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Continued Improvements in Gasoline Sulfur and Octane to Meet Tighter Fuel Efficiency Standards

Stratas Advisors

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Gasoline remains an important fuel for the on-road sector, particularly in 2- and 3-wheelers, passenger cars, vans and light trucks, especially in developing regions. Stratas Advisors observes that sulfur reduction and octane enhancement continue to be the two most dominant gasoline fuel quality issues being considered by governments and stakeholders globally. Emerging markets are in the process of lowering sulfur content in gasoline to reach the 10 ppm level achieved by mature nations in Europe, North America, Japan and others. However, Stratas Advisors expects continued delays in the implementation of lower sulfur gasoline.

Furthermore, Stratas Advisors observes more regulations and industry proposals calling for lower octane gasoline grades to be phased out and replaced with higher octane gasoline. Several options to meet or boost octane requirements are available where MTBE and ethanol remain as popular choices. Three case studies are presented in the full report for Ecuador, Greece/Bulgaria and Indonesia discussing challenges with moving to higher octane gasoline in Ecuador and Indonesia, as well as increasing risks for gasoline adulteration with low-octane solvents in Greece amidst current high oil prices. This year's report includes a section on water contamination, where a case study on Libya discusses recent claims on gasoline adulteration with water, which is likely a result of fuel smuggling although the source is not known.

In analyzing the trends occurring in local, regional and global gasoline fuel quality, Stratas Advisors selected the world's top 10 gasoline markets for comparative analysis. The top 20 countries, by gasoline market size, are shown in the figure below.

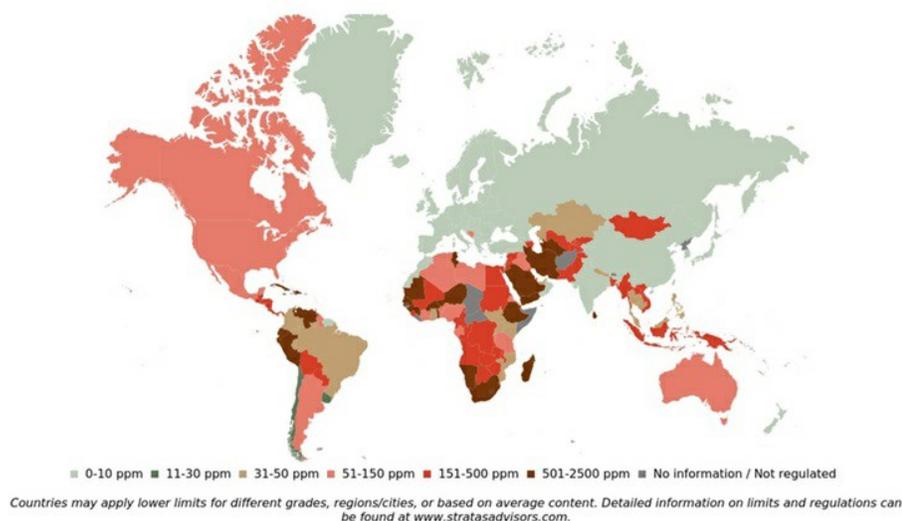
Top 20 Gasoline Markets

Sulfur

Current maximum gasoline sulfur limits worldwide still vary widely from 10 ppm to 2,500 ppm (see map below). For several

countries, gasoline sulfur reductions to either 50 ppm or 10 ppm are expected within the next five years. In 2022, a total of eight countries and one sub-region plan to reduce gasoline sulfur content nationwide to 50 ppm and below or import lower sulfur gasoline. So far, three of them have implemented sulfur reductions from January 2022 including Morocco, Colombia, as well as Uzbekistan requiring the import of lower sulfur fuels.

