University of Pittsburgh

Opportunities for the Power Grid in the Changing Energy Economy

National Academies GUIRR
Cross Sector Impact of the Smart Grid
February 10, 2015 – Washington, D.C.

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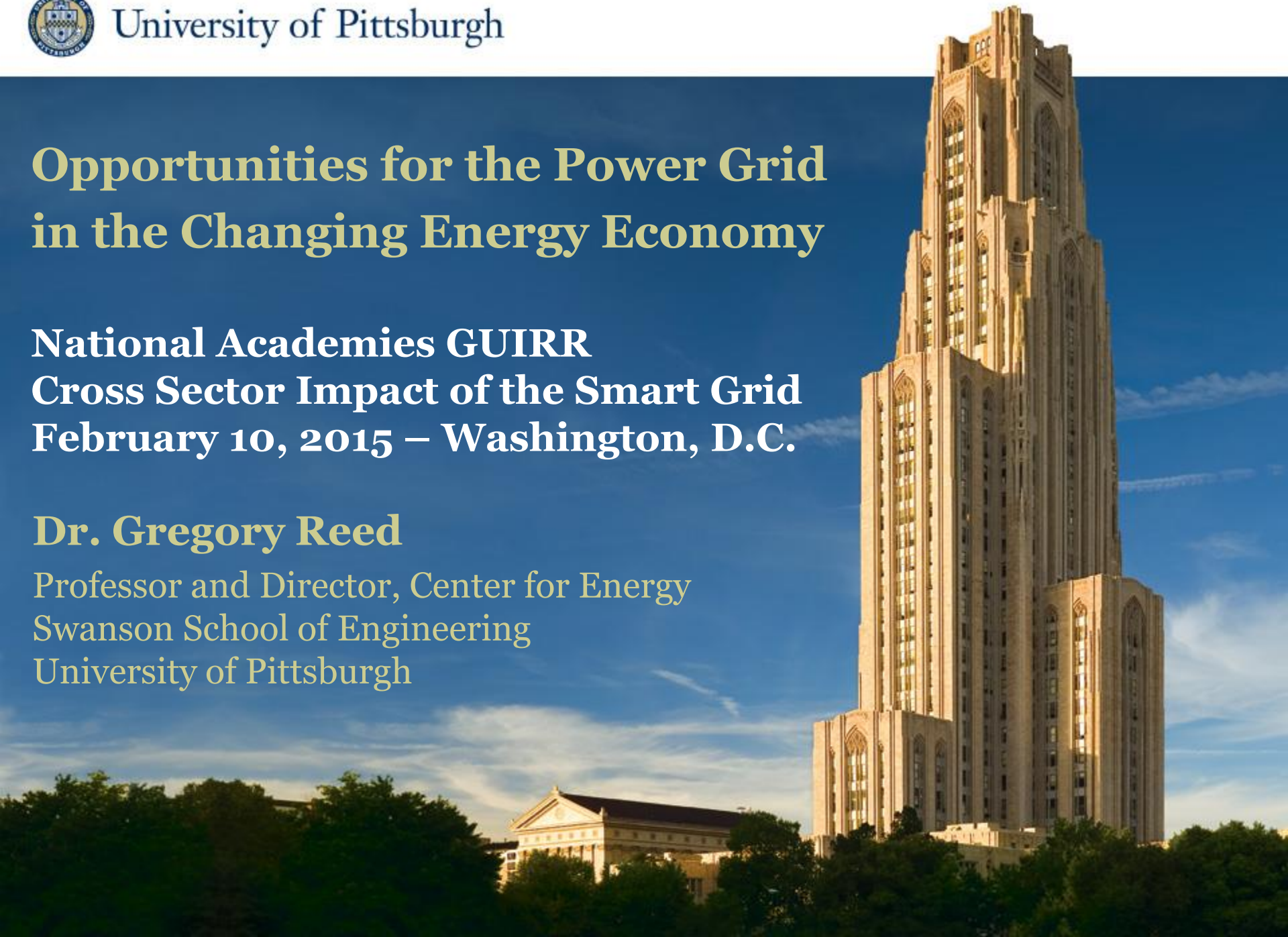
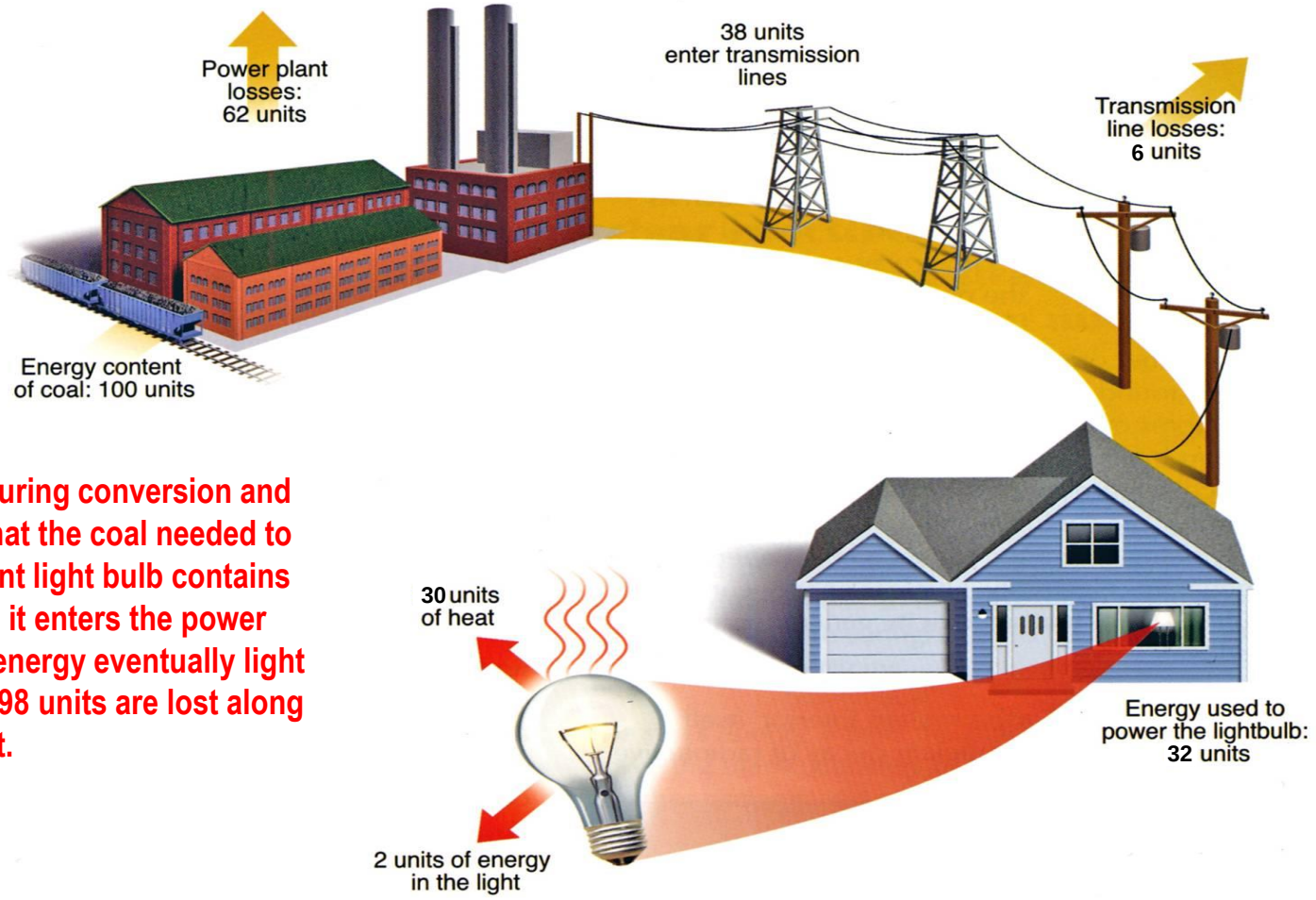


