"Urban mobility and hydrogen fuel cell – international experience"

Perspectivas do Vehiculo com Cellular de Hydrogenio

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Brazilian Hydrogen Fuel Cell Bus Seminar
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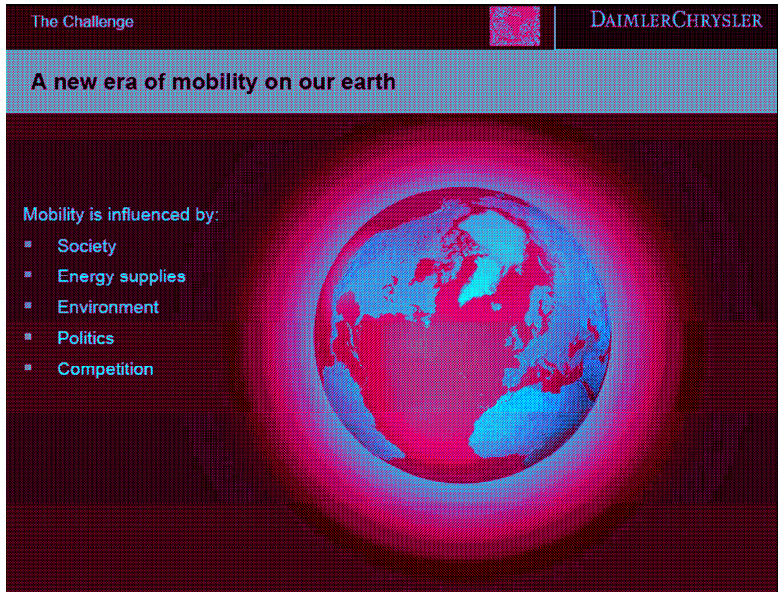
A new Area of Mobility



Megatrend

Sustainabel Mobility

In order to allow further growth of economics a world of energy and mobility has to be created which is not further exhausting the natural resources of the earth and is in balance with environmental and social needs.

Status Of Fuel Cell Vehicle Development

California Fuel Cell Partnership Celebrates 10th Anniversary

CaFCP Hydrogen "Test the Future Tour 2009"

The **2008 TOYOTA FCHV** represents the advancement on the FCHV-4 prototype, which underwent 18 months and over 80,000 miles of real-world testing in California and Japan. On December 2, 2002, Toyota began leasing FCHVs in the US and Japan. The TOYOTA FCHV has a remarkable balance of high efficiency and a luxury car-like smooth, quiet ride.

Year: 2008
PSI: 10,000
Kilograms: ~ 6 kg
Range in Miles: 491 miles
Max Power: 90 kW
Max Torque: 192 lb-ft
Max Speed: 96 mph

The **2009 KIA Borrego FCEV** is the company's second generation in development. This vehicle, based on the gasoline/diesel version of the same name, is built on a small preproduction line. Borrego FCEVs are being tested in the United States and Korea. With this vehicle, KIA is closer to making fuel cell vehicles available for consumers.

Year: 2009
PSI: 10,000
Kilograms: 7.9 kg
Range in Miles: 426 miles
Max Power: 110kW
Max Torque: 300Nm
Max Speed: 100 mph

In 2008 Honda began limited production of an all new fuel cell car, "FCX Clarity" targeted primarily for leasing to private individuals. This newest generation powerplant features an advanced Honda "V-Flow" fuel cell stack that is 30% lighter, 20% smaller, offers 100kw output, and a power/density improvement of 50%. Driving range has been increased 9% from 210 to 240 miles, using 5,000 psi gaseous hydrogen. With sub-freezing startup temperatures as low as -22F, it is a practical vehicle for a wide range of real-world applications. Honda continues research on hydrogen refueling solutions right-sized for individual vehicle at-home refueling.

