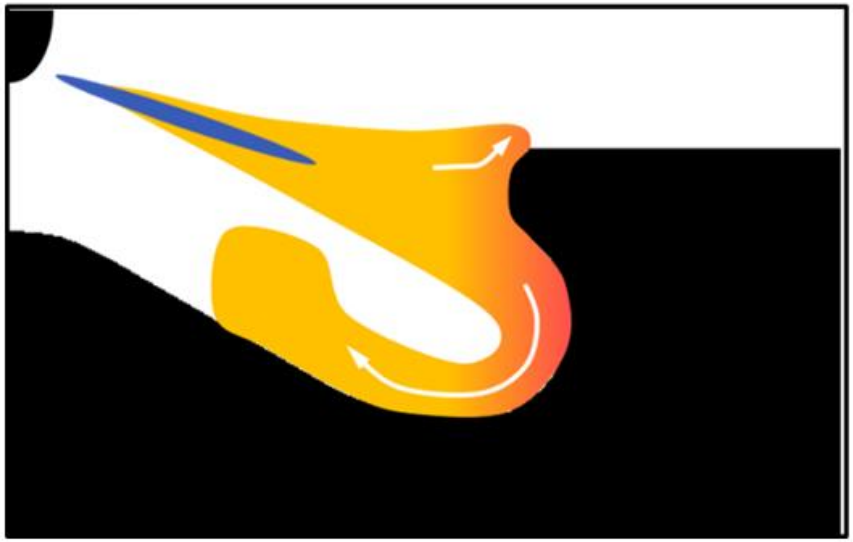
Technische Universität Berlin
FG Verbrennungskraftmaschinen

Diesel, Petrol or Electricity for Future Road Traffic

Zürich, June 2017

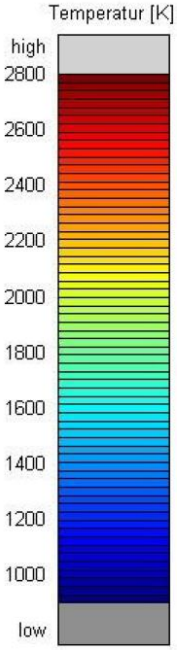
Conventional Diesel combustion

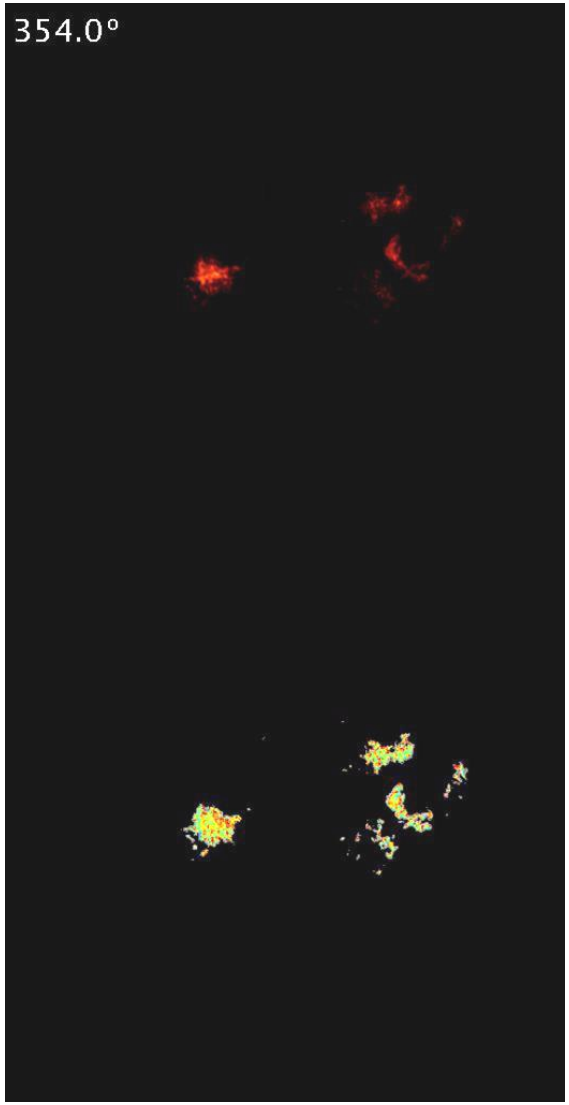
- In Diesel engines the majority of the combustion happens within the piston bowl
- Conventional light duty engines have the typical omega bowl within the piston
- Due to the relative small piston diameter there is – depending on operation point – a strong share of combustion close to the wall



Conventional Diesel combustion

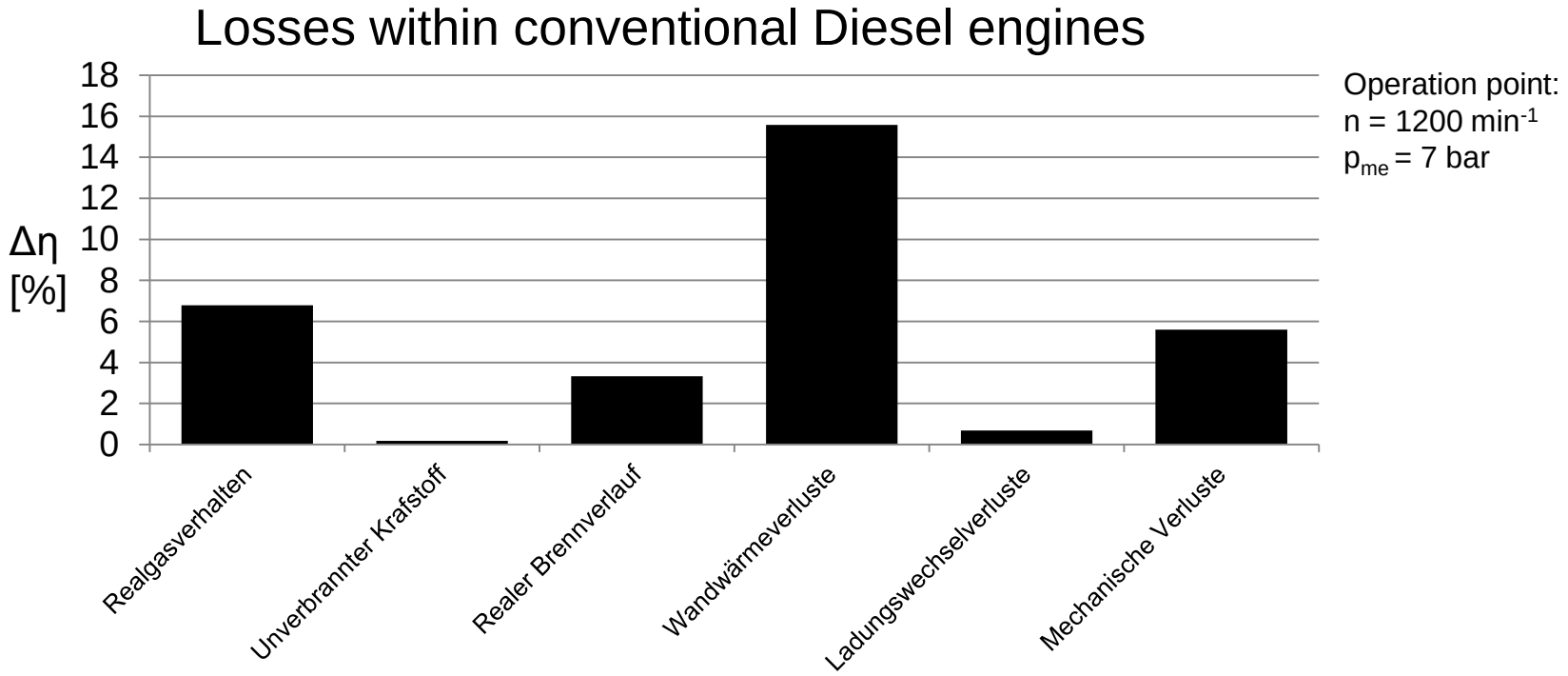
- Through the shape of the piston bowl air can be utilized in the centre as the combustion moves back there, even in part load operation
- The intense contact with the piston surface nevertheless leads to heavy heat losses that can be recognized via the lower temperatures in the back flowing combustion





