
2025
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# Innovative Solutions for Flared Gas: Enhancing Revenue and Reducing Emissions

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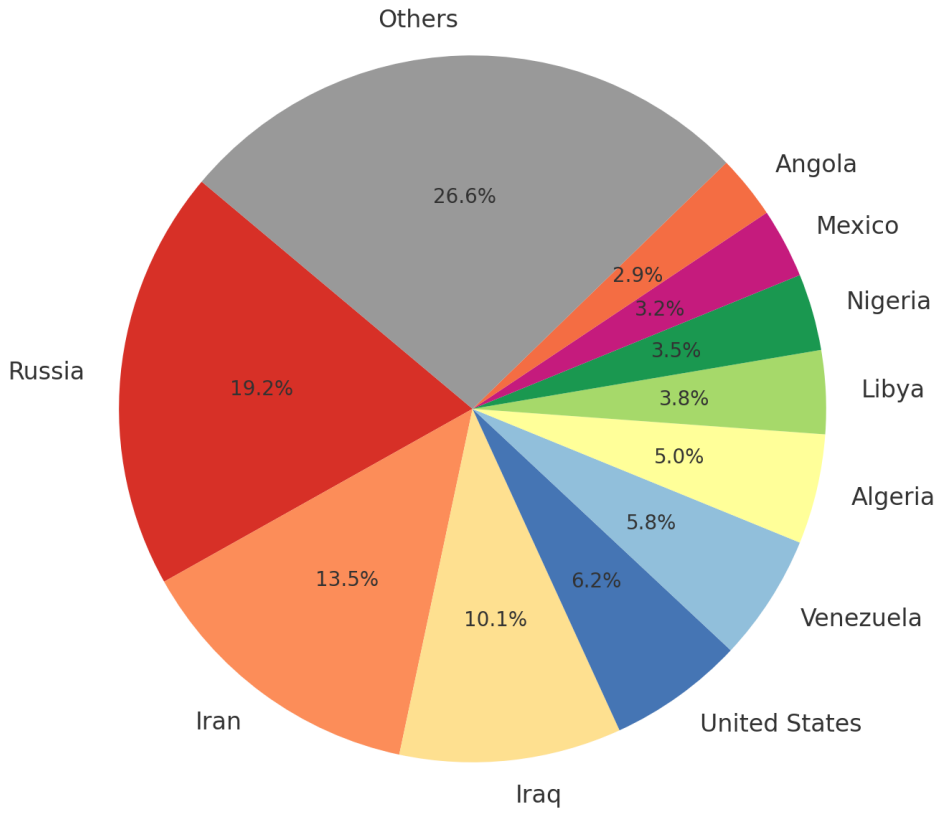
# Flaring Challenge and Opportunity

- **Globally:** ~5,000+ bcf of gas flared each year = wasted energy + 500 mt $CO_2$ emissions
- **US:** ~330 bcf flared in 2024 (~0.5% of gross withdrawals), concentrated in Texas and North Dakota
- Rising ESG and regulatory pressure – growing penalties, restrictions, and investor scrutiny
- **Untapped opportunity:** 5 mmscfd to 15 mmscfd streams can be monetized with modular solutions
- **Modular solutions:** scalable recovery, power generation, and NGL products

**Global Gas Flaring Volumes by Country (~BCF)**

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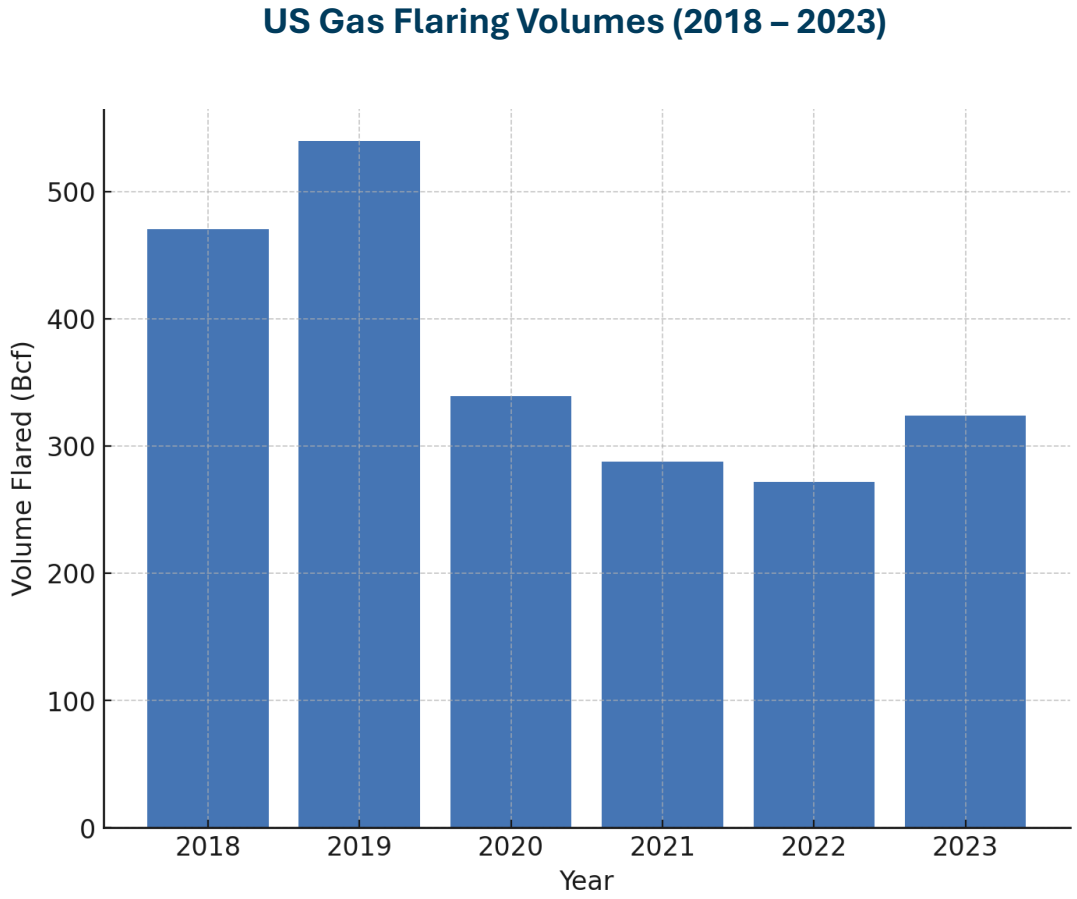
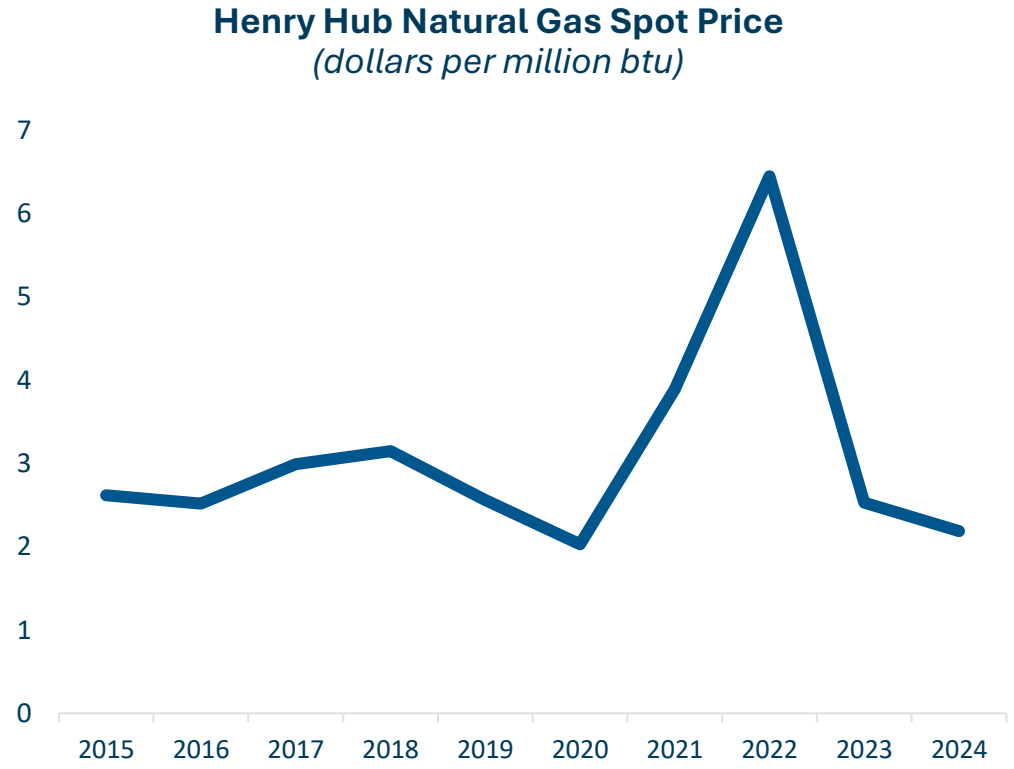
# Understanding the Problem