Year: 2009
PSI: 5,000
Kilograms: 3.9 kg
Range in Miles: 240 miles
Max Power: 100kW
Max Torque: 189 lb.-ft
Max Speed: 100 mph
Fuel Economy: 60 city/60 hwy (m/kg)

California Fuel Cell Partnership Celebrates 10th Anniversary

CaFCP (**www.cafcp.org**) was formed in 1999 as a collaboration between two state agencies and six private sector Companies with the goal of testing and promoting zero-emission fuel cell vehicles. At the time, California had four fuel cell vehicles and one hydrogen station. Within months, other auto, energy and technology companies, and Federal and local government agencies joined the effort. Today, CaFCP has 30 members who are all active in Hydrogen and fuel cell technology in the state of California.

The California Fuel Cell Partnership is a consensus-based organization that focuses moving toward a commercial market for hydrogen fuel cell vehicles. By collaborating between industry and government on projects such as defining and measuring hydrogen quality or coordinating the rollout of vehicles and stations,CaFCP reduces processes from years to just months.

Key milestones over the last 10 years include:

- Moving from early concept vehicles to fleet demonstrations, including some automakers placing vehicles with customers in lease programs.
- 25 hydrogen stations, including six that are publically accessible and a plan to place 40 more stations in six target in the next few years.
- Designating hydrogen as an automotive fuel, an important step to sell the fuel at a station.
- Reaching hundreds of thousands of people through a fact-based outreach program.

Market Preparation Strategies

The Roadmap: Visions

„The 21st Century will become the Century of Electric Drive Technology"

Mr. Toyoda, Ex-President of Toyota Motor Company (1994)

„There will be a Paradigm Change.
The Roadmap for the Automotive Industry has to be oriented towards emission free vehicles, which are not using any more crude oil "

Mr. Dieter Zetsche, Head of Daimler
May 10th,2008

Introduction Scenario

In order to build up a robust product strategy for the future, automotive and energy companies are preparing themselves towards a broader portfolio of drive-trains and fuels which may consist of five steps:

- **Optimization of Combustion Engines**
- **Improvement of Conventional Fuels**
- **Introduction of Fuel Efficient Hybrid Vehicles**
- **Introduction of Renewable Fuels**
- **Introduction of Fuel Cells and Hydrogen as a Fuel**

Fuel Cells and Hydrogen are positioned last in a row of innovations because of the disruptive changes required, and because of the fact, that the current technological barriers and costs preclude it from being considered as a short or mid-term solution.

