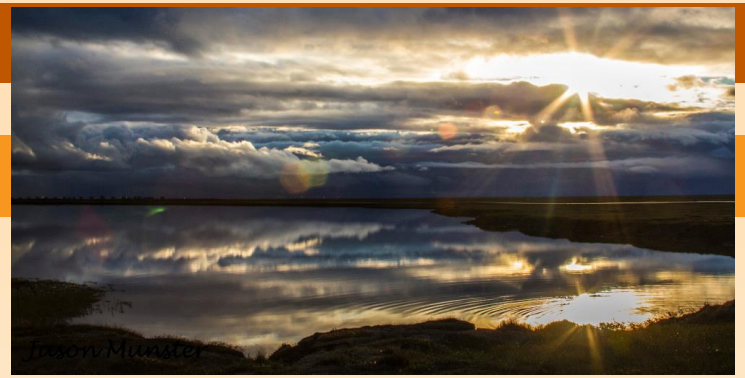

Comparing Life-Cycle Environmental Impacts of Electricity Generation Systems

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Bureau of Economic Geology, Jackson School of Geosciences, University of Texas at Austin
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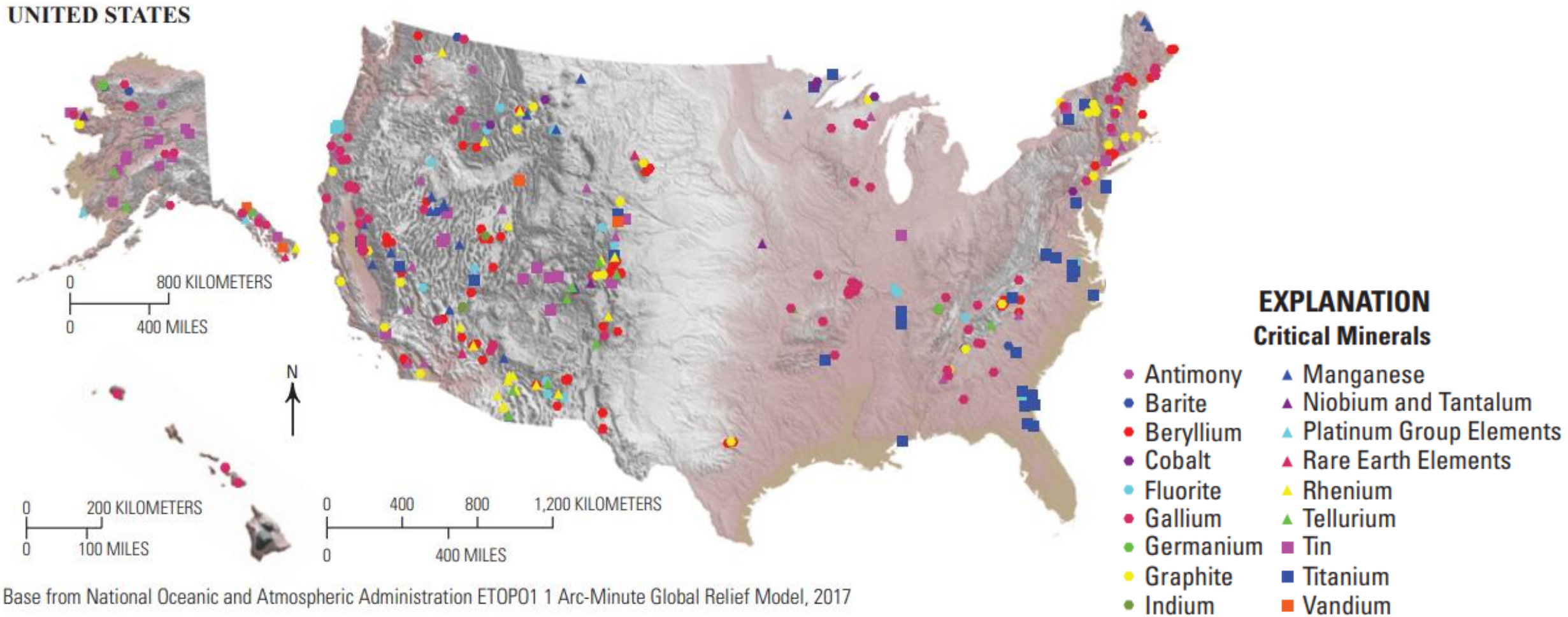
Critical Materials in the US



Base from National Oceanic and Atmospheric Administration ETOPO1 1 Arc-Minute Global Relief Model, 2017

