NATIONAL ENERGY TECHNOLOGY LABORATORY

NETL Modular Framework:

Optimization of existing plants & IGCC with CO_2 capture & water minimization

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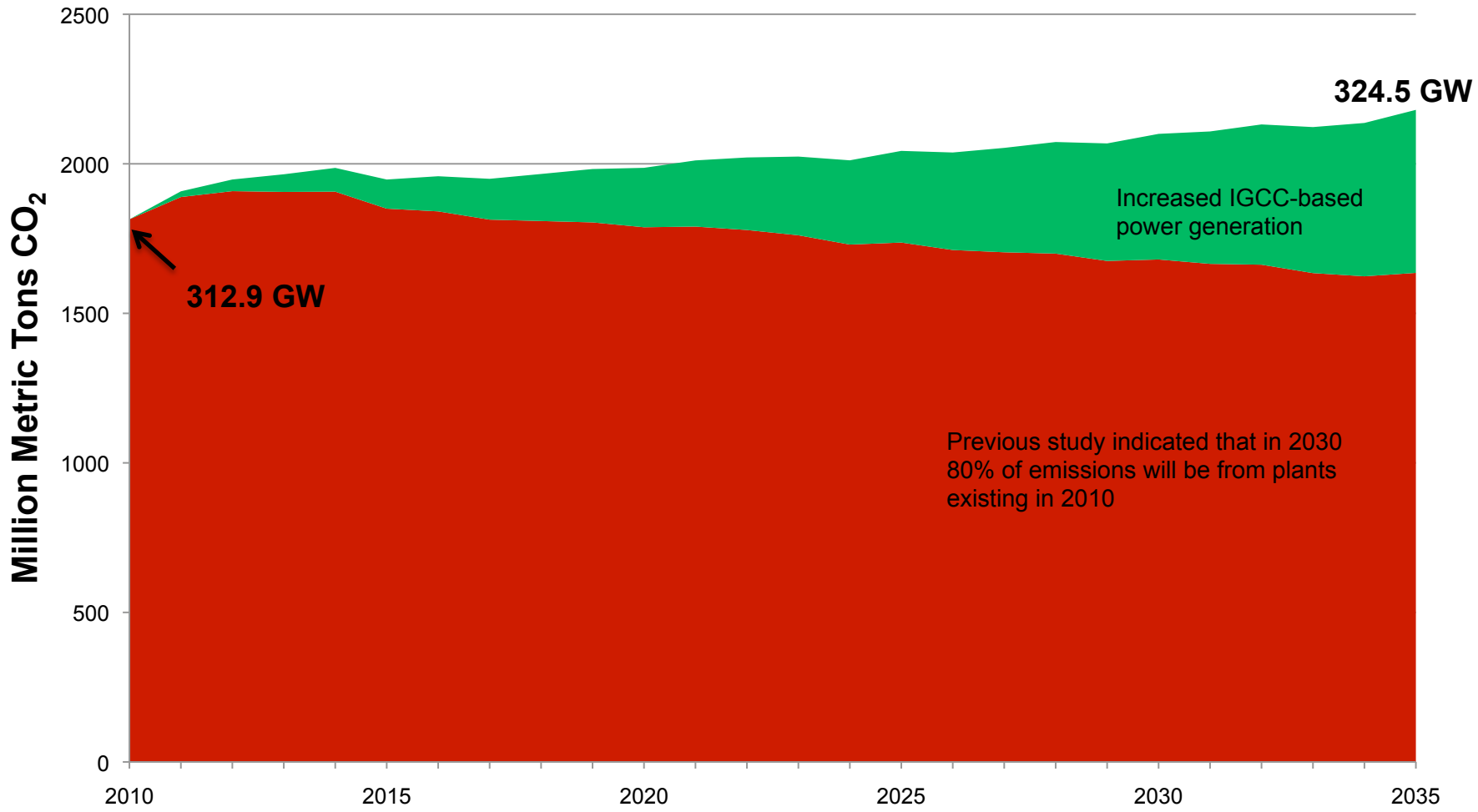
U.S. DEPARTMENT OF ENERGY

