DAIMLER

Hybrid at Daimler Trucks – Technology for the world

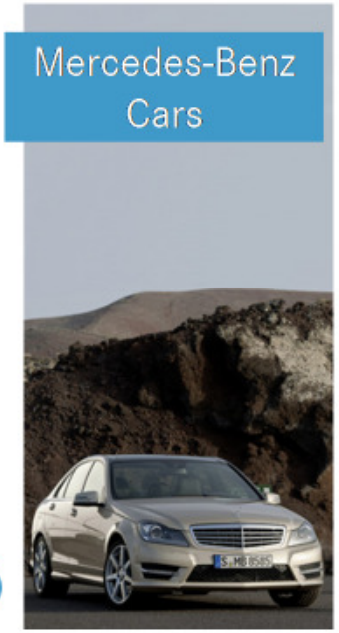
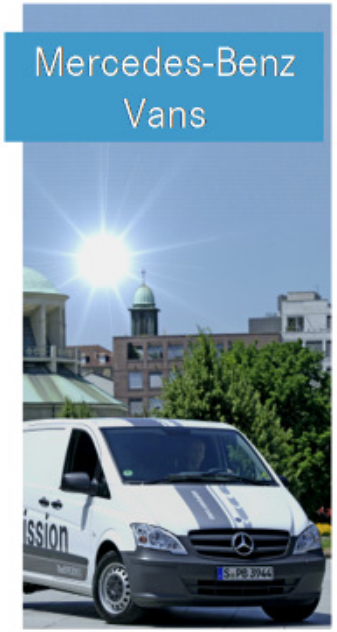
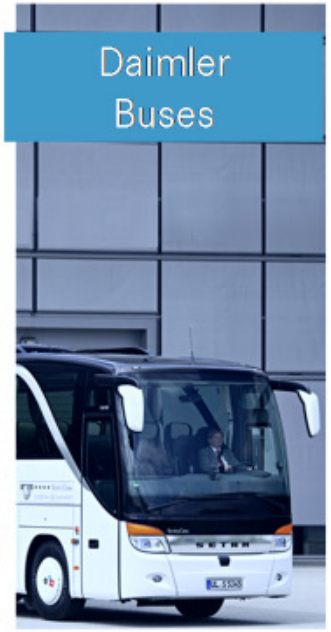
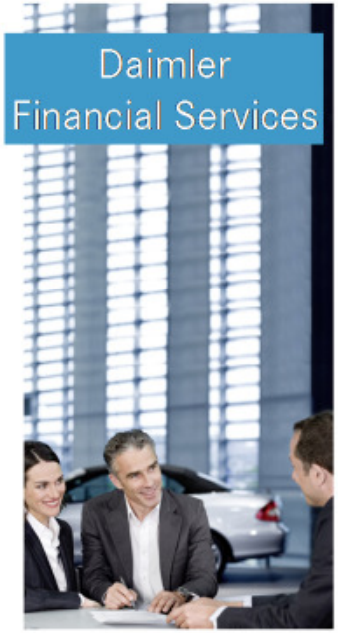
Current status and working direction

Mercedes-Benz FREIGHTLINER FUSO WESTERN STAR Thomas BUILT BUSES BHARATBENZ

4. Fachtagung Hybridantriebe für mobile Antriebsmaschinen
Karlsruhe, 20. Februar 2013
Stephan C. Treusch

Contents

Daimler consists of five divisions

	Mercedes-Benz Cars	Daimler Trucks	Mercedes-Benz Vans	Daimler Buses	Daimler Financial Services
2011					
Revenues	€ 57.4 bn	€ 28.8 bn	€ 9.2 bn	€ 4.4 bn	€ 12.1 bn
Employees	99,091	77,295	14,889	17,495	7,065

Mercedes-Benz · smart · MAYBACH · FREIGHTLINER · WESTERN STAR · FUSO · BHARATBENZ

SETRA · Thomas BUILT BUSES

Mercedes-Benz Bank · Mercedes-Benz Financial · Daimler Truck Financial

Note: 2011: Revenue Group € 106.5 bn; Employees: 271,370; sales organization 49,699, Corporate/Others 5,836

Daimler Trucks worldwide vehicle portfolio

Trucks with high variety: Actros with more than 2.500 base variants

Engine Performance		Cabs		Axles & Wheel Bases		GVW**		Total Variants
								
9	(x)*	4	(x)*	28	(x)*	7	=	2.583*

Plus countless further combinations of fuel economy relevant options (e.g. aero devices, axle ratios, tranmission options, ...)

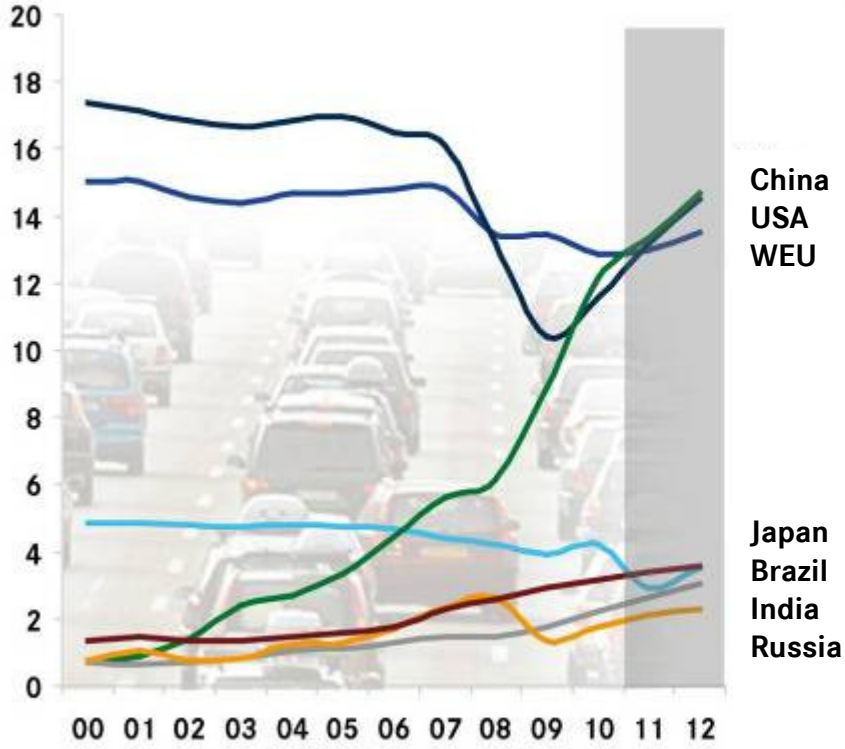
In total more than 4.000 variants available for all MB Trucks products

* not all theoretically possible variants are actually offered

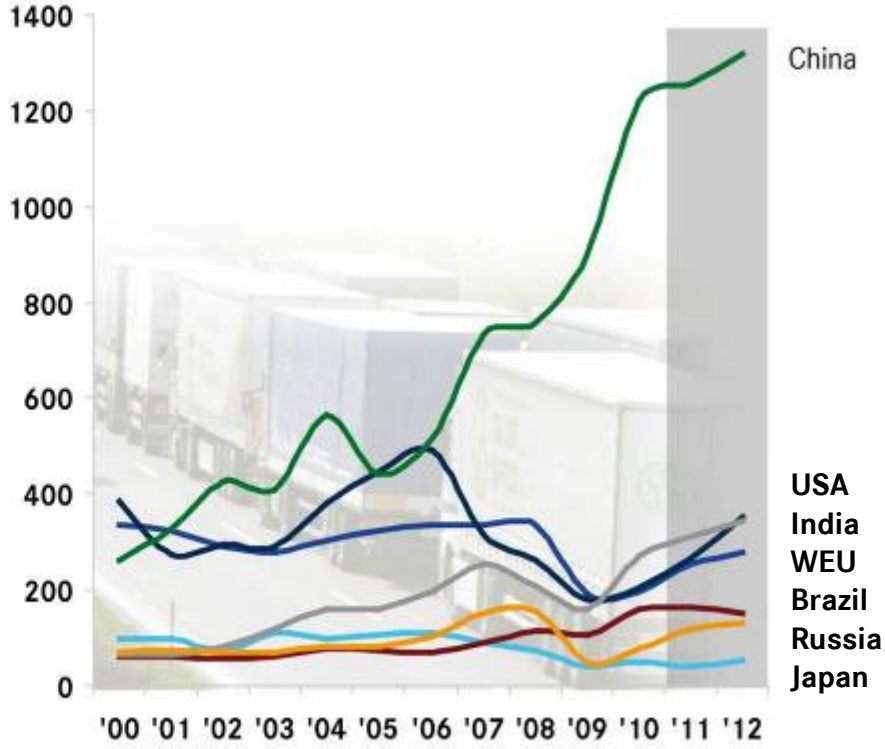
** GVW = Gross vehicle weight

Trucks are international: China as the biggest market worldwide, every second truck is sold there

Sales Cars (in millions of Units)



