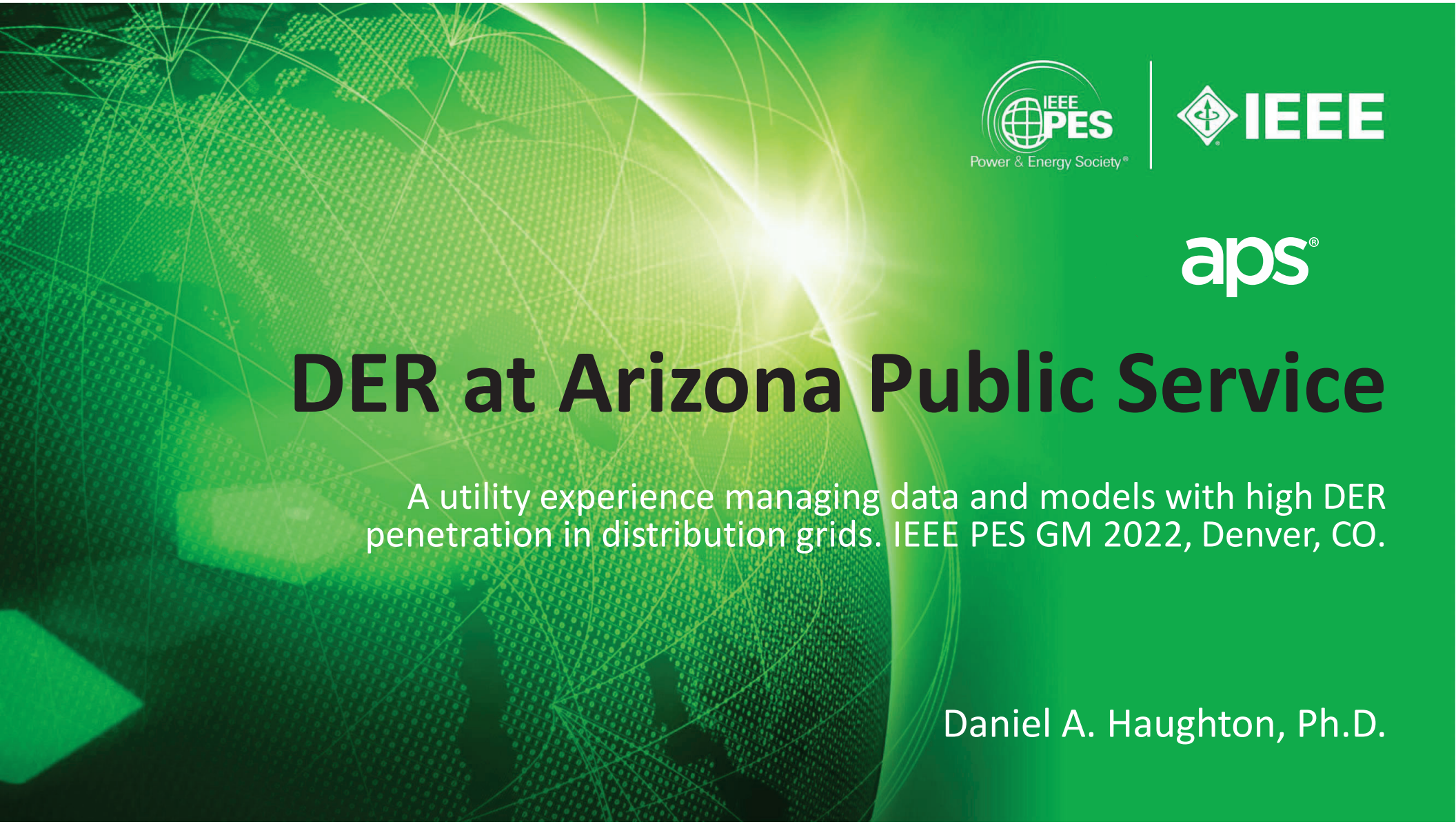


DER at Arizona Public Service

A utility experience managing data and models with high DER penetration in distribution grids. IEEE PES GM 2022, Denver, CO.

