EVALUATING THE TECHNO-ECONOMIC FEASIBILITY OF FORWARD OSMOSIS PROCESSES UTILIZING LOW GRADE HEAT

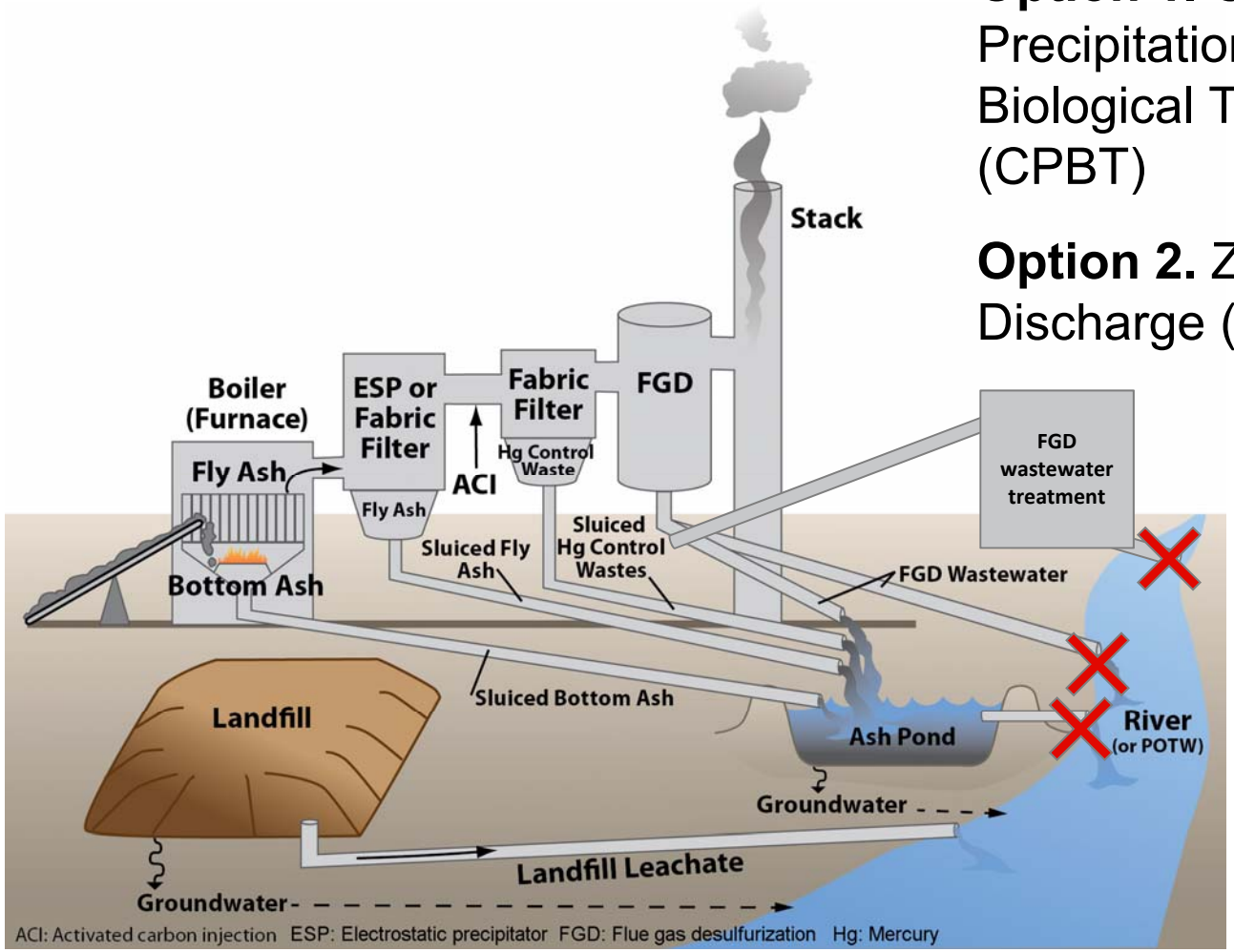
Daniel B. Gingerich[1], Meagan S. Mauter[1,2]

[1]Department of Engineering and Public Policy

[2]Department of Civil and Environmental Engineering

Project Identification Number: DE-FE0024008
Period of Performance: October 1, 2014-Sep 30, 2017
Project Manager: Jessica Mullen

EPA Final Effluent Limitation Guidelines for Steam Electric Power Generation Facilities

