

# **Practical Approaches for Long-Range Decarbonization Planning under Uncertainty**

## **EPRI RESOURCE PLANNING FOR ELECTRIC POWER SYSTEMS**

Mort Webster

Pennsylvania State University

Energy and Mineral Engineering / Industrial and Manufacturing Engineering

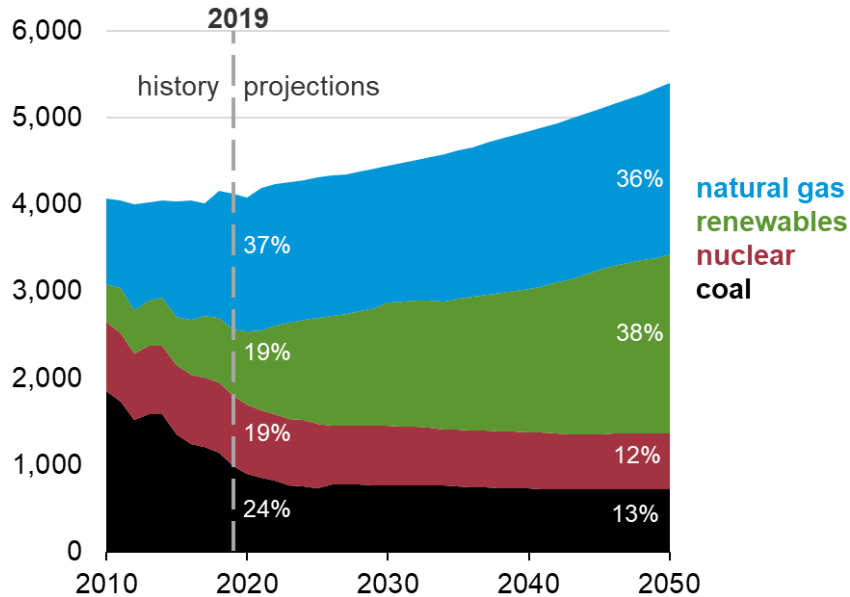
November 10, 2022

# Outline for Today

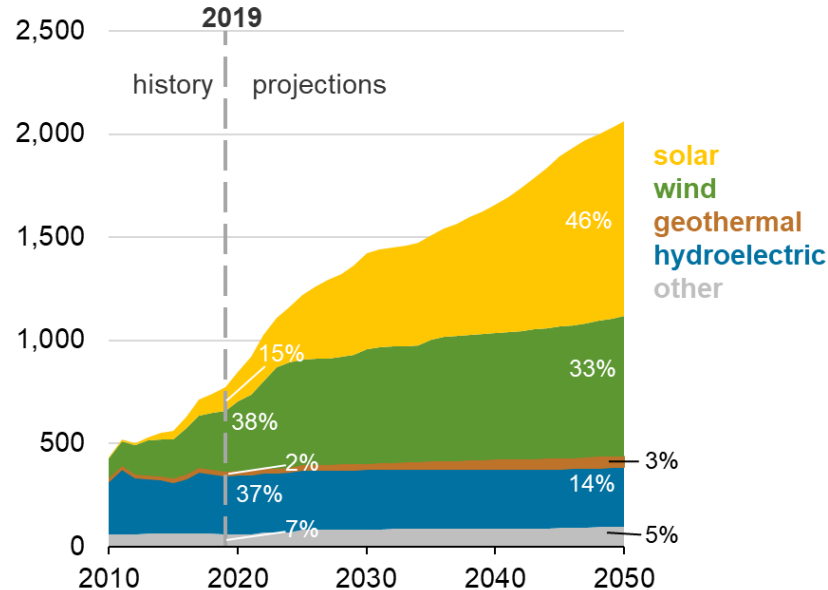
- Context:
- Example of Long-Term Planning for 80% target
- Common Myths about Stochastic Planning
- Discussion