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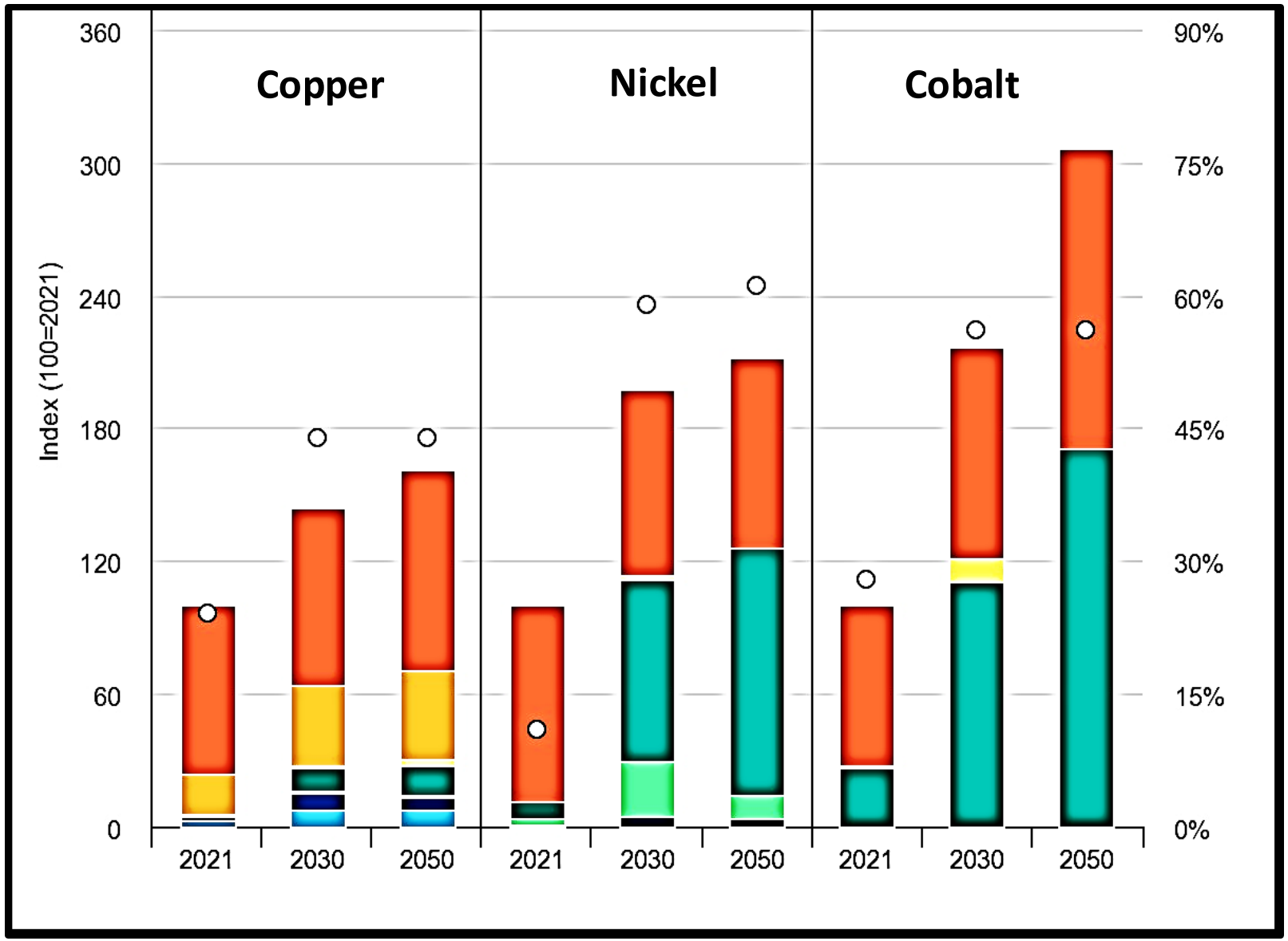
Ref: United States Geological Survey (USGS):https://www.usgs.gov/media/images/united-states-critical-minerals-locations

Critical Materials in the Energy Transition



- Solar PV
- Wind
- Other low-emissions power generation
- Electric vehicles
- Grid storage batteries
- Electricity networks
- Other
- Share of clean energy technologies

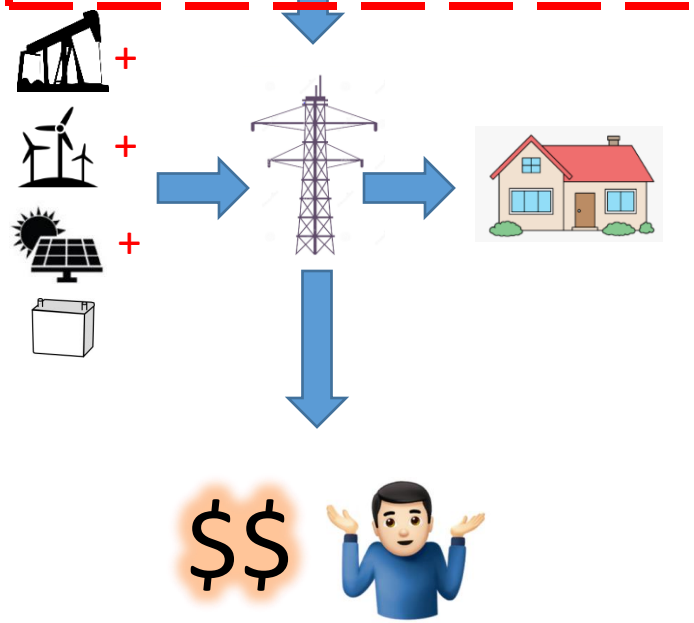
Motivation for Our Studies

- **We can expect significant Earth material processing needs at decadal and global scales to reach climate change mitigation goals.**

- *We are motivated to understand tradeoffs between society's goals of mitigating climate change, preserving biodiversity and ecosystems, and providing reliable and affordable energy to a global community of 8 billion people.*

Three Phases in This Research

Phase 1 – conduct and compare cradle-to-grave life-cycle assessment of electricity generation options (+ battery storage). Consider 17 environmental pathways, plus CO_2e and ecosystem services

