Sustainable Mobility - The Role of Bioenergy

Rystad Energy - MME

Thiago Sinzato – Senior Analyst Bioenergy

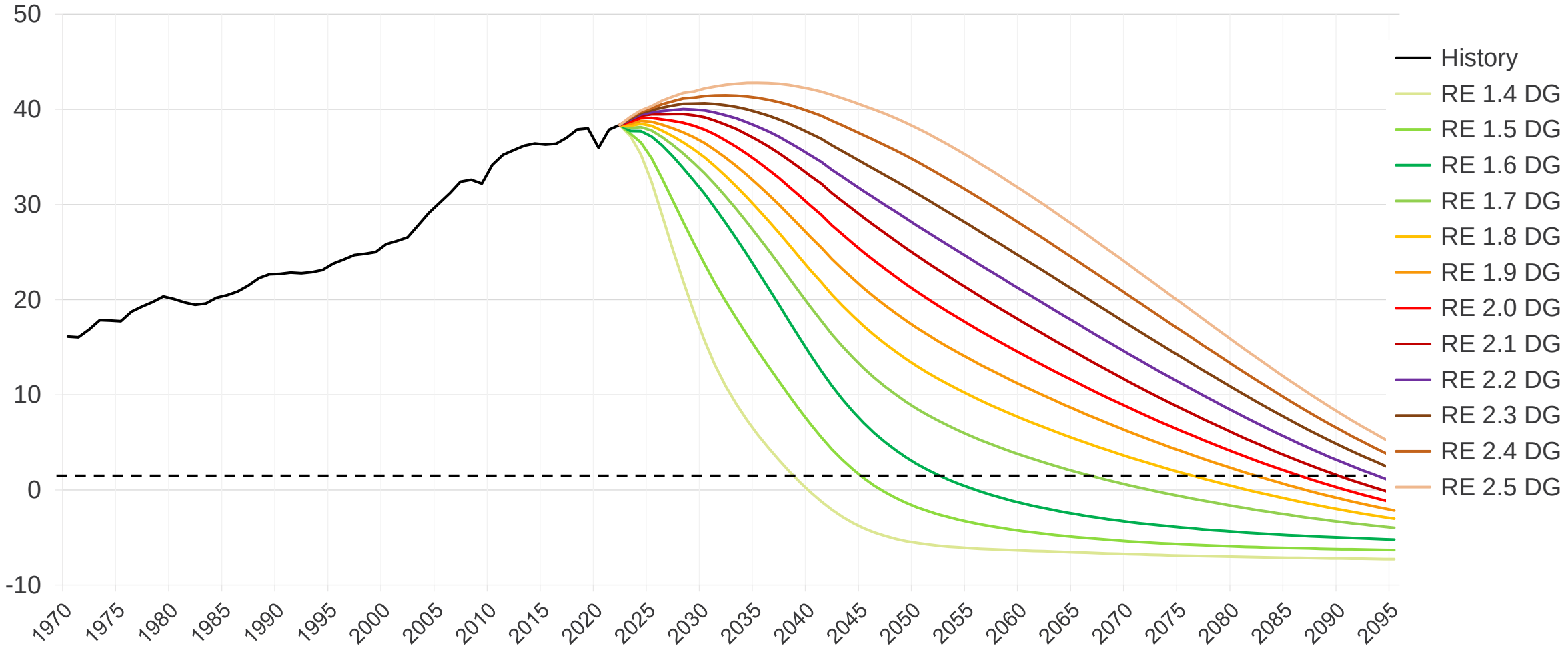
New Energies

December 2024

2030 climate goals: 40% reduction in fossil CO2 emissions needed to limit warming to 1.5°C

Global carbon dioxide emissions, history and future scenarios

Gigatonnes

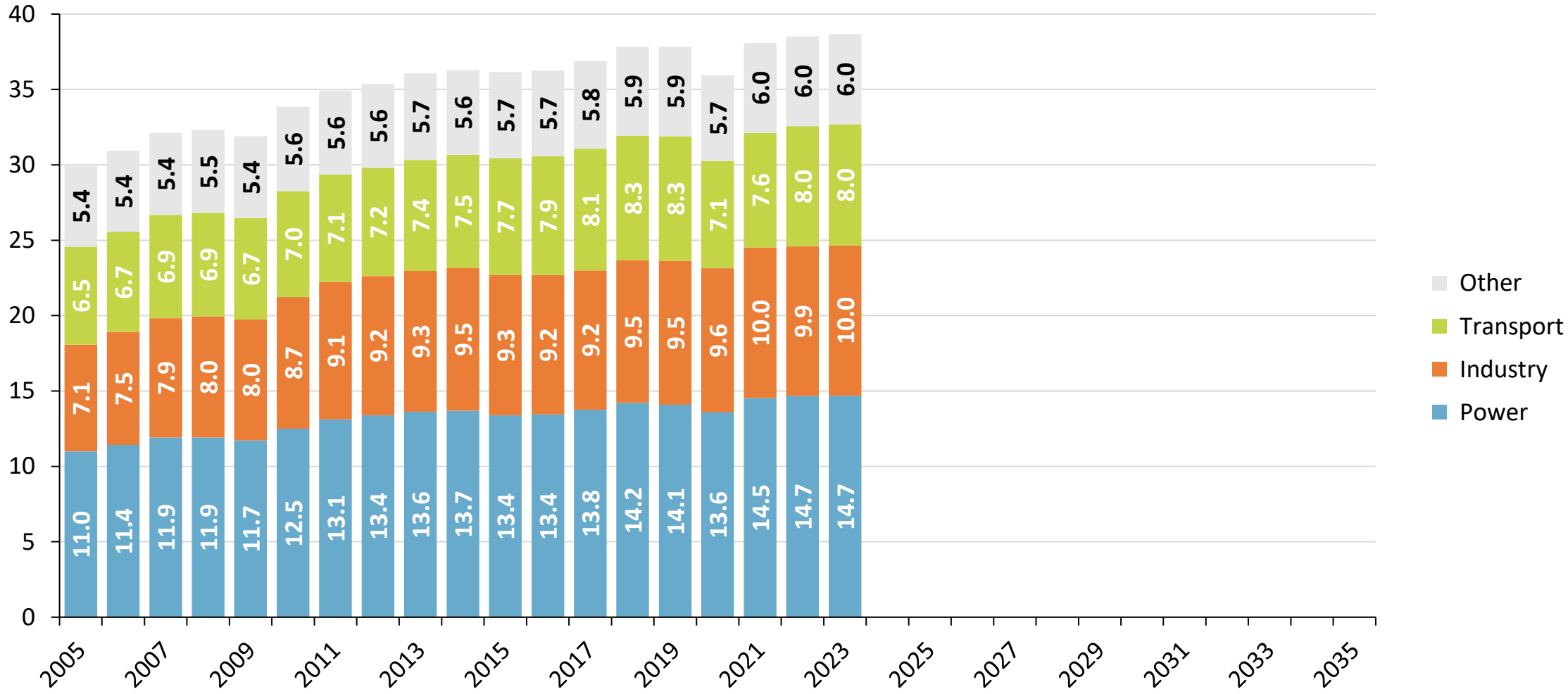


*Includes carbon capture contribution in each scenario

Source: Rystad Energy EnergyScenarioCube, December 2024

We have not been able to “bend the curve” yet, but we might be close to the structural peak

Fossil CO2 by year and sector – current pathway
Gigatonnes



Source: Rystad Energy research and analysis, December 2024

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By 2035, only the power sector is set for major decarbonization

Fossil CO2 by year and sector – current pathway
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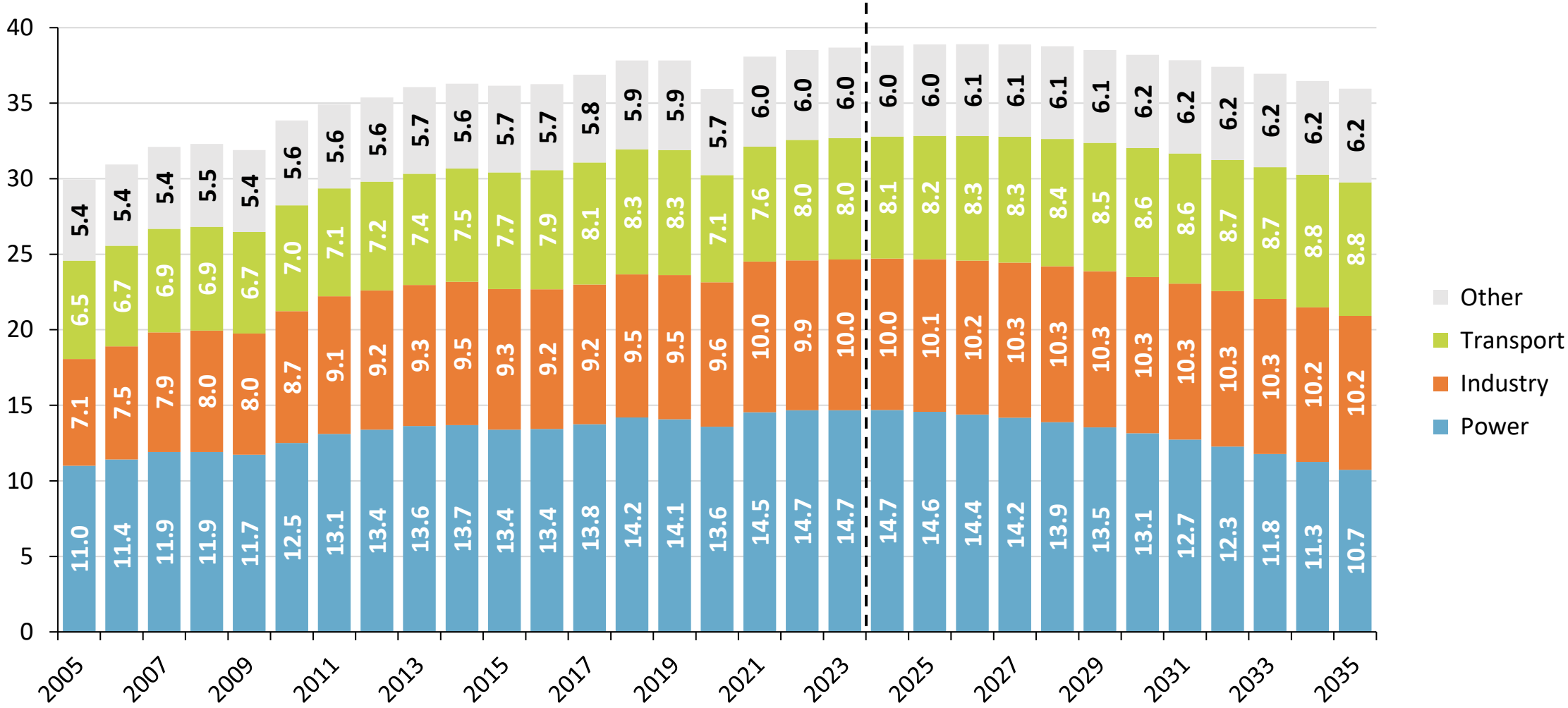

Source: Rystad Energy research and analysis, December 2024

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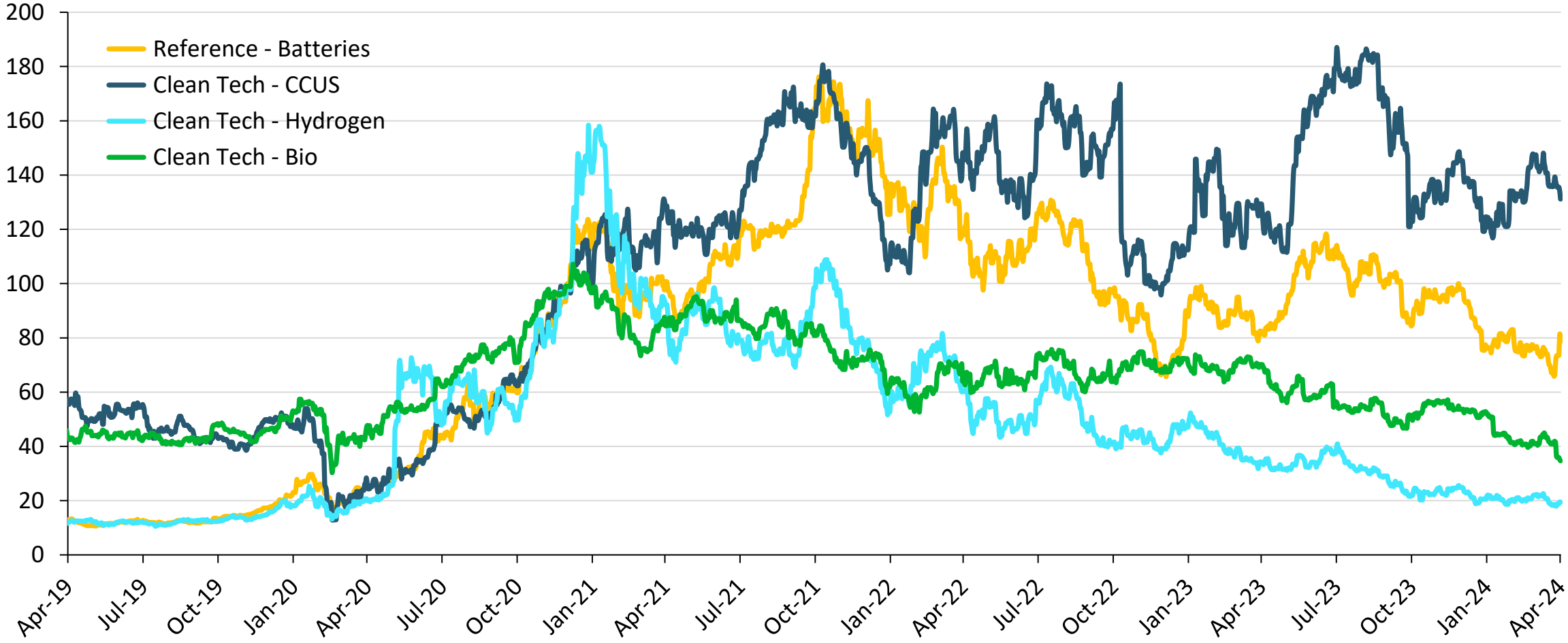
We observed countless new project announcements, but green energy investors are not convinced

