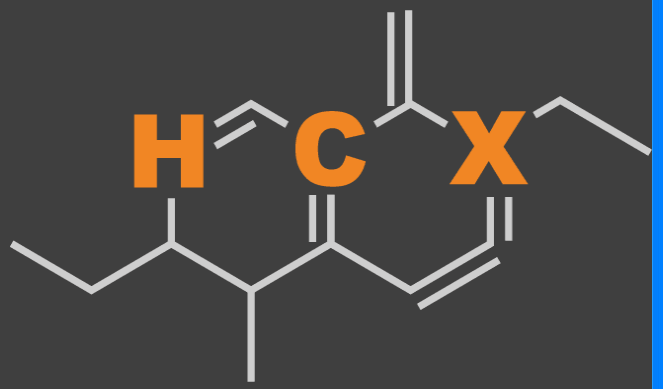


FARO90

Ethanol Blending in Gasoline - Bolivia

June, 2023

Ethanol Blending in Latin America

There are important fuel quality and environmental impact of vehicle emission challanges in the Region.

- The use of ethanol improves gasoline quality and creates flexibility in gasoline production.
- Ethanol use is a cost-effective way to increase gasoline octane and to replace more expensive gasoline components.
- Ethanol contributes to transport decarbonization and air quality improvement.
- There are opportunities across Latin America to increase the ethanol blend level and implement new policies on the use of gasoline-ethanol blends.

Sixteen countries with potential and additional use of ethanol were studied: 1) gasoline market profiles; 2) Optimization of gasoline blends with ethanol and 3) Environmental impact of gasolines blended with ethanol.

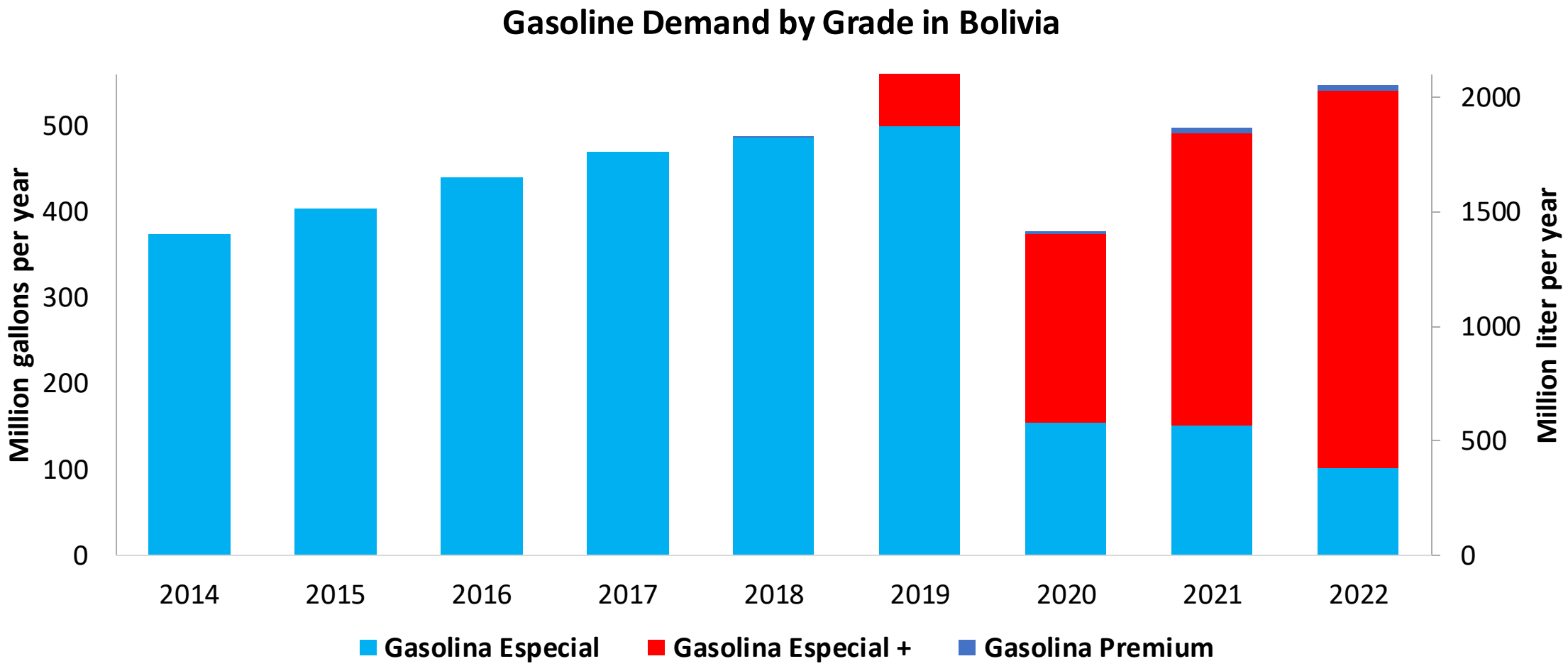
Ethanol Blending in Gasoline - Bolivia

In 2022, gasoline demand was 526 million gallons (2,000 million liters). Gasoline Imports represented 38.4% of current demand,supplied from Brazil, Chile, Argentina, and the United States. Regular Gasoline (Especial) with 85 RON Octane represented 96% of demand and Premium Gasoline with a 95 RON octane the rest. In the short term, new intermediate octane gasolines will be available in the market.

80% of gasoline demand contains ethanol. Gasoline E8 and E12 are currently marketed. All ethanol consumed in Bolivia is produced by five local companies: Azúcar Aguaí, Unagro, Poplar Capital, Granosol, and Guabirá.

