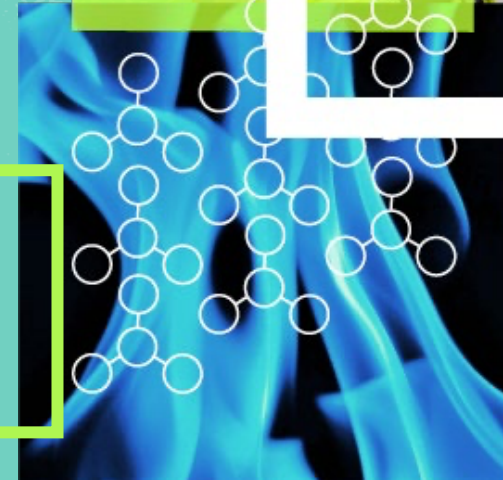


# Delivering Flexible, Low Carbon & Dispatchable Power

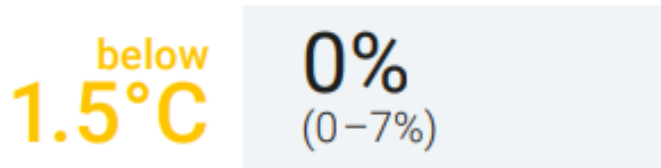
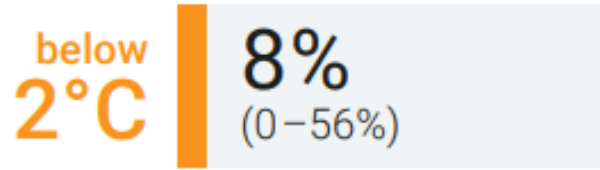
## UKCCSRC & FERF 10<sup>th</sup> AM

Daniel Mullen PhD, CEng, MEI

Senior Technology Engineer | SSE Thermal



## Likelihood of limiting warming below a specific temperature limit (%) over the twenty-first century



**Scenarios:** Current policies continuing

Emissions Gap Report 2025: Off target – Continued collective inaction puts global temperature goal at risk (<https://doi.org/10.59117/20.500.11822/48854>)

# SSE Thermal

**VISION: To be the leading provider of flexible energy in a net zero world**

## STRATEGIC PRIORITIES

### OPTIMISE OPERATIONS

*Deliver the flexible energy required by a renewables-led power system*

### ACCELERATE DECARBONISATION

*Deliver the enduring low-carbon power generation required for net zero*

### UNLOCK HYDROGEN

*Support the accelerated development of a low-carbon hydrogen ecosystem*

## 2030 GOALS



Reduced carbon emissions by >70% and on course to deliver SSE's Net Zero by 2040 target



Deliver extended operational and commercial contribution from existing assets



>2.5GW of low-carbon flexible generation



150GWh of low-carbon H2 storage



>250MW of low-carbon H2 production



# Carbon Capture (Dispatchable Low Carbon Power)

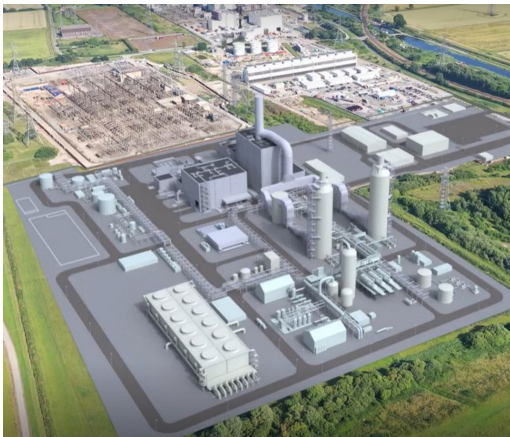


## Scottish Cluster

### Peterhead Carbon Capture

Capacity: 750 MW | 1.5MT of CO<sub>2</sub> per year

Consortium: Mitsubishi, Worley and Technicas Reunidas (FEED Phase 1 complete 2025, Phase 2 2026)



## Humber Cluster

### Keadby Carbon Capture

Capacity: 750 MW | 1.5MT of CO<sub>2</sub> per year

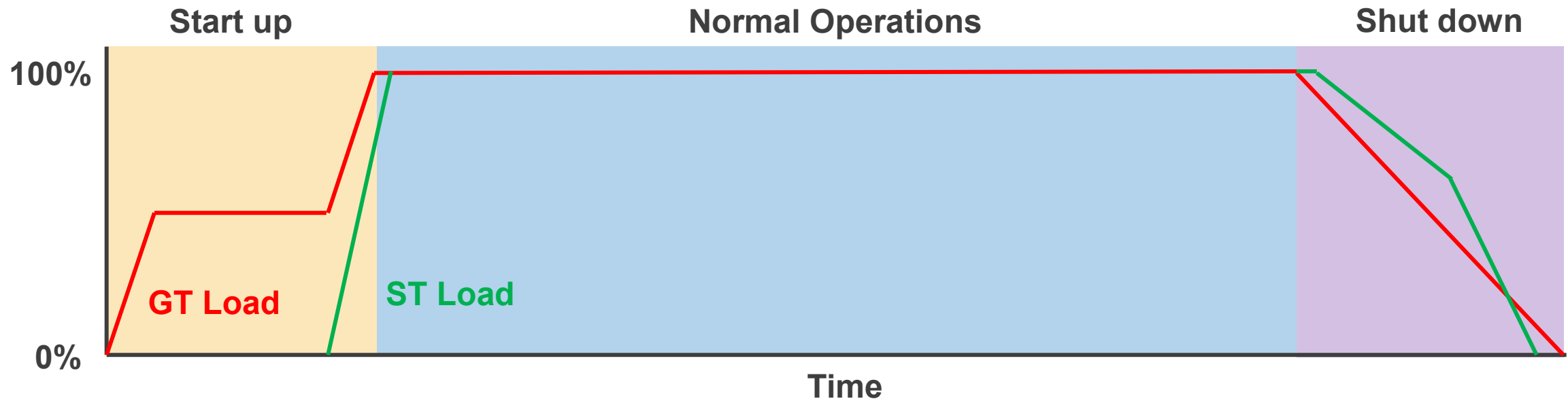
Consortium: Aker (SLB Capturi), Siemens, and Doosan (FEED complete in 2024)

# Dispatchability in Power CCS

- CCUS plants have traditionally been designed to operate primarily under steady-state conditions.
- This was primarily driven by the operational profile of the facilities and **NOT** a fundamental technical limitation.
- **BUT** operating dynamically in response to a variable demand and/or flue gas flowrate and composition from the power facility poses challenges for CCP designers.
- If unmitigated, the inclusion of a “standard” steady state CCP design will affect the effectiveness of the CO<sub>2</sub> capture process under dynamic conditions, limiting the ability to capture & export CO<sub>2</sub> or meet emission limits.

