Environmental Impact from Vehicle Battery Production and Recycling - Status and Potential for Improvement

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- Natural resources, Climate and Environment
- Resource-efficient Recycling and Consumption
- Sustainable Production and Environmental Technology
- Sustainable Urban Development and Transport

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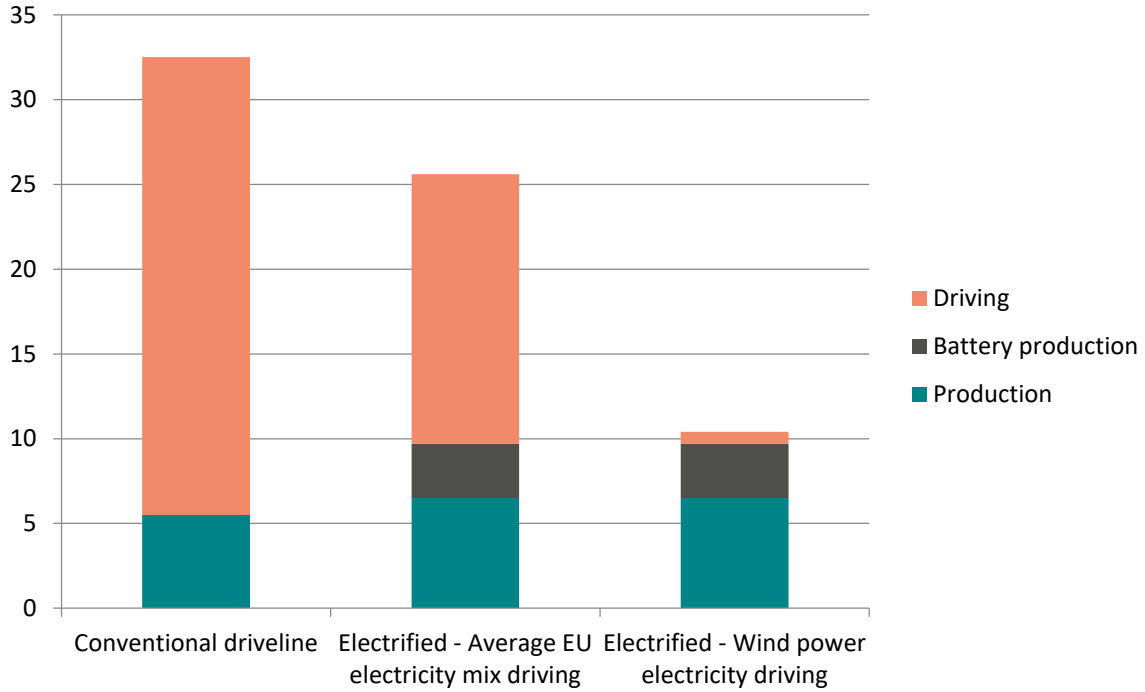
Electrification

– a shift in the life cycle environmental impact of cars (and the principle is valid for buses too)



- Use phase decreases in importance
- The production phase increases in importance, largely because of the battery

Example medium sized car, 180000km life

Graphics based on LCA results from Ellingsen et al 2016 - The size and range effect: lifecycle greenhouse gas emissions of electric vehicles

