



**UNIVERSITY  
OF ALBERTA**

# ECON 366: Energy Economics

## Topic 2.1: Oil and Gas Markets

Andrew Leach, Professor of Economics and Law

 [aleach@ualberta.ca](mailto:aleach@ualberta.ca)

 [leachandrew](https://github.com/leachandrew)

 [.\\_andrew\\_leach](https://twitter.com/_andrew_leach)

# Oil and gas prices

Oil, gas, and related product prices tend to vary based on four characteristics:

- Fundamentals of the commodity
- Quality differences like heating values or sulphur content
- Location where the price is set
- Time – gas prices are seasonal, oil and gas futures prices vary over time

For example, the answer to the question “what’s the price of oil,” should not be, “\$54.15 per barrel.” It should be, “what type of oil, when, and where?” Similar variations exist in gas markets.

## Oil

- All oil *blends* are *mixtures* of various *hydrocarbon* molecules and impurities
- *Crude assay* tells you the properties of any given mixture
- *Benchmark crudes* (WTI, WCS, Brent) have target assays
- Key components of value are *density* (or *API gravity*, which is an inverse density), and sulphur content (*sweet vs sour*)
- Different crudes with the same API gravity and sulphur content may differ in other characteristics (light ends, bottoms, etc) which lead to premia or discounts

# WCS specifications

Density: 928 kg/m<sup>3</sup>  
API: 20.9°

WCS is technically classified as a "heavy" crude (defined as having an API density of 10 to 22.3°), bordering on "medium".

Sulphur: 3.5%

WCS is slightly less sour than most dilbits, which typically average closer to 4% sulphur. Sulphur is considered an impurity since it must be completely removed from all final products, and sulphur can poison the catalyst during catalytic reforming.

MCR: 9.7%

Micron Carbon Residue (MCR) is a measure of the crude's ability to form coke, representing the fraction of large high-carbon molecules contained in the crude. Undiluted Athabasca bitumen has an MCR of about 13.6% while a typical diluted bitumen has an MCR of about 10.5%. Crudes with a higher MCR are more costly to refine.

Sediment:  
295 ppmw

WCS has a higher sediment content than a typical Dilbit, which averages about 150 ppm by weight. Sediment accelerates erosion of both the pipeline and refinery components.

TAN<sup>[1]</sup>:  
1.0 mg KOH/g

TAN (Total Acid Number) is a measure of the crude's naphthenic acid concentration, which can corrode refinery equipment at elevated temperatures and pressures. Bitumen from the oil sands tends to have a higher TAN than heavy conventional oil. Crudes with TAN values greater than 1.0 are considered "high-TAN" feedstock.

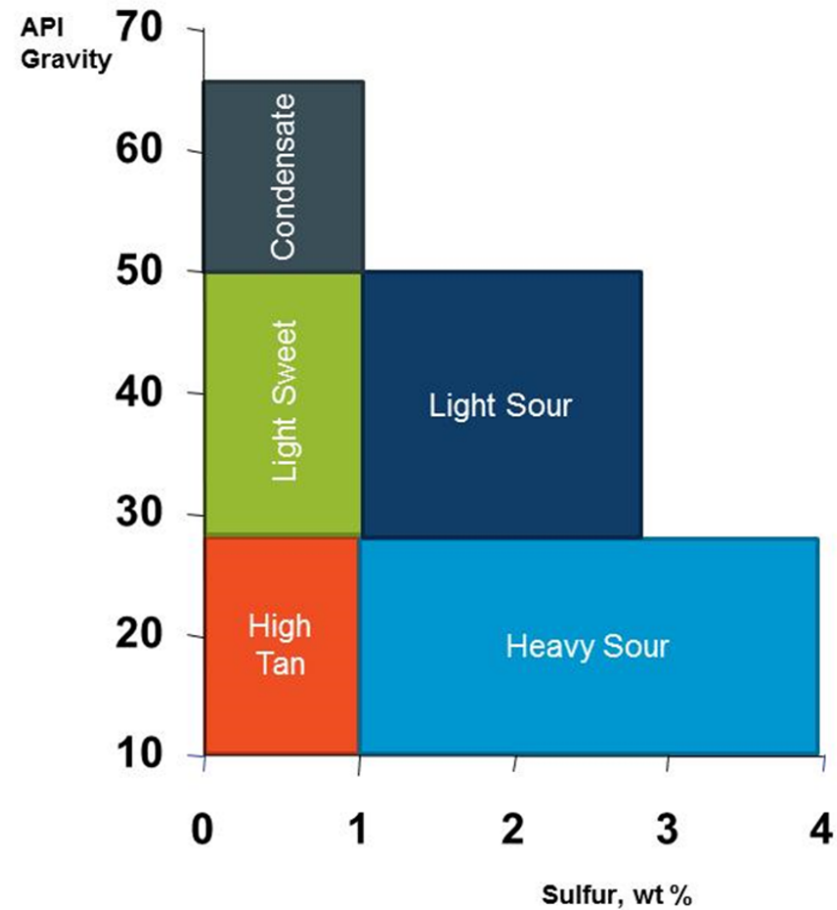
Salt<sup>[2]</sup>: 36 ptb

WCS is much higher in salt than a typical Dilbit, sometimes as much as four times higher. Salt concentrations are higher in heavy conventional crudes, which feed into WCS, increasing its salt content.

Nickel: 60 mg/L  
Vanadium: 140 mg/L

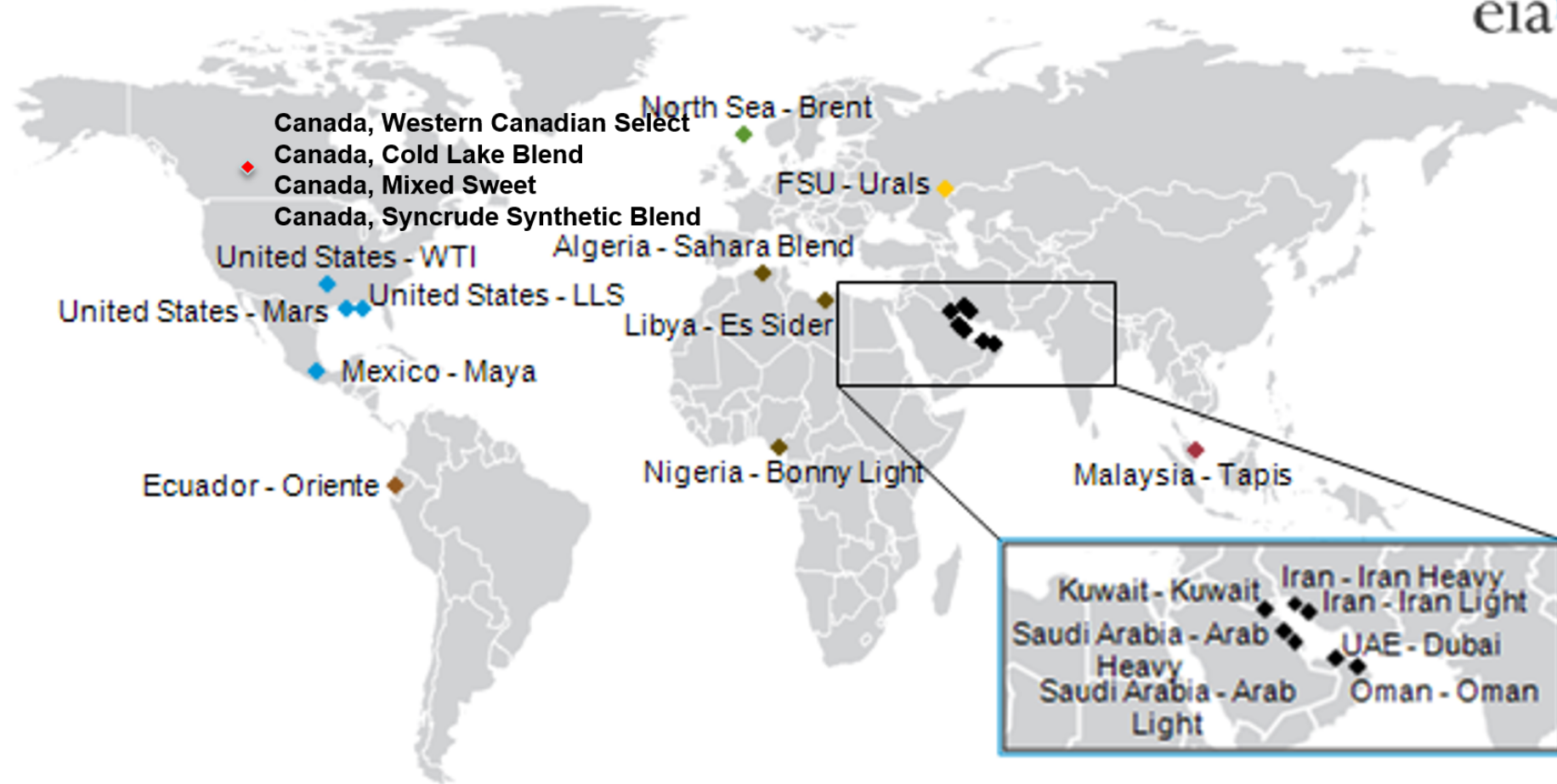
The nickel content of WCS is on par with most other Dilbits or even most conventional heavy crudes. In contrast, the concentration of vanadium in WCS is slightly lower than the average

# Crude Quality



# Global oil – main pricing locations

## Select crude oil price points



Source: EIA

# Global oil – main pricing locations

## Basis and Differentials: More than One Oil Price Around the World

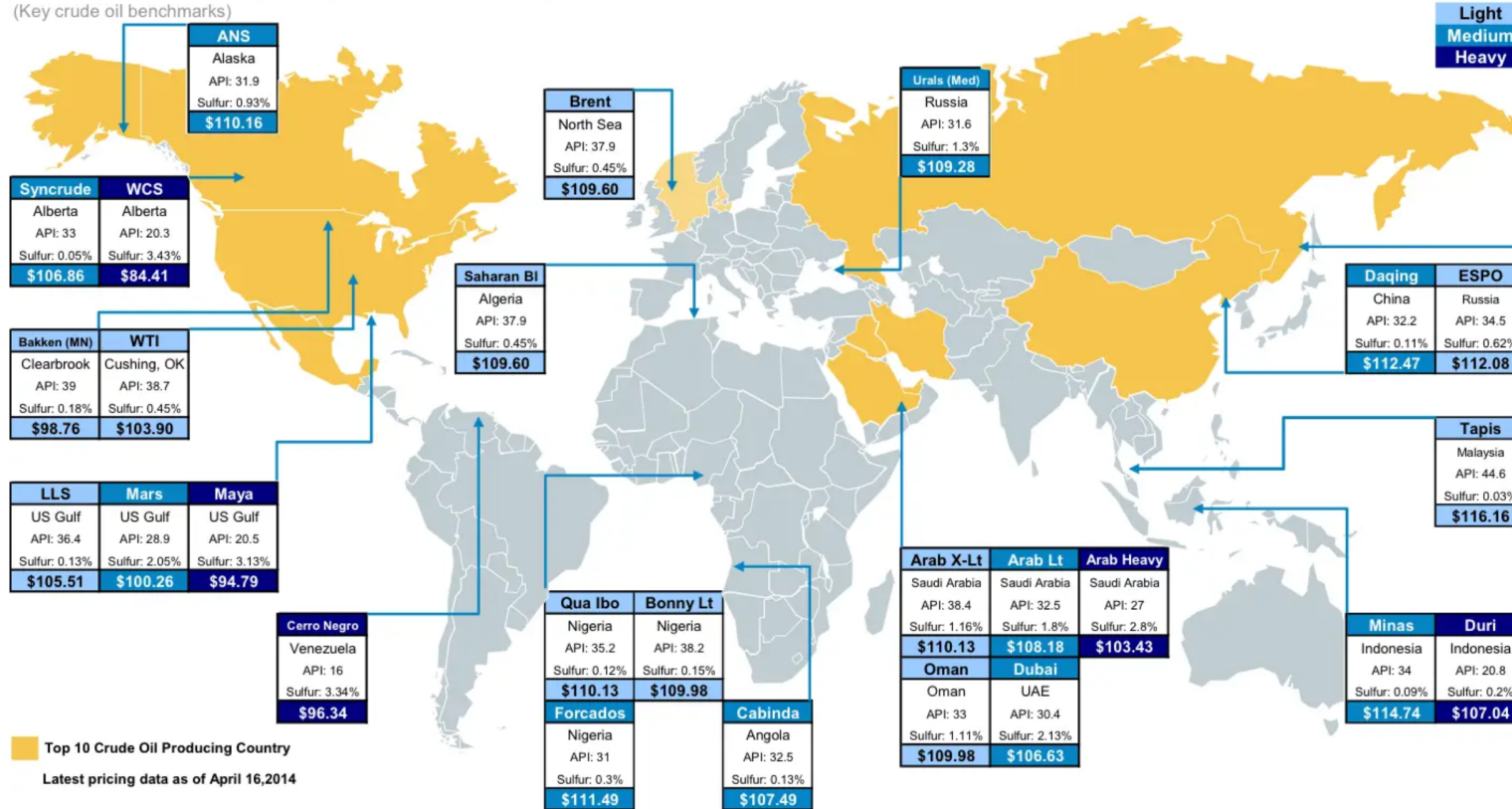
**No Perfect Benchmark** – Regional dynamics (supply/demand) and various other issues impact each benchmark

