artberman.com

ENERGY AWARE #4: THE DEVIL IS IN THE DIESEL - Art Berman

Art Berman

8–10 minuter

Global diesel is in short supply.

Analysts are concerned about diesel because it is the hemoglobin of the global economy. The world's mines, oil rigs, construction, ships, trains and trucks run on diesel.

> Typically, inventories should be 30% higher this time of the year. Such low levels are alarming because diesel is the workhorse of the global economy. It powers trucks and vans, excavators, freight trains and ships. A shortage would mean higher costs for everything from trucking to farming to construction.
> –Javier Blas, Washington Post, October 18, 2022

Most government leaders, journalists and industry analysts don't understand why there is a problem. That's because it's a refining issue and it's not something simple that can easily be fixed by pressuring refiners to make more diesel. Let me explain.There is a sequence of products made in a refinery that includes gasoline, kerosene, jet fuel, and diesel that *all* must be distilled from each barrel of oil. It's not an a la carte menu in which you can order diesel but tell the waiter to hold the gasoline, kerosene and jet fuel.

Petroleum products are distilled from crude oil like whisky is distilled from fermented grain. For both petroleum and whiskey, a liquid is heated to create a vapor that is then condensed back into a

liquid again. In the case of whiskey, distillation removes the heavier molecules that condense at the bottom of the still—the wash—and are later thrown away. Only the lightest fraction—the whiskey—that condenses at the top of the still is kept.

For petroleum, the whiskey is gasoline and a few lighter molecules. The wash is everything else including fuel oil, diesel, jet fuel and kerosene. These are not thrown away because in today's market, they are worth more than gasoline.

Oil is a complex molecule that consists of a long chain of mostly carbon and hydrogen atoms (Figure 1).

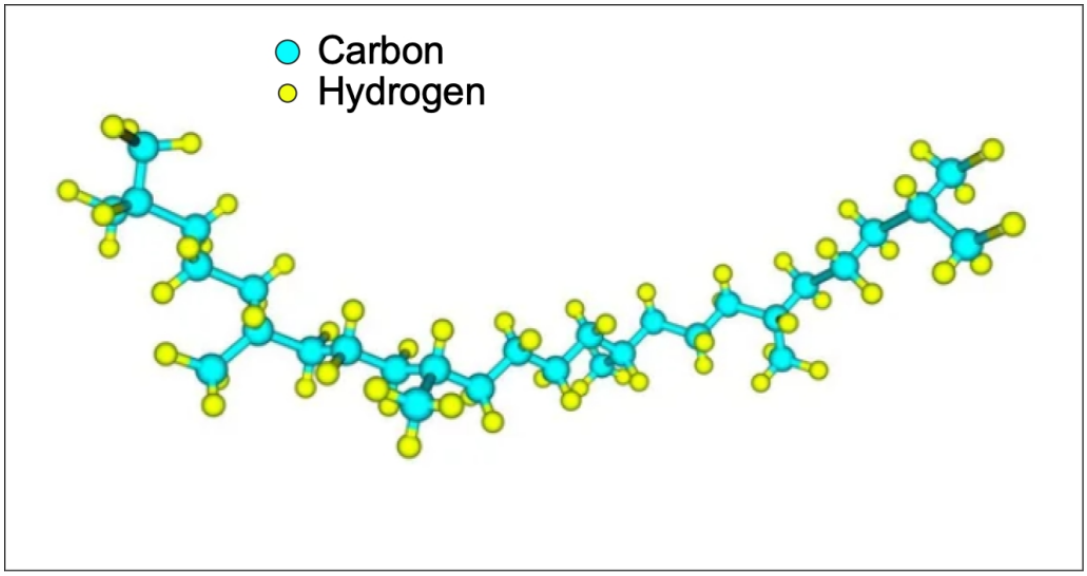
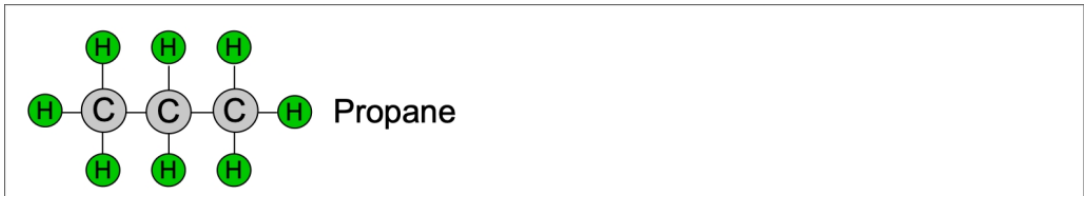


Figure 1. Oil is a complex molecule that consists mostly of long-chains of carbon and hydrogen. Source: Labyrinth Consulting Services, Inc.