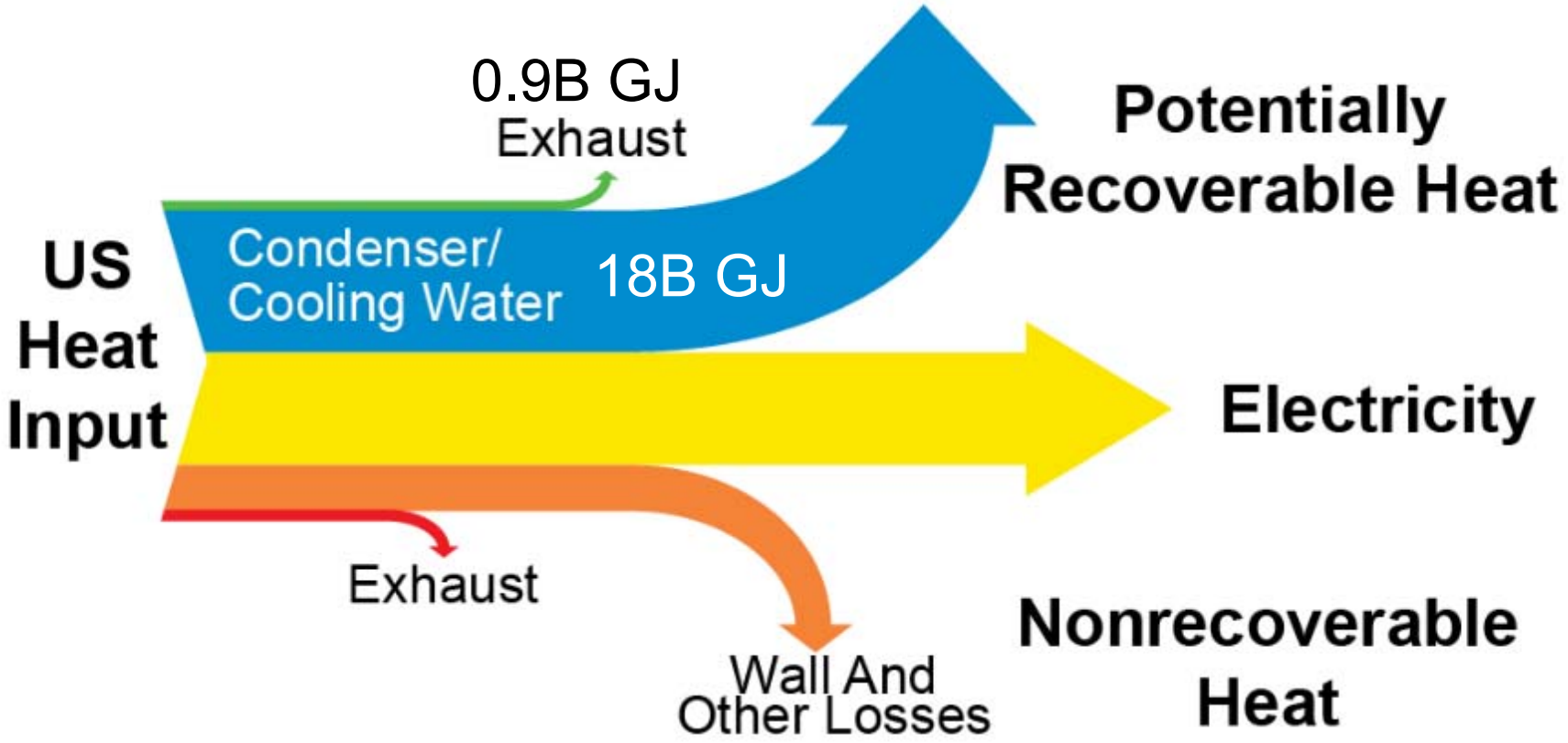


Option 1. Chemical Precipitation and Biological Treatment (CPBT)

Option 2. Zero Liquid Discharge (ZLD)

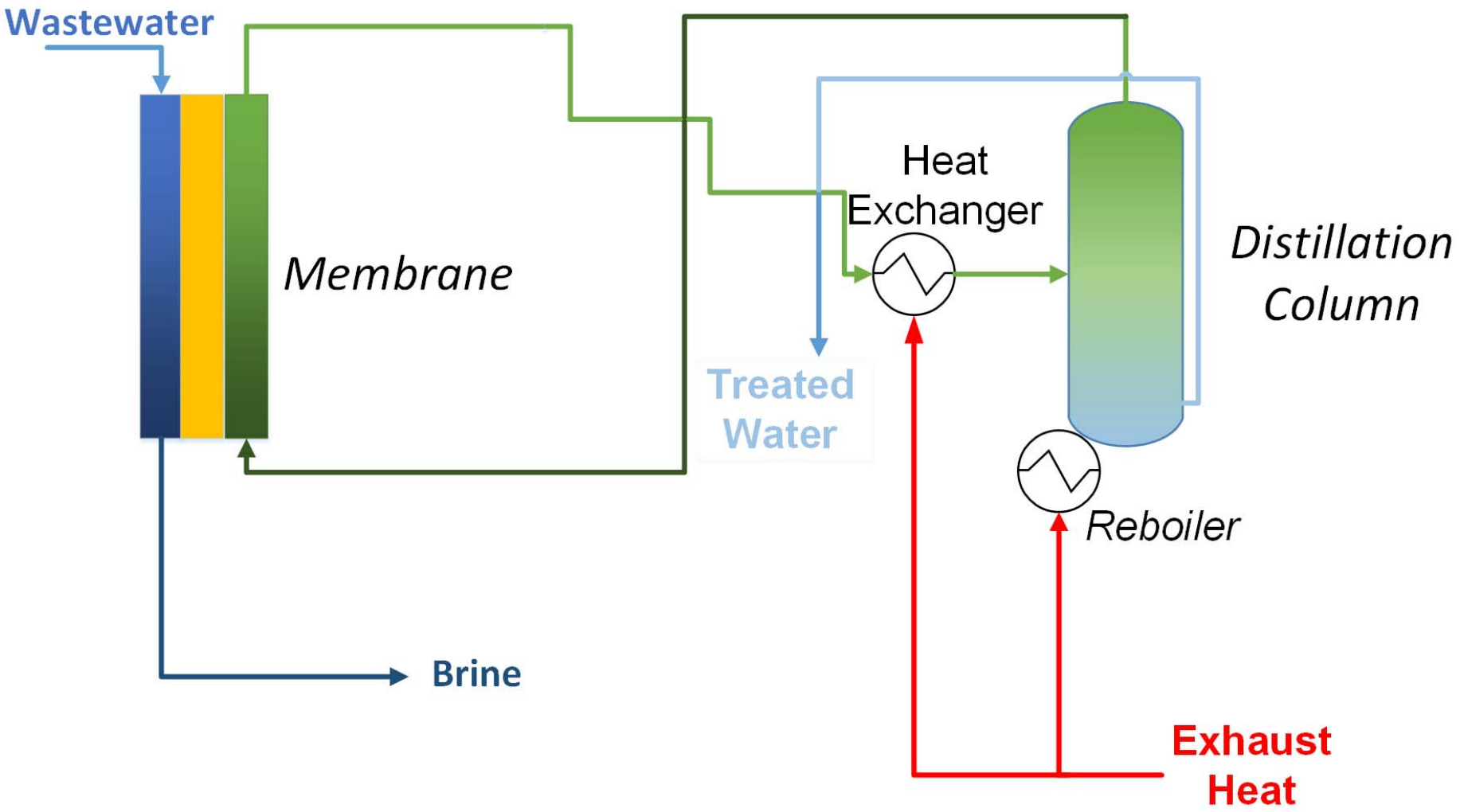
US EPA Final Effluent Guidelines for the Steam Electric Power Generating Category EPA 821-R-13-003, Sept. 2015

