Probabilistic LCA

A fast and effective approach to Life-Cycle Assessment of Greenhouse Gas Emission impacts of Electric vehicles

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ERMES Plenary 2021

Global fuel use in perspective

- Global road transport
  ~ 3 trillion litres of fuel per year
  (diesel, petrol, LPG/CNG)
- One of the World's biggest swimming pools:
  San Alfonso del Mar, Chile...
- Road transport burn almost 12,000 of these pools filled with fossil fuels per year.
- One pool full of fossil fuel, every 45 minutes.

- Two olympic-size swimming pools every minute...
- Australia: 1.2% of road transport fuel use (~ 150 pools) – 0.3% world population

Australian PV fleet CO_2 performance

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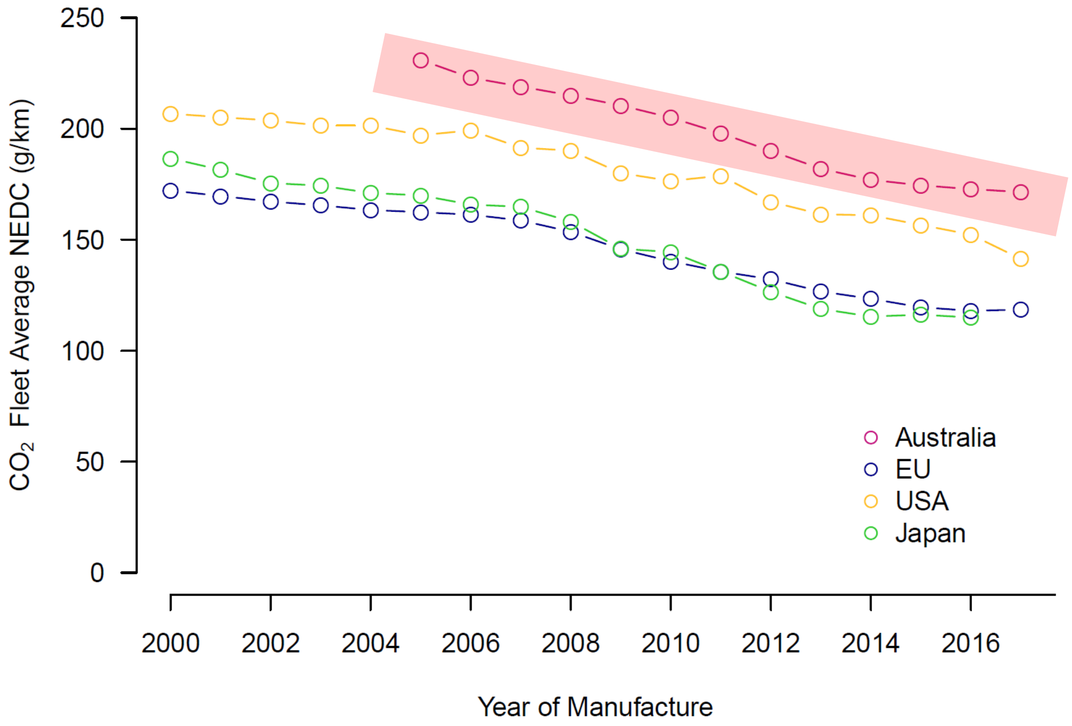

A comparison with the EU, USA and Japan confirms that new Australian passenger vehicles are underperforming in relation to CO_2 emissions (and fuel economy).

TER, 2019. Real-world CO_2 emissions performance Australian new passenger fleet
https://www.transport-e-research.com/publications

