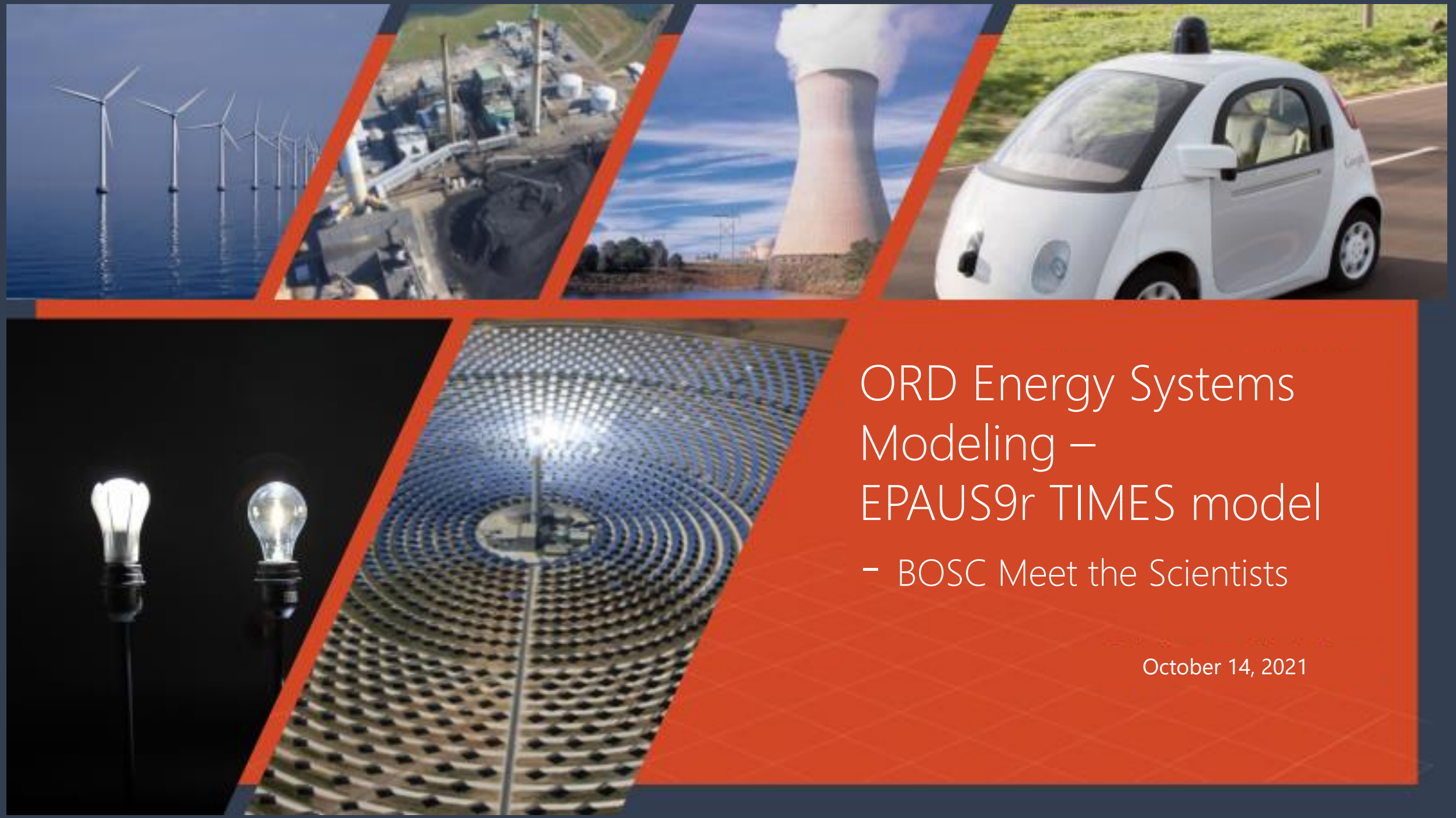
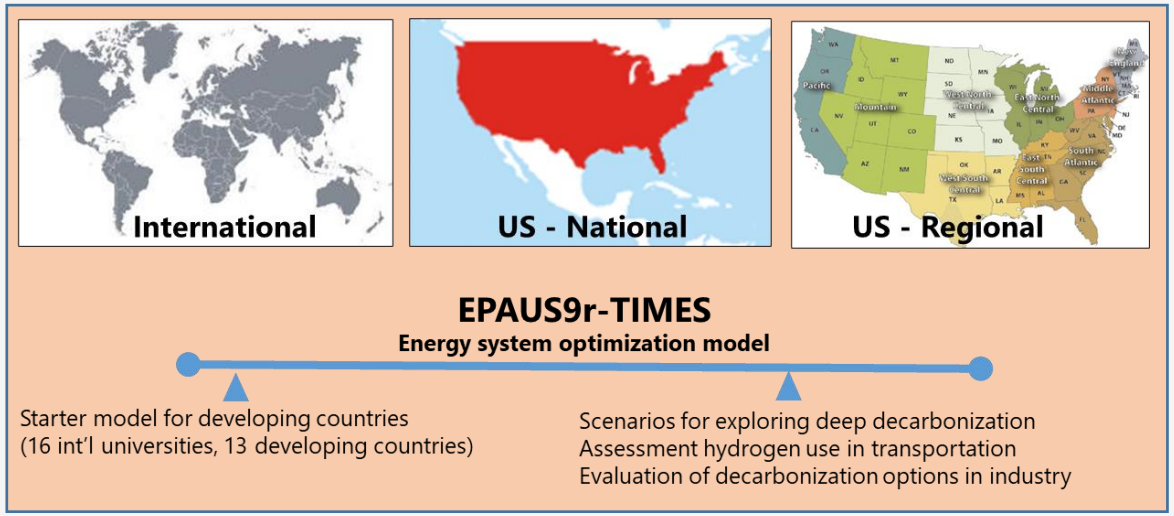