### Primary Pricing Factors:

**Crude Quality** – API Gravity (light/medium/heavy), sulfur, refined product yield, cost to process

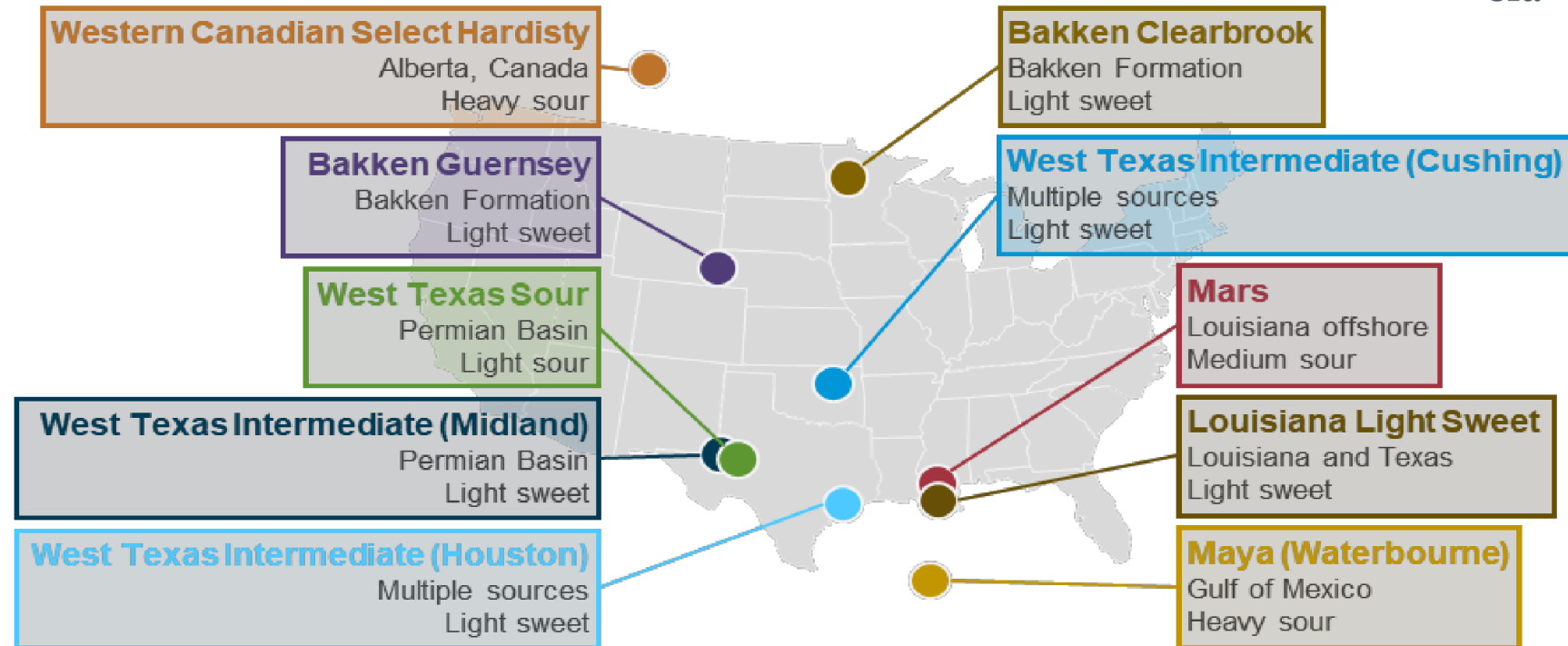
**Geography and Transportation** – cost of transporting the marginal barrel to its end-market

(Key crude oil benchmarks)



# North American oil – main pricing locations

## Pricing locations of selected North American crude oils

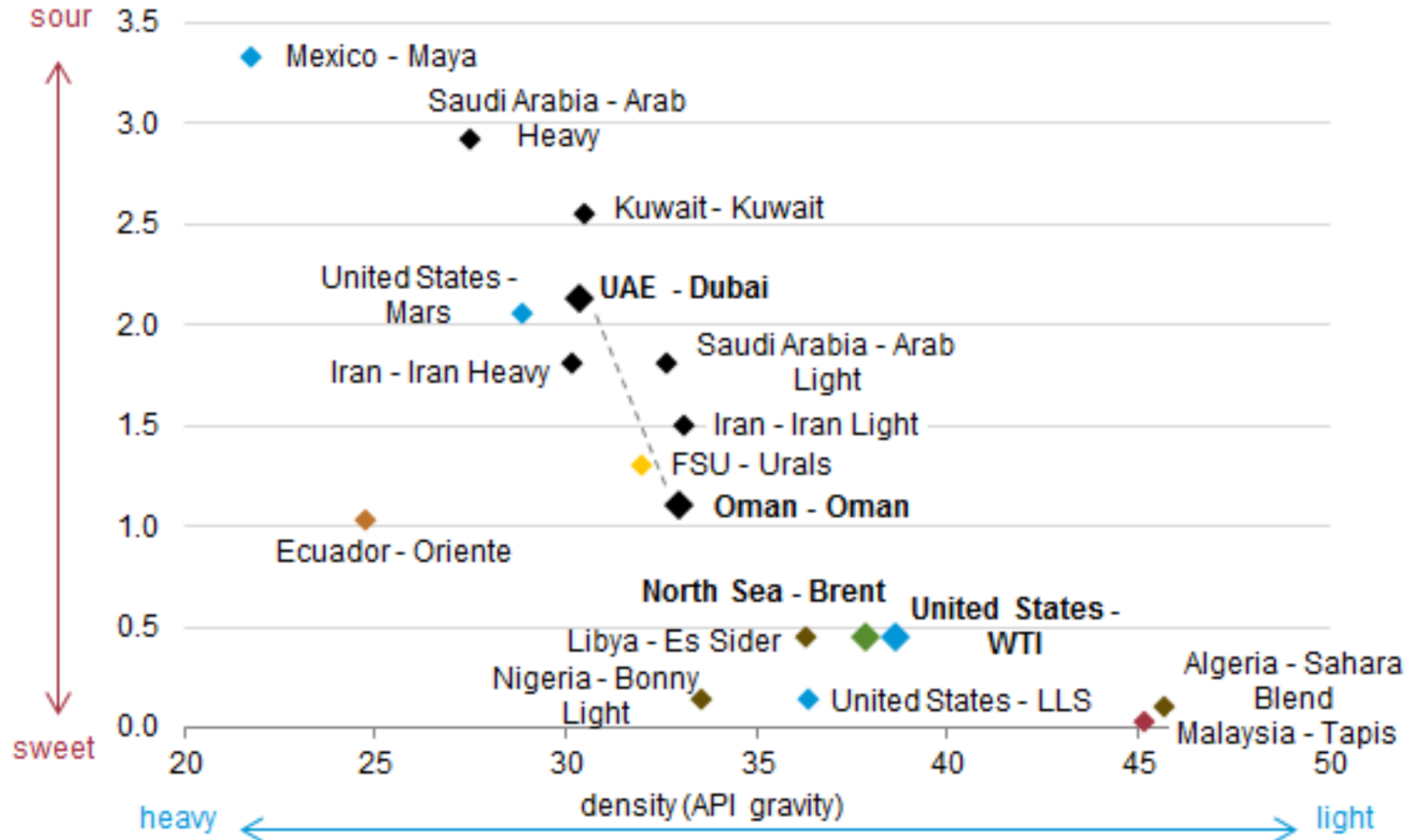


Source: U.S. Energy Information Administration



# Crude Quality and Location

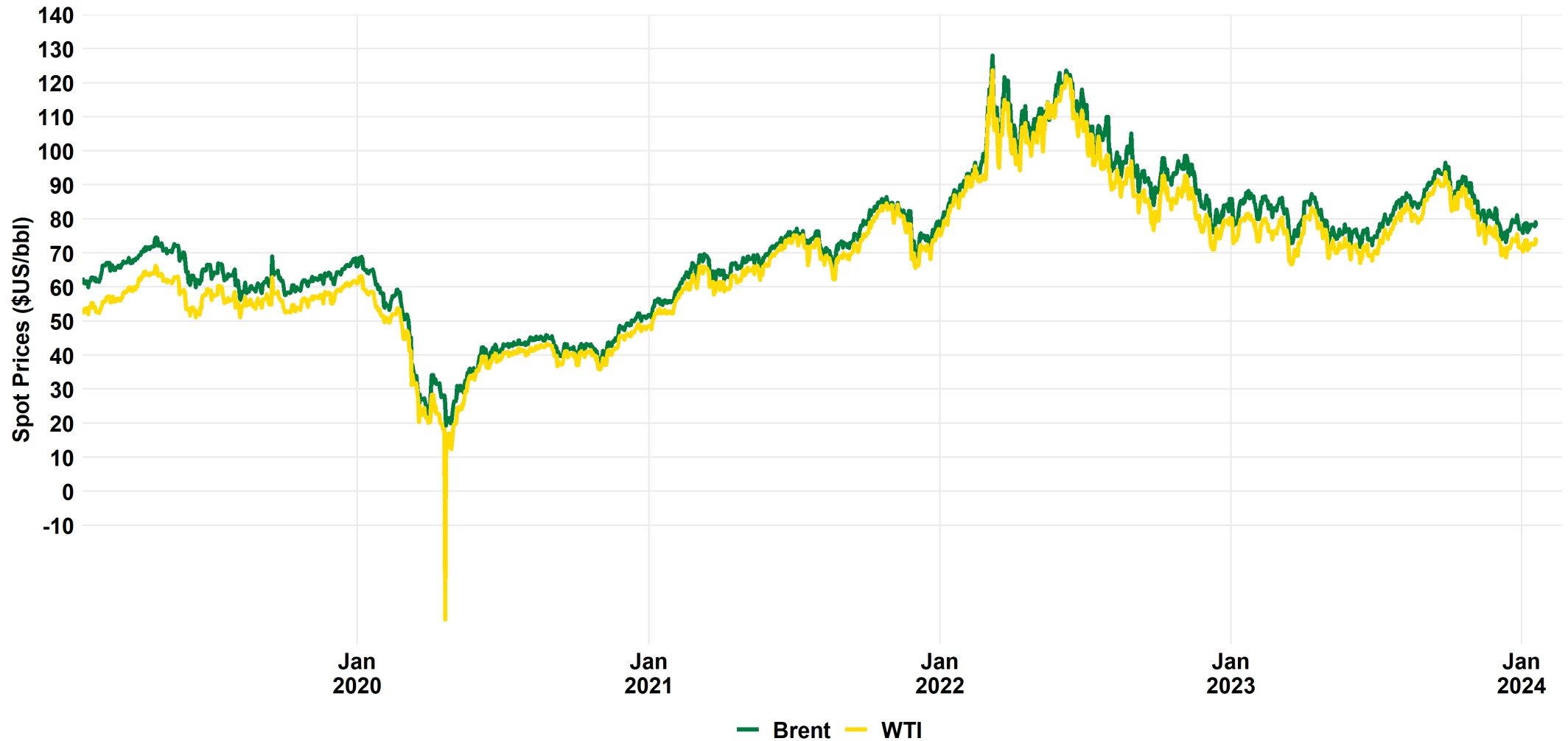
Density and sulfur content of selected crude oils  
sulfur content (percentage)



