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Draft Transportation Fuels Transition Plan
Appendix B
ICF/CARB Refinery Model Documentation

Table of Contents

Tables and Figures

Glossary of Terms and Acronyms

AATE3 – Advanced Clean Transportation Forecast Scenario 3. A scenario developed by the California Energy Commission (CEC) as part of its Integrated Energy Policy Report (IEPR) forecasting process.
AEO – Annual Energy Outlook. A long-term energy projection published by the U.S. Energy Information Administration (EIA), used to inform national energy policy and planning.
BD – Biodiesel. A renewable, biodegradable fuel manufactured domestically from vegetable oils, animal fats, or recycled restaurant grease. It is tracked under California's Low Carbon Fuel Standard (LCFS) program.
B/cd – Refinery capacity units; barrels per calendar day
BTS – Bureau of Transportation Statistics. A division of the U.S. Department of Transportation that provides data on transportation systems, including aviation fuel consumption.
CAFE – Corporate Average Fuel Economy. A federal regulatory program administered by the National Highway Traffic Safety Administration (NHTSA) and the Environmental Protection Agency (EPA) to improve the average fuel economy of cars and light trucks.
CARB – California Air Resources Board. CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards.
CARBOB/CARBOB gasoline – California Reformulated Gasoline Blendstock for Oxygenate Blending. This fuel is a specific type of gasoline blendstock used in California, designed to meet the air quality standards set by the California Air Resources Board. CARBOB gasoline is blended with ethanol to produce a finished gasoline that complies with the Phase 2 or Phase 3 California Reformulated Gasoline Regulations.
CEC – California Energy Commission. The state's primary energy policy and planning agency, responsible for the IEPR and transportation fuel demand forecasting.
EIA – U.S. Energy Information Administration. A federal agency that provides independent statistics and analysis on energy production, consumption, and trends.
EPA – Environmental Protection Agency. A federal agency that regulates emissions and fuel standards, including GHG and vehicle emissions under programs like MOVES4 and CAFE.
EV – Electric Vehicle. A vehicle powered entirely or partially by electricity, central to California's ZEV strategy.
GHG – Greenhouse Gas. Emissions regulated by both federal (EPA) and state (CARB) agencies due to their role in climate change.
IEPR – Integrated Energy Policy Report. A biennial report by the CEC that assesses California's energy trends and forecasts.
IFTA – International Fuel Tax Agreement. A cooperative agreement among U.S. states and Canadian provinces to simplify the reporting of fuel use by motor carriers operating in multiple jurisdictions.
LCFS – Low Carbon Fuel Standard. A CARB-administered program that reduces the carbon intensity of transportation fuels used in California.
MOVES4 – Motor Vehicle Emission Simulator, version 4. A modeling tool developed by the EPA to estimate emissions from mobile sources.

PIIRA – Petroleum Industry Information Reporting Act. A California law requiring refiners and fuel suppliers to report production and inventory data to the CEC.
POLA – Port of Los Angeles. A major port facility referenced in the model's infrastructure constraints.
POLB – Port of Long Beach. Another key port facility used in the model's logistics assumptions.
RD – Renewable Diesel. A low-carbon fuel that meets CARB's LCFS requirements and is produced from non-petroleum renewable sources.
SAF – Sustainable Aviation Fuel. A low-carbon alternative to conventional jet fuel, tracked under CARB's LCFS and supported by federal incentives.
Stillwater – Refers to Stillwater Associates, a consulting firm whose petroleum market analysis and data (e.g., on imports, exports, and intrastate fuel movements) are used in the ICF/CARB refinery model. Their analysis informs assumptions about port capacity and historical fuel flow volume. Access the Stillwater Associates webpage here: www.stillwaterassociates.com.
TBD – Thousand Barrels per Day. A unit of measurement used throughout the report to quantify fuel production and consumption.
TFTP – Transportation Fuel Transition Plan. A CARB-CEC lead initiative to guide California's transition away from petroleum-based fuels, required by SBX1-2 legislation
ZEV – Zero-Emission Vehicle. A motor vehicle that emits no tailpipe pollutants or other pollutants from the onboard source of power during vehicle operation. Examples include battery electric and hydrogen fuel cell vehicles. ZEV deployment is a central goal of the 2022 Scoping Plan.

1 Introduction and Study Purpose

1.1 Overview

ICF, in collaboration with the California Air Resources Board (CARB) and with data support from the California Energy Commission (CEC), developed a comprehensive modeling framework (the “model”) to assess the implications of declining fossil fuel demand on California’s refinery infrastructure. This work directly supports CARB’s and CEC’s Transportation Fuel Transition Plan (TFTP) and is designed to anticipate unintended consequences of the state’s energy transition.

The model evaluates:

- The timing and likelihood of refinery closures in California.
- The impact on fuel supply chains in neighboring states, particularly Arizona and Nevada.
- The infrastructure constraints (e.g., ports, pipelines, production capacity) that could affect the transition.
- The balance between refinery conversion to biofuels and permanent closures through 2045.

The key objective of this work is to analyze how declining gasoline and diesel demand will affect California’s refining sector, identify risks to fuel supply reliability and infrastructure adequacy, and support CARB’s planning with scenario-based insights on fuel supply, demand, and infrastructure resilience.

This effort was made possible through close coordination with both CARB and CEC, with ICF leveraging public and proprietary data to ensure a robust and independent assessment. The model’s findings are intended to inform CARB’s and CEC’s public workshops and internal planning processes.

1.2 California’s Petroleum Market Context

At the time of model development, California had 9 refineries that produce California Reformulated Gasoline Blendstock for Oxygenate Blending (CARBOB) gasoline. Two additional refineries (Marathon Martinez and Phillips Rodeo in Northern California) stopped processing crude oil in 2020 and 2024, respectively, and were subsequently modified to produce renewable diesel. The remaining refiners who can produce CARBOB in California are listed below in Table 1 with their calendar day crude processing capacity. Based on company announcements, the Phillips 66 refinery in Wilmington, California will close in the Fall of 2025, and the Valero Benicia refinery will close in the Spring of 2026.

Company Name	Site (City in California)	Calendar Day Capacity (b/cd)
Chevron USA Inc	El Segundo	285,000
Chevron USA Inc	Richmond	245,271
Kern Oil & Refining Co	Bakersfield	26,000
Marathon Refining	Carson	365,000
PBF Martinez Refining	Martinez	156,400
PBF Torrance Refining	Torrance	160,000
Phillips 66 Company	Wilmington	138,700
Valero Refining Co	Wilmington	85,000
Valero Refining Co	Benicia	145,000

Table 1. California Refinery, Location, and Capacity

California is often described as an energy island because of its minimal connection to other regions of the U.S., its distance from the global market, and the state's unique gasoline specifications designed to reduce pollution in California. As California refinery processing capacity has declined, California has become increasingly dependent on fuels and gasoline blendstocks (including jet fuel) imported from other domestic and foreign sources.

While reducing refinery capacity is an intended outcome of California's transportation fuels planning, a smooth transition would be for refinery capacity reduction to decline commensurate with gasoline demand. However through mid-2025, the growth in ZEV penetration has not affected gasoline demand as much as anticipated. As a result, existing and planned refinery closures as well as refinery operational issues has led to more volatility in the market. This stage of the transition has been referred to as the "mid-transition" period, in which market and supply volatility can be expected.

As this supply-demand pattern has developed, the dependence on port infrastructure, pipelines within the state, and storage facilities has become more critical to enable the level of imports needed until gasoline demands further decline. This "mid-transition" period is critical to recognize in the TFTP. In order to anticipate the future supply and demand through 2045, CARB requested an assessment of the supply and demand outlook based on several scenarios for the change in gasoline, diesel, and jet fuel supply over the next 20 years.

2 Modeling Framework and Methodology

2.1 Model Overview

In order to reflect the potential scenarios that could be possible in the TFTP, ICF developed a supply and demand model (the “model”) incorporating actual flows of clean products (gasoline, diesel and jet fuel) into, from and within California. The model developed to address these tasks relies on actual data from 2023, including refinery production levels and volume data (from PIIRA) on imports, interstate supply, exports, and intrastate movements on petroleum fuels. Base year 2023 demand levels were assessed from CEC and CARB data, and several demand projection scenarios were evaluated. These demand projection scenarios are applied to the 2023 base year volumes, serving as an input for the supply modeling.

The model is designed to first include announced refinery closures in 2025 and 2026. As demand for each product changes over time, the model then adjusts refinery utilization to balance supply and demand for gasoline. The refinery utilization adjustments implemented in each year and demand scenario also impact diesel and jet fuel production, relative to each refinery. After these adjustments, the model determines the flow of products required through northern and southern ports to achieve balance in each market. If the refinery utilization adjustment reaches allowable limits and the volume of port traffic needed to balance all products exceed historical maximum levels, the model will then shut down a refinery. The decision of which refinery to close is based on an estimate of the relative competitiveness of each refinery based on criteria discussed in more detail in Section 2.5. For results shown later in Chapter 3, it is also assumed that if gasoline exports exceed 50 TBD in either the North or South regions, the model will also shut down a refinery regardless of whether the total port traffic remains below historic maximum levels. As discussed in more detail in that section, this export constraint is a key limitation which determines when refineries will close.

The logic that underwrites the model decision making is illustrated below in Figure 1. Historical trends indicate that refinery shutdowns are often influenced by corporate strategic decisions based on market and regulatory outlook. Consequently, the model has been updated several times since its creation to account for announced closures in 2025 and 2026. These decisions by the refiners also reflect the fact that a model based on supply and demand volumes and infrastructure constraints cannot determine individual refinery profitability or corporate decisions. The remaining sections in this chapter discuss how the model interprets supply and demand to determine refinery closures in more detail.

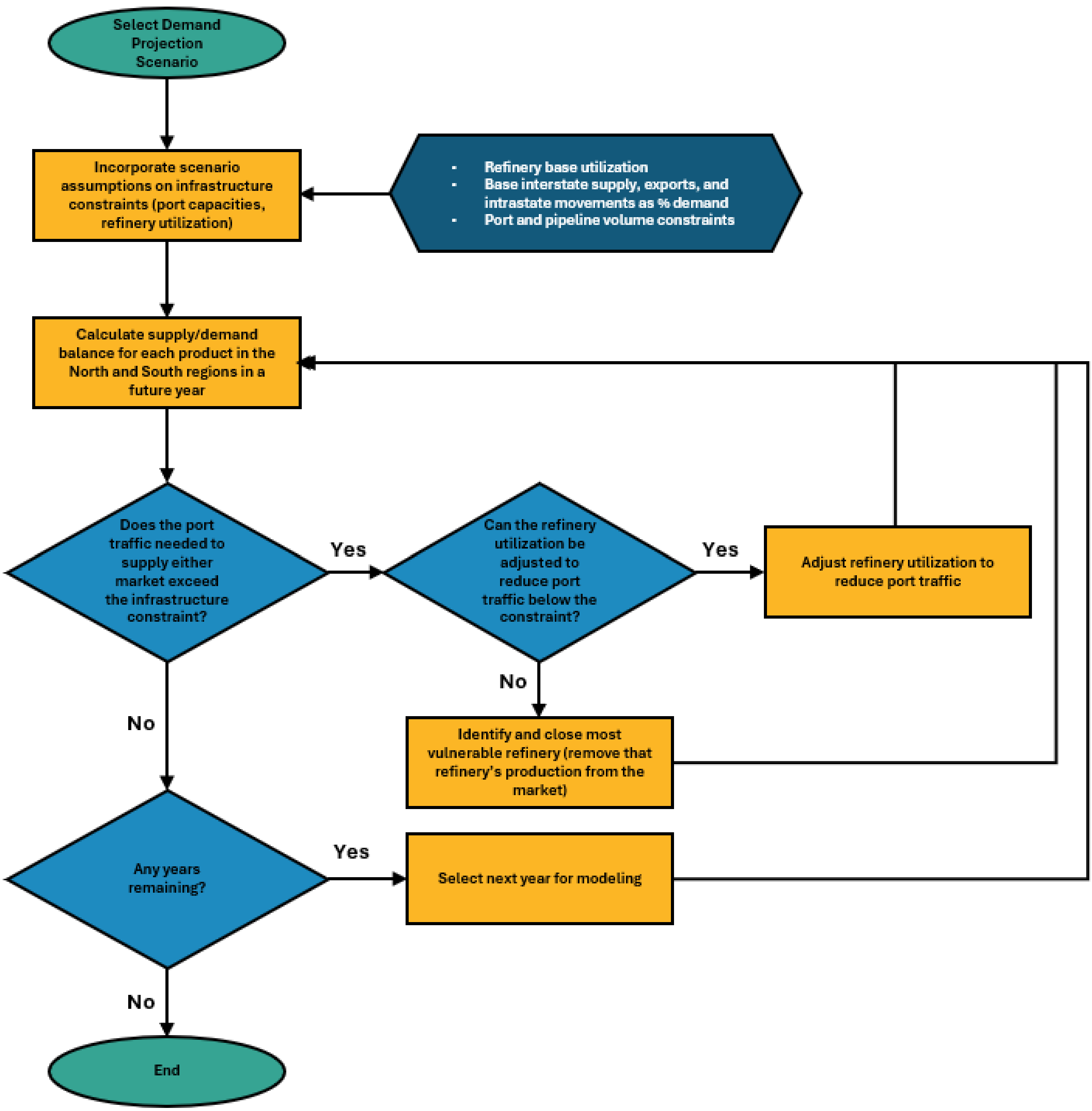


Figure 1. Model Logic Decision Matrix

2.2 Fuel Demand Scenarios

The model encompasses three demand scenarios: Rapid ZEV growth, Moderate ZEV growth, and Slow ZEV growth. These scenarios each provide assumptions related to the future demand for gasoline and diesel in California and vary based on assumptions related to ZEV growth and market penetration. The Rapid ZEV growth scenario is based on the 2022 Scoping Plan, the Moderate ZEV growth scenario is based on the 2024 Integrated Energy Policy Report (IEPR) AATE3, and the Slow ZEV growth scenario is based on the 2024 IEPR Baseline. The TFTP modeling analysis also incorporates projections of future demand for jet fuel based on 2024 IEPR data.

The Rapid ZEV growth scenario includes the sharpest decline in fuel demand. This decline is driven by a rapid market expansion of ZEVs, and a decline in per capita passenger vehicle miles traveled (VMT). The Moderate ZEV growth scenario includes a gradual decline in gasoline and diesel demand in California. This scenario incorporates ZEV adoption as required with CARB regulations, including the Advanced Clean Cars II and Advanced Clean Fleets, and does not assume a decline in per capita VMT.[1] Finally, the Slow ZEV growth scenario includes the least amount of fuel demand decline. This scenario is driven by market trends and existing and project consumer preferences for ZEVs. It is also not driven by CARB regulations and assumes the lowest ZEV adoption rate.

2.3 Model Assumptions

Table 2 provides a listing of other assumptions which the model can incorporate when generating results. One key assumption in the model is the constraint implemented on the volume of gasoline exports. This constraint indicates to the model that a refinery closure must occur if gasoline exports determined by the model exceed 50 TBD. This assumption is very influential on model results because in scenarios where demand declines more rapidly, gasoline surplus builds more quickly, and exports reach this constraint earlier in the projection period.

Another example includes allowing for the total port capacity constraints to be adjusted. This assumption is meant to reflect potential actions that industry and ports may take to increase system flexibility and to ensure the market remains supplied. The assumption allows for the ability to increase the total port capacity constraint before refinery shutdowns are initiated. Increasing overall port capacity allows for refineries to continue operating longer, as there is more capacity available to support the port traffic needed to keep the market in balance. More detail on these constraints and how they are interpreted by the model is provided in Section 2.6.

[1] Revocation of federal waivers granted to CARB for new motor vehicle emission standards could impact fuel demand projections assumed in model results.