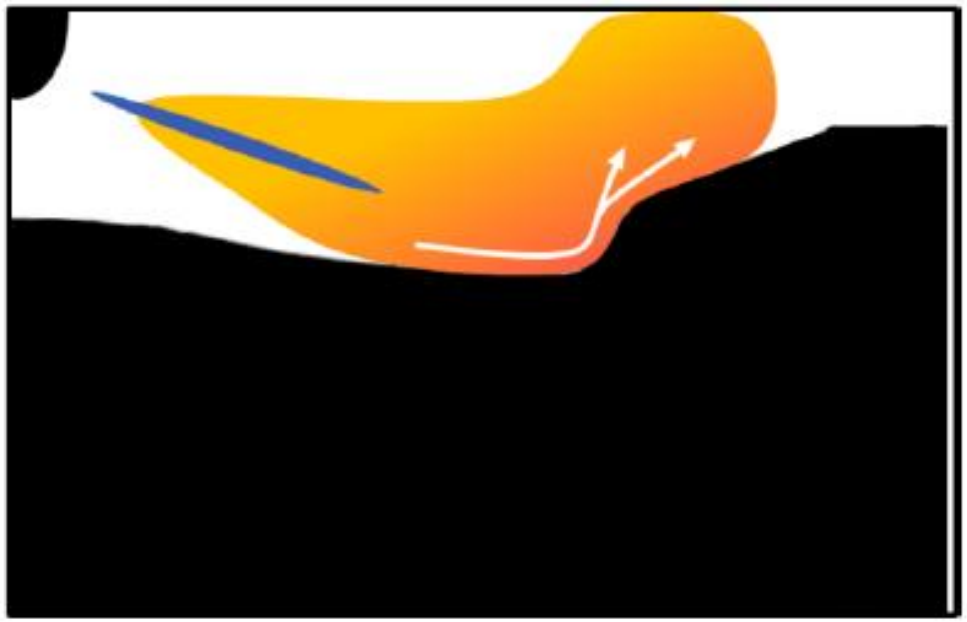
Conventional Diesel combustion

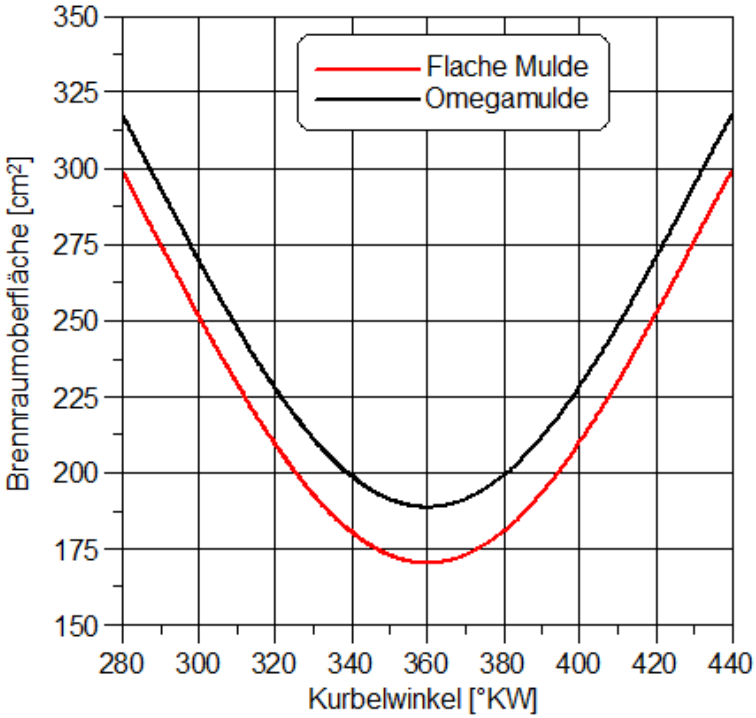
- In part load heat losses cause the highest share of losses in Diesel engines.



Diesel combustion with a flat bowl

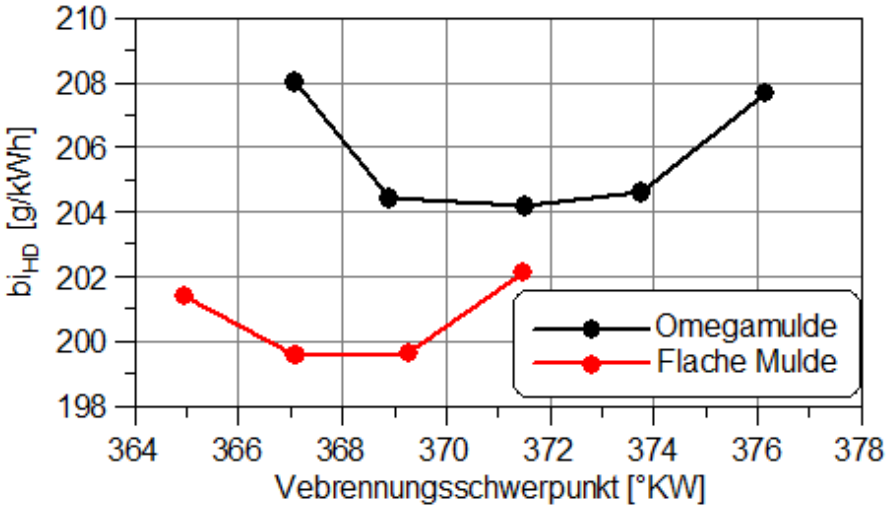
- The use of a flat bowl reduces wall heat losses
- The combustion system is less close to the wall

