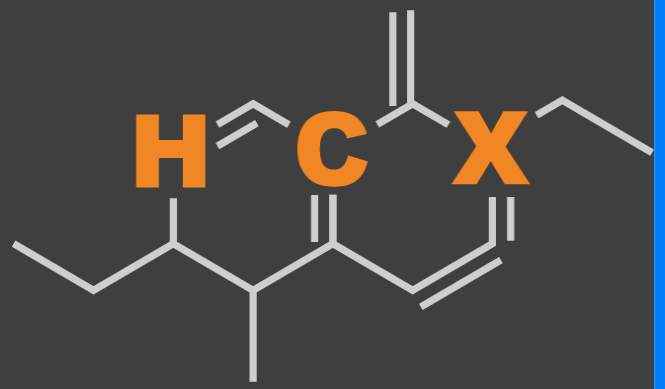


FARO90

Ethanol Blending in Gasoline - México

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.

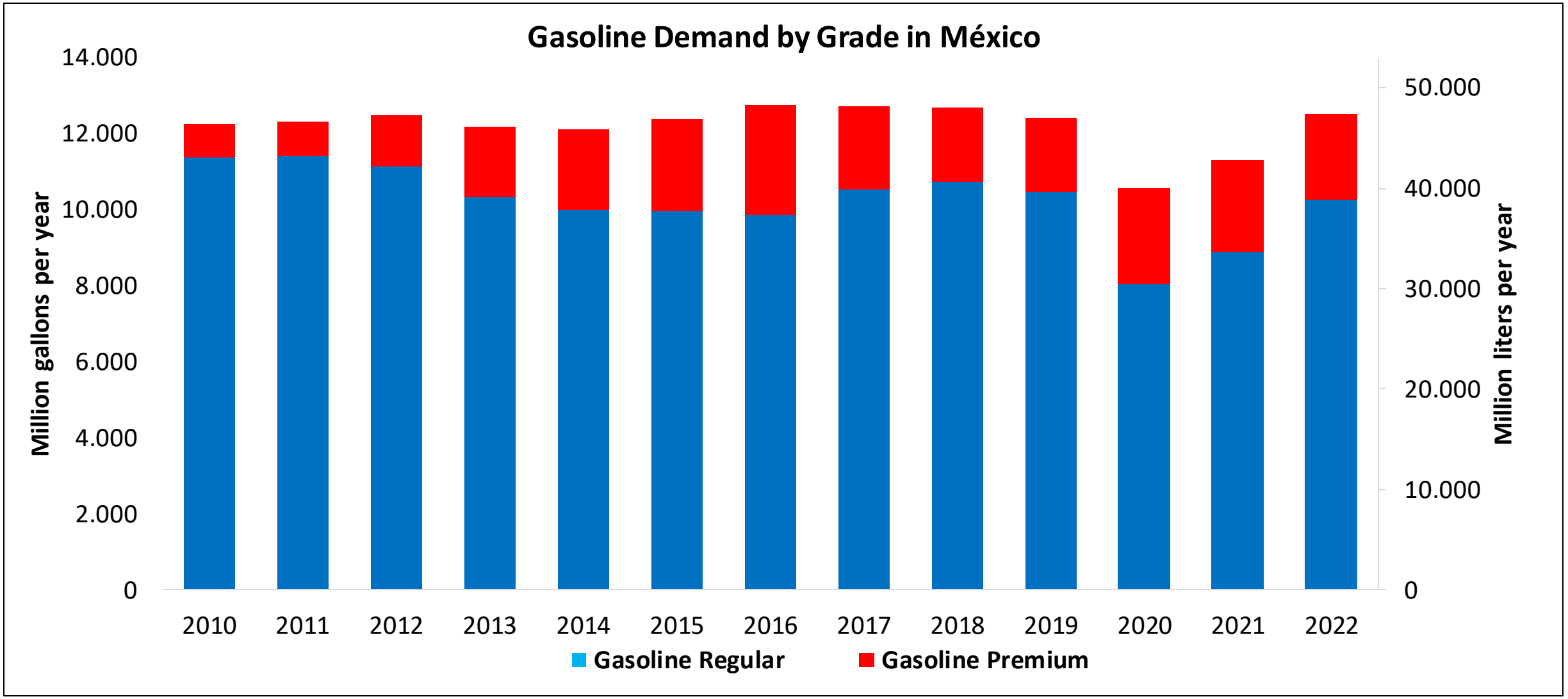
Ethanol Blending in Gasoline - México

In 2022, gasoline consumption was 12,500 million gallons (20,000 million liters). There are two grades of gasoline, Regular (AKI 87) and Premium (AKI 91). Regular gasoline is the main grade in the market, representing 90%. There are stringent gasoline specifications for major metropolitan areas in Mexico City, Guadalajara and Monterrey. Demand is much higher than production, making necessary to import 40% of gasoline mainly from the United States.

Blends with a maximum of 5.8% v/v of ethanol are allowed with the exception of metropolitan regions of Valle de Mexico, Guadalajara and Monterrey. Current ethanol use is equivalent to an average of 1.06% in the Rest of the Country grade gasoline.

