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W. Winkler

Green transportation - automotive integration options in sustainable infrastructures and industries

Global/Local Innovations for Next Generation Automobiles
International Symposium 2015
October 27 – 29, 2015 in Sendai, Japan

- Technical requirements and background
- Integration in sustainable infrastructure
- Integration in sustainable industries
- Economic boundaries for sustainable development
- Conclusion and recommendations

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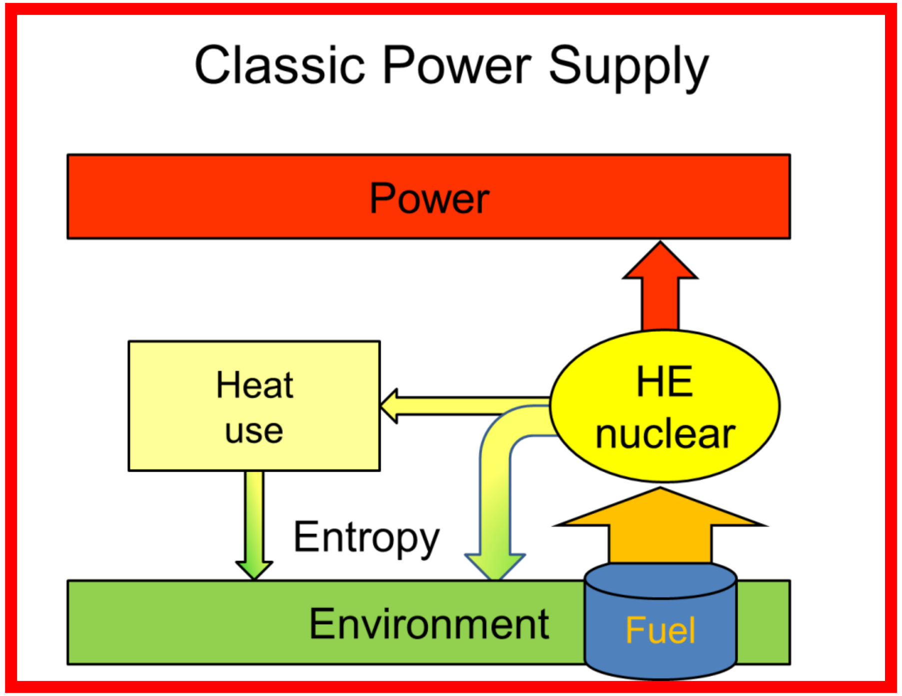
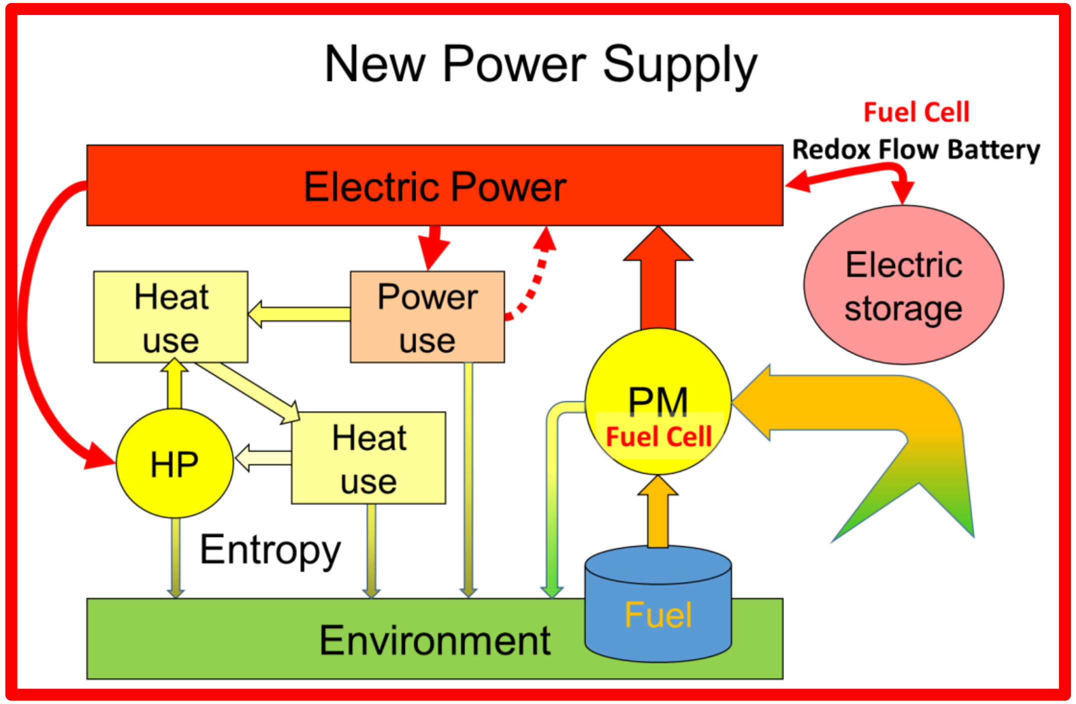
Changing role of industry





- Combined heat and power
- Optimized heat generation
- Thermal processes

Substance ⇆ heat

- Fluctuatiing operation
- Optimized heat management
- Electrochemical processes

Substance ⇆ electricity

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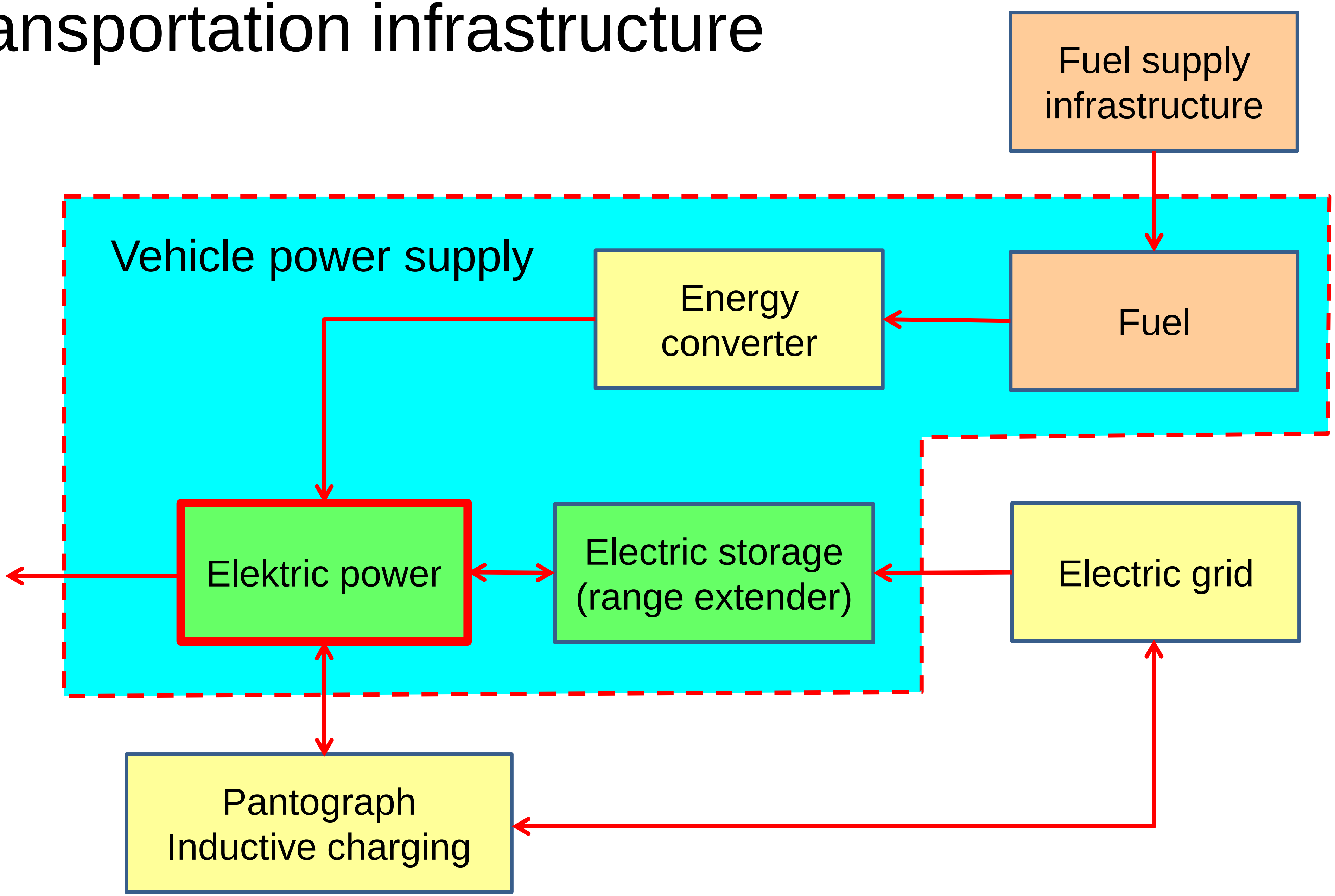
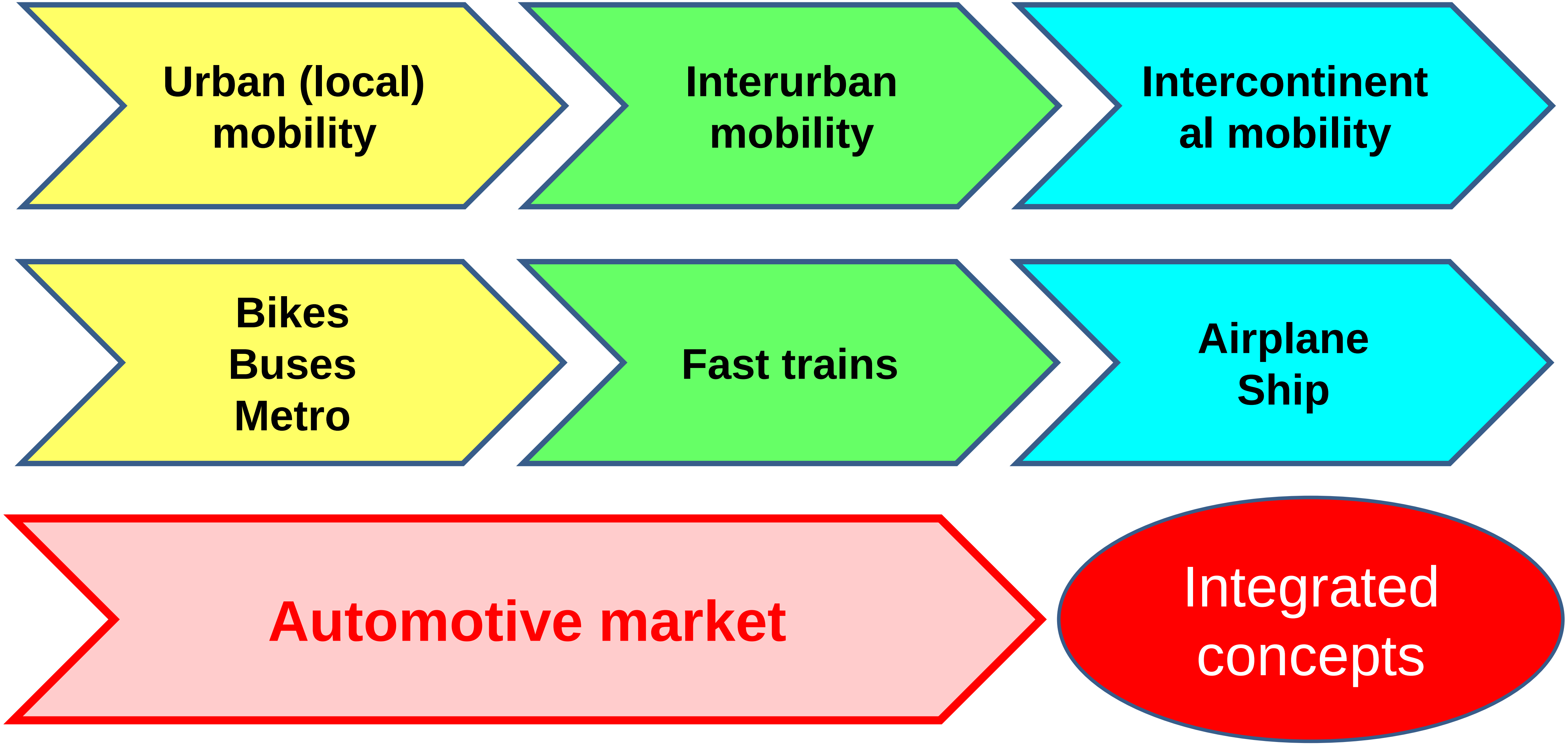
Transportation infrastructure



