Vignesh Venugopal

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ENERGY AND ENVIRONMENTAL ECONOMICS, INC. New York, NY
Managing Consultant

Vignesh joined E3 in 2019 and manages long-term resource planning projects for clients in the electricity industry. He has employed E3's load forecasting, capacity expansion and loss-of-load probability models, for organizations working towards cost-effective decarbonization without compromising reliability. In addition to conventional resource planning, his areas of expertise include- climate change impacts on electric supply and demand and emerging technologies like hydrogen, CCS and long duration battery storage that can help maintain grid reliability when solar and wind output are not enough. He brings both depth and breadth built by addressing similar questions for a varied range of clients in different parts of North America. Vignesh came to E3 after completing his master's degree in Energy Resources Engineering from Stanford University. His research focused on short-term solar PV power forecasting. He developed skills related to optimization and machine learning in that process, which he combines with his knowledge of energy economics and policies in his work today at E3. During his undergrad in the department of Chemical Engineering at the University of Mumbai, he researched biodiesel technologies. Select projects at E3 include:

- **Impact of Climate Change on the Electric Grid (Confidential Client) (Sep 2022 – Present)** – Quantified impact of warming on electricity demand, resource outages, transmission derates, etc. The study is also speaking to the differences in impacts expected based on the decarbonization policies adopted (or lack thereof).

- **CCS Feasibility in the US (Confidential Client) (Jun 2023 – Aug 2023) –** Assessing the feasibility of retrofitting existing natural gas plants or building new gas plants with carbon capture and storage as part of a diverse resource portfolio that also includes solar, wind and battery storage, to help reliably meet demand with zero-carbon resources when solar and wind underperform. Both general and location-specific environmental risks associated with CCS were considered in the study.

- **NY 2022 Storage Roadmap, New York State Energy Research and Development Authority (Jan 2022- Dec 2022) -** Conducted analysis and drafted a roadmap for NY state to meet their 6 GW by 2030 target in collaboration with NYSERDA and the New York State Department of Public Service. In addition to the pathway charted for NY to meet the 2030 target, E3 also assessed the role short and long duration storage can play in the long term to make net-zero goals cost effective.

- **Assessing the Value of Long Duration Energy Storage, California Energy Commission (Apr 2020-Present) -** Using RESOLVE and RECAP to assess the role LDES can play in meeting CA's decarbonization goals. Developing a new modeling toolkit and dataset to better capture the impact of climate change on load, generation and thus system operations.

- **Resource Planning for NY to meet the Climate Leadership and Community Protection Act goals, NYSERDA (Oct 2020- Present) -** Using RESOLVE to determine cost optimal resource portfolios for different scenarios all of which attain 100% zero-carbon electricity by 2040 as part of the CLCPA goals. Leading the RECAP modeling to determine the capacity value of variable and energy-limited resources NY will need to rely on, while maintaining reliability.

- **Effective Load Carrying Capability of Demand Response, California Independent System Operator (Nov 2019-Present) -** Determining the ELCC (i.e capacity value) of existing demand response (DR) programs and guide future DR program valuation and design. Led the preliminary RECAP analysis and currently participating in a working group led by the CEC to update the resource adequacy framework in CA to accurately value DR.

- **Predicting Operating Reserve Needs Using Machine Learning, Advanced Research Projects Agency–Energy (Oct 2020-Dec 2021) -** Developed a machine learning model, RESERVE, for predicting operating reserve requirements given solar, wind and load forecasts. The model produces probabilistic forecasts to accurately capture uncertainty and support efficient grid operations with reduced costs and emissions.

- **Net-zero New England, Calpine Corporation (Mar 2020-Nov 2020) -** The study charted pathways for New England to attain net-zero emissions, economy-wide by 2050. Led the RECAP modeling to determine the ELCC of different resources and stress-test the New England system under challenging conditions to ensure reliability. Highlighted the value of zero-carbon firm resources in periods with high load and low renewable generation.

- **Hydrogen Pathways in WECC, Mitsubishi Power (Dec 2019-Feb 2020) -** Developed cost projections for producing hydrogen from different energy sources and electrolyzer technologies through 2050.

STANFORD UNIVERSITY Stanford, CA
Teaching Assistant January 2019 – March 2019

- Held weekly office hours to help students with course content, weekly assignments, and projects for *ENERGY 191/291: Optimization of Energy Systems*
- Aided both the theoretical understanding of optimization and its practical implementation in the Julia for Mathematical Programming (JuMP) framework

STANFORD UNIVERSITY Stanford, CA
Research Assistant, Environmental Assessment and Optimization Group September 2017 – June 2019

- Researched short-term solar panel output forecasting with machine learning
- Employed Convolutional Neural Networks for predictions using sky images
- Investigated merit of multi-modal input architectures used in the field of robotics to make use of images, PV output history and weather parameters for improving accuracy
- Supplementary projects included stochastic unit commitment modeling and market research to quantify the costs and benefits of a better solar forecast

UNIVERSITY OF MUMBAI Mumbai, India
Undergraduate Researcher, Department of Chemical Engineering August 2016 – March 2017

- Researched biodiesel production from used cooking oil to avoid "food vs. fuel" debates
- Experimented with microreactors to induce slug flow, increase interfacial area and thus the rate of reaction without the need for agitation or co-solvents

JACOBS ENGINEERING INDIA PVT LTD Mumbai, India
Intern, Department of Process Engineering June 2016 – July 2016

- Re-engineered a batch operating plant producing food flavorings and performance chemicals into continuous production mode

BHABHA ATOMIC RESEARCH CENTER Mumbai, India
Intern, Department of Health Physics June 2015 – July 2015

- Collected environmental samples and conducted radiation detection and measurement of H3 and C14 levels in those samples using a Liquid Scintillation Counter

Education

Stanford University Stanford, CA
M.S., Energy Resources Engineering June 2019

University of Mumbai Mumbai, India
B.Eng., Chemical Engineering June 2017

Peer-Reviewed Publications

- Yuchi Sun, James H. Nelson, John C. Stevens, Adrian H. Au, Vignesh Venugopal, Charles Gulian, Saamrat Kasina, Patrick O'Neill, Mengyao Yuan, Arne Olson (2022); Machine learning derived dynamic operating reserve requirements in high-renewable power systems. *Journal of Renewable and Sustainable Energy*; 14 (3): 036303.

- Venugopal, V., Sun, Y., & Brandt, A. R. (2019). Short-term solar PV forecasting using computer vision: The search for optimal CNN architectures for incorporating sky images and PV generation history. *Journal of Renewable and Sustainable Energy*, *11*(6), 066102.

- Sun, Y., Venugopal, V., & Brandt, A. R. (2019). Short-term solar power forecast with deep learning: Exploring optimal input and output configuration. *Solar Energy*, *188*, 730-741.