



Repowering Earth. . .

The Future Ain't What it Used to be

. . .Storage is the Silver Bullet

Terry Boston

Retired PJM President & CEO

DOE/OE Storage, Safety & Reliability

May 4, 2022

Raccoon Mountain Pumped Storage 1700 MW



10. Air Conditioning/
Refrigeration

9. Telephone

8. Computers

7. Agricultural Mechanization

6. Radio and Television

5. Electronics

4. Water Supply and
Distribution

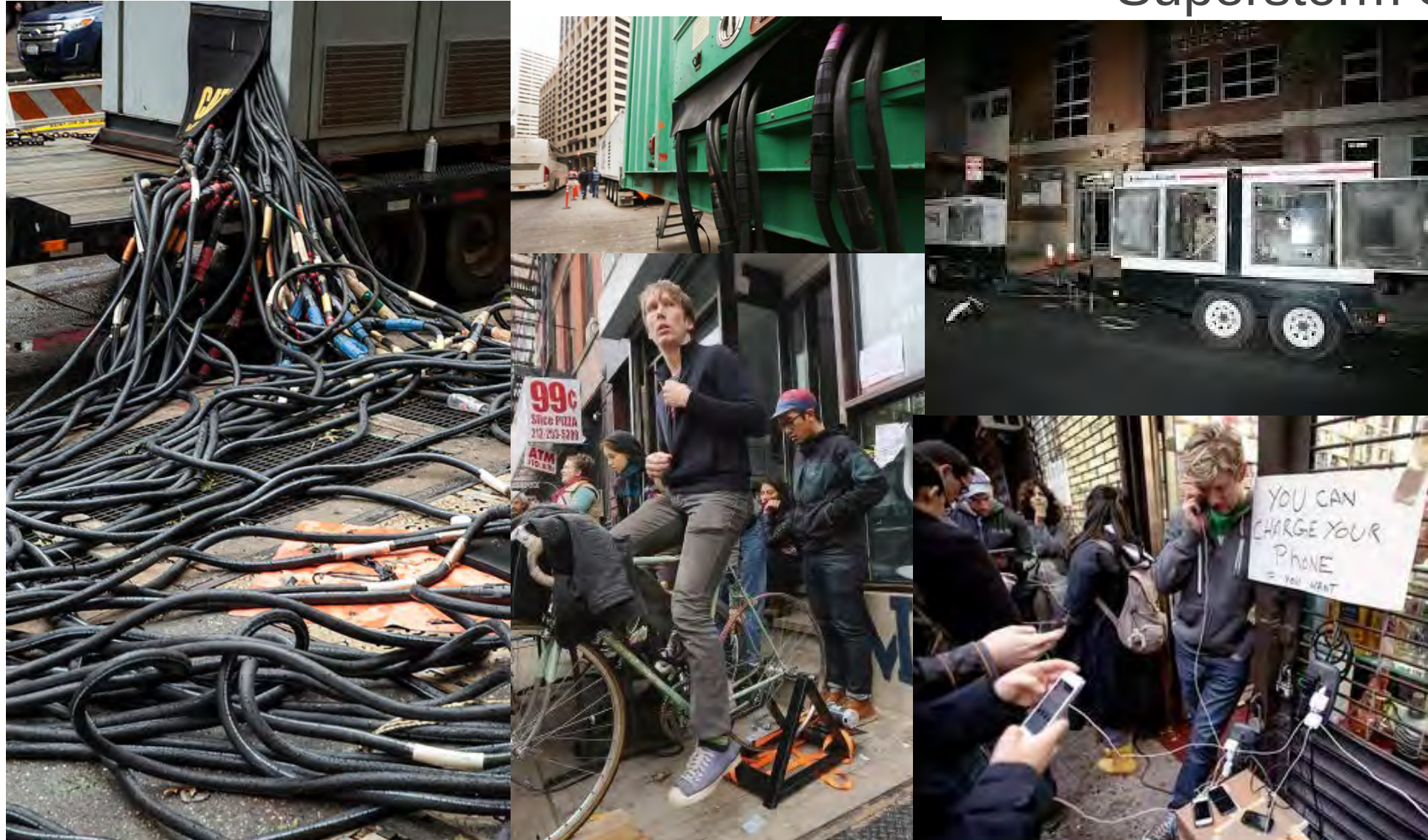
3. Airplane

2. Automobile
(EVs Soon)

1. The Grid/ Electrification

