WAYMO

Waymo One Avoided Emissions Methodology

1.0 Introduction

Waymo One provides autonomous ride-hailing services with a fleet of shared electric vehicles in Phoenix, San Francisco, and Los Angeles, with expansion to Austin and Atlanta currently underway.[1] As a transportation services company, Waymo seeks to build trust and awareness of its environmental benefits. To succeed in this mission, Waymo has developed a methodology that documents our approach to estimating the greenhouse gas (GHG) emissions avoided by our zero-emissions Waymo One service.[2],[3]

To estimate avoided GHG emissions, we compare the estimated emissions from the fully electric, zero-emissions Waymo One service to the emissions targets set for ride-hailing companies – which typically include a mix of zero-emissions and non-zero-emissions vehicles – by California's Clean Miles Standard (CMS).[4] This allows us to inform riders, partners, and stakeholders of the environmental benefits of individual Waymo One rides and the collective impact of our service.

2.0 Scope

The California Air Resources Board adopted the CMS in May 2021 as— a first-of-its-kind fleet regulation to reduce vehicle emissions from ride-hailing services.[5] The CMS is a regulation developed by the California Air Resources Board and implemented by the California Public Utilities Commission. The CMS regulation set annual emissions targets that are reduced each year (Table 1), culminating with a goal of 90% electric vehicle miles traveled by 2030 and 0 grams of carbon dioxide (CO_2) per passenger mile traveled (g CO_2/PMT) by 2030.

Our methodology estimates the GHG emissions of a single Waymo One trip and compares them to the annually decreasing GHG emissions targets per passenger mile traveled (PMT) set for ride-hailing companies by California's CMS (Table 1). This aligns with the CMS by focusing on tailpipe CO2 emissions – as specified in the enabling legislation –[6] excluding upstream emissions related to fuel production and distribution.

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1 As of Fall 2024.

2 Waymo's overall corporate GHG emissions are reported and consolidated under Alphabet's annual CDP Climate Change Response Report.

3 Alphabet, "Alphabet's 2023 CDP Climate Change Response."

4 California Air Resources Board. "Final Regulation Order Clean Miles Standard."

5 California Air Resources Board, "Clean Miles Standard - About."

6 California Air Resources Board, "Addendum to the Final Statement of Reasons for Rulemaking Public Hearing to Consider the Clean Miles Standard Regulation."

Table 1. Clean Miles Standard Annual GHG Target ($\frac{gCO_2}{PMT}$)						
2024	2025	2026	2027	2028	2029	2030+
237	207	161	110	69	30	0

While the CMS provides a robust framework for ride-hailing emissions standards in California, there are no directly comparable ride-hailing emissions standards in other states where Waymo operates.[7] Therefore, we also use the CMS baseline emissions factor to estimate avoided emissions for Waymo's operations outside of California. This approach may yield conservative estimates of emissions avoided, as the compositions of ride-hailing fleets in other states may have lower percentages of electric and hybrid-electric vehicles than in California, which would result in ride-hailing trips with greater typical emissions rates than are modeled in the California CMS.[8],[9]

3.0 Methodology

A custom methodology is created to produce reasonable estimates of per-PMT emissions avoided by the Waymo One service. The methodology is premised upon the fact that Waymo One's fully electric fleet produces zero tailpipe emissions, and pulls from regulatory standards and Greenhouse Gas Protocol (GHG Protocol) guidance on product comparisons and policy and action standards to create a counterfactual per-PMT emissions profile of a typical non-Waymo ride-hailing trip for comparison.[10]

3.1 Waymo One Emissions

The Waymo One fleet of Jaguar I-PACE electric vehicles is certified by the California Air Resources Board as a zero-emission vehicle,[11] and all Waymo One fleet vehicles are fully electric and zero-emission. Thereby, under the CMS emissions methodology, the CO_2 emissions factor for Waymo One remains consistently 0 grams of CO_2 per mile.

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7 As of Fall 2024.

8 For example, electric vehicles (electric vehicles) currently comprise a smaller share of vehicles in Arizona, Texas, and Georgia than in California. California's regulatory environment, which includes state incentives for electric vehicles and supported earlier buildout of electric vehicle charging infrastructure, has accelerated electric vehicle adoption in California ride-hailing fleets. Accordingly, using the California Clean Miles Standard (CMS) targets, which by design reflects a higher share of electric vehicles than the status quo, may underestimate the actual emissions avoided from Waymo One in jurisdictions with lower electric vehicle adoption rates than in California. This gap could widen as California's policies, including the CMS, further drive electric vehicle adoption. (Energy Information Administration, "Electric Light-Duty Vehicles Overview.")

