Environmental footprint of electric vehicles

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ENERGY MODELING

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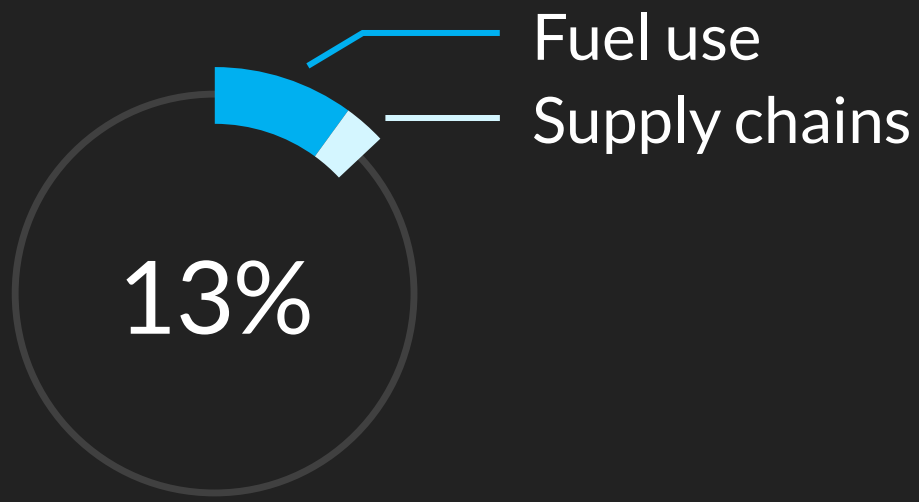
Personal vehicles and greenhouse gas emissions

Personal vehicles contribute substantially to total emissions



of global GHG emissions

IEA 2012, EPA 2015

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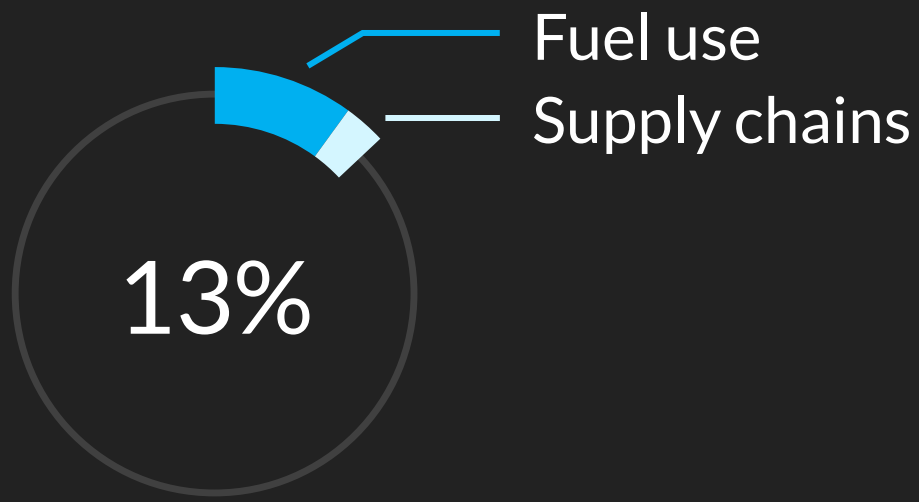

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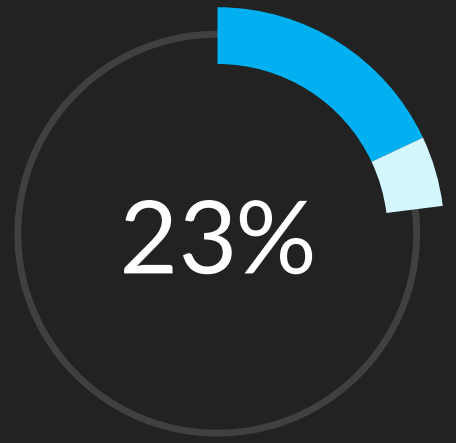
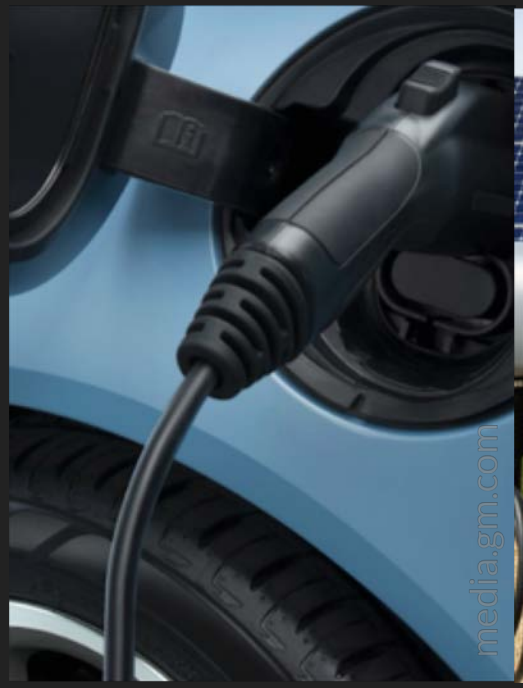