# Context: Where are we going?

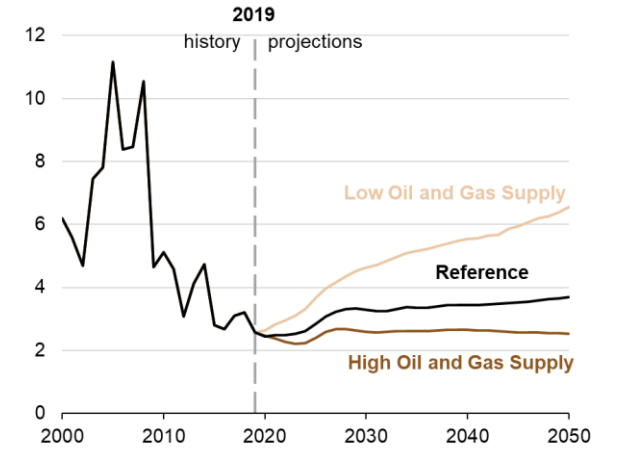
Electricity generation from selected fuels  
(AEO2020 Reference case)  
billion kilowatthours



Renewable electricity generation, including end use  
(AEO2020 Reference case)  
billion kilowatthours



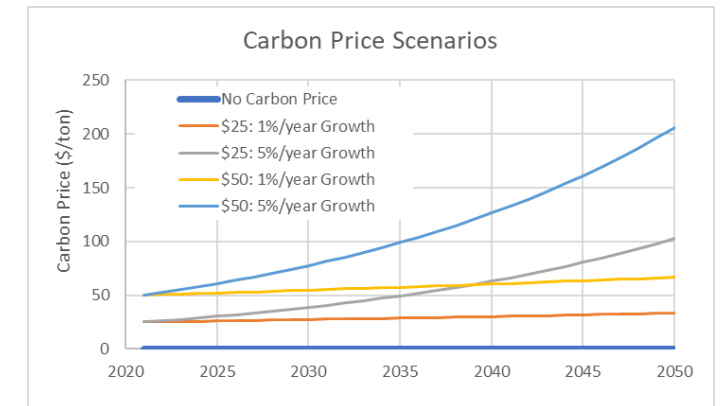
AEO2020 natural gas spot price at Henry Hub  
2019 dollars per million British thermal units