Refineries upgrade crude oil into higher value gasoline and distillate products by breaking this long molecule down into smaller chains of carbon and hydrogen by a process called fractional distillation. The general molecular structures of propane, butane, gasoline and diesel are shown in Figure 2.



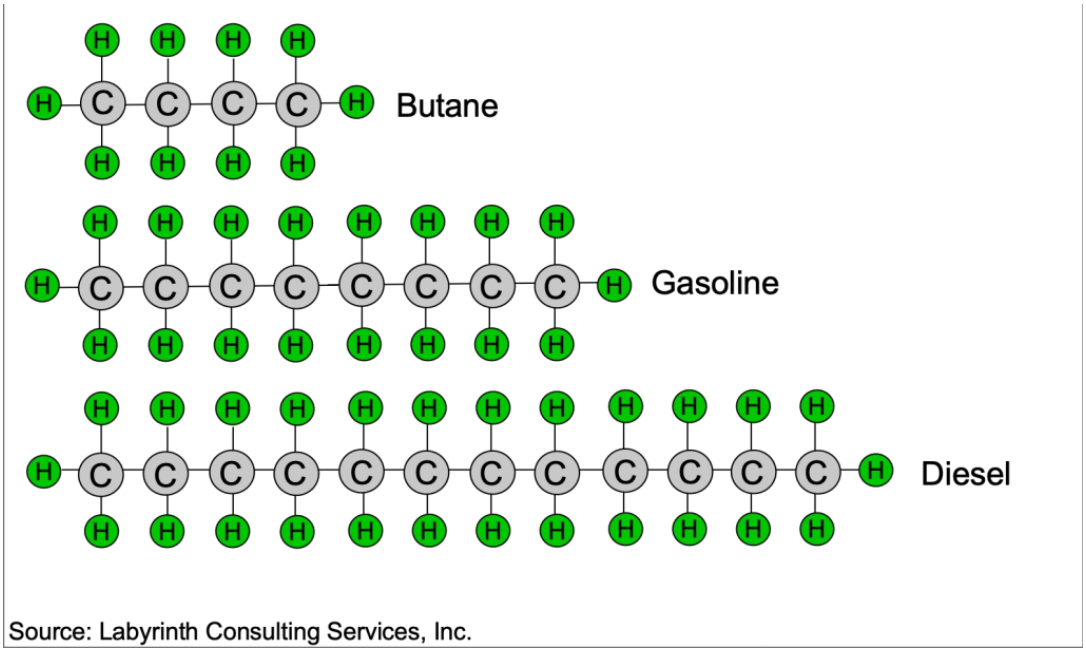
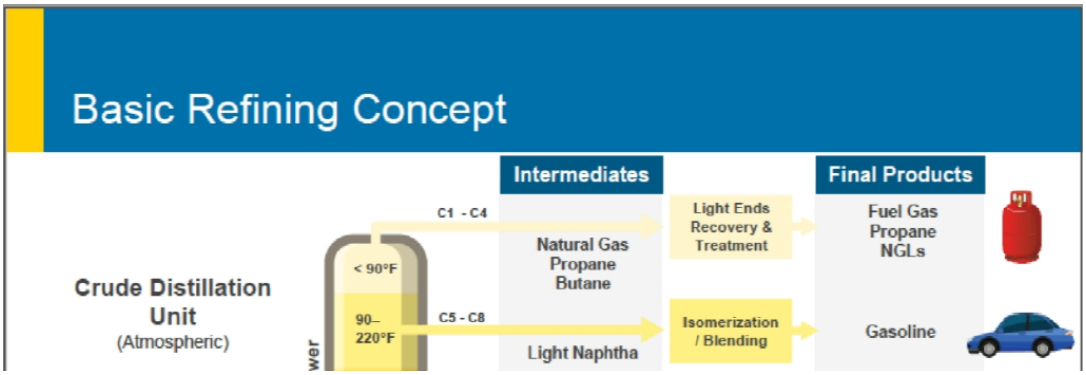


Figure 2. The general molecular structure of propane, butane, gasoline and diesel. Source: Labyrinth Consulting Services, Inc.

