ONGOING EVOLUTION OF THE US GRID
INNOVATION
1882 - Pearl Street (DC)
1896 - Niagara Falls and Buffalo (AC)
1907 - Commonwealth Edison – First Utility
1914 – Expansion for 43 states (with regulation)
1932 – Grid consolidated into 8 holding companies
1935 – Structure of utilities formalized with PUHCA
1937 – Rural co-ops created
EXPANSION

- **1914** - By the end of the year, 43 states have regulatory commissions with oversight of electric utilities.
- **1932** - By the end of the year, eight large holding companies control about three-quarters of the investor-owned utility business. Many of these holding companies cross state lines.
- **1960 - 1969** - Economies of scale make it cheaper to make electricity. The number of miles of high-voltage transmission lines tripled in the decade to 60,000 circuit miles.
LEGISLATION

• **1935** - Public Utility Holding Company Act (PUHCA)
• **1978** - The Public Utility Regulatory Policy Act (PURPA)
• **1985** – Advent of the silicon grid
• **1992** - The Energy Policy Act (EPACT)
• **1995 to present** - FERC passes several orders to better enforce EPACT
Bangkok 2017
1892 General Electric Plug
PATENT DRAWING OF HUBBLE PLUG

Separable attachment plug invented by Harvey Hubbell. Images redrawn from figs 1 and 8 of US patent 774251. Application filed May 27, 1904. Patented Nov. 8, 1904.
1832 - Hippolyte Pixii (France) built the first dynamo using a commutator, his model created pulses of electricity separated by no current. He also by accident created the first alternator. He did not know what to do with the changing current, he concentrated on trying to eliminate the alternating current to get DC power, this led him to create the commutator.

1830s-1860s - The battery is still the most powerful way to supply electricity for the various experimentation going on in that period. Electricity was still not commercially viable. A battery powered electric train from Washington DC to Baltimore failed, proving a gross embarrassment to the new field of electricity. After millions of dollars wasted steam still proved to be a better power source. Electricity still needed to prove to be reliable and commercially viable.

1860 - Antonio Pacinotti - Created a dynamo that provided continuous DC power

1867 - Werner Von Siemens and Charles Wheatstone create a more powerful, more useful dynamo which used a self powered electromagnet in the stator instead of the weak permanent magnet.

1871 - Zenobe Gramme sparked the commercial revolution of electricity. He filled the magnetic field with an iron core which made a better path for magnetic flux. This increased the power of the dynamo to the point were it was usable for many commercial applications.

1870s - There was an explosion of new designs in dynamos, designs ranged a wild assortment, only a few stood out as being superior in efficiency.

1876 - Charles F. Brush (Ohio) developed the most efficient and reliable dynamo design ever to that point. His inventions was sold through the Telegraph Supply Company.

1877 - The Franklin Institute (Philadelphia) conducts test on dynamos from around the world. Publicity from this event spurs development by others like Elihu Thomson, Lord Kelvin, and Thomas Edison.
“20 YEAR TECHNOLOGIES”

- Fusion
- Magnetohydrodynamics
- Storage?
NOW, MAYBE WE CAN GET A JOB DONE!!

WOW! HE'S TOUGH!

HE'S SMALL, BUT HE'S WIREY!
LIVING IN THE INTERESTING TIME

1883 → 1990
Control Through Angular Momentum
Reliability through overbuilding
Lack of overall model
Changing Technology
Complicated Transition

Transition

2025? →
Analytically Driven Control
Knowledge of state
Precise control
High performance analytics
SO HOW WILL THE GRID EVOLVE

• Diluting the dichotomy
• Greater emphasis on resiliency
• Emphasis on Power Quality
• Distributed Generation
• Ownership
• Operational Authority
• Method of Control
• Control Technology
“20 YEAR TECHNOLOGIES”

- Fusion
- Magnetohydrodynamics
- Storage
- HVDC
- Solid-state power electronics
THE VULCAN MIND MELD

“DOUG’s of a different stripe”