ILLINOIS
Prairie Research Institute

Energy-Efficient Waste Heat Coupled Forward Osmosis for Effluent Water Management at Coal-Fired Power Plants

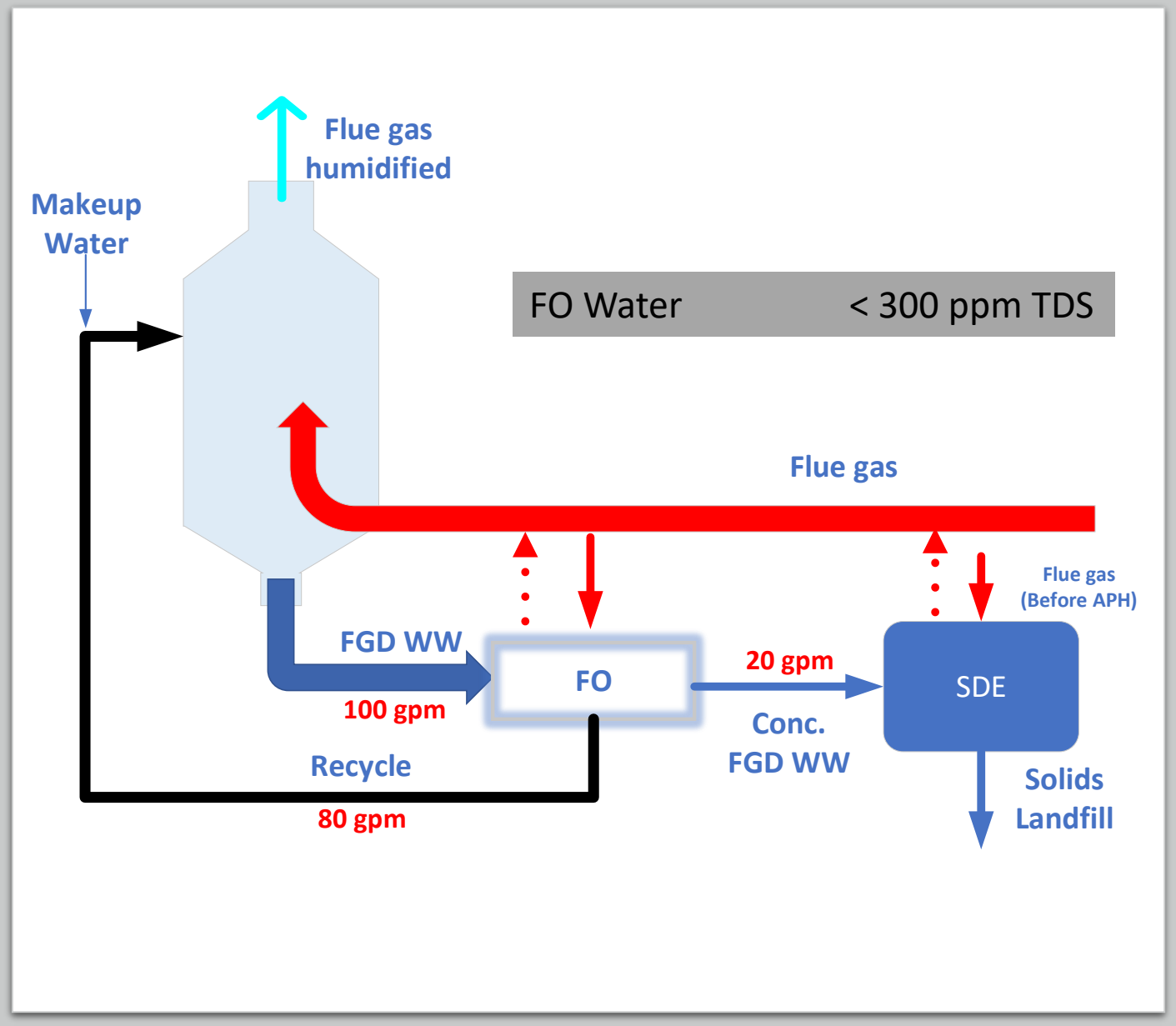
N. Rajagopalan, Ph.D., UIUC
Partners: Trimeric Corporation, IL Power Plant
Project Manager: Mr. Charles Miller
Project: FE-0031551