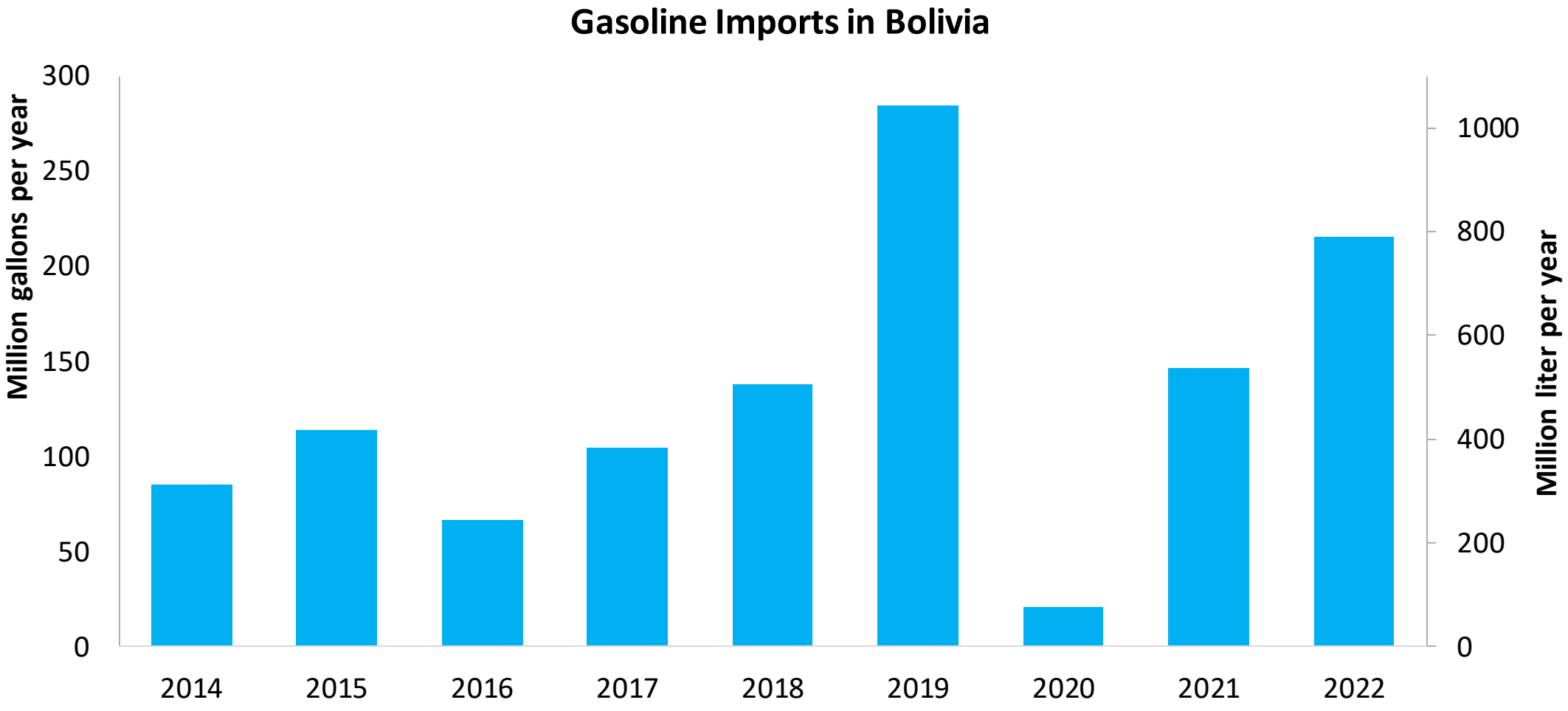
Source: ANH- Bolivia

Gasoline Demand in Bolivia



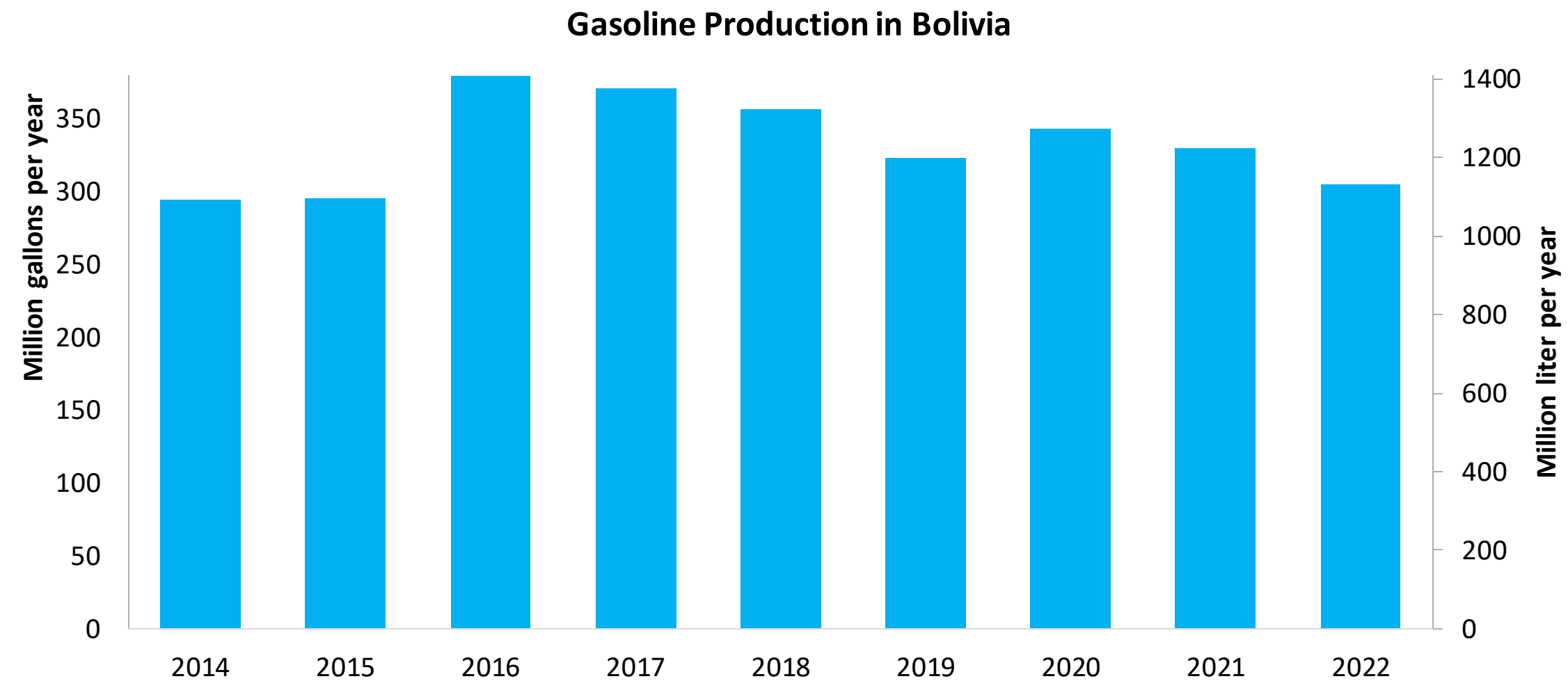
Source: ANH,INE - Bolivia

Gasoline Imports in Bolivia



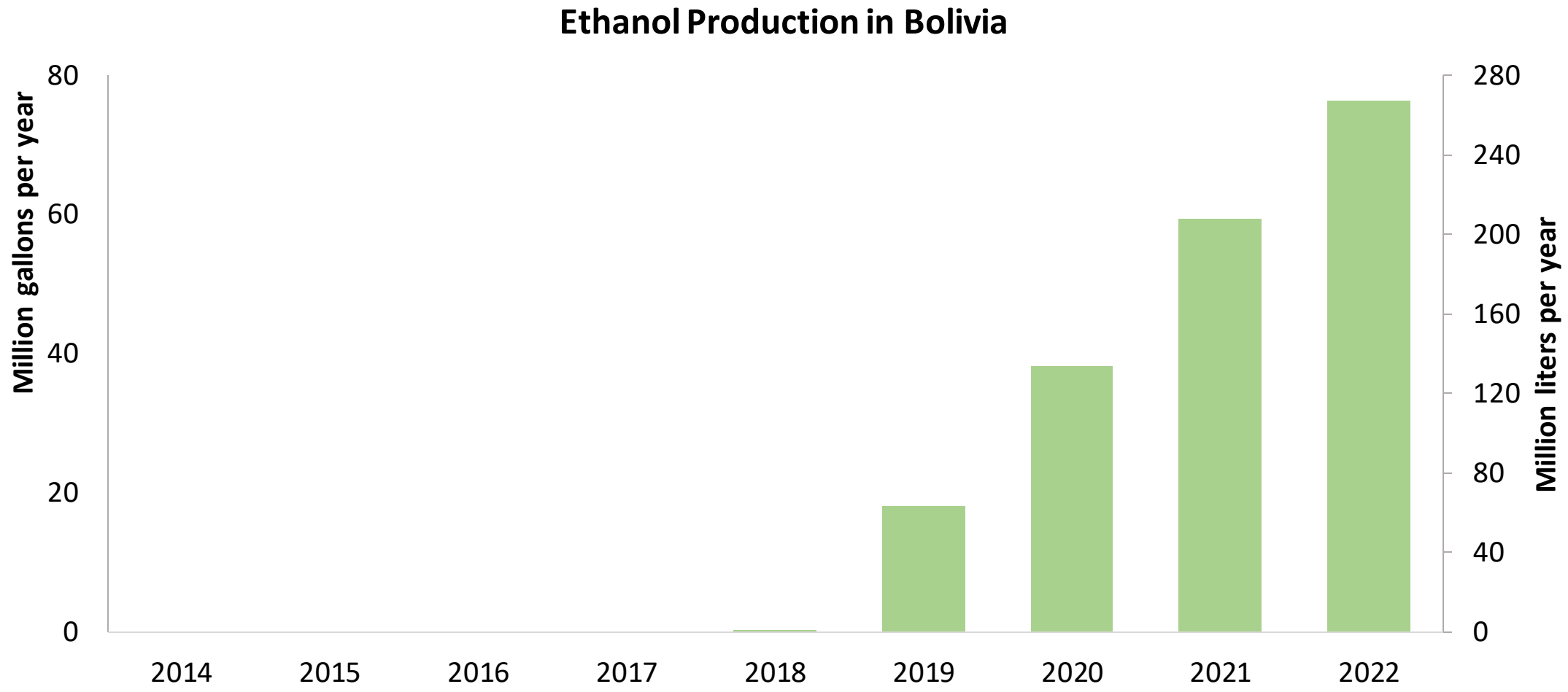
Source: ANH,INE - Bolivia

Gasoline Production in Bolivia



Source: ANH,INE - Bolivia

Ethanol Production in Bolivia



Source: ANH,INE - Bolivia

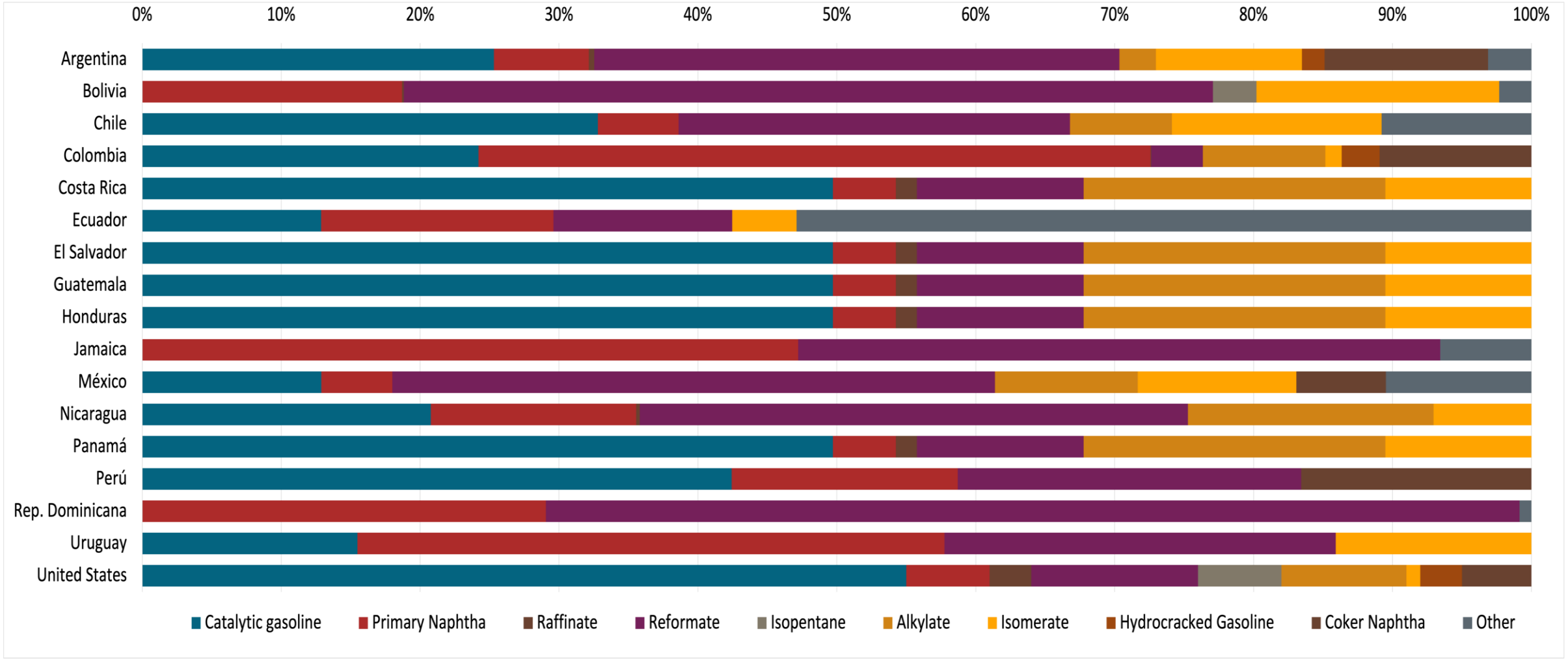
Gasoline Quality in Bolivia

Name	Supreme Decree 2741		Resolution 121-18	Resolution 042-19	EN 228:2012 + A1:2017 (Euro 6 enabling)			
Implementation Date	2016		2018	2019	2017			
Applicability	Whole country	Whole country	Whole country	Whole country	All countries			
Selected Grade	Gasoline Regular	Gasoline Premium	Gasoline for E8	Gasoline for E12	RON 95 E5	RON 95 E10	RON 98 E5	RON 98 E10
Benzene Content	< 3%v/v (2,7%v/v for E12 in summer)	< 3%v/v (2,7%v/v for E12 in summer)	< 3%v/v (2,7%v/v for E12 in summer)	< 3%v/v (2,7%v/v for E12 in summer)	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v