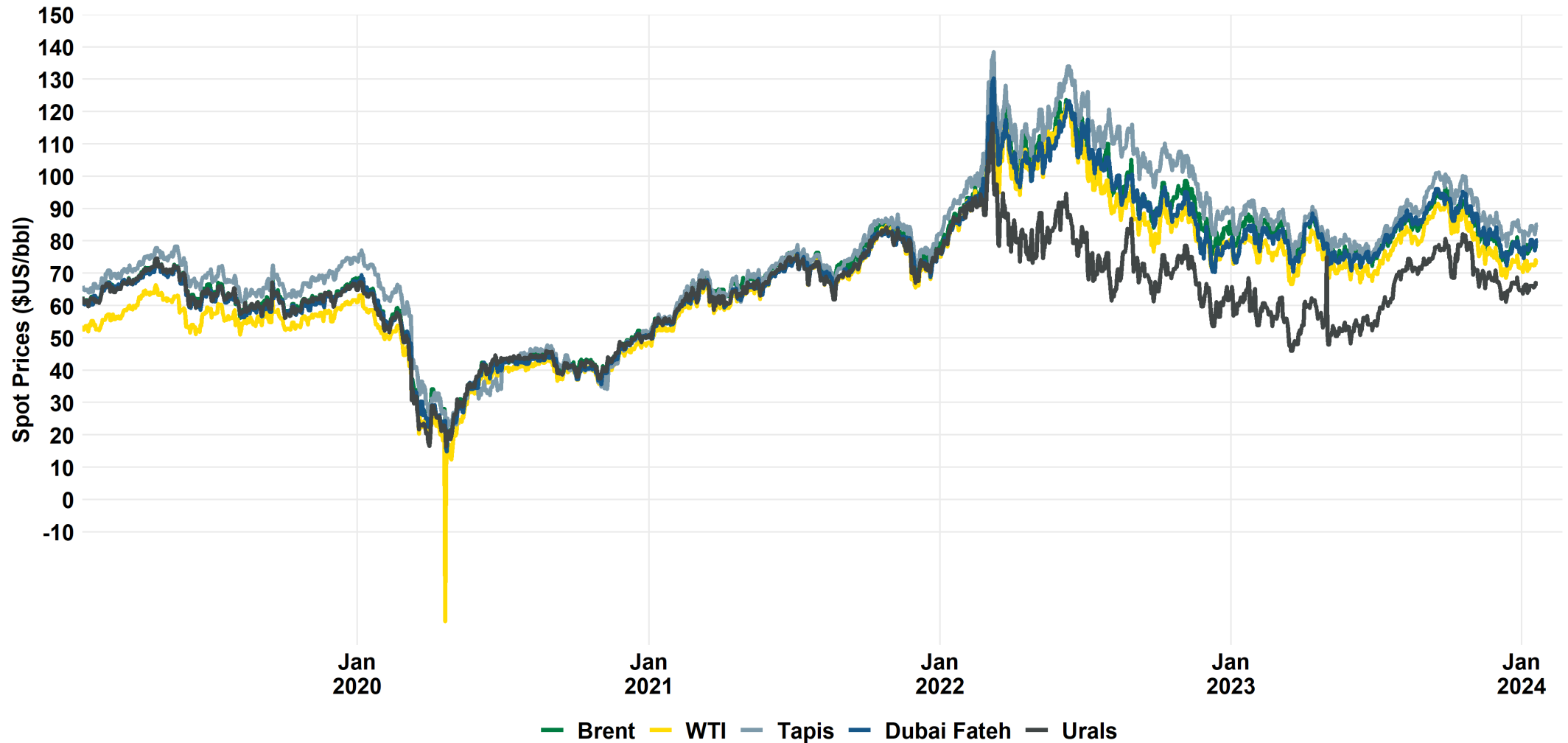
# Crude prices vary by location

- Export (long) markets tend to have lower crude prices than import (short) markets
- Location-based price relationships determined by transportation costs, infrastructure availability, and trade flows