Another adjustment that can be made by the model shown in Table 2 involves increasing the share of Arizona and Nevada fuel demand met by California refineries, thereby reducing reliance on supply from Utah and Texas. This assumption tells the model to maximize pipeline transfers of gasoline and diesel to these neighboring states. When this assumption is enabled, the model ensures flows outbound from California maximize the available pipeline shipment capacity from Northern California to Nevada at 46.5 TBD and from Southern California to Nevada and Arizona at 253 TBD. These volumes are based on historical peak flows from 2007 to 2023.

Finally, the model also allows for a shift in product pipeline takeaway capacity from jet fuel to gasoline and diesel to accommodate rising in-state jet fuel demand. Under this assumption, pipelines that previously carried volumes of jet fuel for export now accommodate more gasoline and diesel. However, the gasoline and diesel demand decline trends in Arizona and Nevada drive the reduced need for pipeline deliveries in most scenarios. As discussed in more detail later, the model adjusts the supply from California higher or lower based on the original percentage of supply in Arizona and Nevada from California and Texas/Utah.

It should be noted that although the model is capable of implementing these last two adjustments, neither is utilized in scenario results presented in Section 3. Incorporating these assumptions would require additional considerations for impacts in other state markets which are not addressed as part of this analysis. It is also important to recognize that the model is based on supply and demand and does not attempt to develop a rigorous economic assessment of every option that could influence refiner and industry or State actions.

Assumption	Assumption Designation
Gasoline and Diesel Demand Scenario	Rapid – 2022 Scoping Plan Moderate –2024 IEPR AATE3 Slow – 2024 IEPR Baseline
Jet Fuel Demand Scenario	2024 IEPR AATE3
Maximize KM North pipeline export capacity	Y/N
Maximize KM South pipeline export capacity	Y/N
Allow KM North pipeline shift from jet fuel	Y/N
Allow KM South pipeline shift from jet fuel	Y/N
Increased North Port Capacity Flexibility (TBD)	0*
Increased South Port Capacity Flexibility (TBD)	225*
Limit Gasoline North Exports	Y/N
Gasoline Export Limit North (TBD)	50*
Limit Gasoline South Exports	Y/N
Gasoline Export Limit South (TBD)	50*
** denotes items that can be modified*	

Table 2. Assumptions Available in the Model – Primary Control Levers

Table 3 below provides a list of specific market actions incorporated in model results. The model first incorporates these actions before performing the supply/demand balance to determine if a refinery closure is necessary. Actions may occur only once in a specific year or may occur in all years throughout the projection period. Certain actions (such as the announcements of specific refinery closures in 2025 and 2026) impact the volumes used in the supply balance in a specific year and continue that impact in all remaining years throughout the projection period.

The model is set to accommodate volumes of foreign and domestic imports of gasoline at the proportions indicated below relative to demand, regardless of the supply/demand balance in a given year. This is to ensure volumes are available during unplanned refinery turnarounds. Foreign exports of gasoline are similarly accommodated as a proportion of production to account for seasonal demand changes. Foreign exports of diesel are set to reduce with production to avoid requiring unnecessary imports to reach export requirements. This avoids port traffic constraints in the model which would not occur in real world conditions. Because both demand and production change over time, all volumes mentioned above also change based on the 2023 baseline proportions indicated below.

In addition to the announced closures of specific refineries (P66 Wilmington and Valero Benicia), the model also accommodates the conversion to renewable diesel (RD) production at P66 Rodeo and Marathon Martinez. RD imports are reduced to zero in 2025 due to loss of the blender tax credits on imported RD. The model can also convert a designated amount of RD to sustainable aviation fuel (SAF) production, increasing jet fuel supply. Finally, the range of refinery utilization that the model allows can be adjusted. More discussion around the utilization assumptions listed below, and the impact those assumptions have on results is provided in Section 2.6.

Market Action	Impacted Year	Assumed Parameter
North gasoline foreign imports requirement to ensure supply during refinery turnarounds, 2023 proportion of imports to demand (%)	All	3.7%
South gasoline foreign imports requirement to ensure supply during refinery turnarounds, 2023 proportion of imports to demand (%)	All	5.2%
North domestic marine imports of gasoline to ensure supply during refinery turnarounds, 2023 proportion of imports to demand (%)	All	11.5%
South domestic marine imports of gasoline to ensure supply during refinery turnarounds, 2023 proportion of imports to demand (%)	All	1.4%
North foreign exports of gasoline to reflect seasonal demand changes, 2023 proportion of exports to production (%)	All	2.7%
South foreign exports of gasoline to reflect seasonal demand changes, 2023 proportion of exports to production (%)	All	0.2%
North foreign exports of diesel to avoid forcing unnecessary imports in model results, 2023 proportion of exports to production (%)	All	22.2%
South foreign exports of diesel to avoid forcing unnecessary imports in model results, 2023 proportion of exports to production (%)	All	5.6%
Removed P66 Rodeo Refinery Fossil Fuel Production in North	2024	-
Added P66 Rodeo Refinery Renewable Diesel Production in North (TBD)	2025	45
Added Marathon Martinez Renewable Diesel Production in North (TBD)	2025	43.2
Renewable diesel imports (north and south) decrease to zero	2025	-
Removed P66 Wilmington Refinery Production in South	2026	-
Removed Valero Benecia Refinery Production in North	2026	-
Convert 40% of RD production into SAF in North	2025*	0%*
Utilization floor/ceiling allowed in North Refineries (%)	2024*	60% or 90%*
Utilization floor/ceiling allowed in South Refineries (%)	2024*	60% or 90%*
All other flows held constant	All	-
** denotes items that can be modified*		

Table 3. Specific Model Assumptions – Constraints and Fixed Relationships with Refiners

2.3.1 California Fuel Demand

In modeling California's future demand for transportation fuels, three distinct scenarios were developed to reflect varying rates of transition away from fossil fuels. These scenarios are modeled through the three different fuels considered in this analysis; gasoline (Figure 2), diesel (Figure 3), and jet fuel (Figure 4).

The first scenario, referred to as Rapid ZEV growth, assumes a more rapid decline in in-state gasoline and diesel demand compared to the 2024 Integrated Energy Policy Report (IEPR)

AATE3 forecast. This scenario (and all others described below) aligns the base year 2023 demand for both gasoline and diesel with the 2022 Scoping Plan's assumptions. However, an important adjustment is made to diesel demand: it is reduced to account for fuel purchased outside California but combusted within the state, as captured by the International Fuel Tax Agreement (IFTA) and reflected in the state's greenhouse gas inventory. Gasoline demand for 2023 remains unchanged in this scenario, excluding ethanol volumes at an assumed ethanol content of 8%.

The second scenario, referred to as Moderate ZEV growth, is based on the 2024 IEPR AATE3 forecast and represents a more moderate pace of demand decline. The difference in projected in-state demand between the Rapid ZEV and Moderate ZEV growth scenario is driven by the annual rate of decline applied to the 2023 baseline value from the 2022 Scoping Plan. To account for the possibility of a slower transition to electric vehicles, a third scenario—referred to as Slow ZEV growth —was based on data developed in the 2024 IEPR Baseline. This scenario provides a conservative outlook in which the shift to zero-emission vehicles (ZEVs) lags behind the expectations of the other two scenarios.

Throughout the modeling period, the geographic distribution of fuel demand between Northern and Southern California remains constant. The proportions are first established in the 2023 base year by comparing the proportion of implied demand in the North and South when considering the balance of all other regional movements for each product. This proportion of implied demand in Northern and Southern California is then applied to the 2023 base year demand and preserved through 2045, ensuring that regional dynamics are consistently represented in the analysis. This approach allows the model to capture the distinct infrastructure and market characteristics of each region while assessing the broader implications of the state's energy transition.

Figure 2 provides the **gasoline demand** volumes utilized in the model for each projection scenario. The Rapid ZEV growth scenario reduces gasoline demand by 50% by 2031 and over 90% by 2045. The Moderate ZEV growth scenario results in a decline of over 30% by 2031, and by 85% by 2045. The Slow ZEV growth scenario reduces gasoline demand by 23% by 2031 and 52% by 2045. Specific data for each year is included in the model for each scenario.

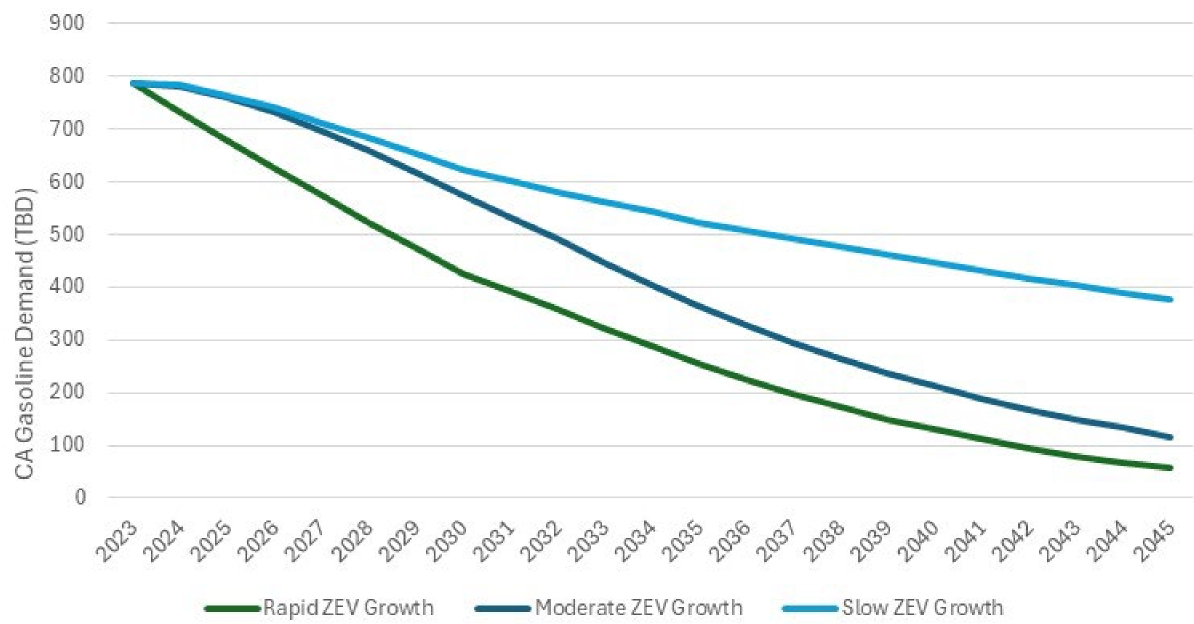


Figure 2. Demand Analysis, California Gasoline

Diesel demand in California is projected to follow distinct trajectories depending on the pace of zero-emission vehicle (ZEV) adoption. Both the Rapid and Moderate ZEV growth scenarios follow similar trajectories, as diesel demand begins at 266 thousand barrels per day (TBD) in 2023 and declines to approximately 75 TBD by 2045. In terms of changes over time, the Moderate ZEV growth scenario sees a more direct decline to the 75 TBD demand projection, while the Rapid ZEV growth scenario results in total diesel demand which is slightly higher throughout.

The Slow ZEV growth scenario presents a different outlook. It assumes a much slower rate of electrification and transition away from diesel, resulting in only a modest decline in demand. Until 2034, the Slow ZEV growth scenario is comparable to the Rapid ZEV growth demand, with both resulting in approximately 200 TBD diesel demand in that year. However, the Slow ZEV growth demand does not decline nearly as quickly after this point, resulting in a total demand volume of 180 TBD by 2045. This volume is over double the amount of demand assumed in the Rapid and Moderate ZEV growth scenario in that year. Importantly, these figures represent total diesel demand in California and include all diesel fuel types—petroleum-based diesel, renewable diesel (RD), and biodiesel (BD). The specific volumes of diesel supply, including the contributions from RD and BD, are addressed separately in the supply section of the analysis.

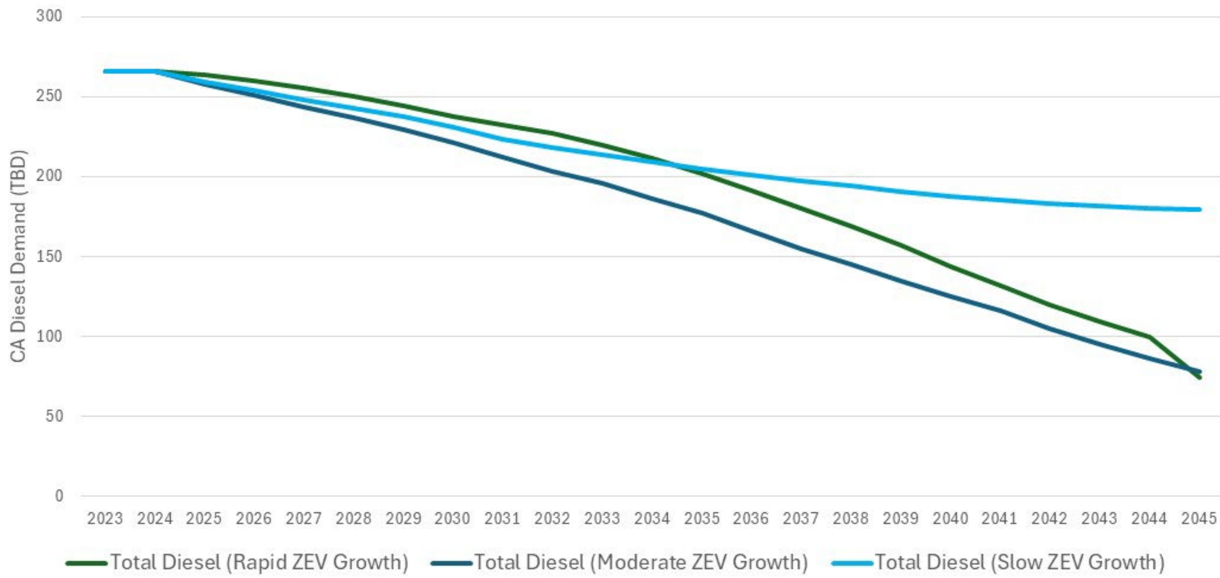


Figure 3. Demand Analysis, California Diesel

In contrast to the declining trends for gasoline and diesel, in-state **jet fuel** demand is projected to increase steadily through 2045. This projection is based on the 2024 IEPR AATE3 forecast and encompasses the full spectrum of aviation activity, including intrastate, interstate, and international flights. The model assumes that this growth in jet fuel demand will be met through a combination of conventional and sustainable aviation fuels, depending on economic and policy factors.