ORD Energy Systems Modeling – EPAUS9r TIMES model

- BOSC Meet the Scientists

October 14, 2021

ORD Energy Modeling Tool Overview: EPAUS9r-TIMES



Problem: Because the production and use of energy emit air pollutants and greenhouse gases, research is needed to understand of the health and environmental consequences of future energy and climate scenarios, including multi-pollutant, multi-sectoral approaches for mitigation options and responses.

Approach: EPA-ORD **developed in-house** a regional database representation of the U.S. energy system for use in the TIMES modeling platform. This platform is used to analyze multipollutant and multi-media impacts, and the unintended consequences of the evolution of energy systems.

Examples of past research in collaboration with Program offices:

- Development of marginal abatement curves for NOx reductions that incorporate controls, renewables, and energy efficiency (Office of Air Quality Planning and Standards)
- Scenario-based exploratory modeling to anticipate opportunities and challenges for air quality management in future decades (Office of Air Quality Planning and Standards)
- Analysis of the co-benefits of renewable portfolio standards for state and local governments (Office of Atmospheric Programs)

EPAUS9r Database User Community

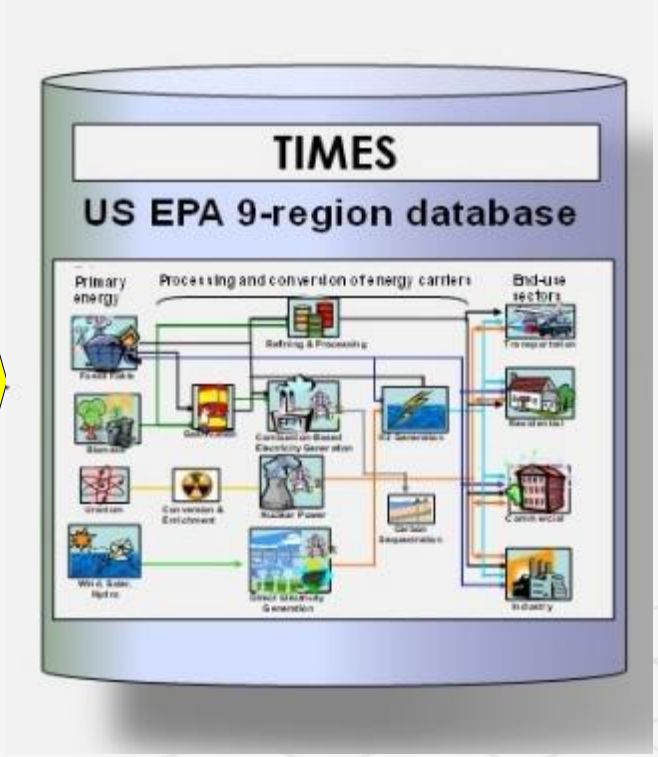
The EPAUS9r database has been utilized to a wide range of external parties. These users represent more than 50 organizations, including:

