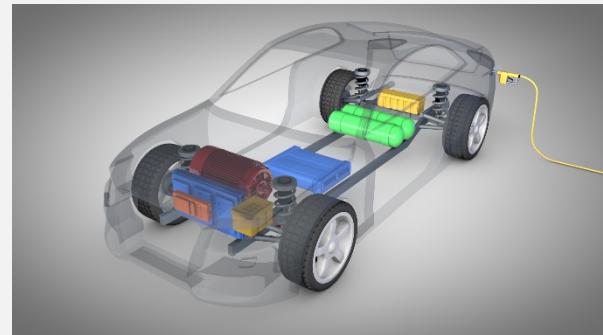
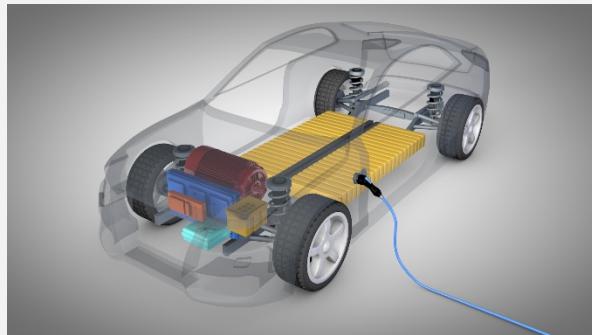
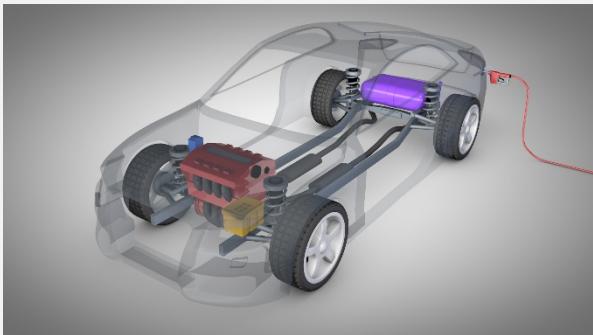
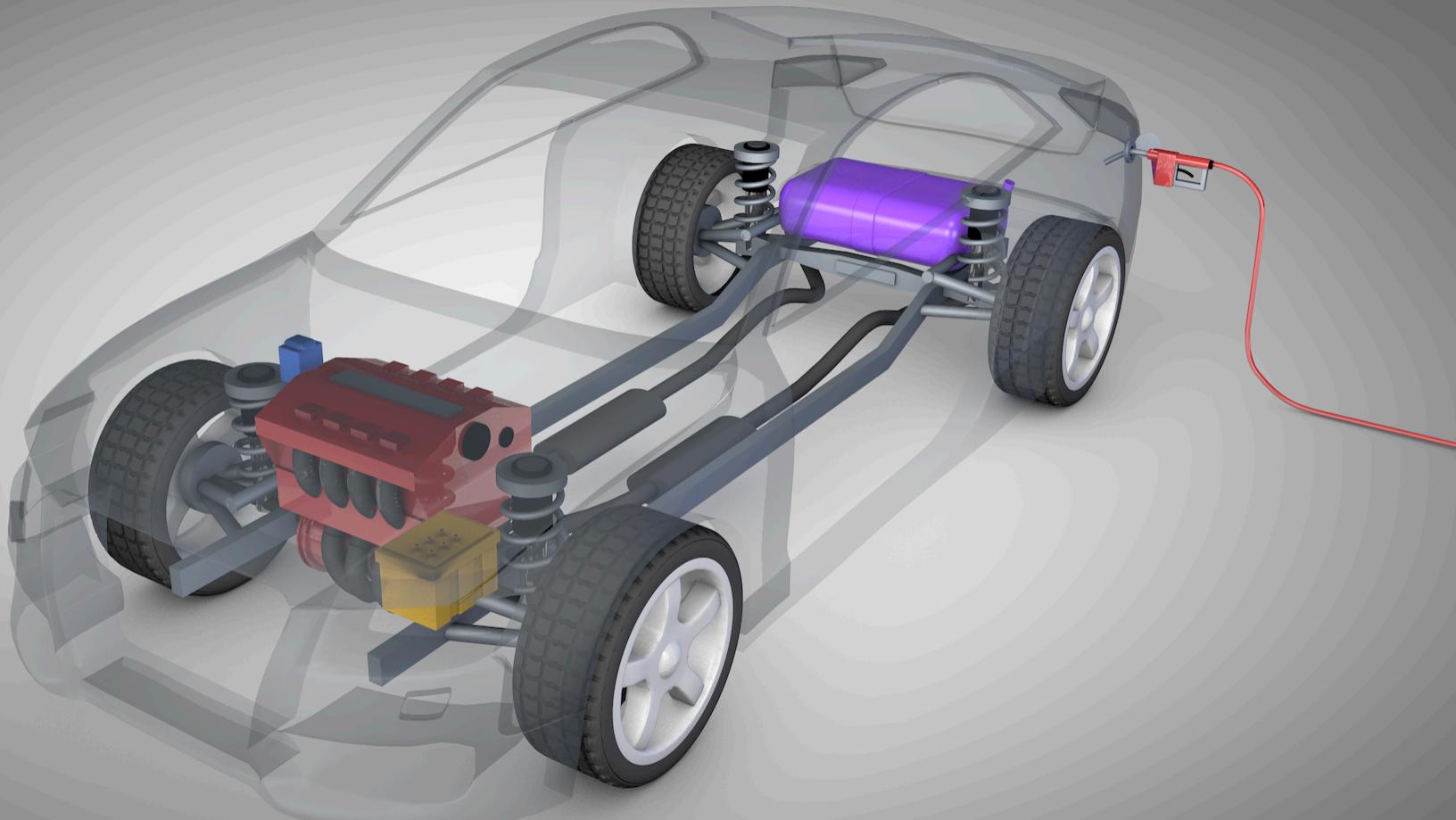