Research Program Overview and Goals

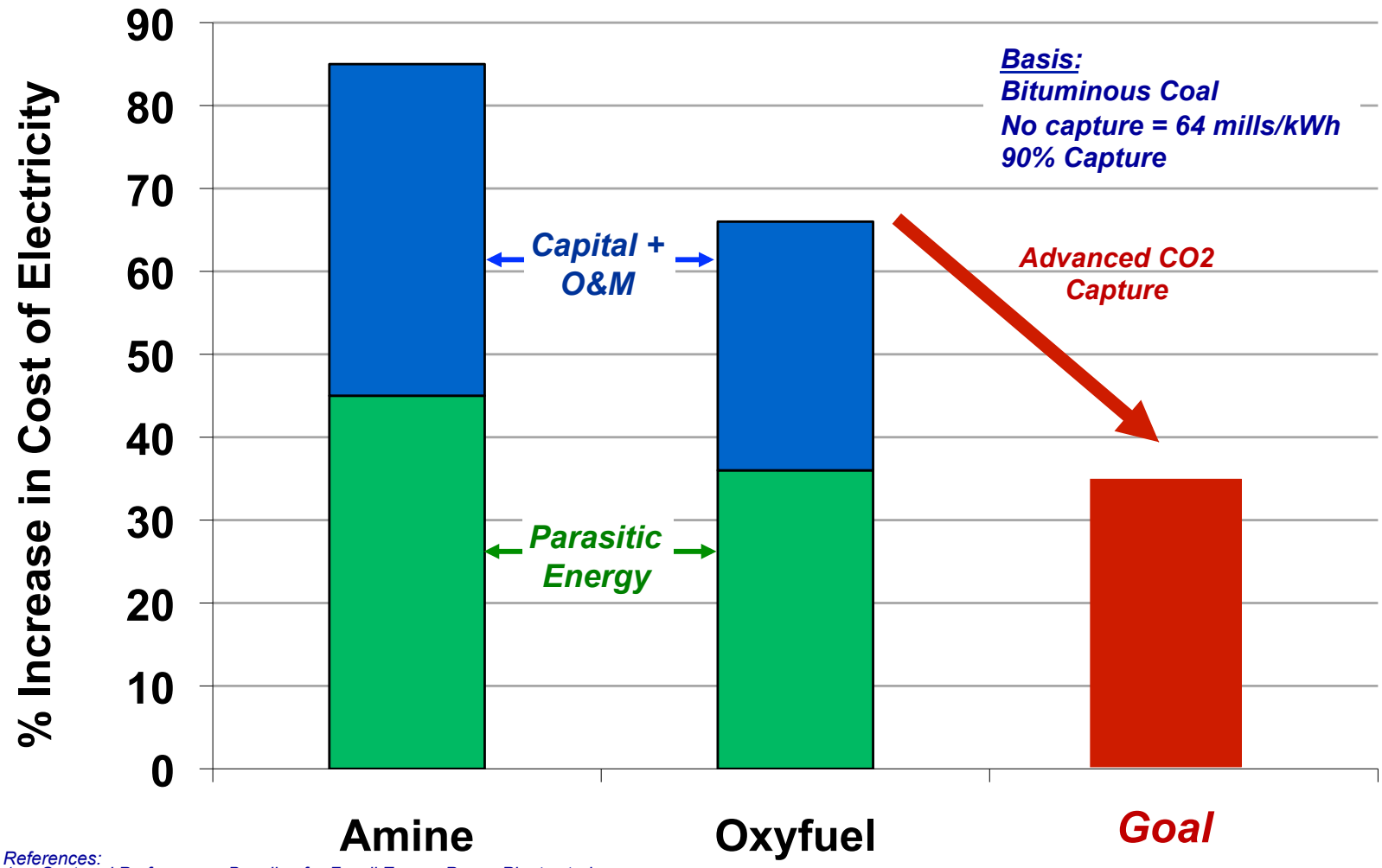
- **Large-scale problem**
  - 2 billion tons CO_2 from coal by 2020 in US
  - Flue gas: 5 million lb/hr for 550MW plant
- **No existing economical solution**
  - Process synthesis
  - Process integration & optimization
- **National importance**
  - Inexpensive, abundant electricity
  - Water resources growing scarcer
- **Time critical (deployable by 2015/2020)**
- **Comprehensive modeling and optimization framework**
  - Integrated research program
  - Multiple significant research activities
  - Contribute to solving larger problem