Mobility solutions



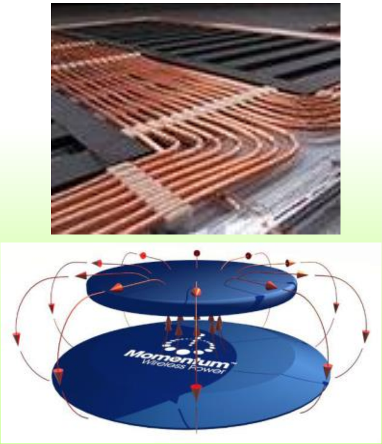
Energy infrastructure options for e-mobility

Grid connected operation

Autonomous operation

Pantograph

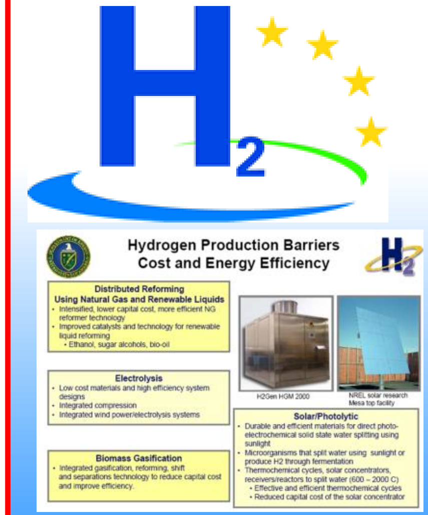
Inductive Charging



Battery

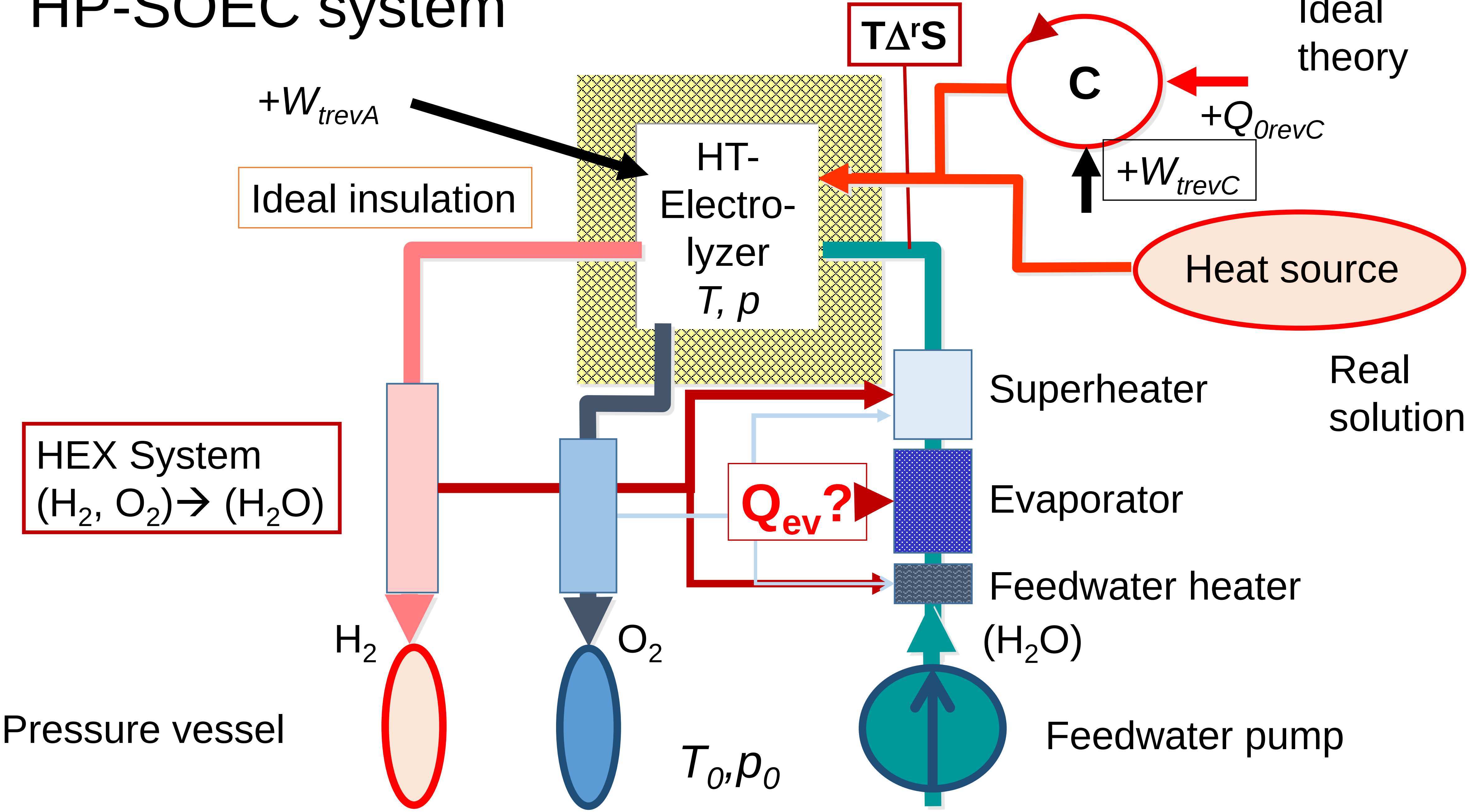
Hydrocarbons Biofuels

Hydrogen

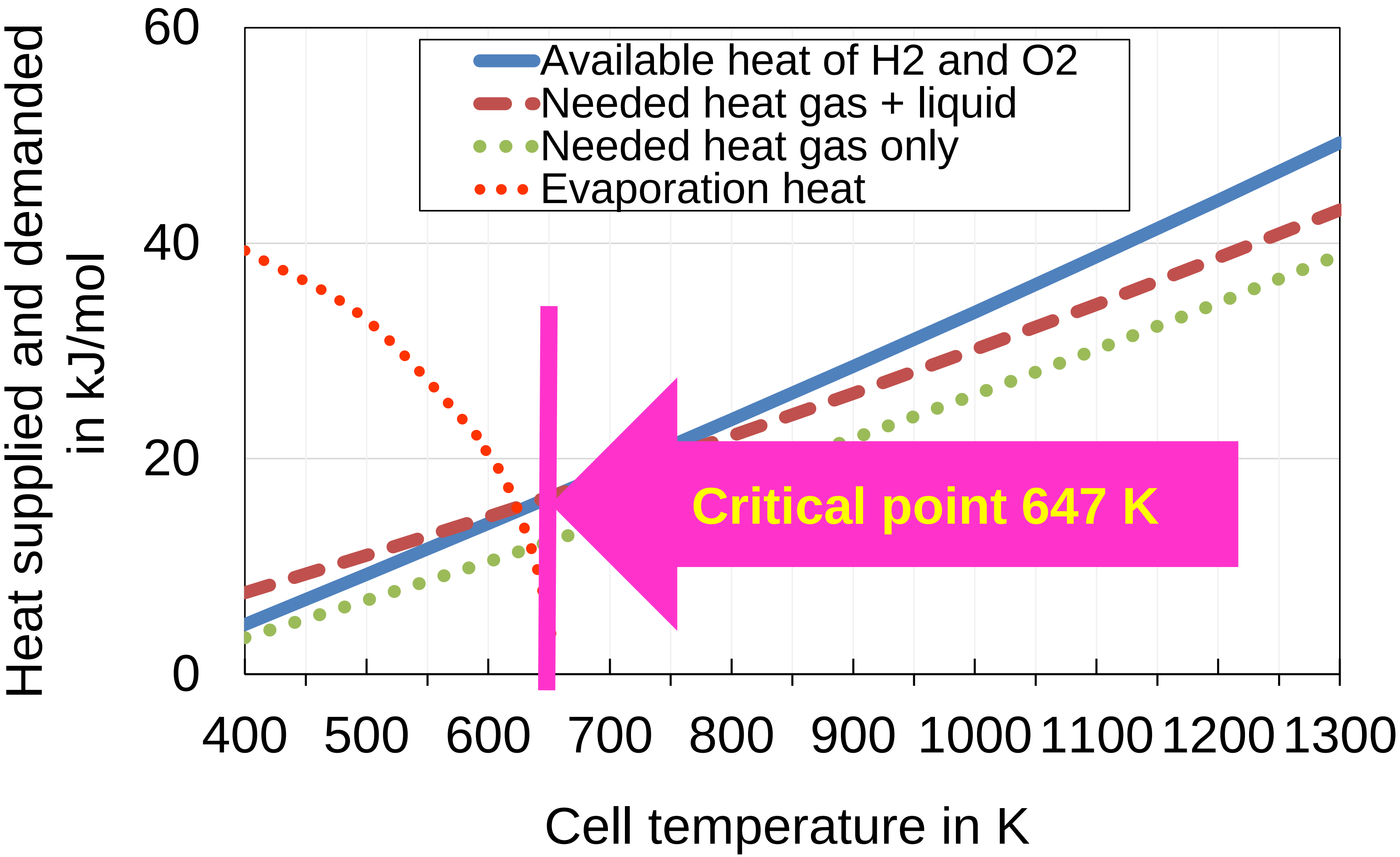


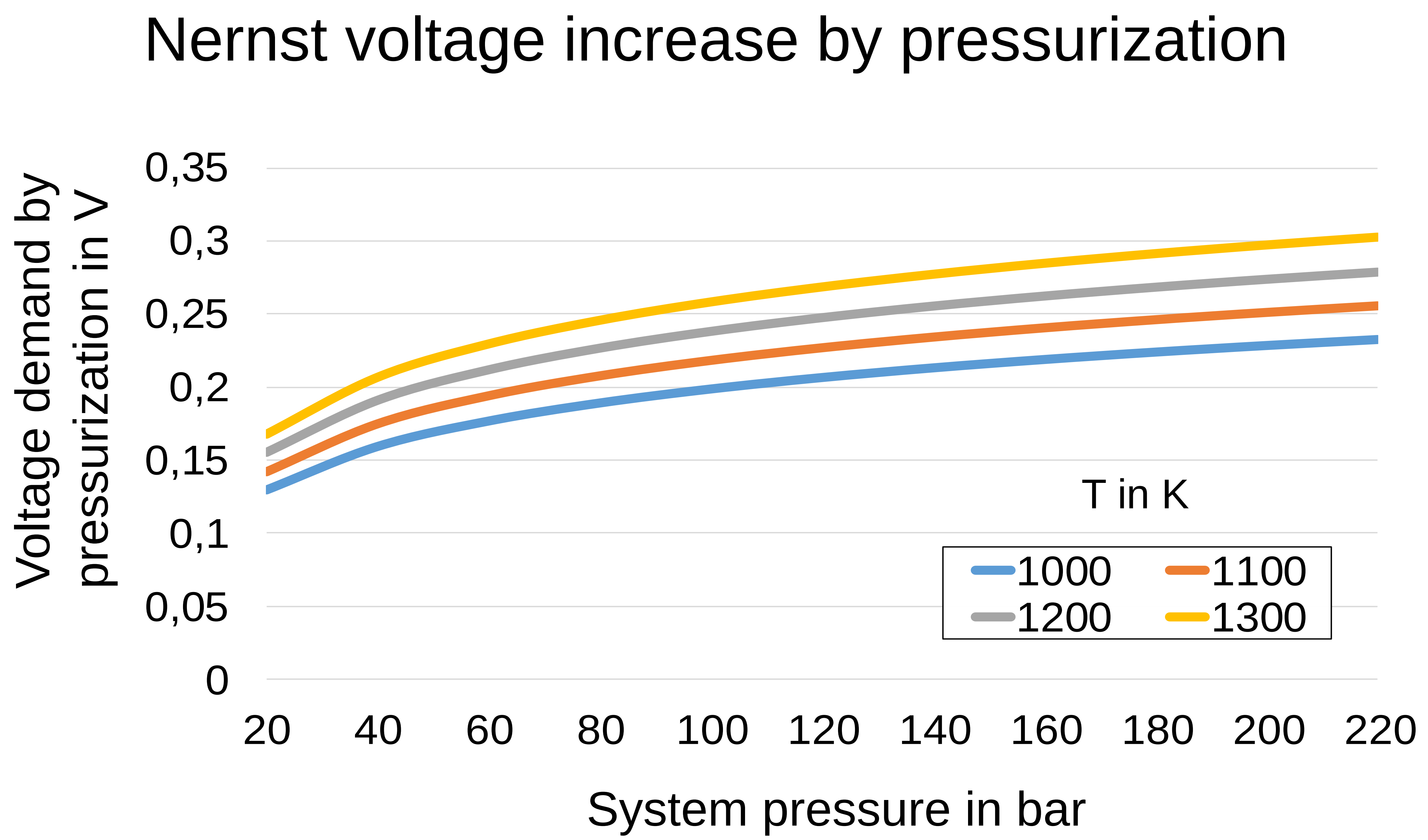
Sources: DKE, EU, Fraunhofer, hybridcars, Mercedes, US DoE

HP-SOEC system

