Analysis of Declining Petroleum Refining Capacity, Biomass Based Diesel Capacity Expansion, and the Impact of Expanded Biomass Based Diesel Production on Diesel Prices

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Petroleum Refining Capacity Idled

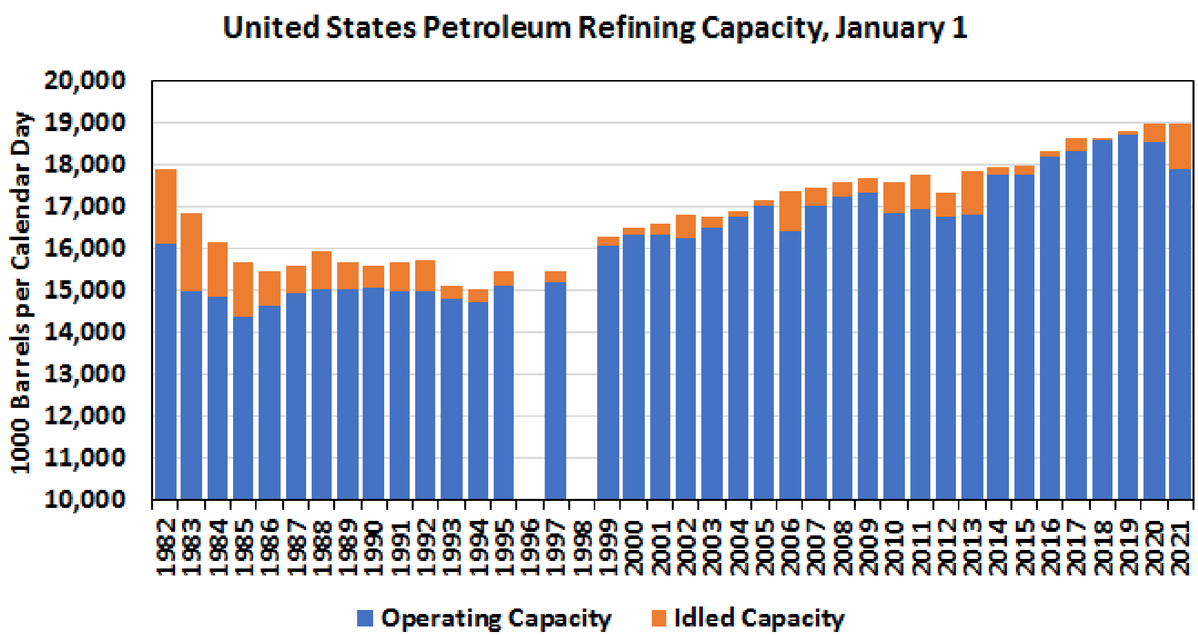
At the beginning of 2020, the Energy Information Administrations, "Refinery Capacity Report" already showed an increase in the idled capacity of petroleum refiners. Of the 427,100 barrels per calendar day idled on January 1, 2020, 78.4 percent was attributable to the badly damaged Philadelphia Energy Solutions refinery that was sold to a Chicago developer who plans to demolish the plant.

COVID-19 has placed further pressure on the profitability of the petroleum refining industry due to significantly reduced demand for both gasoline and diesel. The United states is now seven months into the pandemic and overall gasoline and diesel demand is expected to be down nearly 10% in 2020 relative to pre-COVID projections. The decline in domestic demand combined with a 35% year over year decline in diesel fuel exports has squeezed the bottom line of petroleum refiners. Seeking to minimize losses, some refineries have announced closure or conversion to renewable diesel production facilities. The first table below provides a list of those petroleum refineries that are shutting down and/or converting renewable diesel plants.

Conversion of Petroleum Refineries

	Petroleum Capacity Idled/Converted barrels/calendar day	Capacity Converted to Renewable Diesel barrels/calendar day	Renewable Diesel Production Million Gallons/year	Construction Completed Year
Marathon Petroleum Corporation				
Martinez, CA	161,000	48,000	725	2022
Gallup, NM	27,000	0	0	not applicable
Dickinson, ND	19,000	12,000	175	late 2020
Holly Frontier				
Cheyenne, WY	48,000	6,000	90	1st qtr 2022
Artesia, NM	110,000	7,200	110	2nd qtr 2022
Phillips 66				
San Francisco, CA (Rodeo)	120,200	52,000	800	2024
Global Clean Energy				
Bakersfield, CA (formerly Kern Oil & Refining Co)	15,000	6,500	100	2022
CVR Energy				
Wynnewood, CA	74,500	7,000	100	mid 2021
Sinclair Wyoming Refining Co				
Sinclair, WY	75,000	9,800	150	not available
Subtotal	649,700	148,500	2,250	