Drivetrains of conventional and electric vehicles

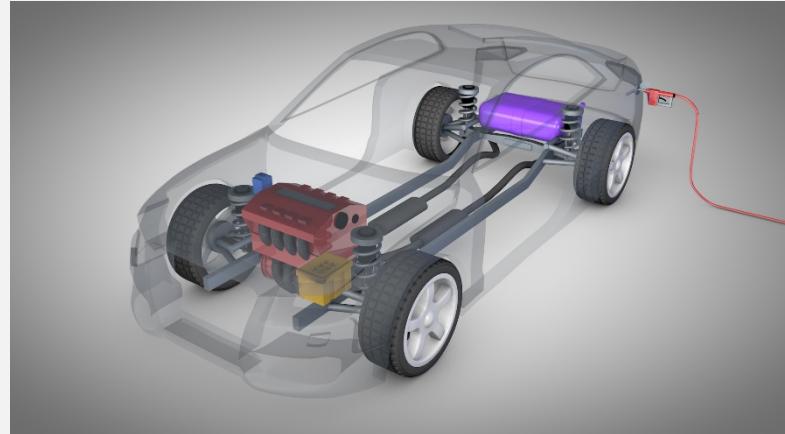
Auke Hoekstra - Senior Advisor Electric Mobility, Eindhoven University of Technology
@aukehoekstra – SparkCity.org



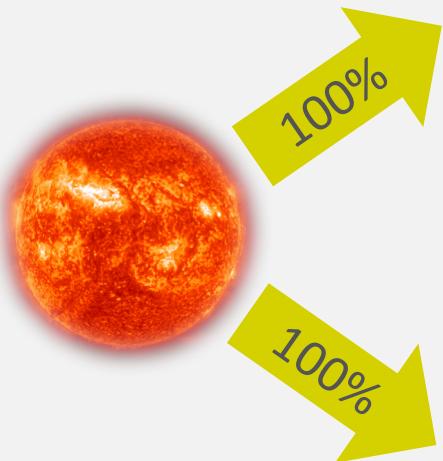


Internal Combustion Engine

- Global warming
- Particulate matter (PM)
- 75% of energy lost
- Noise pollution
- Motor is heavy and expensive
- Lots of maintenance required