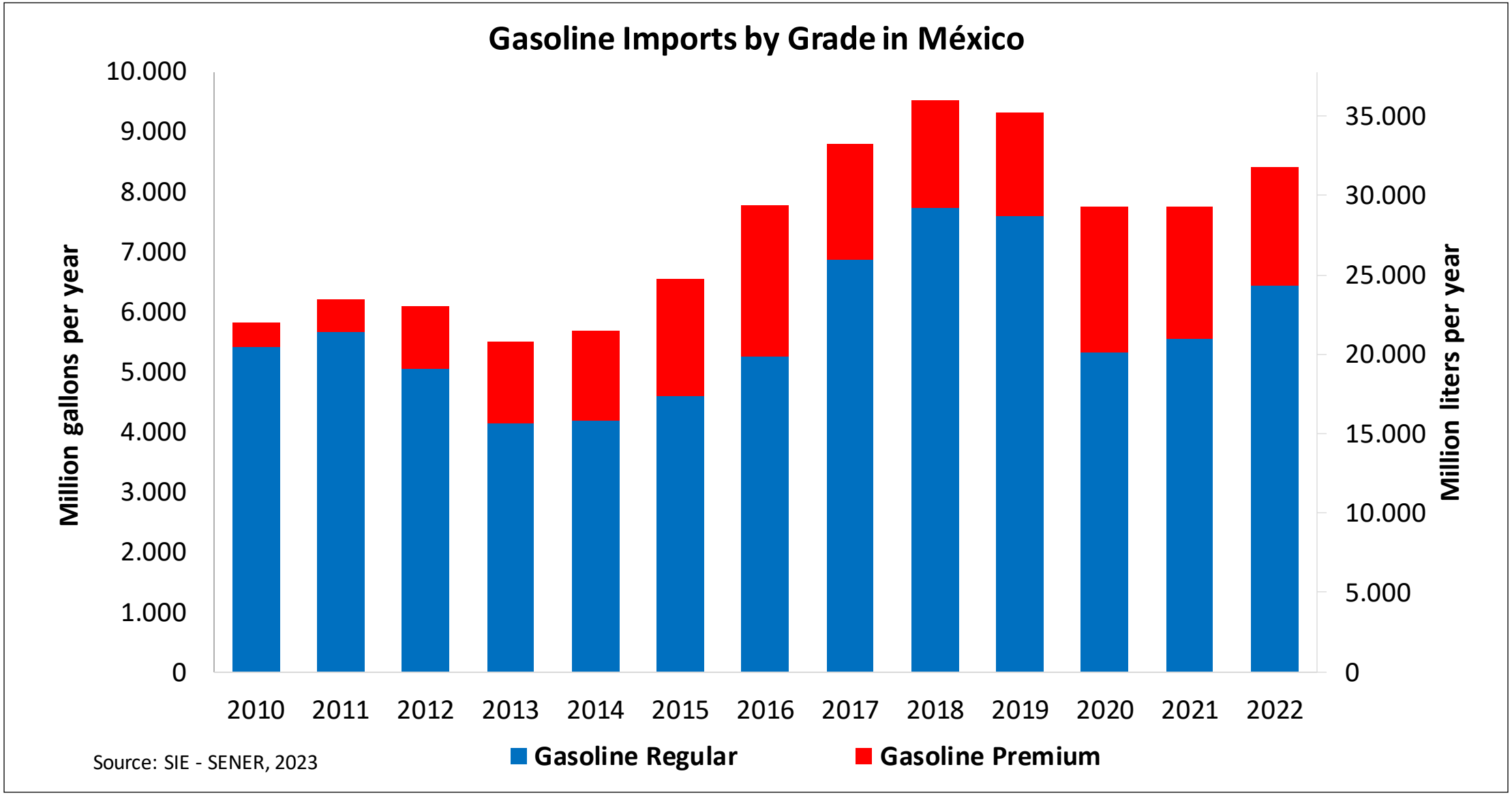
Source: SIE - SENER, 2023

Gasoline Demand in México

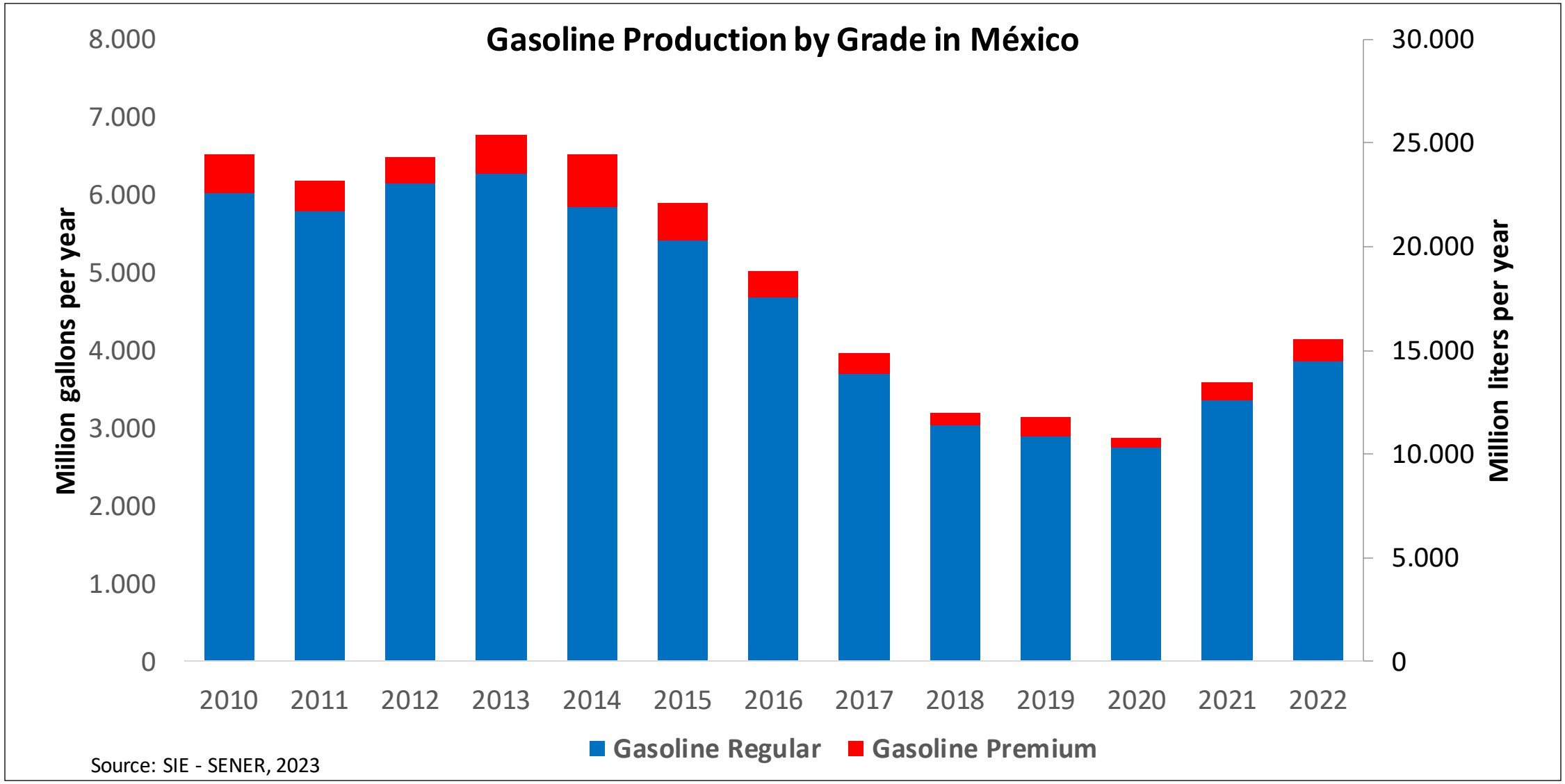


Source: SIE - SENER, 2023

Gasoline Production in México

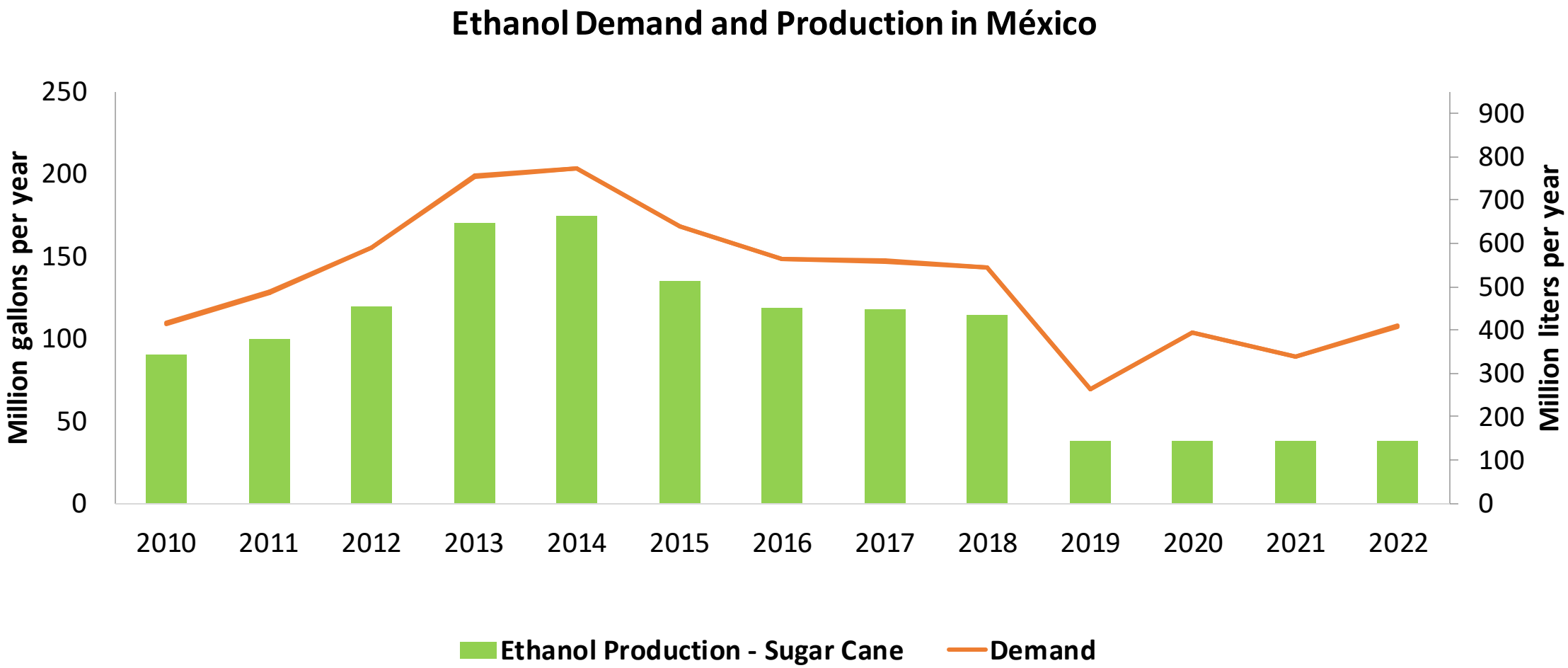


Gasoline Imports in México



Source: SIE - SENER, 2023

Ethanol Balance in Mexico



Source: CEDRSSA, 2020; EIA, 2023; Sanchez, 2014.