# WHY CAPTURE?

Case	% CO <sub>2</sub> Emissions*
Hot Start	2.5%
Warm Start	4.3%
Cold Start	5.8%
Shutdown	0.9%



# FOCUSS

## Flexibly Operated Capture using Solvent Storage

**Partners:** University of Sheffield, AECOM | **Budget:** £670K (Grant<sup>1</sup> £515K) | **Schedule:** May 2022 to March 2025

**Aim:** Demonstrate cost-effective and high CO<sub>2</sub> capture levels during plant start-up, shutdown and transients

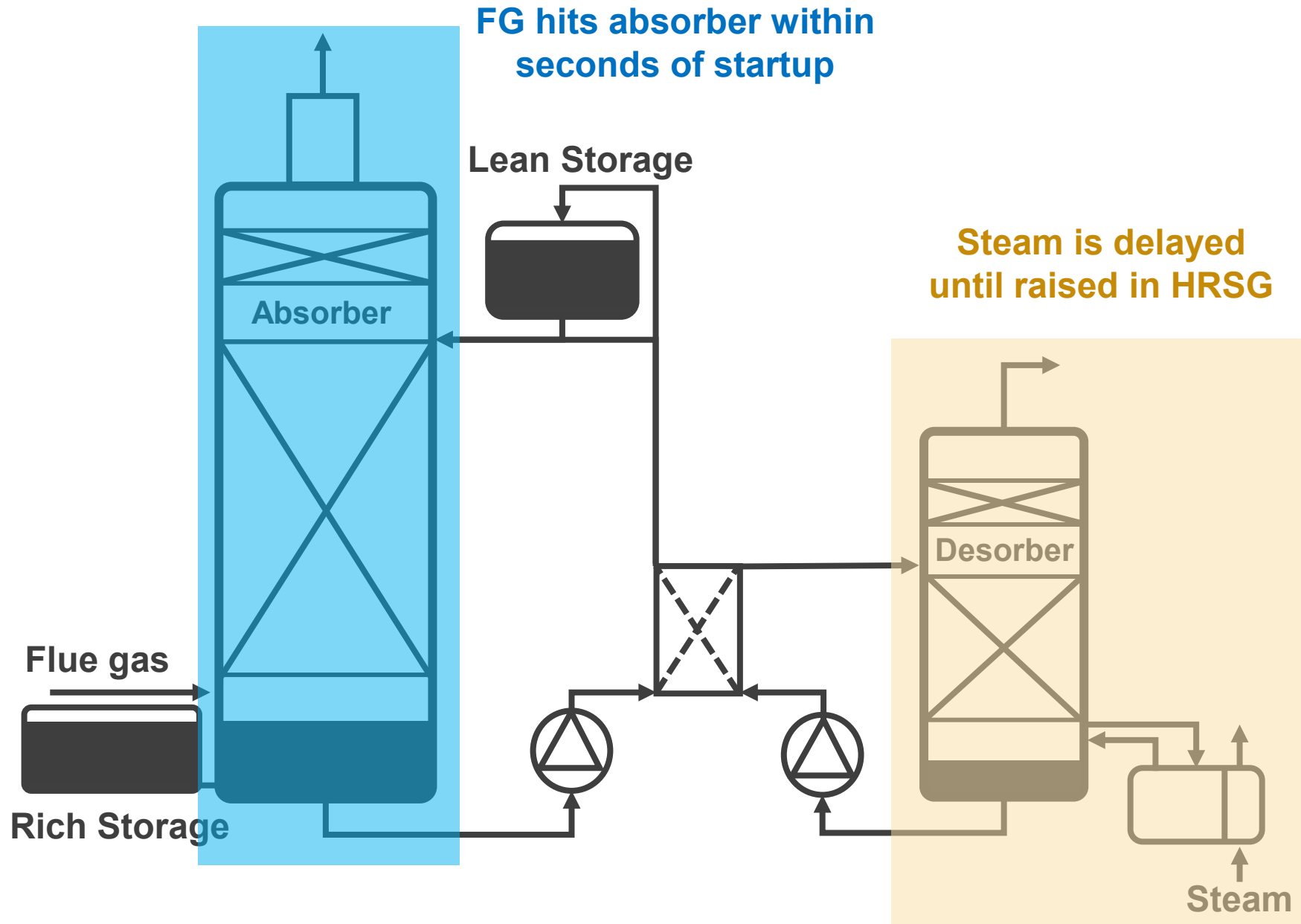


Disclaimer: The contents of this presentation do not necessarily represent SSE's views but rather, the conclusions of the FOCUSS project

<sup>1</sup>Funded by the CCUS Innovation 2.0 Call

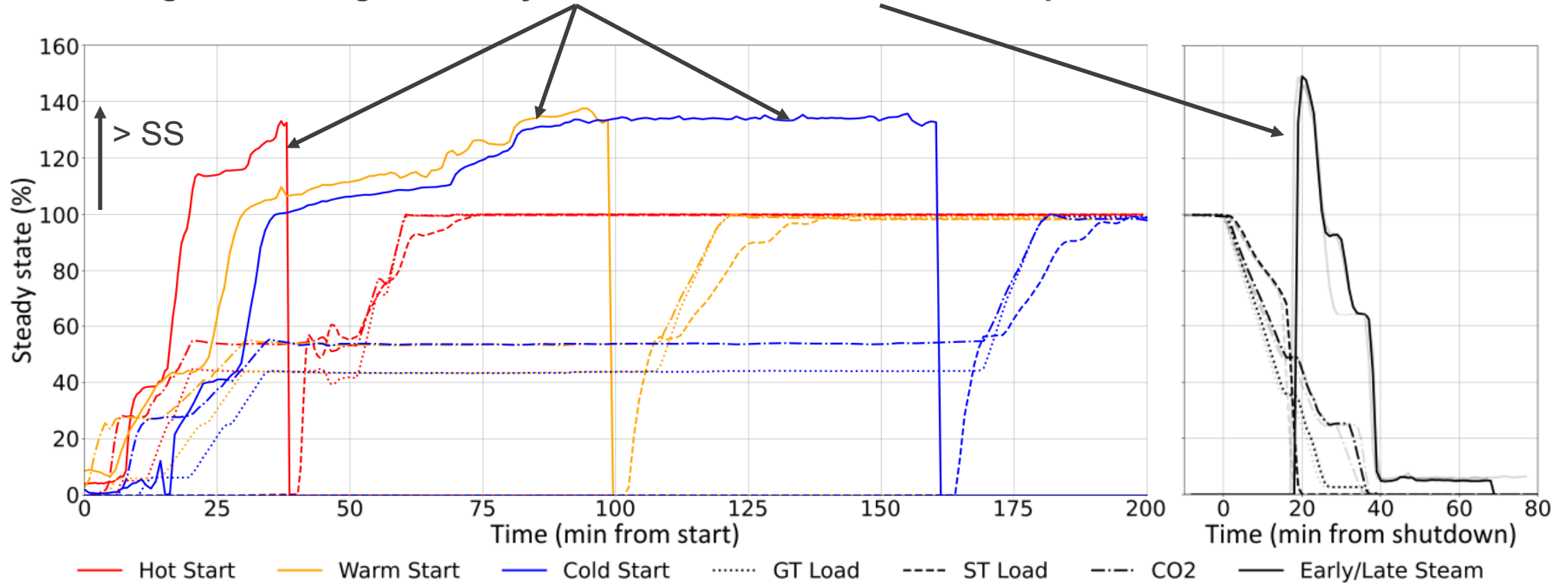
# FOCUSS

Flexibility



A CCGT start-up sequence produces steam that cannot be admitted into the steam turbines  
Normally bypassed and dumped into the condenser.