Green Energy* total return index
Normalized to a value of 100 on January 1, 2021

*Includes 53 significant public companies with primary business focus on variable renewables, CO2 management, clean hydrogen or biofuels
Source: Rystad Energy research and analysis

Within the clean tech space, hydrogen sector has seen the biggest value correction since 2021

Green Energy - Clean Tech total return index by sub-sector
Normalized to a value of 100 on January 1, 2021



*Clean Tech – Hydrogen, CCUS and Bio indexes consist of 19, 7 and 4 public companies with primary business focus in respective sectors.
Source: Rystad Energy research and analysis

How do we get to different transition scenarios? Call on clean tech by sector

	Decarbonization indicator	Current (2023)	1.5 DG in 2050	2.0 DG in 2050	2.5 DG in 2050
	Carbon capture and tech removal capacity, mtpa	49	8,396	4,115	956
	Share of fossil fuels in final energy demand for industry (direct use)	86%	10%	60%	84%
	Share of renewables in global primary energy mix	20%	89%	45%	26%
	Variable renewable power generation, TWh	4,600	85,600	34,900	10,400
	Share of electricity, biofuels and hydrogen in final energy demand for transport	4.8%	89%	50%	26%
	Compliance carbon price range, USD per tonne	5-100	100-200	60-150	0-50
	Total energy investment needed by 2050	$2.7 trillion per year	$3.5 trillion per year	$2.9 trillion per year	$2.6 trillion per year

Source: Rystad Energy research and analysis

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Fossil CO2 by year and sector – current pathway

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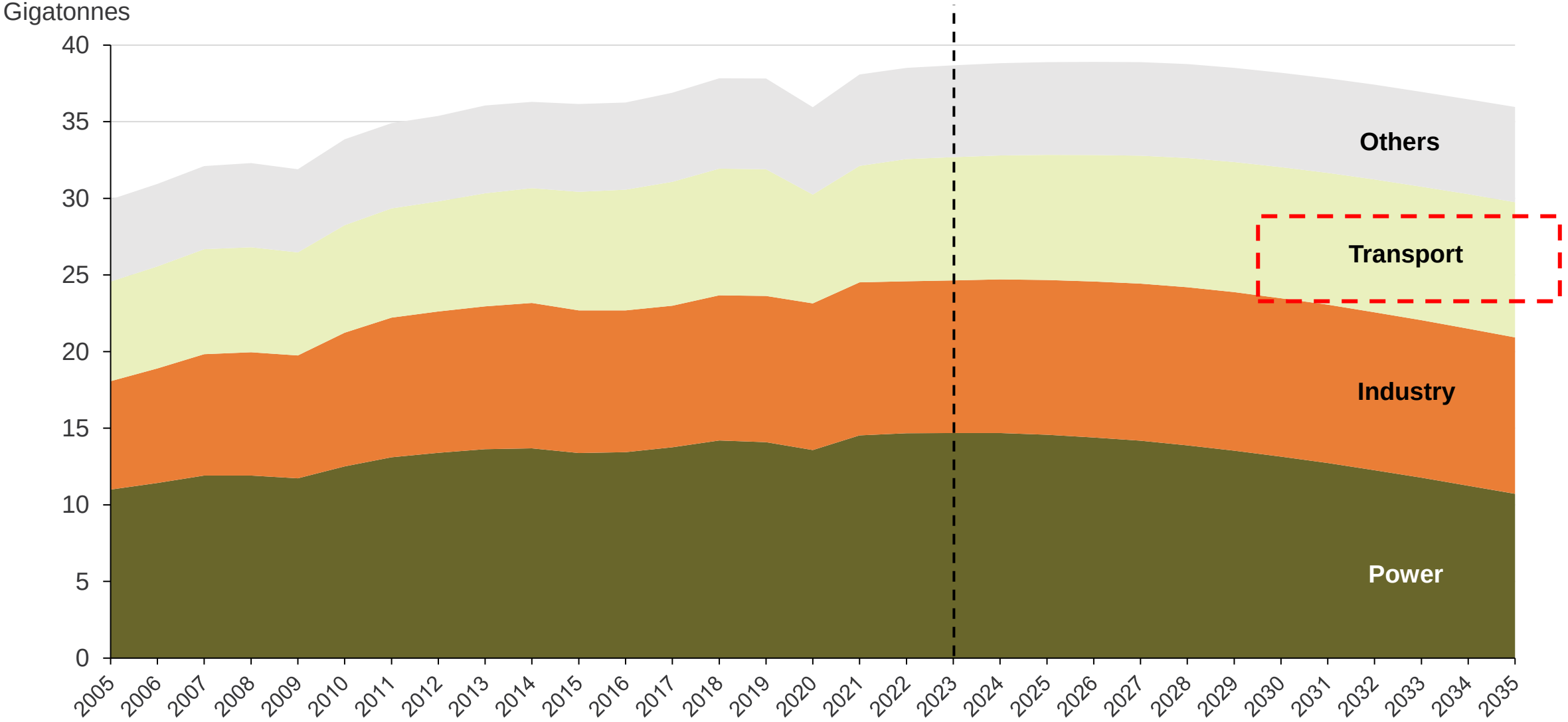

Source: Rystad Energy research and analysis, December 2024

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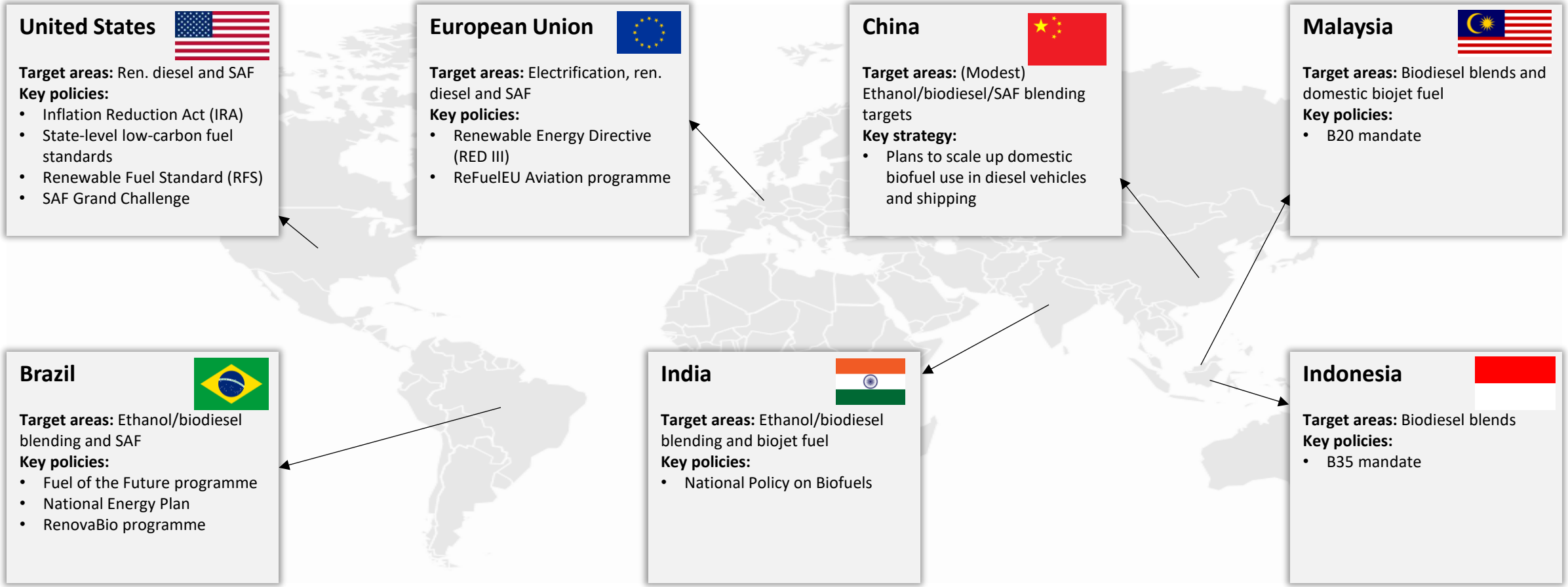
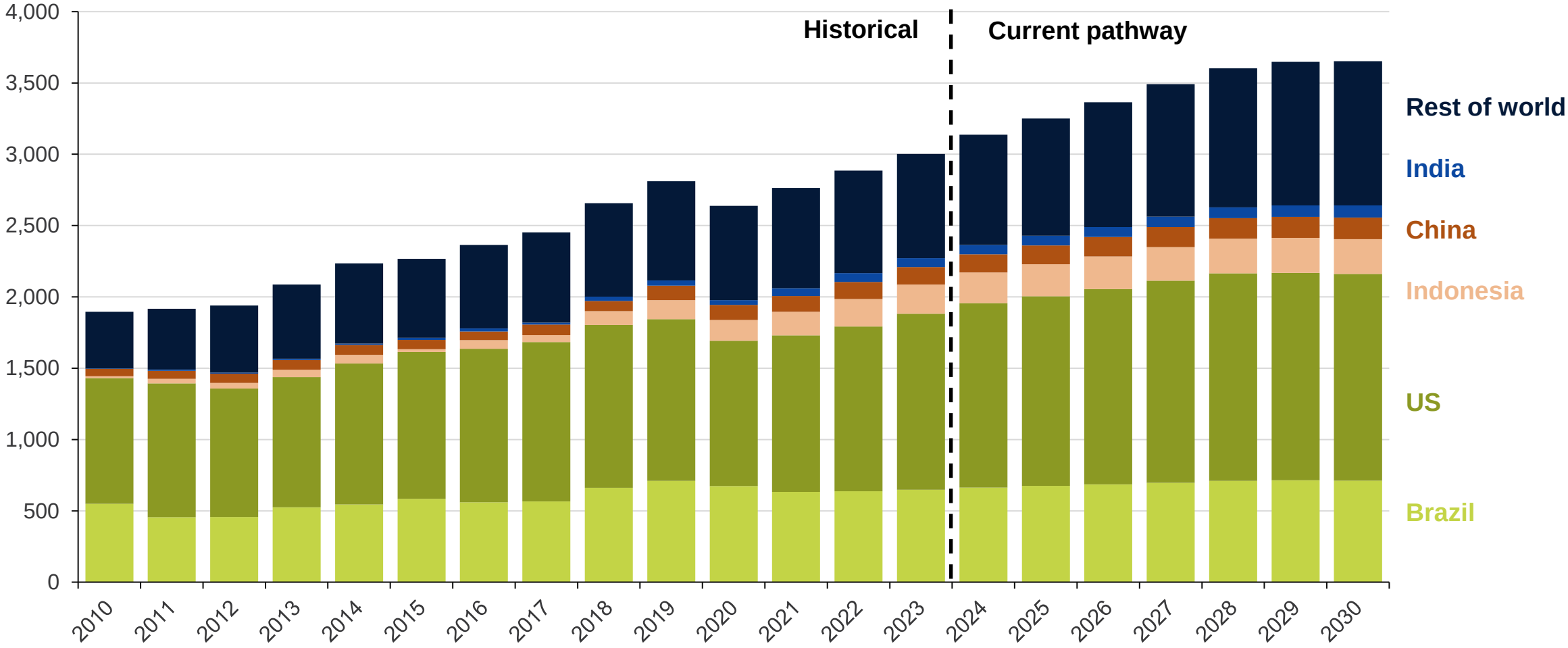
Advanced economies largely adopted electrification while emerging economies targets fuel blends going forward



Source: Rystad Energy research and analysis

Brazil and the US will continue to lead the world market

Global biofuels production by product, history and current pathway
Thousand barrels of oil equivalent per day



