Draft Concepts

Statewide Clean Aviation Initiative (SCAI)

January 2026

This document outlines draft concepts under consideration by the California Air Resources Board (CARB) as part of the Statewide Clean Aviation Initiative (SCAI). In the 2022 State SIP Strategy,[1] CARB committed to explore strategies to reduce emissions from the aviation sector. These strategies include advancing clean technologies, setting operational efficiency practices, and developing regulations, voluntary measures, and incentive programs. CARB held an initial public workshop[2] on December 10, 2024, to begin discussions on concepts that target on-ground and near-ground emissions from aircraft operations in California.

CARB is exploring opportunities to address the need for statewide reductions of nitrogen oxides (NOx), a key precursor for ozone formation, and particulate matter (PM) to meet federal air quality standards and protect public health. Statewide aviation activities contributed 42 tons per day (tpd) of NOx emissions in 2022 and are projected to increase to 63 tpd by 2037.[3] The aviation sector is the only mobile source category in California where emissions are expected to substantially increase in the future. Certain areas of the state, such as the South Coast Air Basin, are unable to attain federal ozone standards without emissions reductions from aviation. In addition to criteria pollutants, airports are sources of air toxics that are hazardous to the health of workers and those in adjacent communities.[4] Any strategy that reduces combustion (including in aircraft propulsion engines, auxiliary power units, and ground support equipment) would reduce emissions of any air toxics, which would provide near-source public health benefits.

Airports are already subject to some regulations and have their own policies to reduce emissions, and airlines have voluntarily entered into agreements with regulatory agencies. Below is a list of known agreements and regulations currently in place:

- Five major airports (LAX, SNA, ONT, BUR, and LGB) have signed a memorandum of understanding with the South Coast Air Quality Management District to reduce NOx emissions from their ground support equipment.[5]

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[1] 2022 State Strategy for the State Implementation Plan. *https://ww2.arb.ca.gov/sites/default/files/2022-08/2022_State_SIP_Strategy.pdf*

[2] *https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-ground-support-equipment/ze-airport-gse-meetings-workshops*

[3] California Aircraft Emissions Inventory (2024). *https://ww2.arb.ca.gov/sites/default/files/2024-10/CAI2024%20-%20Main%20Document_Final1021_ada.pdf*

[4] SEIU-USWW, *Poisoned From Above* (2024).

[5] South Coast Air Quality Management District Memorandum of Understanding with Commercial Airports. *https://www.aqmd.gov/home/air-quality/air-quality-management-plans/air-quality-mgt-plan/facility-based-mobile-source-measures/commercial-airports-mous*

- The LAX airport has established a new policy that requires all Ground Support Equipment (GSE) to be zero-emission by 2033 (with some exceptions).[6]
- CARB and Airlines for America have signed a Sustainable Aviation Fuel (SAF) Partnership agreement, which committed to 200 million gallons of SAF in California by 2035.[7]
- CARB's Airport Shuttle Bus Regulation requires airport shuttle operators to transition to 100 percent zero-emission technologies by 2035.[8]
- CARB's In-Use Off-Road Diesel (ORD) Regulation reduces emissions from airport GSE fleets by requiring older and high-emitting diesel equipment to be retired, replaced, or repowered.[9]
- CARB's Large Spark Ignition (LSI) Regulation requires operators of certain off-road equipment (including airport GSE) to achieve fleet average emission standards to reduce NOx and hydrocarbon emissions.[10]

Nevertheless, existing programs remain insufficient to combat the projected increase of aviation emissions. This document expands and provides more details on four draft concepts, previously discussed at the December 2024 workshop, which would provide further emission reductions from aircraft operations in California. The four concepts include:

(1) Controlling emissions from aircraft auxiliary power units for the duration of visit;
(2) Reducing emissions from airport ground support equipment;
(3) Reducing emissions from aircraft taxiing at the airport; and,
(4) Reducing emissions from aircraft takeoffs and landings.

Note that these concepts are in draft form. CARB staff is determining operational, technical, and economic feasibility of these expanded concepts. To do this, CARB is hosting a public workshop on January 15, 2026, to continue engaging with, and soliciting input from, affected industry, other stakeholders, communities, and members of the public. If you have any comments, feedback, or responses to questions in this document, CARB staff welcomes you to submit them to *aircraft@arb.ca.gov* by March 2, 2026.

CARB staff will report to the Board in 2027 with an update on the Statewide Clean Aviation Initiative, which as mentioned above may include regulatory, incentive, or other voluntary emissions reduction

[6] LAX Zero-Emission GSE policy. https://www.lawa.org/sites/lawa/files/documents/LAX%20ZE%20GSE-Vehicles%20Policy.pdf
[7] CARB and Airlines for America Sustainable Aviation Fuel Partnership. https://ww2.arb.ca.gov/resources/documents/sustainable-aviation-fuel-partnership
[8] CARB Zero-Emission Airport Shuttle Regulation. https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle
[9] CARB In-Use Off-Road Diesel-Fueled Fleets Regulation. https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation
[10] CARB Large Spark-Ignition Regulation. https://ww2.arb.ca.gov/our-work/programs/large-spark-ignition-lsi-engine-fleet-requirements-regulation

programs. If a formal regulatory proposal is developed, it would be publicly posted and there would be a 45-day public comment period prior to any board hearing.

Potential List of Aircraft Within Scope of Draft Concepts

All Commercial Large Aircraft, Commercial Small Aircraft, and Non-Commercial Jet Engine Aircraft operating at the airports defined below would be included in the draft scope of aircraft.

- *Commercial Large Aircraft*: According to federal regulation Title 14 (Aeronautics and Space) definition[11], Large Aircraft are aircraft originally designed to have seating capacity of more than 60 seats or a maximum payload capacity of more than 18,000 pounds. Commercial Large Aircraft are Large Aircraft carrying passengers or cargo for hire or compensation. This includes US and foreign-flagged carriers. This also includes any piston engine aircraft meeting this criterion.
- *Commercial Small Aircraft*: According to federal regulation Title 14 (Aeronautics and Space) definition[11], Small Aircraft are aircraft designed to have a maximum seating capacity of 60 seats or less and a maximum payload capacity of 18,000 pounds or less. Commercial Small Aircraft are Small Aircraft carrying passengers or cargo for hire or compensation. This includes both jet engine and piston engine aircraft.
- *Non-commercial Jet Engine Aircraft*: non-commercial jet engine aircraft of any size for private, corporate, or personal flying.

Type of aircraft under consideration for exemption:

- Agricultural aircraft (FAA Use Code 137)[12]
- Flight training aircraft operated by FAA-approved flight schools (FAA Use Code 141)[13]
- Military tactical support aircraft
- Helicopters
- Firefighting and emergency-response aircraft
- Non-commercial piston engine aircraft
- Aircraft which are excepted from FAA registration requirements under 49 U.S.C. §. 44101(b)(1)-(2)

[11] 14 CFR Part 298. *https://www.ecfr.gov/current/title-14/chapter-II/subchapter-A/part-298*
[12] 14 CFR Part 137. *https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-137*
[13] 14 CFR Part 91. *https://www.ecfr.gov/current/title-14/chapter-I/subchapter-H/part-141*

Potential List of Airports Within Scope of Draft Concepts

Prioritizing Reducing Emissions from Airports Surrounded by Disadvantaged Communities (DACs)[14]. To achieve more emission benefits and reduce emissions faster to relieve the pollution burden in DACs, CARB staff is considering developing more stringent requirements for airports where over 30% of the surrounding communities (within 3 miles) are DACs. As of November 2025, airports meeting this criterion are marked with asterisks in Table 1 and 2. Please see detailed draft requirements for these prioritized airports in the following sections.