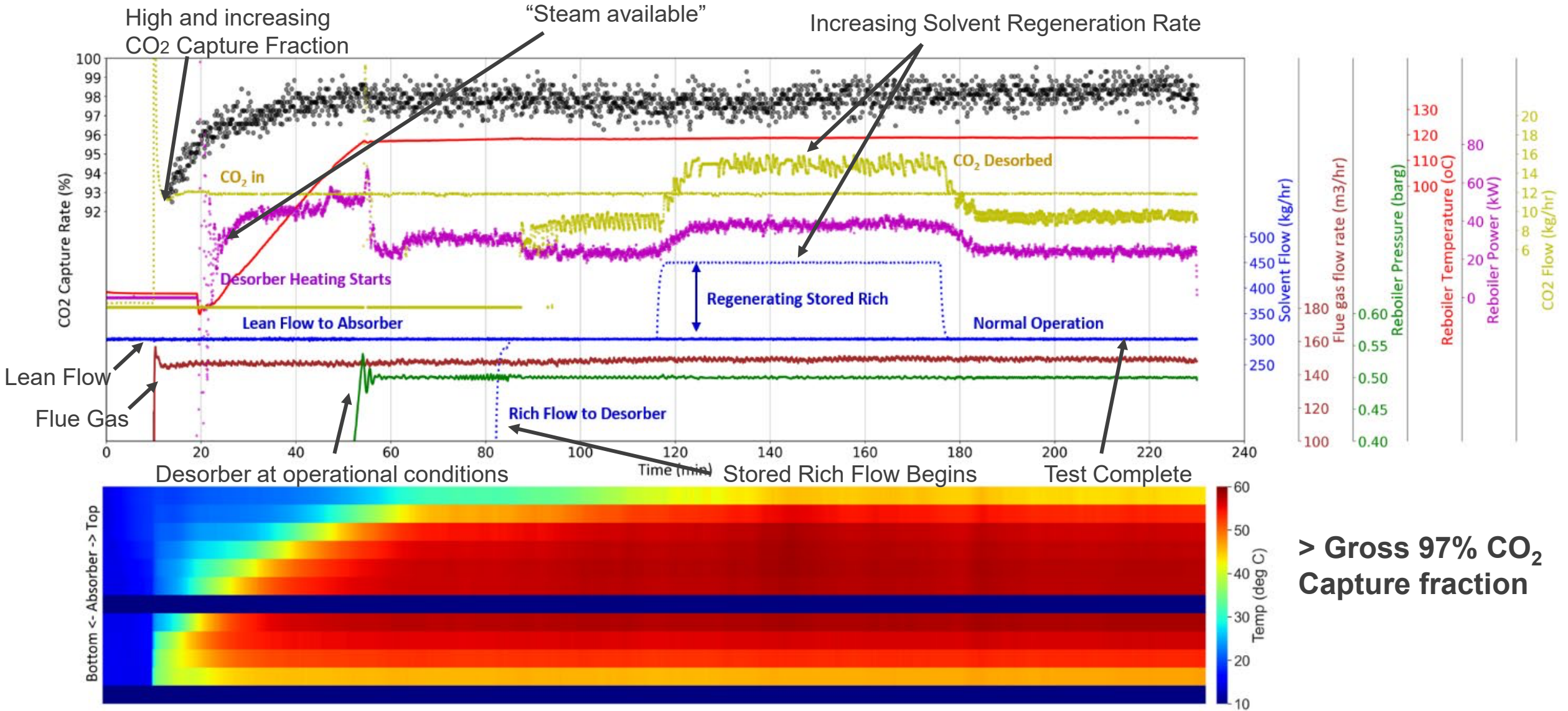
Investigates utilising this “Early Steam” & “Late Steam” for startup acceleration



Rich solvent storage/required increase in solvent inventory<sup>1</sup>

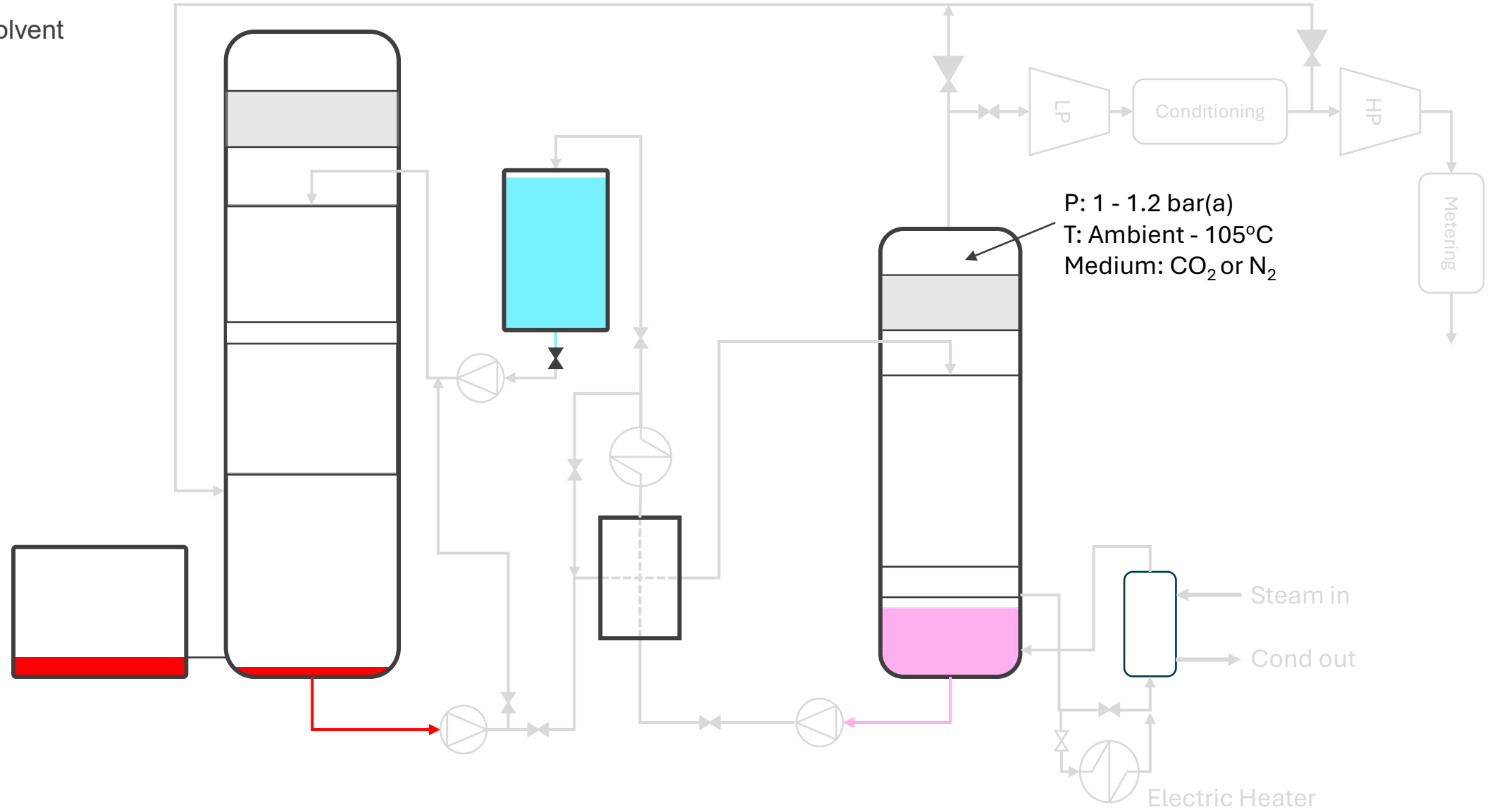
<b>Start</b>	<b>Without the use of Early Steam</b>	<b>With the use of Early Steam</b>
Hot	+89%	<b>+24%</b>
Warm	+226%	<b>+40%</b>
Cold	+344%	<b>+49%</b>

