Stephen J. Lee, PhD

Researcher, MIT
Fellow, Energy for Growth Hub

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Research Statement

I am designing novel AI/machine learning systems to produce high-resolution geospatial maps of electricity and heating demand across countries and continents, collaborating with intergovernmental organizations, NGOs, governments, utilities, and universities. I specifically combine deep learning and Bayesian inference methods to build systems for multimodal data fusion capable of encoding constraints from physics- and economics-based theory. The resulting geospatial maps are being used to improve infrastructure decision-making and affect international development and climate outcomes.

Education

2018 – Present **Ph.D. Electrical Engineering and Computer Science**, *Massachusetts Institute of Technology, Cambridge, MA, USA*.
Expected
- Concentrations in Machine Learning and Energy Systems
- Committee: Prof. Ignacio J. Pérez-Arriaga, Dr. John Fisher III, Dr. Robert Stoner, Prof. Jay Taneja

2020 **Ph.D. Minor, Energy Economics**, *MIT Sloan School of Management, Cambridge, MA*.

2017-2018 **S.M. Electrical Engineering and Computer Science**, *Massachusetts Institute of Technology, Cambridge, MA*.

2015-2018 **S.M. Technology and Policy**, *Massachusetts Institute of Technology, Cambridge, MA*.

2009-2013 **B.S. Materials Science & Engineering; Nanotechnology Concentration**, *Johns Hopkins University, Baltimore, MD*.

2009-2013 **Second Major in Economics**, *Johns Hopkins University, Baltimore, MD*.

Papers

2022 A. González-García, P. Ciller, **S.J. Lee**, R. Palacios, F. de Cuadra, I.J. Pérez-Arriaga, A Rising Role for Decentralized Solar Minigrids in Integrated Rural Electrification Planning? Large-Scale, Least-Cost, and Customer-Wise Design of Grid and Off-Grid Supply Systems in Uganda, *Energies*

2021 **S.J. Lee**, D. Suri, P. Somani, C. Dean, J. Pacheco, R. Stoner, I.J. Pérez-Arriaga, J. Fisher, J. Taneja, How probabilistic electricity demand forecasts can expedite universal access to reliable electricity, *Energy for Economic Growth*

2021 M. Luke, P. Somani, T. Cotterman, D. Suri, **S.J. Lee**, No COVID-19 Climate "Silver Lining" in the U.S. Power Sector: CO_2 Emissions Reductions Not Statistically Significant, Additional Risk to Coal Generators is Minimal, *Nature Communications*

2021 J. Shekhar, D. Suri, P. Somani, **S.J. Lee**, M. Arora, Reduced renewable energy stability in India following COVID-19: Insights and key policy recommendations, *Renewable & Sustainable Energy Reviews*

2020   C. Dean, **S.J. Lee**, J. Pacheco, J. Fisher, Learning to Count: Lightweight Data Fusion with Deep Conjugate Mappings, *arXiv preprint arXiv:2011.10607*

2019   **S.J. Lee**, E. Sánchez, A. González-García, P. Ciller, P. Duenas, J. Taneja, F. de Cuadra, J. Lumbreras, H. Daly, R. Stoner, I.J. Pérez-Arriaga, Investigating the Necessity of Demand Characterization and Stimulation for Geospatial Electrification Planning in Developing Countries, *MIT Center for Energy and Environmental Policy Research Working Papers*

2019   A. González-García, P. Ciller, **S.J. Lee**, T. Cotterman, R. Amatya, R. Stoner, I.J. Pérez-Arriaga, Promotion of mini-grids for rural electrification in Uganda, *Deutsche Gesellschaft für Internationale Zusammernarbeit (GIZ) GmbH*

2019   P. Ciller, D. Ellman, C. Vergara, A. González-García, **S.J. Lee**, C. Drouin, M. Brusnahan, Y. Borofsky, C. Mateo, R. Amatya, R. Stoner, F. de Cuadra, I.J. Pérez-Arriaga, Optimal Electrification Planning Incorporating On- and Off-Grid Technologies: The Reference Electrification Model (REM), *Proceedings of the IEEE*

2018   **S.J. Lee**, Adaptive Electricity Access Planning, *Massachusetts Institute of Technology*

2018   R. Amatya, M. Barbar, M. Brusnahan, P. Ciller, T. Cotterman, F. de Cuadra, P. Dueñas, D. Ellman, A. González-García, **S.J. Lee**, C. Mateo, R. Palacios, I.J. Pérez-Arriaga, R.J. Stoner, C.R. Vergara, Computer-aided electrification planning in developing countries: The Reference Electrification Model (REM), *Working Papers IIT No. WP-IIT-18-112A*

