# Xiaoyuan (Charles) Li, Ph.D.

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**ENERGY AND ENVIRONMENTAL ECONOMICS, INC.**                    San Francisco, CA
*Senior Managing Consultant*

Dr. Li joined E3 in 2018 after completing his Ph.D. in environmental engineering from Princeton University. His work focuses on analyzing and modeling long-term greenhouse gas mitigation strategies, and on combining E3's strengths in electricity planning and building electrification to assess how electrification and decarbonization of electricity contribute to reducing economy-wide emissions. He has been leading recent building electrification and decarbonization studies in California, Maryland, Washington and New York, as well as recent economywide deep decarbonization studies in North Carolina, Maryland and Nova Scotia. Dr. Li brings extensive research experience at the nexus of renewable energy, air pollution, and climate change. In addition to his doctoral degree, he holds a B.S. in atmospheric and oceanic sciences from Peking University in China.

Selected E3 projects include:

- **Black Hills Colorado Clean Energy Plan Phase II Resource Acquisition (2023 – 2024).** Leading E3's team to support Black Hills Colorado Electric (BHCE) in resource acquisition for its 2022 Clean Energy Plan. Contributions include: (1) Led the portfolio optimization modeling for bid selections among 100+ bids received by BHCE; (2) Led E3's technical modeling team to adapt E3's RESOLVE portfolio optimization model for bid evaluation from a linear model to a discrete choice model; (3) Co-led the bid solicitation and translation process with the BHCE team starting from devising clear templates for bidders, curing and screening of the 100+ bids received during the process, to translating bidder-provided information into model-ready formats; (4)Led a technical appendix report in support of BHCE's regulatory filing in their 120-day report to the Colorado Public Utilities Commission; (5) Presented E3's modeling approach and results at a technical conference with stakeholders in Colorado.

- **Xcel Energy Public Service Company of Colorado (PSCo) Clean Heat Study (2023 – 2024).** Led the technical modeling in support of Xcel Energy's Clean Heat filing in Colorado to devise a near-term plan to reduce greenhouse gas emissions from the use of natural gas for heating in the PSCo's gas service territory. Contributions include: (1) Built a first-of-its kind clean heat portfolio optimization model with the team that find least-cost portfolios of clean heat resources including building electrification, recovered methane, hydrogen and carbon offsets to achieve PSCo's emissions reduction targets while considering budget constraints; (2) Led the development of key modeling assumptions including cost and potential of each clean heat resource types that are critical to the modeling of least-cost portfolios; (3) Supported PSCo and E3 Partner in the regulatory process, including direct testimony, responses to discovery requests and rebuttal testimony, to defend E3's analysis.

- **North Carolina Deep Decarbonization PATHWAYS Study (2022 – 2023).** Led E3's team of four consultants to support the North Carolina Governor's Office in assessing three potential pathways to achieve the state's near-term and long-term climate targets, with the ultimate goal of achieving net zero by 2050. Contributions include: (1) Developed a PATHWAYS model for North Carolina to analyze various measures across the state's economy, as well as the timeframes in which

emissions reductions would occur; (2) Lead coordination with multiple state agencies and working groups to gather best information and knowledge for representing the various sectors of the state in the PATHWAYS model; and (3) Presented to multiple stakeholder groups to share key assumptions, scenario design and results and solicit feedback.

- o **Black Hills Colorado Clean Energy Plan Phase I (2021 – 2023).** Led E3's team of seven consultants to support Black Hills Corporate in developing its 2022 Clean Energy Plan for its Colorado service area, which commits to meet state greenhouse gas goals with alternative resources while maintaining reliable and affordable electricity service. Contributions include: (1) Developed a Resource Options study to characterize the cost, performance and resource potential for a variety of resource options available to Black Hills Colorado including solar, wind and energy storage resources; (2) Led a Planning Reserve Margin (PRM) study to identify the capacity needed for Black Hills Colorado to meet long-run electric reliability requirements as well as the Effective Load-Carrying Capability (ELCC) of each candidate resource, using E3's RECAP model; (3) Developed a Portfolio study that identifies optimal portfolios of demand-side and supply-side resources to meet 2030 and 2050 GHG targets while meeting the PRM requirement, using E3's RESOLVE model; (4) Developed a operability study to identify challenges of operating a system with high levels of solar, wind and storage required to achieve high levels of greenhouse gas reduction with PLEXOS; and (5) Provided regulatory support throughout the process including presentations to stakeholder workshops and support for E3 partner as expert witness in front of the Colorado Public Utilities Commission as needed.

