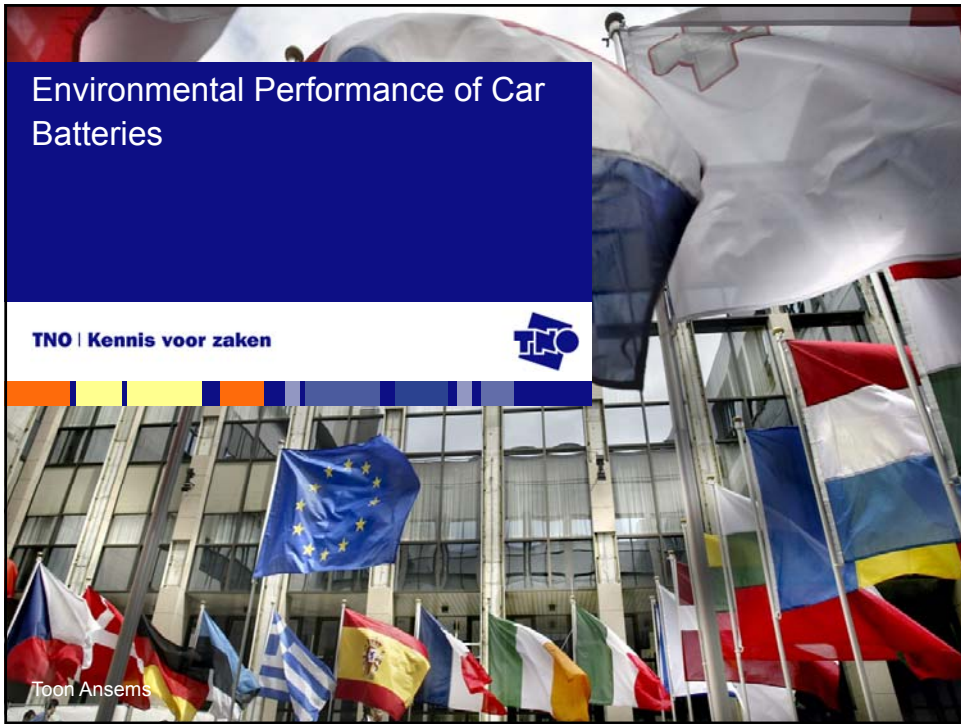


# Environmental Performance of Car Batteries

TNO | Kennis voor zaken



Toon Ansems

## Contents

- CO<sub>2</sub> emissions of cars need to be lowered
- Other fuel/driving systems are an environmental challenge (LCAs)
- Advantages/disadvantages battery systems for electric cars
- LCA battery systems
- Why lithium batteries?
- Aspects to be solved
- Main conclusions

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## CO<sub>2</sub> emissions cars

	g CO <sub>2</sub> /km
• Daihatsu Cuore	112
• Fiat Grande Punto	145
• Opel Corsa	163
• Peugeot 207	167
• BMW 320	178
• Volkswagen Passat	185
• Mercedes C 200	189

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## CO<sub>2</sub>; EU target

In 2012: New cars below 120 g CO<sub>2</sub>/km

	g CO <sub>2</sub> /km
• Smart 450	101
• Volkswagen Polo	102
• Toyota Prius	104

In the future target will be lowered.

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## Realization Eco-Car

### *Decrease CO<sub>2</sub> burden*

- Light cars (Al, plastics)
- Aerodynamics
- Less friction losses regarding driving forward
- Other engines
- Other fuels

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## Alternative fuels

- Biofuels
- Hybrid; Electric motor + fossil fuels
- Hydrogen
- Pressurized air
- Electricity

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## Simplified LCA for different cars; only use phase (Belgian study)

	g CO <sub>2</sub> /km
• Mitsubishi 2000 (petrol)	217
• Seat Ibiza (diesel)	170
• Peugeot 106 (electricity average)	73
• Peugeot 106 (electricity without nuclear power)	163
• Toyota Prius (hybrid)	104



## Conclusions simplified LCA

- LCA results depend on energy needs
- LCA results depend on efficiency of energy supply chains
- The way of electricity production has a strong influence



## Environmental performance Internal Combustion Engine (ICE) versus Battery Electric Vehicle (BEV)

- Production of ICE car causes slightly less environmental damage than BEV car production
- Use phase gives strong environmental performance of BEV car
- Efficient ICE cars might be competitive with BEV cars when electricity is from pure coal power plants



BEV cars are favourable from an environmental perspective



## Growing support electric cars

- USA and Germany support developments of electric cars and battery systems
- All car manufacturers have interest and build prototypes
- Initiatives to build infrastructures to charge batteries
- Tax benefits for driving electric cars
- Attention for the weak part “battery systems”



