Smith & Burgess
Process Safety Consulting

SCENARIOS IN REFINERY BLENDING
& OPERATIONAL IMPACT

CRUDE OIL COMPOSITON & RELIEF SYSTEM DESIGN

7600 W. Tidwell Rd., Ste. 600 | Houston, TX 77040
713.802.2647 | smithburgess.com

WHO WE ARE

Your Trusted Process Safety Advisors

- **Smith & Burgess was founded in 2007** with a commitment to providing unmatched customer service.
- Our founders bring **25+ years** of process safety expertise.
- Our team has a combined **500+ years** of process safety experience.
- Active members of the **API Subcommittee on Pressure Relief Systems.**



WHO WE ARE

Your Trusted Process Safety Advisors

- We've helped clients save an estimated **$300 million** in avoided costs.
- Successfully completed **3,000+ projects worldwide**.
- Published **15+ research papers** at national levels.
- Offices in **Houston, Chicago, Singapore and India**.
- Opened our **Research & Development Center in 2021**.



John Burgess, P.E.

Co-Founder &
Principal Consultant

25+ years experience in process safety management

Led 200+ successful projects across multiple industries

M.S. in chemical engineering from the University of Missouri



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Process Safety Consulting

Dustin Smith, P.E.

Co-Founder &
Principal Consultant

25+ years experience in process safety management

Led 200+ successful projects across multiple industries

B.S. in chemical engineering from Texas A&M University



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TODAY'S DISCUSSION

01 Are All Crude Oils the Same?

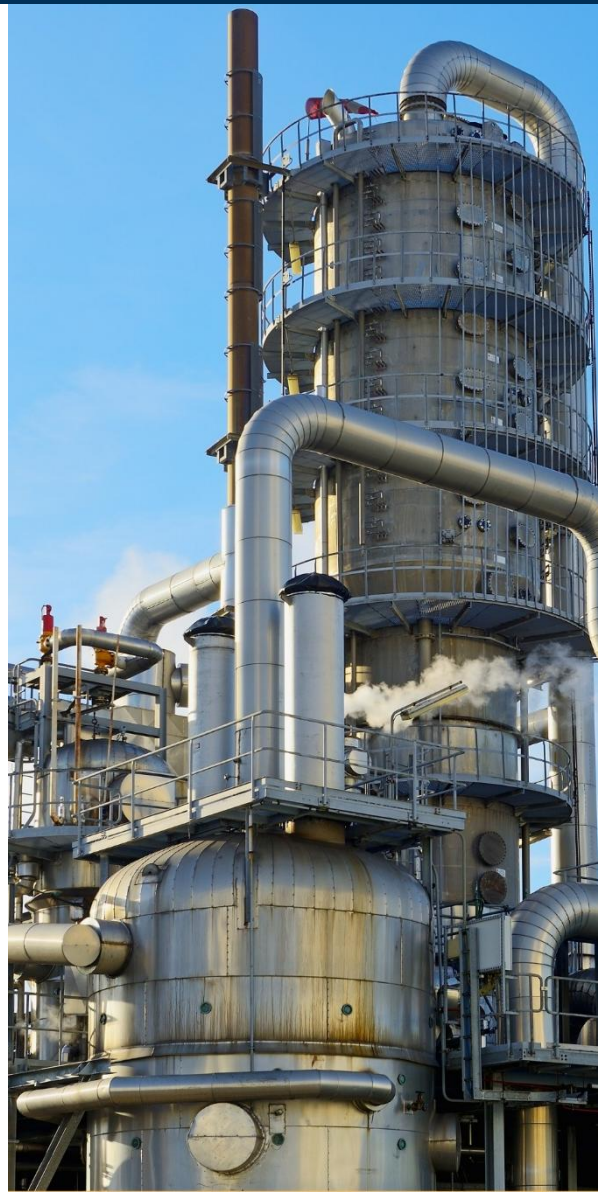
02 Overview of Refinery Process Flow Diagrams

03 Crude Unit Process Overview

04 Different Crude Oils Worldwide

05 Crude Oil Impacts On A Hypothetical Crude Unit

06 Conclusion & Key Takeaways



ARE ALL CRUDE OILS THE SAME?

Understanding the Key Differences
That Influence Processing Outcomes

ARE ALL CRUDE OILS THE SAME?



Sour Heavy Crude Oils

- Historically more affordable, these crude oils tend to be high in sulfur and contain heavier components.

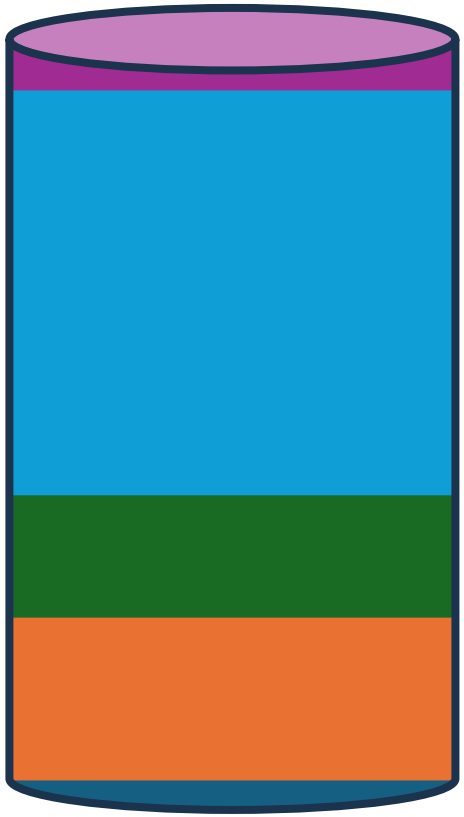
“Traditional” U.S. Crude Oils

- Medium or balanced crude oils with higher reside yields and fewer light ends (gas/NGLs)

“New” U.S. Shale Crude Oils

- Light, sweet crude oils that yield more gasoline and diesel, with minimal heavy residue.