# FOCUSS Test Campaign



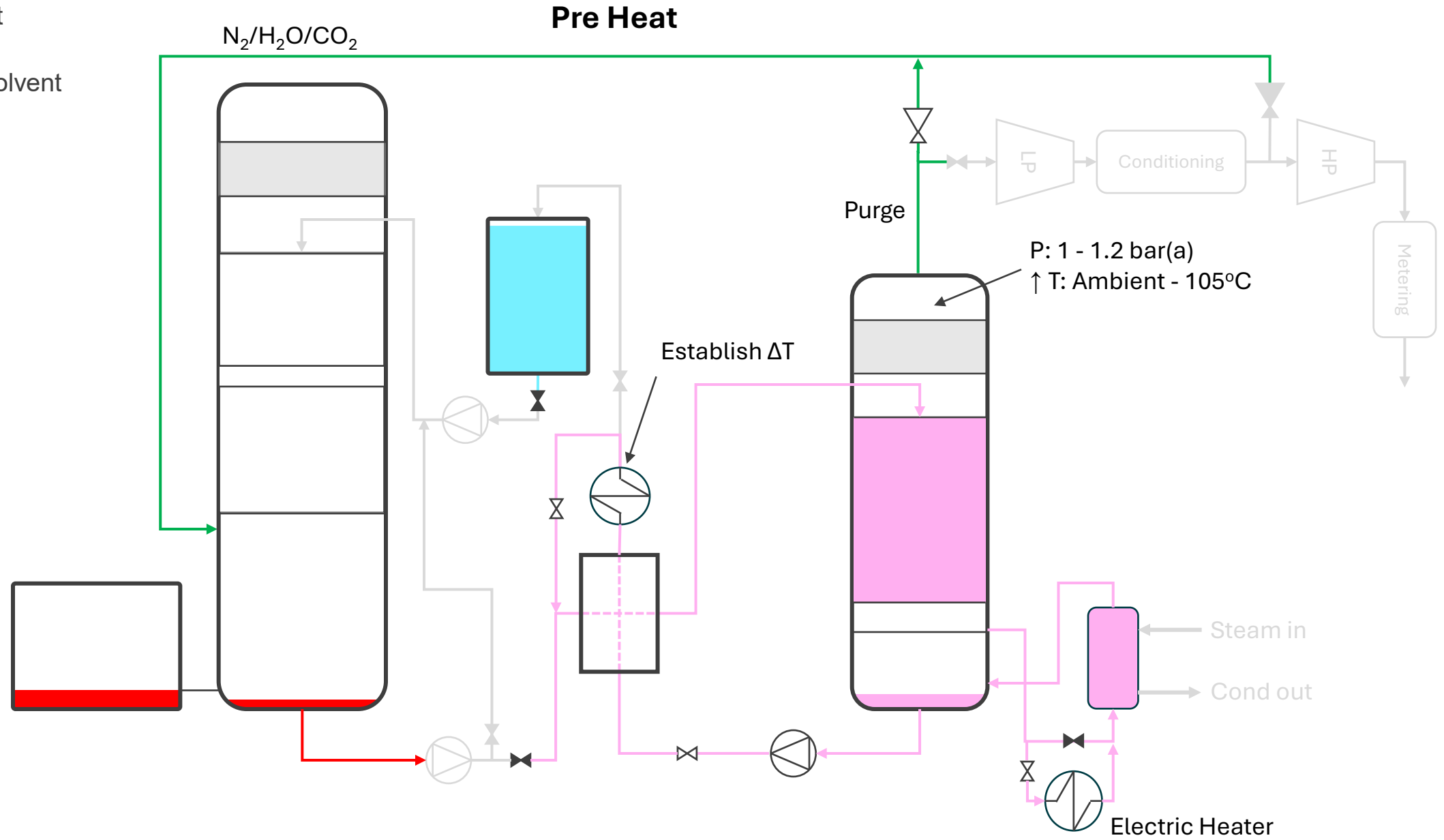
# Hot/Cold/Warm Start

- Lean Solvent
- Rich Solvent
- Semi Rich Solvent
- CO<sub>2</sub>



- Rich Solvent at a minimum
- Desorber: Warm/Hot (c. 105°C under CO<sub>2</sub>) Cold (Ambient under N<sub>2</sub>)
- Desorber contents likely “semi lean”