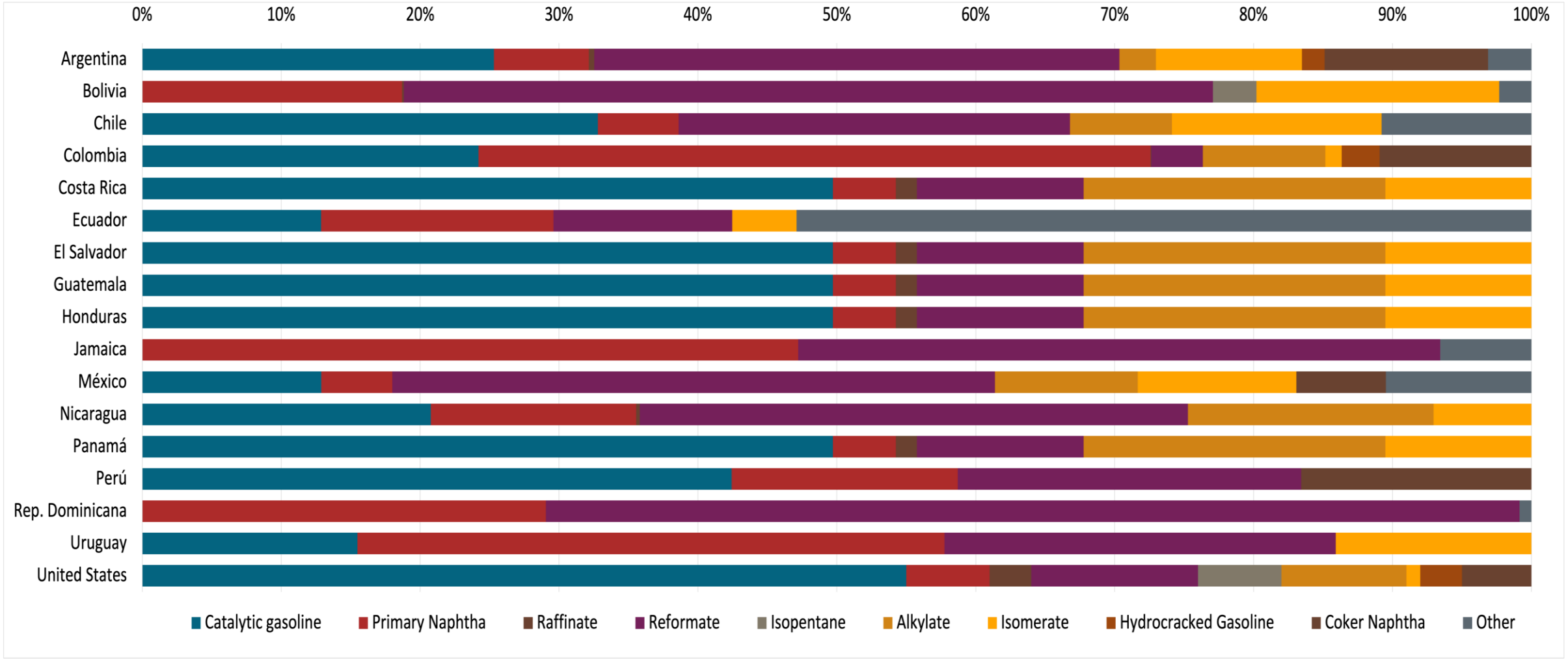
Gasoline Quality in México

Name	NOM-016-CRE-2016						EN 228:2012 + A1:2017 (Euro 6 enabling)			
Implementation Date	2016						2017			
Applicability	Mexico City	Mexico City	Guadalajara and Monterrey	Guadalajara and Monterrey	Rest of the country	Rest of the country	All countries			
Selected Grade	Gasoline Regular	Gasoline Premium	Gasoline Regular	Gasoline Premium	Gasoline Regular	Gasoline Premium	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	< 2 %v/v	< 2 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v	< 1 %v/v
Aromatics	< 25 %v/v	< 25 %v/v	< 32 %v/v	22,6% v/v	Report	22,6% v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v	< 35 %v/v
Olefins	< 10 %v/v	< 10 %v/v	< 11,9 %v/v	< 11,9 %v/v	Report	< 2,5 mg/l	< 18 %v/v	< 18 %v/v	< 18 %v/v	< 18 %v/v
Lead Content	-	-	-	-	-	-	< 5 mg/l	< 5 mg/l	< 5 mg/l	< 5 mg/l
Manganese	0 mg/l	0 mg/l	0 mg/l	0 mg/l	0 mg/l	0 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l	< 2,0 mg/l
RON		94		94		94	> 95	> 95	> 98	> 98
MON	82		82		82		> 85	> 88	> 85	> 88
AKI										
Sulfur Content	< 80 mg/kg	< 80 mg/kg	< 80 mg/kg	< 80 mg/kg	< 80 mg/kg	< 80 mg/kg	< 10 mg/kg	< 10 mg/kg	< 10 mg/kg	< 10 mg/kg
Oxygen Content	< 3,7 %m/m	< 2,7 %m/m	< 3,7 %m/m	< 2,7 %m/m	< 3,7 %m/m	< 2,7 %m/m	<2,7 % m/m	<3,7 % m/m	<2,7 % m/m	<3,7 % m/m
Ethanol (EtOH)	Not allowed	Not allowed	Not allowed	Not allowed	> 5,8 %v/v	> 5,8 %v/v	<5 %v/v	<10 %v/v	<5 %v/v	<10 %v/v
RVP 37.8°C (Summer)	< 62 kPa	< 62 kPa	< 62 kPa	< 62 kPa	< 69 kPa North, < 62 kPa Center, South, Pacific	< 69 kPa North, < 62 kPa Center, South, Pacific	<> 60 - 70 kPa *Depends on the country, RVP is regulated in the EU Fuel Quality Directive			
RVP 37.8 °C(Winter)	< 79 kPa	< 79 kPa	< 79 kPa	< 79 kPa	< 79 kPa	< 79 kPa				
RVP 37.8°C (Transition)	< 54 kPa	< 54 kPa	< 54 kPa Guadalajara	< 54 kPa Guadalajara						
MTBE							-	-	-	-
Ehters 5 or more C Atoms	-	-	-	-	-	-	Based on oxygen content	<22 %v/v	Based on oxygen content	<22 %v/v

Source: CRE, 2016

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:



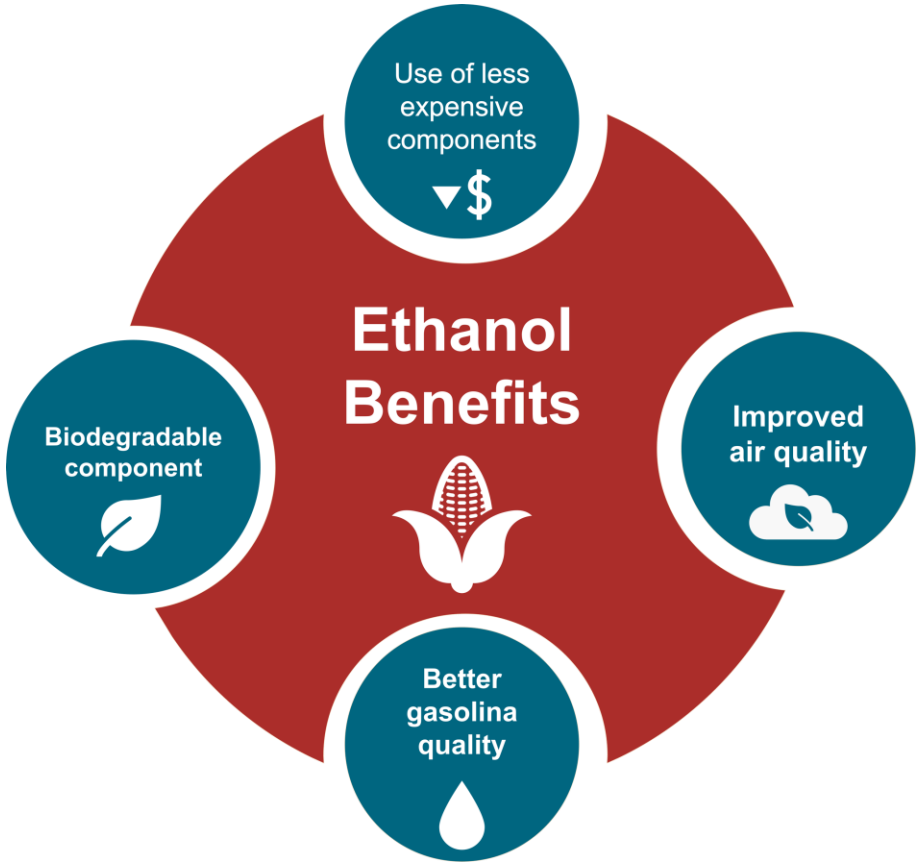
Gasoline Blending Optimization

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:

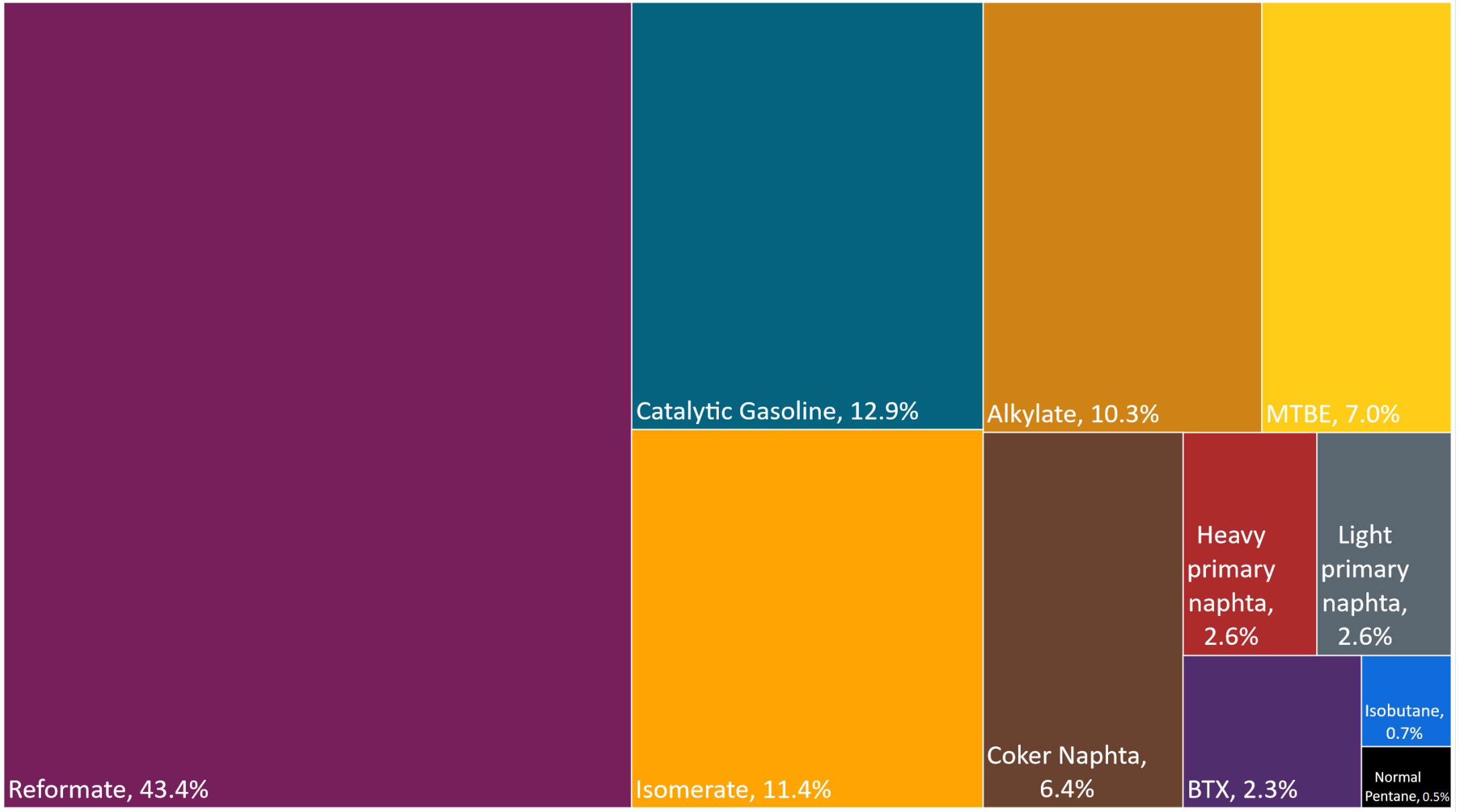
- Components prices,
- Properties each component affects,
- Quality parameters by country, and
- Component availability by country.

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.

