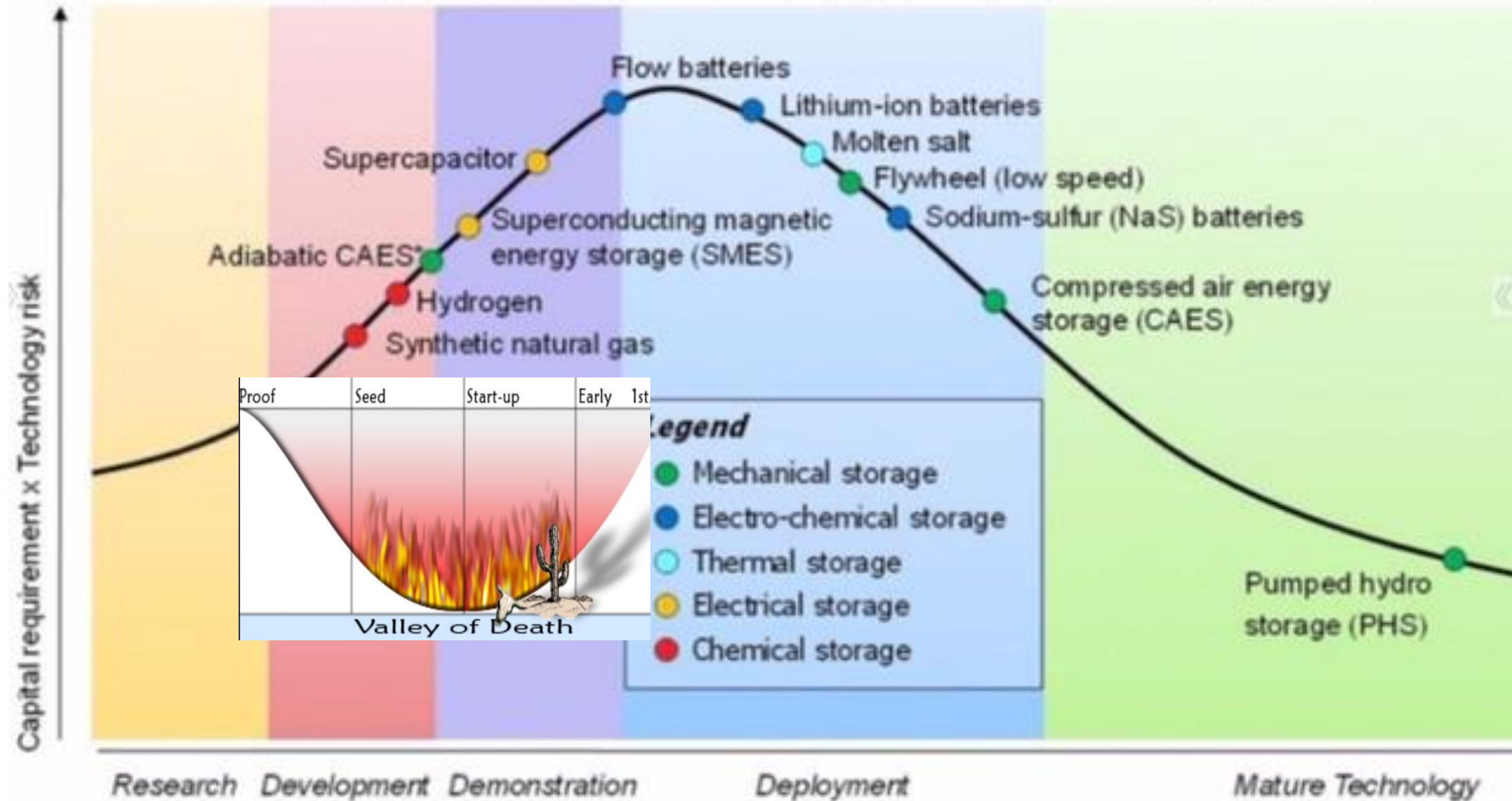
**50,000 cycle--no power fade
Tested 2 Years -- 2MW in
PJM**