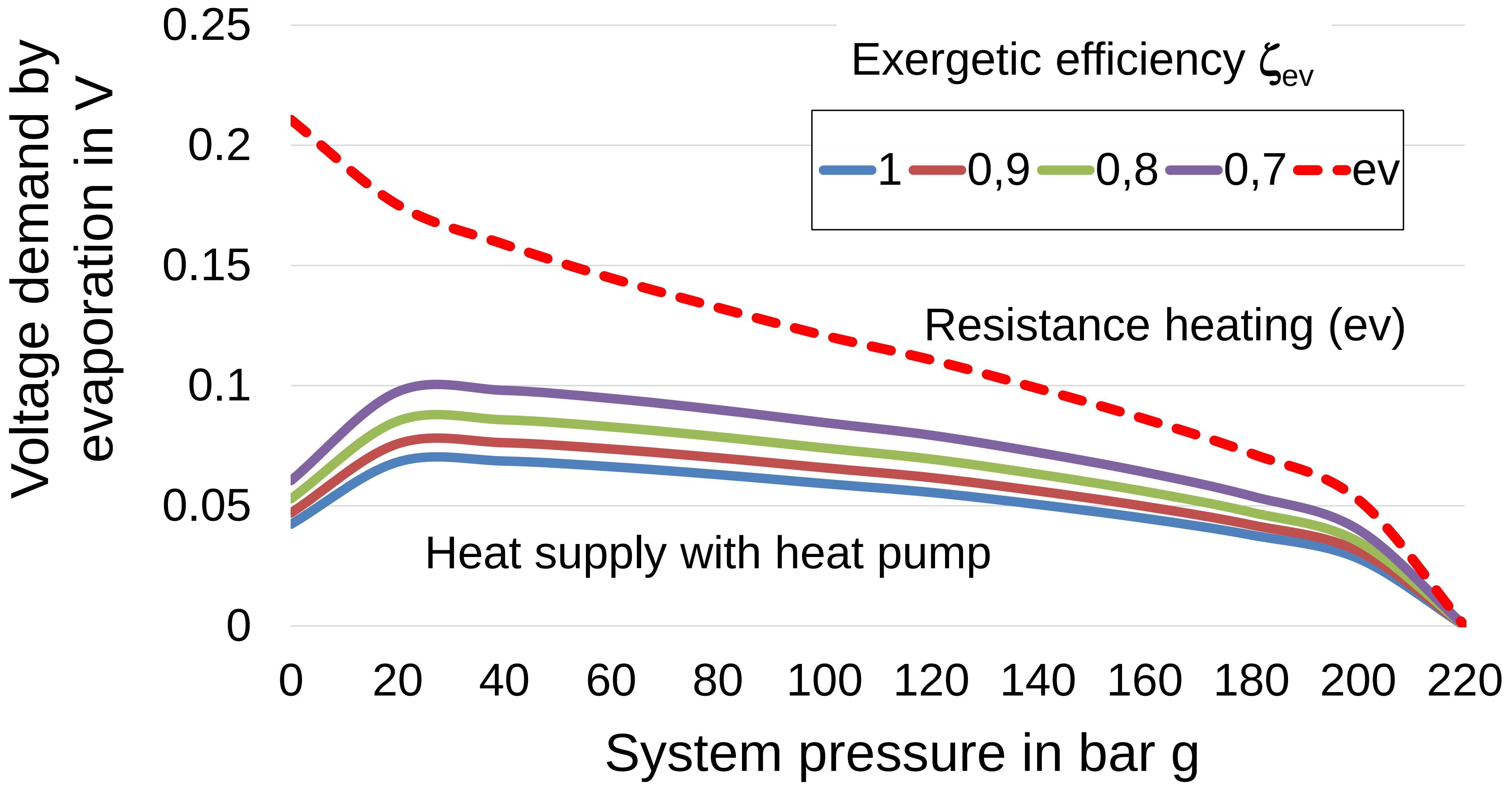


Heat recovery of electrolyzers




Nernst voltage increase by pressurization
Voltage demand by pressurization in V
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
20
40
60
80
100
120
140
160
180
200
220
System pressure in bar
T in K
1000
1100
1200
1300

Evaporation heat supply influence on voltage



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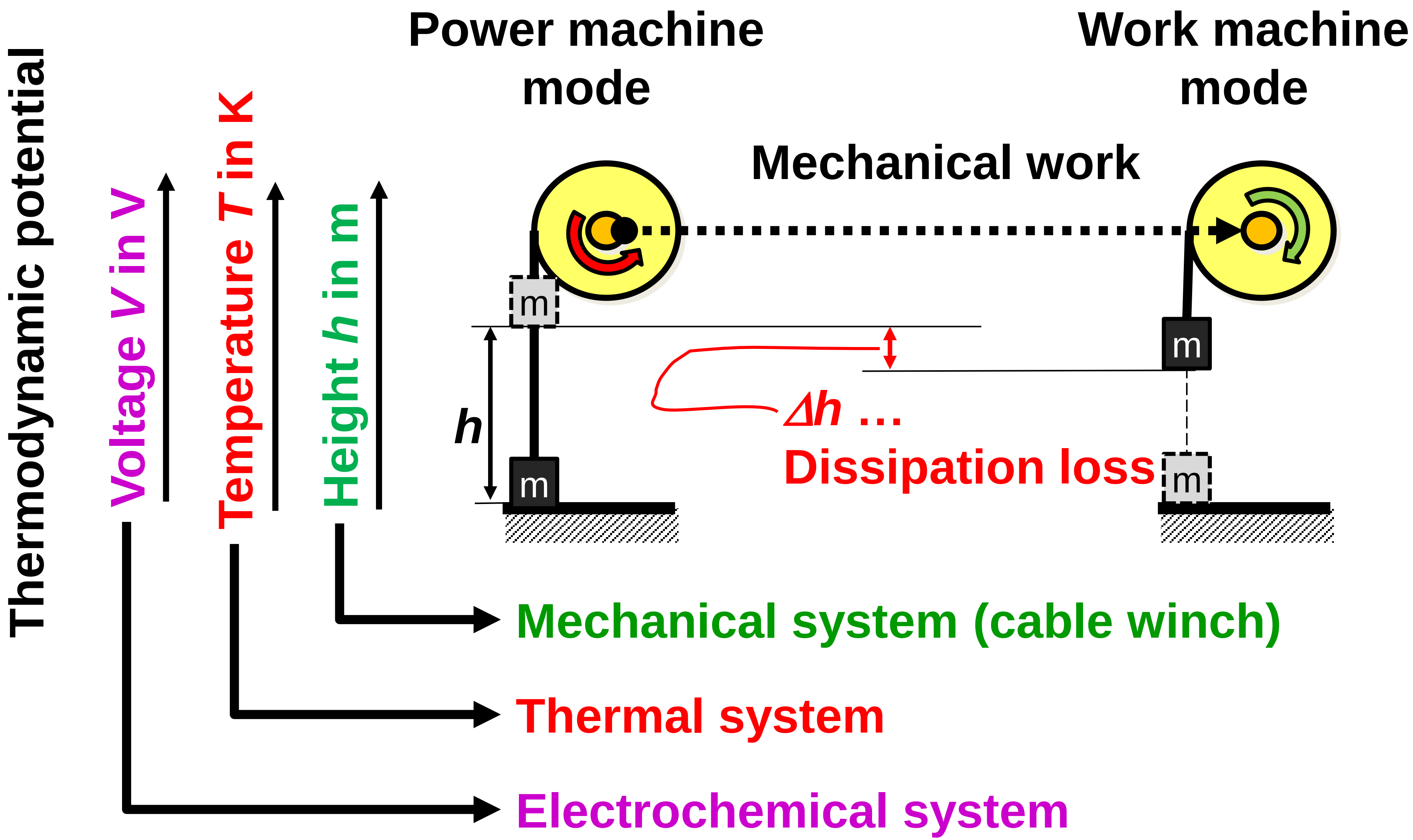
Regenerative machines



