

# **Critical review of Life Cycle Assessment of Electric Vehicles**

**LCA Practitioner: Arup  
LCA Commissioner: Energy Efficiency and Conservation  
Authority**

**Critical review by: Tim Grant**

**Version 2**

**17<sup>th</sup> December 2015**

## 1. The brief

Life Cycle Strategies was asked to critically review the Life Cycle Assessment (LCA) of electric vehicles undertaken by ARUP Pty Ltd for Orica Specialty Chemicals. The information provided for the review was:

- Word document - Arup-Verdant Vision - NZ EECA Electric Vehicles LCA - Draft Final Report ....docx received on the 15<sup>th</sup> of June; and
- SimaPro project database on NZ\_EECA\_EV\_LCA\_2015-06-15\_10-07-54.SPBackup dated 15<sup>th</sup> of June 2015.

This initial review was provided on 17<sup>th</sup> of June 2015 to the client.

The modified report was supplied 13<sup>th</sup> October 2015

The life cycles assessment (LCA) is being assessed against the international LCA standards ISO 14040 Principles and Framework (International Organization for Standardization 2006) and Requirements and Guidelines (International Organization for Standardization 2006).

The focus of the review is on the compliance with the standards and the robustness of the data and methods used to draw the conclusions in the LCA.

## 2. General comments

I congratulate the authors on pulling together this study in such a short time and in a practical and understandable manner.

It is recognised that the aim of the report is to have a readable robust study in plain English and with a minimum of jargon and technicalities of the LCA. The report has achieved this with the aid of appendices and has struck a good balance. The revised version has improved on the original version which had a significant number of missing elements that are required by the ISO standards.

The data used for the study are sufficient for the high level view of the issues however with so much generalised data, the results are stretched when trying to make comment on indicators such as human toxicity. Modelling of the New Zealand air shed and accounting local drive cycle impacts would be needed to accurately model such impacts which are taken from rather different city types and vastly different air sheds. Having said this, the shift from ICE engines to electric represents an almost complete removal of mobile emissions therefore the detailed modelling of air shed and drive cycles would most likely only adjust the extent of the conclusions and not their direction. It should be noted in the study that the aim is not to compare petrol and diesel vehicle against each other as the data quality is not sufficient for this. It may be an idea to avoid this by combining these into current ICE average – as this is needed for the uncertainty assessment approach – noted below.

The update to version 3.1 of ecoinvent and the new USETOX indicators is a major improvement.

The uncertainty analysis has been changed to take account of correlated uncertainties which solves the issues in the first version.

### 3. Specific comments

Section	Comment	Action required	Second review comment
<b>General Aspects</b>			
LCA commissioner	Present page 4	None	
LCA practitioner	Present page 4	None	
Date of report	Present front page	None	
Statement on ISO compliance	Present page 5	None	
<b>Goal of the study</b>			
Reasons for study	Present in overview page 4	None	
Intended application	Not stated how the results will be used – published to motorist, website tool, purchasing policy?	Add additional text	Fixed - ok
Target Audience	Inferred it's for “among motoring enthusiasts, sustainable transport advocates, and energy providers” but not clear who the audience is.	Add additional text	Fixed - ok
Statement on Comparative Assertions	It should be noted that this is a comparative assertion which will be disclosed to the public.	Add additional text	Fixed - ok
<b>Scope of the study:</b>			
Statement of performance	There is no clear statement of the characteristics of vehicles being compared. The segment of vehicles being considered should be included – for example, small to medium two wheel drive passenger car.	None	Fixed - ok
Omission of functions	Are the car types equivalent, e.g. towing is difficult with electric cars?	Add additional text	Improved
Functional unit	If the statement of performance narrows the vehicle type, this should be included in the functional unit definition	Update	Improved
System boundary omissions	Documented on page 13	None	
System boundary inclusions	Documented on page 12	None	
Cut-off criteria	Documented on page 15	None	