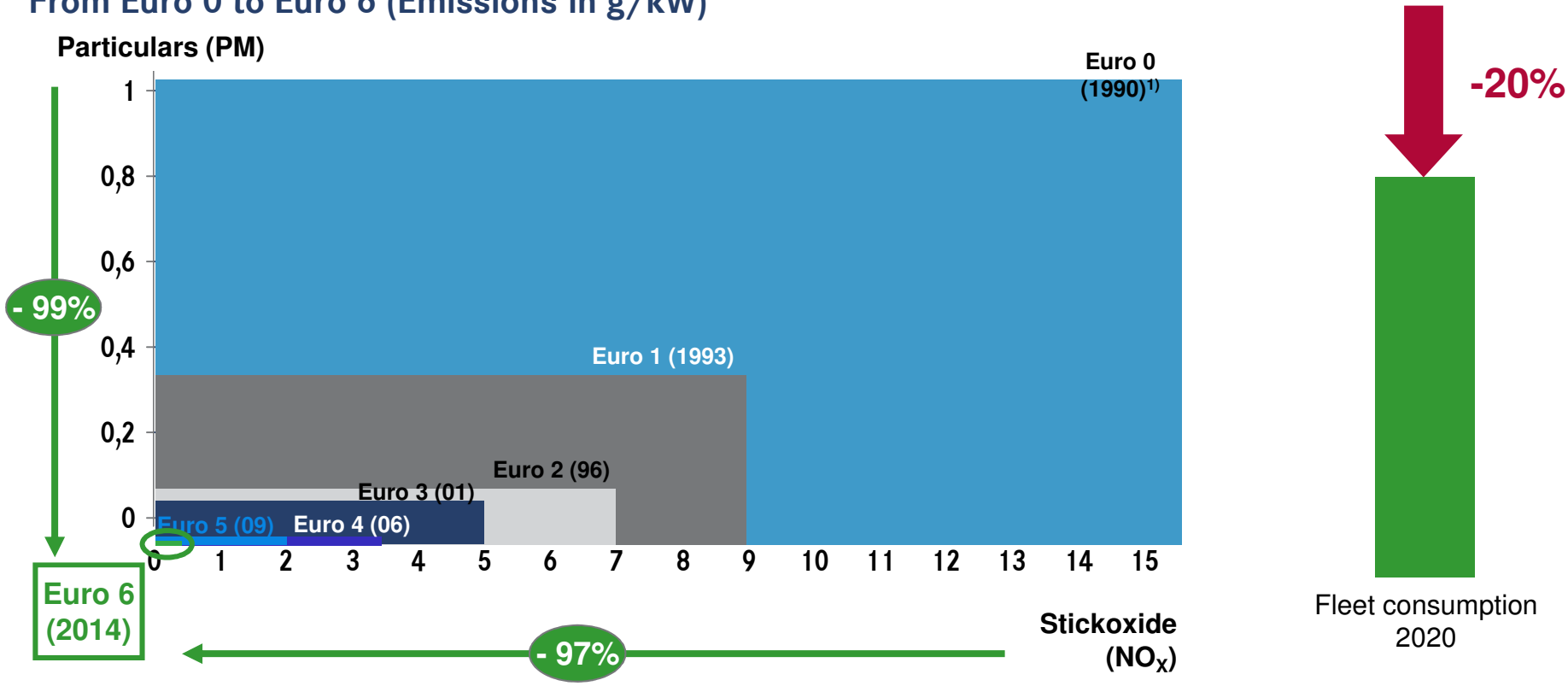
Sales Trucks (> 6 t in thousands of Units)



Trucks are clean: In the past 20 years, emissions have been reduced by almost 100 % - what's next?

„Era Emission“ „Era CO2“

From Euro 0 to Euro 6 (Emissions in g/kW)



(1) Average Truck before EURO1

DAIMLER GLOBAL HYBRID CENTER

Contents

Fuel consumption is influenced by different things - truck technology is only one lever

Use profile / Infrastructure

Significant influence

Vehicle technology

Engineering competence of Daimler Trucks

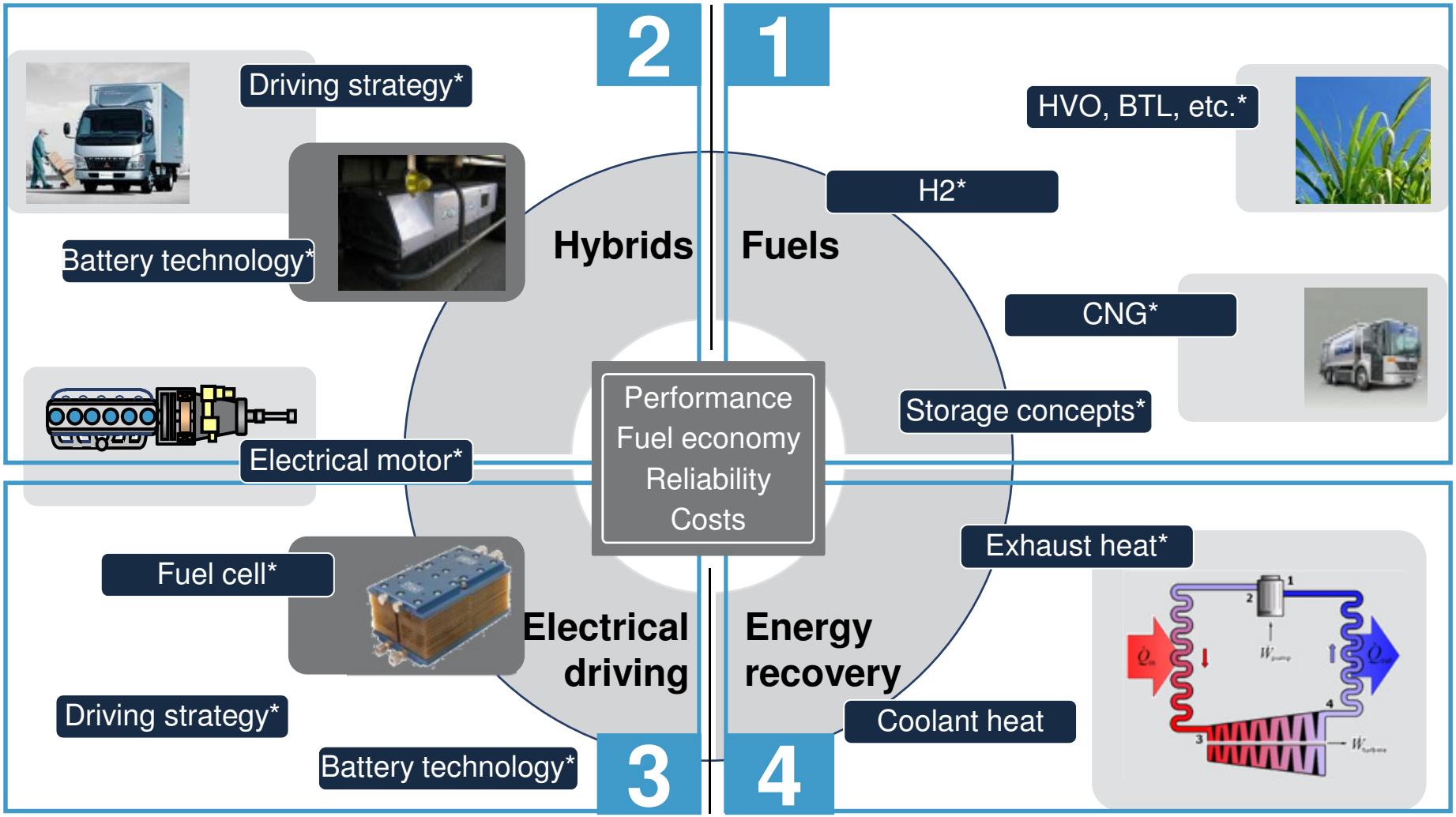
Driver

Up to 25% fuel consumption

Vehicle condition

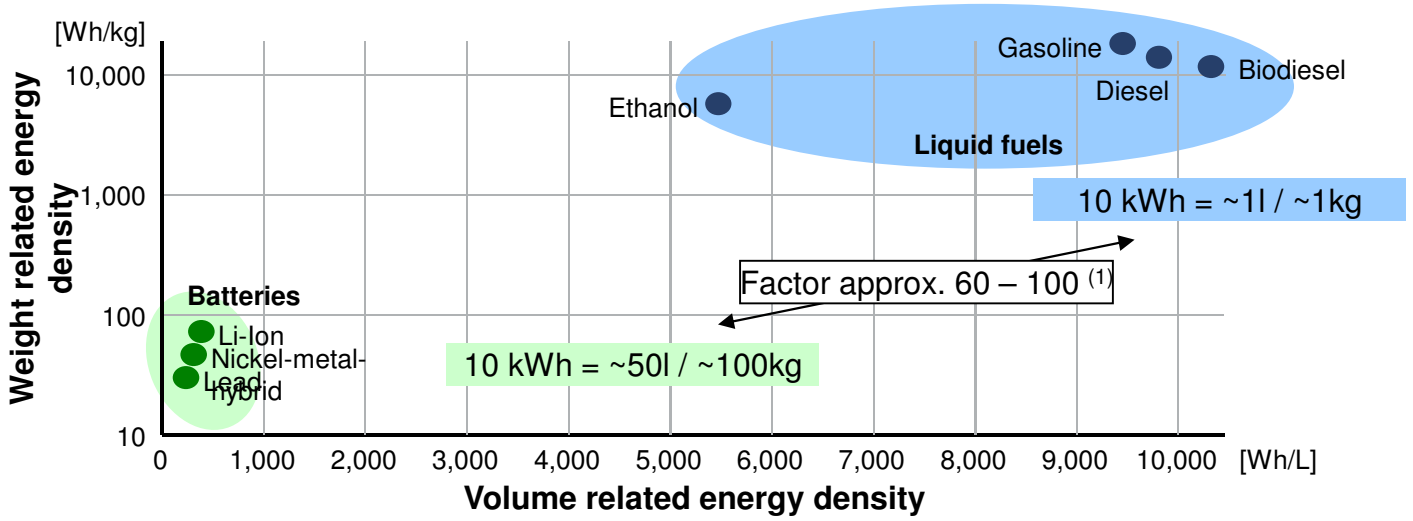
e.g. tire pressure and condition, correct position of aero devices