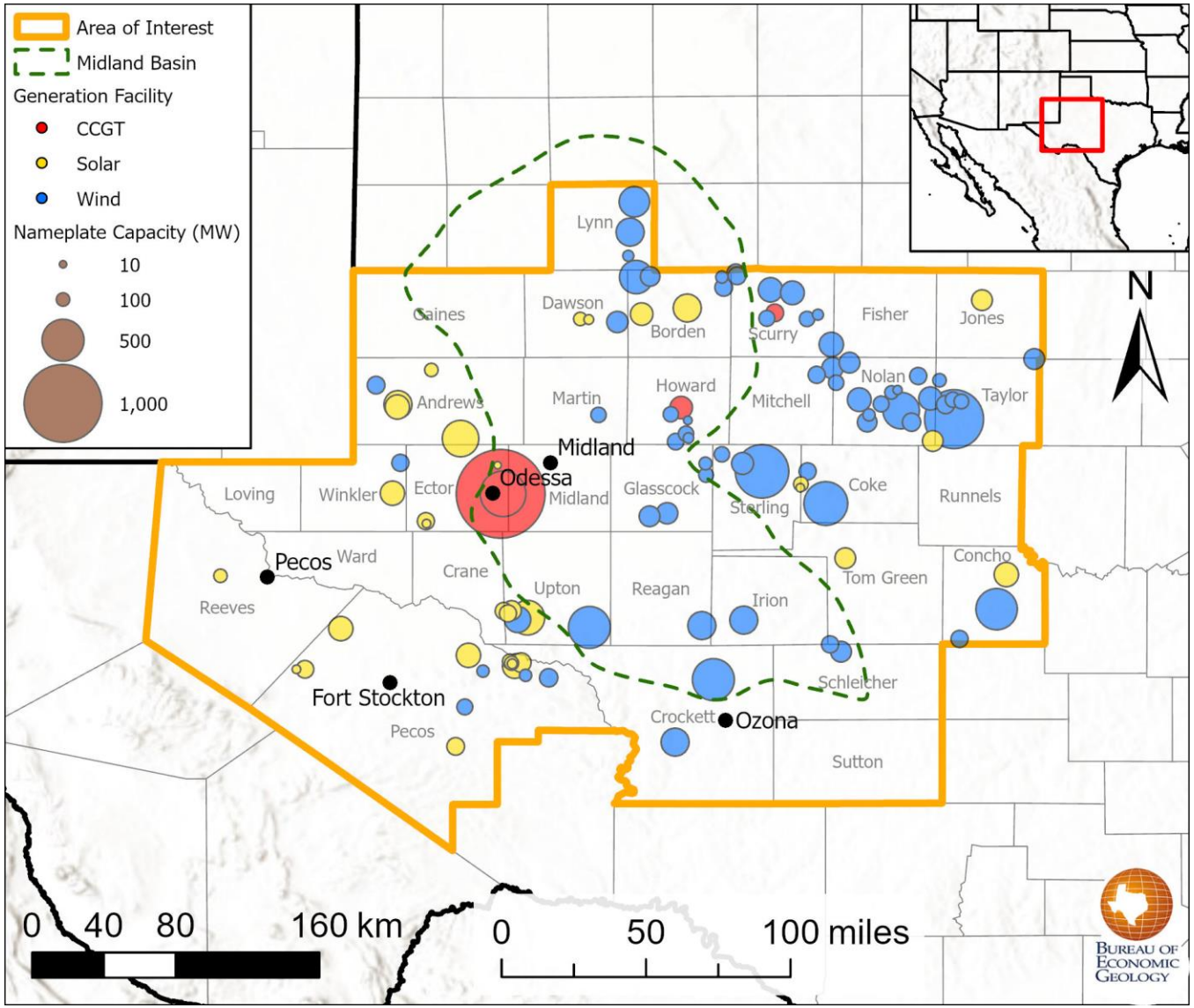


Phase 2 – combine and test different combinations of generation options using electricity dispatch models, assess the highest reliability at the lowest environmental demand throughout 30 year period.

Phase 3 – estimate the cost of electricity to the consumer, including integration costs, externalities, etc.

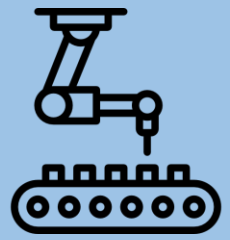
Area of Interest*

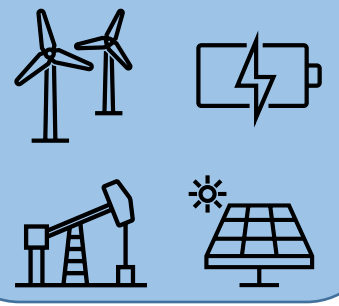
- West Texas – including Midland and Delaware Basins
- *Approach is designed for portability, so that "facility" can be moved to any location, changing fuel cycle and T&D parameters



Life Cycle Assessment of Global Supply Chain and Power Plants

Sourcing	Processing	Manufacturing	Operations	End-of-Life
All materials from Earth and ecosystems REE's, Co, Cu, Li, Ni, natural gas	Conversion to useable forms Individual processing techniques	Manufacturing of components (e.g., solar panels, wind turbines, magnets, gas turbines, batteries)	Operation of electricity generating units (30 years)	Land allocation for by-products, expired components, recycling, disposal, etc.





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Some Impact Categories Being Considered

WATER CONSUMPTION & CONTAMINATION

GLOBAL WARMING POTENTIAL

RESOURCE DEPLETION

LAND USE

ACIDIFICATION

EUTROPHICATION – FRESHWATER, TERRESTRIAL

ECO-TOXICITY (FRESHWATER)

BIODIVERSITY AND ECOSYSTEM SERVICES

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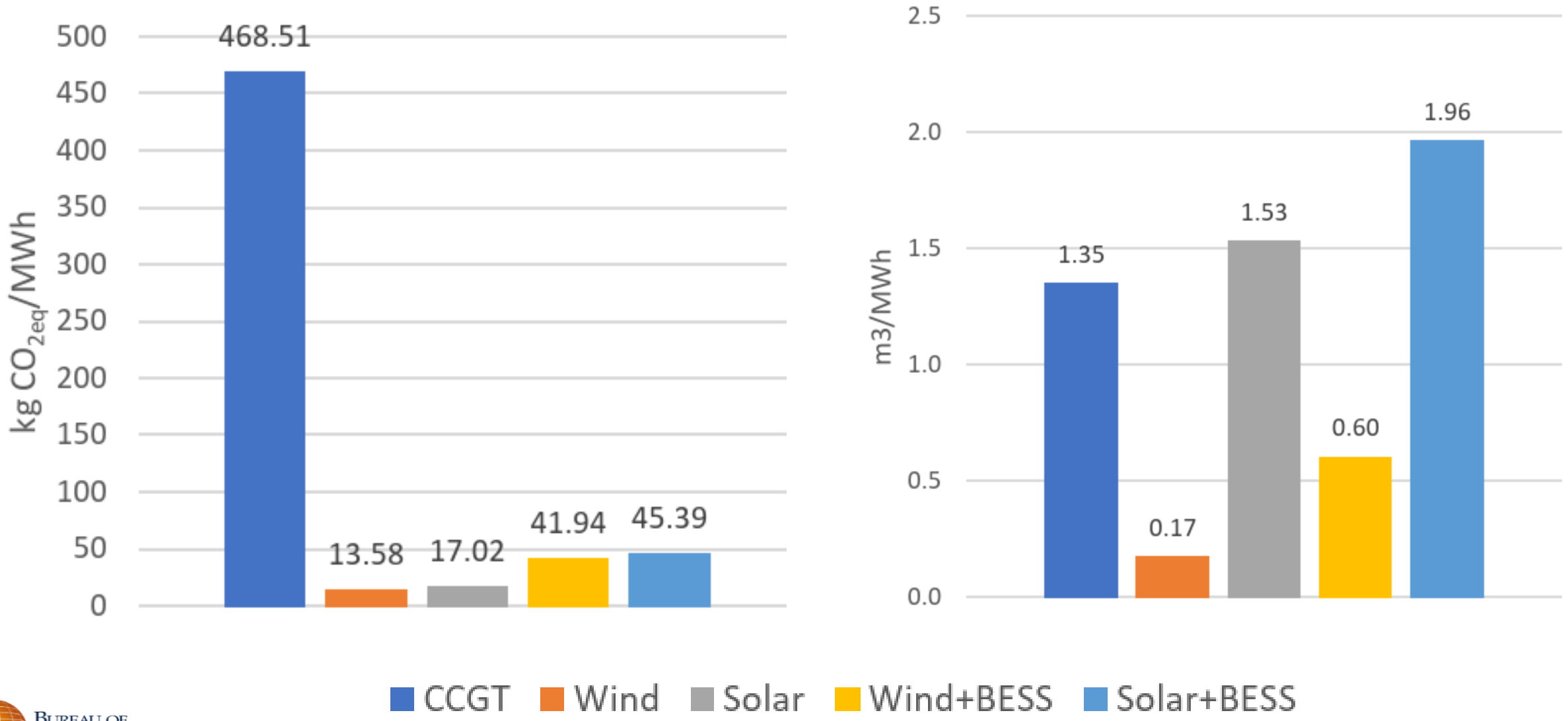
Images: Shutterstock, https://eplca.jrc.ec.europa.eu/