Australian PV fleet CO_2 performance

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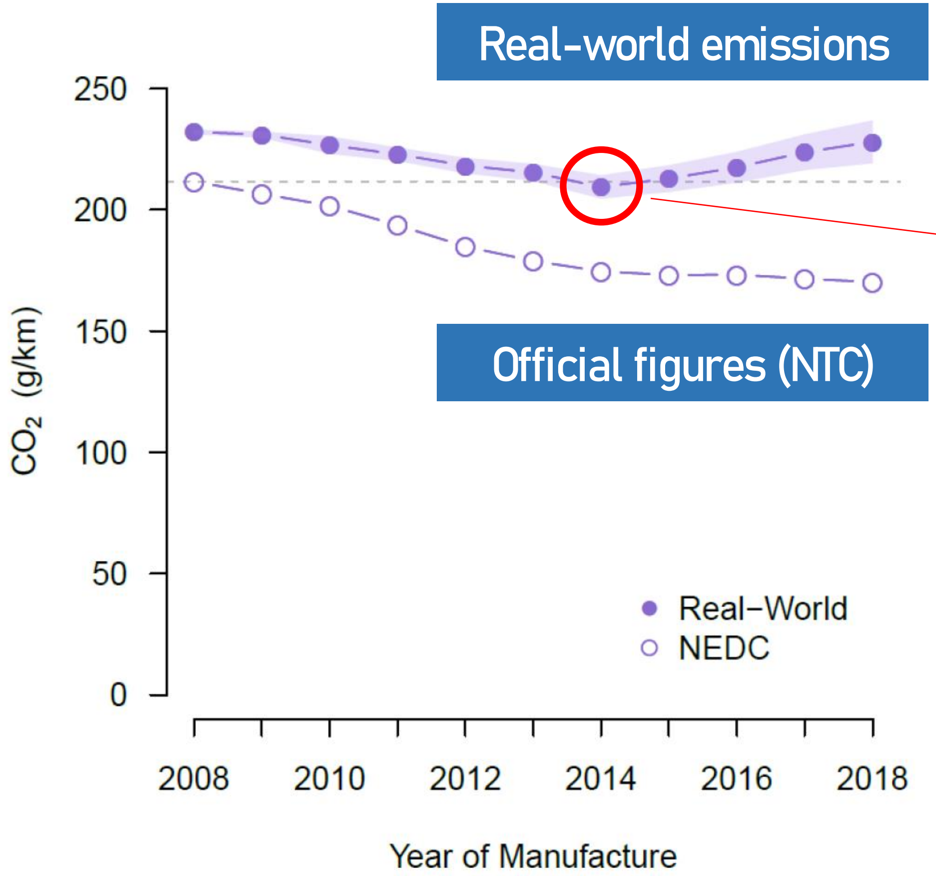

New cars/SUVs:

- Trend reversal: on-the-road average emission rate has been increasing with +2% to +3% since 2015.
- Culprits: continuous increase in vehicle weight + shift to more 4WD vehicles (diesel).
- The gap between the official test and real-world on-the-road CO_2 performance has increased from 10% in 2008 to about 35% in 2018.

TER, 2019. Real-world CO_2 emissions performance Australian new passenger fleet
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What to do?

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- GHG emissions from road transport:
  Australia = moving in the wrong direction.
- So the question is: what to do?
  How can we change this?
- Battery electric vehicles (BEVs) are generally seen as the best solution to rapidly reduce GHG emissions from road transport.
- But does this hold true for the Australian on-road fleet with its own unique characteristics?

GHG LCA – electric versus fossil-fueled

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- Life-Cycle Assessment (LCA)
- Systematic method that considers + evaluates all aspects of a vehicle's life and its associated impacts (cradle-to-grave).
  - Vehicle production
  - Fossil fuel production (ICEVs)
  - Electricity production (BEVs)
  - Vehicle operation
  - Disposal and recycling
- Clarify potential trade-offs between different environmental impacts and between different stages of the entire life cycle.

GHG LCA – electric versus fossil-fueled

copert AUSTRALIA

Vehicle emissions software,
226 vehicle classes, GHGs (CO_2, CH_4, N_2O)

AFM

Australian Fleet Model: predicts dynamic changes in on-road vehicle population and total vehicle kilometres travelled for 1240 vehicle classes for past, current and future base years.

Detailed vehicle parameter data such as vehicle weight, battery capacity: Australian + International databases (e.g. GVG, VFACTS, TER, …).