Source: Rystad Energy research and analysis, December 2024

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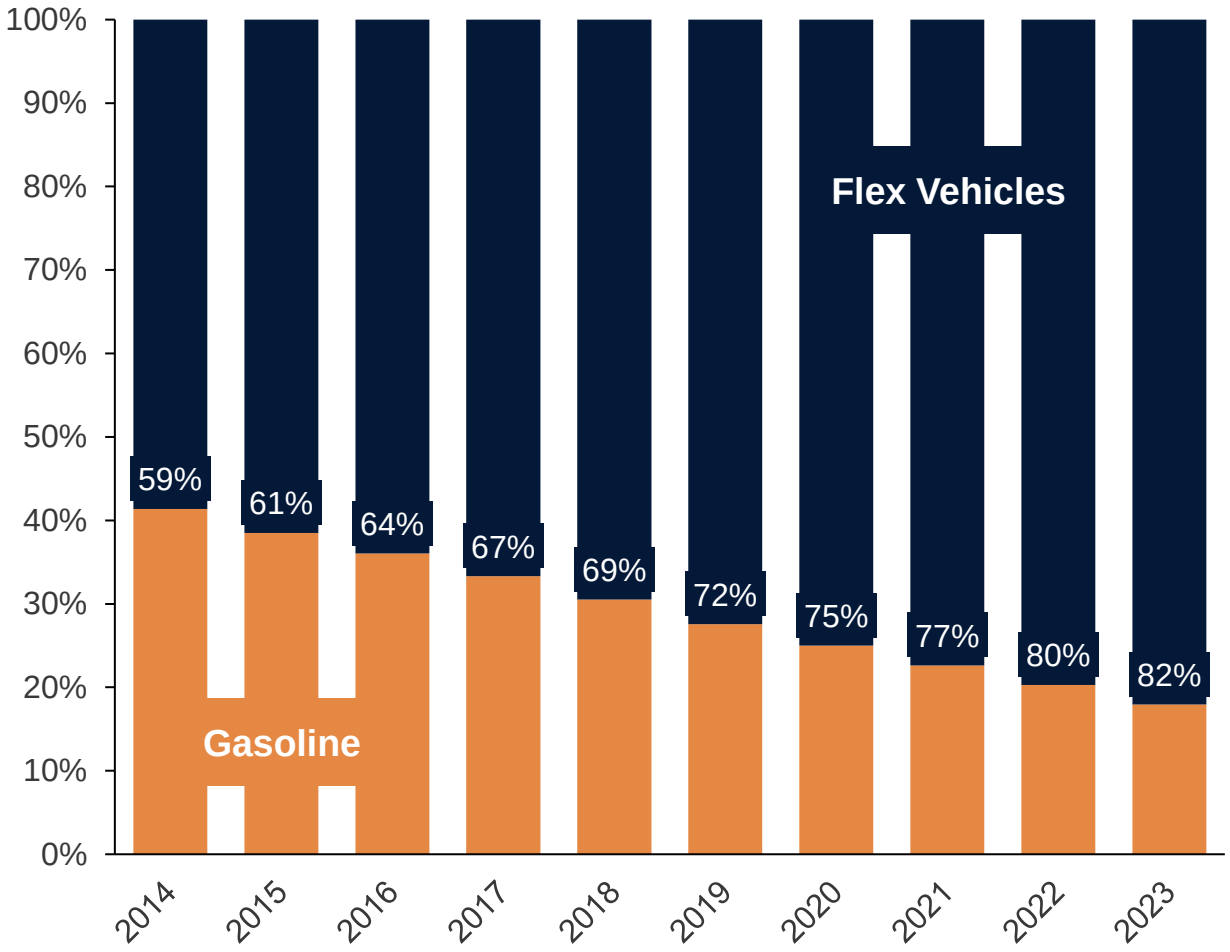
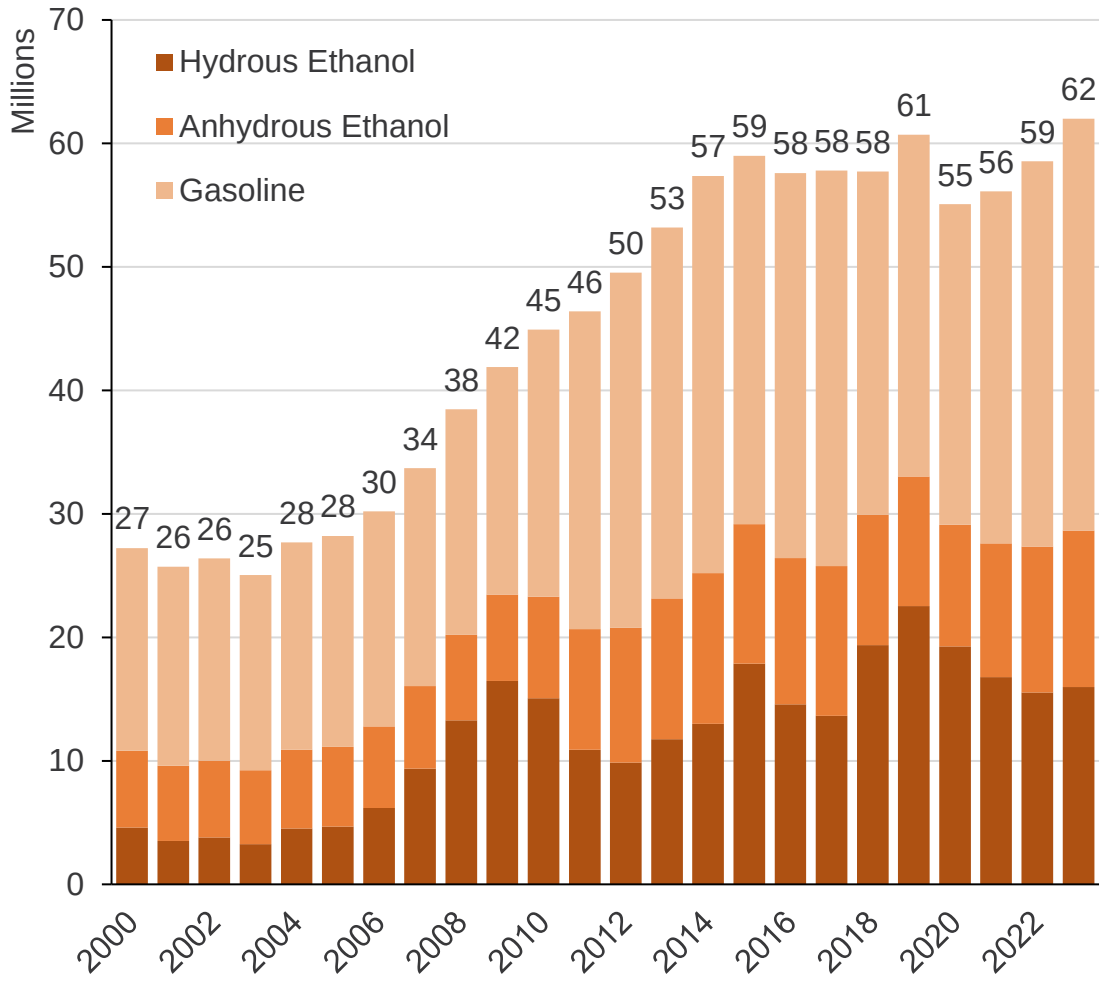
Mobility in Brazil is ready for decarbonization

Brazilian vehicle split by engine type
Percentage of total



Internal Combustion Engine demand in Brazil by year
Million cubic meters per year



Source: Rystad Energy research and analysis, December 2024

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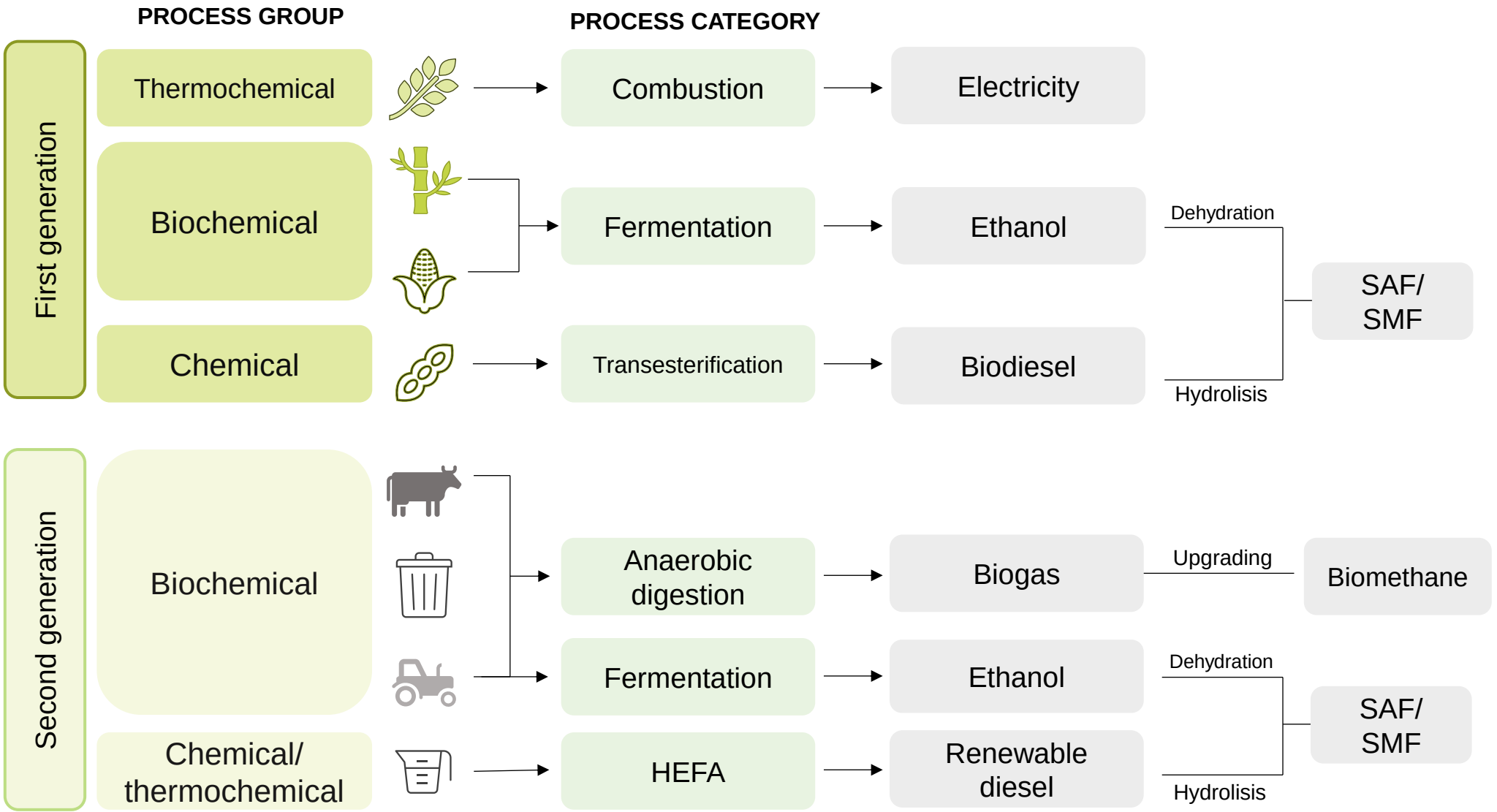
Pathways of biofuels production – first and second generation



*SAF – sustainable aviation fuels, SMF – sustainable maritime fuels
Sources: Rystad Energy research and analysis, December 2024

