Deutscher Wasserstoff- und Brennstoffzellen-Verband

Hydrogen and Fuel Cells as strong partners of renewable energy systems

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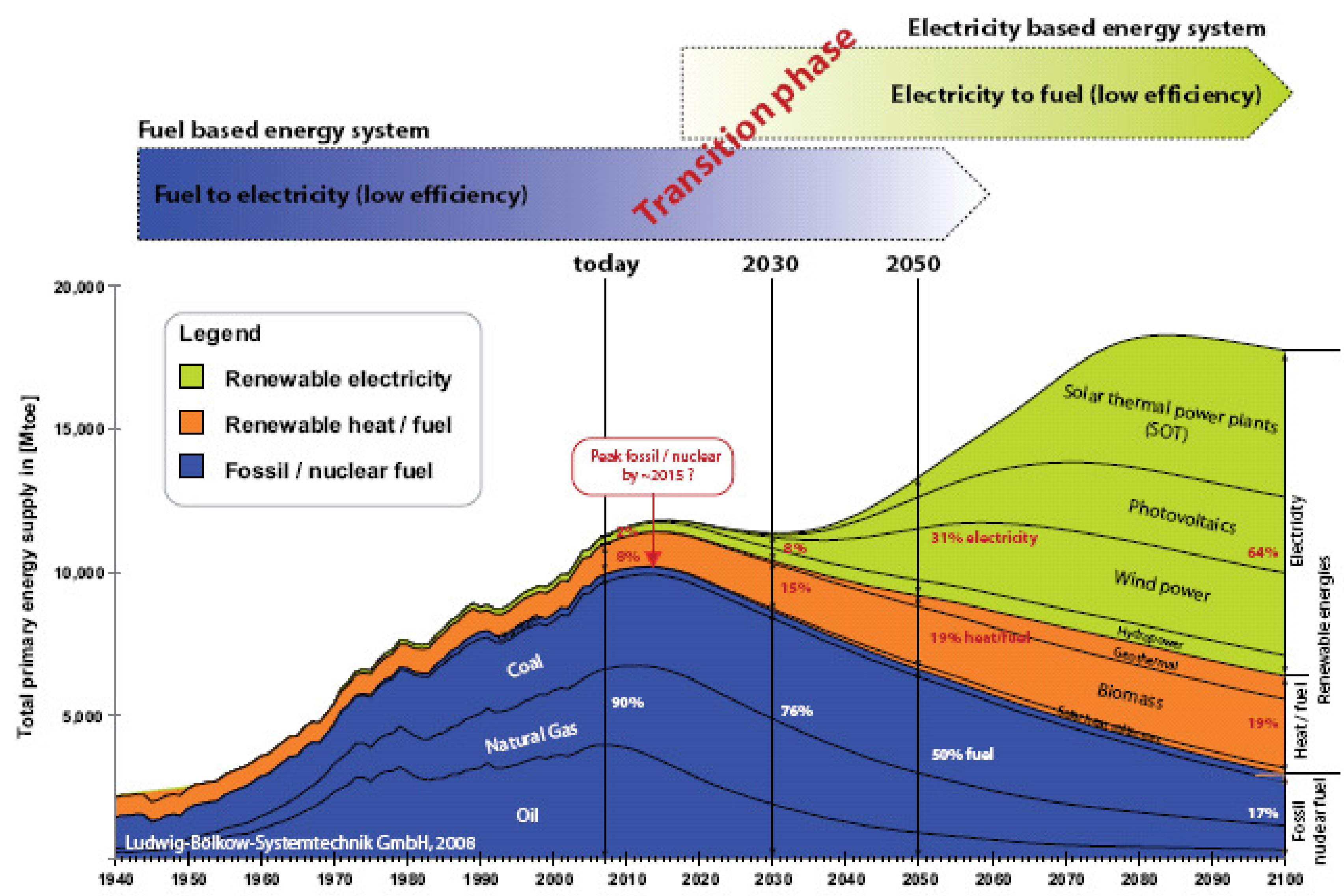
Drawn up by *Ludwig-Bölkow-Systemtechnik*

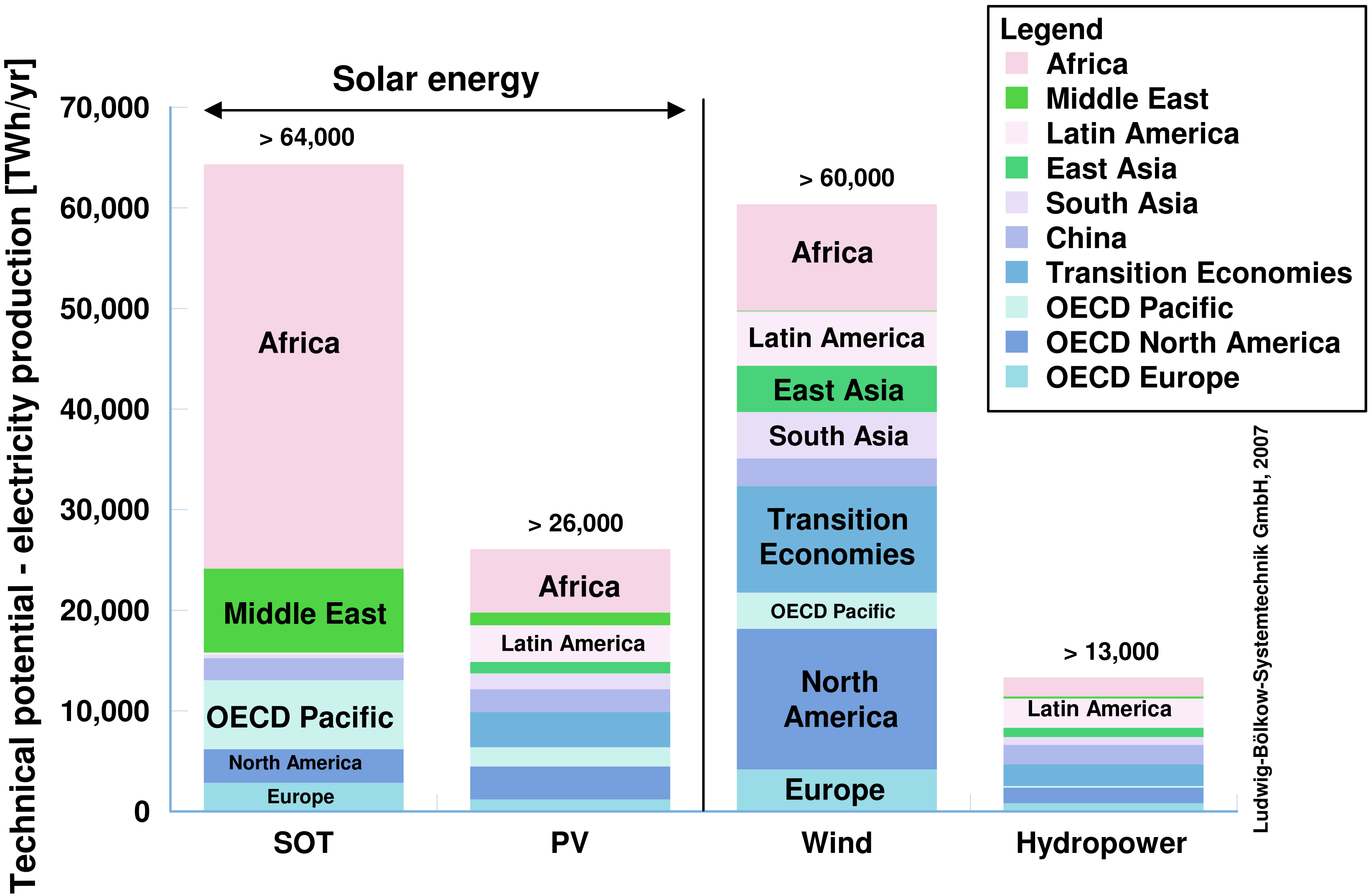
Future primary energy supply



Future primary energy supply - Consequences -

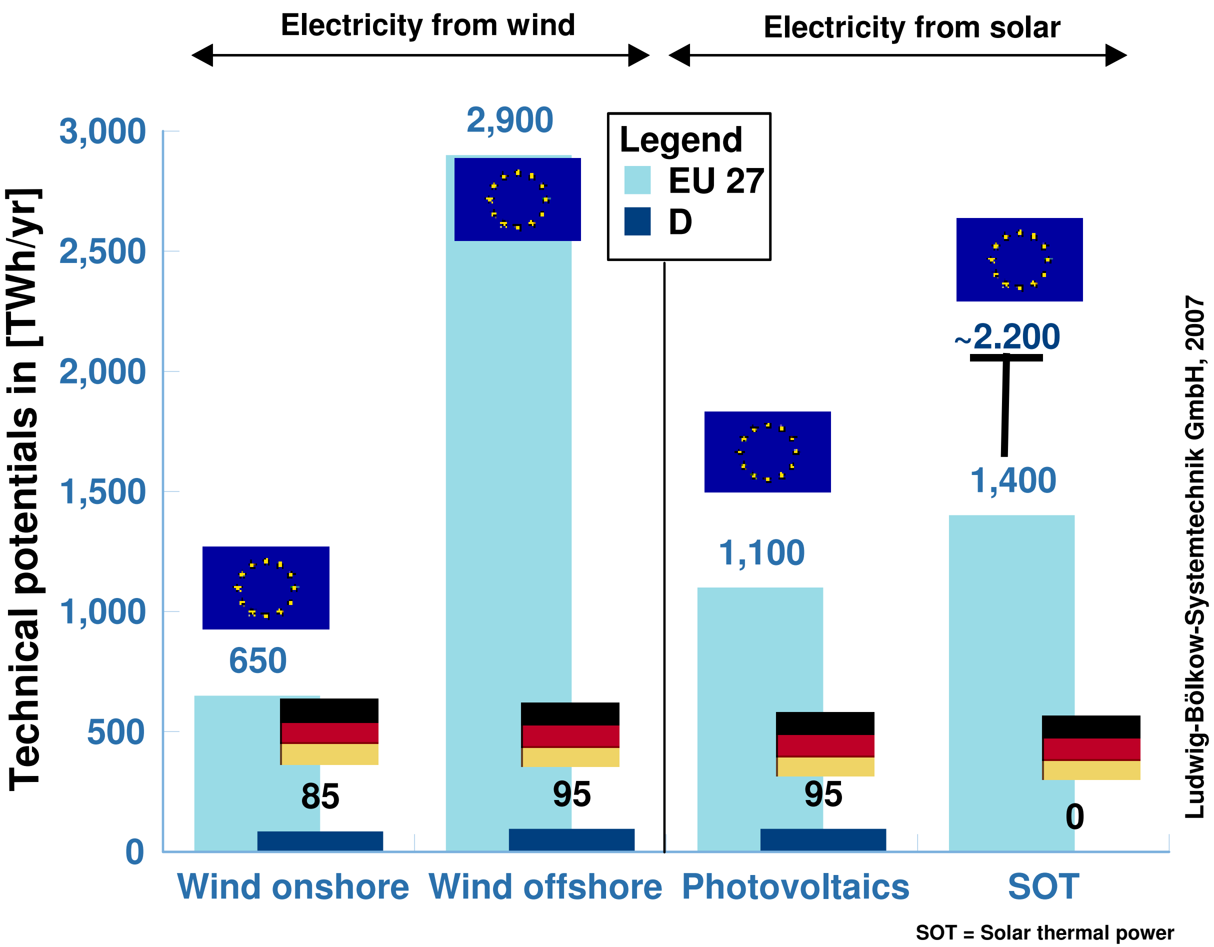
- *Peak of fossil and nuclear fuels by 2015*
- *In the long term, the future primary energy system will be electricity dominated*
- *Transition from a fuel based energy system to an electricity-based one*
- *Transport sector will use "electricity as major primary energy source"*
- *Future infrastructure has to change: electricity will need to substitute fossil fuels*
- *Storage of electricity will become essential – hydrogen will function as an important electricity storage media and become a strong partner for renewable energies and the transport sector*