Biofuel is inefficient compared to EVs



PV
20%



Transport + charge
17%



EV
14%



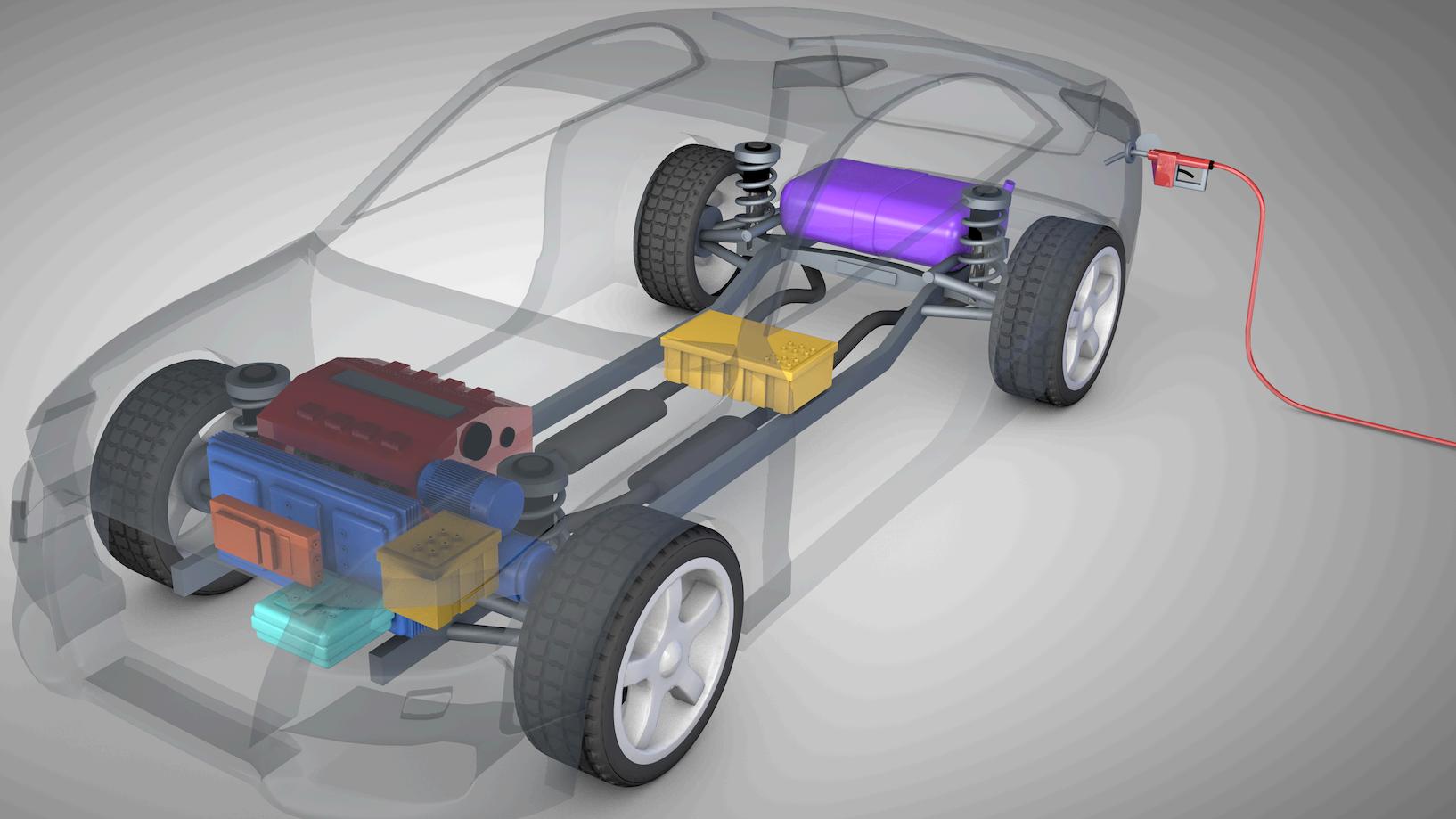
Photosynthesis
0,38%



Refining, transport and fuelling
0,16%

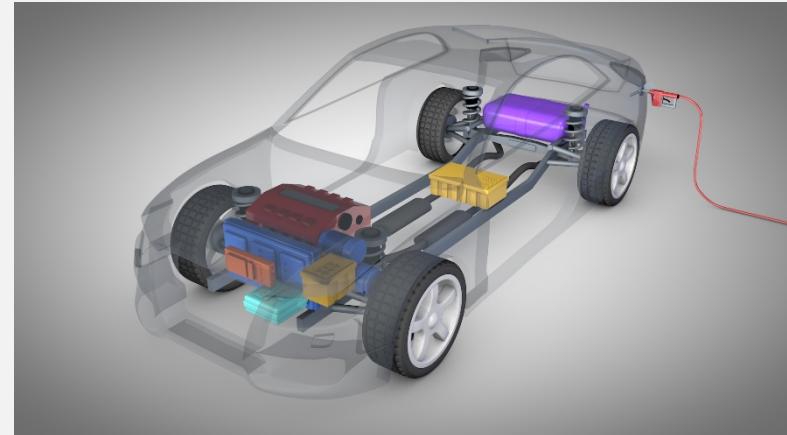


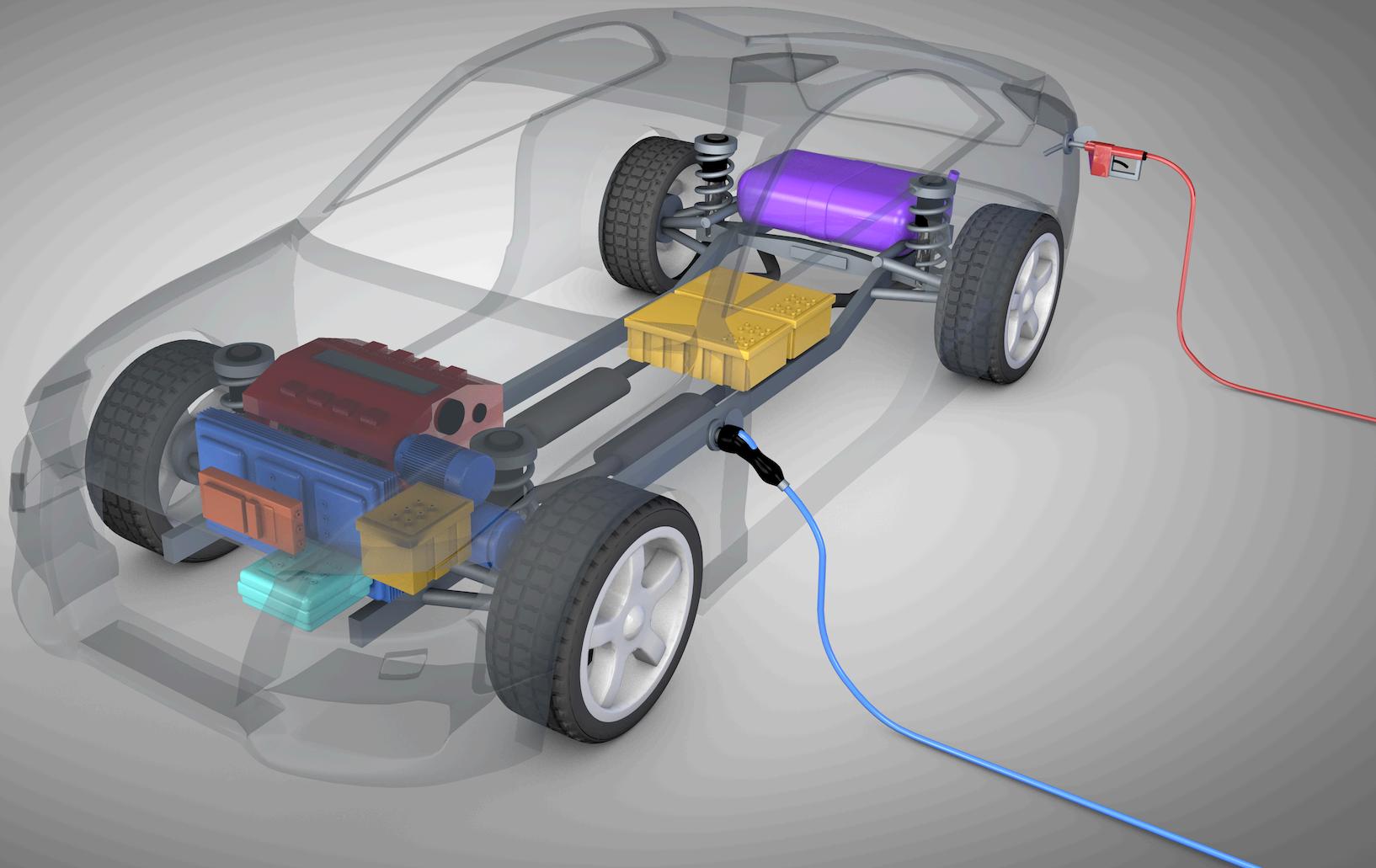
ICE & car
0,03%



Hybrid Electric Vehicle (HEV)

- Electric motor is not only used to start the gasoline engine but also to support it at short stops and low speeds
- Less brake wear and other maintenance.
- Up to 20% fuel savings.