IEC ACEE and thermodynamic view of motor system

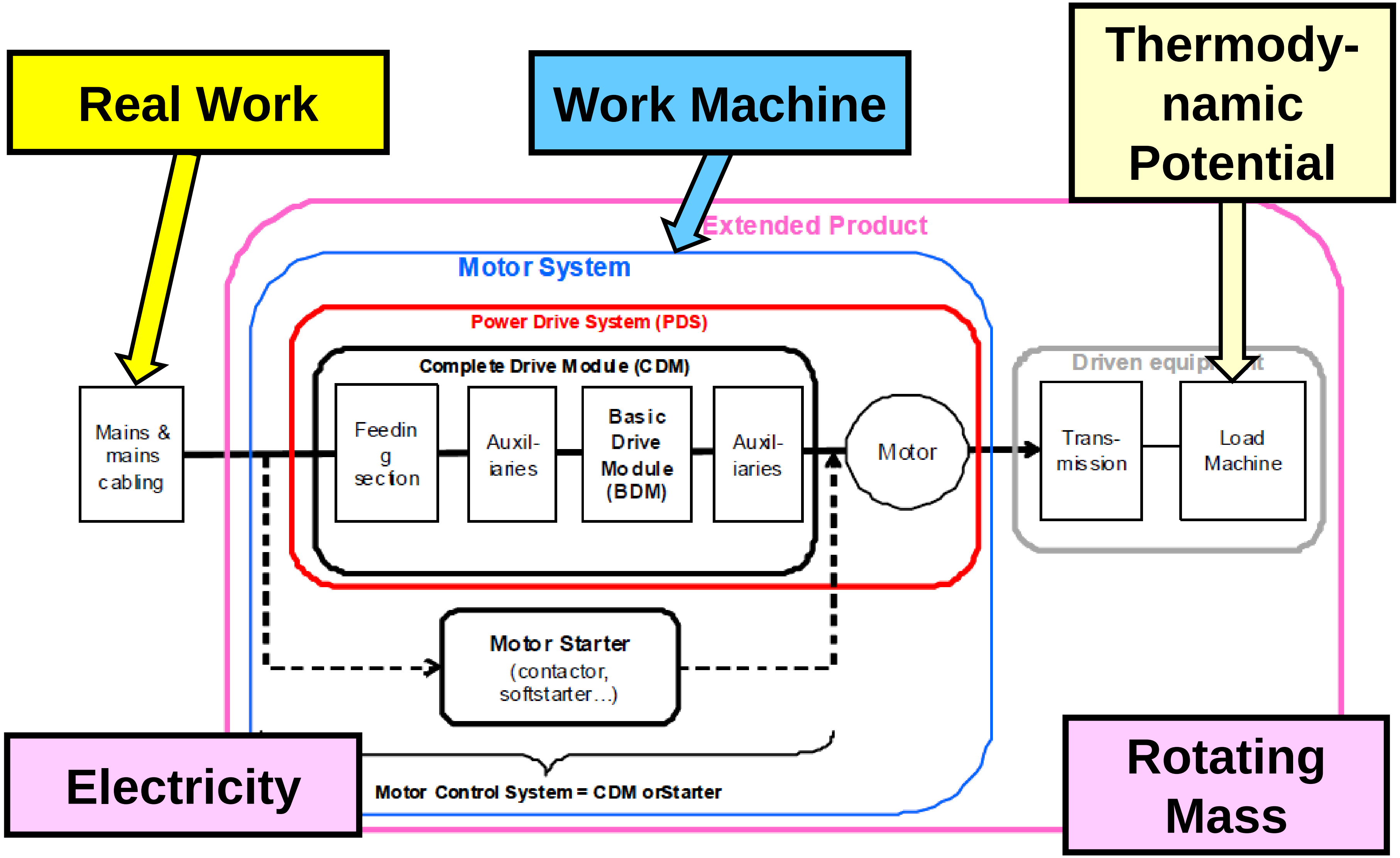


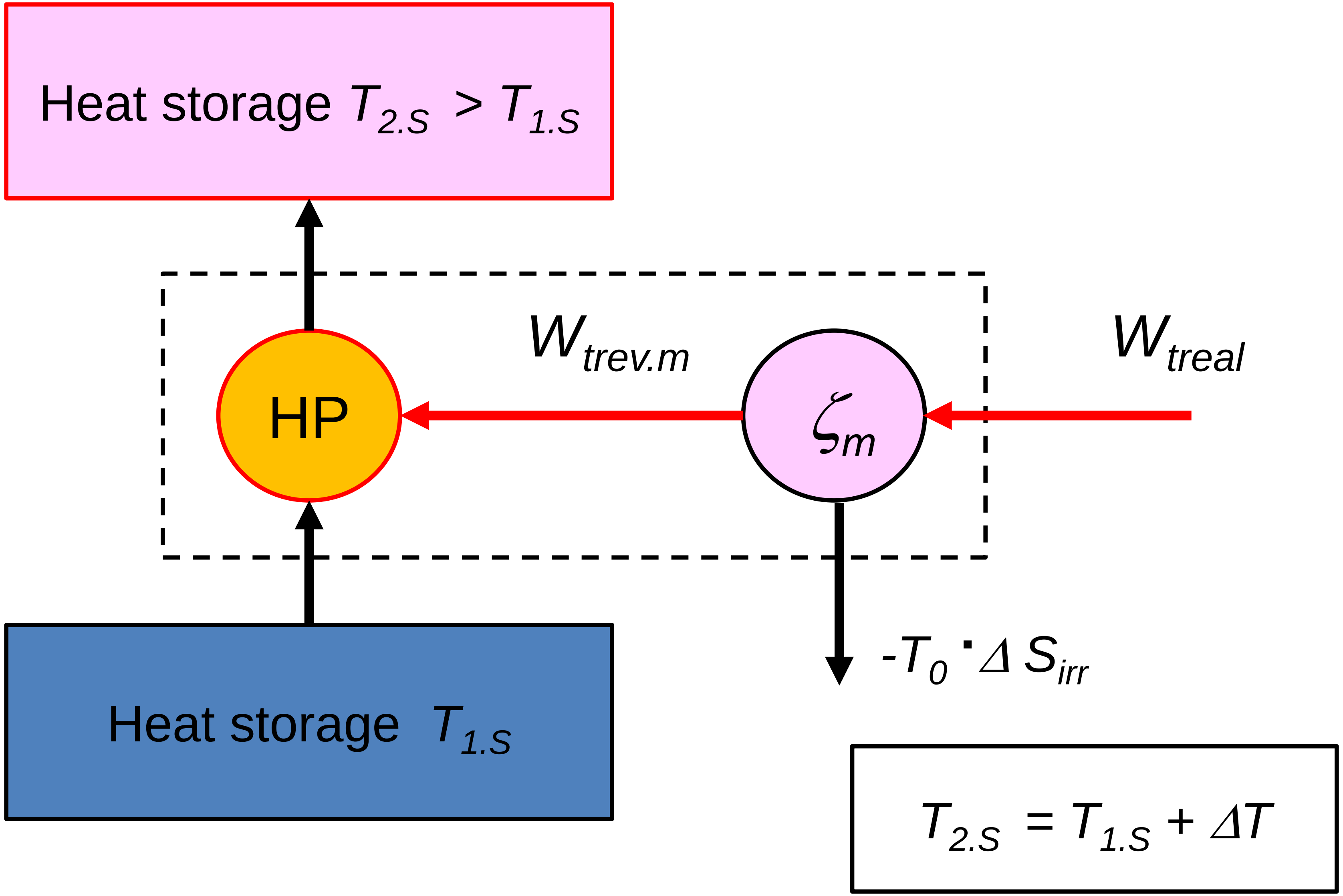
Figure 1: Illustration of the Extended Product with embedded Motor System