Renewable electricity potentials - global



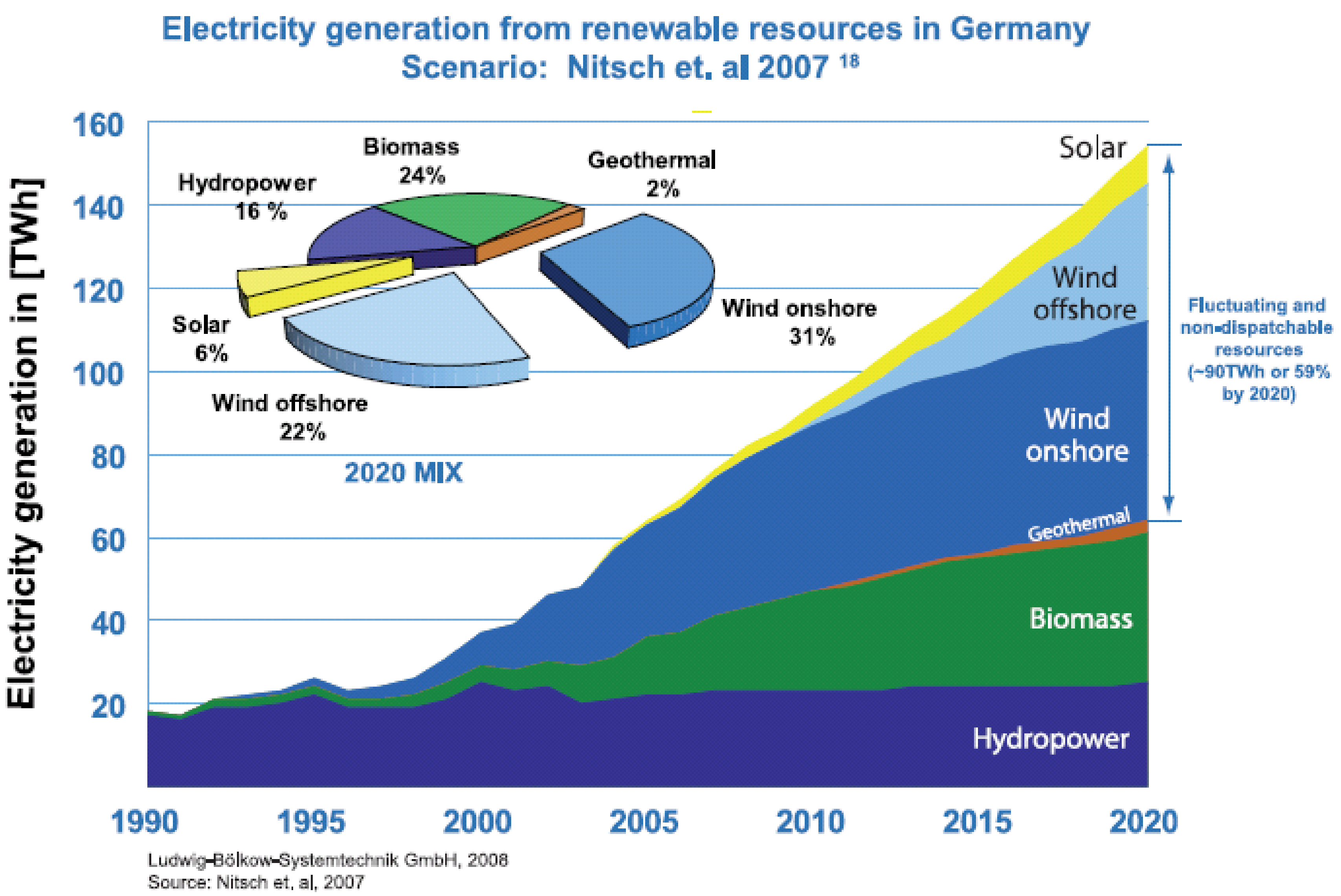
Technical potential of renewable electricity – worldwide

Renewable electricity potentials
- Europe and Germany -



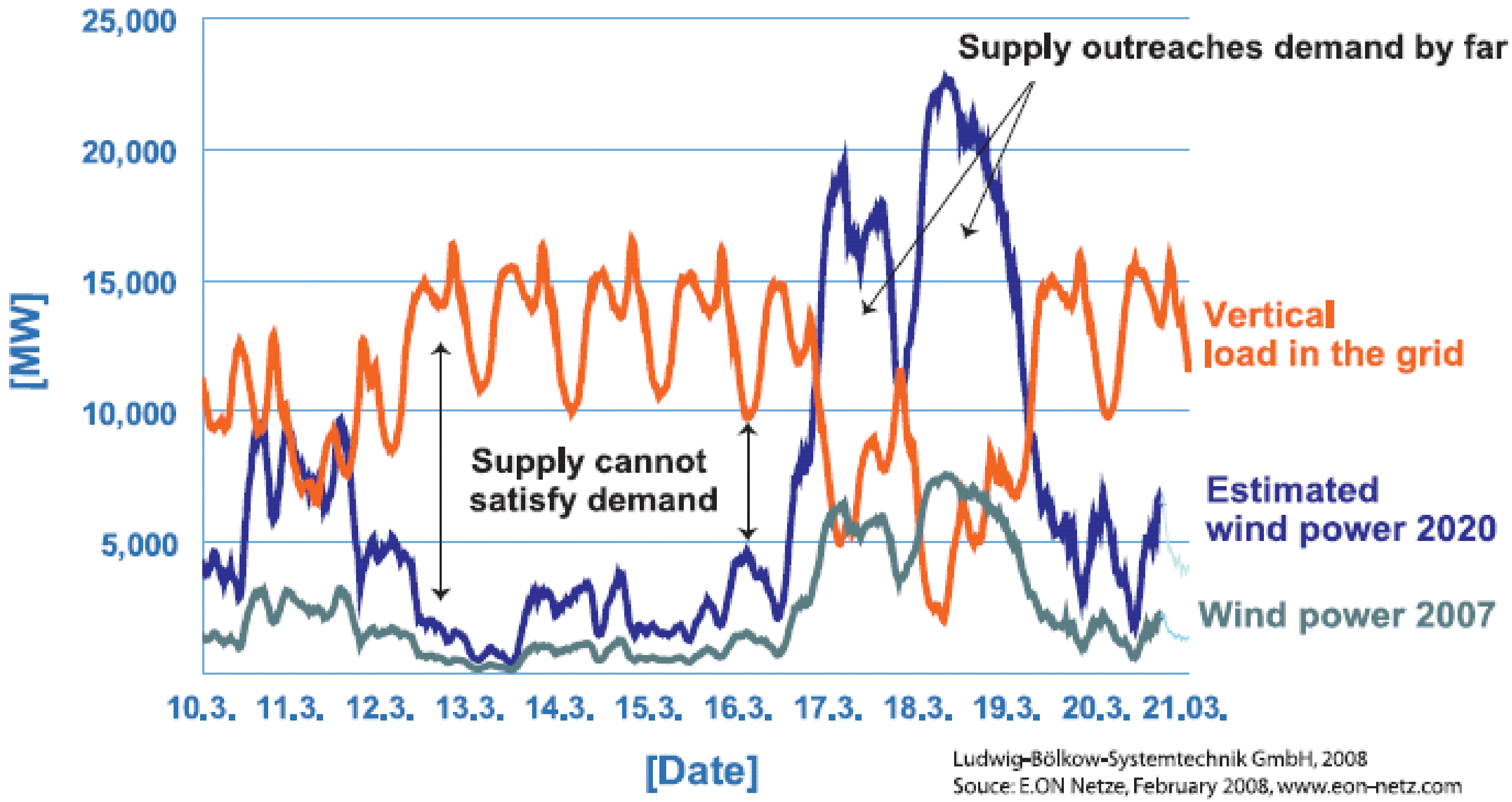
Technical potential of electricity production from wind and solar energy in Europe (EU) and Germany (D)

Fluctuating renewable electricity



Fluctuating renewable electricity

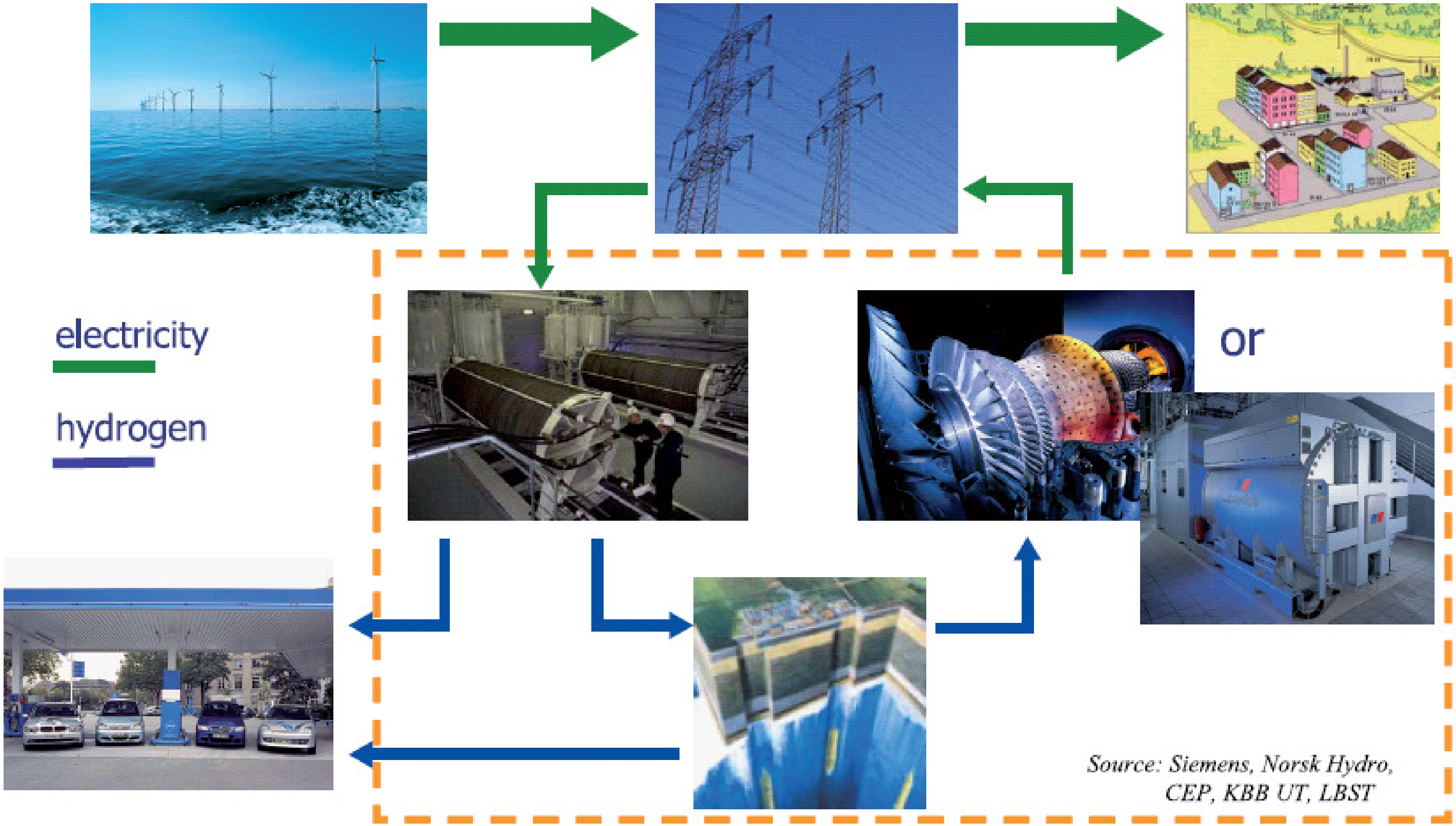
Vertical load curve and feed-in of wind power in the E.ON grid