Table 1. Major Airports Under Consideration to be Included in the Scope

Rationale: Table 1 lists major commercial airports in California that account for 98% of Commercial Large Aircraft and 70% of Commercial Small Aircraft NOx emissions. Including these in the scope could yield most emission benefits.

Airport	Commercial Large Aircraft NOx Emissions (tons per day)	Statewide Share	Commercial Small Aircraft NOx Emissions (tons per day)	Statewide Share
Los Angeles International Airport (LAX)*	11.5	39.0%	0.15	7.4%
San Francisco International Airport (SFO)	5.6	18.9%	0.17	8.5%
San Diego International Airport (SAN)	2.1	7.1%	0.06	3.1%
Ontario International Airport (ONT)*	1.9	6.6%	0.02	1.2%
Oakland San Francisco Bay Airport (OAK)*	1.8	6.0%	0.11	5.6%
Sacramento International Airport (SMF)	1.6	5.3%	0.02	0.9%
San José Mineta International Airport (SJC)	1.2	4.1%	0.11	5.7%
John Wayne Airport (SNA)	1.0	3.5%	0.14	7.1%

[14] A Disadvantaged Communities is defined by CalEPA as census tracts receiving the highest 25 percent of overall scores in CalEnviroScreen 4.0, plus a few other criteria. *https://oehha.ca.gov/calenviroscreen/sb535*

Hollywood Burbank Airport (BUR)*	0.7	2.4%	0.14	7.0%
Palm Springs International Airport (PSP)	0.4	1.4%	0.06	3.2%
Long Beach Municipal Airport (LGB)*	0.4	1.2%	0.02	1.3%
San Bernardino International Airport (SBD)*	0.3	1.1%	0.01	0.4%
Fresno Yosemite International Airport (FAT)*	0.3	0.9%	0.04	1.9%
Santa Barbara Municipal Airport (SBA)	0.1	0.4%	0.04	2.1%
Van Nuys Airport (VNY)*	0.005	0.02%	0.26	13.2%
Sum	28.8	98%	1.36	70%

Table 2. Additional Airports Under Consideration to be Included in the Scope

Rationale: airports are included in Table 2 if they: (1) have over 365 Commercial Large Aircraft or 1,999 Commercial Small Aircraft annual operations during 2022, or (2) are in the same area as at least one airport in Table 1, because of the potential for flights being redirected to the airport.

Airport Name and Code	Commercial Large Aircraft Operations	Commercial Small Aircraft Operations	Total Operations
Monterey Regional Airport (KMRY)	5566	21834	27400
McClellan-Palomar Airport (KCRQ)	14	24963	24977
Charles M. Schulz-Sonoma County Airport (KSTS)	8921	13626	22547
San Luis Obispo County Regional Airport (KSBP)	7048	9671	16719
Meadows Field Airport (KBFL)*	3695	11203	14898
Jacqueline Cochran Regional Airport (KTRM)*	75	14712	14787
Napa County Airport (KAPC)	5	14706	14711
Camarillo Airport (KCMA)	28	12781	12809
Redding Regional Airport (KRDD)	1721	10326	12047
McClellan Airfield (KMCC)*	647	9176	9823

Sacramento Mather Airport (KMHR)	3115	6253	9368
Brown Field Municipal Airport (KSDM)	243	8972	9215
California Redwood Coast-Humboldt County Airport (KACV)	2743	5086	7829
Visalia Municipal Airport (KVIS)	26	7637	7663
Hayward Executive Airport (KHWD)	53	7574	7627
Montgomery-Gibbs Executive Airport (KMYF)	1	7262	7263
Hawthorne Municipal Airport (KHHR)*	51	6975	7026
Truckee Tahoe Airport (KTRK)	1	7009	7010
Point Mugu Naval Air Station (KNUQ)	16	6713	6729
Stockton Metropolitan Airport (KSCK)*	2833	3875	6708
Buchanan Field Airport (KCCR)	12	6455	6467
Chino Airport (KCNO)	372	5743	6115
Perris Valley Airport (L65)*	0	5574	5574
Santa Monica Airport (KSMO)	16	5424	5440
Del Norte County Regional Airport / Jack McNamara Field (KCEC)	7	4741	4748
Gillespie Field (KSEE)	274	4188	4462
March Air Reserve Base (KRIV)*	4019	357	4376
Point Mugu Naval Air Station (KNTD)*	40	4180	4220
Livermore Municipal Airport (KLVK)	50	4133	4183
Bermuda Dunes Airport (KUDD)	1	4113	4114
Santa Maria Public / Capt G Allan Hancock Field (KSMX)	410	3321	3731
Modesto City-County Airport (KMOD)*	8	3601	3609
Palmdale Airport / USAF Plant 42 (KPMD)	297	3193	3490
Marine Corps Air Facility Camp Pendleton (KNZY)	48	3124	3172
Paso Robles Municipal Airport (KPRB)	30	3129	3159
Mammoth Yosemite Airport (KMMH)	0	2797	2797
Sacramento Executive Airport (KSAC)	2	2673	2675
Lake Tahoe Airport (KTVL)	29	2577	2606

Mojave Air & Space Port (KMHV)*	104	2445	2549
Oxnard Airport (KOXR)	23	2517	2540
Salinas Municipal Airport (KSNS)	4	2475	2479
Chico Regional Airport (KCIC)	246	2137	2383
John Nichol's Field Airport (0CL3)	0	2359	2359
French Valley Airport (F70)	19	2250	2269
Los Alamitos Army Airfield (KSLI)	22	2242	2264
Imperial County Airport (KIPL)*	0	1999	1999
Eastern Sierra Regional Airport (KBIH)	646	1274	1920
Southern California Logistics Airport (KVCV)*	835	1015	1850
Travis Air Force Base (KSUU)	1107	114	1221

(1) Controlling Emissions from Aircraft Auxiliary Power Units for the Duration of Visit

Background

An auxiliary power unit (APU) is a small gas turbine engine that is powered by jet fuel and is typically installed in the back section of an aircraft. When aircraft are parked on the airport apron and the main engines are not running, the APU is used to provide electrical power and air conditioning services. It is also needed to start the main engines. In 2022, statewide APU emissions accounted for 2.7 tpd of NOx and 0.3 tpd of PM2.5, representing 6% and 15% of statewide aircraft LTO NOx and PM emissions, respectively.[15] APUs are powered by jet fuel and have similar emission indices as the main aircraft engines on the basis of NOx emissions per unit of fuel burned.[16] APU emissions also contribute to jet exhaust exposure for workers who support airside operations.

Reducing APU usage can lead to substantial fuel, emissions, and cost savings. The technology needed to avoid these excess APU emissions is already readily available and in use at many airports. As an alternative power source to APUs, many airport gates are equipped with ground power (GP), either in the form of fixed 400-Hz power cables that supply energy from the airport's electrical grid, or a mobile ground power unit (GPU). Pre-conditioned air (PCA) units can provide the aircraft's air conditioning services, which are powered by either building electricity or the GPU. PCA units can either be mounted on the jet bridge, installed on the ground on the aircraft stand, or can be mobile units. Fixed GP and PCA systems are generally powered by electricity from the grid. However, the majority of mobile (self-propelled or towed) GPUs and PCA units are powered by diesel generators. Based on statewide GSE population data, only 15% of mobile GPUs and 27% of PCA units currently use zero-emissions technology.