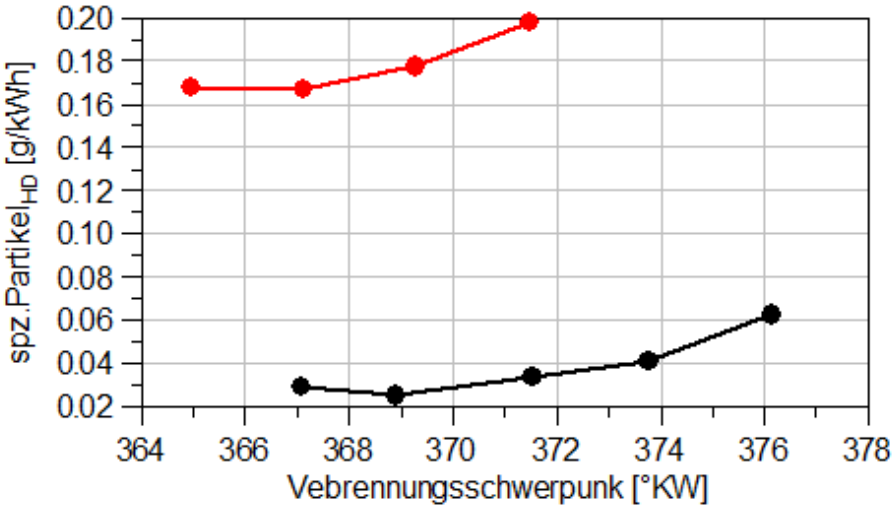




Diesel combustion with a flat bowl

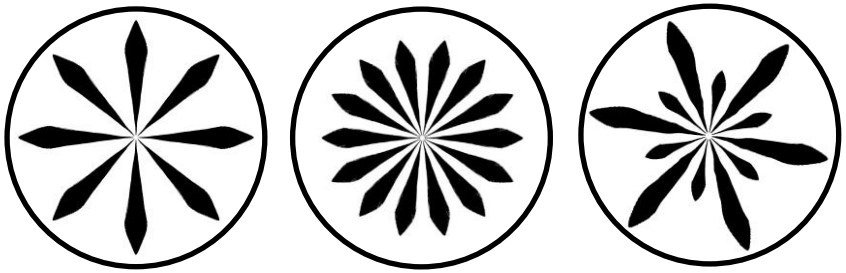
- The reduced heat losses lead to improved fuel efficiency.
- Soot emissions are increased.





Diesel combustion with a flat bowl

- Due to the flat bowl there is a reduced back flow of the combustion to the centre
- The worse air utilization leads to a combustion that is more rich so that there is more soot
- Adjustments of the injection system can reduce spray penetration length



Hey Roland…

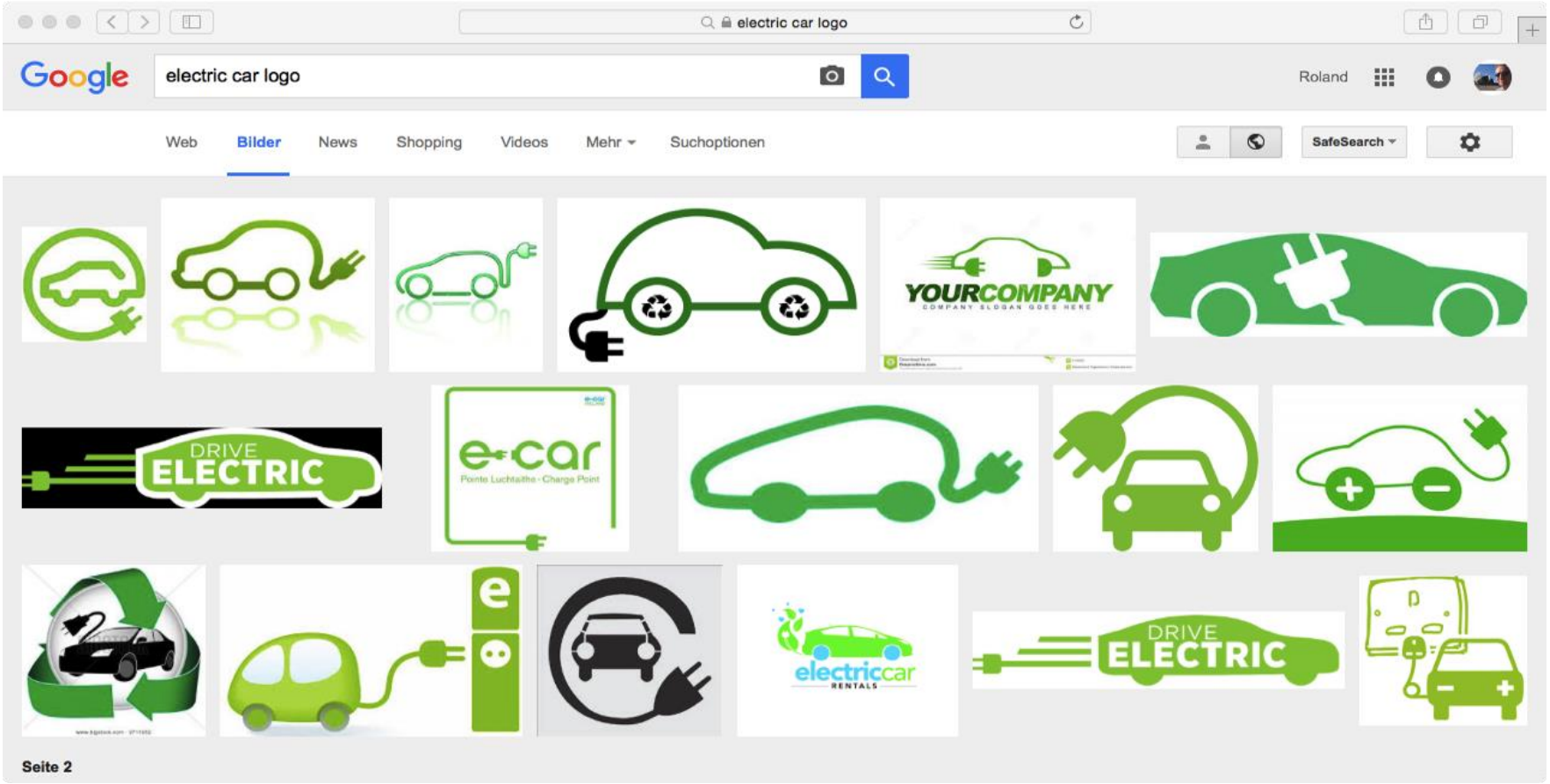
… this is not an engine conference

Car with
combustion engine

Car with
electric motor

Lets talk about „green“ electric cars?

Lets talk about „green“ electric cars?