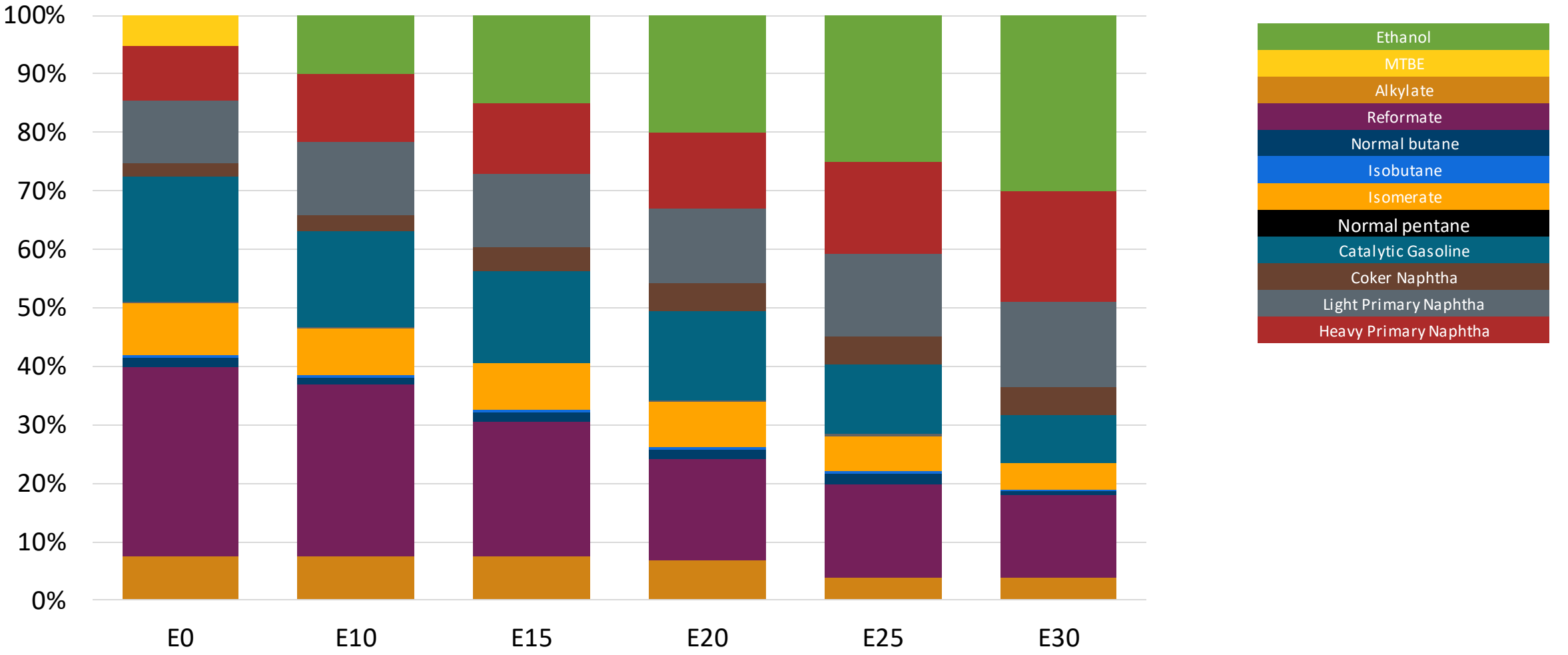


Available Blending Components



Source: Faro90

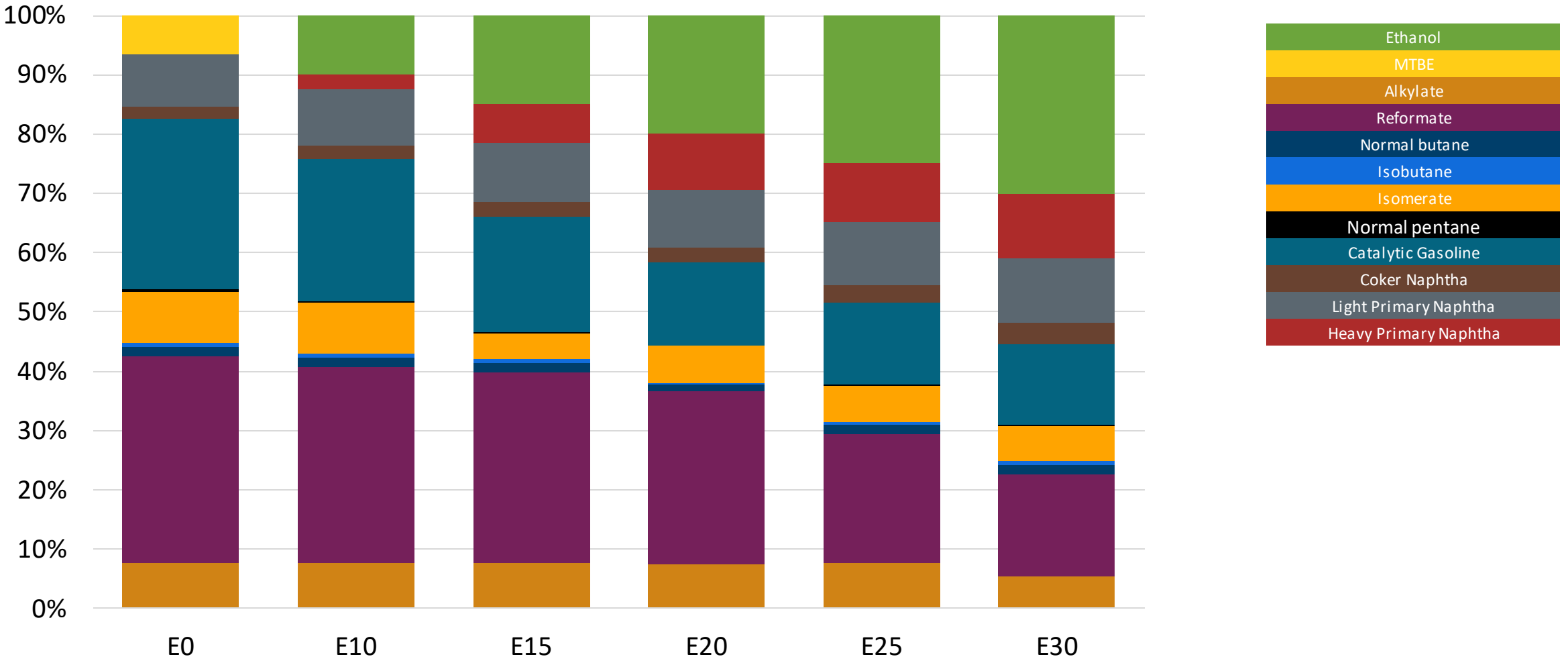
Ethanol Blending - Gasoline Regular RP – Constant Octane



Octane (AKI)	87.0	87.0	87.0	87.0	87.0	87.0
Price (USD/gal)	$ 2.337	$ 2.283	$ 2.237	$ 2.191	$ 2.154	$ 2.134

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

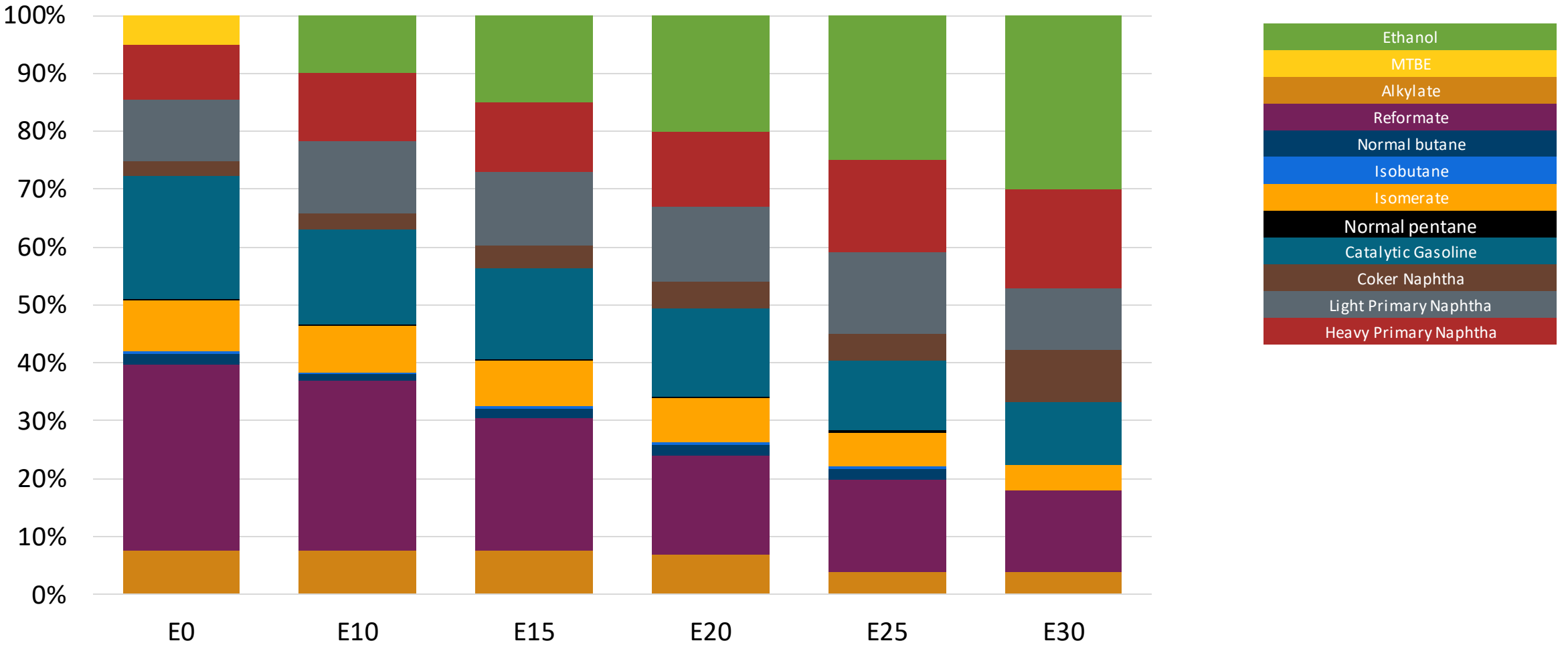
Ethanol Blending - Gasoline Premium RP – Constant Octane



Octane (AKI)	91.0	91.0	91.0	91.0	91.0	91.0
Price (USD/gal)	$ 2.429	$ 2.371	$ 2.336	$ 2.309	$ 2.257	$ 2.212