Source: IEC

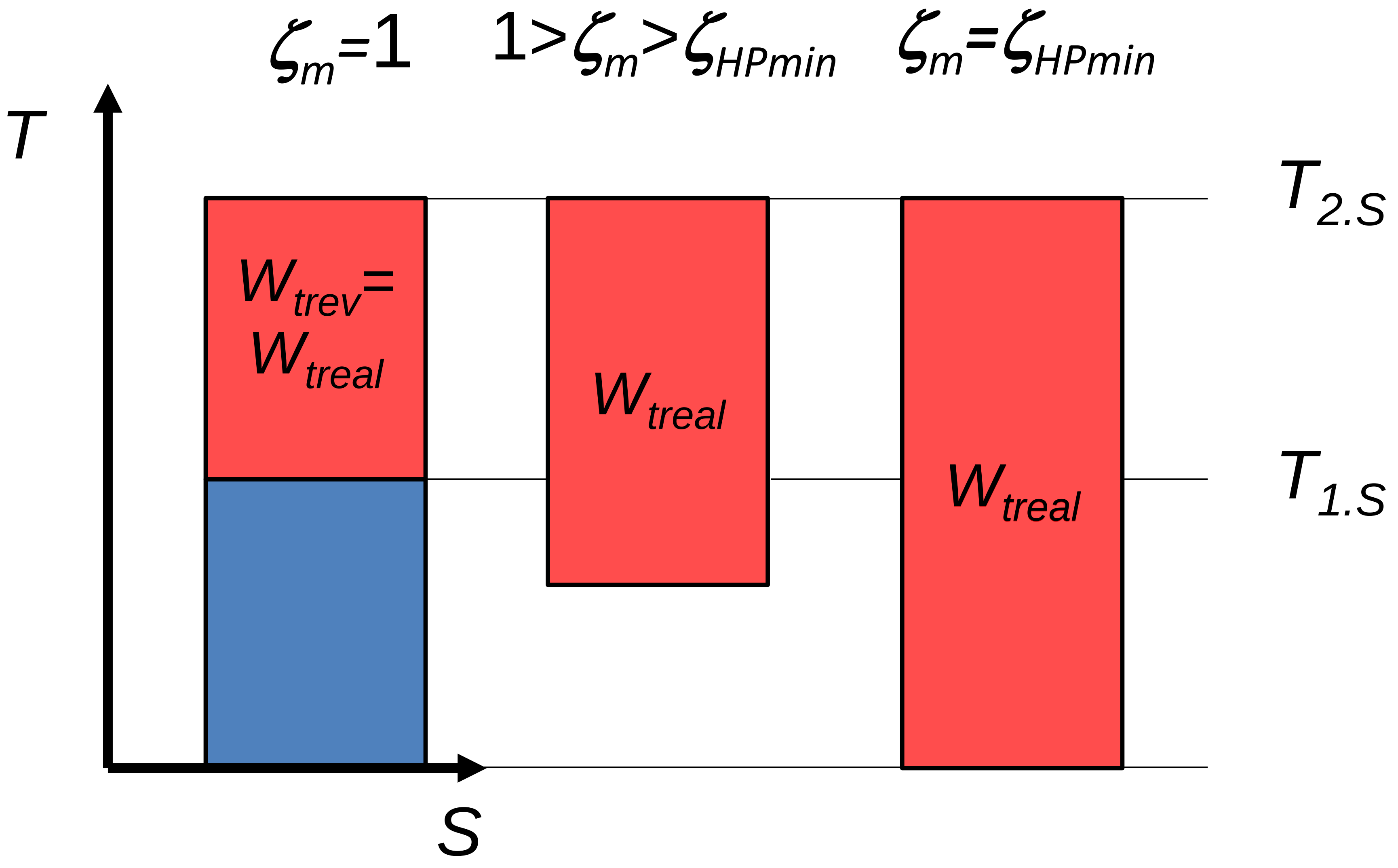
Reversible engineering solutions

Entropy Production by Temperature Differences	Heat Engines Heat Pumps
Generation of Mixing Entropy	Electrochemical Processes

Real HP structure

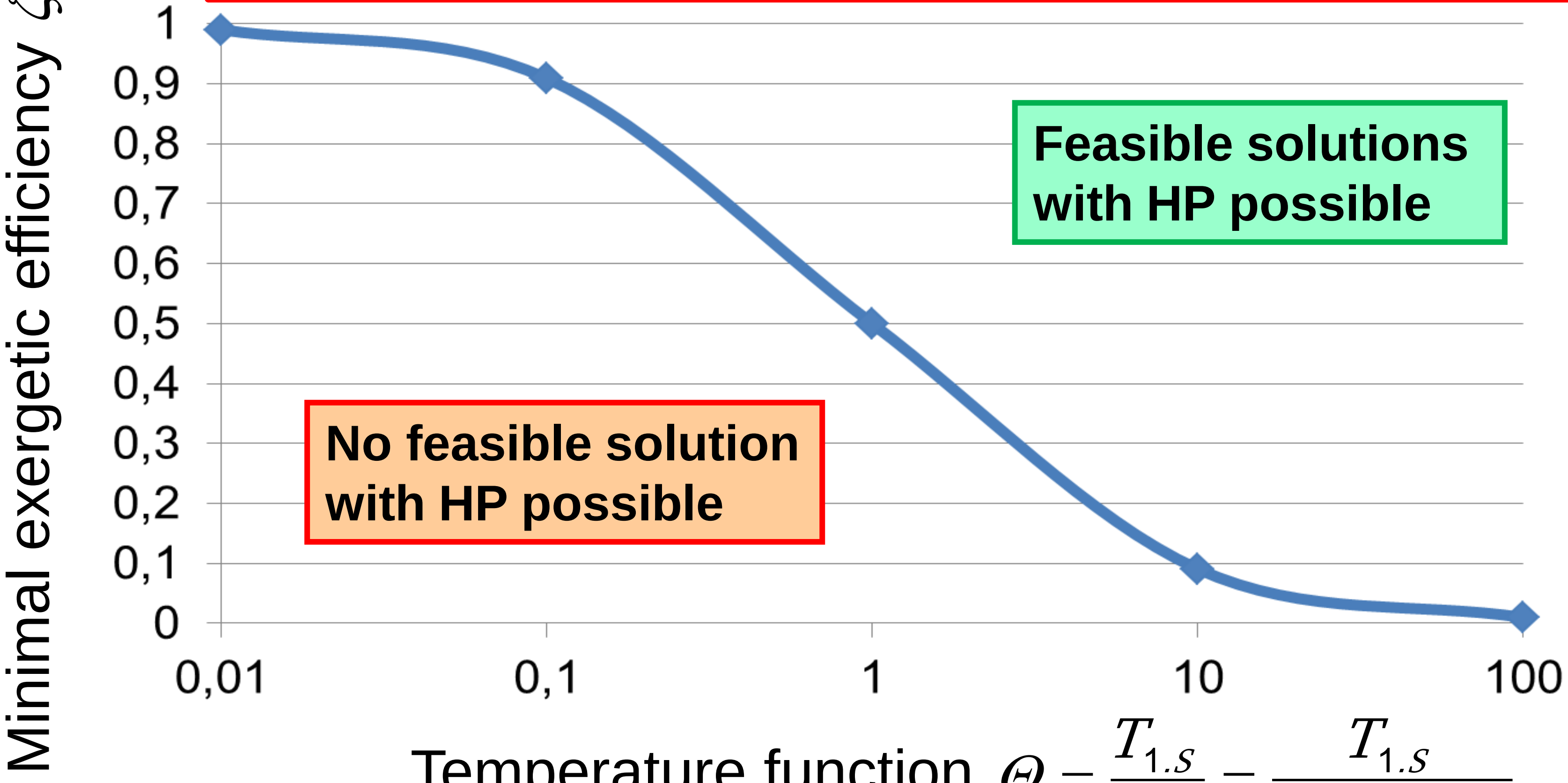


Exergetic efficiency and HP work



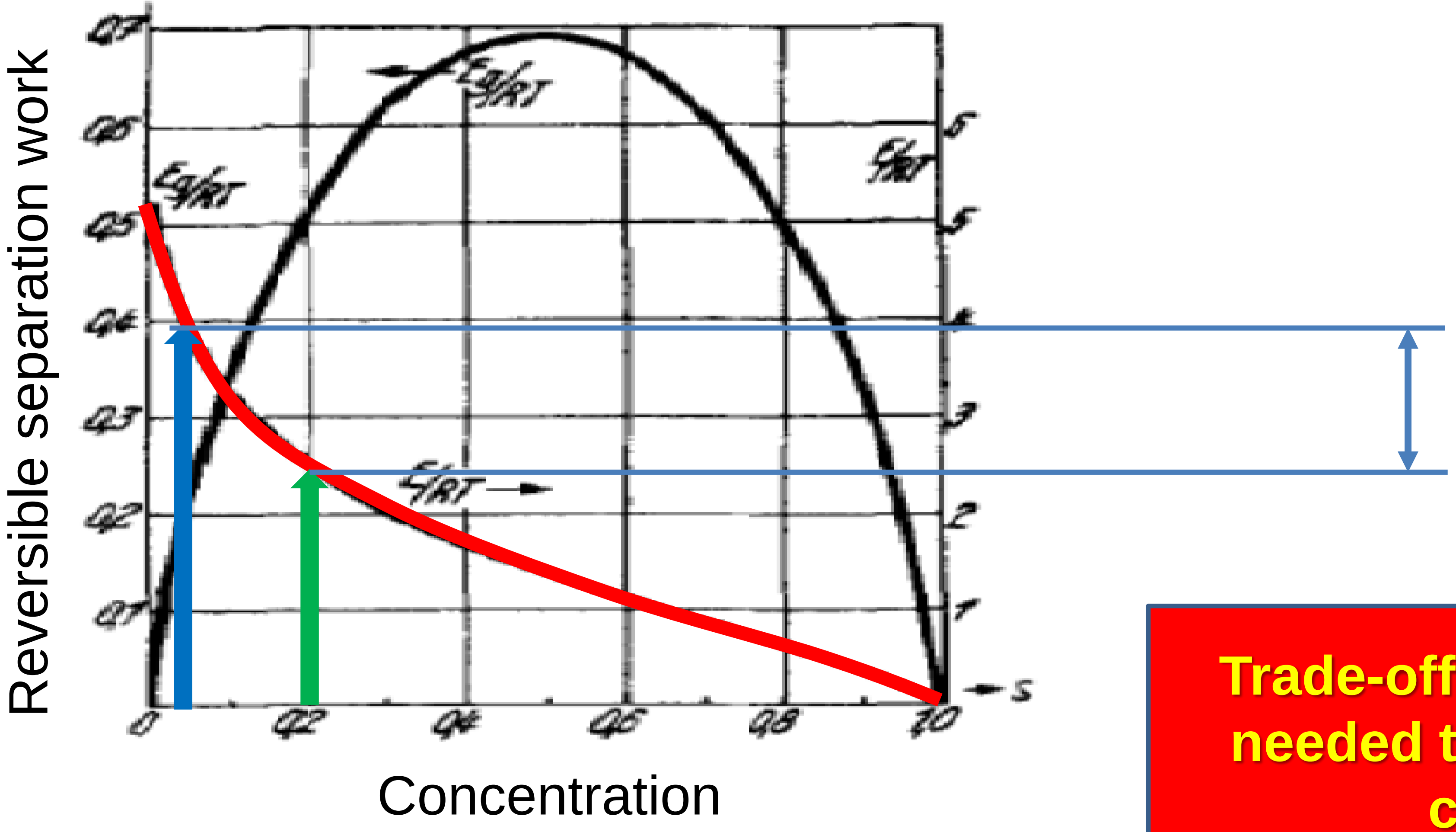
Feasibility chart of HP

$$\zeta_{HP\,min} = \frac{\Delta S \cdot (T_{2.S} - T_{1.S})}{\Delta S \cdot T_{2.S}} = 1 - \frac{T_{1.S}}{T_{2.S}} = 1 - \frac{T_{1.S}}{T_{1.S} + \Delta T} = \eta_C$$



Temperature function $\Theta = \frac{T_{1.S}}{\Delta T} = \frac{T_{1.S}}{T_{2.S} - T_{1.S}}$