The Pitt Center for Energy

- University-wide Research Center
  - $30+ Million R&D portfolio
  - 90+ Faculty and 250+ Graduate Student Researchers
- General Areas of Research Focus:
  - Energy delivery and reliability (Electric Power)
  - Advanced materials for energy-related applications
  - Energy efficiency and sustainability
  - Clean energy development and integration
  - Unconventional gas resources
  - Carbon management and utilization
  - Direct energy conversion and recovery
  - Various non-engineering areas

Electricity – the Life Blood of Modern Society

Energy and Electricity (In)Efficiency – Losses

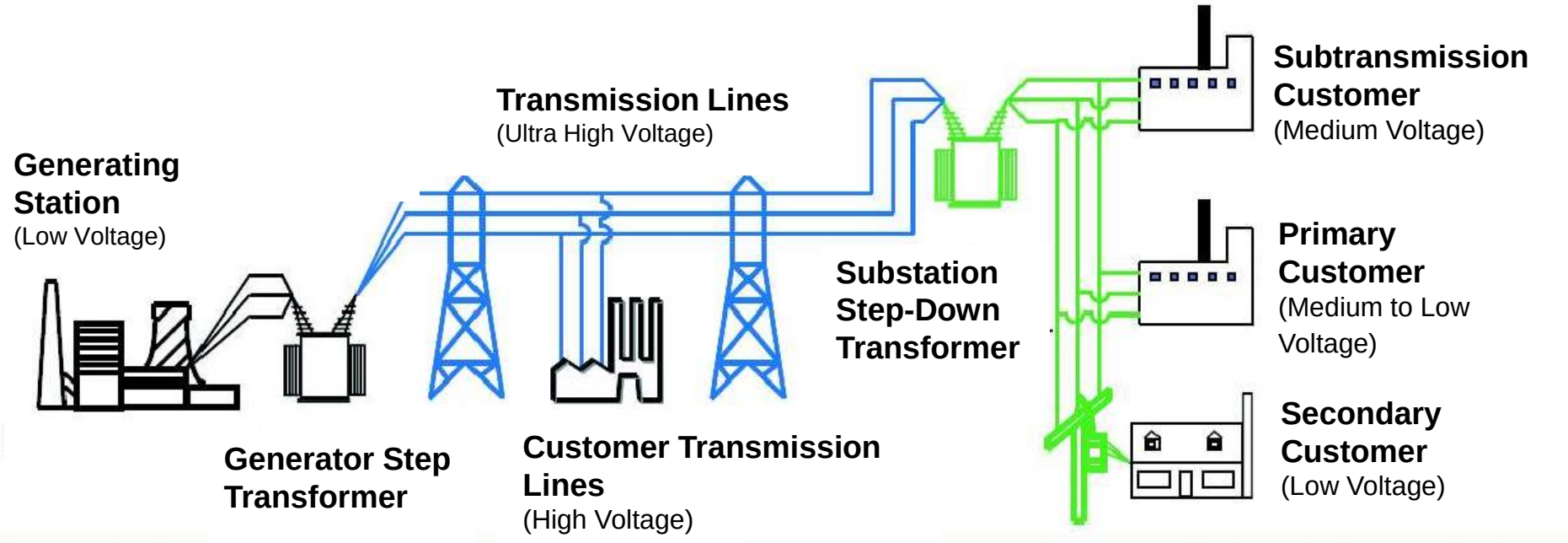


Example of energy lost during conversion and transmission. Imagine that the coal needed to illuminate an incandescent light bulb contains 100 units of energy when it enters the power plant. Only two units of energy eventually light the bulb. The remaining 98 units are lost along the way, primarily as heat.

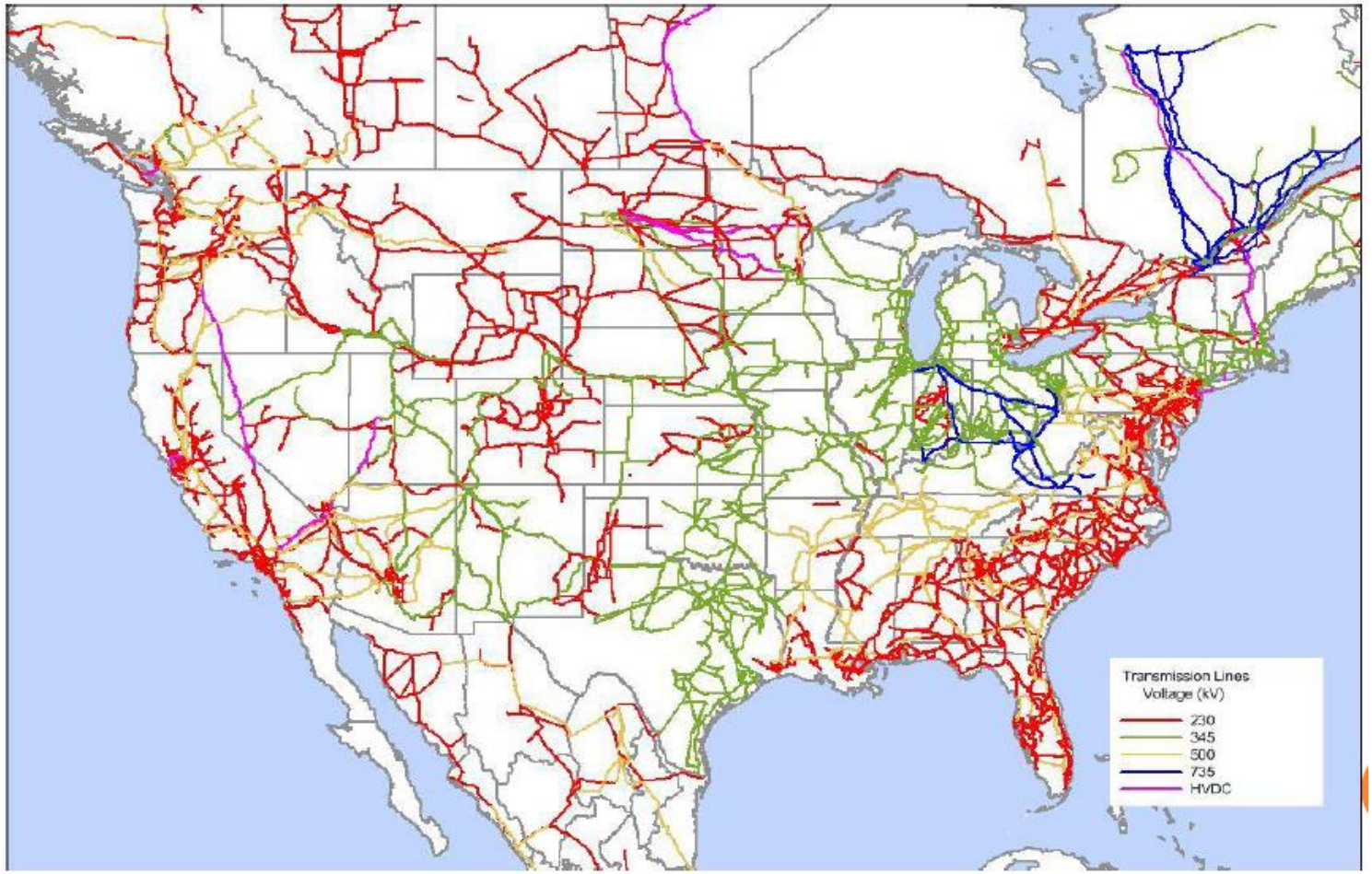
Power Grid Infrastructure and Reliability

