

Future LCA databases for prospective LCA of electric cars – Does the electricity used to make steel and batteries make a difference?

In this work we create future versions of the ecoinvent 3.3 database that reflect potential developments of the electricity sector until 2050. We modify the efficiency and direct emissions of future fossil, biomass and nuclear power plants as well as the share of technologies in the electricity supply mix for 26 global regions based on results from two scenarios from the IMAGE integrated assessment model.

We use these future versions of the ecoinvent database to assess the environmental impacts of electric passenger vehicles. Using the same assumptions about the future performance of electric vehicles, we find that considering changes to the upstream electricity sector can change results by over 50%, depending on environmental impact category and electricity scenario. This illustrates the importance of future electricity supply not only for electric vehicle charging, but for the entire life cycle.

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Research goal

The current best practice for LCA of future vehicles includes improvements to future vehicle performance and use of different scenarios for the energy mix used for refilling/ recharging [1]. However, the changes to the electricity mix are not propagated through the entire LCA database, potentially underestimating differences between different scenarios.

In this work we make a first attempt at including the changes to the electric sector into the whole LCA database, affecting impacts of producing vehicle inputs such as steel, roads, and lithium batteries.

We use electricity scenario results from the IMAGE model [2] to create future versions of the ecoinvent LCA database [3] that can be used to perform LCA of future vehicle technologies.