Background of Recycling

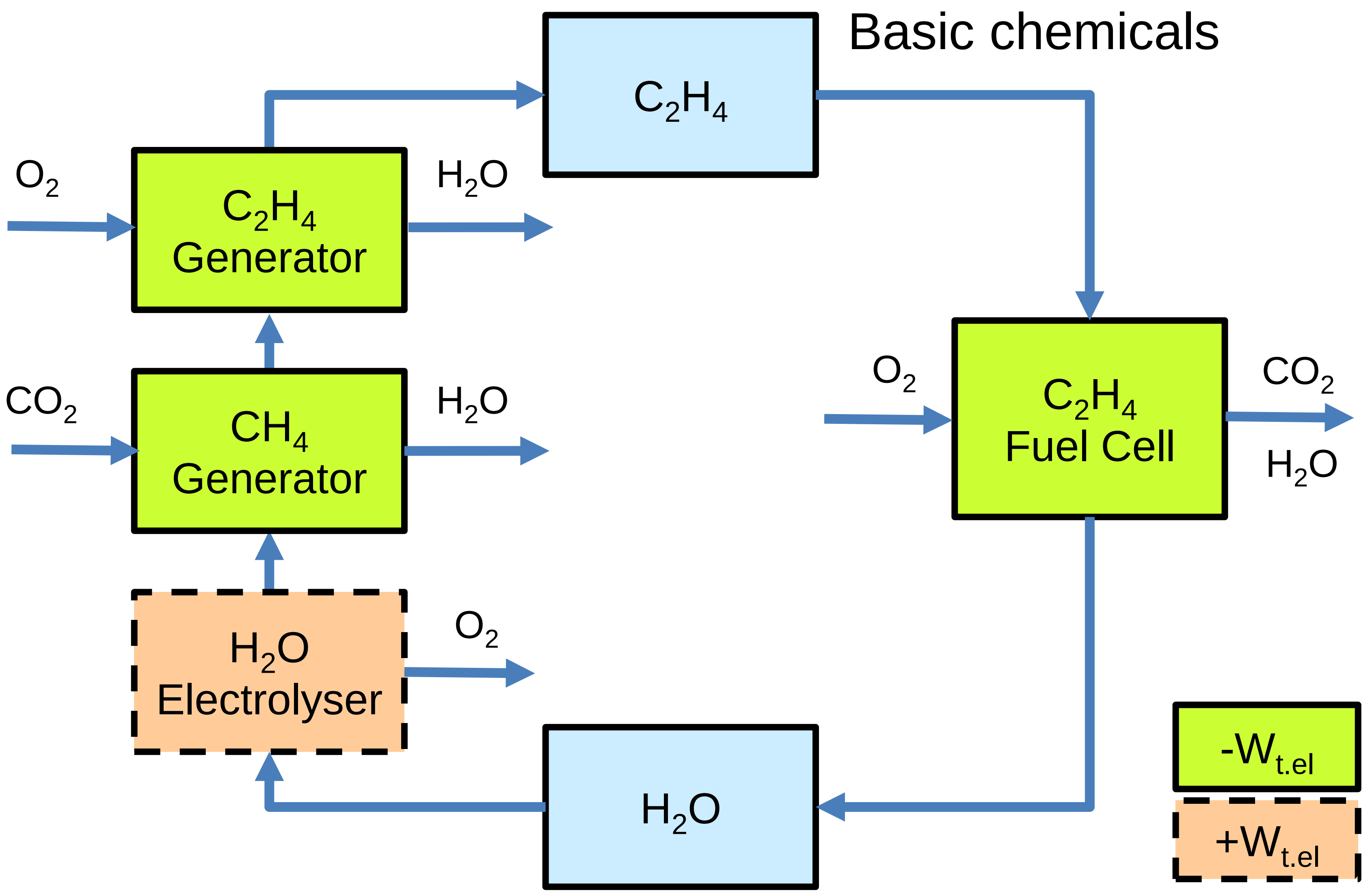


Reduction of reversible separation work

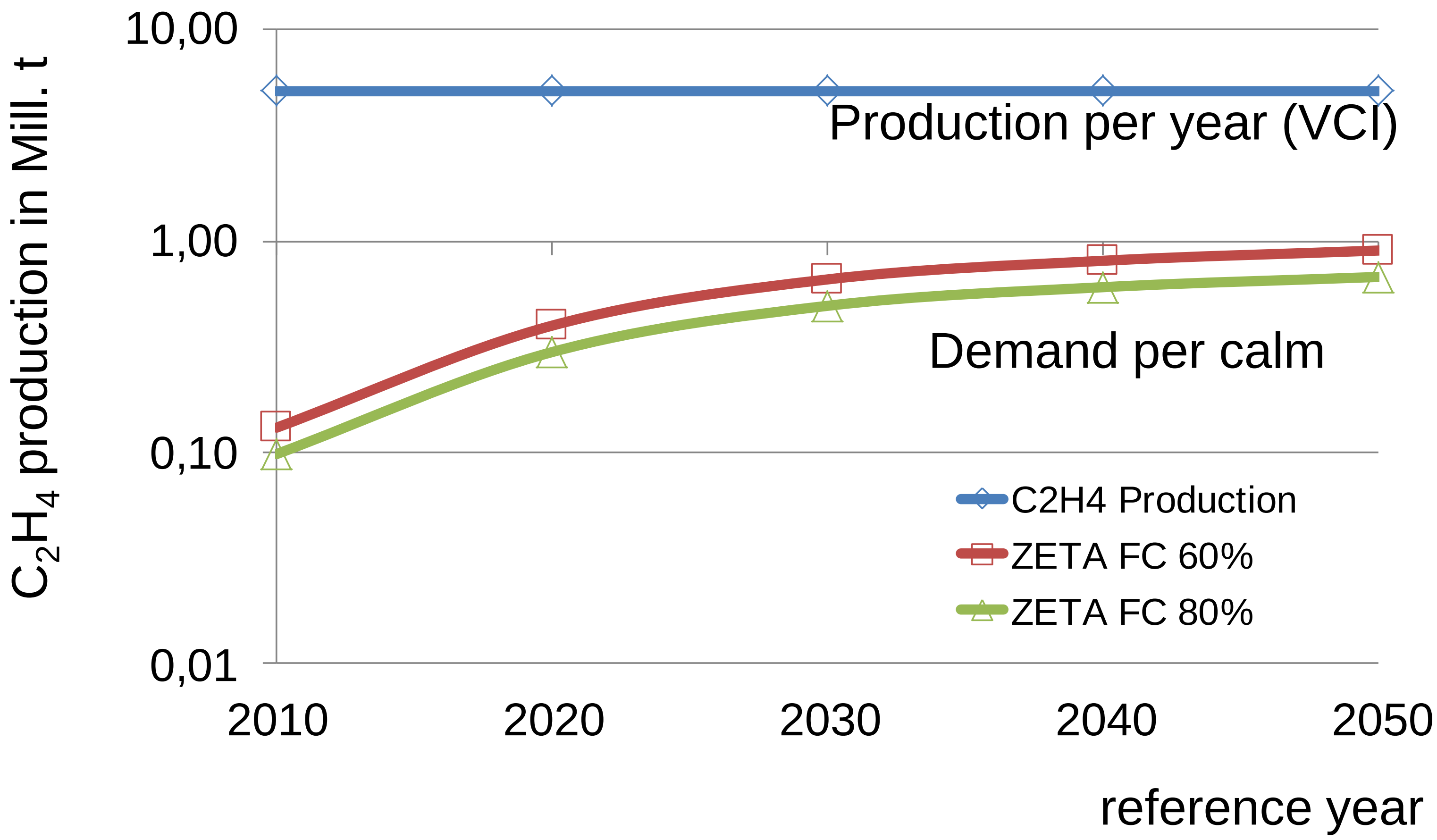
Trade-off with reversible work needed to prepare the higher concentration

Source: F.G.: Houtermans. Über den Energieverbrauch bei der Isotopentrennung. Annalen. der Physik. 5. Folge. Band 40. 1941 p 493 - 508

