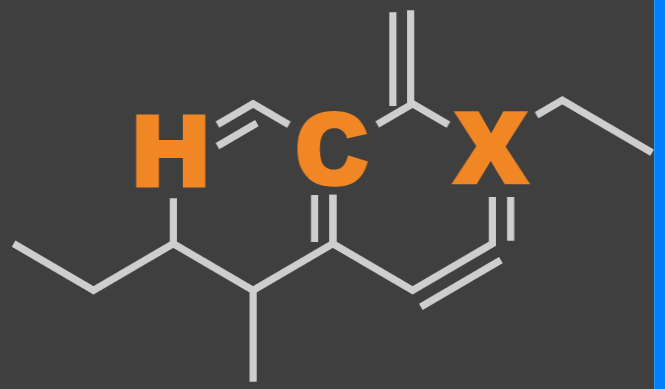


FARO90

Ethanol Blending in Gasoline - Uruguay

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.

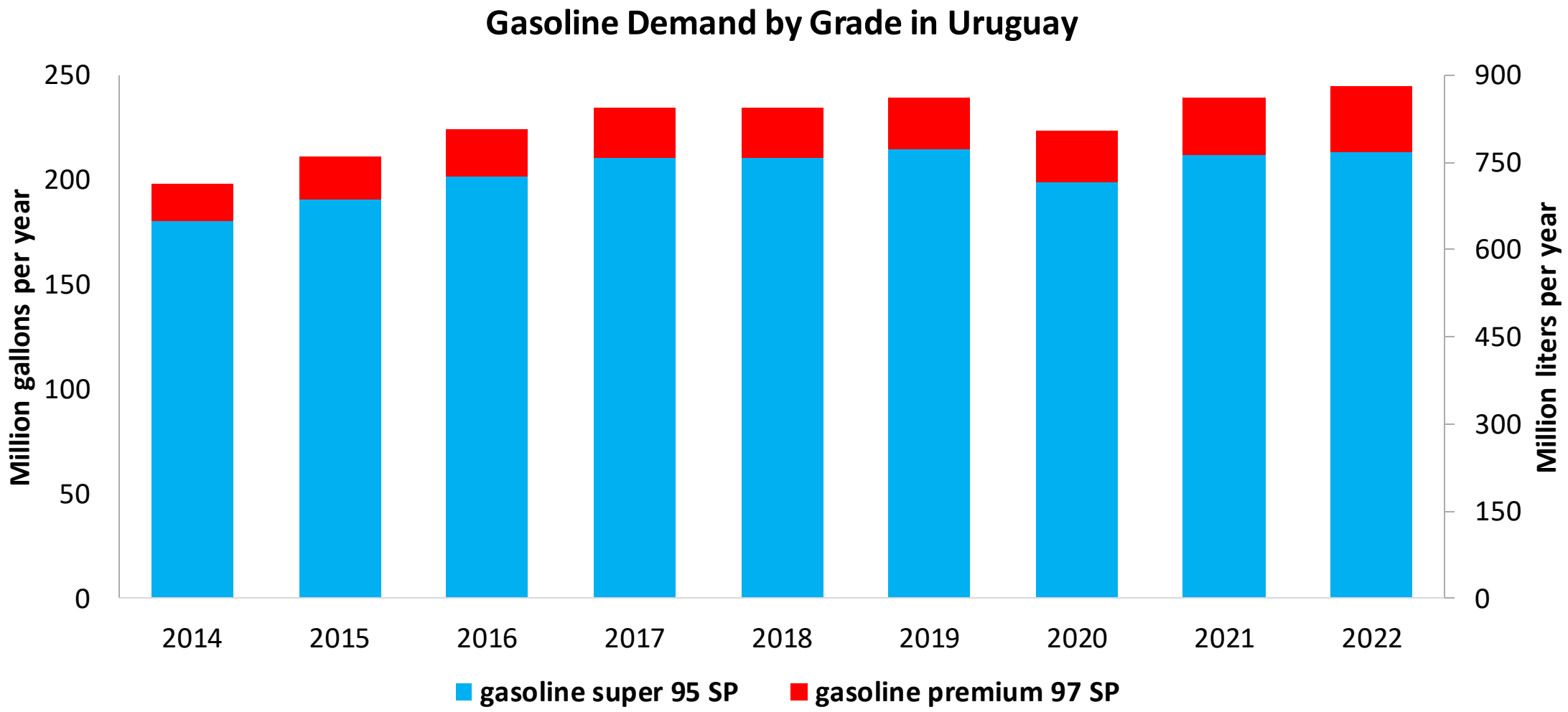
Ethanol Blending in Gasoline - Uruguay

In 2022, gasoline demand was 233 million galons (880 millon liters). Super Gasoline with RON 95 represented 87% of total demand and Premium Gasoline with RON 97 the rest.Gasoline production was 810 million liters and covers almost 100% of local demand.

Since 2015, 5% v/v blends with a maximum limit of 10% v/v were allowed. In Uruguay there are two ethanol plants with an overall capacity of 100 million liters per year, raw material commonly used are sugar cane, sorghum, barley, corn, and wheat. In 2022, ethanol consumption was 22 million gallons (84 million liters).

