BRING ME SOME NATURAL GAS – A KEY DRIVER BEHIND TODAY'S HIGH REFINING MARGINS

July 21, 2022

Refining margins today — whether in the U.S. Gulf Coast (USGC), Rotterdam, or Singapore — are at record highs. Given current high crude oil prices, gasoline and diesel prices at the pump everywhere are also at unprecedented levels, making refinery profits a major topic of conversation — and not just for politicians. While some of the explanations of refining margins are just political talking points, several others are well-established and accepted, and still others consider factors that are less frequently cited, even by those familiar with energy markets. One such factor is the price of natural gas and how it's impacting refinery operations and competitiveness around the world. Today's RBN blog discusses the crucial role natural gas prices play in refinery operating expenses and refining margins, and examines how favorable natural gas prices in the U.S. are providing a substantial competitive advantage for domestic refiners.

Today's high refinery margins are the result of a confluence of several factors, including:

- Strained global refining capacity due to demand returning to pre-COVID levels following refinery closures during the pandemic-related demand collapse;
- The effects of Russia's invasion of Ukraine, which began in February and led to reduced exports of Russian refined and intermediate products to the U.S. and Western Europe;
- Restrictions on exports of refined products from China; and
- Record natural gas prices in Europe and Asia due to supply/demand fundamentals exacerbated by Russia's invasion.

The first three factors are often cited as the direct or indirect causes of today's high margins and are major contributors. However, often overlooked is how higher natural gas prices in Europe and Asia have dramatically increased the operating costs of refineries in those regions.

Gas Price Increase and Divergence

Global gas benchmarks are typically talked about in terms of Henry Hub (U.S.), the Netherlands' Title Transfer Facility (TTF), and Asia's LNG-based price, the Japan-

Korea Marker (JKM). As shown in Figure 1 below, natural gas prices in the U.S. and the two international regions began diverging significantly about a year ago. Starting in the third quarter of last year (2021), European (TTF, green line) and Asian (JKM, yellow line) prices began a steep climb to $25/MMBtu-$50/MMBtu levels. In the U.S., the Henry Hub price (blue line) trended as high as $8/MMBtu before declining in June and early July. (Henry Hub settled Tuesday at $7.264/MMBtu and has averaged $6.384/MMBtu so far in July).