Section	Comment	Action required	Second review comment
<b>Life cycle inventory analysis</b>			
Data collection procedures	Contained through section 4	None	
Description of unit processes	Section 4 is broken into different processes. There is no explicit listing of unit processes but these have been reviewed in the SimaPro process model. It's possible they are to be pasted as flow charts in Appendix C	Check Appendix C	Done ok
Sources of published literature	Data sources are listed in main section and in Appendices	None	
Calculation procedures	<p>There is no mention in the study of the approach to modelling. If the study is taking an attributional or consequential view point. This is particularly important given the study is addressing a potential shift from one liquid fuel production system to electric fuel system which will change the demand for electricity and fuels in the future.</p> <p>On page 7 it states  This study does not attempt to predict the future, but rather conducts the LCA comparison based on a snapshot in time (the present). The only forecasts included</p> <p>This is a prediction of the future – that the future will be the same as the present.</p> <p>A justification as to what approach has been taken - looks predominantly attributional – a sensitivity of alternative assumptions around grid supply based on future marginal production would be valuable.</p>	Consider adding section on calculation procedure.	Fixed ok
Data quality assessment	Data quality indicators were included in Pedigree score. Still some qualitative assessment of data quality would be useful for understanding the report	Consider updating	Not done
Treatment of missing data;	Covered on page 7	None	
Sensitivity analysis	Present and comprehensive in section 6	None	
Allocation principles and procedures	Not present. Although there are no major allocation issues in the study	None	
<b>Life cycle impact assessment</b>			
LCIA Procedure and results	Results presented in section 5	None	

Section	Comment	Action required	Second review comment
Rational for Indicators	There is no rationale provided for the impact indicators. Justification for inclusion and exclusion of indicators needs to be provided	Add	
Selection of Indicators	The choice of toxicity model from Australian data from 2006 seems odd given the importance of global supply chain involved in vehicle manufacture. The model is giving very high results for metal emissions which are known to be poorly handled by the USESLCA model which the Lundie paper was based on. “USEtox is a scientific consensus model endorsed by the UNEP/SETAC Life Cycle Initiative for characterizing human and ecotoxicological impacts of chemicals.” <a href="http://www.usetox.org/">http://www.usetox.org/</a>	Consider revising to USETOX	Done - fixed
Definition of characterisation models	Provide in section 2.7.	None	
Description of value choices	Weighting and normalisation is not used, so there is no need to describe value choices.	None	
Statement of limitations of LCIA	There is no statement that the LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.	Add statement	Limitations better described in results
<b>Life Cycle Interpretation</b>			
Results	Provided in section 4 for all indicators	None	
Assumptions and limitations	Provided in section 4 for all indicators	None	
Data quality assessment	There is no structured data quality assessment and this would be valuable addition. While uncertainty assessment is provided in		
<b>Requirements specific to Comparative Assertions disclosed to the public.</b>			
Analysis of material and energy flows	While not explicitly undertaken for materials, energy flows are tracked in embodied energy indicator	None	
Assessment of the precision, completeness and representativeness of data used	This has not been undertaken and should be added, at least in the appendix as part of the data quality assessment mentioned earlier. This is part of the qualitative data quality assessment.	Consider adding	Not Added

Section	Comment	Action required	Second review comment
Description of the equivalence of systems being compared	As mentioned in goal and scope a narrower description of the system is required with commentary on the equivalence or not of electric vehicles compared to conventional vehicles	Add additional text	Vehicle descriptions improves this
Evaluation of the completeness of the LCIA	The rational of the indicators chosen should include statement on completeness of those indictors to represent environmental comparison of alternative vehicles.	Add additional text	Added - ok
A statement on international acceptance exists	Comment on the International acceptance of indicator models should be added to indicator descriptions in Appendix B	Add additional text	Added - ok
Scientific and technical validity of indicators used	As the indictors are explained in detail and are all based on major indicator models their scientific and technical validity can be taken as being compliant	None	
Uncertainty and sensitivity analysis.	<p>Figure 22, Figure 23 and the error bars in D2 are incorrect as they ignore correlated uncertainty and therefore overestimate the uncertainty of the comparison. SimaPro will not produce the graphs as shown due to the problem of correlated uncertainty. SimaPro takes account of correlated uncertainty by assessing the difference between two options.</p> <p>The comparative assessments show no uncertainty in the PM results from electric vehicles compared to petrol, while figure 29 suggests substantial overlap in error bars. Terrestrial ecotox and freshwater ecotox show no significant difference.</p> <p>Method: NZ EECA LCA Impact Assessment v2 V2.00 , confidence interval: 95 %</p> <p>1 km Transport, passenger car, electric {NZ}   per km   Alloc Def, U' (B),            Uncertainty analysis of 1 km Transport, passenger car, small size, petrol, EURO 5 {NZ}   per km   Alloc Def, U' (A) minus</p>	Amend	Fixed ok