LIGHT VS HEAVY – CRUDE OIL EXTEREMES



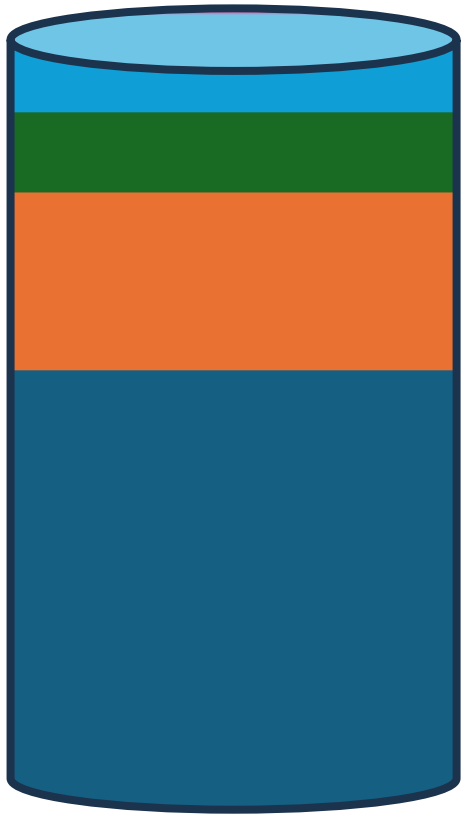
Gases / NGL

Naphtha / Gasoline

Kerosene

Diesel

Heavy Gas Oil / Residuals



American Shale Oil

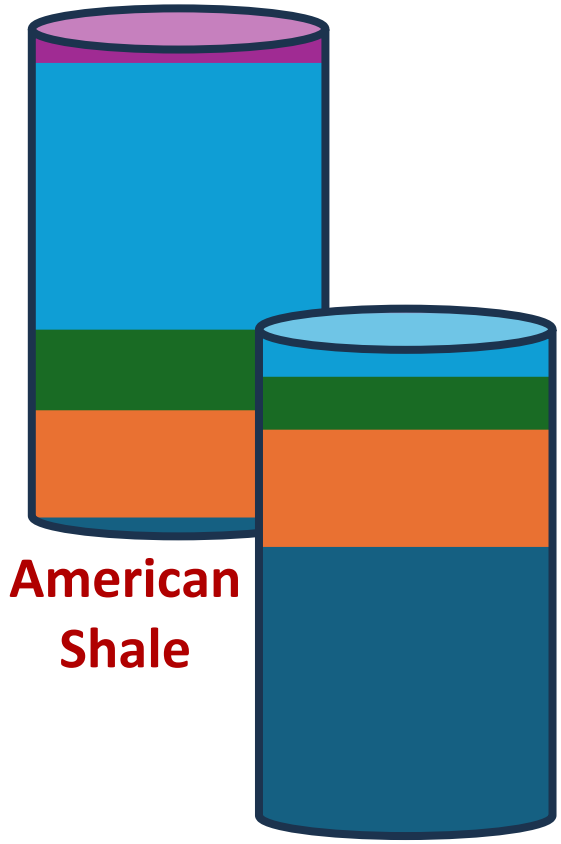
Venezuelan Heavy Oil

WHY DO REFINERS BLEND CRUDE OILS?

Why Use Multiple Crude Oils?

Blending crude oils enables refiners to balance cost, availability, and performance while maintaining flexibility in operations.

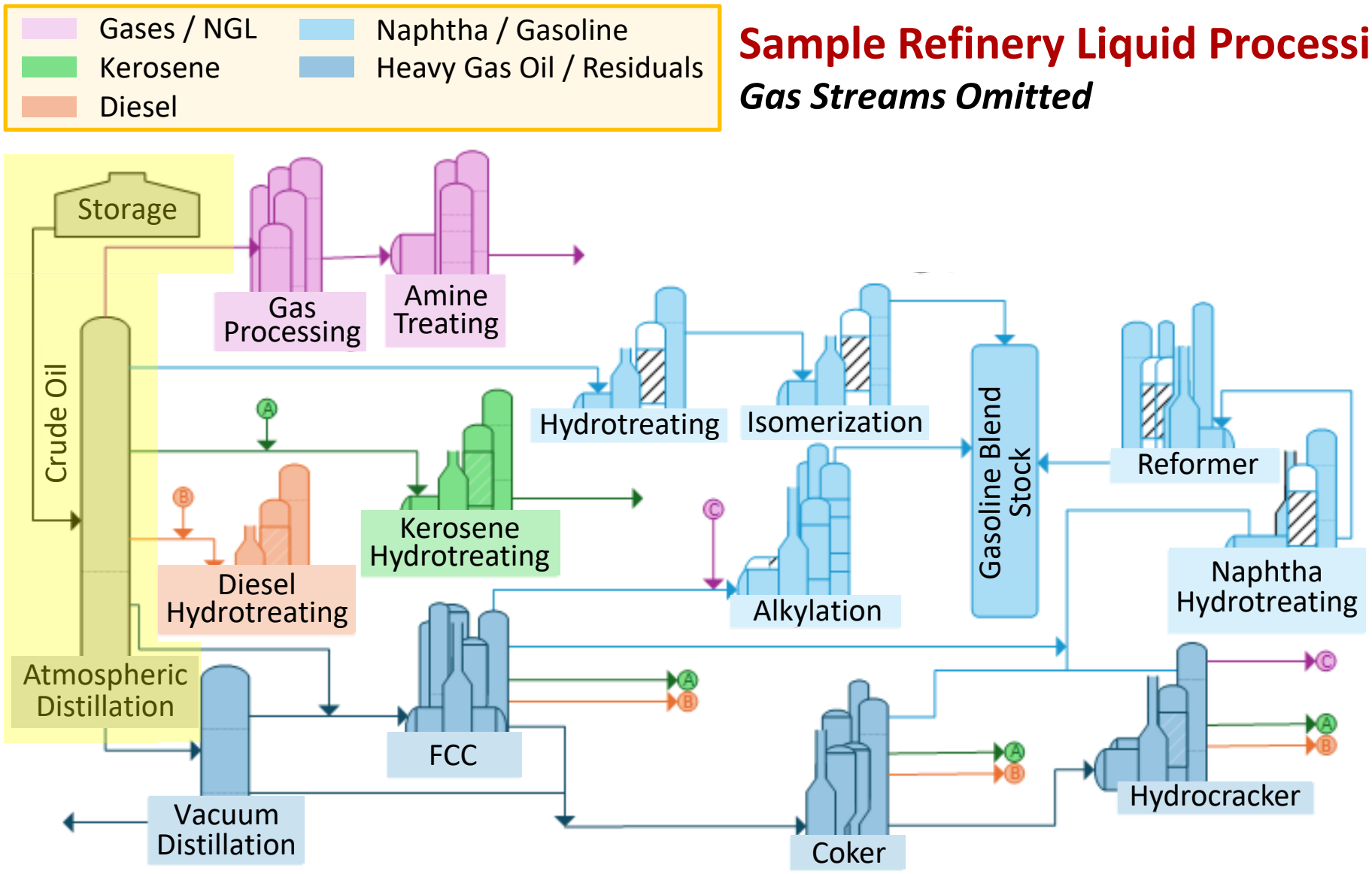
- **Economics** – minimize costs or improve margins
- **Availability** – respond to market or supply constraints
- **Capacity** – optimize unit throughput
- **Performance** – meet product quality specs
- **Flexibility** – adjust for operational or seasonal variation