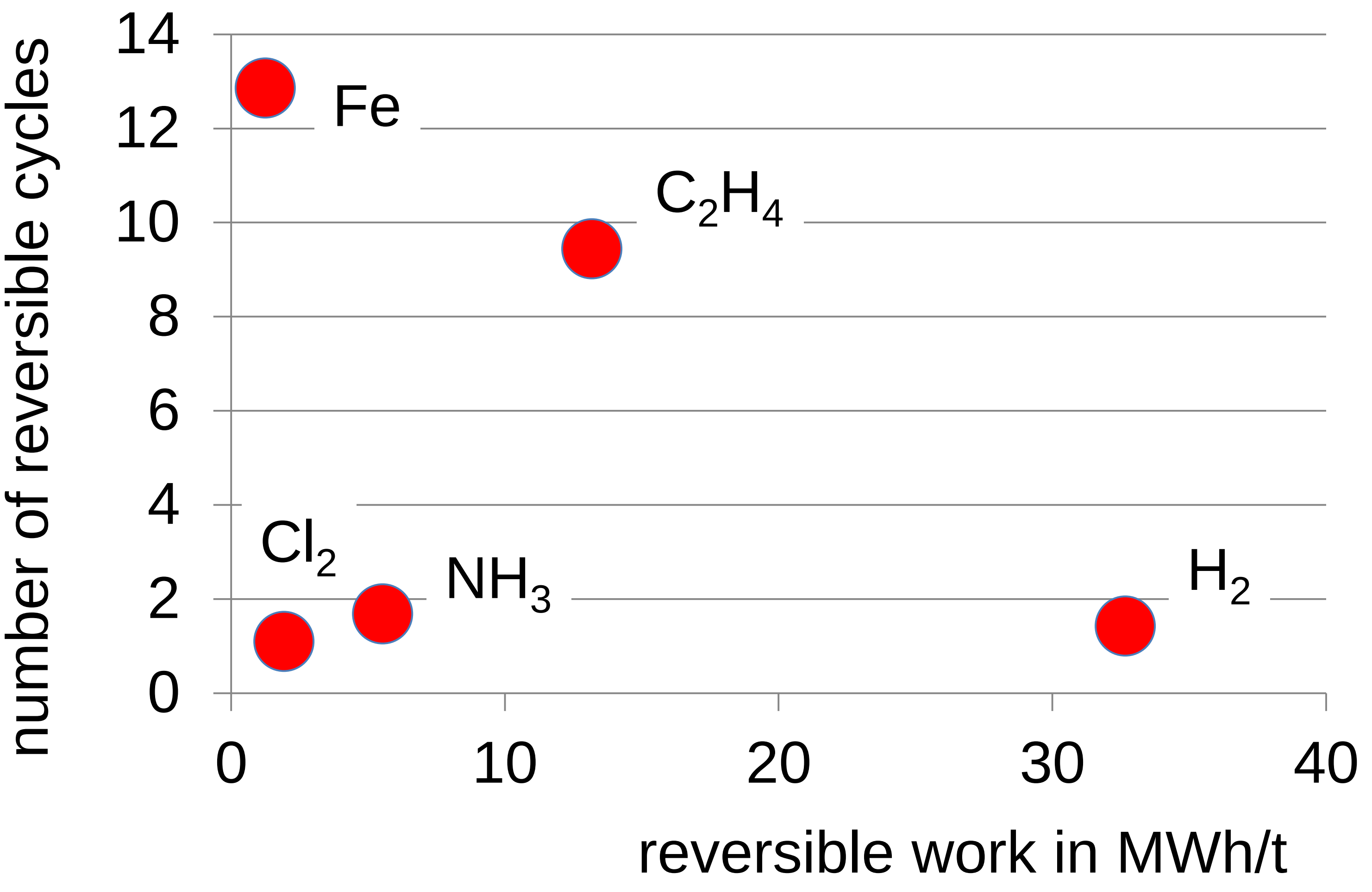
Industrial reverse process



C_2H_4 as storage for 10 days calm



Industrial storage options for covering calms



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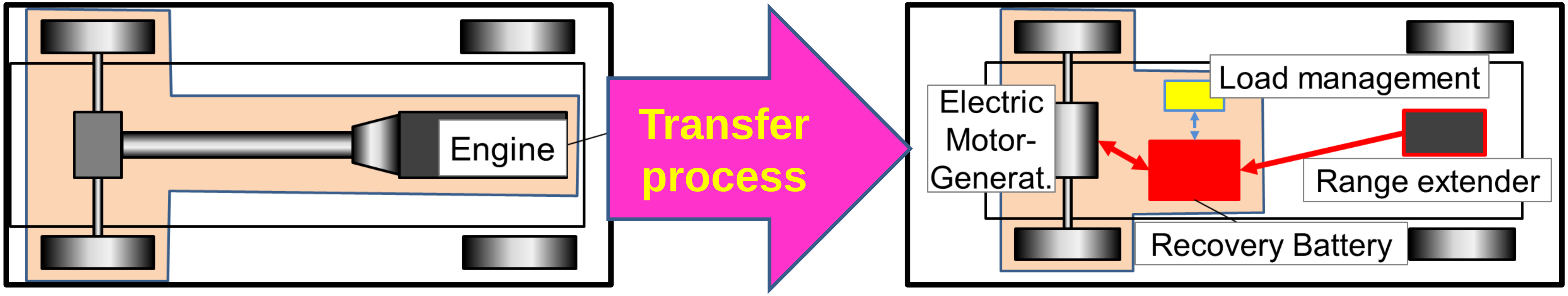
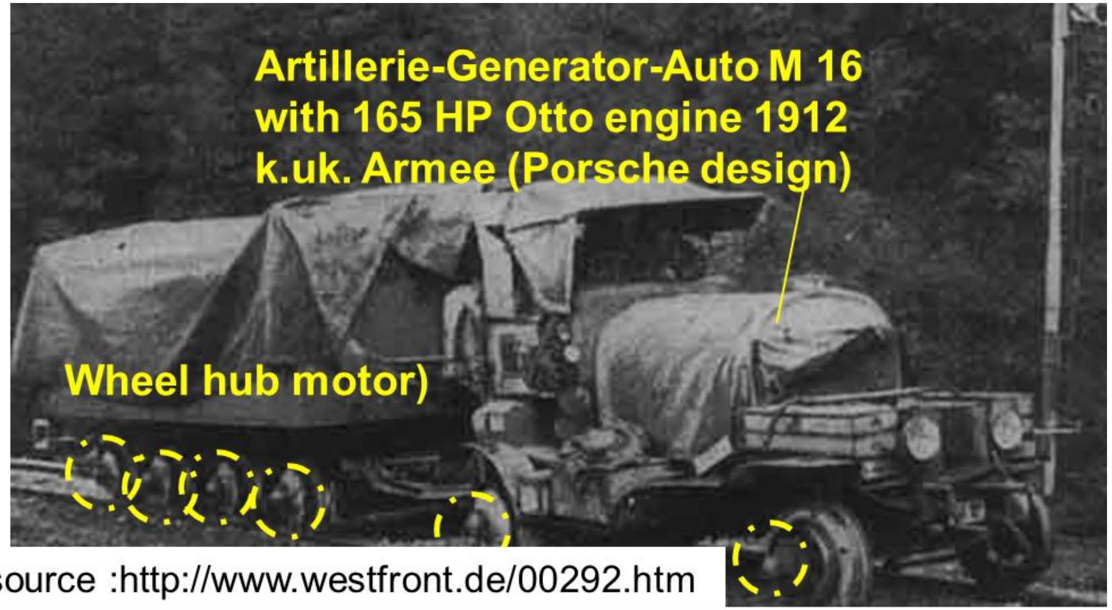
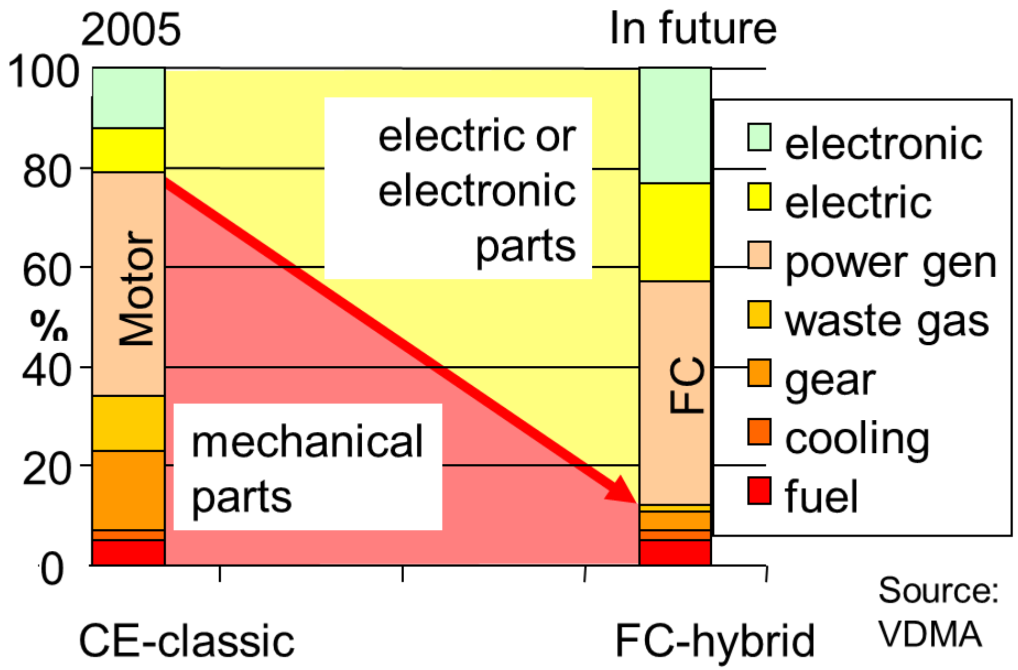
Transition to full electric systems



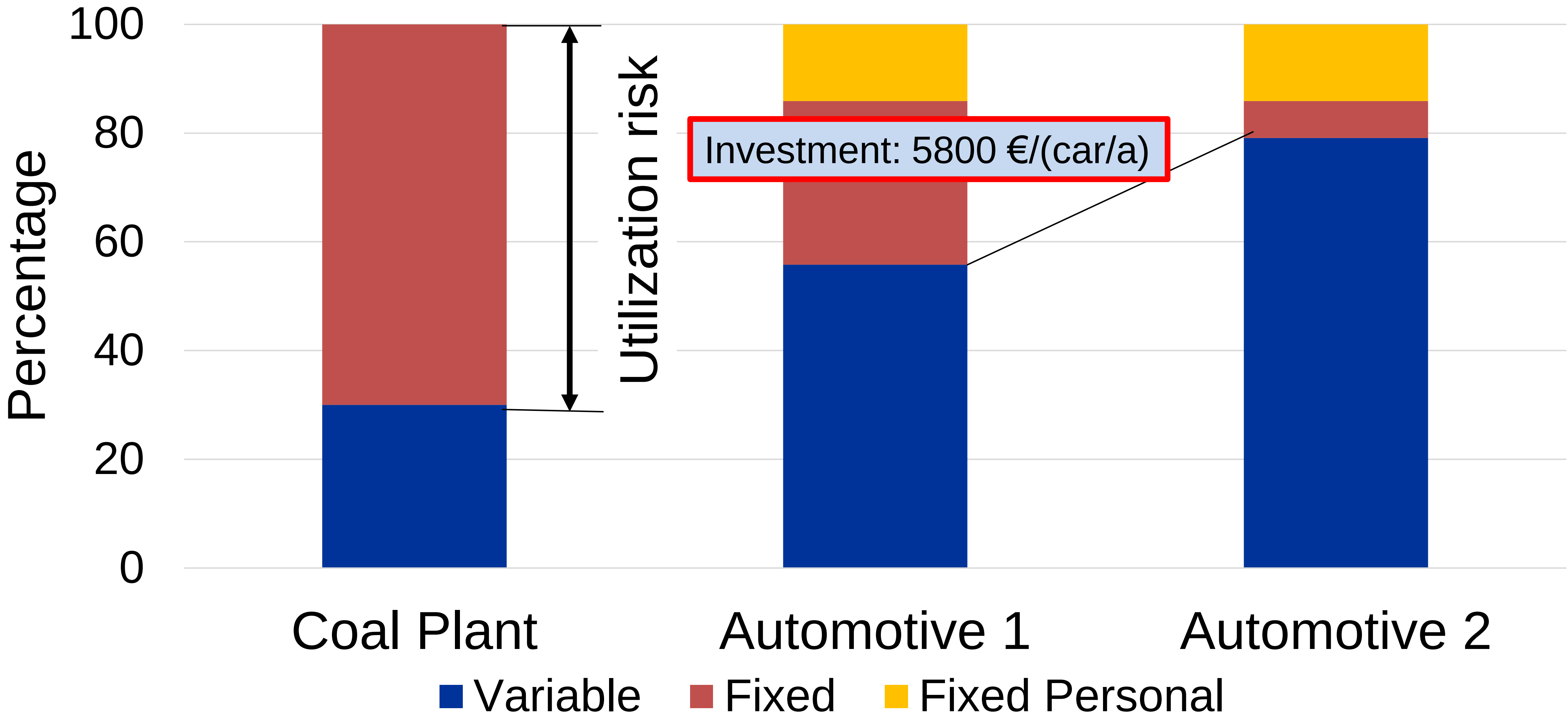


source :http://www.westfront.de/00292.htm



Source: VDMA

Average cost structure in industry



Sources: Audi, BMW, IFA, Manager Magazin

Energy saving options for trucks

Engine

Variable valve actuation **1% - 2%**
Sequential turbo/downsizing → **5%**
Speed control (injection) → **5%**
Oil and water pump with variable speed **1% - 4%**
Controllable air compressor **3.5%**
Smart alternator, battery sensor electric accessory drive **2% - 10%**
Start/stop automatic **5% - 10%**
Dual fuel systems **10% - 20%**
Pneumatic booster: air hybrid → **4%**
Turbocompound (mechanical/electric) **4% - 7%**
Bottoming cycles/waste heat recovery (*e.g.* organic Rankine) **1.5% - 10%**