U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

Goals	Achievements
• Recover at least 50% water from problematic power plant effluents such as FGD scrubber blowdown for reuse using FO	✓**80% achieved /90% possible**
• Thermal Energy (200 kJ/kg)	✓ **Achieved**
• Electrical Energy (< 3.6 kWh/m^3)	✓ **2.2 kWh/m^3**

DOE Alignment

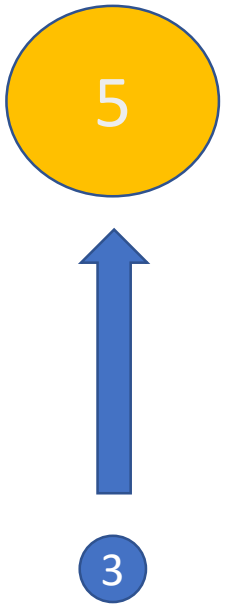
- DE-FOA-0001686/ AOI 5
  - innovative effluent water management
  - developing water treatment and reuse methods that employ low energy or waste heat solutions
  - reduce overall treatment requirements



Summary

- Met project goals of low energy requirement, waste heat utilization and reuse of power plant effluent
- FO can treat FGD wastewater with minimal pretreatment to achieve wastewater volume reduction
- Currently limited to 80% water recovery to avoid gypsum precipitation
- 90% reduction in wastewater volume possible with intermediate gypsum desaturation/other process variations
- Process scale-up and testing in power plant required to further advance TRL level; reduce uncertainties (e.g., membrane lifetime)
- Membrane residuals treatment costs can and must be reduced further- several pathways exist to achieve mid-single digit $/m^3 total treatment costs

