OIL REFINING IN A CO$_2$ CONSTRAINED WORLD: IMPLICATIONS FOR TRANSPORT POLICYMAKING.

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Overview

The world is experiencing an energy conundrum. On the one hand, population growth, economic progression and increased affordability are driving the need for larger quantities of inexpensive energy sources. But on the other hand, concerns over changes in global climate, as well as initiatives to boost energy security and domestic economies, are forcing policymakers to intervene to shift and diversify the supply of energy sources, and reduce consumption through efficiency gains.

Today, the transport sector consumes more than 50% of global oil production. Oil currently accounts for more than 90% of the sector's overall energy needs. An average oil refinery today produces about 14% more diesel fuel than gasoline as demand is slightly skewed toward the commercial nonpassenger transport sector. The push toward greater efficiency, coupled with transport electrification and the rise in biofuels mandates worldwide, will largely affect the passenger transport sector. These factors are projected to gradually lead to a more severe shift in demand favoring diesel over gasoline.

This presentation explores the CO$_2$ emissions performance of diesel versus gasoline from a refining standpoint by drawing implications from a recently published work that investigated the effects of carbon pricing on refinery operations globally [1].

Methods

Linear programming (LP) models were developed to represent the refining systems in six geographical regions, consisting of North America, Latin America, Europe, Middle East, Asia (excluding China), and China. China was modelled separately given the size of their refining industry and the relative importance of their market in understanding the future of sustainable mobility. The models were subsequently calibrated to meet actual production in these regions in 2014 based on detailed market intelligence on actual refinery and process unit capacities in each region. Refinery CO$_2$ emissions were estimated from fuel gas combustion, utility consumption, hydrogen production, and the burning of coke in the FCC units. These were incorporated in the regional models as byproducts of refinery operations. By imposing a price on refinery CO$_2$, the LP models internalize the cost of emissions; and, therefore, the optimal production plans effectively reflect refinery operations in a CO$_2$ constrained environment.

Results and Discussion

The study has shown that by adopting a typical lifecycle assessment (LCA) approach, gasoline manufacturing would account for larger CO$_2$ emissions than diesel given that gasoline is composed of streams that have gone through energy intensive processes within the refinery. This is consistently reflected by many LCA studies to date, some of which underpin regulatory measures that favor dieselization. On the contrary, this study also shows that in a world that internalizes the cost of CO$_2$ emissions, refineries would favor gasoline over diesel production, which is counter intuitive given the earlier finding (Figure 1). A key contributing factor is the refinery hydrogen balance. The shift towards more gasoline allows for the co-production of hydrogen from the reforming unit and therefore reduces the need for on-purpose hydrogen production via steam methane reforming of natural gas, which is more CO$_2$ intensive. The typical LCA practice of modelling a snapshot of refinery operation today, also known as attributional LCA, is less useful for understanding the consequences of policy actions. The approach that has been taken in this study is effectively a consequential LCA method, which provides better insights to guide policymaking.
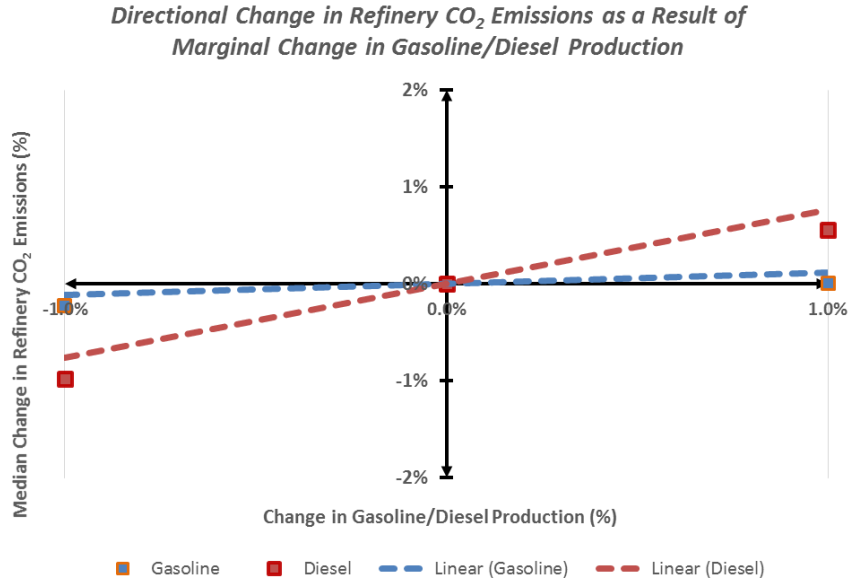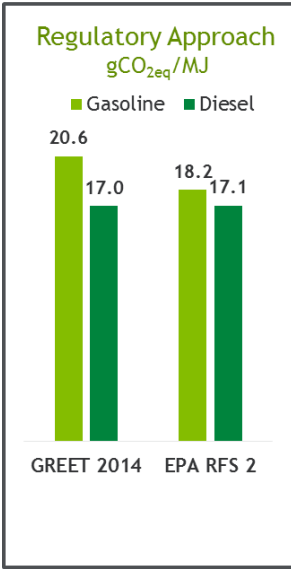
Figure 1. The relative CO_2 values of gasoline and diesel depends on the methodological approach [1].

