



Google Maps Eco-Friendly Routing
Accelerating the journey to
sustainability for one billion people



Abstract

Ground transportation is a key contributor to climate change, making up almost [18% of global CO₂ emissions](#). Reducing the carbon footprint of ground transportation can be accomplished in many ways and technology has a critical role to play. That's why we recently launched eco-friendly routing on Google Maps, a new tool that helps drivers make more sustainable choices when getting from point A to point B.

Launched in the U.S. in October 2021, eco-friendly routing utilizes an entirely new routing model that enables people to navigate to their destination as quickly as possible, while also optimizing for lower fuel consumption. This reduces CO₂ emissions, saves users money on fuel, and even helps reduce air pollution—with nearly no trade-off in terms of travel time. Google developed this enhanced machine learning model together with the U.S. Department of Energy's National Renewable Energy Laboratory (NREL).

We estimate that eco-friendly routing has the potential to prevent over one million metric tons of carbon emissions per year, the equivalent of removing over 200,000 internal combustion engine vehicles from the road.

In this paper, we'll discuss why we built the feature, the key insights and technology that went into developing it, the feature's potential positive impact, and our plan for the future.



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Why reducing transportation emissions is challenging

Cars with internal combustion engines make up [99% of vehicles on the road](#) around the world. These vehicles are a major contributor to climate change and account for almost [75% of transportation CO₂ emissions](#), which negatively impacts environmental and human health—polluting the air, increasing extreme weather events, and causing pollution-related diseases, such as respiratory issues.

Accelerating the shift to more environmentally-friendly transportation is critical. According to the [Transformative Urban Mobility Initiative](#), there are three key ways in which we can all work to reduce road transportation emissions: **avoiding** and reducing travel, **shifting** to more environmentally-friendly travel modes, and **improving** the fuel efficiency of every trip.

Avoiding and reducing travel is important, yet often not possible. Shifting to more environmentally friendly transportation modes, like electric vehicles (EVs) is underway, yet only [4.6% of new passenger vehicles](#) sold worldwide today are electric. And while EV sales are expected to grow in the coming decades, recent analysis from [BloombergNEF estimates](#) that by 2040 electric vehicles may only make up 33% of total cars on the road.

At Google, we see this challenge as a clear call to action. Driving is essential for many and remains the most popular mode of transportation used on Google Maps. While the world transitions to more eco-friendly alternatives, such as public transit, cycling, and walking, we can be helpful today by improving the fuel efficiency of every driving journey, reducing carbon emissions, and supporting action on climate change.



Introducing eco-friendly routing on Google Maps

With over one billion active monthly users, Google Maps helps people navigate and explore while aiming to make every journey better. Since the day we launched in 2005, Maps has continuously worked to [redefine what a map can be](#).

Sustainability has [long been part](#) of our journey, and we have worked hard to provide alternative navigation options to driving. For example, in 2005 we began adding public transportation options, and in 2010 we started offering cycling directions. Today we offer cycling directions in over 30 countries and territories worldwide. Recently, we made bike and scooter share information available in 300 cities around the globe. Beyond this, we now make it easy for drivers of electric vehicles to quickly find charging stations and see real-time information about whether or not a charger is available.

In addition, Google Maps' existing routing algorithm—which prioritizes the fastest driving route—already helps prevent carbon emissions. We know, based on a [study conducted in Salt Lake City](#) using city-scale traffic simulations, that drivers who used Google Maps spent less time stuck in traffic and subsequently took shorter trips—ultimately leading to more fuel savings and better overall utilization of the road network.

But given the scale and urgency of climate change, along with advancements in machine learning (ML) and routing techniques, we have the responsibility to do more. **That's why Google Maps developed eco-friendly routing.**

Launched in the U.S. in October 2021 as a part of [Google's larger commitment](#) to help one billion people make more sustainable choices, eco-friendly routing is an entirely new routing model that gets users to their destination quickly, while optimizing for lower fuel consumption.



This means that in addition to displaying the fastest route to a user's destination, Google Maps now shows the most fuel-efficient route—if it doesn't also happen to be the fastest. With just a few taps, users can compare the relative fuel savings and estimated time of arrival (ETA) differences between two routes and choose the one that works best for them. And, of course, users will always be able to opt-out of this feature within Google Maps settings.