Aromatics	< 42 % v/v	< 48 %v/v	< 42 %v/v	< 42 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v
Olefins	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v
Lead Content	< 0,013 g/l	< 0,013 g/l	< 0,013 g/l	< 0,013 g/l	< 5 mg/l	< 5 mg/l	< 5 mg/l	< 5 mg/l
Manganese	< 18 mg/l	< 18 mg/l	< 18 mg/l	< 18 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l
RON	> 85	> 95	> 85	> 92	> 95	> 95	> 98	> 98
MON	-	-	-	-	> 85	> 88	> 85	> 88
AKI								
Sulfur Content	< 500 mg/kg	< 500 mg/kg	< 500 mg/kg	< 500 mg/kg	< 10 mg/kg	< 10 mg/kg	< 10 mg/kg	< 10 mg/kg
Oxygen Content	< 2,7 %m/m	< 2,7 %m/m	< 2,7 %m/m	< 2,7 %m/m	<2,7 % m/m	<3,7 % m/m	<2,7 % m/m	<3,7 % m/m
Ethanol (EtOH)	-	-	< 8 %v/v	< 12 %v/v	<5 %v/v	<10 %v/v	<5 %v/v	<10 %v/v
RVP 37.8°C (Summer)	<> 48-79 kPa	<> 48-79 kPa	<> 48-79 kPa	<> 48-79 kPa	<> 60 - 70 kPa *Depends on the country, RVP is regulated in the EU Fuel Quality Directive			
RVP 37.8 °C(Winter)								
RVP 37.8°C (Transition)								
MTBE					-	-	-	-
Ehters 5 or more C Atoms	-	-	-	-	Based on oxygen content	<22 %v/v	Based on oxygen content	<22 %v/v