U.S. CO_2 Emissions from Coal Plants



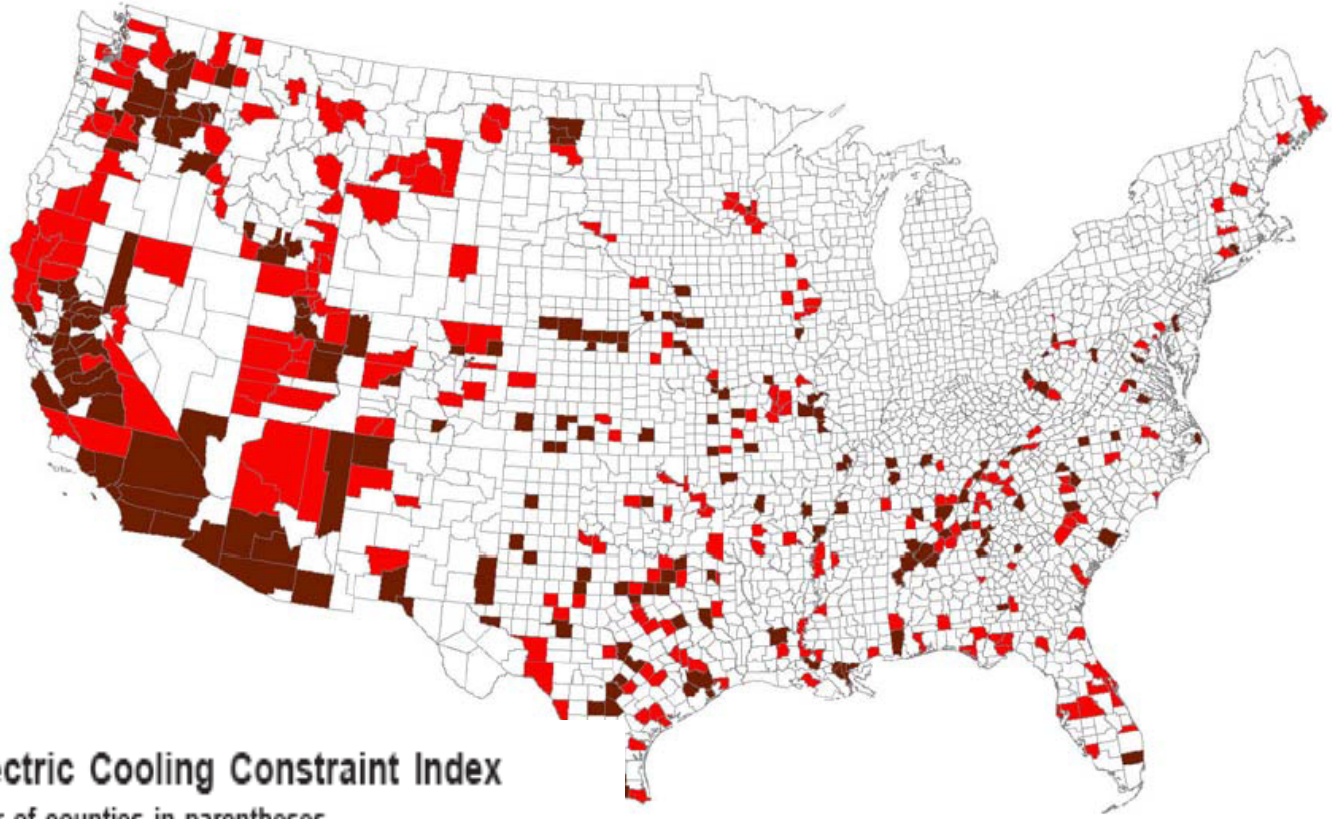
Source: EIA, Annual Energy Outlook 2010 Early Release, Dec. 2009

Post- and Oxy-combustion CO_2 Capture
Increase in COE



References:
1. Cost and Performance Baseline for Fossil Energy Power Plants study, Volume 1: Bituminous Coal and Natural Gas to Electricity; NETL, May 2007.
2. Pulverized Coal Oxycombustion Power Plants, Volume 1: Bituminous Coal to Electricity, U.S. DOE/NETL, Revised Final Report, August 2008