While these individual changes may seem small, they can add up to a big impact. Routing drivers on the most fuel-efficient route will help lower CO₂ emissions, help people save money on fuel, and even help contribute to better air quality. We estimate that eco-friendly routing will help **avoid over one million metric tons of carbon emissions every year, or the equivalent of removing over 200,000 internal combustion engine vehicles from the road.**

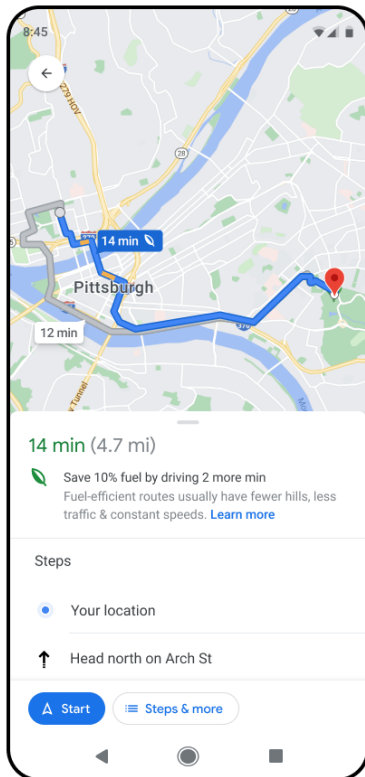
How we calculated the emissions impact of eco-friendly routing

Google, with the help of the U.S. Department of Energy's National Renewable Energy Laboratory's (NREL) RouteE technology, started by analyzing the fuel consumption for all routes driven on Google Maps during the last year using a representative set of vehicle types. Then, using AI and Google Maps' record of available alternative routes at the relevant times, we identified and calculated the fuel usage of each of these viable alternative routes.

This enabled us to pinpoint the most fuel-efficient route for any given journey made last year. Next, we removed any fuel-efficient alternative that noticeably increased drive time or did not provide meaningful fuel savings. And finally, to achieve the resulting one million metric tons of CO₂ calculation, we tallied the total fuel usage of the more fuel-efficient routes, subtracting this number from the fuel usage that actually occurred, and input this value into [EPA's Greenhouse Gas Equivalencies Calculator](#).

FIG. 1

Eco-friendly routing user interface



How eco-friendly routing works

For any given journey, there are often numerous ways to get from point A to point B. To calculate the fastest ETA today, and instantly help people select the best route to their destination, Google Maps' algorithm generates a set of potential route candidates. To determine the best candidates, we incorporate data on road conditions—like road closures, live traffic data, and historical traffic patterns—into our machine learning algorithms [to accurately predict traffic](#) during the course of a user's journey. With eco-friendly routing, we take our routing technology one step further, identifying and scoring route candidates according to their expected fuel consumption.

To develop the eco-friendly routing algorithm, the Google Maps team had to overcome the technical challenge of accurately predicting fuel consumption of a vehicle for any given route across diverse road segments and driving conditions. Google's expertise, however, lies in live traffic prediction, not fuel consumption prediction.