In 2023, Brazil led global production of major energy crops

Corn

Production

131 M ton

3º

Exports

2º

Area

22.0 M ha

Sugarcane

Production

713 M ton

1º

Exports

1º

Area

8.3 M ha

Soybeans

Production

154 M ton

1º

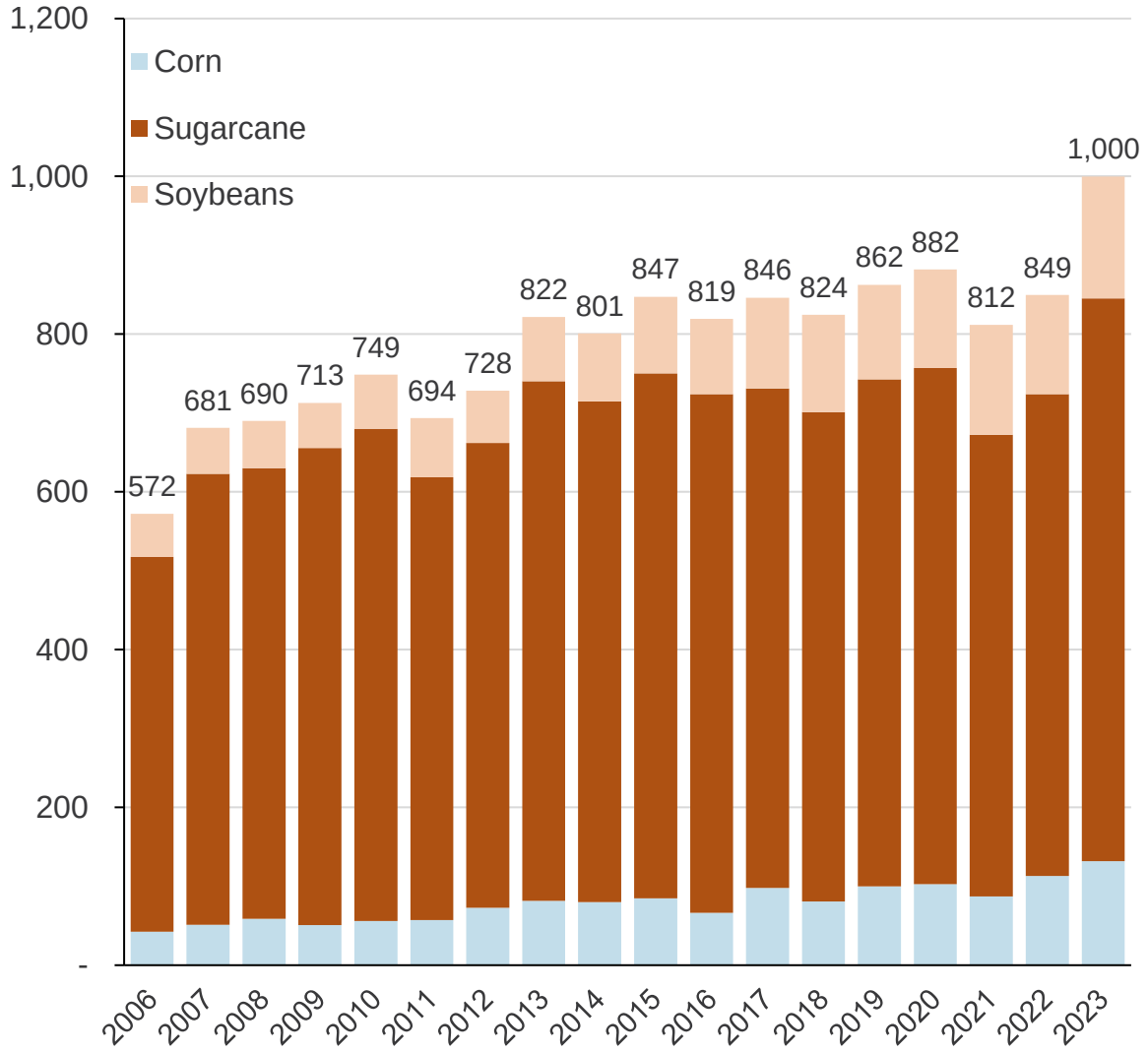
Exports

1º

Area

44.0 M ha

Brazil's agricultural production by crop
Thousand tons per harvesting season



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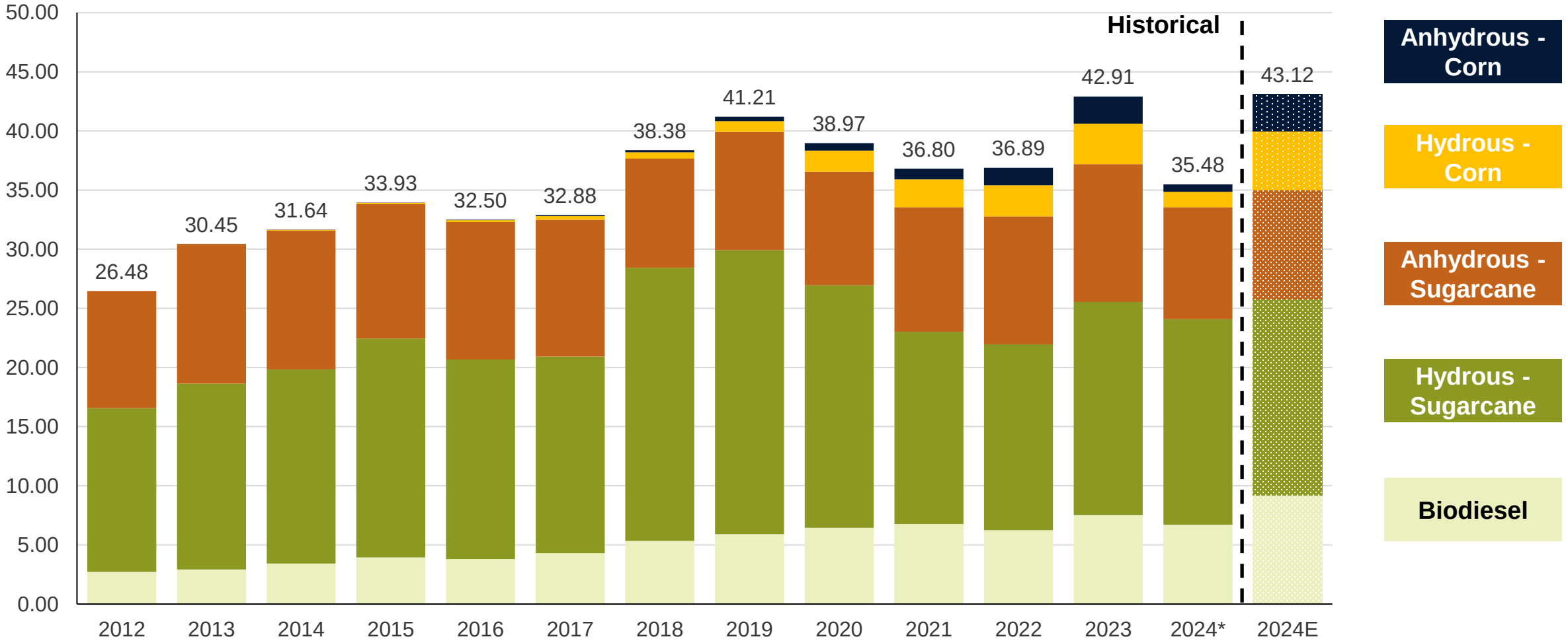
Source: Rystad Energy research and analysis, June 2024

2024 will be the year with the highest biofuel production ever in Brazil

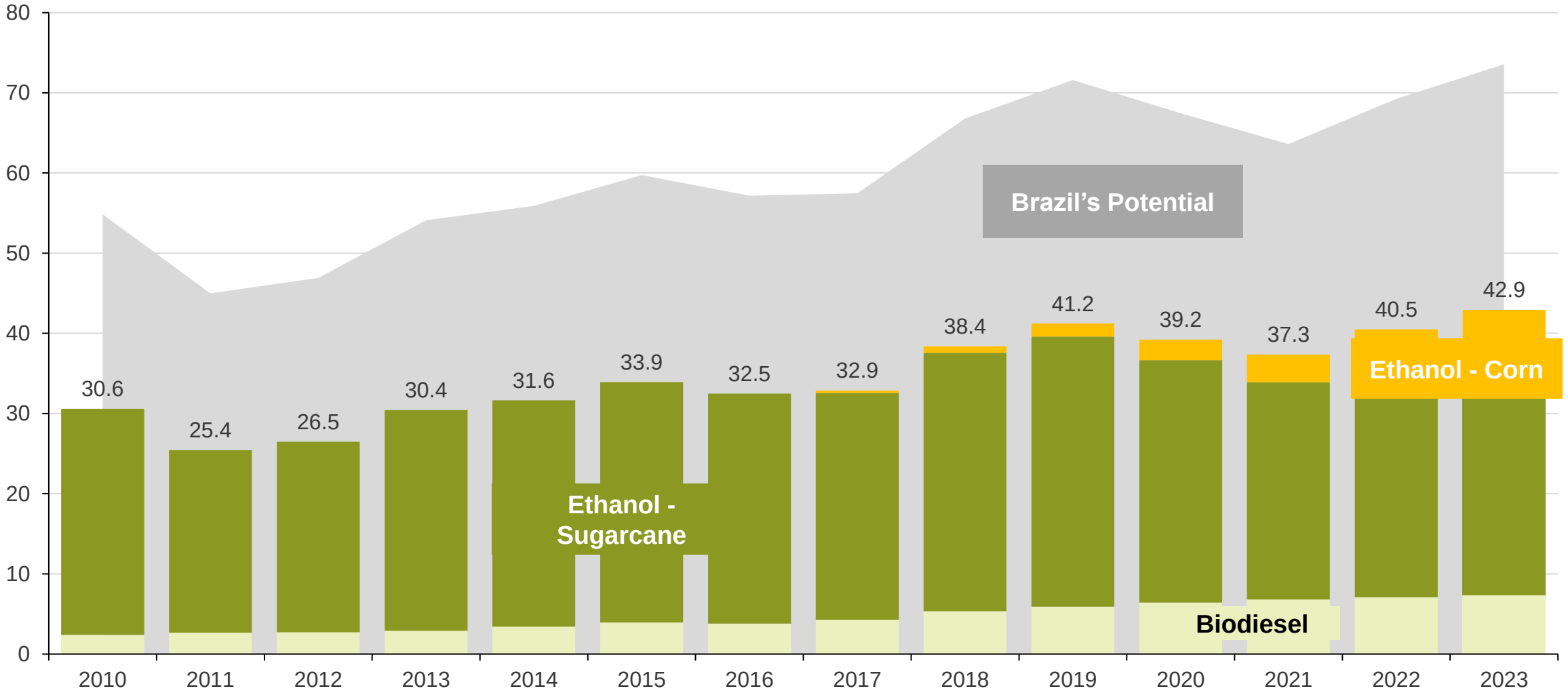
Biofuel production by product type and feedstock
Million cubic meters per harvesting season



*Data up until September 2024
Source: Rystad Energy research and analysis, November 2024

Corn and sugarcane drive the biofuels production in Brazil

Biofuel production by feedstock
Million cubic meters per year



Source: Rystad Energy research and analysis, June 2024

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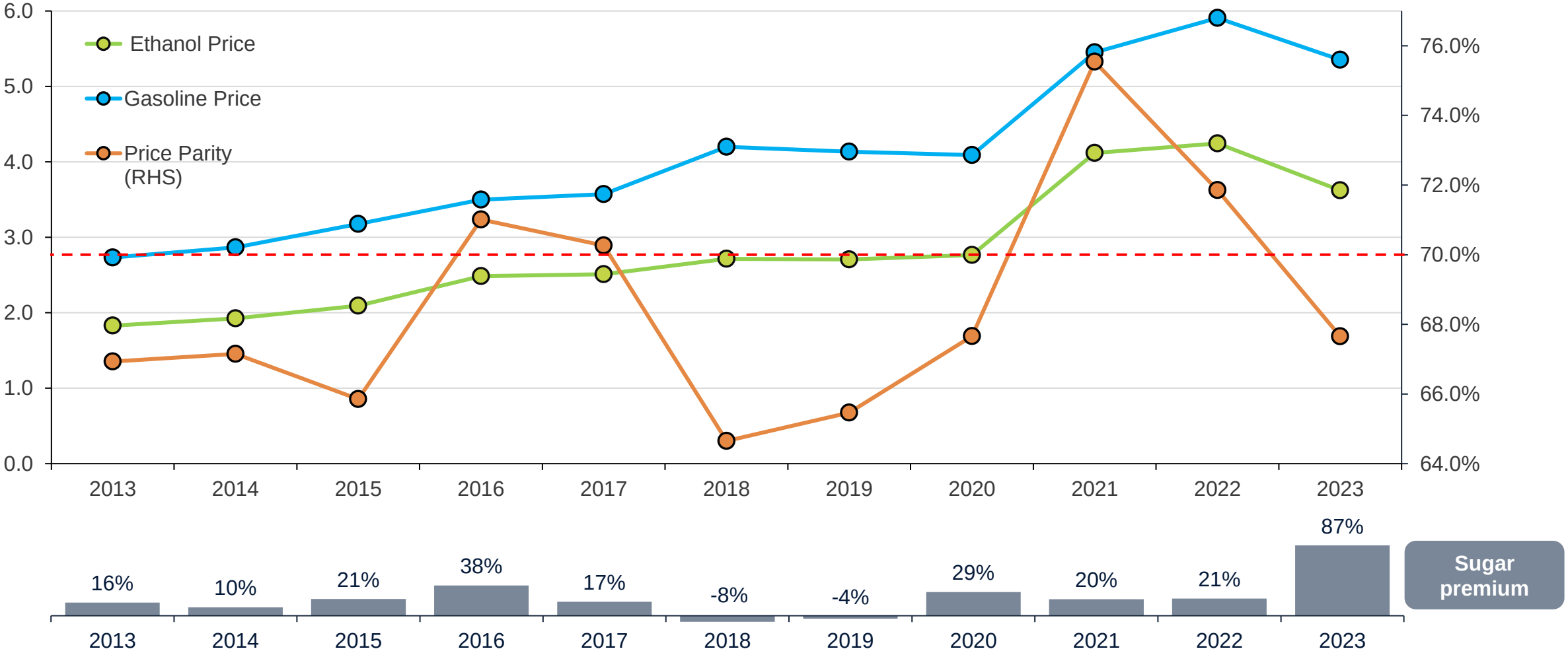
Competition with gasoline and sugar puts growth through traditional means at risk

Ethanol and gasoline prices and sugar premium over ethanol production
Brazilian Reais BRL per liter (LHS) and ethanol parity against gasoline % (RHS)



Source: Rystad Energy research and analysis, ANP

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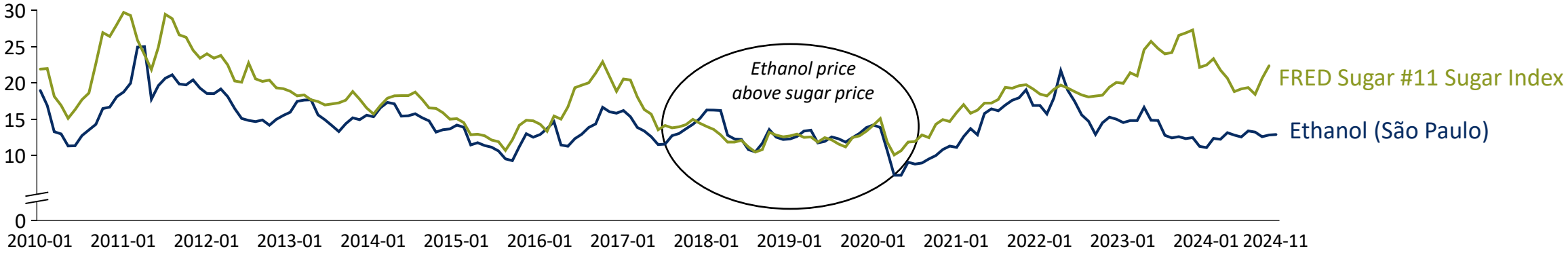
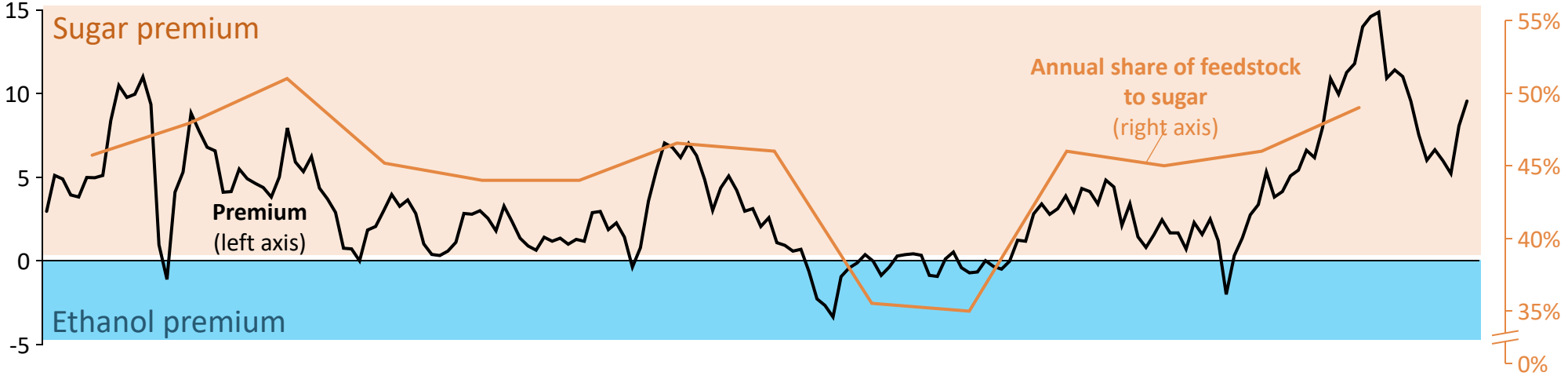
There is usually a premium for those who produce sugar...