Today's Electric Power Systems (AC Networks, One-Way Flow)

Generation → **Transmission** → **Distribution** → **Consumption**



The U.S. Power Grid

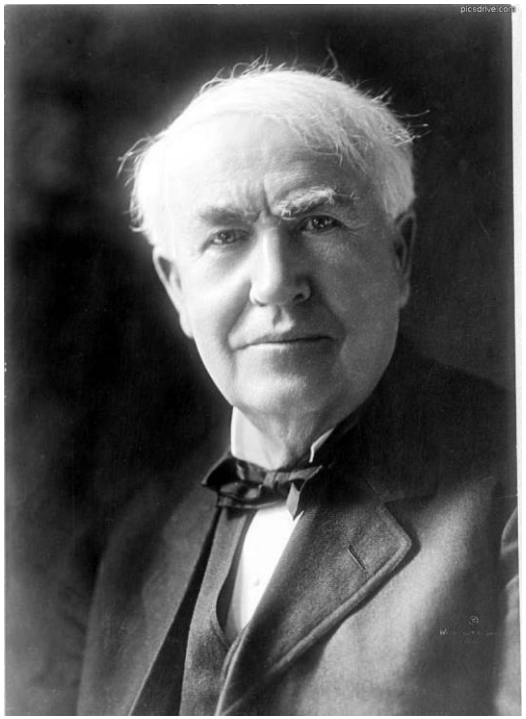


T&D (the Grid) Delivers Electricity

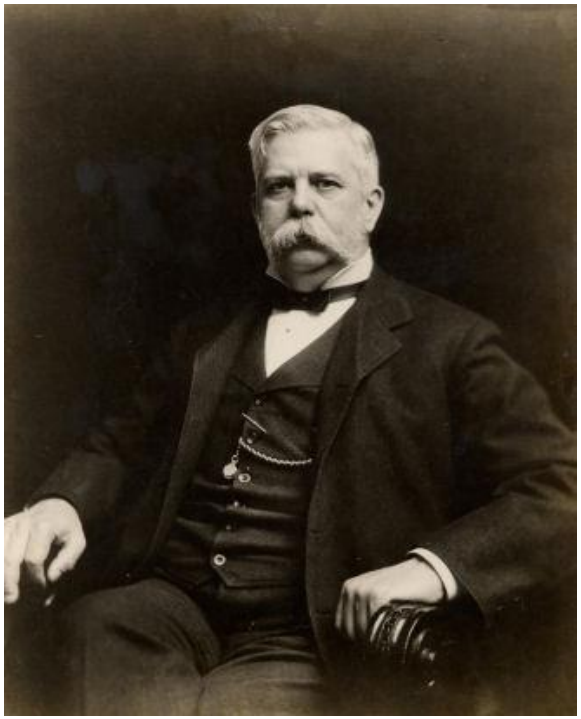
Transmission
- High voltage
- 400,000 miles
- 16,000 substations

Distribution
- Lower voltage
- 5,000,000 miles
- 60,000 substations

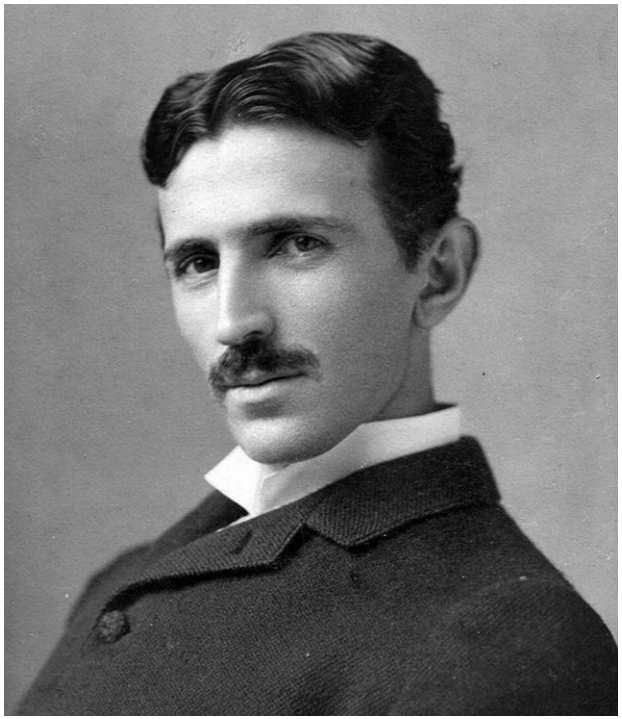
In the late 1800s and early 1900s, Pittsburgh was at the center of the war of the currents — AC vs. DC electricity