Maximum Gasoline Sulfur Limits, 2022



Source: *Stratas Advisors, April 2022*

Octane and Fuel Efficiency

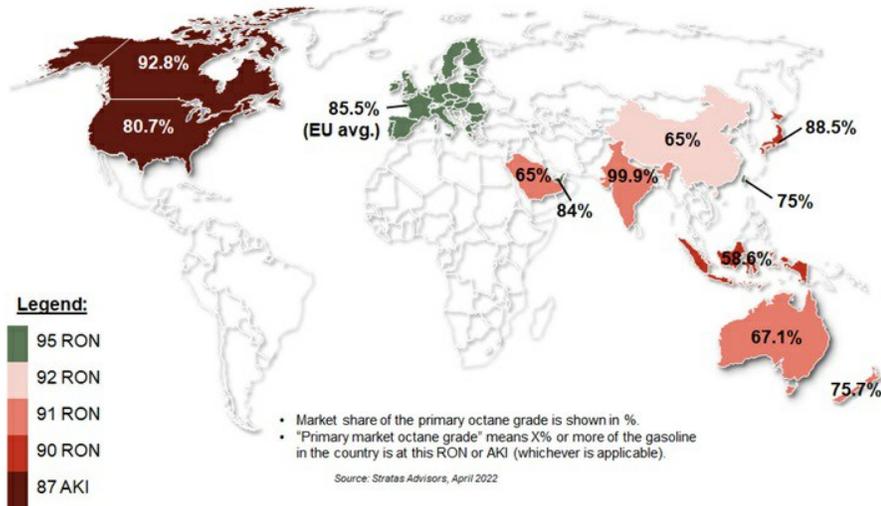
Several countries are setting stricter targets for vehicle fuel efficiency between 2022 and 2025. Developed regions, countries and territories such as the U.S., EU, Japan, Canada, South Korea and Taiwan have already set stringent mandatory targets primarily set in line with overall CO2 reduction targets. Other countries are aiming to follow their footsteps to reduce dependence on gasoline consumption such as India and Indonesia. Among the Top 10 gasoline markets, only Iran and Russia have yet to set mandatory targets for improving their vehicle fuel efficiency.

Most of the countries with fuel economy targets already set national requirements for gasoline with current sulfur of 50 ppm and below, except for Australia, Indonesia and Saudi Arabia. Saudi Arabia and Australia will reduce sulfur to 10 ppm by 2022 and 2027 (or 2024 at the earliest) respectively, while Indonesia plans to reduce sulfur to 50 ppm over 2021-2024 and further to 10 ppm in 2025. On the other hand, octane requirements will remain the same for most countries. As shown in the figure below, our initial analysis suggests that gasoline octane levels may not be sufficient to meet automaker needs to improve fuel economy in the coming years, as market octane levels continue to remain below RON 95 outside of Europe, and at AKI 87 in the Americas.

Primary Market Octane Grade in Countries Expecting Fuel Economy Changes

Primary Market Octane Grade in Countries Expecting Fuel Economy Changes

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Source: Stratas Advisors, April 2022

Case Study: Greece/Bulgaria

Fuel smuggling and adulteration appear to be a widespread cross-border phenomenon between Greece and Bulgaria, involving illegal networks of smugglers importing fuel and solvents from Bulgaria through ghost companies, as well as at fuel pumps in various regions of Greece. The existence of such schemes is well documented by a series of judicial inquiries. For instance, several police raids that took place in recent years led to similar outcomes, showing a common pattern as demonstrated by the following table:

Summary of Fuel Smuggling and Adulteration Cases in Greece

Date	Incident
Feb. 5, 2022	A police raid in Northern Greece led to the arrest of nine people and the seizure of 29,301.5 liters of solvents, a tanker truck, tanks and other equipment.
Nov. 9, 2021	26,100 liters of uncertified fuels, a tanker, as well as tanks and various equipment used for mixing fuel and solvents were seized. Six people were arrested.
Sept. 25, 2021	A truck was seized carrying 30 tons of gasoline from Bulgaria to Greece.
January 2021	A tanker was seized carrying a blend of light oils and ethanol also known as "Designer Fuel Oil" (described in details below). Within the same operation, raids took place in the premises of two ghost companies, which imported 151,219 liters and 390,000 liters of chemical solvents respectively from July 2020 to January 2021.

Nov. 11, 2019	A smuggling ring of as many as 47 people and serving 20 fuel stations was dismantled. 20 people were arrested. 24 tons of solvents due to be mixed with gasoline were found and seized. Empty tanks, vehicles, cash money and various equipment were also seized.
Dec. 22, 2018	Two trucks along with a total of 35 vats containing 1,000 liters of chemical solvents were seized.
May 23, 2017	A tanker was seized with 18 tons of adulterants at a fuel station. The driver was arrested.
March 22, 2017	A total of 53,180 liters of solvent mixture, 11 bottles full of LPG with a total quantity of 8,294 kg, 2 tankers loaded with LPG with a total quantity of 6,870 kg and 4 tankers were found and confiscated. Five people were arrested in a warehouse upon completion of the transfusion of a mixture of solvents.

Source: Hellenic Police, Ministry of Public Order & Citizen Protection

Investigators and experts view these incidents as indicators of the existence of a much broader and endemic phenomenon, which has been difficult to address due to the involved parties' unwillingness to cooperate with the inquirers. The incidents documented so far show a clear pattern: fuel and solvents have been traded from Bulgaria to Greece (often transiting through North Macedonia) using ghost companies registered in both countries, with fictitious addresses and no real commercial activity. Each of these companies ceases to exist after a few months, to be replaced by a newly created entity following the same modus operandi. Some of these entities are known to have imported to Greece hundreds of thousands of liters of solvent throughout their short lifespan.