- **Untapped potential:** valuable $C_3$+ content is lost to flaring
- **Flaring persists:** common practice for small, stranded gas streams
- **Rising penalties:** regulatory fines and restrictions increasing worldwide
- **$CO_2$ emissions:** flared gas contributes heavily to greenhouse gases



# The Value of Stranded Gas

- 75% to 80% of flared gas can be realized sales gas revenue – higher netbacks when blended into pipeline or used locally
- **Dual benefit:** monetization + emissions reduction
- **Best suited for remote locations:** for AI training centers and bitcoin mining power generation

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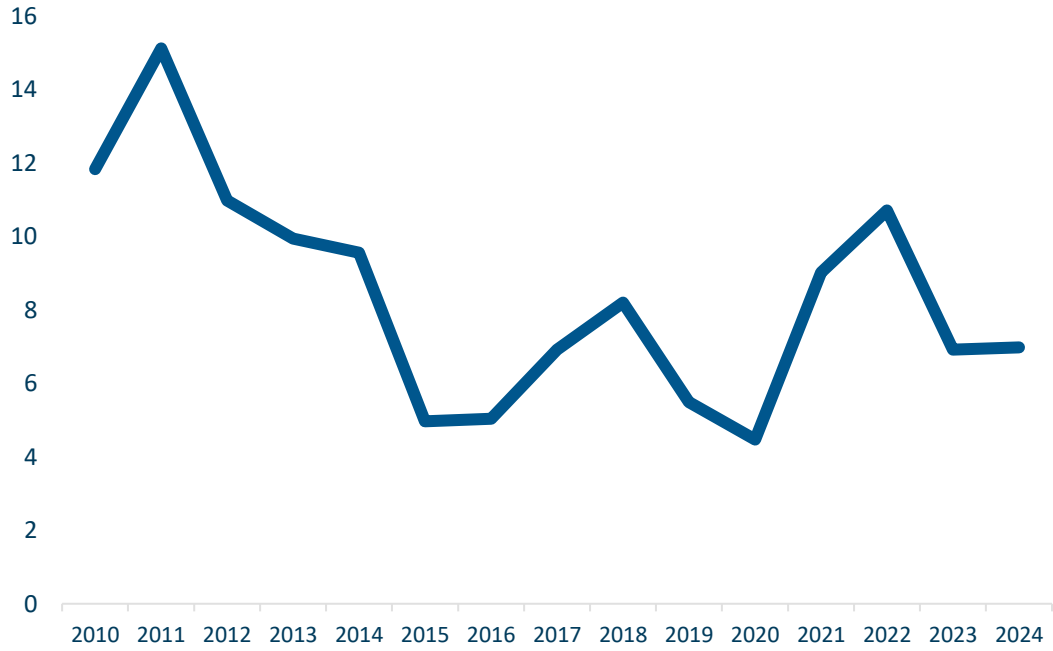
# The Value of $C_3$+ Recovery

- **Recoverable liquids:** $C_3$+ often represents ~10% to 20% of flare gas stream
- **Economic upside:** recovered NGLs versus cost of continued flaring
- Depending on facility and location, can be **recovered as Y-Grade or Stabilized Condensates**

**US Natural Gas Liquid: Y-Grade Composite Price**
*(dollars per million btu)*

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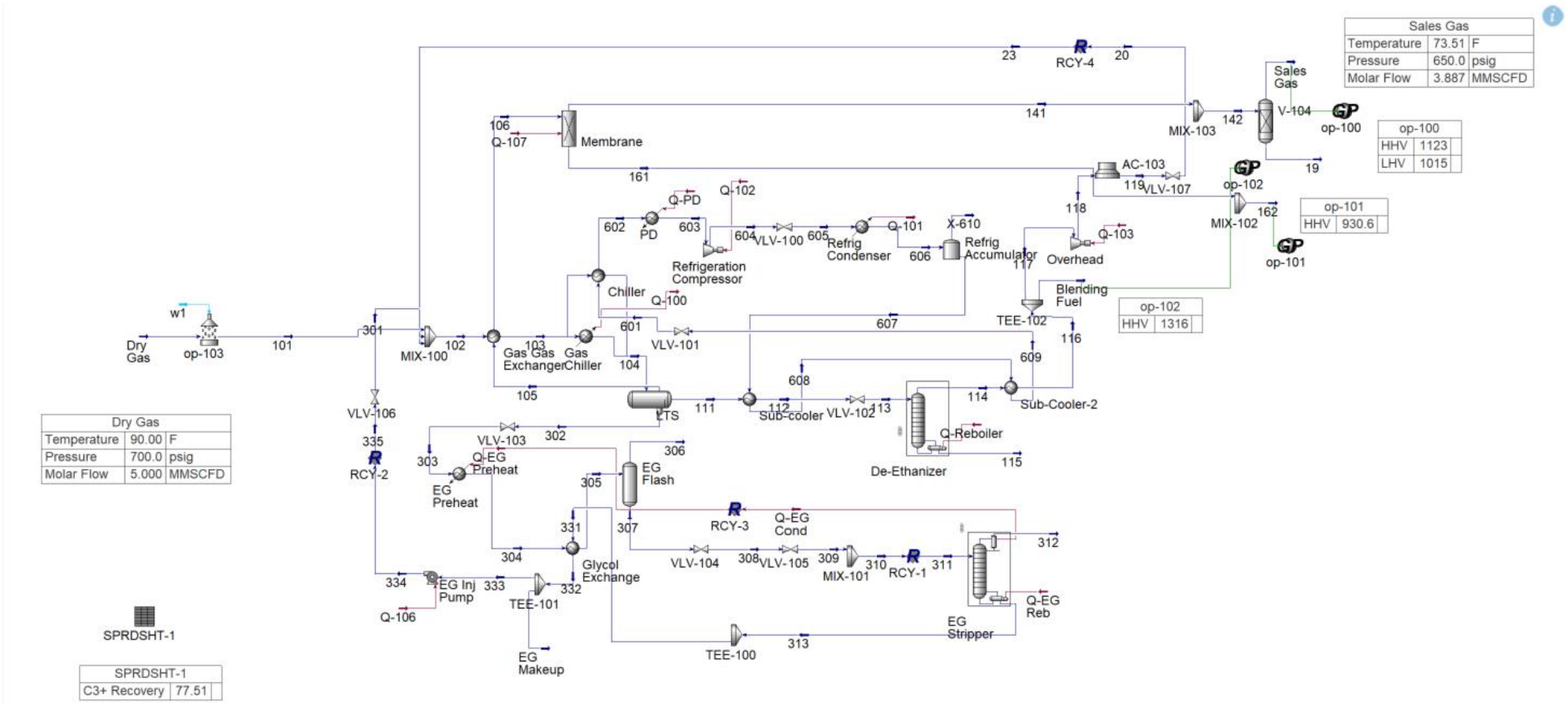
# Flare Gas Recovery – PFD