9 Energy Information Administration, "Electric Light-Duty Vehicles Overview."

10 GHG Protocol, "About Us."

11 California Air Resources Board, "Exec. Order. No. A-409-0075."

While the CMS doesn't require it, Waymo sources renewable energy to power our passenger carrier vehicles to eliminate upstream emissions associated with electricity generation when possible. We source renewable energy to power our electric vehicle fleet through a combination of 1) enrolling in renewable energy programs offered by utilities and community choice energy providers, 2) partnering with our charging network providers to purchase renewable energy, and 3) purchasing Renewable Energy Certificates to fill gaps.

- In California, Waymo purchases renewable electricity directly from local utilities and community choice energy programs, including the CleanPowerSF SuperGreen program and the Los Angeles Department of Water and Power's Green Power for a Green L.A.™ program.[12],[13] Electric vehicle chargers powering Waymo's fleet are also enrolled in California's Low Carbon Fuel Standard (LCFS) program. The renewable electricity meets applicable LCFS standards under the Book-and-Claim pathway and is reported to the California Air Resources Board's LCFS program quarterly. The LCFS program considers the carbon intensity of renewable electricity to be zero (0 grams of CO_2 per kWh).[14]

- Outside of California, Waymo purchases renewable electricity directly from local utilities when possible. In Arizona, Waymo participates in the Arizona Public Service Green Choice Program,[15] and partners with the Salt River Project and Google to source clean energy from a mix of dedicated wind power, solar energy and battery storage from three facilities operated by NextEra Energy Resources on SRP's power grid in Arizona: Sonoran Solar Energy Center, Storey Energy Center, and Babbitt Ranch Energy Center.[16] In Texas, Waymo sources renewable energy from Austin Energy's Green Choice program.[17] When Waymo cannot purchase renewable energy from local utilities, Waymo will, when possible, purchase renewable energy certificates that are certified by the Green-e® program.[18]

3.2 Baseline Scenario

We estimate the emissions avoided under each Waymo One trip using a baseline scenario, or counterfactual, where we assume the same trip would be fulfilled by a non-Waymo ride-hailing platform with mixed fleet composition (i.e., not 100% zero-emissions vehicles). We estimate that counterfactual trips on average would result in per-PMT GHG emissions equivalent to the California CMS target value in the relevant year (Table 1).

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12 CleanPowerSF, "2023 SuperGreen Prospective Product Content Label."

13 Los Angeles Department of Water & Power. Go Green: Green Power for a Green L.A.™ Program.

14 California Air Resources Board, "Low Carbon Fuel Standard (LCFS) Guidance 19-01 Book-and-Claim Accounting for Low-CI Electricity."

15 Arizona Public Services, "Business Green Choice Program."

16 Salt River Project, "SRP and NextEra Energy Resources Unveil New Wind Energy Resource for the Valley."

17 Austin Energy. "GreenChoice® Wind Energy: FAQs."

18 Center for Resource Solutions, "Green-e ® Renewable Energy Standard for Canada and the United States."

The baseline scenario is "a reference case that represents the events or conditions most likely to occur in the absence of the assessed product," and "represents what would have happened in the absence of the policy or action being assessed."[19]

The methodology follows the guidelines from the GHG Protocol to identify a baseline comparison.[20] The GHG Protocol establishes standardized frameworks to measure and manage emissions from private and public sector operations, value chains, and mitigation actions.

While the GHG Protocol lacks specific standards for comparing emissions from different transportation modes, it does provide guidance on how to 1) quantify comparative product emissions, and 2) estimate emissions impacts from policies and actions. The methodology builds on *Estimating and Reporting the Comparative Emissions Impacts of Products*, a neutral framework for estimating and disclosing the GHG emissions impact of a good or service.[21] The methodology also incorporates the Policy and Action Standard, which provides a standardized approach for estimating and reporting the changes in emissions resulting from policies and actions, including introduction of new products.[22]

3.3 Comparison

Avoided emissions are estimated by comparing Waymo One emissions, described in Section 3.1, to the baseline, or counterfactual, described in Section 3.2. Briefly, Waymo One emissions are set to zero due to Waymo One's fully electric, zero-emission fleet, while the baseline is set as the equivalent trip emissions of a ride-hailing vehicle with an emissions factor equivalent to the California CMS GHG target in the relevant year (Table 1).[23]

$$\underset{(gCO_2)}{\textit{Avoided Emissions}} = \underset{(gCO_2)}{\textit{Waymo One Trip Emissions}} - \underset{(gCO_2)}{\textit{Baseline Trip Emissions}}$$

Equation (1) Waymo One Avoided Emissions

Baseline Trip Emissions

To calculate baseline emissions we use the following CMS equation for ride-hailing companies to calculate GHG emissions per passenger mile.

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19 World Resources Institute, "Estimating and Reporting the Comparative Emissions Impacts of Product."; Greenhouse Gas Protocol, "Policy and Action Standard."