Source: National Academy of Engineering

Microgrids ... New York City After Superstorm Sandy



A Brief History of Power Disturbances

1965 to Date

1965 to Date

August 14, 2003: Midwest/Northeast & Canada

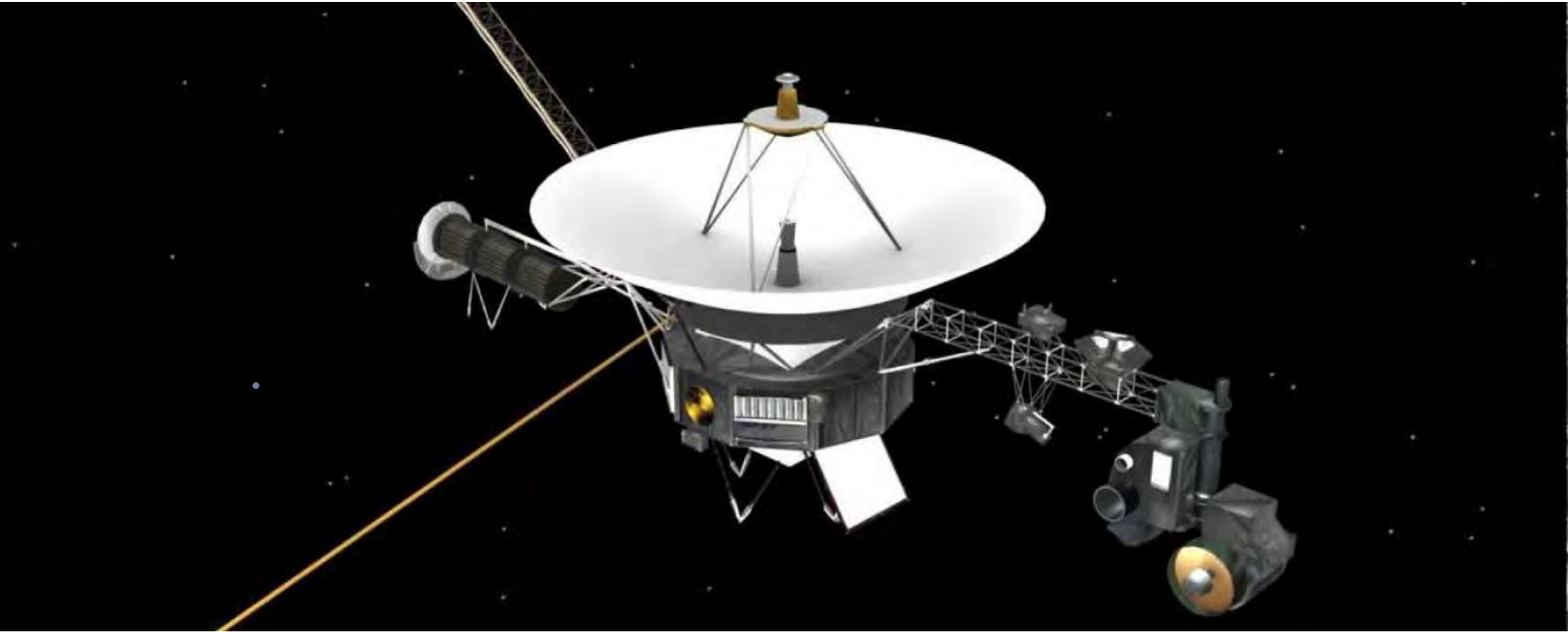


Power Engineering is not Rocket Science. . .



. . . It is much more important than that!

NASA Marshall Request TVA --7 years for Voyager --No Power Outages

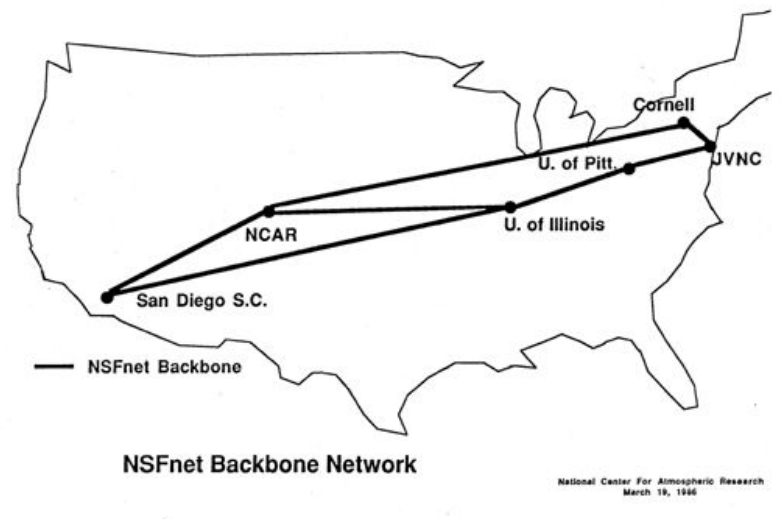


Still transmitting 43 years and 15 billion miles later!