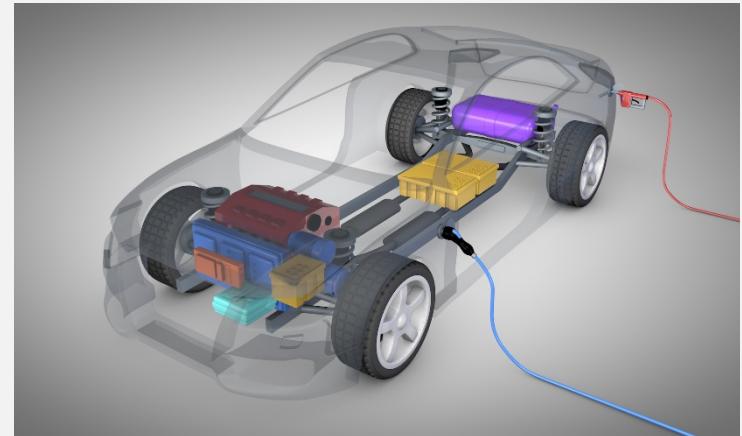
Plug-in Hybrid Electric Vehicle (PHEV)

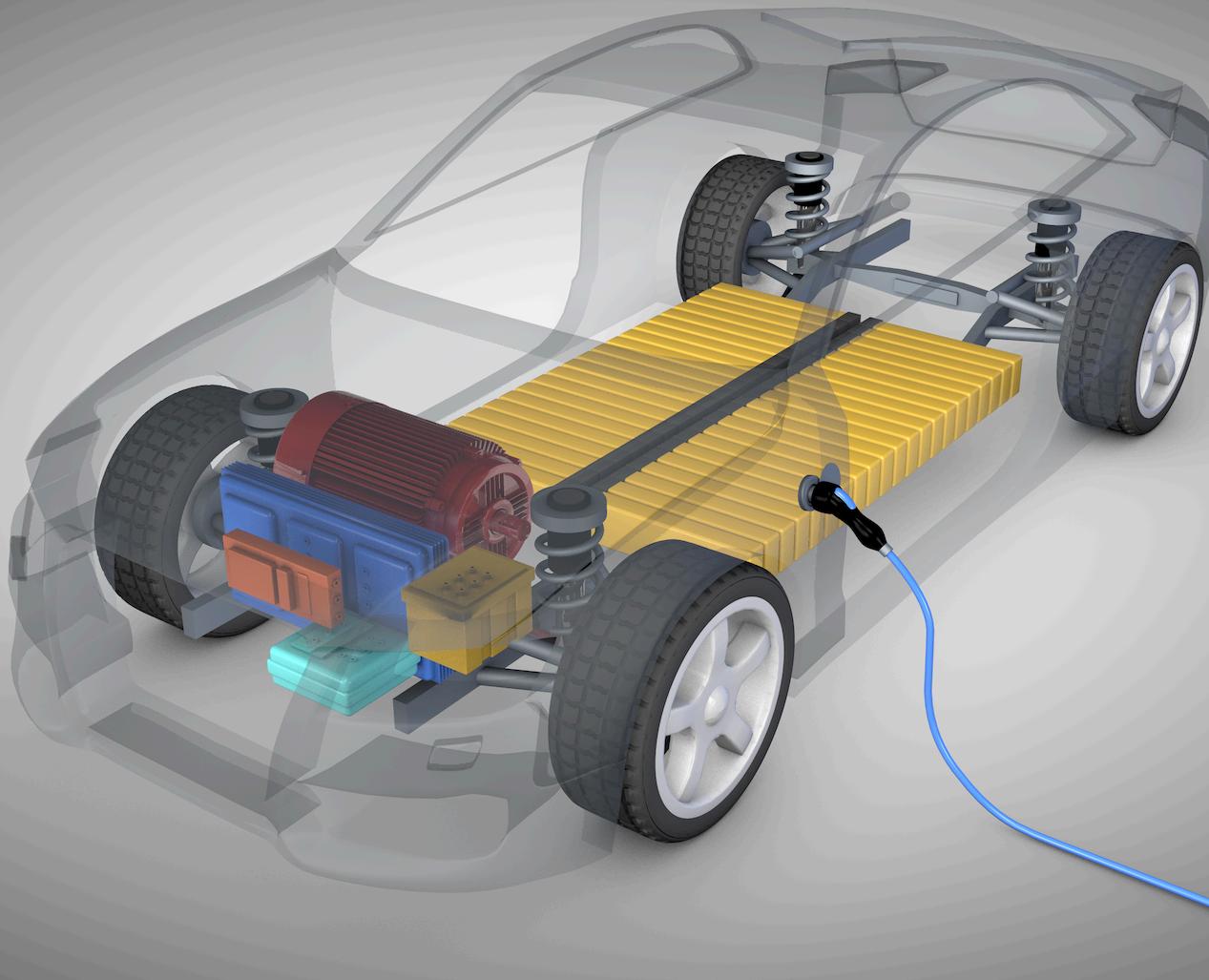
Advantages

- Range not limited by the battery
- Most energy can come from electricity with relatively small (<100 km range) battery

Disadvantages compared to FEV

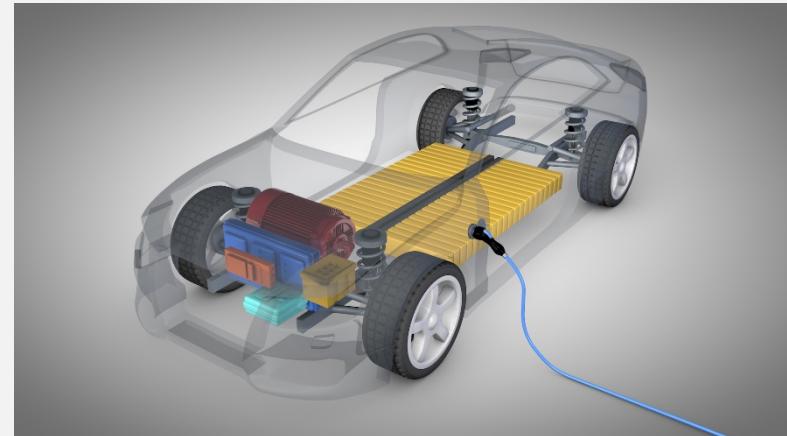
- Drive train cost and maintenance
- Less energy and emission savings





Full Electric Vehicle (FEV)

- Electricity only power source
- Runs entirely on cheap, small and efficient electric motor
- Low maintenance
- One pedal driving with regeneration
- Big battery for long range
