The Role of Life Cycle Assessment in Evaluating Alternatives for Electrification of Roads and Long Haul Trucks in Sweden

Anders Nordelöf, Anna Björkman, Maria Ljunggren Söderman, Anne-Marie Tillman

Environmental Systems Analysis, Department of Energy and Environment, Chalmers University of Technology, Sweden

Aim of Presentation

To show how **life cycle assessment (LCA) has been used as an evaluation and learning tool in** a case study of emerging technologies for vehicle and road electrification.

A master thesis project at Scania CV AB and Chalmers University of Technology.

Background

In 2012 the Swedish Government presented a 1.3 billion SEK investment to improve infrastructure for transportation of iron ore powder. This has enabled the construction of a test track for evaluation of electric road technologies for long haul trucks.

Scania is the supplier of 90 tonne long haul trucks for transport of iron ore powder. They electrify their vehicles to offer their customers better fuel economy and reduced tailpipe CO_2-emissions. The Hybrid Systems Development department is active in the rapidly evolving area of electric roads but has little prior LCA experience.

Goal of LCA Study

Commissioned to investigate environmental impact:

1. **What is the difference in impact between two electrified alternatives and a conventional truck?**
2. **Which added component has the largest impact?**
3. **Which life cycle phase has the largest impact?**
4. **Assuming a constant extraction rate per year, how long time must the mine be operated before a break-even is reached?**

Alternatives for Electrification of Long Haul Trucks

Reference vehicle:

Conventional long haul truck

- Total weight, 90 tonnes
- 65 tonne iron ore powder load capacity
- Conventional diesel based drivetrain

Parallel hybrid truck

Equivalent to the reference except for:

- More efficient drivetrain – 4 % less fuel per km, but no external charging
- Main added components: inverter, electric machine, DCDC converter, lithium-ion battery and housing.
- 0.8 % decrease of total load capacity per truck

Catenary hybrid truck

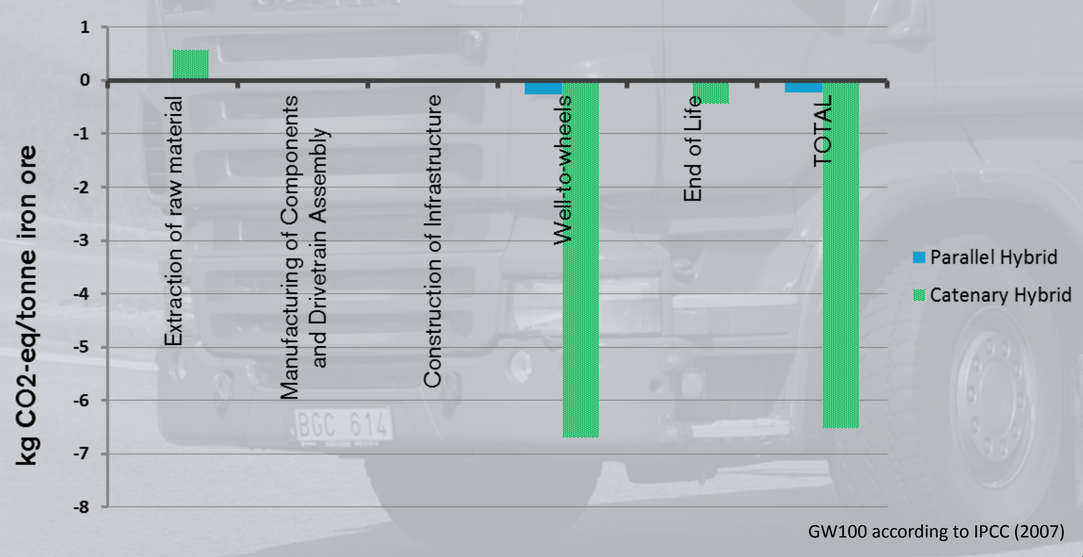
Identical to the parallel hybrid except for:

- External electric power supply from overhead wires
- New infrastructure to provide electricity
- A pantograph to collect electricity
- No lithium-ion battery
- Three times bigger electric machine

The life cycle of the added components for all required vehicles and added infrastructure on 140 km of road (raw material extraction, manufacturing and assembly, waste handling and recycling of materials) have been compared to the effect of the reduction of total energy use in the well-to-wheels life cycle of the energy carriers over 16 years of mining operation.