18.9 BILLION GJ OF POTENTIALLY RECOVERABLE HEAT IS AVAILABLE FROM THERMAL POWER PLANTS

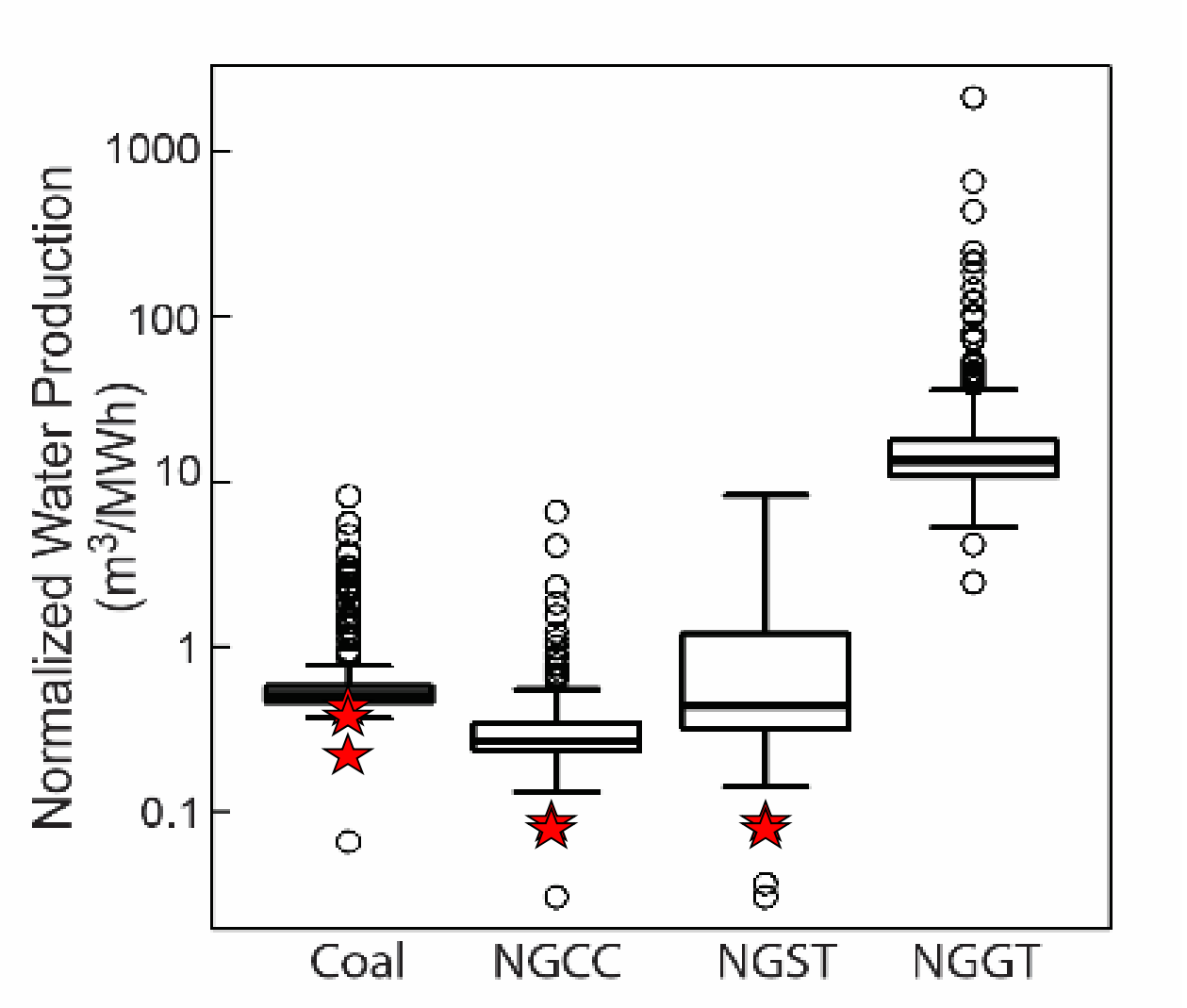


Gingerich and Mauter, *ES&T, 2015*

FORWARD OSMOSIS UTILIZES WASTE HEAT TO TREAT WATER



THEORETICAL FORWARD OSMOSIS CAPACITY EXCEEDS NON-COOLING WATER TREATMENT DEMANDS



Zhou, Gingerich, and Mauter, *I&ECR, 2015*

RESEARCH QUESTIONS

We've shown that waste heat driven FO is technically feasible, but **FO also needs to be economically competitive**.

1. What is the **minimum cost** of waste heat driven forward osmosis to treat power plant wastewater and boiler feedwater?