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Battery production impact

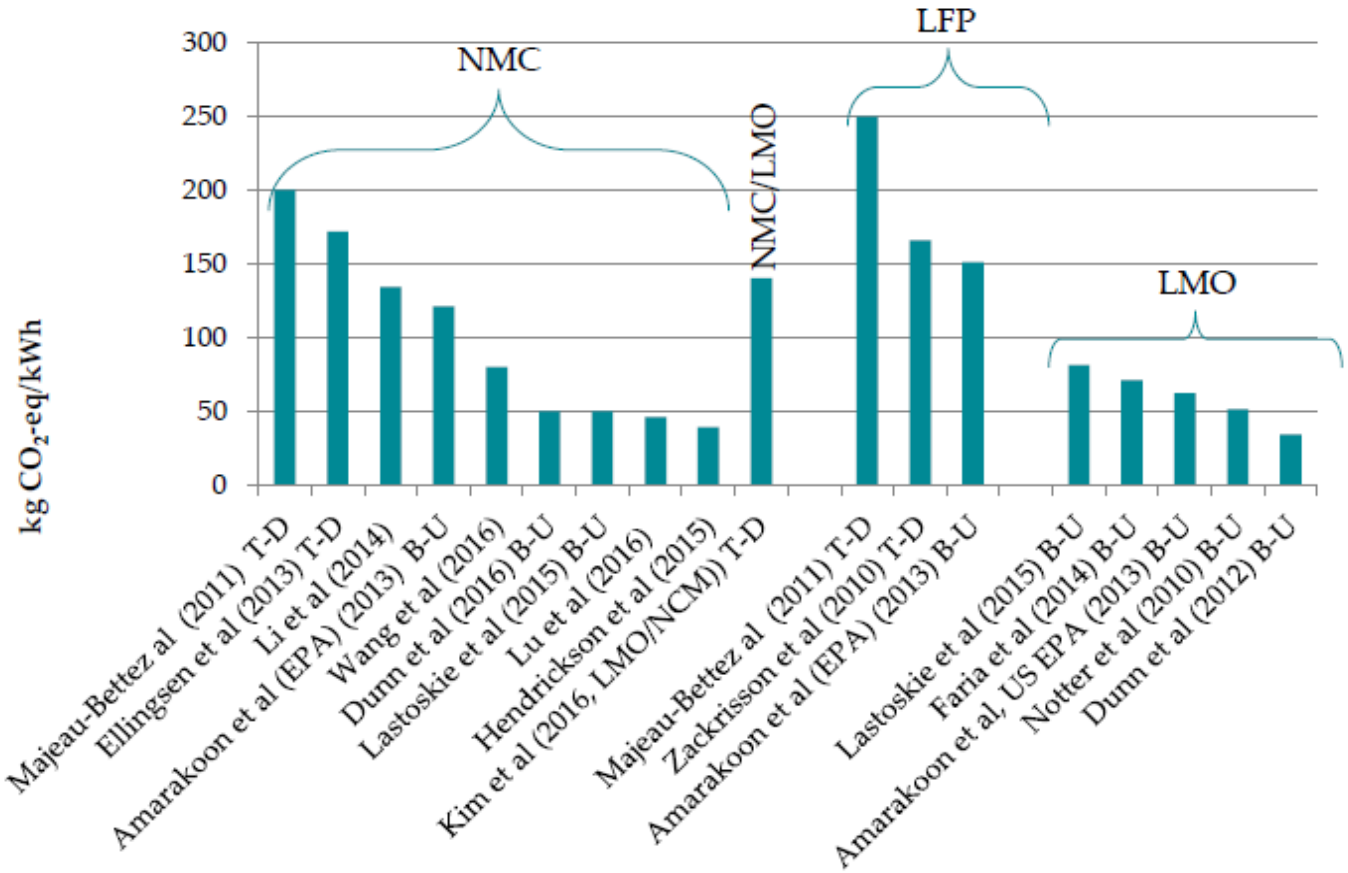
- We often talk about battery emissions in terms of kg CO_2/kWh battery

- Example on previous slide has an impact of 131 kg CO_2/kWh battery with a 24,4 kWh battery