20 GHG Protocol, "About Us."

21 World Resources Institute, "Estimating and Reporting the Comparative Emissions Impacts of Products."

22 Greenhouse Gas Protocol, "Policy and Action Standard."

23 California Air Resources Board, "Final Regulation Order Clean Miles Standard."

$$\frac{gCO_2}{PMT} = \frac{\sum(VMT_{P1,P2,P3} \times CO_2\ factor)_{trip}}{\sum(VMT_{P3} \times occupancy)_{trip}}$$

Equation (2) Clean Miles Standard GHG emissions per passenger mile

Where:

- $VMT_{P1,P2,P3}$ equals vehicle miles traveled in miles (sum of Periods 1, 2 and 3) of trips for all vehicles
- VMT_{P3} equals vehicle miles traveled in miles for the Period 3 portion of a trip
- CO_2 factor equals the CO_2 emissions factor in grams CO_2 per mile
- Occupancy equals the occupancy value assumed by the California Air Resources Board: 1.5 passengers for non-pooled or pool-requested-unmatched trips and 2.5 passengers for pool-matched trips[24]

Definitions:

- "Period 1" are those miles traveled by a ride-hailing vehicle when a ride-hailing vehicle driver or operator is logged onto the app and waiting for a ride match.
- "Period 2" are those miles traveled by a ride-hailing vehicle when a ride-hailing vehicle driver or operator has accepted a ride request and is en route to the passenger.
- "Period 3" are those miles traveled by a ride-hailing vehicle when the passenger, or passengers, are in the ride-hailing vehicle and en route to their destination until the passenger exits the vehicle.
- "Passenger Miles Traveled" or "PMT" means the miles traveled by a passenger, or miles traveled by each passenger if there are multiple passengers for a trip.
- "Vehicle miles traveled" or "VMT" means the distance traveled by a ride-hailing vehicle, and includes all miles traveled (sum of Periods 1, 2, and 3).

Estimating the Baseline Trip Emissions

The Baseline Trip Emissions refers to the trips emissions for a baseline case. Mathematically, it is the numerator of Equation (2).

$$\underset{(gCO_2)}{Baseline\ Trip\ Emissions} = \sum \underset{(VMT)}{(VMT_{P1,P2,P3}} \times \underset{(gCO_2/VMT)}{CO_2\ factor)_{trip}}$$

Equation (3) Baseline Trip Emissions calculated per VMT

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[24] Waymo's baseline trip estimates follow the CMS assumed occupancy value of 1.5 passengers for non-pooled rides in the methodology. As explained above, Waymo One trips are fully electric and therefore result in zero emissions. Therefore vehicle occupancy is irrelevant to the calculation of Waymo One trip emissions. Waymo does not currently offer pooled rides, therefore the pooled occupancy value is not included in the Waymo One Avoided Emissions Methodology.

The CMS requires ride-hailing companies to stay below emissions targets per passenger mile traveled (PMT) through 2030 (Table 1). As described in Section 3.2, we utilize California's CMS annual emissions targets for ride hailing platforms as the baseline comparison.

The Baseline Trip Emissions can be estimated using Equation (4) below, which is derived from Equations (2) and (3). Equation (4) leverages the known annual GHG emissions target, VMT_{P3}, and an assumed occupancy of 1.5 passengers:

$$\underset{(gCO_2)}{\textit{Baseline Trip Emissions}} = \underset{(gCO_2/PMT)}{\textit{Annual GHG Target}} \times \underset{(PMT)}{(VMT_{P3} \times \textit{occupancy})_{trip}}$$

Equation (4) Baseline Trip Emissions calculated per PMT

Waymo One Avoided Emissions Calculation

The avoided emissions are then calculated by subtracting the Waymo One Emissions from the BaselineTrip Emissions using Equation (5):

$$\underset{(gCO_2)}{\textit{Avoided Emissions}} = \underset{(gCO_2)}{\textit{Baseline Trip Emissions}} - \underset{(gCO_2)}{\textit{Waymo One Emissions}}$$

$$\textit{Avoided Emissions} = \textit{Baseline Trip Emissions} - 0$$

$$\textit{Avoided Emissions} = \textit{Baseline Trip Emissions}$$

Equation (5) Waymo One Avoided Emissions

4.0 Conclusion

Waymo is committed to transparent, rigorous, and continuously evolving methodologies for estimating avoided emissions from shared electric mobility. Waymo recommends continued research and the development of industry standards to estimate environmental benefits from shared electric mobility.

We will actively monitor, update, and revise our approach in key areas including:

- Standards: Aligning of our methodology with relevant regulations, standard practices, and emissions estimation methodologies within the mobility and transportation industries.
- Performance: Tracking our success in delivering emissions reductions, including through our renewable energy sourcing efforts.
- Comparisons: Continuing to refine ride-hailing emissions comparisons, including by integrating non-California regional ride-hailing emissions data as they become available.

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