

ENERGY AND ENVIRONMENTAL ECONOMICS, INC.

San Francisco, CA

Director

Mr. Ming is a Director in E3's market design practice, with an emphasis on markets operating under penetrations of renewable energy. He also has extensive expertise in resource planning, regulatory and rate design issues, and distributed resource cost effectiveness. Recent projects include developing a market design proposal to improve electric system reliability in Texas and studying pathways to net-zero carbon in Nebraska. Mr. Ming has been the lead author on several high-profile resource planning studies including *Long-Run Resource Adequacy under Deep Decarbonization Pathways for California*¹ and *Resource Adequacy in the Pacific Northwest*.²

Mr. Ming teaches a graduate level course at Stanford University titled *Electricity Economics* that provides a foundation of economic principles on the topics of regulation, planning, and operation of electric utilities, with a particular emphasis on emerging electricity sector topics such as renewable energy, energy storage, distributed resources, and market design.

Mr. Ming holds an M.S. in management science and engineering (energy and environment track) and a B.S. in civil and environmental engineering (atmosphere and energy) from Stanford University. Select projects at E3 include:

- **Capacity Market Design, PJM, 2020-2021:** Mr. Ming provided advice to PJM on the incorporation of the effective load carrying capability (ELCC) metric into the PJM capacity market as a method to quantify the contribution of renewable energy and storage resources. Mr. Ming presented publicly the findings of the project at a PJM stakeholder workshop
- **ERCOT Market Design, NRG, 2021:** Mr. Ming developed a whitepaper outlining a proposal to implement a load-serving entity reliability obligation (LSERO) product in the ERCOT market to both improve reliability and make the state less susceptible to scarcity pricing.³
- **Wholesale Market Tariffs, Nova Scotia Power, 2020-2021:** Mr. Ming developed testimony to support reforms to existing wholesale market tariffs to ensure they were consistent with best practices in competitive markets across North America.
- **Santee Cooper, the State of South Carolina, 2019-2020:** Mr. Ming managed an engagement with the State of South Carolina to advise on the potential sale of Santee Cooper, a state-owned utility with significant debt due to the abandonment of the V.C. Summer nuclear units 2 & 3. Mr. Ming testified before the South Carolina legislature to present the pros and cons of a potential sale, management arrangement, or reform of the utility.
- **Pathways to Net-Zero Carbon, Omaha Public Power District, 2021:** Mr. Ming led a study on behalf of OPPD to analyze pathways to net-zero carbon. The study found that significant quantities of wind, solar, and battery storage would be components of a least-cost/least-regrets resource plan, supplemented

¹ https://www.ethree.com/wp-content/uploads/2019/06/E3_Long_Run_Resource_Adequacy_CA_Deep-Decarbonization_Final.pdf

² https://www.ethree.com/wp-content/uploads/2019/03/E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf

³ https://www.ethree.com/wp-content/uploads/2021/09/LSE-Reliability-Obligation-E3-ERCOT-Whitepaper_2021-09-29.pdf

by firm resources for reliability such as natural gas or hydrogen. Mr. Ming led a series of six public stakeholder workshops to provide an opportunity for transparency and public input.