Drive train

Automated manual transmission **4% - 6%**
Full hybrid urban**15% -30%**
Full hybrid long haul **4% - 10%**
Flywheel hybrid urban **15% - 22%**
Flywheel hybrid long haul **5% - 15%**
Hydraulic hybrid urban **12% - 25%**
Hydraulic hybrid long haul **Avg 12%**

Vehicle

Low rolling resistance tyres **5%**
Aerodynamic fairings **0.5% - 5%**
Aerodynamic trailer/boat tail **12% - 15%**
Single wide tyres **5% - 10%**
Light-weight materials **2% - 5%**
Active aerodynamics → **5%**

IST/ITC

Predictive cruise control **2% - 5%**
Driver support system **5% - 10%**
Acceleration control → **6%**
Vehicle platooning → **20%**

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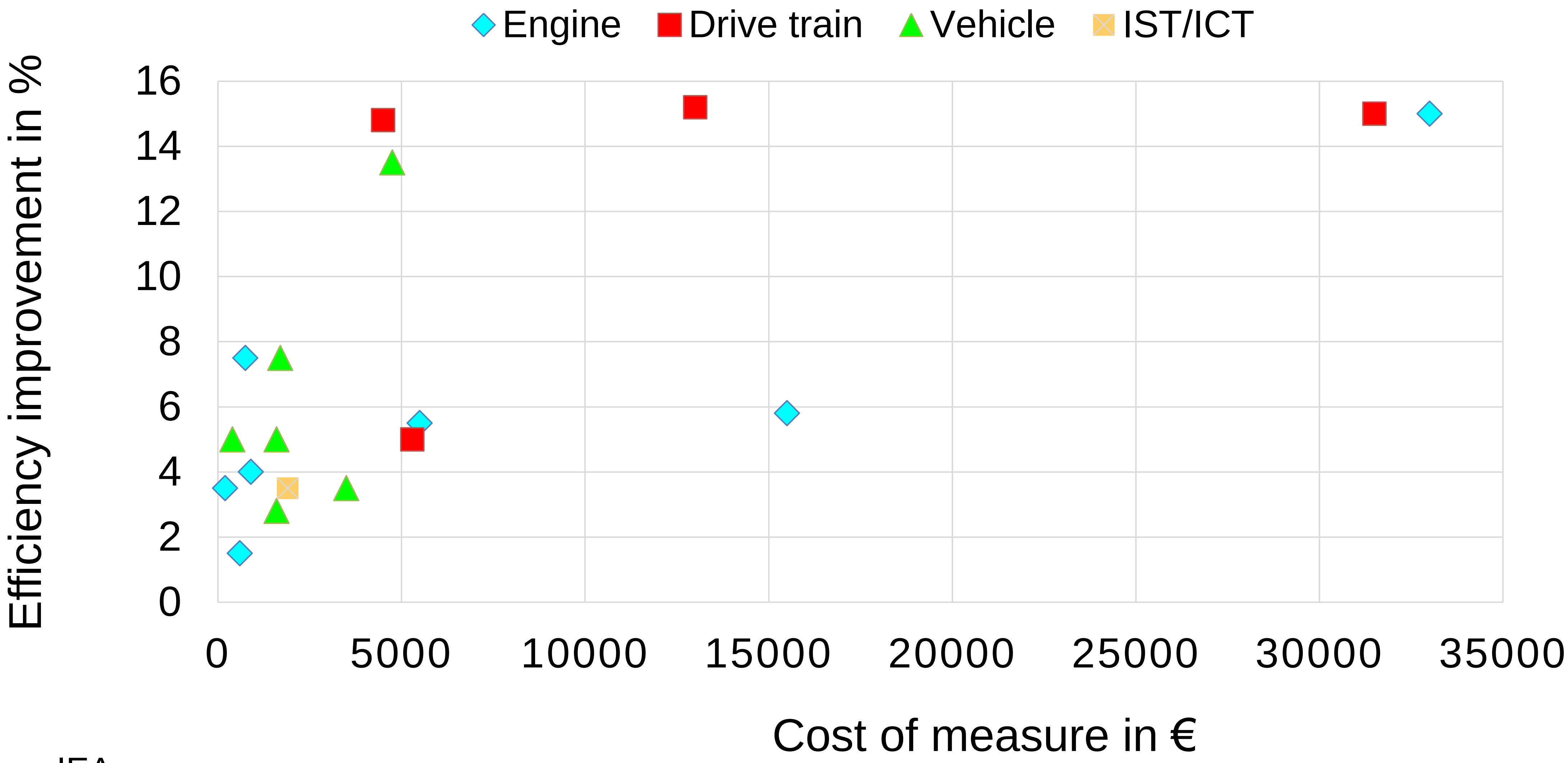
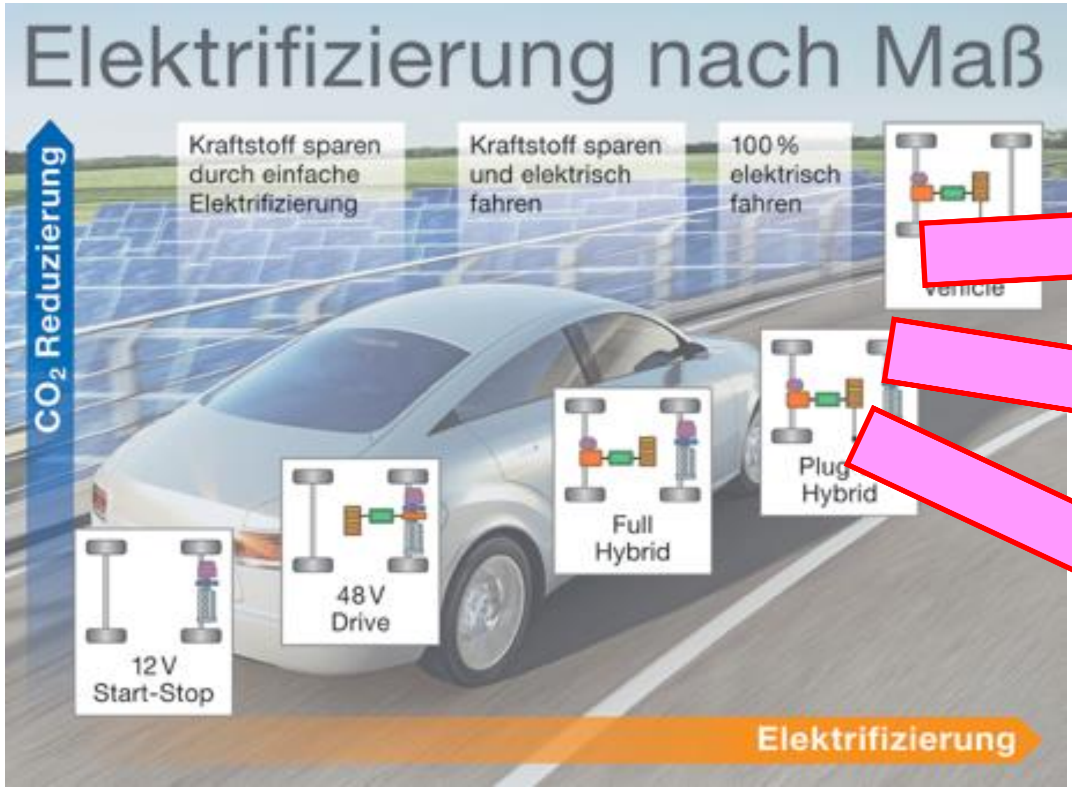
Source: IEA

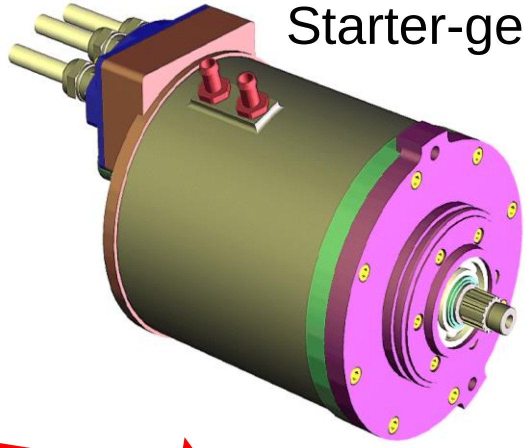
Efficiency improvement-cost relation (trucks)



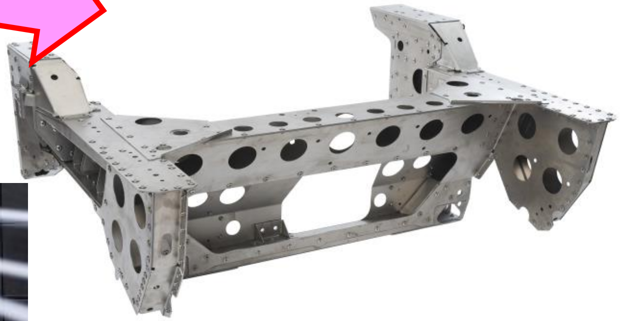
Source: IEA

Examples of the roadmap





Starter-generator



Lightweight design

Aerodynamics

Source: Bosch, Continental, Lotus, Mercedes

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Requirements

- Minimizing irreversible entropy is design rule
- General reversible structure is benchmark
- Energy recovery (system) & energy saving (component)
- Electrochemical-all electric process structure
- Lightweigt design, minimimizing of friction

Infrastructure

- Integration of automotive transport in general transportation
- Grid connected and autonomous operation can be combined to maximze flexibility
- Electrolyzers are key components in converting electricity in thermodynamic potential
- Pressurization of electrolyzers is an interesting option for HT electrolyzers

Industrial production

- Optimization of industrial production by reversible structures
- Recovery of electricity by motor/generators in industry
- Heat recovery with heat pumps in industrial processes
- Integration of industrial production in seasonal electricity storage
- Reversible separation work base for recycling strategies

Boundaries

- Industrial transition depends clearly on supply structure
- Evaluation of efficiency potential needs system approach
- Efficiency increase strategies show intelligent compromises between classical solutions to new concepts
- Prominent examples are starter-generator, leight weight design, and aerodynamics

Acknowledgement

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Thank you

Questions?