Expected Cooling Water Shortage in 2025



Thermoelectric Cooling Constraint Index

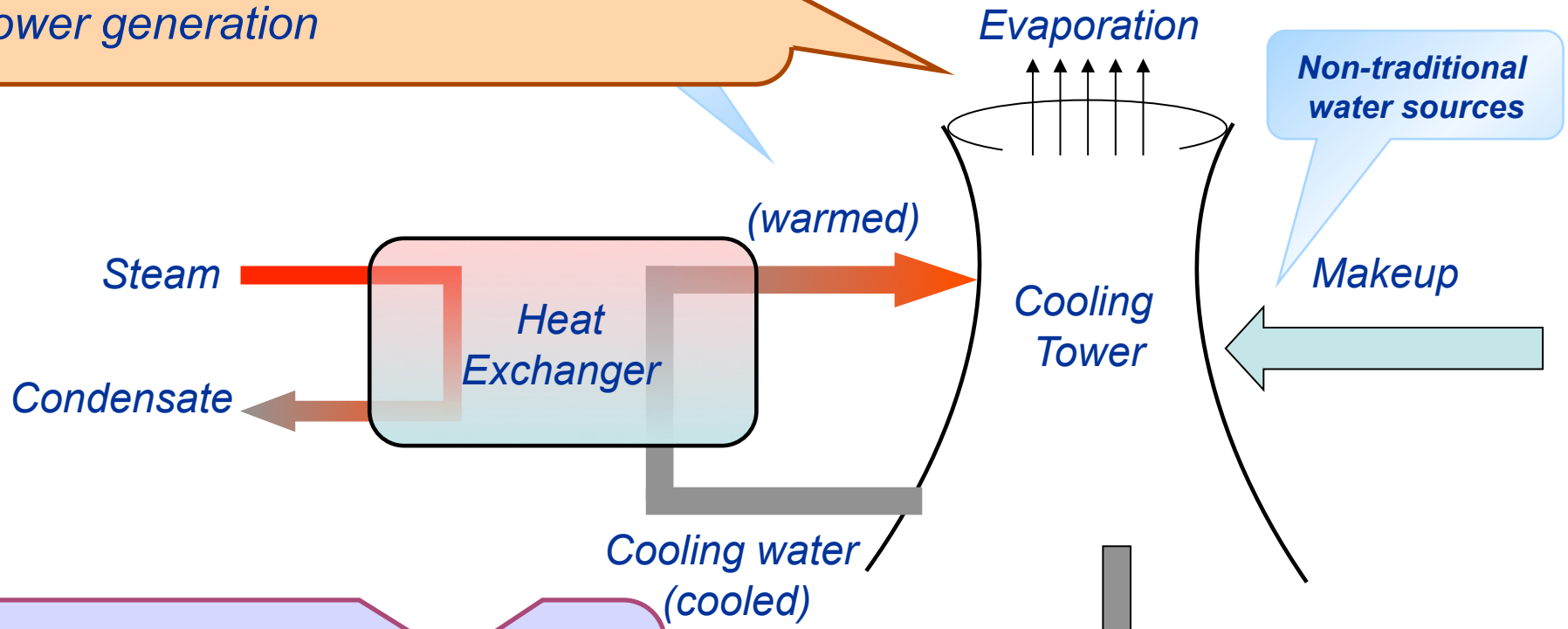
number of counties in parentheses

Highly constrained	(191)
Moderately constrained	(235)
No existing generation or constraints unlikely	(2685)

Source: Roy et al., (2003) A Survey of Water Use and Sustainability in the United States with a Focus on Power Generation. EPRI

