Yuchi Sun, Ph.D.

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

Dr. Yuchi Sun works primarily in E3's resource planning practice area. Having worked on close to twenty projects across ten plus jurisdictions, he is especially experienced with IRP type projects with capacity expansion optimization and operational reliability analysis. He is a crucial developer and architect of E3's resource planning tools: RESOLVE, RECAP, and RESERVE. His leadership and work on the development of the RESERVE tool has contributed to an industry leading reserve requirement assessment tool based on machine learning. Dr. Sun has a background in machine learning and solar forecasting from his Ph.D. degree at Stanford University. He also holds an M.S. in Energy Resources Engineering from Stanford University and both a B.S. and a B.A. from Tsinghua University.

Relevant E3 projects include:

Avangrid Wind Energy Flexibility and Balancing Needs, 2022. Supported a mid-western generation only utility to assess their needs for firming up a growing wind fleet.

New Brunswick Power Decarbonization Study, 2022. Calculated intra-hour operational reserve requirement for a maritime Canadian utility

PNM Western Energy Imbalance Market Benefit Cost Analysis Update, 2022. Identified monthly monetary savings for a southwest utility comparing to not joining a regional market.

Hawaiian Electric Company Decarbonization Study, 2022. Offered technical support in implementing HECO's ERM reliability constraint.

Puget Sound Energy Reliability study for electric progress report, 2022. Offered high level advice and data analysis, especially relating to climate scenarios and probability.

Puget Sound Energy Balancing Area wide Flexibility Reserve Study, 2022. Managed a training program for using the machine learning based operation reserve derivation.

Pacific Gas & Electric Wildfire Risk Review, 2021 – 2022. Assessed PG&E's current ignition risk model and offer statistical insight on improving their model.

California Energy Commission Long-Duration Storage Study, 2021. Led a large developer team to revamp capacity expansion models to model long duration events. Implemented first-of-its-kind solution in time-series sampling to balance performance and runtime.

DOD ARPA-E (Department of Defense, Advanced Research Projects Agency–Energy) dynamic operation reserve tool (RESERVE) development Project, 2021. Led a large developer team to implement machine

learning based operation reserve derivation tool. Helped manage a long-term and multi-threaded project with demanding clients

LS Power PJM interconnection Offshore Wind Reliability Impact Study, 2021. Evaluated offshore wind assets value as a grid reliability contributor.

El Paso Electric Integrated Resource Plan Support, 2021. Evaluated resource adequacy requirement for El Paso resources.

Ameren Decarbonization, 2020. Supported full cycle integrated resource planning, supporting resource, carbon, and reliability planning.

HECO IGP support , 2020. Supported full cycle integrated resource planning, supporting resource, carbon, and reliability planning.

EPSA Regional Policy Mechanisms in PJM, 2020. Created new functionality for the capacity expansion tool to model Eastern U.S. policy.

NV Energy Resource Adequacy Study, 2020. Supported NV Energy in assessing its reliability with increased solar penetration.

Idaho PC VER Integration Cost Assessment, 2020. Support Idaho Energy in assessing its reliability with increased wind penetration

PSE 2030 Preferred IRP Portfolio Flexibility Needs Assessment, 2020. Led analysis effort to optimize a future portfolio to achieve 80% renewable by 2030.

El Paso Electric IRP Support, 2018. Supported the capacity expansion planning in the context of cheap renewable resources.

BOSCH RESEARCH AND TECHNOLOGY CENTER Palo Alto, CA
Battery System Intern June – August 2017

- Modeled battery performance and internal state with machine learning (NN and LSTM-RNN)
- Modeling delivered comparable accuracy faster than traditional electrochemical models

STANFORD UNIVERSITY Stanford, CA
Teaching Assistant Autumn 2014 and Winter 2016

- Assisted courses Energy 293A (Solar Cells) and Energy 291 (Energy Systems Optimization)
- Responsibilities included holding office hours, grading homework, and instructing students

WORLD RESOURCE INSTITUTE (CHINA OFFICE) Beijing, China
Intern Analyst Summer 2012

- Participated in developing carbon reduction plan for Chengdu (Capital city of Sichuan Province)

- Calculated greenhouse gas emissions from different industrial sectors in Chengdu

Research Experience

Short-term Solar Forecast with Convolutional Neural Network Jun. 2016 – Aug. 2019

- Build a first of its kind machine learning model to predict solar power with cloud images.
- Identify and predict cloud movement with camera images at 5- to 15-minute time scale.
- Frequently cited and among the first papers in this specific area.

Performance of a CO2 - reduction Based Seasonal Storage System Sep. 2015 – Jun. 2016

- Calculated the mass and energy balance of a CO2 electrochemical reduction system.
- Compared the energy and cost performance of the system to other long-term storage solution.

Exergetical Life Cycle Analysis of CCS Enabled Coal Fired Power Jun.2014 – Aug.2015

- Provided a new perspective on CCS technology by accounting the life cycle exergy input/output.
- Constructed a detailed CCS system model with an emphasis on material cost.
- Poster spotlight in the global climate and energy forum 2015.

