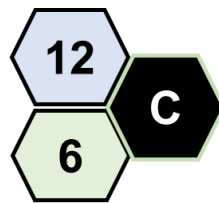




RE-THINKING BITUMEN RESOURCES

ASPHALT BINDER MARKET ANALYSIS 2022



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Asphalt Binder Challenges

“CARBOVATE research shows North American refiners are extracting the “good stuff” as fuel and producing asphalt binders with less asphaltenes.

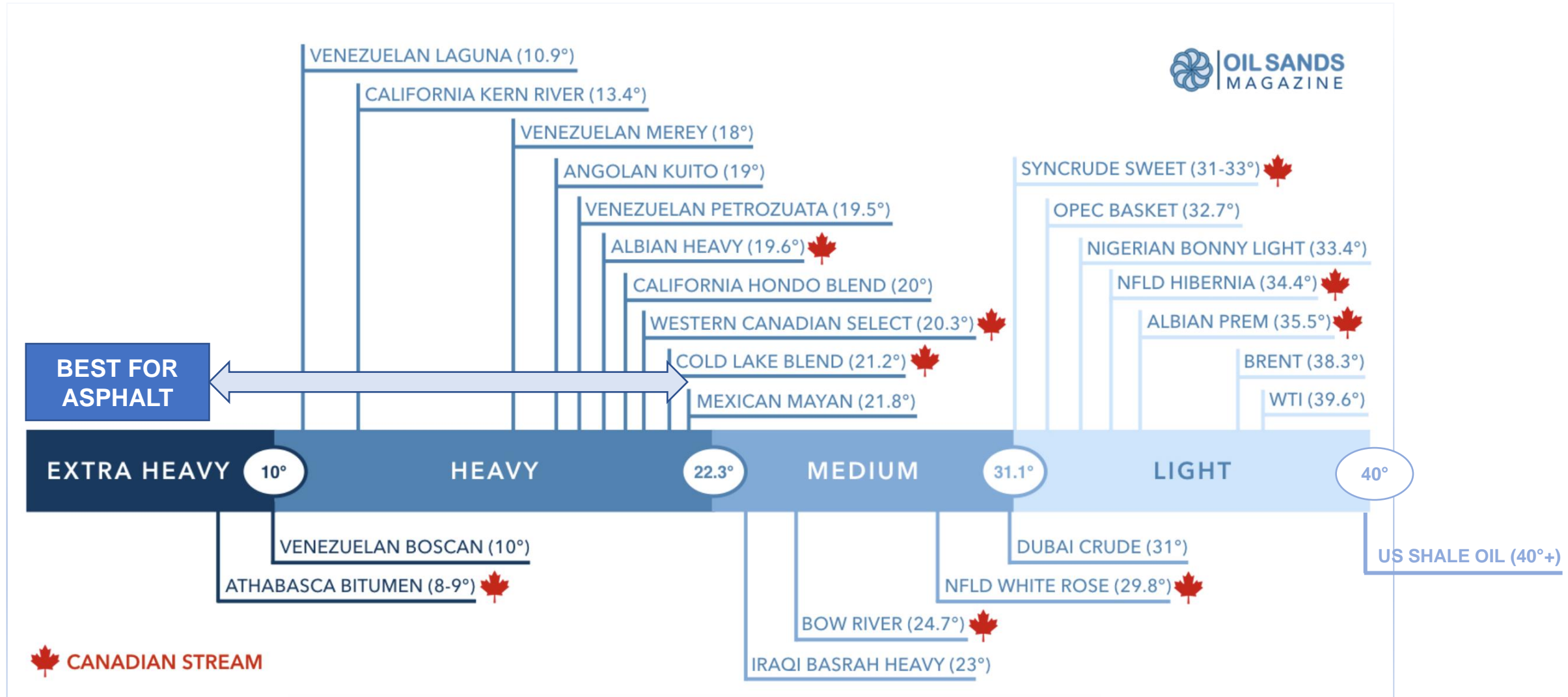
❖ “There is a perception that bitumen properties have changed and performance has declined over the years. There have certainly been changes in crude oil sources and associated rheological properties. This is likely the result of refineries using new technologies to extract more high-demand products from crude oil sources of reducing quality and increasing variability. This has led to reduced confidence in non-performance based specifications and increased use of rheological bitumen testing.” *Science Direct: International Journal of Pavement Research and Technology Jan 2018*