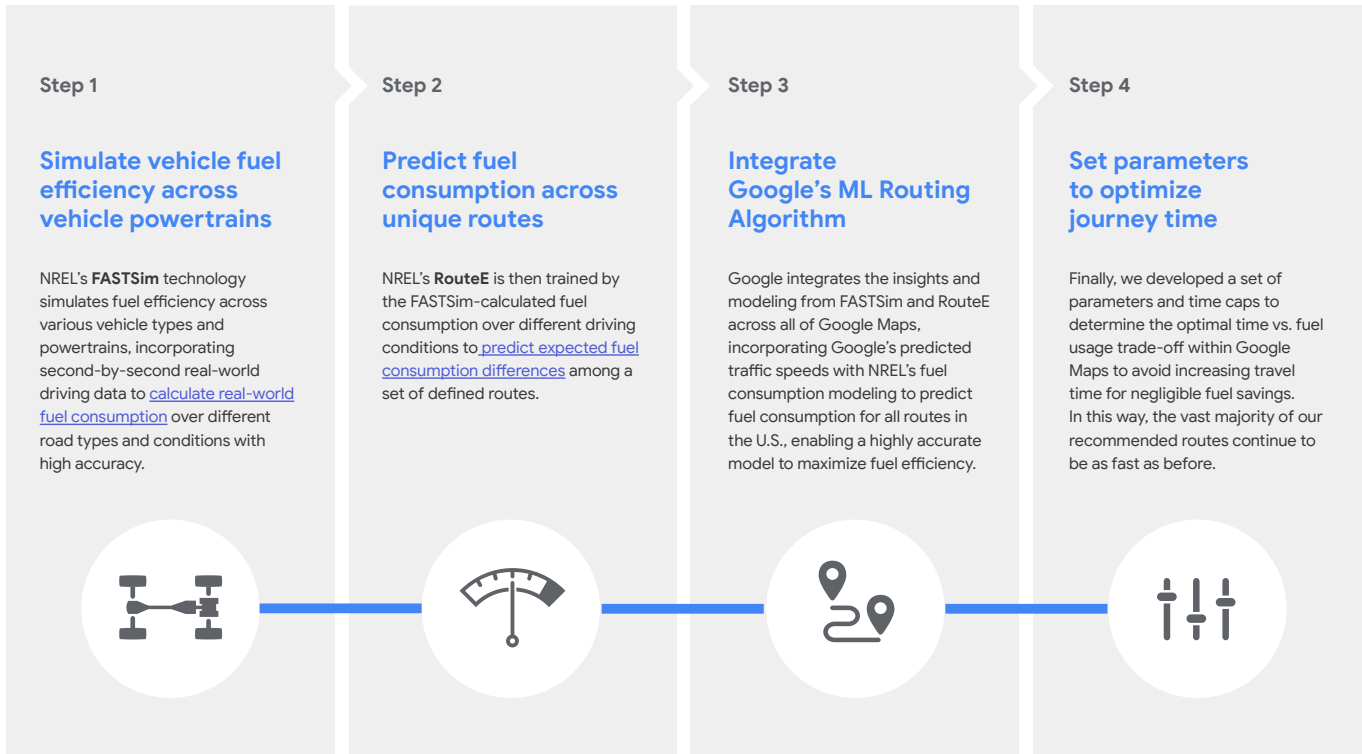
That's why we partnered with [NREL](#), world-leading experts in mobility research. NREL has extensive experience simulating how different vehicle powertrains¹ affect fuel efficiency. NREL also has best-in-class energy prediction modeling, informed by real-world driving data, that enables their model to predict the fuel consumption of a broad set of vehicle types across a wide range of routes and driving conditions in the U.S.

This partnership enabled us to integrate NREL's fuel consumption models, including their FASTSim and RouteE technologies, together with Google's ML routing model and real-time traffic predictions.

¹ The system, including engine and transmission, that creates power and propels vehicles forward

FIG. 2

Google Maps eco-friendly routing at a glance



NREL technology: FASTSim and RouteE

To solve the challenge of achieving an accurate model of fuel consumption across different vehicle types, NREL's Future Automotive Systems Technology Simulator ([FASTSim](#)) was essential. This technology simulates fuel use, energy consumption, and performance across a variety of powertrains (e.g. conventional gasoline, diesel, hybrid electric, battery electric, etc.) and spans light-, medium-, and heavy-duty vehicles. Coupled with a representative sample of second-by-second speed trajectory "driving profiles," which NREL has available through their detailed,



anonymized Transportation Secure Data Center ([TSDC](#)), FASTSim is able to quantify energy consumption across a variety of vehicles, powertrains, environments, and conditions. By leveraging second-by-second driving profiles, FASTSim is able to estimate, with a high degree of accuracy, the amount of fuel consumed for a specific real-world journey, allowing us to understand not only the fuel consumed on the route as a whole, but with a high degree of specificity between discrete points along a journey.