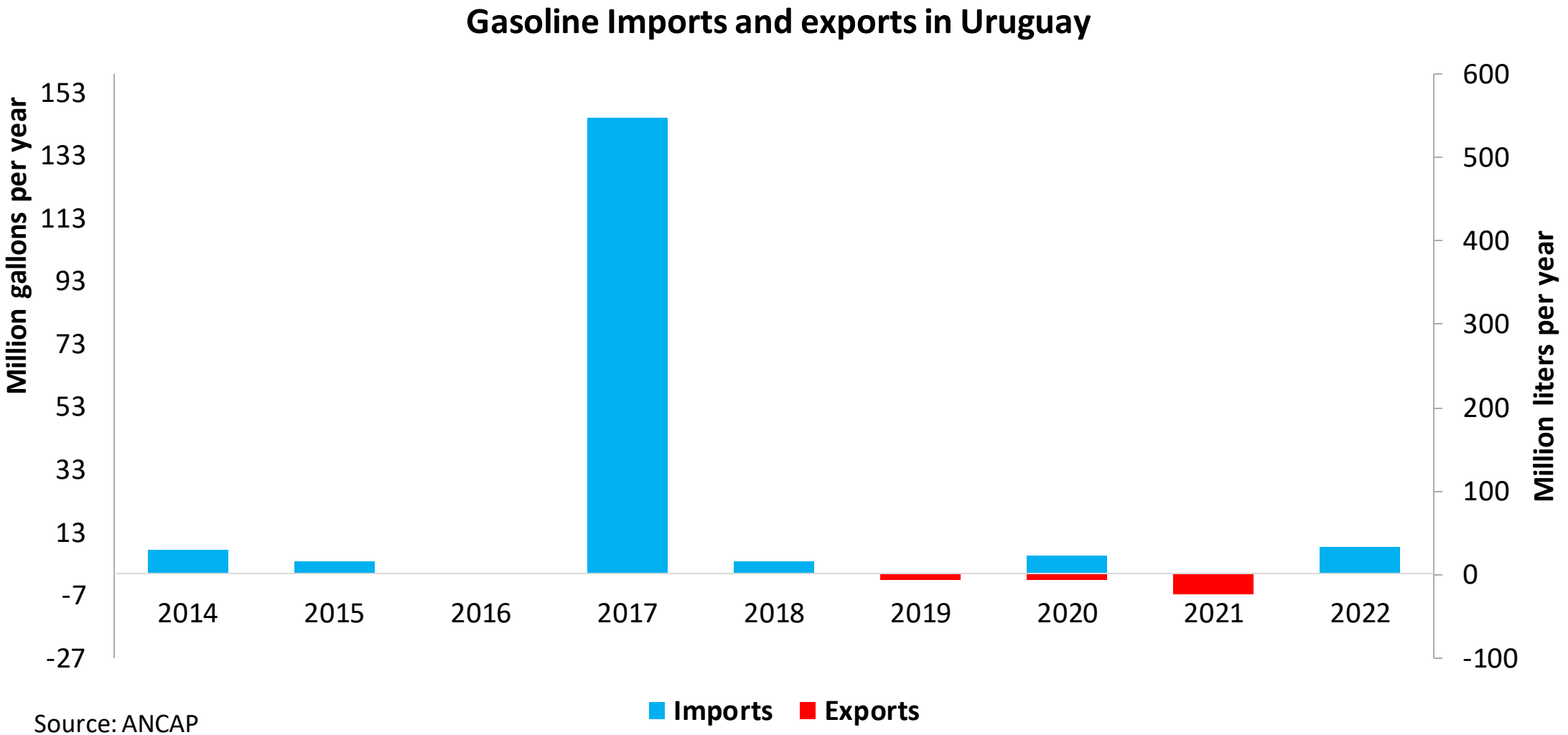
Source: ANCAP

Gasoline Demand in Uruguay



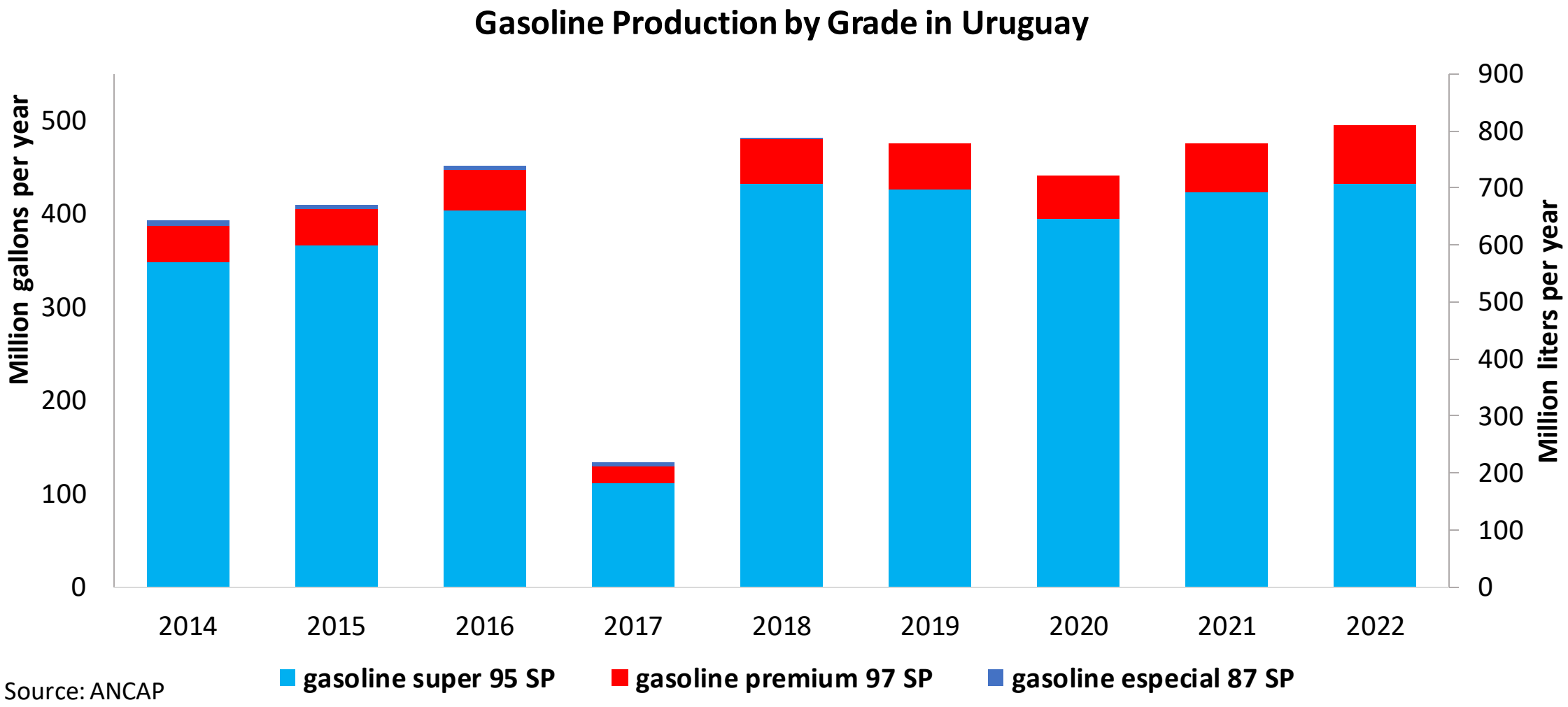
Source: ANCAP

Gasoline Imports in Uruguay



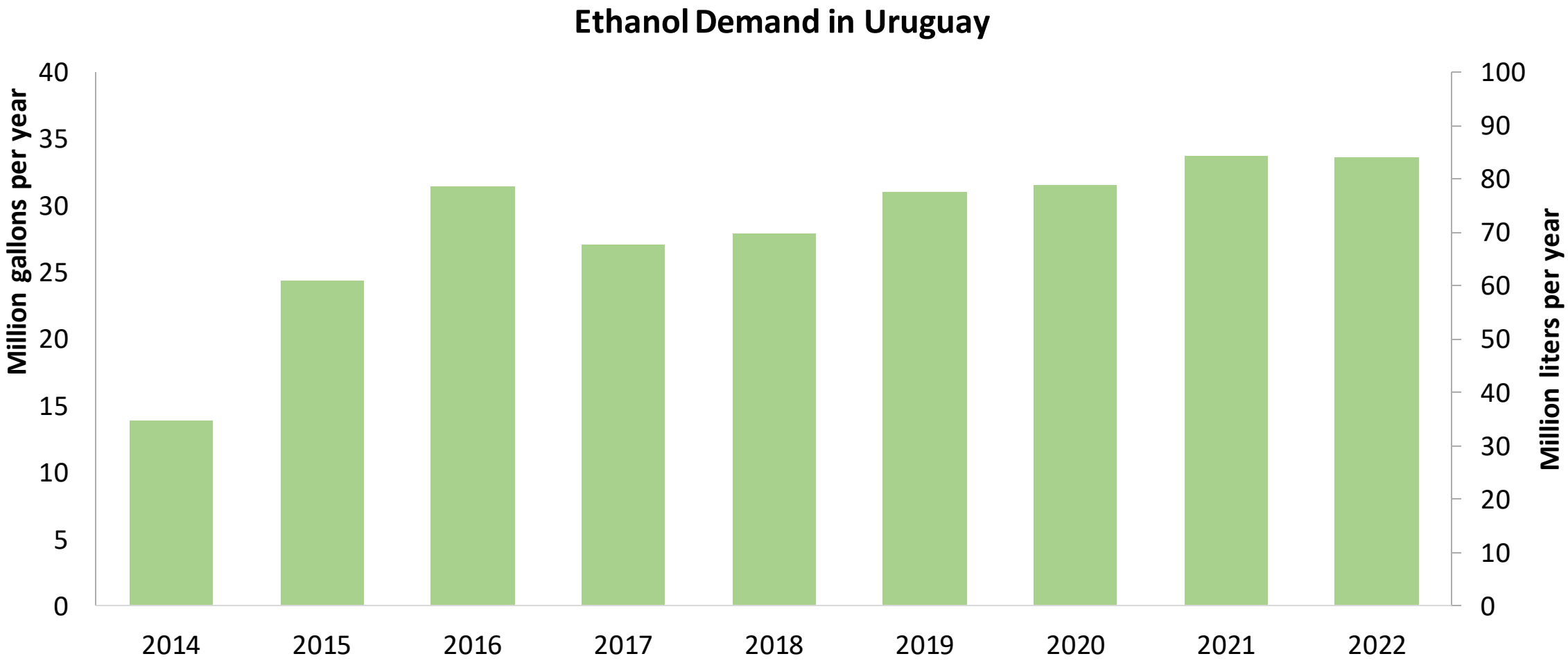
Source: ANCAP

Gasoline Production in Uruguay



Source: ANCAP

Ethanol Demand in Uruguay



Source: ANCAP

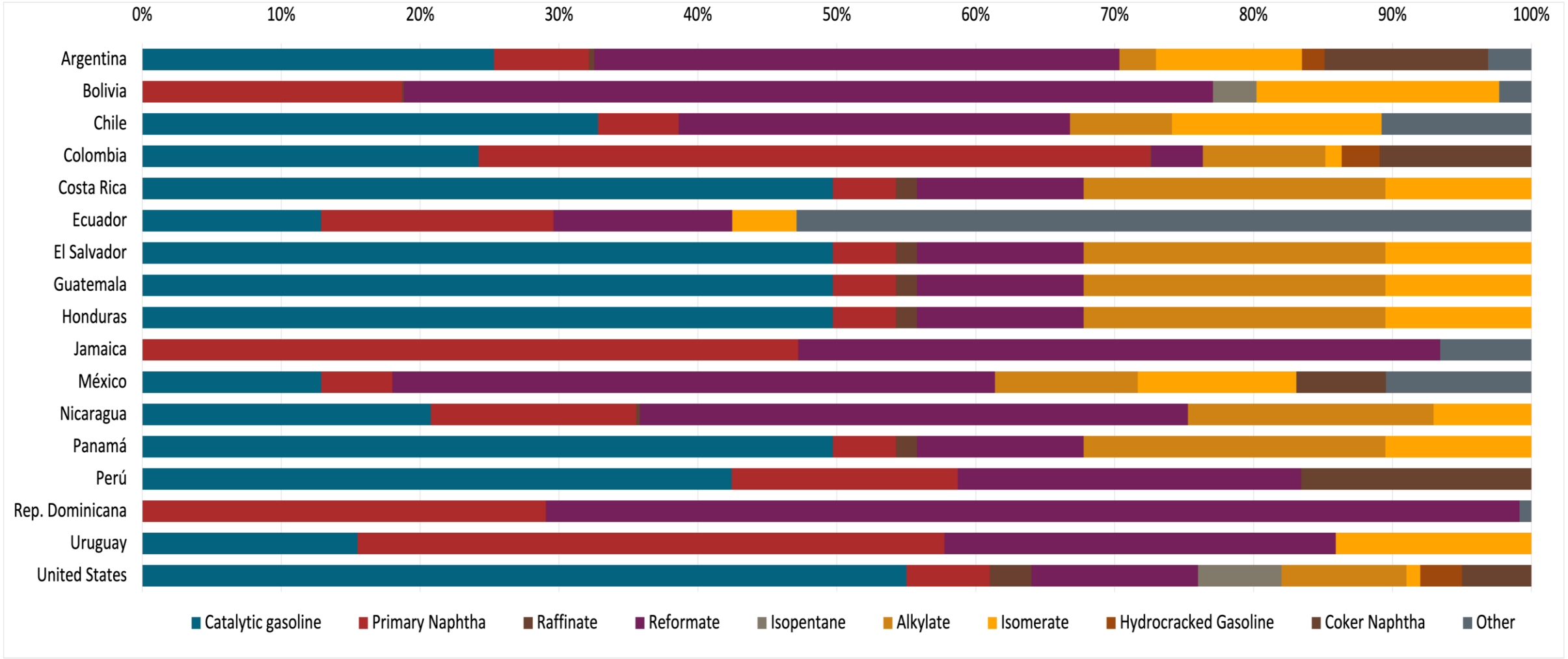
Gasoline Quality in Uruguay

Name	Resolution 110/2014		ANCAP		EN 228:2012 + A1:2017 (Euro 6 enabling)			
Implementation Date	2019		2020		2017			
Applicability	Whole country	Whole country	Whole country	Whole country	All countries			