❖ “USA light frac oil from shale sources has reached equivalent of 1/3 of refinery capacity, *MARATHON predicts an increase of 4 million BPD by 2030 to 13 million BPD, (light frac oil has very little asphalt)* *Marathon Petroleum*

❖ Asphalt production capacity declined in the USA 22% 2009 to 2018. From 2012 Midwest refiners added cokers to process heavy crudes and bitumen to increase supply of distillates & diesel fuel, converting part of the asphalt to higher netback fuels, reducing asphalt quality. *CARBOVATE Research*

❖ “A coker refinery upgrades most of the fuel oil to lighter products and thus makes the low-value fuel oil effectively “disappear.” Coking breaks down the heaviest fractions of crude oil into lighter, higher-value products and elemental carbon (coke) that is sold for steel production and anode manufacturing. Hydrocarbon compounds used in cokers would otherwise only be usable as residual fuel or asphalt.” *Petroleum Science Volume 14, February 2017*

Crude Oil API



Asphalt Binder Challenges

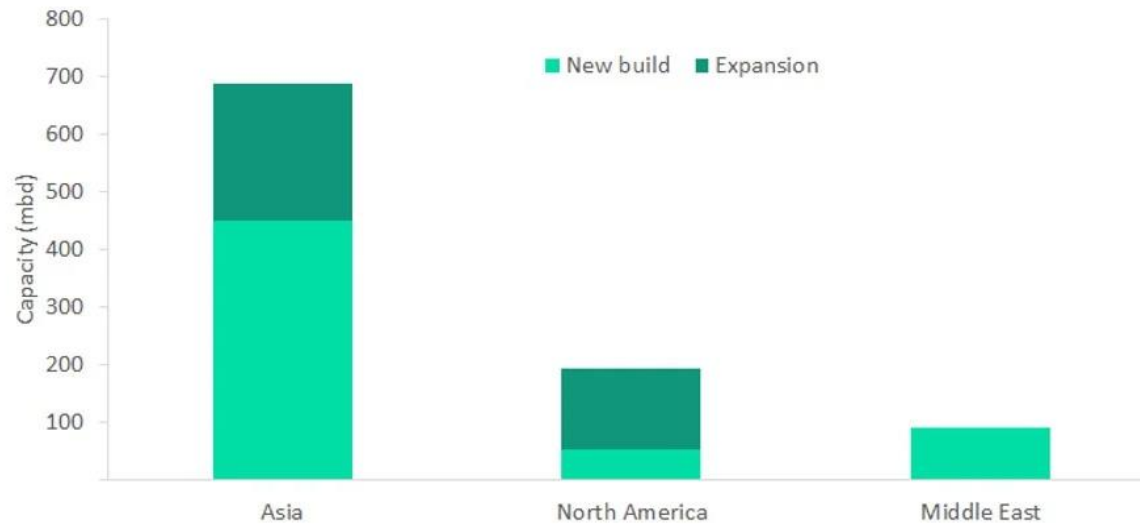
Short road life - Inconsistent quality - High production emissions - High capex associated with processing facilities

- ❖ Most production is from large refineries focused on lighter fuel products and not asphalt binders
- ❖ Increased production of US shale oil (low resid for asphalt production)
- ❖ The addition of refining cokers further reduce the quantity and quality of asphalt by product
- ❖ Oil supply variability, changing production product slate produces inconsistent asphalt binder quality leading to road degradation and cracking
- ❖ Increased use of expensive polymer additives to achieve PG grades
- ❖ Capital cost and emissions associated with traditional refining are high