Carbon Emissions of Petroleum Production in Global Oilfields Sep.2013 – Sep. 2014

- Calculated the GHG emission from oil production in thirty major oilfields across the globe.
- Accounted for vastly different oil production technology and indexed them.
- Policy advocacy from these results carried out by Carnegie Endowment for International Peace.

Development of a Carbon Footprint Calculator on Android Platform Jun.2011 - Sep.2011

- Developed a methodology to calculate direct and indirect carbon footprint for Chinese citizens.
- 1st place winner of the 7th HACH™ Env. Friendly Technology Competition
- Resulted in the free downloadable Android App Mr. Carbon available for advocacy

Education

Stanford University — Stanford, CA
Ph.D., Energy Resources Engineering — August 2019

Stanford University — Stanford, CA
M.S., Energy Resources Engineering — August 2015

Tsinghua University — Beijing, China
B.S., Energy Resources Engineering; B.A., English — June 2013

Academic Publications

1. **Sun, Y.** (2019). *Short-term solar forecast using convolutional neural networks with sky images*. Stanford University.

2. **Sun, Y**., Nelson, J. H., Stevens, J. C., Au, A. H., Venugopal, V., Gulian, C., Kasina, S., O'Neill, P., Yuan, M., & Olson, A. (2022). Machine learning derived dynamic operating reserve requirements in high-renewable power systems. *Journal of Renewable and Sustainable Energy*, *14*(3), 036303.
3. **Sun, Y.**, Smith, S. S., & Brandt, A. R. (2015). *Life cycle exergy analysis on monoethanolamine-based carbon dioxide capture system* [PhD Thesis]. Stanford University.
4. **Sun, Y.**, Szucs, G., & Brandt, A. R. (2018). Solar PV output prediction from video streams using convolutional neural networks. *Energy & Environmental Science*, *11*(7), 1811–1818.
5. **Sun, Y.,** Venugopal, V., & Brandt, A. R. (2018). Convolutional neural network for short-term solar panel output prediction. *2018 IEEE 7th World Conference on Photovoltaic Energy Conversion (WCPEC)(A Joint Conference of 45th IEEE PVSC, 28th PVSEC & 34th EU PVSEC)*, 2357–2361.
6. **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.
7. Brandt, A. R., **Sun, Y.**, Bharadwaj, S., Livingston, D., Tan, E., & Gordon, D. (2015). Energy return on investment (EROI) for forty global oilfields using a detailed engineering-based model of oil production. *PloS One*, *10*(12), e0144141.
8. Brandt, A. R., **Sun, Y.**, & Vafi, K. (2015). Uncertainty in regional-average petroleum GHG intensities: Countering information gaps with targeted data gathering. *Environmental Science & Technology*, *49*(1), 679–686.
9. Nie, Y., Li, X., Scott, A., **Sun, Y.**, Venugopal, V., & Brandt, A. (2022). SKIPP'D: a sky images and photovoltaic power generation dataset for short-term solar forecasting. *ArXiv Preprint ArXiv:2207.00913*.
10. Nie, Y., **Sun, Y**., Chen, Y., Orsini, R., & Brandt, A. (2020). PV power output prediction from sky images using convolutional neural network: The comparison of sky-condition-specific sub-models and an end-to-end model. *Journal of Renewable and Sustainable Energy*, *12*(4), 046101.
11. 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.

Conference Presentations

1. **2022 Panel Presentations.** Sun, Y., Nelson, J. H., Stevens, J. C., Au, A. H., Venugopal, V., Gulian, C., ... & Olson, A. (2022). Machine learning derived dynamic operating reserve requirements in high-renewable power systems. IEEE PES general meeting 2022.
2. **2018 Poster**. Sun, Y., Venugopal, V., Brandt, A. R., Convolutional Neural Network for Short-term Solar Panel Output Prediction, 7th World Conference on Photovoltaic Energy Conversion. 2018
3. **2016 Poster**. Sun, Y., Brandt, A. R., Benson, S., Pellow, M., Oxygen Integration in CO2-Electrochemical-Reduction-based Seasonal Storage System, Stanford Center for Carbon Storage 2016 Annual Conference
4. **2015 Poster**. Sun, Y., Sweeney Smith, S., Brandt, A. R., Life Cycle Exergy Analysis on Monoethanolamide-Based Carbon Dioxide Capture System. Stanford Global Climate & Energy Project 2015 Annual Conference

Awards and Grants

Perform Grant, Department of Defense - Advanced Research Projects Agency, Sep. 2020
Deploying E3's RESERVE Tool to Enable Advanced Operation of Clean Grids.

McGee Levorsen Grant, Stanford University, 2017-2018
Image-based solar power short-term forecasting

The UPS Endowment Fund for Transportation, Logistics and Urban Issues, UPS Corp., 2017-2018
Minutely resolution PV Performance Prediction for Urban Rooftop Solar Integration

Frank G. Miller Fellowship Award Stanford University, Spring 2016
Academic Excellence.

Winner of the 7th Env Friendly Tech Competition HACH Corp., Sep. 2011
Personal carbon footprint calculation App on Android