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

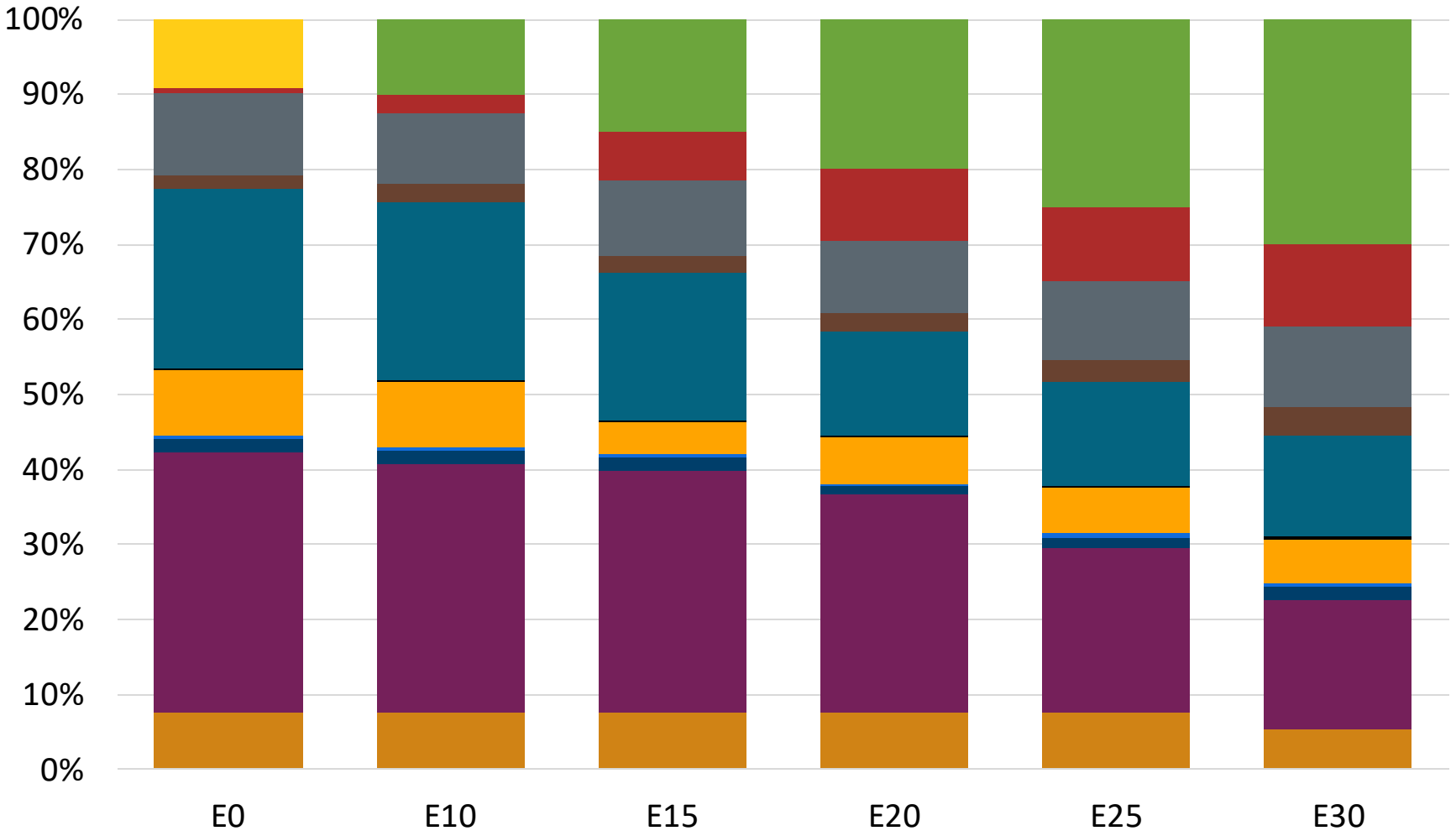
Ethanol Blending - Gasoline Regular ZM – Constant Octane



Octane (AKI)	87.0	87.0	87.0	87.0	87.0	87.0
Price (USD/gal)	$ 2.337	$ 2.283	$ 2.237	$ 2.191	$ 2.154	$ 2.153

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

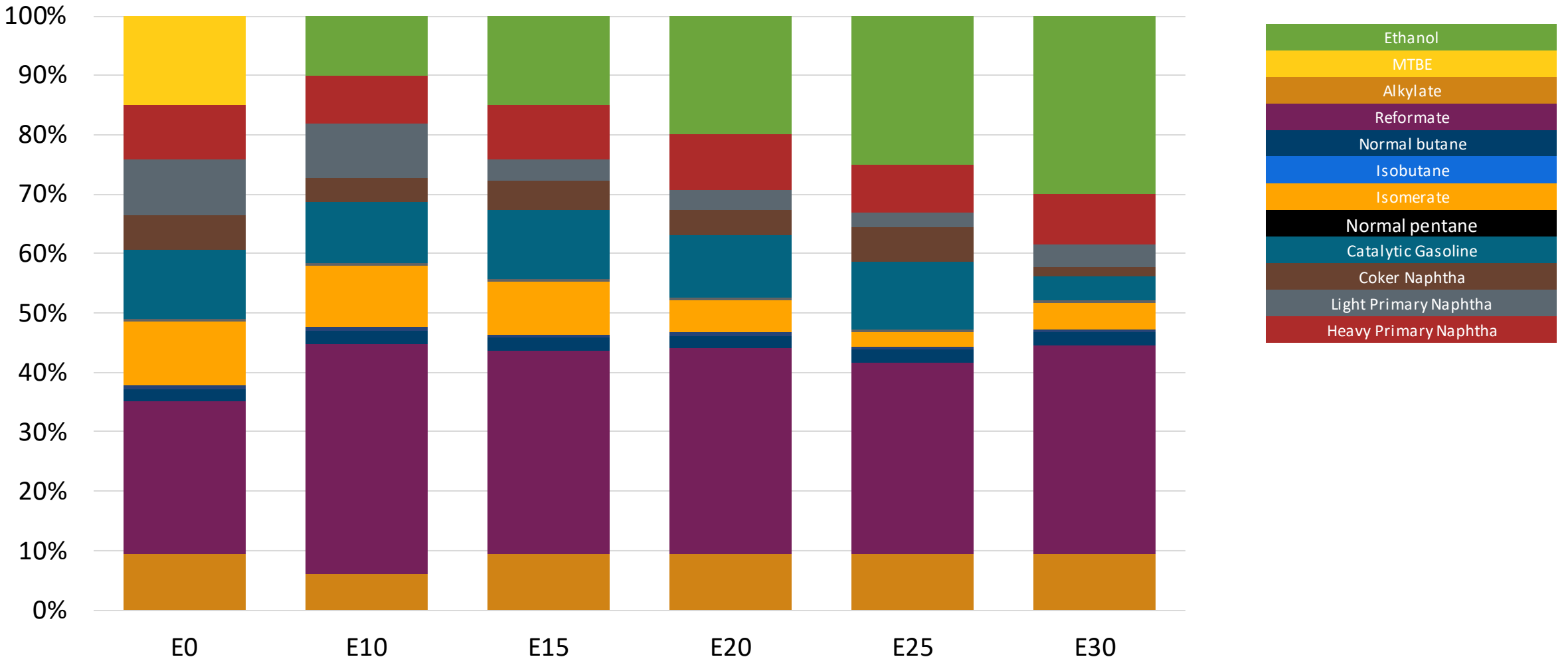
Ethanol Blending - Gasoline Premium ZM – Constant Octane



Octane (AKI)	91.0	91.0	91.0	91.0	91.0	91.0
Price (USD/gal)	$ 2.424	$ 2.371	$ 2.336	$ 2.309	$ 2.257	$ 2.212