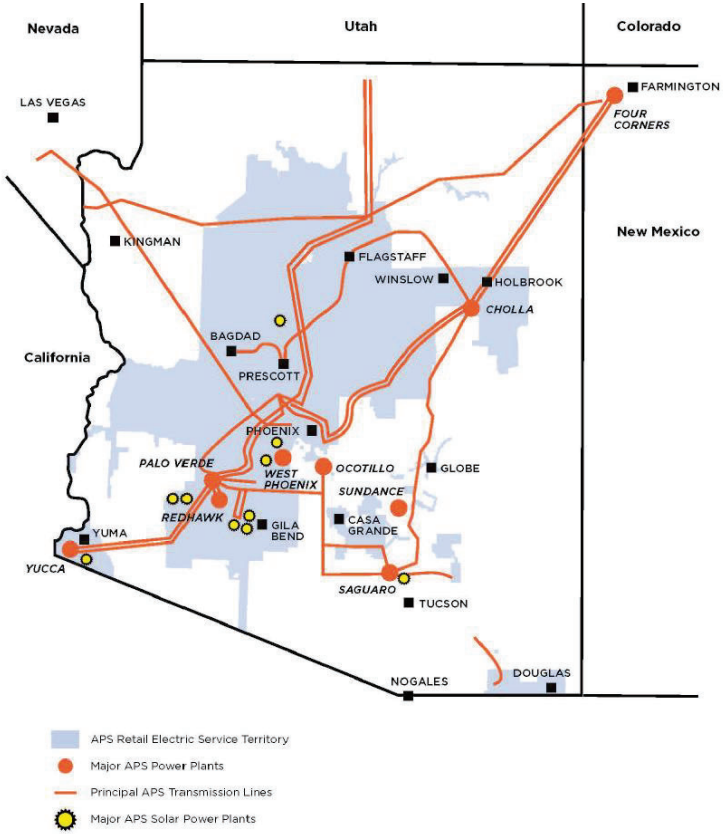
Daniel A. Haughton, Ph.D.

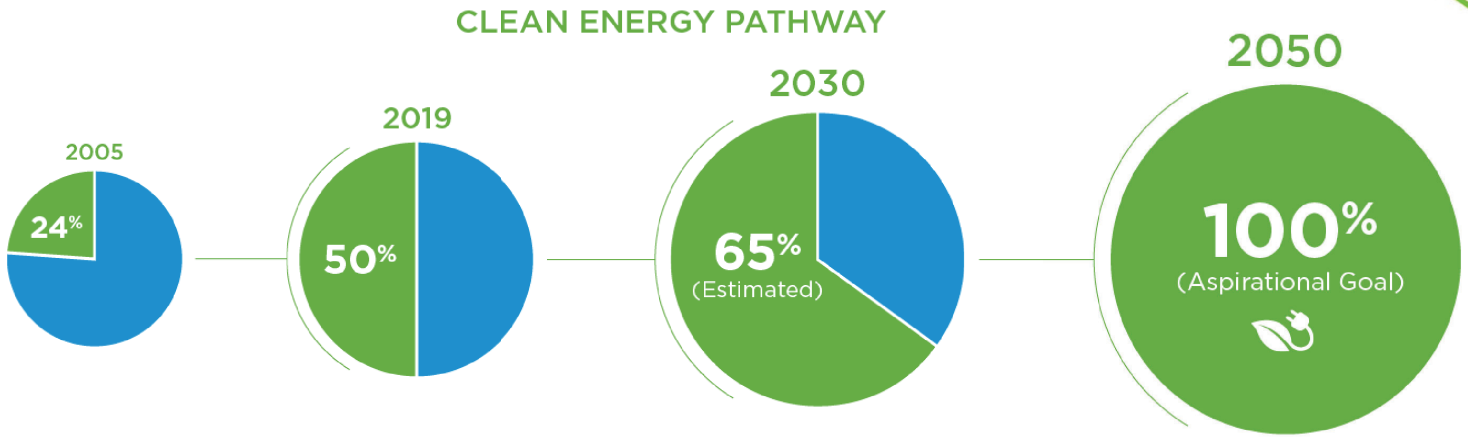
Today's Agenda

- ❑ APS Overview
- ❑ APS Clean Energy Commitment
- ❑ The Electric Power Industry and Decarbonization Efforts
- ❑ Defining The Customer Technology Landscape
- ❑ Data, Modeling, and DER