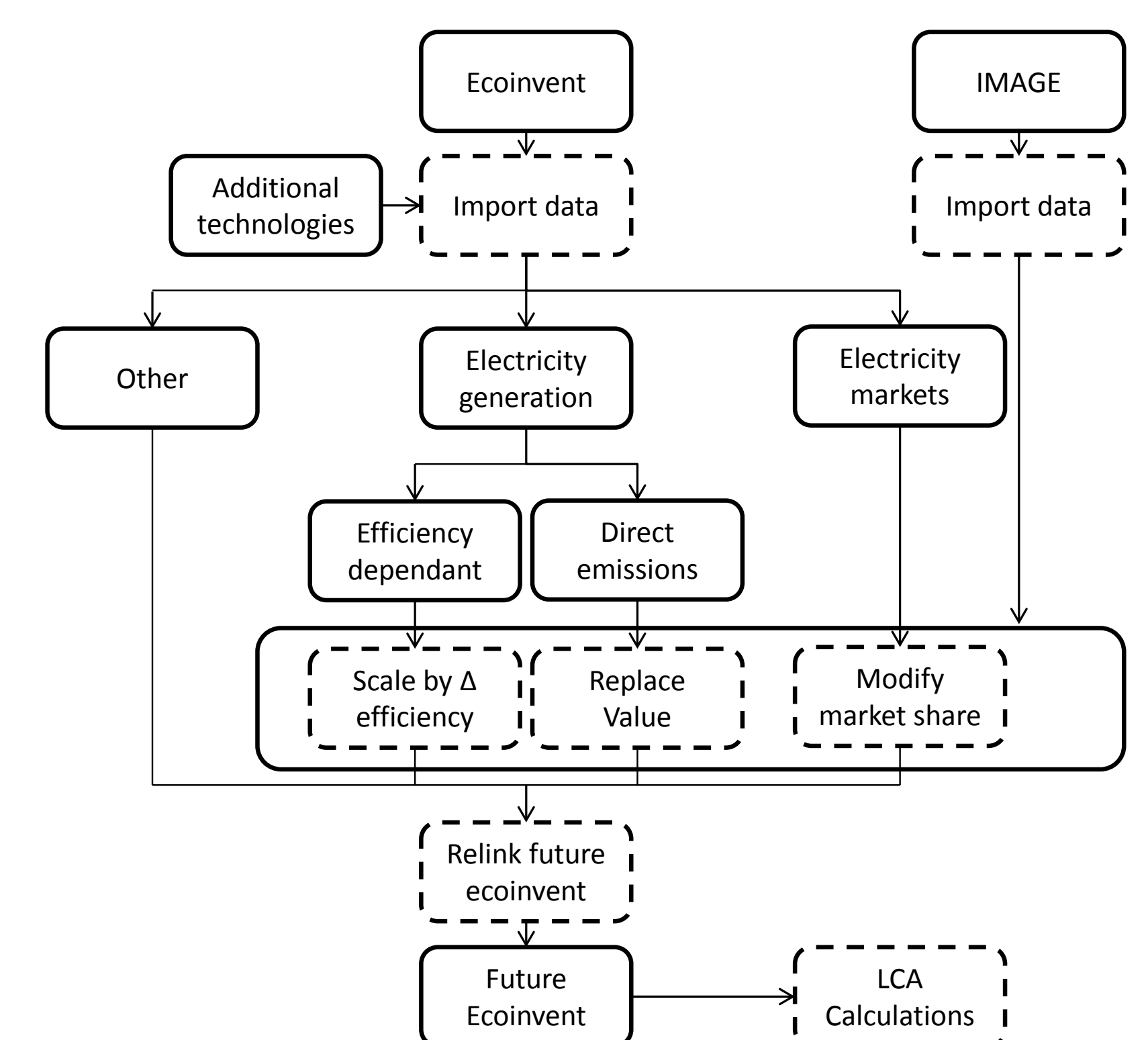
Databases

Ecoinvent is an LCA database with over 10 300 datasets and is widely considered the most comprehensive and transparent LCA database available. Ecoinvent has detailed coverage of the energy, materials and transport sectors, making it ideal for LCA modelling of electric mobility.

IMAGE is an integrated assessment model that focusses on environmental and sustainability issues for 26 world regions. It has been used to generate long term scenario results for the European Commission, IPCC, UNEP and OECD.

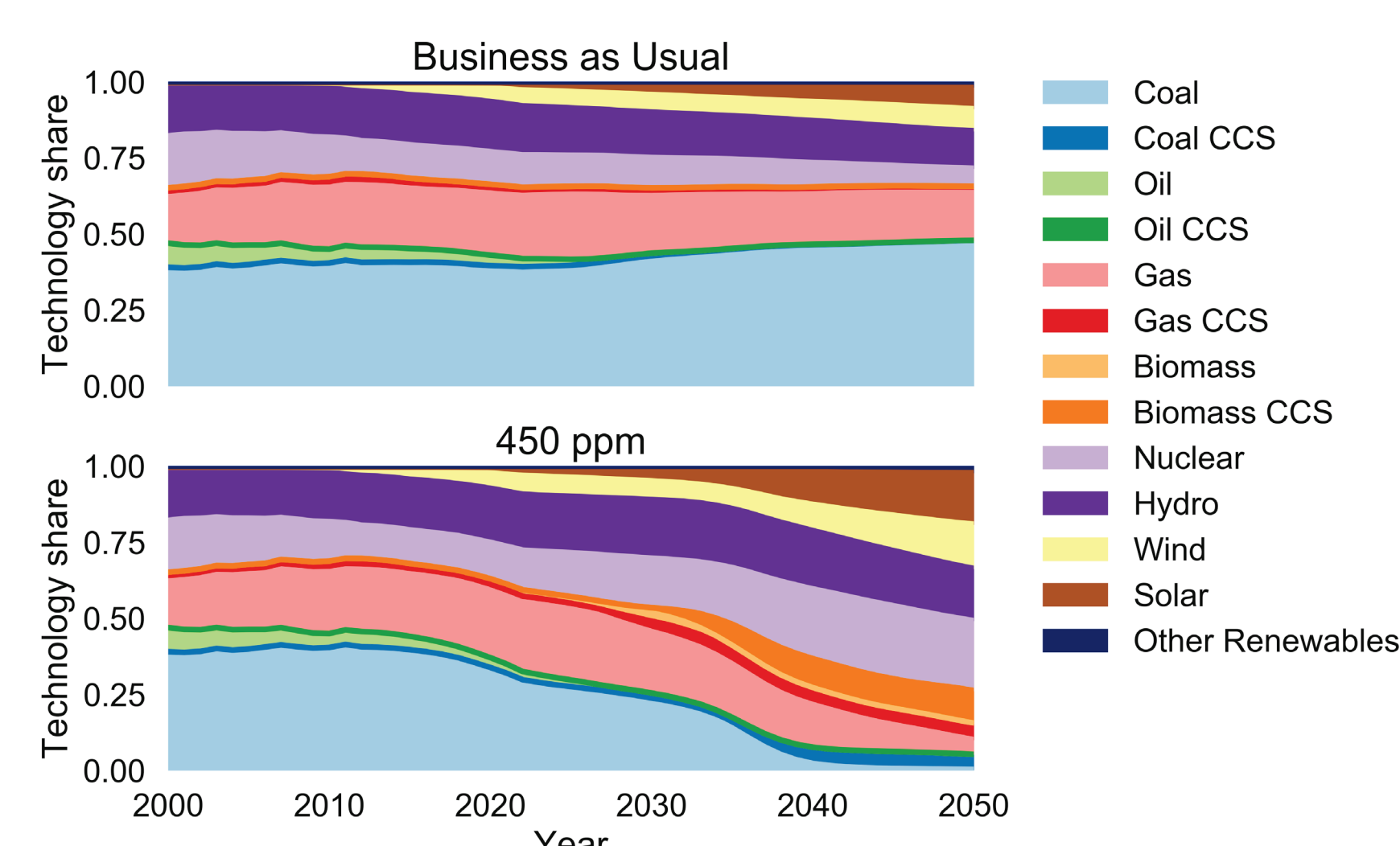
We consider IMAGE electricity sector results for two scenarios for 2050: Business as Usual (BAU) and an aggressive 450 ppm climate policy (450) and use them to create new versions of ecoinvent.