## Car batteries (1)

### *Lead-acid*

#### Advantages

- Best known car battery
- Low costs
- Safety

#### Disadvantages

- Low specific energy (~30 Wh/kg)
- Increase specific energy  
→ Much shorter life time



## Car batteries (2)

### *Nickel-metal hydride*

#### Advantages

- Commercially available
- Higher specific energy

#### Disadvantages

- Relatively high price
- Relatively heavy, high weight
- Questions regarding life time in full electric cars



## Car batteries (3)

### *Lithium*

#### Advantages

- High specific energy
- Relatively light weight
- Promising car battery solution

#### Disadvantages

- Not commercially available
- Safety
- High production costs



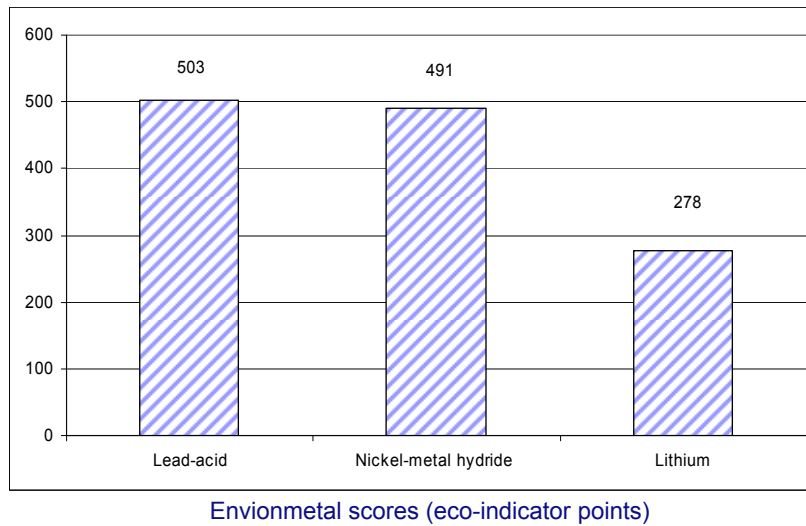
## Car batteries (4)

### *Comparison*

	Lead-acid	Nickel-metal hydride	Lithium
Energy density (Wh/kg)	30-40	60-70	80-120
Specific power (W/kg)	200-300	100-500	20-2000
Charge/discharge cycles	300-500	500-1000	1000-5000



## Environmental Impact Battery Types (1)



## Environmental Impact Battery Types (2)

### Conclusions study

- Assembly and production phase can be compensated to a large extent when collection and recycling is efficient
- Lithium batteries have the lowest impact
- Results strengthen the support to improve and to develop lithium batteries for electric cars



## Lithium batteries (1)

Rapid improvements are the objectives

Main aspects of concern:

- Scarcity; Li is a critical element
- Safety
- Electricity of fossil fuel power stations (for instance coal power plants)



## Lithium batteries (2)

Scarcity

- Improvement performance batteries
- 100% Li recycling (use take back system of lead-acid batteries)
- Winning of Li from sea water desalination

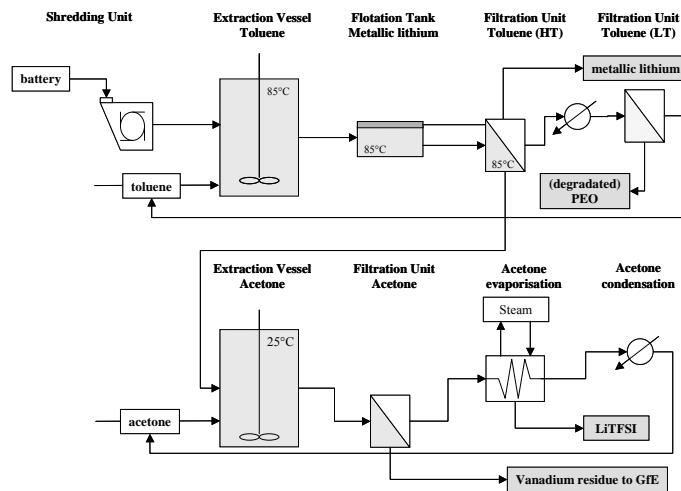
Electricity supply

- Storage of electricity from the (irregular) sustainable sources wind/solar
- Application of CCS for coal power plants



## Recycling of Lithium batteries

### Process flow sheet Lithium Battery Recycling (double solvent extraction route)



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## Main conclusions

- Electric cars can become a sustainable solution for CO<sub>2</sub>-impact
- Application of lithium batteries is a promising innovation
- Improvements of the performance of lithium batteries are needed
- The critical availability of Li can be solved
- A sustainable electric supply can be realized

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