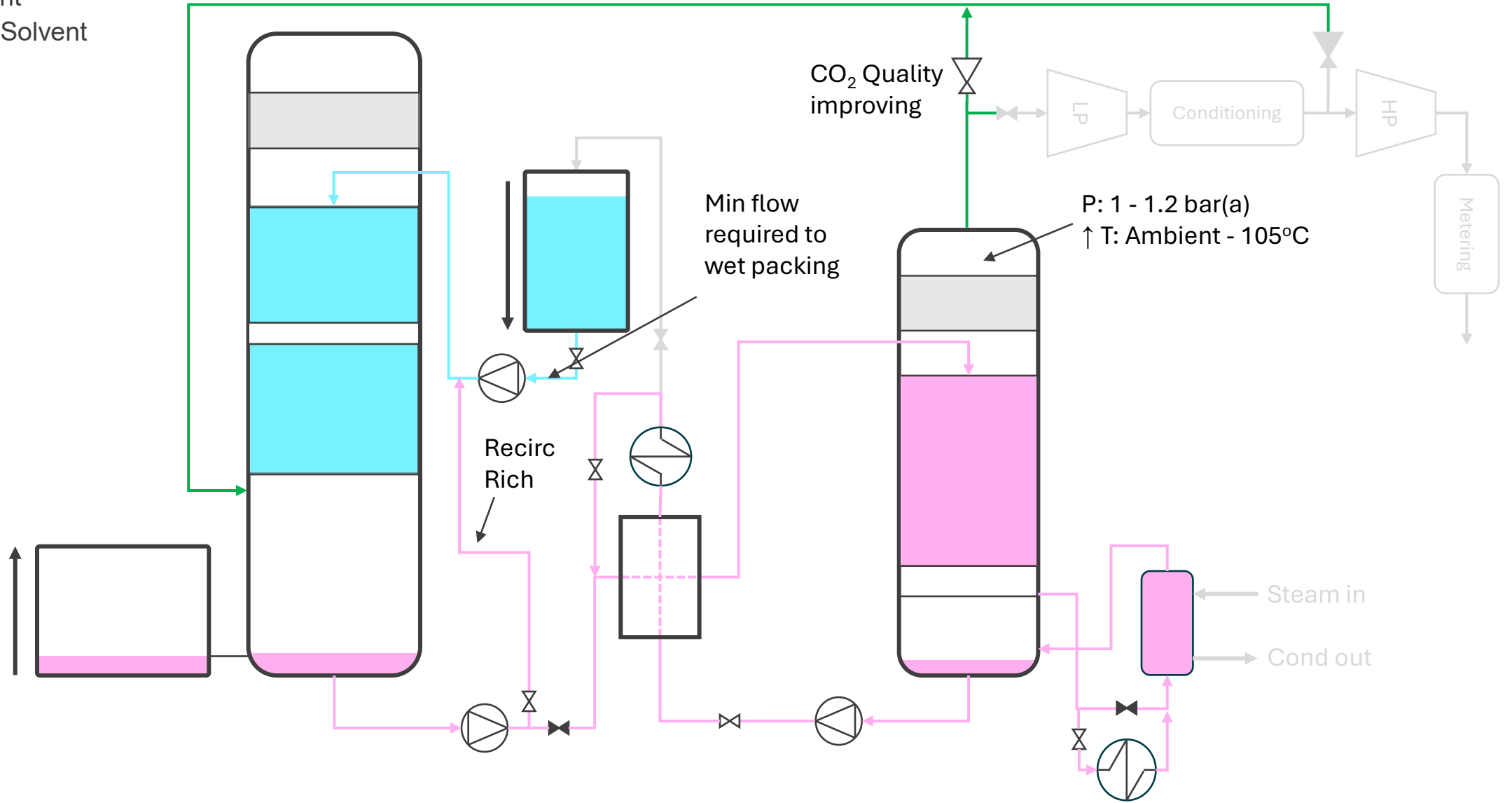
- Lean Solvent
- Rich Solvent
- Semi Rich Solvent
- CO<sub>2</sub>



- Heating desorber side using aux boiler
- Vent desorber contents to maintain pressure
- Recirculate semi lean solvent through Cross HX and trim cooler to establish temperature gradient

# Wet Absorber Packing

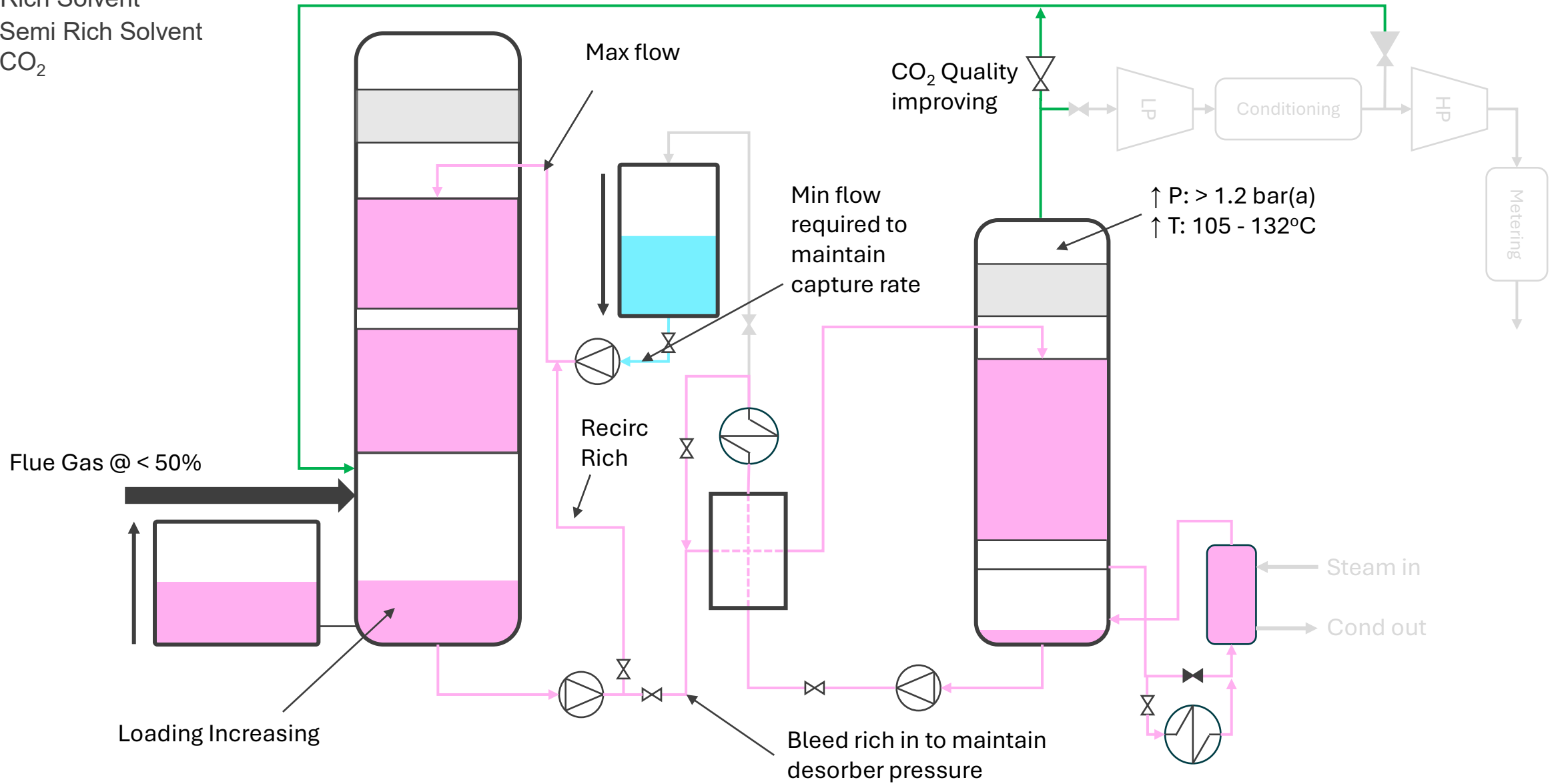
- Lean Solvent
- Rich Solvent
- Semi Rich Solvent
- CO<sub>2</sub>