Methodology



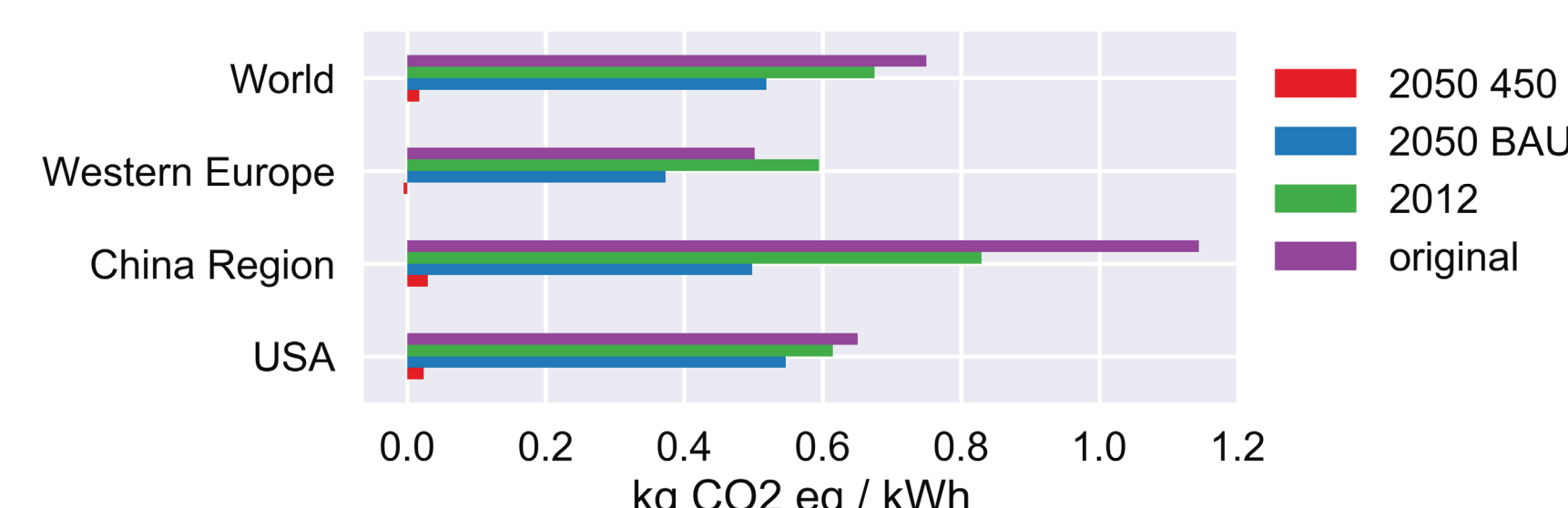
Updating ecoinvent's electricity sector

We modify all ecoinvent fossil, biomass and nuclear electricity generation technologies. NO_x , SO_2 , CO , CH_4 and N_2O emissions per kWh are used directly from IMAGE. Other exchanges amounts, where applicable, are scaled by the relative efficiency difference between IMAGE and ecoinvent. Ecoinvent regional electricity markets are also modified using IMAGE market shares. Image results for the global electricity mix are shown below, though results are differentiated for 26 regions.