**Sodium can replace Li at
much Lower cost**



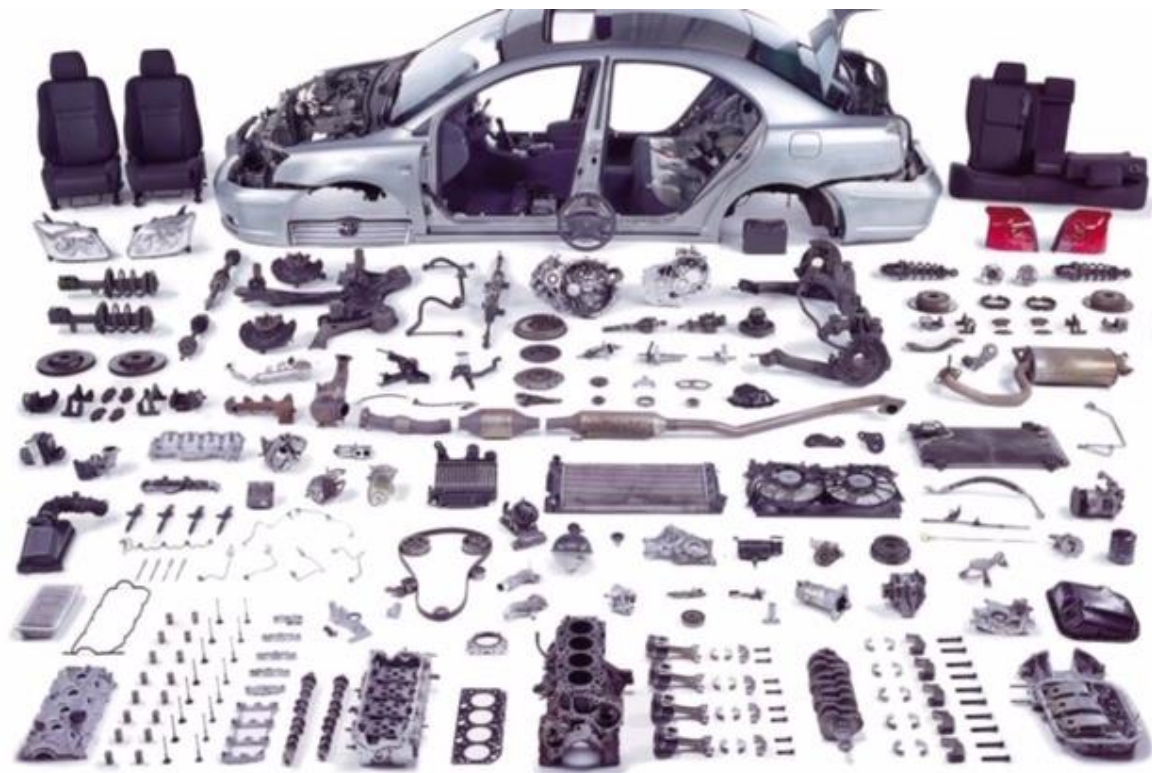
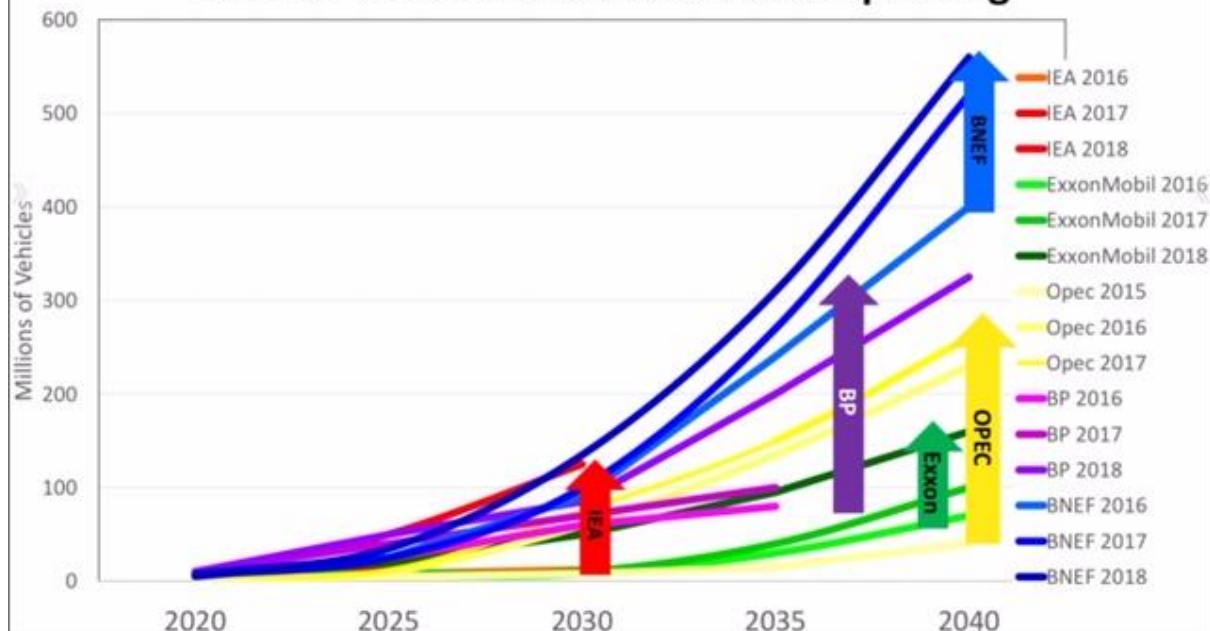
Choose Wisely for GW Scale

