

Calculating Electric Drive Vehicle Greenhouse Gas Emissions

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Outline

- Vehicle Efficiency Measurement
- Upstream Energy Supply GHG Intensity Determination
- Vehicle Activity Level Determination
- Additional Research Opportunities



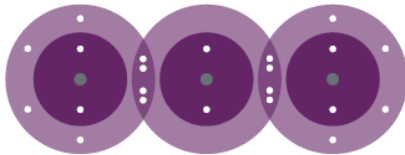
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VEHICLE ELECTRIFICATION POLICY STUDY
TASK 5 REPORT

AUGUST 2012

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BY ED PIKE



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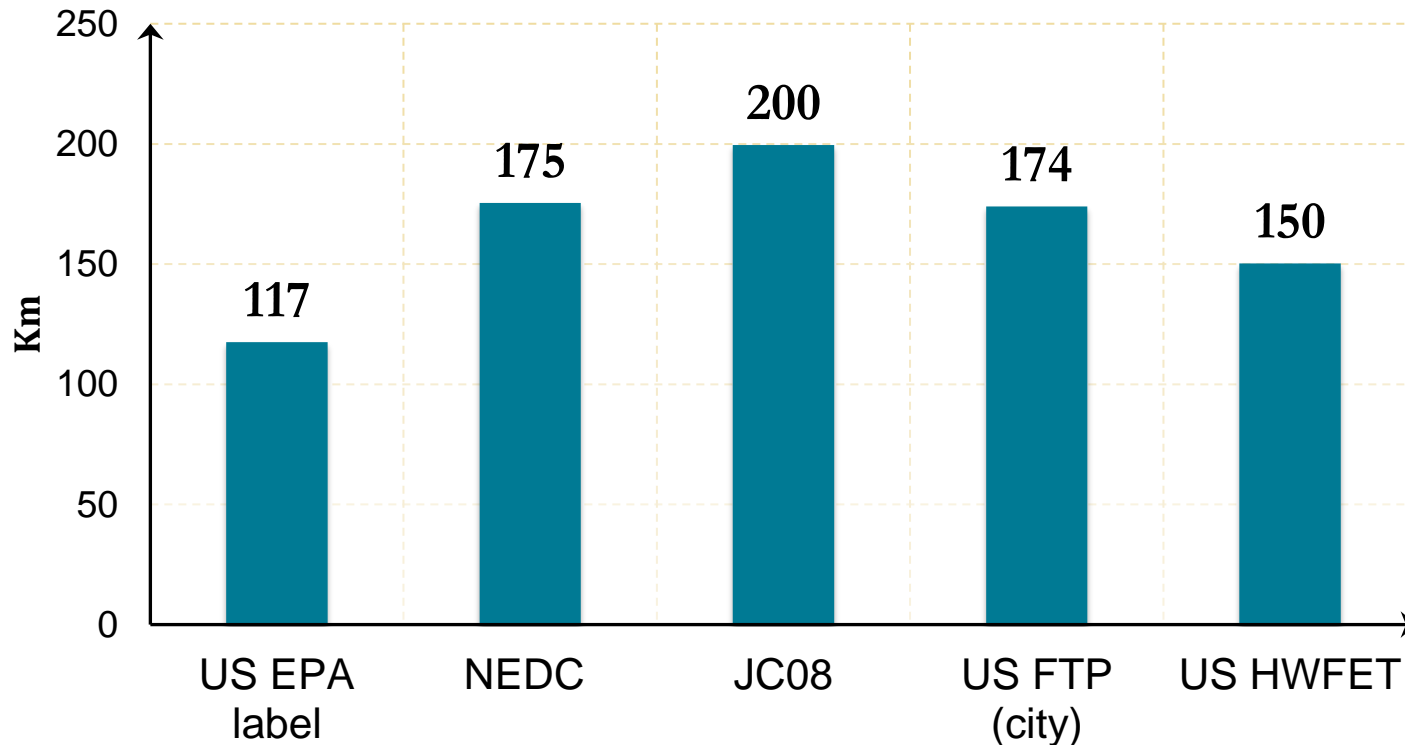
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ENERGY SOLUTIONS