Based on site visits to, or conversations with, the ten largest commercial airports in California, CARB staff observed that over 95% of passenger gates at major airports are already equipped with GP and PCA.[17] However, previous studies have observed that ground power is broadly underused. A case study at SFO airport showed that 36% of operations did not use GP at all.[18] Of the flights that did use GP, it was only used for 63% of the turnaround time on average. In aggregate, this equates to an APU

[15] California Aircraft Emissions Inventory (2024). https://ww2.arb.ca.gov/sites/default/files/2024-10/CAI2024%20-%20Main%20Document_Final1021_ada.pdf

[16] Winther, M., Kousgaard, U., Ellermann, T., Massling, A., Nøjgaard, J. K., & Ketzel, M. (2015). Emissions of NOx, particle mass and particle numbers from aircraft main engines, APU's and handling equipment at Copenhagen Airport. *Atmospheric Environment*, *100*, 218-229.

[17] This number is based on airport visits or conversations with staff at 10 major commercial airports in California (LAX, SFO, SAN, LGB, SMF, SJC, SNA, ONT, BUR, FAT)

[18] Antonelli, P. A. (2023). *A Framework for Monitoring, Modeling, and Management of Airport Ground Power Systems During Aircraft Turnaround Operations* (Doctoral dissertation, UC Berkeley).

usage time of approximately 42 minutes when the turnaround times averaged 72 minutes. Overall, this indicates that GP is only used approximately 40% of the time.

Draft Concept

Upon Arrival

Under this draft concept, starting on January 1, 2032, operators of all Commercial Large Aircraft and Commercial Small Aircraft operating at the included airports would need to minimize emissions from APUs for the duration of the airport visit, starting within five minutes after arrival at the airport apron. Arrival time would be defined as the moment when the aircraft is parked in the apron area with the wheels chocked, aligning with existing rules at SEA[19] and SFO[20] airports.

Upon Departure

APU emissions would need to be minimized up to a designated period before scheduled departure, which would be determined by aircraft type:[21]

(a) 15 minutes for Code C or below aircraft
(b) 25 minutes for Code D or above aircraft
(c) 45 minutes for A380 aircraft.

These timeframes align with existing policies at Los Angeles (LAX), San Francisco (SFO), and Seattle-Tacoma (SEA) airports. To minimize APU emissions during these timeframes, operators may implement one or more of the following strategies:

- Shut off APUs
- Connect to fixed 400-Hz ground power or mobile ground power units
- Utilize preconditioned air (PCA) units
- Employ any alternative compliance options capable of achieving equivalent reductions, such as but not limited to emissions capture and control systems or prospective onboard zero-emissions APUs. Such strategies would have to demonstrate that they reduce NOx emission rates by at least 80% relative to the average APU emission rate.

Infrastructure Requirements

Airports subject to this rule would be responsible for installing and maintaining zero-emissions apron infrastructure needed to reduce emissions from aircraft APUs. Such apron infrastructure would

[19] Seattle-Tacoma International Airport (2015). Schedule of Rules and Regulations No. 5. *https://www.portseattle.org/page/airport-tariffs-rules-and-regulations-sea-tac*
[20] San Francisco International Airport (2022). Rules and Regulations. Issued by The Airport Commission City and County of San Francisco. *https://www.flysfo.com/about/airport-operations/policies-regulations/rules-and-regulations*
[21] Aircraft types are defined based on the aircraft wingspan in ICAO Annex 14 – Aerodome – Vol. I

be needed to support all in-scope aircraft defined on page 3 of this document. The necessary zero-emissions infrastructure would need to be ready for use by December 31, 2031.

Airport operators would need to submit a plan describing the infrastructure additions or modifications that would be necessary to comply with this rule. The plan would include evidence that the necessary infrastructure modifications are being developed, have been completed, and/or report any modifications that are still required. Airport plans would need to be submitted to CARB by July 1, 2030, and would include:

(1) A list of every aircraft stand that services passenger or freight operations of Commercial Large Aircraft, Commercial Small Aircraft, and/or non-commercial jet engine aircraft
(2) Identification and description of which strategy each aircraft stand will use for compliance
(3) Identify any equipment purchases and/or construction that are in progress or must be completed to reduce emissions
(4) Provide a schedule for installing equipment and/or any necessary construction projects
(5) Specify any restrictions for any specific aircraft stands

Reporting Requirements

In-scope California airports would need to report APU runtimes for every turnaround operation on a quarterly basis starting on January 1, 2030. This would include the following information for every commercial operation at each airport:

- Airport visited
- Aircraft stand identifier (or terminal and gate number)
- Flight number
- Aircraft type code (A, B, C, D, or E)
- Aircraft model
- APU model
- Emission control strategy deployed
- Arrival date and time of the aircraft
- Departure date and time of the aircraft
- Dates and times when emission control strategy started and finished controlling emissions
- GPU equipment model and fuel type if used
- PCA equipment model and fuel type if used

Exemptions

Aircraft operators could be granted exemptions from APU minimization requirements on a case-by-case basis and under limited situations such as:

- When it is necessary to use the APU to diagnose and/or rectify aircraft faults (technical or maintenance reasons) that cannot be finished within the required timeframe above
- Under safety or emergency events

- Participation in research that tests alternative technology
- Restrictions due to any applicable federal or state law
- Unforeseen issues with airport infrastructure

All cases requiring an exception would need to be reported to CARB within seven days of the incident.

If APU emissions are not reduced due to defective airport infrastructure, it would be the responsibility of the airport operator to remedy the issue within 45 days of the incident.

Questions to Stakeholders

(1) Are the designated APU runtimes achievable?
(2) Are there any other exceptions that should be considered?
(3) For each airport, what percentage of aircraft stands are currently equipped with (a) fixed ground power, (b) mobile GPUs, and (c) no ground power at all?
(4) What percentage of aircraft stands are currently equipped with (a) fixed PCA units (b) mobile PCA units, and (c) no PCA at all?
(5) For GPUs and PCA units, what are the usage rates of electric, diesel, and gasoline-powered equipment?
(6) What percentage of airport stands have zero-emissions GP and PCA installed that is defective or non-operational?
(7) What are expected timeframes for installing new zero-emissions infrastructure that would be needed to minimize APU emissions (e.g., fixed ground power and pre-conditioned air)? Is it feasible to have the airport infrastructure ready for use before December 31, 2031?
(8) What are the expected costs associated with installing new zero-emissions apron infrastructure, specifically fixed ground power and electric pre-conditioned air units?
(9) What is the lifetime of zero-emission apron infrastructure (fixed ground power and electric pre-conditioned air units) and the timeframes for necessary upgrades or replacements to maintain operations?

(2) Reducing Emissions from Airport Ground Support Equipment

Background

For this draft concept document, CARB staff defines ground support equipment (GSE) as all motorized equipment that support aircraft operations and are used on airside surfaces at airports. This includes equipment that may leave airside surfaces to perform part of their duties, but are predominantly used at the airport (e.g. catering trucks)[22]. GSE is essential for aircraft functions and is used to service the aircraft and fulfill other duties, such as loading and unloading baggage and cargo. Historically, GSE has been powered by gasoline, diesel, propane, and battery-electric technologies. Table 4 shows the equipment categories for airport GSE, a brief definition, and their current zero-emission penetration in California.