Total Life-Cycle CO_2e and Water Consumption



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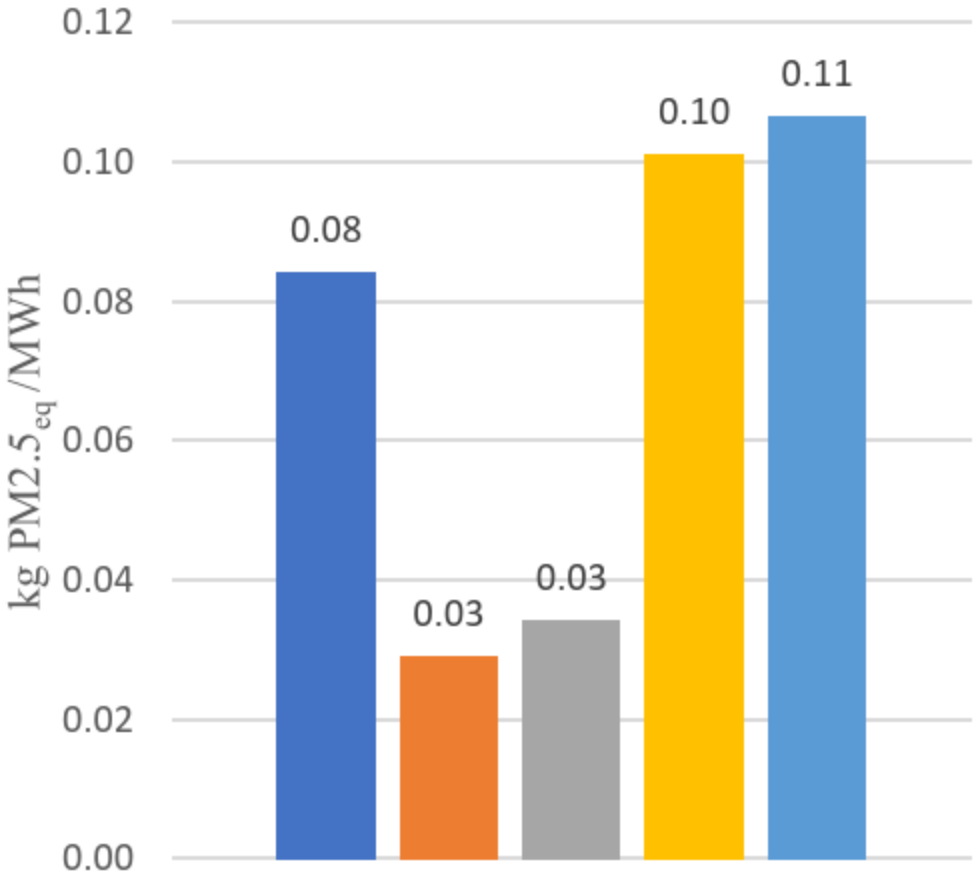
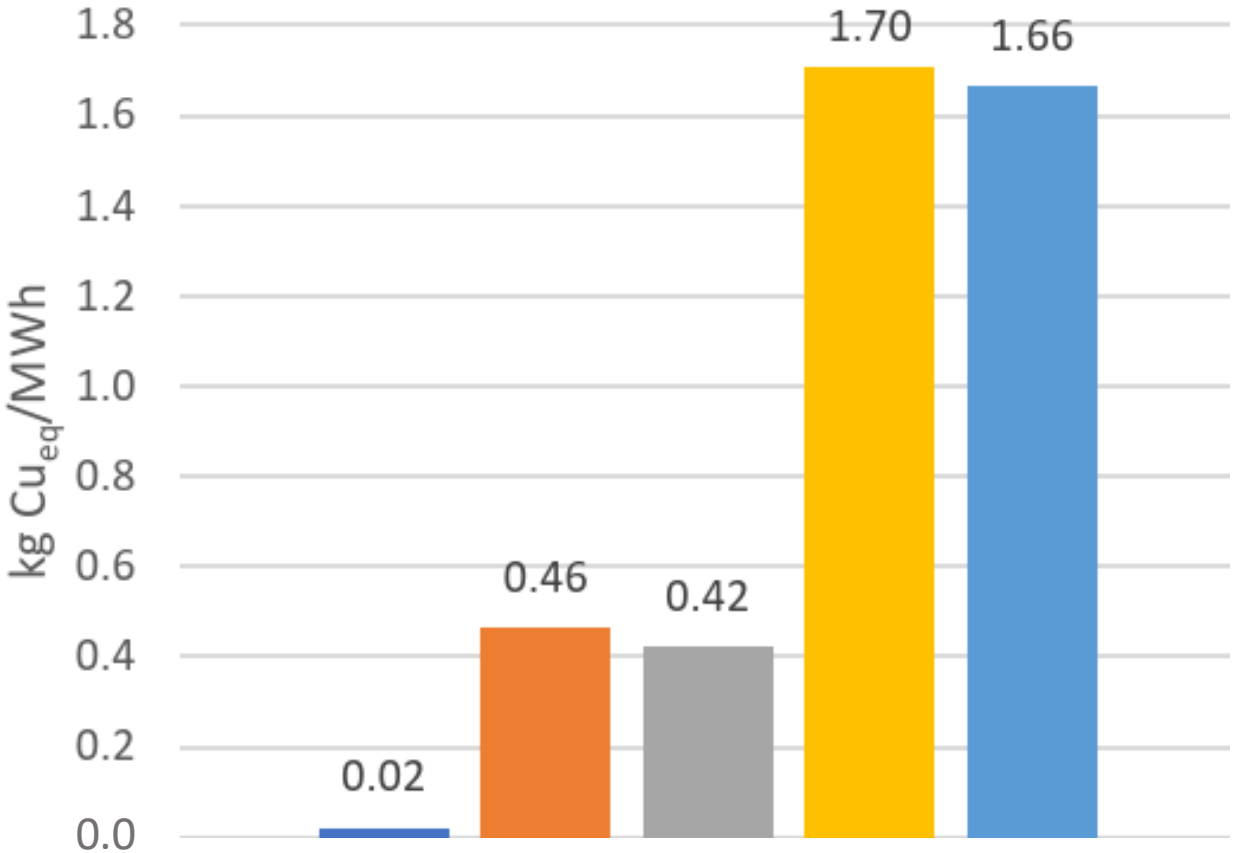
Total Life-Cycle PM2.5 and Mineral Scarcity