- Add minimum required lean solvent to absorber to wet packing

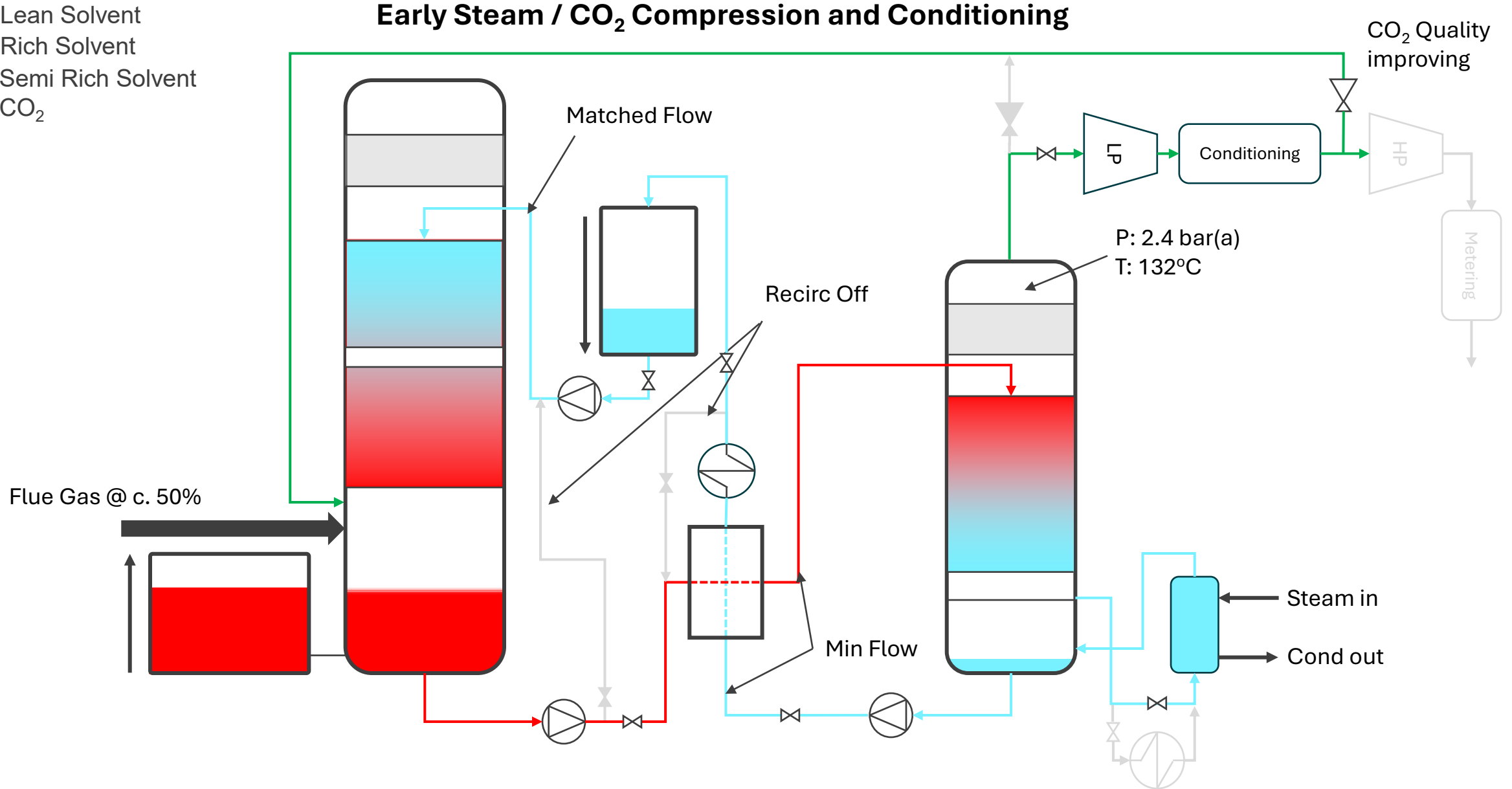
# CCGT Fires

- █ Lean Solvent
- █ Rich Solvent
- █ Semi Rich Solvent
- █ CO<sub>2</sub>



- Recirculate absorber sump contents at max flow to increase rich loading, adding lean as required to maintain CO<sub>2</sub> capture fraction
- Increase Desorber pressure, contents may be too lean to increase pressure, so bleed in rich solvent as required