Table 4. Airport GSE Definition and Current Zero-Emission Penetration in California

Equipment Category	Photo Description	Written Description	Zero-Emission Penetration
Small Motorized Carts (i.e. golf carts)		Transportation between gates, airport and other airside locations	80%
Belt Loaders		Loading baggage into aircraft	58%
Baggage Tractors		Transport baggage between aircraft and airports	46%
Lavatory Carts		Service aircraft lavatories	36%

[22] Motorized equipment that is either already regulated by other CARB rules or equipment that is temporarily at the airport, such as construction equipment or lawn and garden equipment may also receive an exemption. See exemption section below for further details.

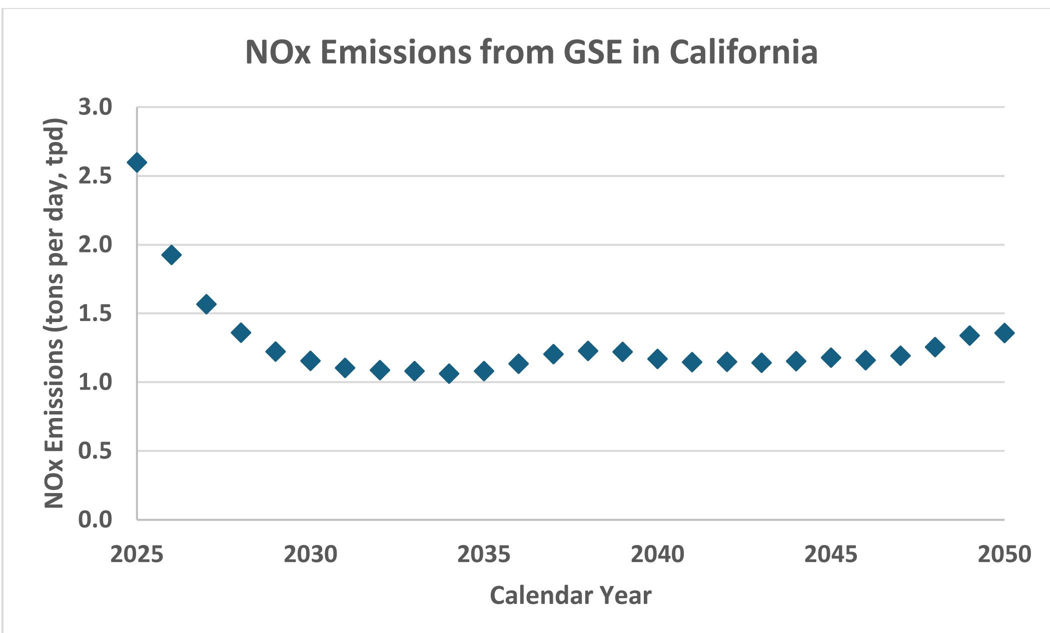
Narrow-Body and Regional Jet/Air Taxi Aircraft Tractors		Push back narrow-body aircraft, regional jets and air taxis	35%
Lifts		Aircraft maintenance or loading cargo into aircraft	30%
Cargo Tractors		Transport cargo between aircraft and airports	28%
Portable Air Conditioners		Supply conditioned air to aircraft	27%
Wide-Body Aircraft Tractors		Push back wide-body aircraft	18%
Ground Power Units		Supply power to aircraft when parked at gates, or undergoing maintenance	15%
Forklifts		Handle baggage, cargo, aircraft maintenance and other general use	12%
Passenger Stands		Boarding or de-boarding passengers from aircraft	11%

Fuel Trucks		Transport and dispense fuel to aircraft	10%
Cargo Loaders		Loading and unloading cargo into aircraft	10%
Water Trucks		Supply aircraft with potable drinking water and replenish water tanks	9%
Service Trucks		Repair services on airside of terminals	3%
Lavatory Trucks		Service aircraft lavatories	2%
Bobtails		Luggage and cargo transportation at long distances and up to 25 MPH	0%
Catering Trucks		Supply food and beverages to aircraft	0%
Generators		Supply power during power outages or in areas where ground power is unavailable	0%
Hydrant Trucks		Refueling aircraft at gates	0%

De-Icers		Remove ice that is built up on aircraft	0%

CARB staff are in the process of updating and creating a new dedicated emissions inventory model for GSE, which has not yet been finalized. Based on data collected thus far for calendar year 2022, GSE accounted for 2.7 tons per day (tpd) of NOx statewide. Figure 1 shows the projected NOx emissions for GSE statewide and includes the impact of CARB's In-Use Off-Road Diesel Regulation (ORD) rule for GSE. While there will be some emissions reductions between 2025 and 2030 due to continued implementation of the ORD rule, following the full implementation of the rule and MOUs, NOx emissions from GSE will be relatively flat to 2050 with a potential for increasing emissions in 2030 and beyond. This is due to increasing demand for air travel, which will necessitate larger GSE fleets.

Figure 1. Projected NOx Emissions from GSE in California



Many categories of GSE have zero-emission options available. For example, battery electric belt loaders have been used in the aviation industry for several decades. Electric GSE has shown many benefits including increased reliability, better safety features with increased sensor usage, and more cost effectiveness over time with lower operating and maintenance costs[23]. Some larger pieces of GSE such as fuel trucks or de-icers have not historically had electric or other zero-emission options.

[23] https://www.iata.org/en/programs/ops-infra/ground-operations/ground-support-equipment/electric-gse/

Historically, there has been a lack of zero-emission GSE for larger equipment, but there are many manufacturers that are now starting to offer larger zero-emission GSE.

To reduce emissions from GSE, South Coast Air Quality Management District (AQMD), Los Angeles International Airport, and Port of New York and New Jersey have developed ground support equipment emissions reductions policies that are outlined here:

- South Coast AQMD and 5 major airports in the South Coast Air Basin signed Memorandums of Understanding (MOU) in December 2019 to reduce NOx emissions from GSE.
- By 2033*, tenants at Los Angeles International Airport (LAX) will be required to achieve 100% zero-emission GSE fleets with intermediate targets outlined here:
  - By 2028, all new GSE added to LAX shall be zero-emission.*
  - By 2030, all carts baggage tractors/tugs, belt loaders, and aircraft tractors/tugs shall be zero-emission.*
  - By 2033, all GSE at LAX shall be zero-emission.*

  *Unless exempt or zero-emission replacements are not operationally feasible or commercially available

- By 2030*, tenants at The Port Authority of New York and New Jersey will be required to achieve 100% zero-emission GSE fleets with intermediate targets outlined here:
  - By August 1, 2027, the Port Authority will not renew the registration of existing internal combustion engine baggage tractors, belt loaders, and aircraft tractors.*
  - By August 1, 2028, the Port Authority will not renew internal combustion engine GSE that is 30 years old or more unless it meets:
    - U.S. EPA Tier 3 emissions standards for nonroad diesel equipment,
    - U.S. EPA Tier 3 emissions standards for nonroad large spark-ignition gasoline equipment,
    - The most stringent applicable U.S. EPA emissions standards in effect at the time of registration expiration for other categories of airside vehicles.

  *Unless exempt or zero-emission replacements are not operationally feasible or sufficient charging/refueling equipment for zero-emission models does not exist.

Draft Regulatory Concept

The draft concept for GSE would transition current fleets to 100% zero-emission by 2037.[24] Additional phase-out requirements would also be included for older engine tier diesel, gasoline, and propane equipment. The In-Use Off-Road Diesel-Fueled Fleets Regulation (ORD), the Large Spark Ignition Regulation (LSI), and the Zero-Emission Forklift Rule (ZEF) would be amended to exempt

[24] Motorized equipment that is not GSE (as defined in the 22 categories in this document) but performs regular maintenance and/or construction activities at airports (e.g. manlifts, lawn and garden, snow removal, construction) would not be subject to this regulation.

airport GSE from those regulations since airport GSE would be subject to equally or more stringent requirements through SCAI.