Source: Energy Information Administration, Annual Energy Outlook 2020

***“It's tough to make predictions, especially about the future”***

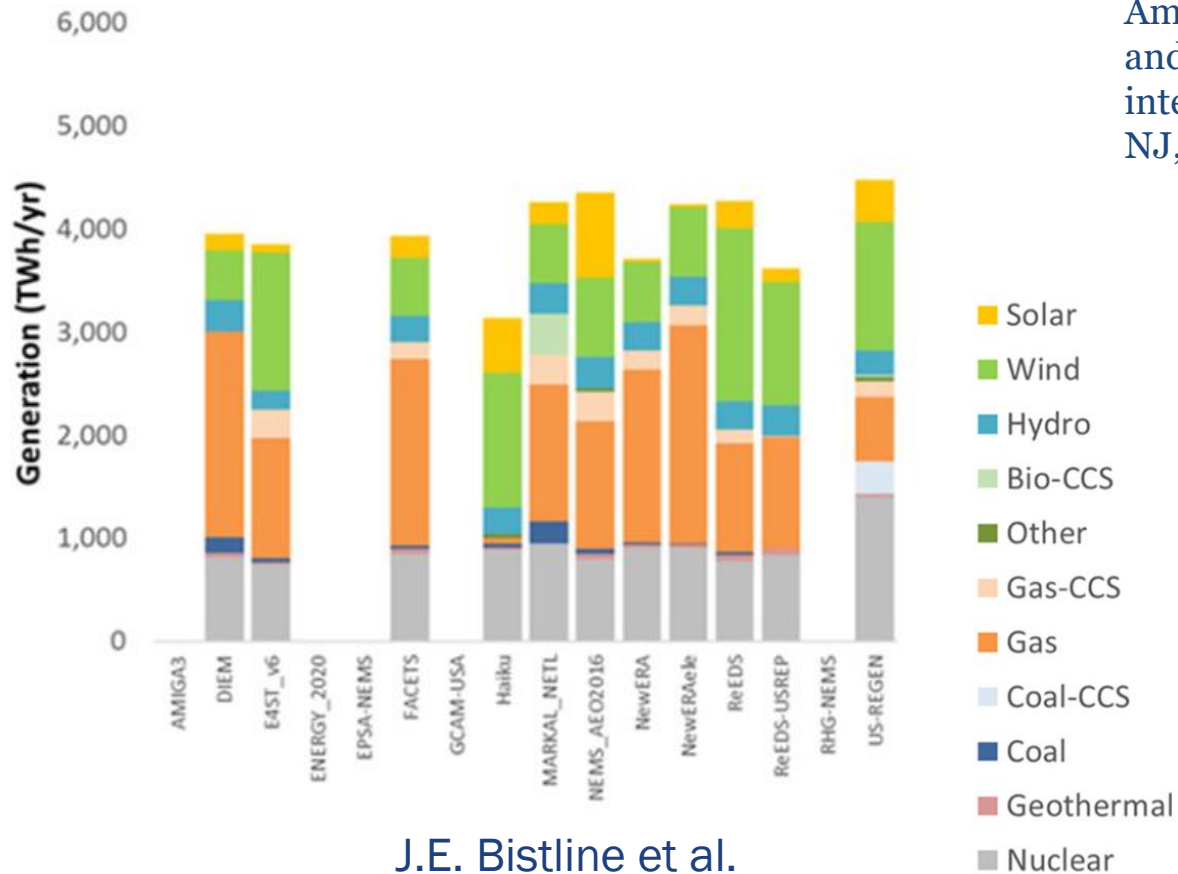
-- Yogi Berra, Baseball Player, Philosopher



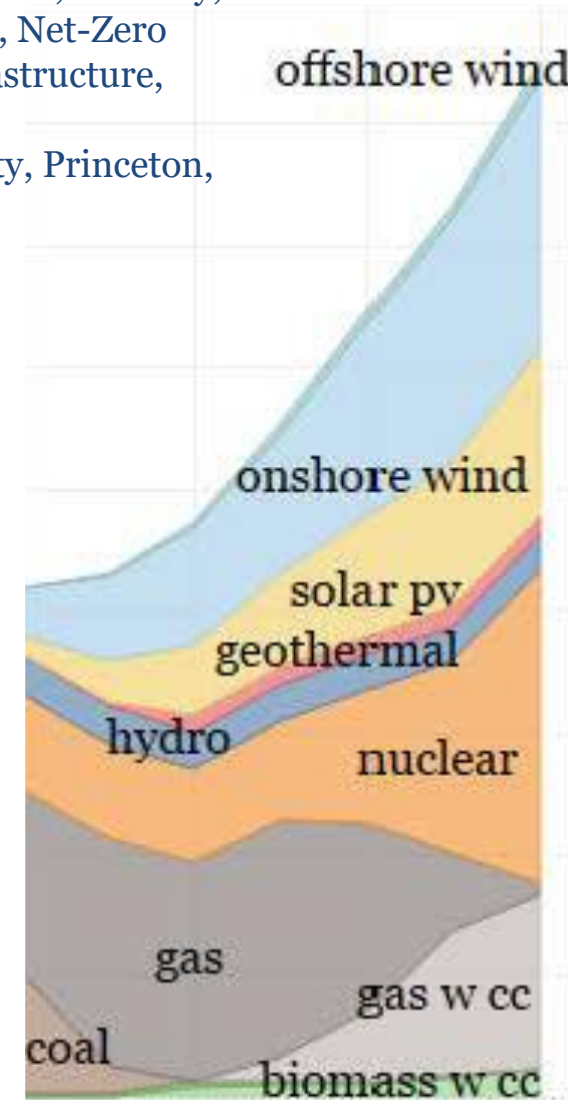
Barron, A.R., Fawcett, A.A., Hafstead, M.A., McFarland, J.R., & Morris, A.C. (2018). POLICY INSIGHTS FROM THE EMF 32 STUDY ON U.S. CARBON TAX SCENARIOS\*. Climate change economics, 9.