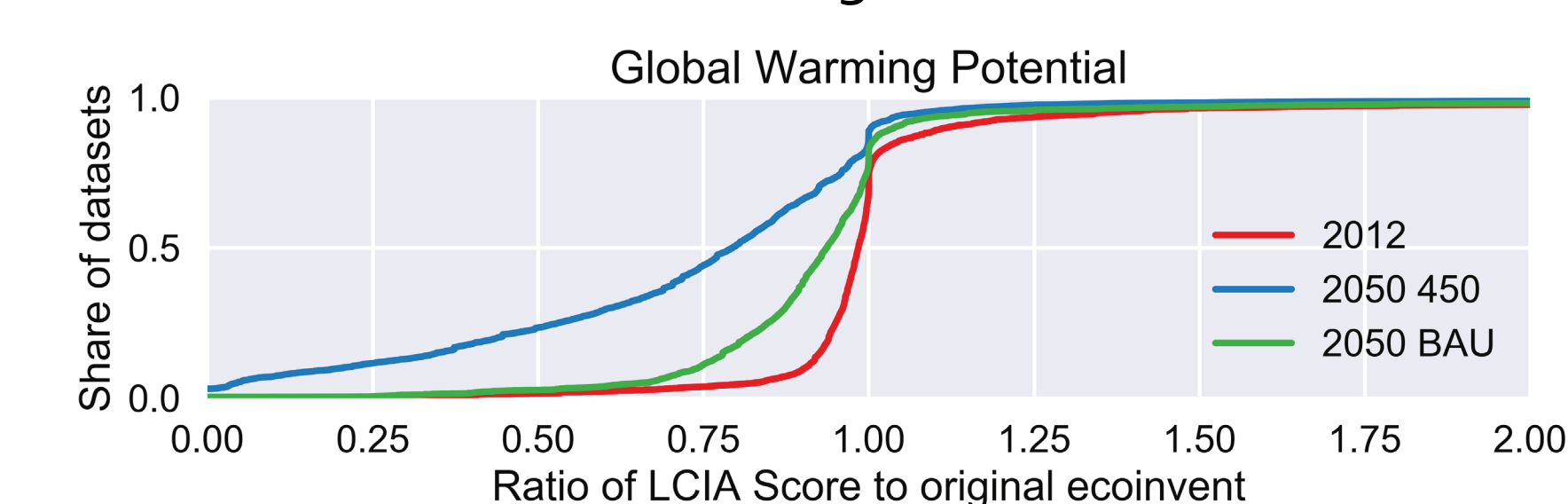


Database results

We show global warming potential scores for selected electricity markets for versions of ecoinvent: original ecoinvent, 2012 (ecoinvent modified to use values from image results in 2012), 2050 BAU, and 2050 450.