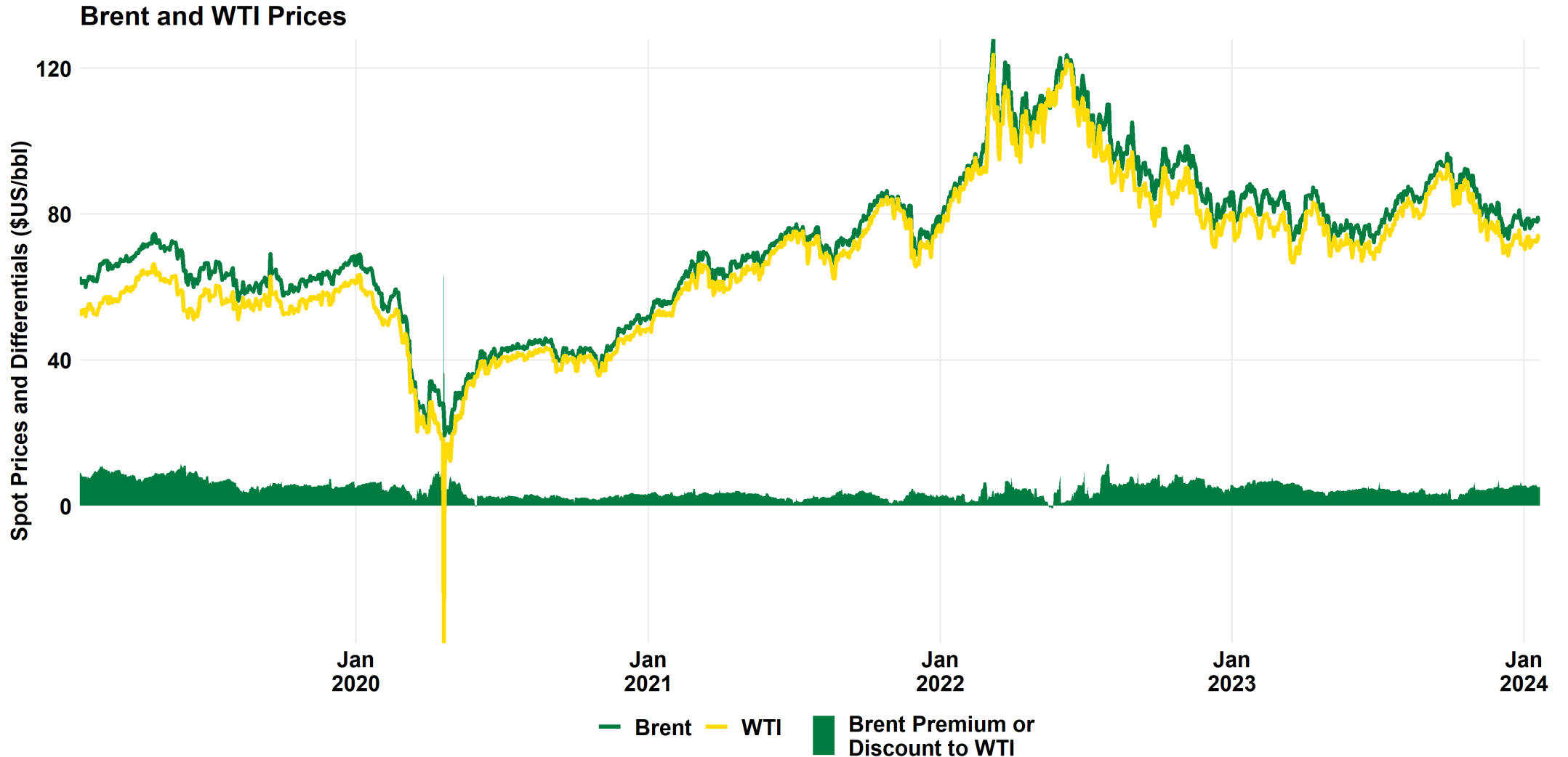
# Location differences



# Global Crude

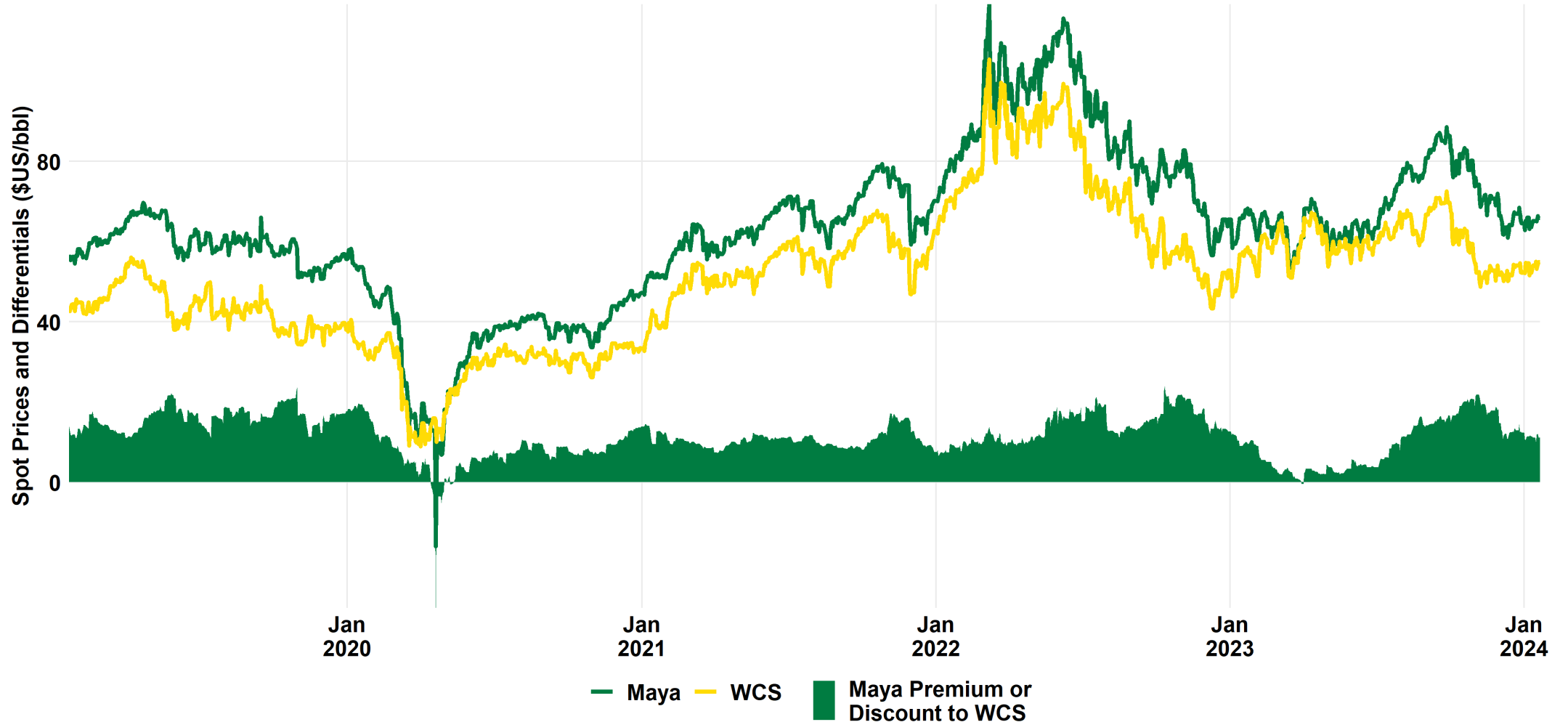


# Location differences



# Location differences

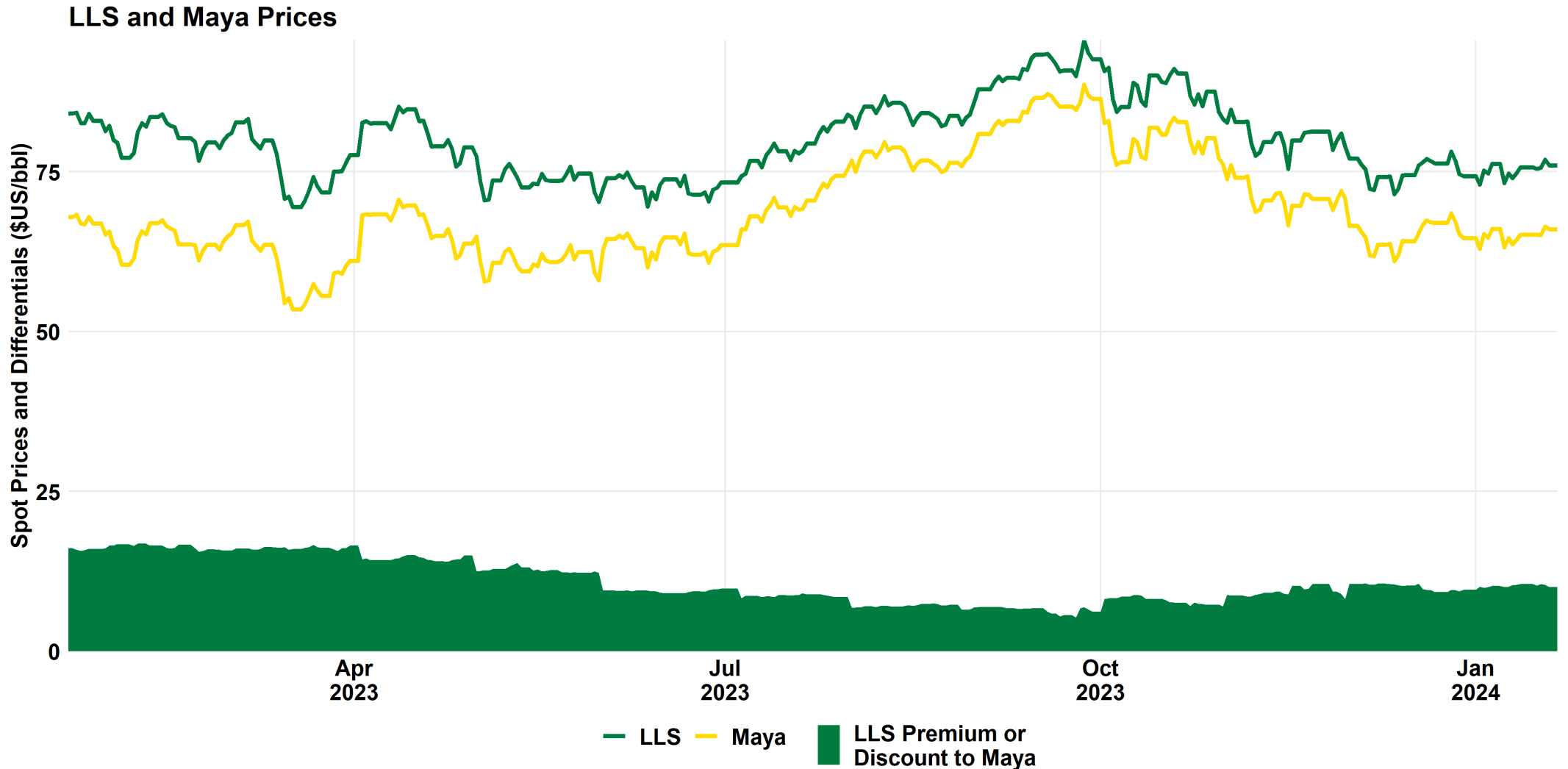
## Maya and WCS Prices



# Heavy pricing higher than light? Check location

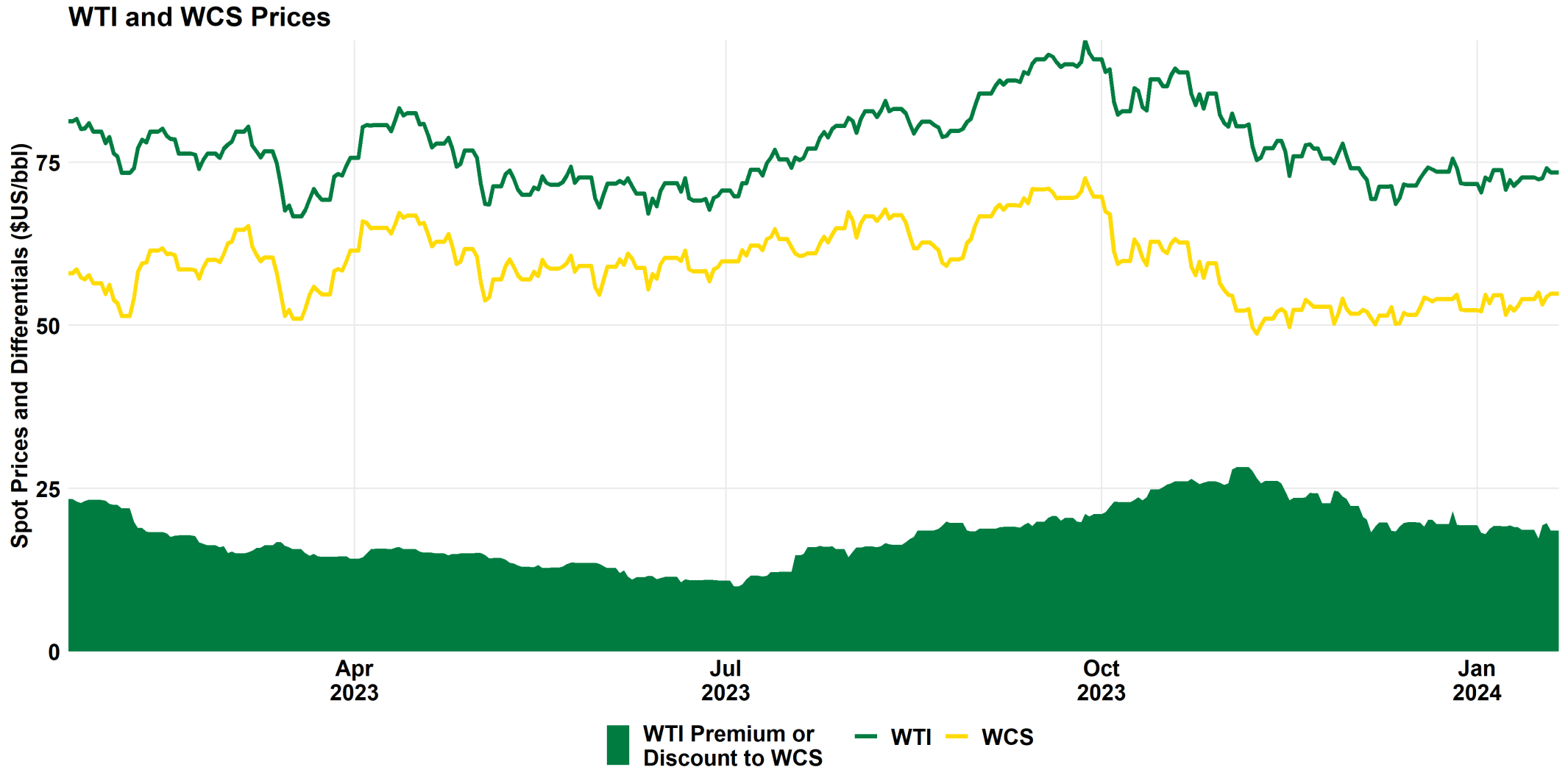


# Quality Differences



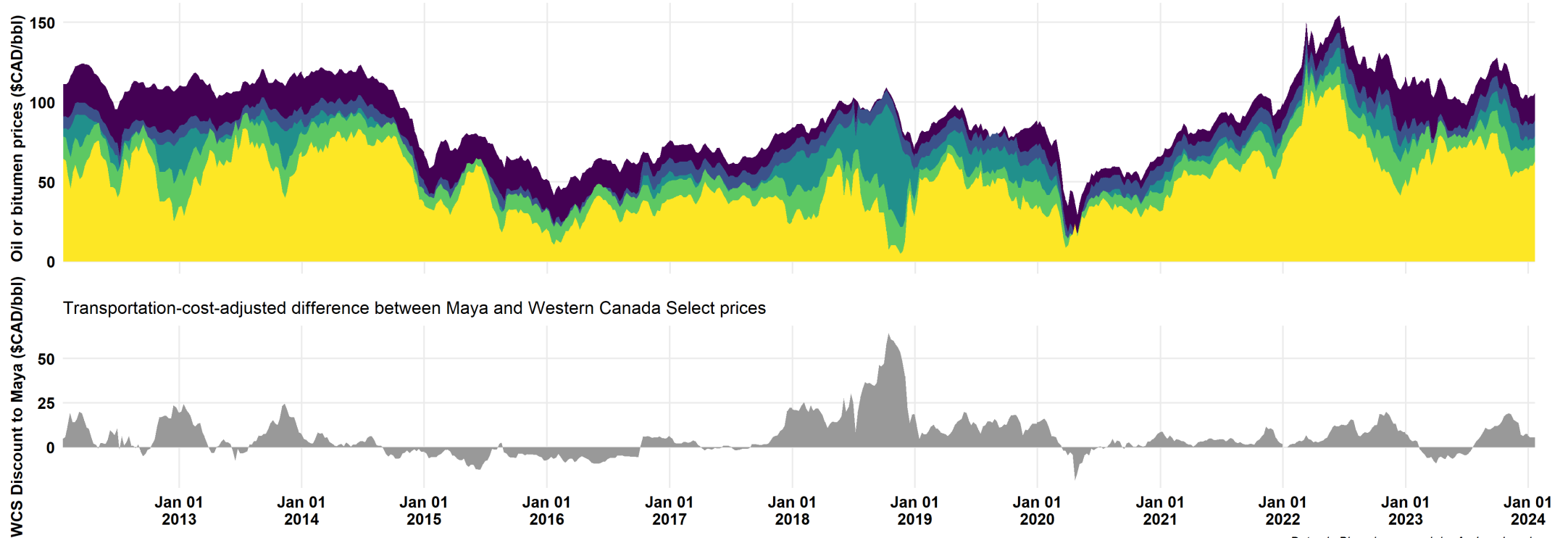


# Quality and Location Differences



# Bitumen – even larger differentials

Decomposed Brent Crude to Implied Athabasca Bitumen Value Differential

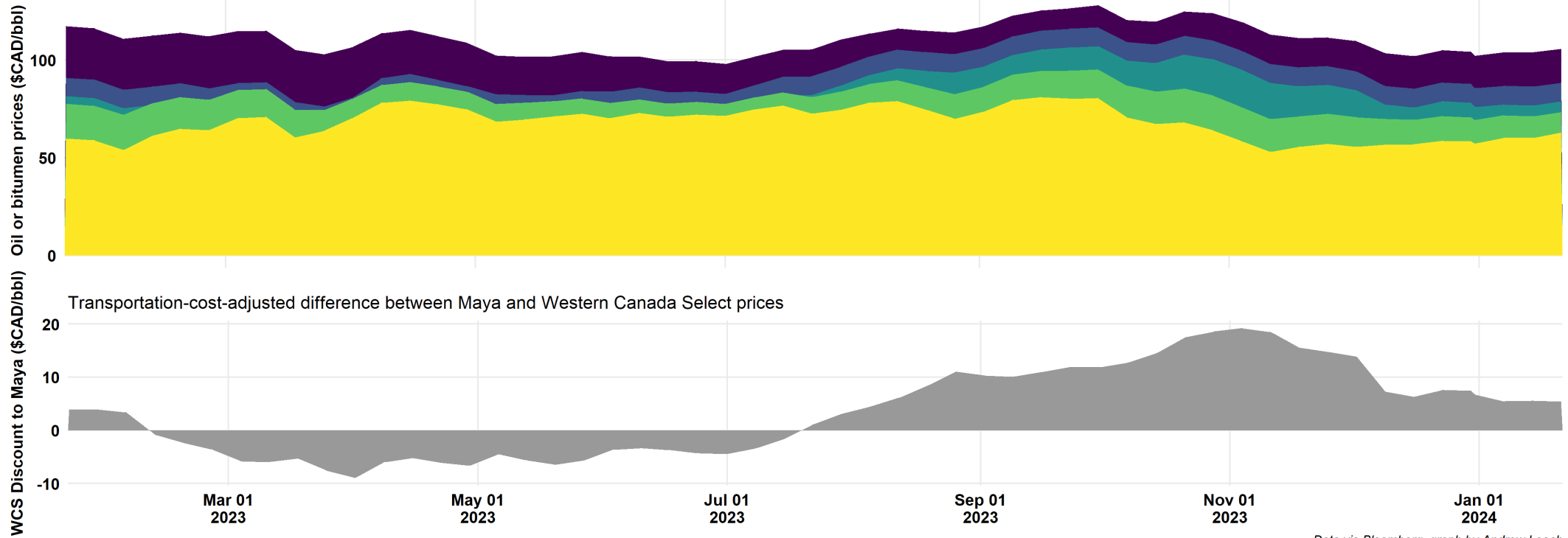


Data via Bloomberg, graph by Andrew Leach

- Global light (Brent) vs heavy sour (Maya) crude differential
- Transportation cost, Alberta to U.S. Gulf Coast
- Implied export transportation constraint cost
- Alberta local transportation and diluents cost
- Bitumen value at site

# Bitumen – even larger differentials

Decomposed Brent Crude to Implied Athabasca Bitumen Value Differential



Data via Bloomberg, graph by Andrew Leach

- Global light (Brent) vs heavy sour (Maya) crude differential
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- Bitumen value at site
- Implied export transportation constraint cost

# Time dimension of oil prices: the futures contract

- Futures contracts are promises to deliver a commodity at a future date
- The contract has value based on the expected future value of the commodity in question
- Futures contracts are either cash settled or physically delivered.
