# Advanced Solvent Configurations for Superstructure Optimization

**Katherine Hedrick**[a,b], Anuja Deshpande[a,b], Anca Ostace[a,b], Brandon Paul[a,b], Daison Yancy Caballero[a,b], Miguel Zamarripa[a,b], Michael Matuszewski[a,b], Joshua Morgan[a], Benjamin Omell[a]

[a] National Energy Technology Laboratory (NETL), [b] NETL Support Contractor

## Overview

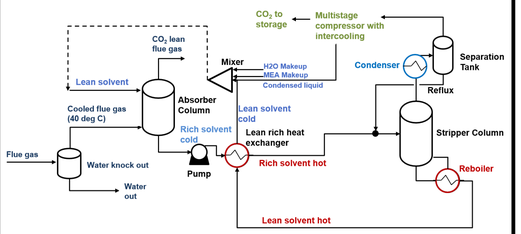
- Modeling and analysis of solvent-based $CO_2$ capture systems with alternative process configurations
- Increase driving force for $CO_2$ uptake in absorber and/or reduce energy requirement for solvent regeneration

## Objectives

- Identify viable solvent-based process configurations
- Develop models of nine configurations for MEA and CESAR1 solvents
- Determine feasible operating regions for each configuration
- Perform superstructure optimization considering advanced configurations

## Base Configuration

- Solvent-based capture system – MEA or CESAR1 – processing flue gas from NGCC plant




Model Robustness

- Essential for models to be robust in order to develop effective surrogates
- Thermodynamic limits on $CO_2$ lean loading result in infeasibility of achieving desired capture level

## References

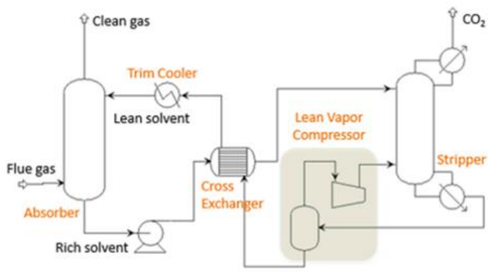
[1] Jiang Y et al., 2021. Techno-economic comparison of various process configurations for post-combustion carbon capture using a single-component water-lean solvent. IJGCC.
[2] Bhattacharyya D, Miller DC, 2017. Post-combustion CO2 capture technologies – a review of processes for solvent-based and sorbent-based CO2 capture. Current Opinion in Chemical Engineering.
[3] Morgan JC, et al., 2022. Development of process model of CESAR1 solvent system and validation with large pilot data. Proceedings of the 16th International Conference on Greenhouse Gas Control Technologies.
[4] Hong B, 2020. Economic optimization of next-generation carbon capture plants using the Framework for Optimization, Quantification of Uncertainty and [*Surrogates*] (FOQUS). Internal report.

## Acknowledgements

The authors graciously acknowledge funding from the U.S. Department of Energy, Office of Fossil Energy and Carbon Management, through the Carbon Capture Program.

