# Vignesh Venugopal

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

Vignesh joined E3 in 2019 and primarily works on resource adequacy and long-term resource planning projects. He has employed RESOLVE and RECAP, E3's capacity expansion and loss-of-load probability models, respectively, for organizations working towards cost-effective decarbonization without compromising reliability. He brings both depth and breadth built by addressing similar questions for a varied range of clients in different parts of the US. As part of these studies, Vignesh has built expertise in assessing the capacity value of variable and energy limited resources. 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 continues to employ at E3. Select projects at E3 include:

- **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, New York State Energy Research and Development Authority (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

## Citizenship

India

## Peer-Reviewed Publications

- 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.