MANY MORE STORAGE TECHNOLOGIES



Why EVs-- Anyone See a Problem Here

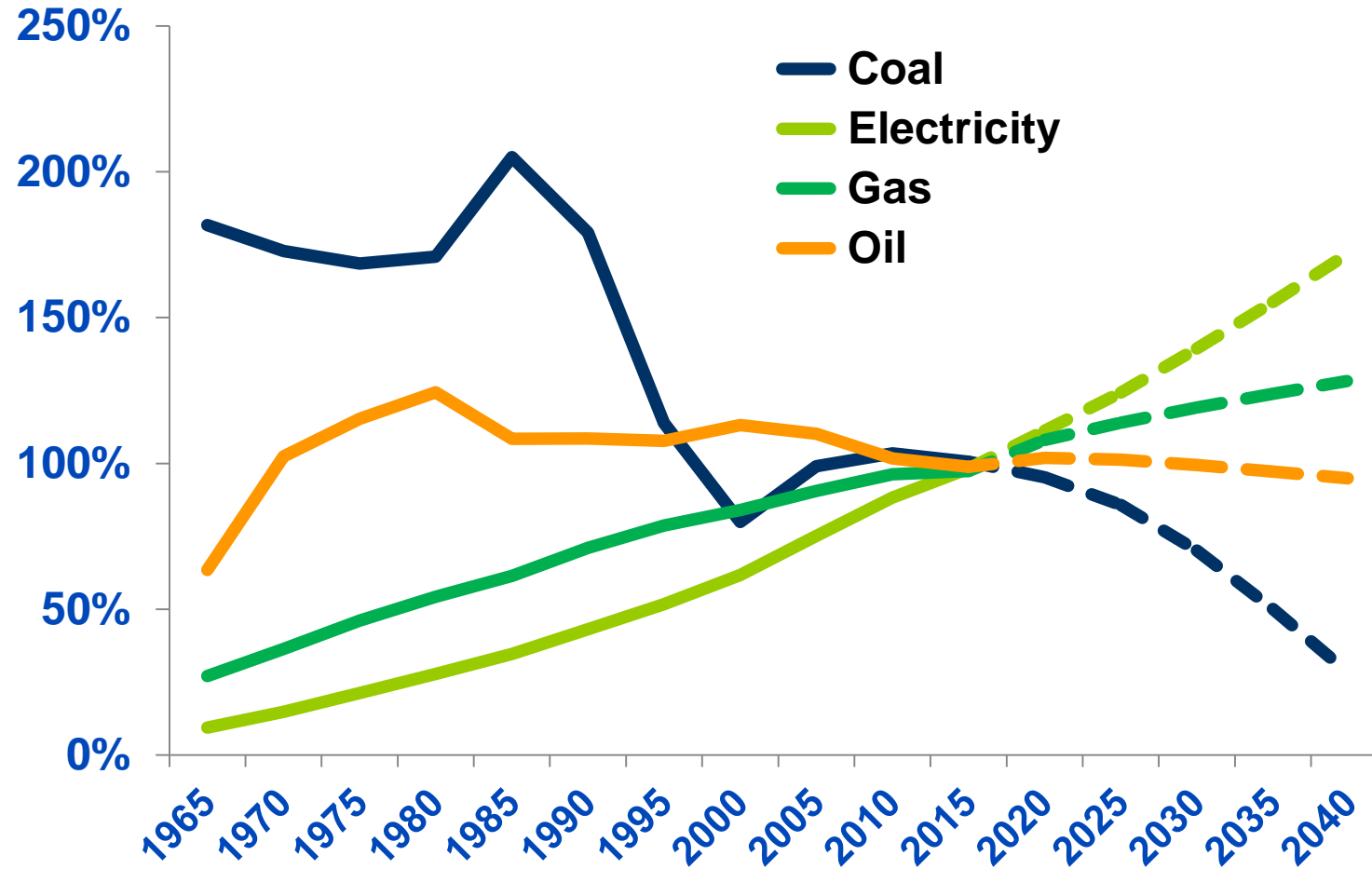
Electric Vehicle Fleet Forecasts Keep Rising