- o **Washington State Department of Commerce, Financial Impacts of Building Electrification on Consumer Owned Utilities and their Customers (2021 – 2022).** Led E3's team of five consultants that supported the Washington State Department of Commerce in assessing the economics of electrification for consumer owned utilities and their customers in Washington. Recruited and worked directly with four utilities that participated in the study to (1) draw on utility data to develop a detailed building stock characterization, (2) solicit timely feedback from the utilities for the analysis, and (3) distill key utility-specific findings from the study. Developed a benefit cost analysis that assessed the impacts of building electrification across cost tests, as well as an assessment of the cumulative impact of different building electrification portfolios on the utilities' hourly loads. Presented study results to the general public and the Governor's Office. Led the development of a public report that summarized key findings from the study.

- o **Maryland Commission on Climate Change, Maryland Building Decarbonization Study (2021).** Led E3's team of five consultants that supported the Maryland Commission on Climate Change (MCCC) and the Maryland Department of the Environment (MDE) in examining three potential pathways to achieve decarbonization of Maryland's building stock by mid-century and additional targeted sensitivities. Led both technical analysis and stakeholder engagement throughout the projects. Led the development of a public slide report that summarized key findings and documented technical details of the analysis. Supported MCCC on the Buildings Energy Transition Plan that was published in November 2021.

- o **Maryland State Climate Plan (2018 – 2021).** Led E3's support to the Maryland Department of Environment (MDE) in exploring the feasibility, timing, and cost of achieving steep greenhouse gas reductions in the 2030 and 2050 timeframes. Developed a Maryland-specific PATHWAYS model to analyze various measures across the state's economy, as well as the timeframes in which emissions reductions would occur. Presented study results to the Maryland Commission on Climate Change, state agencies and public stakeholders. E3's work forms the basis of Maryland's 2030 climate plan, which was released in February 2021.

- o **California Public Utilities Commission Integrated Resource Plan (2020).** Supported E3's work with the California PUC in its administration of the state's IRP program, mandated by the passage

of SB 350 in 2016.  Led the analysis that leveraged E3's California PATHWAYS model which evaluates alternative pathways for meeting California economy-wide GHG goals to estimate long-term impacts that these pathways would have on electric load due to electrification of transportation and buildings. Developed hourly profiles for incremental electrification loads from vehicles and buildings, which were used to forecast long-term peak demand changes that utilities should plan for to meet system reliability. Presented results to California PUC staff and California Energy Commission staff.

- o **Silicon Valley Clean Energy (SVCE) Distributed Energy Resources and Electrification Potential (2019 – 2020).** Worked with a community choice aggregator (CCA) to explore the potential of building electrification, electric vehicles, residential solar PV, behind-the-meter storage and smart home technologies. Developing a model to project consumer adoption of building electrification technologies based on current and projected costs and various rate designs and incentive levels.

- o **Nova Scotia Power Incorporated (NSPI) Integrated Resource Plan and Electrification Strategy (2019 – 2020).**  Led the technical analysis E3 provided for NSPI retained in developing its Integrated Resource Plan, which considered alternative resource options to meet provincial and federal greenhouse gas goals while maintaining reliable and affordable electricity service. Technical contributions include: (1) Developed a Resource Options study to characterize the cost, performance and resource potential for a variety of resource options available to Nova Scotia Power including solar, wind, hydro, thermal, and energy storage resources; (2) Developed a Portfolio study that identifies optimal portfolios of demand-side and supply-side resources, including remote resources paired with new high-voltage transmission lines, to meet year-by-year GHG targets while meeting the PRM requirement, using E3's RESOLVE model in conjunction with NSP's PLEXOS LT; and (3) Led the analysis that evaluated the cost and value of replacing a key hydro asset of NSPI.

- o **New York State Heat Pump Potential Analysis (2019).** Supported the New York State Department of Public Service (DPS) by analyzing the economic and achievable potential of heat pumps in New York. Developed a consumer adoption model to project the uptake of air-source heat pumps and ground-source heat pumps from 2020 to 2025 in each of the state's utilities' service territories given projected cost reductions and assumed incentive levels.

- o **Residential Building Electrification Market Assessment in California (2018 – 2019).** Developed a building electrification model to assess the capital costs, energy costs and greenhouse gas impacts of various electric appliances including air-source heat pumps, heat pump water heaters, induction cookstoves and heat pump clothes dryers in residential dwellings versus traditional fossil-based appliances. The study, commissioned by three of California's largest electric utilities – Southern California Edison (SCE), Sacramento Municipal Utility District (SMUD), and the Los Angeles Department of Water and Power (LADWP) – found that building electrification would deliver lifecycle cost savings for most home types and would significantly reduce greenhouse gas emissions from homes, starting today.