This Project

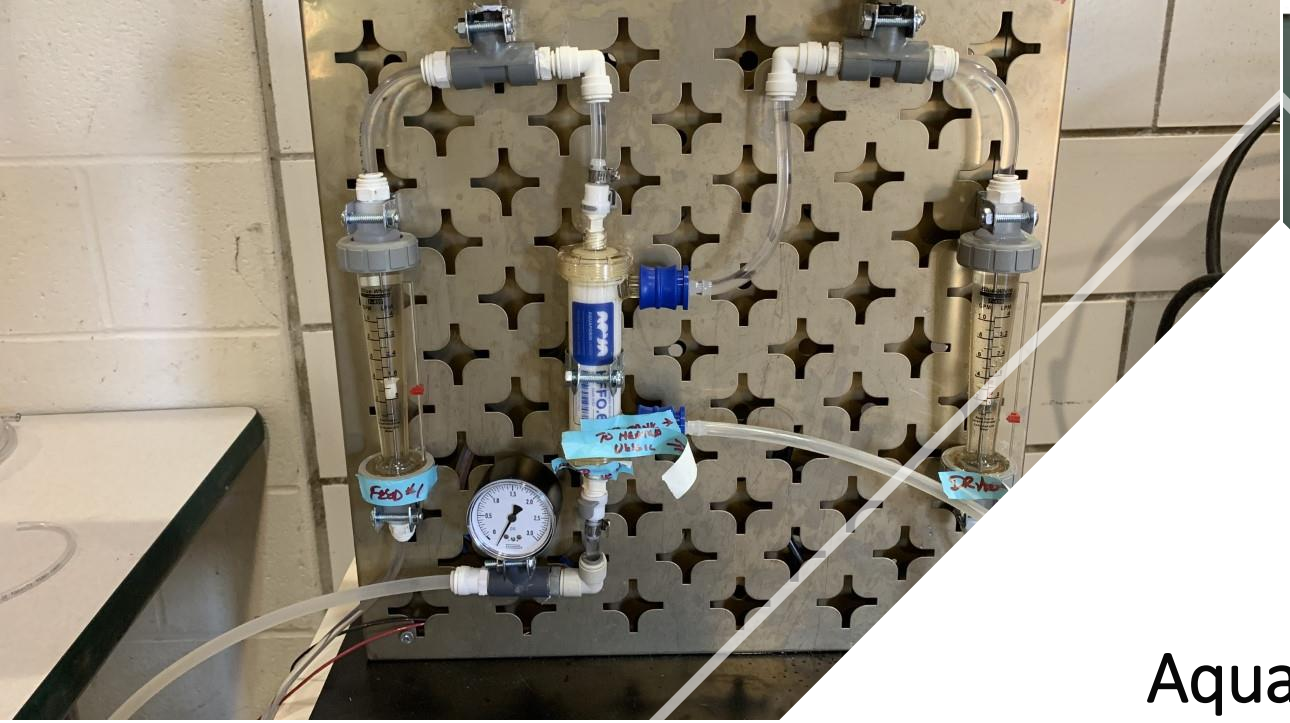


Laboratory scale, similar system validation in relevant environment

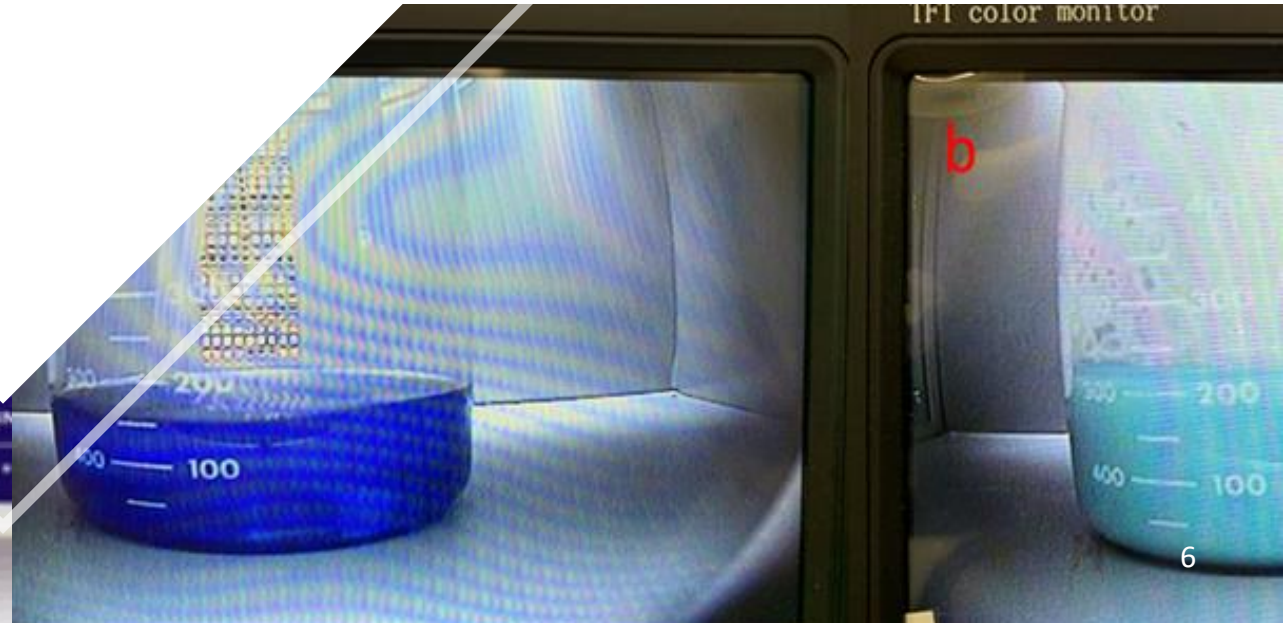
Research to prove feasibility

Next Steps

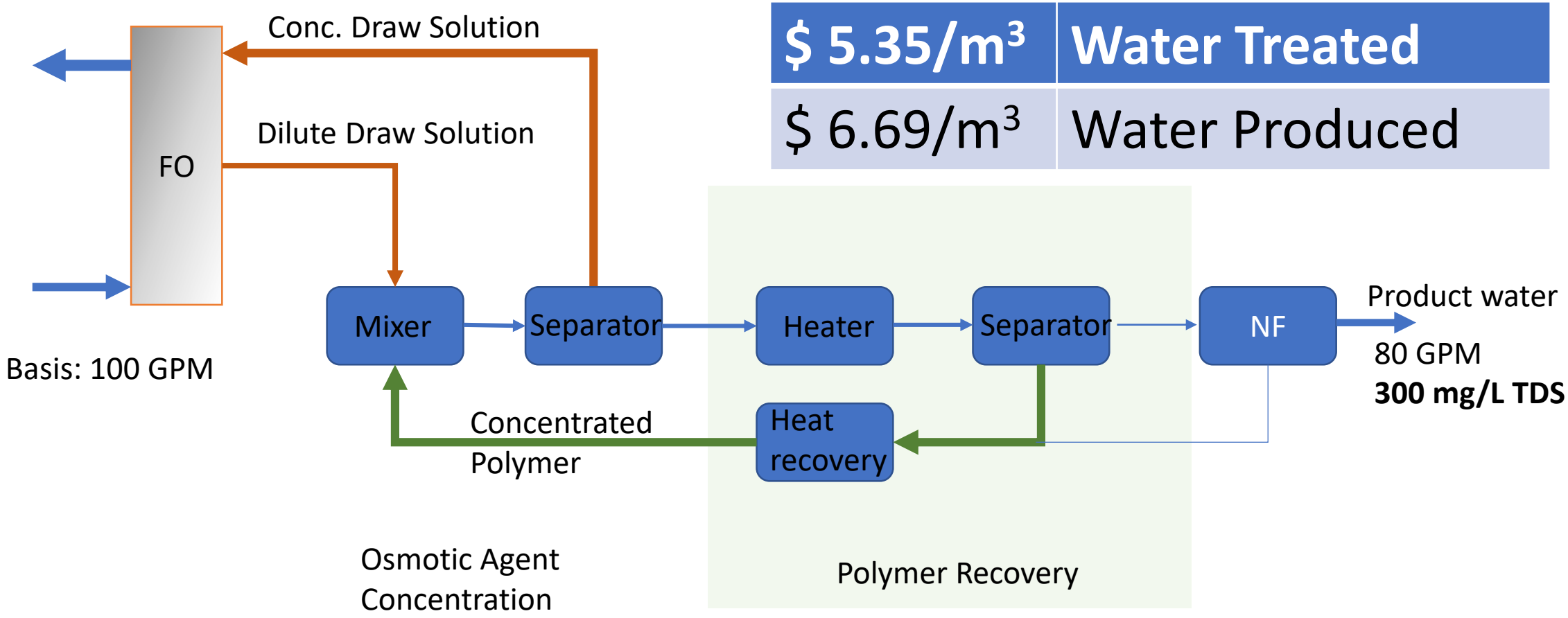
- Long-term membrane module stability testing;
  3 modules/3 – 6 months
- Test scaled-up system at power plant (~1 gpm)
- Conduct proof-of-concept of very ***low energy/low-cost residuals management approach***