Simple Solution is good for
The Environment and Power Sales

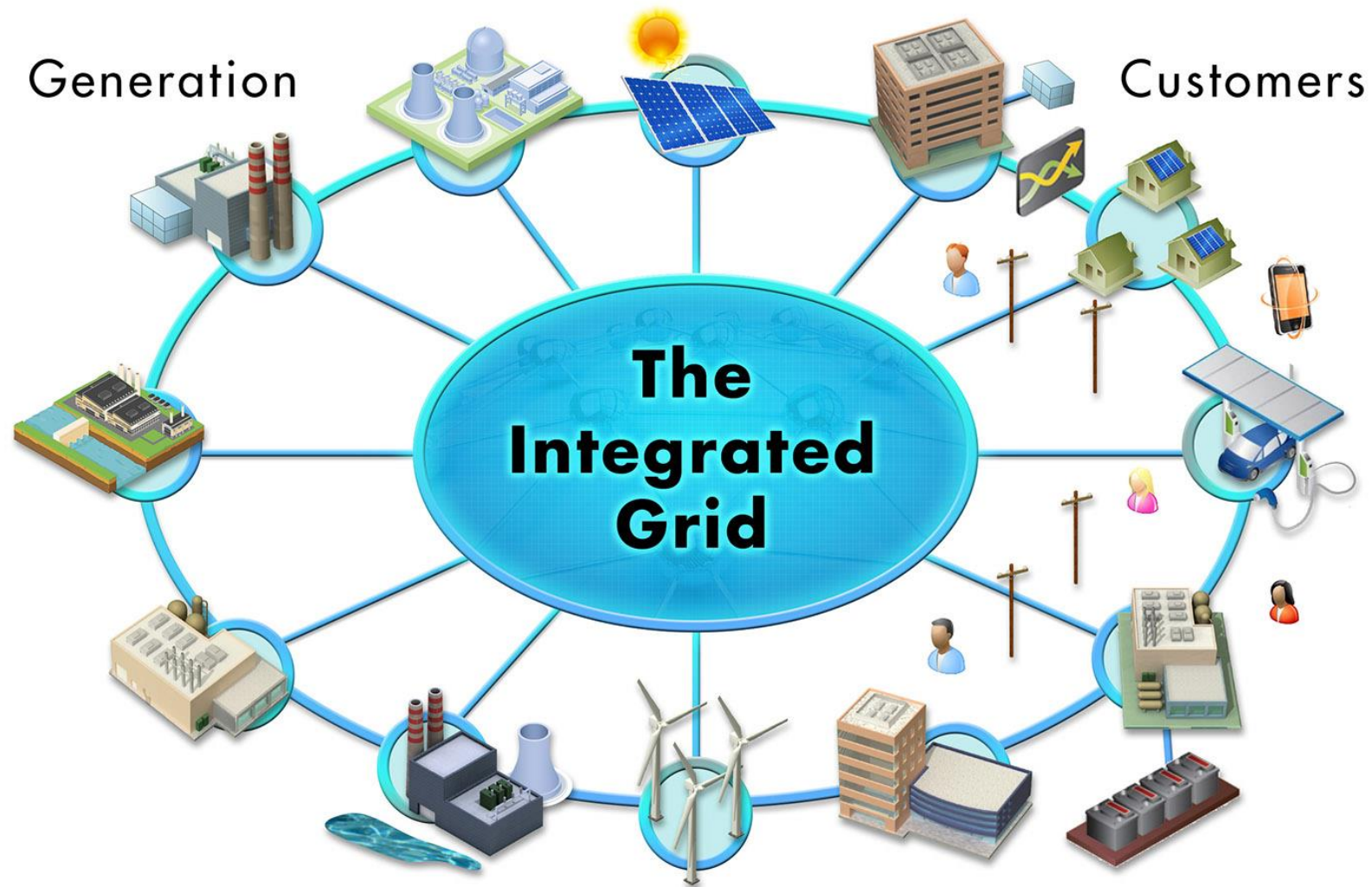
Global Energy Use By Fuel Type

(percent of 2016 consumption)



Source: BP 2018 Energy Outlook

Grid of the Future--Meeting the Challenge



Source: EPRI

A map of the United States with state boundaries outlined in black. The landmass is light gray, and the surrounding oceans are light blue. A large area in the Northeast and Great Lakes region is highlighted in red, including parts of Ontario, Quebec, Michigan, Indiana, Ohio, Pennsylvania, New York, and New Jersey. This red area represents the region affected by the August 14, 2003 blackout.

August 14, 2003 Blackout

Led to NASPI and PMUs



26 Project Partners

Advanced Synchrophasor Protocol Project

sttp



DOE FOA 1492
DE-OE0000859

ASP

Streaming Telemetry Transport Protocol

Project Collaborators	Project Financial Partner	Vendor	Utility	Demonstration Host