2018   I.J. Pérez-Arriaga, R. Stoner, R. Rahnama, **S.J. Lee**, G. Jacquot, A. González-García, and P. Dueñas. A utility approach to accelerate universal electricity access in less developed countries: A regulatory proposal, *Economics of Energy & Environmental Policy*

2018   M. Luke, **S.J. Lee**, Z. Pekarek, and A. Dimitrova, Blockchain in Electricity: a Critical Review of Progress to Date, *eurelectric*

2013   J. Sinha, **S.J. Lee**, H. Kong, T. Swift, and H.E. Katz, Tetrathiafulvalene-functionalized Thiophene Copolymerized with 3, 3"'-Didodecylquaterthiophene: Synthesis, Response to Trinitrotoluene, and Thermoelectric Behavior, *Macromolecules*

2013   J. Sinha, R. Ireland, **S.J. Lee**, and H.E. Katz, Synergistic Thermoelectric Power Factor Increase in Films Incorporating Tellurium and Thiophene-based Semiconductors, *Materials Research Society Communications*

Book Contributions

2018   Sunny-side up: electricity for clean cooking, *World Energy Outlook 2018, IEA*, Paris, *https://doi.org/10.1787/weo-2018-en*.

2018   Enlightened thinking: the value of high-resolution electrification planning for achieving universal electricity access, *World Energy Outlook 2018, IEA*, Paris, *https://doi.org/10.1787/weo-2018-en*.

Short Articles

2022   **S.J. Lee**, J. Taneja, Long-tailed distributions and electrification planning: why we need to model the 'long tail' of large consumers, *Energy for Growth Hub*

2022   **S.J. Lee**, I.J. Pérez-Arriaga, Imagining the 'Google' of electrification: how digital twins and computational systems for continuous planning can reinvent century-old practices, *Energy for Growth Hub*

2021   **S.J. Lee**, Z. Shah, B. Min, J. Taneja, Nighttime Lights Satellite Imagery: Challenges and Opportunities, *Energy for Growth Hub*

2021   **S.J. Lee**, A planner's guide to acquiring building locations data, *Energy for Growth Hub*

2020   **S.J. Lee**, R. Stoner, I.J. Pérez-Arriaga, The Integrated Distribution Framework and the Global Commission to End Energy Poverty: Exploring Pathways for Accelerating Universal Access to Modern Energy Services, *Working Paper, DOI: 10.13140/RG.2.2.23442.20162*

2020   **S.J. Lee**, L. Aoudi, Opportunities for Mutually Beneficial Public Policy and Machine Learning Climate Solutions, Working Paper, DOI: 10.13140/RG.2.2.12575.10401

2020   **S.J. Lee**, J. Taneja, Why Demand Demands More Attention, *Energy for Growth Hub*

2019   **S.J. Lee**, The Virtuous Cycle of Clean Cooking and Electricity Costs, *Energy for Growth Hub*

2018   **S.J. Lee**, Empowered Planning with Models, Satellites, & Machine Learning, *Energy for Growth Hub*

2018   M. Luke, **S.J. Lee**, Z. Pekarek, and A. Dimitrova, Blockchain in Electricity: A Call for Policy and Regulatory Foresight, *eurelectric*

Selected Talks and Presentations

2022   Presenter, *MIT Energy Initiative Fall Seminar*, Cambridge, MA, USA

2021   Webinar Panelist, *Energy Modelling for Better Policymaking, Applied Research Programme on Energy and Economic Growth (EEG)*, Oxford, United Kingdom

2021   Webinar Presenter, *MITEI-Madhya Pradesh Energy Department Energy Seminar*, Bhopal, Madhya Pradesh, India

2020   Webinar Presenter, *Load Research Chapter of the South African Institute of Electrical Engineers (SAIEE)*, Johannesburg, South Africa

2019   Presenter, *Asian Development Bank Innovation Speakers' Series*, Manila, Philippines

2018   Panelist, *2018 MIT Africa Innovate Conference, Power & Energy*, Cambridge, MA, USA

2018   Presenter, *University Program Review, NNSA's Office of Defense Nuclear Nonproliferation Research and Development*, Ann Arbor, MI, USA

2017   Presenter, *Hack4Climate, associated with the 2017 United Nations Climate Change Conference (COP23)*, Bonn, Germany

2016   Presenter, *Tata India Symposium*, Cambridge, MA, USA

2013   Presenter, *Provost's Undergraduate Research Award Recognition Ceremony*, Baltimore, MD, USA

Selected Awards and Honors

2021-2022   Graduate Research Fellowship, *Jacobs Social Entrepreneur Fellowship*

2021-2022   Graduate Research Fellowship, *Legatum Center for Development & Entrepreneurship*