Aquapod Process



FO Lifetime Cost Estimates



$ 5.35/m³	Water Treated
$ 6.69/m³	Water Produced

Total Plant Costs	$7,361,542
PEC	$1,372,398

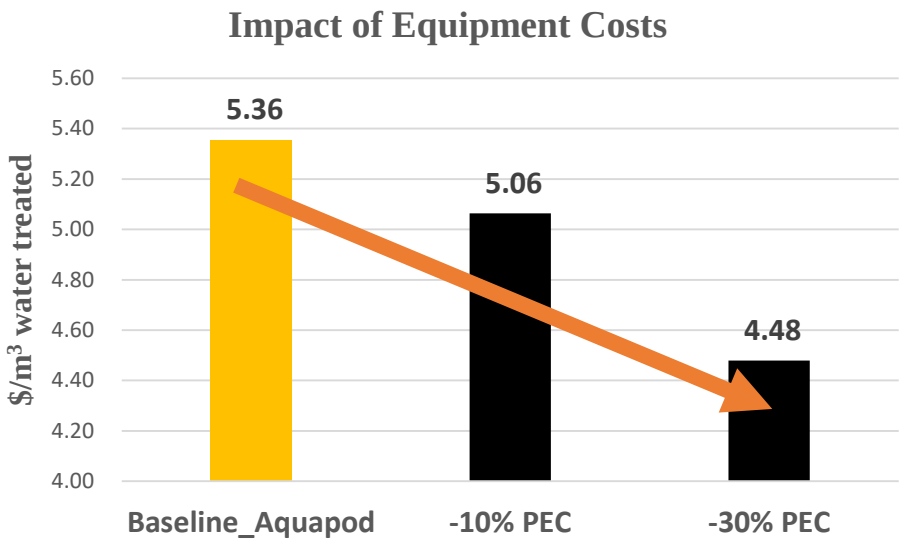
Operating Cost Estimates

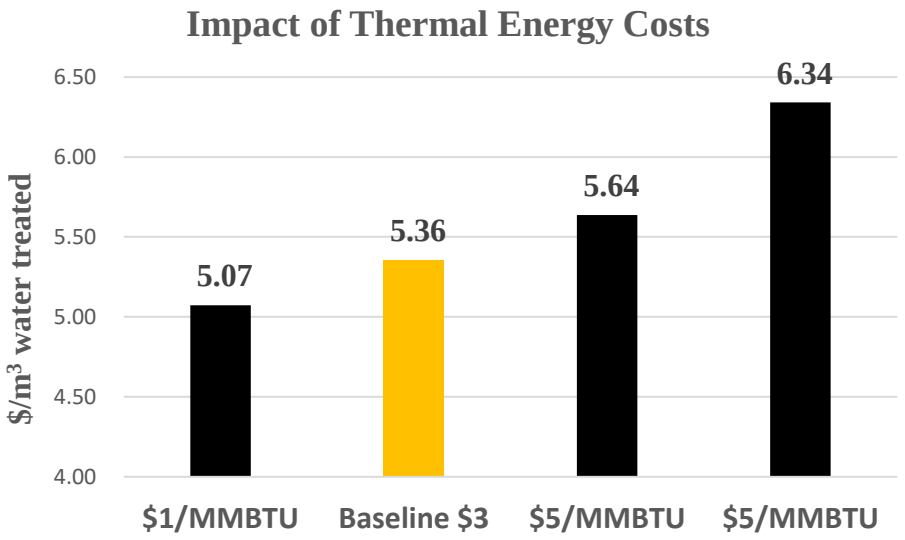
Variable O&M Costs

$ 1.50/m^3	Water Treated
$ 1.88/m^3	Water Produced

Fixed O&M Costs

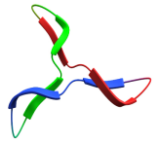
$ 1.87/m^3	Water Treated
$ 2.34/m^3	Water Produced