Source: ANH

Gasoline Component Blending in Latin America

Gasoline is a blend of a base gasoline and other components. This blending is usually done at blending terminals as only 30% of the world's finished gasoline is distributed directly from refineries. Each component provides different properties to the final blend, for example, isomerates, alkylates and butanes increase the octane. The components commonly used in Latin America are:



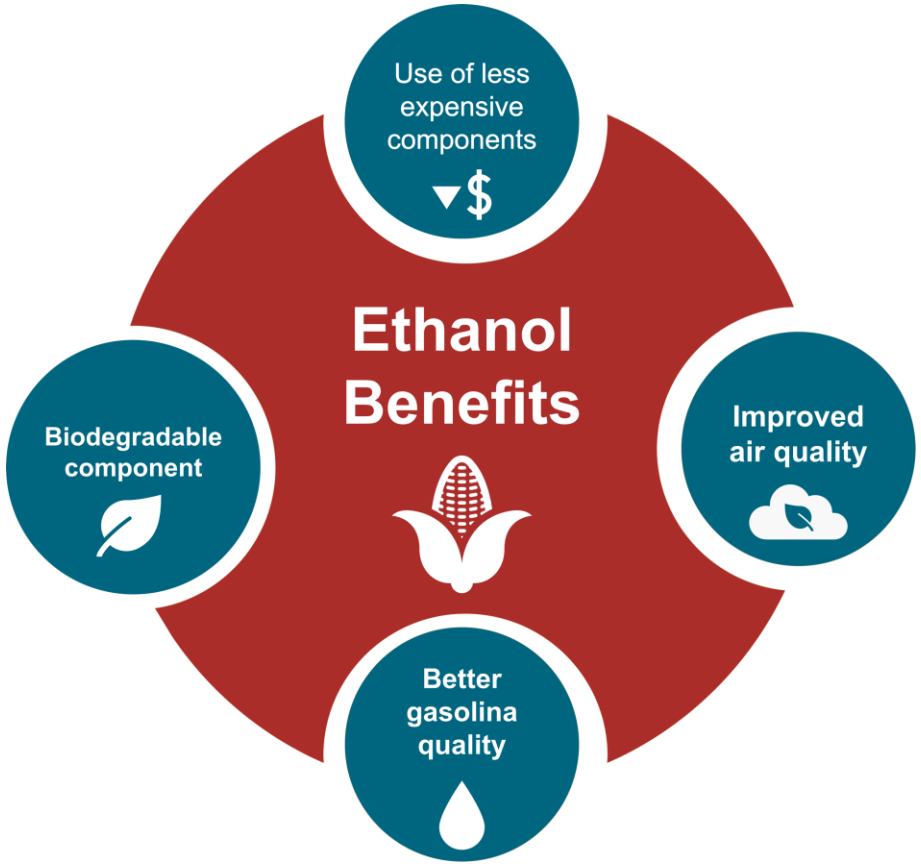
Gasoline Blending Optimization

In some parts of the world, ethanol is added to gasoline as a blending component.The advantages of ethanol include that it is a renewable fuel made of biomass; that it is an octane booster that helps to dilute sulfur; and that it allows the fulfillment of environmental objectives.To determine the optimal components to be blended with ethanol, a **blending model** was used. This model selects the components to add in the gasoline/ethanol blend based on:

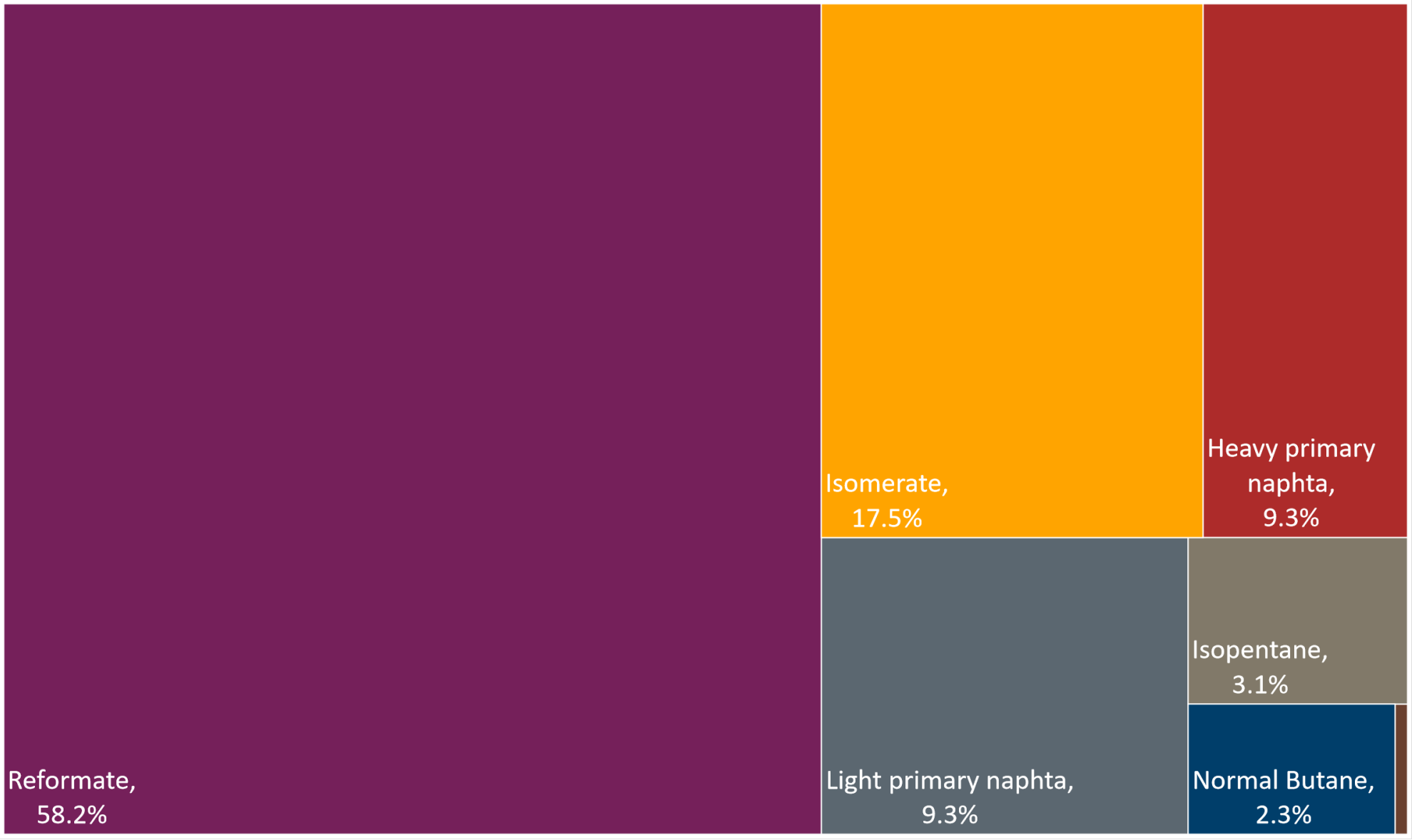
- Components prices,
- Properties each component affects,
- Quality parameters by country, and
- Component availability by country.

Through iterations, the model obtains the %v/v of the components to be blended with 10%, 15%, 20%, 25% and 30% of ethanol, in such a way that the final blend complies with the required properties of a finished gasoline by country.

The blending model uses gasoline component spot average prices January 2022 – February 2023 and provides fuel prices that do not include country distribution costs, local taxes and subsidies and import or gas station margins.