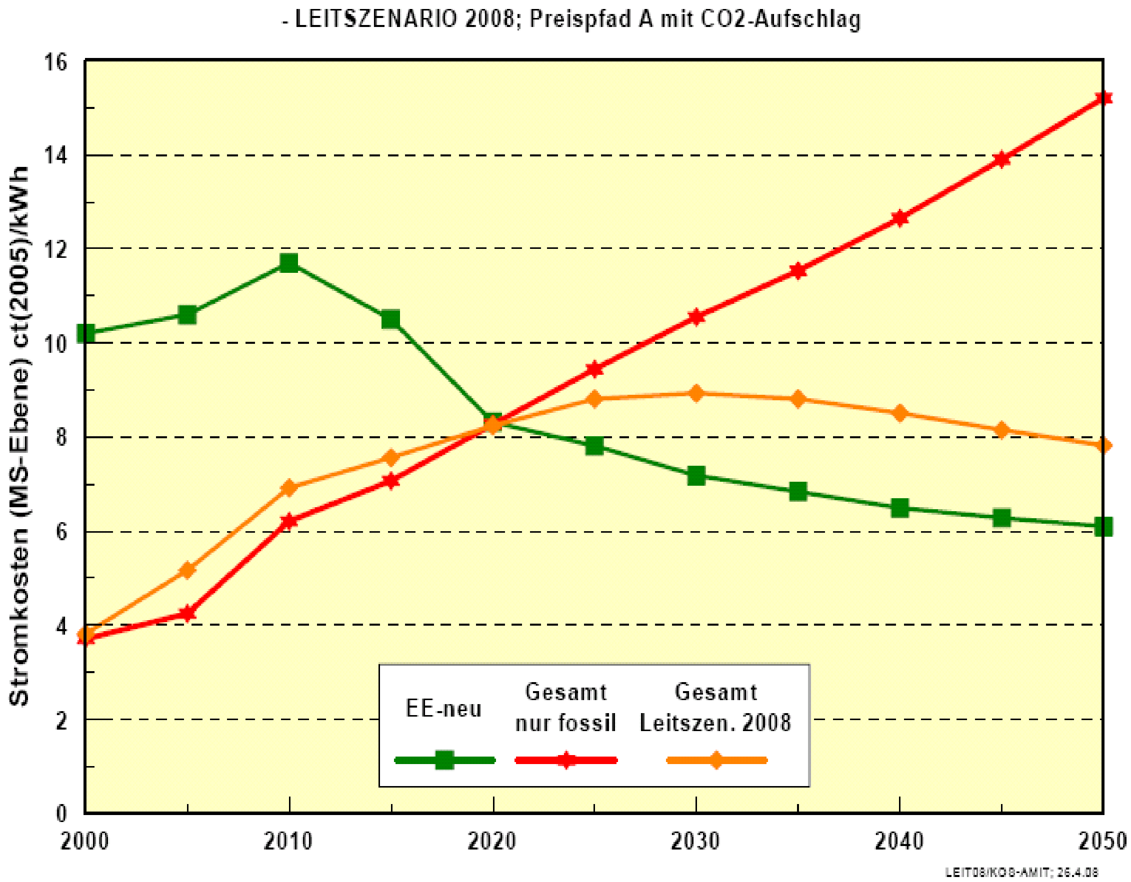
Ludwig-Bölkow-Systemtechnik GmbH, 2008
Souce: E.ON Netze, February 2008, www.eon-netz.com

Hydrogen as storage option

Hydrogen storage as an option



Competitive renewable electricity



Average electricity cost scenario for renewable and fossil plants (with CCS)

The graph shows rising costs for fossil energy sources (including costs for emission trading, respectively CCS implementation) and decreasing costs for renewable energies depending on the assumption that the break-even point between fossil and renewable electricity production will occur sometime between around 2020.

Up to this date, the introduction of renewable energies will lead to higher average energy cost whereas after passing the break-even point, the growing contribution of renewable energy sources will reduce electricity costs compared to a purely fossil scenario.

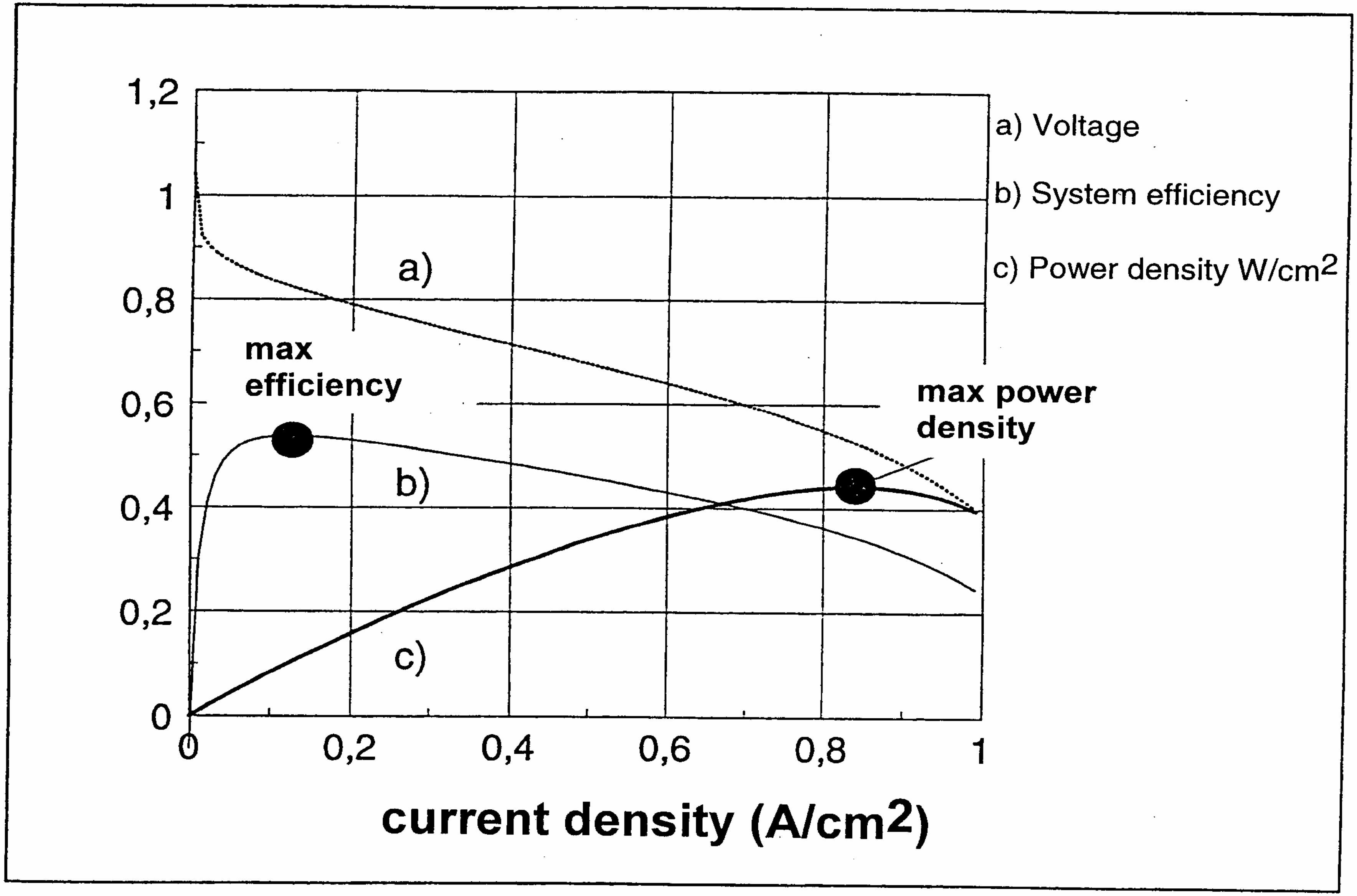
[Source: Nitsch et. al 2008]

System-Combinations for Propulsion and Storage

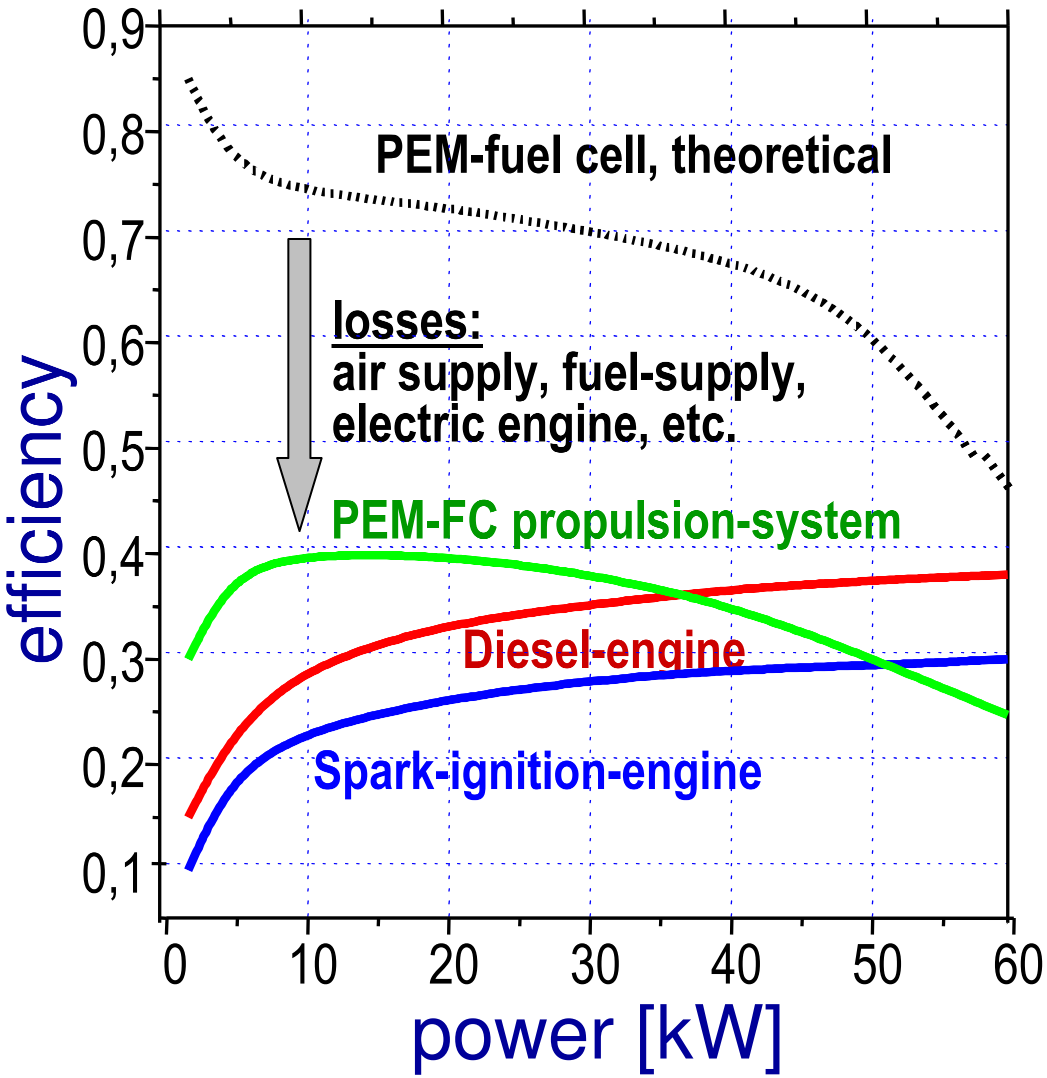
H_2

Storage Systems	***Propulsion Systems***
Compressed H2 (10 bar<p<700 bar; -40C<T<85C)	Internal Combustion Engine („ICE“)
Liquid Hydrogen 3 bar < p < ca.8 bar; T~ 22K)	Fuel Cell
Metal-Hydrides (spec. Appl.) (3 bar< p<50 bar; -15C <T< 60 C)	Hybrid-Drive (Fuel Cell + Battery)