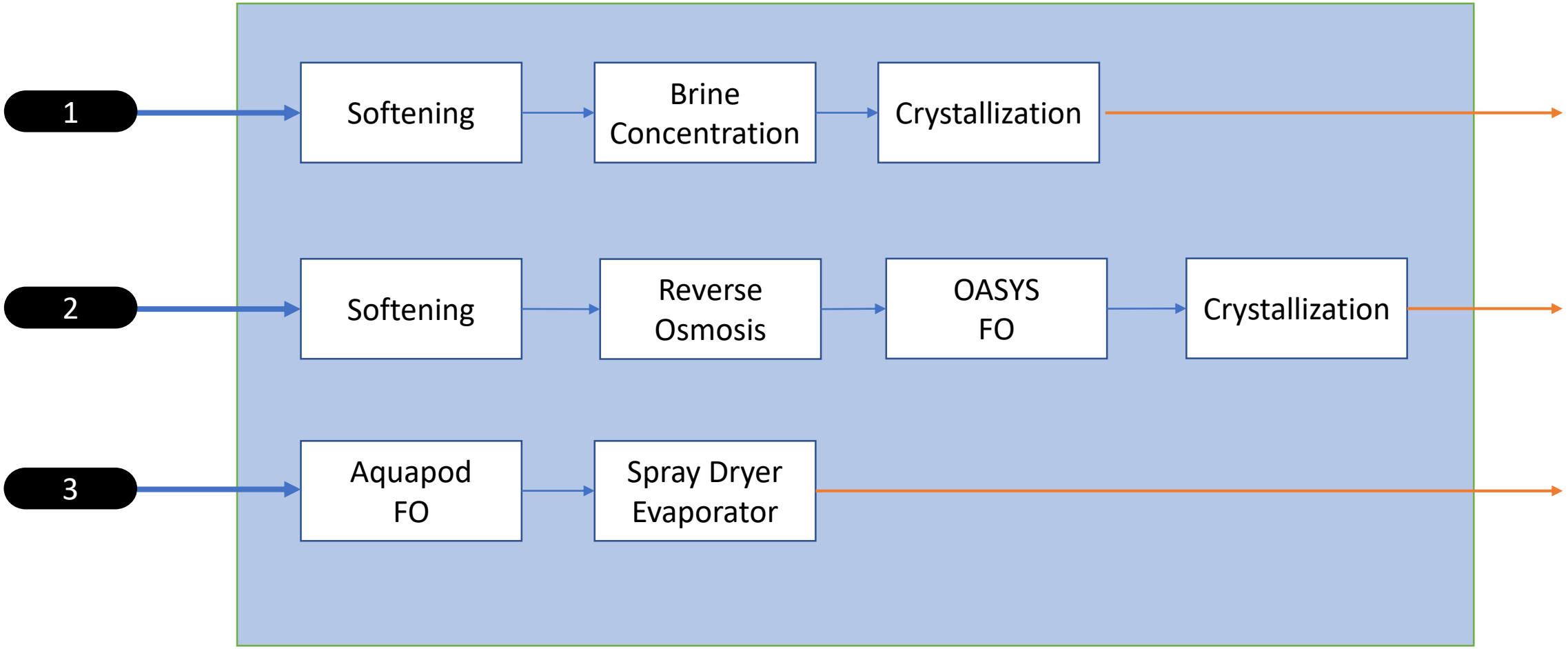


- -30% PEC reduction target for second iteration
- Cost reductions possible due to derisking, lower FO costs, engineering optimization

- FO Membrane Costs of $75/m^2 HF in <1 year ($25/m^2 available NOW in different chemistry)



Membrane Residuals Treatment/ZLD



1, 2, 3

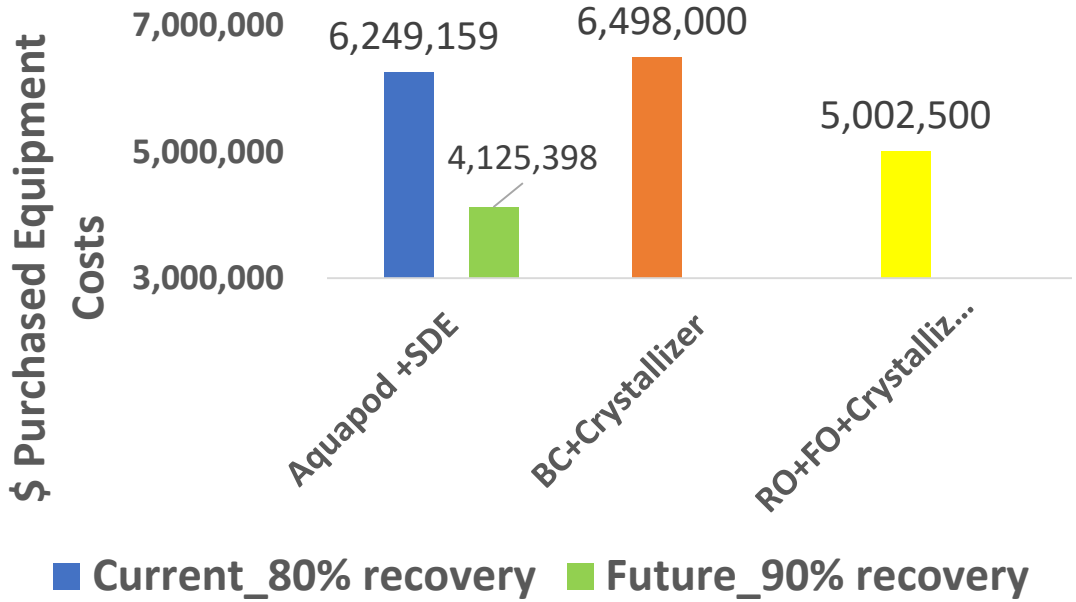
FGDWW desaturated and treated to remove metals, Hg, etc..