- White paper issued August 2012
- Available on International Council on Clean Transportation website: <http://www.theicct.org/>



Vehicle Efficiency Measurement: Effect of Test Cycle on Range



US EPA consumer label estimate and global test cycle measurements of Nissan Leaf range (sources: Nissan, US EPA)



Vehicle Efficiency Measurement

- Why are these ratings so different?
 - Speed
 - Acceleration (stop and go; aggressive driving)
 - Cabin climate control adjustment (US EPA label only)



Vehicle Efficiency Measurement

- Vehicle efficiency measurement
 - Use US EPA 5-cycle or similar test cycles to capture the effects of urbanization, aggressive driving, ambient temperature and cabin climate control
 - Evaluate edrive vehicle performance in the real world
 - Test with 240 V charging while monitoring usage of DC fast charging (and in the US 120V)



Upstream GHG Intensity

- Upstream energy supply GHG intensity determination
 - Use average electricity CO₂e intensity as a default
 - evaluate, as vehicle deployments grow over time, the feasibility of determining marginal CO₂e intensity
 - Regional factors can be applied if accurate data on vehicle placements and regional assessments of electricity CO₂e intensity are available
 - EU harmonization requirements impose special constraints

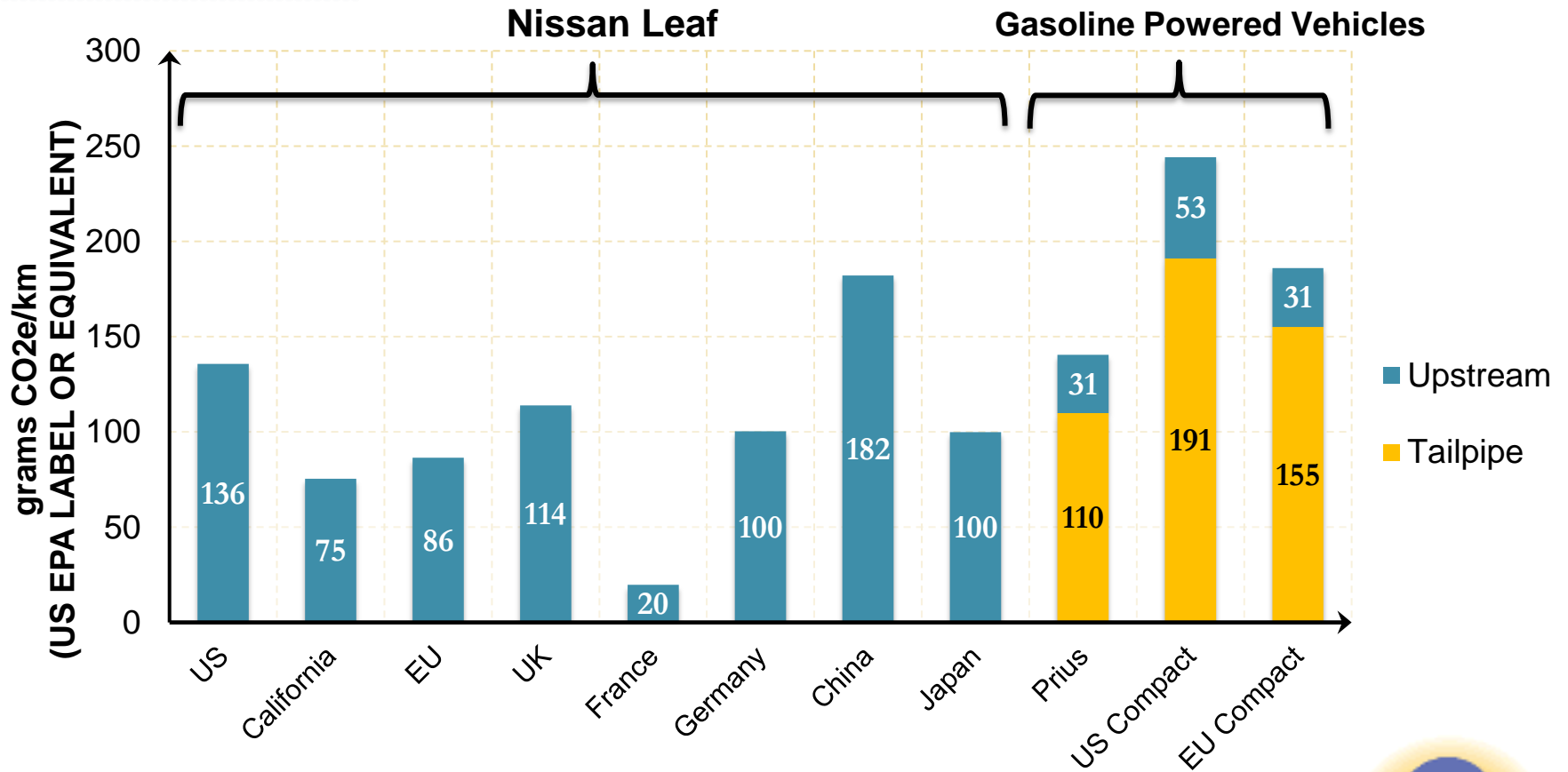


Upstream GHG Intensity

- Hydrogen CO₂e intensity factors should be adjusted for specific production processes when sufficient data is available, especially where renewable or low carbon hydrogen requirements are in place
- Edrive vehicle fuel-cycle emissions should be compared against the combined vehicle and fuel cycle emissions of internal combustion engine (ICE) vehicles



Upstream GHG Intensity



Projected 2015 Emissions (source: ICCT)



Vehicle Activity Level

- Vehicle activity level determination
 - Plug-in hybrid electric vehicle utility curves adjusted to account for blended operation that would extend charge depleting range
 - Edrive vehicle total emissions and emissions displaced based on relationship between daily travel range and annual vehicle kilometers traveled