Global Coking Capacity

Global coking capacity additions to cross 11.3MMbd by 2026

New Build and Expansion Refinery Coking Capacity Additions by Key Countries, 2022–2026 (mbd)



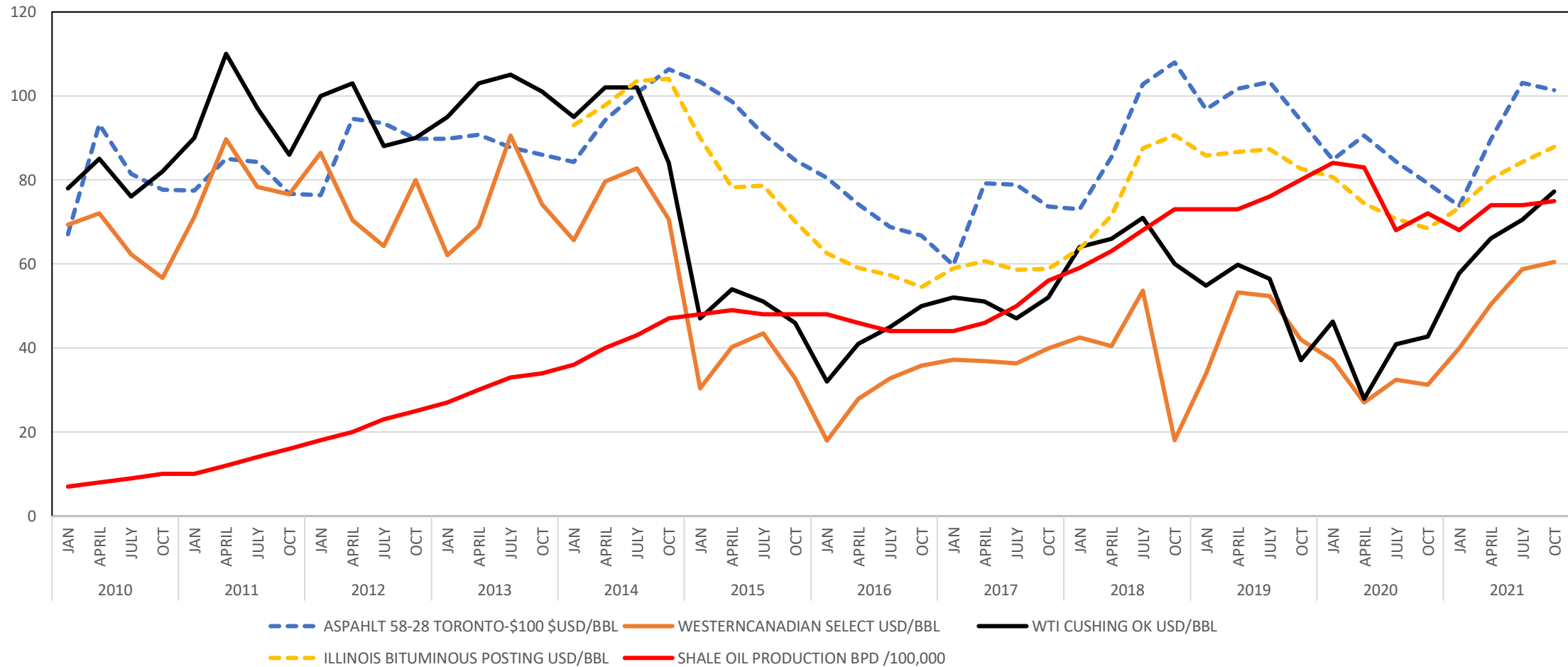
According to GlobalData, global coking capacity is expected to grow at 10.3% over the next years, with Asia set to show the highest globally.