- Fast charging capability



Full Electric Vehicle (FEV) cost comparison

Cost type	Gasoline	FEV 2000	FEV 2030
Drive train	\$15k	\$20	\$5
Battery	\$0	\$100k	\$10k
Fuel	\$17k – 40k	\$6k – 10k	\$6k – 10k
Maintenance	\$18k	\$12k	\$6k
Total	\$50k – 73k	DISADVANTAGE \$65K – 92K	ADVANTAGE \$19K – 46K



Full Electric Trucks (like the Tesla Semi)

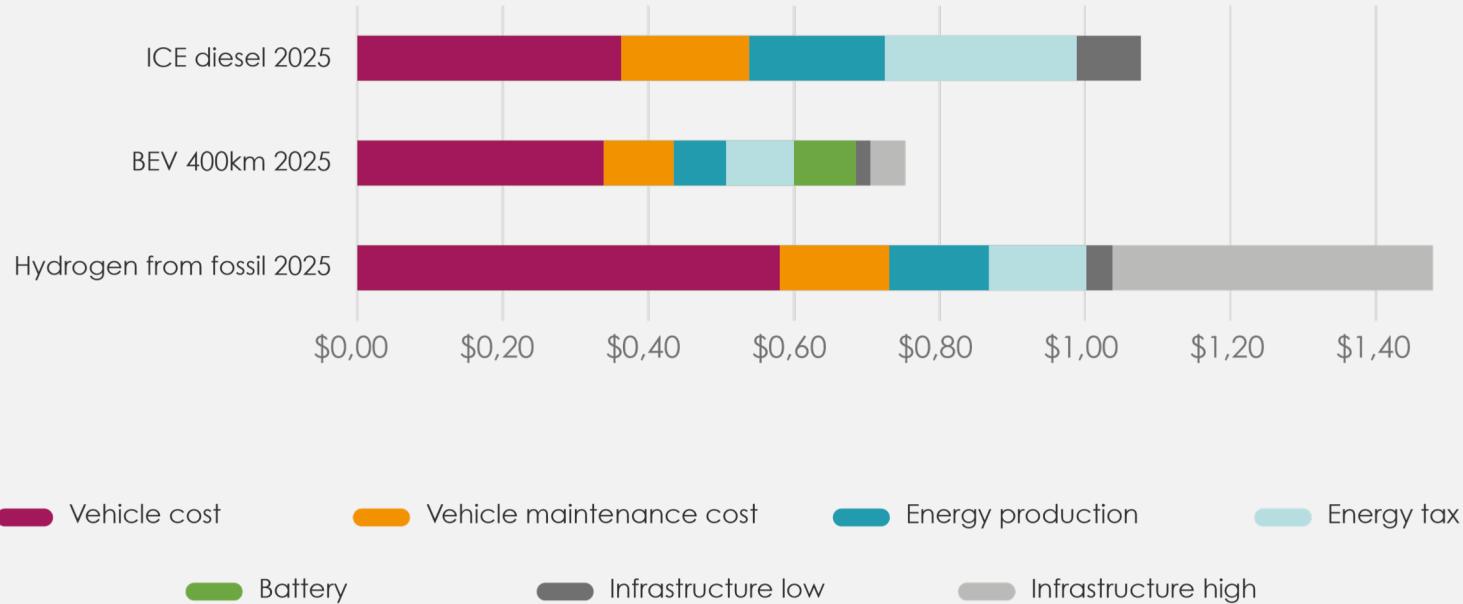
- More energy use means bigger cost savings
- More TCO focus means quicker adoption
- My prediction: electric heavy truck adoption will be *faster* than normal car adoption
- But only if we roll out fast-charging infrastructure