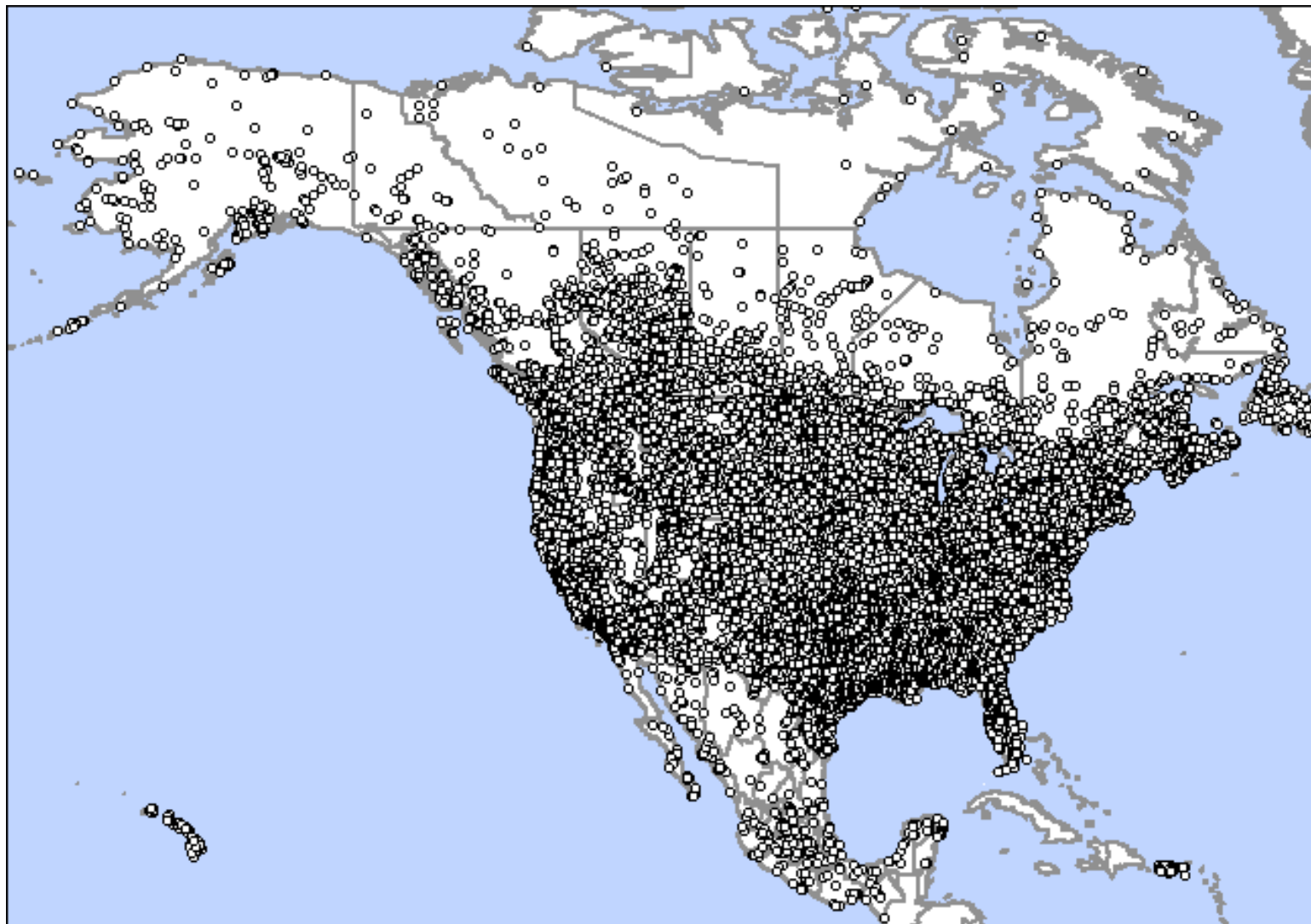
1980's Reliability. . .
. . .Lightning & squirrels