GlobalData Energy
March 2022

mbd – thousand barrels per day

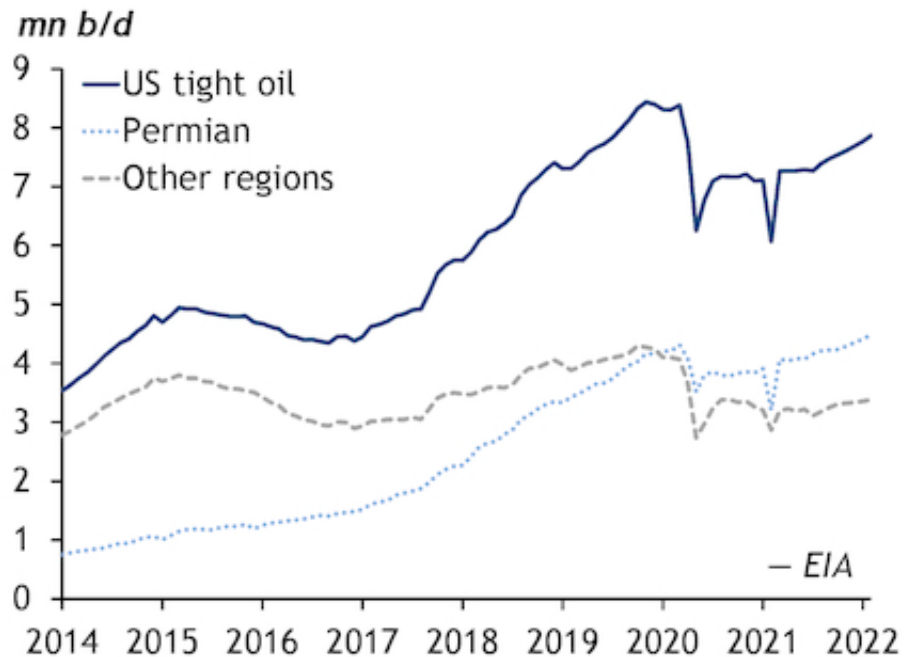
Asphalt and Oil Prices vs Shale Oil Production

ASPHALT AND OIL PRICES vs SHALE OIL PRODUCTION



US Shale Oil - Impact

US tight oil production




Shale oil characteristics vary widely

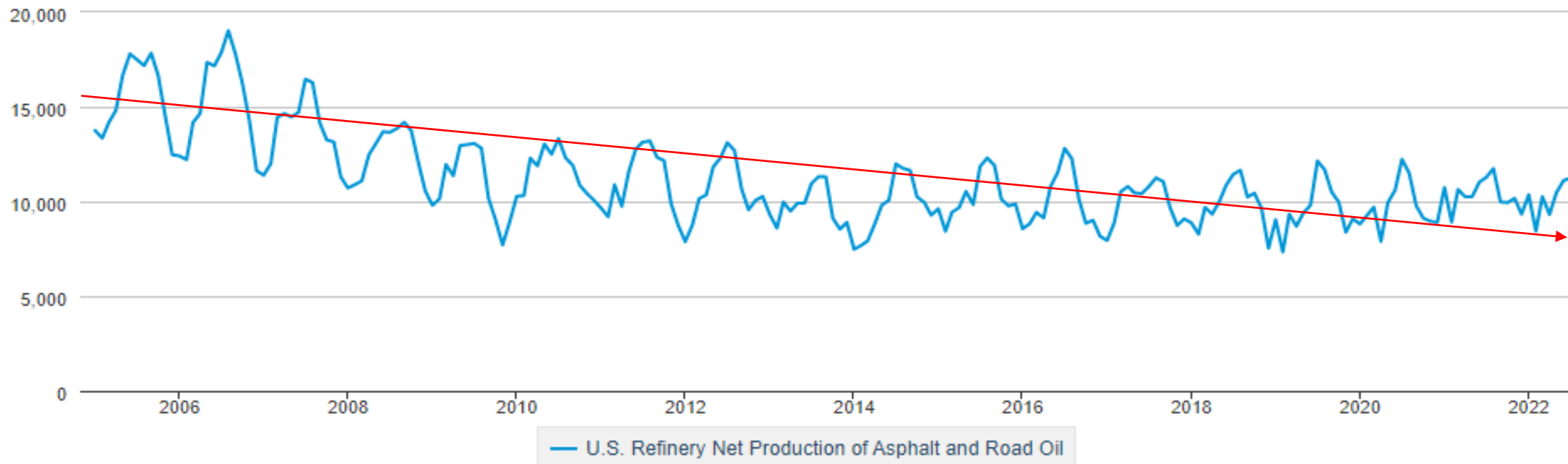
- API gravity ranges from 30°API to 55°API
- High paraffin content with wax appearance temperatures greater than 200°F (93°C)
- Sulfur content as low as <0.2%
- Occasionally high hydrogen sulfide and mercaptan content
- Total acid number as low as <0.1 TAN (mg KOH/g)
- Very low asphaltene content, <0.1%
- Filterable solids content as high as 295 lbs (134 kg) per thousand barrels
- Light crude with little residual material, <10% of total yield
- Highly variable crude quality from the same reservoir