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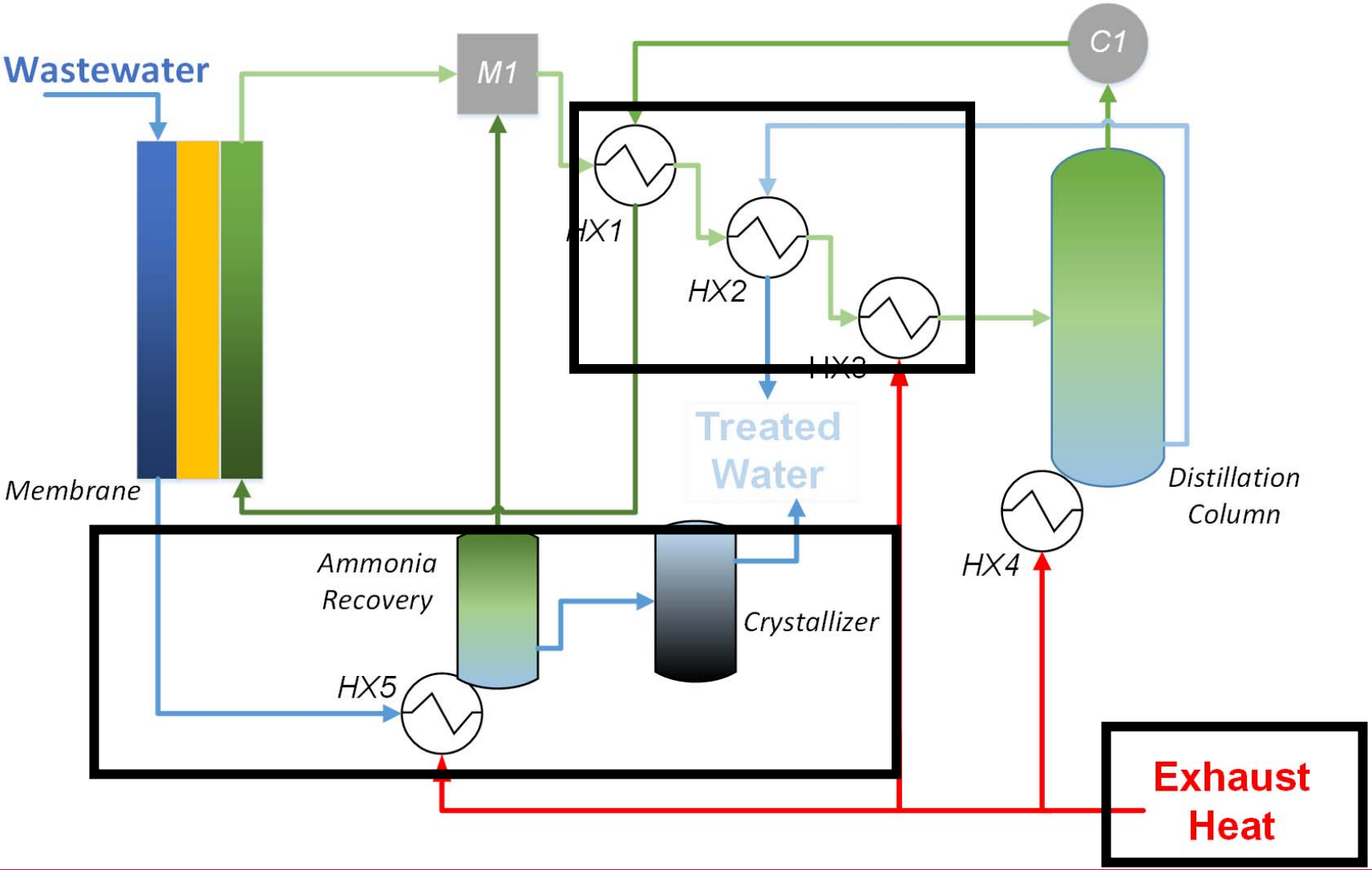
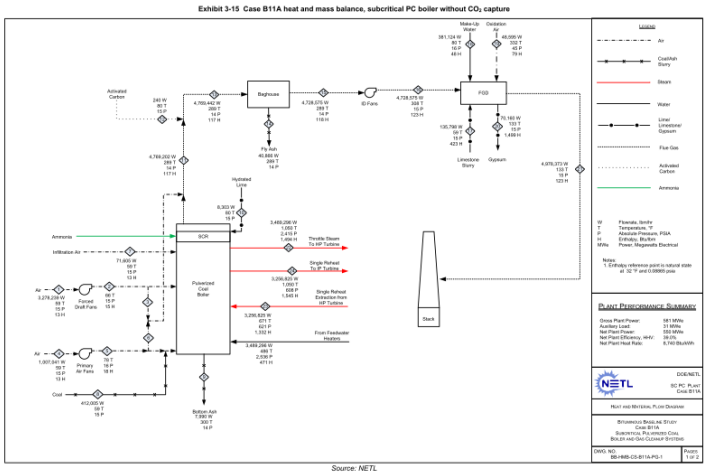
FORWARD OSMOSIS AND CRYSTALLIZATION PROCESSES AT POWER PLANTS



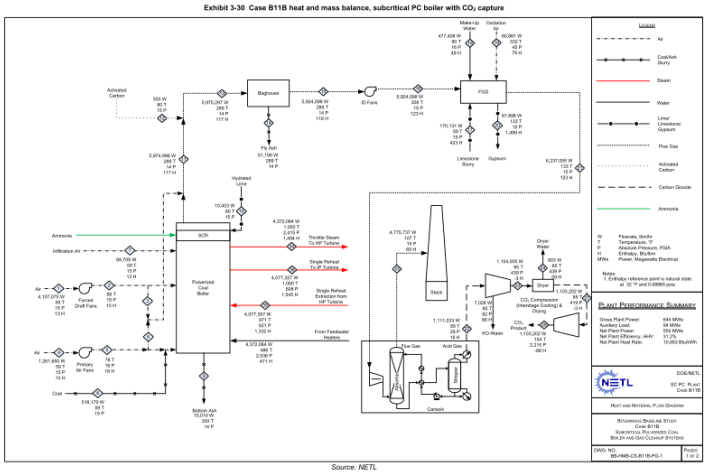
OVERALL MODELING AND OPTIMIZATION APPROACH