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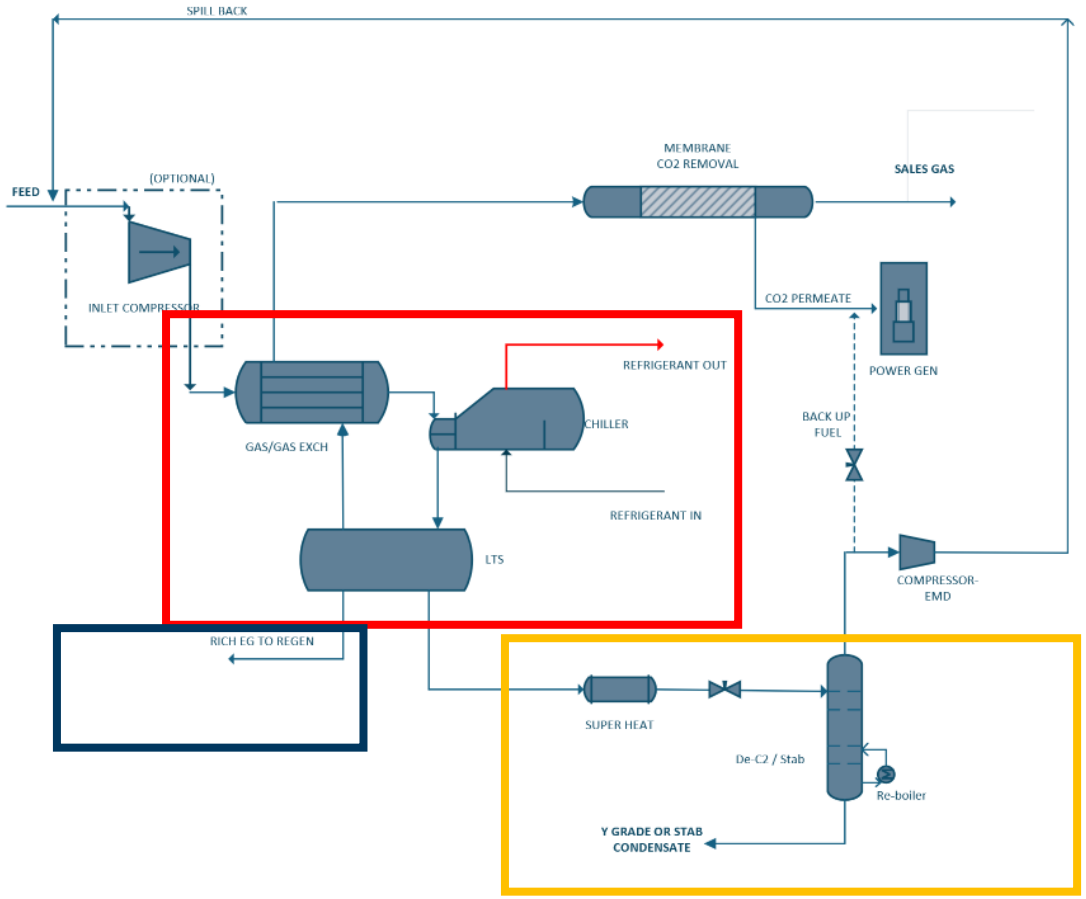
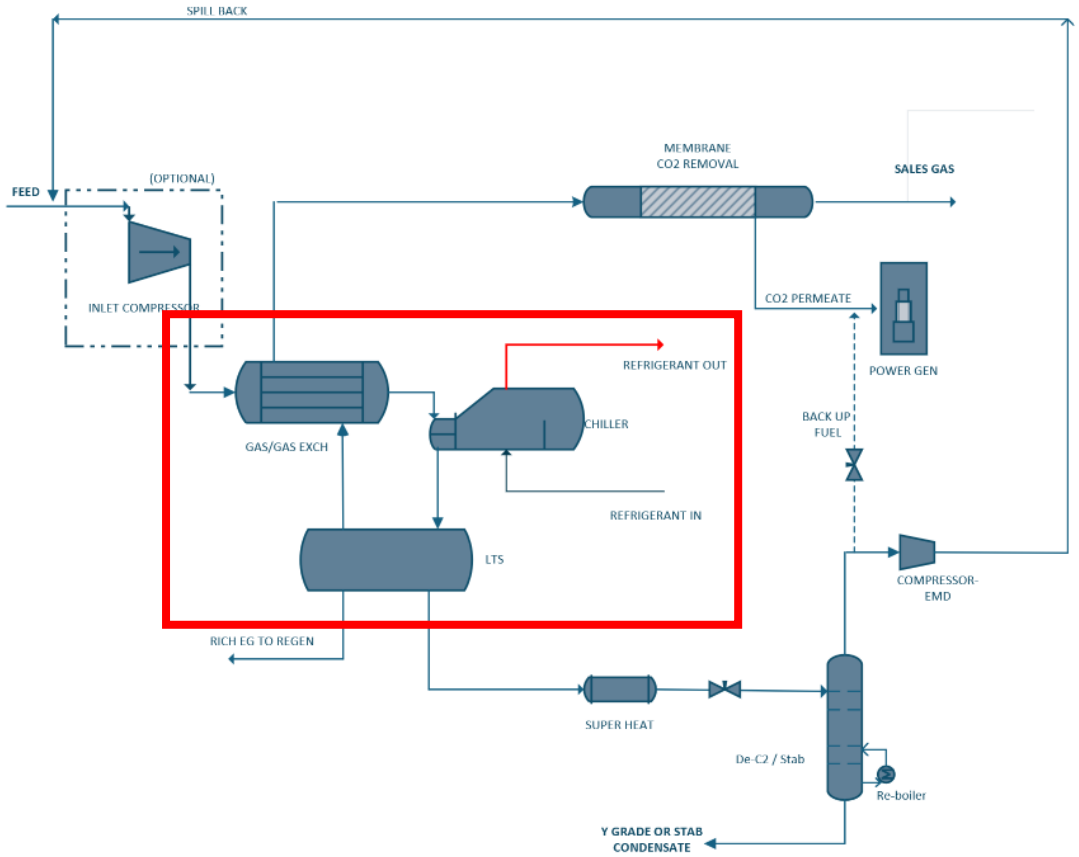


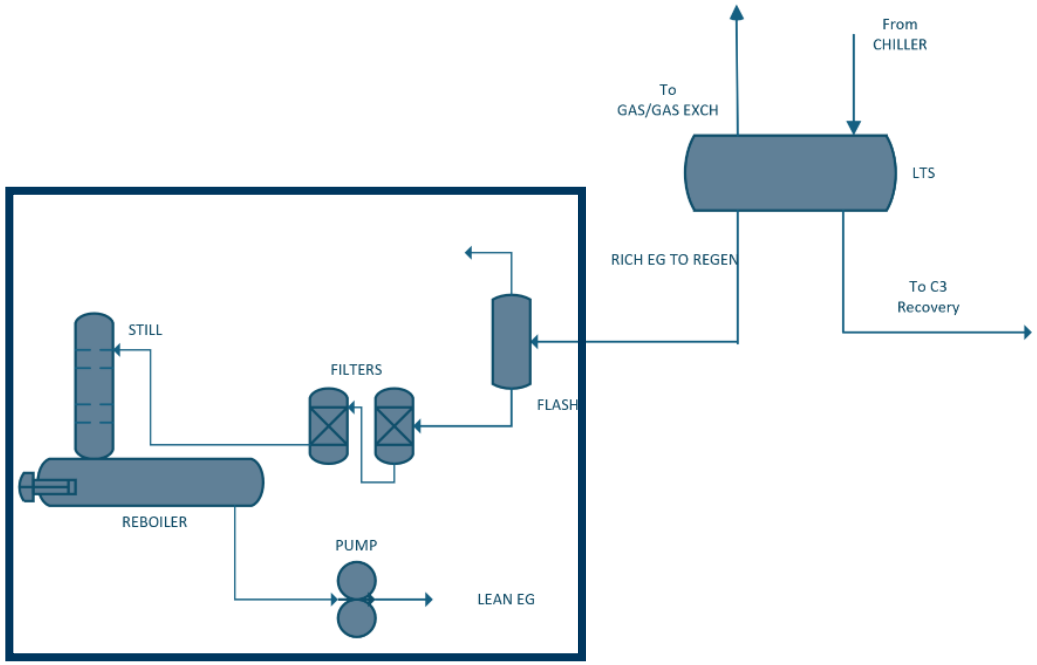

- Main module consists of:
  - Gas conditioning
  - Refrigeration
  - Dehydration
  - $C_3$ recovery systems
- Sub-modules include:
  - Inlet compression (optional)
  - Membrane system
  - Overhead compression
  - Power generation

