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TERM Report 2018

Electric vehicles from life cycle and circular economy perspectives

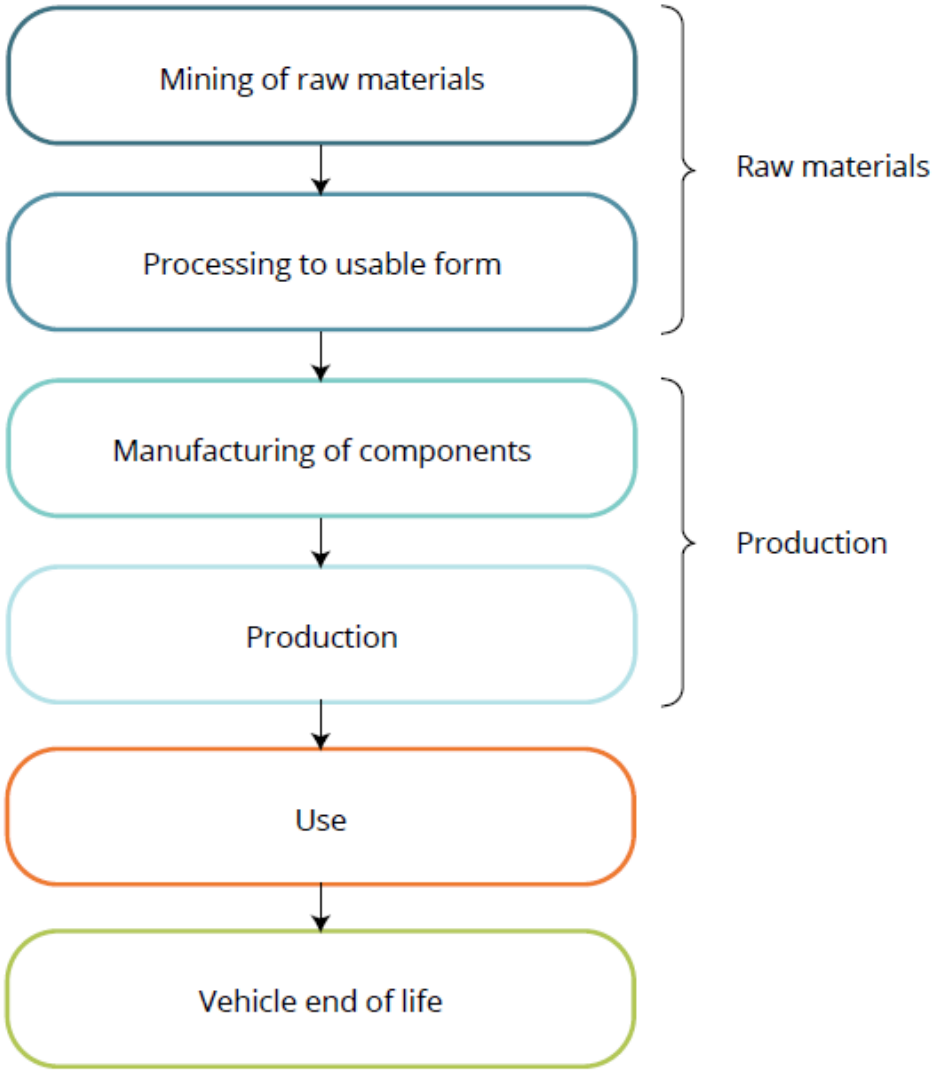
Warsaw, 11 February 2019

European Environment Agency

Objectives

Look at electric vehicles from a systemic perspective:

- Impact across **life cycle** stages
- Role of **circular economy** in reducing impacts



Approach

Impacts considered

- Climate change (GHG)
- Air quality with focus on:
  - nitrogen oxides (NOx)
  - particulate matter (PM)
- Other health impacts particularly focused on:
  - human toxicity
- Ecosystem impacts, including:
  - freshwater ecotoxicity

Focus on **battery electric cars**
Compared to **diesel** and **petrol**
Based on **literature review**

Conclusions

Renewable energy

- Low carbon / clean electricity is decisive
- Dominant factor in production and use phase

Circular economy

- Make EVs last and promote intensive / shared use
- Design with reuse and recycling in mind

EVs are only part of the solution

- Insufficient to tackle systemic problems
- New approach to personal mobility is still required

What does it say about air quality?

Potential shift in pollution

From local to background

From exhaust to non-exhaust

From use to production

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From local to background

Expected

- Local benefits due to zero exhaust emissions
- Possible rise in background pollution from electricity generation

Factors

- Grid mix (share of coal etc.)
- Location of power stations

Uncertainty

- To what extent will additional electricty demand add to power plant emissions of PM, NOx, SO_2, etc. ?
- Studies predict overall benefits[1], but there are exceptions[2]

[1] Soret, A., et al., 2014, 'The potential impacts of electric vehicles on air quality in the urban areas of Barcelona and Madrid (Spain)', Atmospheric Environment 99, pp. 51-63.

[2] Huo, H., et al., 2015, 'Life-cycle assessment of greenhouse gas and air emissions of electric vehicles: a comparison between China and the U.S.', Atmospheric Environment 108, pp. 107-116.

From exhaust to non-exhaust

Expected

- Local benefits due to absence of tailpipe emissions
- Still local PM emissions from road, tyre and brake wear

Factors

- Vehicle mass
- Driving behaviour (effect of regenerative braking)

Uncertainty

- Effect of resuspension on PM concentrations over time?
- Estimates of local PM emissions from BEVs vary strongly:
  - Significantly lower than Euro 6 ICEVs[1]
  - Similar or only slightly lower than Euro 6 ICEVs[2]

[1] Hooftman, N., et al., 2016, 'Environmental analysis of petrol, diesel and electric passenger cars in a Belgian urban setting', Energies 9(2), p. 84.

[2] Timmers, V. R. J. H. and Achten, P., 2016, 'Non-exhaust PM emissions from electric vehicles', Atmospheric Environment 134, pp. 10-17.

From use to production

Expected

- PM and SOx from raw materials and production greater for BEVs[1]
- Overall use phase emissions from BEVs similar to ICEVs (with 2013 EU electricity mix)[2] / does not mean same exposure

Factors

- Share of coal in electricity mix for battery production
- Battery chemistry and size (nickel / cobalt content)

Uncertainty

- Will material composition / amount of nickel and cobalt change?
- Where will batteries for the EU market be produced?

[1] Bauer, C., et al., 2015, 'The environmental performance of current and future passenger vehicles: life cycle assessment based on a novel scenario analysis framework', Applied Energy 157, pp. 871-883.

[2] Hawkins, T., et al., 2013, 'Comparative environmental life cycle assessment of conventional and electric vehicles', Journal of Industrial Ecology 17, pp. 53-64.

Limitations of the current literature

- Lack of **comparability**:
  - Type-approval vs. real world emissions of ICEVs
  - Estimation methods for non-exhaust emissions
- Some studies are old and based on **outdated LCA data** (i.e. early BEV models, small scale production)
- Some studies lack **transparency** as to the treatment of upstream emissions from fossil fuels

Need for future research

Data gathering

To better gauge air quality impacts, **better data** is needed on:

- **Electric vehicle use** (incl. driving and charging behaviour)
- **Non-exhaust emissions** in real driving conditions
- **End-of-life treatment of batteries**

Transport and energy system interaction

- AQ benefits expected to rise in tandem with grid decarbonisation[1]
- Transport and energy systems increasingly intertwined
- How will additional electricity demand be met?

[1] Öko-Institut and Transport & Mobility Leuven, 2016, Electric mobility in Europe — future impact on the emissions and the energy systems.