Selected Grade	Super 95 30-S	Premium 97 30-S	Super 95 30-S	Premium 97 30-S	RON 95 E5	RON 95 E10	RON 98 E5	RON 98 E10
Benzene Content	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v
Aromatics	< 40 %v/v	< 40 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v
Olefins	< 20 %v/v	< 20 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v
Lead Content	< 0,005 g/l	< 0,005 g/l	< 0,005 g/l	< 0,005 g/l	< 5 mg/l	< 5 mg/l	< 5 mg/l	< 5 mg/l
Manganese	< 2,5 mg/l	< 2,5 mg/l	< 2,5 mg/l	< 2,5 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l
RON	> 95	> 97	> 95	> 97	> 95	> 95	> 98	> 98
MON	> 82	> 84	> 85	> 85	> 85	> 88	> 85	> 88
AKI								
Sulfur Content	< 30 mg/kg	< 30 mg/kg	< 10 mg/kg	< 10 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)	< > 10 %v/v	< > 10 %v/v			<5 %v/v	<10 %v/v	<5 %v/v	<10 %v/v
RVP 37.8°C (Summer)	<> 72 kPa	<> 72 kPa	<> 50-80 kPa	<> 50-80 kPa	<> 60 - 70 kPa *Depends on the country, RVP is regulated in the EU Fuel Quality Directive			
RVP 37.8 °C(Winter)	<> 83 kPa	<> 83 kPa	<> 45-67 kPa	<> 45-67 kPa				
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: ANCAP

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:



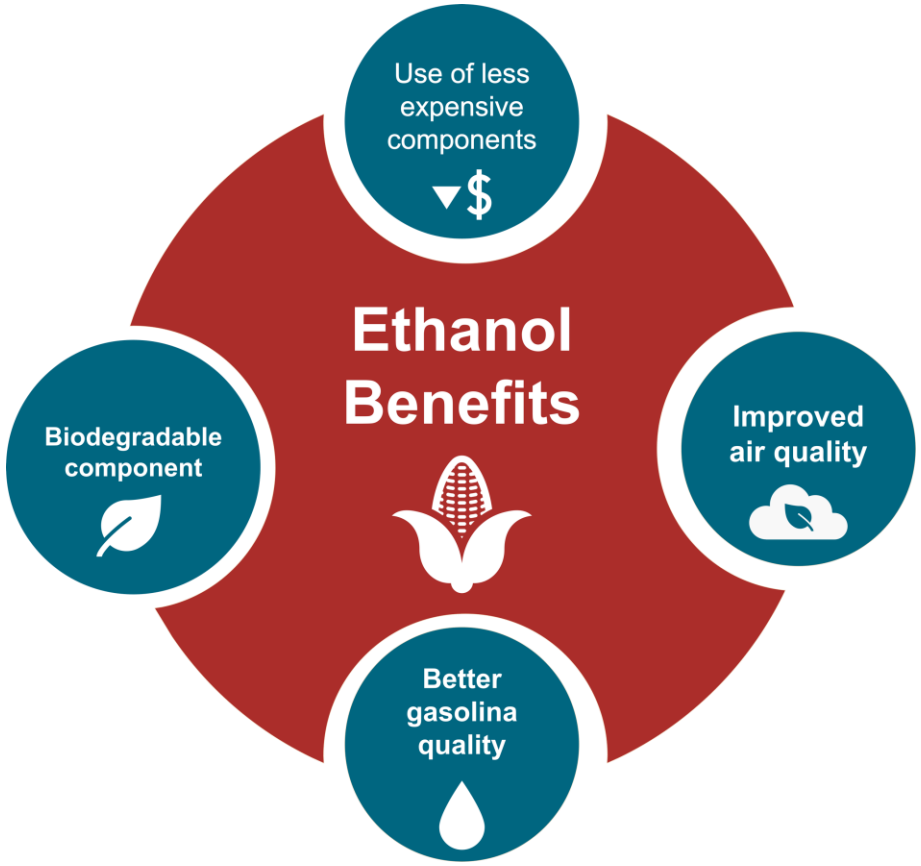
Gasoline Blending Optimization

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:

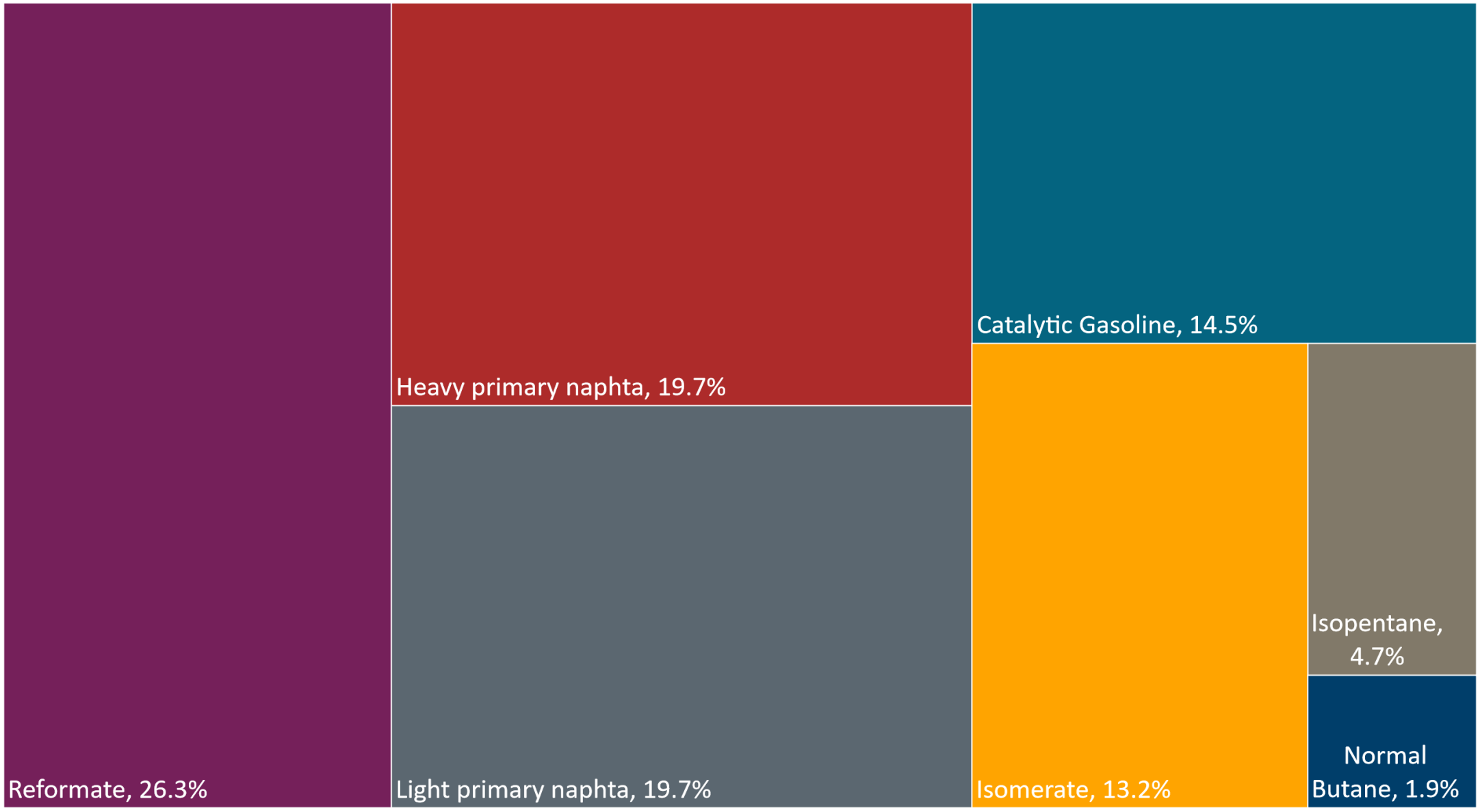
- Components prices,
- Properties each component affects,
- Quality parameters by country, and
- Component availability by country.

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.