- **Long-Run Resource Adequacy under Deep Decarbonization Pathways for California, 2018-2019:** Mr. Ming authored a report analyzing the resource adequacy requirements of a high-renewable electricity system, consistent with California's long-term decarbonization goals of 80% by 2050. The report demonstrated that despite significant additions of renewable energy and storage, significant quantities of firm capacity were still needed to maintain sufficient reliability.
- **Reliability Value of Demand Response in California, CAISO, 2019-2022:** Mr. Ming led an effort to study the reliability impacts of demand response in the California electricity system using the effective load carrying capability (ELCC) methodology. The study showed that current methods overvalue the reliability value by 25-50%. Mr. Ming presented the findings publicly at multiple stakeholder workshops.
- **Resource Adequacy in the Pacific Northwest, Public Generating Pool, 2018-2019:** Mr. Ming authored a report analyzing the resource adequacy requirements of the Pacific Northwest under various low carbon electricity systems, including 100% carbon-free. This report was presented to multiple stakeholders and utilities in the region and has led to further discussions around resource adequacy coordination and planning.
- **Once-Through Cooling Retirement Analysis, Los Angeles Department of Water and Power, 2017:** Mr. Ming managed a project analyzing the reliability implications of retiring three once-through cooling natural gas power plants in the Los Angeles basin and replacing them with a combination of clean resources including solar, storage, energy efficiency, and transmission. The results of this study were used to support the decision to retire all three plants and replace them with clean resources.
- **Planning Reserve Margin Study, Nova Scotia Power, 2019:** Mr. Ming led analysis to evaluate the required planning reserve margin (PRM) necessary to achieve a 1-day-in-10 year reliability standard in the province of Nova Scotia. The study also evaluated the contribution of several intermittent and energy-limited resources toward the PRM including solar, wind, energy storage, and demand response. This report was published publicly and formed a basis for Nova Scotia Power's 2020 integrated resource plan.
- **Integrated Resource Planning Support, Confidential Mid-Size Utility, 2018:** Mr. Ming managed a project evaluating the potential replacement of coal resources with renewable, energy storage, and natural gas resources in order to achieve decarbonization targets for a confidential mid-size utility.
- **Net Energy Metering Analysis, Various Clients, 2014-2017:** Mr. Ming performed analysis and published reports for various state utility commissions (California, Nevada, New York, South Carolina) evaluating the costs and benefits of net energy metering policies.
- **Transmission Rate Design Analysis, AltaLink, 2017-2021:** Mr. Ming conducted rate design and regulatory analysis on the existing wholesale transmission tariff in Alberta and proposed alternative designs that were more aligned with cost-of-service principles.
- **Heat Pump Analysis, New York State Energy and Research Development Authority, 2017:** Mr. Ming performed analysis on the costs and benefits of electric heat pumps to replace oil and natural gas heating in New York state as well as increase the efficiency of existing air conditioners. This work was published in a public report that led to the development of policies to incentivize heat pump adoption.
- **Resource Adequacy Program Design, Calpine, 2016:** Mr. Ming performed analysis on behalf of Calpine and presented to the California Public Utilities Commission (CPUC) to recommend the use of the effective load carrying capability (ELCC) metric in the Resource Adequacy (RA) program for wind and solar resources. The CPUC ultimately adopted this recommendation along with several market design features proposed by E3.
- **California Avoided Cost Calculator, California Public Utilities Commission, 2016-2018:** Mr. Ming led an update of the avoided cost forecast used to conduct cost and benefit analysis for demand-side programs in California, including energy efficiency, demand response, and distributed generation.

- **Title 24 Building Standard Development, California Energy Commission, 2016-2017:** Mr. Ming developed a forecast of future energy costs for the State of California used to establish building energy efficiency standards under Title 24.
- **Resource Value of Solar, Oregon Public Utilities Commission, 2016:** Mr. Ming contributed to expert testimony on the resource value of solar before the Oregon Public Utilities Commission.
- **Policy and Technology Scenario Analysis, Confidential Large U.S. Utility, 2015:** Mr. Ming modeled policy and technology-change scenarios for a large U.S utility as part of their strategy planning process.

GENERAL ELECTRIC

Renewable Energy Development Program (REDP) Intern

Schenectady, New York

Summer 2012

- Developed new acceptance test for the WindBOOST product used by technicians in the field during product installation
- Created a long-term validation tool to ensure the WindBOOST product continues to perform as expected after installation

CITIGROUP

Commodities Summer Analyst

Houston, Texas

Summer 2011

- Modeled new EPA air pollution regulations (CSAPR) on the impact to coal and natural gas prices and power generation
- Developed pricing tool used by natural gas traders to compare historical basis spreads in the eastern U.S.
- Created an automated daily report on incremental gas production in the Marcellus Shale
- Analyzed weather vendor and in-house temperature predictions to increase accuracy of natural gas pricing models

OGE ENERGY CORP (Enogex)

Capacity Management Intern

Oklahoma City, Oklahoma

Summer 2010

- Managed natural gas interruptible transportation (IT) capacity on 2300 miles of pipe (full time position)
- Transacted and negotiated transportation and storage sales of 125+ million cubic feet of gas per day
- Conducted data research on developing unconventional supply areas near gas gathering assets

MAP ROYALTY

Engineering Intern

Oklahoma City, Oklahoma

Summer 2009

- Researched production data of horizontal gas drilling in the Granite Wash play in western Oklahoma and Texas panhandle
- Created geological and stratigraphic cross sectional maps through well log analysis to visually depict the new gas reserves
- Synthesized above findings in a report that aided company leadership in pricing and acquisition of mineral rights

Education

Stanford University
M.S., Management Science and Engineering (Energy and Environment)

Stanford, California
2013

Stanford University
B.S., Civil and Environmental Engineering (Atmosphere and Energy)
Minor in Economics

Stanford, California
2012

Citizenship

United States