Photo: Scania CV AB

Global Warming Potential Relative to the Reference Vehicle



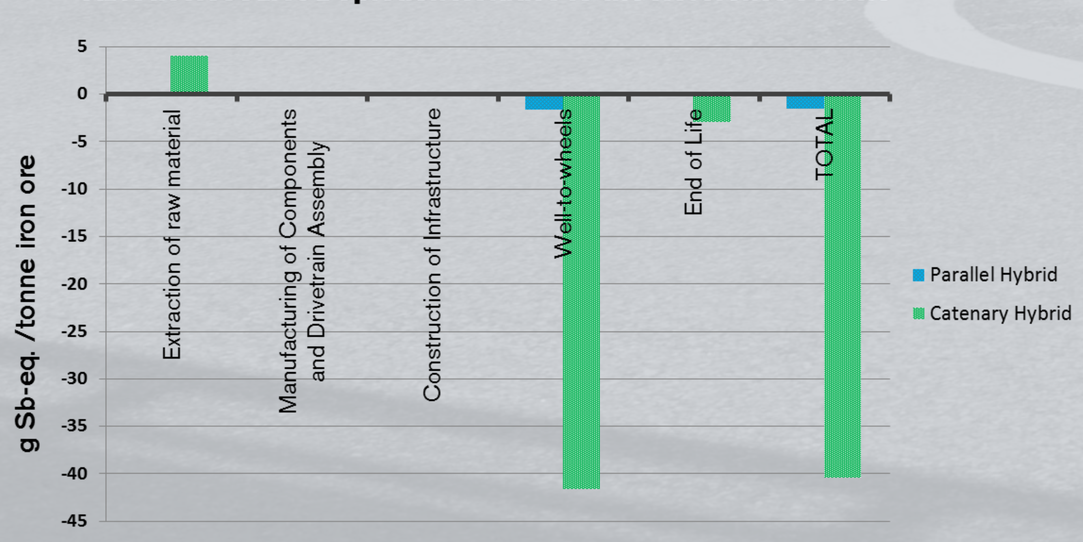
GW100 according to IPCC (2007)

Results and Conclusions of the LCA Study

1. The catenary hybrid was the most favorable choice for investigated types of impact*.
   Because: *The use of a Swedish electricity mix in operation instead of diesel*
2. Largest additional environmental impact comes from:
   Parallel hybrid – Li-ion battery *due to advanced materials in its design*
   Catenary hybrid – the infrastructure *which demands large amounts of materials*
   Because: *Raw material extraction*
3. The well-to-wheels life cycle is the most important for the reduction of impact
   Because: *Vehicle operation consumes a lot of fuel, and the potential savings are large*
4. Break-even analysis showed that it takes around four and a half month of mining operation before the investment in infrastructure is repaid by the savings made with the catenary hybrid.

** Studied impacts: GWP, ADP and a selected inventory of emissions: particulate matter, NO_X and hydrocarbons.*

Abiotic Resource Depletion Relative to the Reference Vehicle



ADP according to CML (2002)

Learning Outcomes for Scania*

Scania's aim with study was better understanding of the environmental impact of their technology selection. The outcome was:

- LCA has strengthened position as an **important assessment tool** in the development toolbox
- The main learning is the very **rapid payback** of electric road infrastructure in all aspects of environmental impact
- A **strengthened case** for road electrification within the company – direct result presented to other departments
- Dialogue with government agencies and other actors based on **general learnings rather than direct results**

** Summary of an interview with Nils-Gunnar Vågstedt, manager of the Hybrid Systems Development department, Scania, April 25:th 2013.*

References:

Björkman, A. (2013) *Comparative LCA of Electrification Alternatives for Long Haul Trucks - The Case of Iron Ore Powder Transportation from the Pajala Mine.* Environmental Systems Analysis, Energy and Environment. Göteborg, Sweden: Chalmers University of Technology. ESA Report No. 2013:4, ISSN No. 1404-8167.

Trafikverket (2012) *Malmtransporter från Kaunisvaaraområdet och elektriskt drivna lastbilar*. Publ.no: 2012:147. ISBN: 978-91-7467-354-8.

Reinfeldt, F. and Elmsäter-Svärd, C. (2012) *Investeringar för ett starkt och hållbart transportsystem*. Government proposition 2012/13:25.

Photo: Scania CV AB

CHALMERS
UNIVERSITY OF TECHNOLOGY

Environmental Systems Analysis
Department of Energy and Environment
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden

Presenting author: Anders Nordelöf (anders.nordelof@chalmers.se)