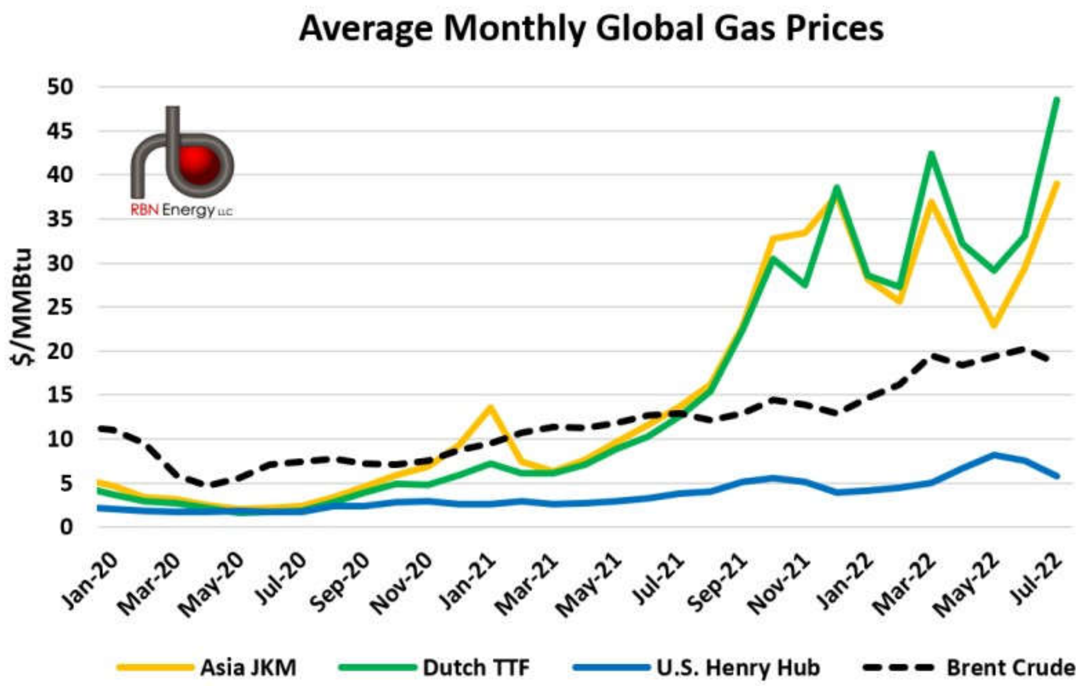

Figure 1. Global Natural Gas Prices. Source: RBN

The unprecedented European and Asian gas prices led to the rare phenomenon of gas being worth much more than crude oil on a per-Btu basis. Even with the price of international crude benchmark Brent between $100/bbl and $120/bbl (black line; it settled Tuesday at $107.35/bbl), its energy-equivalent value is $16/MMBtu to $19/MMBtu, or about one-half of today's natural gas price in Europe.

Refinery Operating Expenses Highly Dependent on Natural Gas

High natural gas prices can be particularly devastating to refiners because they affect operating costs in three primary ways: (1) thermal needs; (2) electricity costs; and (3) hydrogen.

Thermal Heating

Heating and vaporizing streams are critical steps in nearly all refining processes. Typically, this is accomplished using either direct natural gas-fired furnaces or steam, which also requires natural gas (or "fuel gas"). A refinery's thermal energy needs are concentrated around a few critical units, including the main crude oil fractionation train, the catalytic reformer, and the coker.

Some refining processes produce fuel gas as a byproduct, which the refinery can use for its internal heating requirements. However, this internal fuel gas production rarely fulfills all the refinery's thermal energy requirements. Supplemental natural gas must be purchased. A simple rule of thumb is that 60% of a refinery's thermal energy needs are supplied by its own produced fuel gas (i.e., from crude oil) and 40% is provided by purchased gas.

Electricity

Refineries use significant amounts of electricity to operate their compression-and-pumping equipment. Usage ranges from approximately 7 to 10 kilowatt-hours (kWh) per barrel input, depending on the degree of processing. For example, a smaller, less-complex refinery might use 30 megawatts (MW), whereas a large, full-conversion plant might use over 100 MW. Electricity is typically purchased from a regional power grid or a local utility. Some refineries operate cogeneration facilities that use refinery gases and natural gas to produce steam and electricity; however, they require an external electrical power source for additional reliability and to operate under certain conditions.

Depending on the refinery's location, the cost of electricity is often tied to natural gas prices, given that power generation through combined-cycle (or even simple-cycle) facilities is often the marginal power supply source. Though not always the case, the natural gas price is usually a significant factor in the cost of purchased electricity.

Hydrogen

Hydrogen is a critical component in every refinery. It is used in processes to remove contaminants (such as sulfur) from products to meet strict quality requirements or rearrange low-value molecules to produce higher-value products. A refinery's hydrogen demand depends on the crude slate (lower-quality, heavier crude oils require more hydrogen) and the amount of upgrading and "conversion" the refinery performs (e.g., coking requires plenty of hydrogen to treat the coker products; hydrocracking requires much more hydrogen than hydrotreating).

A refinery produces hydrogen in the catalytic reformer, but the amount produced is typically not enough to meet all the facility's hydrogen needs. Therefore, additional "on-purpose" hydrogen is required. Almost all on-purpose hydrogen used in refineries is made in steam methane reformers (SMRs). SMRs convert and separate the hydrogen molecules in natural gas and steam (i.e., water) to produce pure hydrogen (for more on hydrogen production, see Help! Part 2). A refinery may have its own SMR or purchase hydrogen from a "merchant" gas supplier under a long-term contract. (Some refineries affiliated with olefins plants can receive the hydrogen byproduct from the ethylene cracking process).