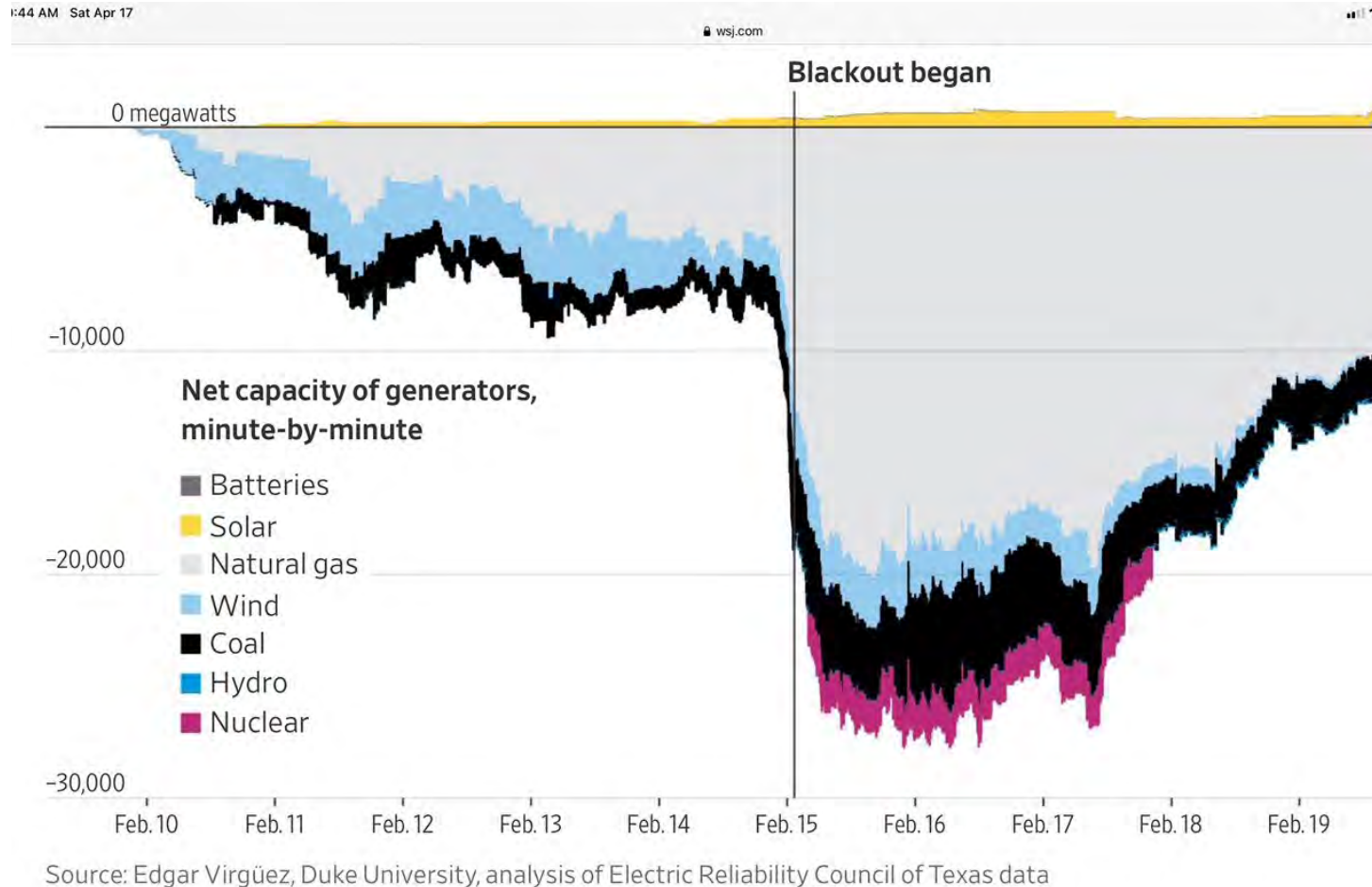
The future is not
1986 NSF
Internet 56k



Substations We Need to Protect in North America



Texas Policy—No Payment for Capacity No Penalty for No Shows



...Policy are Important—lives depend on them!

Ice Storms are Hard on Power Systems



Safety Leadership All Levels

Take what you learn at OE home with you

TN 1983



MS 1994



Quebec 1998



Ice storms will be in our future,

Never Compromise your family's **Safety**

Have a Home Emergency Kit

**Think – Water, light, heat and eat,
radio, batteries and CO alarm.**



July 17, 2021

**2 Solar Storms
sends particles
Into deep space
missing earth**

**11-year cycle
will peak in 2025**



SOLAR KILLSHOT | The Sun Sent a Wake-Up Call



NREL Finding: Current DC to AC inverter designs may cause:
..."electromagnetic transients that can propagate throughout a large geographic area and trigger system-level problems—a cascading event"



Boston's Finding: Achieving an effective level of resilience with DER requires sound planning, improved design standards and fast acting storage.