The additional capacity idled adds up to 649,700 barrels per calendar day in addition to those plants already idled on January 1, 2020, bringing the current total to 1,076,800 barrels per calendar day (5.6% of total capacity). Idled petroleum refining capacity hasn't been at those levels since 2013. This idled capacity would translate into 3.9 billion gallons less diesel fuel produced by petroleum refineries in 2021 versus 2019. As COVID-19 is brought under control and diesel fuel demand recovers, that demand will be likely be met increasingly by renewable diesel, particularly in the California area where the Low Carbon Fuel Standard provides strong incentives to use renewable fuels. As the table above shows, the planned conversions suggest an additional 2.25 billion gallons of renewable diesel will be produced offsetting over half of the loss in diesel fuel production capacity.



In addition to the conversion of existing refineries to renewable diesel plants, existing renewable diesel production facilities are being expanded and new renewable diesel production facilities are being built. Planned expansion and new construction total nearly 2.6 billion gallons. Combined with the planned conversions of idled petroleum refiners, 4.8 billion gallons of renewable diesel production capacity is planned. Although it is plausible that not all of this capacity may come on-line as planned, this exceeds the diesel production capacity lost from idled refineries.

New Renewable Facilities Not Converted from Petroleum Refineries

	Total Capacity Existing and Planned Million Gallons	Construction Completed Year
World Energy - California	305	1st qtr 2023
RHD Plant - Newton, IL	90	not available
Seaboard Energy - Kansas	85	not available
Diamond Green		
Louisiana	675	end of 2021
Port Arthur, Texas	400	2024
REG - Geismar, Louisiana	150	not available
Greentech Materials - Louisiana	350	
Epitome Energy - Crookston, MN	30	not available
Jaxon Energy - Jackson, Mississippi	105	not available
Conoco Philipps 66 - Ryze Renewables		
Las Vegas, Nevada	100	not available
Reno, Nevada	50	not available
BP's NEXT Renewable Fuels - Port Westward, OR	600	2021
Fulcrum Bioenergy - Sierra - Reno, NV	11	not available
Emerald Biofuels - Emerald One - Pork Arthur, TX	85	not available
Chevron - Readifuels, IA	34	not available
Subtotal	3,070	
Grand Total	5,320	

If diesel demand recovers more quickly from the COVID-19 effects, expanded renewable diesel supply will help compensate for the idled petroleum refining capacity and moderate diesel fuel prices. As the following section discusses, biomass-based diesel production reduces #2 diesel prices because it increases the supply of diesel fuel. In the recovery of diesel fuel demand from COVID-19, biomass-based diesel is also likely to help moderate increases in diesel fuel prices due to the idled petroleum refining capacity.

The Impact of Biomass-Based Diesel Production on Diesel Prices

Growth in the biomass-based diesel industry has occurred due to the Environmental Protection Agency's (EPA's) expansion of volume obligations in both the advanced and biomass-based diesel categories as outlined in the Renewable Fuel Standard. Biofuels, and particularly advanced biofuels such as biomass-based diesel, significantly reduce carbon emissions relative to petroleum fuels. These higher carbon emissions of petroleum-based fuels create a negative externality cost to society that is not reflected in petroleum prices resulting in overconsumption of petroleum fuels and significantly higher carbon emissions.

Since biofuels, and particularly advanced biofuels, produce lower carbon emissions, they are generally more expensive to produce than petroleum fuels and subsequently require policy backing to support their use by consumers. For biomass-based diesel the combination of biodiesel blenders' credit and the RIN price compensates biomass-based diesel producers for the extra cost of production.