Unfortunately reality is not as simple as one answer…

Battery production impact

- A review of available LCAs in 2016 showed highly varying results



Battery production impact

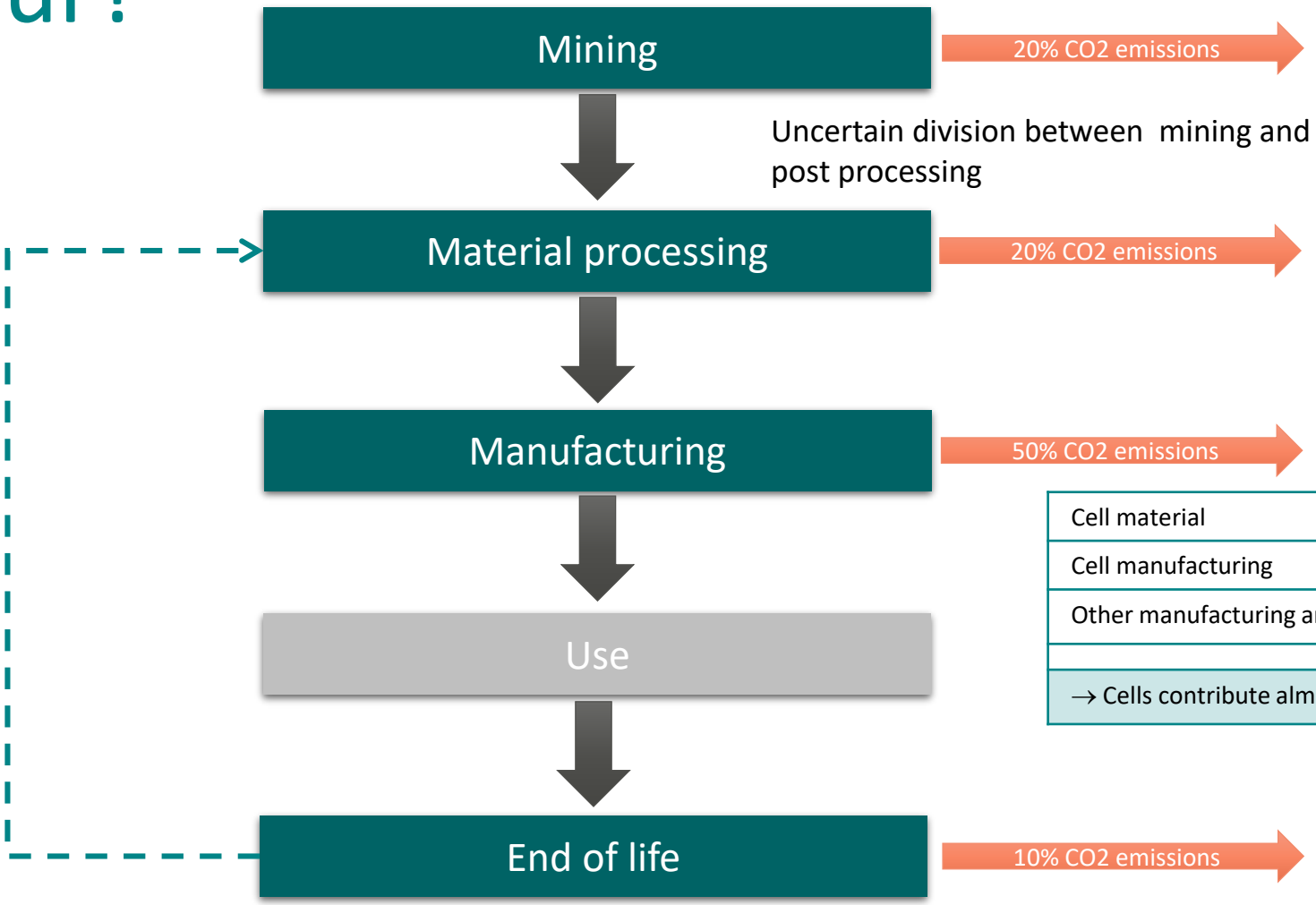
- Conclusion from previous slide?

- There are reasonable variation in the results due to
  1. Very few had real data from battery cell production
  2. Different production location (i.e. electricity mix in production)
  3. Top down or bottom up approaches
  4. Design
  5. LCI data varies

- We need to work hard to get better data
  - From actual production
  - Updated

- The data is good enough to support general conclusions

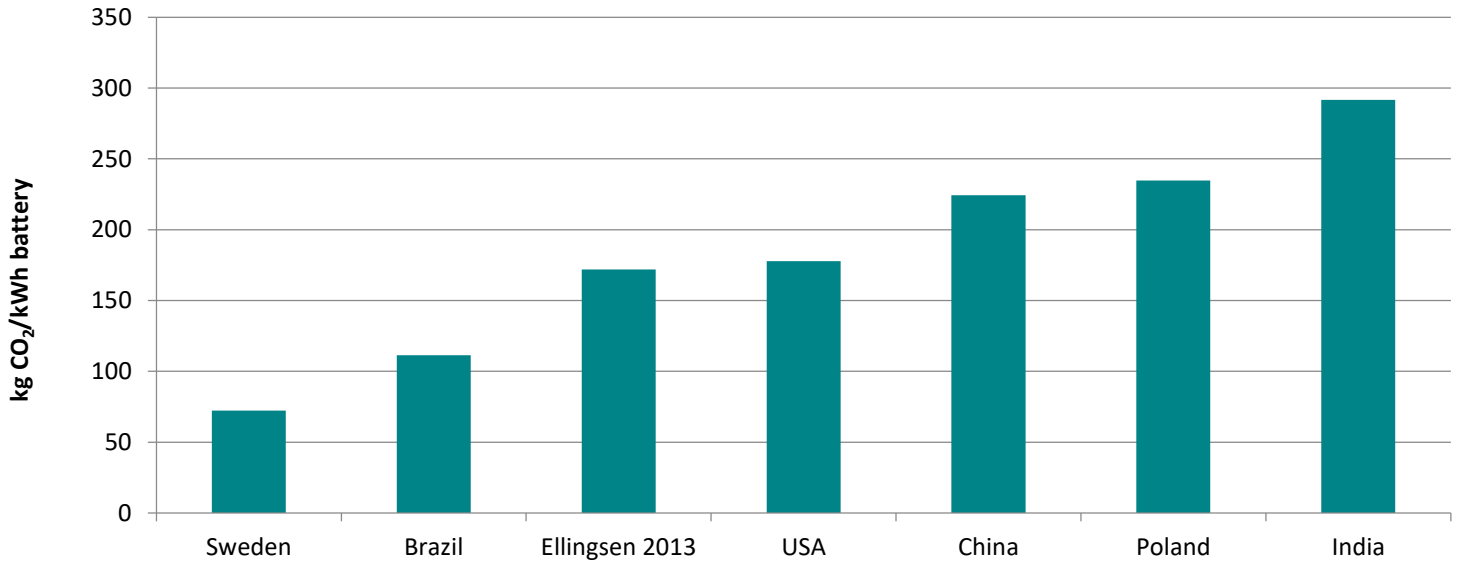
Where do the emissions occur?