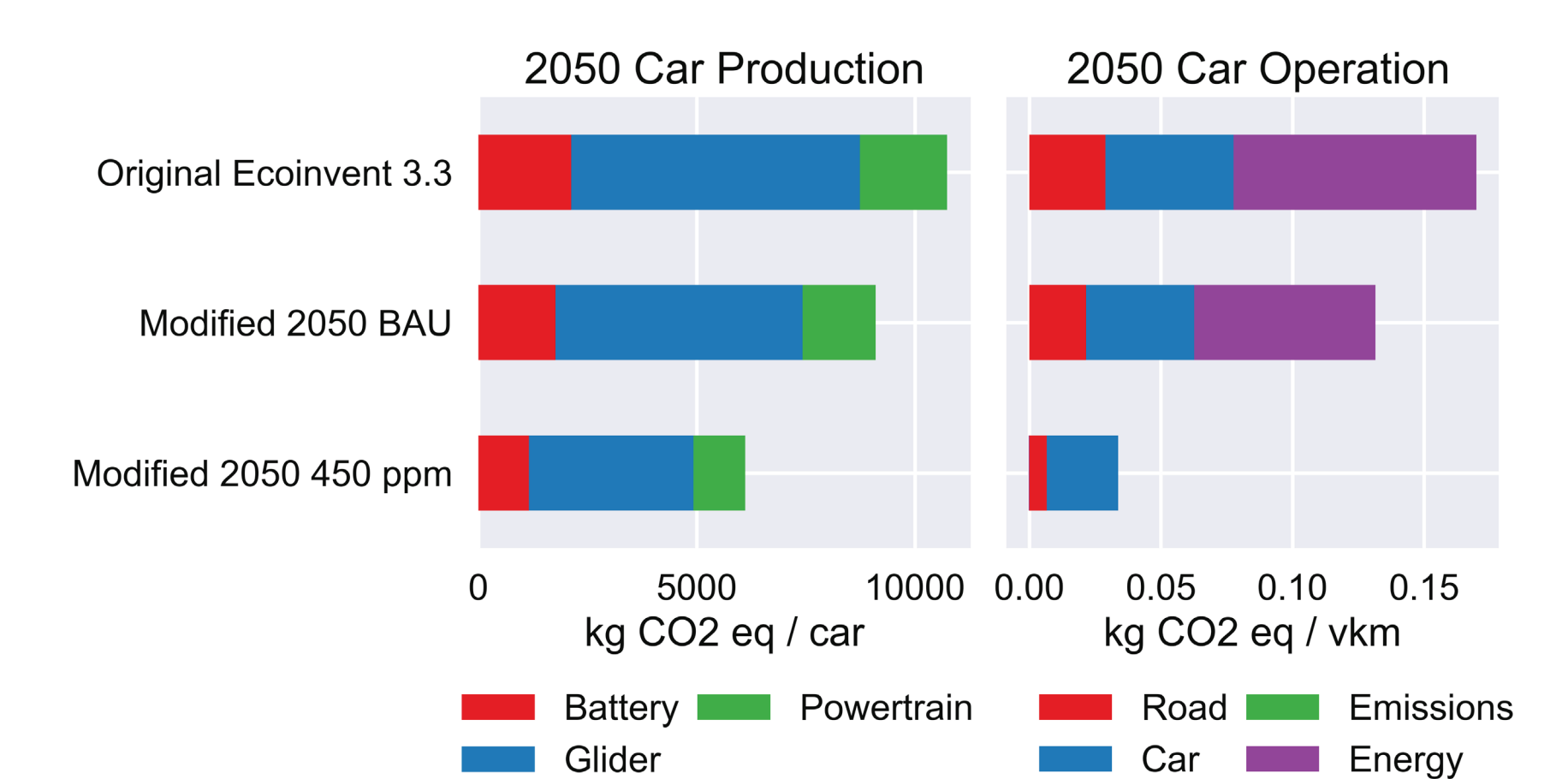
Here we compare the ratio of the global warming score in the updated database to the original database for every dataset in ecoinvent. Steep curves indicate little change, while shallow curves indicate greater differences.



Results for electric cars

We examine the life cycle global warming impacts of a 2050 electric car (500 km range, European average electricity used for charging, dataset from project THELMA [1]) calculated with the original ecoinvent database and our two future versions of ecoinvent.

We show the impacts from producing electric cars (left), and the total impacts per vehicle kilometer travelled (right). It is clear that the electricity mix is important for more than just the impacts of charging electric vehicles. Future work should focus on finding robust and reliable methods to develop future LCA databases.



References

- [1] Hirschberg, Stefan et al. 2016. Opportunities and challenges for electric mobility: an interdisciplinary assessment of passenger vehicles. Final report of the THELMA project in co-operation with the Swiss Competence Center for Energy Research "Efficient technologies and systems for mobility". PSI, EMPA and ETHZ. Available at <https://www.psi.ch/ta/thelma>
- [2] <http://themasites.pbl.nl/models/image>
- [3] <http://www.ecoinvent.org>