# Energy Transition Studies

E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang,  
 J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020.

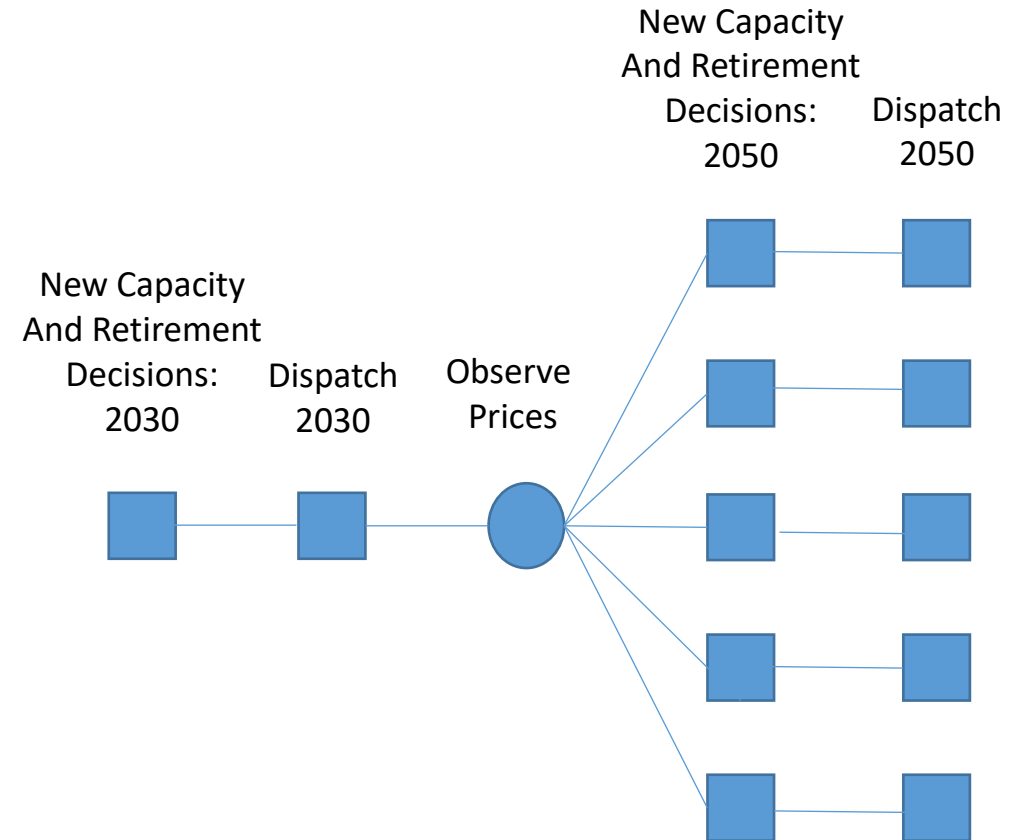


J.E. Bistline et al.  
*Energy Economics*  
 73 (2018) 307–325.