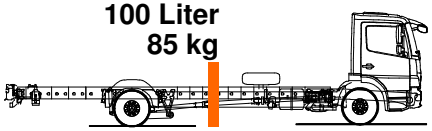
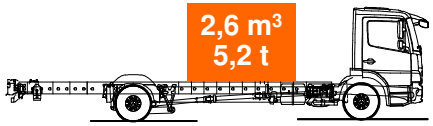
As conventional options are becoming scarce, we investigate alternative drivetrain options as well



*) Synergies within Daimler

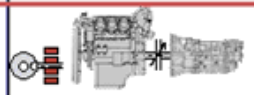
Full electrical drive not an option for trucks in the near future due to low energy density of batteries



Range	Diesel	100% electric with Li-Ion battery
Vito	75 Liter 64 kg  800 km range	0.4 m³ 0.6 t 36 kWh  130 km range 80 km/h V_{max} Vito E-Cell
500 km 12 ton distribution	100 Liter 85 kg 	2,6 m³ 5,2 t 
3000 km 40 ton long-haul	990 Liter 837 kg 	26 m³ 52t 

Evaluation of hybrid architectures lead to P2 as most promising option for Trucks

Parallel and Dual-Hybrids tested

Concept		Starter Function	Electric Starting	Recuperation	Boosting	Assembly/ Complexity	Shifting w/o traction interruption	All wheel drive	ICE operating in the efficient area	E-Drive Climbing Performance	Overall Evaluation
P1		+	--	-	++	++	-	-	-	--	3 -
P2		+	+	+	++	++	-	-	0	++	7 +
P1/2		+	+	0	++	--	-	-	++	+	3 +
P3		-	0	++	+	++	+	-	0	-	4 +
P4		-	0	++	+	+	+	+	0	-	4 +
P2/3		+	++	++	++	-	+	-	+	+	8 +
Dual-Hybrid		+	++	++	--	----	+	0	++	o	2 +

- The P2/3 design is less economical than the P2 design.

  The output of the P3 el. machine (after the transmission) is barely sufficient to exploit the advantages of serial driving and electrical starting. These advantages cannot compensate for the increased weight and costs.

Broad range of vehicles with hybrid technology

S 400 HYBRID

Vision S 500 Plug-in HYBRID [1)]

E 300 BlueTEC HYBRID [2)]/E 400 HYBRID

Fuso Canter Eco Hybrid

Freightliner Business Class M2eHybrid

Atego BlueTec Hybrid

Citaro G BlueTec Hybrid

Freightliner CC Walk-in Van Hybrid

Atego BlueTec Hybrid is the first hybrid series vehicle available in Europe

Till today, about 120 vehicles in the hands of customers

- P2 Hybrid
- 44 kW E-Motor, 420 Nm
- 1,9 kWh Li-Ion battery

- First European series hybrid truck
- Contribution to sustainable mobility
- Fuel Savings of 10-15%
- Significant CO_2-, NOx- und particle emission reduction
- Significant reduction of noise emissions
- Increases know-how in alternative and innovative powertrain applications in Mercedes-Benz Trucks

New Canter TF EcoHybrid represents the second generation of hybrid products at Daimler Trucks

2006 → **2008** → **2011** → **From 2012**

CANTER ECO HYBRID

From 2006:

- Canter TD EcoHybrid introduced into market
- More than 1.000 vehicles sold to customers
- First hybrid truck available with Li-Ion battery
- 15-30% improved fuel economy in Japanese applications

From 2008:

- 10 TD Canter EcoHybrid vehicle test fleet in London
- About 450.000 km total testing achieved
- Up to 15% better fuel economy

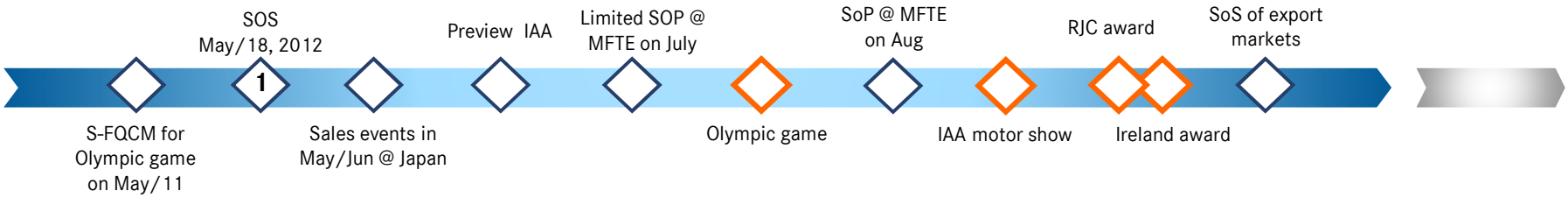
Banner · RINGWAY · John Lewis · Royal Mail · amey · TESCO · DHL · TNT · Scottish and Southern Energy

THE HINO TOKYO MOTOR SHOW 2011

NEW Canter TF EcoHybrid

- All-new hybrid powertrain based on new Canter TF
- Significant progress
  - Improved performance (Power, Fuel economy)
  - Improved Comfort
  - Reduced weight
  - Reduced costs

Highlights – "DUONIC with Hybrid Motor" Wins 2013 RJC Car of the Year Special Award



- First in History for Commercial Vehicle Manufacturer to Win One of RJC Car of the Year Awards.
- LIFT HEV project will come to QG0 till at the end of this year.

RJC : Automotive Researchers' & Journalists' Conference of Japan

IAA Motor show 20th to 27th Sep

Support to LONDON Olympic game 2012

RJC car of the year special award

Fleet Transport Green Commercial of the Year Award

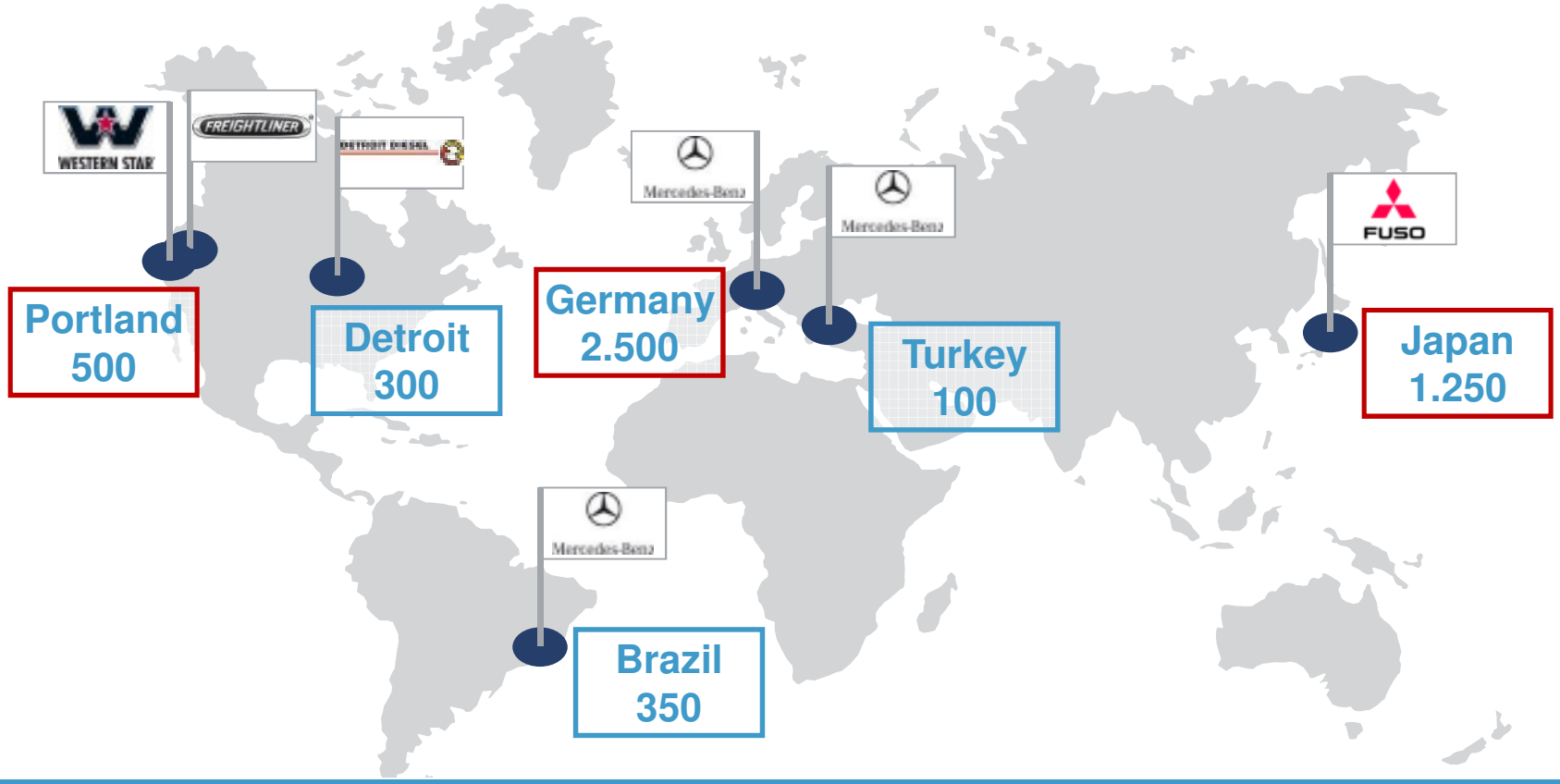
Broad HEV portfolio as technology base for future series vehicles – more than 5.500 sold as of today