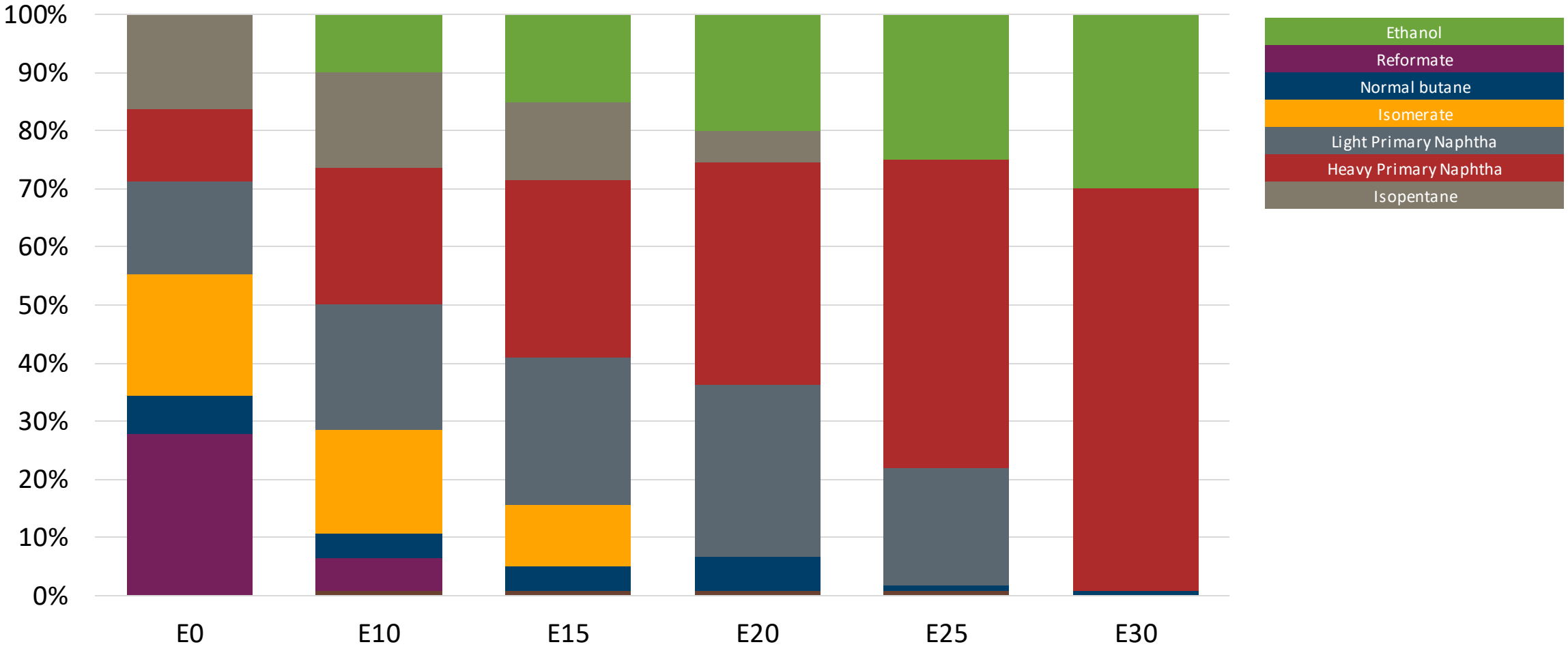


Available Blending Components



Source: Faro90

Ethanol Blending - Gasolina Super – Constant Octane

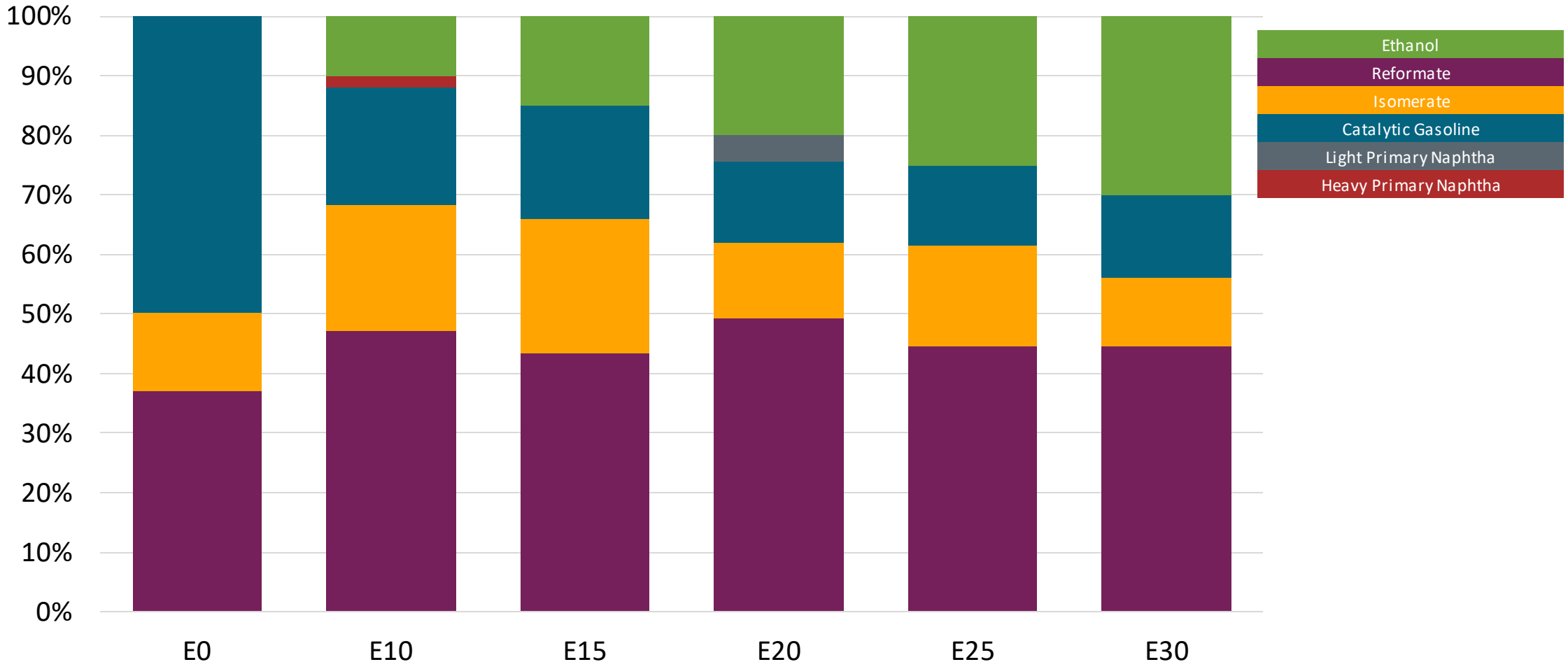


	E0	E10	E15	E20	E25	E30
Octane (RON)	95.0	95.0	95.0	95.0	95.0	95.0
Price (USD/gal)	$2.44	$2.30	$2.24	$2.19	$2.14	$2.09

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 - Gasolina Super – Octane Increment