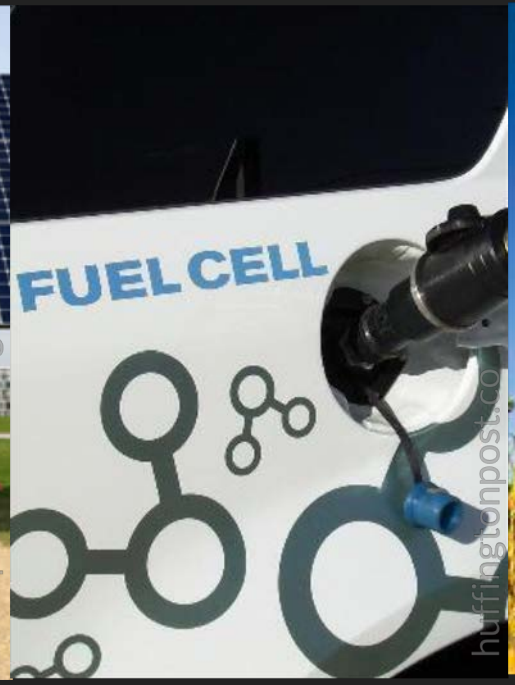
of U.S. GHG emissions

IEA 2012, EPA 2015

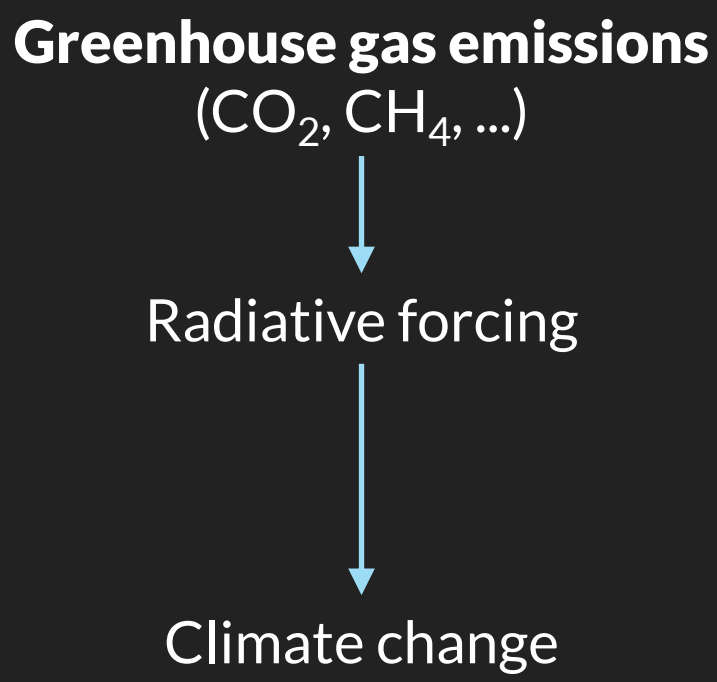
Technological alternatives exist to reduce emissions

But what is their emissions reduction potential, and what does it depend on?





Greenhouse gas emissions vs air pollutant emissions



Greenhouse gas emissions vs air pollutant emissions

Greenhouse gas emissions
(CO_2, CH_4, ...)

↓

Radiative forcing

↓

Climate change

Air pollutant emissions
(Particulate matter, NO_x, SO_x, ...)

↓

Pollutant
concentration in air

↓

Human health
Soil quality
Water quality

Greenhouse gas emissions vs air pollutant emissions

Greenhouse gas emissions
(CO_2, CH_4, ...)

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Radiative forcing

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Climate change

Global issue

Air pollutant emissions
(Particulate matter, NO_x, SO_x, ...)