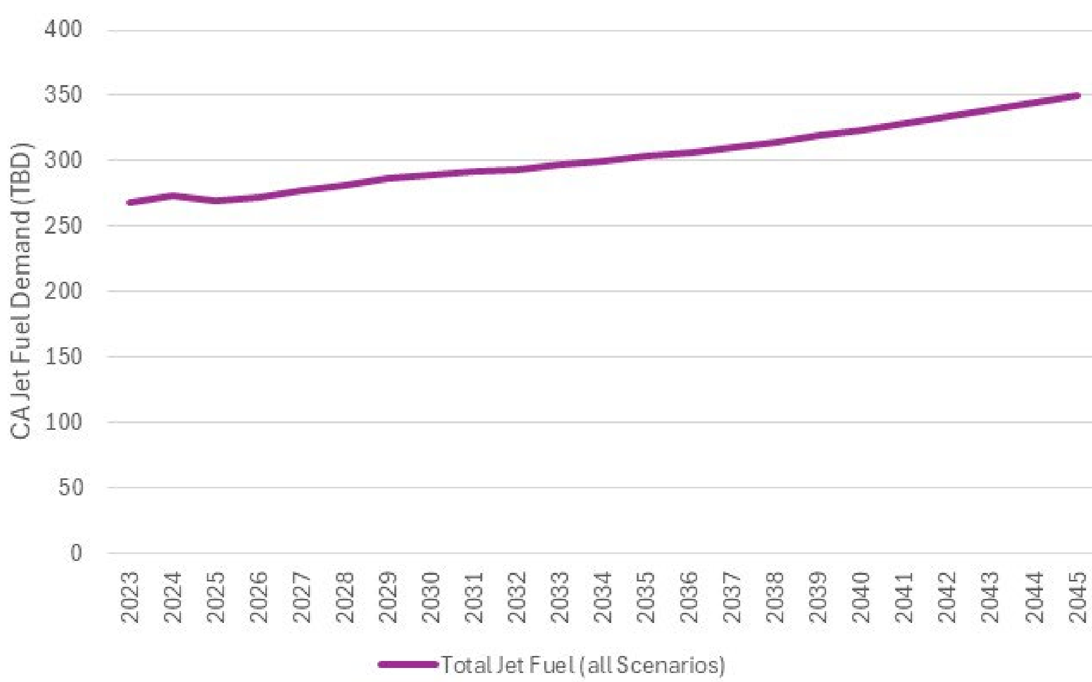


Figure 4. Demand Analysis, California Jet Fuel

2.3.2 Nevada and Arizona Fuel Demand

ICF developed a single, unified projection for gasoline, diesel, and jet fuel demand in Arizona and Nevada to support CARB's broader refinery transition modeling. These projections span from 2022 to 2050 and are grounded in the most current version at the time of model development of the EPA's Motor Vehicle Emission Simulator (MOVES4) available at the time of model development. Developed and released in 2023, MOVES4 did not incorporate the full impact of the federal regulations adopted in 2024, ICF adjusted the model to reflect anticipated changes stemming from several key policies. These include the Multi-Pollutant Emission Standards for model years 2027 and later for light- and medium-duty vehicles, the Phase 3 greenhouse gas (GHG) standards for heavy-duty vehicles, and updated Corporate Average Fuel Economy (CAFE) standards. These regulations are expected to significantly reduce GHG emissions. By model year 2032, light-duty vehicles are projected to achieve a 50% reduction in GHG emissions compared to model year 2026, while medium-duty vehicles are expected to achieve a 44% reduction. For heavy-duty vocational vehicles and tractors, the reductions are projected to reach up to 50% and 40%, respectively, by model year 2032.

The EPA does not mandate the use of zero-emission vehicles (ZEVs) in Arizona and Nevada, nor does it endorse specific technologies.[2] As a result, the projected GHG reductions could be achieved through a mix of cleaner internal combustion engine technologies and ZEV adoption. These regulatory changes are expected to drive a gradual decline in demand for gasoline (Figure 5) and diesel (Figure 6) across both states. ICF's modeling uses 2022 actual state-level data as the baseline for all fuel types, ensuring that the projections reflect real-world consumption patterns at the outset of the forecast period. Forecasts of gasoline and diesel demand for the residential, commercial, and industrial sectors are derived from EPA's State Inventory and Projection Tool, while transportation sector forecasts are drawn from MOVES4, adjusted to reflect applicable federal regulations as described above.

[2] Given that certain policies are not in place and there may be additional uncertainty under current federal standards, changes could occur to assumed future demand volumes in Arizona and Nevada. Barring substantial changes, the impact on modeling results should not be significant as the share of demand in these states supplied from California is approximately 20% of all demand supplied by California refineries.

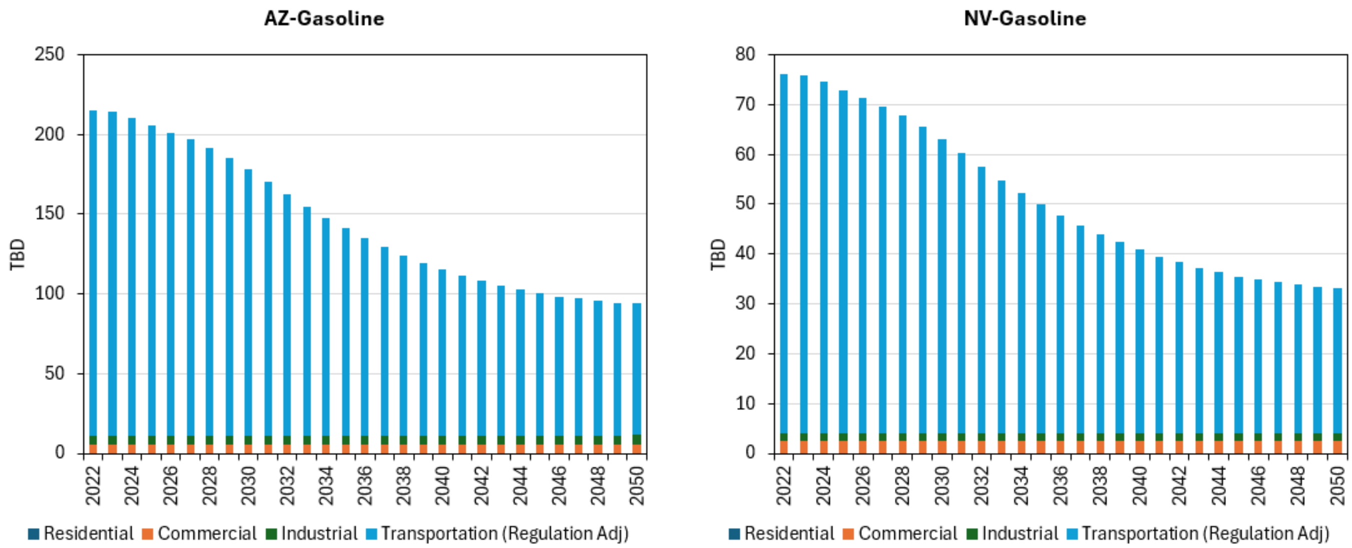


Figure 5. Arizona (Left) and Nevada (Right) Gasoline Demand Outlook

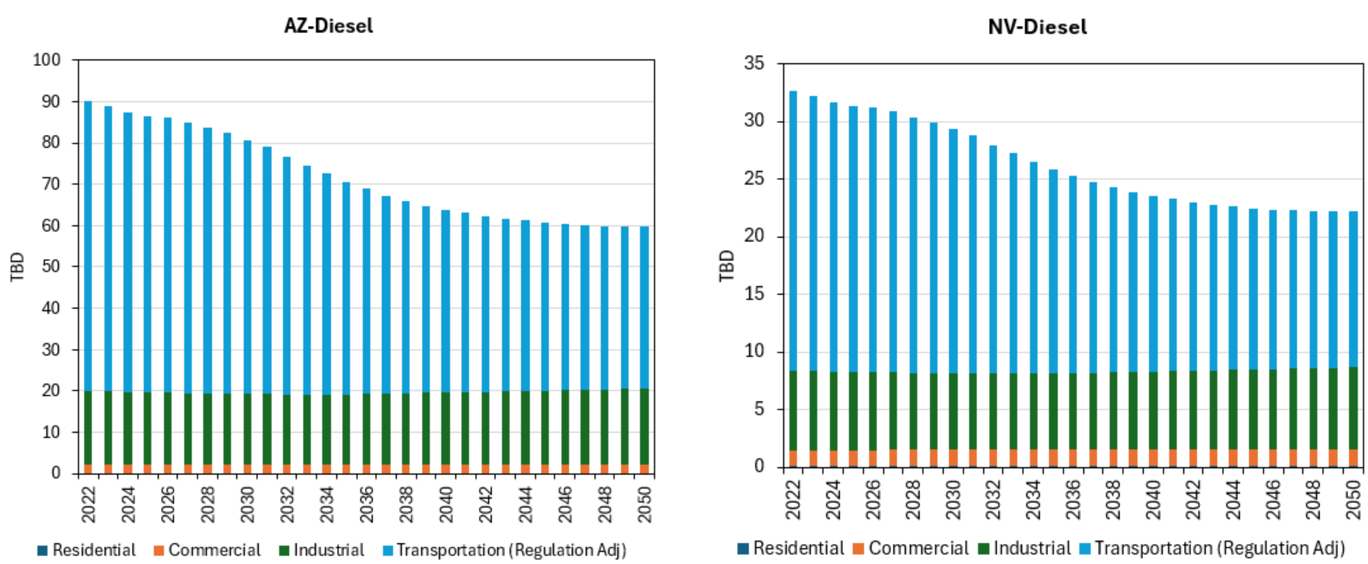
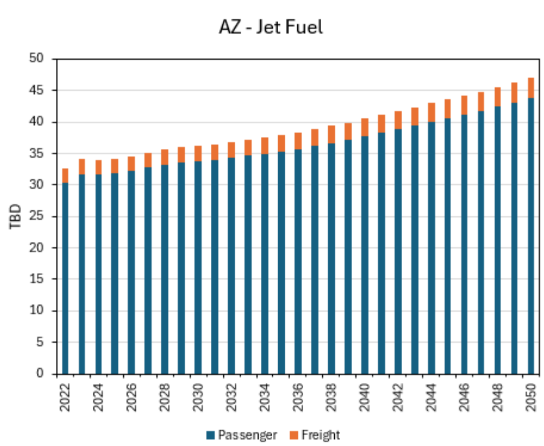


Figure 6. Arizona (Left) and Nevada (Right) Diesel Demand Outlook

ICF developed projections for jet fuel consumption in Arizona and Nevada by adapting and expanding the modeling framework originally used for the 2024 Integrated Energy Policy Report (IEPR), illustrated below in Figure 7. This enhanced model extends beyond California to include Arizona and Nevada and incorporates both passenger and cargo freight aviation activity. The foundation of the model is built on data from the Bureau of Transportation Statistics (BTS), particularly the T-100 and T-2 datasets, which provide detailed information on flight activity, aircraft types, and fuel consumption. These datasets were used to establish base-year values for domestic and international passenger seat miles and freight ton miles. To forecast future trends, ICF relied on projections from the U.S. Energy Information Administration (EIA), specifically the Annual Energy Outlook (AEO) 2023, which includes assumptions about aircraft fuel efficiency improvements and load factors through 2050.

The modeling approach assumes that jet fuel demand in Arizona and Nevada will increase over time, driven primarily by growth in aviation activity. For Arizona, jet fuel consumption is projected to rise from 32.7 thousand barrels per day (TBD) in 2022 to 47.0 TBD by 2050. In Nevada, demand is expected to grow from 36.2 TBD in 2022 to 51.3 TBD by 2050. These increases reflect anticipated expansions in both passenger travel and air freight, with adjustments made for international flight activity where applicable. For example, Phoenix accounts for nearly all international passenger miles in Arizona, while Nevada’s aviation activity is predominantly domestic. The model also incorporates improvements in aircraft fuel efficiency and evolving load factors, ensuring that the projections account for both operational and technological advancements in the aviation sector.



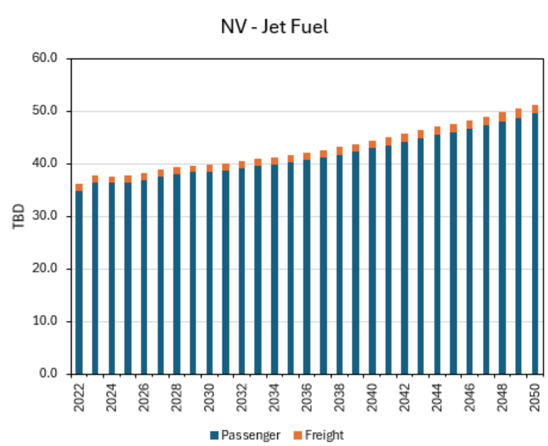


Figure 7. Arizona (Left) and Nevada (Right) Jet Fuel Demand Outlook

2.4 Supply Assumptions and Constraints

The model adjusts in-state California refinery production according to declining in-state demand for petroleum fuels. For each demand scenario, the model provides a progression of in-state refinery operational parameters and estimated production of gasoline, diesel fuel and jet fuel. Refinery production in the base year 2023 is used in conjunction with base year demand and other supply and demand variables (imports, exports, pipeline movements, etc). Refinery production capacity is also adjusted in 2024 to reflect the Phillips 66 Rodeo conversion to renewable diesel production and in 2025 and 2026 to reflect the announced closures of the Phillips 66 Wilmington and Valero Benicia refineries. These assumptions (and others) are detailed more in Section 2.3.

The model first attempts to balance supply and demand by adjusting refinery utilization. The utilization adjustment attempts to balance gasoline demand (with any adjustment also reflected in the production of other products) and are allowed between a set range of 60-90%. If northern or southern California utilization falls below 60% based on the gasoline demand, gasoline surplus will build, and more exports will be needed for the market to balance. If the volume of exports needed exceeds established port constraints, the model selects a refinery to close. The model then rebalances supply, without the selected refinery production, by adjusting utilization of the remaining refineries. Since the model is balancing declining gasoline and diesel demands and increasing jet fuel demands, it is necessary to ensure that all fuels balance by adjusting both imports and exports. Note that the model assumes no inventory gains or losses over the calendar year. More information on how refinery production is adjusted and when refinery closures are determined is provided in Section 2.6.

Model results related to the changing production for each transportation fuel are visualized in Figure 8 below. The volumes shown represent the amount of production after refinery utilization adjustments. The yields of clean fuels, including gasoline, diesel, and jet fuel by each refinery are maintained at their base year proportions as the model changes utilization.

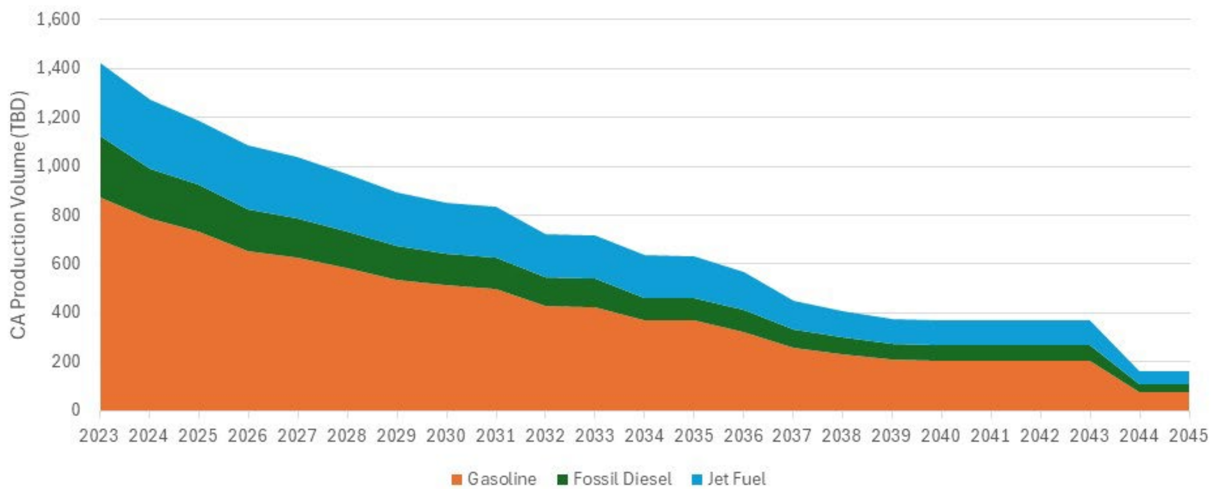


Figure 8. Model Output Production Results, All Fuels; Rapid ZEV Growth Scenario

Renewable diesel (RD) and biodiesel production included in the model are aligned with base year 2023 Low Carbon Fuel Standard (LCFS) volumes. The model also incorporates future production volumes from the Phillips 66 and Marathon Martinez RD conversions. It is important to note that actual production volumes are not required to be reported by PIIRA although biodiesel and renewable diesel displace fossil fuel-based diesel barrel for barrel.

The model assumes future renewable diesel supply will increase above 2023 levels in 2024 and beyond as the P66 and Marathon production is assumed at 90% utilization of the RD facilities. The in-state production of RD in 2023 increased due to more capacity, but at the same time RD imports are assumed to be eliminated in 2025 due to loss of the blender tax credits on imported RD. Biodiesel production is assumed to continue at the small volume seen in 2023 base year data, and differences in supply and demand are met via rail shipments.

Sustainable Aviation Fuel (SAF) production in the model represents anticipated capacity from several announced future projects. The model can also incorporate a 40% conversion of RD production into SAF production in the projection forecast. There is no requirement to report actual SAF production. The model assumes that SAF demand volumes in the 2022 Scoping Plan can be met by known production capacity in California, as known production capacity exceeds projected SAF demand in the Scoping Plan.