Australian Government
Department of Industry, Science, Energy and Resources

Australian Government
Clean Energy Regulator
CLEAN ENERGY REGULATOR

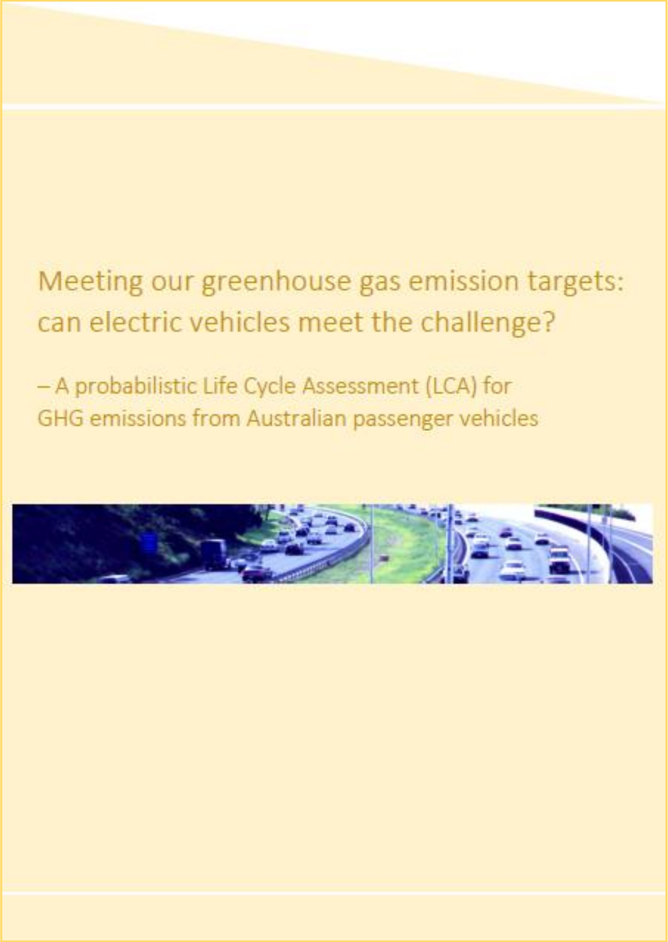
Analysis of Australian GHG data, energy data and fuel statistics (NGA, AES, CER).

Meta-analysis studies: relevant data requested and received from authors (e.g. infrastructure GHG).

International scientific papers/reports + analysis underlying data (e.g. grid transmission losses, battery charging losses, on-road electricity use BEVs, etc.)

GHG LCA – electric versus fossil-fueled

- Life cycle impacts = complex, localised, dynamic.
- Important that uncertainty is quantified.
- Probabilistic Life-Cycle Assessment.
- Functional unit =
  PV fleet-average emission rate
  in g CO_2-e per km


Meeting our greenhouse gas emission targets: can electric vehicles meet the challenge?

– A probabilistic Life Cycle Assessment (LCA) for GHG emissions from Australian passenger vehicles

TER, 2020. https://www.transport-e-research.com/publications.

GHG LCA – electric versus fossil-fueled

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- Probabilistic LCA:
  - Considers most likely (plausible) values for each LCA aspect + associated levels of uncertainty.
  - Define input probability distributions:
    - Bootstrap resampling technique
    - Review of scientific literature
    - Australian and international data
    - Australian models
  - Monte Carlo simulation propagates uncertainty to the model outputs (grams GHG per kilometre).

GHG LCA – electric versus fossil-fueled

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Table 3 – LCA GHG emission factors for Australian ICEVs and BEVs (Monte Carlo).

Technology	Average $g\ CO_2$-e/km	Lower 95% confidence limit $g\ CO_2$-e/km	Upper 95% confidence limit $g\ CO_2$-e/km
ICEV	362	336	389
BEV	260	227	297
Difference (BEV-ICEV)	-102	-144	-57

- BEVs will reduce GHG emission rates with 16% to 40% (28% on average) for the current (2018) Australian electricity mix.

- None of the 100,000 uncertainty simulations generated a higher emission rate for BEVs.

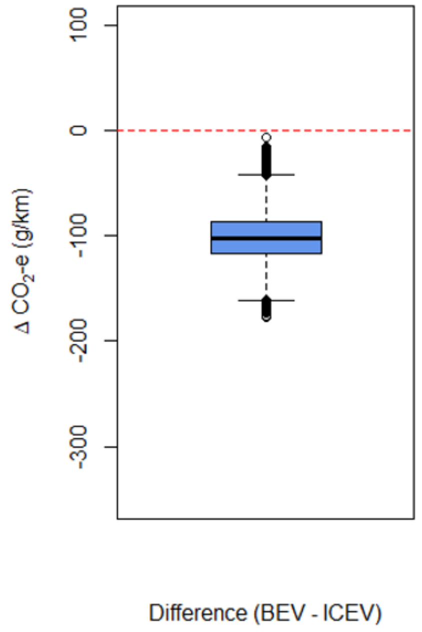


Figure 2 – Box-plot showing Monte Carlo simulation results for the difference in GHG emission rate distributions of BEVs and ICEVs.