- Futures contracts that are physically delivered require the holder to either produce the commodity (seller) or take delivery (buyer).
- Futures contracts that are cash settled are not deliverable and a simple debit or credit is issued when the contract expires based - on the value of the underlying commodity or commodities.

# Time dimension of oil prices: the futures contract

## WTI Futures Contract:

- Contract Unit: 1,000 barrels
- Price Quotation: U.S. Dollars and Cents per Barrel
- Settlement: Deliverable
- Delivery between the first and last calendar day of the delivery month
- Delivery shall be made free-on-board ("F.O.B.") at any pipeline or storage facility in Cushing, Oklahoma with pipeline access to Enterprise or Enbridge Cushing storage.
- At buyer's option, delivery may be made by inter-facility transfer ("pumpover"), in-line (or in-system) transfer; or simple transfer of title to the buyer in tank farm.

# Time dimension of oil prices: the futures contract

## WTI Futures Contract Specifications:

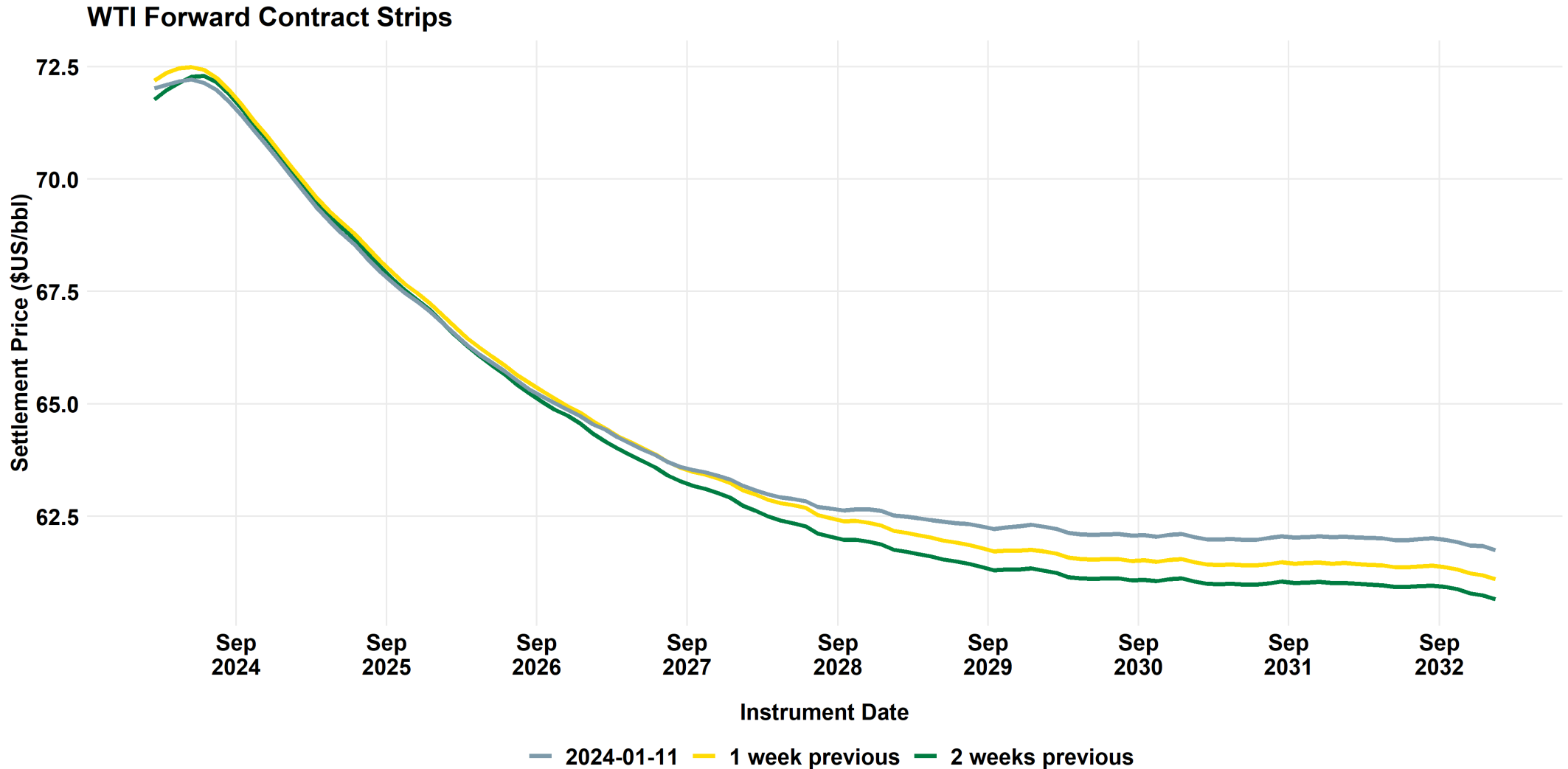
- Gravity: Not less than 37 degrees American Petroleum Institute (“API”), nor more than 42 degrees API
- Sulfur: 0.42% or less by weight
- Viscosity: Maximum 60 Saybolt Universal Seconds at 100 degrees Fahrenheit
- Reid vapor pressure: Less than 9.5 pounds per square inch at 100 degrees Fahrenheit
- Basic Sediment, water and other impurities
- Pour Point: Not to exceed 50 degrees Fahrenheit

# Time dimension of oil prices: the futures contract

WTI Futures Contract Grades in lieu:

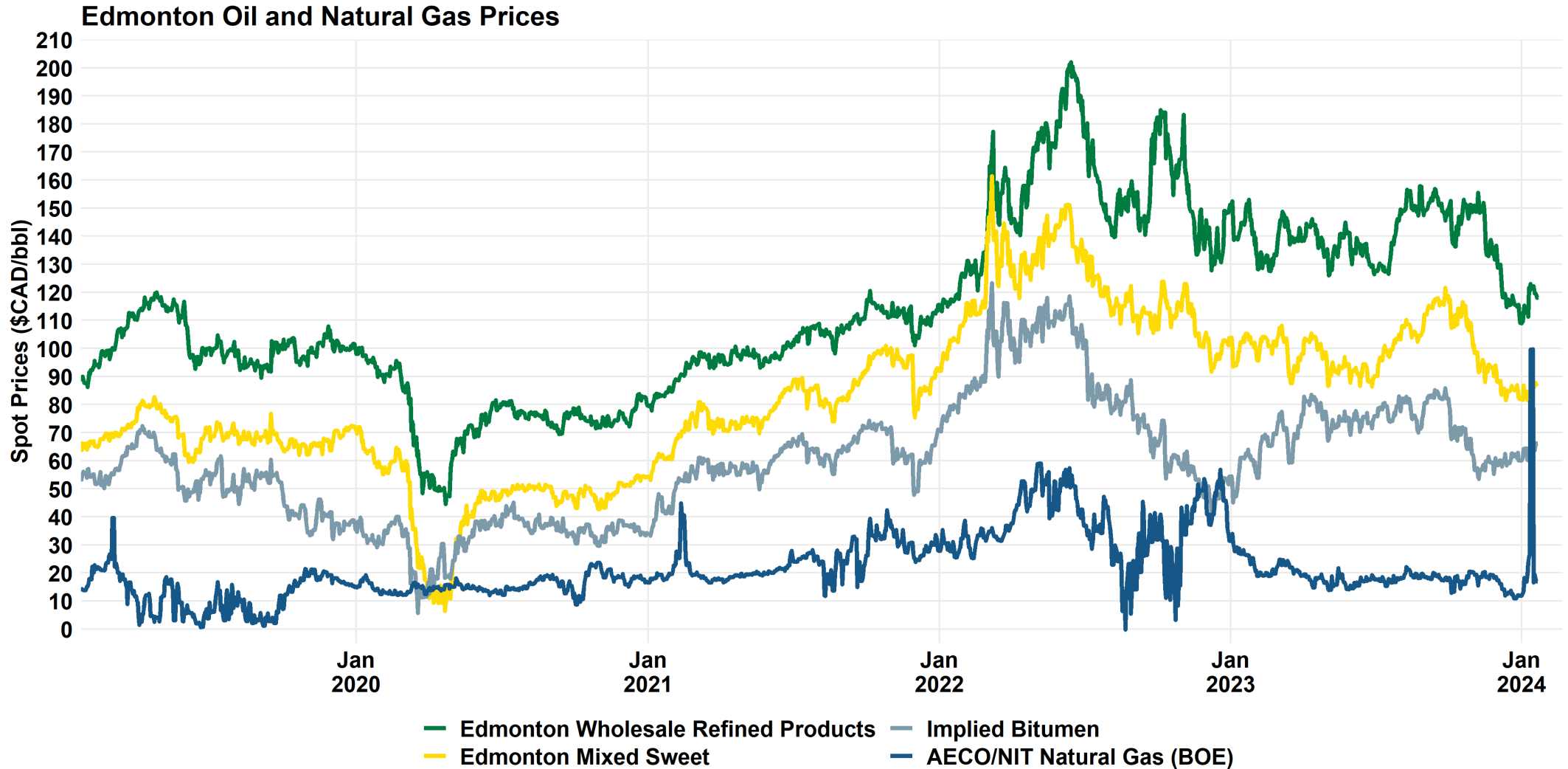
- West Texas Intermediate, Low Sweet Mix (Scurry Snyder), New Mexican Sweet, North Texas Sweet, Oklahoma Sweet, South Texas Sweet (deliverable at par)
- U.K.: Brent Blend (seller paid 30 cent per barrel discount)
- Nigeria: Bonny Light (seller paid 15 cent per barrel premium)
- Nigeria: Qua Iboe (seller paid 15 cent per barrel premium)
- Norway: Oseberg Blend (seller paid 55 cent per barrel discount)
- Colombia: Cusiana (seller paid 15 cent per barrel premium)

# Time Dimension of Oil Prices





# We trade energy commodities, not energy



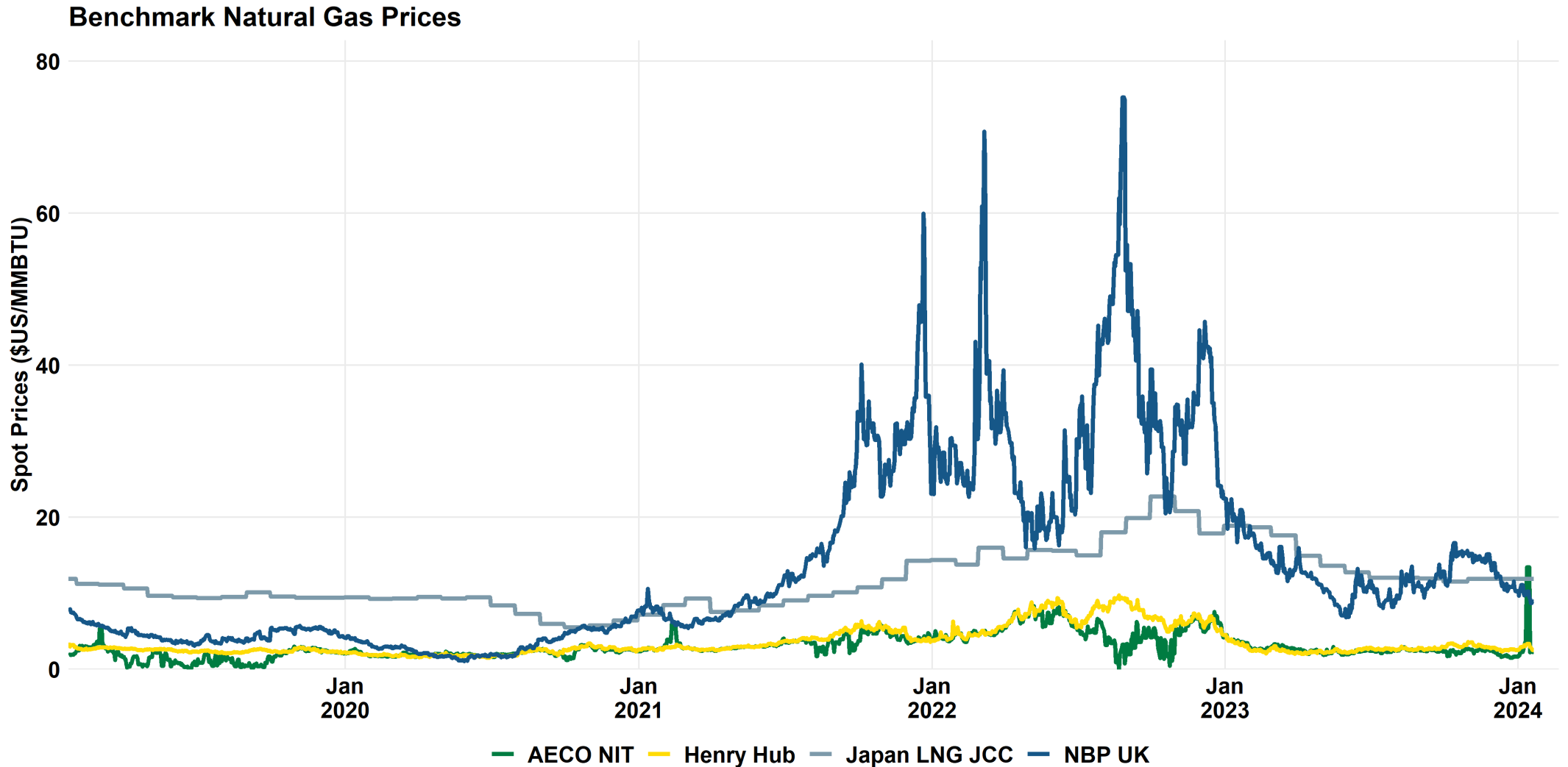
# What is natural gas?

- Natural gas is a naturally occurring hydrocarbon consisting primarily of methane, but it may also contain small amounts of ethane, propane, butane and pentanes. (capp.ca)
- Produced natural gas is not perfectly homogeneous
- Pipeline quality gas is nearly homogeneous, and trades based on heating value, not volume which facilitates transactions. See [here](#)
- Contracts may be priced in \$/MMBtu (US) or \$/GJ (Cdn)

# Produced gas

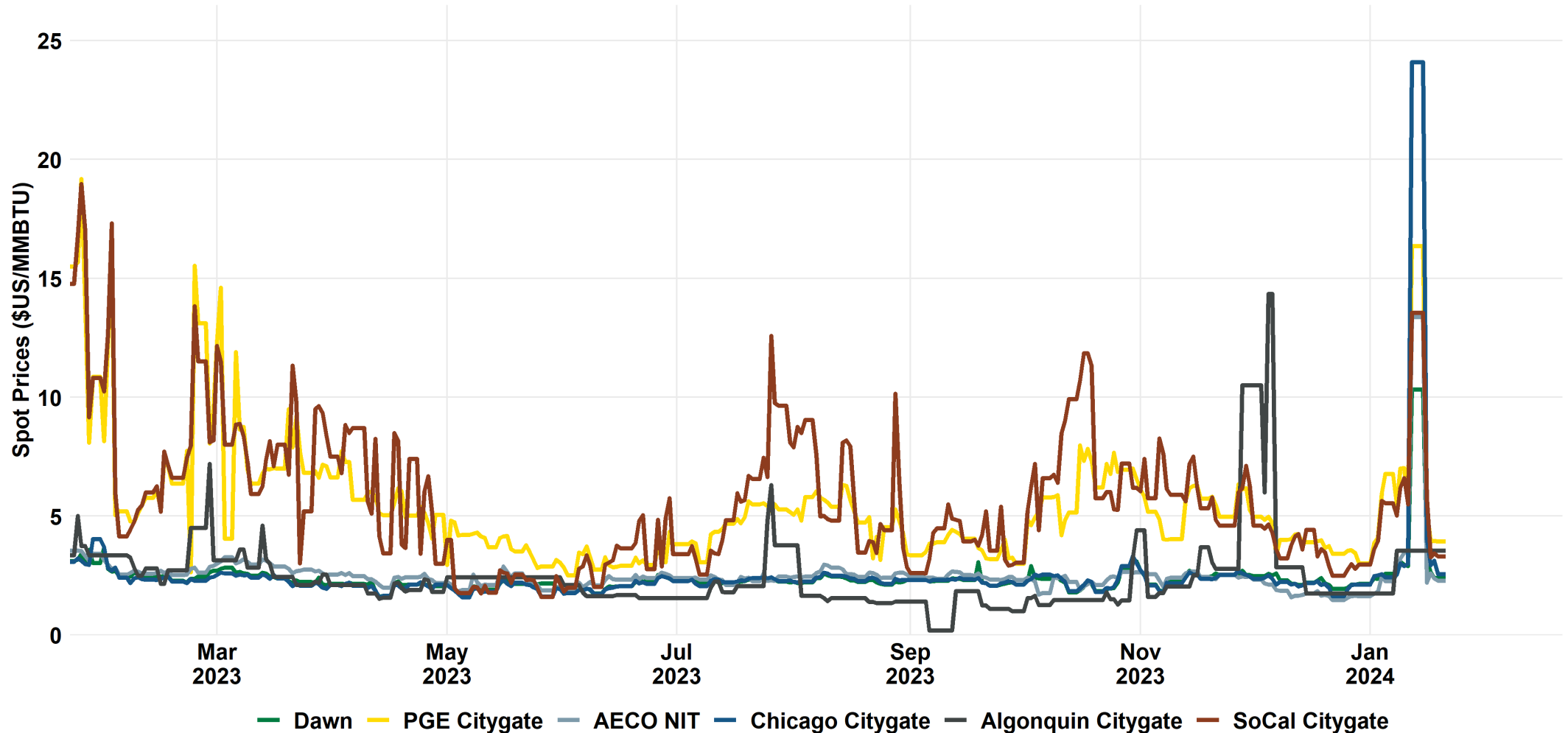
- At the well-head, gas will have different values by volume
- Hot gas, or gas with high heating values will sell for more per unit volume
- Liquids-rich gas, or gas with high concentrations of propanes, butanes, pentanes, etc will sell for higher prices
- Sour gas, or gas with measurable amounts of hydrogen sulfide is more difficult to handle and process, and therefore less valuable per unit volume or per unit heating value
- Gas processing plants process produced gas into pipeline gas which is mostly methane with some concentrations of liquids remaining