# Flare Gas Recovery – Dew Point Unit



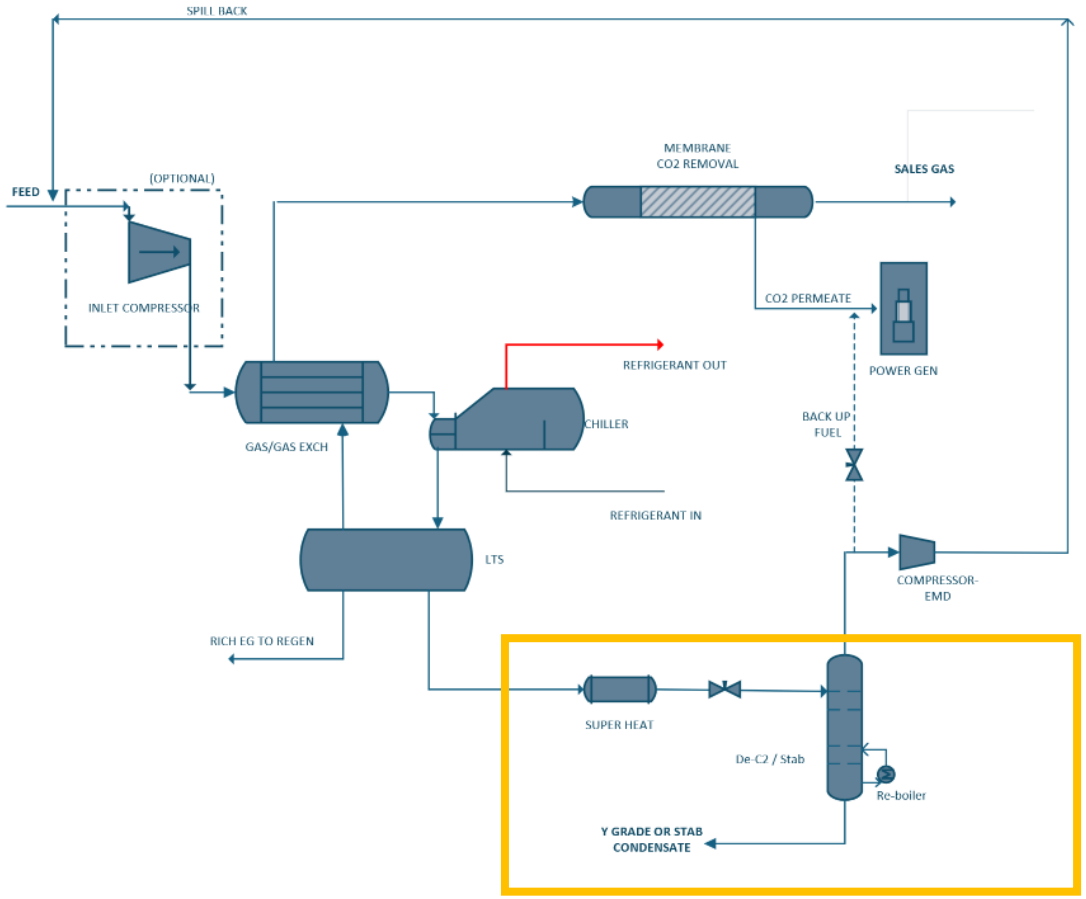

- LTS temperature
  - Surface area of exchanger
  - Refrigeration horsepower
  - Optimum temperature
- Mechanical refrigeration is designed with flexibility in mind to tune up to specific requirement
- LHV of sales gas versus $C_3$+ recovery

# Flare Gas Recovery – Dehydration



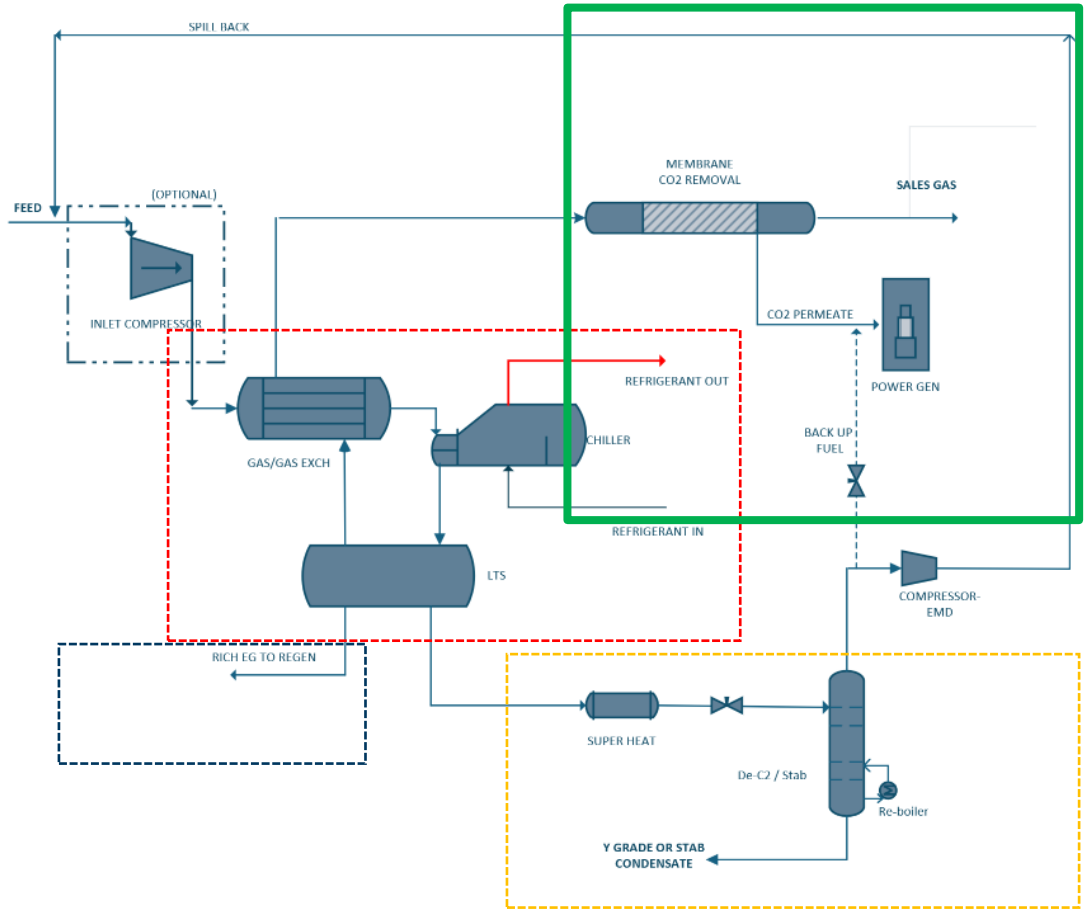

- Dehydration via low temperature with hydrate inhibitor (EG)
- EG regeneration circuit to be used as heat medium for de-ethanizer column / stabilizer
- **Sustainable design:** EG reboiler is modified to be electric – potential waste heat recovery from power generation is possible

# Flare Gas Recovery – NGL Type



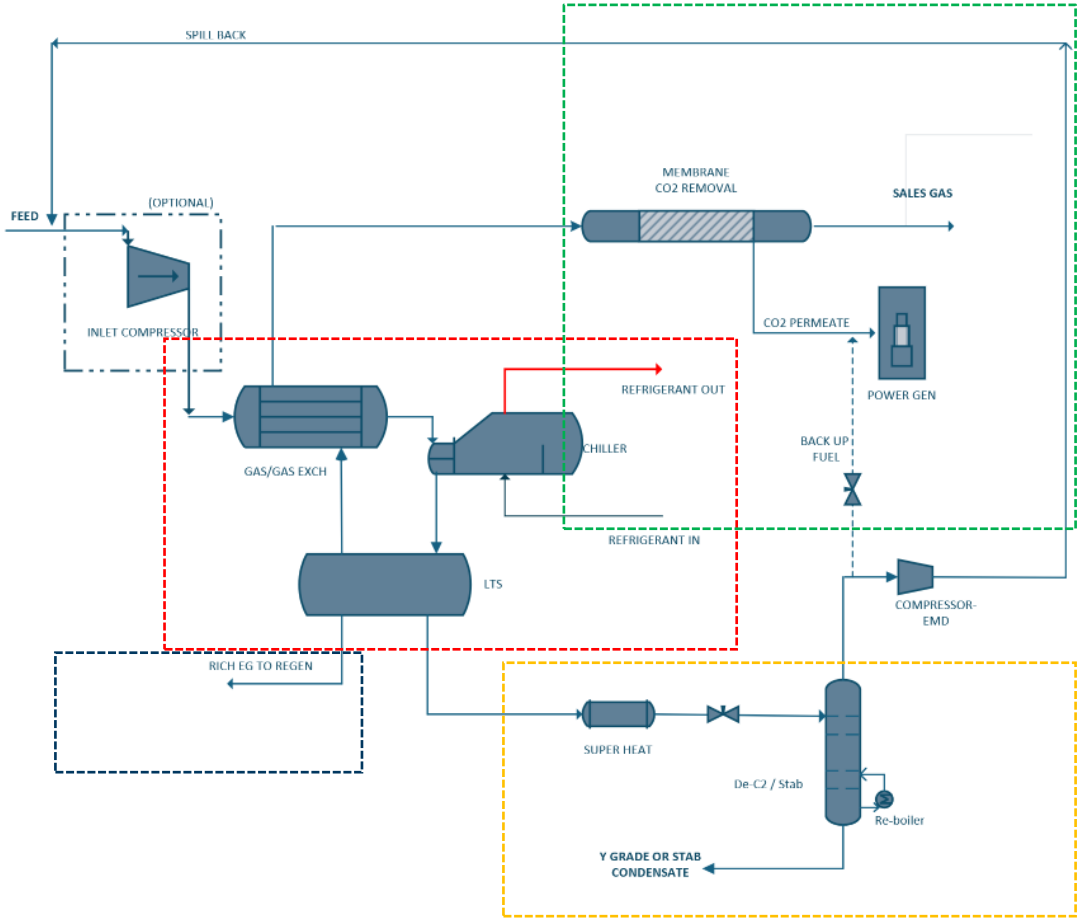

- **Stabilizer:** RVP (Reid Vapor Pressure) Condensate – lower recovery of heavier components
  - *Suitable for power generation / remote operations, where gas is used as fuel for onsite generators or datacenters*
- **De-ethanizer:** Y-Grade NGL – high recovery of liquid hydrocarbons ($C_3$+ fraction)
  - *Best for liquid markets, e.g., fractionation, sales to pipeline, or condensate blending*
  - *Tower overheads can be used as fuel for power generation*