For illustration, Figure 2 summarizes hydrogen balances for three USGC refineries — one simple and two complex, each with different crude slates. In the simple light-sweet cracking refinery (left column), the facility's overall hydrogen intensity is mild at only 156 standard cubic feet (SCF, pronounced "scuff") per barrel of input (SCF/bbl, blue oval), nearly all of which is supplied by the reformer. The two coking refineries (center and right columns) process higher sulfur crude oil and have more upgrading capacity (e.g., coking, hydrocracking). These refineries have much higher hydrogen intensities (> 700 SCF/bbl) and thus require significant amounts of hydrogen from either an on-site SMR, as in the case of the light-sour refinery in the right column (yellow oval) or a merchant supplier, as in the case of the medium-sour refinery (red oval).

Hydrogen Balances: Individual Refinery Examples

	USGC Cracking Refinery Light Sweet Crude Oil No SMR	USGC Coking Refinery Medium Sour Crude Oil No SMR	USGC Coking Refinery Light Sour Crude Oil With 90 MMSCFD SMR
Hydrogen Supply, MM SCFD			
Refinery Reformer	9	51	64
Refinery SMR	-	-	88
Refinery other	-	-	13
Purchased from Industrial Gas Supplier	1	113	-
Total	**10**	**164**	**165**
Hydrogen Demand, MM SCFD			
Distillate Hydrocracking	-	87	88
Diesel Hydrodesulfurization	10	37	38
VGO Hydrodesulfurization	-	32	11
Resid Hydroprocessing	-	-	21
Naphtha Hydrodesulfurization	0.3	3	2
Gasoline Hydrodesulfurization	0.4	1	1
Kerosene Hydrodesulfurization	-	4	1
Other	-	-	3
Total	**10**	**164**	**165**
Refinery Hydrogen Intensity			
Avg SCF H2/bbl Crude Oil Input	156	722	727

Figure 2. Refinery Hydrogen Balances. Source: Baker & O'Brien's *PRISM* database

Refinery Operating Expenses

The above factors combine to make natural gas the single largest component of a refinery's operating expenses, or OpEx. In the U.S., with its low historical natural gas prices, it barely amounts to much. Even at its recently elevated price, (around $6/MMBtu) the natural gas-related OpEx for a simple refinery in the U.S. is about $1.30/bbl (left pie chart in Figure 3); for a complex refinery, it's about $2.50/bbl (right pie chart). In the light-sweet coking refinery example, power generation makes up approximately half of the natural gas needs (blue slice in left pie chart). Conversely, in a complex refinery, hydrogen and thermal-related natural gas consumption is proportionately higher (gray and orange slices, respectively, of right pie chart) and the power is relatively less than for the simpler refinery so that each of the three main uses of natural gas comprises roughly one-third of this cost.