	Japan	Europe	NAFTA
HDT	Fuso Super Great HEV 	MB Econic HEV 	FL Cascadia P4 
MDT	Shaping Future Transportation. CleanDrive Technologies.	MB Atego 12t HEV 	FL MT45/55 HEV  FL M2e 
LDT	Fuso Canter HEV 	Fuso Canter HEV 	

Technology vehicle

Series vehicle

To ensure the worldwide market success for Trucks, a global development organization is essential



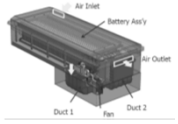
More than 5.000 engineers worldwide working together on future products and innovations

Global Hybrid Center Trucks (GHC) delivers hybrid trucks to all Daimler Truck brands worldwide

- **GLOBAL :** All Daimler Truck brands worldwide

Mercedes-Benz FREIGHTLINER FUSO WESTERN STAR BHARATBENZ

- **HYBRID:** Target configuration is P2
  Diesel-electric Hybrid System



- **CENTER** (Trucks)
  - From light duty truck (3,5 tons) to heavy duty truck (40 tons)
  - Standardized powertrain
  - Focus is main high volume models (and a possible use in bus coach)





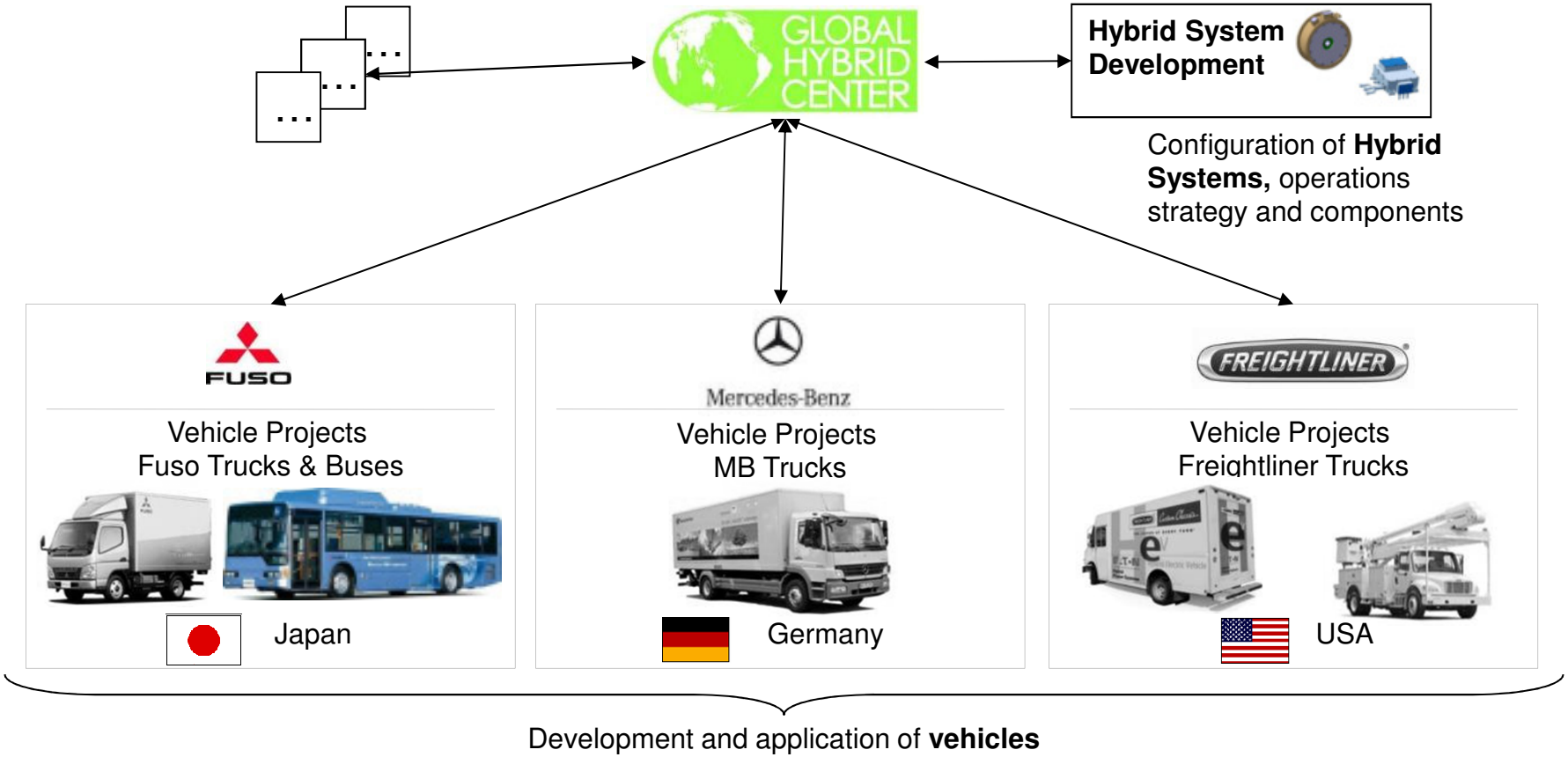

- Provides **hybrid systems** with
  - **standardized, modular components**
  - **common E/E interface**

  for easy vehicle integration
- Provides **system functionality** for application & calibration in **each regional project**
- Leverages **global presence** of Daimler Trucks for new technology applications
- Realize synergies within Daimler

Daimler Trucks with integrated worldwide hybrid development to realize synergies

Only the integration of all worldwide hybrid activities in one organization leads to synergies in budget and cost. If this is done right, this allows at the same time vehicles with market and brand-specific benefits.

Collaboration and alignment with key-partners leads to further improvements.

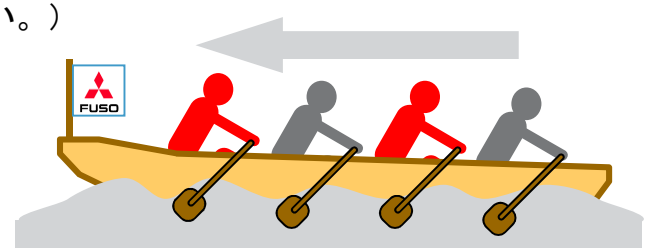


A successful global R&D network requires strong intercultural skills

私たちは、三菱ふそうの国際的な経営陣として
三菱ふそうとダイムラークライスラーが持つ異なる文化・ビジネスモデル・伝統を互いに認め、尊重するが、
新しい三菱ふそうを共に築くために、異なる文化的背景を持つ相手に対応する際は以下のことを考慮する。

日本人以外/ダイムラークライスラー側へのヒント：
1）ディスカッションでは、まず相手の言い分を聞く。
2）注意：沈黙は必ずしも合意ではない。
3）注意：自分ではアイデア・提案・意見のつもりの発言が、相手には命令と受け取られているかもしれない。
4）相手の論旨の背景を考えてみること。
5）結論を急がずに、オープンで同等な立場でのディスカッションを心がける

日本人/ふそう側へのヒント：
1）言葉にしなければ伝えたことにはならない。
（自分の気持ちや言いたいことを相手が察してくれると期待してはいけない。）
2）自分の真意を伝えること。（本音と建前）
3）報告をする際は、まず結論から始めること（そのあとに説明）。
4）よくわからない時は質問（確認）すること。
5）ふそうにいるDC派遣者もふそうの一員。
6）親（株主）に対しても自分の意見は明確に説明すること。



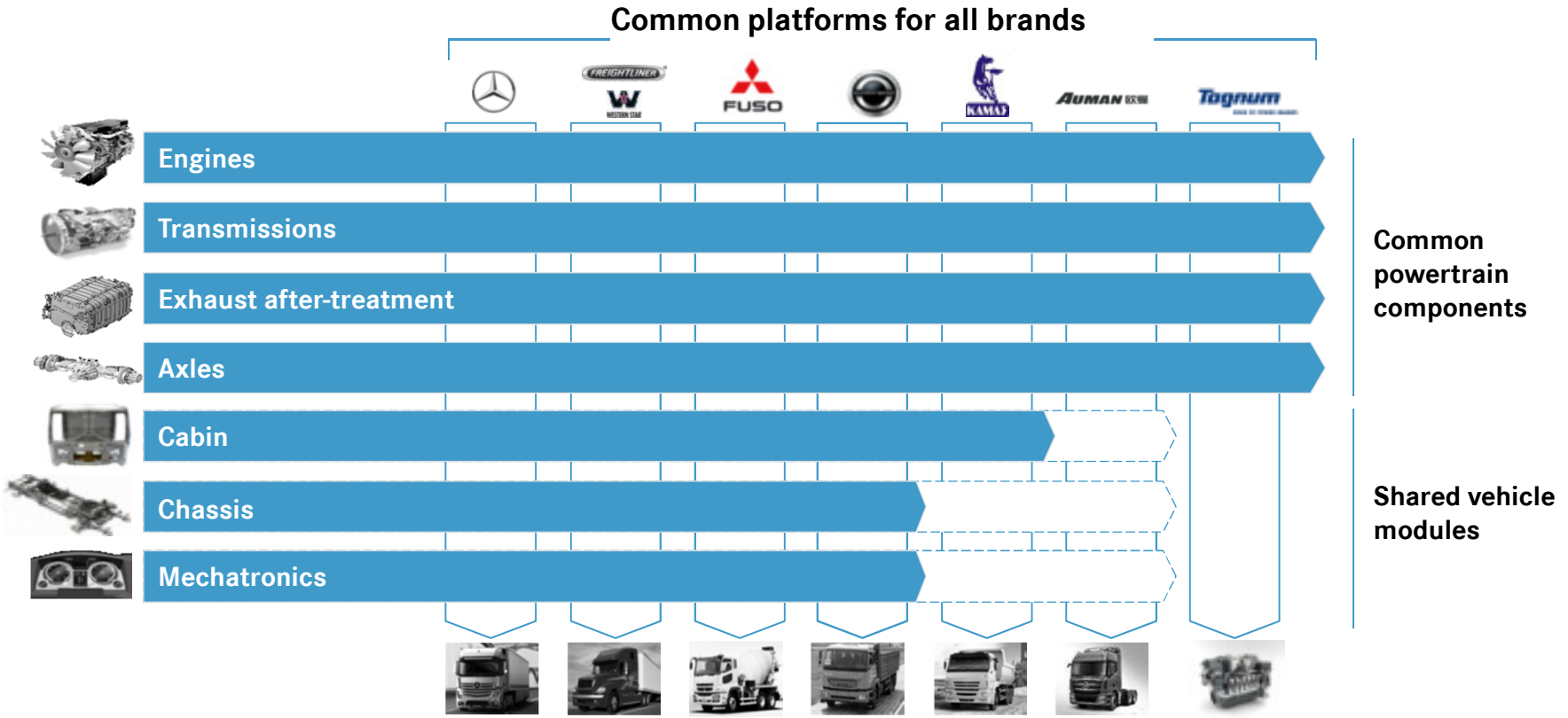
＞英語はドイツ人にとっても日本人にとっても外国語
＞CVDのビジネスユニットは「兄弟」（同じレベルのパートナー）であり「親子」ではない。