OVERVIEW OF REFINERY PROCESS FLOW DIAGRAMS

Visualizing the Core Processes Behind Crude Oil Refining

TYPICAL REFINING PROCESS FLOW



CRUDE OIL SELECTION IMPACTS ON RELIEF & FLARE DESIGN

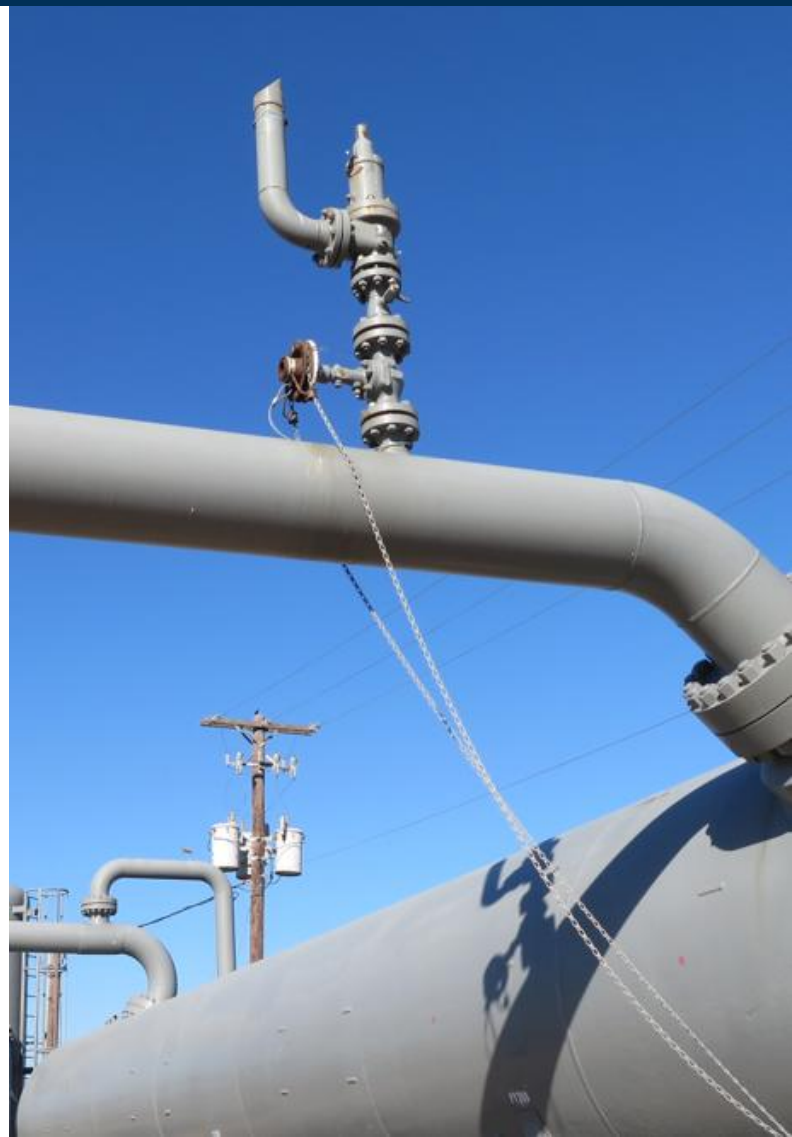
Crude Unit

- Both the **composition** and **flowrate** of crude oil impact how relief and flare systems are designed at the crude unit.

Remaining Units

- Downstream units are affected only by **flowrate**, since composition has already been split by the atmospheric tower.

Even tank farms are impacted by crude oil variability!



CRUDE BLENDING IMPACTS ON RELIEF & FLARE SYSTEMS



Tank Utilization

Additional surge capacity may be needed due to operational inefficiencies or unstable crude oil blends.

Tank Scenarios

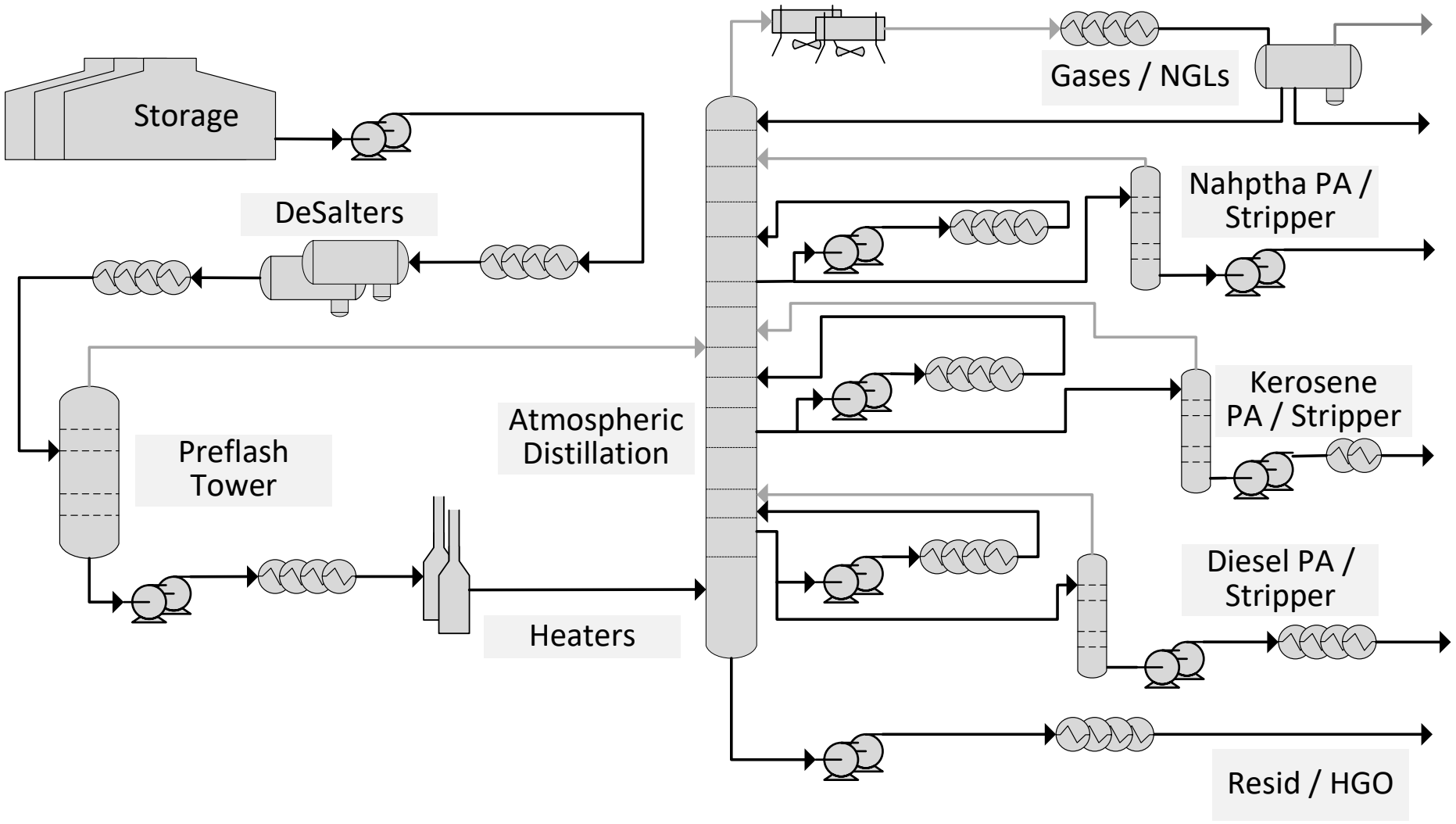
Common Issues Include:

- Sinking Floating Roofs
- Gas Blowby From Upstream Units
- Lighter Materials in Day Tanks
- Increased Volatiles in Storage