Freshwater Use in Thermoelectric Power Plant

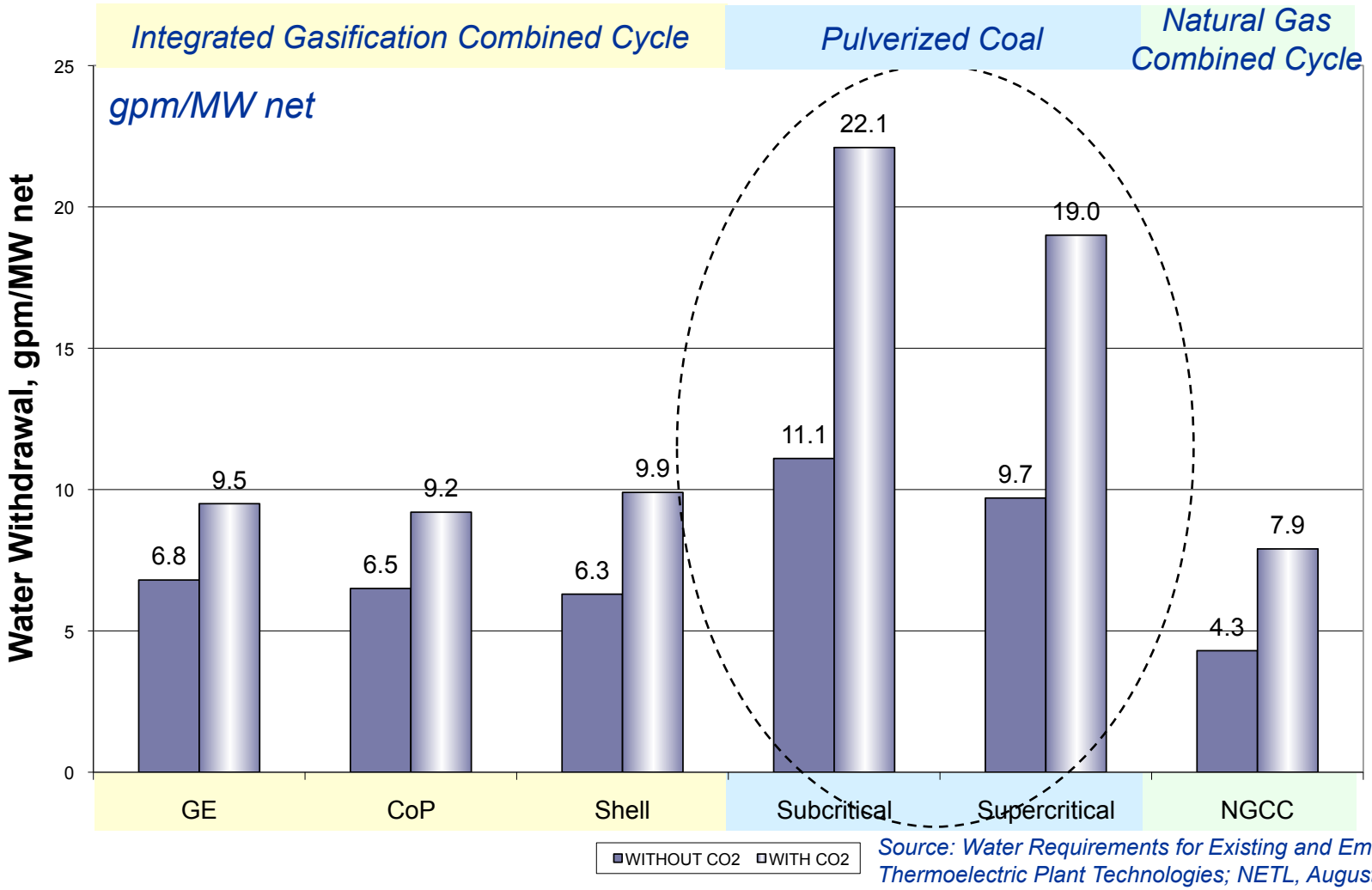
Approximately 3% of U.S. freshwater consumption used for thermoelectric power generation



Approximately 39% of U.S freshwater withdrawal used for thermoelectric power generation