Fuel cells system efficiency



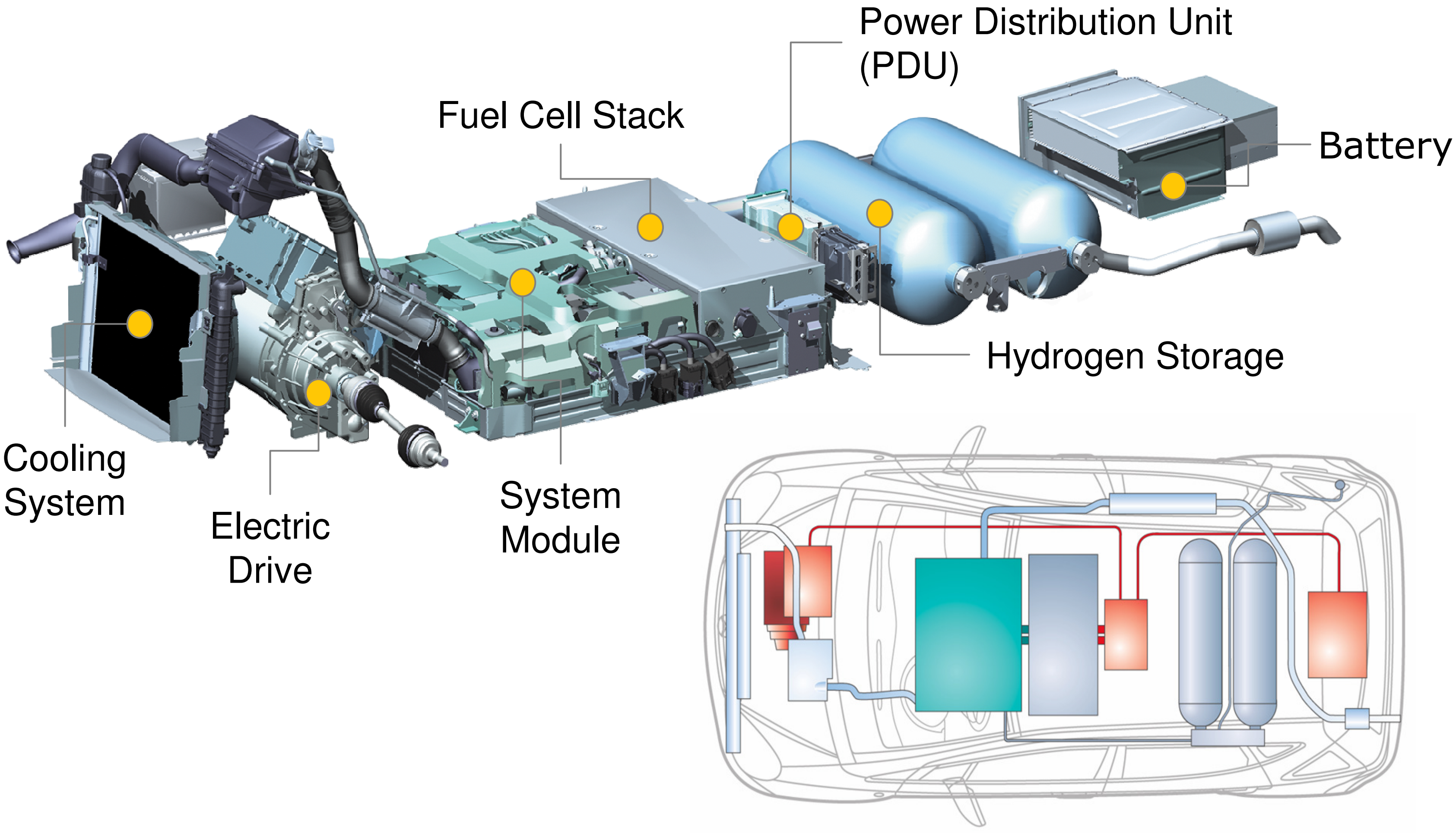
Comparison: Fuel Cell System ↔ Internal Combustion Engine



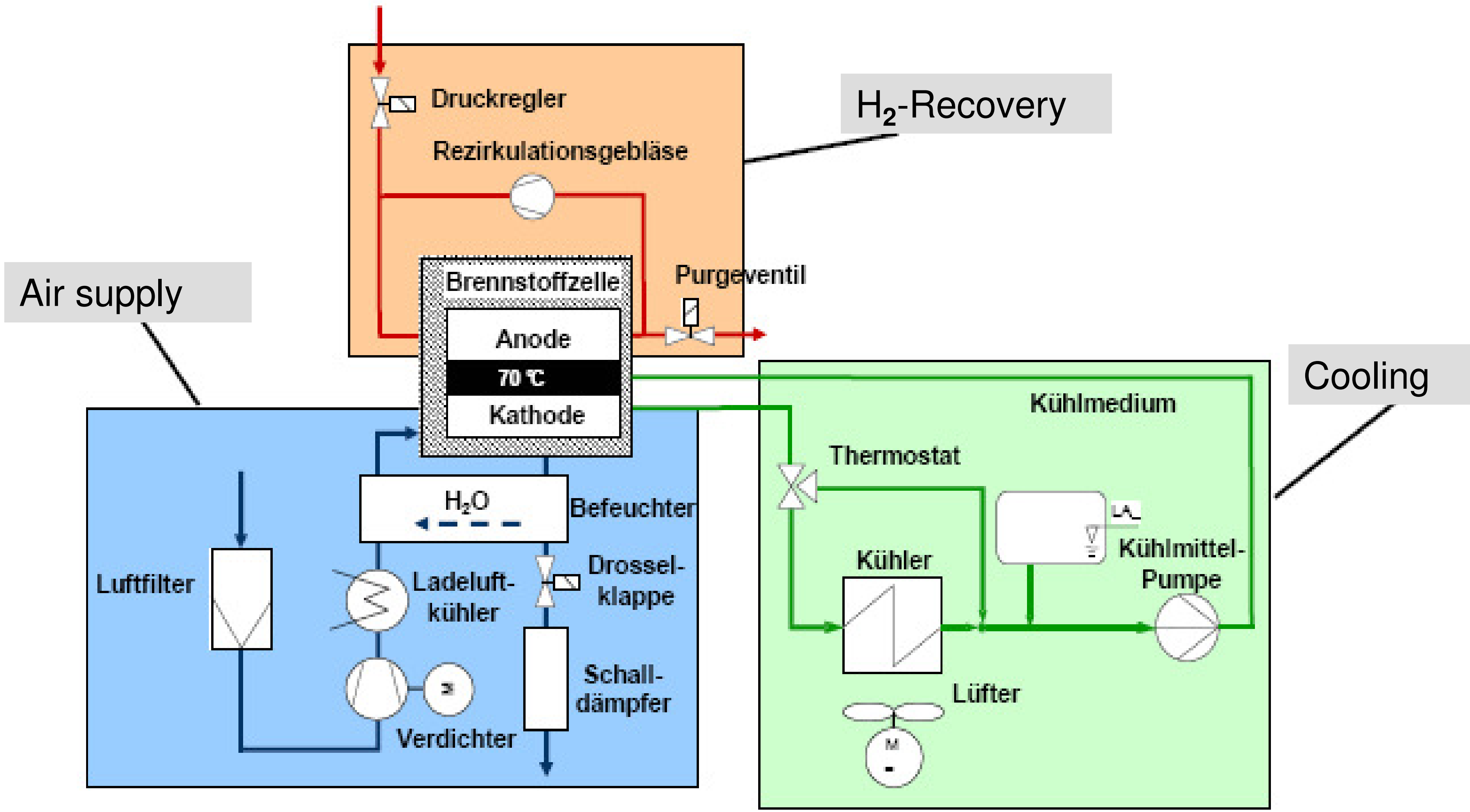
- Fuel Cells in Propulsion Systems
- Advantage of efficiency in low load
- High Potential by Optimising of ancillary units

Source: FEV, Aachen

Daimler, FCell Packaging

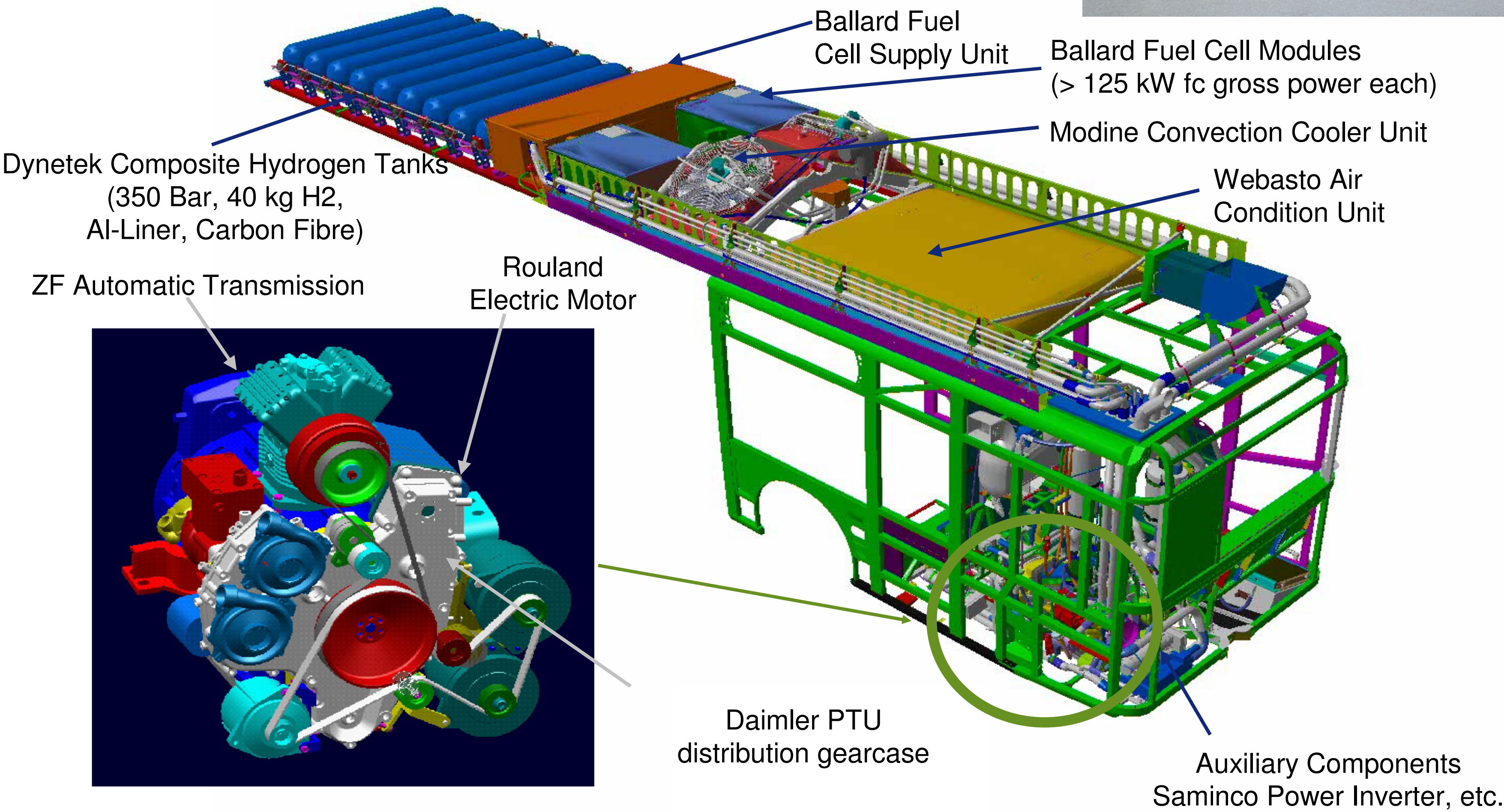


System-concept of Low Temperature-PEM (V W)