Edison



Westinghouse



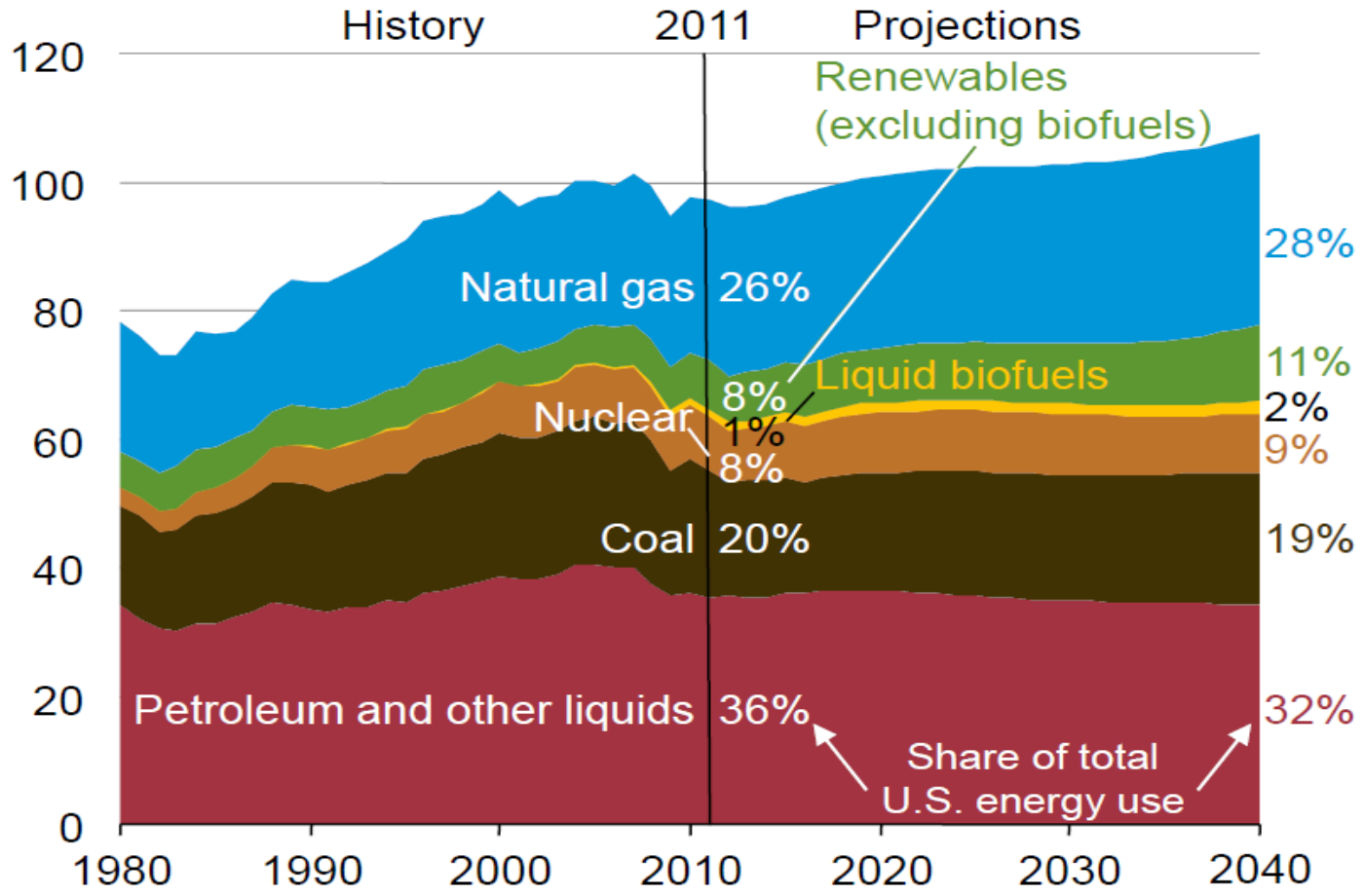
Tesla

Challenges for Today's Power Grid

Resource Transition

Consumer Participation

Energy Utilization

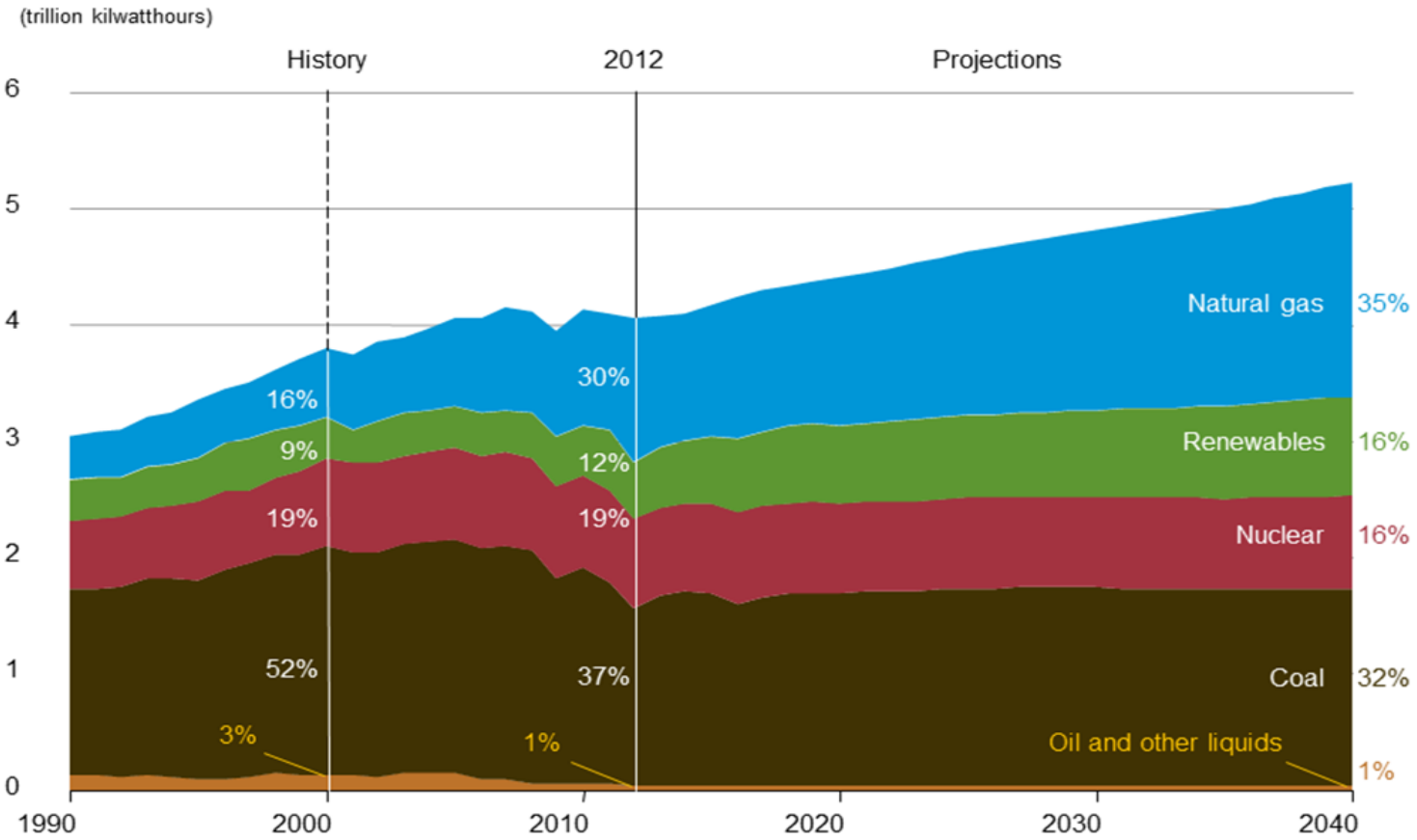


Primary Energy Use by Fuel (quadrillion Btu)