# Two-Stage Decision Under Uncertainty

- Choose near-term capacity additions and retirements
- Later, when you have more information, choose additional capacity, retirements
- Adaptive

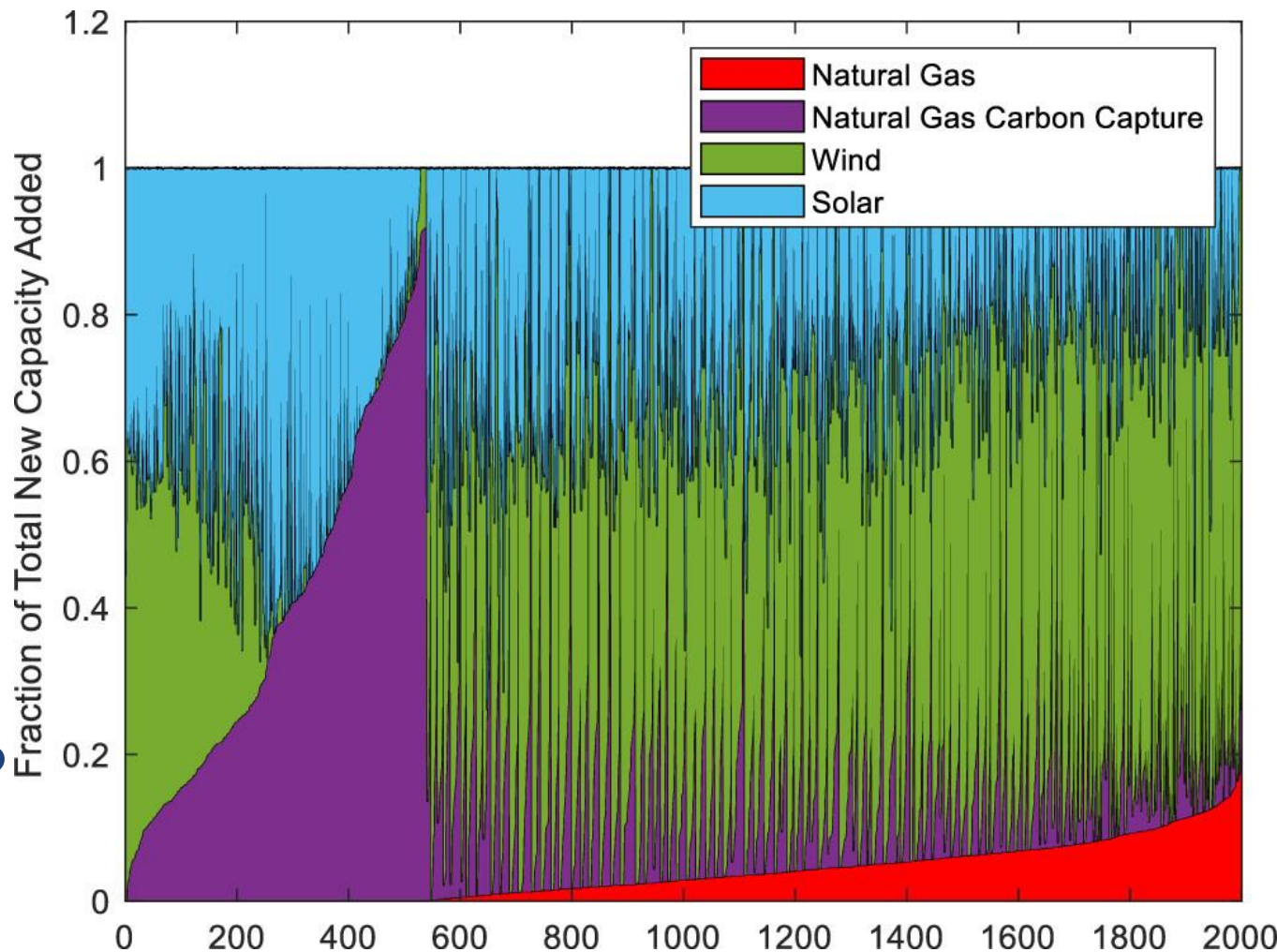


# Stylized Example

- Test System: ERCOT
- Two periods (2030,2050)
- 80% Carbon Reduction
- 2000 future scenarios
  - Fuel prices, tech costs
- Many candidate technologies