Domestic marine imports and exports are fixed to historic averages through 2045. Gasoline foreign imports are maintained at the same proportion of demand through 2045 based on base year 2023 volumes. Pipeline exports to Arizona and Nevada are adjusted to match projected changes in demand. Gasoline and diesel pipeline flow volumes decrease, reflecting demand declines in the same percentages as the base year supply. Additionally, pipeline transfer of jet fuel from California is increased to meet the rising jet fuel demand in Arizona and Nevada. Utah and Texas sourced jet fuel increases at the same rate as California jet fuel.

Gasoline, diesel, and jet fuel volumes in and out of ports are limited to rough historic volumes from 2019 to 2024. The model imposes constraints of 216 thousand barrels per day (TBD) in and out in Northern California and 217 TBD in and out of Southern California (without adjustment). The values represent the highest monthly volumes from 2019 to 2024, based on Stillwater Analysis of PIIRA data. Note that vessel traffic data extending back to 2007 indicates that the Southern California region has previously supported monthly petroleum product traffic volumes as high as 428 TBD. This suggests that the 217 TBD constraint may be conservative and that higher throughput could be achievable under optimized infrastructure conditions although over the same period container vessel traffic has dramatically grown.

The model assumes no loss in North port capacity, even with the operation of the Rodeo and Marathon renewable diesel (RD) facilities, and no loss in South port capacity at the Ports of Los Angeles (POLA), Long Beach (POLB), and El Segundo. It also assumes that marine crude imports will continue and decline as refinery production capacity drops. The model does not incorporate crude import constraints. Imported (foreign and domestic) gasoline volumes are maintained as a percentage of demand to reflect probable regulations or necessity, requiring that volumes of gasoline and blendstock imports will be needed to cover refinery planned downtime with supply from outside of California. Exported diesel volumes are maintained as a percentage of production to avoid forcing the model to require unnecessary imports, and exported gasoline is also maintained as a percentage of production to reflect seasonal demand changes.

2.5 Refinery Vulnerability Evaluation Process

The model examines supply and demand for both northern and southern California. When the model identifies that demand declines may impact port traffic product constraints, the model adjusts refinery utilization in the impacted region to reduce the volume of fuels (primarily gasoline and diesel) required for export. At the same time, the lower utilizations increase the imports of jet fuel.

Refinery closures in the model are triggered when infrastructure constraints prevent market balance without refinery utilizations falling below 60%[3]. ICF conducted a comprehensive qualitative assessment to rank California refineries by their potential for closure under modeled infrastructure constraints. This ranking was based on 10 key criteria, including:

- **Operations** – Stability of utilization over time. Refiners with strong operations and maintenance practices are more easily able to optimize their operations and maximize utilization. Basis for assessment: PIIRA data

[3] As refineries' utilizations decline, their fixed costs (labor, maintenance and other) become more and more difficult to offset by operating margin. The study optimistically assumes 60% as a floor – in many cases refineries may elect to shut down at higher utilizations based on their overall ability to realize corporate profit goals.

- **Yield Flexibility** – Ability to adjust product output based on market conditions allows a refinery to better optimize their margin. Yield flexibility assessed by ICF based on PIIRA yield data and market prices.
- **Yields** – Relative production of jet fuel, gasoline, and diesel. With likely lower gasoline and fossil-based diesel demands due to ZEV and RD growth, refiners who can produce higher percentages of jet fuel would have a strategic advantage. Assessed by ICF from PIIRA data.
- **Costs** – Indicators of operating cost efficiency included refinery data received under SB X1-2 as well as utilization history from PIIRA data (lower utilizations impact fixed costs per barrel).
- **Sole Supply Role** – Importance to regional logistics. Refiners who may be the sole supplier to a specific market, or refiners who produce key products that other refiners may not (asphalt, Military jet fuel, specialty products, etc) may have some advantage over other refiners. Assessed by ICF analysis of refinery production.
- **Policy Risk** – Exposure to regulatory or locational disadvantages. All refiners in California are impacted by regulatory actions. However, some of the regulations affect individual refineries more than others, and this was a determining factor in ICF's vulnerability assessment.
- **Crude Access** – Flexibility and logistics for crude supply are very important characteristics. The ability to optimize feedstock to match the refinery configuration is essential to generating a strong return on the investment. Crude runs and capability were reviewed by ICF based on import data from EIA and assessment of pipeline and port infrastructure.
- **Product Access** – Market access and distribution options. Refiners who have multiple options to distribute their products have an advantage over refiners with fewer options. Ready access to ports as well as pipelines allows a refiner to grow their sales in areas where markets may better optimize margins. ICF analysis of the refiners' distribution options.
- **Phase-Down Ability** – Capacity to reduce operations gradually. Refiners with multiple crude units and upgrading units may have an advantage in being able to lower utilization and at the same time reduce fixed costs. Estimates of this characteristic were from ICF research.
- **Sales Mix** – Share of branded or dealer tank wagon (DTW) sales[4]. Refiners who have higher percentages of DTW/branded gasoline sales will, generally, have higher margins

[4] Dealer Tankwagon sales (DTW) are refiner wholesale sales of gasoline that are delivered from the terminal rack and sold on a delivered basis to the service station; Branded rack sales are sold at the terminal rack to wholesalers who deliver the branded gasoline to the service station on a rack price plus delivery basis.

on their gasoline sales than refiners who tend to sell unbranded or bulk spot. Data from SB X1-2 and PIIRA and ICF analysis.

These criteria were informed by ICF subject matter experts review of publicly available data such as refinery configurations from EIA Refinery Process Unit Capacity data, 10-K filings, investor presentations, and media sources. In addition, confidential actual volumes of runs and yields were used from the CEC PIIRA database. As a baseline, ICF reviewed historical refinery utilization and clean product output—specifically CARBOB, jet fuel, and diesel—for the 2023 base year. Yields were calculated as a percentage of crude runs using California Energy Commission (CEC) data.

This analysis produced a ranking of refineries in both the northern and southern California markets, which is used to assess shutdown priorities. The model directly incorporates the planned closures of the P66 Wilmington refinery in 2025 and the Valero Benicia refinery in 2026, leaving seven refineries for optimization within the model[5]. These rankings are kept confidential to align with PIIRA Requirements.

2.6 Transition-Driven Refinery Closure Logic

The model calculates the surplus or deficit of each refined product in California by applying flow assumptions and tracking demand changes over time. Based on these calculations, it determines the volume of imports or exports required to balance the market for each product. It then assesses whether the existing infrastructure can support those volumes.

If the infrastructure capacity is exceeded, the model will first attempt to rebalance the region's supply and demand by reducing refinery utilization as noted earlier. If utilization adjustments below 60% are required, the model then initiates a shutdown of the refinery with the lowest (poorest) ranking determined as above and recalculates the product balance for that year. This process is repeated annually through 2045—or until all refineries have been shut down—accounting for each identified refinery closure. When a refinery is scheduled to close in a given year, the model then attempts to readjust the utilization rates of the remaining refineries in the region. This "readjustment" helps offset the impact shock of the closure and rebalances supply and demand within the constraints of port and pipeline infrastructure.

2.6.1 Infrastructure Constraints

To manage the evolving demand for petroleum fuels in California, the ICF/CARB refinery model incorporates several infrastructure limitations to reflect real-world flexibility and infrastructure

[5] The model permits the Marathon Los Angeles refinery to either close as one refinery, or as two refineries since it could possibly break down to the original Wilmington and Carson refineries which merged.

constraints, ensuring that supply and demand remain balanced as the state transitions away from fossil fuels.

Table 4 shows the port and pipeline capacity limits referred to in Figure 1. The pipeline capacity limits are based on the maximum monthly volumes (on a TBD basis) shipped to the Reno market in Northern California, and the Las Vegas and Arizona markets in Southern California from 2019 to 2024. The marine volume limitations are based on total product traffic shipped (receipts and deliveries) in Bay area ports and Los Angeles area ports from 2019 to 2024. Both capacity constraints can be adjusted in the model.

North	Gasoline		
North	Diesel		
North	Jet Fuel		
North	Total		

South	Gasoline		
South	Diesel		
South	Jet Fuel		
South	Total		

Table 4: Port and Pipeline Capacity Limits (TBD) by California Region

Note that in assessing constraints, it was determined that the pipeline constraints were “firm” in that there was no historic evidence of higher volumes. However, the “port volume limits likely have flexibility since 1) Higher volumes were achieved in the more distant past and 2) There have been no demonstrated constraints on marine product traffic from 2019 to 2024. It should also be noted that the CARB “At-Berth” requirement beginning at POLA and POLB in 2025 and all other ports by 2027, was excluded from the analysis as it was assumed that CARB, the ports, and the oil industry would resolve the timing of full implementation.

One other key requirement involves limiting gasoline exports from both Northern and Southern California. This constraint is critical because excessive exports can trigger refinery closures when infrastructure capacity is exceeded. The model sets a gasoline export constraint of 50 TBD per region. This reflects the practical limitations of assembling, testing, and loading 250,000–300,000 barrel cargos every 5–6 days. Maintaining this export rate would require at least 1 million barrels of dedicated shore storage to accommodate continuous gathering and marine traffic delays. Additionally, the market for California gasoline exports is limited, with most demand concentrated along the Pacific coast and in Latin America. Unlike the Gulf Coast, where infrastructure supports over 1 million barrels per day of exports, California lacks the same scale of dedicated export terminals.

3 Model Scenario Results

3.1 Model Assumptions Utilized in Scenario Results

ICF has quantified model results for three different scenarios. Each scenario reflects a set of assumptions in the model which impact the timeline of transportation fuel production and refinery closures. The three scenarios, Rapid ZEV growth, Moderate ZEV growth, and Slow ZEV growth, are each distinguished by the gasoline and diesel demand projection considered. The Rapid ZEV growth scenario assumes the most aggressive demand decline (from 2022 Scoping Plan), the Moderate ZEV growth scenario assumes a more modest decline (2024 IEPR AATE3), and the Slow ZEV growth scenario declines the least (2024 IEPR Baseline). These demand projections are discussed in more detail in Section 2.3.1. All three scenarios also incorporate the following set of assumptions consistently:

- 2024 IEPR jet fuel demands in California; ICF estimated demands for gasoline, diesel, and jet fuel in Arizona and Nevada
- The total port capacity is constrained to 216 TBD in the North and 317 TBD in the South (based on historical monthly maxes)
- Gasoline exports are constrained at 50 TBD max in the North and 50 TBD in the South
- Supply ratios in Arizona and Nevada are maintained (from California, Texas, and Utah)
- 2023 baseline refinery operations reflect the following:
    - P66 Rodeo closed in 2024
    - P66 Wilmington closes at the end of 2025
    - Valero Benicia closes in 2026
    - Refinery utilization can be adjusted from 60% to 90% to meet gasoline demand
    - Existing pipeline limits on the Kinder Morgan pipeline system to AZ and NV
- Certain import and export volumes are based on fixed proportions of production or demand (see Section 2.3 for more detail)
- Pipeline volumes to AZ and NV change based on declining gasoline/diesel demand and jet fuel growth; pipeline capacity not maximized
    - Volumes from TX and UT reflect similar changes in demand
- CA product pipeline takeaway is not shifted from jet fuel to other products

3.2 Timeline of Refinery Closures

Figure 9 provides the timeline of refinery closures determined by the model in all three scenarios identified in this analysis. The timeline and number of refinery closures determined by the model varies by demand projection scenario. Refinery closures by 2045 range from seven of nine in the Rapid ZEV growth scenario to three of nine projected under the Slow ZEV growth scenario. In the Rapid ZEV growth scenario, demand for gasoline and diesel declines the most quickly. This results in gasoline surplus building faster, thus requiring a higher volume of gasoline exports and reaching the export constraint sooner. Combining this with jet fuel imports needed to meet expected demand increases results in the most aggressive refinery closure timeline and the most refinery shutdowns.

While increased gasoline exports are the primary constraint determining refinery closure results in all scenarios, the increase in jet fuel imports in the Rapid ZEV growth scenario requires port traffic volumes which suggest historic port capacity maximum levels may be insufficient, particularly in the South region. Results in this scenario indicate that historic maximum port capacity levels may be potentially exceeded at the end of the projection period (2040s), when demand for jet fuel has increased and jet fuel production has declined due to the closure of most refineries within the state.

The Moderate ZEV growth scenario (reflecting 2024 IEPR AATE3 demand declines for gasoline and diesel) resulted in both fewer total refinery closures, and a delayed timeline of two or three years. In this scenario, six of the nine refineries are expected to close by 2045. The Slow ZEV growth scenario (2024 IEPR Baseline demand for gasoline and diesel) assumes the slowest decline in demand, resulting in the least number of refinery closures of the three scenarios. Because demand remains high, gasoline surplus does not build as quickly as in the Rapid and Moderate ZEV growth scenarios. Because less gasoline exports are needed, there is more port capacity available in this scenario than those with more aggressive demand declines.

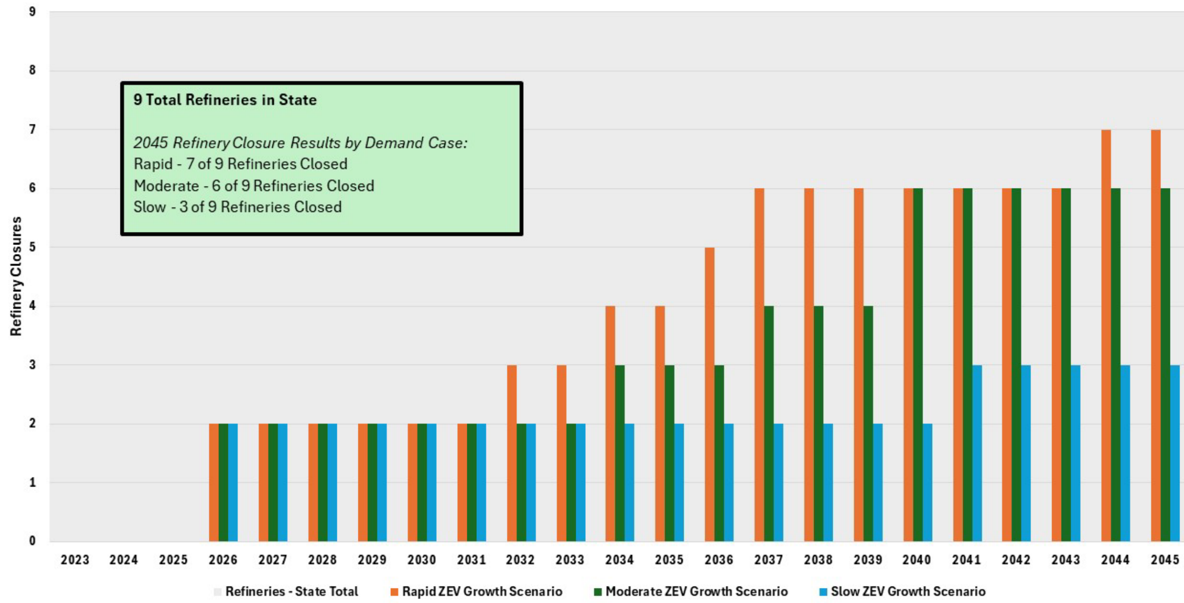


Figure 9. Timeline of California Refinery Closures by Demand Scenario

3.3 Refinery Production Decline

Figures Figure 10–Figure 12 below provide California refinery production model results over time for each fuel type and demand decline scenario. All volumes reflect the amount of production after utilization shifts to balance gasoline demand have been implemented.

The Rapid ZEV growth scenario results in the quickest decline in transportation fuel production, due to surplus gasoline exports and a high number of expected refinery closures over time. Declining production is also reflected in the Moderate and Slow scenarios, at slower paces, as refinery closures are determined in later years. While production generally follows a smooth downward trend, as refineries adjust production within their utilization windows, sharper drop-offs indicate years featuring refinery closures.