↓

Pollutant
concentration in air

↓

Human health
Soil quality
Water quality

Regional issue

Lifecycle perspective for evaluating emissions

Fuel feedstock
Crude oil extraction, natural gas extraction

→

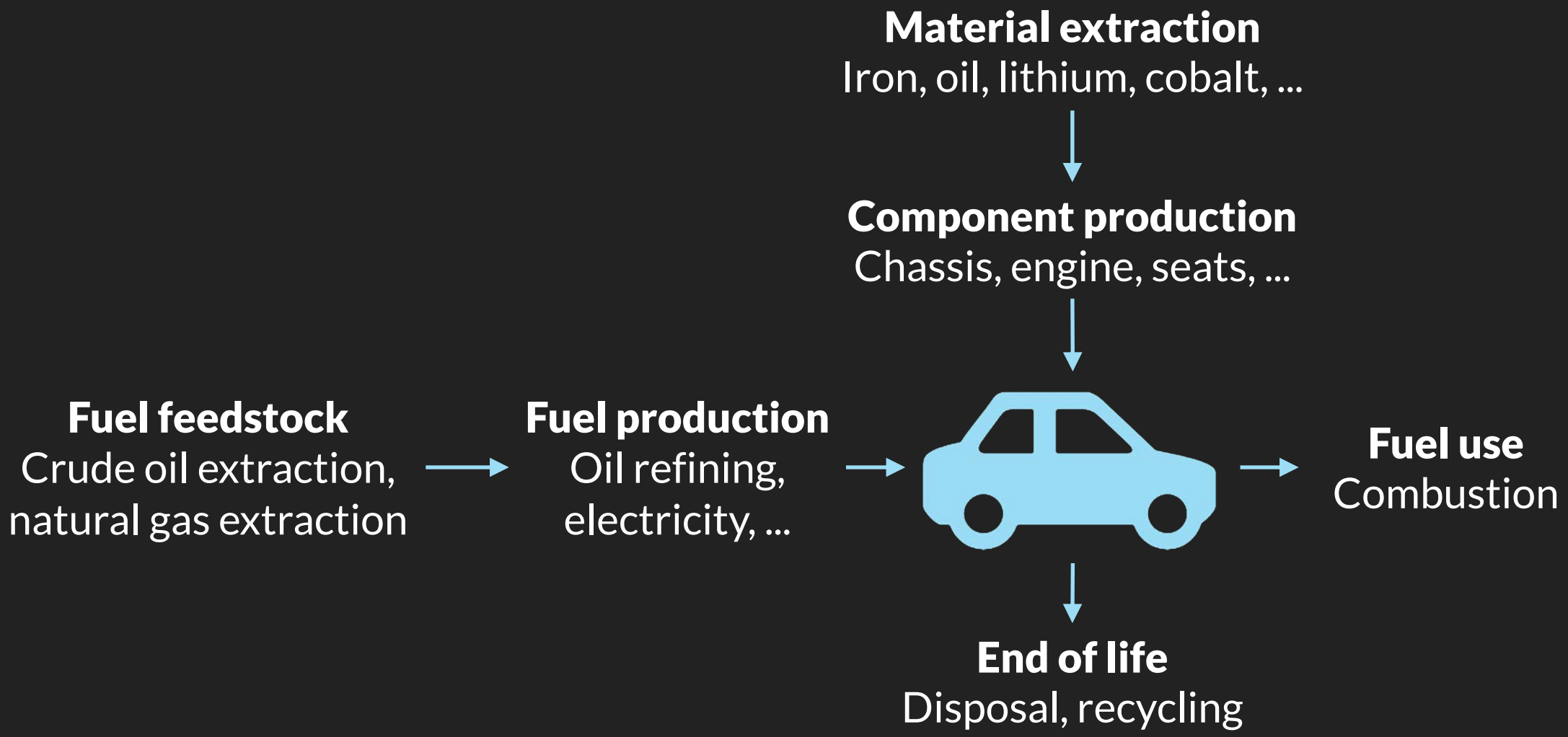
Fuel production
Oil refining, electricity, ...