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

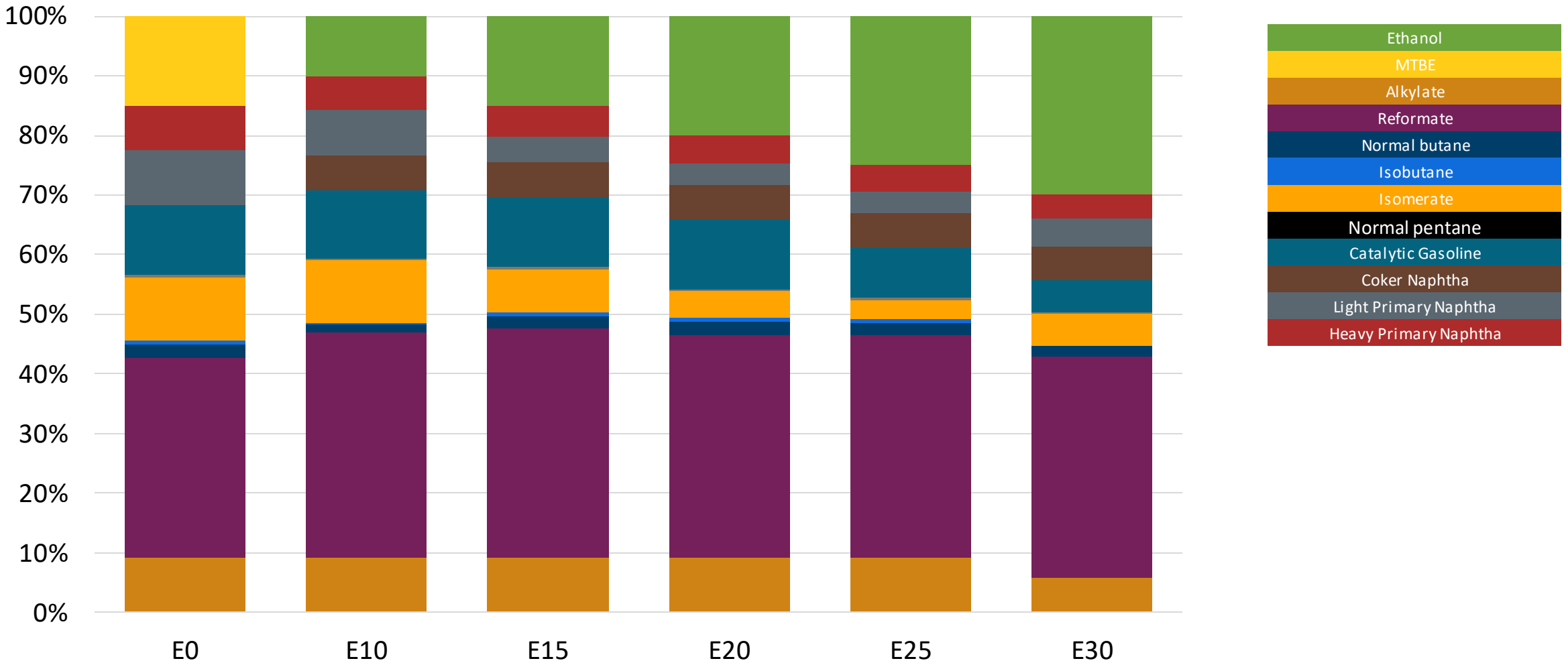
Ethanol Blending - Gasoline Regular RP – Octane Increment



Octane (AKI)	87.0	90.5	92.1	93.7	95.2	96.6
Price (USD/gal)	$ 2.359	$ 2.359	$ 2.359	$ 2.359	$ 2.359	$ 2.359

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

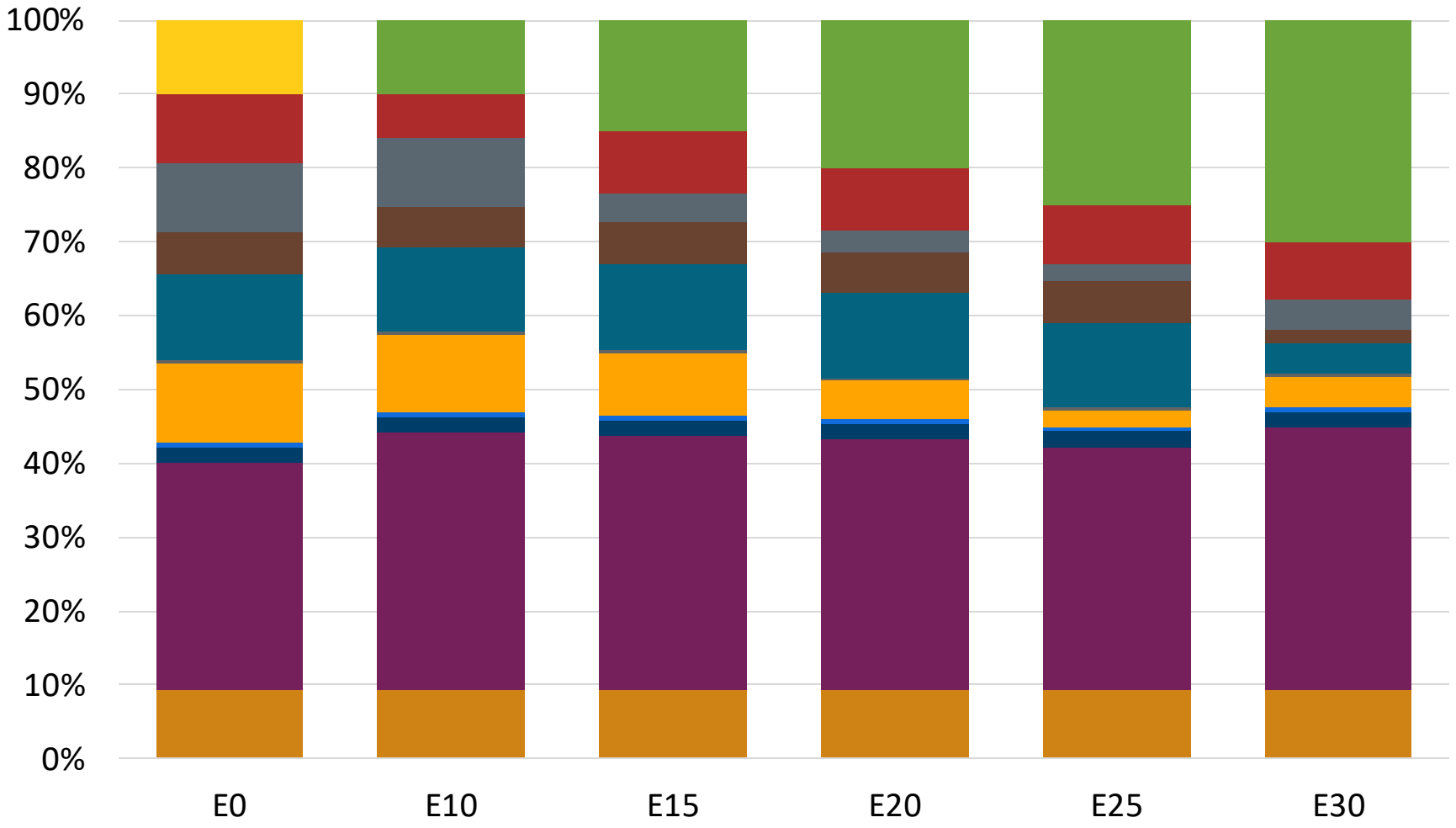
Ethanol Blending - Gasoline Premium RP – Octane Increment



Octane (AKI)	91.0	91.5	93.8	95.3	96.8	97.9
Price (USD/gal)	$ 2.403	$ 2.403	$ 2.403	$ 2.403	$ 2.403	$ 2.403