(U.S. DOE EIA, 2014 report)

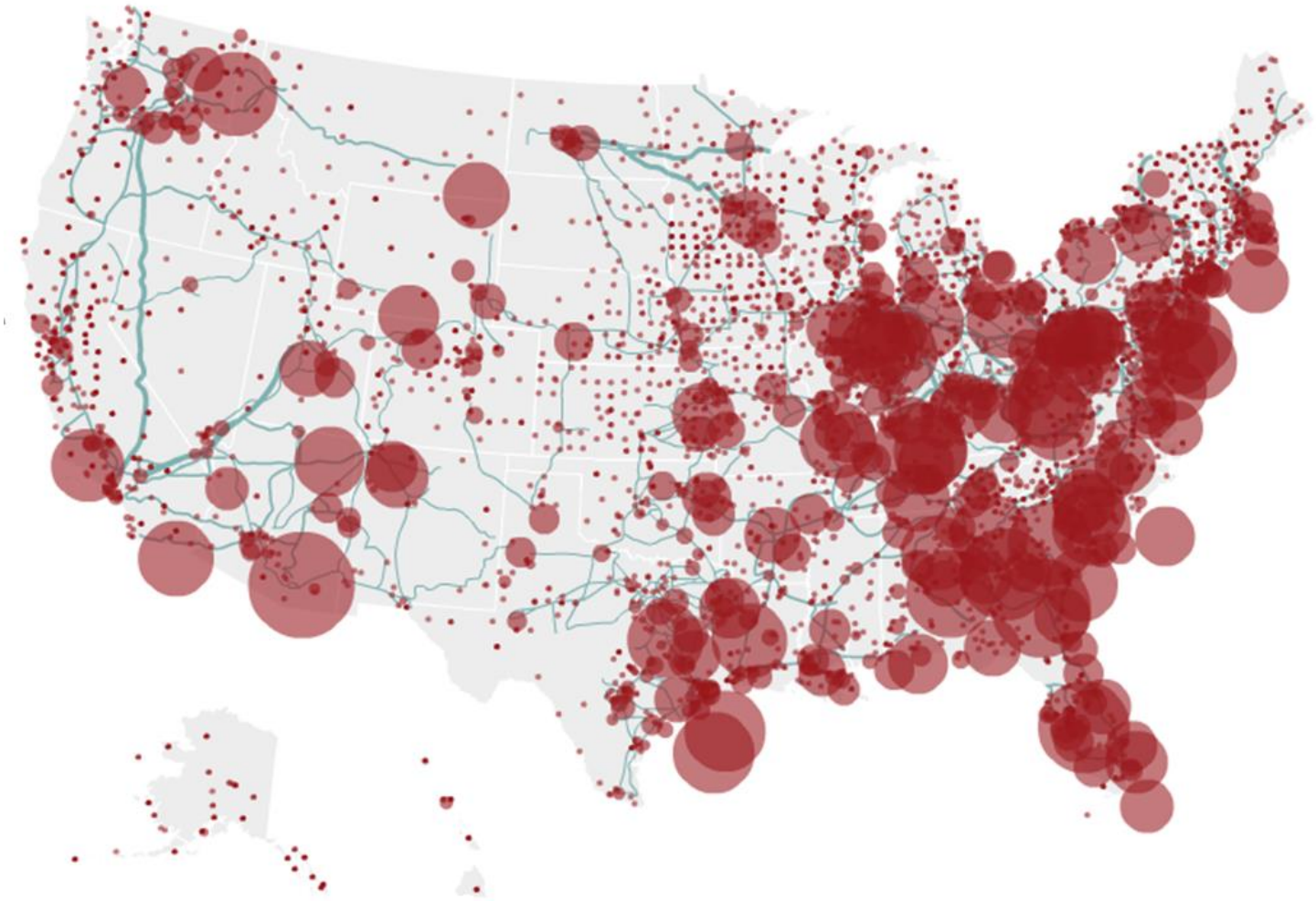
Electricity Generation

Figure 13. Electricity generation by fuel, 1990-2040

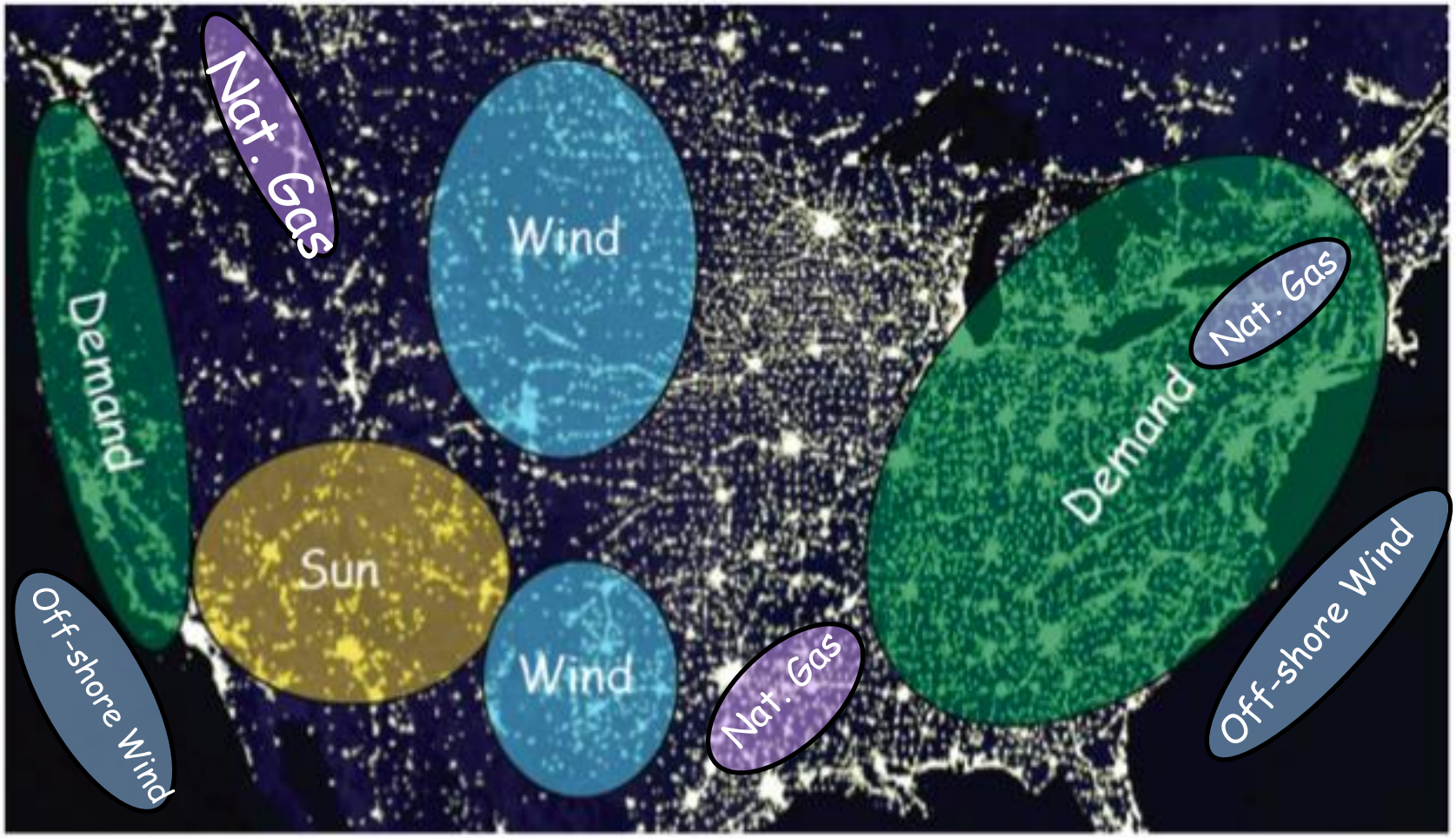


eia

Electricity Generation Portfolios are Changing



Future Energy Supply and Demand Trends

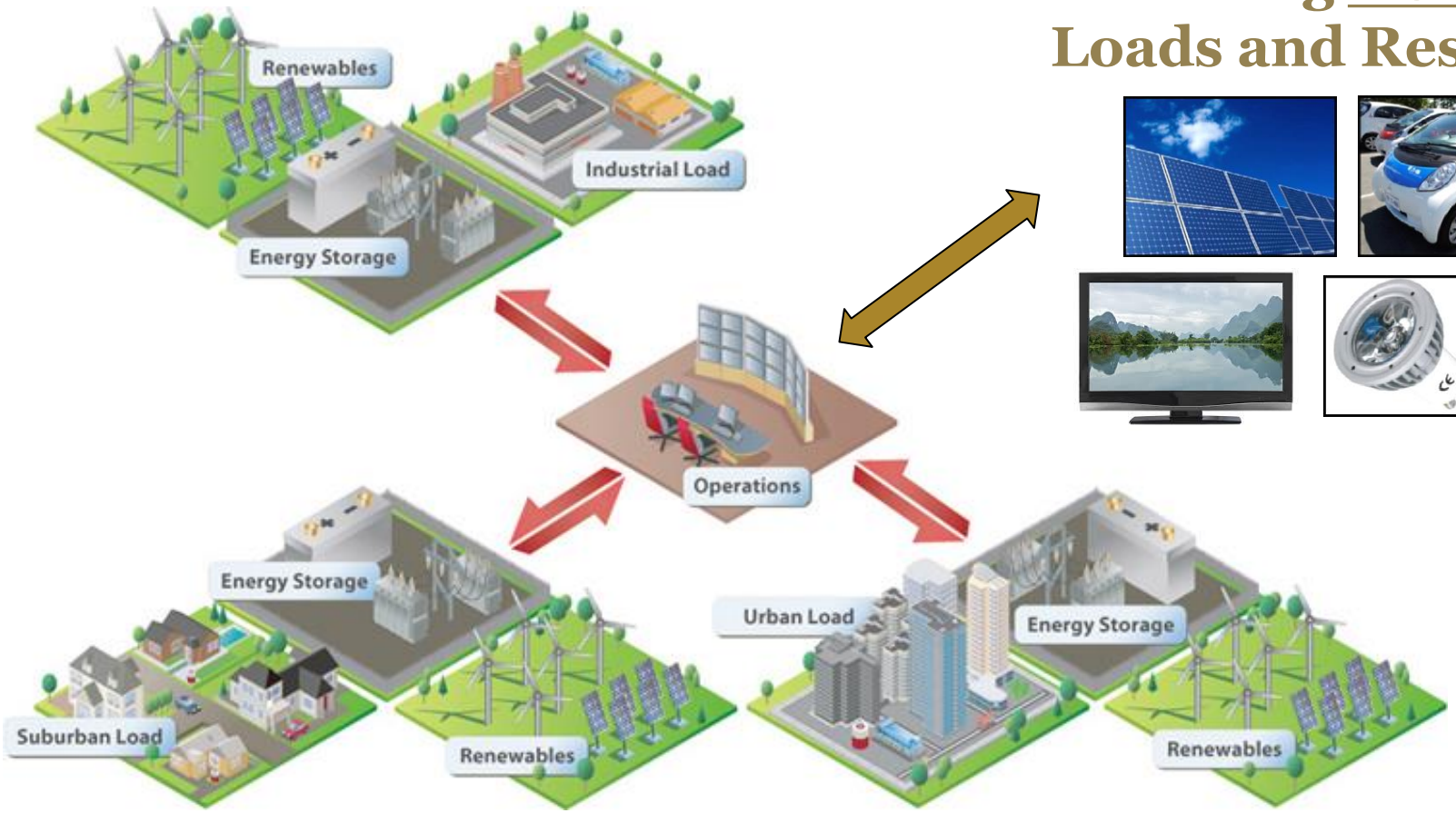


Grid Impacts from Powerful Weather Events

Hurricane Sandy

Distributed Energy Resources and Microgrids

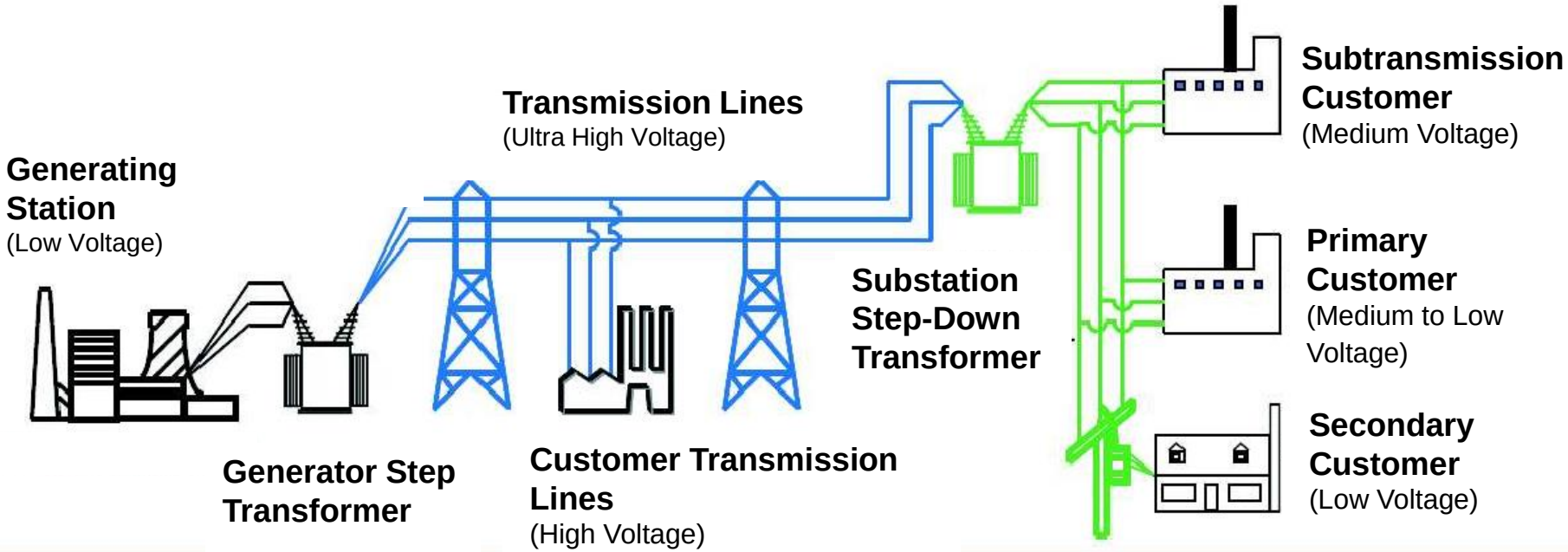
Evolving DC-based Loads and Resources