→

→

Fuel use
Combustion

Lifecycle perspective for evaluating emissions



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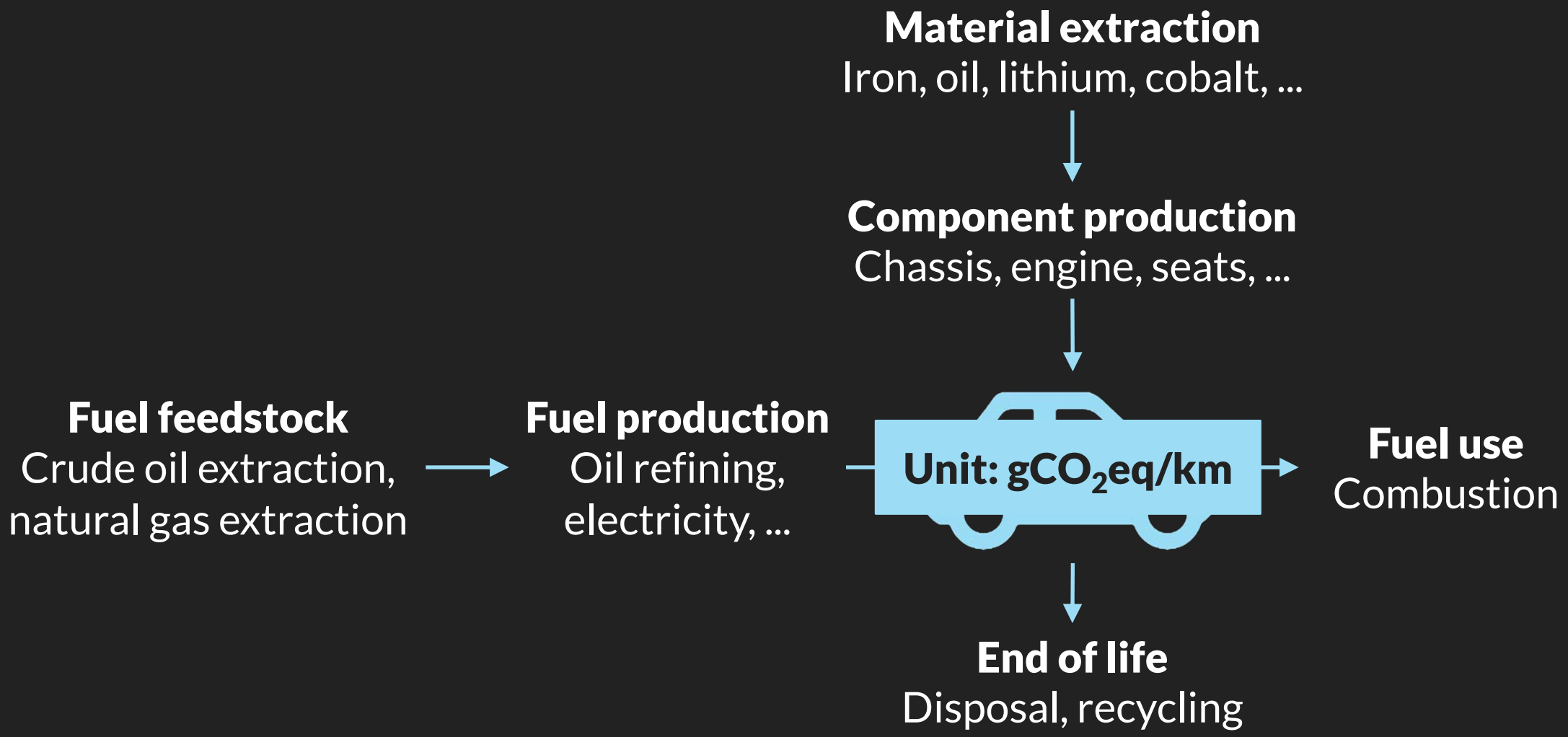


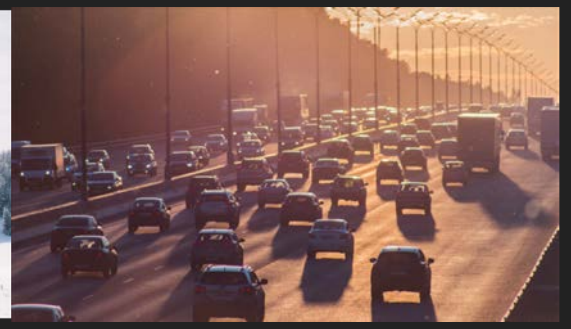
Three key challenges to evaluating emissions