Bonneville Power Administration	♦		♦	
Bridge Energy Group				
Dominion Energy	♦		♦	EPG
Electric Power Group	♦	♦		
Electric Power Research Institute				
ERCOT			♦	
Grid Protection Alliance (Prime)	♦	♦		
ISO New England			♦	
MehtaTech		♦		
Oklahoma Gas & Electric	♦		♦	WSU
OSIsoft		♦		
Peak Reliability			♦	
PingThings		♦		
PJM Interconnection			♦	EPG
Southern California Edison			♦	
San Diego Gas & Electric	♦		♦	WSU
Schweitzer Engineering Laboratories	♦	♦		
Southern Company Services			♦	
Southwest Power Pool	♦		♦	WSU
Space-Time Insight		♦		
Trudnowski & Donnelly Consulting Engineers		♦		
Utilicast	♦	♦		
Tennessee Valley Authority	♦		♦	WSU
University of Southern California				
V&R Energy		♦		
Washington State University	♦	♦		

26

11

11

12

6

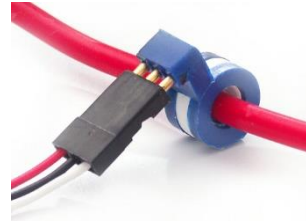


Electric Power Group



What enabling technologies can we now leverage?