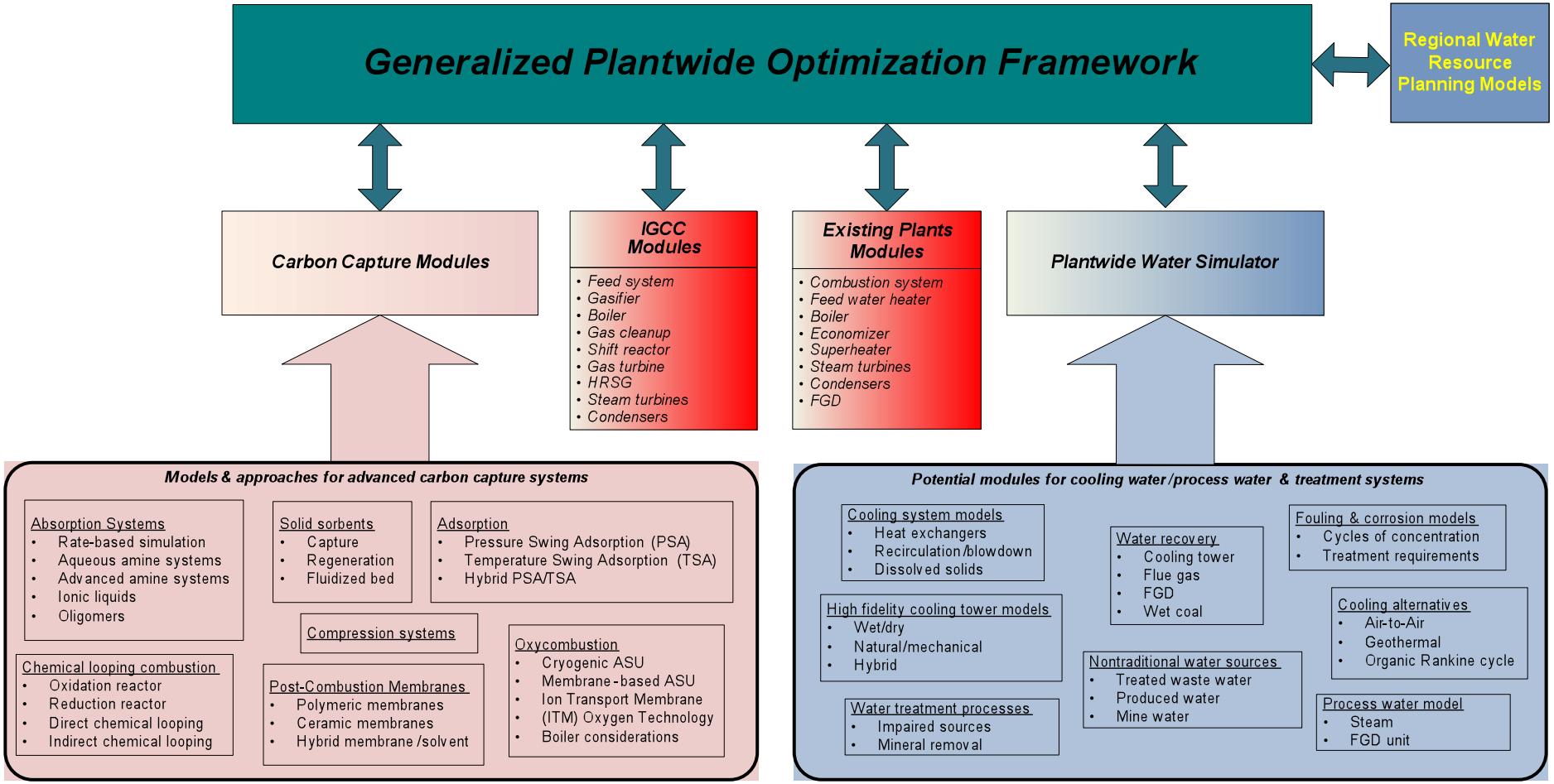
Power Plant Water Withdrawal Requirements