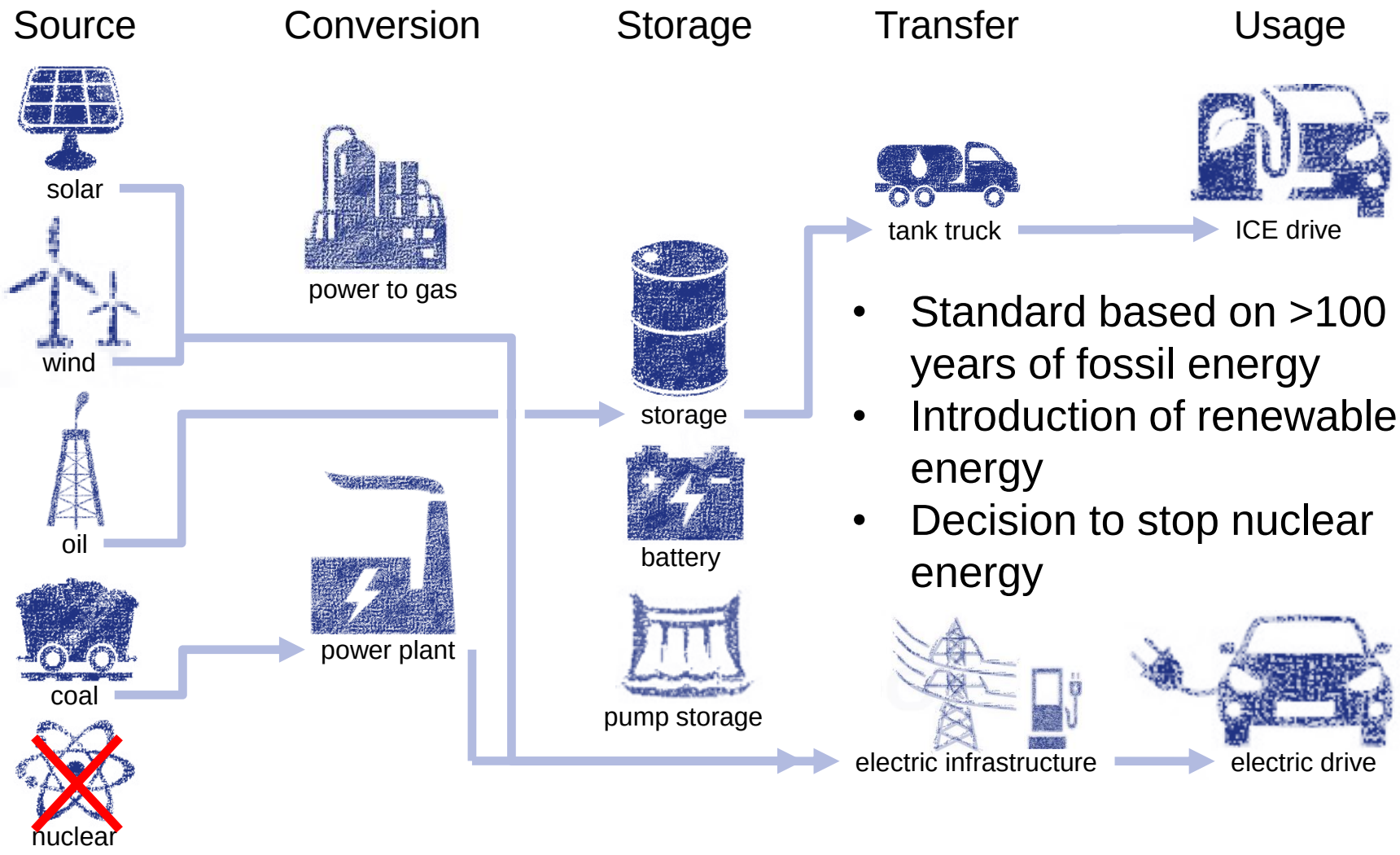


Perspective year 2025

Wir sind schon wieder belogen worden

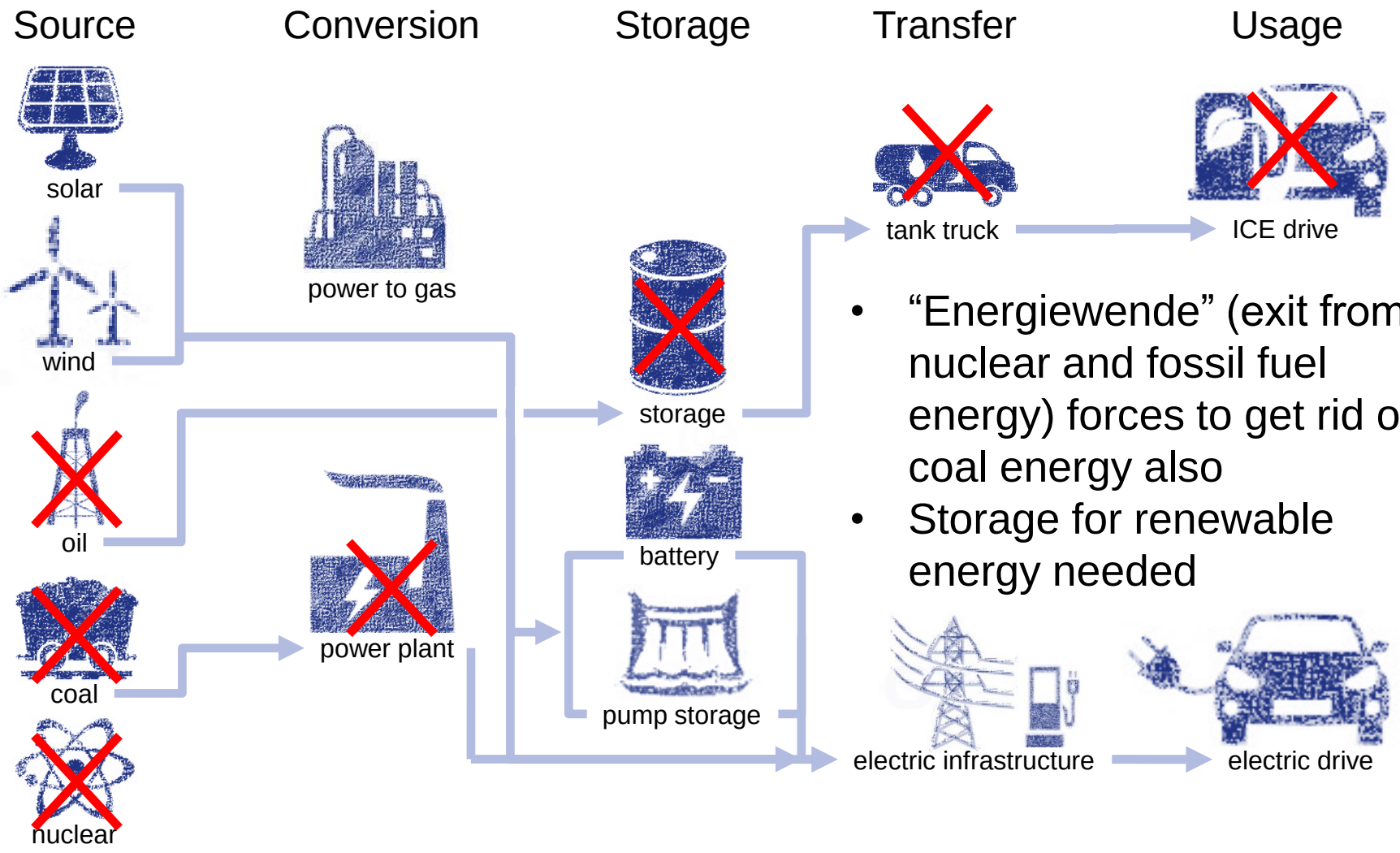
SKANDAL ELEKTRO

Energy for powertrains



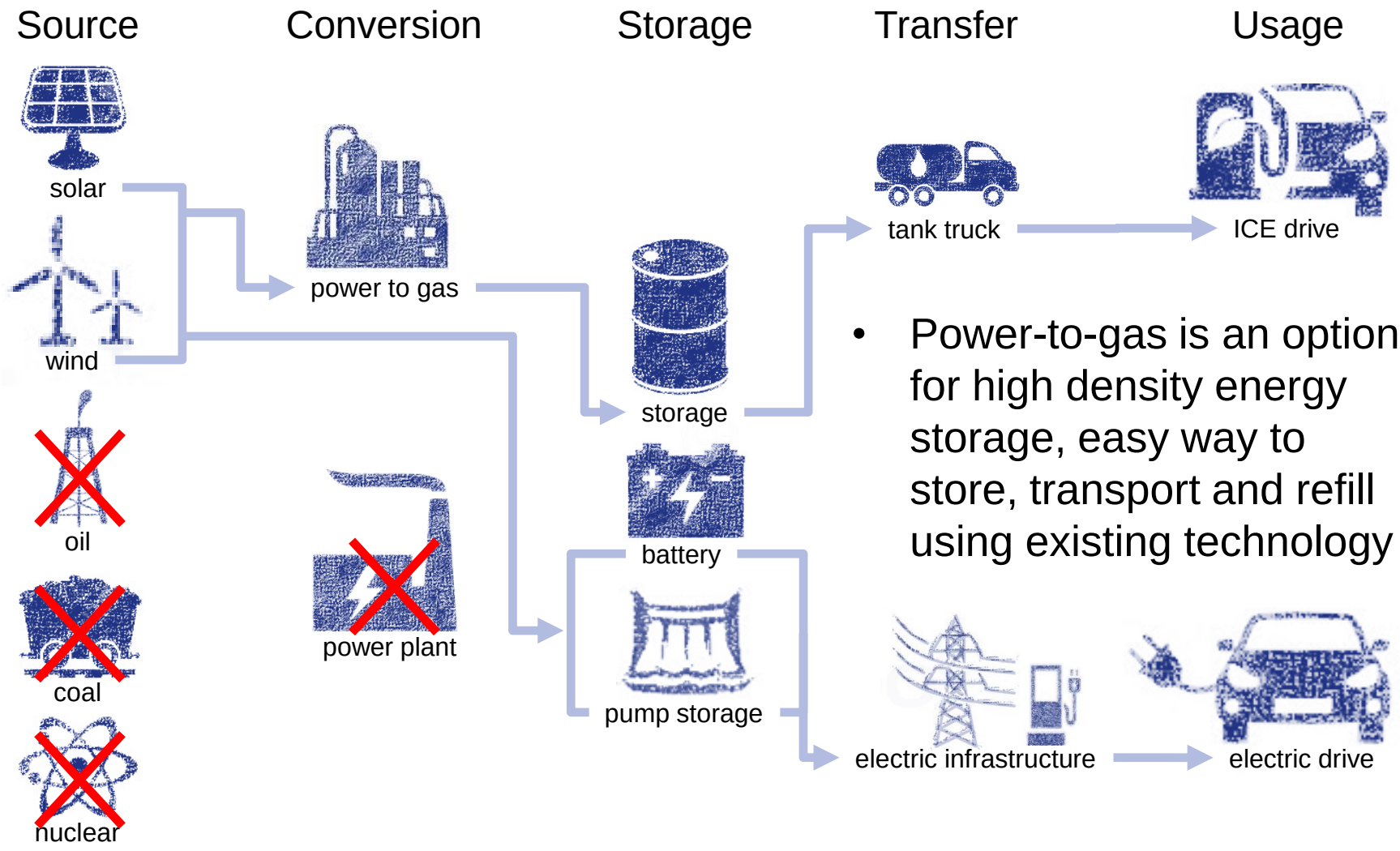
- Standard based on >100 years of fossil energy