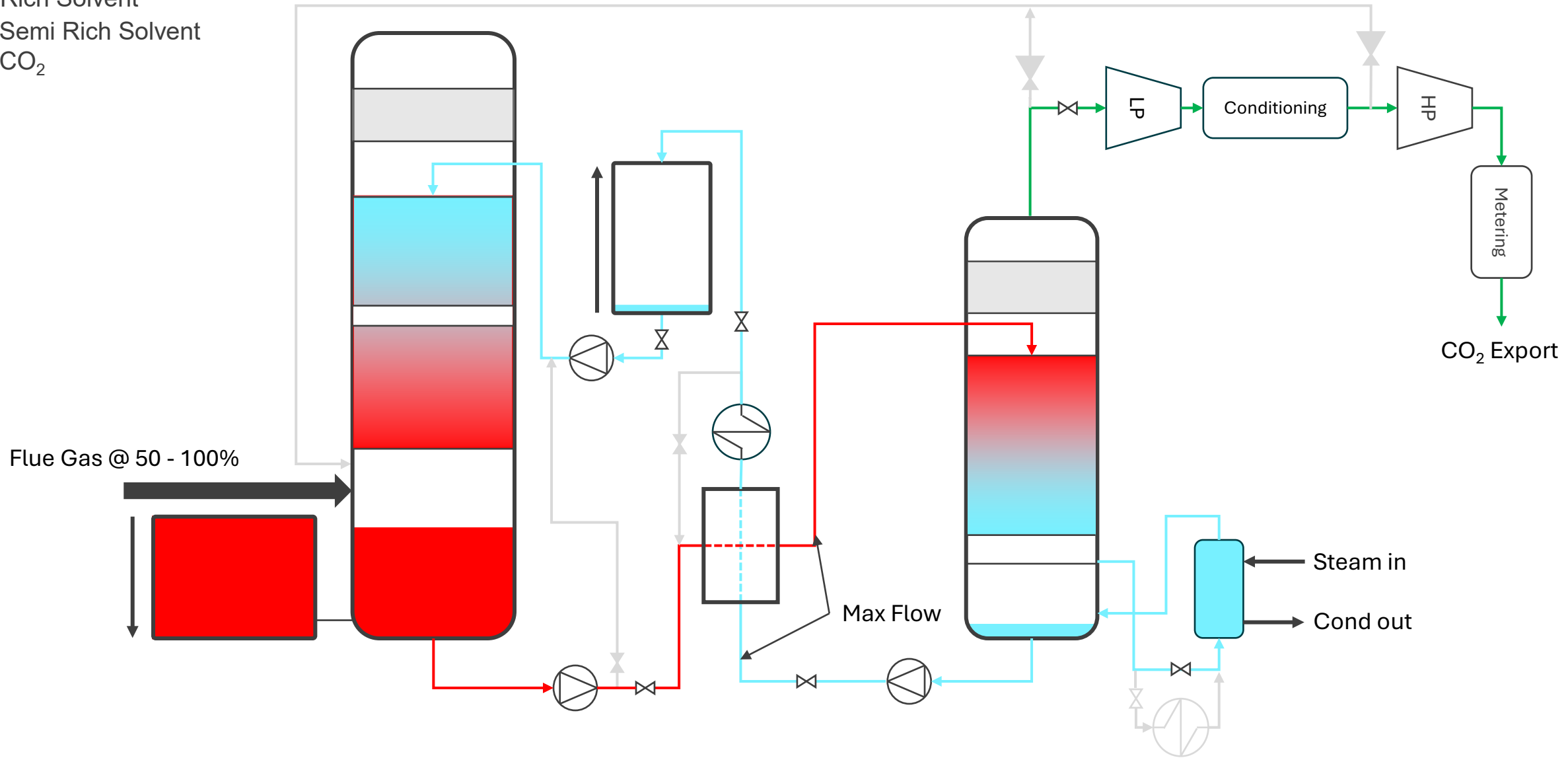
## Early Steam / CO<sub>2</sub> Compression and Conditioning



- Early steam available, admit as required to continue to increase desorber pressure and temperature
- When desorber at operational pressure and temperature begin flow of CO<sub>2</sub> through LP compression and conditioning packages
- When rich loading circa 0.4 mol/mol cease absorber recirculation

# CO<sub>2</sub> Export & Rich Solvent Draw Down

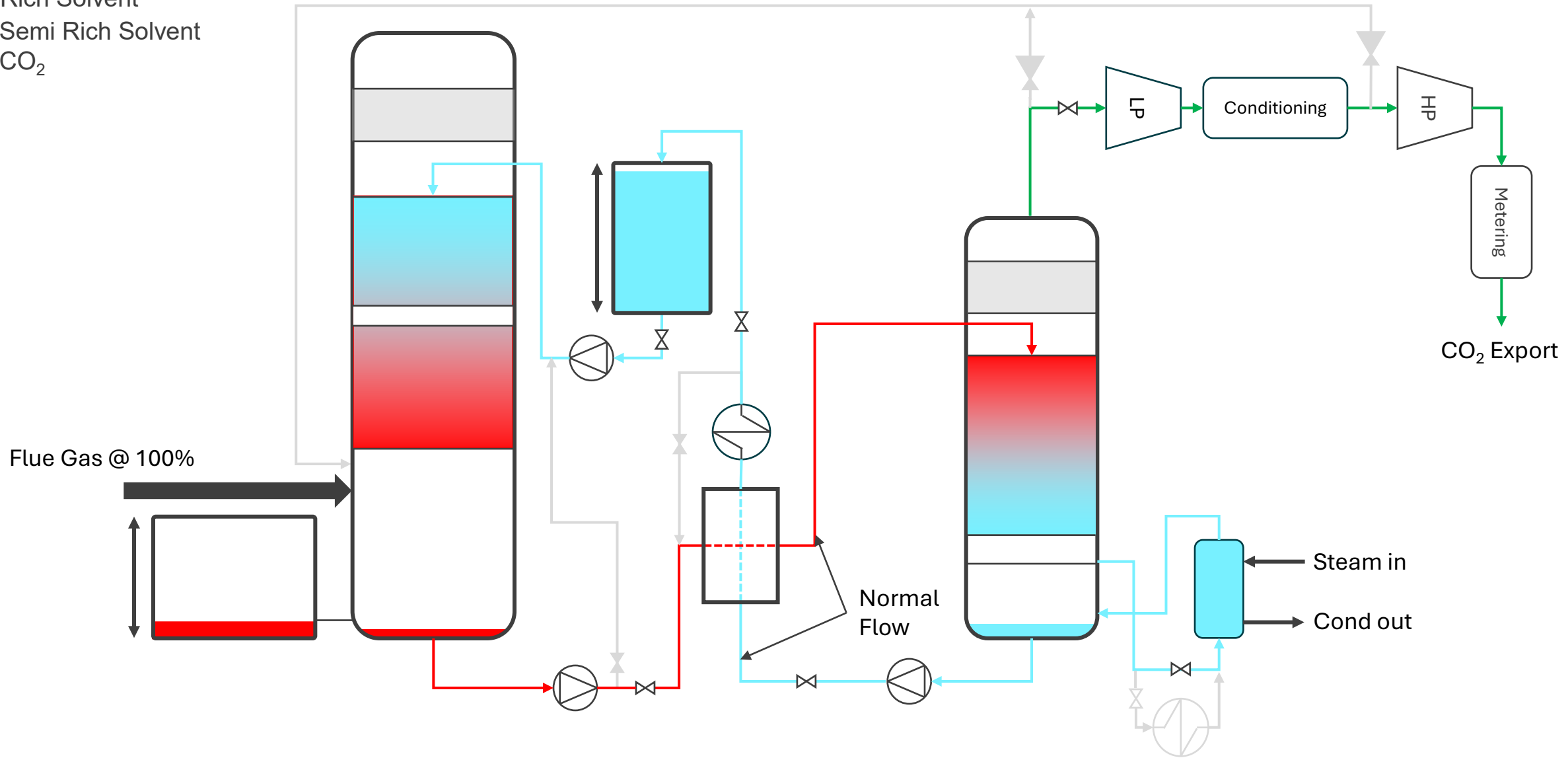
- Lean Solvent
- Rich Solvent
- Semi Rich Solvent
- CO<sub>2</sub>



- Once CO<sub>2</sub> quality confirmed, export at maximum rate, drawing down stored rich solvent