Consumer Participation is Increasing

Tomorrow's electric power systems will have hybrid AC-DC networks and multi-way flow

Generation ⇒ **Transmission** ⇒ **Distribution** ⇔ **Consumption**



Opportunities – Grid Modernization

DC Solutions and Power Electronics Technology

Large-Scale Renewables

Cleaner Fossil Resources

VSC

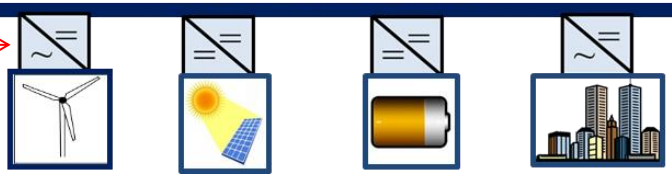
VSC

VSC

HVDC Transmission

Combined Cycle Natural Gas Plant

DC Micro Grid



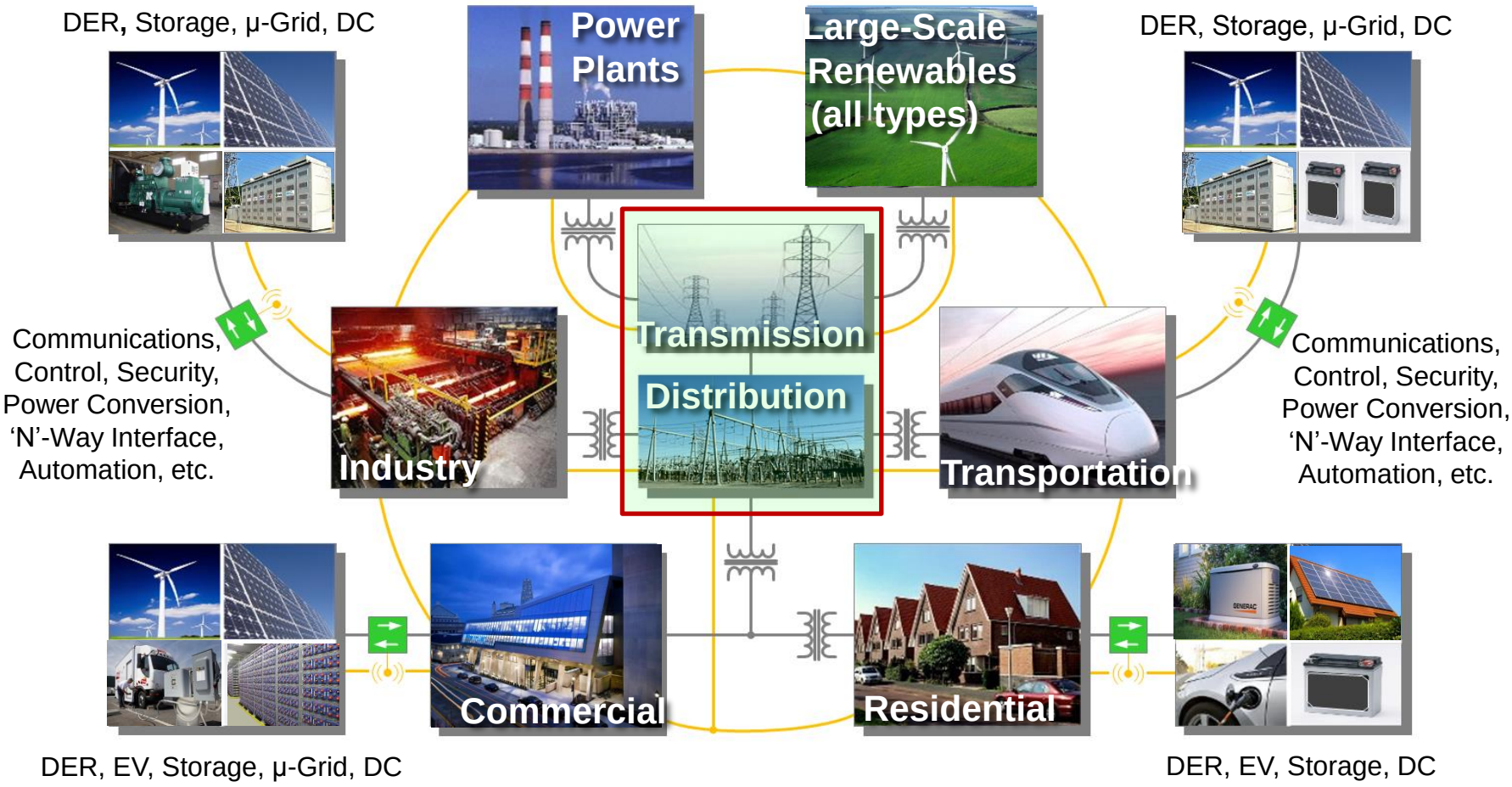
Power Conversion Technologies

Micro-Energy Developments

Advantages of DC and Power Electronics

- HVDC -- Greater Capacity per Right of Way (x6)
- Improved Controllability of T&D Networks
- Less Costly Infrastructure – both O/H and U/G
- Increased Efficiency and Lower Losses
- Reduced Risk of Major Blackout Events
- Enhanced Resiliency of Grid Infrastructure and Integration of Micro-grid Solutions
- Better Match of Supply (renewables/storage) and Demand (consumer devices)
- Technology Development and Economic Growth, U.S. Leadership, and Workforce / Jobs