# Flare Gas Recovery – Other Units




- Membranes are used for selectively removing bulk of $CO_2$ from the system up to ≥ 2mol % $CO_2$
- Membrane system is designed to operate in a single stage unit, why?
- The reject $CO_2$ stream carries not only $CO_2$ but some hydrocarbon, which is suitable for power generation
- **Power generation:** key highlights of this solution is to tie-in with a dedicated power generation system, which can use the membrane reject gas or alternatively, de-ethanizer overhead stream – or blend both at ratios to meet the suitable LHV (lower heating value)

# Flare Gas Recovery – Utilities

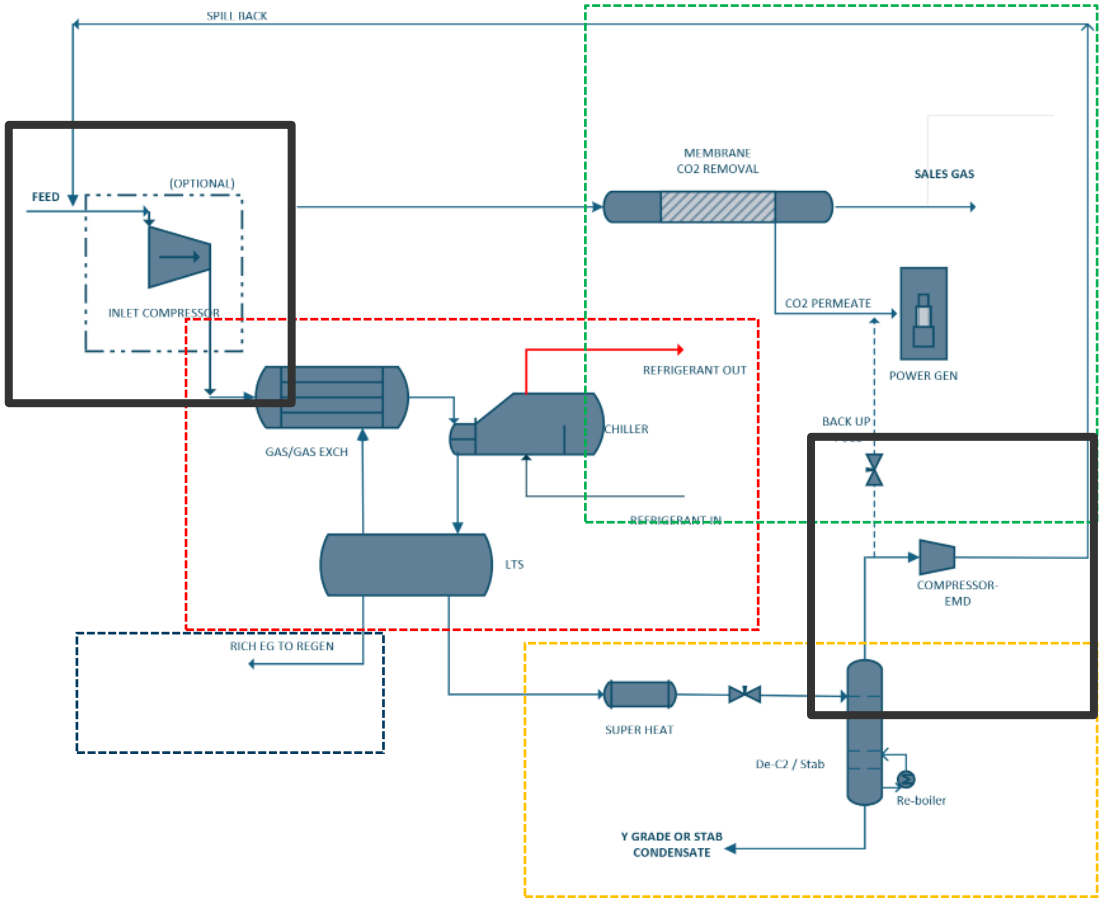



- Refrigeration compressor and MEG (monoethylene glycol) reboiler are electric, with MEG also providing heat to the other units. **Hence no added utilities** *(i.e. hot oil and associated piping)*

- **Advantages:** the entire system can be deployed practically anywhere without any utilities dependent – **A TRUE PLUG AND PLAY DESIGN!!**

*May be instrument air and flare needs tie-in*

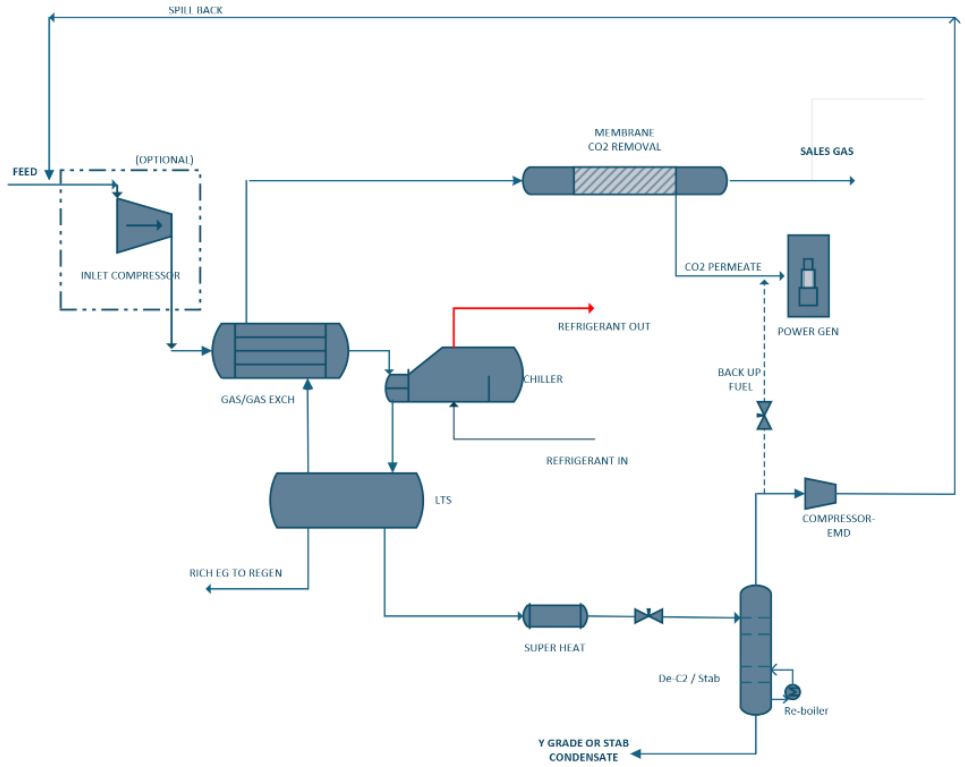
# Flare Gas Recovery – Compression




- Both electric
- **Inlet compression:** boost low-pressure gas to treatment levels
- **Recycle compression:** two different configurations