- DOE's National Energy Technology Laboratory (NETL)
- Northeast States for Coordinated Air Use Management (NESCAUM)
- IEA Energy Technology Systems Analysis Program (ETSAP)
- Open Energy Outlook (an international team of energy system researchers)
- Carnegie Melon University
- University of Colorado at Boulder
- North Carolina State University
- Purdue University

EPAUS9rT Database

Energy Systems Model

Scenario



Environmental Impacts

EPAUS9rT DATABASE

To be utilized in the TIMES modeling framework

Background: MARKAL/TIMES modeling framework originally developed in 70s by BNL. Continued development through the IEA ETSAP community.

Type: a dynamic, bottom-up, large-scale, linear optimization modeling framework for energy systems

Database Developer: US EPA/ORD

Time Horizon: 2010 – 2055, 1, 3, and 5-year increments

Spatial Resolution: 9 US Census Divisions

Sectors: EGUs, transportation, buildings, industrial

Main data source: DOE's Annual Energy Outlook (AEO)

Pollutants: GHG and criteria air pollutants

Runtime: 20-30 mins

Requirements: Desktop PC

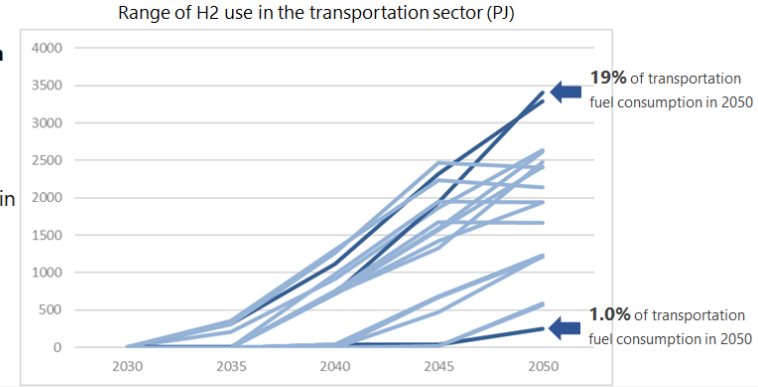
Availability: Developed and housed at EPA/ORD, publicly available

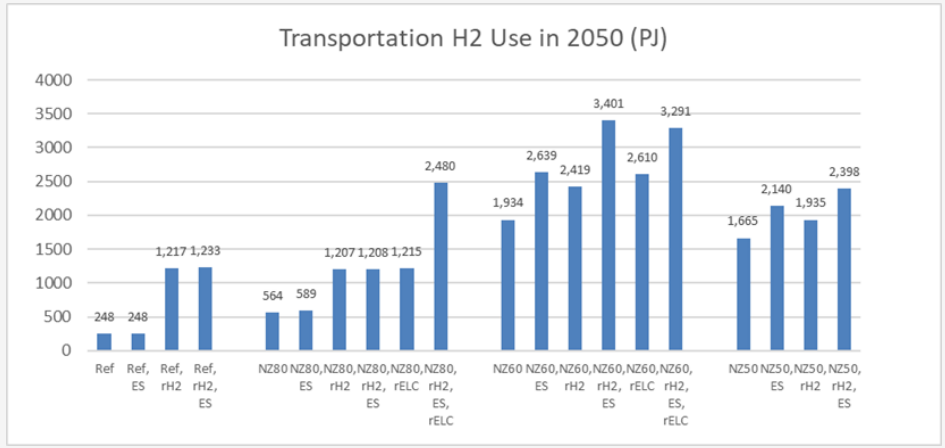
Current TIMES Application: Hydrogen in Transportation