GHG LCA – electric versus fossil-fueled

- A worst-case 'marginal electricity' (ME) scenario, which is relevant for short term impact assessment.

- The ME scenario is 100% fossil fuelled and assumes an Australian electricity mix of 73% coal, 24% gas and 3% oil.

- BEVs will reduce GHG emission rates between 5% and 29% (17% on average) for a 100% fossil-fuelled marginal electricity mix.

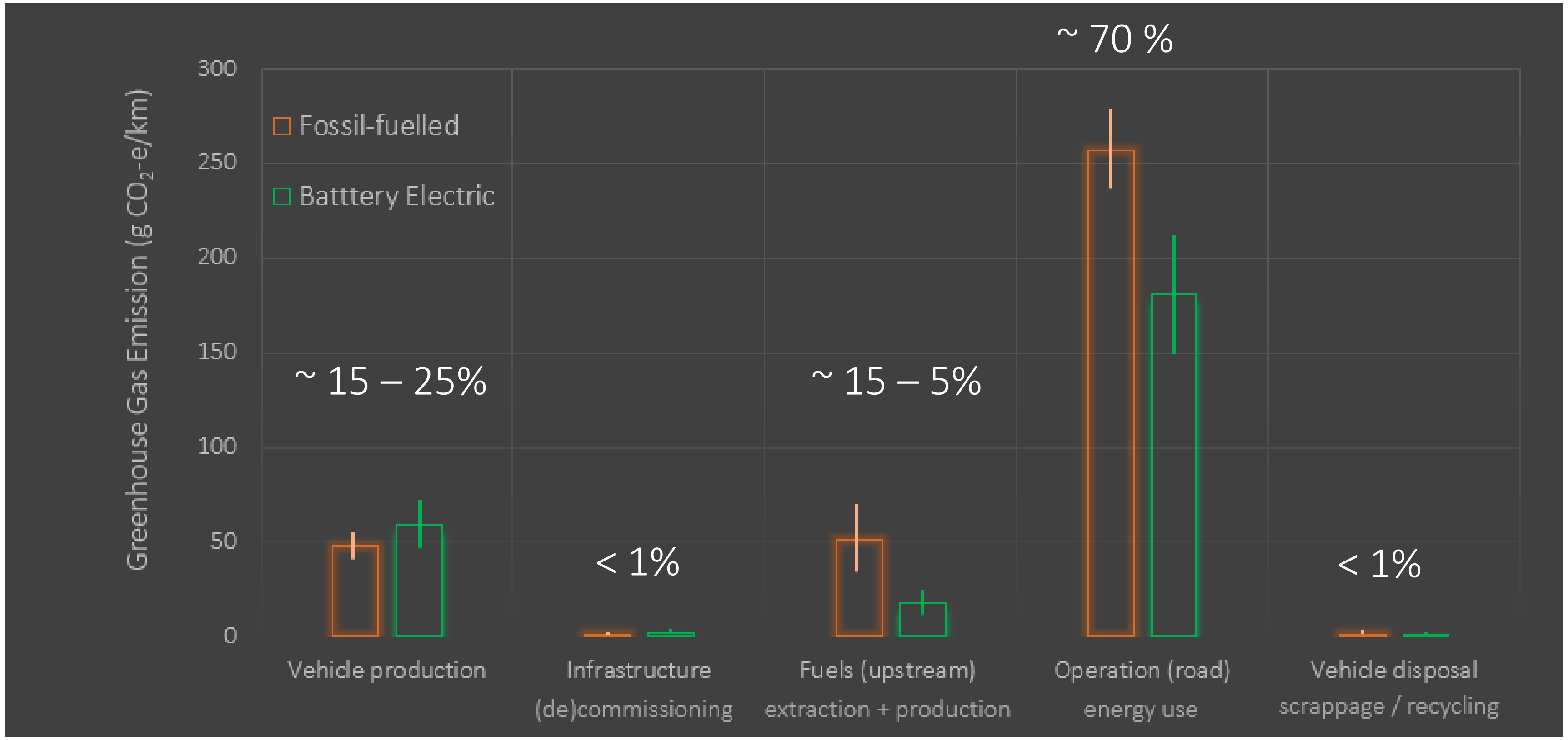
GHG LCA – electric versus fossil-fueled

- A longer term Australian renewable energy (RE) scenario.