In a refinery, crude oil is heated under pressure in a furnace into a vapor and then fed into the bottom of a distillation tower (Figure 3).

Longer-chain molecules have higher boiling points than smaller molecules and condense back into liquids at the bottom of the distillation tower. The vapor cools as it rises through the column and different hydrocarbon molecules or fractions condense and run out of the tower at different levels.

The figure shows the main intermediate products that come out of a distillation tower with their average number of carbon atoms (C1 – C4, C5 – C8, etc. in the figure). These intermediates are then put through a series of blenders, treaters and catalytic processes that result in final products like gasoline, diesel and jet fuel.



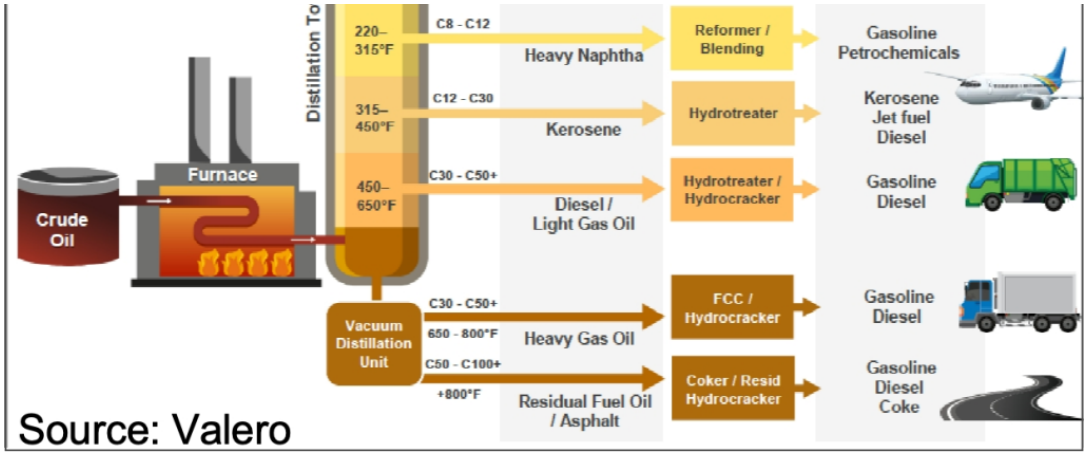


Figure 3. Crude oil is heated in a furnace, vaporized and put into the bottom of a distillation tower. Source: Valero & Labyrinth Consulting Services, Inc.

Most U.S. refineries were built in the 1970s and were optimized for gasoline production because that was the most valuable cash product at the time. Diesel has since become more important but no large refineries have been added in the last 50 years. Increasing the volume of diesel means increasing the volume of all other refined products. The problem is that gasoline accounts for more than half of all petroleum product consumption today in the United States but diesel (distillate) accounts for only 24% (Figure 4).