US Asphalt Production

U.S. Refinery Net Production of Asphalt and Road Oil

 [DOWNLO](#)

Thousand Barrels



Data source: U.S. Energy Information Administration



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Ontario Roads – AG Report 2016

“Our audit objective with respect to construction projects in the transportation sector was to assess whether the Ministry of Transportation had effective policies and procedures in place. The Ministry of Transportation (Ministry) is responsible for the construction and maintenance of provincial highway and bridge infrastructure, which is currently valued at \$82 billion (Section 1.0)

- ❖ “Poor quality asphalt contributes to additional costs to Taxpayers for repairs and inconvenienced drivers” (Section 2.1.2)
- ❖ “Traffic congestion causes \$11B per year losses to public, and causes excessive GHG emissions” (Section 2.1.2)
- ❖ “MTO Budget for road rehabilitation next 10 years (2016/17 to 2025/26) is \$14B while road expansion budget is \$4B, basis is repairs to roads less than 10 years old” (Section 2.1.1)
- ❖ “15 to 20 years road life has the potential to cut this expenditure in half. Save \$1.4 million/km (4 lanes) by extending the life to 15 years” *AG Report 2016* (Section 2.1.1)

North American Regions Need Quality Asphalt

❖ Longer road life needed:

- Dropping from 15-20 years to 5 to 7 years, some failures in first year
- Potholes, vehicle damage
- Repair construction delays damage competitiveness
- Reduction in road builder warranties

❖ Shingles, roofing flux:

- Reduction in consumer warranties

❖ Cause; binder quality decline for last decade from fuel refinery sources leading to;

- Need for post purchase polymer blending to meet specifications
- Polymer production emission intensive
- Blending can lead to increasing quality control issues
- Chain of custody interrupted by intermediaries
- More pressure on management of road construction quality
- Construction risk, poor quality roads

Alberta Bitumen Asphalt Binder Advantage

❖ Long life roads, made from Alberta bitumen, already in place:

- Western Canada
- Northwestern Ontario
- NW USA

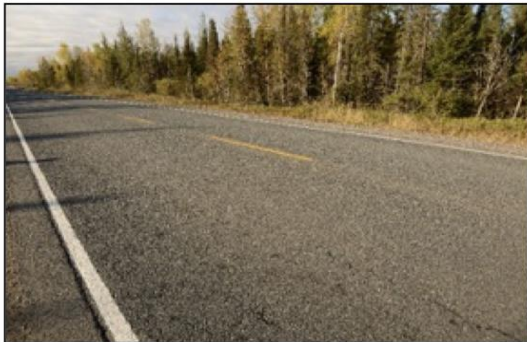
❖ The proof - test strips performance:

- Multiple binders laid end to end in test sections
- Lamont County, late 1980's
- Ontario Ministry of Transportation (MTO), late 1990's-2010, NE ONTARIO
 - *AB sourced asphalt binder strips nearly crack free after 20+years*
- Adjacent asphalt binder strips in various stages of disintegration
- CARBOVATE leveraged testing through Queens U, MTO and Industry players

Evidence: Ontario – Hwy 655

Highway 655 Photographs (2019) 16 Years of Service

Section 1
PG 67-36
Lloydminster Modified



Viscous binder,
low wax,
low oxidative and
physical hardening.