CASE STUDIES – ZLD WASTEWATER

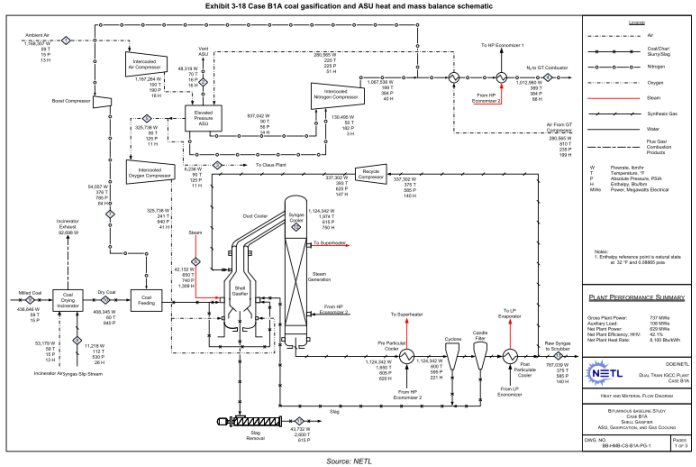
NETL Subcritical Coal w/o CC



NETL Supercritical Coal w/ CC



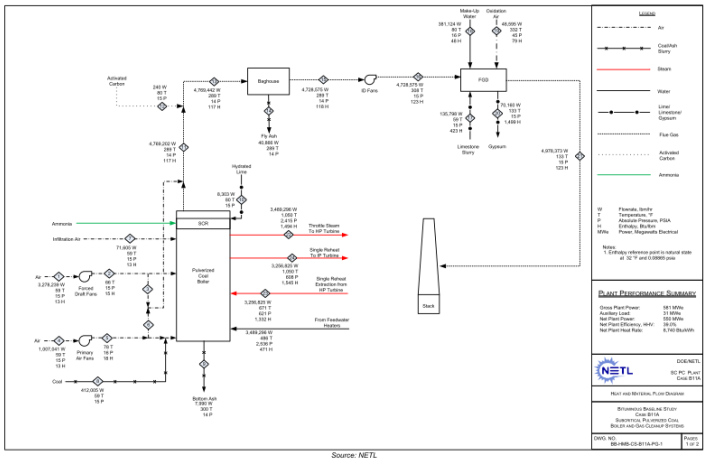
NETL Integrated Gasification



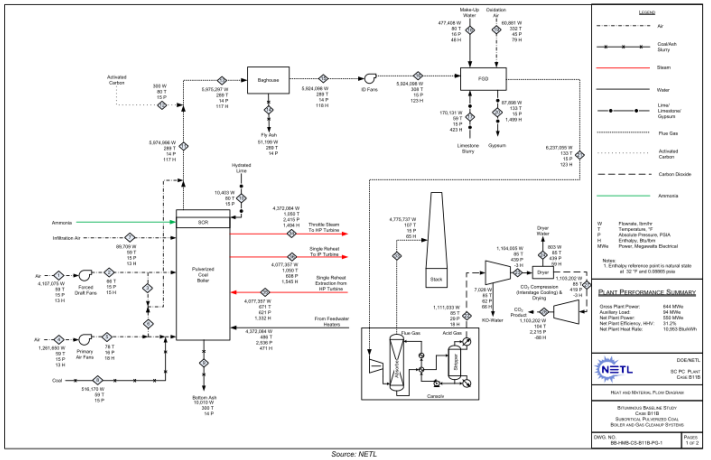
Subcritical Coal - Plant Bowen