**Q: What should we do by 2030?**

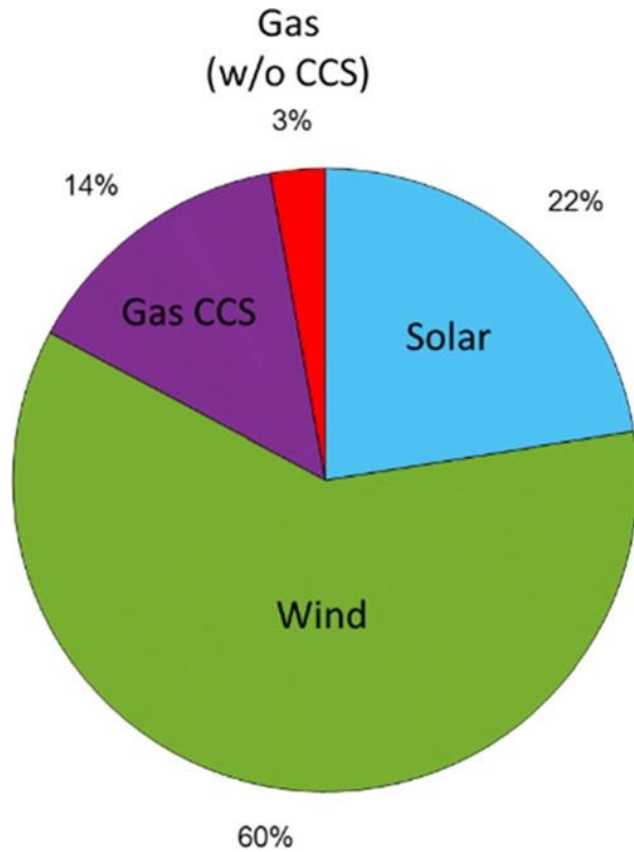
Decisions from Deterministic Scenarios



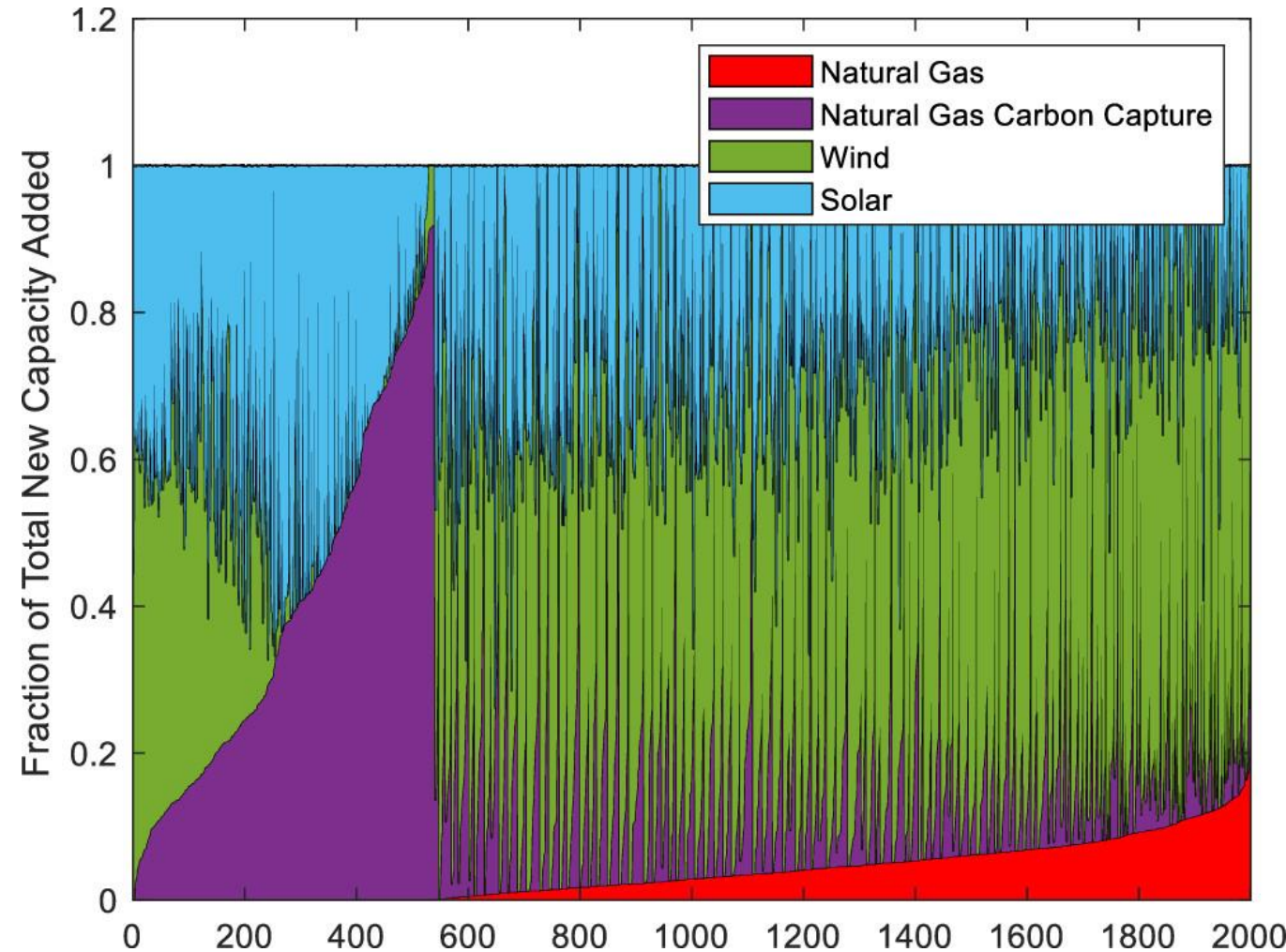


# Scenarios vs. Stochastic Optimization

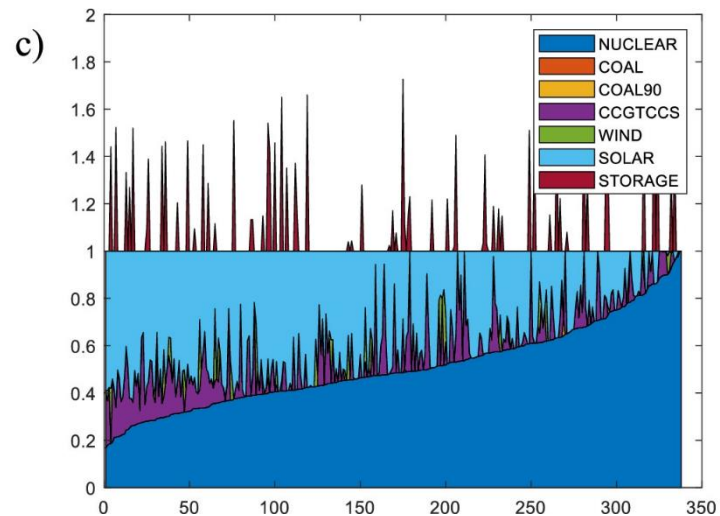
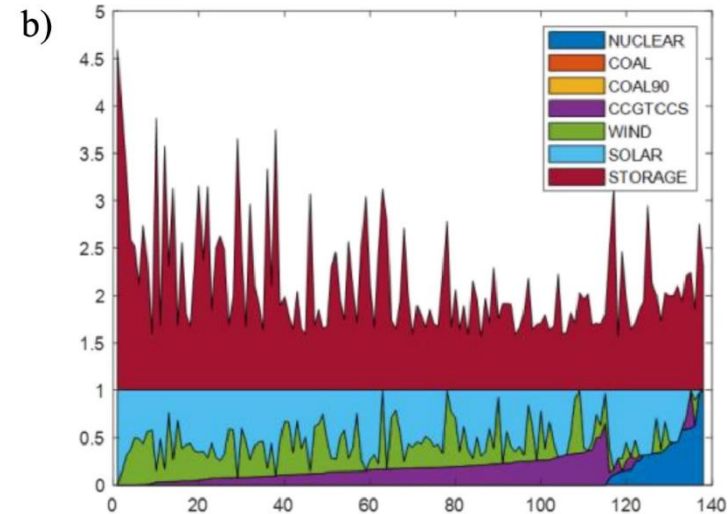
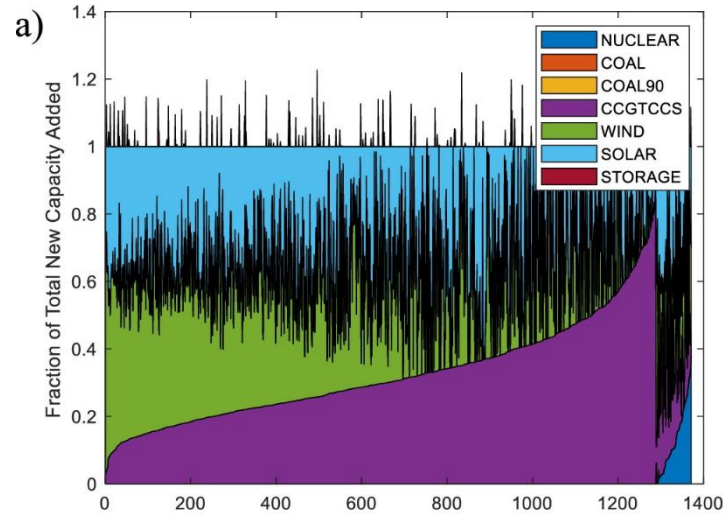
Decisions from Stochastic Planning Model



Decisions from Deterministic Scenarios



# Stochastic Planning: Do not need to commit to one plan for the later periods





# Dispelling Some Common Myths

- It will take too long to run many scenarios
  - Use HPC, scenario selection methods
- We don't know the probability distribution
  - No different than coming up with scenarios
- No one will understand a stochastic/probabilistic analysis
  - Everyone does this in their daily lives (GPS, insurance, games)
- Stochastic analysis is unrelated to resource adequacy