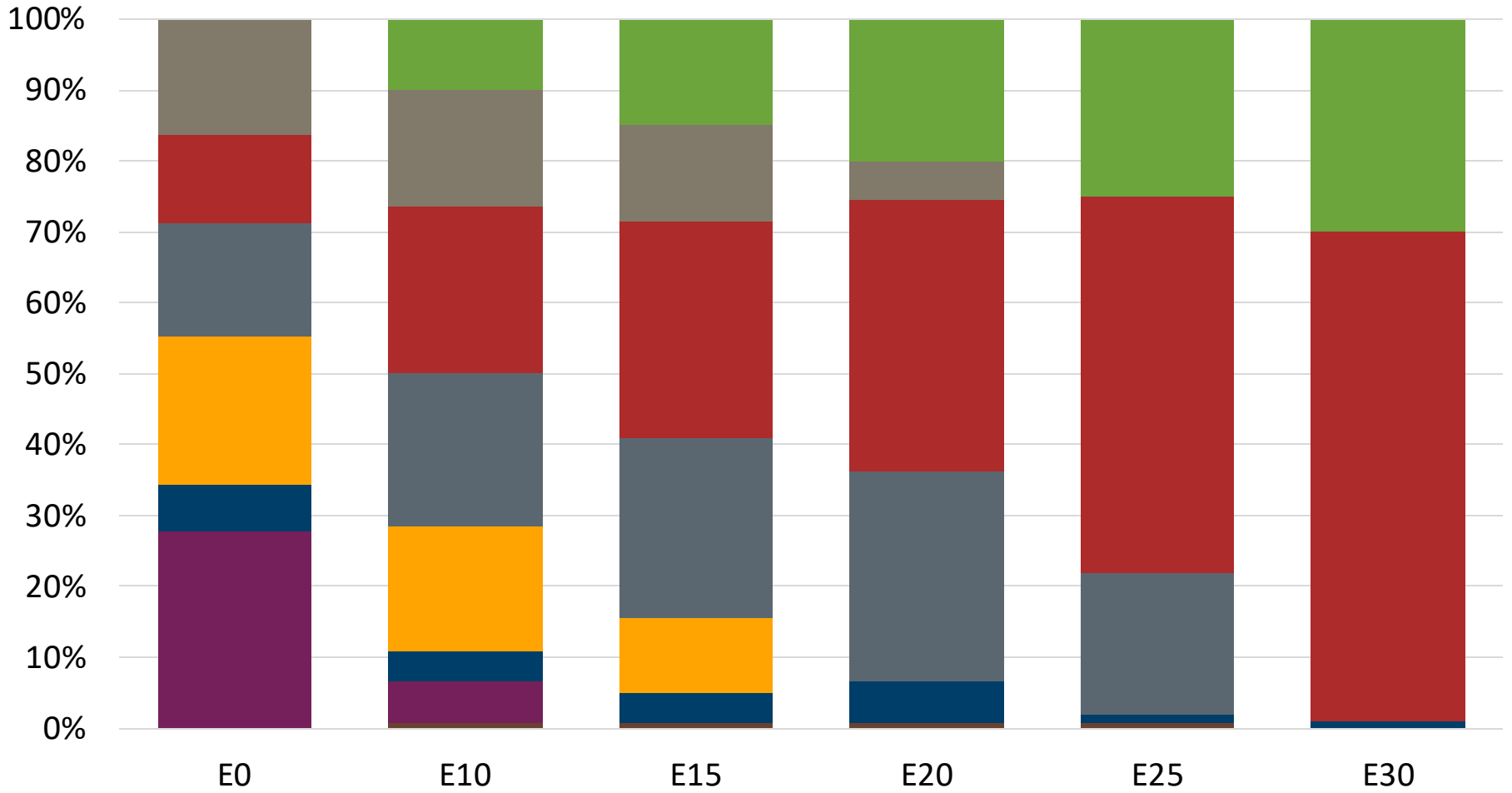


Available Blending Components



Source: Faro90

Ethanol Blending - Gasoline Especial – Constant Octane

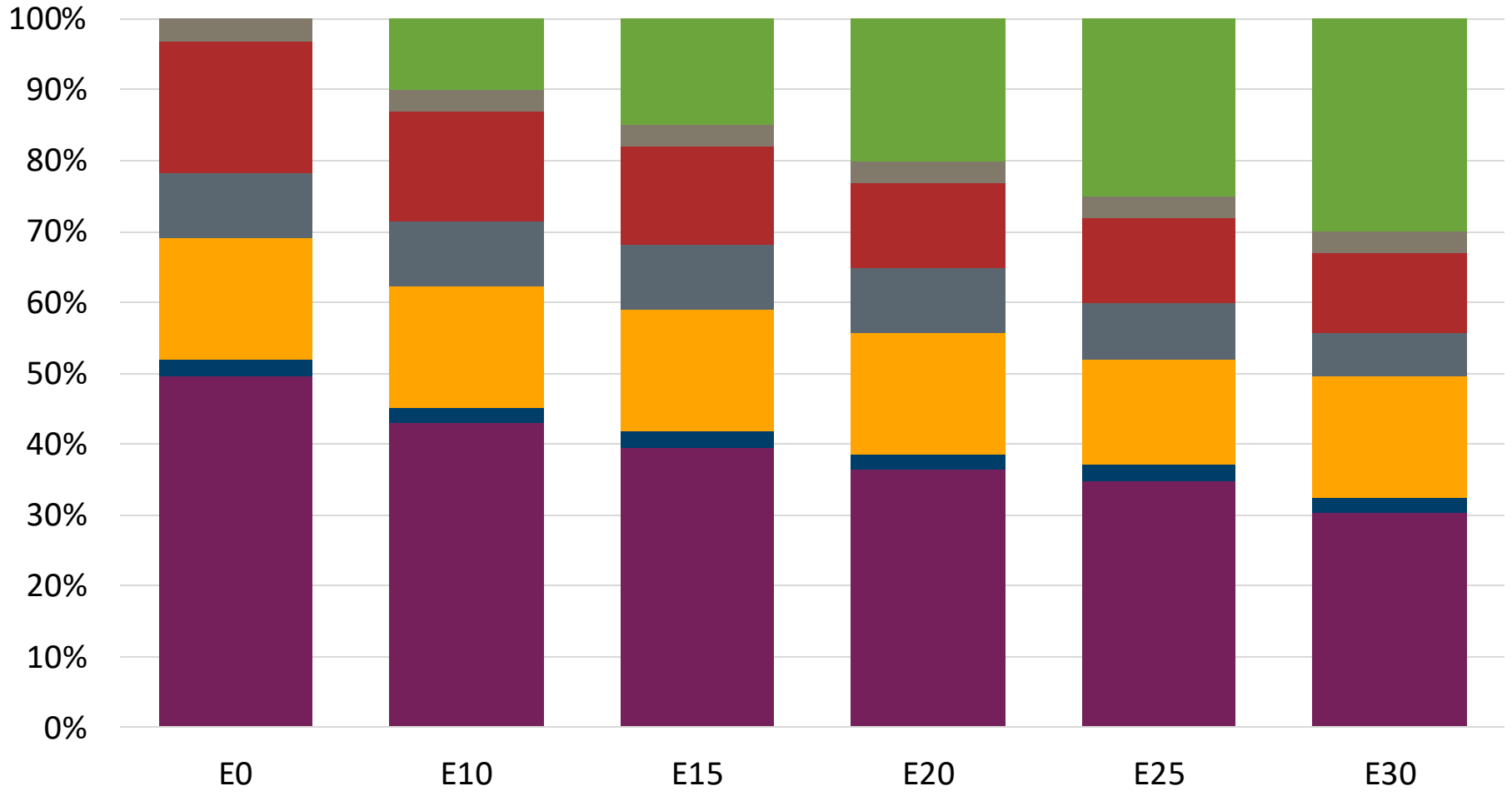


	E0	E10	E15	E20	E25	E30
Octane (RON)	85.0	85.0	85.0	85.0	85.4	87.6
Price (USD/gal)	$2.13	$1.99	$1.92	$1.84	$1.84	$1.80

Prices are average Jan 22 – Feb 23.
They do not include local distribution costs, import or gas station margins, taxes and subsidies.