# Gas prices vary by region



# Gas prices vary by region

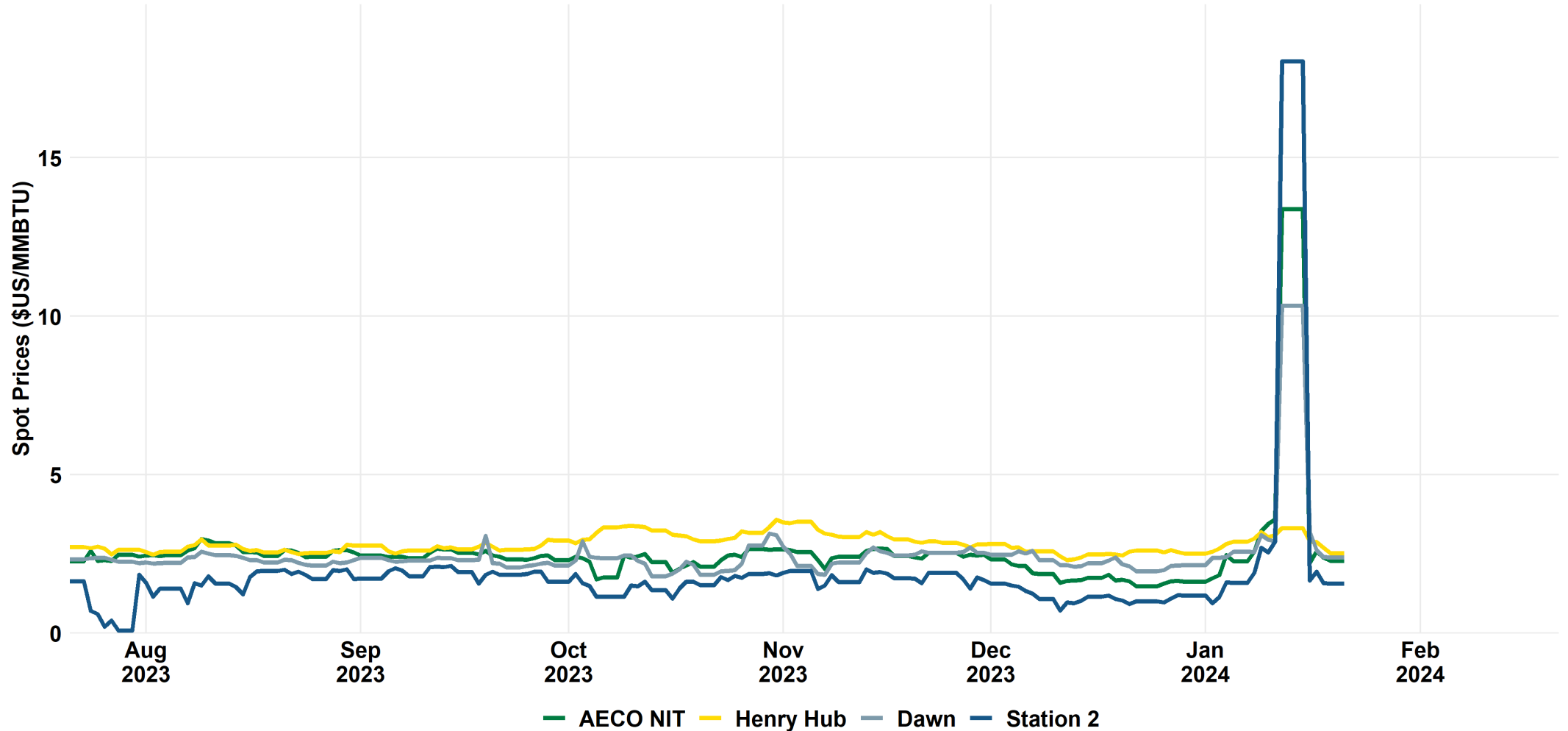
## Natural Gas Daily Spot Prices



Data via Bloomberg

# Gas prices vary by region

## Benchmark Natural Gas Prices



# Time Dimension of Gas Prices

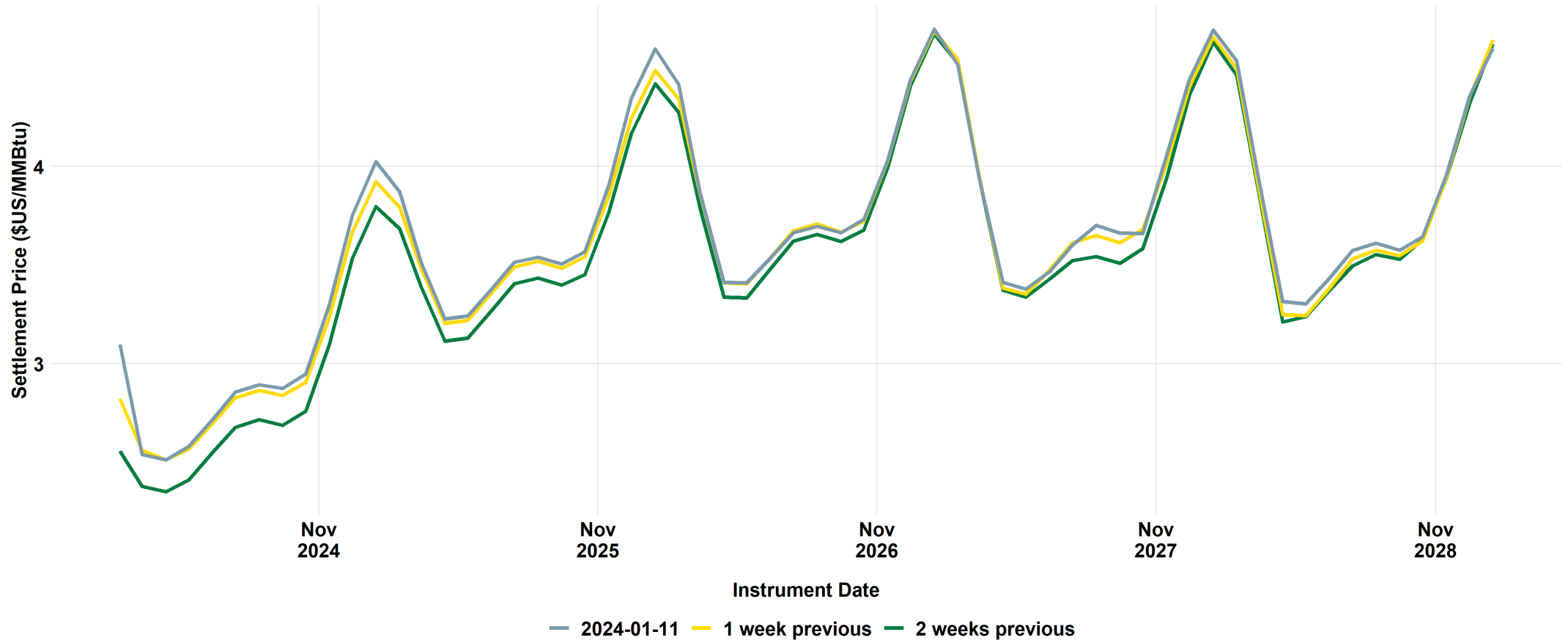
US (Henry Hub)

Alberta(AECO/NIT)

BC (Station 2)

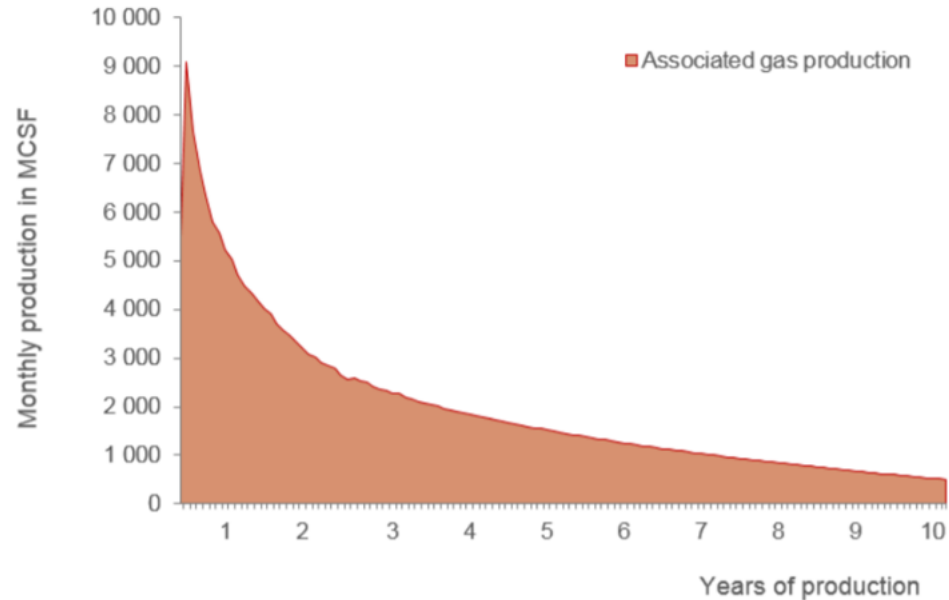
Ontario (Dawn)

Henry Hub Forwards Strips



# Natural gas liquids – the intervening commodity

Figure 17: Average production profile of a Bakken well based on historical data reported by operators to NDIC until 2014. Profile used for the economic modeling.