Conclusion

This study highlights that, on the one hand, the global shift toward transport dieselization can lead to greater refinery CO_2 emissions. But on the other hand, because diesel compression ignition engines are inherently more efficient than a gasoline spark ignition engine, transport dieselization can help reduce the impact of the transport sector on global greenhouse (GHG) emissions. This paper proposes that an optimum fuel and engine combination is the use of gasoline-like fuel in an efficient compression-ignition engine (Figure 2). Policymakers must treat fuels and engines as an integrated entity to enable greater transport emissions reduction. This would allow for an optimal well-to-wheels solution and prevent emissions leakages between the different sectors.
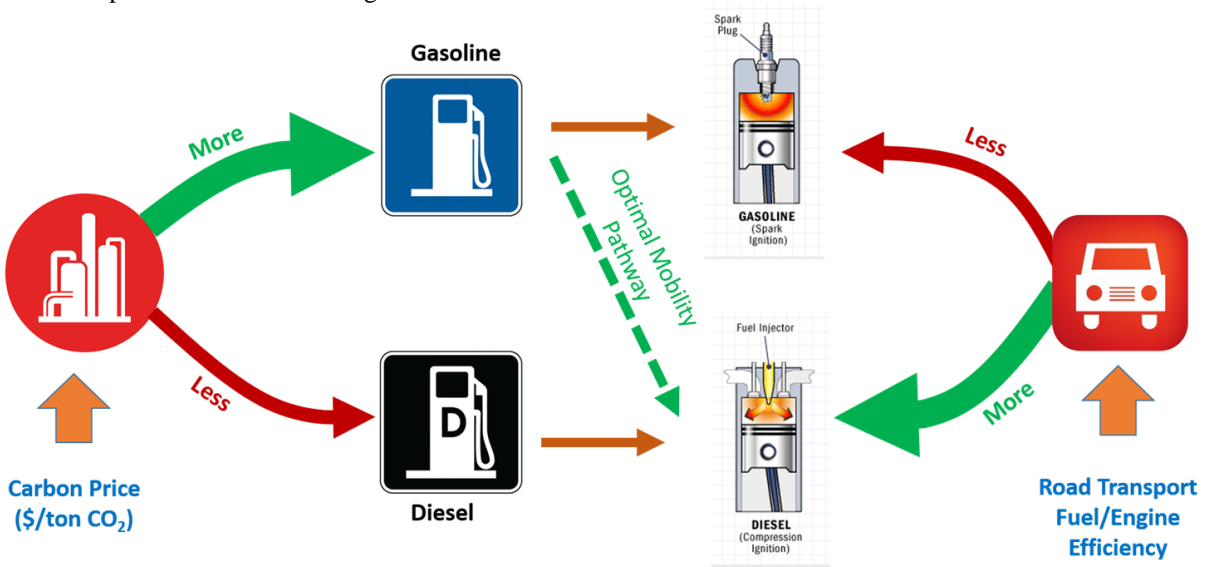

Figure 2. The use of gasoline-like fuel in a diesel-like compression-ignition engine can enable greater well-to-wheels emissions reduction.

References

[1] A. F. Abdul-Manan, A. Arfaj and H. Babiker, "Oil refining in a CO2 constrained world: Effects of carbon pricing on refineries globally," Energy, vol. 121, pp. 264-275, 2017.