Outlined below are proposed zero-emission milestones for each equipment type, which considers commercial availability and operational feasibility. Equipment types have been separated into three different phases to reach 100% zero-emission to allow time for installation of supporting infrastructure, such as higher voltage charging stations at airports. Zero-emission phases also consider current electric penetration for zero-emission equipment and the incremental cost of zero-emission equipment compared to internal combustion engine technologies. Tables 5, 6, and 7 show the zero-emissions target years for each phase of GSE equipment considered in this draft regulatory concept. These targets would need to be met by each GSE owner and operator at each airport. This means that zero-emission targets will not be averaged across an airport and each GSE owner/operator would need to meet the targets for their respective fleets. Owners and operators would not be able to use multi-airport or statewide fleet averages to meet targets and would be responsible for meeting the milestones for every airport where they have equipment. The target number of equipment needed to meet the ZE target for each operator would be rounded up by equipment type (e.g. if an operator has 110 baggage tractors, 83 or greater of those tractors must be zero-emission to meet the 75% requirement by the 2032 target date). Please note that target years refer to the end of the calendar year, so owners and operators would have until December 31 of the target dates to achieve the associated zero-emission targets.

Table 5: Phase #1

Equipment Type	75% ZE Target Date	100% ZE Target Date
Small Motorized Carts	2032	2035
Belt Loaders	2032	2035
Baggage Tractors	2032	2035
Lavatory Carts	2032	2035
Narrow-Body Aircraft Tractors	2032	2035
Lifts	2032	2035
Cargo Tractors	2032	2035
Air Conditioners	2032	2035

Table 6: Phase #2

Equipment Type	50% ZE Target Date	100% ZE Target Date
Wide-Body Aircraft Tractors	2032	2037
Ground Power Units	2032	2037
Passenger Stands	2032	2037
Fuel Trucks	2032	2037

Cargo Loaders	2032	2037

Table 7: Phase #3

Equipment Type	50% ZE Target Date	100% ZE Target Date
Water Trucks	2034	2037
Service Trucks	2034	2037
Lavatory Trucks	2034	2037
Bobtails	2034	2037
Catering Trucks	2034	2037
Generators	2034	2037
Hydrant Trucks	2034	2037

In addition to zero-emission requirements, the concept would advance the transition of diesel, gasoline, and propane equipment to engines meeting the most stringent standards. The In-Use Off-Road Diesel-Fueled Fleets Regulation (ORD) has set tier requirements for self-propelled off-road diesel vehicles 25 horsepower or greater for fleets to reach Tier 2 equipment by 2028 for large fleets. This draft concept now includes phaseout dates for Tier 3 and Tier 4 Interim airport ground support equipment, outlined in Table 8. Please note that phaseout dates refer to the end of the calendar year, so owners and operators have until December 31 of the target years to achieve the associated zero-emission targets.

Table 8. Diesel-Engine GSE

Engine Tier	Phaseout Date
3	2030
4 Interim	2032

For LSI GSE, under the concept, by 2030, fleet owners and operators would need to phase out their current non-forklift LSI gasoline and propane GSE that is engine MY 2009 or older.

Table 9. Non-Forklift LSI Gasoline and Propane GSE

Engine MY	Phaseout Date
2009 or older	2030

The transition of LSI forklifts at airports would follow a similar phaseout schedule to CARB's Zero-Emission Forklift (ZEF) rule.[25] Phase-out requirements for Class IV and Class V LSI forklifts are

[25] *Zero-Emission Forklifts | California Air Resources Board*

included and directly match requirements in CARB's ZEF rule with MY phaseouts outlined in Tables 10 and 11.

Table 10. Class IV forklifts:

Compliance Dates	MY phase-out schedule for Class IV Forklifts with a Rated Capacity of 12,000 Pounds or less	MY phase-out schedule for Class IV Forklifts with a Rated Capacity Greater than 12,000 Pounds
12/31/2027	MY 2018 and older	-
12/31/2030	MY 2019-2021	-
12/31/2032	MY 2022 and 2023	-
12/31/2034	MY 2024 and 2025	-

Table 11. Class V forklifts:

Compliance Dates	MY phase-out schedule for Class V Forklifts with a Rated Capacity of 12,000 Pounds or less	MY phase-out schedule for Class V Forklifts with a Rated Capacity Greater than 12,000 Pounds
12/31/2029	MY 2017 and older	-
12/31/2032	MY 2018-2020	-
12/31/2034	MY 2021 and 2022	-
12/31/2037	MY 2023 - 2028	-

GSE that is converted from an internal combustion engine to a fully zero-emission powertrain, such as a battery electric or hydrogen fuel cell system, would also meet draft targets. Equipment moved out of the state would count toward meeting fleet targets, while internal combustion engine equipment that enters the state would count against meeting zero-emission targets and would be required to be reported. Equipment moving into the state would need to meet diesel, gasoline, and propane standards as outlined above.

Reporting Requirements

Under this concept, ground support equipment owners and operators would need to report their progress toward achieving zero-emission and combustion-engine phase-out requirements. GSE operators would report to airports by January 1, 2030, and annually thereafter. Airports would be required to organize and report the GSE operator information to CARB by March 1 of each reporting year (starting March 1, 2030). Any movement of equipment between airports, into/out of the state, or newly acquired used equipment would need to be included in annual reporting and either added or removed from the airport's report. These reporting requirements would be for individual pieces of equipment, and reporting for equipment would include, but not be limited to:

- vehicle category
- vehicle model year
- engine model year
- engine horsepower
- fuel type
- vehicle purchase date
- engine purchase date
- low use type
- EPA/CARB engine family number
- engine serial number
- vehicle serial number
- location (designated by airport code)
- activity hours
- fuel consumption

Infrastructure Requirements

Airports subject to this rule would be responsible for installing the necessary electrical infrastructure to be able to accommodate 100% zero-emission ground support equipment at their airports. This includes, but is not limited to, coordination with utilities to provide the necessary power and installing electrical lines to enable GSE owners and operators to meet zero-emission requirements. Airports would also be responsible for maintaining and upgrading any charging infrastructure that they own already at the airport, including charging and common-use areas. The necessary zero-emission infrastructure must be ready for use one year ahead of zero-emission equipment targets outlined in the phases above. Therefore, airports would be responsible for installing charging infrastructure to meet the 75% zero-emission target by December 31, 2031, to give GSE owners and operators time to continue to add zero-emission equipment to their fleets by the 2032 requirement for phase #1. Table 12 outlines specific charging infrastructure requirements for airports. Requirements are based on the equipment schedules outlined in Tables 5, 6 and 7. For example, row 1 of Table 12 indicates that charging infrastructure must be able to support 75% zero-emission GSE and 100% zero-emission GSE for all the pieces of equipment that fall into phase #1 as outlined in Table 5. Therefore, airports would be responsible for installing charging infrastructure to meet the 100% zero-emission target for all equipment by December 31, 2036.