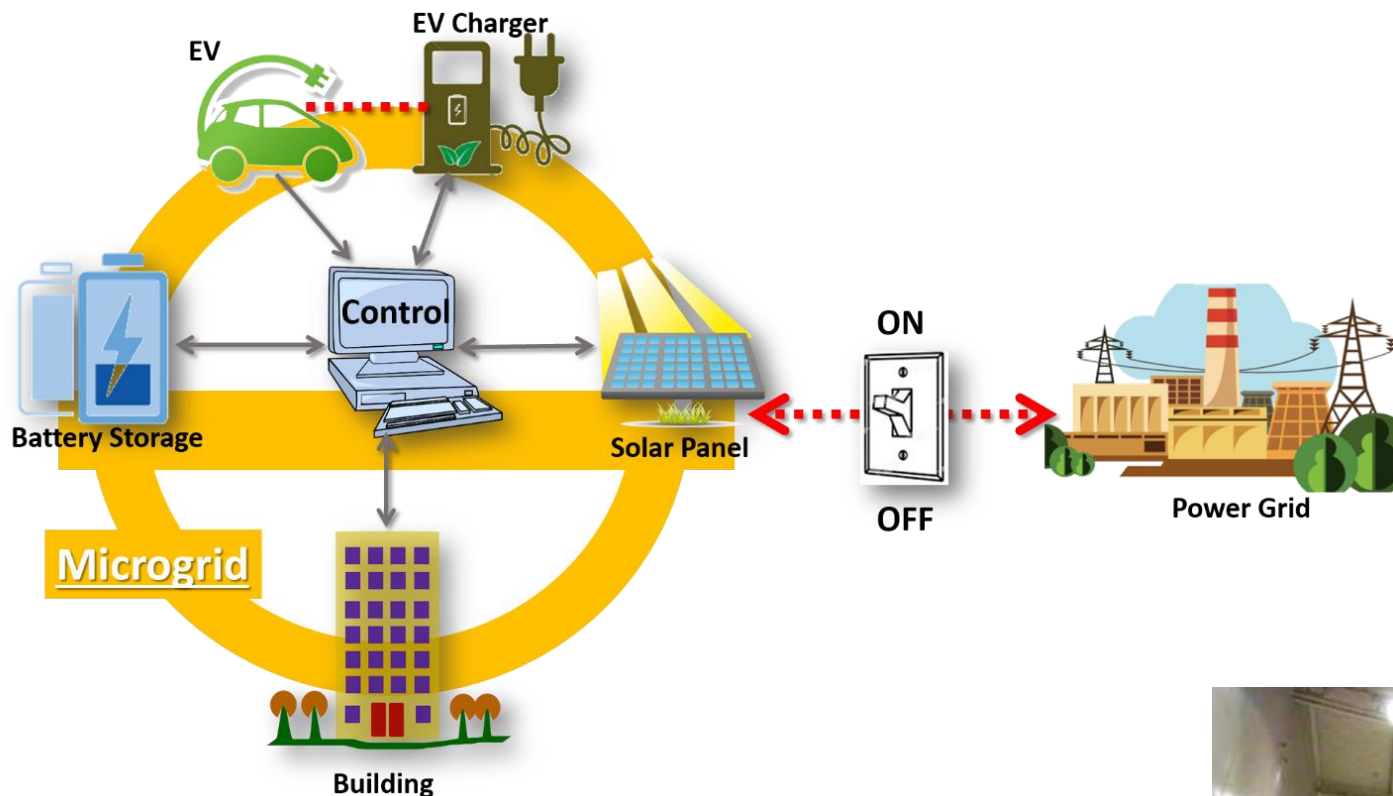
- Power electronics
- Communications & Control
- Sensing
- Cloud computing & Distributed Intelligence
- Data Science



They are all getting cheaper and better!