- The RE scenario assumes a 90% renewable Australian electricity mix of 5% coal, 5% gas, 30% hydro, 25% wind, 5% biomass and 30% solar.

- BEVs will provide deep reductions in GHG emission rates with 68% to 82% (74% on average) for a more renewable Australian electricity mix.

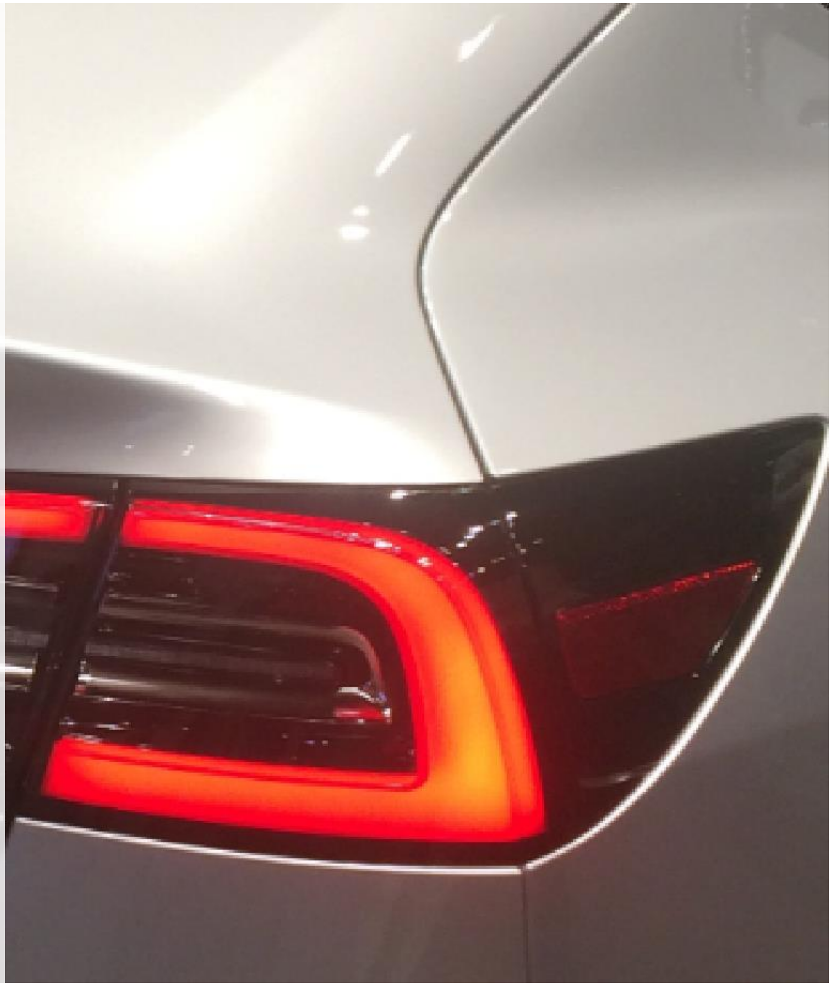
GHG LCA – electric versus fossil-fueled



GHG LCA – electric versus fossil-fueled

In conclusion – the weight of evidence

- Rapid electrification of the Australian PV fleet is a robust way to reduce GHG emissions from road transport.
- It will immediately provide significant reductions in GHG emissions per kilometre travelled.
- GHG emissions will continue to drop further as Australia's electricity system is increasingly decarbonised.



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Real-World CO_2 Emissions Performance of the Australian New Passenger Vehicle Fleet 2008-2018

– Impacts of Trends in Vehicle/Engine Design

September 2019

Non-Exhaust PM Emissions from Battery Electric Vehicles (BEVs)

– does the argument against electric vehicles stack up?

August 2020

Probabilistic Life Cycle Assessment for Greenhouse Gas Emissions from Australian Passenger Vehicles

– What is better: electric or fossil-fuelled?

December 2020


Thanks for your attention
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