CASE STUDIES – BOILER FEEDWATER

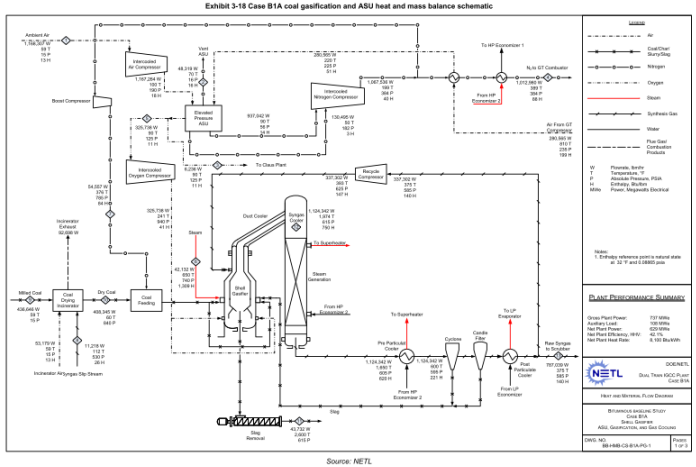
NETL Subcritical Coal w/o CC



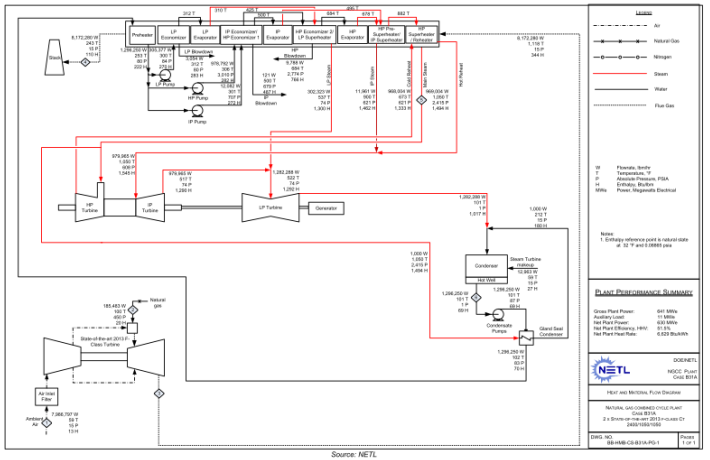
NETL Supercritical Coal w/ CC



NETL Integrated Gasification

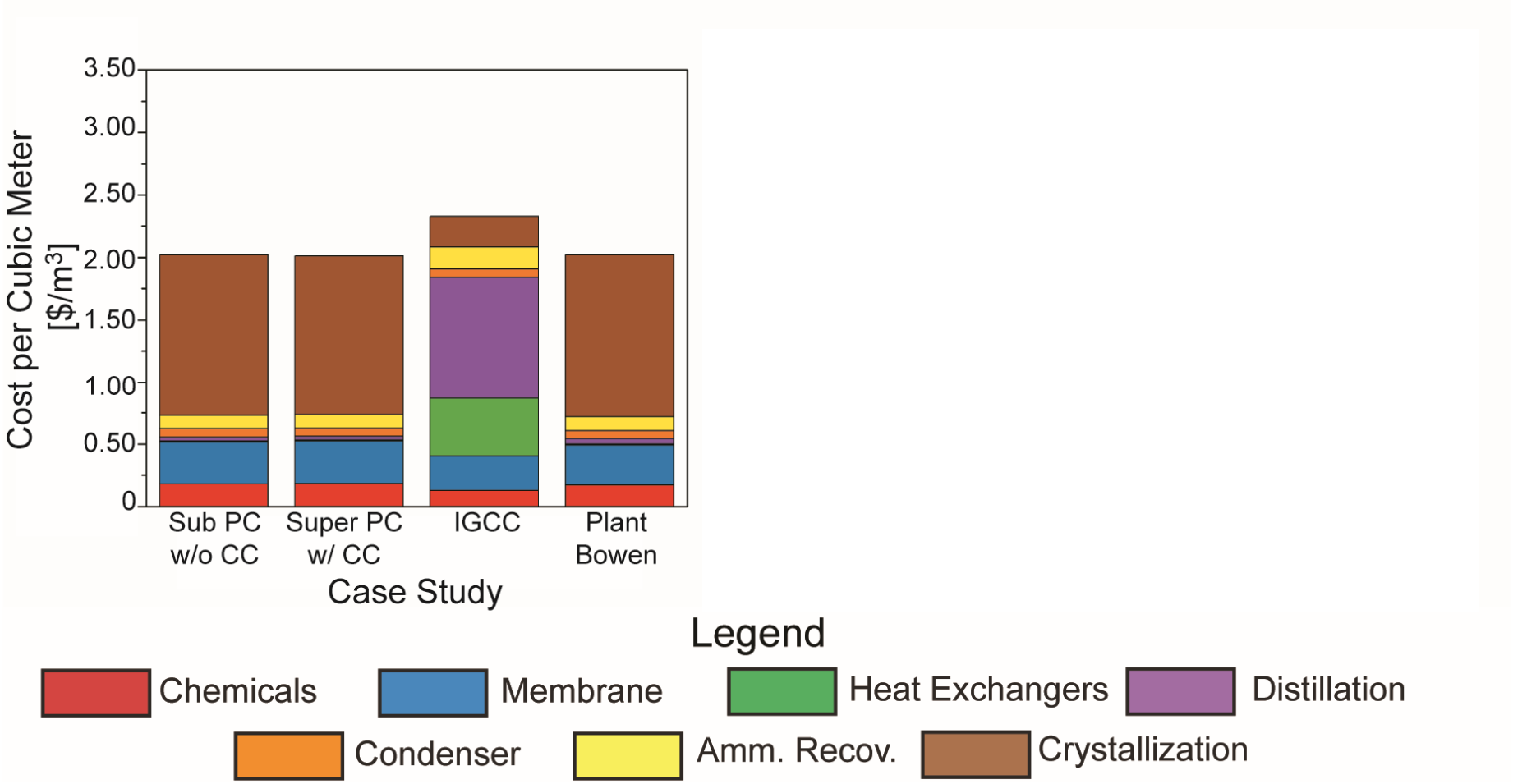


NETL Natural Gas Combined Cycle

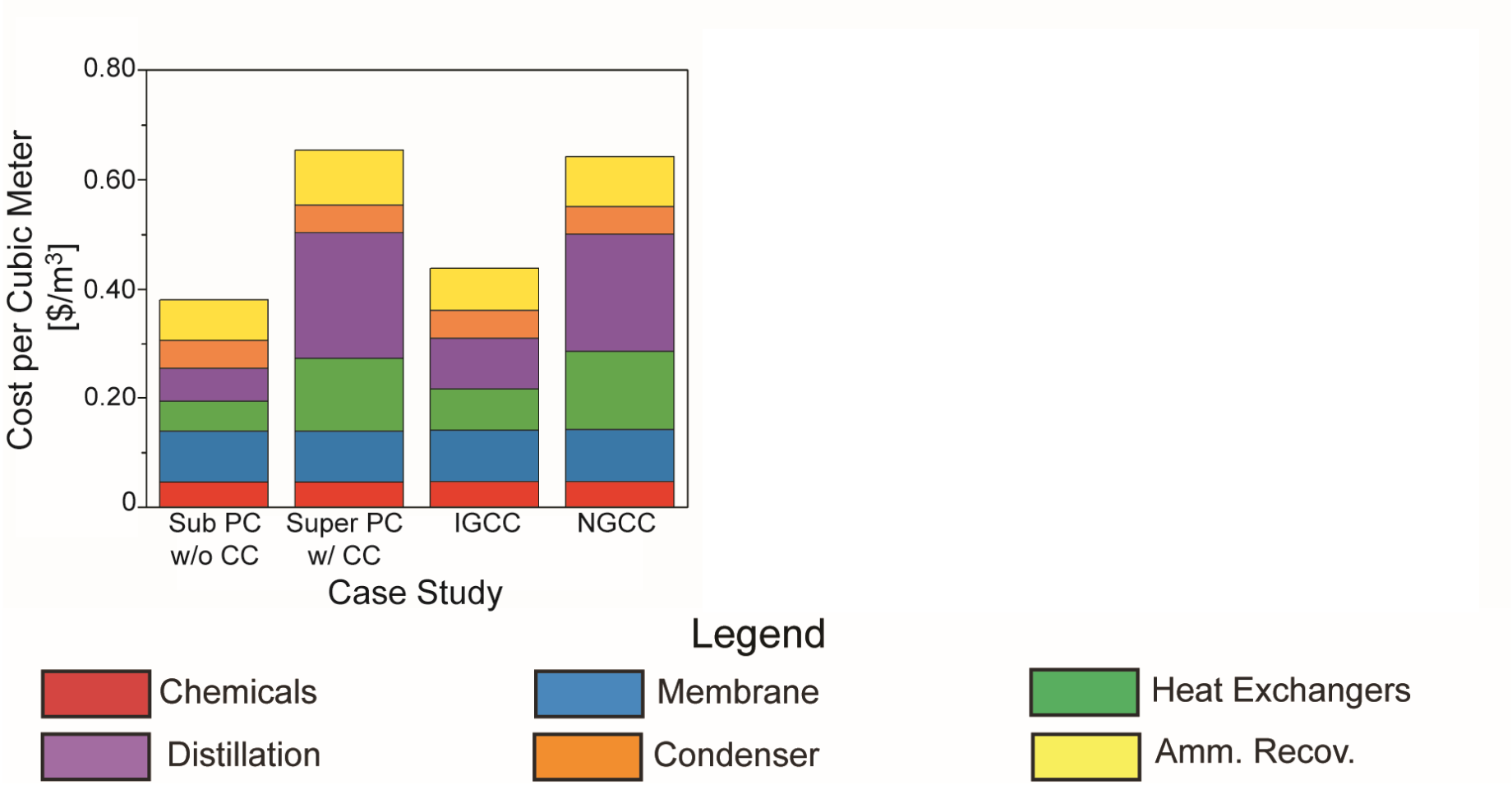