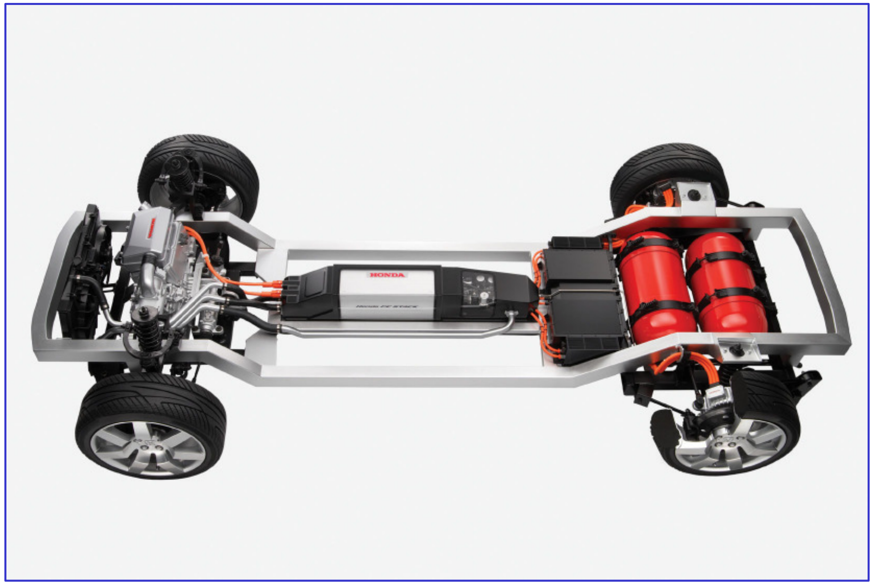


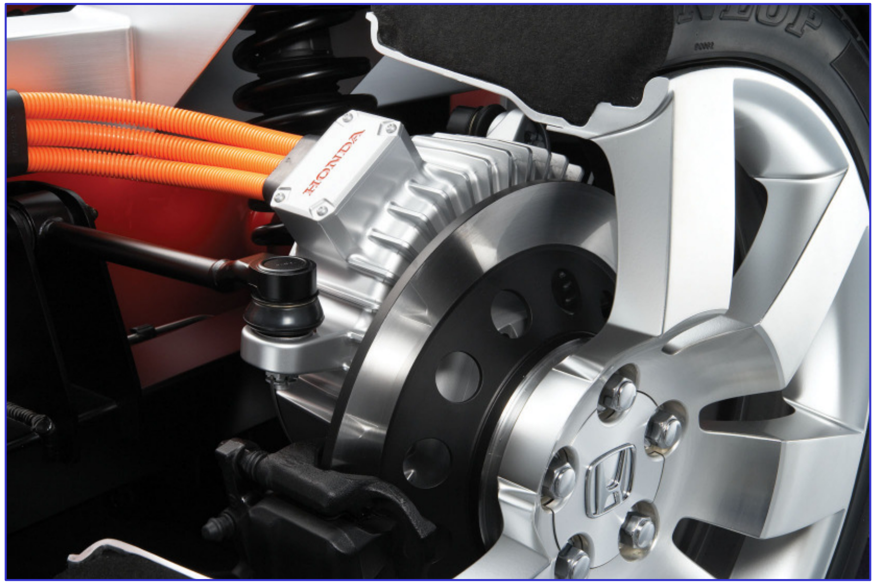
Source: Schmitz, f-cell, Sept.2008

Daimler: Citaro-Bus, Packaging



Concept of Honda





Concept of Honda

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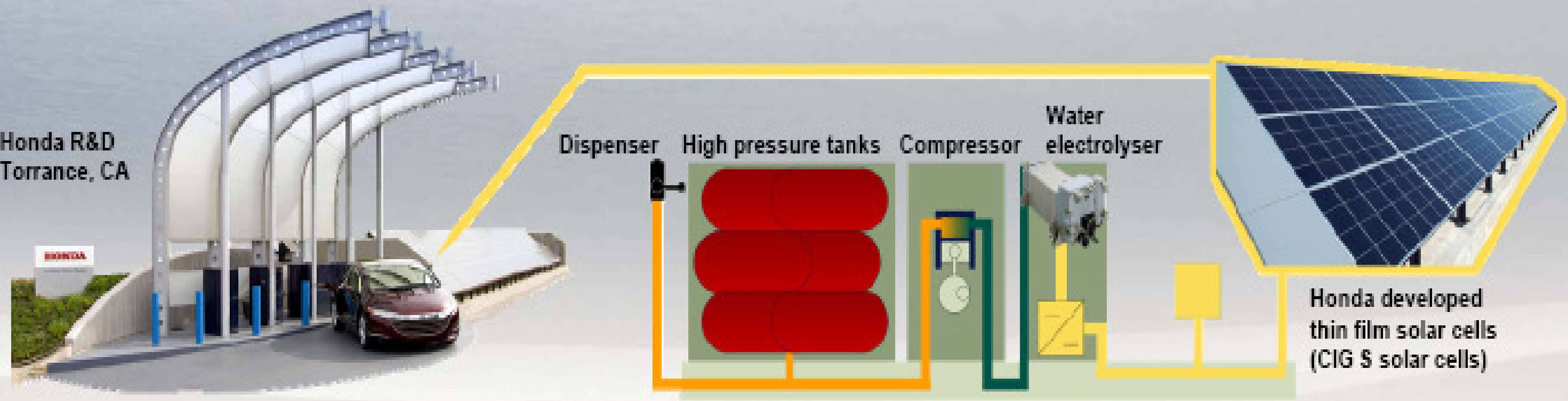
HONDA

Solar-powered Hydrogen Station



Honda is conducting feasibility tests on solar-powered hydrogen re-fueling stations since 2001.

The station built on Honda R&D Americas employs a Honda water-electrolyzing module and utilizes the next generation thin film solar cells of Honda.

Based on a highly efficient water- electrolyzing module, high- pressure hydrogen production efficiency has reached remarkable levels of 52% to 66%.

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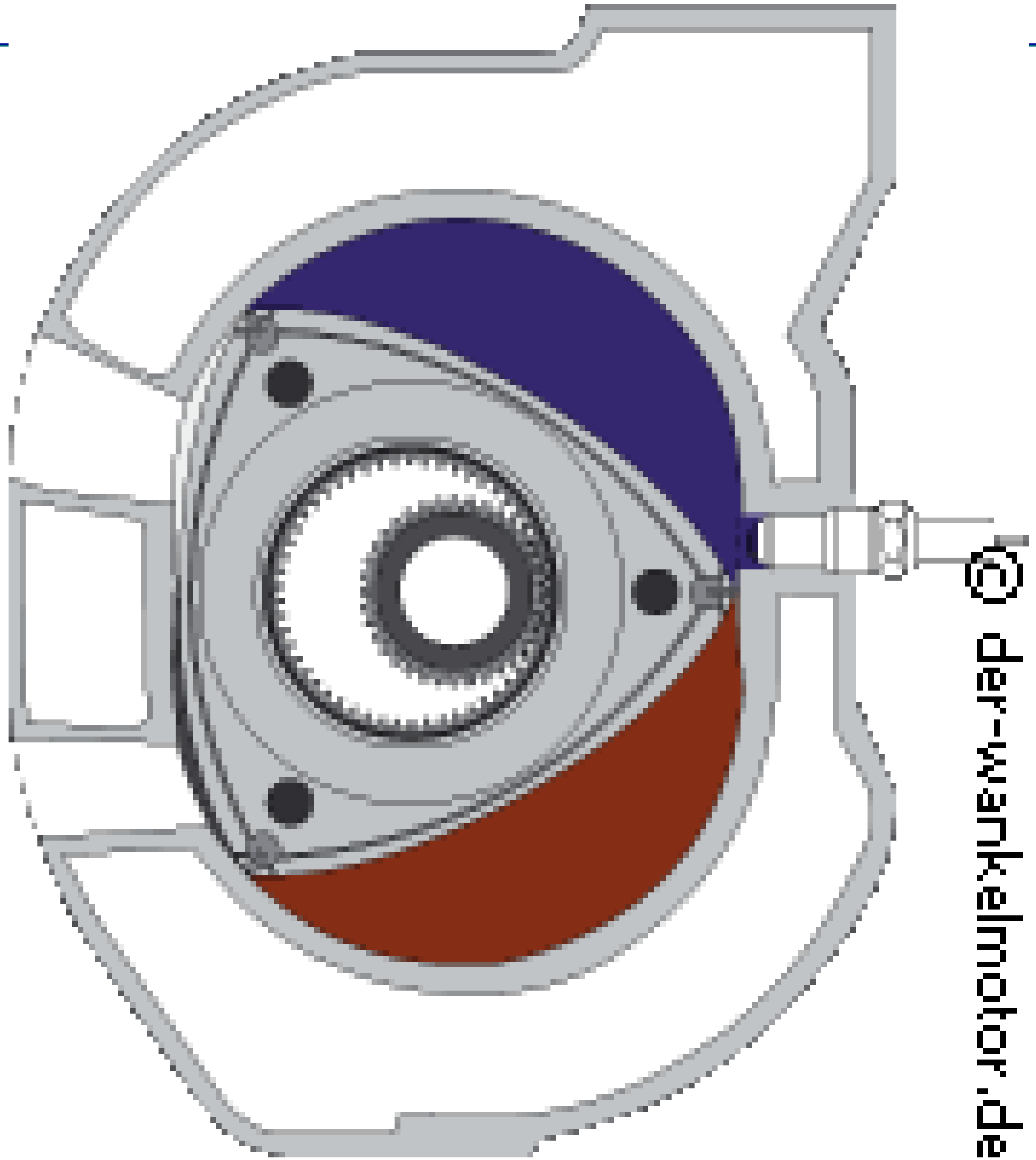
The principle of Wankel-engine



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Fuel leak simulation
Hydrogen car ↔ Gasoline car