＞ 私たちは同じ船に乗り、共通のゴールに向けて船を漕いでいる

DAIMLER GLOBAL HYBRID CENTER

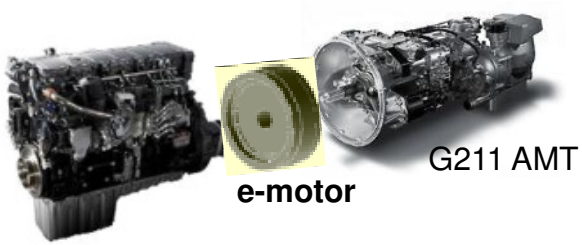
Contents

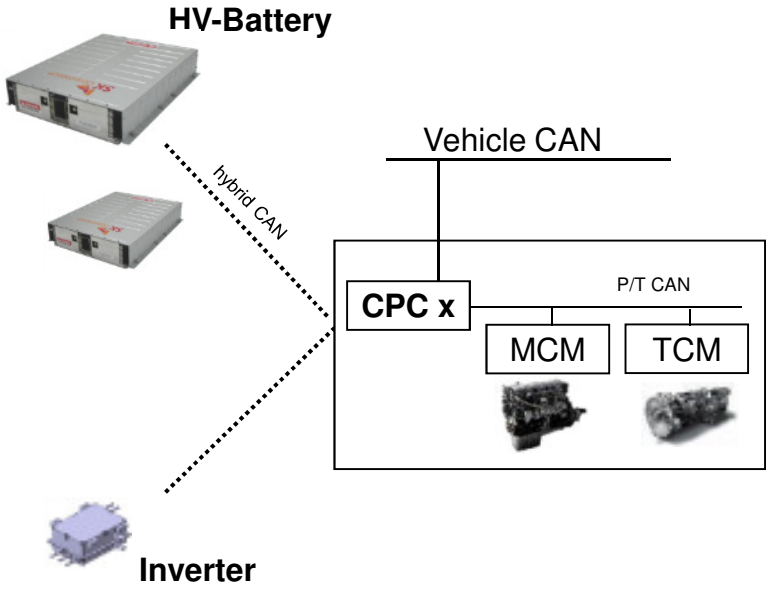
Platform and module strategy to leverage scales in powertrain and vehicles of Daimler Trucks



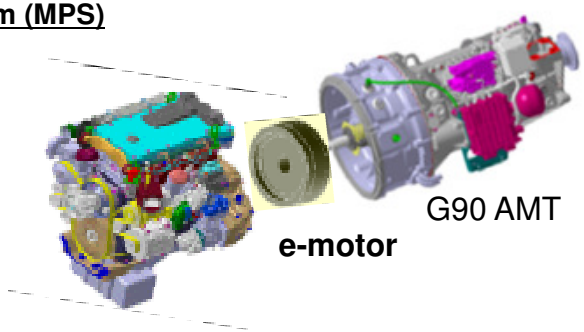
Three systems can cover all Daimler Trucks HEV – components partly scalable

High Power System (HPS)

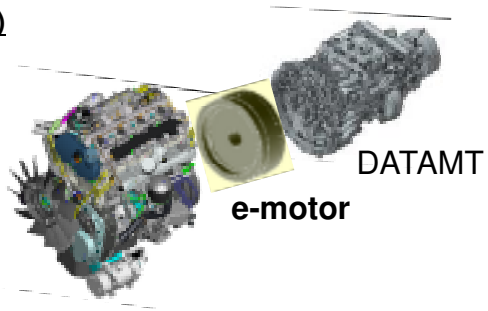


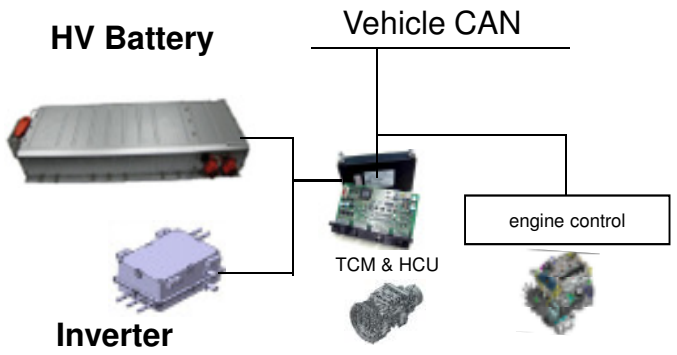


Mid Power System (MPS)



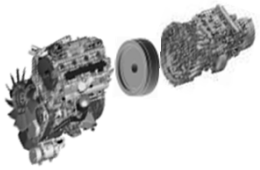
Light Power System (LPS)





Due to yearly mileage, CO2 reduction effect of long-haul HEV is up to 5 times higher than in distribution

Light Duty Truck HEV



Based on city delivery application for Fuso Canter (without ESS*)

GVW: 5 t

Quantity of annual CO2 reduction

2t

Mileage: 30.000km p.a.

Heavy Duty Truck HEV

Based on long haul application (highway only) for HDT (25t) (without ESS)

GVW: 25 t

Quantity of annual CO2 reduction

11t

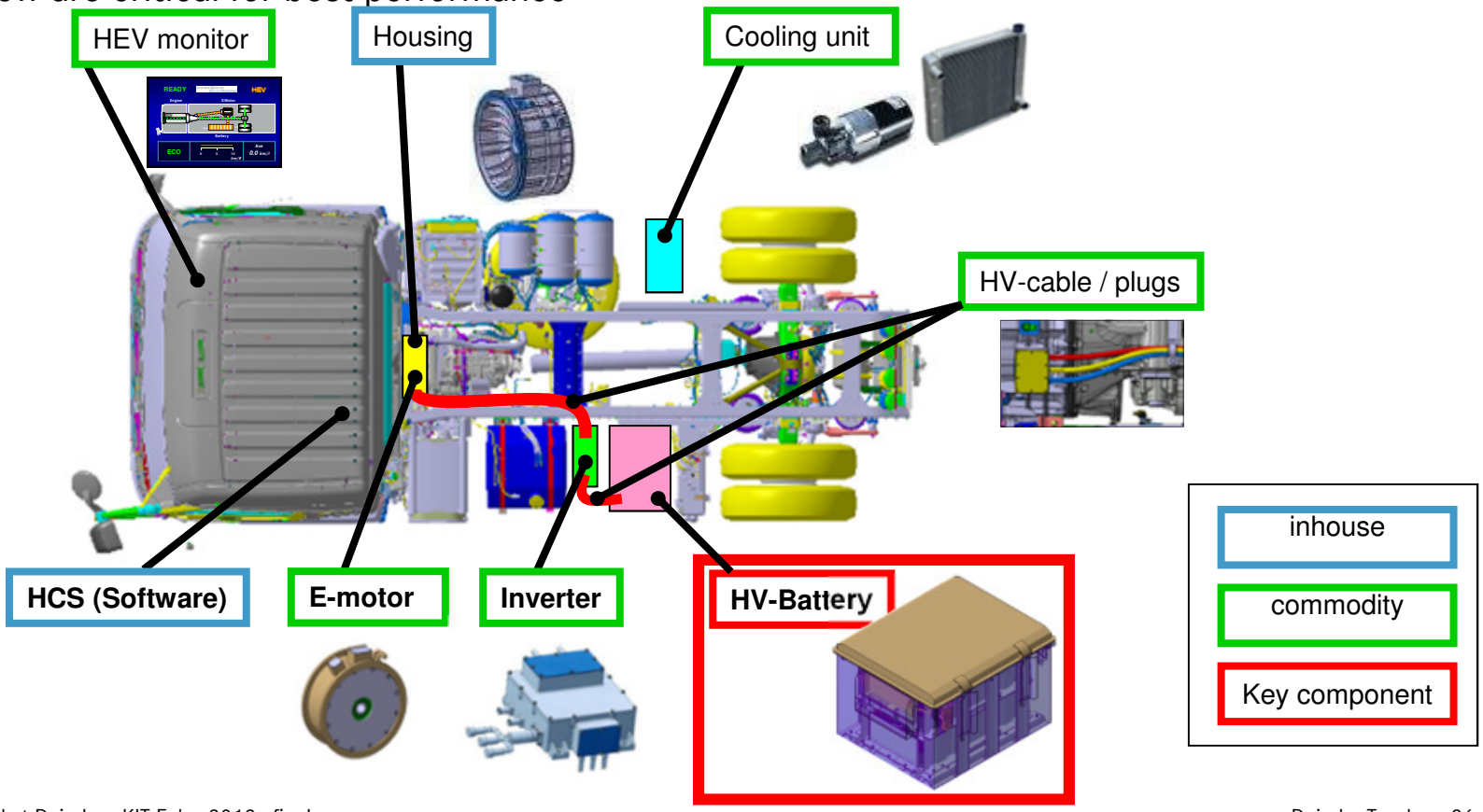
Mileage: 150.000km p.a.