- Introduction of renewable energy
- Decision to stop nuclear energy

Energy for powertrains



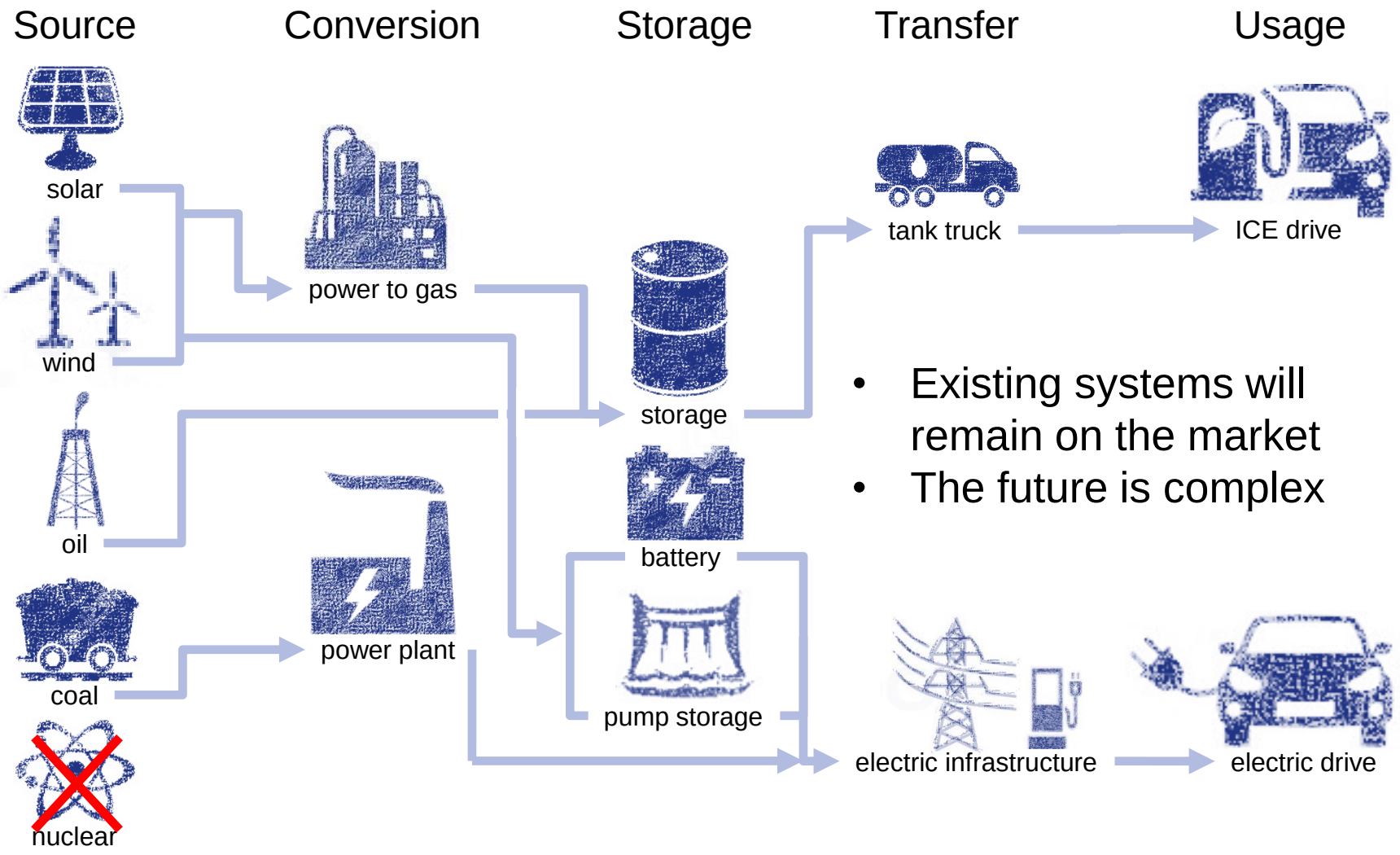
- “Energiewende” (exit from nuclear and fossil fuel energy) forces to get rid of coal energy also
- Storage for renewable energy needed