Arizona Public Service

- Arizona's largest IOU serving 11 of Arizona's 15 counties
- 34,646 square mile service area
- 1.3M customer meters, 2.7 M people
- Over 35,000 transmission and distribution line miles
- 430 substations; 300,000 transformers; over 550,000 poles and structures
- Operating voltages 500, 345, 230, 115, 69, 21, 12.47 kV
- System Peak Load 7,660 MW (2020)





Clean energy commitments

- 100% clean, carbon-free electricity by 2050
- 65% clean energy by 2030 with 45% renewable energy
- Eliminate coal by the end of 2031

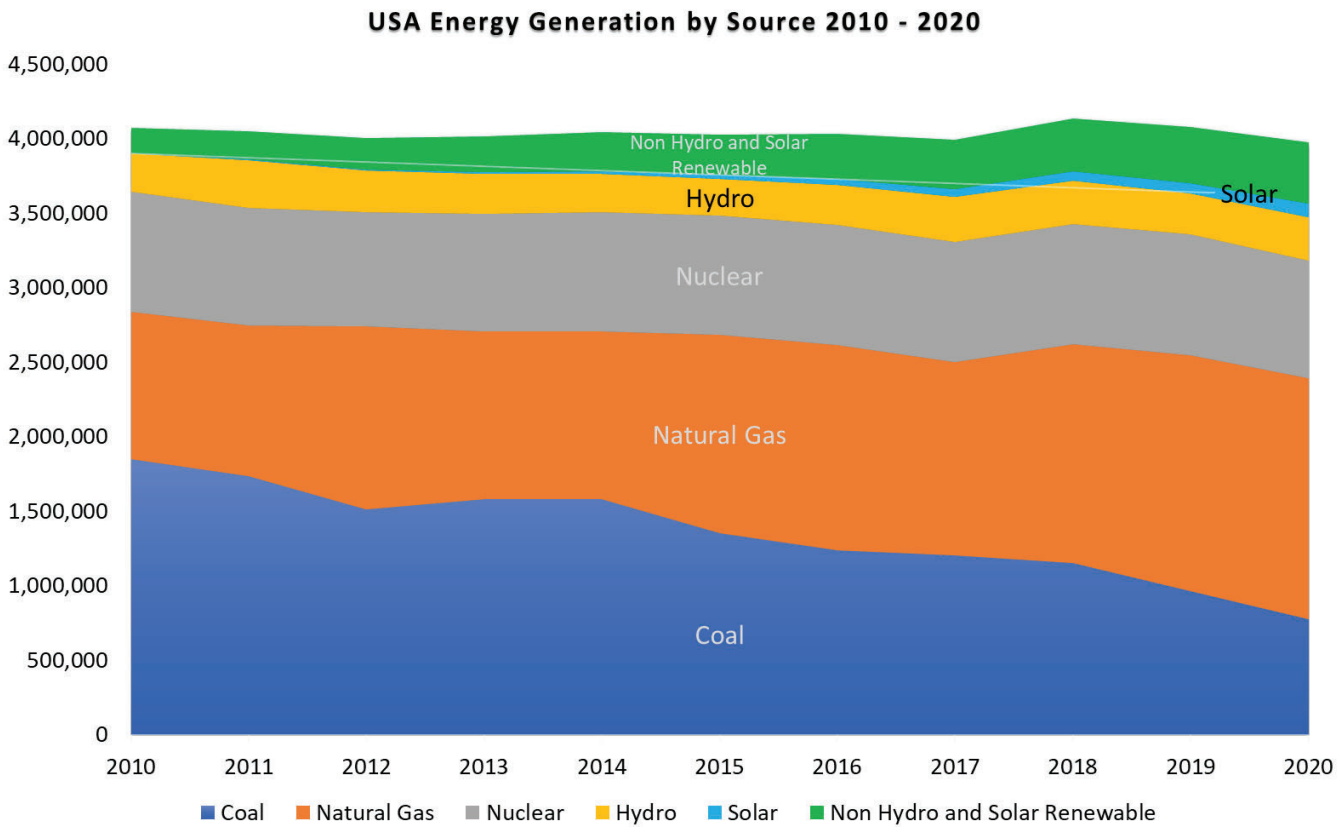
aps.com/cleanenergy

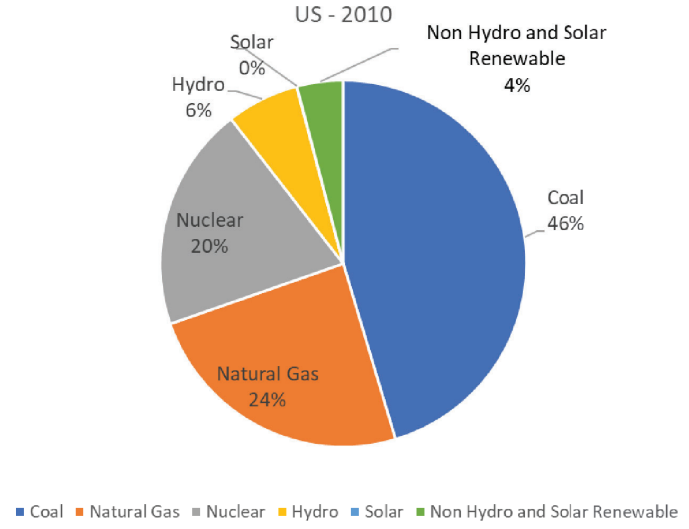
APS Clean Energy Commitment

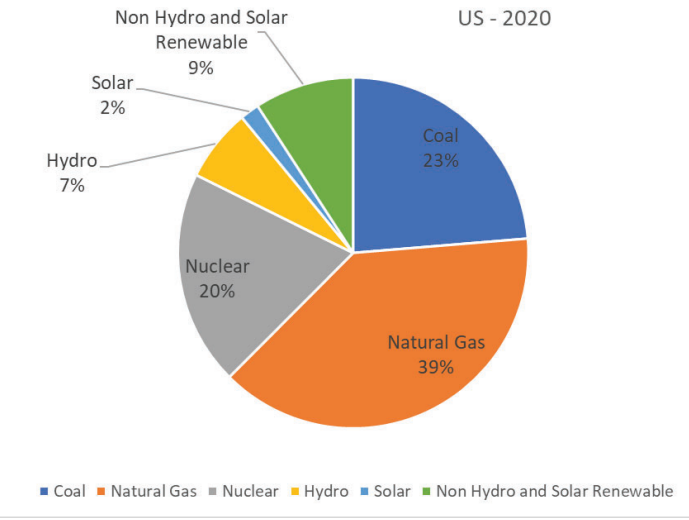
A clean economic future

- Meet our responsibility to power a low-carbon economy in AZ
- Guided by sound science to advance a healthy environment
- Market-driven energy innovation and a strong AZ economy are critical
- Starting from today's 50% clean energy mix, including EE, carbon-free, and clean energy from PVGS