Table 12. GSE Charging Infrastructure Requirements:

ZE Equipment Phase	50% ZE Infrastructure	75% ZE Infrastructure	100% ZE Infrastructure
1	n/a	12/31/2031	12/31/2034
2	12/31/2031	n/a	12/31/2036

3	12/31/2033	n/a	12/31/2036

Exemptions

CARB staff is considering the following exemptions for this draft concept:

- Permanent low-use exemptions from CARB's ORD and LSI regulation would be upheld as part of this draft regulatory concept (under 200 hours/year). However, there would be a more stringent 100 hours/year limit for equipment at airports with a high fraction of DAC communities, as identified in Table 3.
- Any equipment/vehicle that is subject to other CARB regulations (e.g. on-road vehicles such as work trucks or engine certification standards previously set by CARB) would not be included as GSE.
- Equipment that supports military operations, which includes military tactical support GSE, would be considered exempt.
    - Military equipment that does not directly support combat (e.g. equipment used for training exercises) would still be subject to this concept
    - Any military contractors that own or operate GSE would still be subject to this concept.

CARB staff will continue to engage with the public, airports, and GSE owners and operators in evaluating the commercial availability and operational feasibility of zero-emission GSE and will evaluate the need for exceptions in the future. CARB staff intends to establish a process for applying and granting approval for compliance extensions to the dates listed in this section, such as for technical feasibility, manufacturing delays, and infrastructure availability. Details of the process and timelines will be shared in a future workshop in advance of any formal regulatory proposal.

Questions to Stakeholders

(1) What is the status of GSE charging at your airport? Are there any charging usage restrictions, and are you able to track charger utilization? What are your near-term (next 3-5 years) plans for installing additional electrical and charging infrastructure?

(2) For airports, could you provide a list of GSE chargers that are installed at your airport, including the power capacity and charger ownership (e.g. airport vs. tenant)?

(3) Could your airport facilitate 100% zero-emission GSE with current charging infrastructure?

(4) What GSE type will be hardest to electrify for operational feasibility (as opposed to commercial availability)?

(5) What is an acceptable number of GSE chargers needed at each gate to maintain 100% zero-emission GSE? (e.g. 6 chargers are needed, four Level 1 chargers and two Level 3 chargers to maintain full operability of equipment)

(6) For airports, who owns operates and maintains GSE charging infrastructure at each gate? Please provide edge cases as well such as charging infrastructure at common-use gates and or airside hangers/maintenance facilities.

(7) Are there any other exemptions that should be considered?

(3) Reducing Emissions from Aircraft Taxiing at the Airport

I. Single-Engine Taxiing of All Aircraft Beginning 2030

Background:

Aircraft turn on their main engines after pushback from the gate and warm up engines as they taxi toward the runway. This taxi-out procedure takes about 12.4 minutes on average at California airports. The specific warm-up time needed before take-off varies across aircraft and airlines but is generally on the order of a few minutes. When the taxi time is longer than the required warm-up time, part of the taxi can be performed using a single jet engine, thereby reducing emissions and saving fuel. Single engine taxiing can be performed with no additional technology and can therefore be implemented quickly. While some airports in California, such as San Diego International (SAN), John Wayne (SNA), and San José Mineta International (SJC), recommend single-engine taxiing, it is generally either not required or not enforced and ultimately left to the discretion of the aircraft pilot.

Draft Concept:

For taxi-out process: Require that airports achieve single-engine taxiing utilization rate of 80% for all aircraft with a taxi-out time more than 5 minutes. Airports would have discretion on the mechanism by which to achieve the required utilization rate. The measurement of the taxi-out time would begin when the aircraft pushes back from the gate and would end when the taxiing aircraft moves from the final holding point onto the runway. Whether or not a flight surpasses the 5-minute threshold would be determined by the average historical taxi-out time of that flight that used the same route from departing gate to departing runway. The remaining 20% of the aircraft taxi-outs would be permitted to taxi with more than one engine to accommodate unforeseeable situations that make single-engine taxiing challenging.

For taxi-in process: Require single-engine taxiing for all in-bound aircraft. Single engine practice would start when the aircraft has vacated the landing runway (i.e., main gear fully clear of the runway hold line) and maintained until the aircraft comes to a full stop and is chocked with the parking brake set at the assigned gate or parking stand.

Starting January 1, 2030, these requirements would apply to all aircraft and airports within the scope of this work, as defined previously. Starting January 1, 2031 these airports would be required to submit an annual report to CARB including:

- The airport-wide average taxi-time
- Flight level data of all taxis including whether taxi was a taxi-in or taxi-out, taxi time and information of flight number, aircraft tail number, aircraft type (Commercial Large Aircraft, Commercial Small Aircraft, or Non-commercial Jet Engine Aircraft), and whether single-engine taxiing was used for the taxi

Note that any airport with an airport-wide taxi-time less than 5.0 minutes may still have a subset of flights with taxi-times above 5.0 minutes, which would be required to comply with this requirement. Likewise, airports with an average taxi-time over 5.0 minutes may have a fraction of flights taxiing under 5.0 minutes, which would not be required to comply with this requirement.

Any departing aircraft taxied out by a zero-emission (ZE) technology, as specified in requirement II discussed in the next section, would not need to comply with requirement I for their departures, but would still need to comply with requirement I for arrivals.

II. Implementation of Zero-Emission Taxiing Technologies

Background:

ZE taxiing technologies can be either onboard the aircraft or external to the aircraft. External technologies tug the aircraft from the gate to the runway, while onboard technologies are housed inside the aircraft and use power from the aircraft's APU to power the landing gear wheels. External technologies offer the advantages of higher technological readiness, applicable to existing fleets without major modifications, and that a single unit can work with multiple aircraft. Onboard technologies are beneficial in that they do not require connecting and disconnecting from the aircraft, but currently no onboard technologies are approved for use at any airport. External tug technology has been used for multiple years at airports in New Delhi and Bengaluru. More recently Schiphol Airport in Amsterdam deployed the external taxiing technologies as part of an overall initiative to substantially reduce emissions near the airport gates where workers are most exposed. Most of the external technologies deployed at these airports are diesel hybrid technology. However, as of 2025, one external taxiing technology manufacturer has a zero-emission, all-electric external taxiing product ready to order, and has one unit already deployed in Amsterdam. A couple examples of onboard and external technologies are listed in the table below.

Table 13. Examples of onboard and external ZE Taxiing technologies.

Onboard ZE taxiing technologies	External ZE taxiing technologies
Wheel-tug	TLD Taxibot
e-Taxi by Safran	EcoTug
Electric Green Taxiing System (EGTS)	

Draft Concept:

Require external or onboard zero-emission taxiing technologies for narrow-body aircraft to be phased in over an 8-year window from 2030 to 2037.

Definitions:

- An *external ZE taxiing technology* is defined as a zero-emission tug that can move a loaded aircraft at speeds of at least 23 knots. It is not required to be a pilot-controlled tug while taxiing, provided that the airport, operating airlines, and FAA approve of such technology.
- *Compatible Aircraft* are narrow-body aircraft expected to be compatible with external ZE taxiing technologies in calendar year 2030.[26]
- *Qualified Airports* are owned by a city or county entity that meet one of the two following conditions:
    - (1) the airport is not within a DAC region and has commercial airlines collectively operating 8 or more flights per day that have taxi times over 8 minutes using Compatible Aircraft.
    - (2) the airport is within a DAC region and has commercial airlines collectively operating 6 or more flights per day that have taxi times over 6 minutes using Compatible Aircraft. See Tables 1 and 2 for airports that could be considered within a DAC region.
- The *Capable Target* is the number of flights (including both passenger and freight) using Compatible Aircraft that are capable of being taxied by external ZE taxiing technology within the environment of a specific airport's configuration and design. The Capable Target would be less than or equal to the total number of departing flights using Compatible Aircraft. CARB has funded a Zero-Emission Taxiing Feasibility Study with Roland Berger LP, which is expected to be completed by the end of 2026.[27] After completion, CARB staff would use results of this study and the unique configuration and design elements of each airport to develop Capable Targets for each Qualified Airport.
- Airports expected to be classified as Qualified Airports in calendar year 2030, per the definition above using criteria (1), are listed in Table 14.[28] Additional airports from Table 1 and 2 may also be classified as Qualified Airports if they meet criteria (2) above in calendar year 2030.