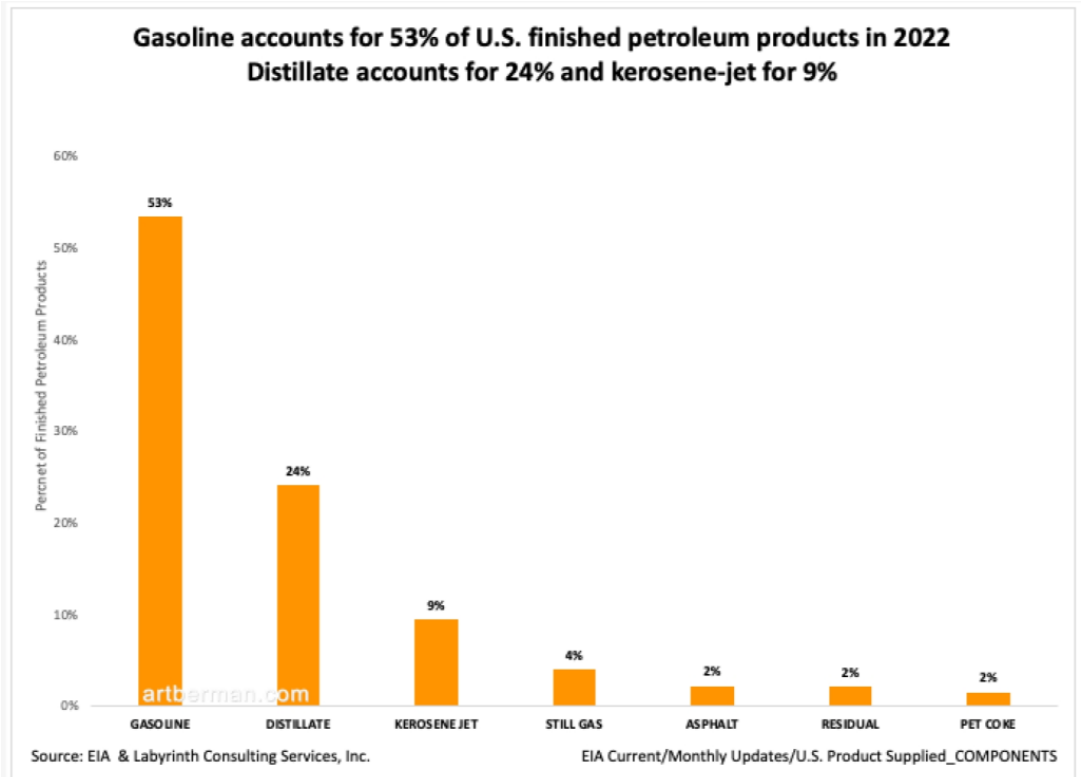


Figure 4. Gasoline accounts for 53% of U.S. finished petroleum products in 2022. Distillate accounts for 24% and kerosene-jet for 9%. Source: EIA & Labyrinth Consulting Services, Inc.

To make matters worse, gasoline consumption has been weak. U.S. gasoline consumption has been below the 5-year average since June 2022 (Figure 5). Refining is a business. For as much as refiners would like to produce and sell more diesel, they can't justify making more gasoline and other products that cannot sold at a profit.