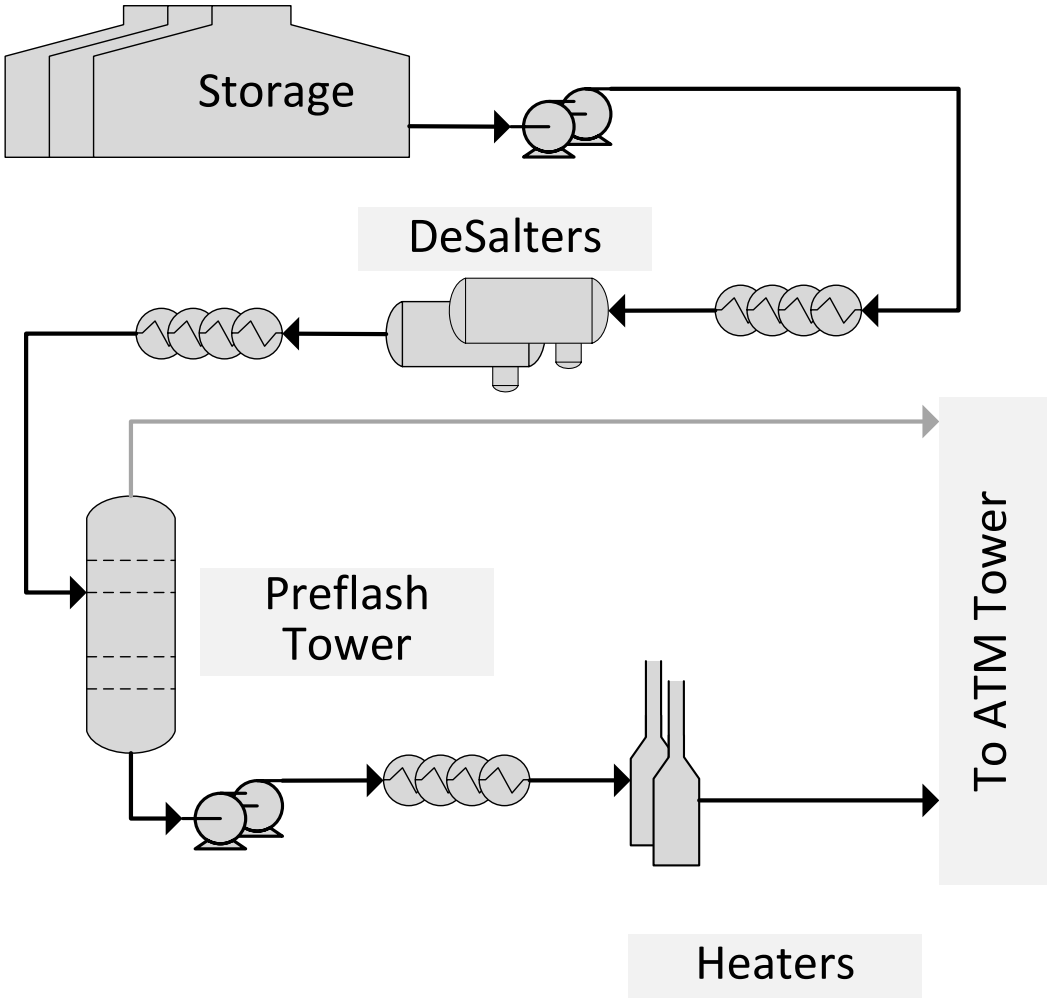
CRUDE UNIT PROCESS OVERVIEW

Simplified Flow Diagram

CRUDE UNIT PFD – SIMPLIFIED VIEW



PRE–TOWER OPERATIONS: MINIMAL RELIEF SENSITIVITY



Minimally Affected by Blends

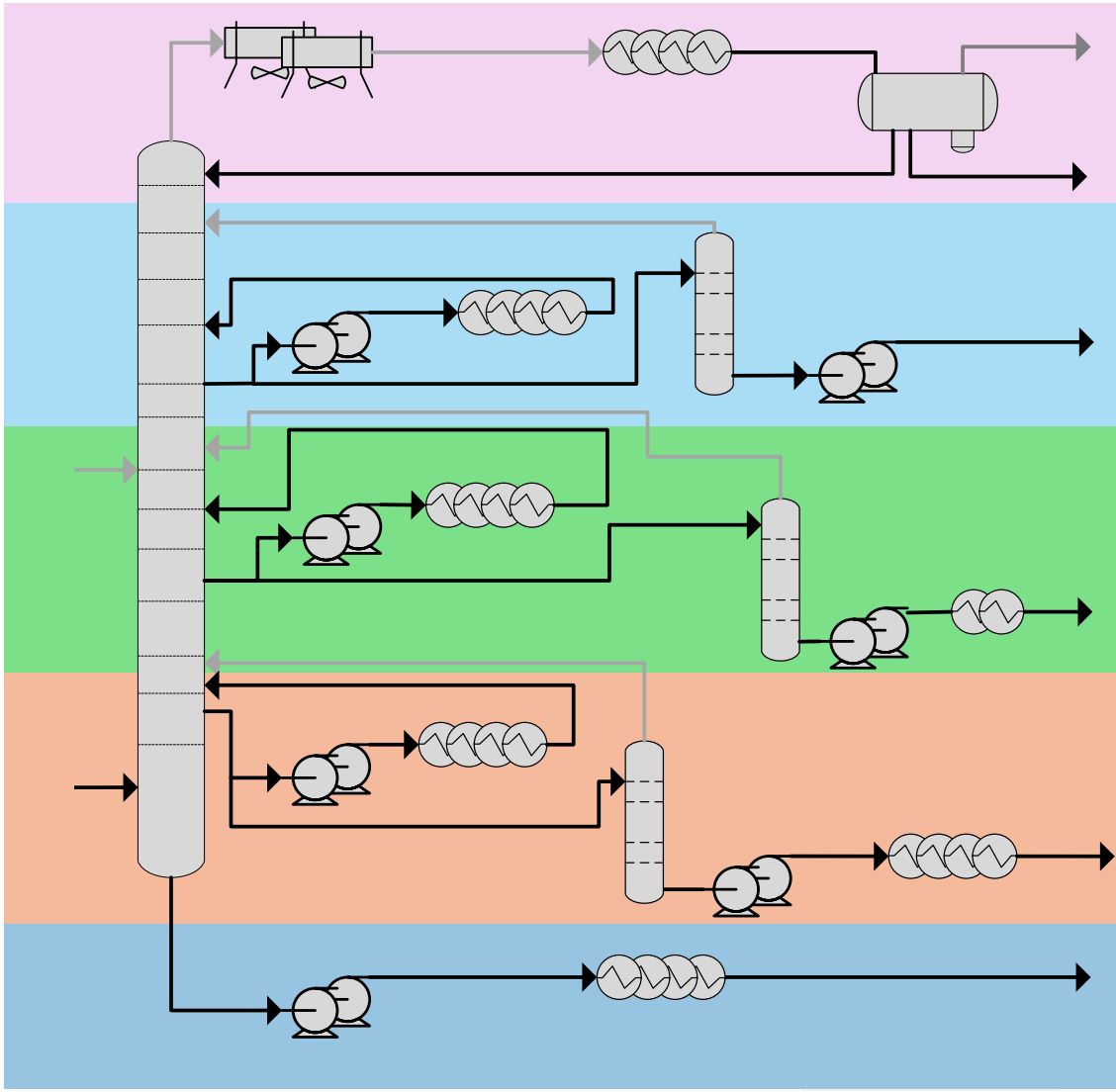
- Primarily liquid service or directly open to the crude tower.
- Relief & flare sizing in this section is driven largely by total liquid flowrate.
- Desalters can be affected by lighter crude oils or increased backpressure.

CRUDE COLUMN FRACTIONATION OVERVIEW

- Gases / NGL
- Naphtha / Gasoline
- Kerosene
- Diesel
- Heavy Gas Oil / Residuals

Relief System Impacts Vary By Stream:

Lighter streams near the top of the column produce more vapor and drive higher relief rates. Heavier streams lower in the column have less vapor impact and typically contribute less.



DIFFERENT CRUDE OILS WORLDWIDE

How Global Crude Oil Blends Affect Downstream Processing

VARIATIONS IN GLOBAL CRUDE OIL COMPOSITION

How Different Are Crude Oils?