[26] The aircraft types compatible with ZE taxiing technologies will likely (1) be modified before CARB formally proposes a rule and (2) may be amended after rule adoption.
[27] https://ww2.arb.ca.gov/our-work/programs/zero-emission-aircraft-ground-operations/aviation-related-contracts
[28] The final list of Qualified Airports will likely (1) be modified before CARB formally proposes a rule and (2) be amended after rule adoption.

Table 14. Anticipated Qualified Airports for Zero-Emission Taxiing

San Francisco International Airport (SFO)
San Diego International Airport (SAN)
John Wayne Airport (SNA)
San José Mineta International Airport (SJC)
Palm Springs International Airport (PSP)
Sacramento International Airport (SMF)
Los Angeles International Airport (LAX)
Hollywood Burbank Airport (BUR)
Oakland San Francisco Bay Airport (OAK)
Ontario International Airport (ONT)
Long Beach Municipal Airport (LGB)
Fresno Yosemite International Airport (FAT)

Potential Compliance Timeline (for all Qualified Airports):

Table 15. Compliance timeline for Zero-Emission technologies implementation

Compliance Date	Requirement
Dec 31, 2031	1 external ZE taxiing technology on-site and available for use.
Jun 1, 2032	The external ZE taxiing technology is implemented into airport operations and is performing at least 1 movement of an aircraft loaded with passengers or freight per week.
Jun 1, 2033	10% of airport's Capable Target aircraft departures are taxied using ZE taxiing technology.
Jun 1, 2035	50% of airport's Capable Target aircraft departures are taxied using ZE taxiing technology.
Jun 1, 2037	100% of airport's Capable Target aircraft departures are taxied using ZE taxiing technology.

- Starting December 31, 2030, and repeating each December 31 of the following years until December 31, 2036, Qualified Airports must submit a report on progress and future plans that would include the following:
  - Current total number and percentage of Capable Target aircraft that are being taxied out using ZE technology
  - Planned changes to operations that would be implemented to meet the next milestone in the timeline (*e.g.*, 1 movement, 10% of Capable Target aircraft, etc.)
  - Planned changes to infrastructure that would be implemented to meet the next milestone in the timeline (*e.g.*,1 movement, 10% of Capable Target aircraft, etc.)

While the Capable Target definition is based external taxing technologies, the Capable Target requirements in Table 15, from June 1, 2033, and beyond can be met with either external or onboard technologies as they become commercially available. CARB will track the development of onboard technologies and may include additional stringencies in the future, either before or after a potential rule is proposed to the Board in 2027.

Extensions

CARB staff intends to provide a process for airports to request extensions from requirements above, which would be subject to CARB Executive Officer review and approval on a case-by-case basis. The length of any extensions (*e.g.*, 6 months), deadline for submitting extensions (*e.g.*, 18 months prior to the compliance deadline), and qualifying criteria will be shared in a forthcoming workshop in advance of any formal rulemaking proposal.

Questions to Stakeholders

(1) What fraction of flights in and out of your airports in California use single-engine taxiing?
(2) What mechanisms have airports used in the past to promote or incentivize airlines to use new procedures or technologies?
(3) What fraction of commercial aircraft (passenger and freight) departing from your airport have taxi-times over 5.0 minutes?
(4) What are possible barriers that could hinder the single-engine taxi requirements specified above in section 3.I?
(5) What are possible hurdles that could delay the phase-in timeline of technologies in Table 15?
(6) What are the costs associated with modifying the operations or layout of your airport to accommodate the phase-in of zero-emission taxiing (both external and onboard technologies)?
(7) What stakeholders, such ground support workers and unions, should be engaged to have further dialog about feedback on deploying zero-emission taxiing technologies?
(8) If onboard technologies are certified soon, would your airport prioritize onboard or external technologies to meet the Capable Target requirements in Table 15?
(9) Are there procedures or technologies not discussed in these concepts that could be used to reduce taxiing emissions?

(4) Reducing Emissions from Aircraft Takeoffs and Landings

These concepts encompass any operational strategy that would reduce emissions – particularly NOx emissions – from aircraft takeoffs and landings. Takeoffs and landings account for approximately 80% of the aircraft emissions at airports, making them the largest category contributor to NOx emissions. Emissions reductions from these concepts may be achieved through using engines that are certified with cleaner emissions levels, but do not set new emissions standards for aircraft or aircraft engines. Below are draft concepts under consideration.

Differentiated Landing Fees

Background

Given the growing demand for flight and aviation travel, it is crucial to begin investing in lower-emission aircraft now to mitigate future increases in aviation emissions. Advanced clean aviation technologies, such as low NOx combustors developed through the FAA's CLEEN program, have demonstrated the potential to reduce NOx emissions as low as 70% below the current International Civil Aviation Organization (ICAO) NOx standard.[29] Such lower NOx engines can also reduce PM emissions by orders of magnitude compared to previous aircraft engines.[30] Their use of cleaner burning combustion (lean-burn or advanced rich-quench-lean) could also lead to reduced emissions of air toxics and ROG. Some technologies that were developed through the CLEEN program are already in commercial use (*e.g.*, the TAPS/LEAP engine), while others could be integrated into the next generation of aircraft. However, it is uncertain whether newly manufactured aircraft engines will adopt these technologies. Fleet turnover to cleaner engines could take decades. Programs that incentivize adoption of clean technology for new purchases are needed to accelerate a transition to cleaner aircraft.

Certain aircraft are already equipped with emissions control technology that achieves lower NOx emission rates than the fleet average. For example, the Airbus A319-NEO is powered by a LEAP-1A engine that emits 50% less NOx than the average narrowbody engine.

Targeted fee structures, such as airport landing fees, could be used to prioritize the use of cleaner aircraft. Airports charge landing fees to their airline tenants on a per-flight basis, often calculated based on the weight of the aircraft. For example, landing fees at Los Angeles International Airport (LAX) in calendar year 2024 were $6.40 for passenger aircraft per 1,000 pounds (lbs). For narrowbody aircraft commonly used in California, the charge per landing would equate to:

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[29] Rolls-Royce CLEEN II Low NOx Combustor Final Report – Public Version. (April 2022). *https://www.faa.gov/sites/faa.gov/files/2022-09/Rolls-Royce%20Low%20NOx%20Combustor%20Final%20Public%20Report.pdf*

[30] ICAO, 2019: Independent Expert Integrated Technology Goals Assessment and Review for Engines and Aircraft, Document 10127.

Table 16. Example landing fees at LAX for narrowbody aircraft in 2024

Aircraft	Maximum Gross Landing Weight (lbs)	Landing Fee (USD)
Airbus A320	142,198	$910.07
Airbus A320 NEO	148,591	$950.98
Boeing 737-800	143,984	$921.50
Boeing 737 MAX 8	152,800	$977.92

In the 1990s, Zurich Airport in Switzerland introduced a differentiated landing fee program to control NOx emissions and reduce ozone.[31] Under this program, airport engines were categorized into five rankings based on their NOx and hydrocarbon emissions certification levels. Aircraft with the cleanest engines (i.e., "Class 5" in the ranking system), received a 5% discount in landing fees, while those with the highest emissions (i.e., "Class 1") faced a 35% surcharge. The program was fee-neutral, in that any increased funds incurred by charging higher-emitting engines were balanced out by the discounts on cleaner engines. This approach successfully reduced the use of high-emitting engines and encouraged adoption of cleaner technologies at Zurich airport. After the initial introduction of the policy in 1993, operations using the cleanest technology (Class 4 and 5) increased from 55% to 85% of all movements by 2009. Use of the highest emitting engines (Class 1 and 2) decreased from 8% to 1% over the same time period.