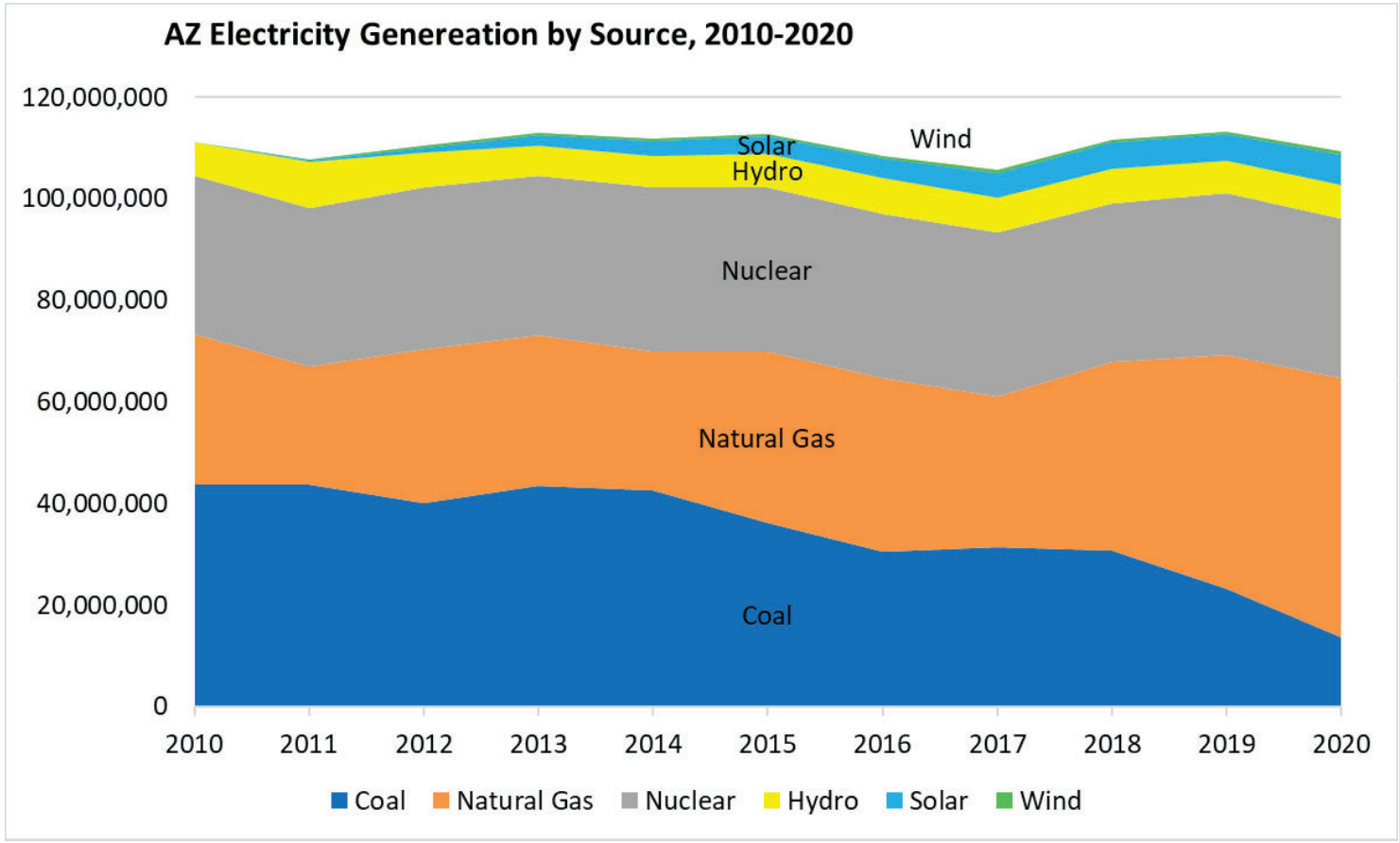
The U.S. Generation Mix

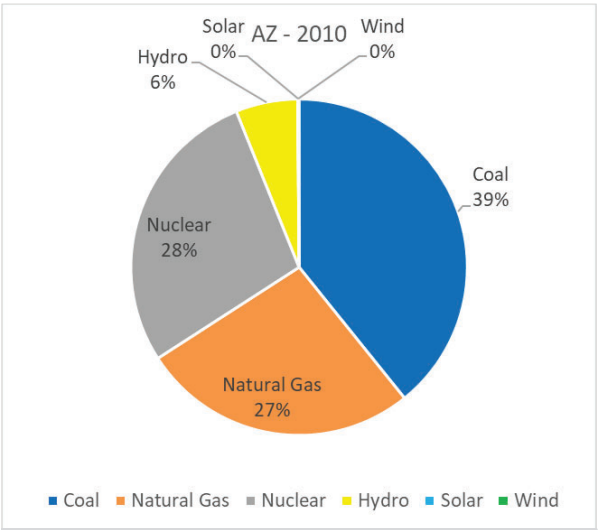


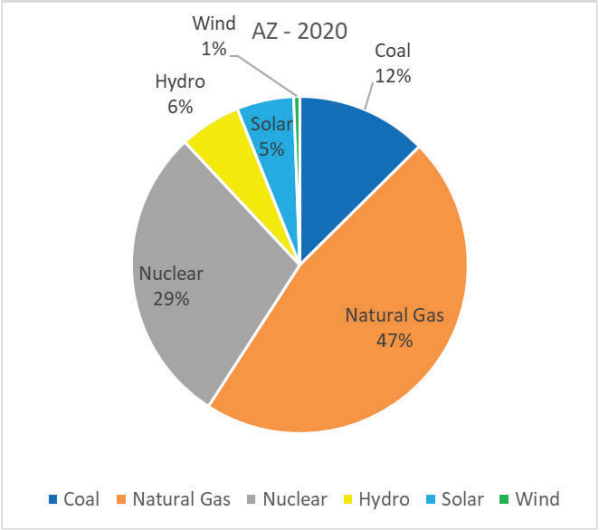




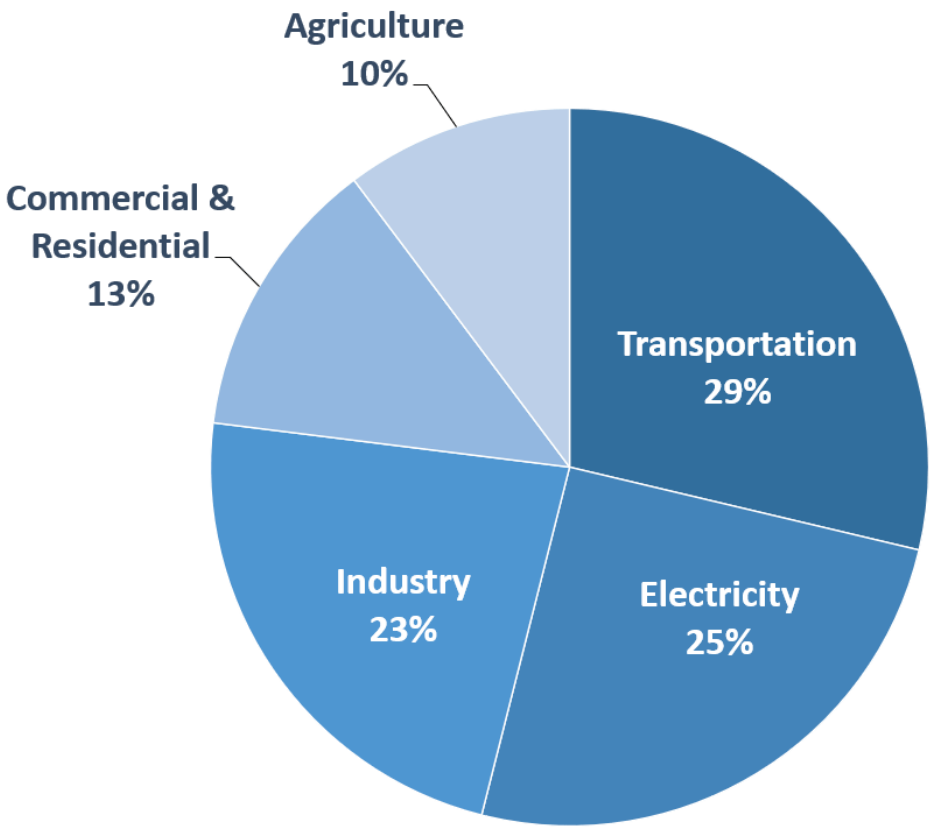
Arizona's Generation Mix







Total U.S. Greenhouse Gas Emissions by Economic Sector in 2019



U.S. Environmental Protection Agency (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019

Key Takeaways

- ✓ Electricity generation accounts for less GHG emissions than transportation
- ✓ Even with 100% reduction of power plant GHG emissions, decarbonization represents a significant challenge
- ✓ Other sectors must also decarbonize