In the Rapid ZEV growth scenario, a period of steady production decline follows announced refinery closures in 2025, before representing a series of refinery closures which result in production declines by 2039. Production then remains constant before again decreasing in 2044.

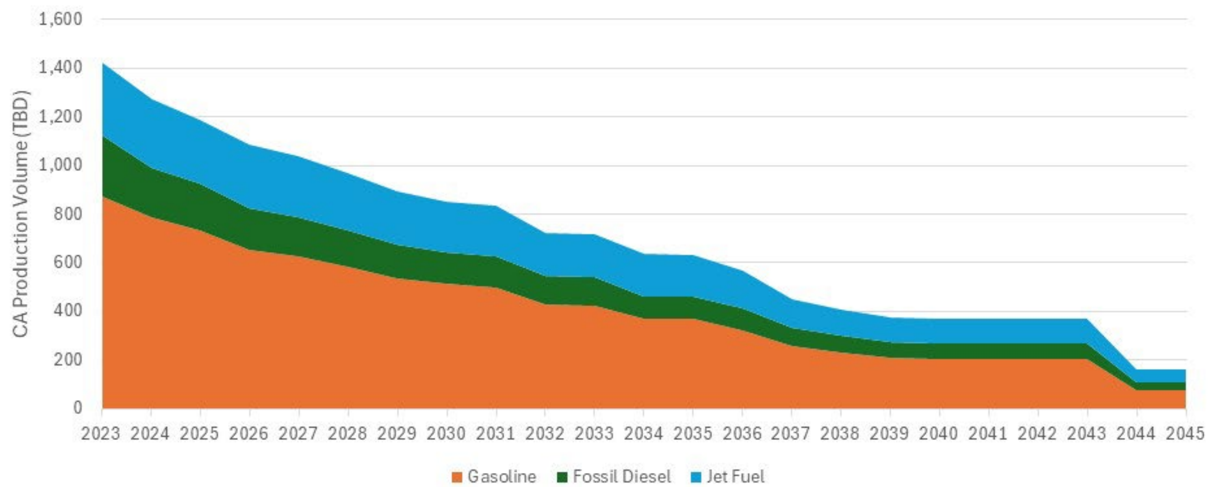


Figure 10. California Transportation Fuel Production by Fuel Type: Rapid ZEV Growth Scenario

The Moderate ZEV growth scenario results in a more modest production decline, with refinery closures in 2025 and 2026 offsetting gasoline surplus and avoiding refinery closures until later in the time period. Production steadily declines until surplus builds, and refinery closures begin occurring starting in 2034, as seen in Figure 11 below. By 2045, total production in the Moderate ZEV growth scenario is expected to be nearly double the roughly 200 TBD of the Rapid ZEV growth scenario.

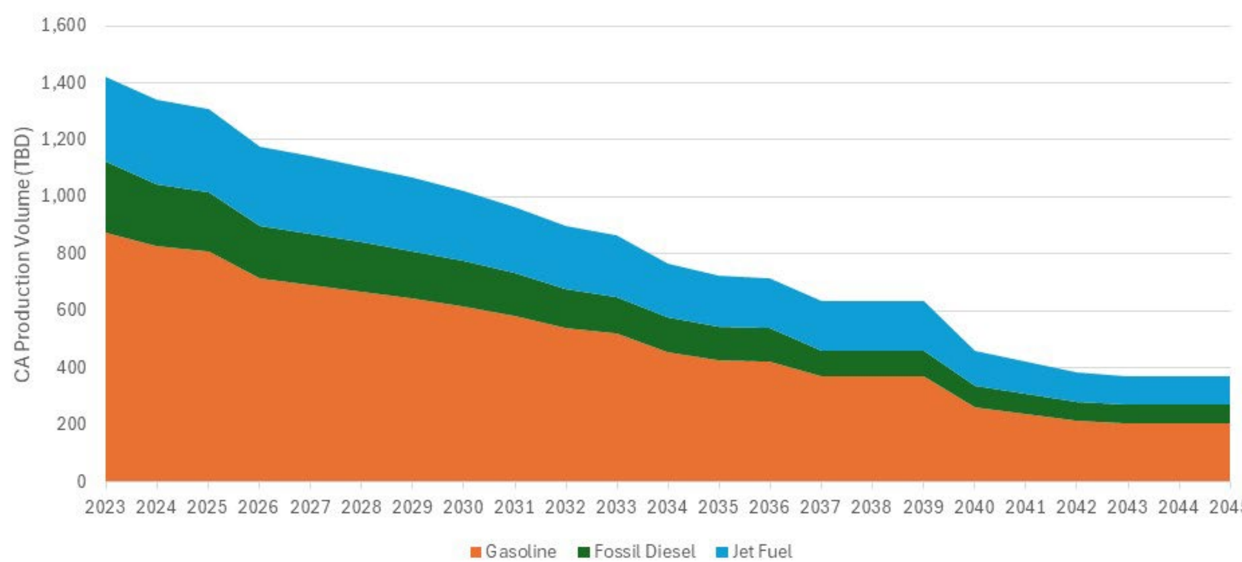


Figure 11. California Transportation Fuel Production by Fuel Type: Moderate ZEV Growth Scenario

The Slow ZEV growth scenario results in a much more stable decline in production over time. This is due to higher demand assumptions, resulting in less port traffic and fewer refinery closures. Production volume results by 2045 in this scenario are expected to be nearly four times higher when compared with those from the Rapid ZEV growth scenario.

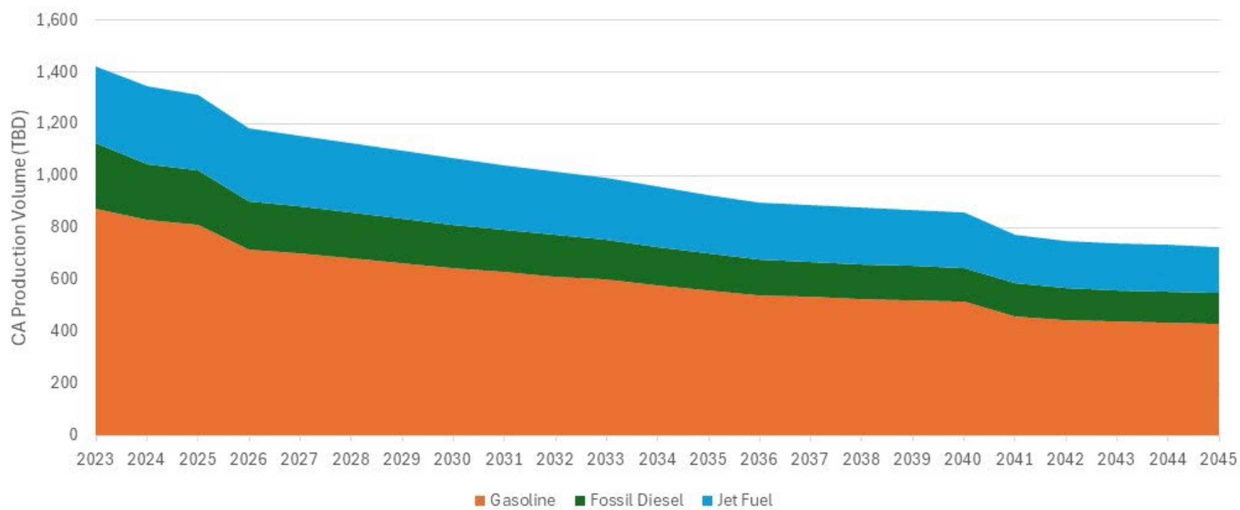


Figure 12. California Transportation Fuel Production by Fuel Type: Slow ZEV Growth Scenario

3.4 California Supply-Demand Results

This section provides a breakdown of supply and demand results for each transportation fuel and demand projection scenario. Positive volumes represent supply, including refinery production (dark blue), port imports (light blue), rail receipts, and other receipts of petroleum products through domestic marine movements (purple hashed area). The negative areas represent consumption sources, including in-state California demand (purple), pipeline shipments for demand in Arizona and Nevada (purple), foreign exports (orange), and other outbound domestic marine movements (red hashed area). Although the proportion of each petroleum product movement varies, the market remains in balance throughout the projection period when total supply and demand are aligned. Model results shown below indicate a balanced market for all fuels in all years and demand projection scenarios.

3.4.1 Gasoline

The Rapid ZEV growth scenario supply-demand results are shown below in Figure 13. This scenario represents the steepest gasoline demand decline, resulting in gasoline surplus building the most quickly. Following announced refinery closures in 2026, gasoline imports are initially needed to supply-demand. However, demand continues to decline and by 2030 gasoline surplus begins to build resulting in needed exports. This surplus eventually reaches the assumed 50 TBD export constraint and results in a refinery closure. The closure reduces surplus gasoline in the market that year (reducing needed exports), until surplus eventually builds again with the patten continuing throughout the projection period. Gasoline imports are needed towards the end of the projection period due to remaining demand in the market (it does not go to reduce to zero by 2045), and the closure of all refineries in the South.

Again, because positive volumes shown here represent supply and negative volumes represent sources of demand, the market is in balance when the totals of each set of flows remain the same. As seen here and in all other scenario results that follow, total supply and demand are aligned throughout the projection period.

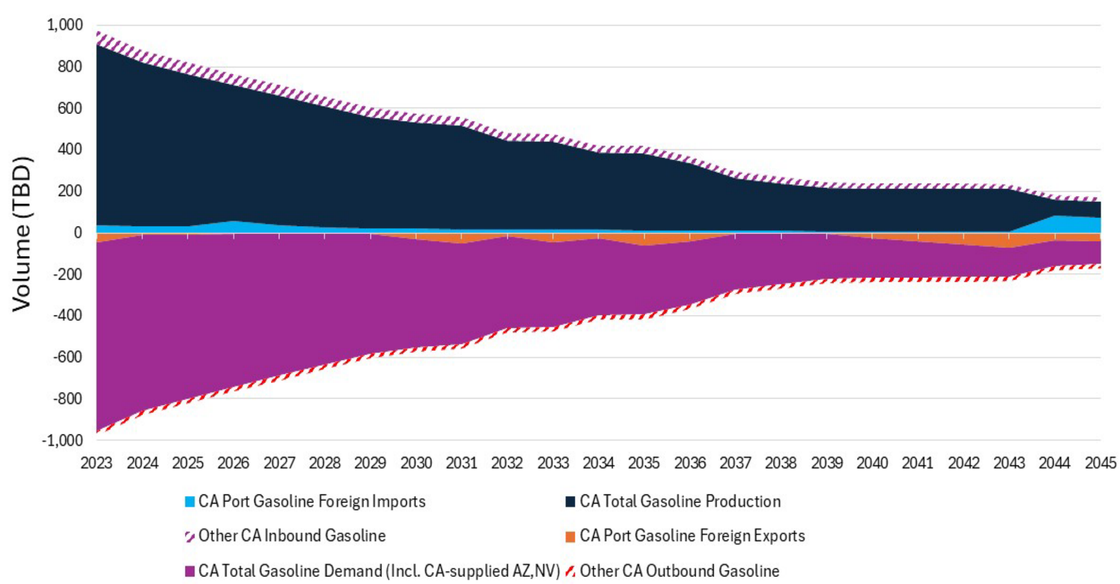


Figure 13. Gasoline Supply–Demand Results through 2045: Rapid ZEV Growth Scenario

Figure 14 provides the supply-demand results for gasoline in the Moderate ZEV growth scenario. Demand does not decline as quickly in this scenario, and more imports are needed to supply higher demand following the announced refinery closures in 2026. In these results, gasoline surplus takes longer to build in the projection period, and therefore gasoline exports are not required as quickly. However, similar to the Rapid ZEV growth scenario, once the 50 TBD export constraint has been reached in the North or in the South, refinery closures begin to occur. Surplus build-up is then reduced, but because it takes longer to reach the port constraint, less refinery closures are seen overall.

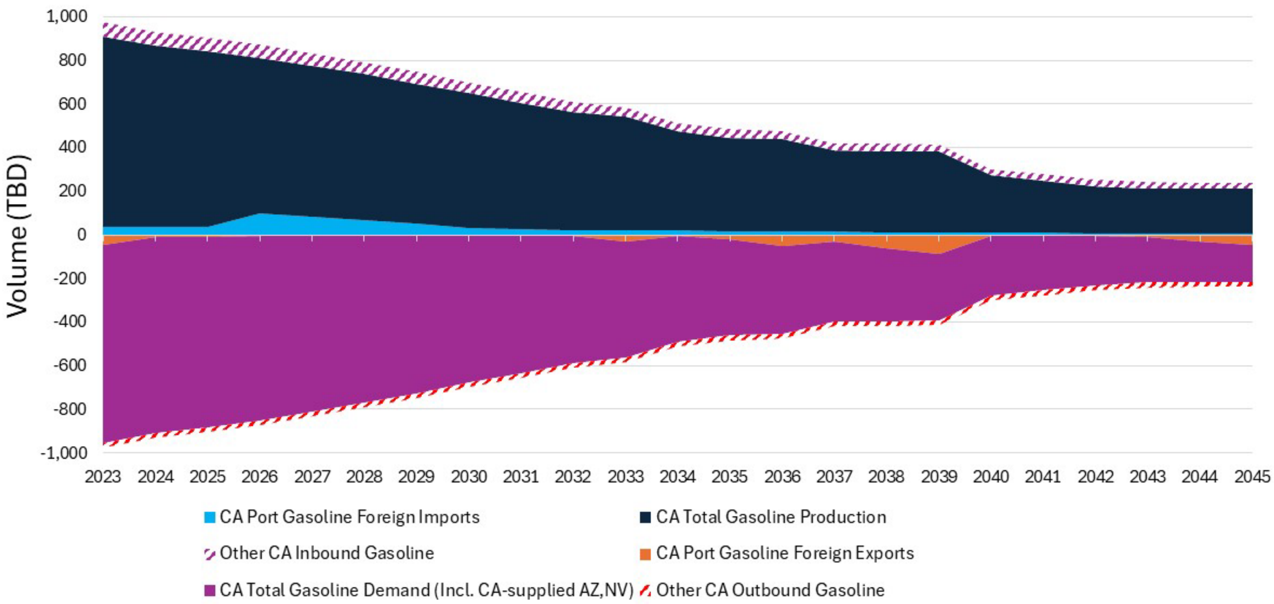


Figure 14. Gasoline Supply-Demand Results through 2045: Moderate ZEV Growth Scenario.

Figure 15 provides the supply-demand results for gasoline under the Slow ZEV growth scenario. In this scenario, demand declines much less quickly than the Rapid and Moderate ZEV growth scenarios. Therefore, more imports are needed after the announced refinery closures in 2026, and gasoline surplus builds even less quickly. Most demand is met by production adjustments, allowing refineries to operate much longer without closing (resulting in only one additional closure). This also indicates that the assumed utilization adjustment range can account for slower demand declines assumed in this scenario.