Somethings are More Resilient Than Others

National Academy

“Resilience is the ability to reduce the magnitude and/or duration of disruptive events.”

NAE Circa 2019

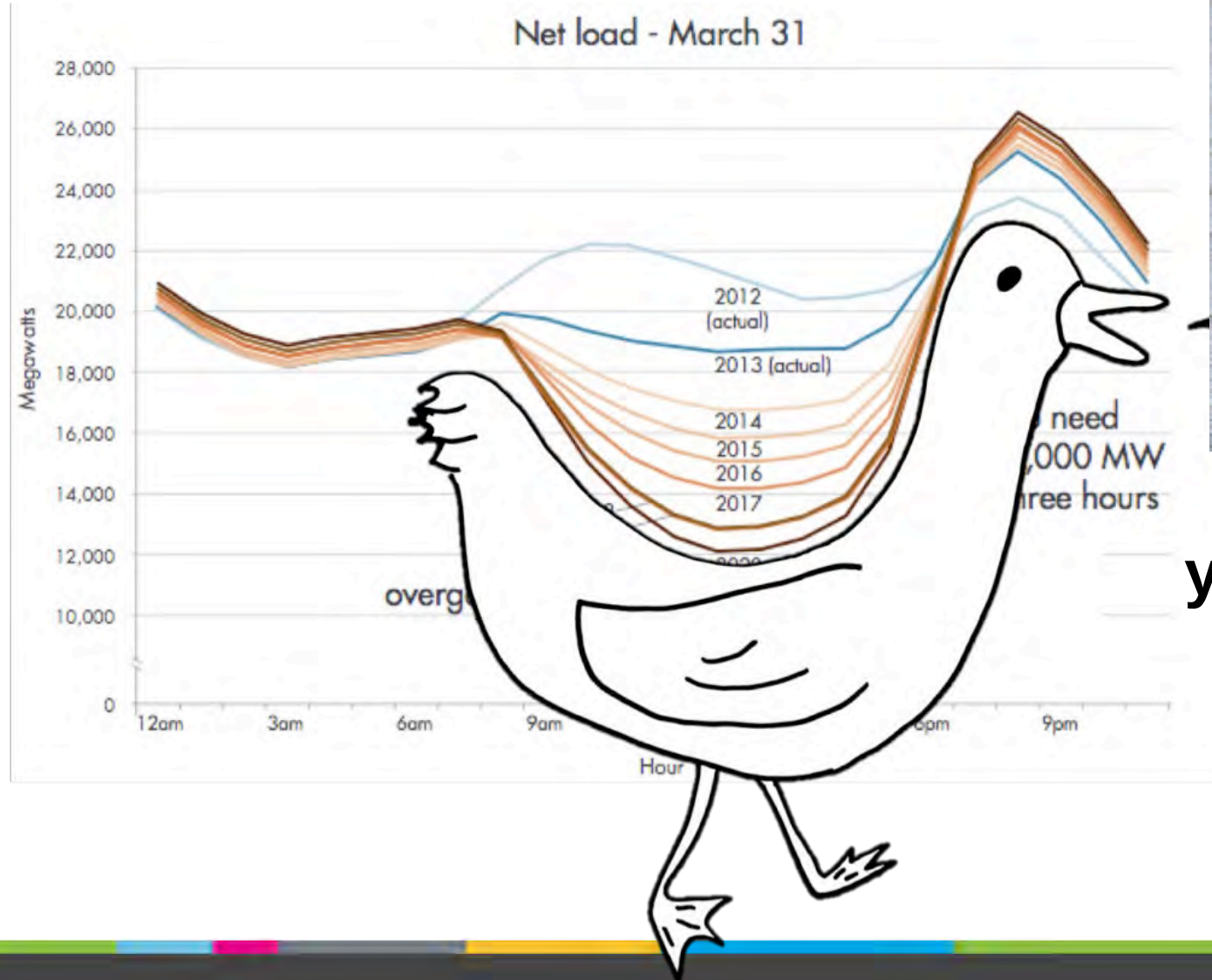


Boston's Definition

“Resilience is the ability to: . . . Take a licking and keep on ticking.”