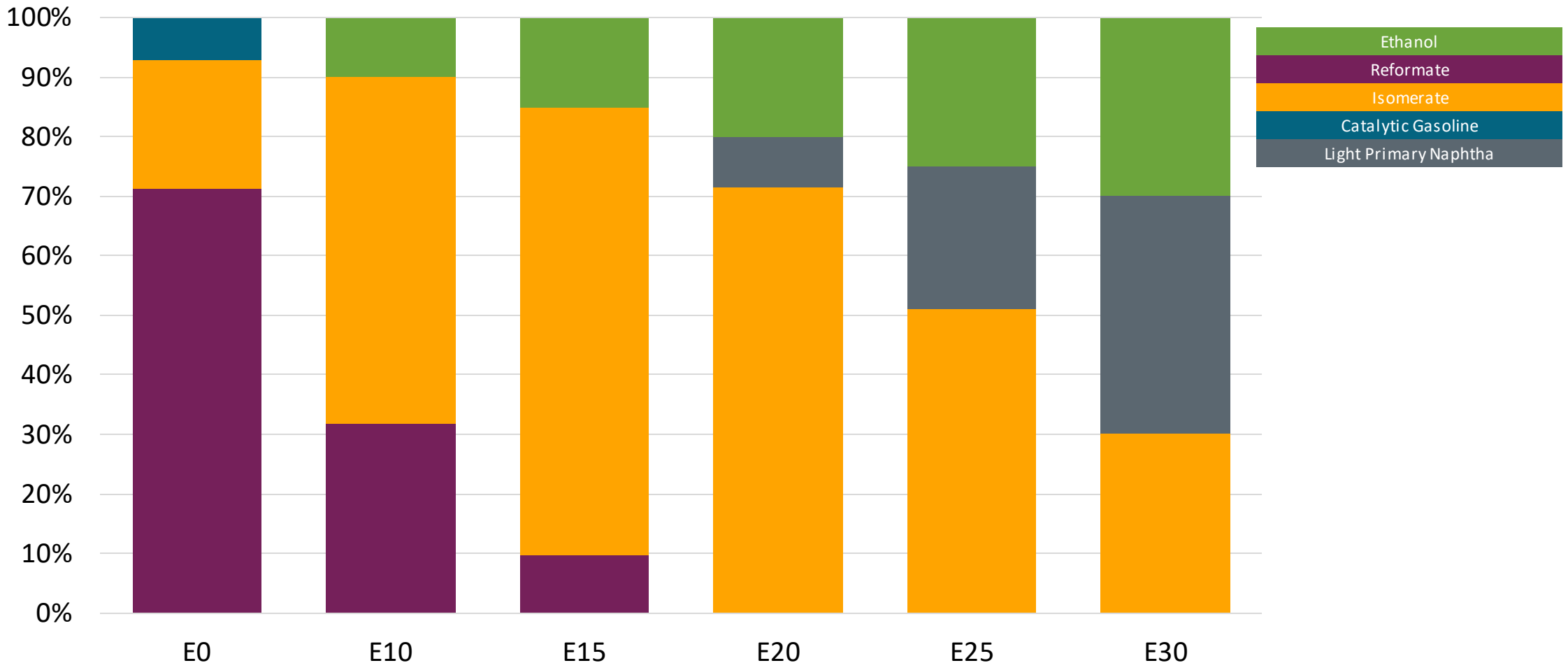


Octane (RON)	95.0	98.9	101.1	102.9	105.0	106.8
Price (USD/gal)	$2.41	$2.41	$2.41	$2.41	$2.41	$2.41

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 - Gasolina Premium – Constant Octane

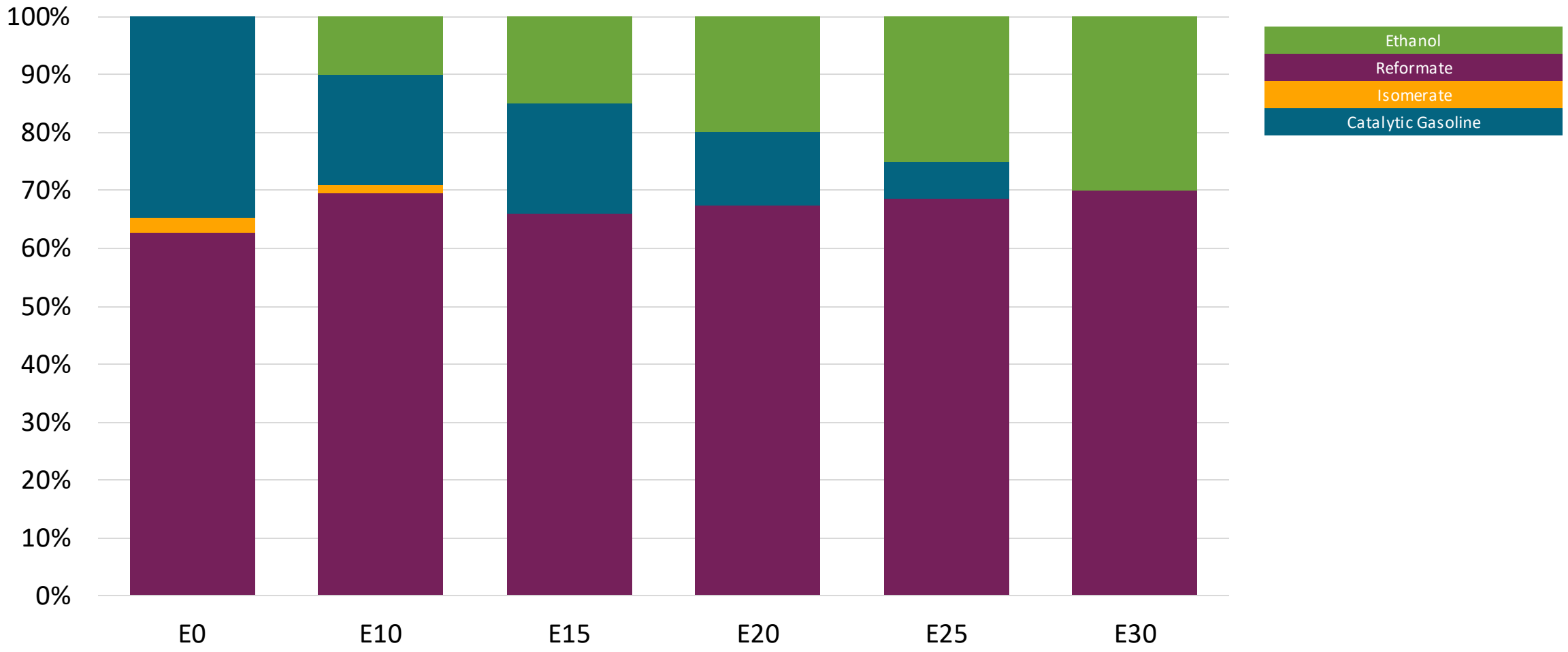


Octane (RON)	97.0	97.0	97.0	97.0	97.0	97.0
Price (USD/gal)	$2.49	$2.37	$2.30	$2.24	$2.19	$2.13

