Realizing Profitable Carbon Capture on Natural Gas Plants with Thermal Energy Storage through Optimization-based Decision Support

Roberto Vercellino, Ethan Markey, Braden Limb, Maxwell Pisciotto, Joe Huyett, Shane Garland
Todd Bandhauer, Jason Quinn, Peter Psarras, Daniel Herber

Introduction and Motivation

• International climate goals and increasing penetration of renewable sources indicate a shift towards energy markets defined by fluctuating electricity demand and prices.
• An opportunity exists for alternative cheap, flexible, and close to carbon-neutral generation sources like natural gas combined cycle plants (NGCC) with post combustion carbon capture (CC).
• Although CC has demonstrated carbon removal rates >90%, it still faces critical challenges preventing commercial deployment:
  1. Unfeasible capital investments
  2. Flexibility Limitations
  3. Up to 10% parasitic load imposed on power plant for solvent regeneration

Optimization-based Decision Support

Motivation
Deliver a versatile and efficient tool to inform engineering decisions of utility operators, carbon capture and energy storage companies.

Methods
Constructed optimization-based model tailored to the maximization of the net present value of the evaluated system. Plant sizing and operational control decisions are considered using a control co-design approach.

Integrating NGCC power plants and CC with hot and cold thermal energy storage units constitutes a promising approach to make CC economically profitable.

Key Operational Modes

• The storage units are charged at low electricity prices.
• At peak prices the units are discharged, from the hot storage to provide steam to the CC and from the cold storage for air inlet chilling.

Optimal Control and Dynamics at Fine Temporal Resolution

Model Current Capabilities

Future Model Expansions

• Robustly integrate market uncertainties for a more realistic, effective and implementable in real-time control strategy.
• Adapt the model to evaluate a wide range of energy generation and storage systems.
• Include experimentally-validated transient states for each of the subsystems.

References