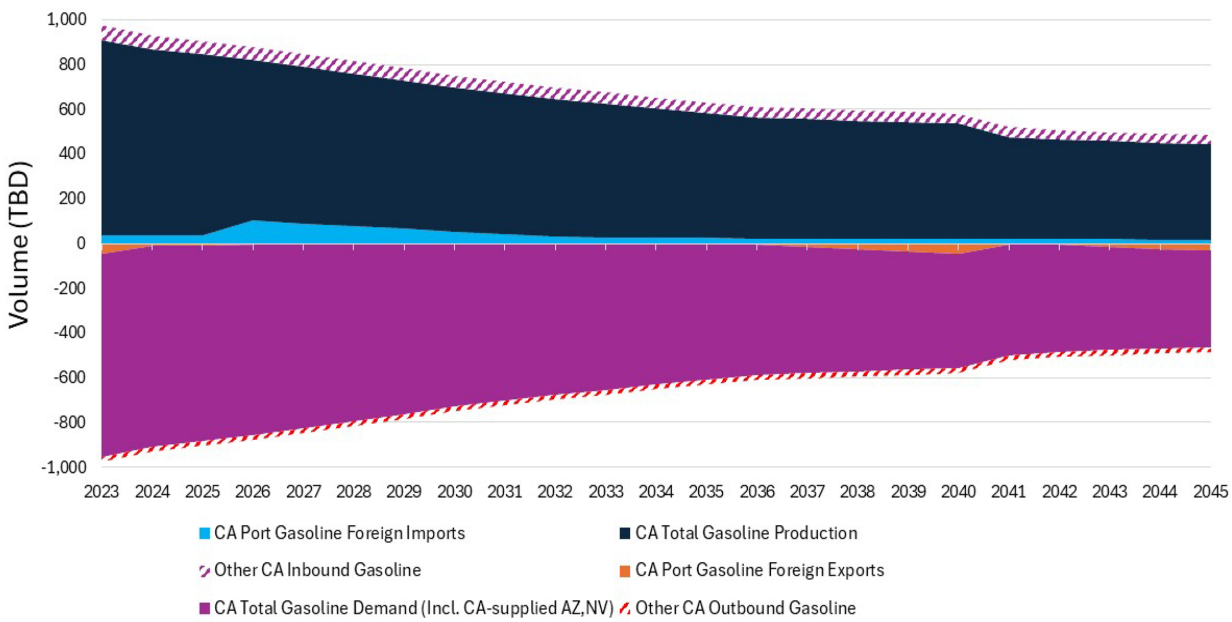


Figure 15. Gasoline Supply-Demand Results through 2045: Slow ZEV Growth Scenario

3.4.2 Fossil Diesel

This section provides the supply-demand results based on model outputs for fossil diesel fuel in each demand projection scenario. Supply-demand results for fossil diesel are a function of fossil diesel refinery production, total diesel demand in California, as well as the amount of renewable diesel (RD) and biodiesel demand penetration that is assumed in the overall California market. Renewable diesel supply-demand results are discussed and shown in more detail in Section 3.4.3.

Results for the Rapid ZEV growth scenario are shown in Figure 16. Despite a decrease in fossil diesel production due to announced refinery closures in 2026, increased fossil diesel exports are expected in the early projection period. This is because the drop in refinery production coincides with a decrease in fossil diesel demand. This decrease occurs due to expected increases in RD demand in the overall diesel market (see Figure 17). As RD demand decreases over time, fossil diesel fuel demand increases as the overall diesel demand is not assumed to decline as quickly as RD. As refinery closures occur due to impacts on port traffic from diesel and other fuels, production decreases and fossil diesel fuel must be imported. In the Rapid ZEV growth scenario, refinery closures are determined by the model to occur the soonest, and more imports of fossil diesel are needed to keep the market supplied.

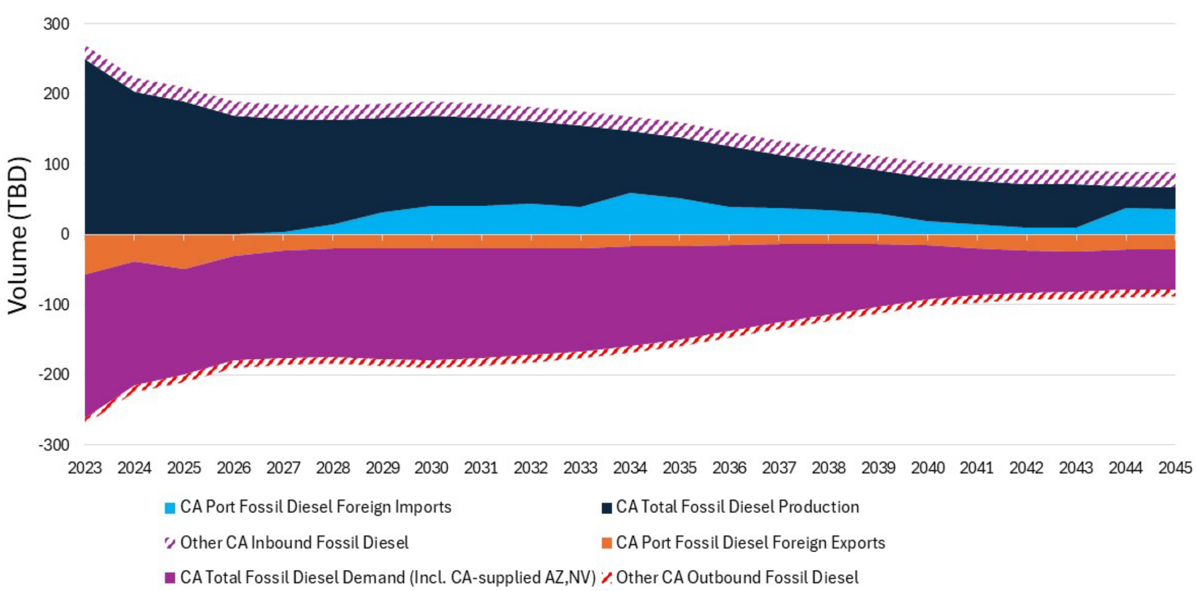


Figure 16. Fossil Diesel Supply-Demand Results through 2045: Rapid ZEV Growth Scenario

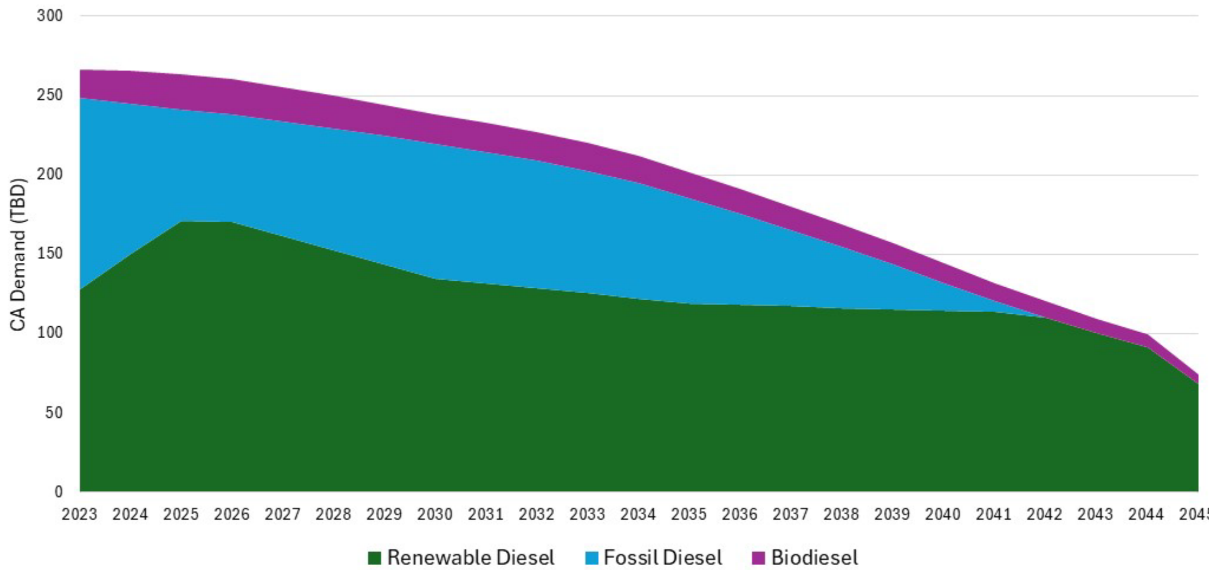


Figure 17. Detailed Diesel Demand Results, Rapid ZEV Growth Scenario

Moderate ZEV growth scenario supply-demand results are shown in Figure 18. In this scenario, overall diesel demand declines more quickly (Figure 19). This results in more exports in the early projection period, despite announced refinery closures in 2026 and the loss in fossil diesel production. Additionally, because overall diesel demand is declining more quickly and RD diesel demand is consistent throughout most of the projection period in all scenarios, less fossil diesel demand is seen in the market overall. This results in less imports over time when compared with the Rapid ZEV growth scenarios, and exports of fossil diesel are needed each year through 2045.

Grow

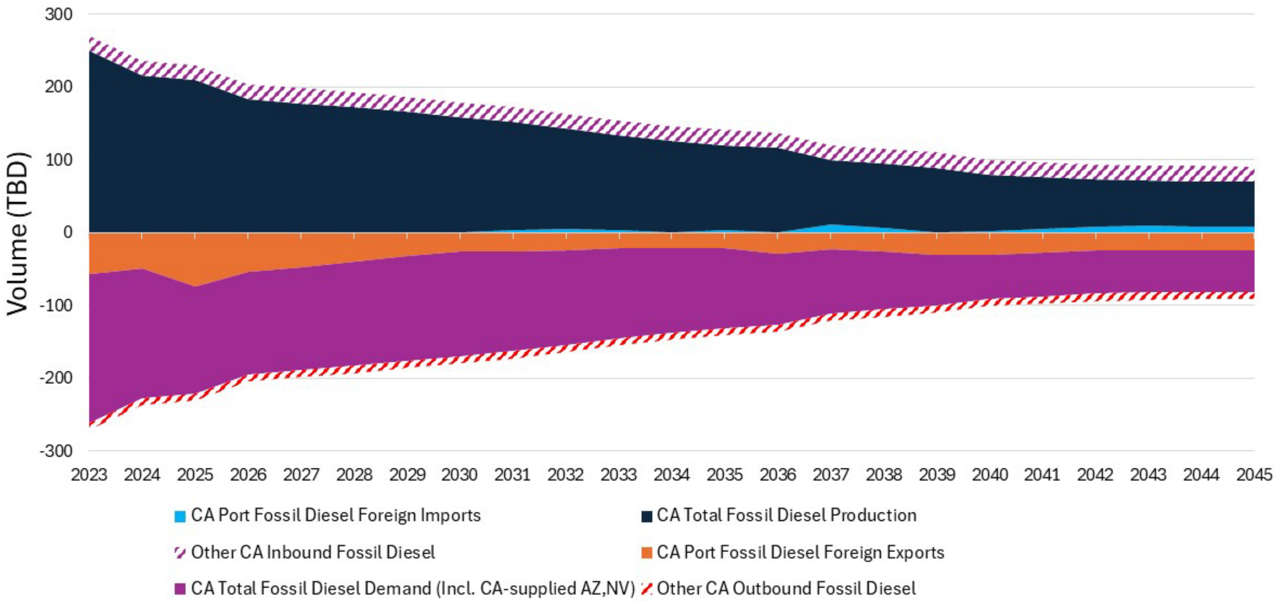


Figure 18. Fossil Diesel Supply-Demand Results through 2045: Moderate ZEV Growth Scenario

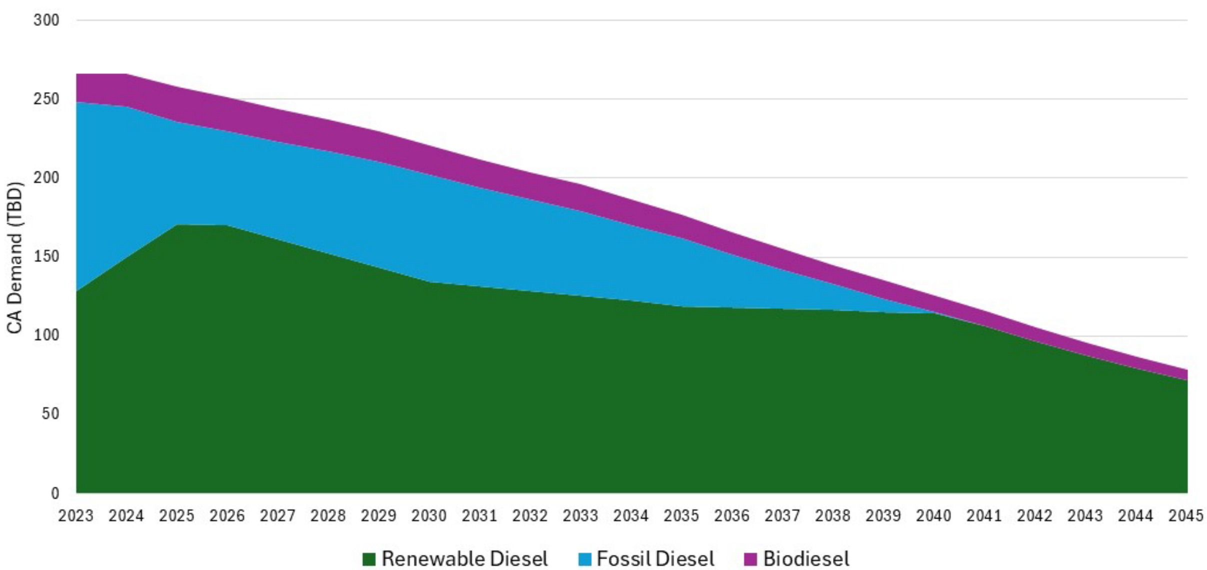


Figure 19. Detailed Diesel Demand Results, Moderate ZEV Growth Scenario

In the Slow ZEV growth scenario results shown in Figure 20, overall diesel demand declines the slowest (Figure 21). The initial increase in fossil diesel exports still occurs, similar to the results in the Rapid and Moderate ZEV growth scenarios. Again, these exports occur due to a decrease in fossil diesel demand (coinciding with an increase in RD demand), despite the loss of refinery production in 2026. In this scenario, because overall diesel demand remains high, fossil diesel demand increases more over time than the Rapid and Moderate ZEV scenarios. Very few imports are needed, and fossil diesel exports remain fairly consistent through 2045.

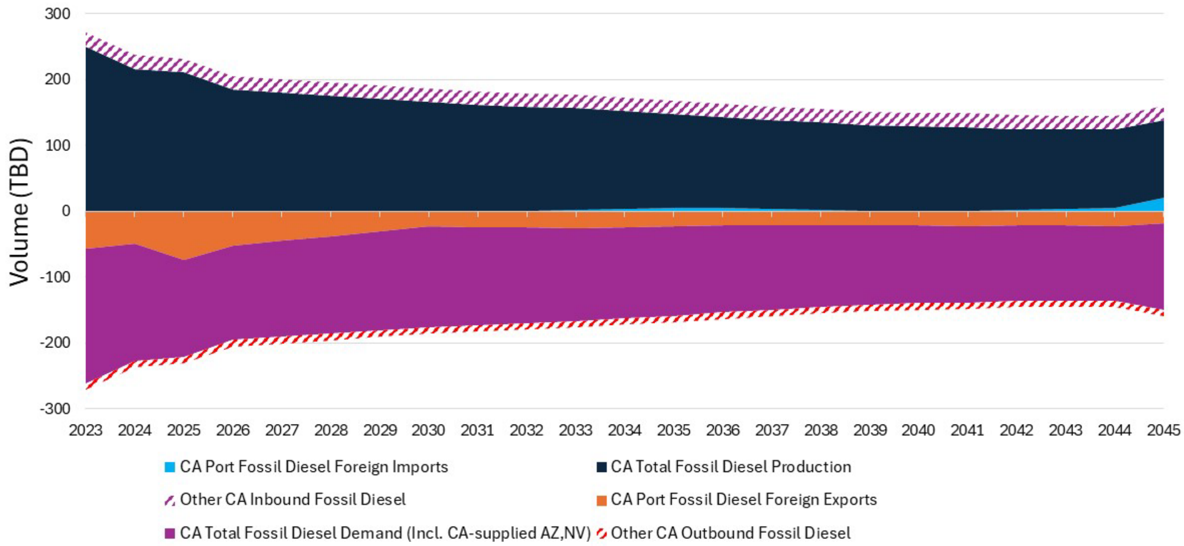


Figure 20. Fossil Diesel Supply-Demand Results through 2045: Slow ZEV Growth Scenario

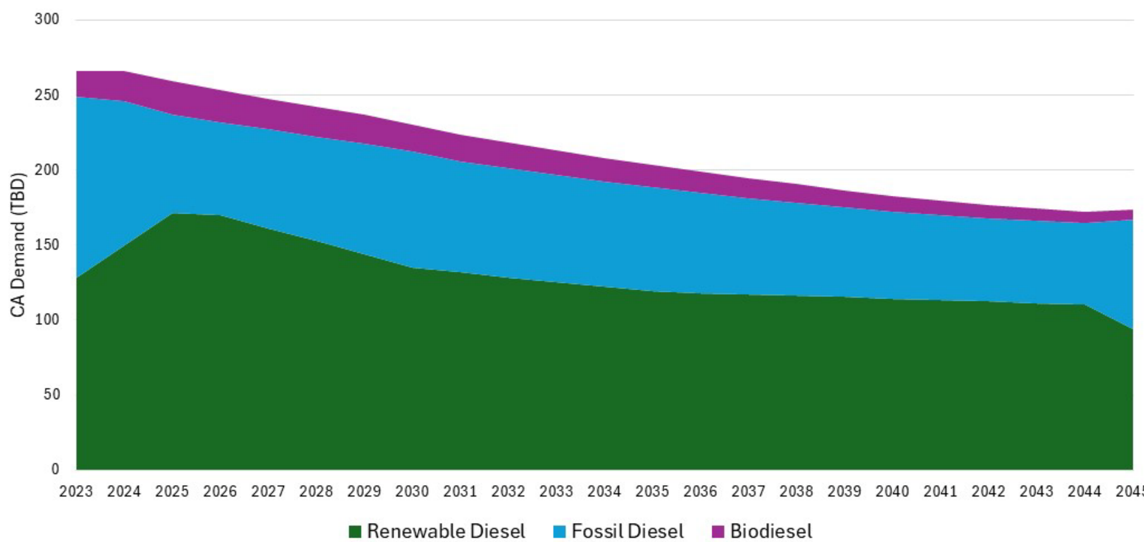


Figure 21. Detailed Diesel Demand Results, Slow ZEV Growth Scenario

3.4.3 Renewable Diesel

Renewable diesel (RD) supply and demand is unique from the other fossil-based fuels discussed in this section due to the fact that changes in the RD market do not assume changes in port traffic are needed to keep the market in balance. Rather the model assumes that expected changes to demand over time will be addressed through future production and domestic rail movements. However, the amount of RD demand assumed in California directly impacts the required amount of fossil diesel movements to keep the market in balance, as discussed previously in Section 3.4.2. Therefore, it is important to properly define RD demand, and the model must ensure supply is sufficient to support that demand.