**PRINCETON UNIVERSITY**                                                              Princeton, NJ
*Assistant Instructor*                                                September 2014 – May 2017

- o Taught six semesters of undergraduate-level courses including *Innovation in Engineering Practice, Global Environmental Policy, Introduction to Environmental Engineering,* and *Environmental Nexus: Science, Ethics and Literature*
- o Supervised 40-plus student engineering projects

**PRINCETON UNIVERSITY**                                                          Princeton, NJ
*Assistant Researcher*                                           September 2012 – March 2018

- o Using a PV performance model (PVLIB-Python), discovered that air pollution in Eastern China can reduce solar PV output by more than 30%, and that the combination of air pollution and panel soiling in Eastern China, Northern India, and the Middle East can reduce solar PV output by more than 50%
- o Developed an integrated energy modeling framework that simulates renewable energy performance using satellite data, optimizes system dispatch, and evaluates system reliability

**PRINCETON UNIVERSITY CHINA ENERGY GROUP**                                       Princeton, NJ
*President*                                                                       2015 – 2016

- o Led the 2016 US-China Environmental Scholars Forum featuring 150 on-site attendees and 200 webcast followers, more than doubling preceding years' participation levels
- o Fundraised over $8,000 to hold 10 campus events and promote discussion of cutting-edge energy and environmental issues

**ASSOCIATION OF CHINESE STUDENTS & SCHOLARS AT PRINCETON UNIVERSITY**    Princeton, NJ
*Cultural Chair*                                                                  2013 – 2014

- o Stage-managed two on-campus performances featuring 50 performers and 20 stage staff
- o Fundraised over $3,000 for cultural programs, increasing the association's financial capacity by over 30%

## Education

Princeton University                                                             Princeton, NJ
*Ph.D., Environmental Engineering and Water Resources*                           2018
*Dept. of Civil and Environmental Engineering*
*Dissertation: Radiative Effects of Atmospheric Aerosols and Impacts on Solar Photovoltaic Electricity Generation*

Peking University                                                                Beijing, China
*B.S., Atmospheric and Oceanic Sciences, College of Physics*                     2012

## Academic Dissertation (Ph.D.)

Li Xiaoyuan (Advisor: Mauzerall, Denise L): Radiative Effects of Atmospheric Aerosols and Impacts on Solar Photovoltaic Electricity Generation (2018). Princeton University, Princeton, NJ. Public Link: https://dataspace.princeton.edu/handle/88435/dsp01wh246v823

## Publications

1. **Li Xiaoyuan**, Mauzerall Denise L, Bergin Mike H (2020) Global reduction of solar power generation efficiency due to aerosols and panel soiling. *Nature Sustainability* 3 (9): 720-727.

2. **Li Xiaoyuan**, Wagner Fabian, Peng Wei, Yang Junnan, Mauzerall Denise L (2017) Reduction of solar photovoltaic resources due to air pollution in China. *Proc Natl Acad Sci* 114(45):11867–11872.

3. **Li Xiaoyuan**, Liu Junfeng, Mauzerall Denise L, Emmons Louisa K, Walters Stacy, Horowitz Larry W, Tao Shu (2014) Effects of trans-Eurasian transport of air pollutants on surface ozone concentrations over Western China. *J Geophys Res Atmos* 119(21):12,338-12,354.

4. Qin Yue, Fang Yuanyuan, **Li Xiaoyuan**, Naik Vaishali, Horowitz Larry W, Liu Junfeng, Scovronick Noah, Mauzerall Denise L (2019) Source attribution of black carbon affecting regional air quality, premature mortality and glacial deposition in 2000. *Atmospheric Environment* 206: 144-155

5. He Xiaogang, Feng Kairui, **Li Xiaoyuan**, Craft Amy B, Wada Yoshihide, Burek Peter, Wood Eric F, Sheffield Justin (2019) Solar and wind energy enhances drought resilience and groundwater sustainability. *Nature Communications* 10 (1): 1-8.

6. Yang Junnan, **Li Xiaoyuan**, Peng Wei, Wagner Fabian, Mauzerall Denise L (2018) Climate, air quality and human health benefits of various solar photovoltaic deployment scenarios in China in 2030. *Environ Res Lett*. doi:10.1088/1748-9326/aabe99.