Energy for powertrains



- Power-to-gas is an option for high density energy storage, easy way to store, transport and refill using existing technology

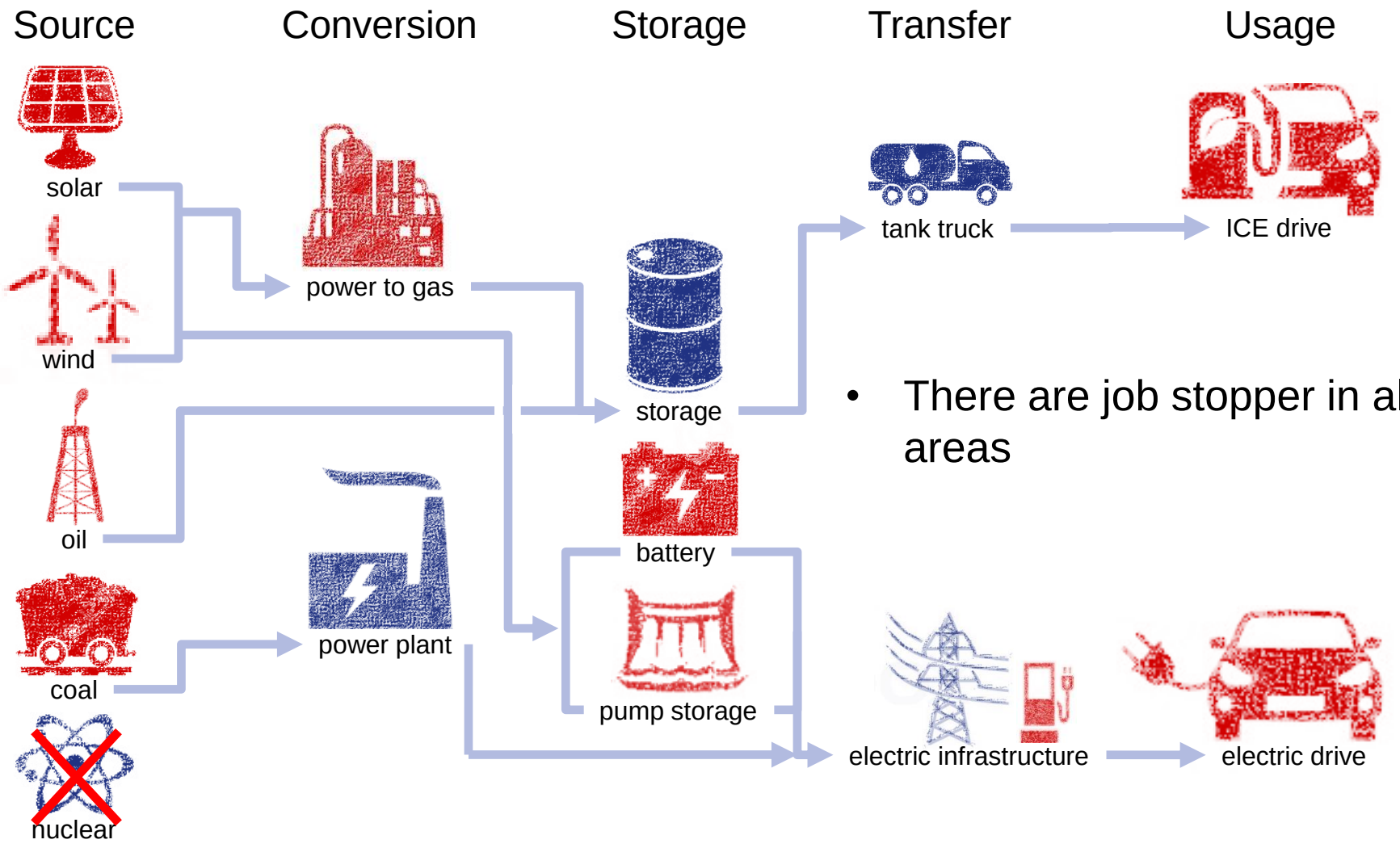
Energy for powertrains



„There will be several systems complementing each other“

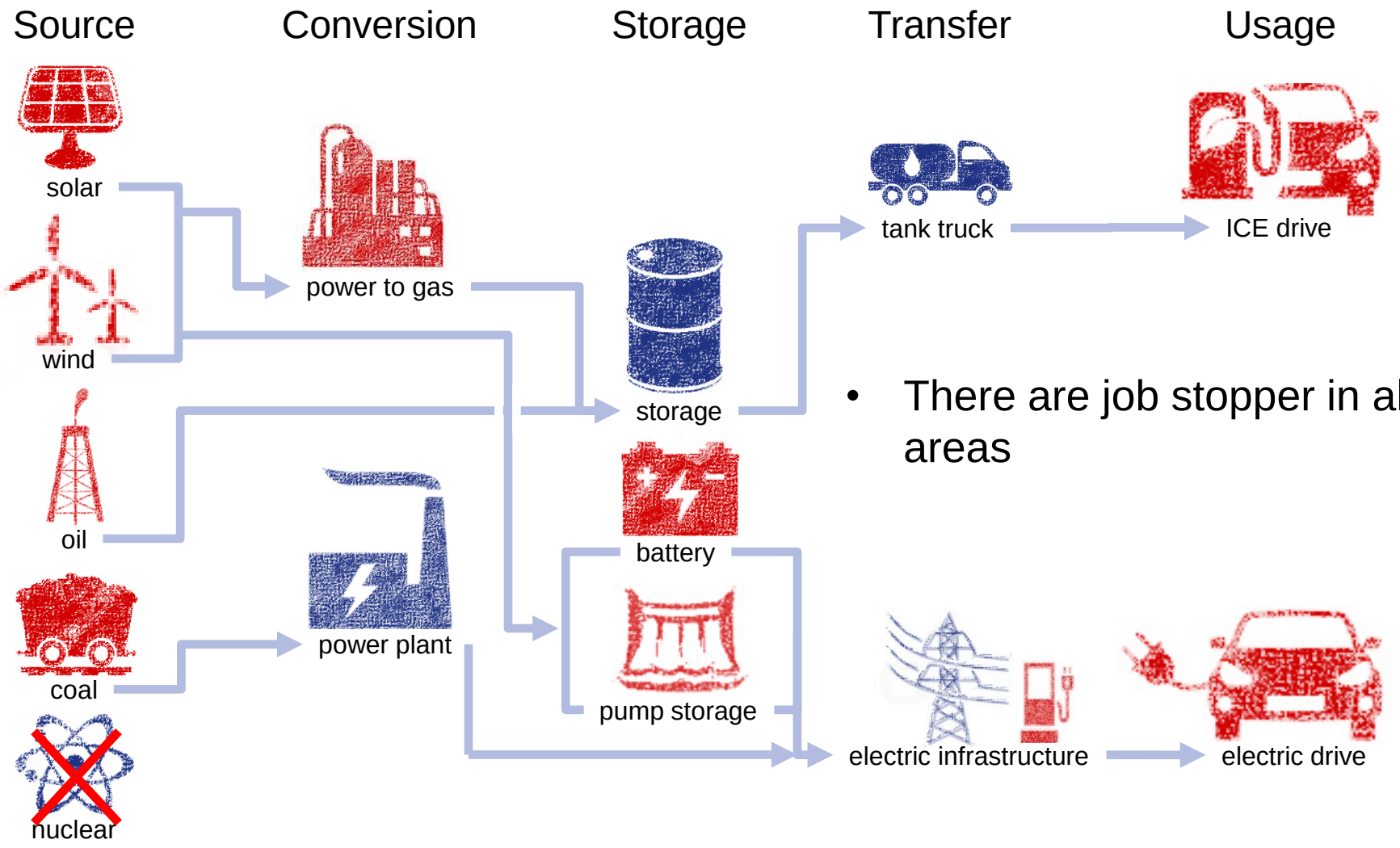
But what are the facts?