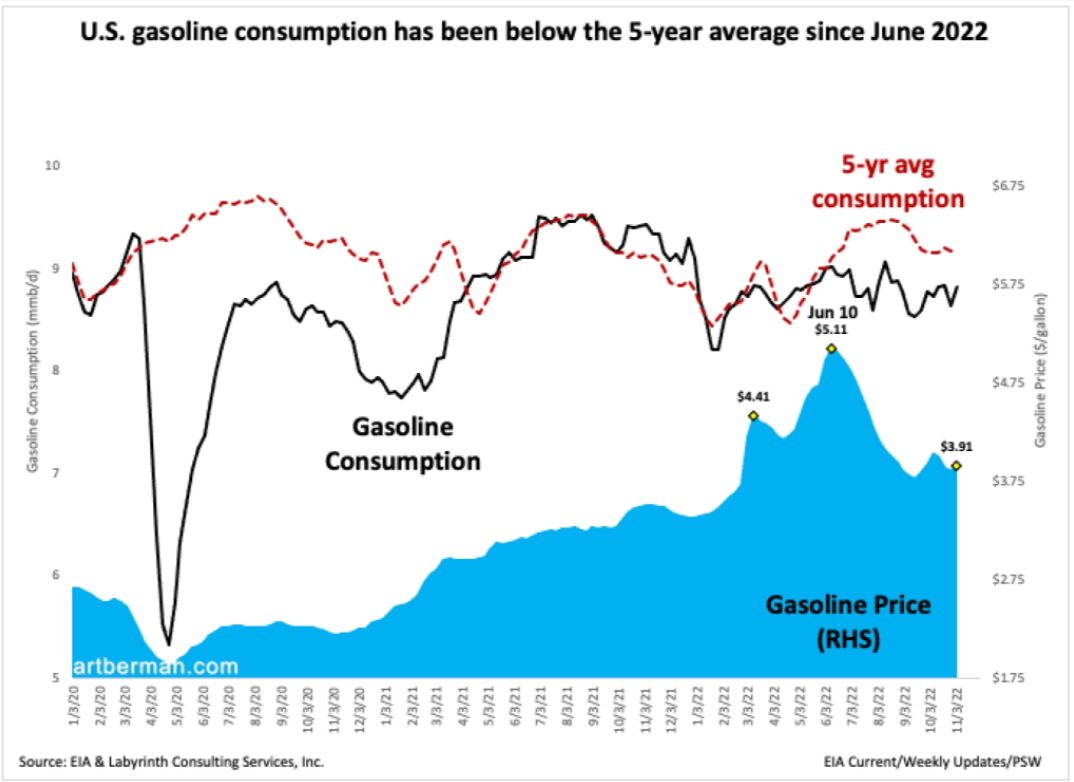
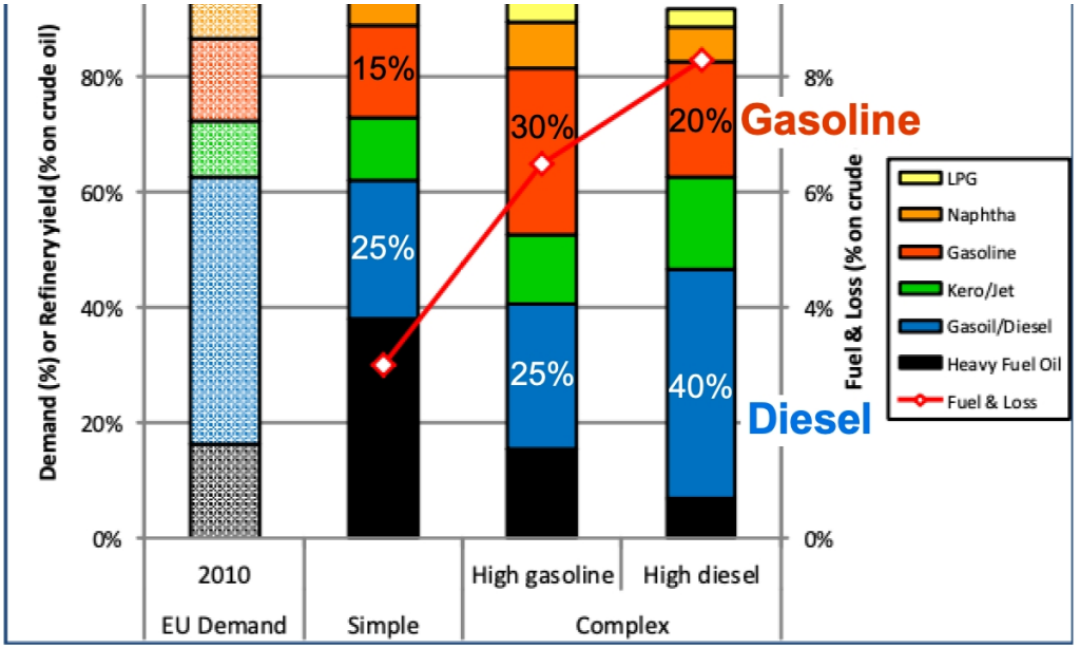


Figure 5. U.S. gasoline consumption has been below the 5-year average since June 2022. Source: EIA & Labyrinth Consulting Services, Inc.

In other parts of the world, refinery configurations are different and often designed to optimize diesel production. In Europe, for example, diesel yields are sometimes as high as 40% and gasoline yields as low as 15 or 20% (Figure 6).



Source: Bourgeois et al (2012) and Labyrinth Consulting Services, Inc.

Figure 6. Typical EU refinery fuel consumption as % of yield in simple and complexrefineries. Source: Bourgeois et al (2012) and Labyrinth Consulting Services, Inc.