7. Guo Yixin, Liu Junfeng, Mauzerall Denise L, **Li Xiaoyuan**, Horowitz Larry W, Tao Wei, Tao Shu (2017) Long-Lived Species Enhance Summertime Attribution of North American Ozone to Upwind Sources. *Environ Sci Technol* 51(9):5017–5025.

8. Li Zhongshu, Liu Junfeng, Mauzerall Denise L, **Li Xiaoyuan**, Fan Songmiao, Horowitz Larry W, He Cenlin, Yi Kan, Tao Shu (2017) A potential large and persistent black carbon forcing over Northern Pacific inferred from satellite observations. *Sci Rep* 7:43429.

## Public Reports

1. **Charles Li**, Dan Aas, Jared Landsman, Michaela Levine, John de Villier, Fangxing Liu, Amber Mahone, Arne Olson (2022) Financial Impact of Fuel Conversion on Consumer Owned Utilities and Customers in Washington. Public Link: https://www.commerce.wa.gov/wp-content/uploads/2022/06/WA-COU-Building-Electrification-Final-Report.pdf

2. Tory Clark, Dan Aas, Bill Wheatle, Liz Wilson, Amber Mahone, Chelsea Petrenko, Kenzie Schwartz, **Charles Li**, Hayden Dahmm (2022) BGE Integrated Decarbonization Strategy. Public Link: https://www.ethree.com/wp-content/uploads/2022/10/BGE-Integrated-Decarbonization-White-Paper_2022-10-07-2.pdf

3. **Charles Li**, Dan Aas, Tory Clark, John de Villier, Michaela Levine, Jared Landsman (2021) Maryland Building Decarbonization Study. Public Link: https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG_Buildings%20Ad%20Hoc%20Group/E3%20Maryland%20Building%20Decarbonization%20Study%20-%20Final%20Report.pdf

4.  **Charles Li**, Tory Clark, Snuller Price (2021) The 2030 Greenhouse Gas Emissions Reduction Act (GGRA) Plan: Documentation of Maryland PATHWAYS Scenario Modeling. Public Link: https://mde.maryland.gov/programs/air/ClimateChange/Documents/2030%20GGRA%20Plan/Appendices/Appendix%20F%20-%20Docuementation%20of%20Maryland%20PATHWAYS%20Scenario%20Modeling.pdf

5.  Sharad Bharadwaj, **Charles Li**, Liz Mettetal, Arne Olson (2020) Deep Decarbonization in Nova Scotia: Phase 1 Report. Public Link: https://irp.nspower.ca/files/key-documents/scenarios/20200225-revised-E3_NSPI_Pathways_Study.pdf

6.  Dan Aas, Amber Mahone, Zack Subin, Michael Mac Kinnon, Blake Lane, Snuller Price, Doug Allen, **Charles Li**, Gabe Mantegna (2020) The Challenge of Retail Gas in California's Low Carbon Future. Public Link: https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-055-F.pdf

7.  Tory Clark, Doug Allen, **Charles Li**, Sharad Bharadwaj, Vivian Li, Snuller Price (2019) 2019 GGRA Draft Plan: Documentation of Maryland PATHWAYS Scenario Modeling. Public Link: https://mde.maryland.gov/programs/Air/ClimateChange/Documents/2019GGRAPlan/Appendices/Appendix%20F%20-%20Documentation%20of%20Maryland%20PATHWAYS%20Scenario%20Modeling.pdf

8.  Amber Mahone, **Charles Li,** Zack Subin, Michael Sontag, Gabe Mantegna, Alexis Karolides, Alea German, Peter Morris (2019) Residential Building Electrification in California. Public Link: https://www.ethree.com/wp-content/uploads/2019/04/E3_Residential_Building_Electrification_in_California_April_2019.pdf

## Selected Presentations

1.  (2020) "Electrifying Homes in California: the Consumer Cost Perspective" Association of Energy Services Professionals Annual Conference, February 19th, 2020, Anaheim California

2.  (2019) "Electrifying Homes in California: the Consumer Cost Perspective" Utility Energy Forum, April 25th, 2019, Cambria California

3.  (2016) "Impact of Atmospheric Aerosols on Solar Photovoltaic Electricity Generation in China" American Geophysical Union Fall Meeting 2016, San Francisco California

4.  (2015) "Impacts of Air Pollution on Solar Photovoltaic Electricity Generation in China" American Geophysical Union Fall Meeting 2015, San Francisco California