Timex Watch Circa 1960s

The Infamous “California Duck Curve”



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

Grid-Scale Energy Storage --- 400+ MW in PJM



NextEra

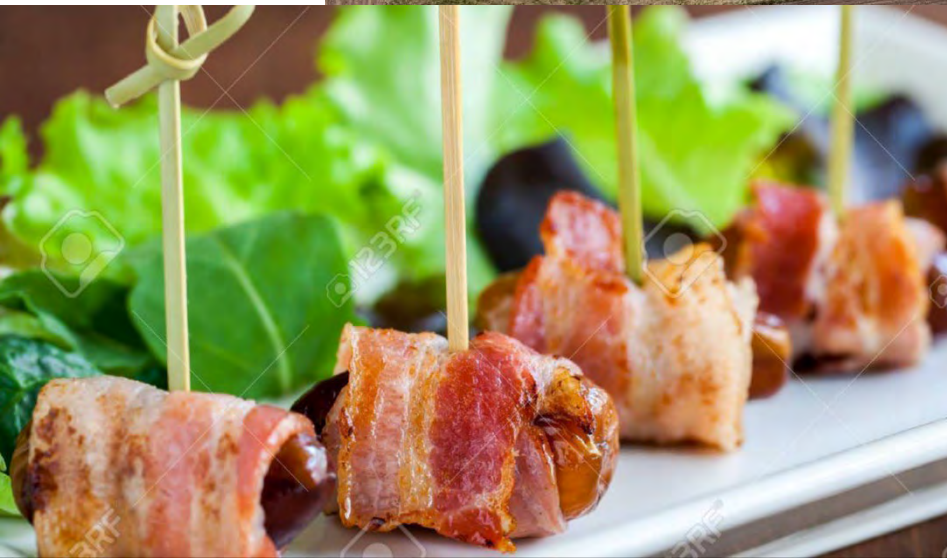
(DeKalb, IL)

Wind + Storage

217.5 MW, 145 turbines

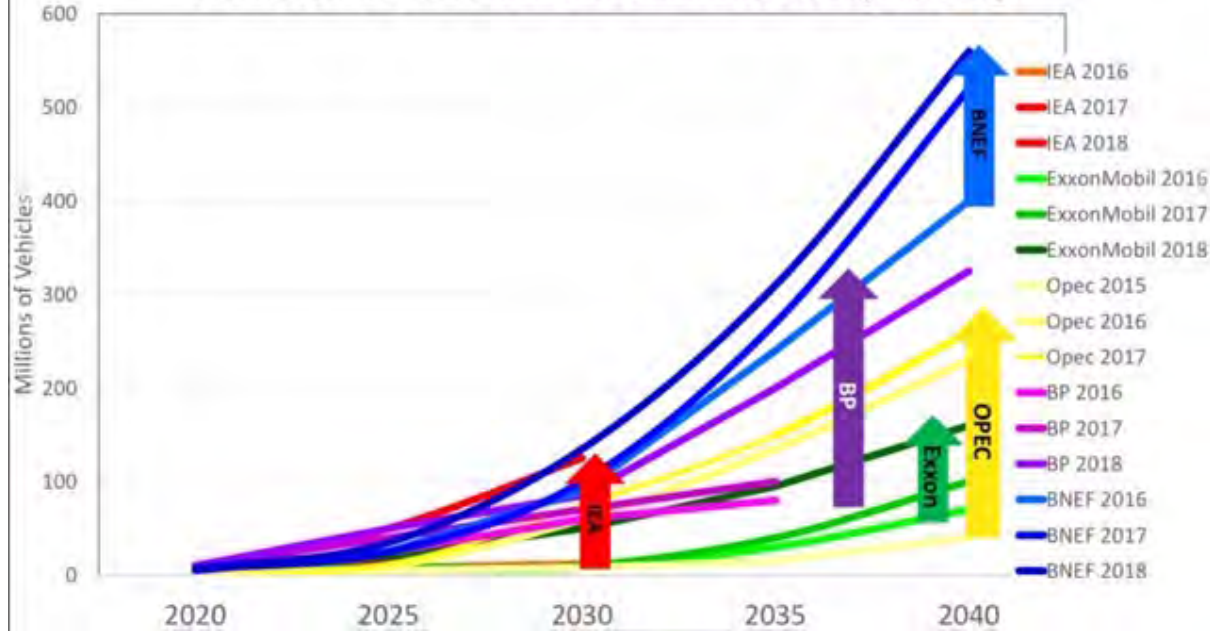
+

20 MW, 8 MWh batteries



Why EVs-- Anyone See a Problem Here

Electric Vehicle Fleet Forecasts Keep Rising



**Simple Solution is good
50% Electric New Car sales
by 2030???**

How Fast Can we Electrify Transportation?