Price equivelancy - São Paulo
USD cents/lb of sugar equivelant[1]



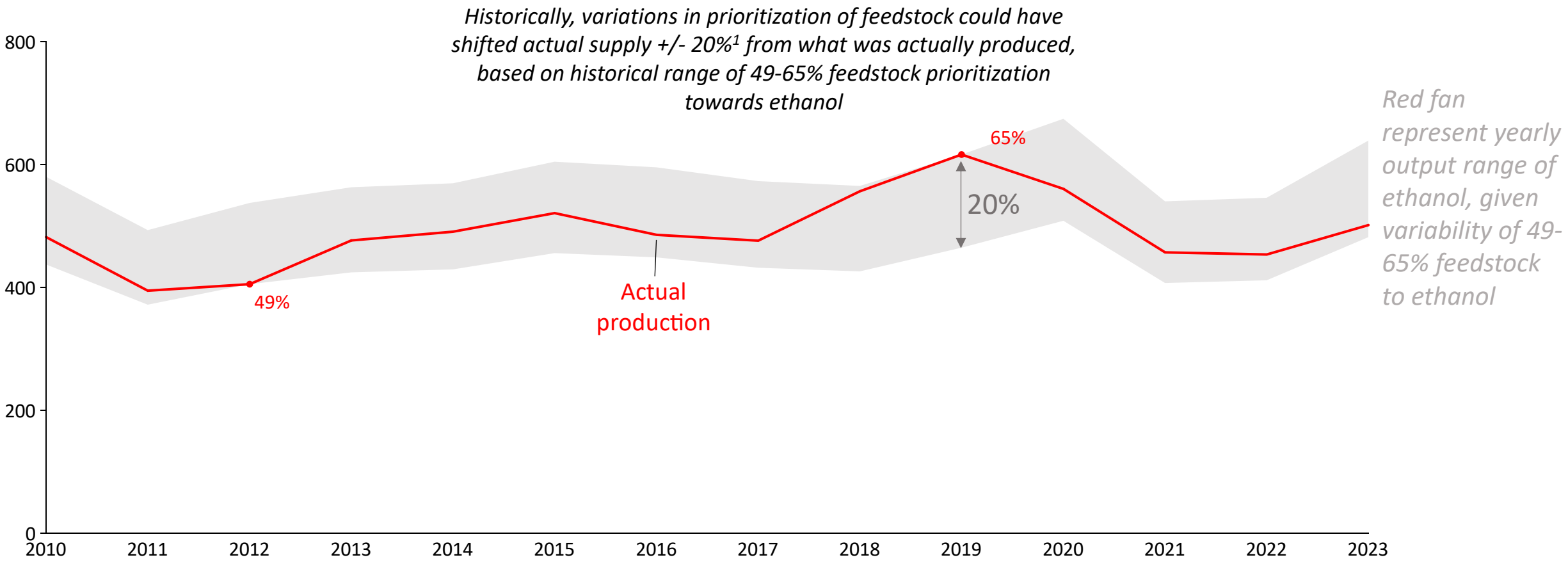
Premium, Sugar #11 – Hydrous ethanol (USD cents/lb of sugar eq.)



1) Monthly average prices
Source: Rystad Energy research and analysis; FRED Sugar #11 index; CEPEA Hydrous ethanol index (Sao Paolo State)

... But variation in feedstock prioritization could shift supply around +/-20% of actual production

Brazilian bioethanol production, split by historical feedstock utilization span
Kbbl/d

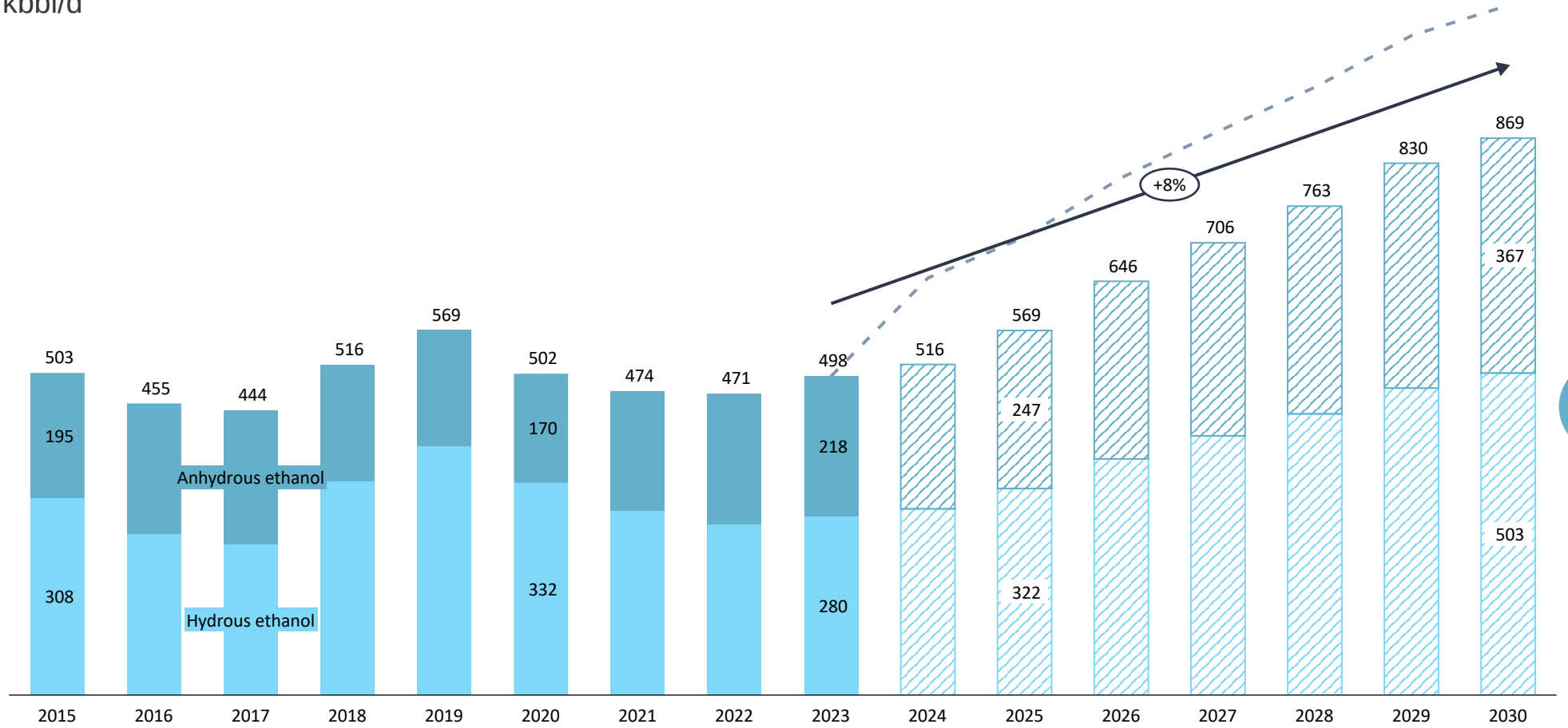


1) Max difference up or down to prioritization range from actual production.
Source: Rystad Energy research and analysis

The current Cbios targets implies an annual ~8% in ethanol demand growth for transportation

Estimated transportation demand for ethanol given Cbios targets

kbbl/d



Theoretical max: All CBIOS units are captured by Ethanol

CAGR 2023-2033 **12%**

Estimated trajectory: ~83%[1] of CBIOS are captured by ethanol

CAGR 2023-2033 **8%**

1) 83% of Cbios are expected to be allocated to ethanol based on the current share of Cbios.
Source: Rystad Energy research and analysis; ANP

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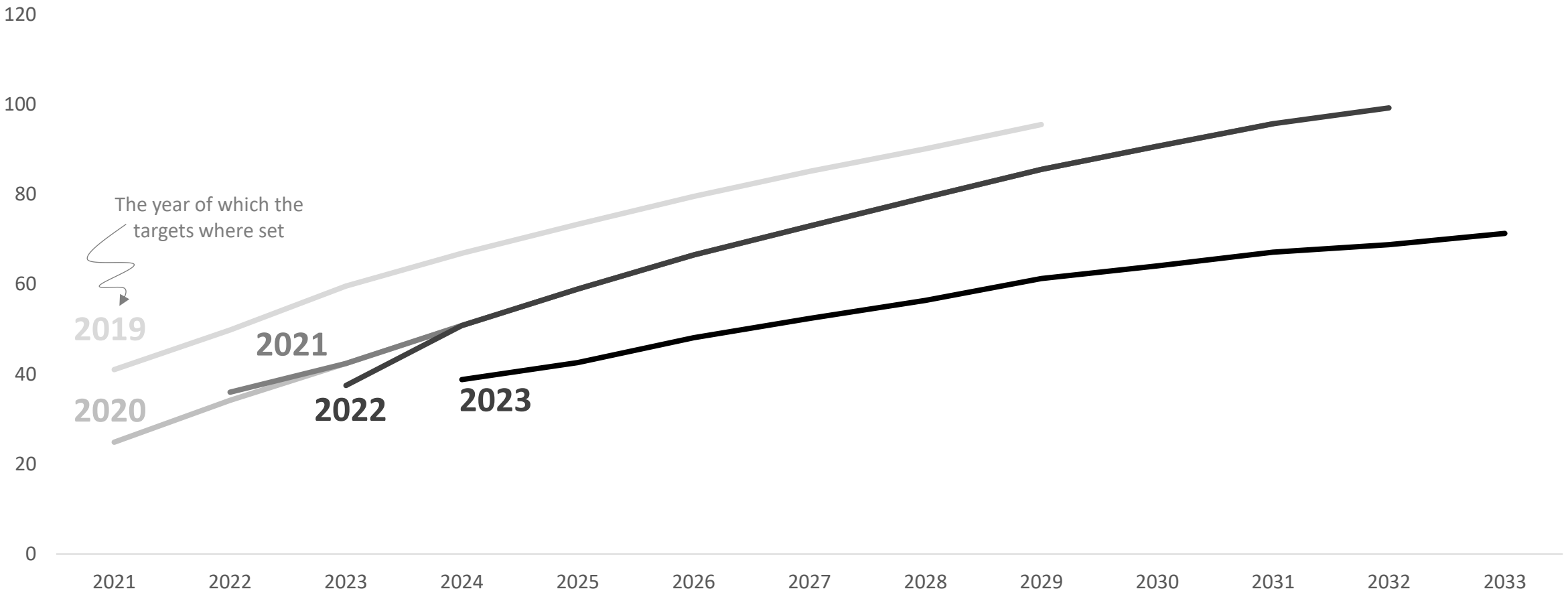
The annual Cbios targets have been reduced each year since 2019

Targets for Decarbonization Credits (Cbios) by vintage, 2019-2023
million CBios



Source: Rystad Energy research and analysis

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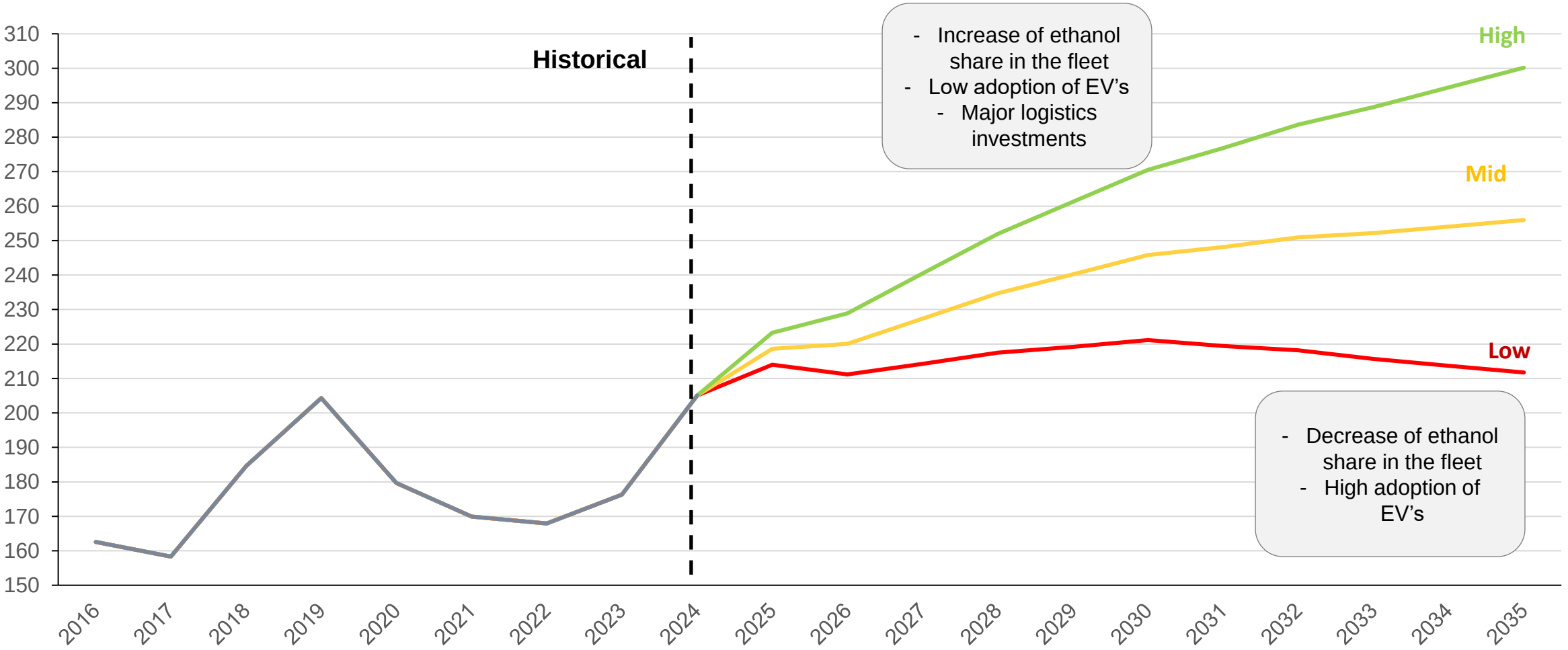
Ethanol could change Brazil's position in the global energy transition scenario