The three figures below provide the supply-demand results for RD in each demand projection scenario. In each scenario, demand is based on 2023 LCFS data and reflects expected changes over time from the 2022 Scoping Plan. Demand increases through 2025 and 2026 before declining the rest of the projection period. To ensure supply, the model includes an increase in domestic rail receipts from out of state, as well as production from the P66 Rodeo and Marathon Martinez refineries, both of which recently converted to renewable diesel production.

While the results below provide a breakdown of movements for the state as a whole, both production facilities are located in Northern California. Because of this, there are noticeable differences in the supply-demand balance in both regions. In contrast to how the model balances other transportation fuels (through changes in marine imports and exports for each fuel and region independently), changes in each region for RD were addressed considering both markets simultaneously.

In the North, surplus RD occurs based on regional demand but is avoided by first reducing RD domestic rail imports. In the South, a deficit occurs due to assumed demand and no production within the region. To avoid unnecessarily curtailing in-state production in the North (while simultaneously increasing the volume of domestic rail receipts in the South), the model assumes surplus RD in the North is sent via intrastate rail movements to the South. If this intrastate RD shipment subsequently results in surplus in the South, domestic rail receipts in the South are then first reduced before curtailing production. Finally, in-state production curtailment does occur if demand across both regions decreases to a volume less than the total assumed RD domestic rail import volume.

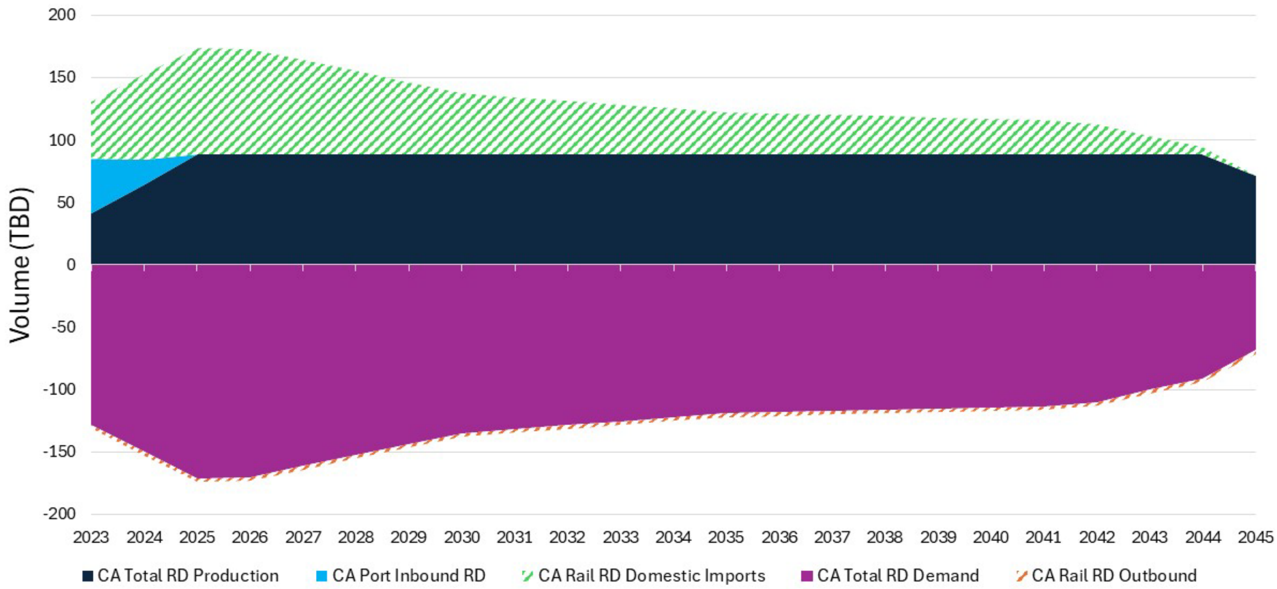


Figure 22. Renewable Diesel Supply-Demand Results through 2045: Rapid ZEV Growth Scenario

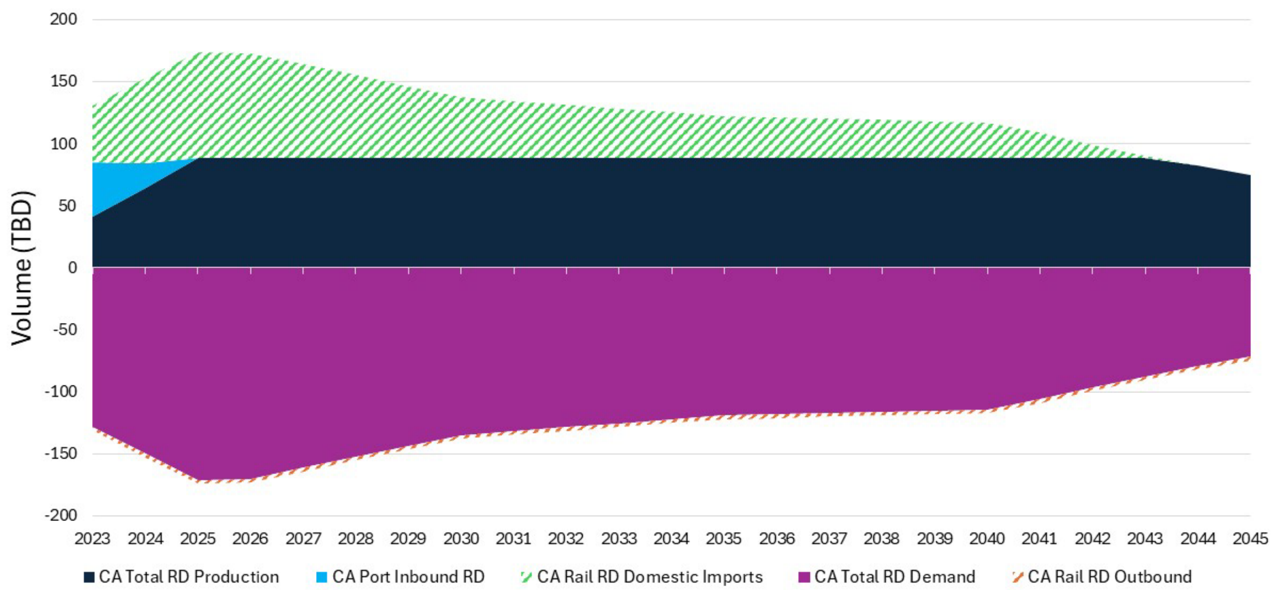


Figure 23. Renewable Diesel Supply-Demand Results through 2045: Moderate ZEV Growth Scenario

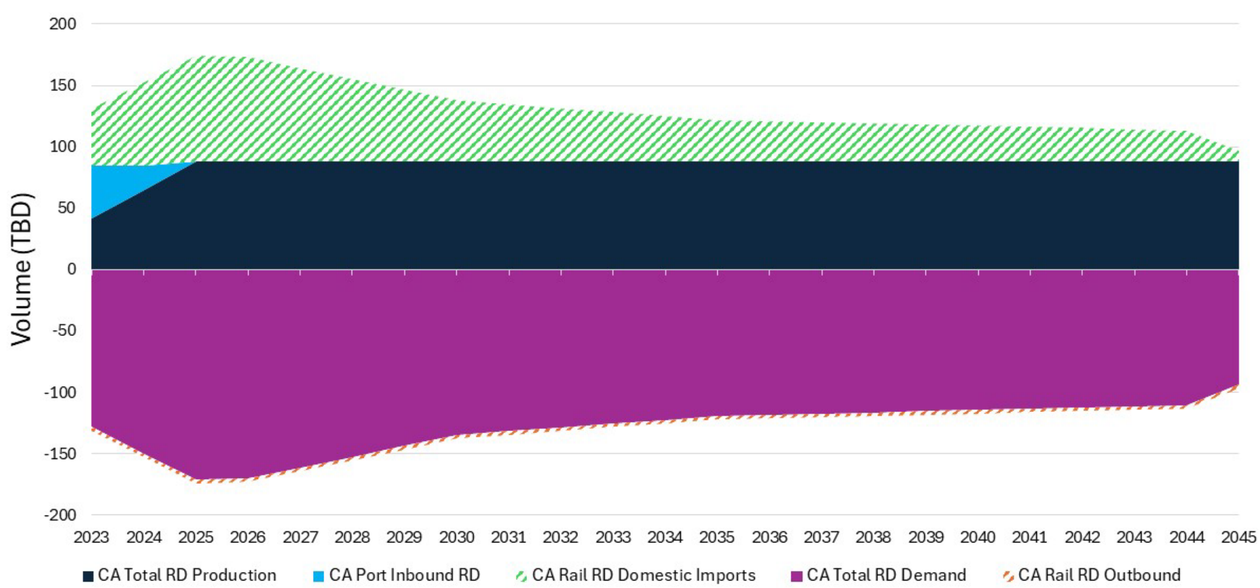


Figure 24. Renewable Diesel Supply-Demand Results through 2045: Slow ZEV Growth Scenario

3.4.4 Jet Fuel

This section provides the supply-demand results for jet fuel in each of the demand projection scenarios. Jet fuel differs from gasoline and diesel in that the projected demand for this fuel is expected to grow (rather than decline) by 2045. This creates a need for increased imports resulting in more port congestion and potentially disrupting the operation of refineries. As refinery production declines with decreasing gasoline demand, additional jet fuel imports are needed to ensure the market remains supplied. The combination of these two factors has a significant impact on the timeline and number of refinery closures.

Jet fuel supply-demand results in the Rapid ZEV growth scenario are shown in Figure 25 below. As described previously, jet fuel imports increase significantly throughout the projection period as demand for the fuel increases and refinery production declines. Production declines over time as refinery closures occur due to port traffic from increases in gasoline exports and jet fuel imports. The proportion of jet fuel supplied to the market through foreign imports increases from less than 12% in 2023 to over 80% by 2045.

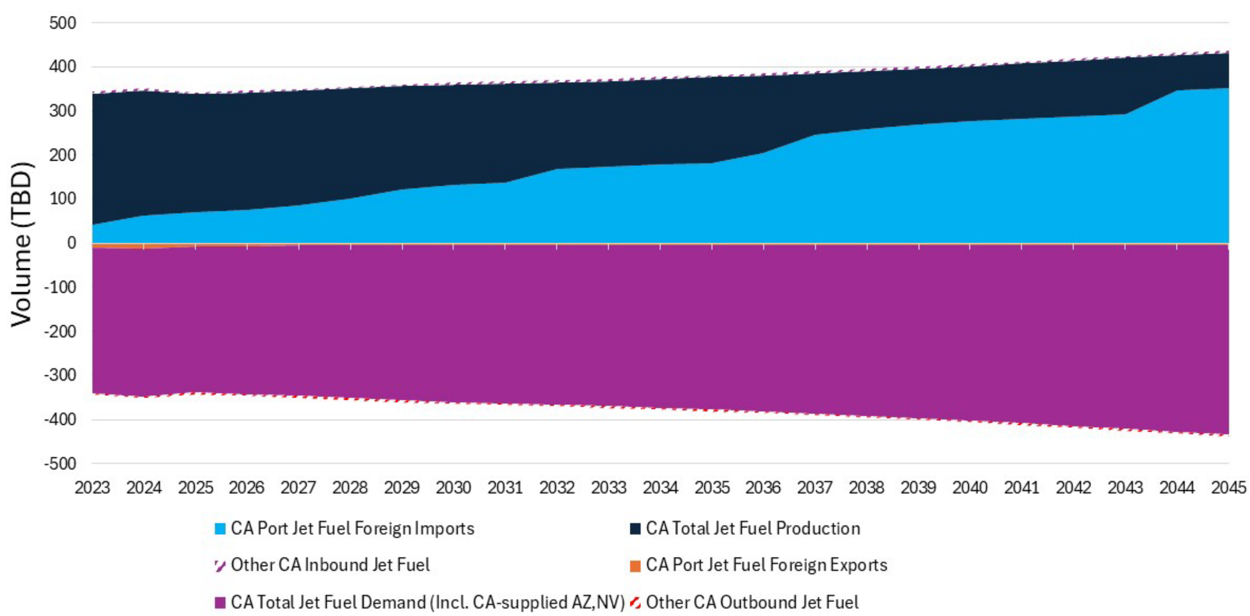


Figure 25. Jet Fuel Supply-Demand Results through 2045: Rapid ZEV Growth Scenario

Figure 26 provides the jet fuel supply-demand results in the Moderate ZEV growth scenario. The results in this scenario are similar to those in the Rapid ZEV growth scenario, in that jet fuel imports still see a significant increase by 2045. However, the proportion of jet fuel foreign imports on overall supply is less than the Rapid ZEV growth scenario, as fewer refinery closures occur and therefore more jet fuel production remains in the market (and longer). Results do not show significant increases in jet fuel imports outside of years where certain refinery closures occur.