  - Deterministic targets – approximate a stochastic solution
  - Probabilistic Targets – need a stochastic tool to assess

# Dispelling Some Common Myths

- Stochastic methods are always better
  - For some problems, deterministic scenarios are sufficient
- Can't use stochastic models for real decisions
  - You don't use deterministic models for decisions either – just information
- I don't have the time/staff to learn a whole new tool
  - Methods can be wrapped around existing production cost tools

# Approaches to Stochastic Planning

- Traditional:
  - One large optimization model that includes investments and operations
  - Use of decomposition methods to reduce solution time
- Alternative:
  - Use an existing operations / production cost model
  - Build the stochastic investment module outside of the operations model
  - Use the costs of sample investments to “learn” the best plan

# Example of Alternative Approach

- GE-MAPS
  - Existing production cost model
  - Use for planning relied on manual/heuristic investments
- Current Project
  - Adding capacity expansion (scenario & stochastic) module for GE-MAPS
  - Will call GE-MAPS for sample plans
  - Uses machine learning techniques to iteratively find the best plan
- Benefits
  - Customers do not need to get/learn a new model
  - Investment solution is already in the format of the production cost model

# Discussion Questions

- What are concerns about exploring stochastic planning?
- What would be the benefit to your organization of adding stochastic planning to the existing tool set?
- What can you not do with current resource planning tools?
- What types of uncertainty are most relevant?
- What does an ideal 30-year plan look like?