1 Uncertainties in emission accounting

Three key challenges to evaluating emissions

1. Uncertainties in emission accounting

2. Dependence on regional conditions



Three key challenges to evaluating emissions

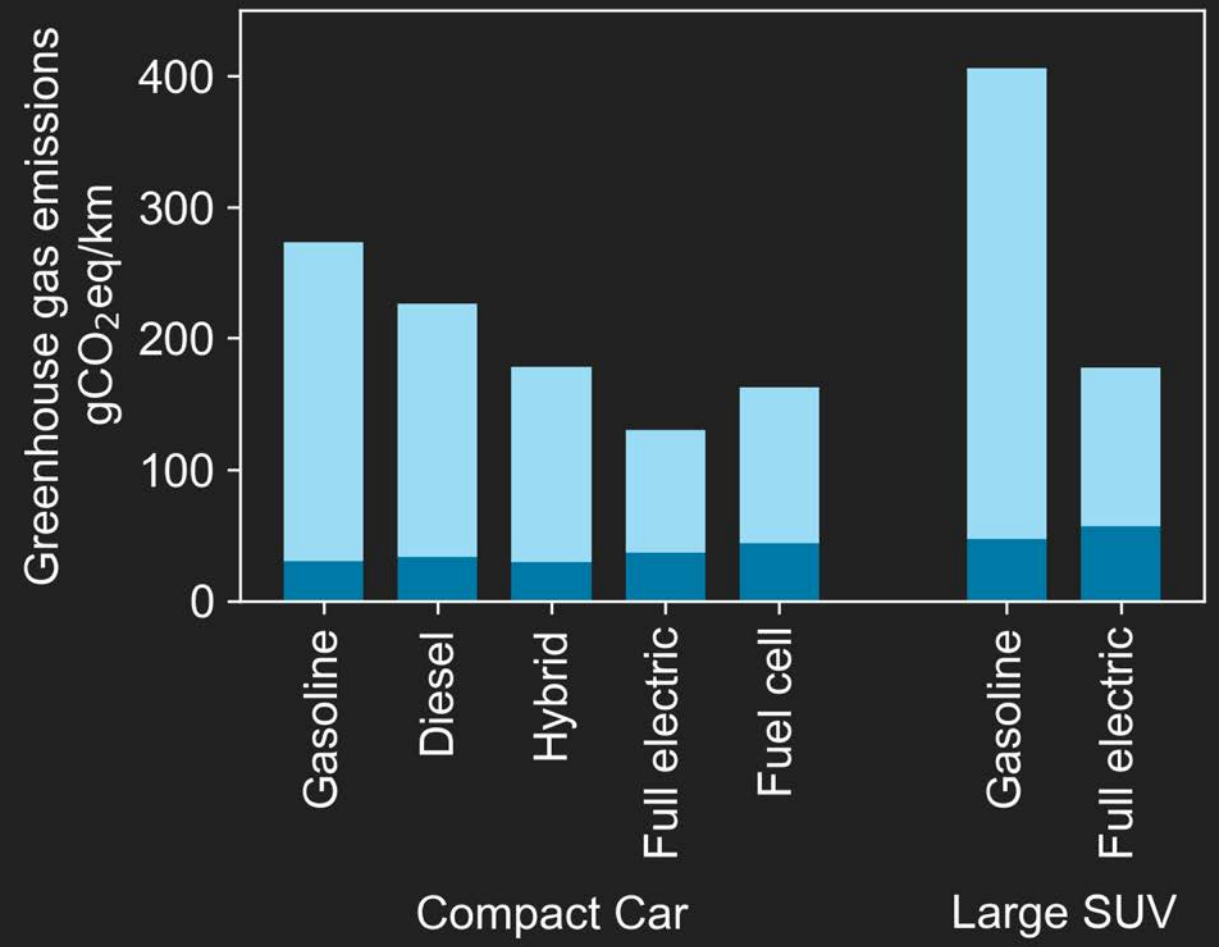
1. Uncertainties in emission accounting

2. Dependence on regional conditions

3. High diversity of technologies and vehicle models

Emissions of personal vehicles under average conditions

Electric vehicles reduce emissions by 50%, fuel cell vehicles by 40%