# Normal Operation

- Lean Solvent
- Rich Solvent
- Semi Rich Solvent
- CO<sub>2</sub>

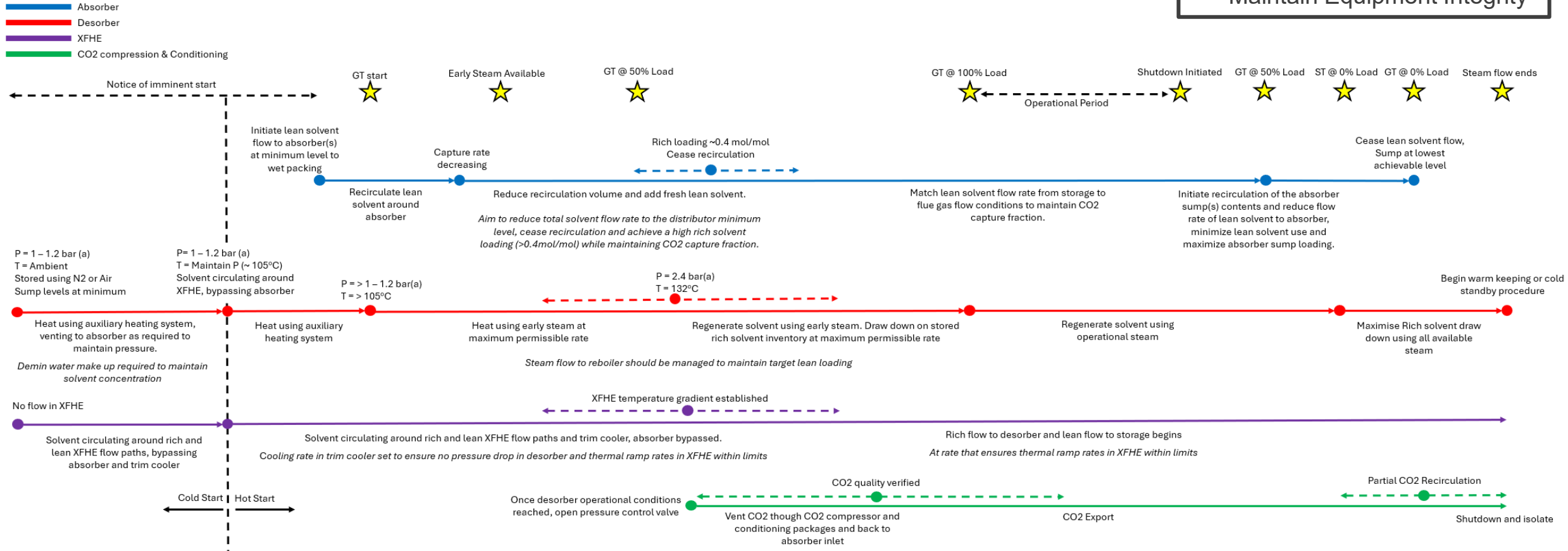


- Rich solvent regenerated, normal operations

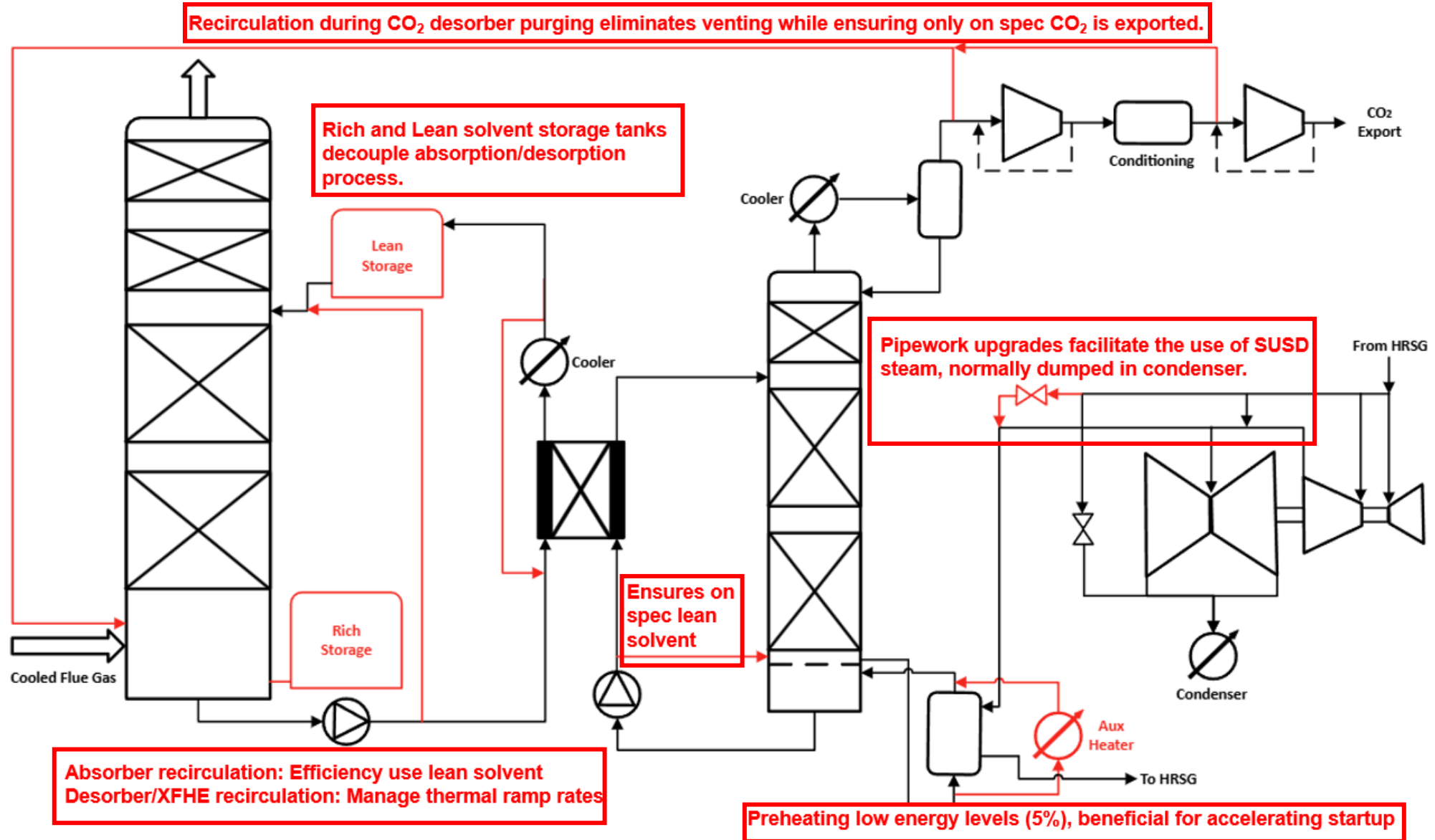
# FOCUSS SUSD Sequence

- Key Features:**

  - Maximise Capture
  - Highest Rich Loading
  - Optimise Early & Late steam
  - Maintain Equipment Integrity



# FOCUSS Proposed Capture Plant Modifications (RED)



# THANK YOU

For more information:  
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