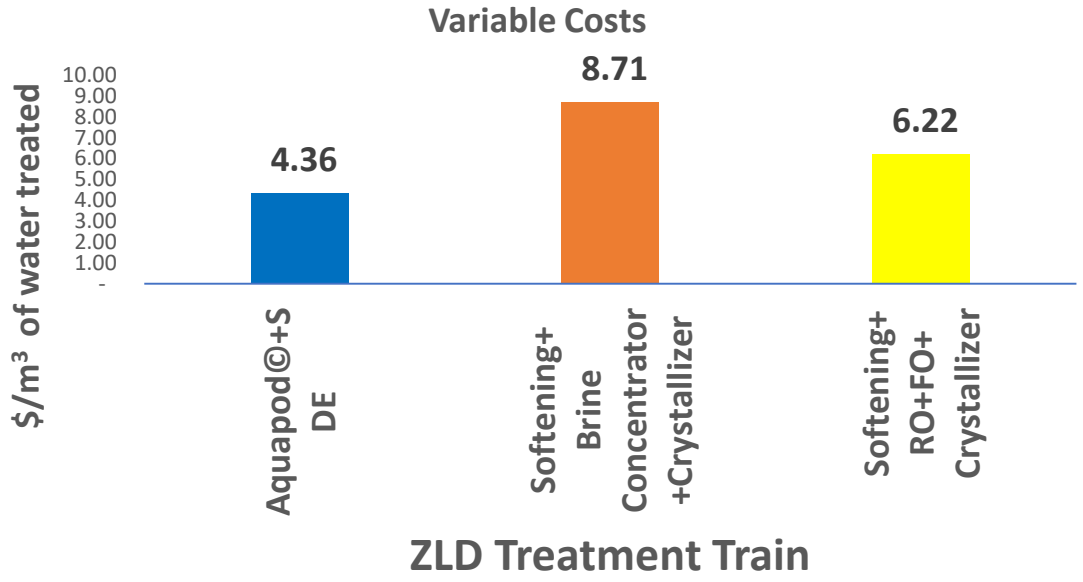
ZLD Treatment Train

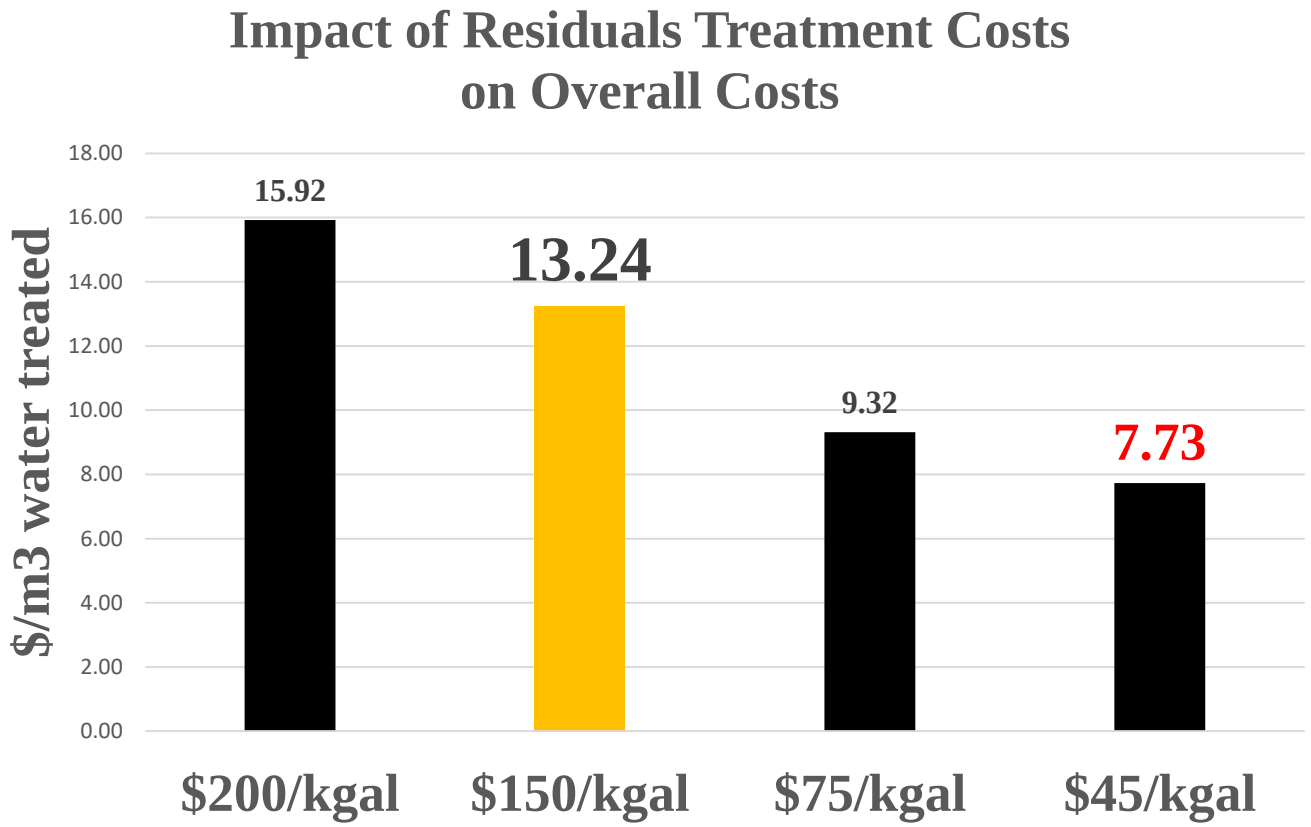
FOR CURRENT PROCESS FLOWSHEET

Aquapod+SDE Variable Costs Are LOWER

But Capital Costs are INTERMEDIATE at 80% recovery & LOWER at 90% recovery







~$8/m^3 achievable in power plant at current Aquapod costs with new residuals treatment approach in development at ISTC; Simulations completed- prototype design in progress.

For reference, PP spends between $4-$9/m^3 currently for discharge.

MVC+crystallizer costs in literature are ~$20/m^3

Summary

- Met project goals of low energy requirement, waste heat utilization and reuse of power plant effluent
- FO can treat FGD wastewater with minimal pretreatment to achieve wastewater volume reduction
- Currently limited to 80% water recovery to avoid gypsum precipitation
- 90% reduction in wastewater volume possible with intermediate gypsum desaturation/other process variations
- Process scale-up and testing in power plant required to further advance TRL level; reduce uncertainties (e.g., membrane lifetime)
- Membrane residuals treatment costs can and must be reduced further- several pathways exist to achieve mid-single digit $/m^3 total treatment costs

Team

UIUC

- K C OBrien
- Chinmoy Baroi
- Martina Del Cerro
- Sriraam Chandrasekaran
- DongHao Chen
- Marihah Muhsinah
- Vinod Patel
- John Scott
- Xuesong Zhang

Trimeric

- Katherine Dombrowski
- Ray McKaskle
- Kevin Fisher

IL PP

- P.J. Becker
- Brandon Powell
- Eric Staley