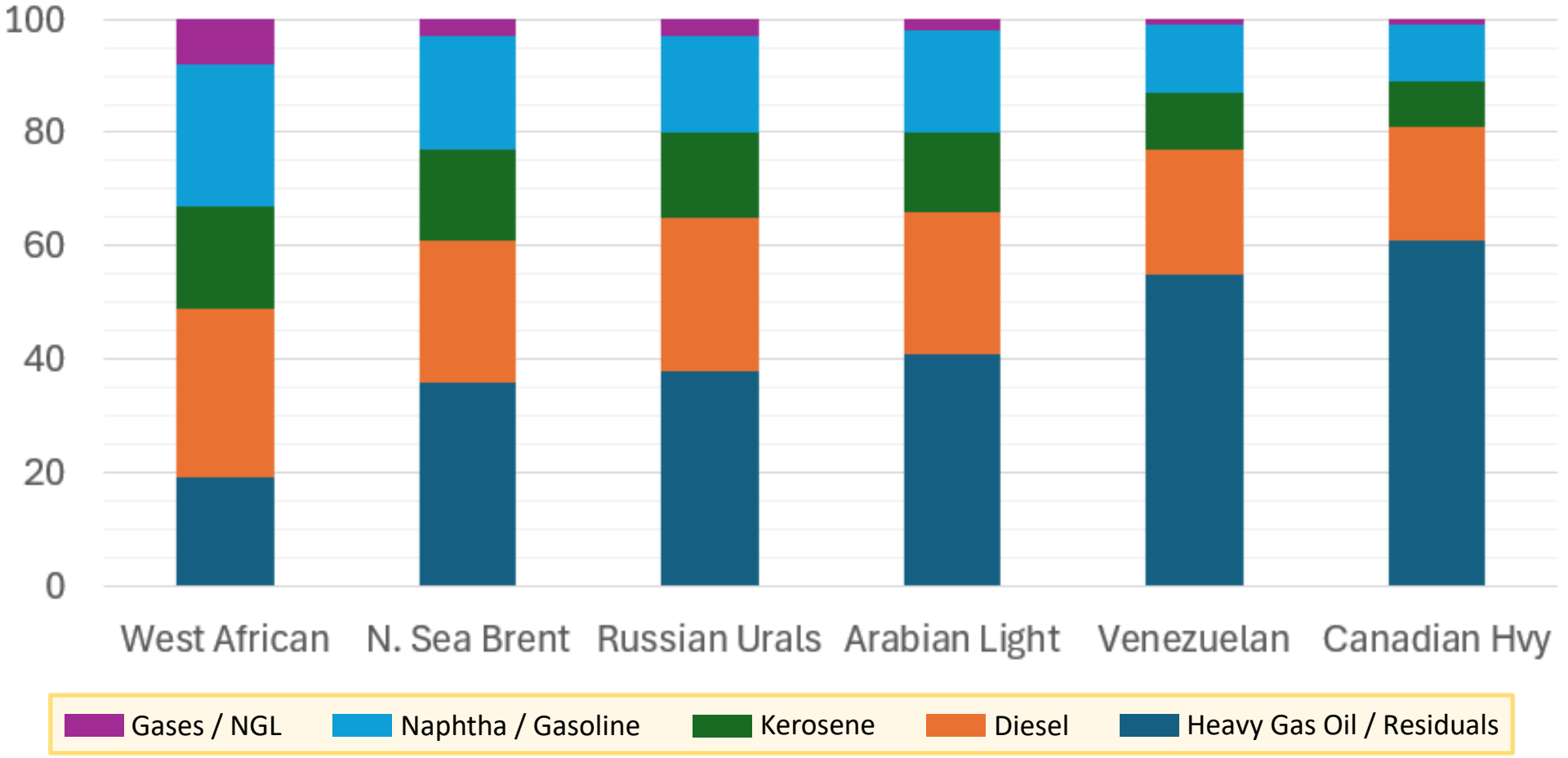
Crude oil composition varies significantly across global sources.

- **Shale oil** is a light crude oil, typically rich in natural gas liquids (NGLs), liquefied petroleum gases (LPGs), and gasoline-range hydrocarbons, with minimal heavy residual components.
- **Heavy crude oil** may contain over 50% heavy gas oil (HGO) and residuals, making it more complex to process.