CCGT Wind Solar Wind+BESS Solar+BESS

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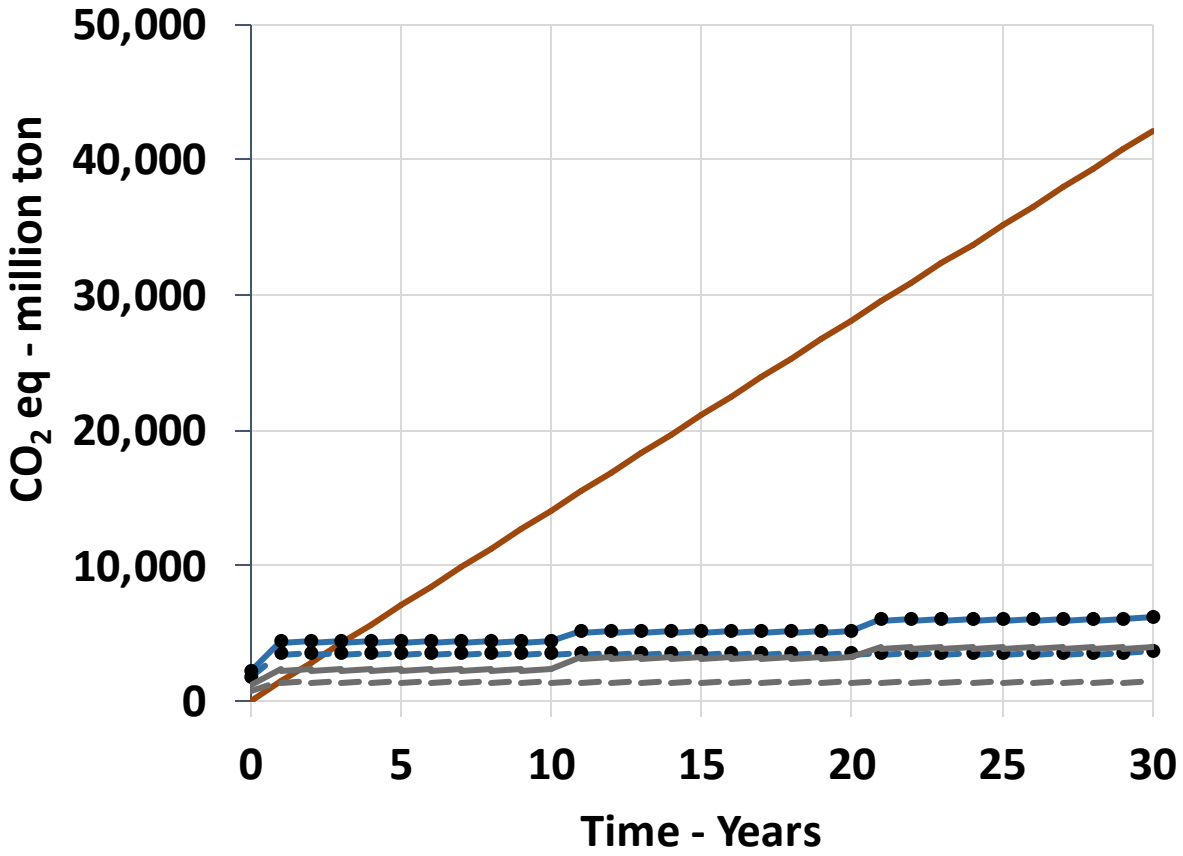
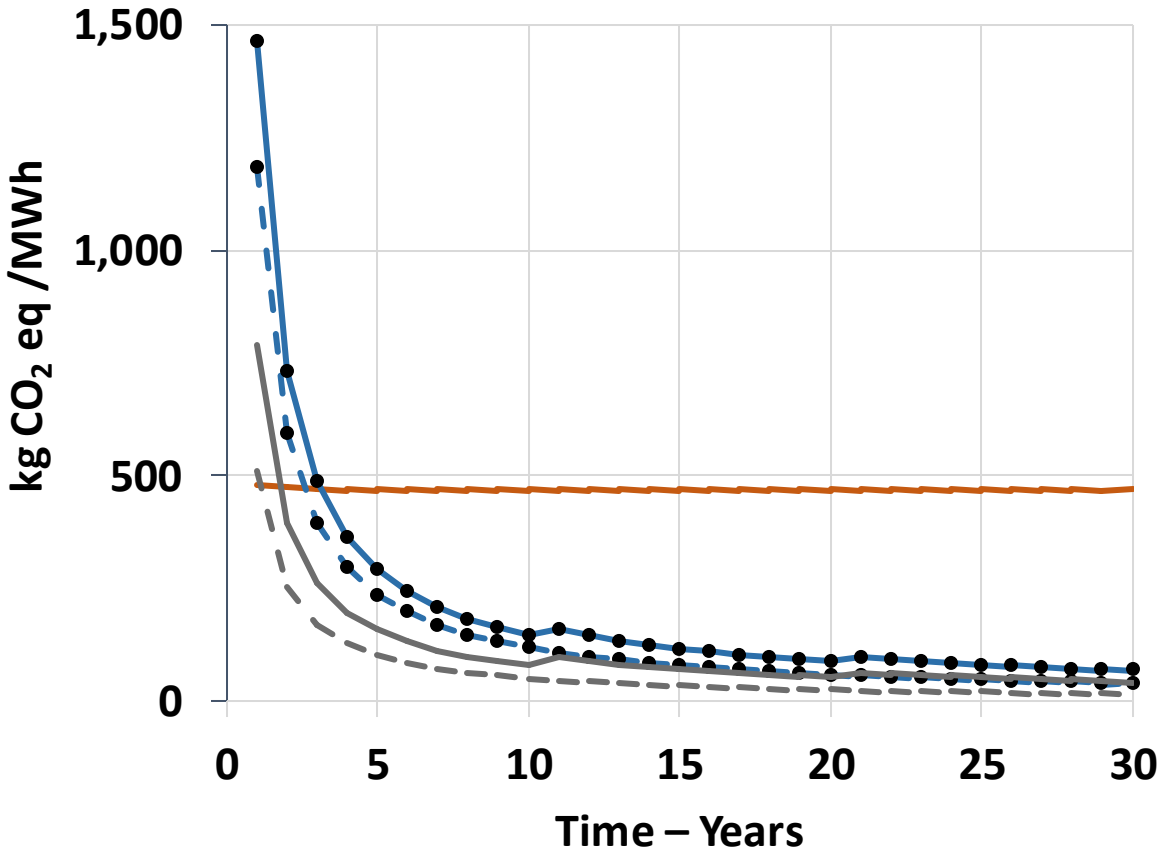
How Do Generation Options Compare with Time – CO_2eq?