Title: *Analysis of the energy and emissions implications of deploying low-emissions hydrogen fuels in the transportation sector.*

The biggest contributors to H2 adoption in transportation:

- Decarbonization goals
- H2 vehicle cost reductions
- DOE cost reduction goals for H2 supply chain
- Reduced electrification gains in other end-use sectors (in combination with decarbonization scenarios)





Team:

- Office of Research and Development: Carol Lenox (lenox.carol@epa.gov), Dan Loughlin
- Office of Atmospheric Programs: Morgan Browning
- Office of Transportation Air Quality: Sharyn Lie, Chris Ramig, Lauren Rafelski, Aaron Sobel, Jessica Daniels

Broad Research Question:

- What is the potential for grey, blue, or green hydrogen (H2) production when technology availability and economic factors are considered?

Importance to partners:

- This work helps build a portfolio of research into the feasibility, costs, and emissions impacts of hydrogen fuel for the transportation sector and builds up technology options for system-wide decarbonization pathways.

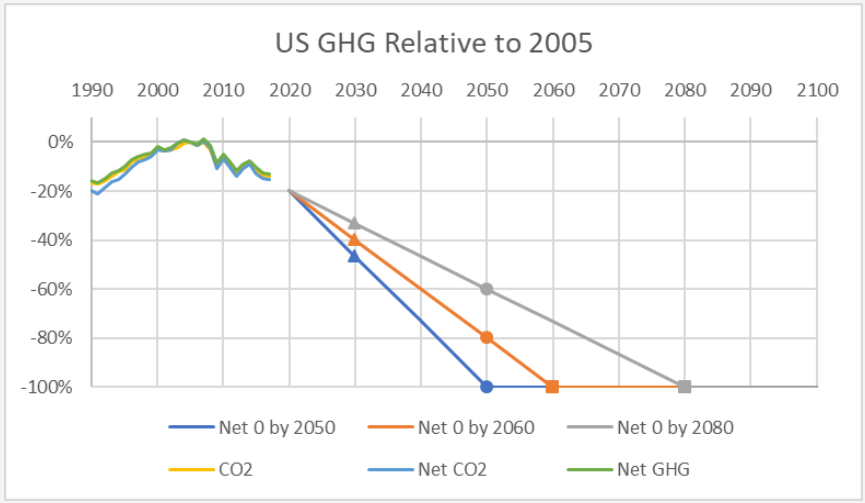
Next Steps:

- This research effort continues, focusing on the potential for green hydrogen production as a technology option for deep decarbonization.

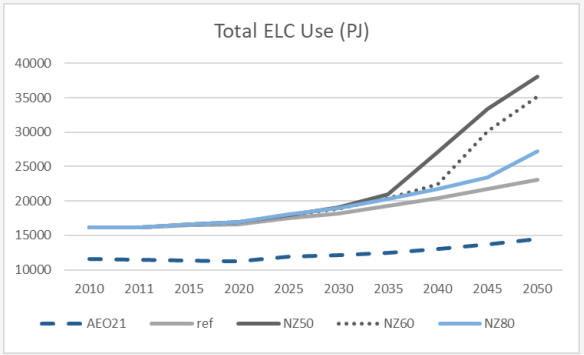
fuelcellsworks.com

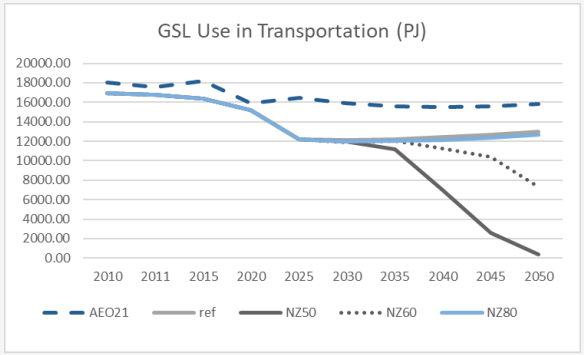
Current TIMES Application: Deep decarbonization pathways