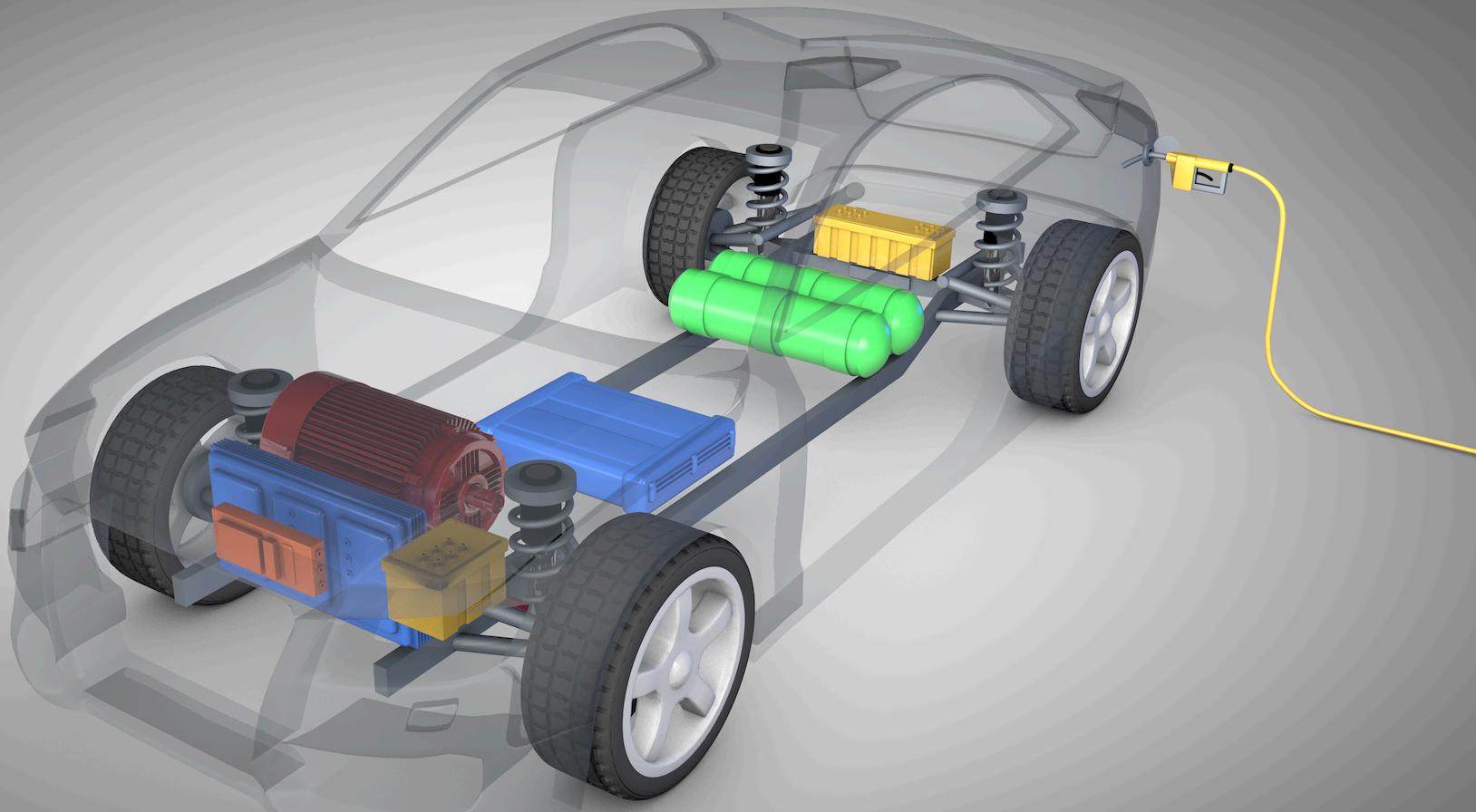


Full Electric Trucks: economics

Diesel vs. electric: cost/km

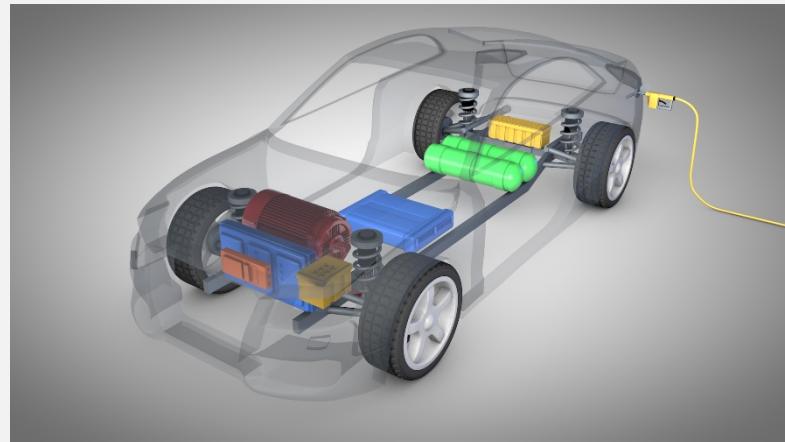
vehicle, maintenance, energy, tax, fast/overhead charging & hydrogen





Hydrogen Fuel Cell Electric Vehicle (FCEV)

- Electric vehicle with hydrogen range extender
- Small battery but long range
- Refuelling is very fast
- Efficiency is lower than FEV



Hydrogen is inefficient compared to EVs



Transport & charging
17% left

Full EV
14% left



Electrolysis
16% left



Compression & distribution