Energy for powertrains



- There are job stopper in all areas

Energy for powertrains

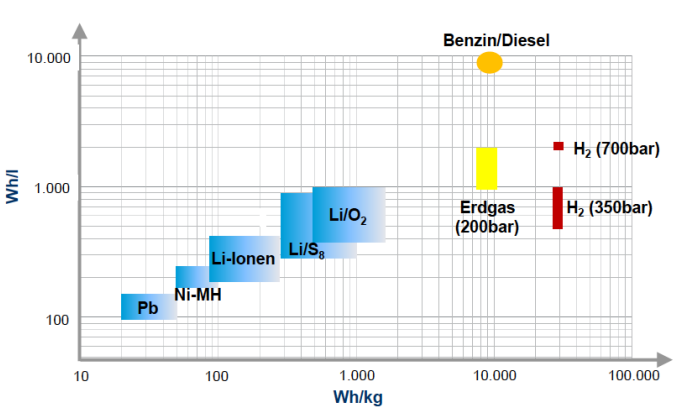


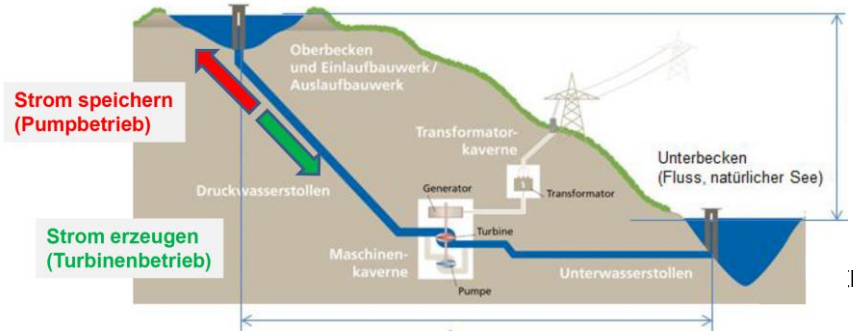
- There are job stopper in all areas

Energy for powertrains

Source | Conversion | Storage | Transfer | Usage

oil





Facts

Fossil fuels are **…**

- limited and
- cause climate change

Battery electric cars are far away from mainstream because …

- Battery capacity is limited
- Reload time still too long
- Clean electric energy is needed
- Storage of renewable energy is needed

Fuel cells are promising but …

- Hydrogen has low energy density
- System technology is still not ready

Power-to-gas is an alternative but have two disadvantages because …

- Conversion relative is expensive
- The system needs the evil combustion engine

„There will be several systems complementing each other“

The truth is …

There is no technical solution

Industrial market introduction
Social memory lead to typical thinking error

1st idea / market success

1956 / 1981
catalytic converter

1905 / 2000
particulate filter

1888 / open
electric car

Long debate between public, politics, media, industry before market introduction, then suddenly full market penetration

What do we learn?

1. Invention
2. Full system integrity
3. Series production readyness

Innovation process
Thinking shortcut leads to typical thinking

1970

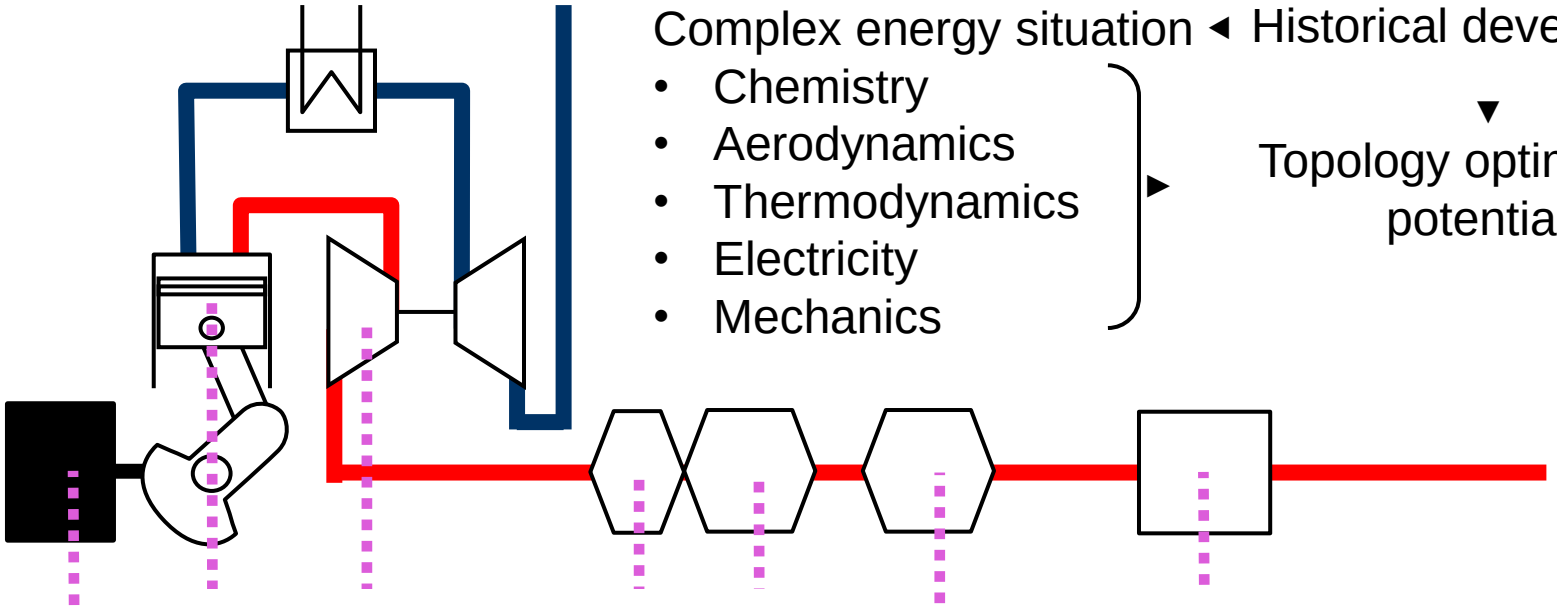
2010

Is warp speed possible?