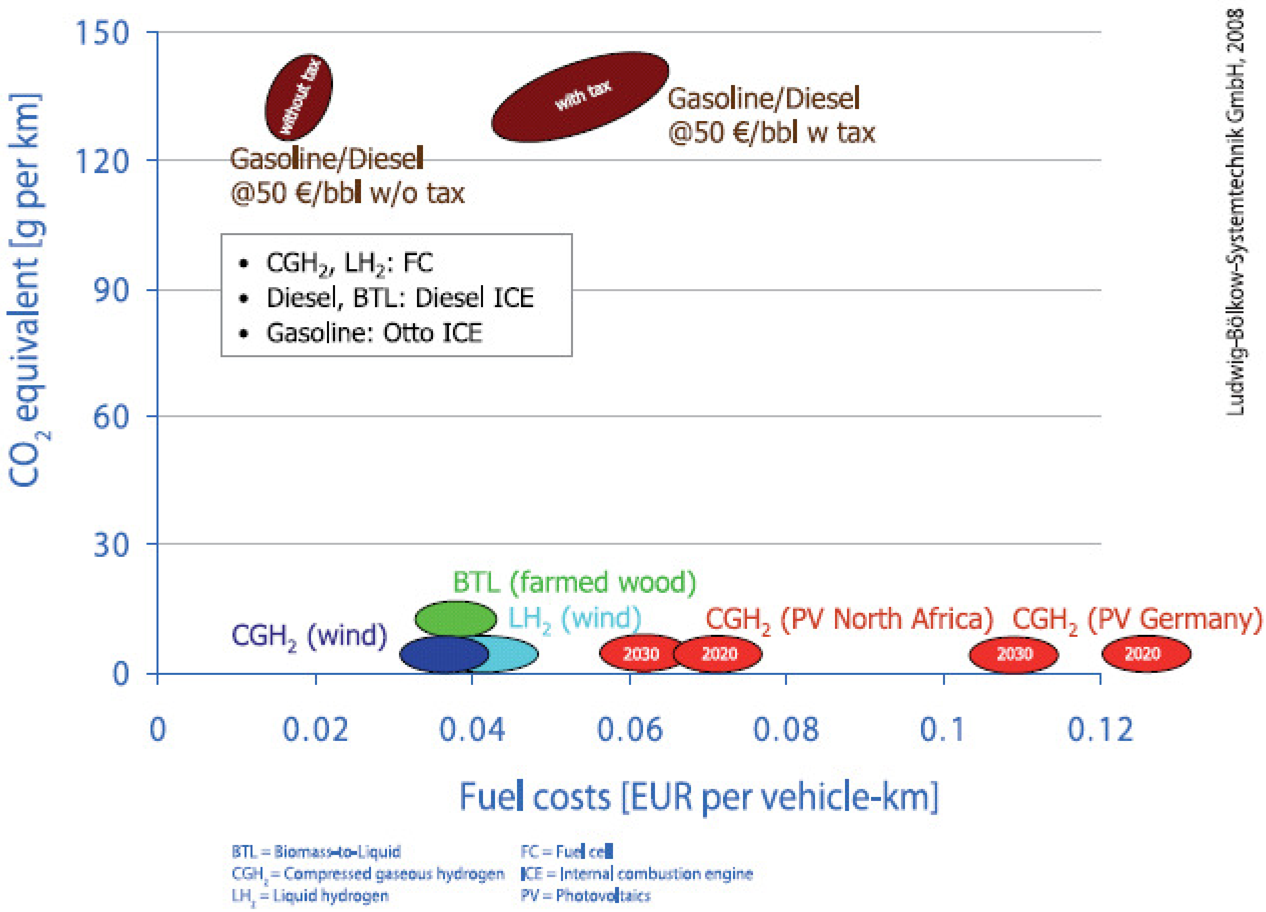
Photo 1 - Time: 0 min, 0 sec - Hydrogen powered vehicle on the left. Gasoline powered vehicle on the right.

Photo 2 - Time 0 min, 3 seconds - Ignition of both fuels occur. Hydrogen flow rate 2100 SCFM. Gasoline flow rate 680 cc/min.

Photo 3 - Time: 1 min, 0 sec - Hydrogen flow is subsiding, view of gasoline vehicle begins to enlarge

Photo 4 - Time: 1 min, 30 sec - Hydrogen flow almost finished. View of gasoline powered vehicle has been expanded to nearly full screen

Costs of transport fuel



Major assumptions

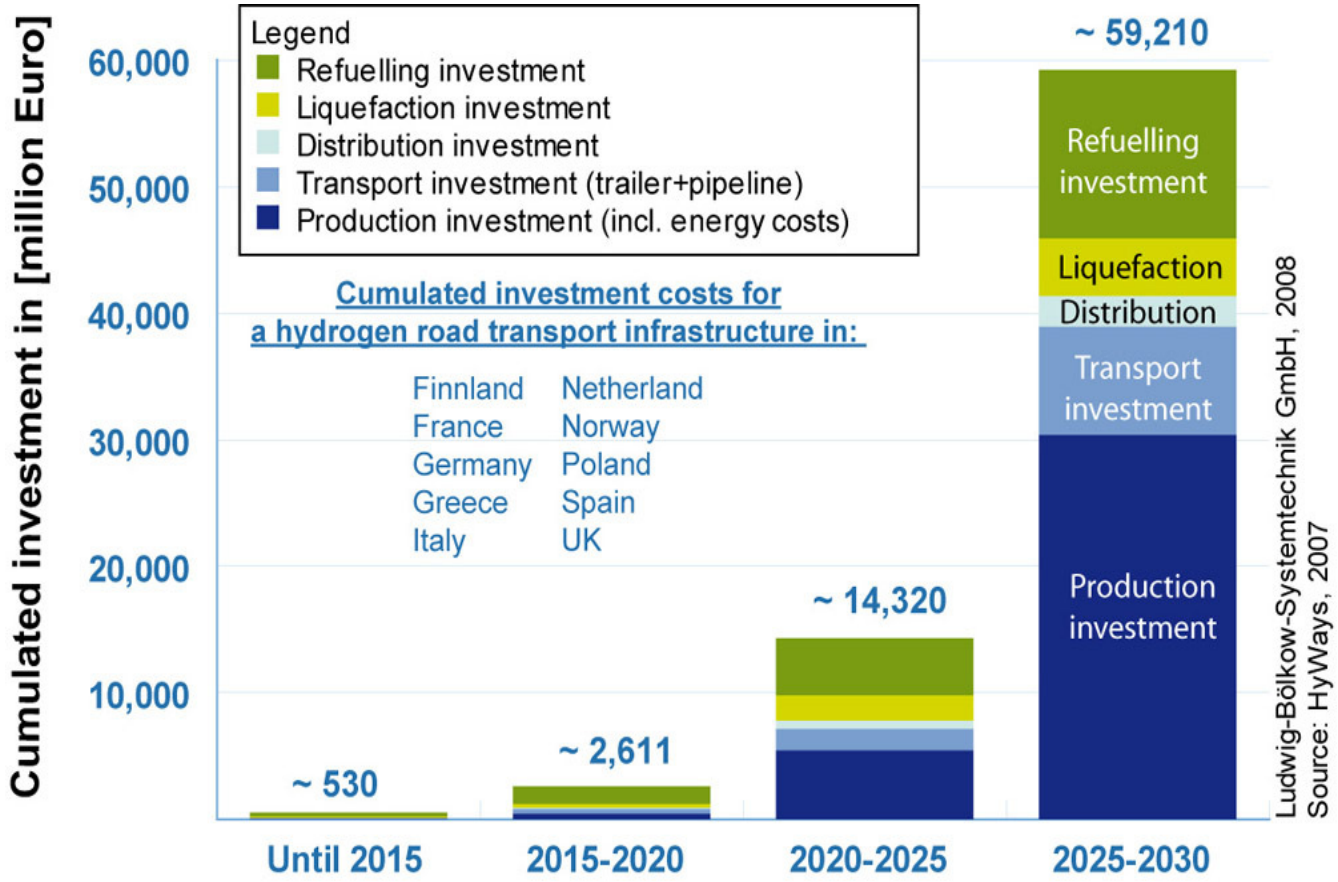
The fuel consumption of the hydrogen fuelled fuel cell hybrid vehicle is assumed to be 0.84 MJ/km (~ 2.6 l gaso-line equivalent per 100 km).

The fuel consumption of the gasoline fuelled hybrid vehicle amounts to about 1.62 MJ/km (~ 5.0 l gasoline equivalent per 100 km)

The fuel consumption of the diesel fuelled hybrid vehicle amounts to about 1.46 MJ/km (~4.5 l gasoline equivalent per 100 km or ~4.0 l diesel per 100 km).

The fuel consumption for the vehicles is derived from [CEJ 2007].

Cost H_2 supply and dispensing



Cumulative Investment Costs for a Hydrogen Road Transport System in 6 European Countries

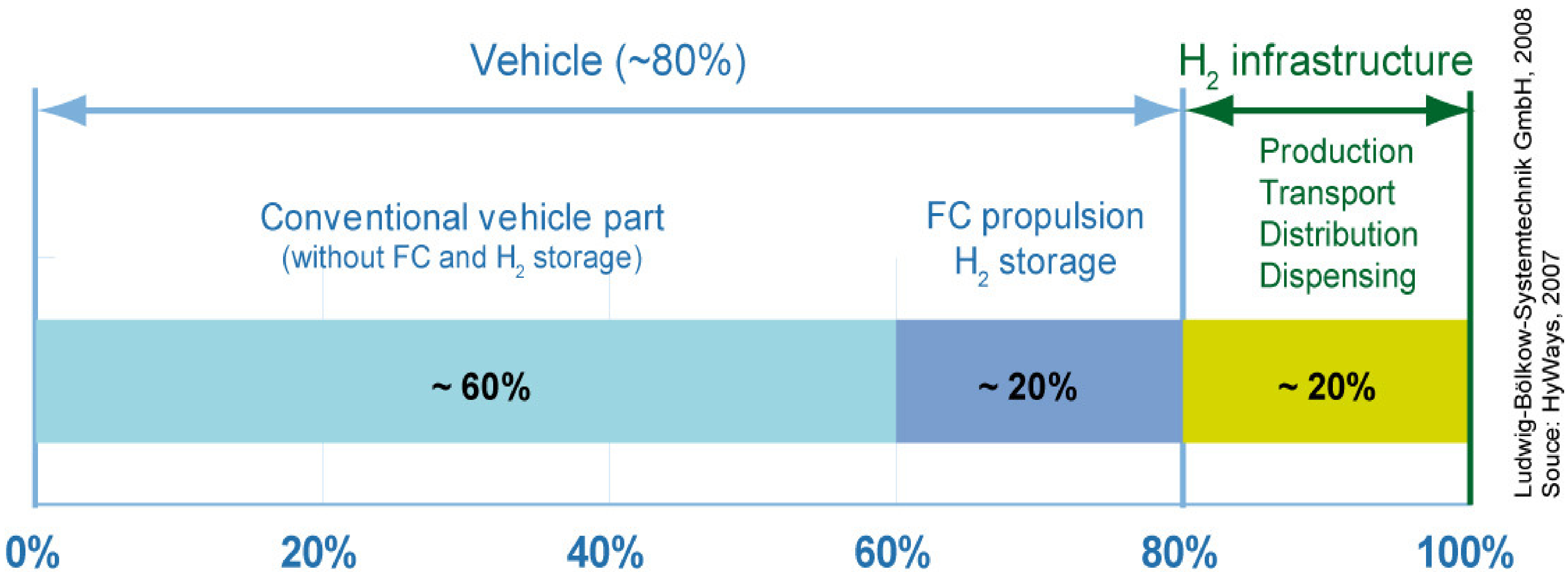
For a fully functioning hydrogen road transport system for a 2035, the HyWays project [www.hyways.de] assumed a scenario covering 6 European countries for which could be shown that more than **60%** of the total investment costs have to be brought up for the **conventional part of the vehicle**.

About **20%** are for the **H_2-specific onboard part** of the vehicle (e.g. FC and storage).