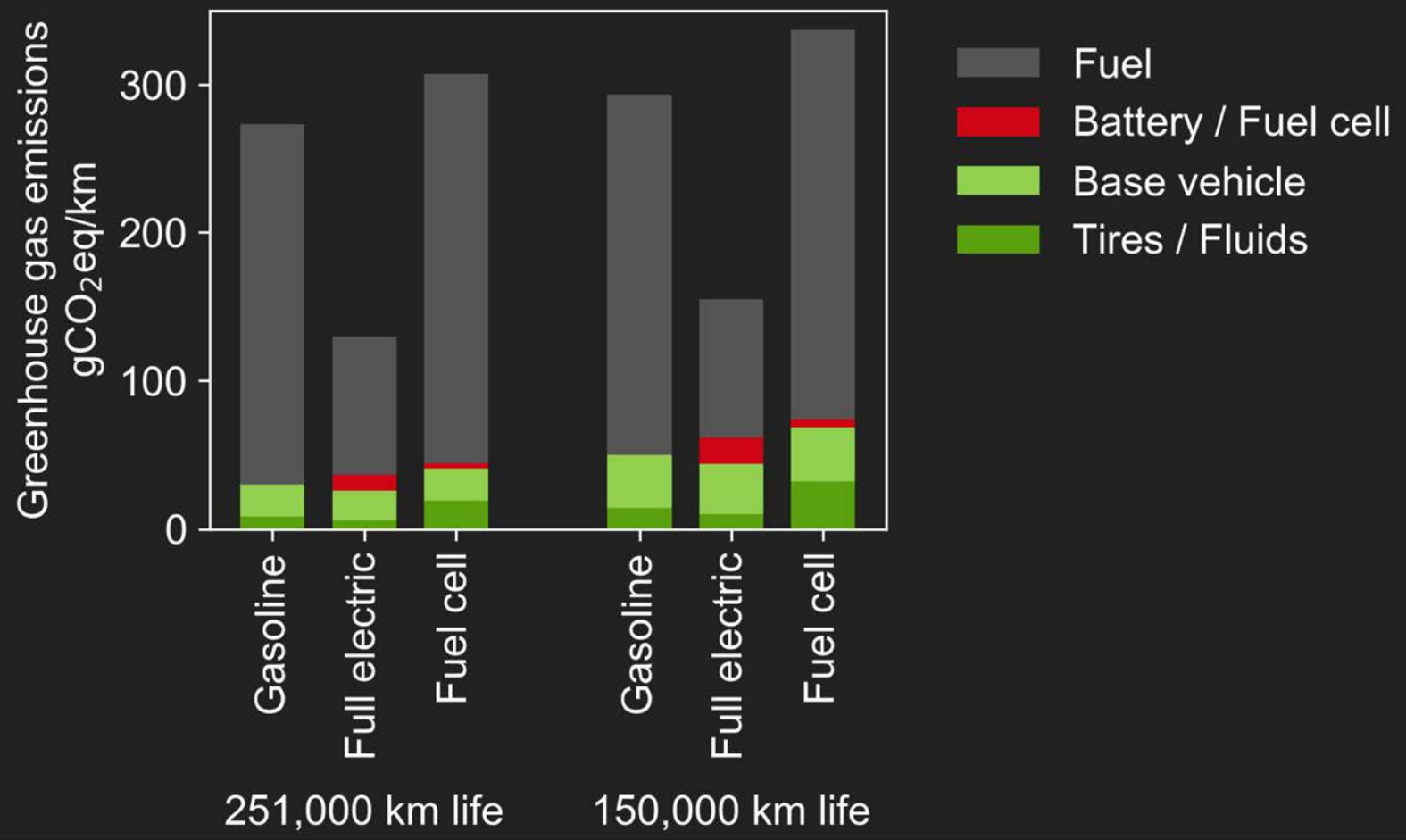
Fuel
Vehicle

U.S. average conditions
251,000 km lifetime distance
U.S. average electricity mix
Hydrogen from reformed methane

Based on: Miotti, Supran, Kim, and Trancik, *ES&T* (2016).

Lithium-ion battery and fuel cell stack production

Batteries and fuel cells only contribute a few % to total emissions



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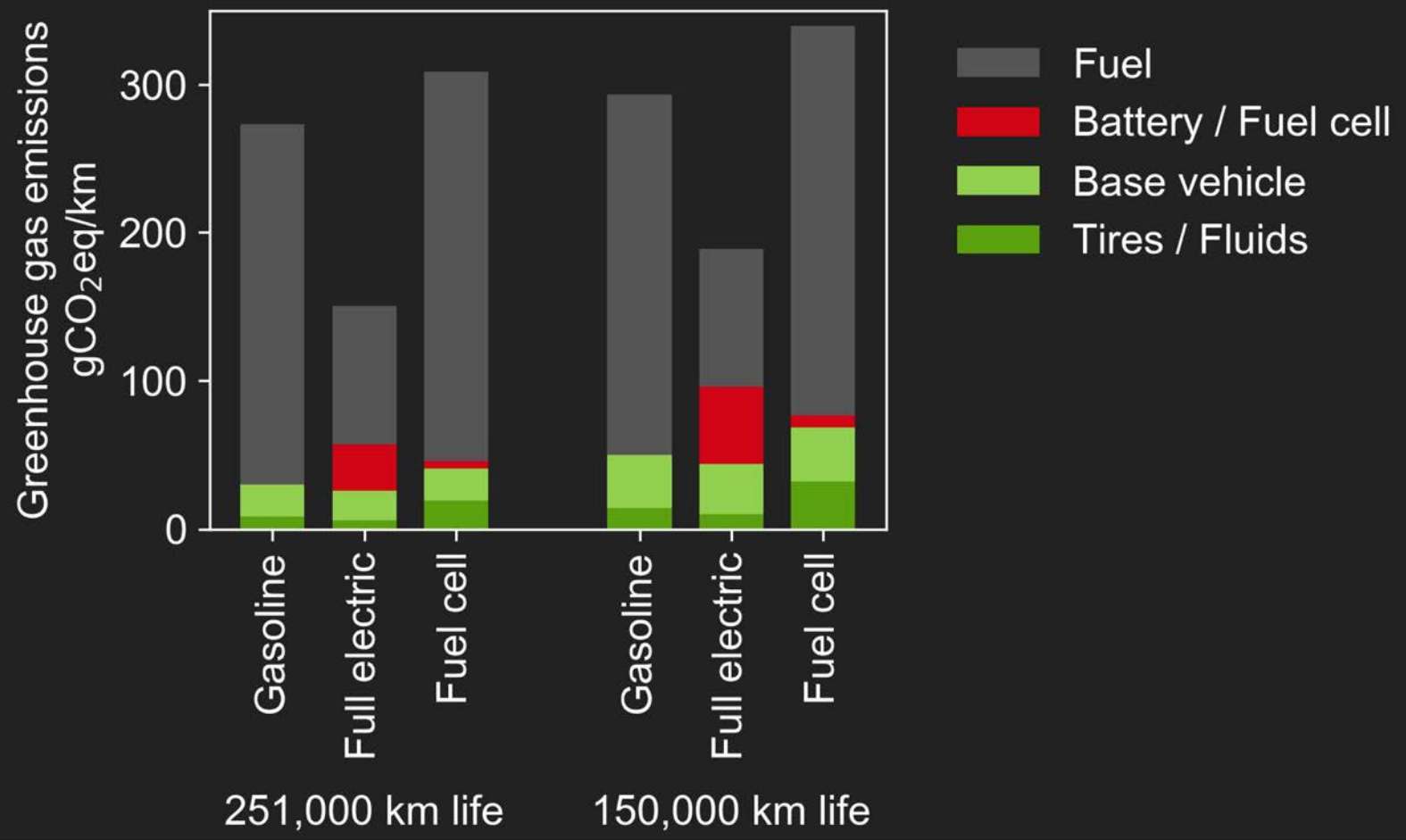
Uncertain battery emission