- Optimized **system specification** and **hybrid control strategy** bring high potential of recuperating energy even on highway
- Actual measurement results on **typical Japanese road** and **application** show about **10 % fuel consumption reduction** compared to the conventional diesel truck

* ESS = Engine Start-Stop

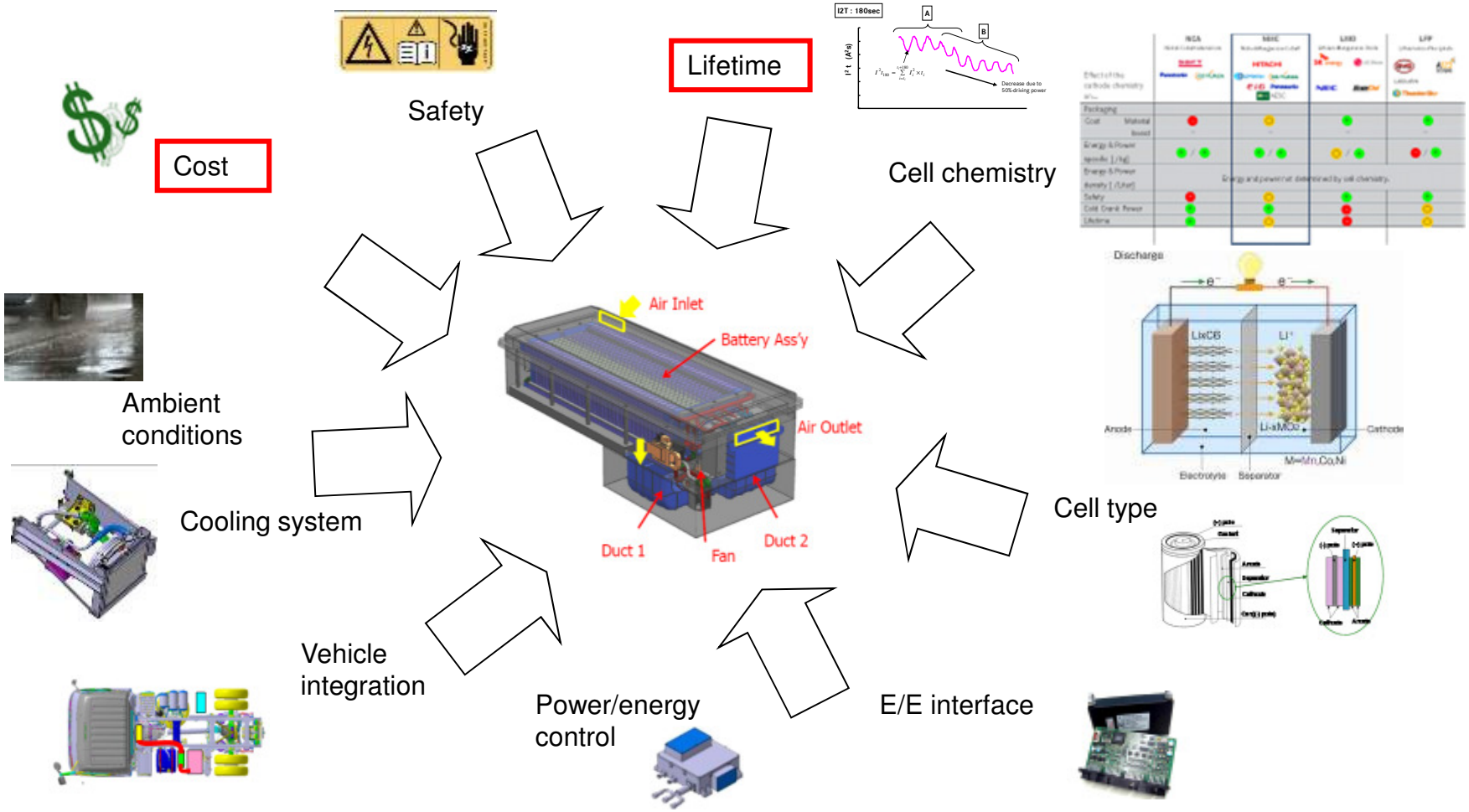
Hybrid systems consist of different elements

- A hybrid system consists mainly of HV components, cooling and control elements
- Some of these are already today available commodities (like cooling systems), others will be with the increased volumes in the automotive industry (e.g. HV cables, eMotors)
- Only a few are critical for best performance



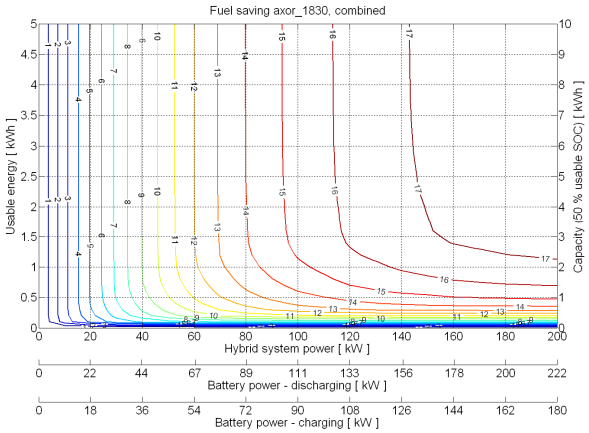
Various and partly opposing requirements have to be considered for the specification of the HV-Battery

The HV-Battery is a complex component, combining electrical, chemical, mechanical and performance elements. With the boundary conditions in a truck, the right combination has to be defined.



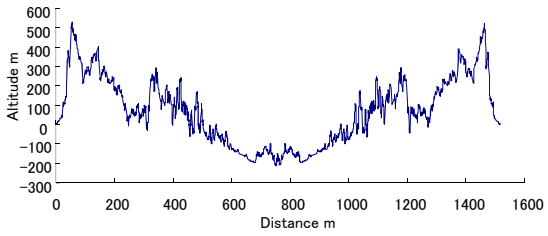
Simulation process to evaluate feasible system configuration

- Energy Analysis: simulation tool for the basic dimensioning of hybrid systems (dimensioning of power and energy).
- I2t limitation study: process to consider battery limitations and lifetime restrictions
- Consideration of route specific driving/recuperation characteristic



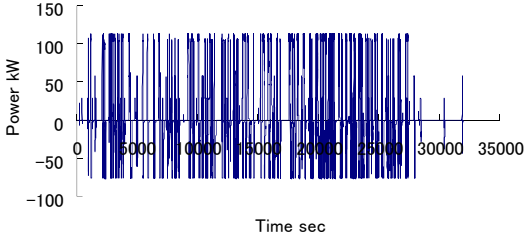
1. Route definition

•***Route profile*** has to be defined for relevant key-applications



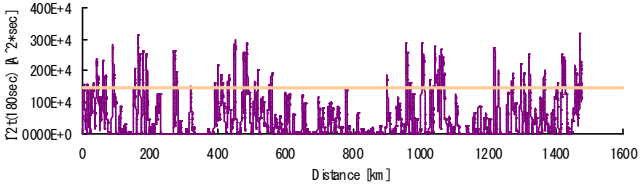
2. Power profile by vehicle simulation

•***Power profile*** is calculated by vehicle simulation



3. Lifetime study

•I^2t is calculated by power profile
•I^2t as limit for battery spec or usage
•If I^2t exceeds the criteria, change to Battery hardware or hybrid control