The products brought into Greece are then mixed, sometimes directly at retail stations, and sold at the pump as gasoline. Details available on the type of solvents seized by the authorities is limited. Paint solvents and low-octane solvents are known to have been found in the past, but it seems that smuggling and adulteration schemes in Greece have recently at least partly switched to a "smart" formula. It consists of a blend of regular gasoline, light oils and 30-40% ethanol, while Greece's current fuel specifications only allow up to 10 vol% ethanol in gasoline. This formula, also known as "*Designer Fuel Oil*", has a RON of 97 and is not likely to be detected by consumers at the pump due to equivalent performance to regular gasoline. Greek authorities have claimed that adulterant samples seized by them may be mixed in such a way to become undetectable even for laboratories.

As adulterated fuel may be sold as standard gasoline at the pump at a lower-than-average price, consumers could expose themselves to fraud and possible engine damage due to the use of nonstandard fuel. Depending on their composition and on the type of solvents used, certain adulterated fuels may cause irreversible damage to the engine. Fuel smuggling and adulteration also inflict considerable losses to public finances in the form of evaded taxes and duties.

Looking at the "smart" formula, in January 2021, it was estimated to cost EUR 0.10-0.20 (US\$0.11-0.21) per liter, thus potentially generating enormous revenues for adulterators, when considering evasion of taxes and duties and if compared

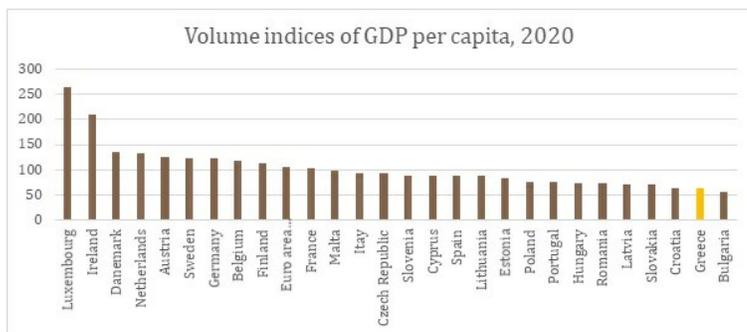
with the much higher wholesale price of gasoline. Fuel prices have been considerably rising in general since the second half of 2021, with a heavy impact on Greece, which already hosted one of the most expensive retail markets in Europe for gasoline and other fuels. As shown in the first figure below, gasoline prices in Greece were among the highest in the EU. At the same time, the relative purchasing power of the average consumer is estimated to be the second lowest in the EU, as reported by Eurostat (see second figure below). It is worth remembering that the overall macroeconomic situation continues to show the impact from the heavy toll taken by the 2008 financial crisis and the subsequent Greek debt crisis.

Comparison of Gasoline Prices in Greece vs. EU-27 (EUR/l), March 21, 2022



Source: <https://www.globalpetrolprices.com/>

Comparison of Volume Indices of GDP per Capita in Greece vs. EU-27, 2020



Source: Eurostat

Considering this data, a number of retailers, especially the smaller independent operators, might feel tempted to become accomplices of such frauds as a way to increase sales and revenues. This may further drive consumers to purchase gasoline below market prices from unreliable sources regardless of the risks.

Given the circumstances explained above, further exacerbated by continuously rising fuel prices in the past few months, Stratas Advisors expects the risk for fuel adulteration and other fuel frauds to increase in Greece, as well as in other countries experiencing similar situations. If the current energy crisis protracts itself for a longer period and measures taken

by the authorities to contain prices at the pump are insufficient, it is possible that the demand for cheaper fuels might increase, thus increasing the risk of fuel adulteration schemes spreading even further.

The full report examines key developments in gasoline quality including Stratas Advisors' outlook for future specification changes, and updates a previous report (see Insights, [May 27, 2021](#)). Although this report primarily focuses on developments and issues regarding sulfur and octane because of the legislative or regulatory developments occurring globally for them, other properties such as benzene, aromatics and olefins are important in determining gasoline quality as well as influencing the composition of emissions. However, there is lesser legislative or regulatory activity for these parameters at this time. The full report also summarizes recent developments in vehicle emissions and provides a technology outlook for vehicles running on gasoline including light-duty vehicles (LDVs). It is now common knowledge that maximum benefits will be achieved when fuel quality requirements are implemented together with stringent vehicle emissions requirements, which would in turn help countries or regions achieve their air quality targets and enable advanced emission control technologies on vehicles. The report shows that governments in some countries have taken this systems approach, particularly when it comes to sulfur reduction, but others either have not or have not been able to do so in a coordinated timeline, hampered by such factors as refinery modernization costs.

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