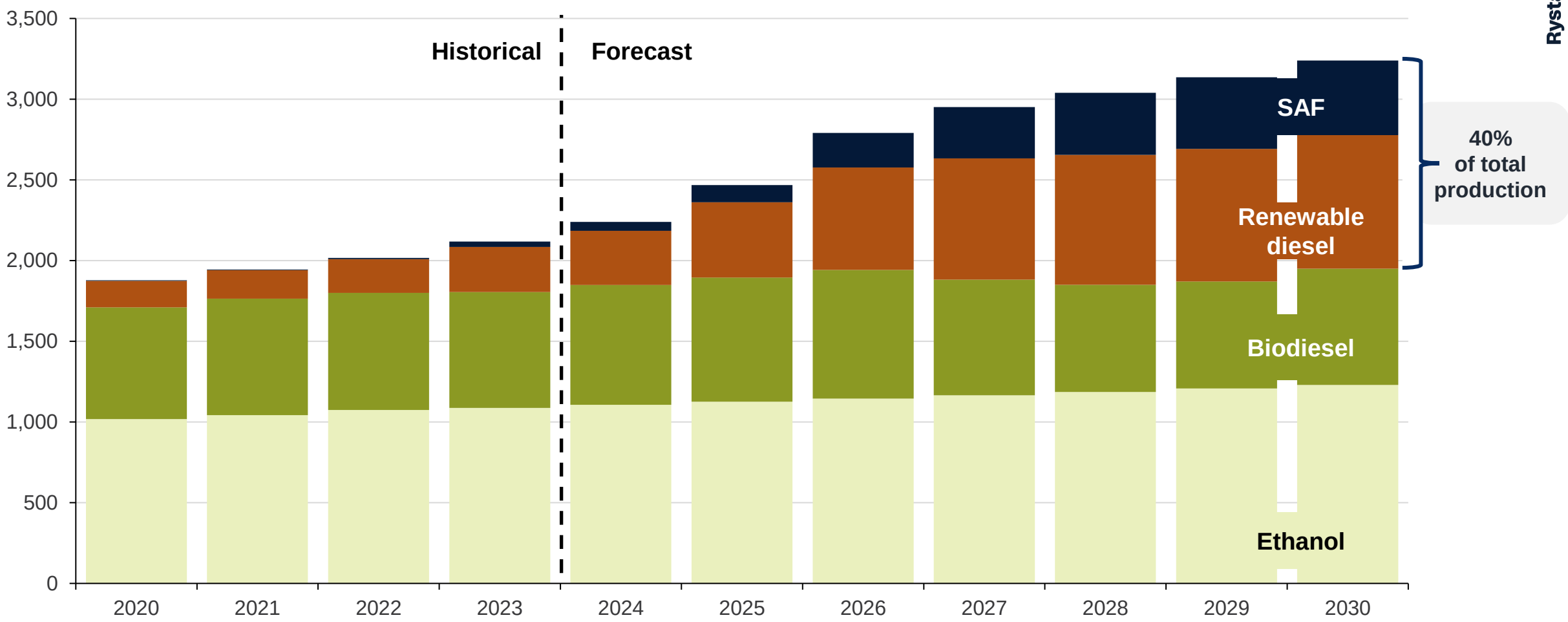
Domestic Hydrous and Anhydrous ethanol demand, Brazil
Million barrels



Source: Rystad Energy research and analysis, September 2024

SAF and renewable diesel production to reach 1.5 million bpd by early 2030s

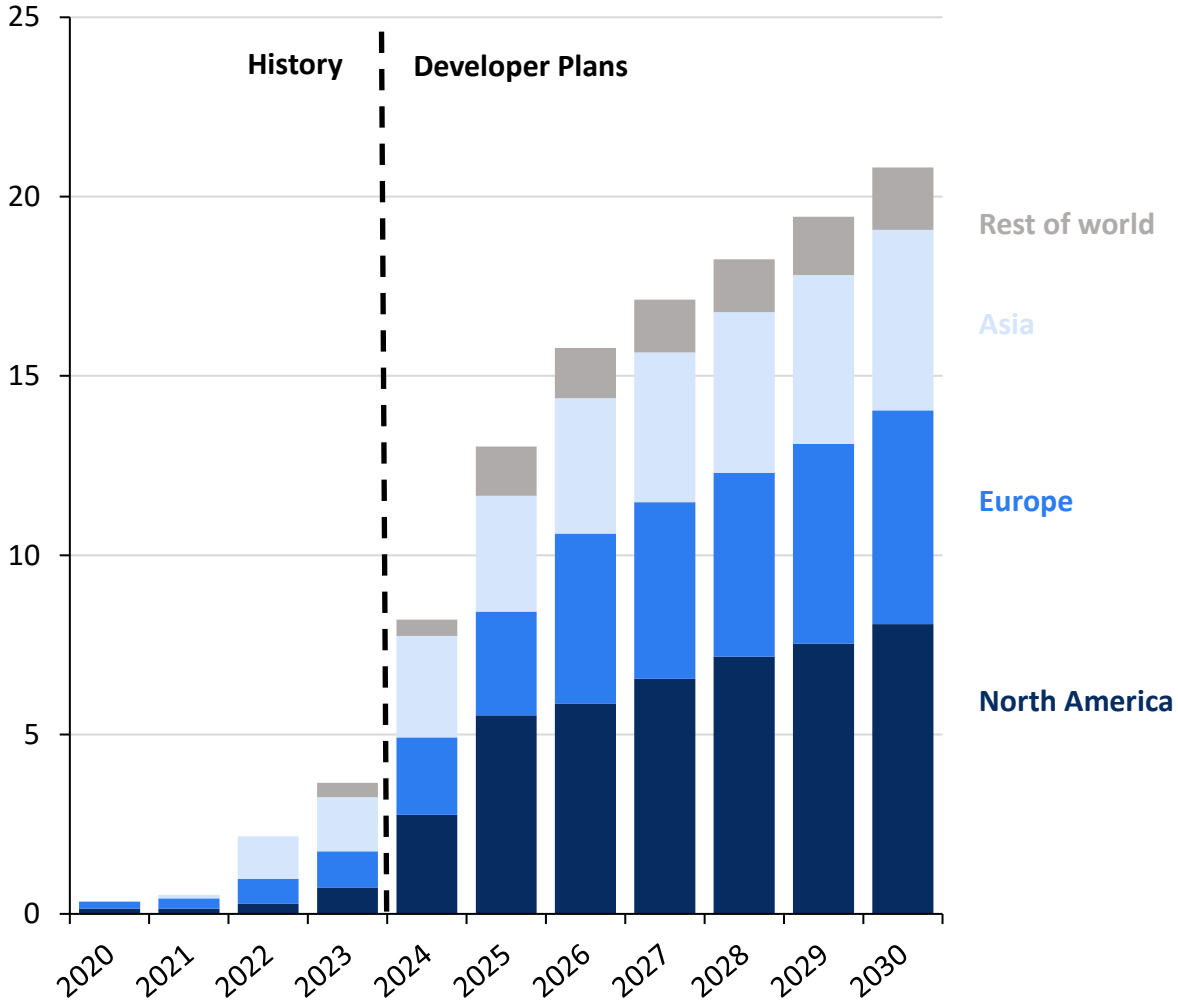
Global biofuels production by product, history and current pathway
Thousand barrels of oil equivalent per day



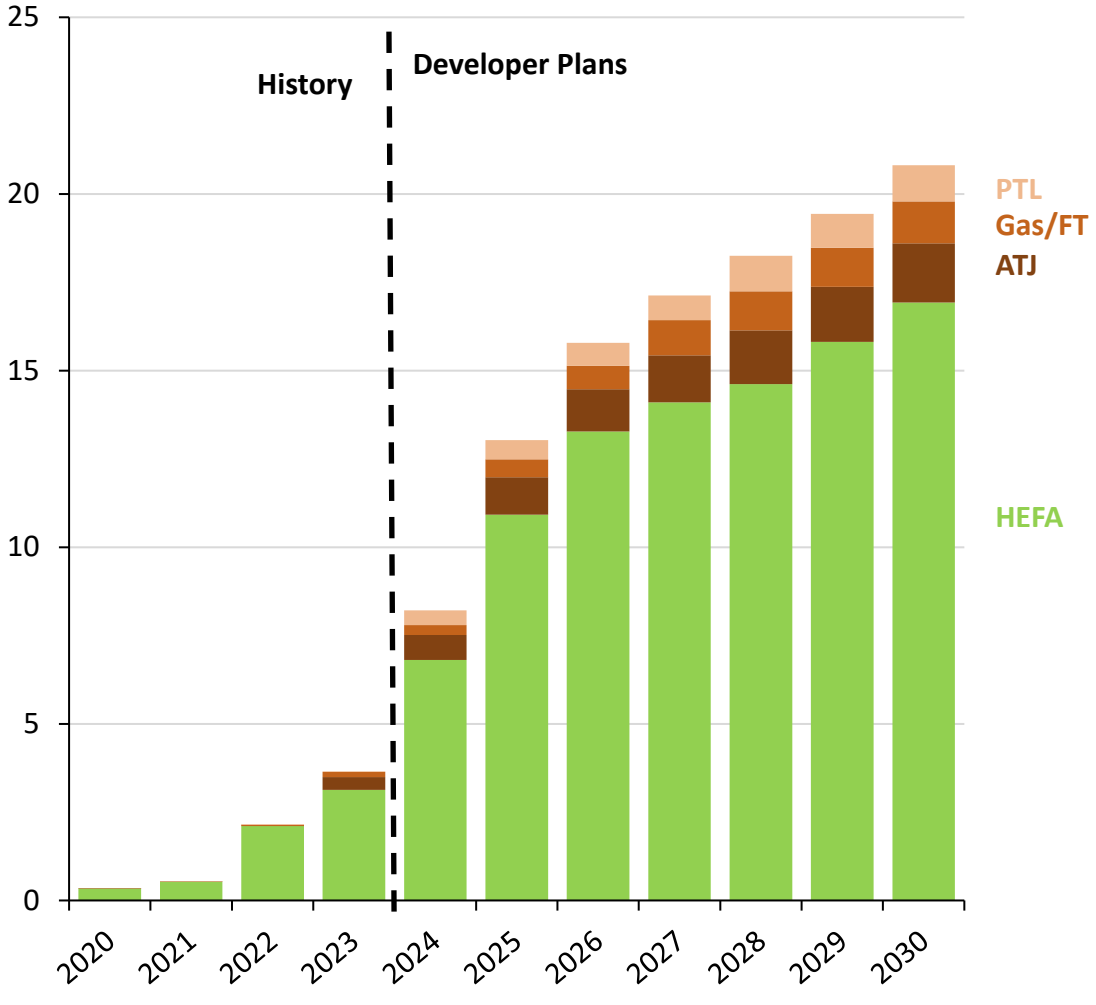
Source: Rystad Energy research and analysis, June 2024

Based on announced projects, global SAF capacity might reach 20 mtpa in the second half of 20s