Section 2
PG 64-35
Modified



Elastic binder,
high wax,
high oxidative and
physical hardening.

Section 4
PG 70-35
Modified



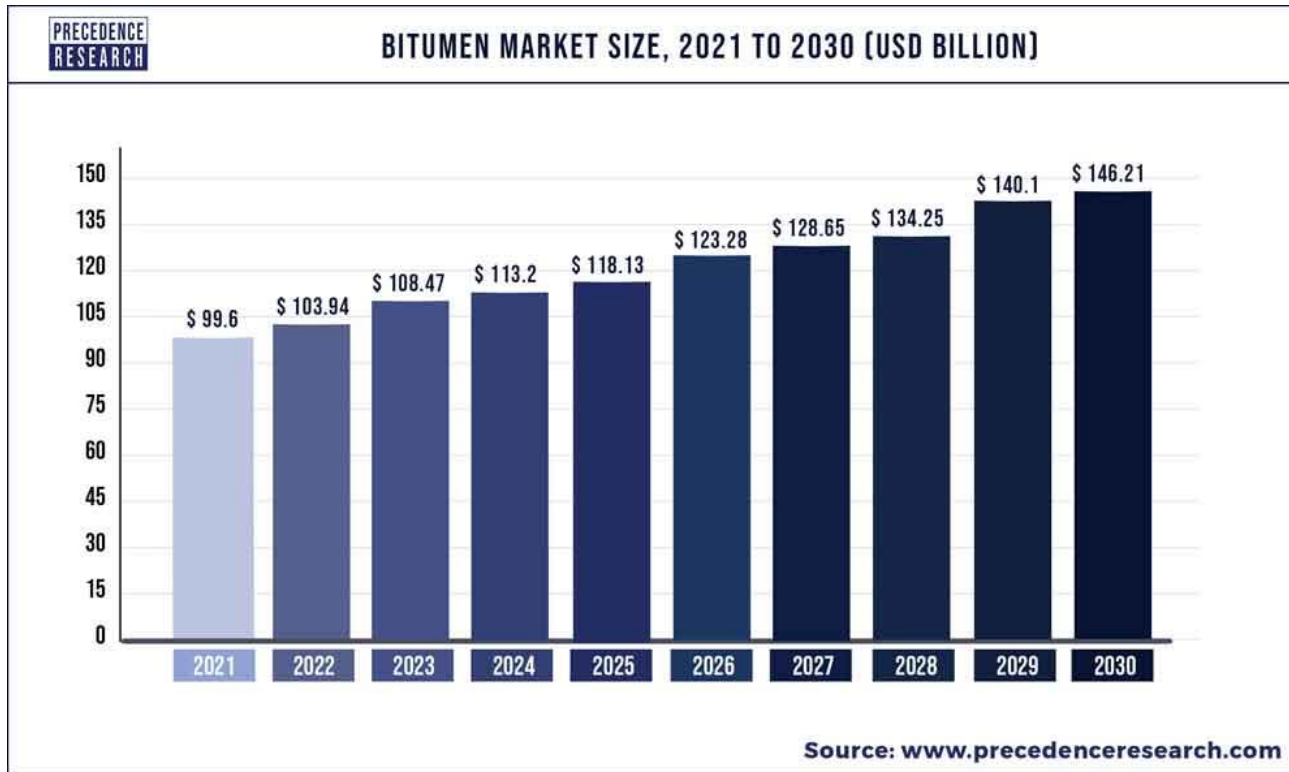
Most elastic binder,
low wax, ...,
very high oxidative/
physical hardening.