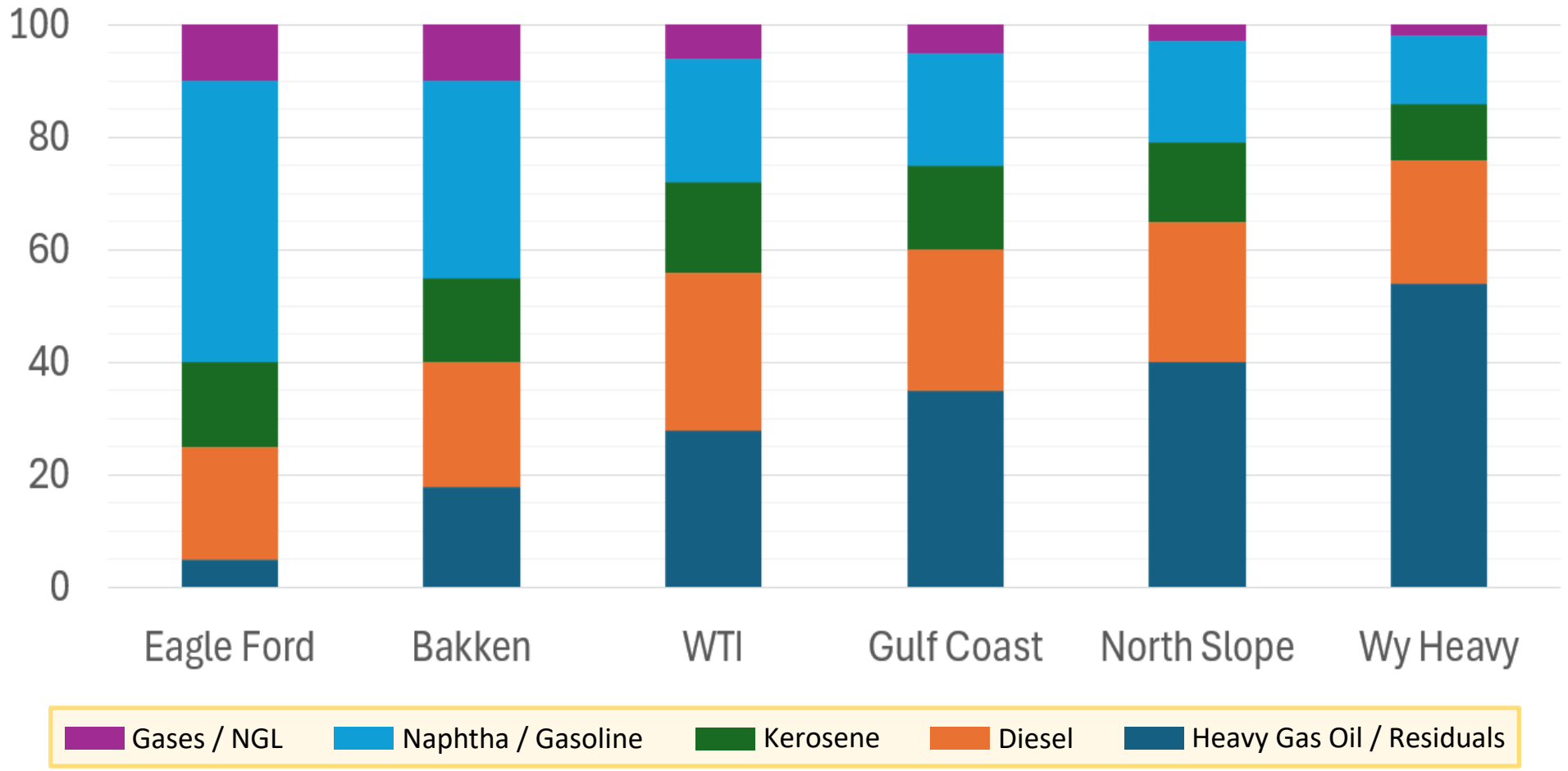
CRUDE OIL COMPOSITION BY REGION

Component Breakdown of Global Crude Oil Sources



CRUDE OIL COMPOSITION BY REGION

Component Breakdown of North American Crude Oil Sources



CRUDE OIL IMPACTS ON A HYPOTHETICAL CRUDE UNIT

Testing Crude Behavior in the
“Galveston Gushers” Test Refinery



CRUDE OIL BLENDING IN ECONOMIC CONTEXT

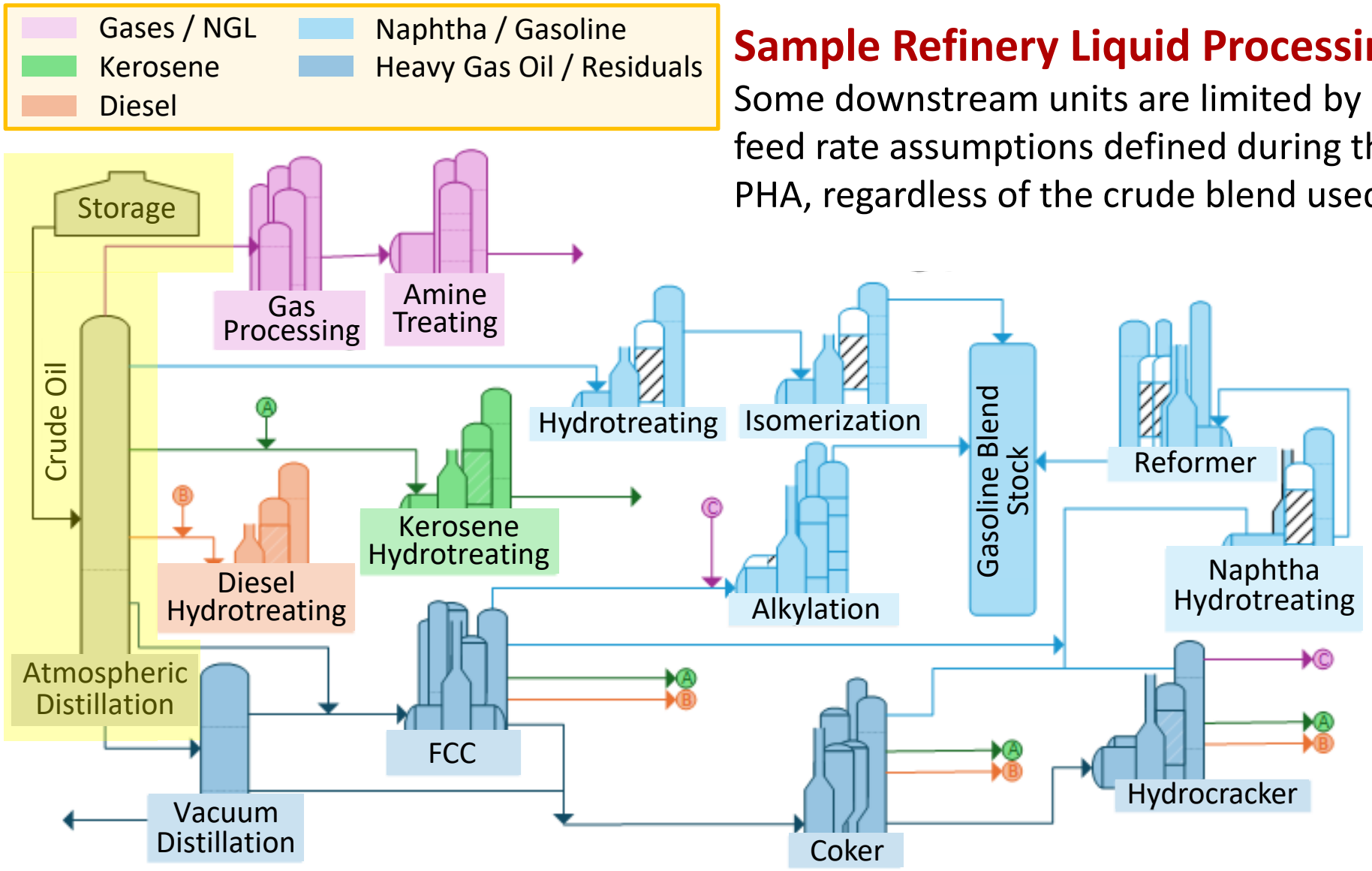


Each scenario assumes the same volumetric crude input.

Common Refinery Blending Scenarios:

- **Baseline** – Balanced blend with average yields
- **Travel Season** – More gasoline, kerosene, and diesel; less HGO
- **Polar Vortex** – Prioritize gasoline and heating oils
- **Ship Sale** – Discounted heavy crude oil from marine delivery
- **Tariff** – Blending shift toward domestic supply

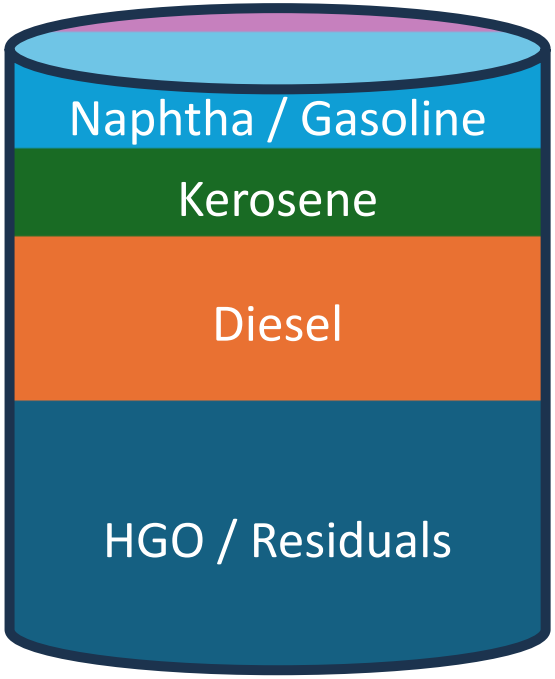
NON-CRUDE FEED RATE LIMITS



Sample Refinery Liquid Processing

Some downstream units are limited by feed rate assumptions defined during the PHA, regardless of the crude blend used.