Compare:
Communication vs. transport
Data flow vs. energy flow

“~~Nothing is impossible~~”

Technical potential in ICE powertrains
Exhaust energy usage



Complex energy situation ◂ Historical development

- Chemistry
- Aerodynamics
- Thermodynamics
- Electricity
- Mechanics

▸ Topology optimization potentials

Hybrid: electrical ▸ mechanical

WHR: thermal ▸ mech. / electr.

SCR: thermal + chemical ▸ chemical

Filter: thermal ▸ chemical

Oxi cat: thermal / electrical ▸ chemical

Turbine: thermal / aerodynamical ▸ mechanical

Combustion: chemical ▸ thermal ▸ mechanical

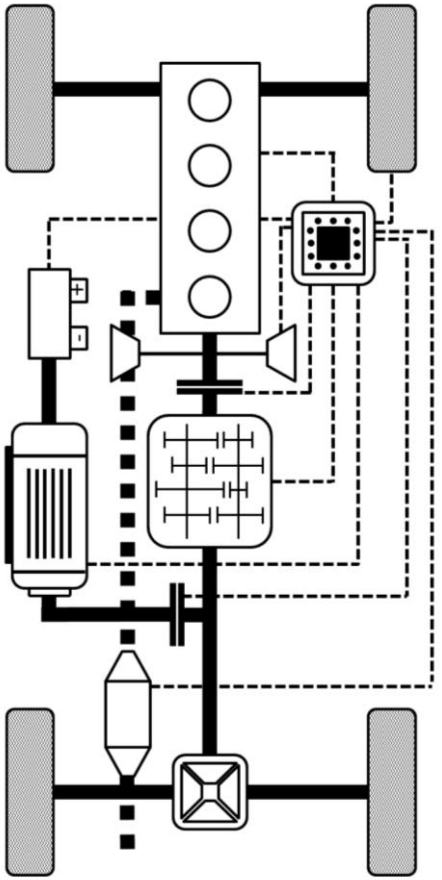
Technical potentials in combustion engines

Combustion improvement
- New combustion systems
- Water injection …
- Natural gas / methane
- Fuels

Powertrain
- Components
- Topology
- Individualization
- Thermal management
- Aftertreatment

Electrification
- Components
- Hybridisation

- ➢ Improved and new compo-nents and functionality
- ➢ New models for integrated development of energy use in system
- ➢ Both, a realis-tic and a de-manding view to facts



Technical potentials in combustion engines

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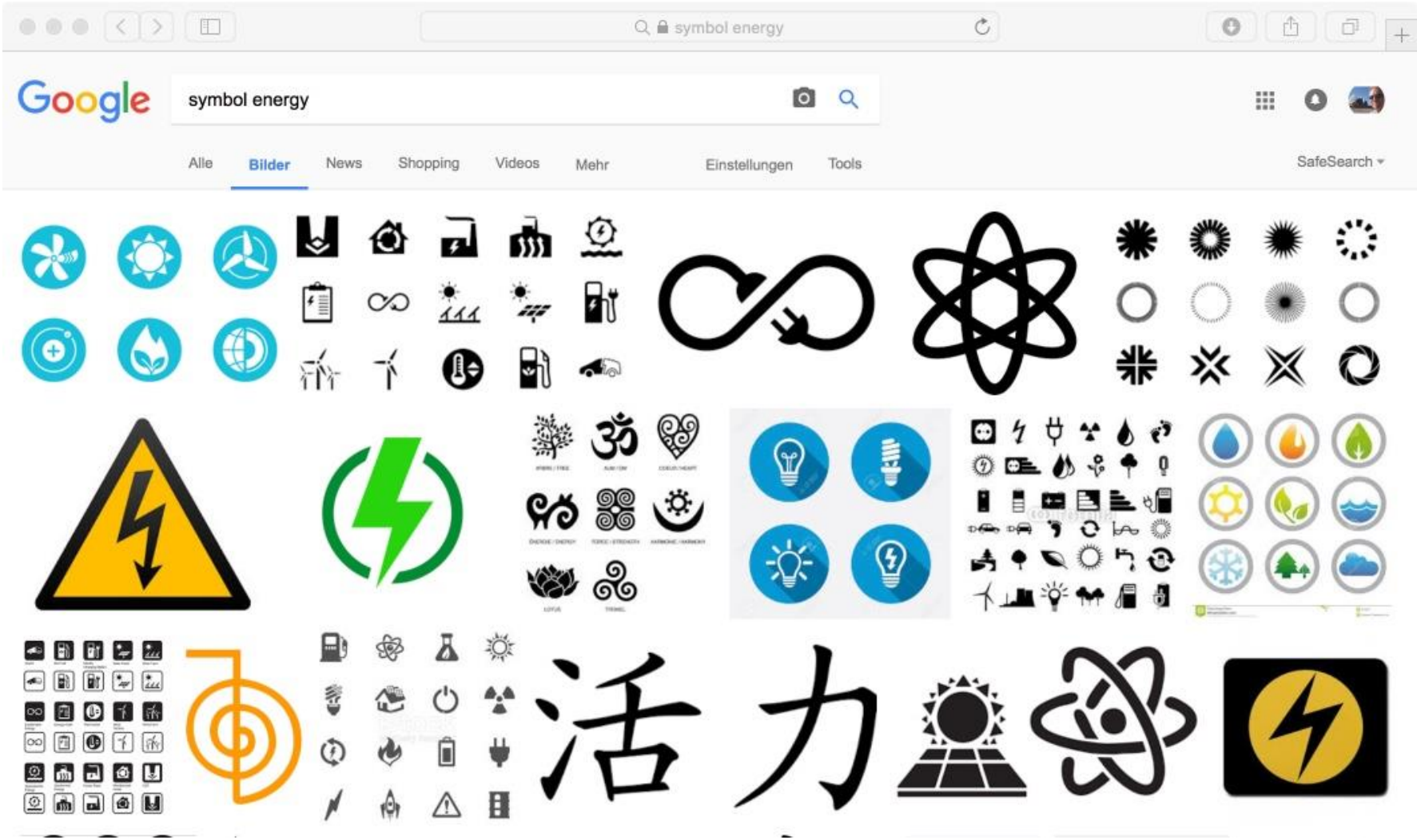
Energy storage and conversion

$$\mathrm{Li_{1-x}Mn_2O_4 + Li_xC_n \rightarrow LiMn_2O_4 + C_n}$$

$$\mathrm{CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O}$$

Idea what energy is and how much energy we need?



Energy for powertrains

Source	Conversion	Storage	Transfer	Usage
solar	power to gas	storage	tank truck	ICE drive
wind	power plant	battery	electric infrastructure	electric drive
oil		pump storage		
coal				
nuclear				

Energy options (Simplification)