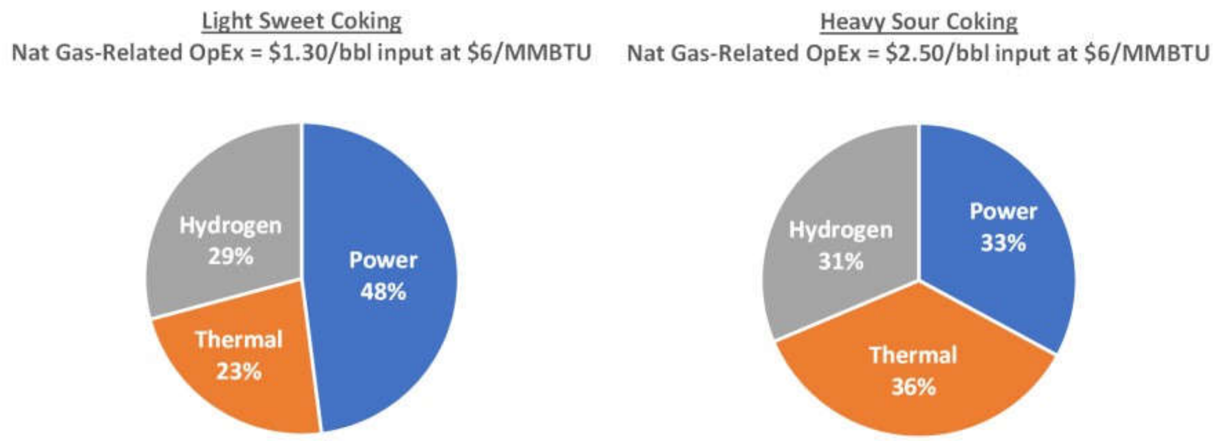

Figure 3. Refinery Operating Costs Influenced by Natural Gas Prices. Source: Baker & O'Brien *PRISM* database **Higher Natural Gas Prices and their Impact on Refinery Costs**

On the other hand, the massive run-up in natural gas prices in Europe and Asia has resulted in much higher refinery OpEx in those regions. Figure 4 compares the OpEx impact of natural gas price increases on a complex refinery in the U.S. and Europe. In the U.S., natural gas has gone from $3/MMBtu in the first half of 2021 to $6/MMBtu in the first half of 2022 (colored bars to left). This has resulted in a refinery operating cost increase of about $1/bbl. Over the same period, European gas has gone from $8/MMBtu (H1 2021) to $32/MMBtu (H1 2022). This fourfold increase in gas costs has caused refinery OpEx to increase by about $9/bbl. Therefore, in Europe, the refining margin would have to increase by at least this amount to maintain operating margins. And it has. The recent sky-high margins caused by tight global supply/demand balance for refined products appear to be allowing for European refining profitability even with elevated natural gas prices.

However, over the same period, the comparative advantage for refiners in the U.S. and other gas-resource-rich regions such as the Middle East has grown substantially. U.S. refining's comparative advantage over European refining has increased from about $1.50/bbl ($3/bbl minus $1.50/bbl) in the first half of 2021 to over $9/bbl ($11.70/bbl minus $2.50/bbl) in the first half of 2022. As we've blogged about a lot recently, that's been a huge boon to U.S. refiners (see Cracking Up) and a source of consternation for some outside observers (see Man in the Box).