From one horse carriage to 22 horsepower model T in 13 years

Easter morning 1900: 5th Ave, New York City. Spot the automobile.



Source: US National Archives.

Easter morning 1913: 5th Ave, New York City. Spot the horse.



Source: George Grantham Bain Collection.

Efficient Matters and Economic Viability Matters

The Model T Ford (1908 – 1927)
transformed transportation by
making it “**a-FORD-able**”

Henry Ford



“ For a battery to be cheap as
dirt it should be made with
dirt—preferable local dirt”

Don Sadoway, MIT



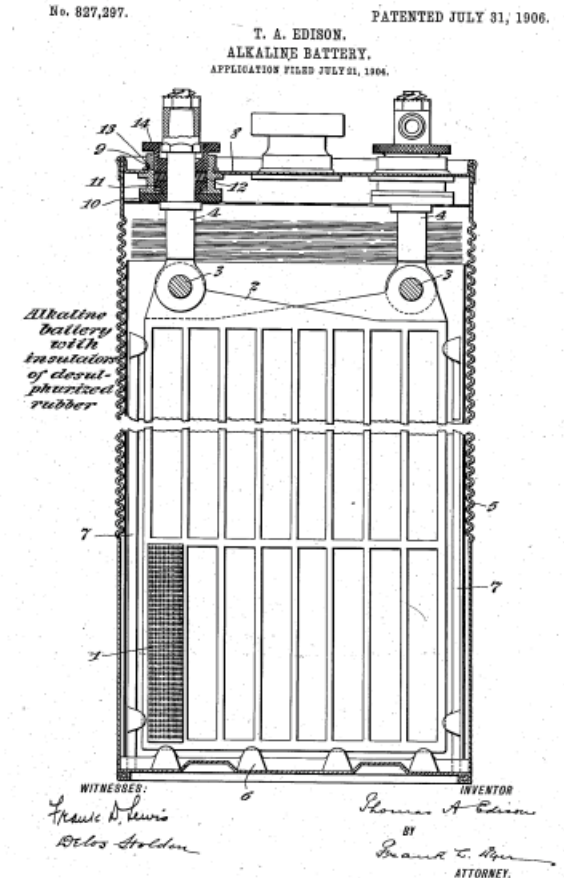
Innovation Matters

Thomas A. Edison



I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that.

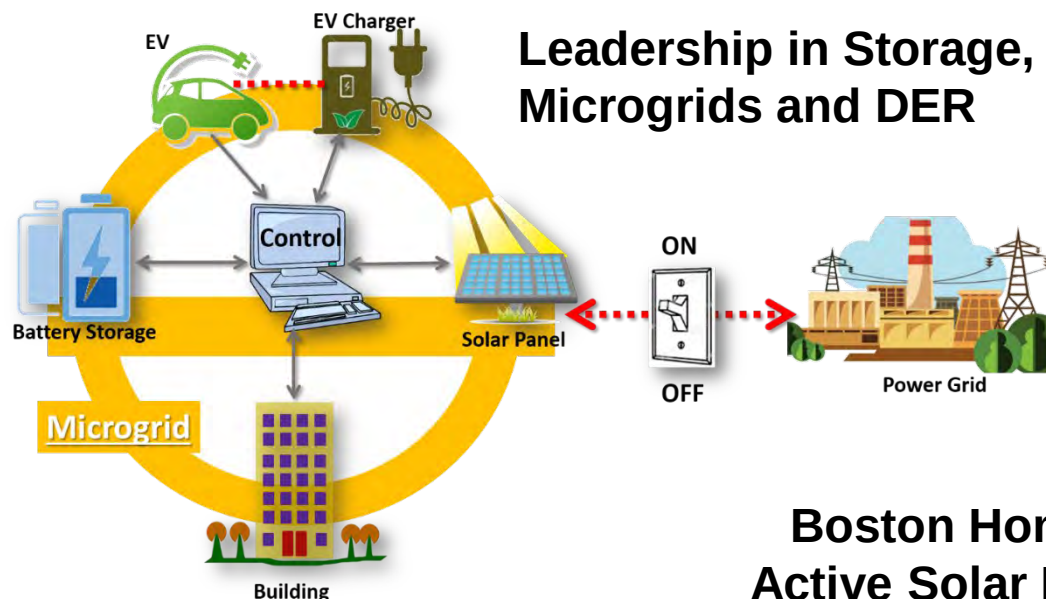
AZ QUOTES



Thomas Edison made more money on Battery Patens than on the light Bulb.