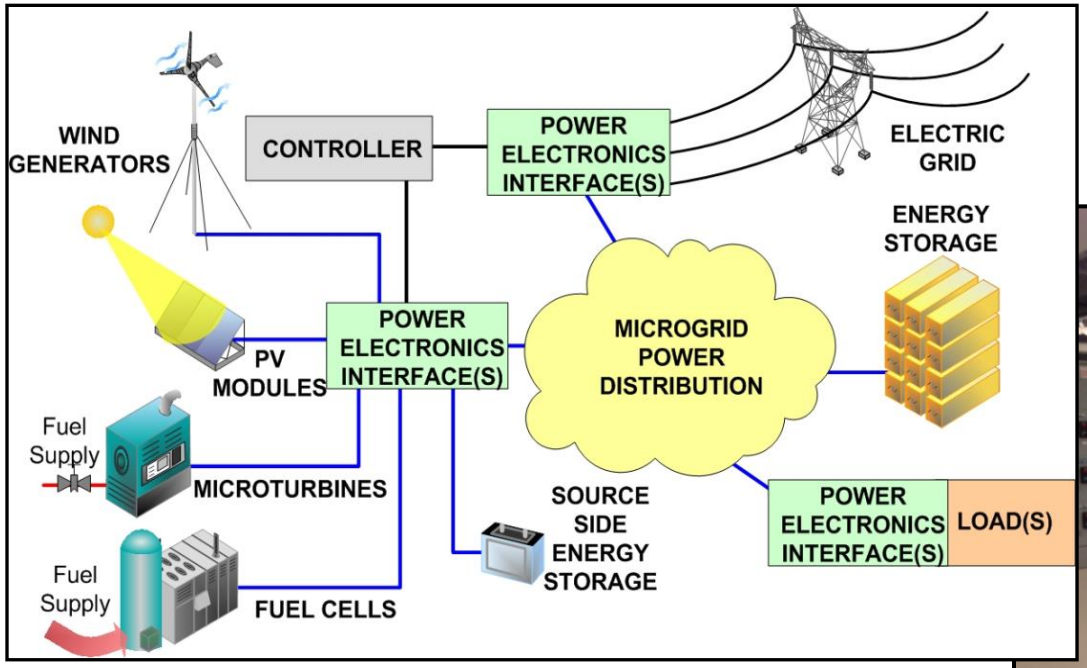
The 21st Century Grid and Its Interactions



DC and Power Electronics Development

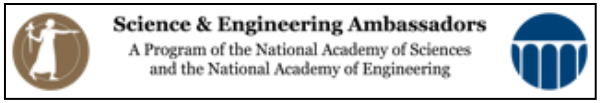
Pittsburgh Leadership, Again, in the 21st Century

Univ. of Pittsburgh / Government, Industry, and Community Partners

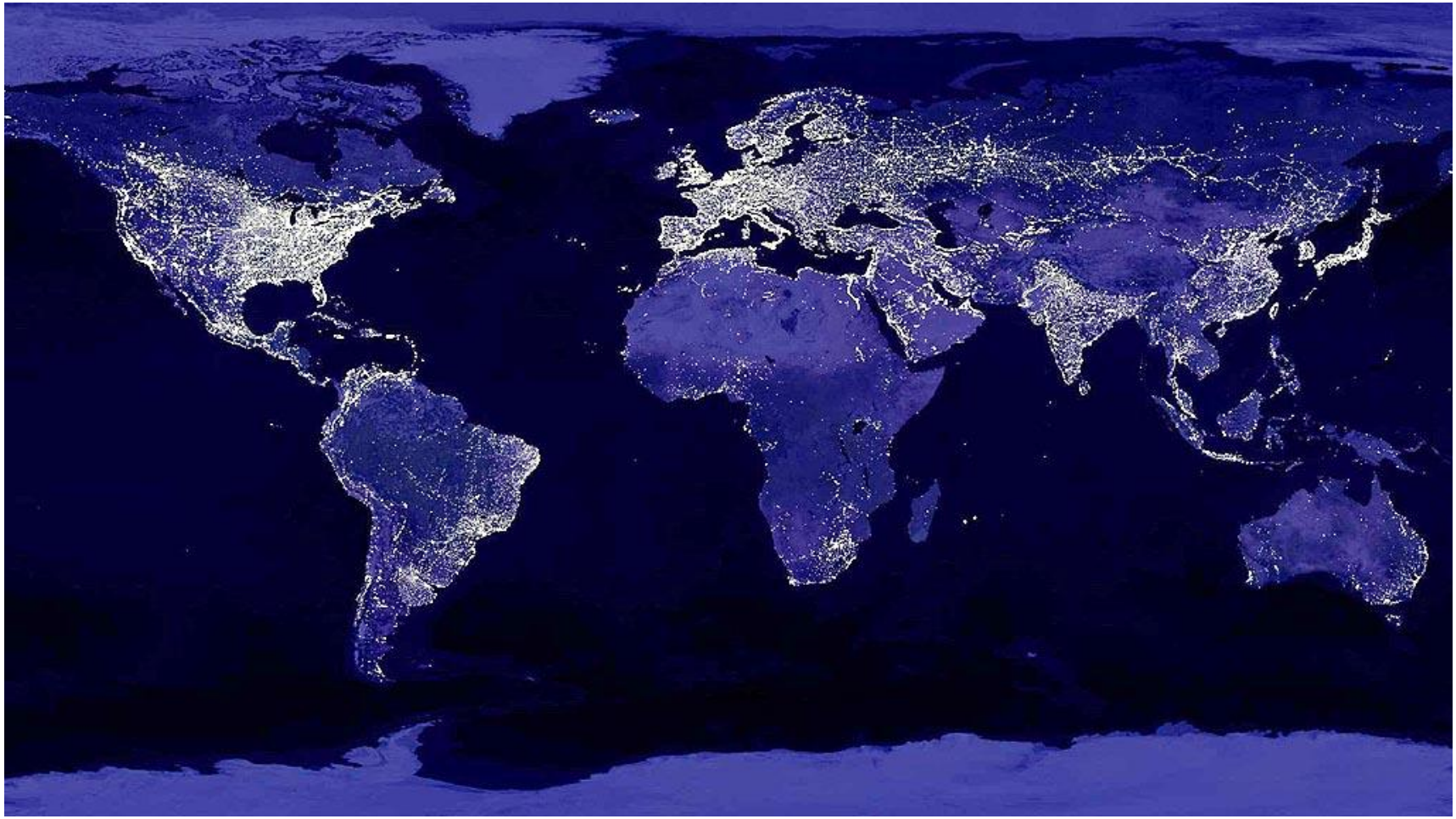


AC-DC Power/Energy Laboratories

Center for Energy and Electric Power Initiative Key Program Constituents / Industry Partners



A Brighter Future with Global Implications



Thank You

Contact Information

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