Refineries that produce higher diesel yields use heavier crude oil as input. Not all oil is the same even though this is rarely considered or discussed by journalists or analysts. Some crude oils are heavy and others are light. That property of oil is expressed by its API gravity, a variant on specific gravity or density. Heavier oils have lower API gravities and lighter oils have higher API gravities. Lighter oils have limited middle distillates and heavy gasoil compounds that are need to make high-quality diesel.

Figure 7 shows a range of common crude oils used in U.S. refineries arranged by sulfur percent and API gravity. Most U.S. onshore oils including tight oils, and Brent oil are light and sweet (orange circles). Many Saudi Arabian and Iraqi oils, and Alaska North Slope oil are heavier and have higher sulfur content (blue circles). Many oils from Canada, Mexico, South America and West Africa are heavy with a range of sulfur content (black circles).

Most U.S. and Brent is fine for refining gasoline but must be blended with heavier grades to produce diesel. This is why the U.S.

cannot be oil independent no matter how much oil it produces.

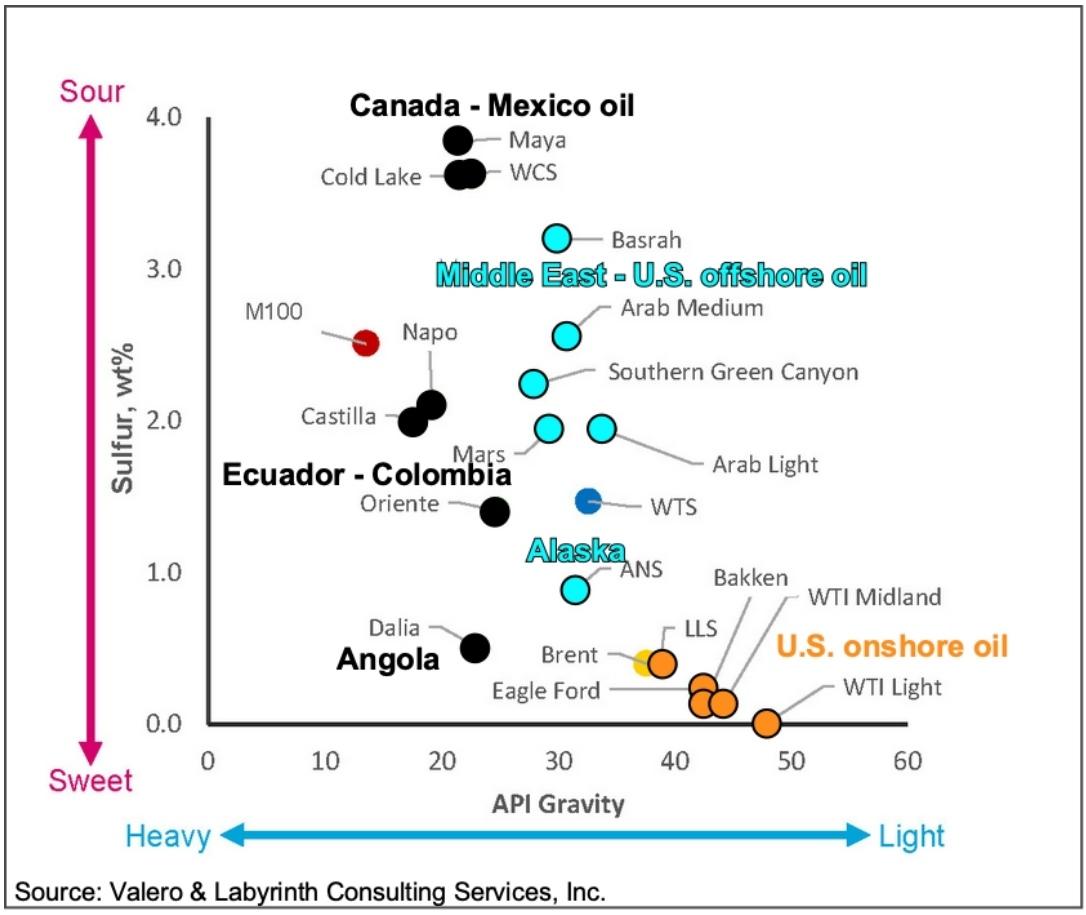
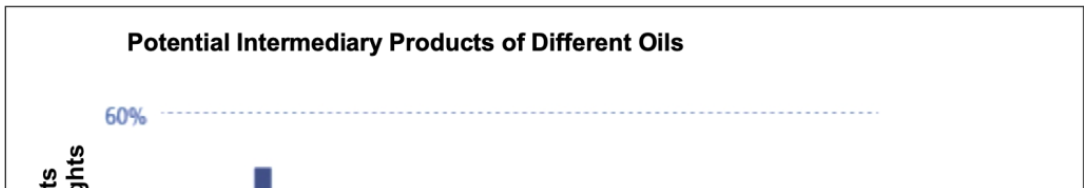