Even under pessimistic assumptions, electric vehicles perform well



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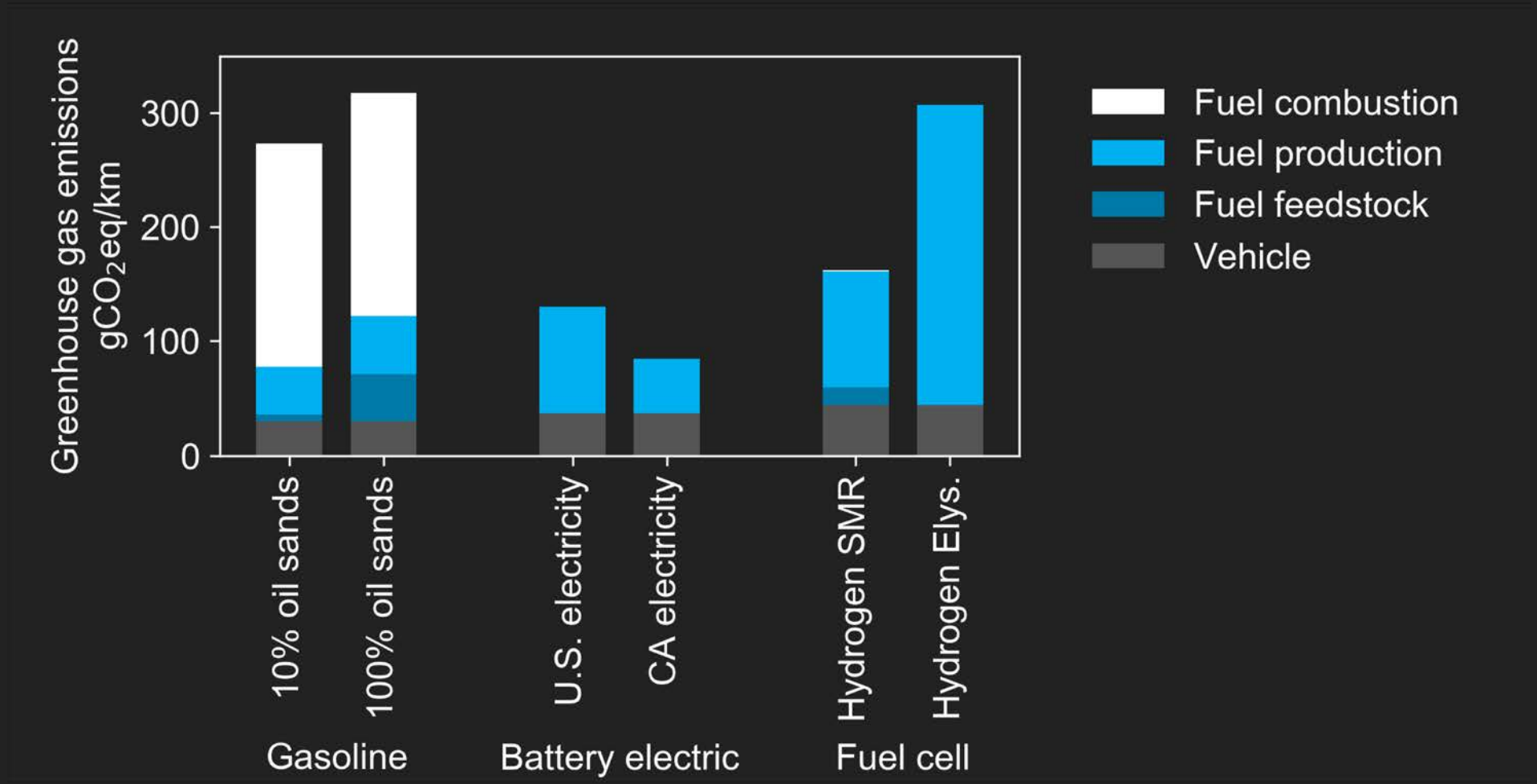
Sensitivity of emissions to fuel production pathways

Diversity in fuel production pathways (including electricity) has major impact



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Regional conditions matter

Emission reduction of electric vehicles depend on where they are driven

Electricity mix
Affects emissions for charging EVs

Difference in emissions:
kgCO_2eq/year

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Local climate
Affects fuel economy

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Trip distance and speed distribution
Affects fuel economy