with and without CO_2 capture

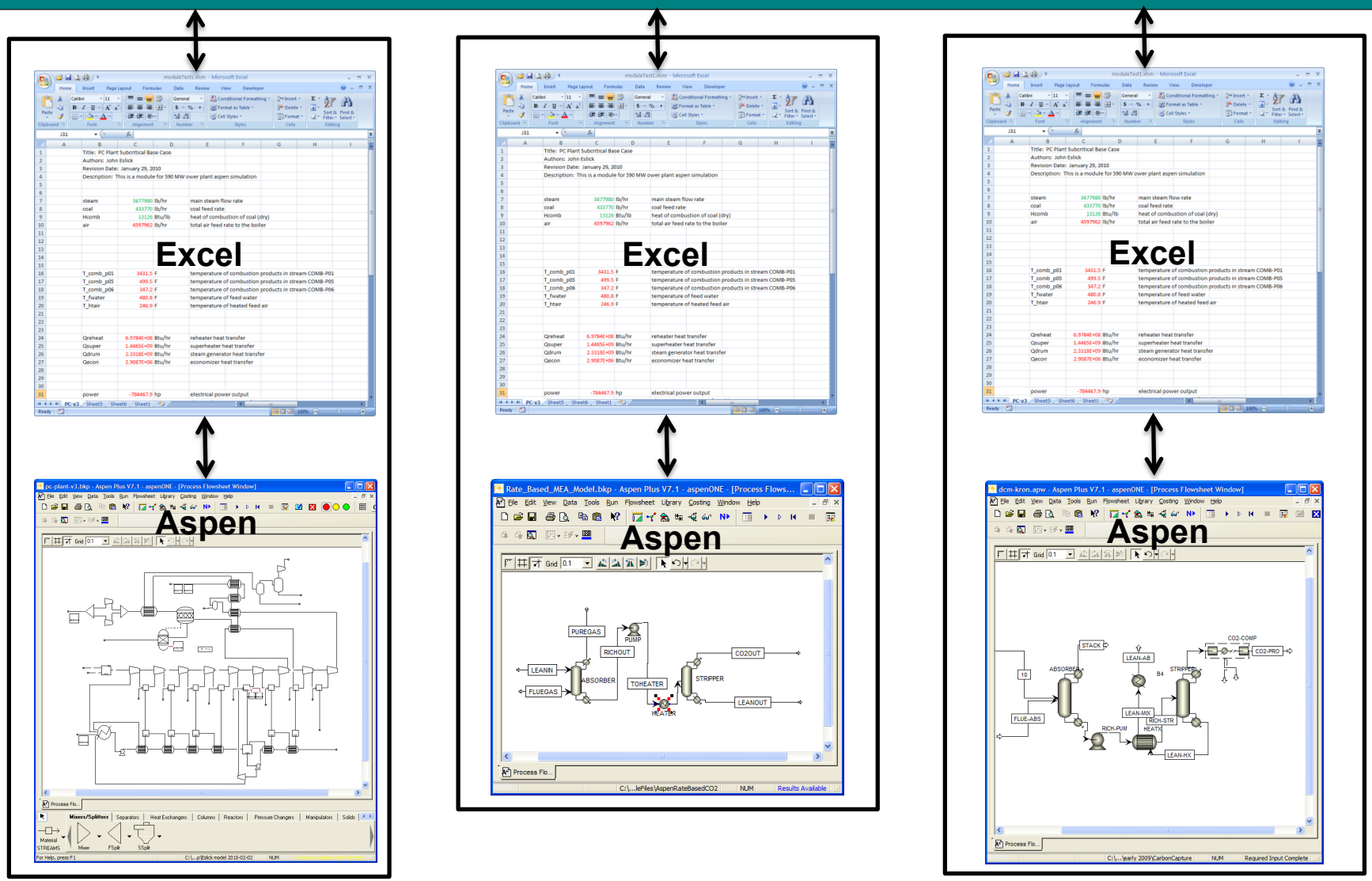


Source: Water Requirements for Existing and Emerging Thermoelectric Plant Technologies; NETL, August 2008

