Forecasting Emissions from Carbon Capture Plants Leveraging Advanced Artificial Intelligence Models

DE-SC0025123

Total Project Cost: $200,000

Project Duration: 12 months

PI/Presenter: Karthik Nithyanandam

Impact Innovations LLC

2024 FECM / NETL Carbon Management Research Project Review Meeting

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Motivation

- Carbon capture plants are subjected to increased demand for operational flexibility.
  - Due to variable renewable penetration
- Constant cycling complicates the emissions profile of amine-based solvent degradation used in carbon capture system.
  - Thermal and oxidative degradation
  - Requires effective solvent management practices.
- Challenge:
  - Traditional analysis methods fall short in capturing the complex, multivariate behavior of carbon capture systems.

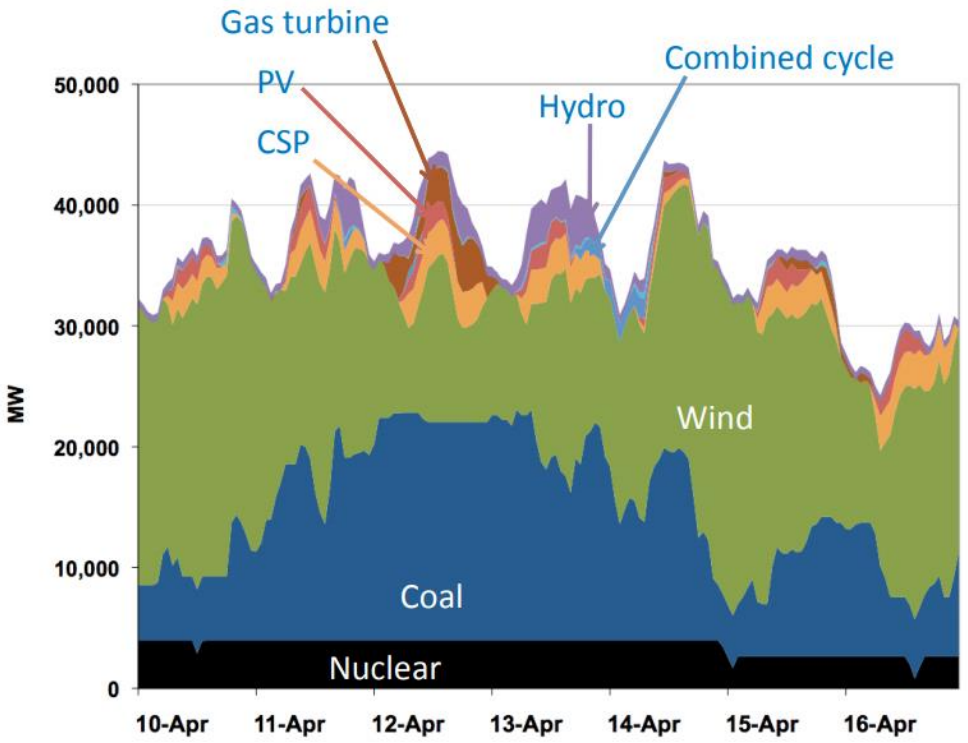


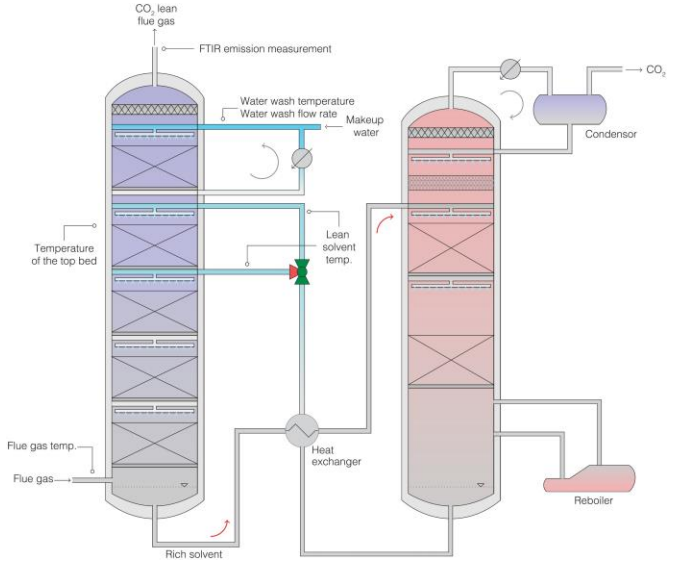
Illustration of frequent cycling of fossil-fueled plants[1]

Sophisticated modeling approach that can accurately capture the dynamic system behavior, forecast emissions and optimize operation

[1]Lew et al.., The Western Wind and Solar Integration Study Phase 2, NREL/TP-5500-55588

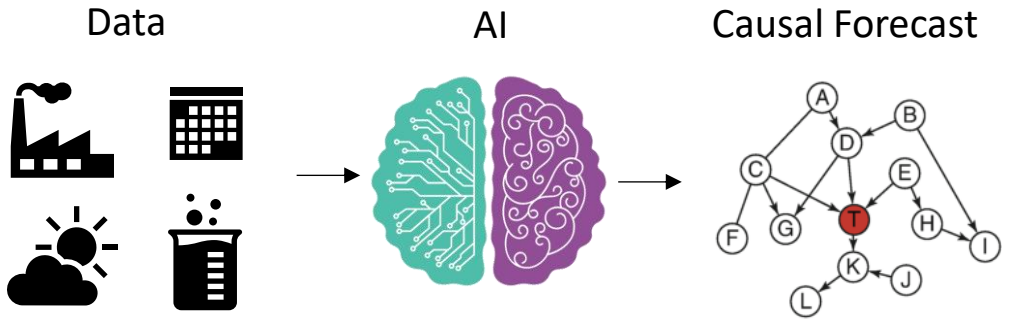
Project Goals & Objectives

- Phase 1 Goal: Develop a hybrid physics informed, and data-driven AI based modeling tool to forecast emissions, elucidate causal relationships in data, inform effective emission control strategies and optimize operation of carbon capture plant.
  - Leverage advanced transformer-based time series models, the latest deep learning techniques for causal modeling, and generative AI for handling sparse data.
  - Use data sources from tests conducted at Technology Center Mongstad (TCM) with CESAR 1 solvent.