With this robust understanding of fuel consumption across different powertrains and driving conditions, NREL's Route Energy Prediction Model ([RouteE](#)) is then applied to predict the fuel consumption required for a given vehicle over any defined route. Next, the RouteE models of any given road segment and condition are trained with the detailed FASTSim data from similar road segments and conditions to provide fuel consumption predictions—from point A to Point B—before a vehicle even hits the road.

To achieve this, RouteE incorporates traffic data while simultaneously considering a full suite of critical fuel efficiency determinants. At Google Maps, we worked with NREL to select a set of determinants with the highest impact to include in our model, such as the steepness of the road, distance, predicted speeds, and the specific impact of the road type (e.g. highway, urban streets, etc.).

Google Technology

From here, Google integrated the insights and modeling from FASTSim and RouteE across Google Maps routes in the U.S. We created a machine learning algorithm that integrates Google's predicted traffic speeds with NREL's fuel consumption modeling to determine relative fuel consumption for a fully representative set of routes in the U.S., allowing us to identify and route drivers on the most fuel-efficient routes available.



Google also developed time vs. fuel efficiency trade-off parameters to ensure the eco-friendly route does not significantly increase the ETA of a journey. Based on this logic, we remove route candidates that would noticeably increase travel time or would not provide meaningful fuel savings. Google conducted extensive testing to understand people's receptivity to trade-off time in order to save fuel and reduce their environmental footprint. We found most drivers selected the eco-friendly option when arrival times were similar—and even considered driving a few minutes extra if fuel savings were significant, or if they were not in a rush to get to their destination. We will continue to balance and optimize based on real-world user behavior and feature usage.

To ensure the accuracy of our fuel efficiency calculations, our routing algorithm compares our results with NREL's second-by-second FASTSim fuel consumption data. It's worth mentioning that while NREL has fuel consumption predictions for various U.S. vehicle types and powertrains, the goal with eco-friendly routing today is to compare relative fuel usage among viable routes, rather than to calculate absolute fuel usage per route. Therefore, when we looked at the average age of vehicles in the U.S. and the type of fuel they consume (key factors in determining fuel efficiency), we found we could use a single representative vehicle for the U.S. market (i.e. a standard mid-size sedan with a gas engine) to reasonably calculate relative fuel efficiency. This allows users in the U.S. to immediately benefit from eco-friendly routing without having to input their car's vehicle type or powertrain, all while retaining a high degree of modeling accuracy for most drivers.



Global roll-out and next steps

Following the launch of eco-friendly routing in the U.S., we plan to launch in Europe and beyond in 2022. To launch globally, we're working on technical modifications to our U.S. machine learning algorithm and, as appropriate, to the supporting tools and datasets provided by NREL and other prospective partners. These modifications are necessary as fuel consumption prediction varies based on vehicle type, powertrain, and the type of fuel used. The average car in Pittsburgh, Jakarta, and Stockholm look very different from one another. In the U.S., most vehicles are gas-powered; in Europe, the ratio of diesel and gas-powered cars varies from country to country. Driving behaviors also differ geographically, meaning that our machine learning model will need to be trained in-house on various driving conditions on real-world journeys to ensure a high degree of accuracy.

Next steps

To ensure that eco-friendly routing remains helpful and accurate, we'll investigate other applications in the years to come. For example, as the world transitions to hybrid and electric vehicles, how do we train our systems to adapt to these different vehicle types?

We are also open to finding new and innovative use cases for eco-friendly routing that could benefit the broader transportation ecosystem—including (but not limited to) ridesharing, shipping, or logistics operations.

Individual change, at scale

Climate change is one of the most profound challenges of our time. At Google, we know that technology can play a part in helping create a sustainable future. While ground transportation is one of the biggest sources of greenhouse gas emissions worldwide, transitioning to sustainable transportation isn't something that any of us can do alone.



We hope that eco-friendly routing will enable our users with more choices—showing them sustainable route and travel options and empowering them with the ability to choose the one that works best for their lifestyle. By building sustainability into Google Maps, we'll ensure a more sustainable choice is an easier choice for everyone—so we can all accelerate toward a more sustainable world.

Acknowledgements

We very much appreciate the contributions from our partners at NREL for helping make eco-friendly routing a reality.