Title: *Analysis of the efficacy of various deep decarbonization pathways in protecting air quality.*



EMF #37 study design





Illustrative results

Team:

- Office of Research and Development: Carol Lenox (lenox.carol@epa.gov)
- Office of Atmospheric Programs: Jim McFarland, Morgan Browning

Broad Research Questions:

- How does employing a multi-decision making strategy in the context of a regional energy system model provide insights on technology deployment to achive stringent emissions targets in the future?
- What is the value of "perfect policy foresight" when used in conjunction with a myopic approach in determining an optimized CO2 mitigation strategy?

Importance to partners:

- This work explores the decarbonization and air quality challenges posed by a variety of factors effecting the overall energy system and improves the ability to provide assessments of the pathways to meeting short and long-term emissions goals cost-effectively and robustly.

Next Steps:

- This research effort is being done in conjuction with Stanford University's Energy Modeling Forum (EMF #37). Beta model runs have been completed and the next several series of modeling runs will be done in 2022.

Bibliography

TIMES Modeling – EPAUS9rT database

Example External Uses

- The IEA-ETSAP TIMES-starter model is built upon the EPAUS9rT technology database. It has been applied to the development of country specific energy systems models in a number of countries including Turkey, Costa Rica, and Armenia.
- The EPAUS9rT technology database is being utilized in the development of an open-source energy system model being developed through a collaboration of universities including North Carolina State and Carnegie Mellon.

Example Peer Reviewed Papers

- Browning, Morgan S. and Carol S. Lenox (2020). Contribution of offshore wind to the power grid: U.S. air quality implications. *Applied Energy*, vol. 276
- Brown, K. and D.H. Loughlin (2019). Assessment of a hybrid solar thermal – gas turbine technology. Clean Energy and Environmental Policy., pp. 1-14. doi: 10.1007/s10098-018-1659-3.
- Kaplan, P.O. and J.W. Witt (2019). What is the role of distributed energy resources under scenarios of greenhouse gas reductions? A specific focus on combined heat and power systems in the industrial and commercial sectors. *Applied Energy*, vol. 235: p. 83-94. Doi: 10.1016/j.apenergy.2018.10.125.
- Brown, Kristen E., Hottle, Troy A., Bandyopadhyay, Rubenka, Babaee, Samaneh, Dodder, Rebecca S., Kaplan P. Ozge, Lenox, Carol S., and Daniel H. Loughlin (2018). Evolutiong of the United States Energy System and Related Emissions under Varying Social and Technological Development Paradigms: Plausible Scenarios for Use in Robust Decision Making. Environmental Science and Technology, doi: 10.1021/acs.est.8b00575
- Lenox, C.S. and D.H. Loughlin. (2017). Effects of recent energy system changes on CO_2 projections for the United States. *Clean Technologies and Environmental Policy*, doi: 10.1007/s10098-017-1417-y.
- Loughlin, D.H., Macpherson, A.J., Kaufman, K.R., and B.N. Keaveny (2017). Marginal abatement cost curves for NOx that incorporate control measures, renewable energy, energy efficiency and fuel switching. *Journal of the Air and Waste Management Assoc*., 67(10), 1115-1125. doi: 10.1080/10962247.2017.1342715.
- Babaee, S. and D.H. Loughlin (2017). Exploring the role of natural gas power plants with carbon capture and storage as a bridge to a low-carbon future. Clean Technologies and Environmental Policy, doi: 10.1007/s10098-017-1479-x.
- Lenox, C.S. and P.O. Kaplan. Role of natural gas in meeting an electric sector emissions reduction strategy and effects on greenhouse gas emissions. Energy Economics, doi: 10.1016/j.eneco.2016.06.009.