“Skate to Where the Puck is Going to Be”

Wayne Gretzky



**Leadership in Storage,
Microgrids and DER**

**Power
Electronics**



**Your house should take care of you
... not the other way around**

**Boston Home Passive Solar 1988
Active Solar Microgrid w/storage 2019**



**Wind & solar+
Storage**

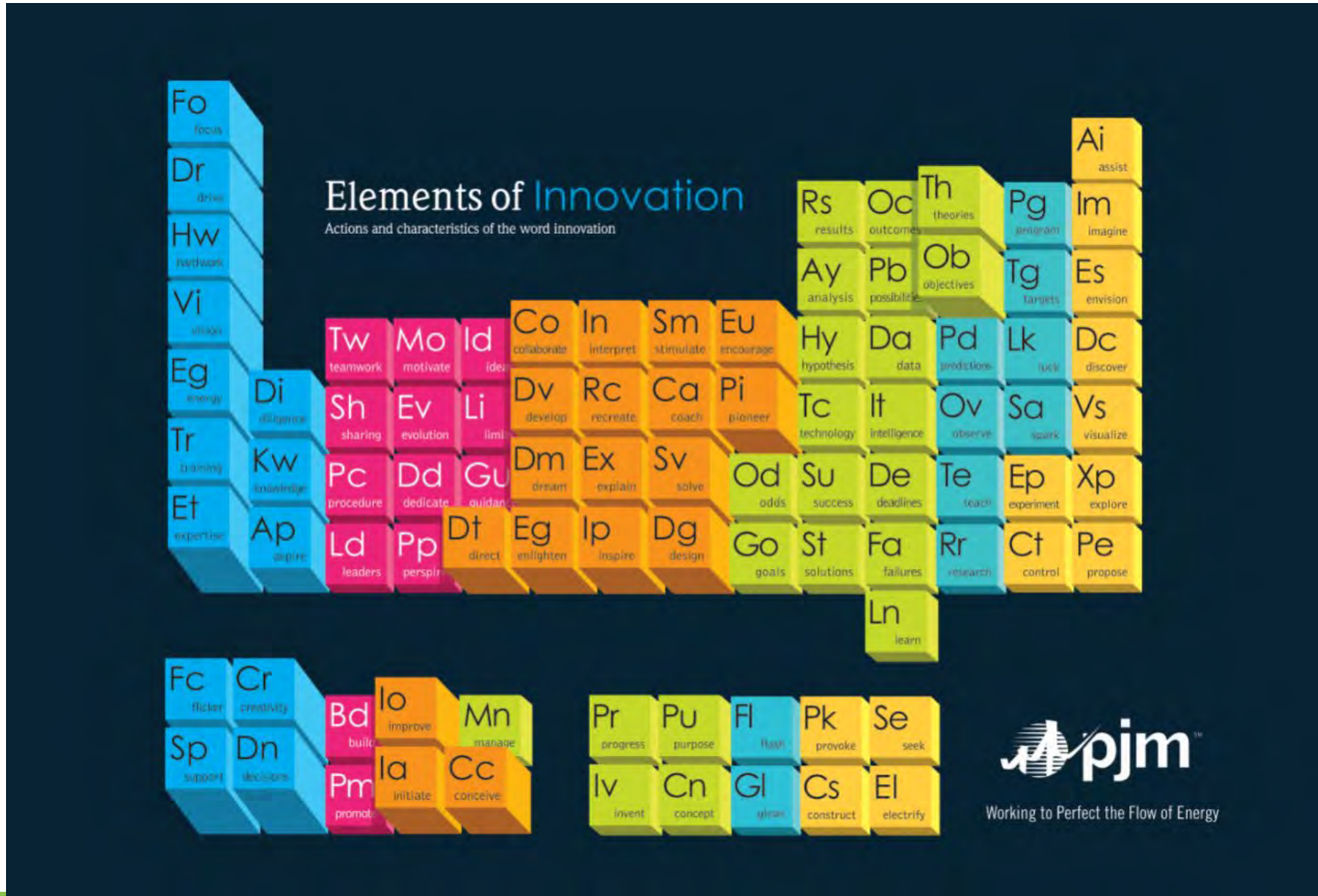


INTERPLANETARY

AC and DC flowing on the same std 3 wires

- ADC Hybrid Transmission
NASA LaRC Validated: 12/19/2019
- ADC 24/7 PV Generation
NASA Validation: Pending

“The Future is Not Ours to See”--Innovation is Key



Union Station — 1908