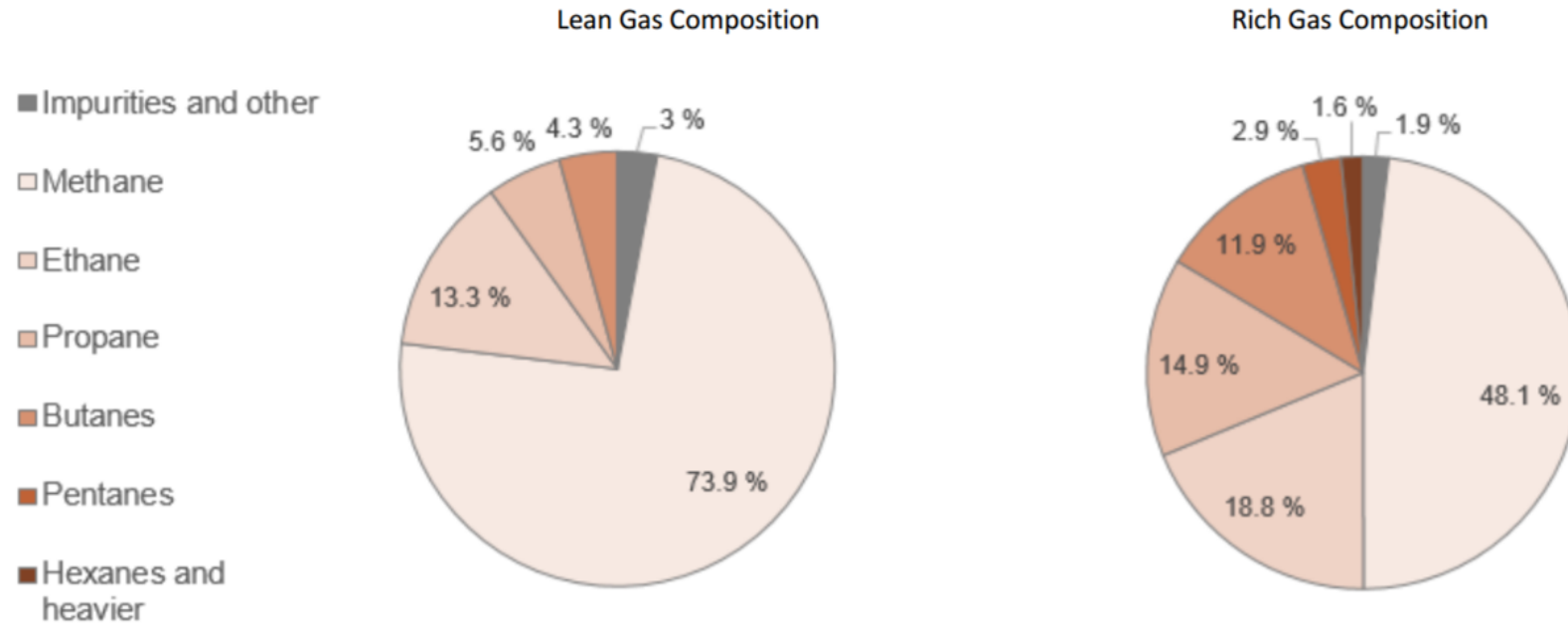


## 4.1.3 Associated Gas Production, gross volumes<sup>51</sup>

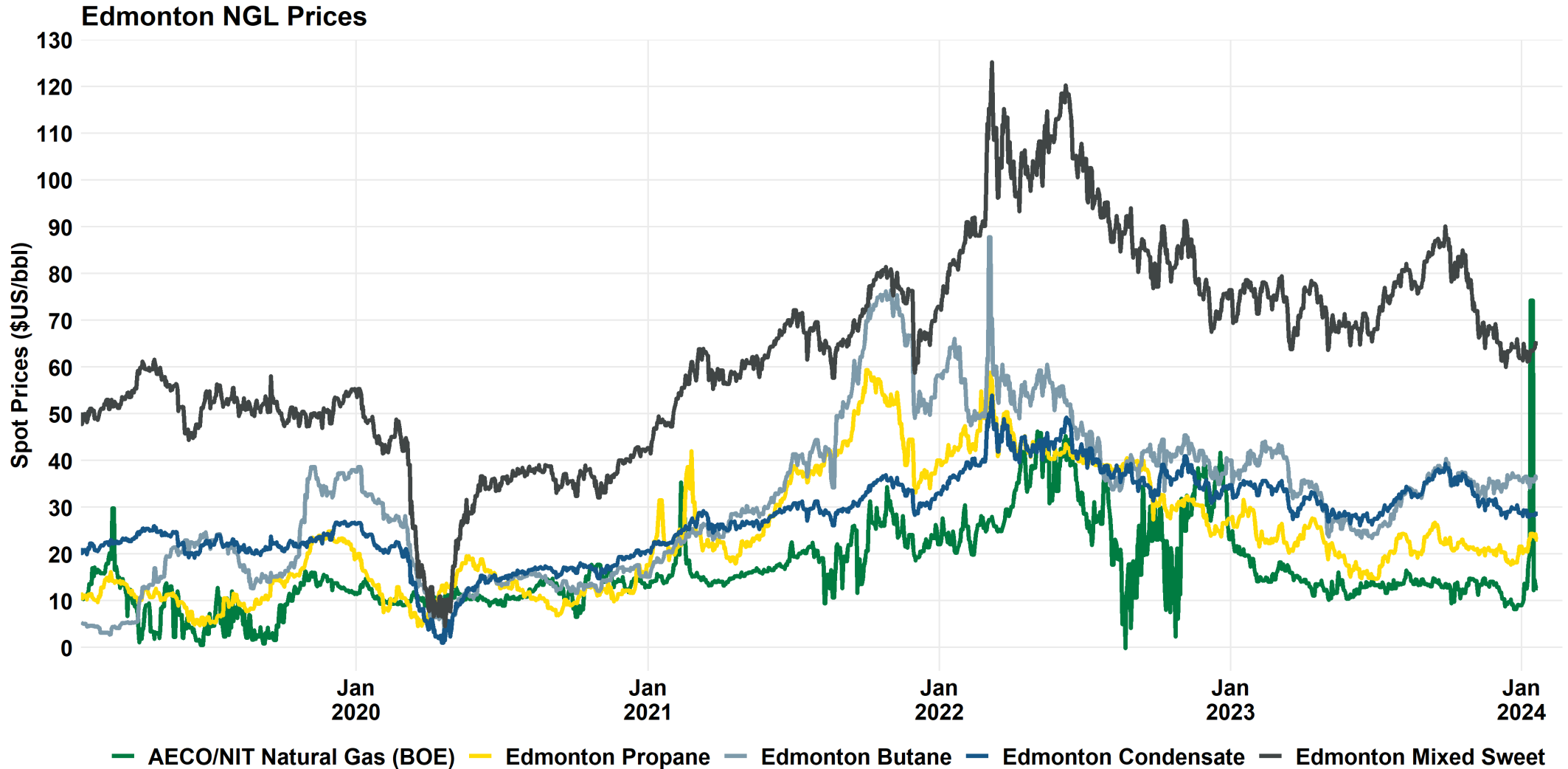


# Natural gas liquids – the intervening commodity

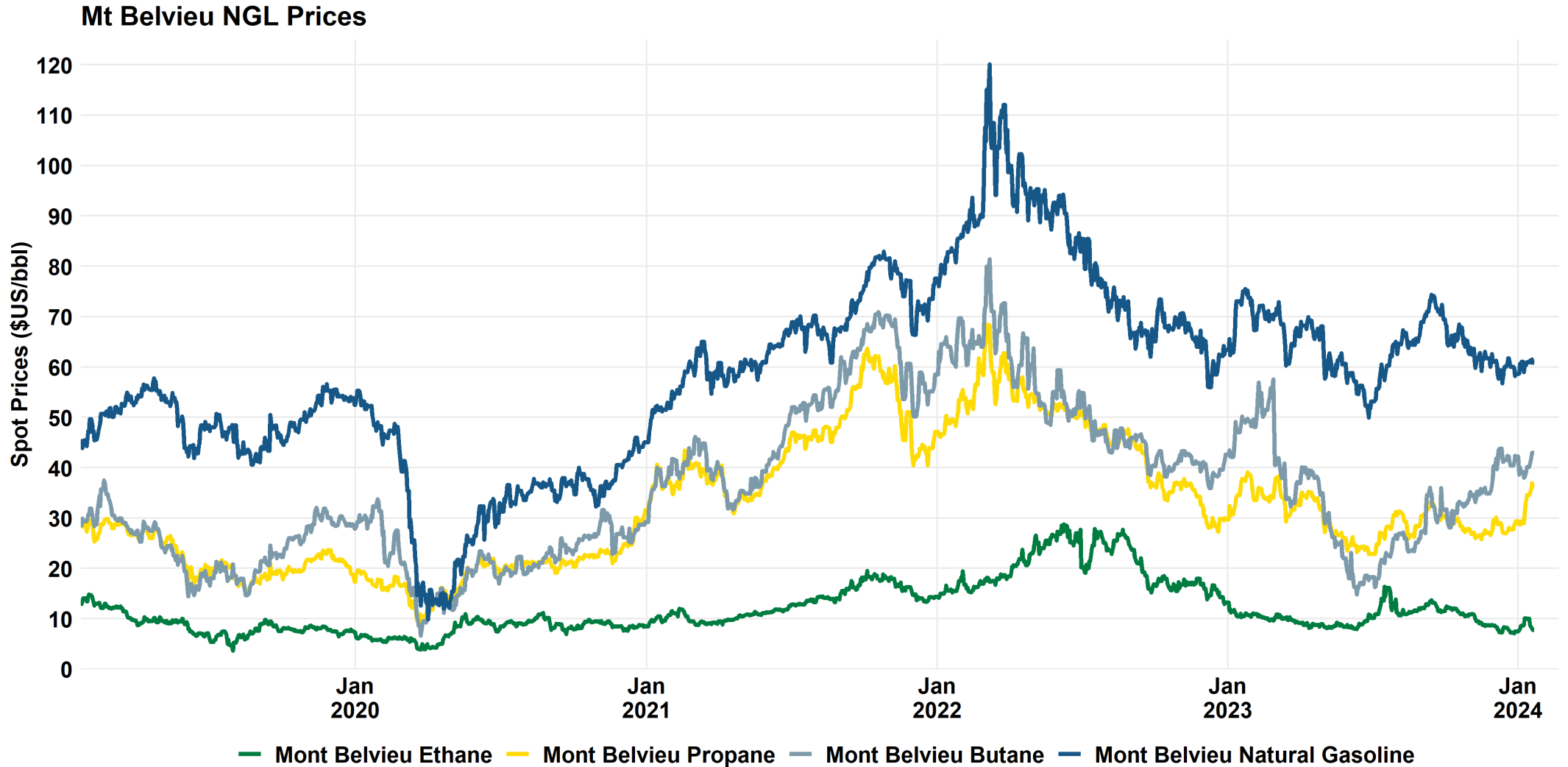
Figure 14: Range of gas compositions used for the model



# Natural gas liquids – the intervening commodity

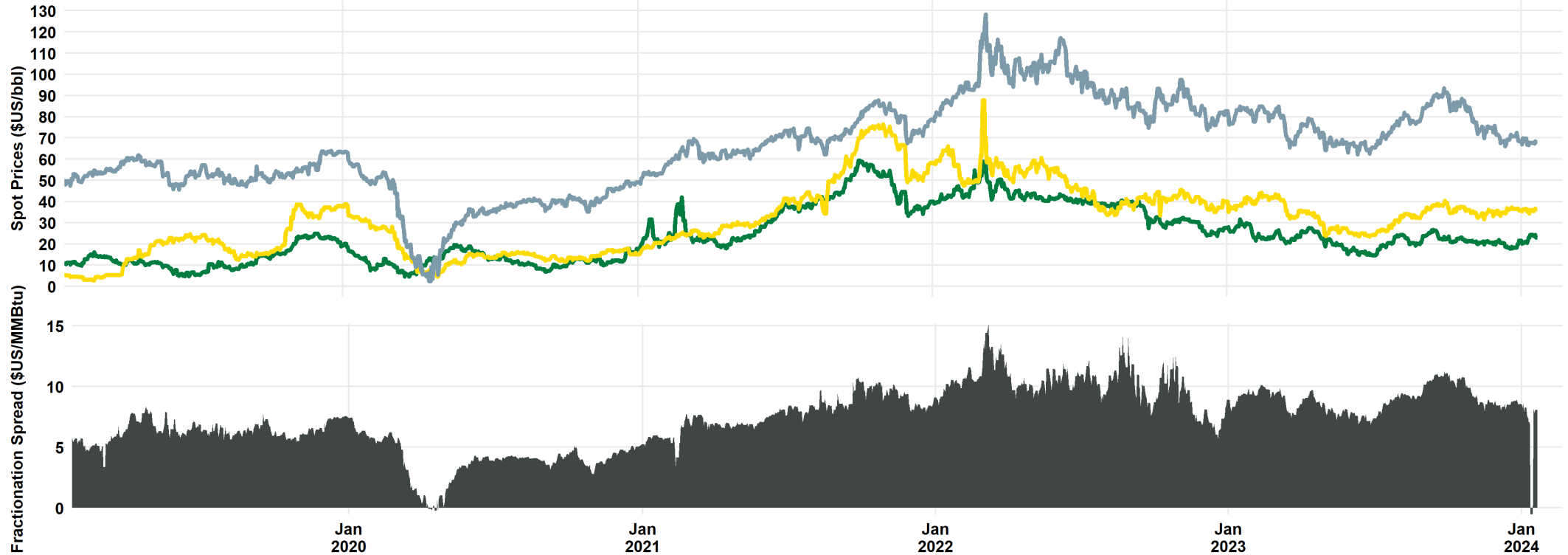


# Natural gas liquids – the intervening commodity



# Natural gas liquids – the intervening commodity

NGL Prices and Implied Fractionation Spread



Assumed NGL fractions are 26% ethane, 13% propane, 6% butane and 55% condensate. Ethane value approximated at 66% of Edmonton propane. Spread is relative to AECO/NIT gas.

— Edmonton Propane — Edmonton Butane — Edmonton Condensate  
■ Approximate Fractionation Spread

Source: Data via Bloomberg, graph by Andrew Leach

# Key concept review

- Contract components
- Commodity
- Location
- Quality
- Time
- Oil vs. gas energy vs quantity
- NGLs and the frac spread