Cell material	40-70%
Cell manufacturing	30-70%
Other manufacturing and assembly	0,5-5%
→ Cells contribute almost all of the manufacturing impact	

Exemplifying improvement potential

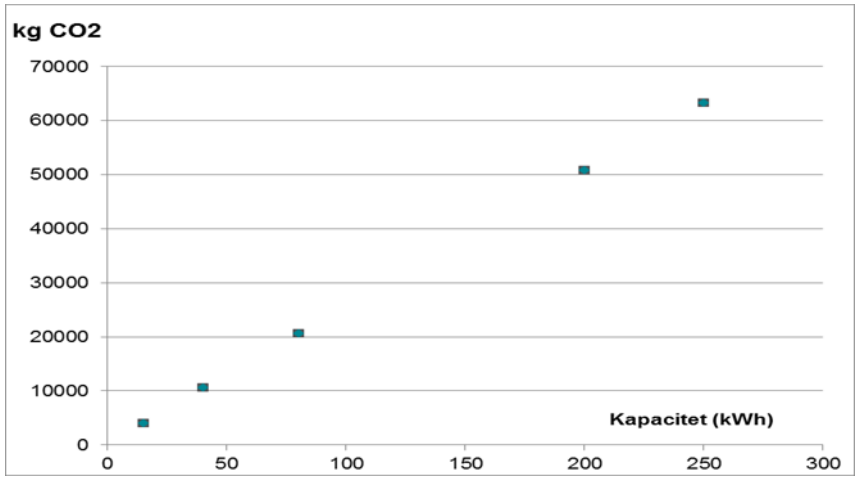
- Cells contribute up to 70% - mainly due to use of fossil based electricity
- By only targeting this stage and its electricity the reduction potential is significant!



Graphics based on LCA results from Ellingsen et al 2013 – Life cycle assessment of a lithium-ion battery vehicle pack

CO_2-emissions increase with higher battery capacity

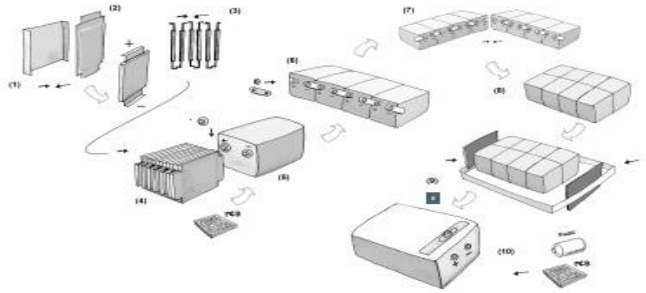
Based on one study and the knowledge that cell production is energy intensive



Recycling

- The driving force is not CO_2 but material scarcity
- **Regulation in Europe:**
  - Battery directive (under revision) 50% must be recycled but can be achieved only by recycling the parts that are outside the cells.
- **Why so few recycled today**
  - Because so few ready for recycling and expensive
  - But in China full scale because of large volumes

Recycling



- **What is recycled and how?**
  - Electronics is removed and the box too. Go to recycling.
  - Materials in cells: Cu, Co, Ni is recycled, but to elementary form again. Costs energy to make them battery grade again.
  - Pyro metallurgy today with leaching for extracting the valuable metals. Causes CO_2 emissions.
- **Future:**
  - Hydrometallurgical technology for recycling of more elementary materials.
  - Mechanical for taking back processed materials (=the best)

Second life

- **Driving forces**
  - Share the costs for recycling and less environmental impact
  - When the battery is removed from the vehicles up to 80% of the capacity is still left.
- **But**
  - Difficult to assess State of Health of the battery
  - The question of responsibility
- **The interest for second life is increasing**
  - For example for energy storage in buildings

Moving forward

- Realizing energy efficiency and fossil-free electricity in the **high energy** stages of the production.

- Increasing the recycling, and also the processing value of the output
  - Avoided CO_2 emissions
  - Material security for large scale adoption

- Batteries have a high processing value and production impact – when we have made them we should use them effectively and for as long as possible!

Thank you for your attention!

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