Unrisked production capacity by region
Million tonnes per year



Unrisked production capacity by process
Million tonnes per year



Source: Rystad Energy research and analysis

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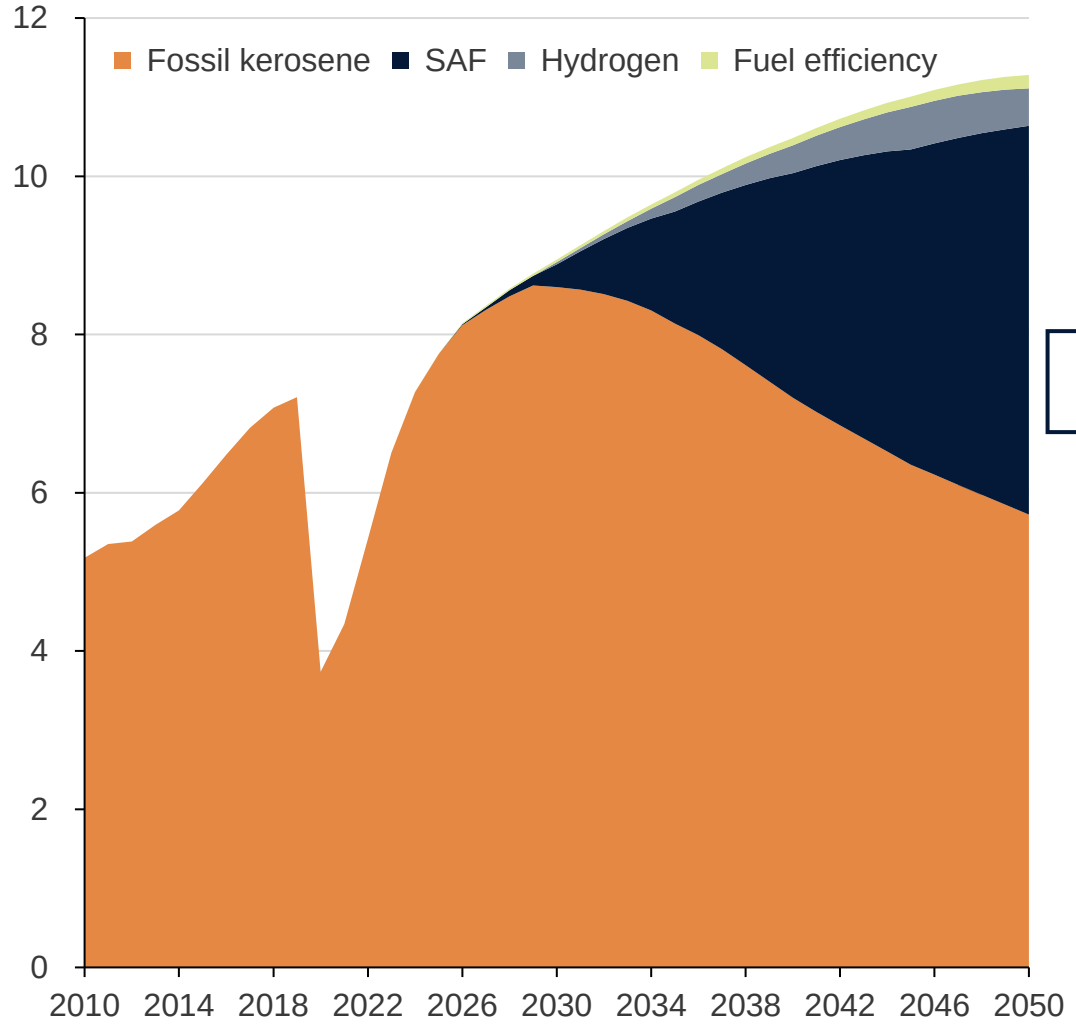
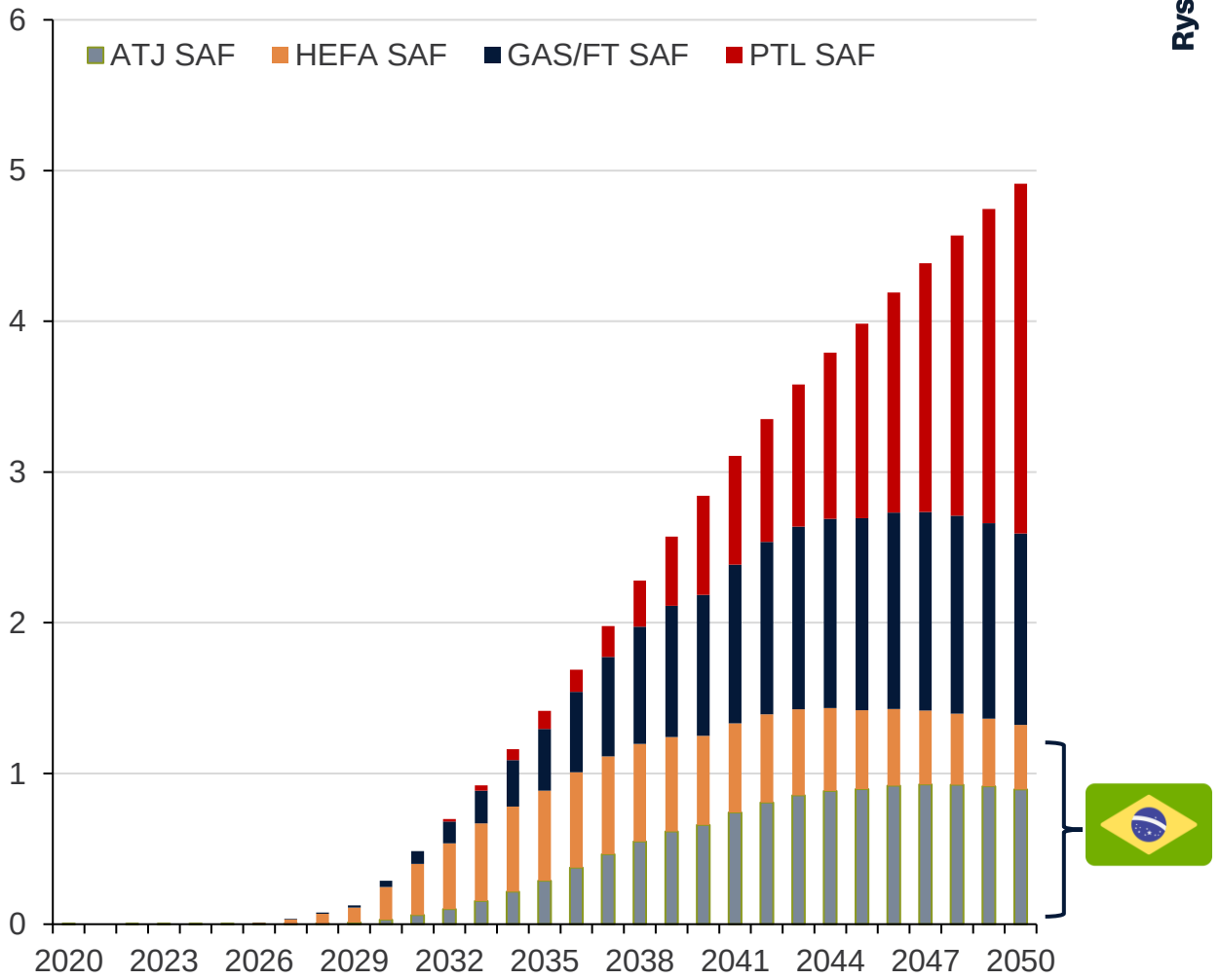
SAF an opportunity to leverage Brazil's strength

Global aviation fuel demand, mean case (1.9 DG scenario)
Million barrels per day



SAF demand by type, mean case (1.9 DG scenario)
Million barrels per day



Source: Rystad Energy research and analysis, September 2024

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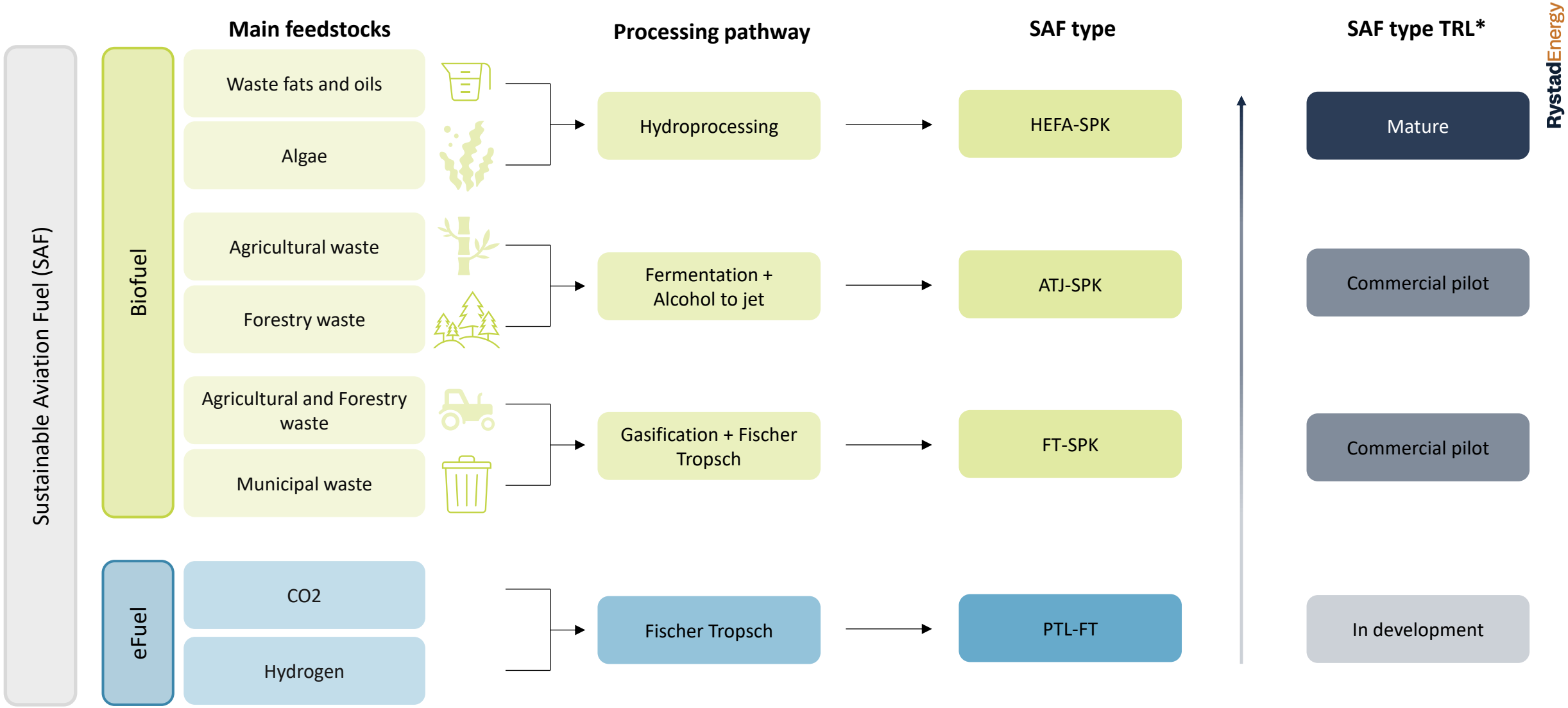
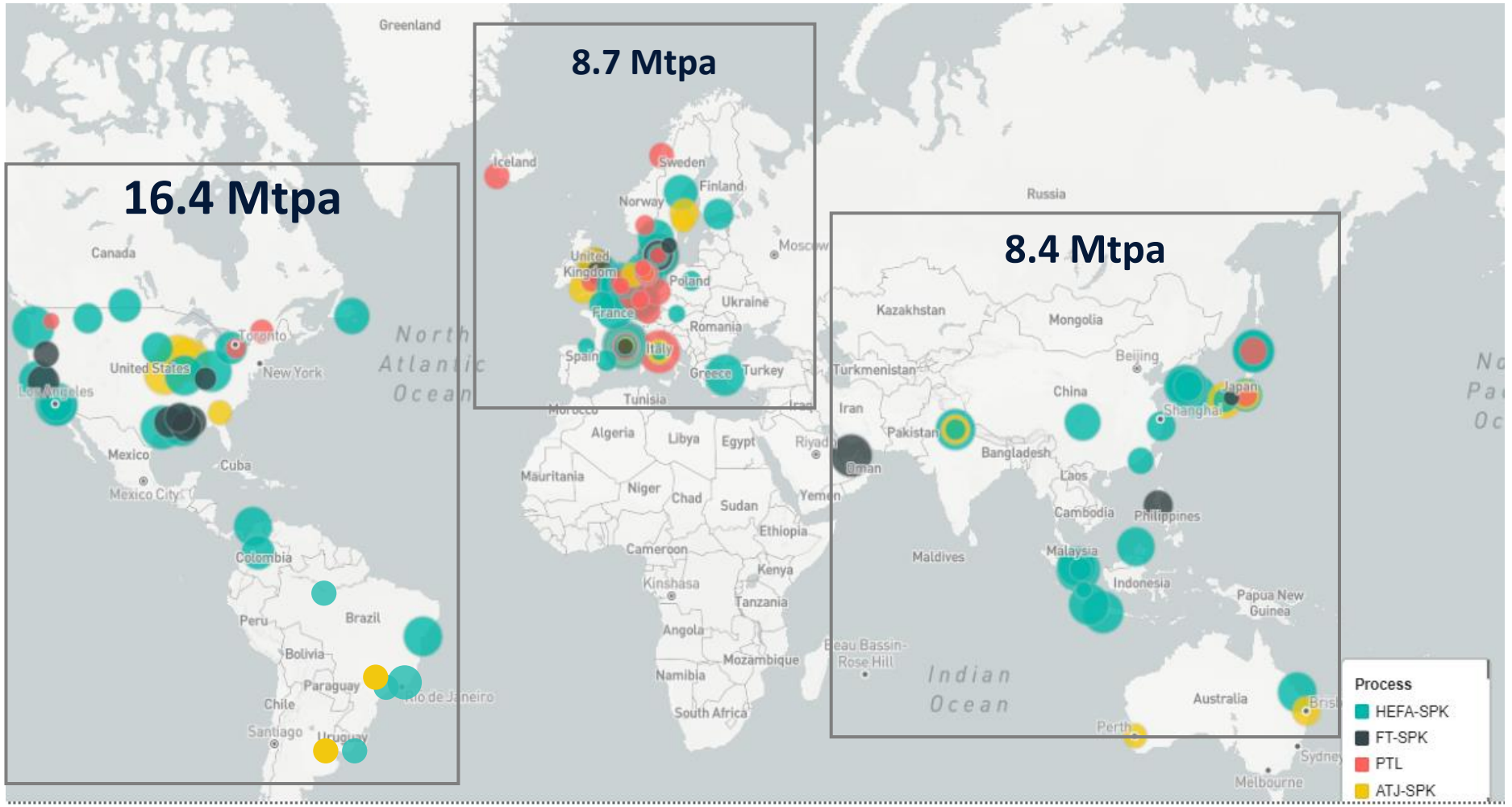
Overview of the four main production pathways for SAF



* Technology Readiness Levels
Source: Rystad Energy Research and Analysis, EIA

200 Operational and Planned Assets Driving SAF Production: US Takes the Lead



Processing pathways: Over 50% of SAF projects rely on HEFA-SPK (75% of total capacity). The US is the primary future market for HEFA-SPK, and Germany leads in announced PtL projects

SAF production capacity by 2030: All operational and announced SAF projects would have a production capacity of 24 Mtpa

HEFA facilities: Even though they often produce Renewable Diesel and SAF, the focus remains on renewable diesel production

Source: Rystad Energy research & analysis

Alcohol to jet is still in the early stages of development, but could represent the main investment destination in the sector

Announced projects: US displays a total of 7 SAF projects using AtJ technology out of 20 announced projects worldwide.

Forecast risks: Changes in commodity scenarios such as sugar and DDGS production could boost or decrease SAF production, given the changes in the biofuel production premium in relation to food in the 1G market.

Feedstock availability: Different pathways for ethanol production will be the differentiator for market development.

Source: Rystad Energy research & analysis

SAF: An opportunity to leverage Brazil's strength

Worldwide ethanol production facilities
Based on status of each bio-refinery

Ethanol potential:
Brazil and the US combined account for around 85% of the global ethanol market share. India's significant ethanol production capacity could shake up the market structure if domestic sugar consumption declines in the coming years.