CCGT Wind Solar Wind+BESS Solar+BESS

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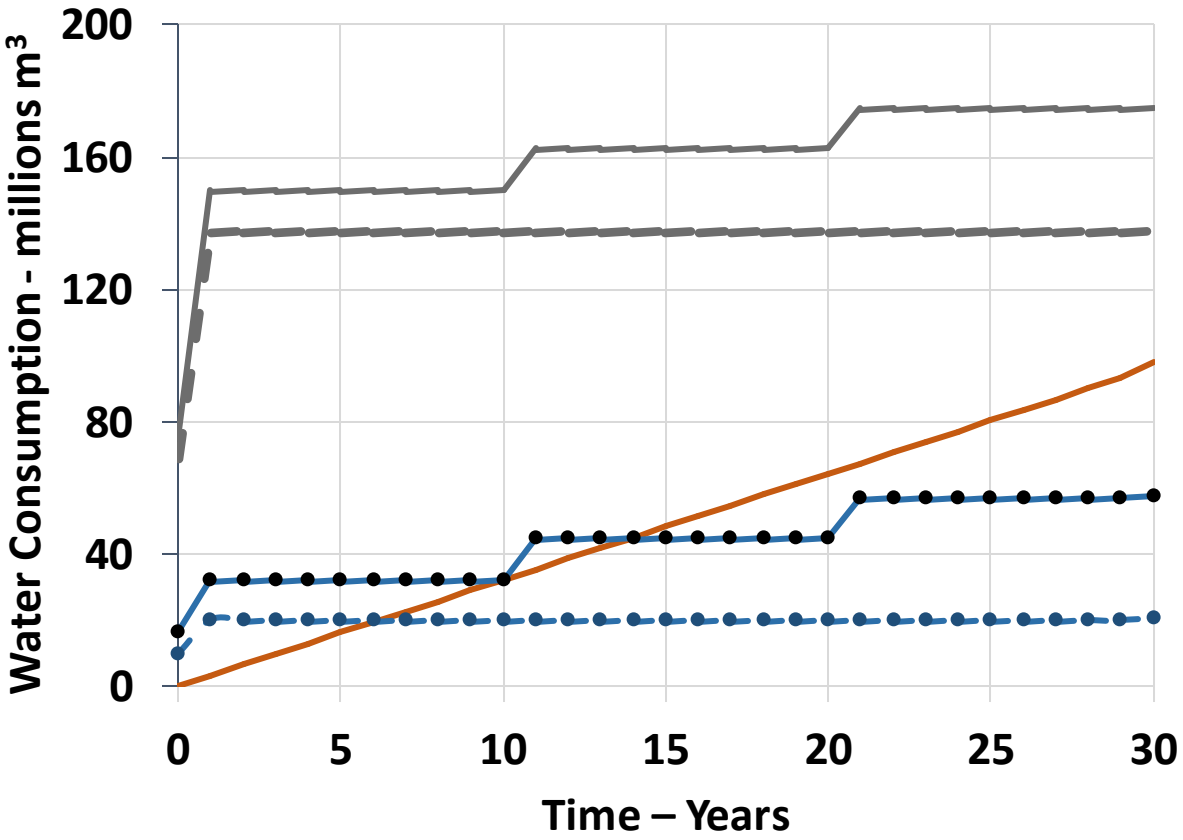
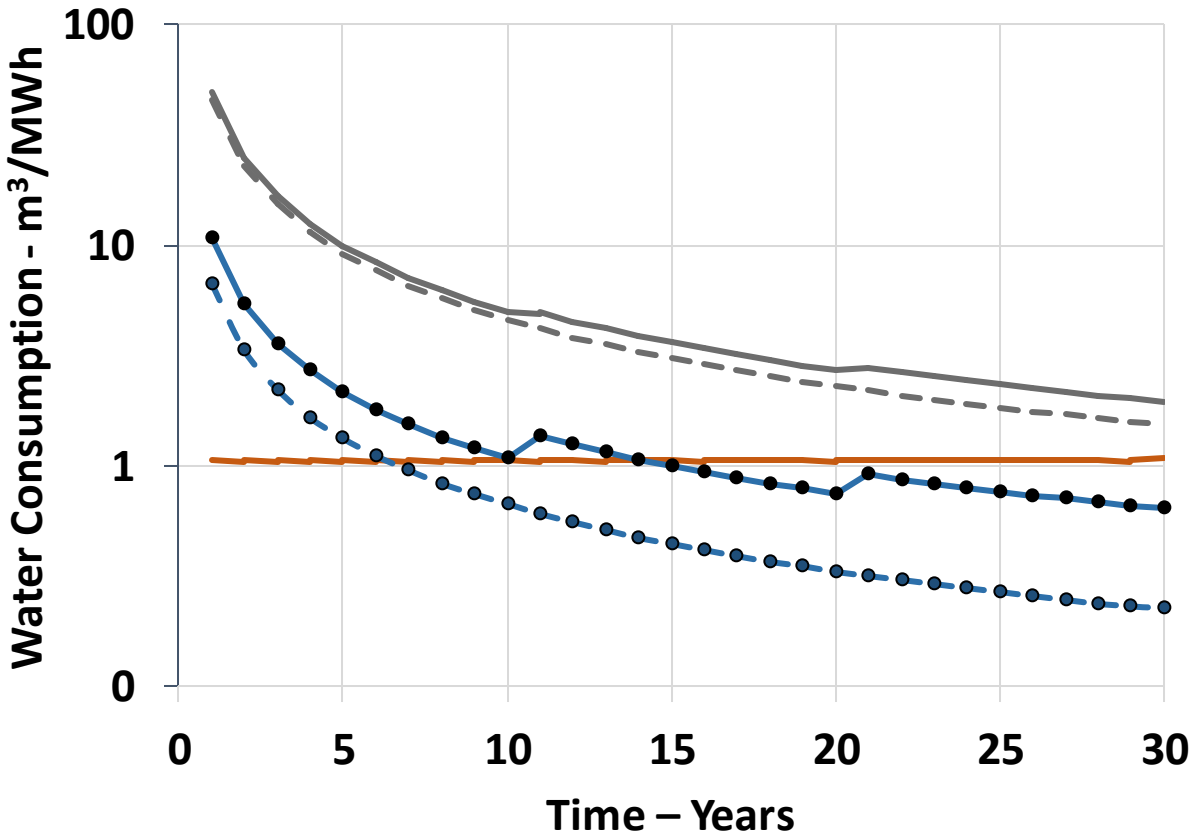
How Do Generation Options Compare with Time – Water?