Depending on circumstances, the fuel effect of a hybrid may even be negative

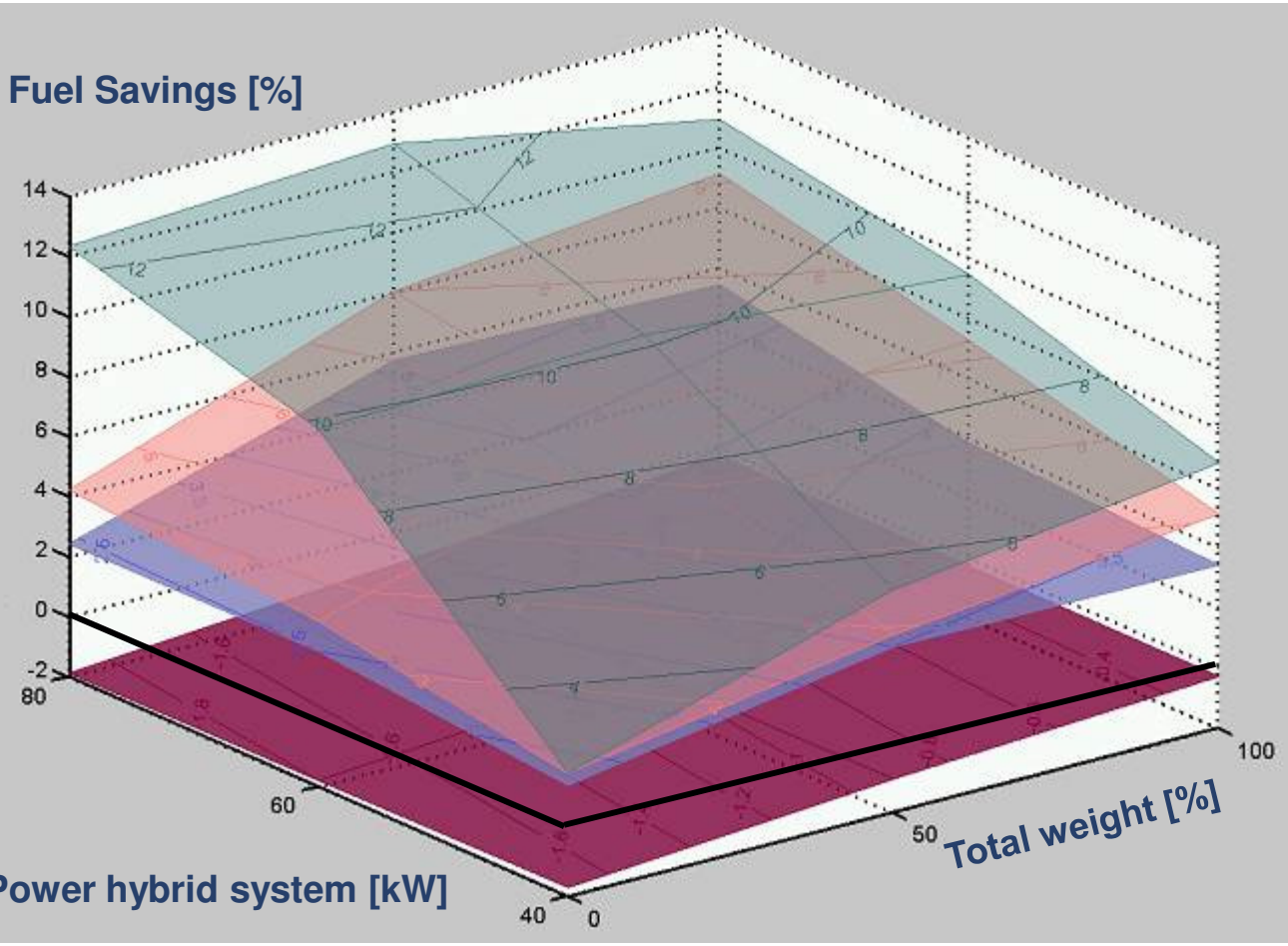
Usage profile:

hard (hilly terrain)

medium (typical long haul)

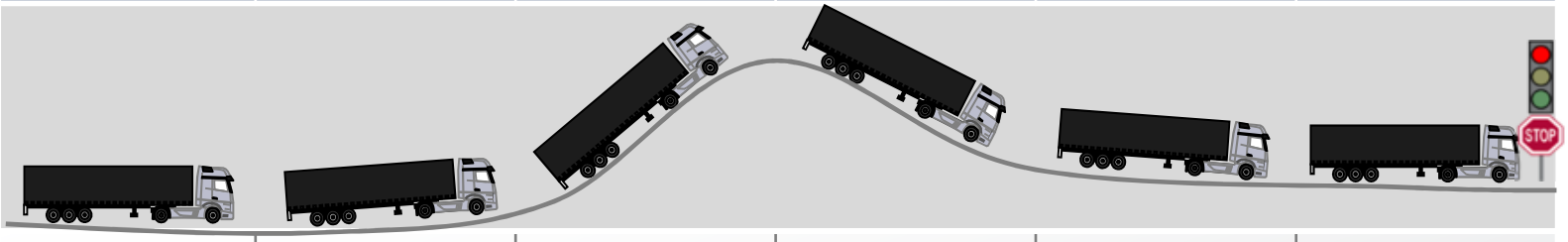
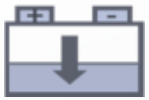
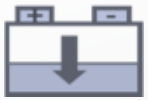
Medium-easy ("Landstraße")

easy (Autobahn without hills)



A hybrid for truck must be carefully selected depending on its usage!

The hybrid control strategy is a major lever for defining the success of a hybrid truck

HEV feature	E-Drive	Hybrid drive	Conventional drive	Recuperation	Sailing	Engine start-stop
Topo-graphy						
battery						
FE* Long haul	0	+ +	0	+ +	+ +	+
FE* City delivery	+ +	+ +	0	+	0	+ +

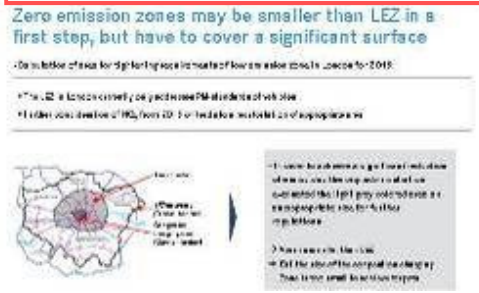
- Most relevant **features for** HD hybrid differ significantly **from other applications**

Future hybrid functions have to consider engine-off and PHEV functionality

- The focus of hybrid development is today on classic hybrid functionality. Advanced hybrid functions will consider the shut-down of the Engine
- pZE and plug-in operations available in cars, and partly for LDT.
- Additional functionality might be required by the customer (ePTO, ZE), or by law (LEZ-ZEZ).
- In addition, synergies with existing components of other Daimler BU might be possible.

Market - PHEV

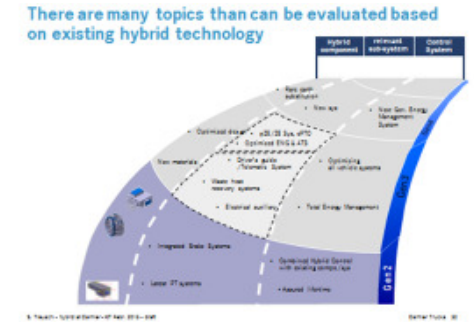
Legislation - pZE



Lead to ...