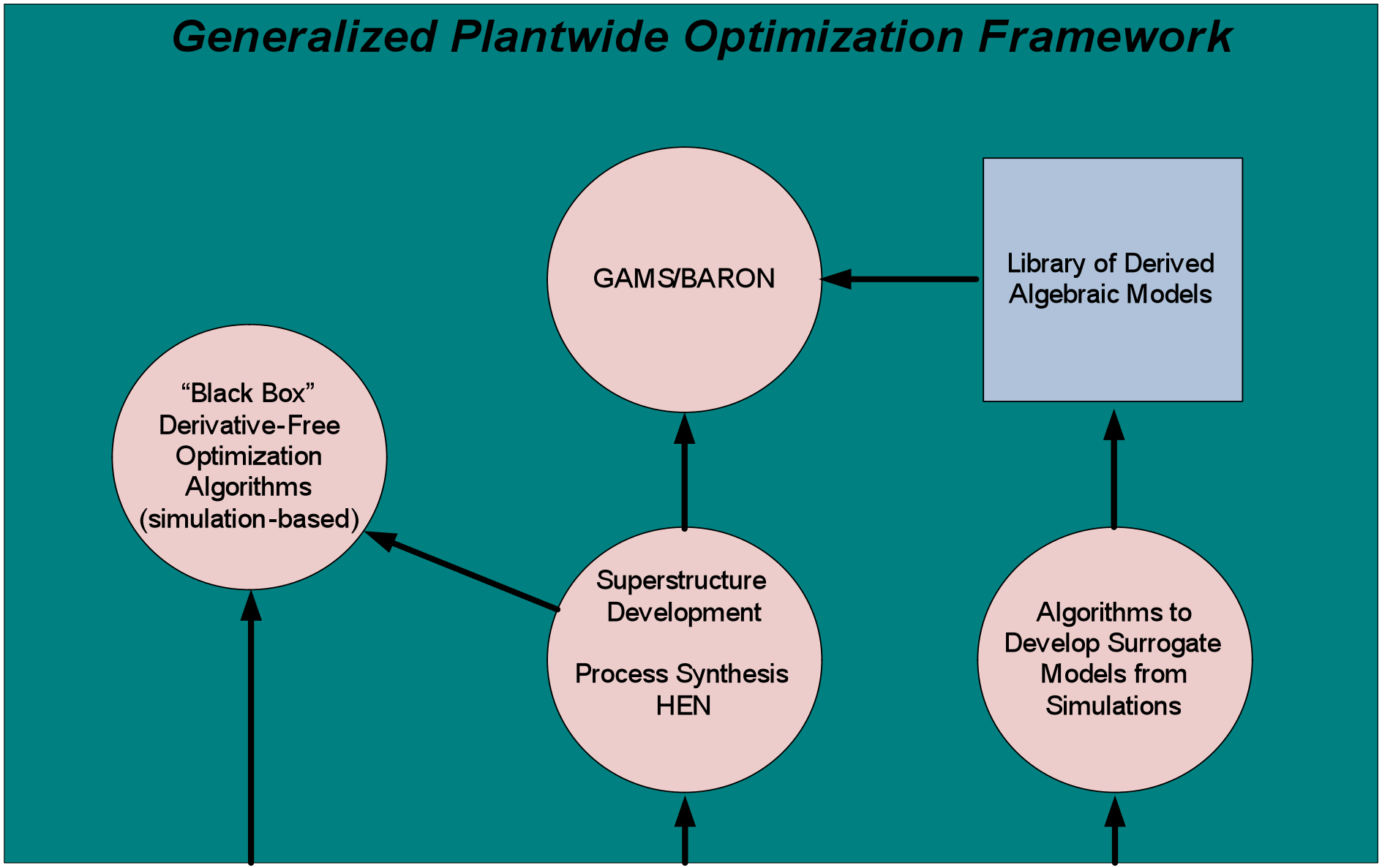
Modular Framework for Analysis and Optimization Of Existing Plants & IGCC: CO2 Capture & Water Minimization



Generalized Plantwide Optimization Framework



Generalized Plantwide Optimization Framework



Project Team

- **Dr. David Miller (NETL)**
  - John Eslick (postdoc) – modular framework
  - Andrew Lee (postdoc) – modular framework (joining April 2010)
  - Juan Morinelly (postgrad) – modular framework (joining April 2010)
  - TBD
- **Prof. Nick Sahinidis (CMU)**
  - Alison Cozad (PhD student) – Blackbox optimization of Advanced CCS Systems
- **Prof. Ignacio Grossmann (CMU)**
  - Linlin Yang (PhD student) –Simultaneous superstructure-based water/energy/heat optimization of conventional power plants
  - Ravi Kamath† (PhD student) – IGCC synthesis and integration
- **Prof. Larry Biegler† (CMU)**
  - Anshul Agarwal (PhD student) – PSA for CC from PC plants
  - Sree Rama Vetukuri (PhD student) – PSA for CC from IGCC
- **Prof. Wade Huebsch (WVU)**
  - Dr. Egemen Ogretim (postdoc) – Predictive cooling tower model
- **Prof. Dave Dzombak (CMU)**
  - Ming-Kai Hsieh (postdoc) - treated municipal waste water as cooling water
- **Profs. Javad Abbasian and Hamid Arastoopour (IIT)**
  - Michael Walker & Iman Safari (PhD students) – Treating nontraditional water sources
- **Ms Cathy Summers* and Dr. Danny Oryshchyn* (NETL)**
  - Sivaram (Hari) Harendra* (postdoc) – Water recovery from oxycombustion/IPR
- **Dr. John van Osdol* (NETL) – Modeling carbon capture processes**
- **Dr. Eric Liese* (NETL) – Predictive turbine models**