CCGT Wind Solar Wind+BESS Solar+BESS

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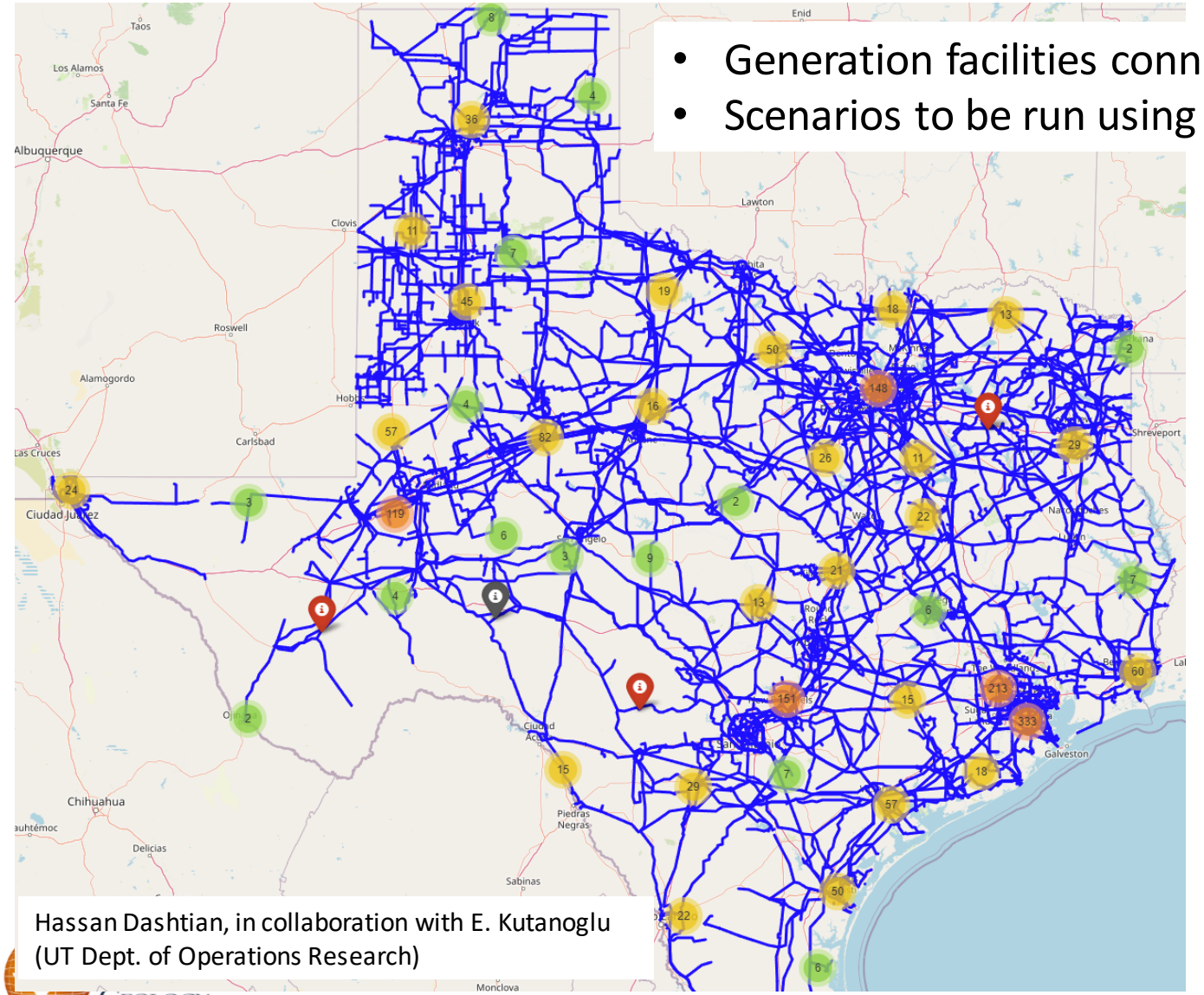
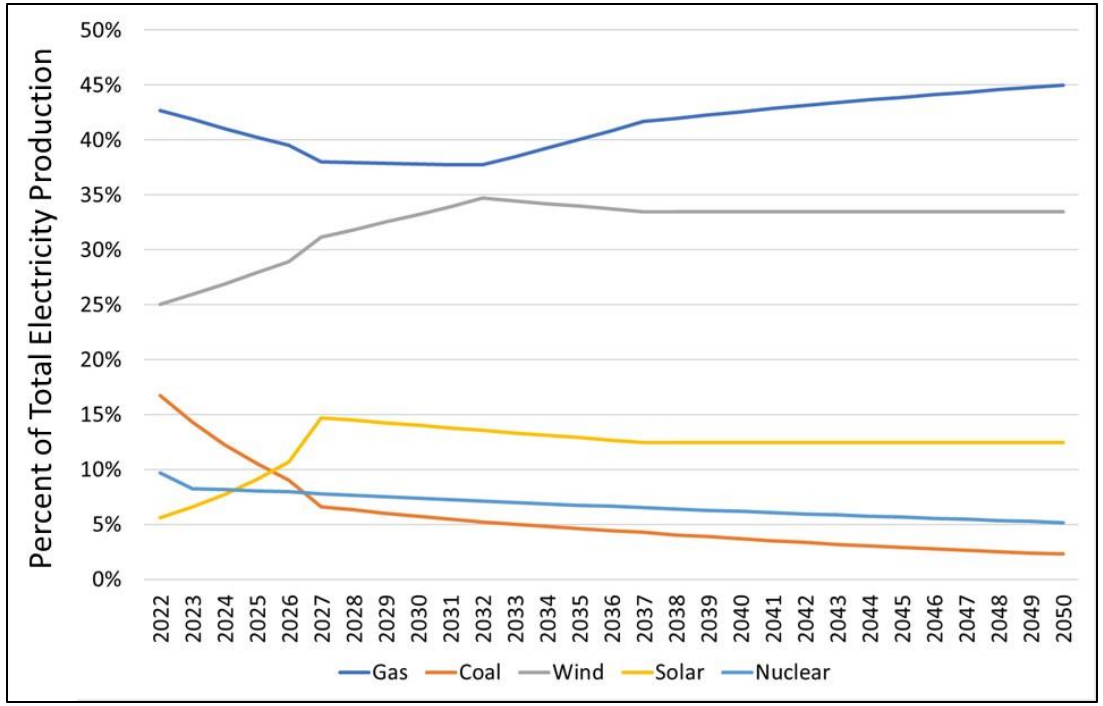
Phase 2 – Dispatch Modeling for System Optimization