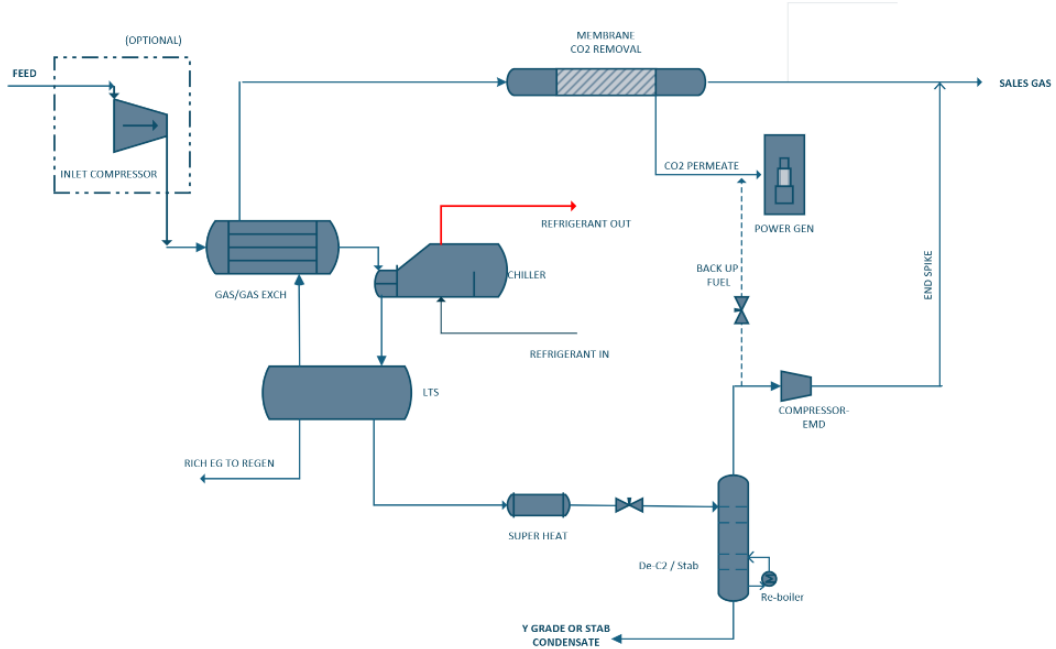
# Recycle Compressor Configuration

- **Spillback:** recycle compressor sends $C_3$+ rich gas back to the front of the plant
- Better suited with Y-Grade liquid product
- **Pros:** increases $C_3$+ recovery in liquid
- **Cons:** typical $C_3$+ cutoff at 15% to17%



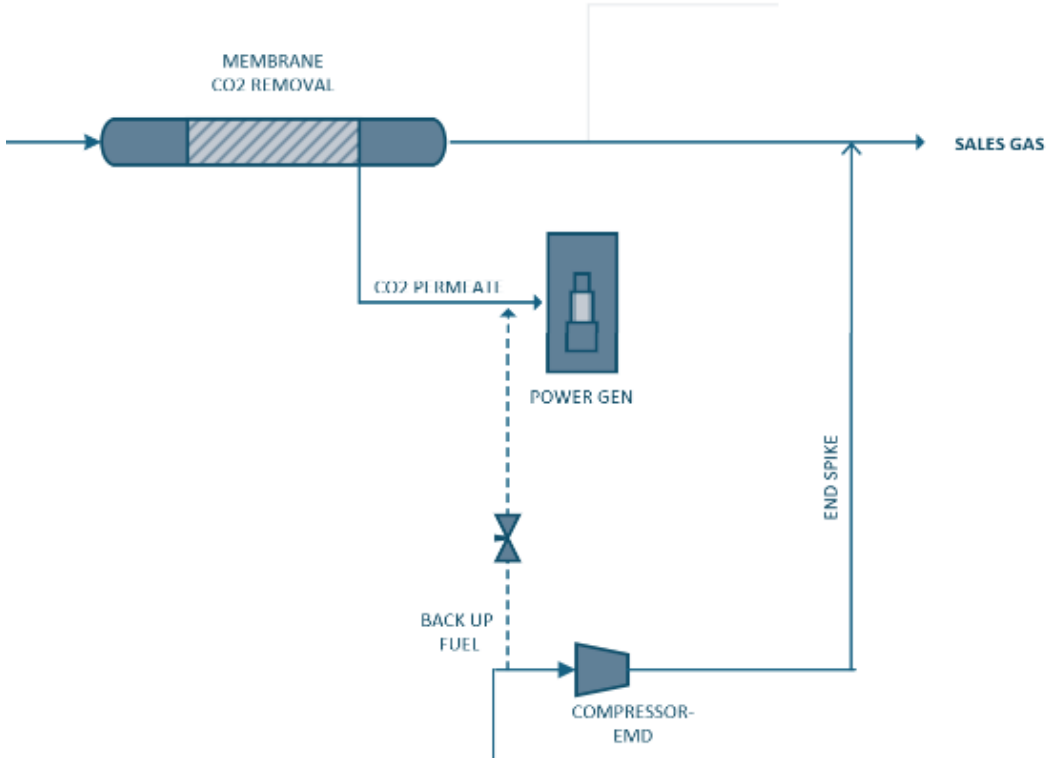
# Recycle Compressor Configuration

- **End spike:** $C_3$+-rich gas sent with sales gas at the end of the train
- **Best suited:** where sales gas spec is not limited by LHV, or power generation applications for datacenters / AI training centers
- **Effect:** reduces $C_3$+ recovery in liquids, but stabilizes product quality
- **Key tradeoff:** higher recovery versus product stability / pipeline specification



# Membrane Unit – Outlet $CO_2$ spec

- **Purpose:** remove bulk $CO_2$ from dew-pointed gas to achieve pipeline specification
- **Location:** feed gas vs. sales gas??
  - Preferred at the tail end – why ??
  - Avoids requirements like pretreatment filters (particulate / carbon)
  - Better control on gas conditions – pressure, temperature, and flow
- **Flexible operation:** handles variable flows and compositions
- Permeate / reject stream can be used for power generation – standalone unit
- **Integration:** works with compression and NGL recovery units in modular trains

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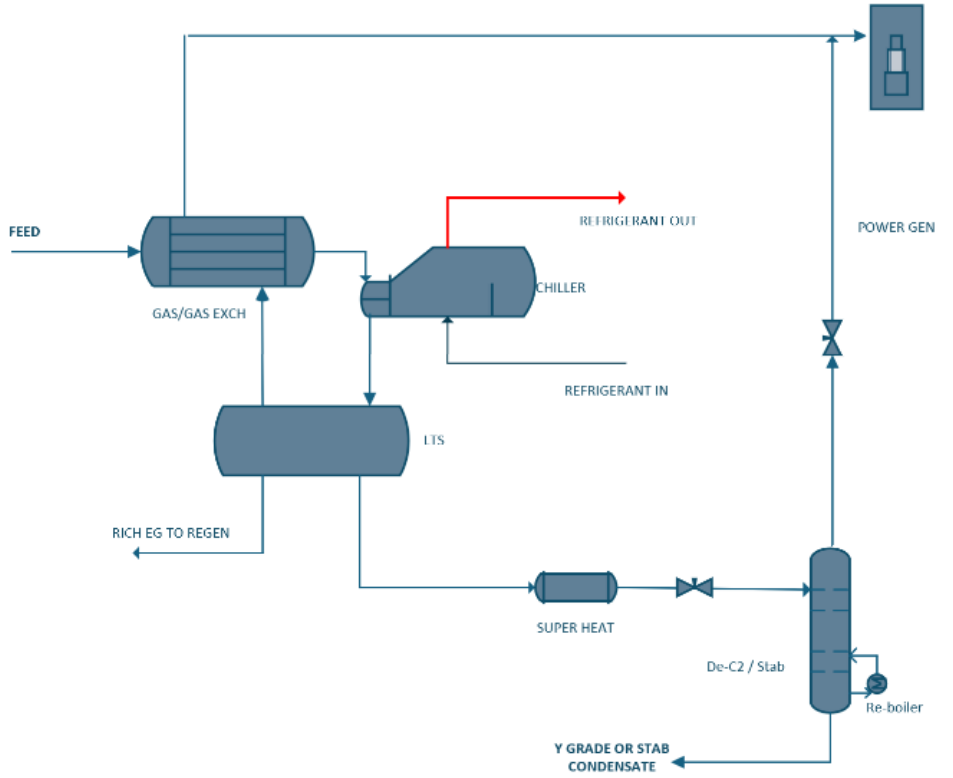
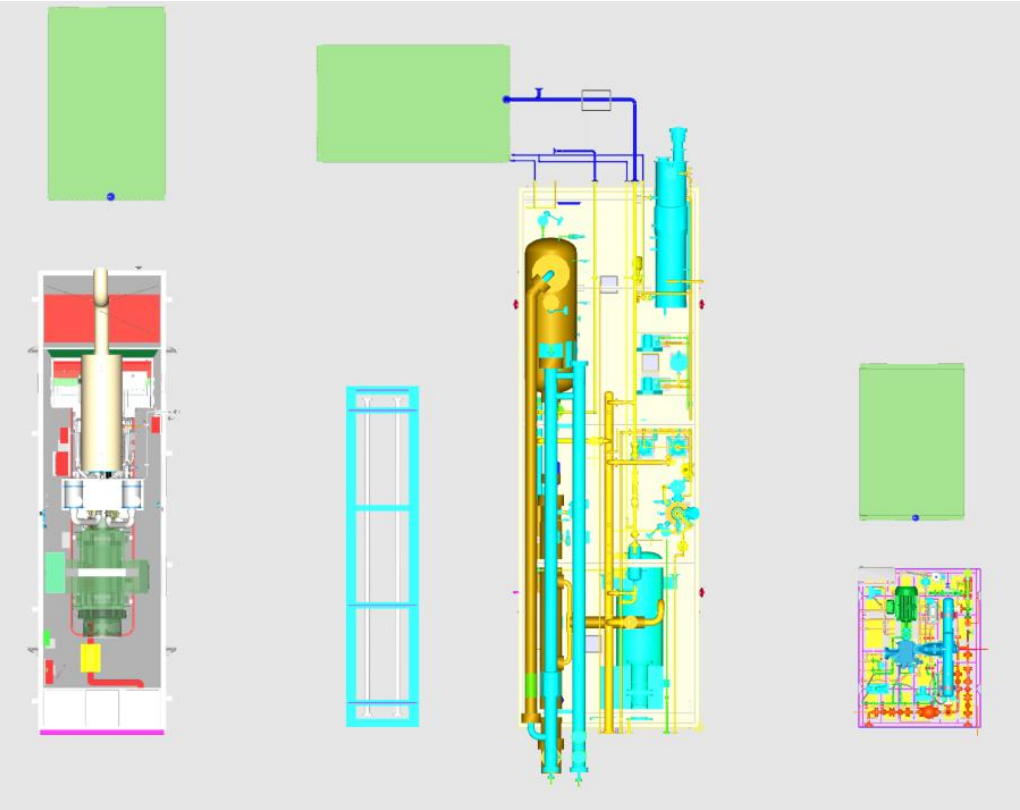
# Gas Export vs. Gas-to-Power