“Skate to Where the Puck is Going to Be”

Wayne Gretzky

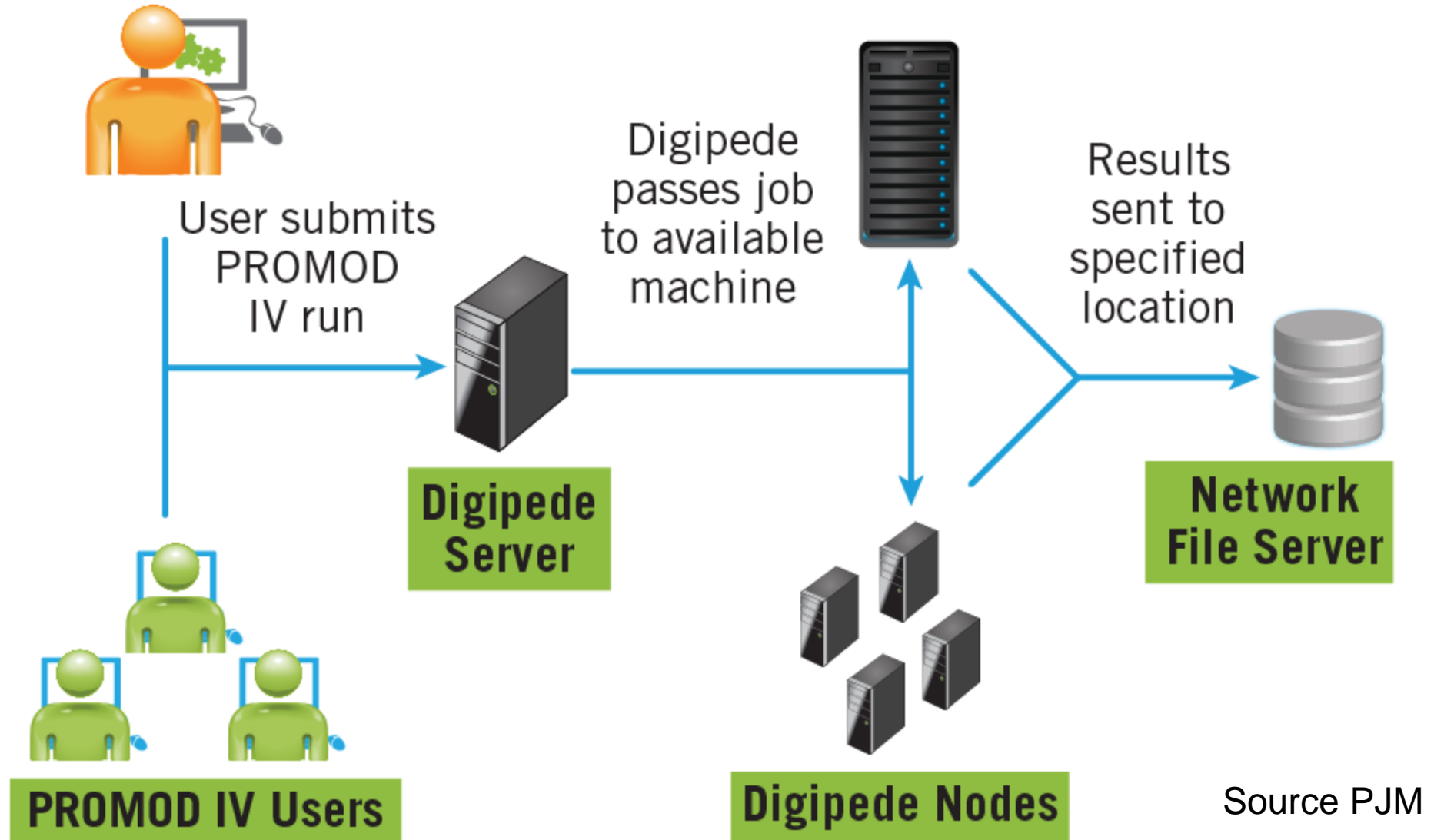


Power Electronics

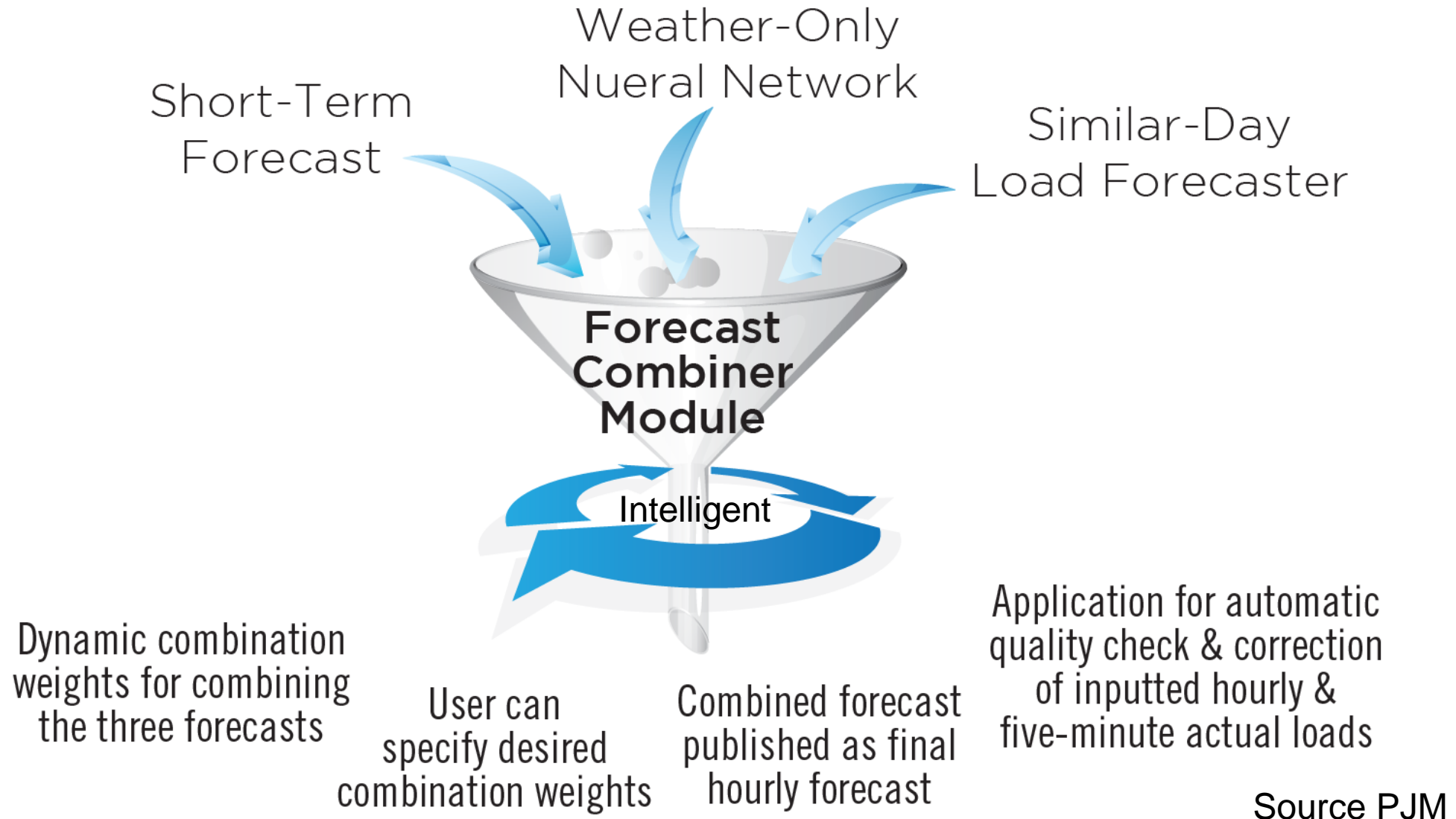


HVDC

PJM Super Computer Cuts Run Time by a Factor of 10



Intelligent Alarm Processing & Artificial Intelligence for Load Forecasting



**The best way to predict
the future is to create it!**
---Peter Drucker