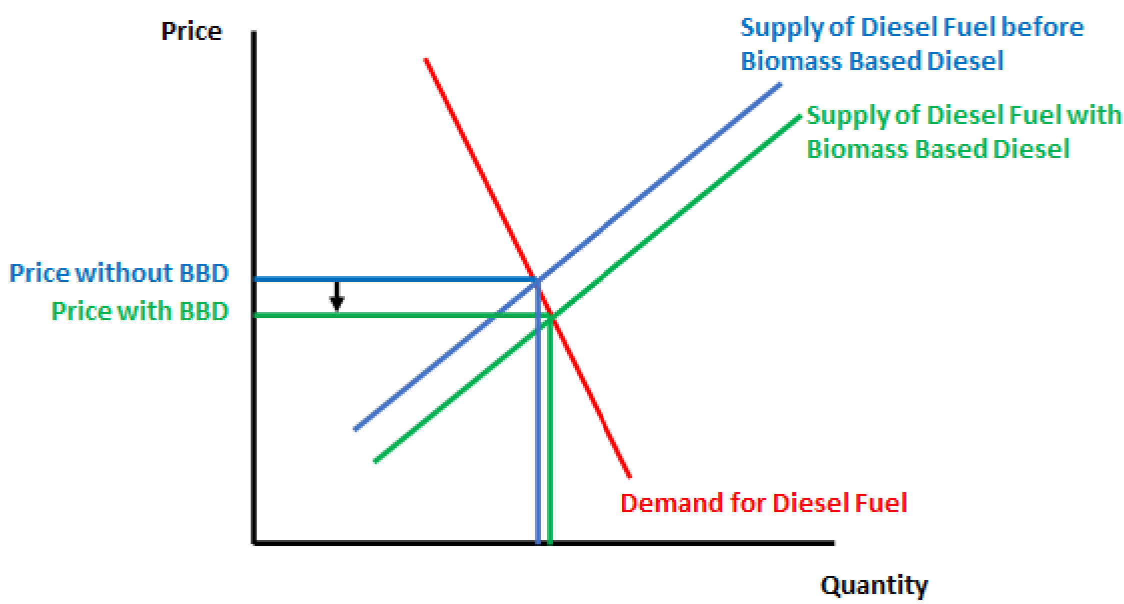
Despite being policy driven, biomass-based diesel is clearly additive to the supply of #2 diesel fuel available both in the US and globally. This additional supply reduces the price of #2 diesel fuel. How much the additional supply reduces the price of #2 diesel fuel depends upon the price elasticity (responsiveness) of demand. The steeper the demand line, the more inelastic the demand is, meaning that even small changes in supply will have a large impact on price. As the diagram below illustrates, the policy driven increase in the supply of diesel fuel including biodiesel results in a drop in the price of #2 diesel.

The demand line pictured in the diagram has a fairly steep slope which economists describe as inelastic. A product is considered to be inelastic when the percentage change in quantity is smaller than the percentage change in price.

There is a considerable literature of studies that have estimated the price elasticity of diesel fuel demand with respect to diesel fuel prices. These studies agree that diesel fuel price elasticity of demand is less than 1 in absolute value, and in the short to medium term (next 10 years), is likely less than 0.5 in absolute value. One of the most extensive studies was conducted in 2012 by Carol Dahl[1] which documents diesel and gasoline price elasticity of demand estimates for over 120 countries in the world. Weighting these elasticity estimates by the diesel fuel consumption in each country results in a global weighted average of -0.23 based on the country elasticities reported by Carol Dahl. In the short to medium term, not only is the diesel fuel price elasticity of demand inelastic, it is very inelastic. This implies that even small changes in the supply of diesel fuel will result in relatively larger changes in the diesel fuel price.

More recently, Edelenbosch[2] et al. measured the price elasticities of fuel demand across several different types of models. Presumably, these models were estimated or derived based on actual data, so the elasticities are still relevant. The authors document transport energy elasticities ranging from 0 to -0.4 in 2030 (short to medium run) across the various models.

Dahl's article mentions that long-run fuel elasticities as measured by dynamic models may be 60 to 100 percent higher than short-run elasticities. Even if these elasticities were 100 percent higher, Dahl's elasticity would become -0.46, suggesting a long-run impact of -8 cents (-$0.08) per gallon.



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[1] [1] Dahl, Carol A. "Measuring global gasoline and diesel price and income elasticities" Energy Policy, Volume 41, February 2012.

[2] Edelenbosch, O.Y., van Vuuren, D.P., Bertram, C., Carrara, S., Emmerling, J., Daly, H., Kitous, A., McCollum, D.L., Failali, N. Saadi. "Transport fuel demand responses to fuel price and income projections: Comparison of integrated assessment models" ScienceDirect, volume 55, pp 310-321, March 2017.

Analysis Methodology

Petroleum and petroleum products are globally traded with a high degree of transparency and arbitrage that keep port prices consistent with transportation costs, tariffs, and other factors. As such, changes in supply and demand in one region of the world or country affect all other regions. Therefore, to determine the impact of biomass-based diesel on #2 diesel prices, we must consider the quantity of biomass-based diesel relative to global demand for diesel.

We derive the price impact from the formula for elasticity:

$$elasticity = \frac{\%\ \Delta\ in\ price}{\%\ \Delta\ in\ quantity}$$

In this analysis, we know the value for % increase (Δ) in quantity equals the amount of biofuels produced divided by the global consumption of diesel. And from other studies, we have a measure of the elasticity (e).

Therefore, we can derive the percentage change (Δ) in price as:

$$\%\ \Delta\ in\ price = \frac{\%\ \Delta\ in\ quantity}{elasticity}$$

Results

The table below shows the derived impact on #2 diesel prices from the introduction of biofuels into the global market over the 2010 to 2020 period. Using the Dahl elasticities, the global impact of biomass-based diesel on #2 diesel prices in the short to medium run varies from year to year ranging from a decline of 8 percent to nearly 16 percent.