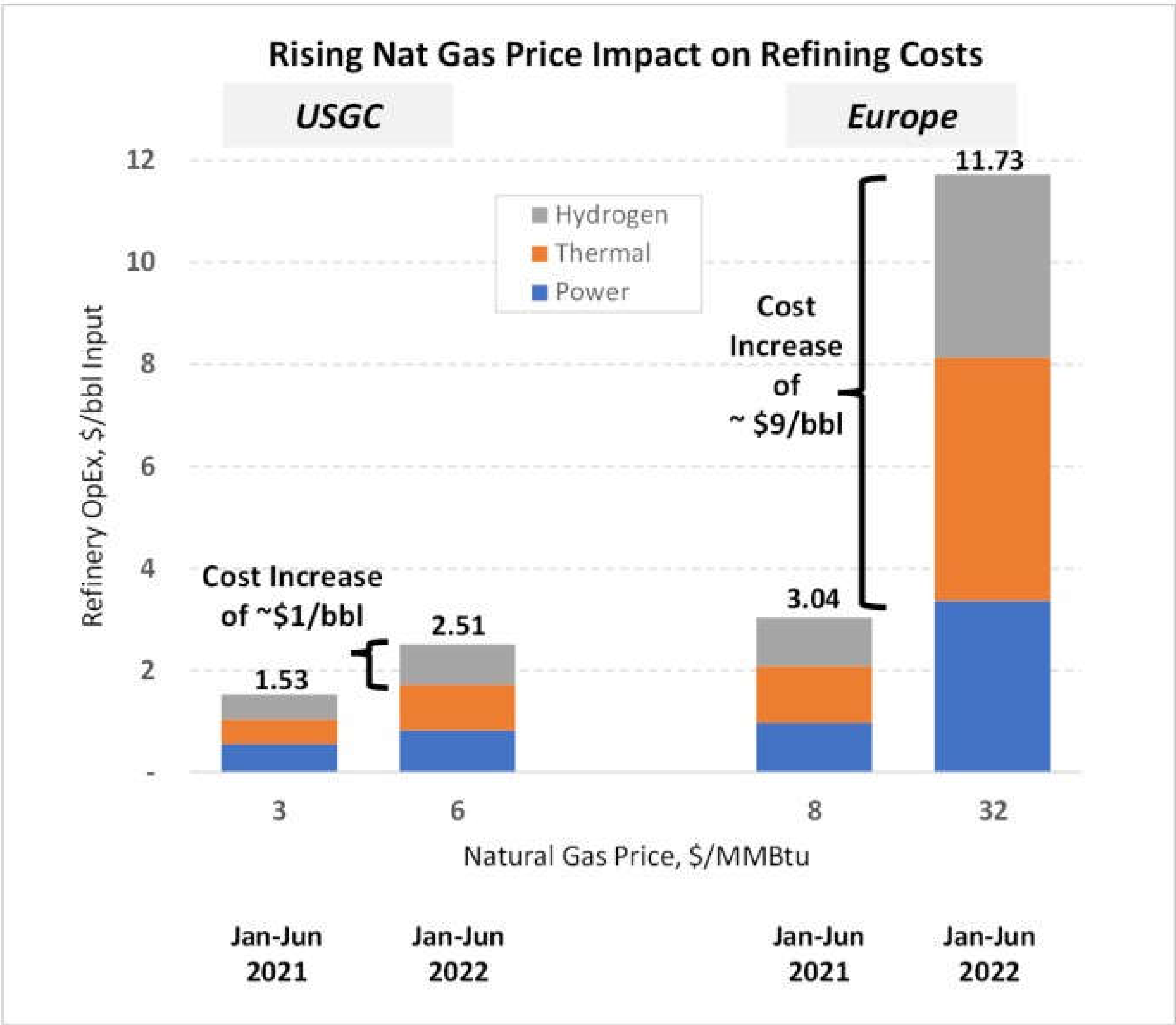

Figure 4. Impact on Refinery Operating Costs Due to Increase in Natural Gas Prices. Source: Baker & O'Brien *PRISM* database

While it's hard to imagine natural gas prices maintaining these lofty levels for an extended period, given the current tightness in global gas supply/demand and plans to reduce Europe's reliance on Russian gas (see Everything has Changed), prices seem unlikely to return to historical norms anytime soon. Even if events unfurl to relax the refined product supply/demand balance, elevated natural gas prices will continue to cause pain for European refiners, limiting how far refinery gross margins can fall, and allow competitively advantaged U.S. refiners to prosper.

The U.S. Refinery Billboard provides an unprecedented view into the economics and operations of domestic refineries. This weekly report includes regional price spreads and netbacks as well as a refinery-specific breakdown of indicative margins based on 5-year average feedstock and yield sets in Baker & O'Brien's PRISM refinery modeling system. Click here *for more information and a sample report.*

Note: The article was authored by Kevin Waguespack of Baker & O'Brien and published on RBN Energy's Daily Energy Post on July 20, 2022.

"Bring Me Some Water" was written by Melissa Etheridge and appears as the ninth song on her debut album, *Melissa Etheridge.* Released as her first single in May 1988, it went to #10 on the Billboard Mainstream Rock Singles chart. Personnel on the record were: Melissa Etheridge (vocals, guitar), Johnny Schell, Waddy Wachtel (guitar), Wally Badarou, Scott Thurston (keyboards), Kevin McCormick (bass), and Craig Krampf (drums, percussion).