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 Premium – Octane Increment



Octane (RON)	97.3	101.8	103.4	105.2	106.9	108.5
Price (USD/gal)	$2.48	$2.49	$2.48	$2.48	$2.48	$2.48

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

Source: Faro90

Vehicle Emission Impact for Ethanol Gasoline Blending

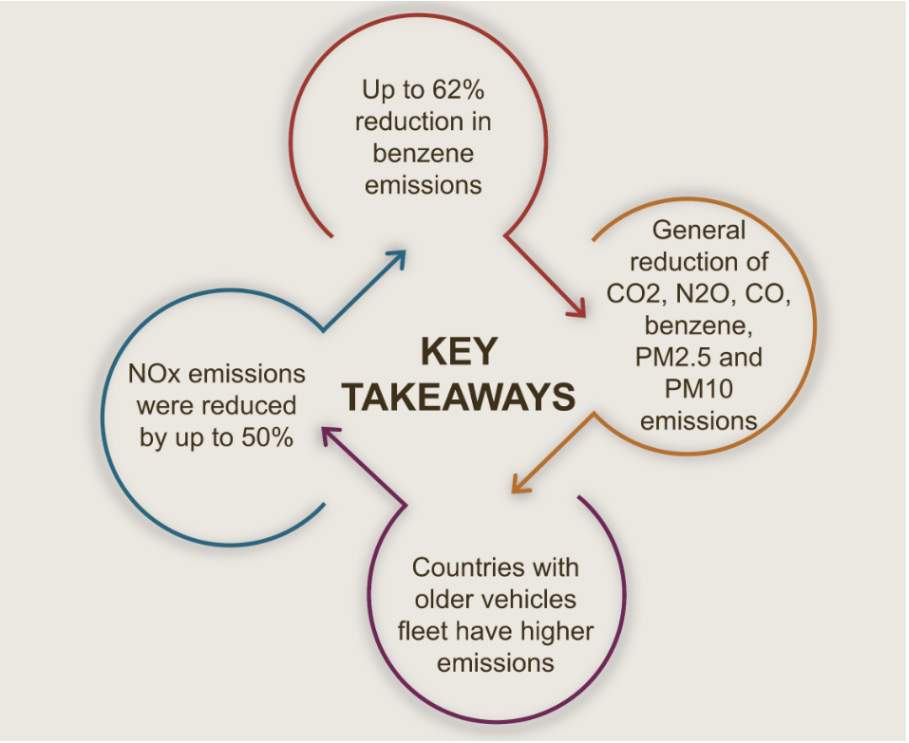
The model used in this analysis takes as a reference the **International Vehicle Emissions Model (IVE).**
The model uses the Base Emission Rates from IVE model, as well as its Adjustment Factors based on:

- 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 - Uruguay

Type	Motor	Tailpipe	Recuperator	Age	Number of vehicles
Auto/Sml Truck	Multi FI-Pt	Euro V	PCV Tank	>4years, >80 mkm	103.186
				4-8 years, 80-160 mkm	117.482
				<8 years, < 160 mkm	78.544
		Euro IV		<8 years, < 160 mkm	76.841
		Euro III		<8 years, < 160 mkm	72.929
		3-Ways		<8 years, < 160 mkm	161.925
Sml Engine	FI 4-ciclos	Euro III	PCV	>4 years, >80 mkm	76.855
				4-8 years, 80-160 mkm	43.751
		Euro II		4-8 years, 80-160 mkm	43.751
				<8 years, < 160 mkm	290.658
Truck	FI	Euro V	PCV	>4 years, >80 mkm	62.981
				4-8 years, 80-160 mkm	71.707
				<8 years, < 160 mkm	47.940
		Euro IV		<8 years, < 160 mkm	46.901
		Euro III		<8 years, < 160 mkm	44.513
		3-Ways		<8 years, < 160 mkm	98.833

Vehicle Fleet: **1,438,798**
Average Age: **9 years**
Motorcycles: **31.6%**

Source: Ministerio de Industria, Energía y Minería, análsis Faro 90

Gasoline Vehicle Fleet Emissions - Uruguay

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	22.65	20.77	20.16	19.62	19.23	18.69	-8%	-13%	-17%	1	3.5
VOC	2.09	1.94	1.90	1.86	1.83	1.79	-7%	-11%	-15%	95	255
VOCevap	0.62	0.62	0.63	0.64	0.66	0.67	0%	4%	7%	0.1	0.273
NOx	0.97	0.68	0.64	0.60	0.56	0.52	-30%	-38%	-46%	0.06	0.203
SOx	0.01	0.01	0.01	0.01	0.01	0.01	-15%	-28%	-41%		
NH3	0.06	0.06	0.06	0.06	0.06	0.06	-2%	0%	1%		
Butadiene	0.01	0.01	0.01	0.01	0.01	0.01	-8%	-12%	-16%		
Acetaldehyde	0.02	0.04	0.06	0.08	0.09	0.11	68%	249%	372%		
Formaldehyde	0.09	0.11	0.12	0.13	0.14	0.16	13%	39%	68%		
Benzene	0.10	0.10	0.09	0.09	0.09	0.09	-9%	-11%	-18%		
CO2	348.07	330.67	324.02	320.73	317.66	311.80	-5%	-8%	-10%		
N2O	0.02	0.02	0.02	0.02	0.02	0.02	-1%	2%	4%		
CH4	0.46	0.46	0.47	0.48	0.49	0.50	0%	4%	7%		
PM 2.5	0.03	0.02	0.02	0.02	0.01	0.01	-22%	-43%	-65%		
PM10	0.05	0.04	0.04	0.03	0.03	0.02	-22%	-43%	-65%	0.005	0.007
THC	0.70	0.71	0.76	0.79	0.82	0.86	3%	14%	23%		

Source: Faro90