- Use recovered gas as fuel for modular generators
- **Applications:** remote oil and gas operations, island mode power, datacenters, and AI training centers
- **Benefit:** reduces dependence on pipeline infrastructure; turns stranded gas into electricity
- **Economic impact:** generates local energy revenue, reduces flaring penalties, and supports ESG goals



# Modularized Design



- **Module 1:**
  - Gas / gas exchanger
  - Chiller evaporator
  - Low temperature separator
  - Refrigeration compressor
  - Refrigeration lube system
  - Ethylene glycol regeneration
  - De-ethanizer tower with reboiler
- **Module 2:** overhead booster compressor
- **Module 3:** membrane skid
- **Module 4:** power generation
- **Module 5:** inlet compression – *optional*

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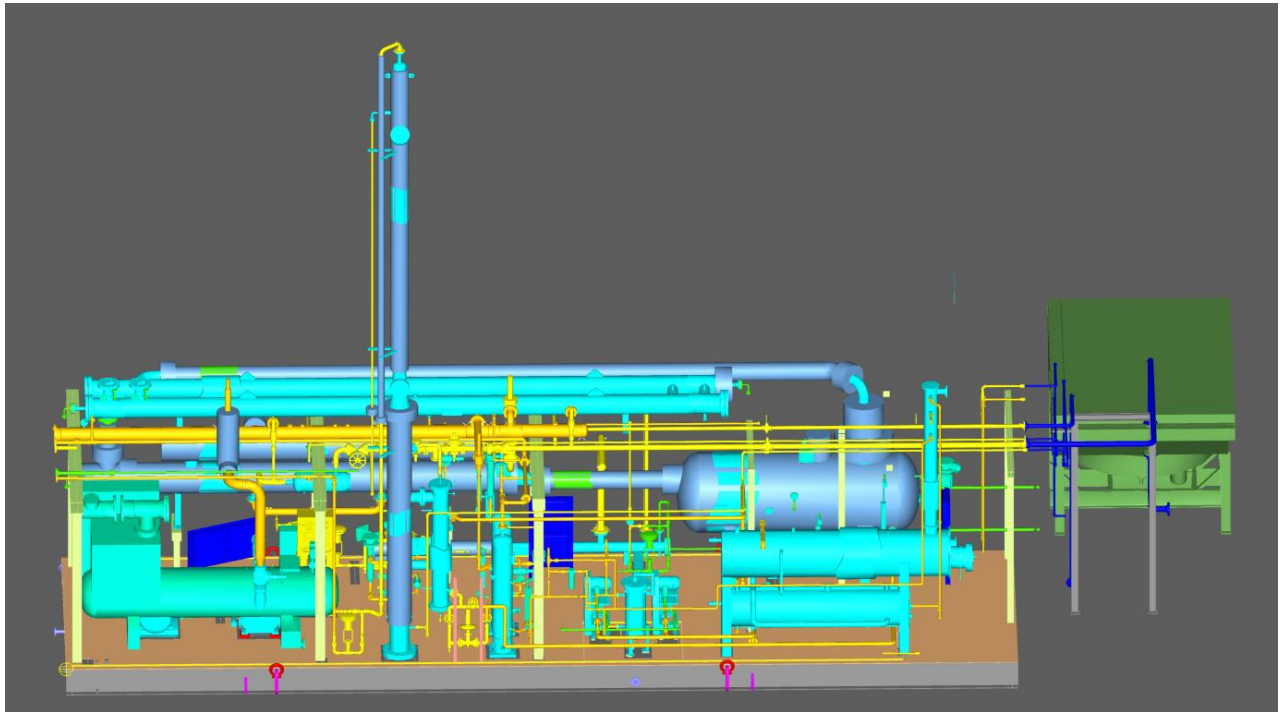

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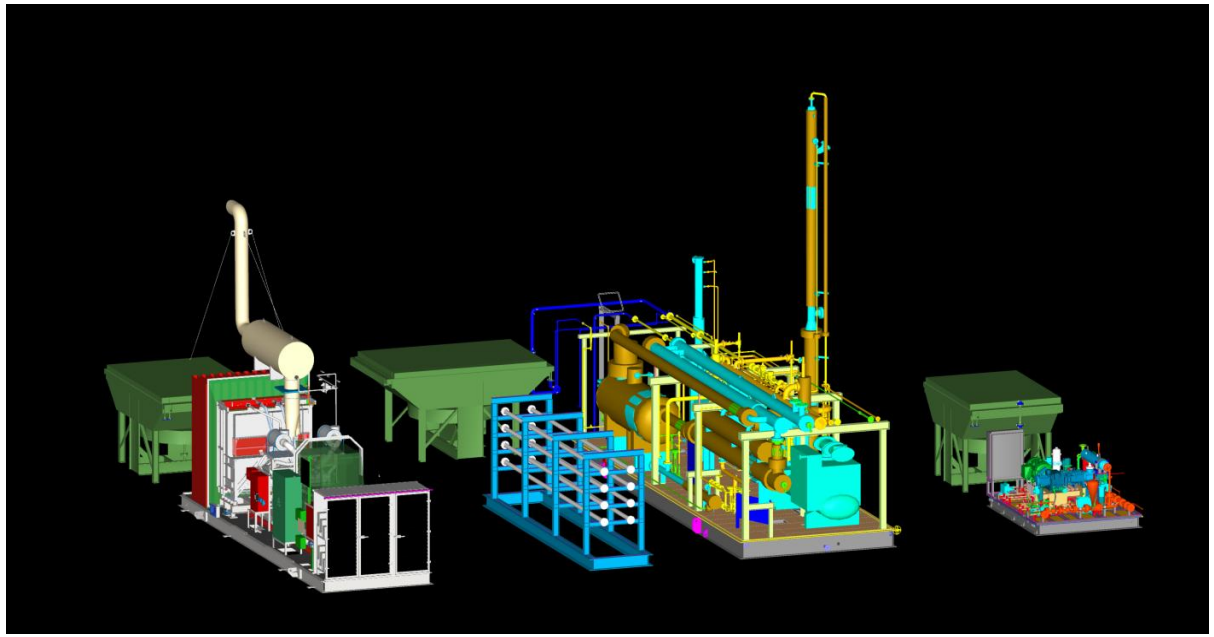
  - Gas / gas exchanger
  - Chiller evaporator
  - Low temperature Separator
  - Refrigeration compressor
  - Refrigeration lube system
  - Ethylene glycol regeneration
  - De-ethanizer tower with reboiler
- Refrigerant condenser is shipped loose
- Main module: 45 Ft (L) x 15 Ft (W) x 15 Ft (H)