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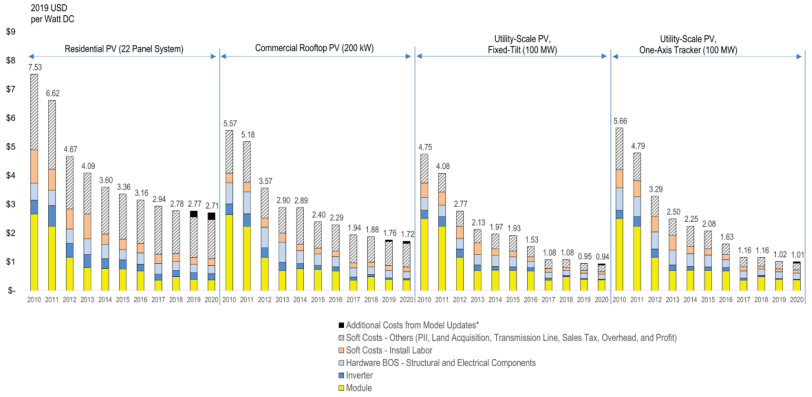
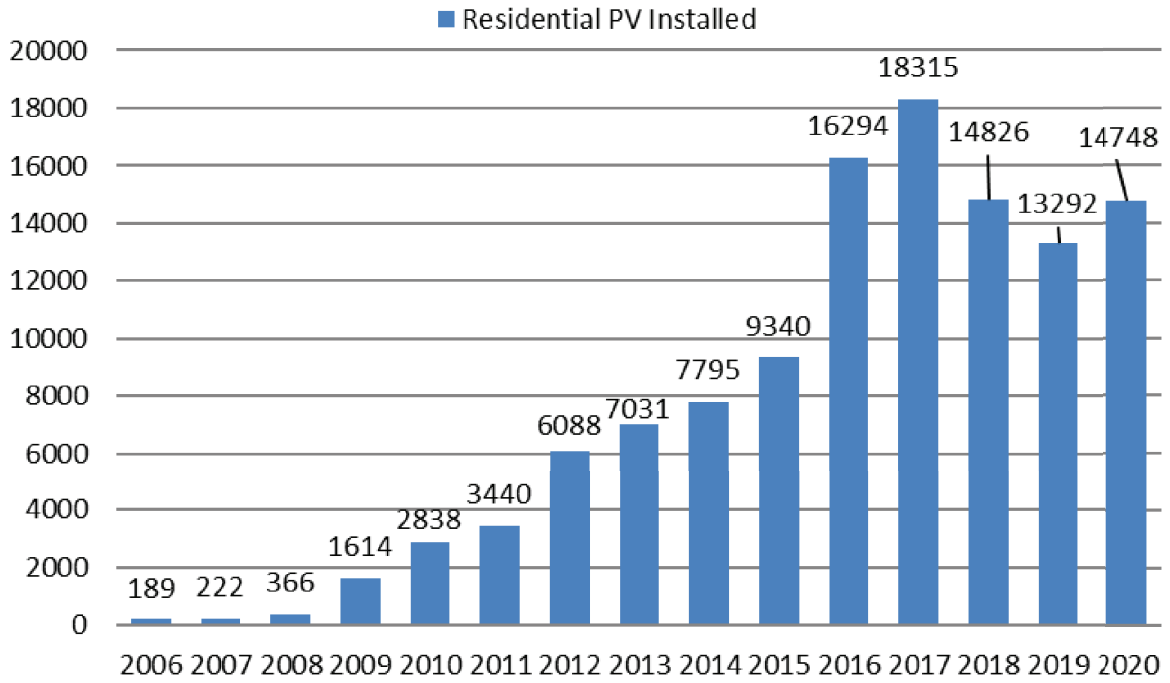


Figure ES-1. NREL PV system cost benchmark summary (inflation-adjusted), 2010–2020



https://www.nrel.gov/docs/fy22osti/80694.pdf

Solar PV

Energy Storage

Smart Thermostat

Electric Car

Home Energy Management

Instant Information

Data, Modeling and DER Conclusions

- The grid is becoming increasingly complex, and highly decentralized
- This decentralization requires a new planning and operating paradigm
- Decarbonization of utility assets is underway
- Decarbonization of other economic sectors must also accelerate
- Requires significant visibility, data and models to provide new insights
- Requires continuously evolving business models and tools