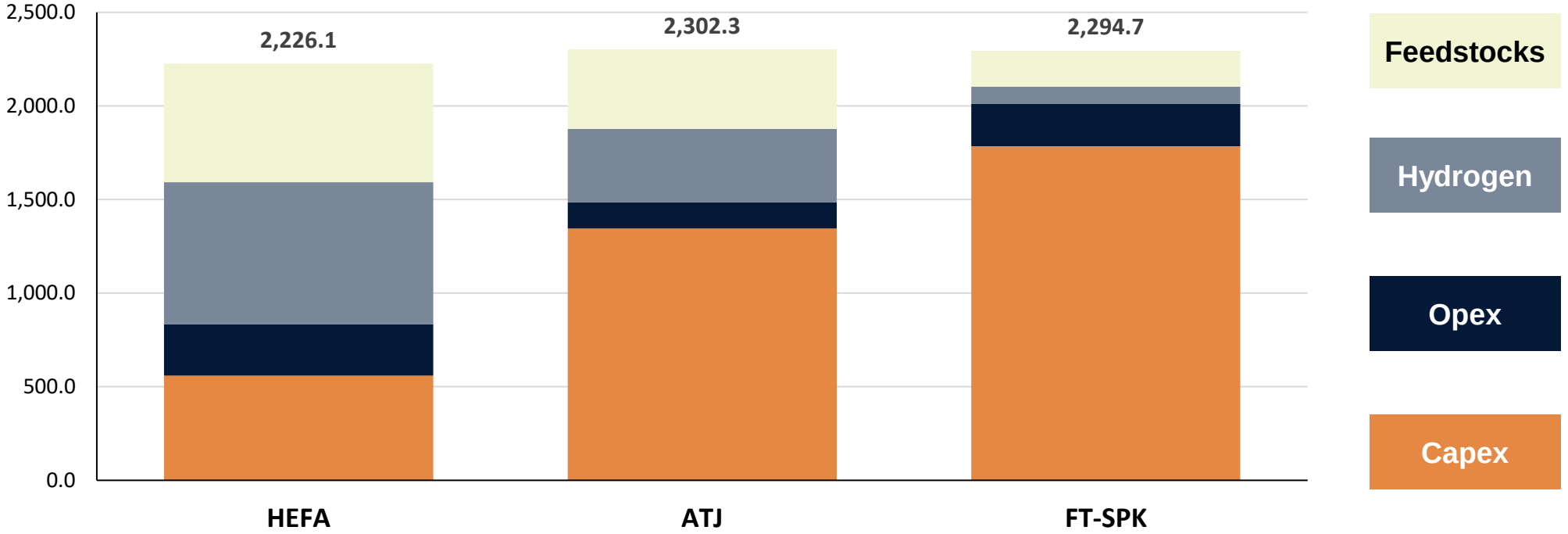
SAF capacity:
The development of 2G ethanol will be the differentiator for markets with high domestic consumption of the fuel. Preliminary production indicates a 40-50% increase in ethanol production with the use of waste.

Source: Rystad Energy research and analysis, December 2024

Comparative model for technological route for SAF

Cost breakdown by technological route for SAF in Brazil

USD/Ton

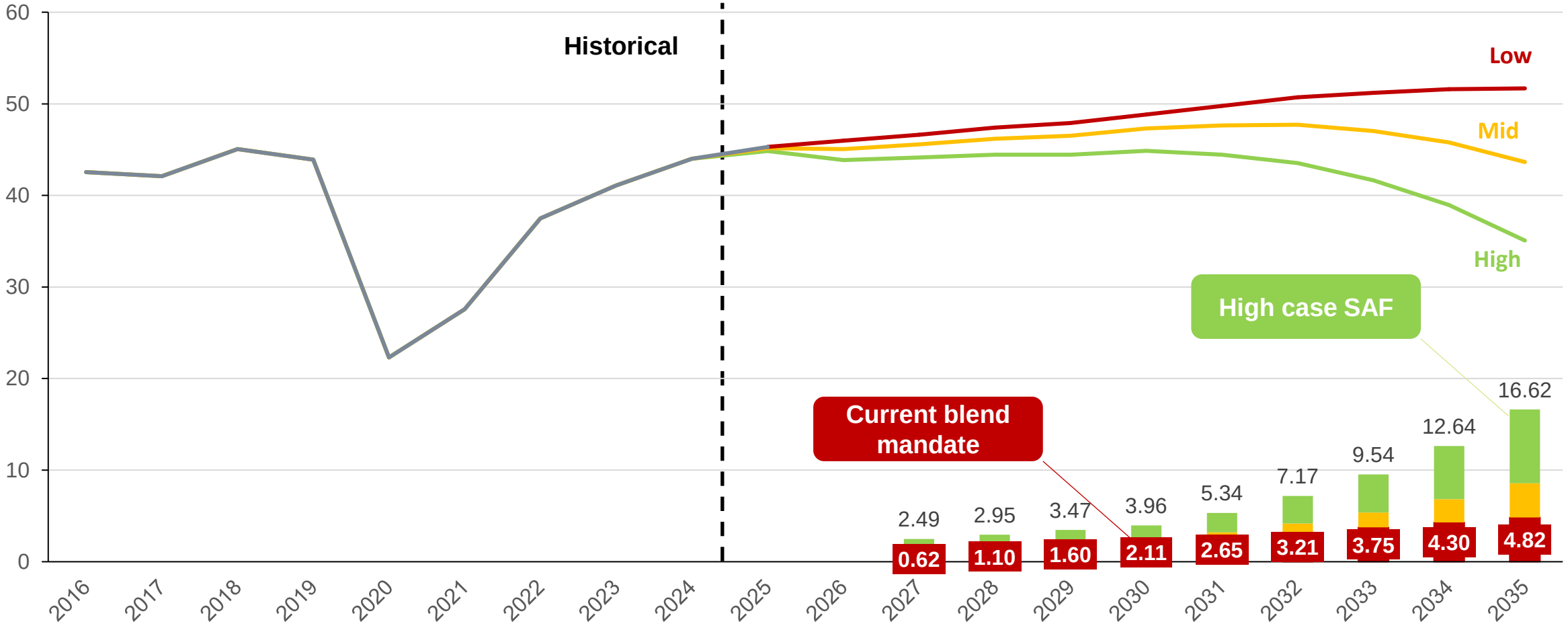


Main Feedstocks	Waste fats and Oils	Ethanol – Agricultural Waste	Agricultural Waste – Forestry
Conversion Efficiency (%)	90%	60 - 95%	16 - 60%
Co-product Yield (%)	Up to 85%	Up to 35%	Up to 75%

Source: Rystad Energy research and analysis, December 2024

ProBioQAV program will be Brazil's first push into SAF

Domestic consumption of Jet Fuel and SAF forecast, Brazil
Million barrels



Source: Rystad Energy research and analysis, December 2024

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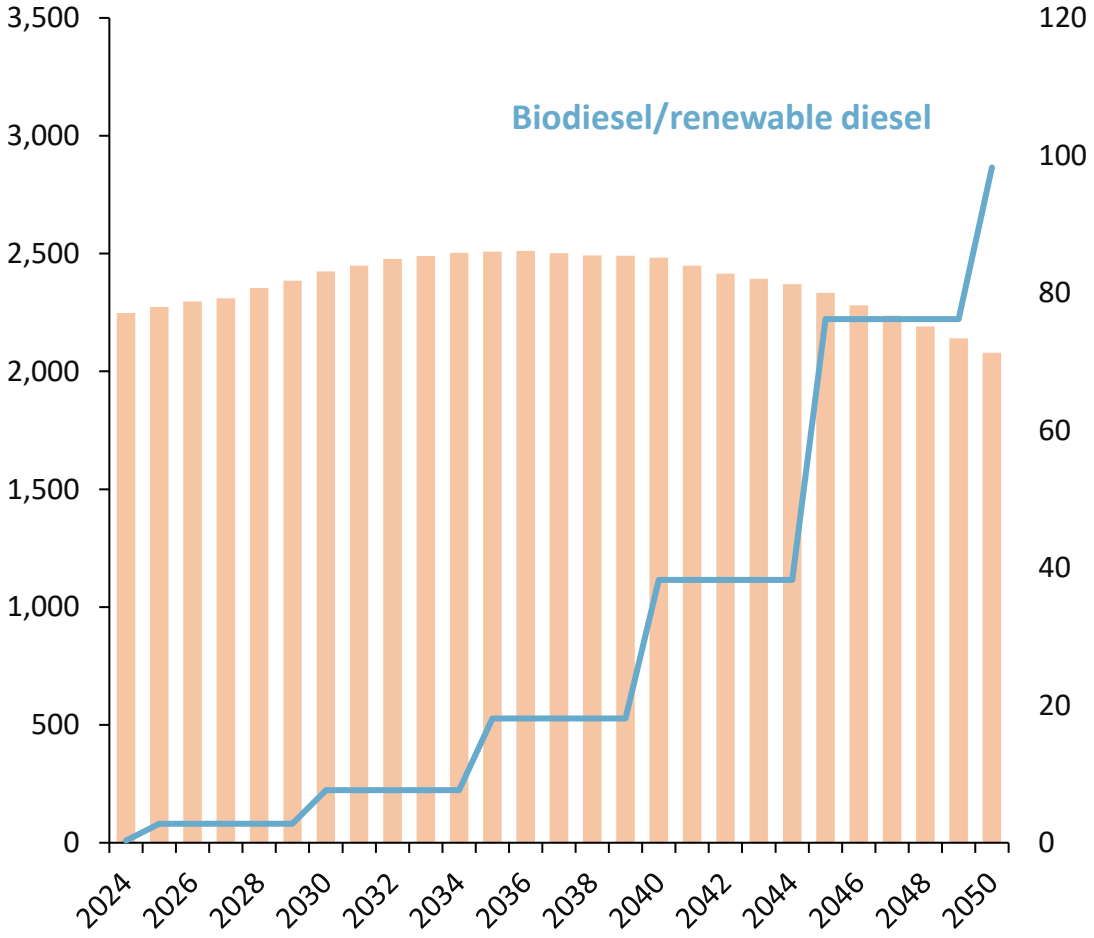
SMF: A new frontier for Brazil's agribussiness

Demand of maritime fuel by year and minimum blend levels of FuelEU Maritime target

Million barrels per year (LHS) and blending mandate %(RHS)

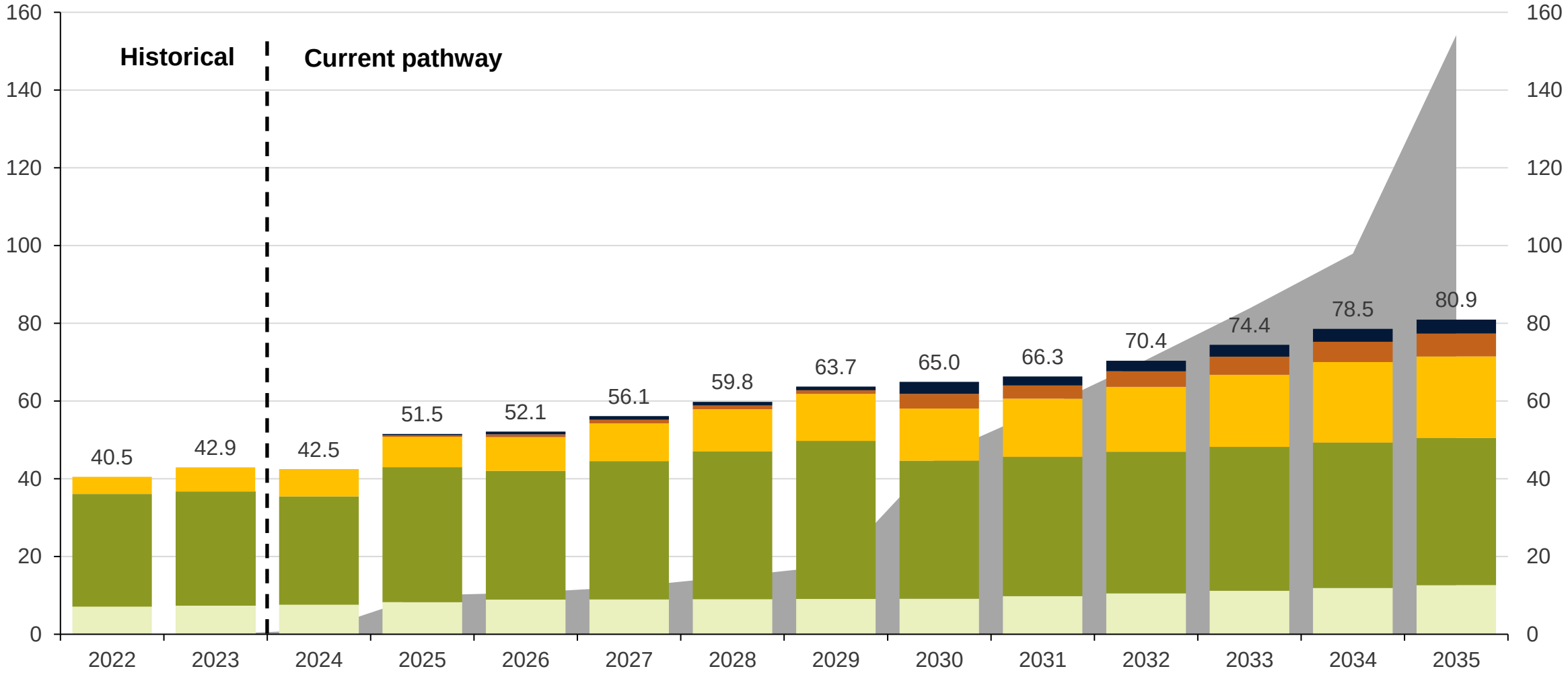


Size	Short-haul	Medium-haul	Long-haul
Large	Ethanol Methanol Hydrogen	Ethanol Methanol Hydrogen Renewable Diesel	Ethanol Methanol Hydrogen Renewable Diesel
Medium	Amonia Biodiesel Renewable Diesel Bio-LNG	Amonia Biodiesel Renewable Diesel Bio-LNG	Biodiesel Renewable Diesel Bio-LNG
Small	Battery Renewable Diesel	Battery Renewable Diesel	Renewable Diesel
	Distance		

Source: Rystad Energy research and analysis, OilMarketCube, ShippingSolution December 2024

Demand will still surpass global supply, even with worldwide investments

Biofuel production by feedstock and global additional demand
Million cubic meters per year



Source: Rystad Energy research and analysis, December 2024

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Navigating the future of energy

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