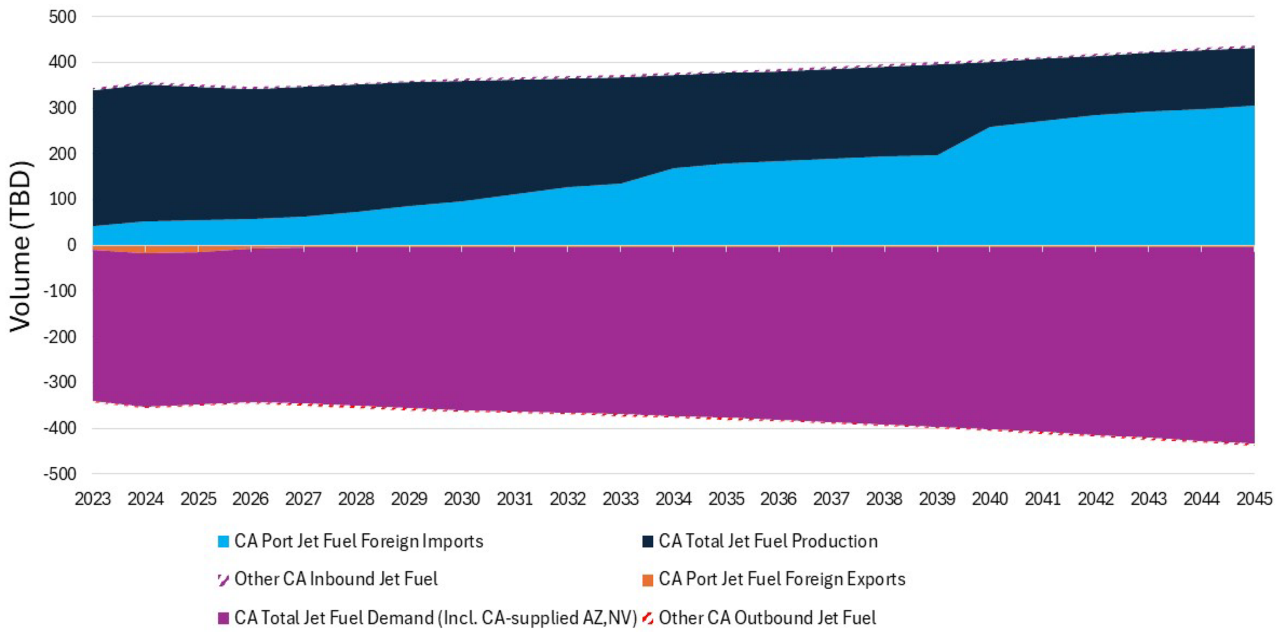


Figure 26. Jet Fuel Supply-Demand Results through 2045: Moderate ZEV Growth Scenario

In the Slow ZEV growth scenario, foreign imports of jet fuel increase noticeably less than in the Rapid and Moderate ZEV growth scenarios. In this scenario, the proportion of supply from imports of jet fuel increases from 12% in 2023 to a little over 50% by 2045, about 30% less than the proportion supplied by imports in the Rapid ZEV growth scenario. This is due to the fact that gasoline demand remains high in this scenario, reducing surplus and required gasoline exports resulting in less refinery closures. Refineries operating longer provide more jet fuel production in the market, and less imports are needed.

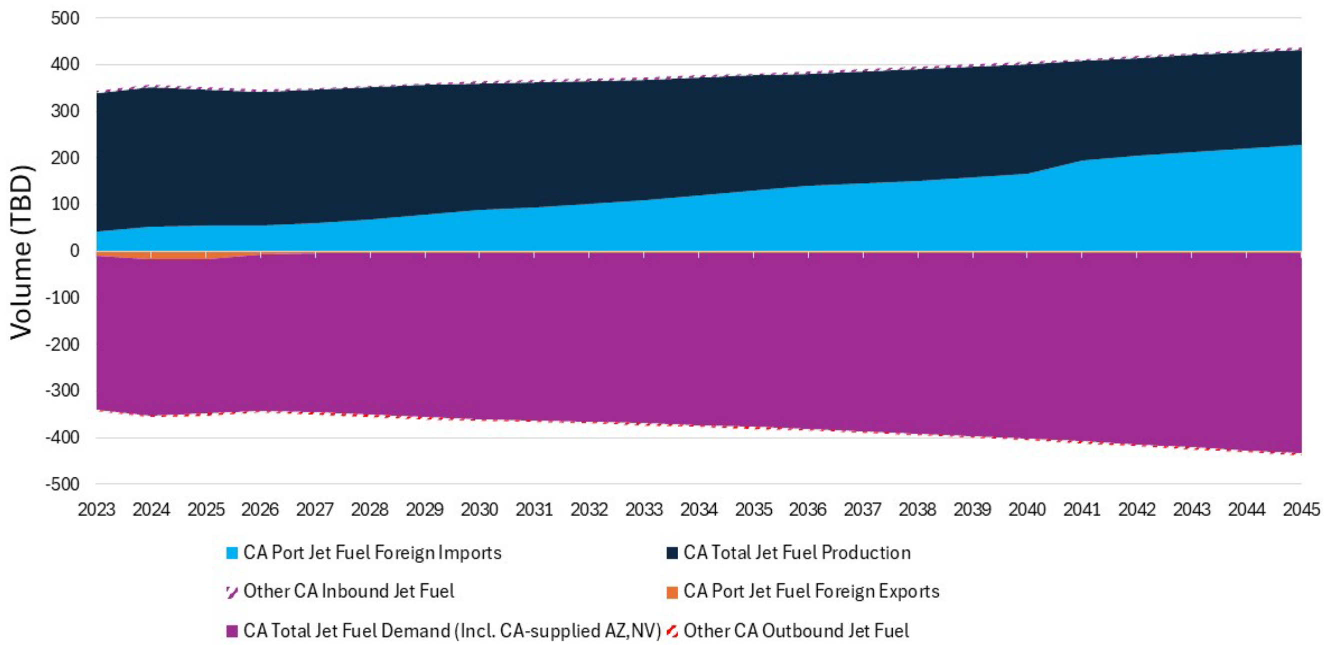


Figure 27. Jet Fuel Supply-Demand Results through 2045: Slow ZEV Growth Scenario

3.5 California Port Traffic Results

The results shown in this section indicate the cumulative volume of marine traffic needed to move through California ports to ensure each market remains supplied and in balance. Results are provided for each demand projection scenario. Ports flows are represented by foreign imports and exports as well as domestic and intrastate movements; gasoline, fossil diesel, and jet fuel movements are all included. Two notable flows are highlighted in each chart: gasoline exports and jet fuel imports. These are isolated from other flows due to their correspondence with changing refinery production and demand, as well as their influence on port capacity constraints and refinery closures.

To illustrate when a refinery closure is determined to occur, the model first considers the build-up of gasoline surplus (lowest purple shaded area). When this build-up surpasses the assumed gasoline export constraint of 50 TBD in the North or South region, the model selects a refinery to close. This closure reduces gasoline production (and surplus) in the market for that year. The model does this until the constraint is no longer surpassed for each year until 2045. As demand for gasoline and diesel decline, refineries close and the production of jet fuel reduces. The combination of building gasoline and diesel exports and jet fuel imports means that the amount of traffic supported by ports inevitably increases over time. As the total volume of traffic reaches the total port capacity constraint, the model will also select a refinery closure to attempt to balance the market.

Port traffic results for the Rapid ZEV growth scenario are provided in Figure 28. A small increase in traffic is seen in 2026 as announced refinery closures occur, temporarily requiring the need for additional imports. Over time gasoline exports build, reaching the port capacity constraint of 50 TBD and indicating that a refinery must close. This reduces gasoline surplus temporarily, before again building as demand declines over time causing additional refineries closures to occur. In this scenario, a large increase in port traffic is also seen in 2044, as a significant amount of refinery production is removed and additional imports of all fuels are needed. Jet fuel imports are the largest port movement by 2045, a result consistent across all demand scenarios.

This scenario results in a total of 7 of 9 refineries closing by 2045.

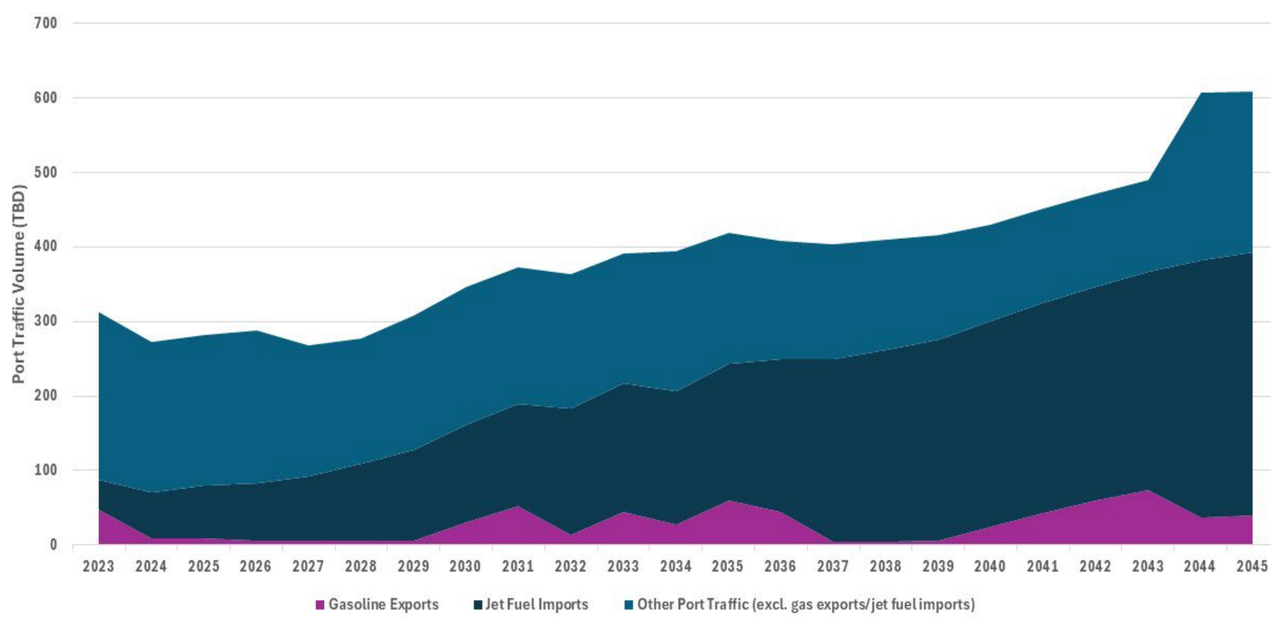


Figure 28. Port Throughput through 2045: Rapid ZEV Growth Scenario

Results for the Moderate ZEV growth scenario are provided in Figure 29. Similar trends in port traffic are seen in these results as in the Rapid ZEV growth scenario. However, this scenario requires less traffic overall as demand for gasoline does not decline as quickly. For reasons mentioned throughout this section, less demand decline results in less port congestion and fewer refinery closures. As observed in the Rapid ZEV growth scenario, jet fuel imports are the largest port movement by 2045.

This scenario results in a total of 6 of 9 refineries closing by 2045.

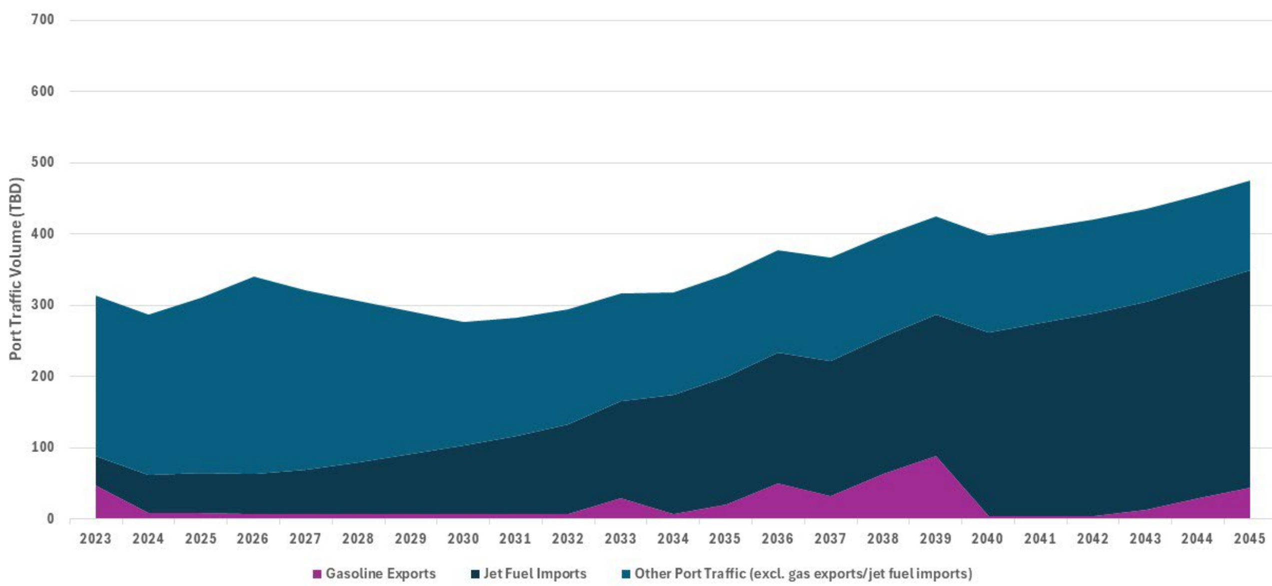


Figure 29. Port Throughput through 2045: Moderate ZEV Growth Scenario

Finally, the Slow ZEV growth scenario results in even less port traffic (Figure 30) than the Moderate ZEV growth scenario. Even less demand decline results in less port congestion and fewer refinery closures, with gasoline surplus not contributing to a closure until 2042. Jet fuel imports are again the largest port movement by 2045, but in this case represent the least amount of traffic proportionally to the total of all of the demand projection scenarios.

This scenario results in a total of 3 of 9 refineries closing by 2045.

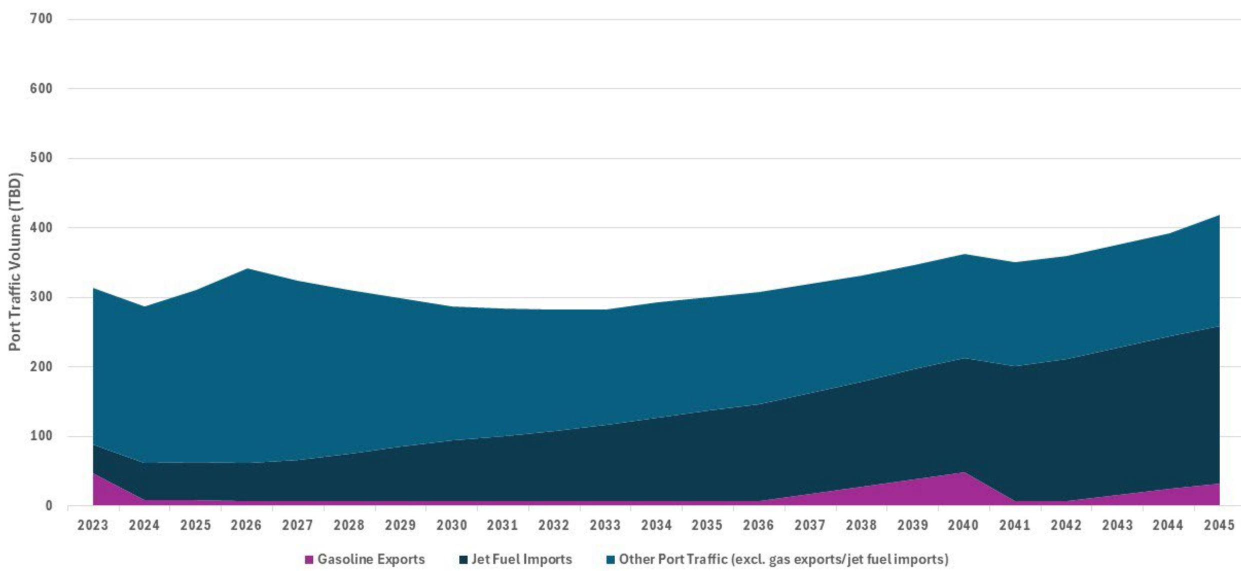


Figure 30. Port Throughput through 2045: Slow ZEV Growth Scenario

3.6 Summary of Key Results

This chapter has provided a detailed breakdown of various model output results for each transportation fuel and demand projection scenario. Each scenario reflects a set of assumptions in the model which impact the timeline of transportation fuel production and refinery closures. The number of refinery closures by 2045 are heavily influenced by the amount of decline in demand assumed for each product, with more aggressive declines resulting in more closures and in a shorter time frame. Key results indicate that refinery closures can range from as many as **seven of nine** in the Rapid ZEV growth scenario to **three of nine** projected under the Slow ZEV growth scenario. While the decisions made by industry are based on a complex combination of factors and the model results discussed here are not meant to represent a formal prediction, outputs do provide insights on potential impacts to industry from declining demand and where future supply and demand issues may occur.