12% left



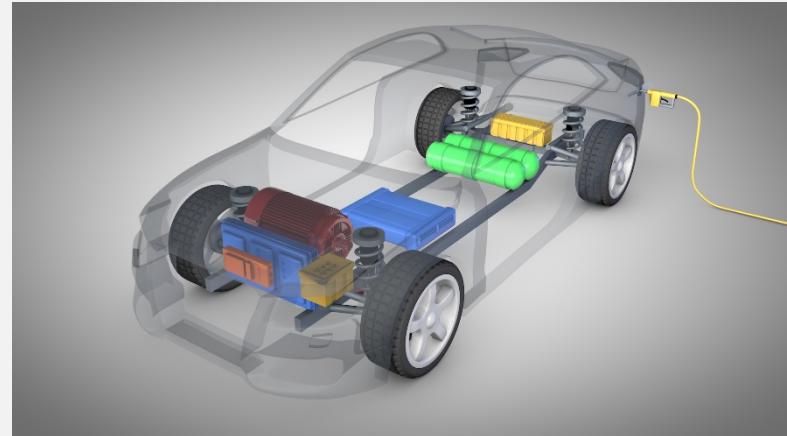
Fuel cell
7% left



Hydrogen EV
5% left

Hydrogen Fuel Cell Electric Vehicle (FCEV)

- Electric vehicle with hydrogen range extender
- Small battery but long range
- Refuelling is very fast
- Efficiency is lower than FEV
- **Future depends on price developments in fuel cells, storage and electrolysis**



Conclusions

- Hybrids are more complex than both ICE and FEV
- Possible that we skip PHEVs and go directly for FEV
- The internal combustion engine is on the way out

Thank you for your attention