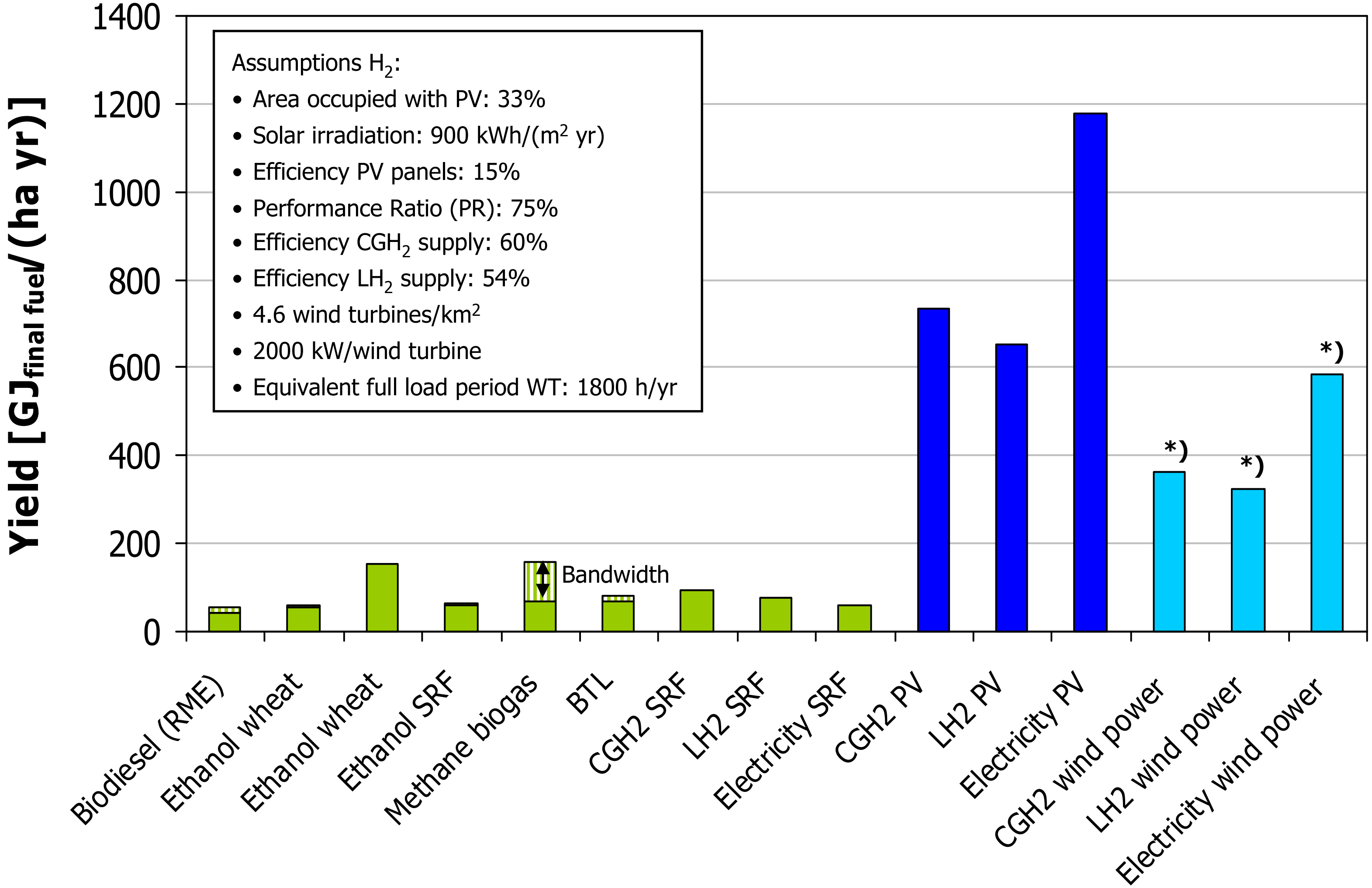
About **20%** are for the **H_2 production, transport, distribution and dispensing**.

[Source: HyWays, 2007]

H_2 infrastructure versus H_2 vehicle investments



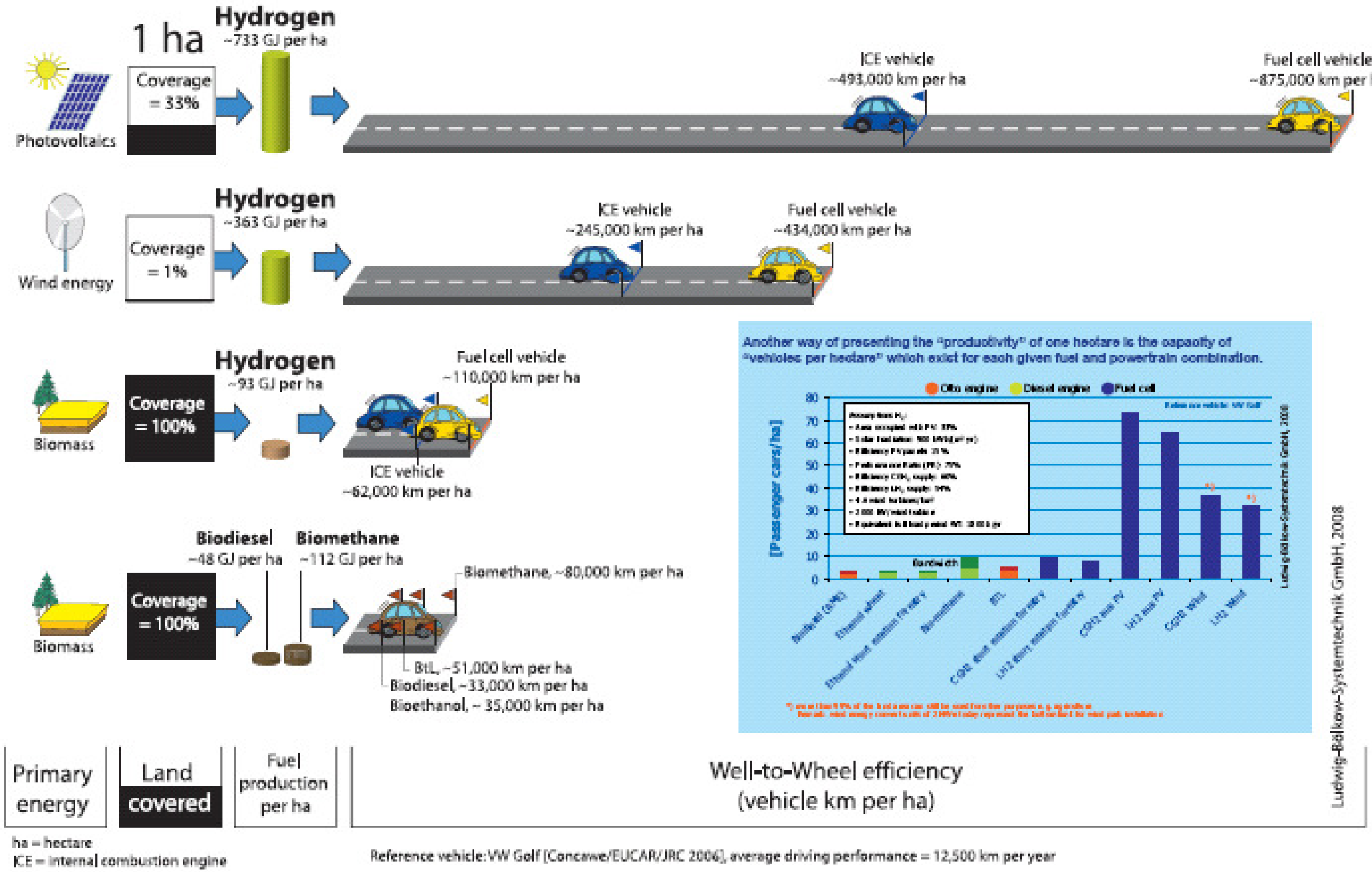
Yield of per ha and year for different transportation fuels



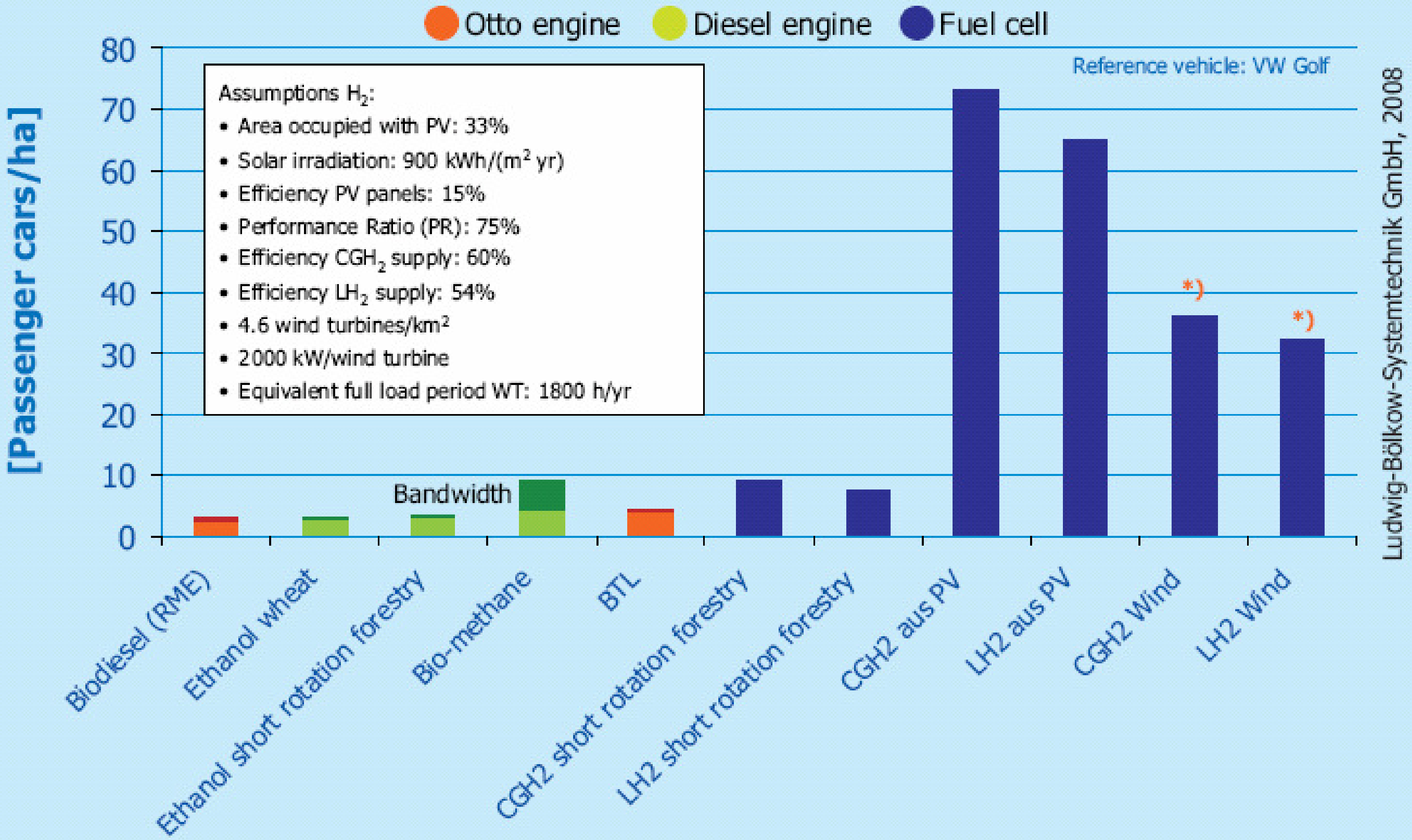
***) more than 99% of the land area can still be used for other purposes e.g. agriculture**

Driving distance with the fuel yield from one hectare of land

Use of one hectare of land for fuel production...