Section	Comment	Action required	Second review comment
Evaluation of the significance of the differences found.	Comparative uncertainty assessment between options should be undertaken to determine the significance of the differences found as suggested in previous point.	Add statistical significance of results	Added Appendix D
<b>Analysis of SimaPro Model</b>			
Diesel impact in ecoinvent 3.1 compared to 3.0	<p>3.0 on the left has much lower acidification impacts than 3.1 due to change in market assumption and correction of data anomalies in 3.0. This change actually shifts the direction of the acidification indicator in the results.</p>	Suggest update to ecoinvent 3.1 for background processes	Fixed - OK
Uncertainty specification	The uncertainty approach outlined in section 6.5.1 has not been applied to the foreground data in the SimaPro model for most parameters and flows used.	Amend	Fixed ok
<b>Other aspects</b>			
Appendix C	Is blank – not sure what is meant to be here	Update	Fixed - ok



Section	Comment	Action required	Second review comment
Results p39	<p>This makes no sense - acidification, mineral depletion, particulate matter etc. do not fall into these categories.</p> <p>This study particularly assesses two general areas of environmental issues:</p> <ul style="list-style-type: none"> <li>• Greenhouse gas emissions; and</li> <li>• Toxicity.</li> </ul>	Amend	Fixed - ok
Results p43	<p>The following sentence seems inaccurate - there are certainly impacts from copper but aluminium does not seem to be major contributor to abiotic depletion from the SimaPro model</p> <p>The BEV and PHEV batteries and drivetrain results are also due to their higher amounts of wrought aluminium (especially the PHEV) and copper (especially the</p>	Check	Fixed ok
Results section 5.5	Note earlier mention that using ecoinvent3.1 the results for acidification are flipped around primarily due to refinery impacts increasing 50%	Update	Updated - ok
Human toxicity	There is no significant difference between the results presented. As suggested earlier change to USETOX would be preferable for this study. Care should still be taken with comparisons based on toxicity.	Update	Fixed ok
Page 50	Revise discussion after updating with USETOX. Particulate matter is not an add on, but has been a separate and important indicator for some years now. Its inclusion should be added to the justification of indicators. The impact of tail pipe from diesels especially are well represented in USETOX .	Revise	Fixed ok

## 4. References

International Organization for Standardization (2006). International Standard, ISO/DIS14040, Environmental Management Standard- Life Cycle Assessment, Principles and Framework. Switzerland.

International Organization for Standardization (2006). International Standard, ISO/DIS14044, Environmental Management Standard- Life Cycle Assessment, Requirements and Guidelines. Switzerland.



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**17<sup>th</sup> December 2015**

**Reviewer Statement**

**Re: Critical review Life Cycle Assessment of Electric Vehicles**

**LCA Practitioner: Arup**

**LCA Commissioner: Energy Efficiency and Conservation Authority**

**To whom it may concern**

The Life Cycle Assessment of Electric Vehicles was reviewed between June and October 2015 by Life Cycle Strategies Pty Ltd. This study provides a rigorous assessment of conventional and electric vehicle used in New Zealand. The data used are sufficient for the purpose of the study as outlined in the goal and scope and the results and interpretation are supported by the data presented. It is my opinion that the study complies with the broad requirements of the ISO 14044 Environmental Management Standard- Life Cycle Assessment, Requirements and Guidelines.

Regards

A handwritten signature in black ink, appearing to read "Tim Grant", written in a cursive style.

Tim Grant  
Director, Life Cycle Strategies