 - Potential adjustment for battery electric vehicle range anxiety, and extra 'plugs'



Vehicle Activity Level

- Total emission calculations based on emission rates and activity levels
 - Useful for policy evaluation and inventory purposes.
 - Can be considered for weighting battery electric vehicle scores for regulatory compliance (ie CO₂e/km or liters/km)



Summing Up Proposed Emission Calculations

- Edrive grams CO₂e/km =
kwh or kg H₂/km x fuel GHG intensity
- Edrive tons CO₂e/year =
edrive activity level x gCO₂e/km
- Edrive avoided tons CO₂e/year=
(ICE tailpipe g CO₂e/km + ICE upstream
gCO₂e/km - edrive gCO₂e/km) x activity level



Potential Additional Research Topics

- Battery efficiency
 - Effect of hot and cold temperatures on battery discharge efficiency
 - Effect of state of charge on battery discharge efficiency
 - Effects of battery temperature management on overall efficiency (air or liquid cooling)
- Vehicle efficiency
 - Additional quantification of effect of cabin climate control on vehicle energy usage
 - Comparison to current and also extremely efficient ICEs
 - Future hybrid ICE may have efficient electric air conditioning systems, but possibly insufficient “free” waste heat for cabin climate control



Potential Additional Research Topics

- Test cycles
 - Coordination of edrive vehicle test cycle development
 - Sharing of testing data



Potential Additional Research Topics

- ◆ Effect of vehicle utilization
 - Are electric drive vehicles driven differently from other vehicle categories, due to self selection and/or increased awareness?
 - Is there a linear relationship between plugs and range?
 - Is there a typical factor for 'range anxiety' that reduces battery electric vehicle daily travel and thus displacement of conventional vehicles ?



Potential Additional Research Topics

- Drive energy supplies GHG intensity
 - Marginal vs average emissions rate
 - Level of geographic specificity
- Additional potential upstream evaluation
 - Battery manufacturing



Thank you

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