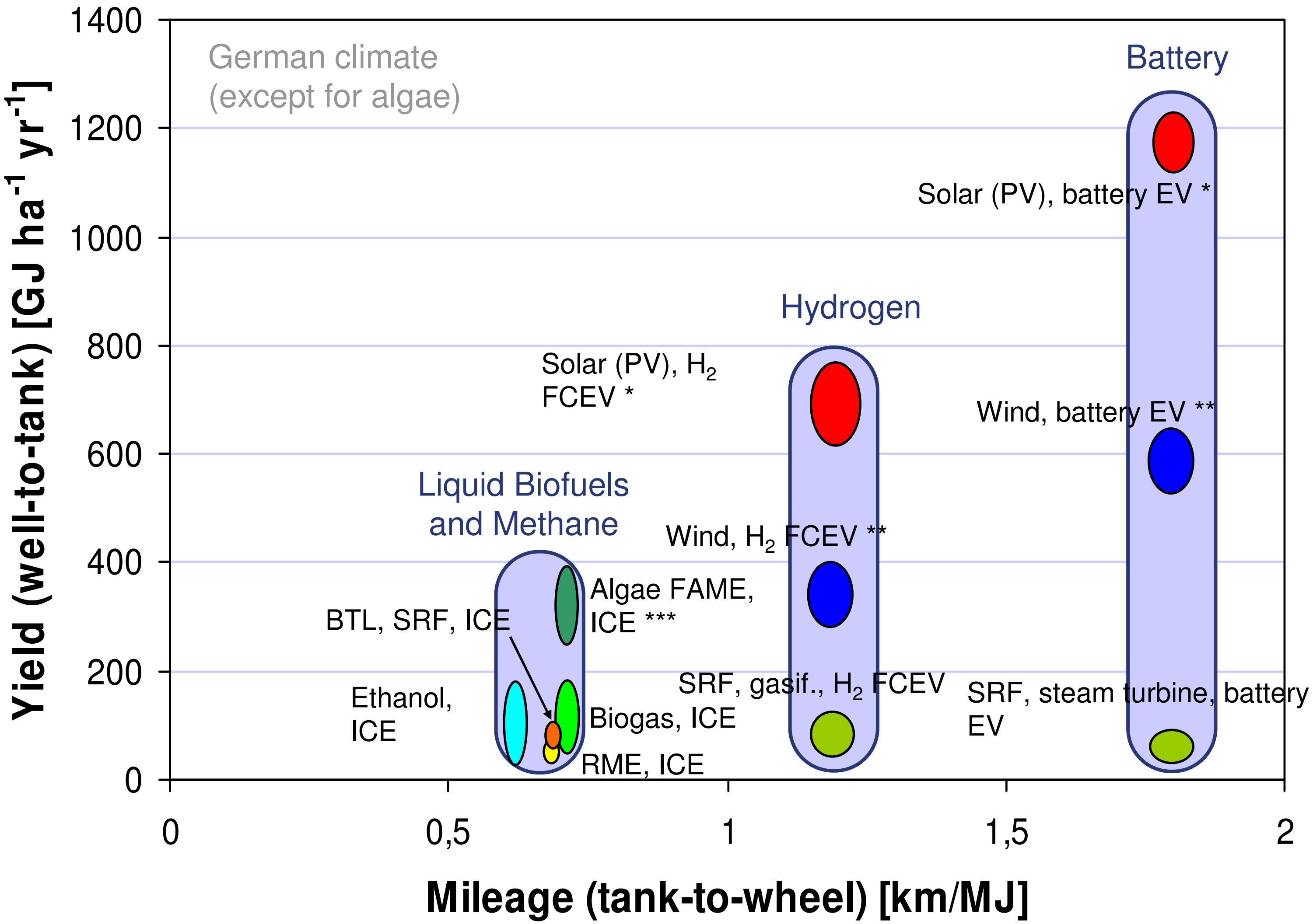


Vehicle per hectare yield



*) more than 99% of the land area can still be used for other purposes e.g. agriculture
Remark: wind energy convert units of 2 MWe today represent the bottom limit for wind park installation

Mapping of key performance criteria: "mileage" versus "yield"

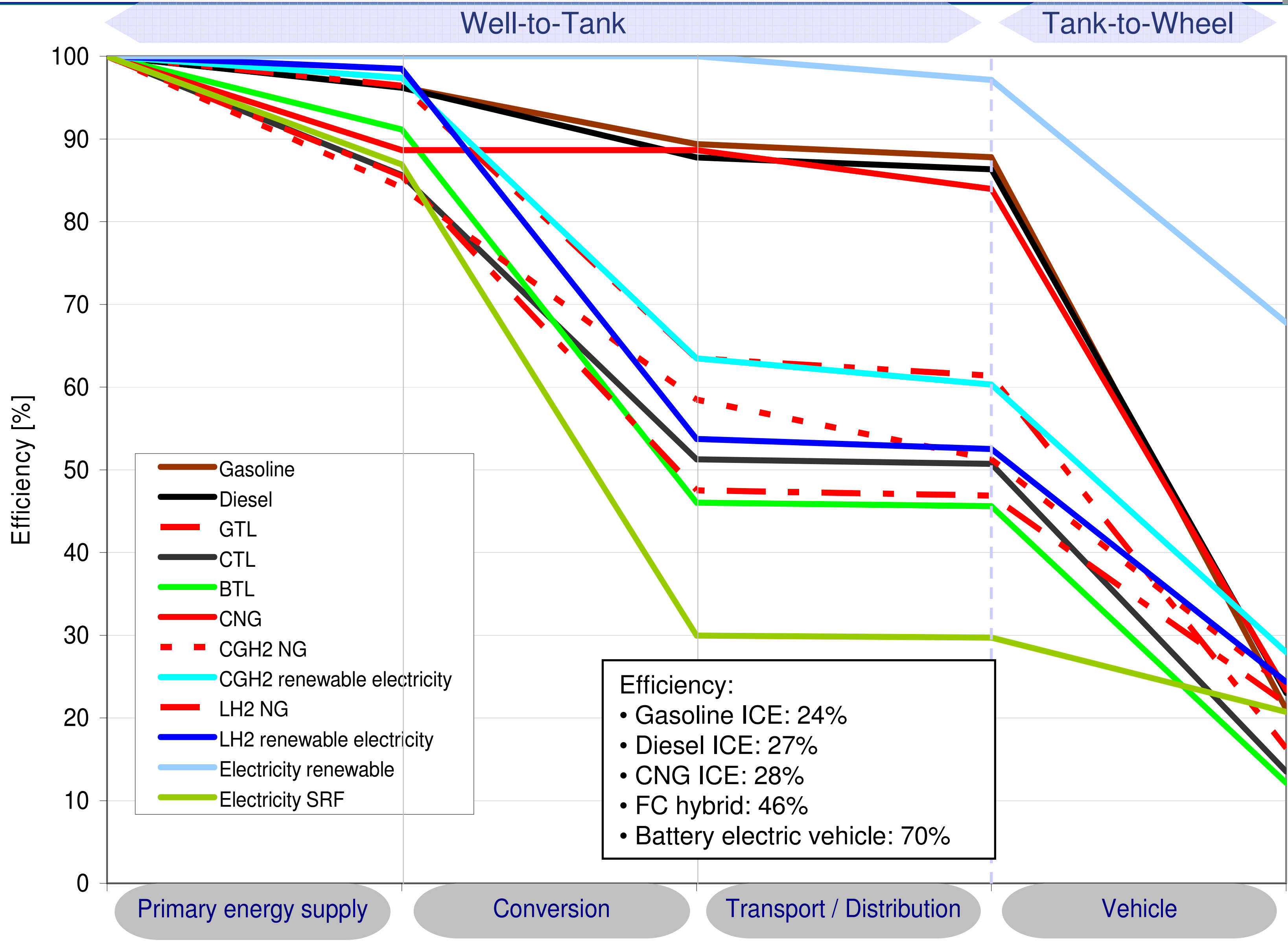


*) One third of the area is occupied with PV panels

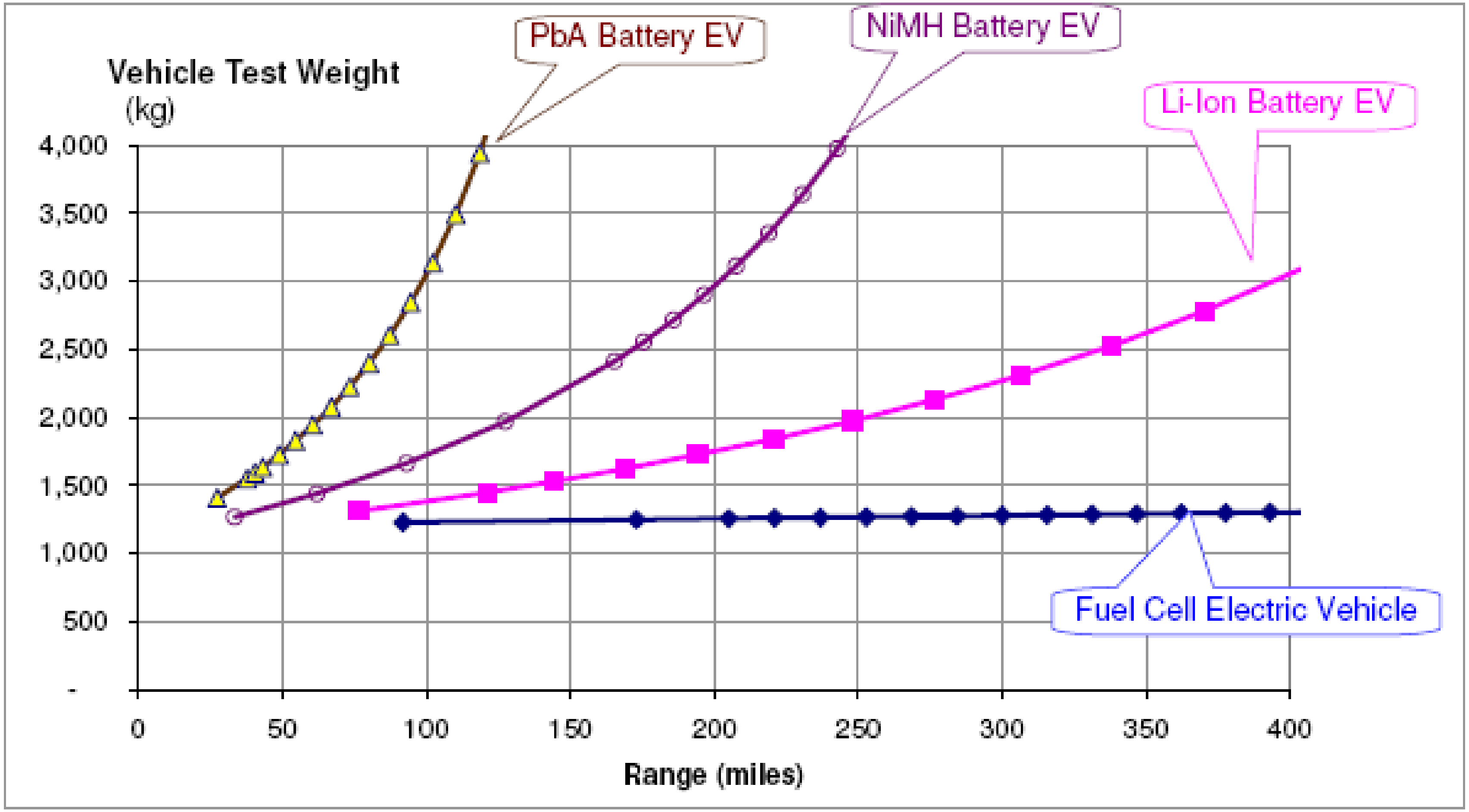
**) more than 99% of the land area can still be used for other purposes e.g. agriculture

***) region with high solar irradiation

Efficiency chains of different fuel/ vehicle technologies



Weight of FC and battery vehicles vs.range



Calculated weight of fuel cell electric vehicles and battery electric vehicles as a function of the vehicle range

Source:S.Thomas 2009

Thank you very much for your attention!

And see us occasionally at

www.H2DE.org

and

www.LBST.de

DWV
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And at the WHEC 2010 in Essen, Germany

Hydrogen Energy
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