Source: Faro90

Ethanol Blending - Gasoline Especial – Octane Increment

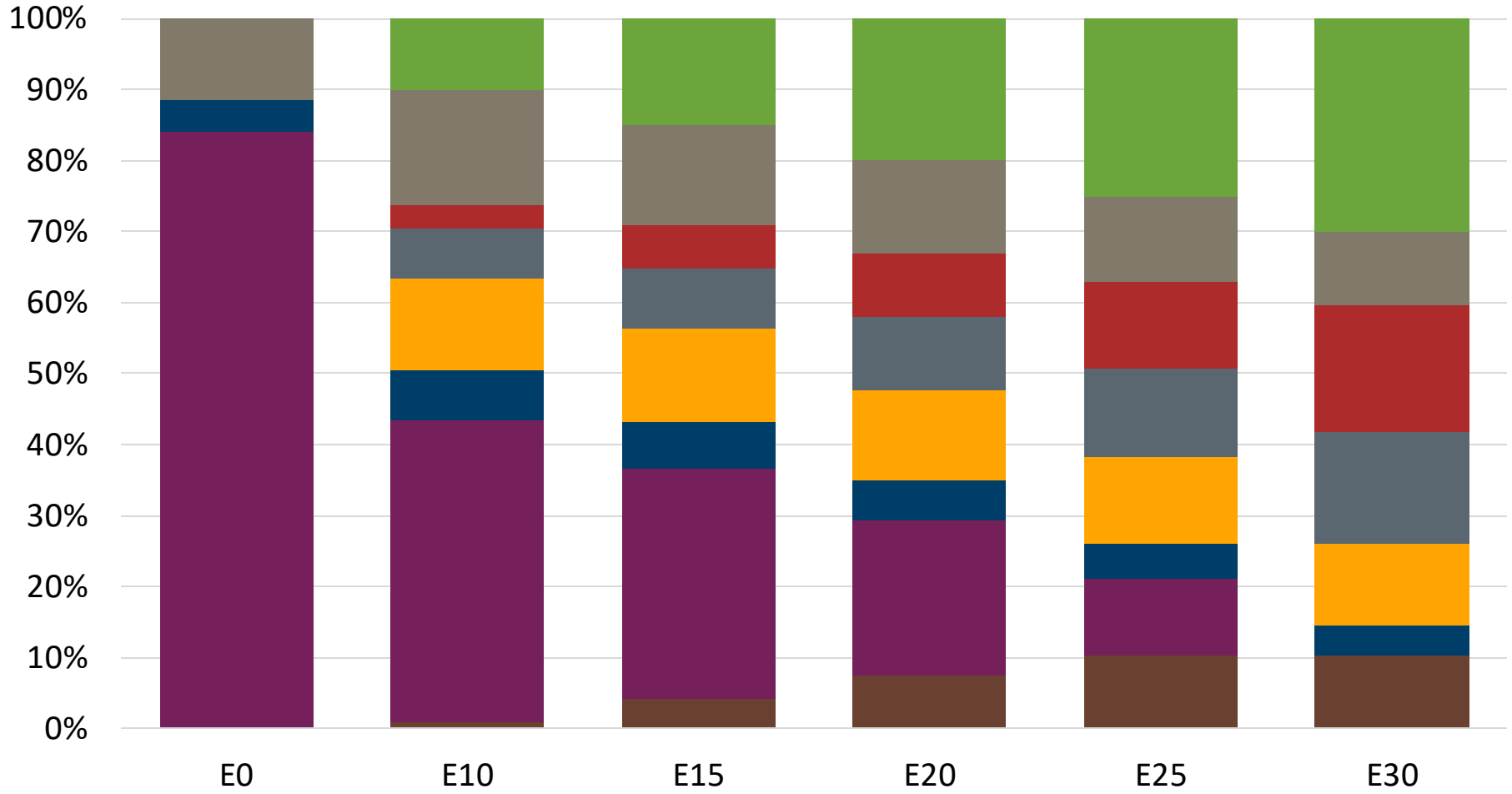


Octane (RON)	85.0	90.9	93.6	96.2	98.5	100.8
Price (USD/gal)	$2.24	$2.24	$2.24	$2.24	$2.24	$2.24

Source: Faro90

Prices are average Jan 22 – Feb 23.
They do not include local distribution costs, import or gas station margins, taxes and subsidies.

Ethanol Blending – Gasoline Premium – Constant Octane

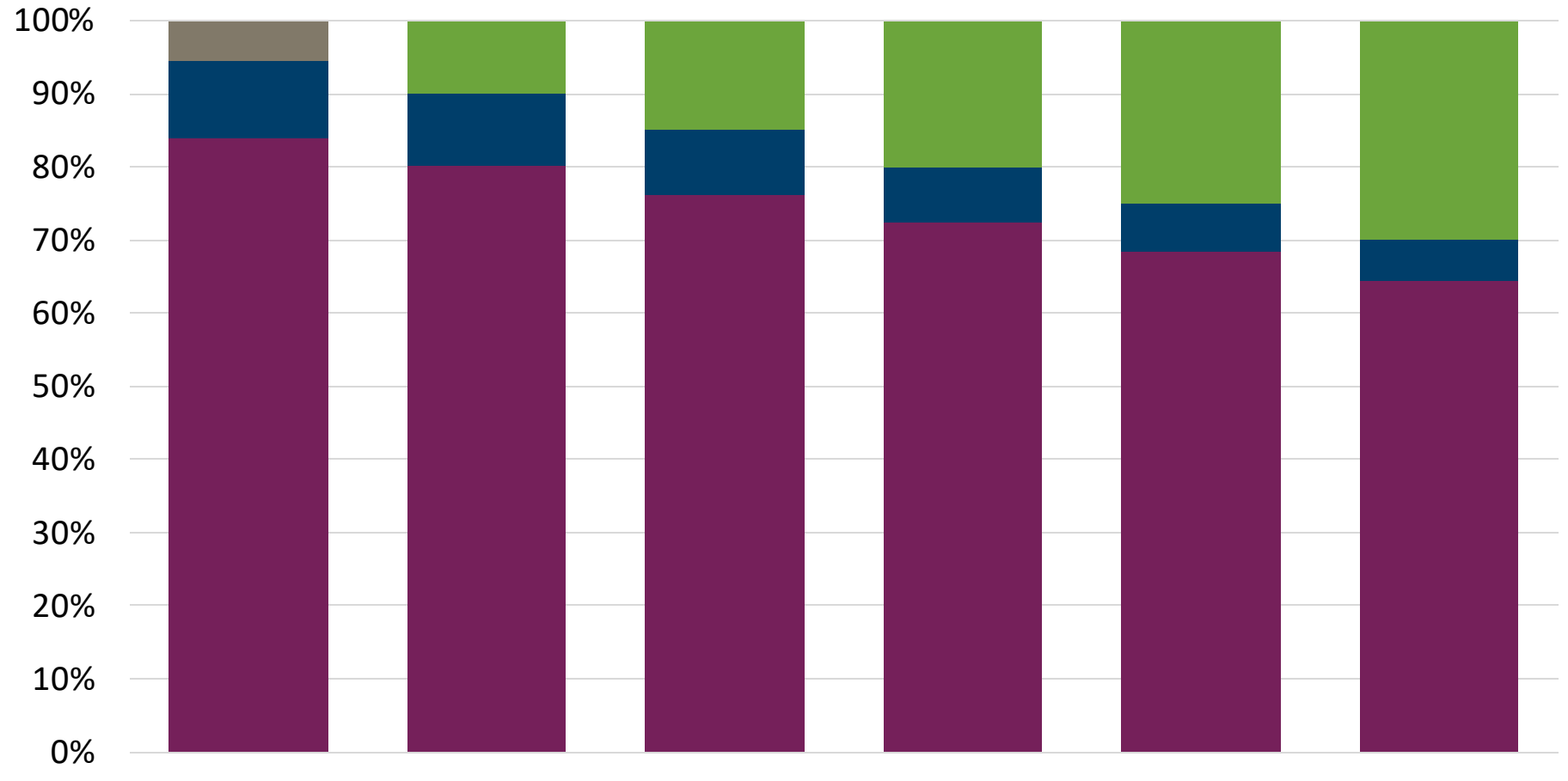


Octane (RON)	94.7	95.0	95.0	95.0	95.0	95.0
Price (USD/gal)	$2.46	$2.25	$2.19	$2.13	$2.06	$1.98

Source: Faro90

Prices are average Jan 22 – Feb 23.
They do not include local distribution costs, import or gas station margins, taxes and subsidies.

Ethanol Blending - Gasoline Premium – Octane Increment



	E0	E10	E15	E20	E25	E30
Octane (RON)	94.7	98.8	100.7	102.5	104.2	105.7
Price (USD/gal)	$2.40	$2.40	$2.40	$2.40	$2.40	$2.40

Source: Faro90

Prices are average Jan 22 – Feb 23.
They do not include local distribution costs, import or gas station margins, taxes and subsidies.