Evidence: Cold Lake Section 655-9 (2007-2019)



Representative 2019 photograph.
 $T_{\min} < -40\text{ }^{\circ}\text{C}$, 5 % PG 52-34 binder

Asphalt Binder is a Growth Market



Global asphalt binder (bitumen) demand
US\$103.94B 2022 growing to US\$146.21B 2030

Annual growth rate 4.5%

Global Volume 126 million tonnes 2020

North America 26 million tonnes

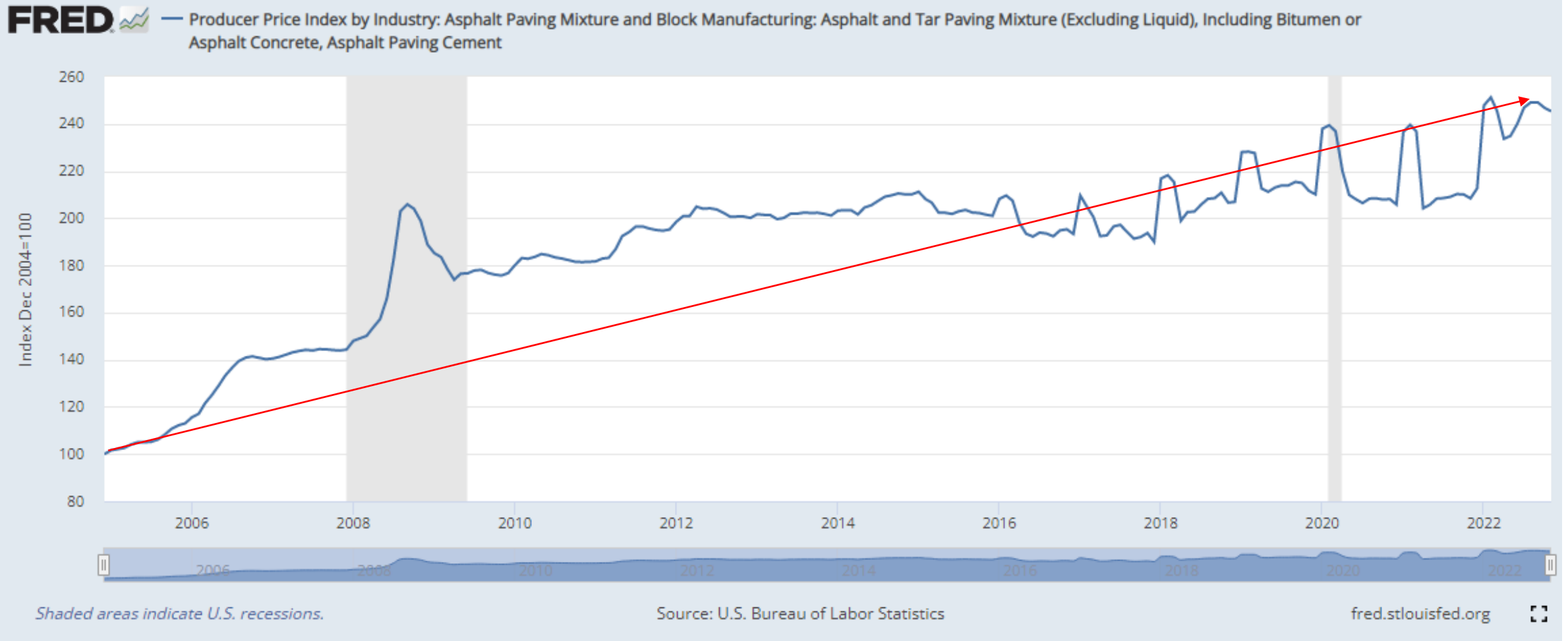
Asia Pacific 44 million tonnes

Europe 29 million tonnes

Middle East & Africa 18 million tonnes

Latin America 10 million tonnes

Asphalt Binder Pricing



Crude Oil and Asphalt Pricing Relationship

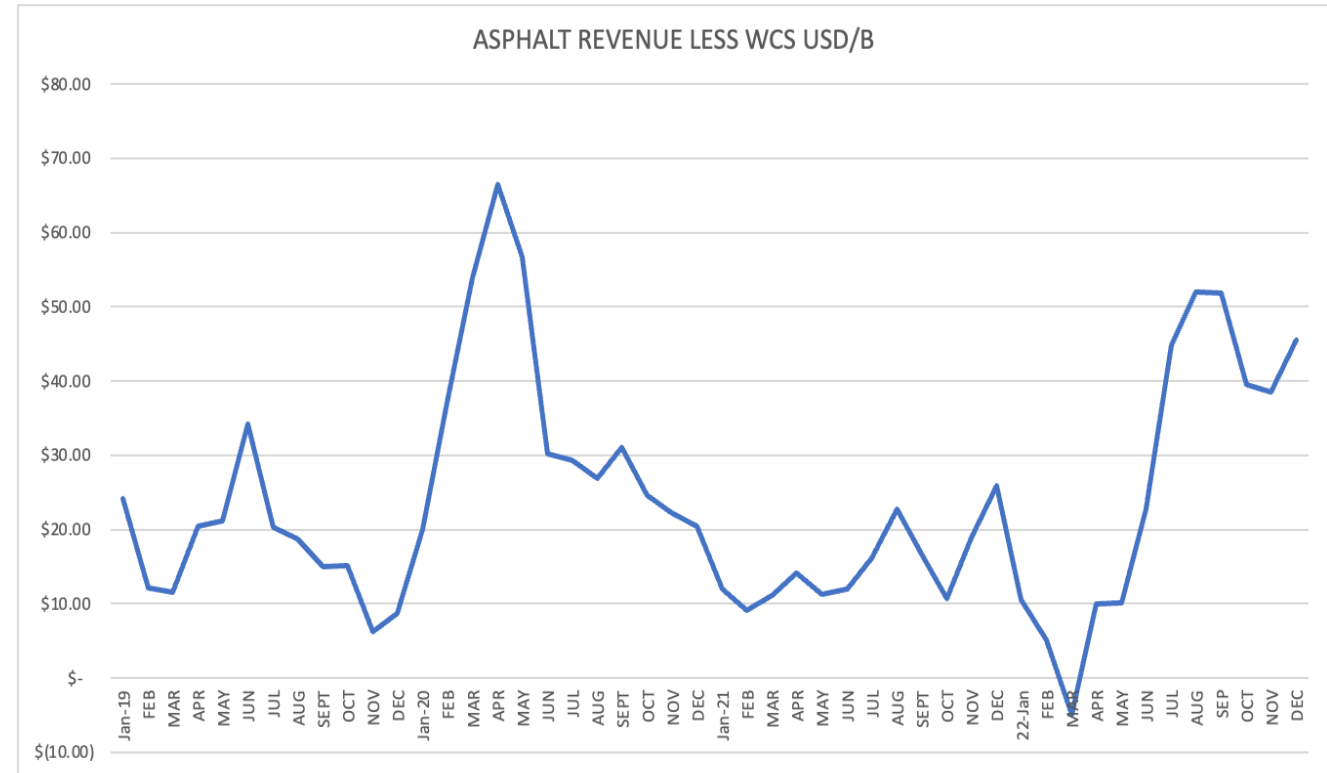
Protocol to Assess the Impact of Crude Oil Price Fluctuations on Future Asphalt Prices

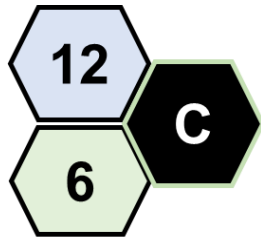
Objectives, this study analyzed the relationship between two price indexes: (1) **ALDOT's** (Alabama) asphalt price index, and (2) the national crude oil price index published by **EIA**.

The analysis of paired critical points across the indexes revealed that the most likely time gap between crude oil and asphalt price fluctuations in Alabama is 3 months, with a change ratio of 0.58. **This means that a 0.58% change should be expected in the asphalt price index for each 1% change observed in the crude oil price index**, with the change in the asphalt market occurring 3 months later.

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