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

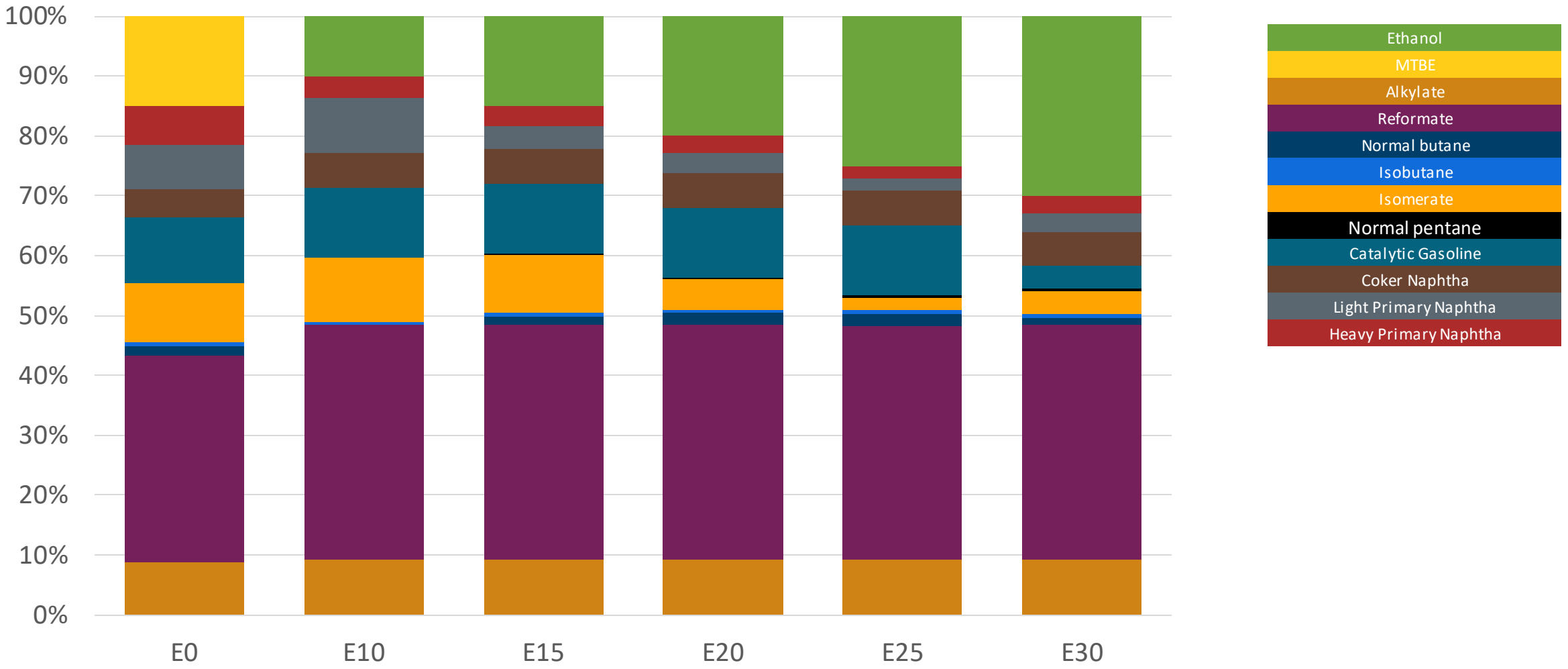
Ethanol Blending - Gasoline Regular ZM – Octane Increment



Octane (AKI)	88.8	90.8	92.3	93.8	95.4	96.8
Price (USD/gal)	$ 2.364	$ 2.364	$ 2.364	$ 2.364	$ 2.364	$ 2.364

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 ZM – Octane Increment



Octane (AKI)	91.7	92.1	94.5	96.2	98.0	98.9
Price (USD/gal)	$ 2.432	$ 2.432	$ 2.432	$ 2.432	$ 2.432	$ 2.432

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

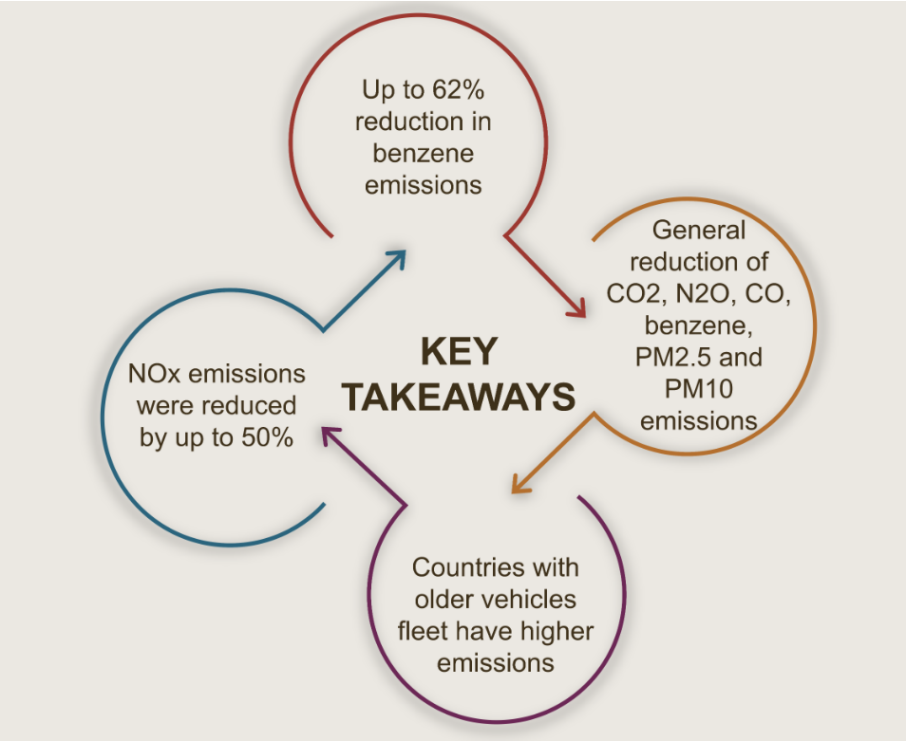
The model used in this analysis takes as a reference the **International Vehicle Emissions Model (IVE).**
The model uses the Base Emission Rates from IVE model, as well as its Adjustment Factors based on:

- 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 - México

Type	Weight	Motor	Tailpipe	Recuperator	Ague	Number of vehicles
Auto/Sml Truck	Light	Carburador	3-Ways	PCV Tank	+8years	14.255
		Single FI	3-Ways		+8years	1.638.045
		Multi FI	3-Ways		+8years	6.559.661
			Euro III		+8years	3.064.588
			Euro IV		+8years	2.425.660
					4-8years	3.611.585
			Euro V		4-8years	855.809
					-4years	2.303.300
	Medium	Carburator	3-Ways	PCV Tank	+8years	2.024
		Single FI	3-Ways		+8years	64.686
		Multi FI	3-Ways		+8years	999.381
			Euro III		+8years	1.065.314
			Euro IV		+8years	770.022
					4-8years	1.274.081
			Euro V		4-8years	386.678
					-4years	1.374.040
Sml Engines	Light	4-Cycle	Euro II	PCV	+8years	2.714.667
					4-8years	1.945.800
			Euro III		-4years	2.797.515
Truck	Heavy	Carburator	3-Ways	PCV	+8years	19.293
		Fuel-Injection	3-Ways		+8years	2.132.687
			Euro III		+8years	1.222.113
			Euro IV		+8years	722.270
			Euro V		4-8years	904.413
					-4years	841.493

Vehicle fleet: **39,709,380**
Average Age: **11 years**

Source: INEGI

Mexico – 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	14.93	13.68	13.27	12.91	12.64	12.24	-8%	-14%	-18%	1	3.5
VOC	1.31	1.24	1.23	1.22	1.22	1.21	-5%	-6%	-8%	95	255
VOCevap	0.53	0.53	0.54	0.55	0.56	0.57	0%	4%	7%	0.1	0.273
NOx	0.75	0.53	0.50	0.47	0.44	0.40	-30%	-38%	-46%	0.06	0.203
SOx	0.01	0.01	0.01	0.00	0.00	0.00	-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	-4%	-5%	-6%		
Acetaldehyde	0.01	0.02	0.04	0.05	0.06	0.07	68%	249%	372%		
Formaldehyde	0.05	0.06	0.07	0.07	0.08	0.09	13%	39%	68%		
Benzene	0.07	0.07	0.06	0.06	0.06	0.06	-9%	-11%	-18%		
CO2	286.17	271.86	266.39	263.69	261.07	256.25	-5%	-8%	-10%		
N2O	0.01	0.01	0.01	0.01	0.01	0.01	-1%	2%	4%		
CH4	0.29	0.29	0.29	0.30	0.30	0.31	0%	4%	7%		
PM 2.5	0.02	0.02	0.01	0.01	0.01	0.01	-22%	-43%	-65%		
PM10	0.03	0.02	0.02	0.01	0.01	0.01	-22%	-43%	-65%	0.005	0.007
THC	0.44	0.45	0.47	0.50	0.51	0.54	2%	14%	22%		

Source: Faro90