Vehicle Emission Impact for Ethanol Gasoline Blending

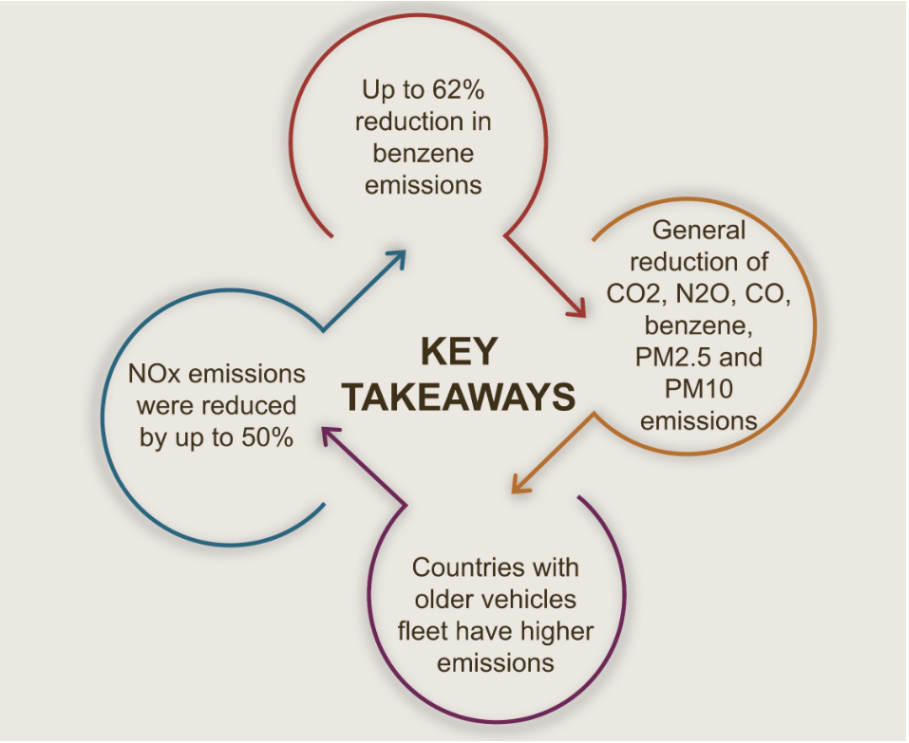
The model used in this analysis takes as a reference the **International Vehicle Emissions Model (IVE).**
The model uses the Base Emission Rates from IVE model, as well as its Adjustment Factors based on:

- Vehicle technology (cars, trucks, buses, motorcycles),
- Vehicle fleet average age,
- Average traveled distance per vehicle by country, as well as
- Geographical and climatic conditions (altitude, humidity, temperature).

Emissions of criteria pollutants, toxic pollutants, and greenhouse gases (GHG) were calculated and calibrated with emission inventories, using real gasoline quality data. The reduction rates for gasoline/ethanol blends were obtained from various sources (IPCC, US Grains, among others).

Emission estimations for different pollutants for gasoline and gasoline/ethanol blends (10%, 15%, 20%, 25% and 30% ethanol) were determined using the IVE Model. A comparison between the results and the European (Euro 6) requirements is made. Results are also compared with real emissions of the United States vehicle fleet*.

Main Results



Source: Bureau of transportation statistics.

Gasoline Vehicle Fleet Bolivia

Type	Motor	Tailpipe	Recuperator	Age	Number of vehicles
Auto/Sml Truck	Multi FI-Pt	Euro V	PCV Tank	>4years, >80 mkm	23.305
				4-8 years, 80-160 mkm	56.910
				<8 years, < 160 mkm	39.735
		Euro IV		<8 years, < 160 mkm	43.590
		Euro III		<8 years, < 160 mkm	24.356
		3-Ways		<8 years, < 160 mkm	289.547
Sml Engine	FI 4-ciclos	Euro III	PCV	>4 years, >80 mkm	124.364
				4-8 years, 80-160 mkm	91.896
		Euro II		4-8 years, 80-160 mkm	91.896
				<8 years, < 160 mkm	484.980
Truck	FI	Euro V	PCV	>4 years, >80 mkm	172.625
				4-8 years, 80-160 mkm	196.541
				<8 years, < 160 mkm	131.399
		Euro IV		<8 years, < 160 mkm	128.552
		Euro III		<8 years, < 160 mkm	122.007
		3-Ways		<8 years, < 160 mkm	270.892

Vehicular Fleet: **2,292,595**
Average Age: **11 years**
Motorcycles: **34.6%**

Source: Instituto Nacional de Estadística – Bolivia (INE), análsis Faro 90

Bolivia – Gasoline Vehicle Emissions

Emissions	E0 g/km	E10 g/km	E15 g/km	E20 g/km	E25 g/km	E30 g/km	E10 - E0	E20 - E0	E30 - E0	Euro 6	TIER USA
CO	34.46	31.89	31.11	30.44	29.97	29.27	-7%	-12%	-15%	1	3.5
VOC	3.02	2.83	2.78	2.75	2.73	2.68	-6%	-9%	-11%	95	255
VOCevap	0.82	0.82	0.83	0.85	0.86	0.88	0%	4%	7%	0.1	0.273
NOx	1.42	1.00	0.94	0.89	0.83	0.76	-30%	-38%	-46%	0.06	0.203
SOx	0.01	0.01	0.01	0.01	0.01	0.01	-15%	-28%	-41%		
NH3	0.05	0.05	0.05	0.05	0.05	0.05	-2%	0%	1%		
Butadiene	0.02	0.02	0.02	0.02	0.02	0.01	-7%	-10%	-13%		
Acetaldehyde	0.03	0.05	0.07	0.10	0.12	0.14	68%	249%	372%		
Formaldehyde	0.12	0.13	0.16	0.16	0.18	0.20	13%	39%	68%		
Benzene	0.16	0.14	0.14	0.14	0.13	0.13	-9%	-11%	-18%		
CO2	449.16	426.70	418.12	413.87	409.98	402.43	-5%	-8%	-10%		
N2O	0.04	0.04	0.04	0.04	0.04	0.04	-1%	2%	4%		
CH4	0.66	0.66	0.67	0.69	0.70	0.71	0%	4%	7%		
PM 2.5	0.04	0.03	0.03	0.02	0.02	0.01	-22%	-43%	-65%		
PM10	0.07	0.05	0.05	0.04	0.03	0.02	-22%	-43%	-65%	0.005	0.007
THC	0.98	1.01	1.06	1.11	1.15	1.19	2%	13%	21%		