# Modularized Design



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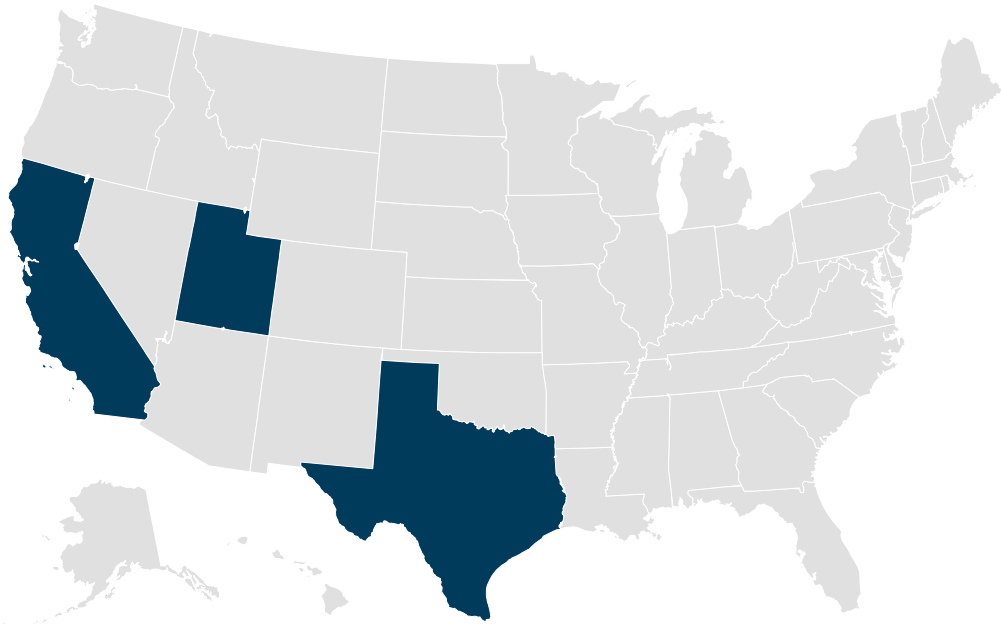
- **Module 5:** inlet compression – *optional*

# Concept Case Studies

| Location | Flow *(MMSCFD)* | $C_3$+ % | Highlights |
|---|---|---|---|
| **California** | 4.5 | 16% | Moderate flow, high pressure |
| **Utah** | 25.2 | 13% | Very High $CO_2$, mid pressure |
| **Indonesia** | 50.1* | 4.70% | Very High flow, very low $C_3$+ |
| **Oman** | 12.2 | 17% | High flow, mid pressure |
| **West Texas** | 2.6 | 19% | Low flow, low pressure, High $C_3$+ |





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# Economical Analysis – Payback Plot

- **Case study:** California
- **Inlet temp:** 90°F
- **Inlet pressure:** 700 PSIG
- **Flow:** 4.5 MMSCFD
- **$C_3$+:** 16.0 mol%
- Four cases (2x2) reviewed
  - *Spill back / end spike*
  - *Y-Grade / 9 PSIA condensate*

| | Spill / Y-grade | Spill/ 9 PSIA | Spike / Y-Grade | Spike / 9 PSIA |
|---|---|---|---|---|
| Refrig HP | 225 | 5,109 | 195 | 195 |
| Recycle HP | 69 | 4,847 | 56 | 105 |
| Sales Gas LHV | 1,015 | 1,013 | 1,027 | 1,152 |
| Sales Gas Flow MMSCFD | 3.5 | 3.1 | 3.6 | 3.8 |
| Liquid Flow BPD | 400 | 52 | 377 | 45 |
| $C_3$+ Recovery % | 77 | 11.7 | 73 | 10 |

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- Four cases (2x2) reviewed
  - *Spill back / end spike*
  - *Y-Grade / 9 PSIA condensate*
    - **Bad idea for spill + 9 PSIA!**
    - **Watchout for LHV on spike + 9 PSIA**

| | Spill / Y-grade | Spill/ 9 PSIA | Spike / Y-Grade | Spike / 9 PSIA |
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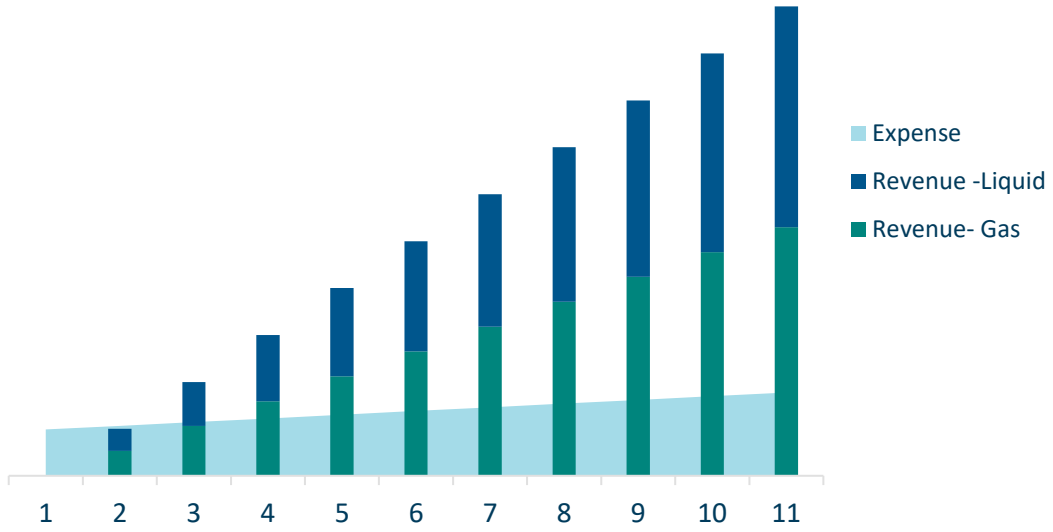
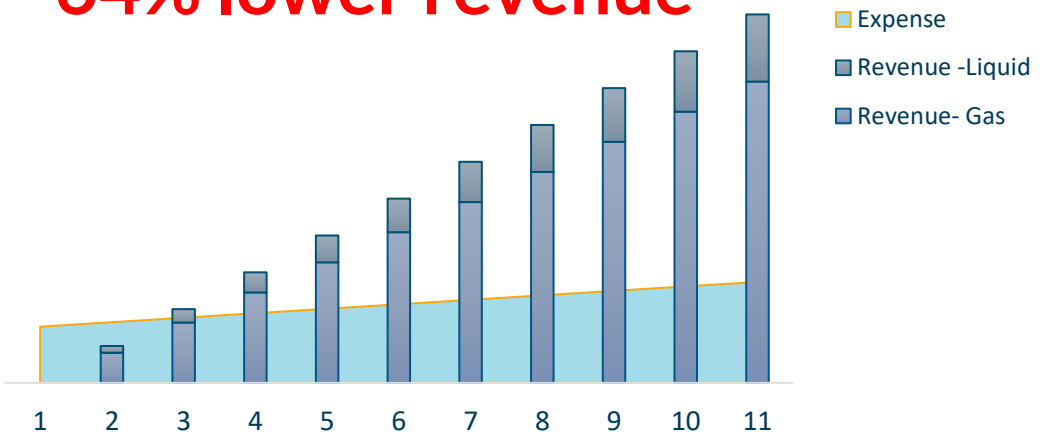
# Economical Analysis – Payback Plot

## End Spike / Y-Grade NGL




## End Spike / RVP Condensate

~64% lower revenue



# Economical Analysis – Other Cases

- Conclusions of other cases
- Short payback periods possible

| Location | Flow *(MMSCFD)* | $C_3$+ % | Notes / Highlights | Spill / Y-Grade | Spike / Y-Grade | Spike / 9 PSIA |
|---|---|---|---|---|---|---|
| California | 4.5 | 16% | Moderate flow, High pressure | 26 months | 26 months | 30 months |
| Utah | 25.2 | 13% | Very High $CO_2$ (65%), Mid pressure | 37 months | 37 months | 84 months |
| Indonesia | 50.1 | 4.70% | Very High flow, Very low $C_3$+ | 138 months* | 96 months* | 110 months* |
| Oman | 12.2 | 17% | High flow, Mid pressure | 19 months | 19 months | 19 months |
| West Texas | 2.6 | 19% | Low flow, Low pressure, High $C_3$+ | 41 months | 41 months | 49 months |

*Assuming no revenue from sales gas

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# Flare Gas Recovery – Key Insights

- **Significant opportunity:** 5 MMSCFD to 15 MMSCFD streams can be monetized, reducing flaring and emissions
- **Flexible solutions:** modular process trains adapt to flow, composition, and site constraints
- **$C_3$+ recovery:** spillback vs. end spike and NGL type (RVP vs. Y-Grade) determine liquid yield and end-use
- **Alternative uses:** gas can be exported, converted to power, or processed into NGLs / liquids depending on site and market
- **Economic benefits:** short payback periods possible; revenue + ESG gains make recovery viable

# Questions?

# Thank you!