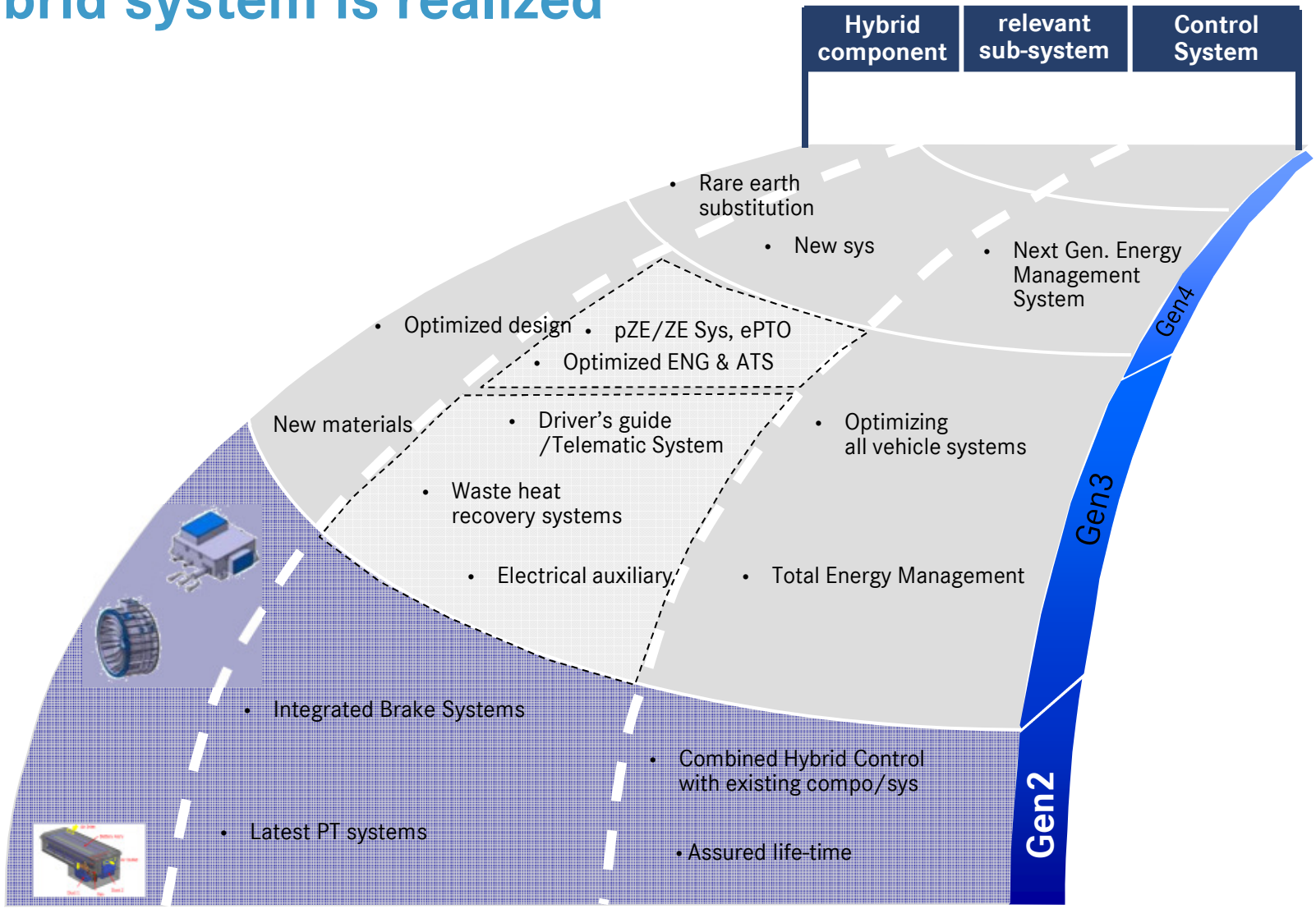
ZE – PHEV evaluations

Advanced hybrid functions



Synergies – Daimler xBU

There are many topics than can be evaluated once the hybrid system is realized

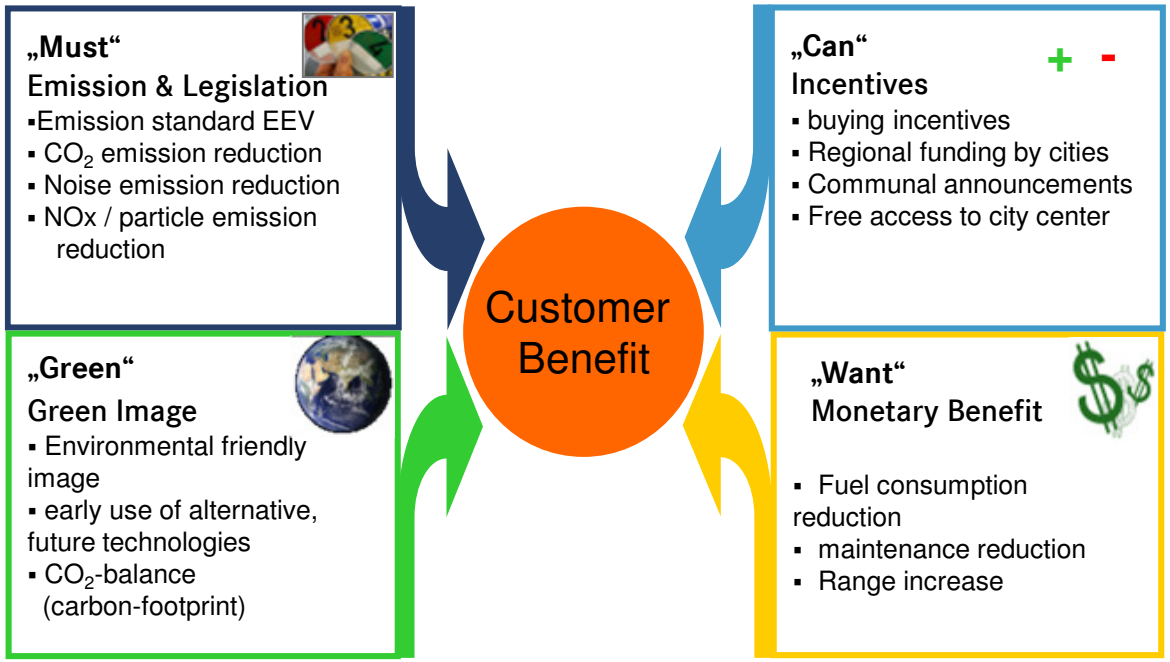


DAIMLER GLOBAL HYBRID CENTER

Contents

Besides technical challenges, different buying motivations exist - only one is stable for development

- Customers buy a HEV Truck for different reasons. They want to be eco-friendly (e.g. green image), they have to (out of legislation or access restrictions) or because of a monetary benefit (subsidies or by better TCO).
- Most trucks are bought to make money. The decision is simple:
  - how much does it cost?
  - How much do I get (in a reasonable time)?
- Besides legislation effects, a hybrid truck has to deliver real monetary benefit to get high volume.
- At the same time, the usage of the vehicle should not be restricted by the system (same durability, payload, functionality, performance, ...).



- As a result, a hybrid system has to be integrated in a way, that keeps the capability of the truck unchanged.

Das Grund-Dilema einer globalen Elektromobilität sind die unterschiedlichen, hundertjährigen Elektizitätsnetze

- Verschiedene Elektrizitätsnetze haben unterschiedliche Ladesysteme zur Folge

AC Laden Typ 1

AC Laden Typ 2

AC/DC Laden „Combo“ Typ 1/2

DC Laden „Chademo“

• • •

etc...

Die Fahrzeughersteller entwickeln die Fahrzeuge in unterschiedlichen Szenarien

Beispiel: Nissan Leaf

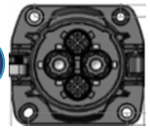
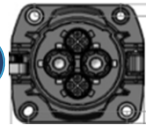
AC Laden Typ 1 oder 2

DC Laden „Chademo“

Induktives Laden*

Source: Daimler Corporate Standardization

Die Einigung auf wenige internationale Standards reduziert die Entwicklungs- und Produktions-Kosten

Region	Aktuelle Situation AC/DC Fahrzeug Inlet	optimales Szenario
	1  IEC Combo 1 (AC + DC) *passend für IEC Type 1 (AC) und Combo 1 (AC + DC) Connector*	1 
	2  IEC Combo 2 (AC + DC) *passend für IEC Type 2 (AC + DC) und Combo 2 (AC + DC) Connector*	2 
	3  IEC Type 1 (AC) 4  CHAdeMO (DC)	1 
	5  National Standard (AC) *GB Part 2, ähnlich IEC Type 2* 6  National Standard (DC) *GB Part 3*	2 
	7  National Standard (AC) *Ähnlich IEC Type 1* 8  National Standard (DC) *Ähnlich CHAdeMO*	1 
Anzahl Varianten	**8**	**2**

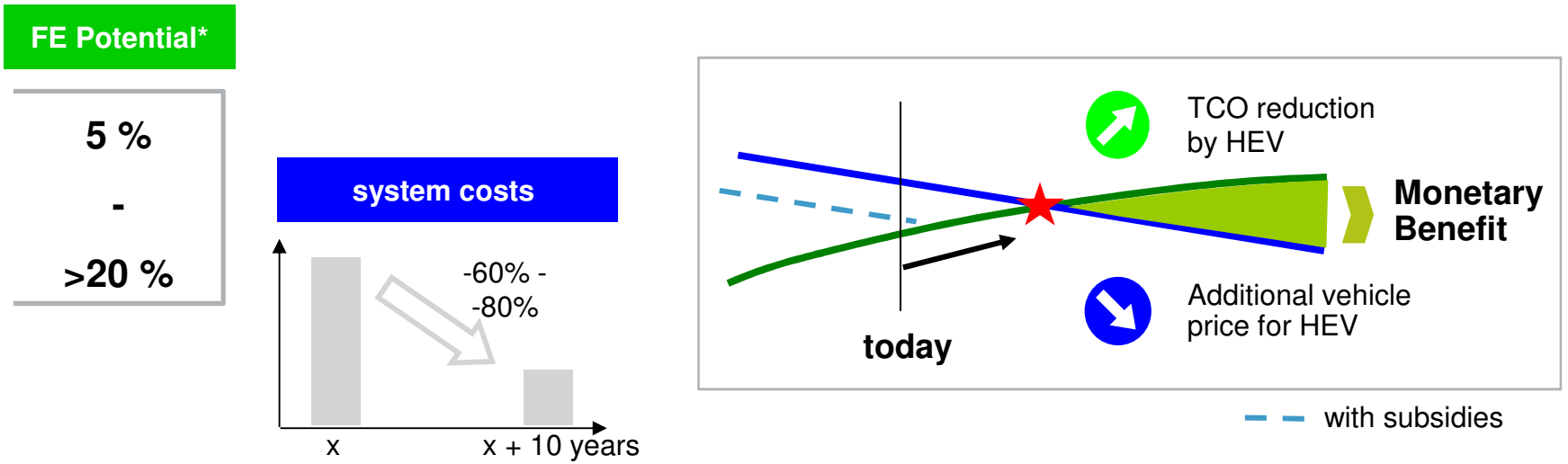
Source: Daimler Corporate Standardization

Contents

By continuously reducing cost and increasing the hybrid benefit, the magic moment is close

To reach the “magic” moment”, two levers have to be used:

- The **monetary benefit** can be influenced mainly by vehicle development and improvements in operations strategy and vehicle integration. As shown with the different models of Canter EcoHybrid, the performance can be significantly improved by fine-tuning (with unchanged system hardware and cost).
- The system **costs** are directly linked to the volume of hybrid components that depend on the development of the automotive industry and the component specification. Governmental subsidies can help to bring volumes up.
- Today, the magic moment can only be reached with subsidies.
  This will drastically improve in the next few years.



*: depending on vehicle and application

Summary

Trucks have specific boundary conditions

- Money driven business (TCO)
- Weight and packaging sensitive
- High variety in vehicles and usage - worldwide

Key success factors for hybrid systems in Trucks

- Optimized, modular system architecture and cost
- Individual operating strategy and seamless vehicle integration
- Strong network for synergies in functions, budget and time
- Target is the best performance/cost ratio!

Boundary conditions / challenges

- Most challenging component: HV battery
- Biggest uncertainty: governmental / City administrations priority
- Standardization as key driver for component cost and volume

Outlook

- HEV is the future for Trucks. But success and schedule are not in engineering responsibility

Daimler Trucks

We are Shaping Future Transportation …