A numerical method for optimizing oxyfuel power plants

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Introduction and Background
The study, a collaborative project within Columbia University between the Earth and Environmental Engineering Department of the School of Engineering and Applied Sciences and the Lenfest Center for Sustainable Energy of the Earth Institute, is working to develop a computational model that will analyze power plant components and will enable modeling exercise to combine existing technology components into innovative thermal power plant designs; evaluate different power plant designs under various energetic, economical, environmental and infrastructural constraints; and perform optimization not just to the individual power plants alone, but pathways connecting current power generation technologies to future technologies.

Program Goal

Modular Approach:
Complex constrains: Energetic, environmental, infrastructural, and economical constrains.
Flexibility: User-defined penalty weights
Pathway Development

A Simple Model

- A hypothetical power plant is a network of m modules
  \[ Y = \{x_1, x_2, x_3, \ldots, x_m\} \]
- A hypothetical pathway is a sequence of n new power plants
  \[ Z = \{y_0, y_1, y_2, \ldots, y_n\} \]

Such algorithm allows for:
- complex optimizations
- multi-dimensional space
- decide between different power plant designs

Results

Pathway Penalties (w/ CO2 regulation)

Pathway Penalties (w/o CO2 regulation)

Figure 3. This diagram describes the schematics of the program. The box in the middle can be a module, a power plant flowsheet, or a pathway.

Reconcile: An iterative process that makes inputs and outputs of any module internally consistent, and makes inter-module material/energy flows internally consistent.

Optimize: The program then assigns penalties and changes design parameters in order to minimize the penalty.

Penalty Hierarchy

Module Level Penalty: cost

Plant Level Penalty: Efficiency and emissions

Pathway level Penalty: Pathway length and path-dependent

Figure 4. A simple example comparing five different power plant pathways, each y represents a unique plant configuration

Vary parameters on:
- individual module x
- individual plant y
- individual pathway z

References:
IPCC Special Report on Carbon Dioxide Capture and Storage, 2005

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