2021   Research Funding Recipient, *International Energy Agency*

2020   Research Funding Recipient, *Enel Foundation*

2019   Research Funding Recipient, *Energy for Growth Hub*

2018   Nominee, Best Master's Thesis Award, *MIT Institute for Data, Systems, and Society*

2018   Finalist, NDSEG Fellowship, *U.S. Department of Defense*

2015-2017   Graduate Research Fellowship, *MIT Tata Center for Technology and Design*

2016   Semifinalist, *MIT Clean Energy Prize*

2013   Departmental and University Honors, *Johns Hopkins University*

Professional Certifications

2014   Oracle Certified Associate, Java SE 7 Programmer (OCAJP 7)

2013   SEMOSS Analytics Certification

Teaching Experience

2019   **Teaching Assistant**, 6.041/6.431 Probabilistic Systems Analysis, *Department of Electrical Engineering and Computer Science*.

2018   **Teaching Assistant and Guest Lecturer**, 15.017/6.934 Engineering, Economics, and Regulation for Energy Access in Developing Countries, *MIT Sloan School of Management and Department of Electrical Engineering and Computer Science*.

2017 **Guest Lecturer**, 15.S02 Planning, Policy, and Technology for Energy Access in Developing Countries, *MIT Sloan School of Management*.

Selected Professional Experience

2015 – Present **Researcher**, *MIT Energy Initiative & MIT CEEPR*, Cambridge, MA.

- Designing machine learning models to produce high-resolution geospatial maps of electricity and heating demand across countries and continents, collaborating with intergovernmental organizations, NGOs, governments, utilities, and universities. These maps are being used to improve infrastructure decision-making and affect development and climate outcomes.
- Employed computational energy systems models and conducted analyses to inform large-scale electrification infrastructure planning efforts as part of the Universal Energy Access Group (universalaccess.mit.edu).

2018 – Present **Fellow**, *Energy for Growth Hub*, Washington, DC.

- Extending electricity demand and access rate estimation algorithms across Africa, South America, and Southeast Asia. Computing estimates of the share of each country that fail to meet the "Modern Energy Minimum" metric as defined by the Energy for Growth Hub.
- Leading ambassador on behalf of the Hub's "Big Data" team to present on research activities and evaluate partnership opportunities internationally.

2023 – Present **Consultant**, *Project InnerSpace*, Boston, MA.

- Leading surface heating and electricity demand characterization efforts for international geothermal project evaluation.

2016 – present **Consultant**, *Highland Energy Analytics*, Cambridge, MA.

- Analytics and software engineering consulting services for top climate NGOs. Developed climate analytics products that appeared in UN Framework Convention on Climate Change (UNFCCC) COP conferences, U.S. congressional reports, and major news outlets.

2015 – 2023 **Researcher**, *MIT Computer Science and Artificial Intelligence Laboratory*, Cambridge, MA.

- Co-developed the Lightweight Data Fusion (LDF) machine learning modeling framework, combining deep learning-based model training with probabilistic graphical models for: (1) improved modeling with sparse data inputs, (2) the ability to combine induction-based models (i.e. learning models *de novo* from unstructured data) with deduction-based models (i.e. human-interpretable models based on theory), and (3) the provision of quantified uncertainty characterizations to power decision theory-based decision-making.
- Designed convolutional neural network architectures for the semantic segmentation of satellite imagery using TensorFlow and Keras. Built a computer vision system to consume imagery, other geospatial vector datasets, and georeference features for large-scale feature extraction on GPU-enabled Amazon EC2 servers. Built a suite of web-based manual image annotation tools and visualization dashboards.

2013 – 2015 **Software Engineering, Full Stack**, *SEMOSS*, Arlington, VA.

- Developed data processing and visualization components of the open source analytics environment, SEMOSS (semoss.org). Led new feature development efforts across the full application stack and refactored client-specific analyses into analytic routines for general-purpose data exploration

2013 – 2015 **Consultant**, *Deloitte Consulting LLP*, Arlington, VA.

- Performed systems and optimization analyses for the National Oceanic and Atmospheric Administration (NOAA) and the Military Health System (MHS) using SEMOSS, Python, and Excel/VBA. Performed network analyses to inform information systems migration efforts towards service-oriented architectures, inform technology investment decisions, and eliminate system redundancies.
- Led a business case analysis for the Defense Logistics Agency (DLA) Energy Sustainment, Restoration and Modernization (SRM) Office with projected cost savings of over $90 million in five years and prepared figures that were presented to Congress.
- Codeveloped web-based dashboards for comparative financial analytics in the Power and Utilities, Retail, and Technology sectors with Deloitte's Global Benchmarking Center. Dashboards allow executives to assess performance relative to competitors by business segment and identify high-priority areas for improvement.