Carnegie Mellon University

COSTS FOR TREATING WASTEWATER TO ZERO LIQUID DISCHARGE



COSTS FOR TREATING BOILER FEEDWATER



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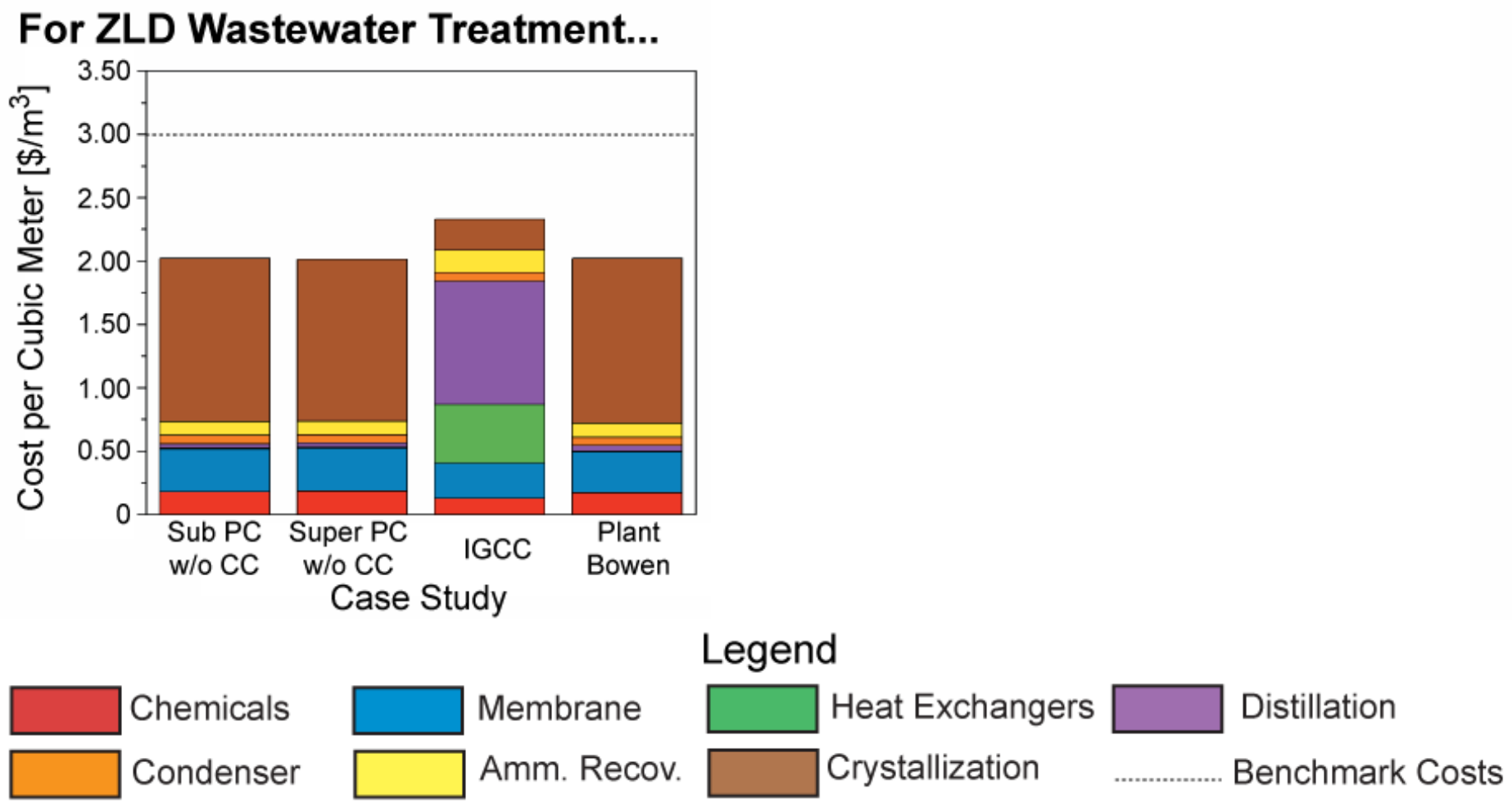
BEST AVAILABLE TECHNOLOGY BENCHMARKS

For ZLD wastewater:

Mechanical Vapor Recompression and Crystallization

MVCC Photo Credit: www.wateronline.com

FO IS COMPETITIVE FOR ZLD



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Research Questions

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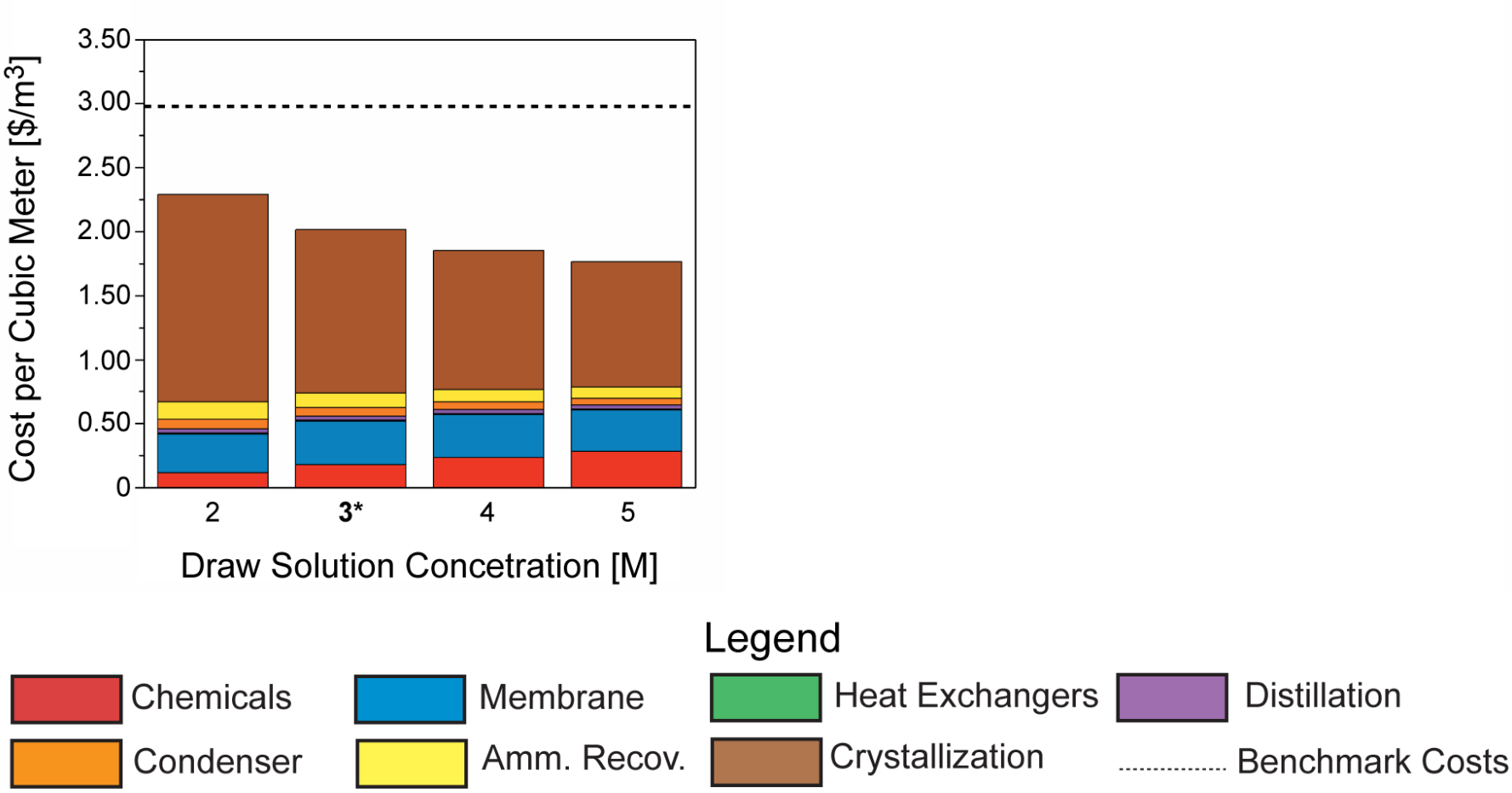
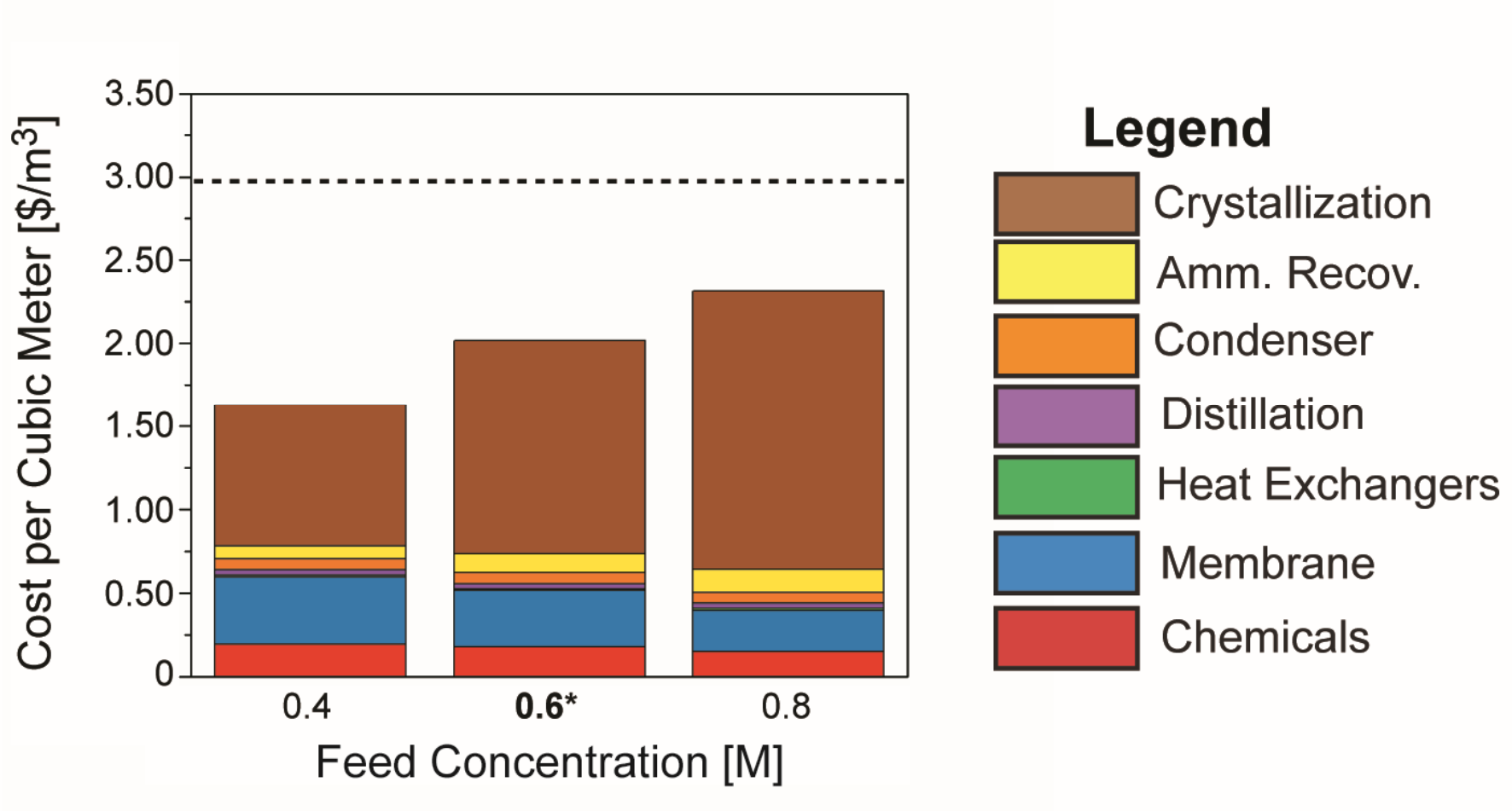
SENSITIVITY ANALYSES ON DESIGN AND OPERATING VARIABLES

$$J_W = A(\pi_D - \pi_F)$$

COST IS ROBUST OVER RANGE OF DECISION VARIABLES



FEED CONCENTRATION INCREASES LEADS TO COST INCREASES



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CONCLUSION/RESULTS

- Treatment with conventional “best available technologies” leads to suboptimal economic decisions for zero liquid discharge processes.

- Additional research needs for FO membranes:
  - Developing high flux membranes
  - Membranes that can handle cycling of wastewater purges
  - Membranes that can handle scaling

ACKNOWLEDGEMENTS

Funding sources

- Department of Energy (DE-FE0024008)

Colleagues in the WE3 Lab

- Tim Bartholomew

Disclaimer

QUESTIONS?