The table also shows the impact from US production only. If only the United States had produced biomass-based diesel, diesel prices would have declined between 1 and 3 percent across the estimation period.

Using Dahl's elasticities, world #2 diesel consumption, and world biomass-based diesel production, the impact on global #2 diesel prices varies from -$0.19 to -$0.42 per gallon depending on the price of #2 diesel, the quantity of biomass-based diesel produced, and the quantity of distillate fuel oil consumed.

Analysis of the Impact of Biomass Based Diesel Production on Diesel Fuel Prices

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	billion gallons										
Distillate fuel oil and biodiesel used by the transportion sector*											
World	255.3	264.2	271.3	275.0	286.2	294.9	299.7	308.0	313.3	318.9	332.7
United States	42.1	43.3	41.5	42.6	44.5	45.2	44.9	48.3	48.9	50.3	51.3
Biomassed based diesel consumption*											
Methyl Ester Biodiesel											
World	4.9	6.4	6.5	7.1	8.0	7.2	8.4	8.7	9.7	10.3	10.9
United States	0.3	0.9	0.9	1.4	1.4	1.5	2.1	2.0	1.9	1.8	1.8
Renewable Diesel											
World	0.1	0.2	0.7	0.8	1.1	1.1	1.2	1.3	1.3	1.7	1.5
United States	0.0	0.1	0.1	0.3	0.3	0.4	0.5	0.4	0.5	0.7	0.7
Energy Equivalence with #2 Diesel Fuel***	*ratio*										
Methyl Ester Biodiesel	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Renewable Diesel	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Biomassed Based Diesel Consumption in Diesel Energy Equivalent											
Methyl Ester Biodiesel	*billion gallons*										
World	4.57	5.91	6.00	6.61	7.41	6.73	7.79	8.13	9.00	9.58	10.15
United States	0.24	0.81	0.84	1.33	1.32	1.39	1.92	1.82	1.76	1.67	1.66
Renewable Diesel											
World	0.10	0.17	0.70	0.79	1.07	1.10	1.17	1.33	1.30	1.71	1.55
United States	0.01	0.08	0.08	0.32	0.28	0.38	0.46	0.45	0.48	0.75	0.74
	ratio										
Global Short to Medium Diesel Alternative Price Elasticities****	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23	-0.23
Biomass Based Diesel Impact on Diesel Fuel Prices	*percent*										
Total global biomass based diesel production	-8.05%	-10.12%	-10.87%	-11.84%	-13.04%	-11.70%	-13.16%	-13.52%	-14.48%	-15.57%	-15.47%
From only US biomass based diesel production	-0.43%	-1.49%	-1.48%	-2.64%	-2.46%	-2.64%	-3.50%	-3.24%	-3.15%	-3.34%	-3.18%
	US dollars per gallon										
Without Biomass Based Diesel (counter factual)											
Wholesale (Refiner Sales Price)	2.41	3.38	3.49	3.44	3.25	1.89	1.59	1.96	2.49	2.32	1.52
Retail	3.19	4.18	4.35	4.33	4.25	2.93	2.51	2.91	3.54	3.42	2.84
With Biomass Based Diesel (Actual)***											
Wholesale (Refiner Sales Price)	2.22	3.04	3.11	3.03	2.82	1.67	1.38	1.69	2.13	1.96	1.29
Retail	2.99	3.84	3.97	3.92	3.83	2.71	2.30	2.65	3.18	3.06	2.61
Price Increase without biomass based diesel											
Wholesale (Refiner Sales Price)	0.19	0.34	0.38	0.41	0.42	0.22	0.21	0.26	0.36	0.36	0.24
Retail	0.19	0.34	0.38	0.41	0.42	0.22	0.21	0.26	0.36	0.36	0.24

*Source: US Department of Energy, Energy Information Administration - International Energy Outlook 2019, Transportation sector energy consumption by region and fuel

** Sources: International data complied from various USDA Gain country reports compiled from 2010 to 2020, Eurostat, and US methyl ester data based on Energy Information Administration monthly reports and renewable diesel estimates from the US EPA's EMTS.

*** Source: Based on EIA Conversions and the Alternative Fuels Data Center - Fuel Properties Comparison.

**** Source: Author calculations based on Carol A. Dahl's article entitled, "Measuring global gasoline and diesel price and income elasticities", Energy Policy, Volume 41, February 2012.

***** Source: US Department of Energy, Energy Information Administration, Monthly Energy Review, September 2020.