BASELINE–
CRUDE SLATE COMPARISONS



Relief and Flare Loading

- 100,000 lb/hr (Mass Flow)
- 100% Area Utilization

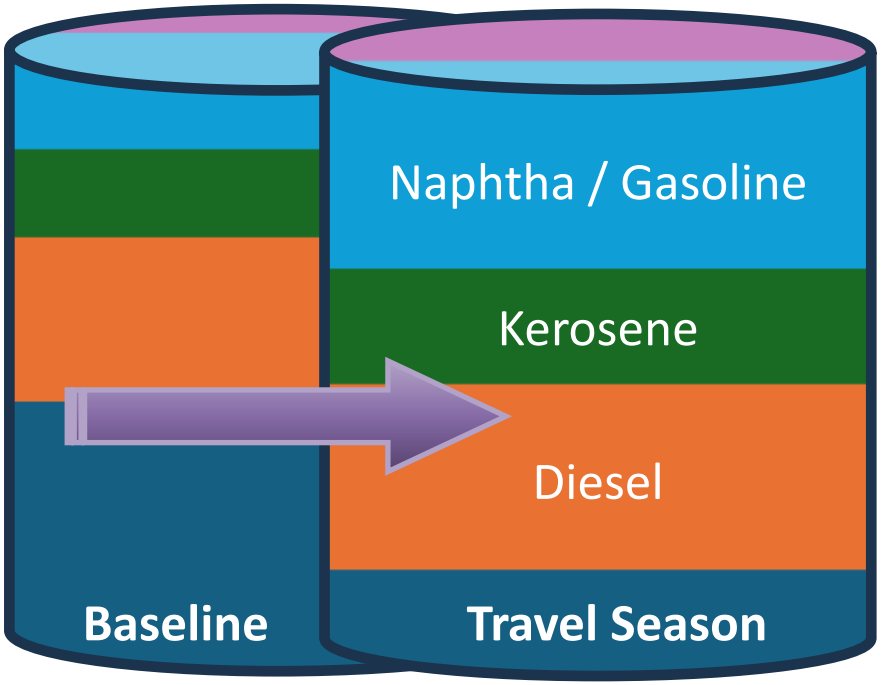
Baseline Crude Oil Blend Assumptions:

This blend represents a balanced processing strategy based on typical regional availability. It serves as the foundation for evaluating relief and flare system impacts in subsequent scenarios.

- 50% Venezuelan
- 25% West African
- 25% Gulf Coast

GALVESTON GUSHERS
OIL RIG

TRAVEL SEASON – CRUDE SLATE COMPARISONS



Relief and Flare Loading

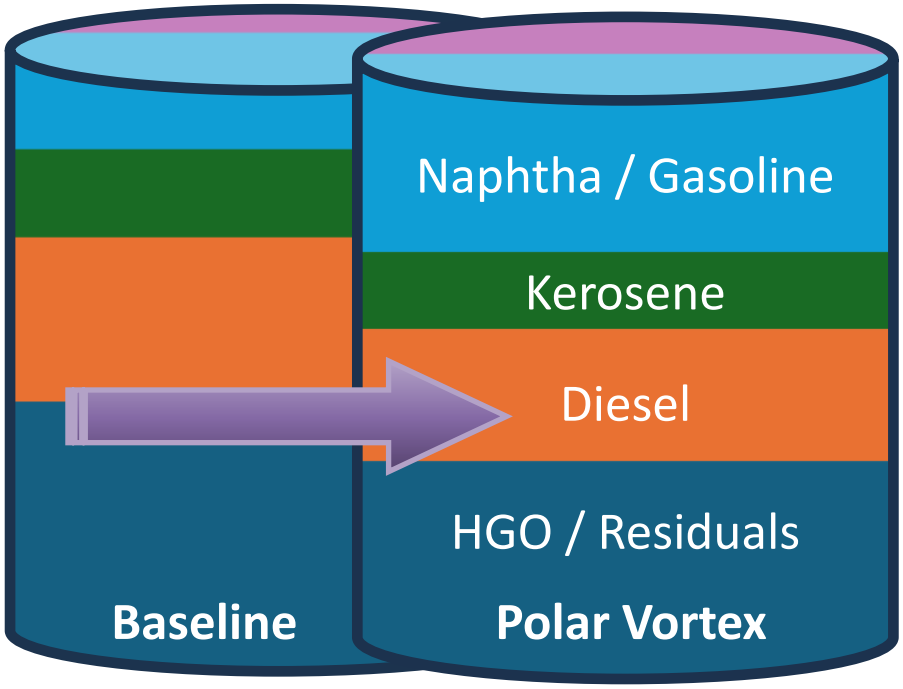
- 154,100 lb/hr (Mass Flow, 54% more)
- 100% Area Utilization (90% more)

Travel Season Crude Oil Blend Assumptions:

This seasonal blend prioritizes gasoline, kerosene, and diesel to meet travel demand, reducing heavy components for lighter product output.

- 50% West African
- 25% West Texas Intermediate
- 25% Eagle Ford

POLAR VORTEX – CRUDE SLATE COMPARISONS



Relief and Flare Loading

- 124,600 lb/hr (Mass Flow, 25% more)
- 150% Area Utilization (50% more)

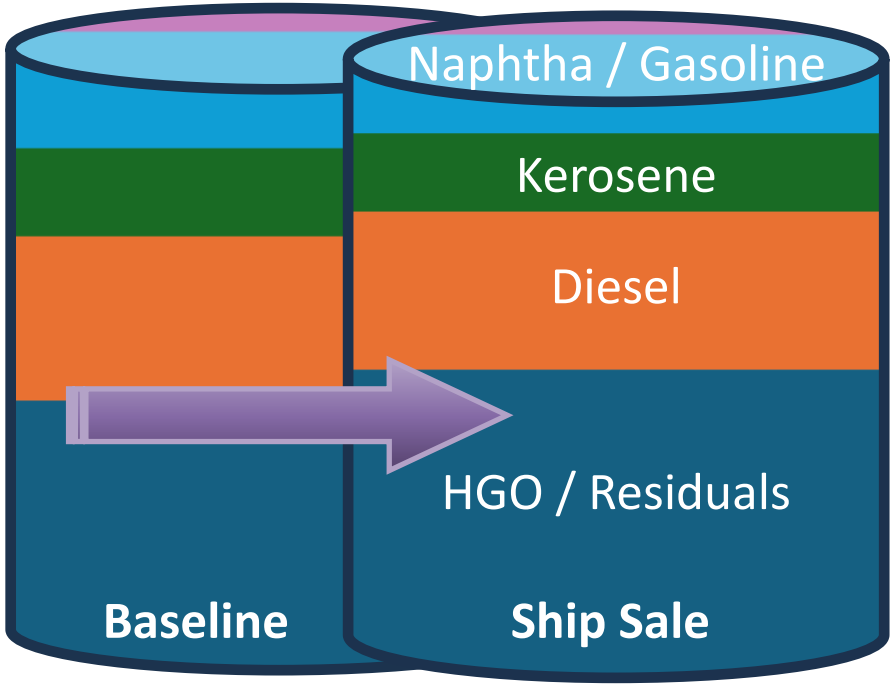
Polar Vortex Crude Oil Blend Assumptions:

Designed for extreme winter conditions, this blend increases lighter fractions to meet heating fuel demand and maintain efficiency in cold-weather operations.