- Generation facilities connected through transmission lines
- Scenarios to be run using python-based network model (PyPSA-TX)

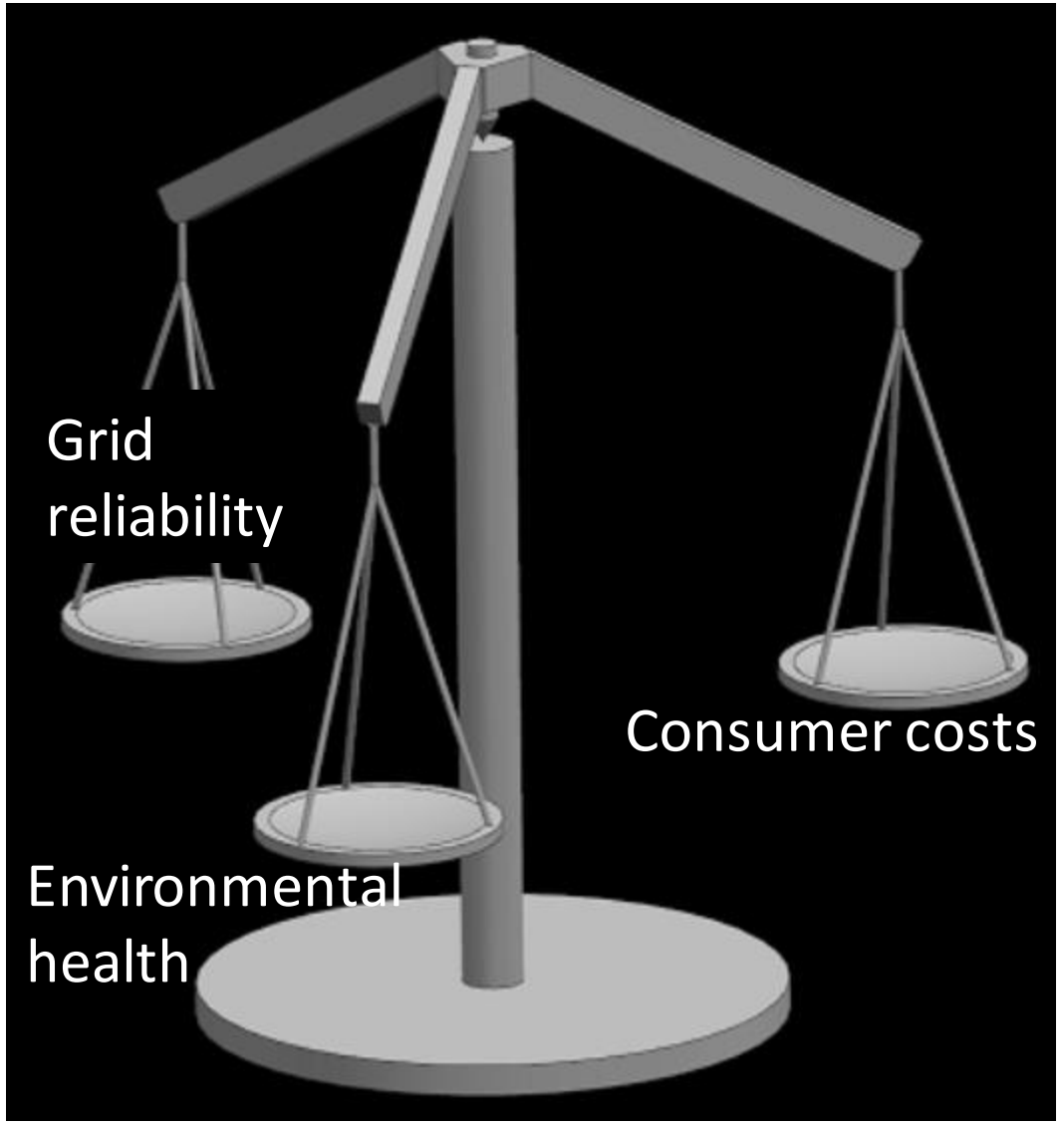
Example resource distribution with time (till 2050)



Hassan Dashtian, in collaboration with E. Kutanoglu
(UT Dept. of Operations Research)

Final Take-Aways

- Environmental impacts are heterogeneous in space and time
- Important to broaden consideration to account for local impacts and to local communities
- CO_2 emissions is only part of the story
- Significant need for understanding and managing Earth resource base – ***geoscientists are needed!***



https://puzzling.stackexchange.com/

Thank you for your interest!!

Acknowledgements:

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