Simplified schematic of the post-combustion carbon capture pilot plant[2]

- Technical Tasks:
  - Development and Validation of a predictive model
  - Incorporation of physics-based insights
  - Execution of a causal analysis
  - Commercialization strategy



[2]Jablonka et al., Science Advances, 9(1). https://doi.org/10.1126/sciadv.adc9576

Project Benefits

Increased Energy Security

- Enable the continued use of low-cost domestic fuel for electricity generation and increase the reliability of a decarbonized electricity system.

Reduced Emissions

- Improved emissions management will lead to better air quality, reducing the impact of pollutants on public health.

Improved Economics

- Reduction in O&M cost.
- Revenue from participation in the electricity market.
- Reduce the cost of a net-zero carbon electricity system by providing firm power to a high VRE grid.

Innovation and Inclusion

- Promotes technological innovation, ensuring that the benefits of advanced technologies are accessible to and inclusive of disadvantaged communities.

Project Team and Past Work

Dr. Karthik Nithyanandam

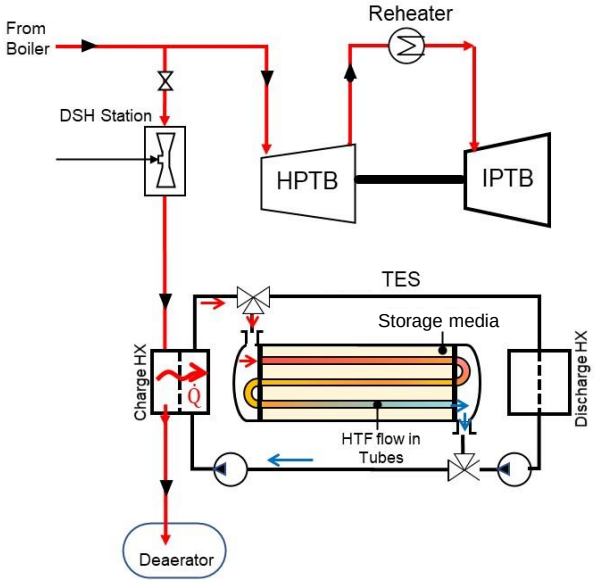
- Principal Investigator
- Previously led product design, optimization and business development at Axiom Exergy and Element 16 Technologies startup.
- Recipient and PI of DOE and California Energy Commission grant projects.
- PhD Virginia Tech 2013.

Dr. Sujal Bhavsar

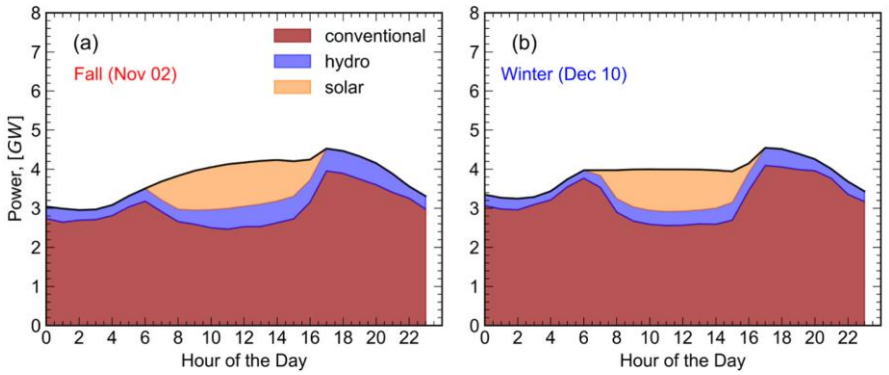
- Technical lead for the development of machine learning models.
- Developed data-driven and machine-learning-based solutions for various applications in power systems and building energy management.
- PhD from Virginia Tech 2022.

Chaitanya Kulkarni

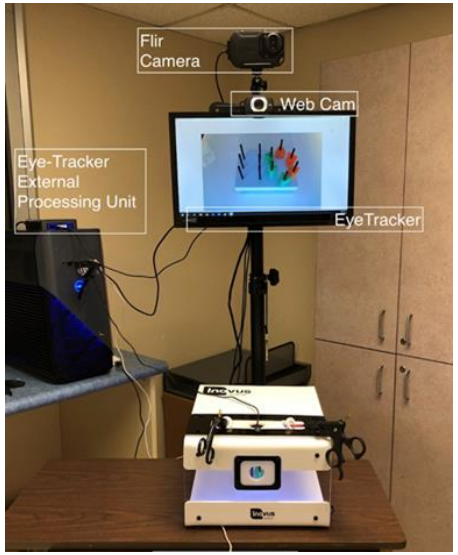
- Experienced Data Scientist who has experience working across different industries.
- Developed a machine-learning-based tool for human factors.
- MS Virginia Tech 2021.



Integration of thermal energy storage for increased flexibility of power plants



Hybrid physics and machine learning based approach for stochastic unit commitment and economic dispatch under uncertainty



Context dependent gaze based assessment methodology using Deep Learning

Thank You

Contact:

Phone/WhatsApp: +1 (540) 449-1719
Email: karthik.nisi@gmail.com