In 2010, Zurich Airport transitioned to a new emissions-based charging model. Instead of a five-category ranking system, each individual engine model is assigned an emissions value, which is calculated as a function of NOx and hydrocarbon emissions certification levels. An emissions tariff is applied to the emissions value to determine the landing charge.[32] Table 17 shows current landing charges at Zurich Airport[33]:

[31] Aircraft Emission Charges, Zurich Airport (2010). *https://www.flughafen-zuerich.ch/-/jssmedia/airport/portal/dokumente/das-unternehmen/politics-and-responsibility/environmental-protection/broschueren-und-positionspapiere/2010_emission_charges.pdf?vs=1&ref=quittingcarbonmedia.com*
[32] Airport Charges Regulation for Zurich Airport (2025). *https://www.flughafen-zuerich.ch/en/business/airlines-and-handling/flight-operations/charge-regulation*
[33] Zurich Airport (2025). Landing and departing – calculate the charges. *https://charges-calculator-app-service-prod.azurewebsites.net/?advancedMode=false*

Table 17. Landing fees at Zurich Airport for a sample of narrow- and wide-body aircraft

Aircraft	MTOW* (tons)	Emission Value	Noise Class	Landing charge (CHF†)	Noise charge (CHF)	Emission charge (CHF)
Airbus A319 NEO (A19N)	78.2	7	5	567.40	0.00	17.50
Airbus A320 NEO (A20N)	77	7	5	567.40	0.00	17.50
Airbus A320 (A320)	77	9	4	567.40	10.00	22.50
Boeing 717-200 (B712)	50.8	10.6	4	567.40	10.00	26.50
Boeing 737-9 (B39M)	88.3	15.6	5	567.40	0.00	39.00
Airbus A321 (A321)	89	17.2	3	567.40	40.00	43.00
Boeing 737-200 (B722)	89.4	18	1	567.40	2,000.00	45.00
Boeing 787-8 Dreamliner (B788)	227.9	25.2	4	1,817.80	10.00	63.00
Airbus A340-300 (A343)	275	34.8	2	1,817.80	400.00	87.00
Airbus A350-900 (A359)	275	40.4	4	1,817.80	10.00	101.00
Boeing 777-200 (B772)	294.2	62.2	1	1,817.80	2,000.00	155.50
Boeing 777-300ER (B77W)	351.5	65.8	2	1,817.80	400.00	164.50

*MTOW = Maximum Take-Off Weight
†CHF = Currency code for the Swiss Franc, the official money of Switzerland. As of December 2025, 1 CHF = 1.25 USD

Any revenue from the program is used for air quality improvement projects on the airport grounds. Over 40 airports in Europe have implemented similar emissions-based charging, mostly for NOx but in some cases for CO2. The European Civil Aviation Conference (ECAC) released a recommended methodology for classifying aircraft according to their NOx emissions to homogenize emission-based landing charges.[34]

Draft Concept

Under this draft concept, California airports would need to set or modify landing fees based on each aircraft's NOx emissions per landing and take-off (LTO) cycle for any newly acquired aircraft beginning January 1, 2030. Newly acquired aircraft refers to any aircraft that an operator begins to own or lease and that is approved for commercial operations in the United States on or after this date. Existing aircraft, or those acquired up through the end of 2029, would not be subject to modified emissions-based landing fees.

The landing fee for each aircraft would be set in proportion to its NOx emissions using engine certification values from the ICAO Aircraft Engine Emissions Databank.[35] A similar approach as implemented in European airports could be followed, as described in the ECAC Recommendation 27-4.[34] CARB staff would develop California-specific landing fee amounts for airports to consider after further discussions with stakeholders. Additional fee increases may apply when aircraft visit airports in ozone non-attainment areas and/or disadvantaged communities. CARB staff is evaluating several options for structuring the fees, including emission factor-based fees (e.g., NOx certification level relative to ICAO CAEP standards), per passenger NOx emissions, and/or aircraft category (e.g., narrowbody, widebody, or regional jet).

The fee structure would be designed to be revenue-neutral, in that increased fees on higher-emitting aircraft would be offset by discounted landing fees on lower-emitting aircraft. To maintain revenue neutrality, landing fees would need be adjusted periodically based on progress toward NOx emission reduction goals. For instance, as cleaner-technology engines become a higher percentage of the fleet mix, charges on high-emitting engines may increase. If any surplus funds are generated, airports would be required to use them for air quality improvement projects on airport grounds.

Table 18 below illustrates potential targets that this program would aim to achieve. CARB staff would develop minimum fees that airports would need to adopt that are expected to reach the targets listed in the table below. More detailed definitions of baseline and targets for each year will be posted and informed by stakeholder input prior to any proposal to the Board in 2027.

[34] European Civil Aviation Conference. (2011) NOx Emission Classification Scheme. Recommendation ECAC/27-4. *https://www.ecac-ceac.org/images/documents/ECAC-Recommandation_27-4_Second_Edition_2012.pdf*
[35] ICAO Aircraft Engine Emissions Databank. (2025) *https://www.easa.europa.eu/en/domains/environment/icao-aircraft-engine-emissions-databank*

Table 18. Draft target, timeline and structure for a potential differentiated landing fee program

Year	Target	Landing Fee Adjustment
2030	*Baseline activity-weighted fleet-average LTO NOx emissions*	*Baseline landing fees*
2035	10% lower than baseline	X_1% decreased fee for lowest-emitting engines 0% change for the median emitting engine Y_1% increased fee for highest emitting engines
2040	20% lower than baseline	X_2% decreased fee for lowest-emitting engines 0% change for the median emitting engine Y_2% increased fee for highest emitting engines
2045	40% lower than baseline	X_3% decreased fee for lowest-emitting engines 0% change for the median emitting engine Y_3% increased fee for highest emitting engines

Questions to Stakeholders

(1) For airports, what are your current landing fees? How are your landing fees determined and what factors affect decisions to modify the fee amounts over time?
(2) What factors should CARB consider for developing potential statewide differentiated landing fee amounts? Should the fees be structured based on emissions per landing and/or per passenger? Should there be different fee categories by aircraft type (narrowbody versus widebody versus regional jet)?
(3) Under a differentiated landing fee program, how feasible is it to reroute aircraft with cleaner engines to airports in NOx burdened areas? What is the decision-making process to determine where specific aircraft get routed to?
(4) What fraction of takeoff and landing operations are currently deploying operational strategies that reduce emissions, such as continuous descent/climb operations, de-rated take-offs, and/or optimized flight path angles?
(5) Are there any datasets that could help quantify the usage rate, emissions benefits, and limitations of these operational strategies? What operational parameters would need to be factored into a model to accurately estimate emissions benefits?
(6) For airlines, how might these draft concepts influence your fleet planning or procurement decisions?

Lower-emission flight techniques

CARB staff is doing further research on this concept and not providing more detail at this time.

Airline Spending Account

CARB staff is not providing more detail on the Spending Account concept at this time.