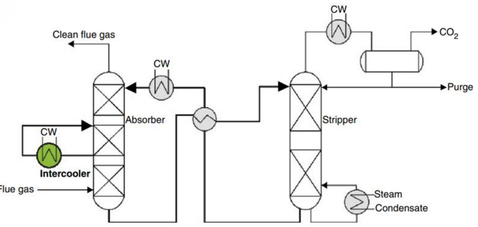
## Advanced Configurations

### Lean Vapor Compression (LVC) [1]



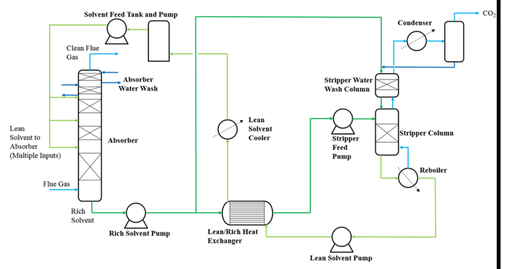

Reduces reboiler duty

### Pump Around Intercooling (PA) [2]



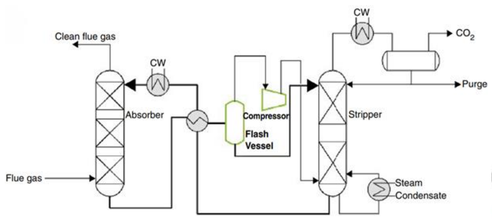

Allows higher $CO_2$ loadings

### Simple Stripper with Bypass (SSB) [3]



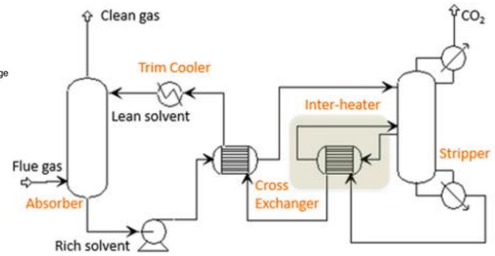

Enhances heat recovery

### Rich Vapor Compression (RVC) [2]



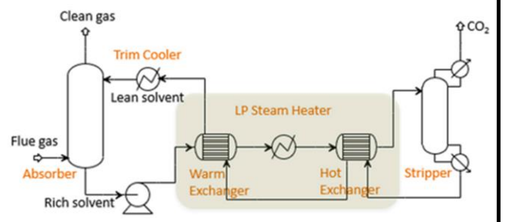

Reduces reboiler duty

### Interheated Column (IHC) [1]



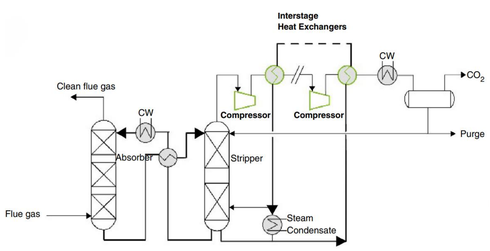

Improves heat exchange efficiency

### Low Pressure Steam Heater (LPH) [1]



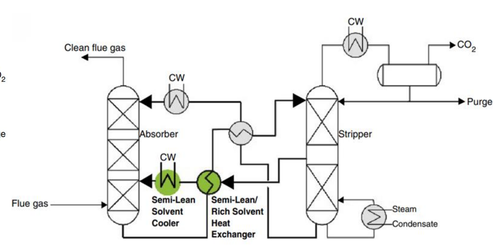

Reduces reboiler duty

### Mechanical Vapor Compression (MVC) [2]



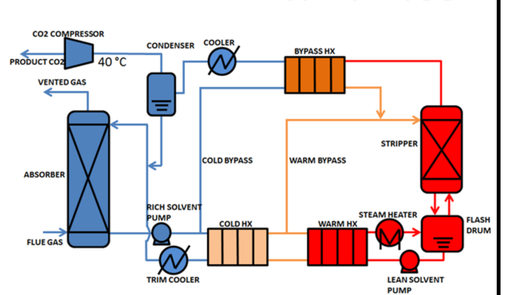

Reduces reboiler duty

### Split Flow Configuration (SFC) [2]




Reduces reboiler duty

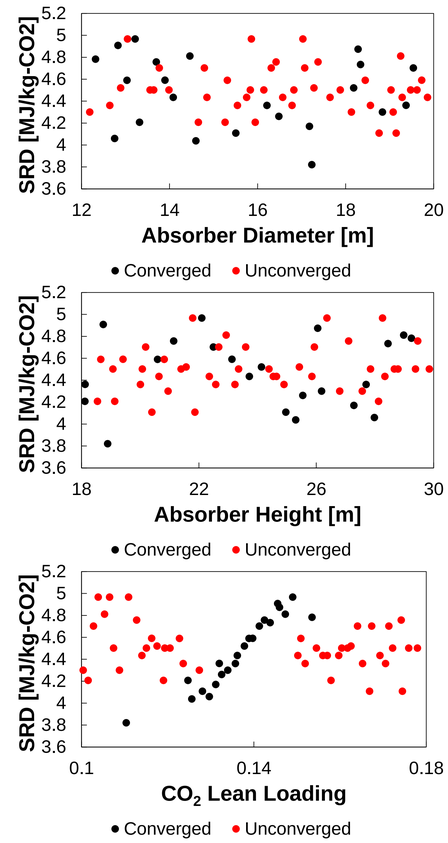
### Advanced Flash Stripper (AFS) [4]




Reduces solvent regeneration duty

## Model Results

- Study of base model with CESAR1 as the solvent to achieve 98% capture




## Future Work

- Develop surrogate models of advanced configurations
- Perform superstructure optimization focused on high capture rates

$$\min_{\tilde{x}} f(\tilde{x})$$ Minimize LCOE

s.t.

$$\tilde{x}^L \leq \tilde{x} \leq \tilde{x}^U$$ Bounded decision variables: design and operation of capture unit

$$h(\tilde{x}) = 0$$ Fixed level of $CO_2$ capture & material/energy balances

$$g(\tilde{x}) \leq 0$$ Maximum flooding in columns: 80%

**Contact**:
Katherine Hedrick, NETL support contractor, Katherine.Hedrick@netl.doe.gov
Daison Yancy Caballero, NETL support contractor, Daison.YancyCaballero@netl.doe.gov

**Disclaimer**: This project was funded by the United States Department of Energy, National Energy Technology Laboratory, in part, through a site support contract. Neither the United States Government nor any agency thereof, nor any of their employees, nor the support contractor, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.