- 50% Canadian
- 50% Eagle Ford

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SHIP SALE – CRUDE SLATE COMPARISONS



Relief and Flare Loading

- 87,400 lb/hr (Mass Flow, 12.6% ***less***)
- 78.7% Area Utilization (12.6% ***less***)

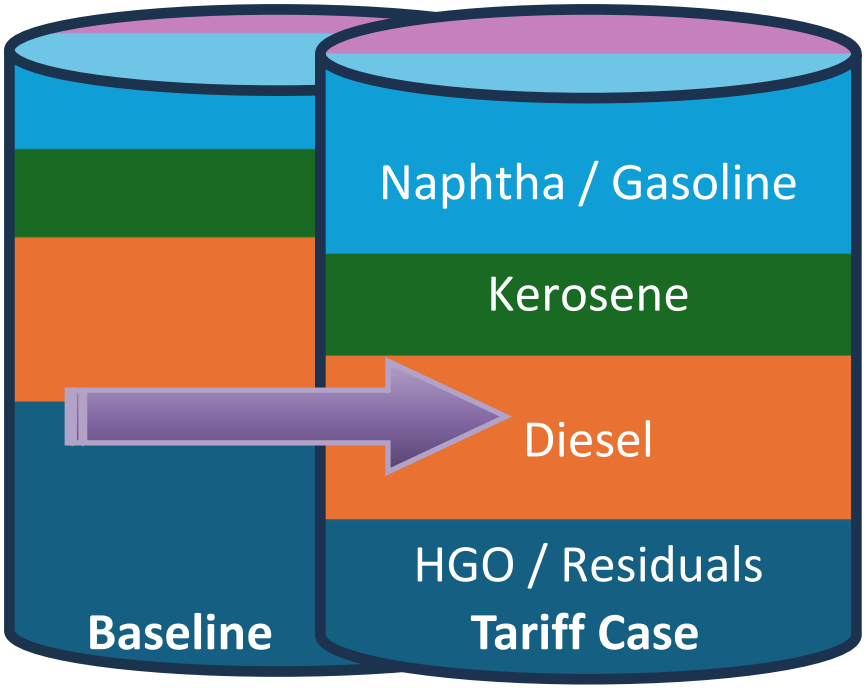
Ship Sale Crude Oil Blend Assumptions:

This blend reflects opportunistic purchasing of discounted heavy crude oils delivered by marine transport. While cost-effective, the higher proportion of heavy components increases relief system demand.

- 75% Venezuelan
- 20% West African
- 5% Gulf Coast

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TARIFF – CRUDE SLATE COMPARISONS



Tariff Crude Oil Blend Assumptions:

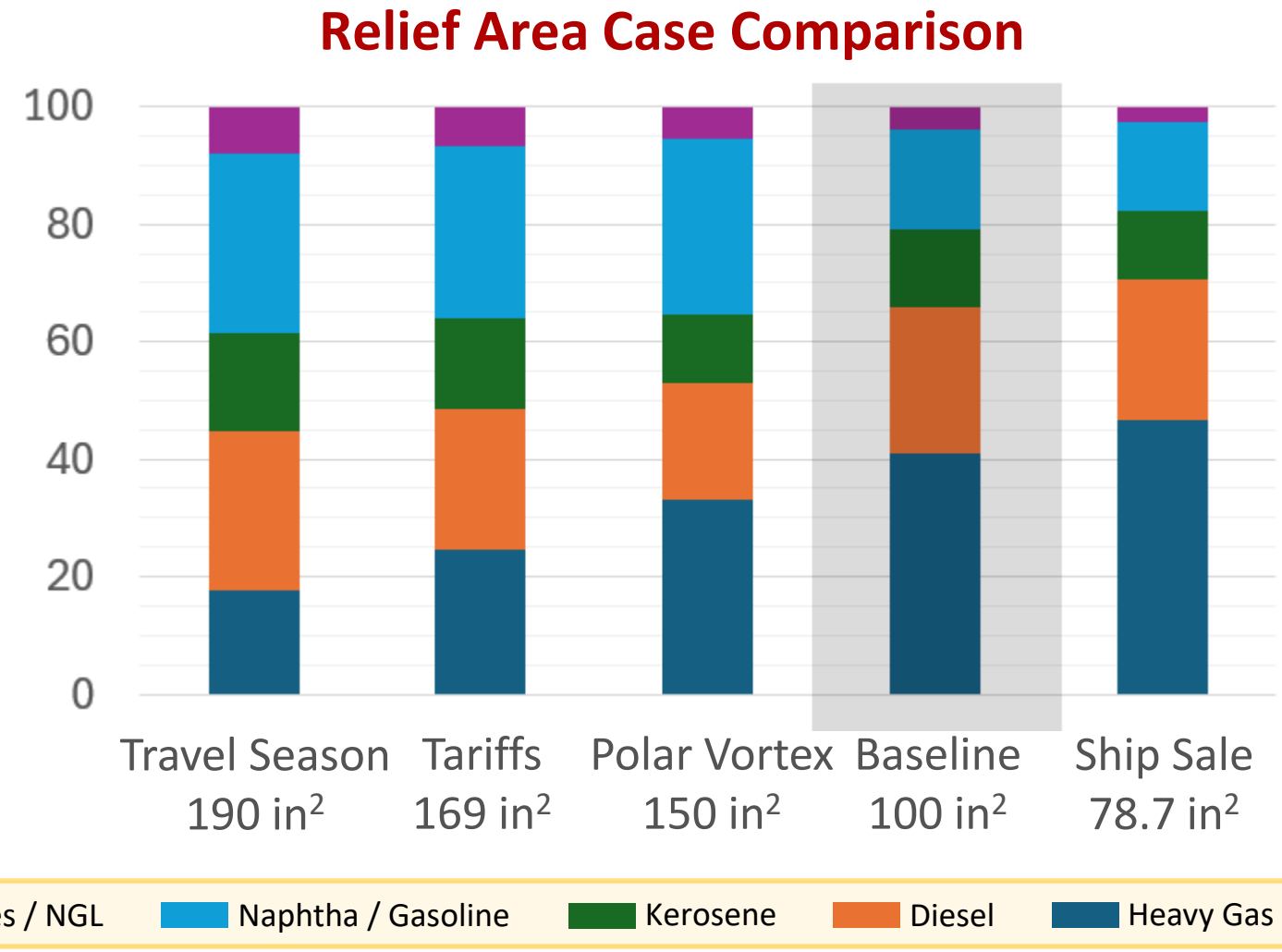
This blend reflects sourcing shifts due to tariffs, increasing reliance on domestic crude oils. The change raises light component levels and impacts relief systems behavior.

- 50% Gulf Coast
- 20% West Texas Intermediate
- 30% Eagle Ford

Relief and Flare Loading

- 139,800 lb/hr (Mass Flow, 40% more)
- 169% Area Utilization (69% more)

RELIEF AREA IMPACT – CRUDE SLATE COMPARISONS



RESULTS SUMMARY – CRUDE SLATE COMPARISONS



PSV requirements ranged from **80-190%** of the baseline – at the same charge rate!

Conclusions:

- Relief rate can be estimated based on expected products, but it remains system-dependent.
- Relief capacity requirements varied by **over 2x** for the same charge rate.
- Tank farm issues such as gas blowby and vapor management were highlighted.
- Downstream unit impacts correlated closely with charge rate assumptions.

CONCLUSION & KEY TAKEAWAYS

Crude Oil Variability Drives Relief System Impact

- No two crude oils are the same – composition directly affects relief, flare, and overall system performance.
- Small changes in crude oil sourcing or blending can have **significant safety and operational implications**.
- Effective relief system design depends on **accurate assumptions** and operational awareness.
- Close coordination across teams is key to maintaining reliable and compliant relief & flare systems performance.

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Thank you for your time.

Dustin Smith
Co-Founder & Principal Consultant
Dustin.Smith@smithburgess.com

John Burgess
Co-Founder & Principal Consultant
John.Burgess@smithburgess.com

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Phone: 713.802.2647 | smithburgess.com