Difference in emissions:
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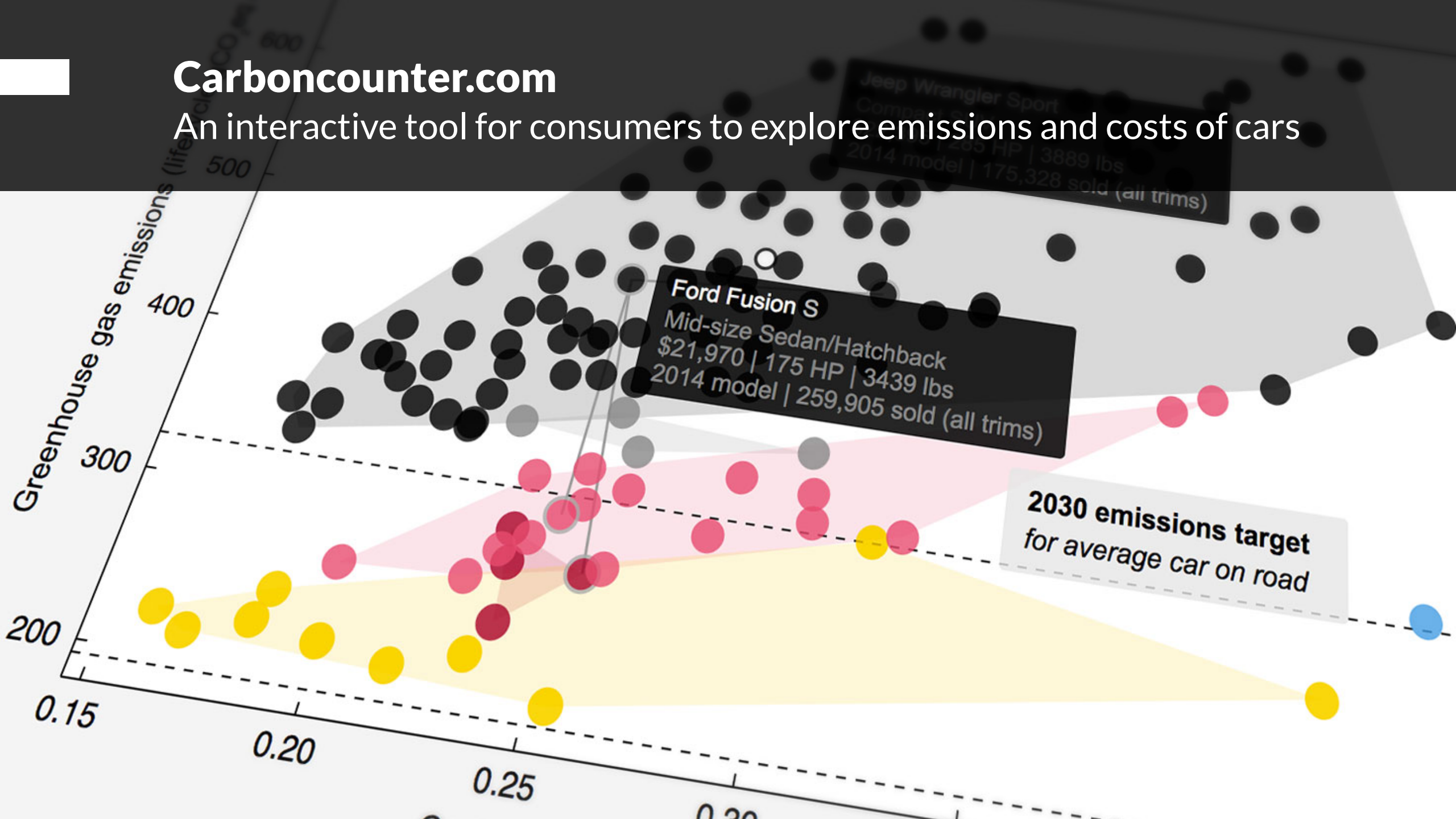
Annual miles traveled
Affects impact of production emissions and cumulative annual emission reductions

Difference in emissions:
kgCO_2eq/year

Carboncounter.com

An interactive tool for consumers to explore emissions and costs of cars



Summary

1. Battery electric vehicles reduce greenhouse gas emissions by almost 50% on average compared to conventional gasoline vehicles.

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2. Emission reductions of electric vehicles strongly depend on electricity mix and regional conditions.

3. Tools that provide information to consumers are important and can impact consumer preferences.

A message from Professor Jessika Trancik

“The environmental impacts of electric vehicles have been much debated. This work shows how important it is to tease out the different contributing factors, such as travel behaviors and energy infrastructure. Only by understanding these factors can we accurately assess the benefits of vehicle electrification, and how these benefits change over time and space. And, in this way, the research can inform decisions at diverse scales, from nations to cities, and even individual consumers. A similar approach can be applied to understanding the impacts of many other technologies.”

Thank you

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Visit: www.carboncounter.com

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