Figure 7. A range of crude oils arranged by sulfur percent and API gravity. Source: Valero & Labyrinth Consulting Services, Inc.Refineries cost billions of dollars to build and are designed to operate for decades.

Figure 8 shows the intermediate product cuts for a range of oil types and API gravities. The red and green columns indicate distillate and heavy gas oil products that are suitable for diesel production, and the yellow and orange bars indicate gasoline components and naphtha products suitable for gasoline production. This clearly shows that an oil's potential for diesel production is inversely and progressively proportional to its potential for gasoline production.



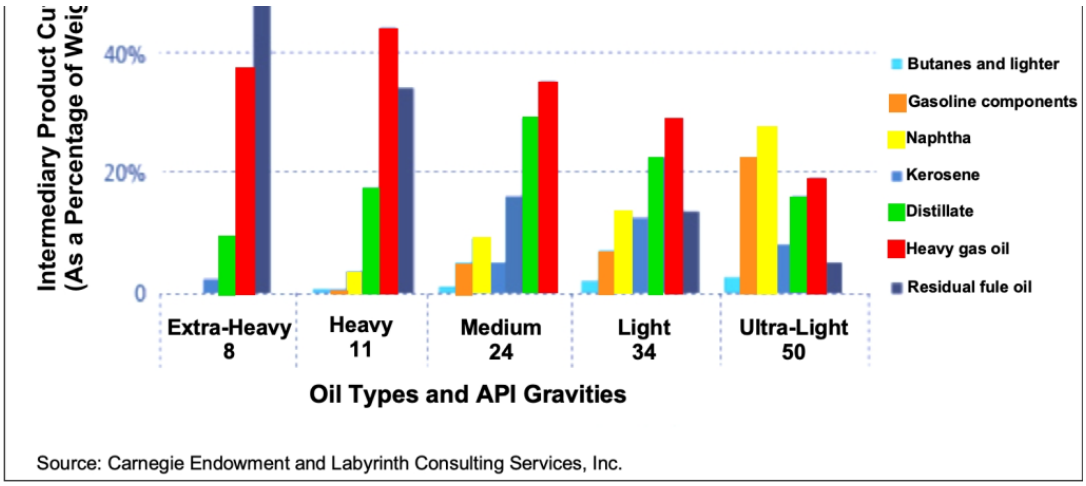


Figure 8. Potential Intermediary Products of Different Oils. Source: Carnegie Endowment and Labyrinth Consulting Services, Inc.

The last refinery built in the U.S. with significant capacity was in 1977 although smaller new plants and existing plant upgrades have occurred more recently. New complex refineries have operating lives of about 40 years can cost $15 to $20 billion. That's a stretch for an industry that struggles with investor expectations of a limited future for fossil fuels.

Refiners understand that low diesel inventories are a relatively temporary problem triggered chiefly by Russia's invasion of Ukraine. The European Union imported 39% of its diesel and gasoil from Russia in 2021 and its loss leaves a huge hole in worldwide supply.

There is little flexibility to modify the kind of crude oil input or distillate yield once the refinery is built. Suggestions by some people to re-design, to build new refineries, or to use new technologies to boost diesel output are not realistic.

Refining is a complex system that cannot be adjusted without unanticipated consequences. Simple solutions are incompatible with complex systems. The world is connected and interdependent for energy and refining in unavoidably fundamental ways. The lesson of the Ukraine War should be that energy cooperation is a far more important and strategic factor than territorial or ideological

disputes.