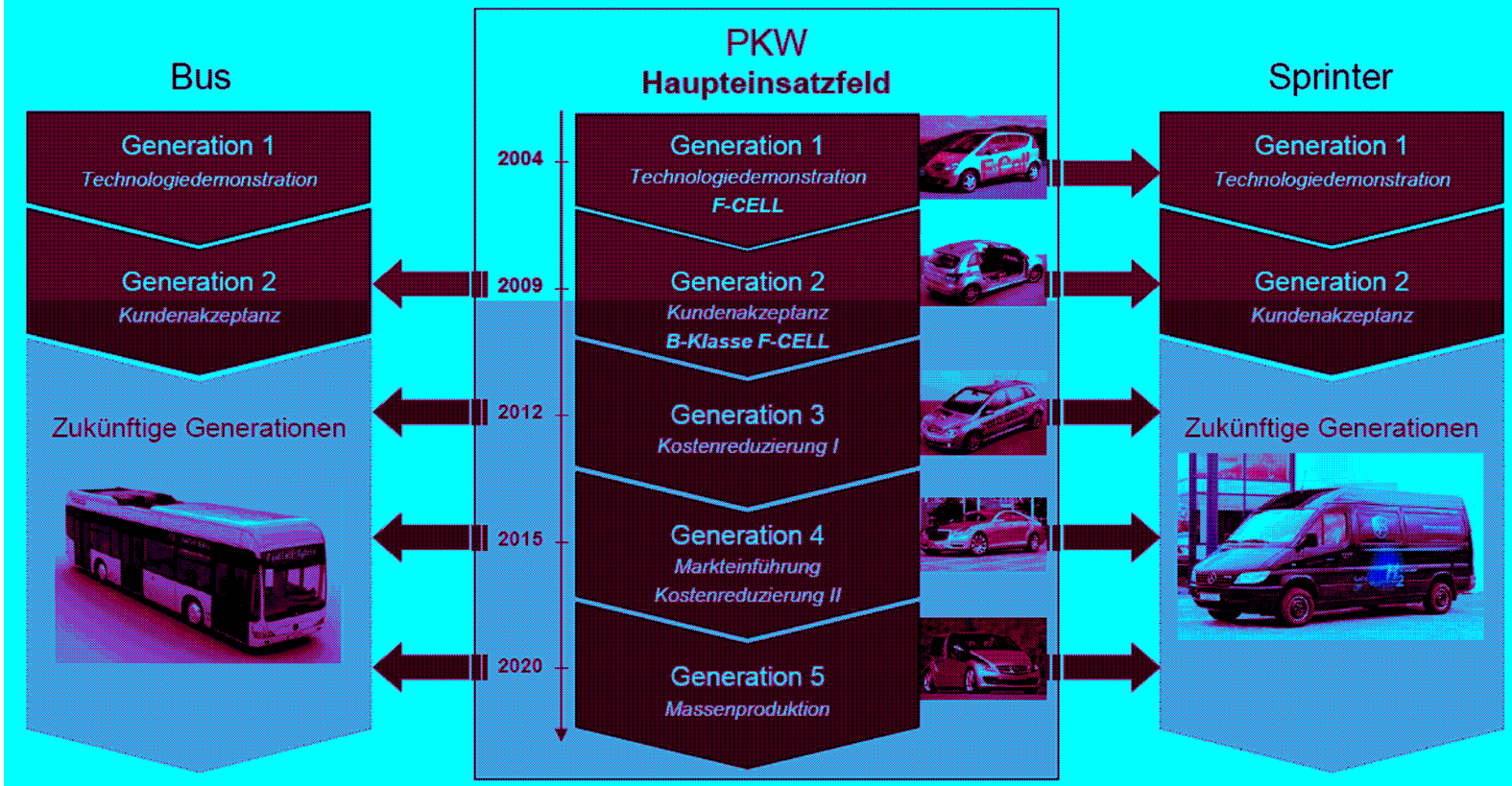
Nevertheless, because of their strategic importance, significant investments were done already and will be done in research, development and demonstration programs by the industry and governments.

Daimler Roadmap to the Future

DAIMLER

Elektrifizierung der Antriebe

Daimlers Brennstoffzellen-Aktivitäten



Zwischenbilanz der 1.Generation Daimler Bz- Fahrzeuge

60 F-Cell Fahrzeuge im Kundenbetrieb	36 Busse (Citaro) in Europa, Australien, China	3 Sprinter mit UPS Europa, USA
		
~ 2.050.000 km ~ 60.000 h	~ 2.120.000 km ~ 139.000 h	~ 64.000 km ~ 2.400 h

2. Generation FCVs:
Honda FCX Clarity "WORLD GREEN CAR 2009"

Honda: Chassis and Drive Train

Daimler F-Cell B- Klasse 2. Generation

Technische Daten	
Fahrzeug	Mercedes-Benz B-Klasse
BZ-System	PEM, 80 kW (108 PS)
Motor	Output (Continuous/ Peak) 70kW / 100kW (136 PS) Max. Drehmoment: 320 Nm
Kraftstoff	Komprimierter Wasserstoff (700 bar)
Reichweite	400 km
Höchstgeschwindigkeit	170 km/h
Batterie	Li-Ion, Output (Continuous/ Peak): 24 kW / 30 kW (40 PS); Kapazität 6.8 Ah, 1.4 kWh

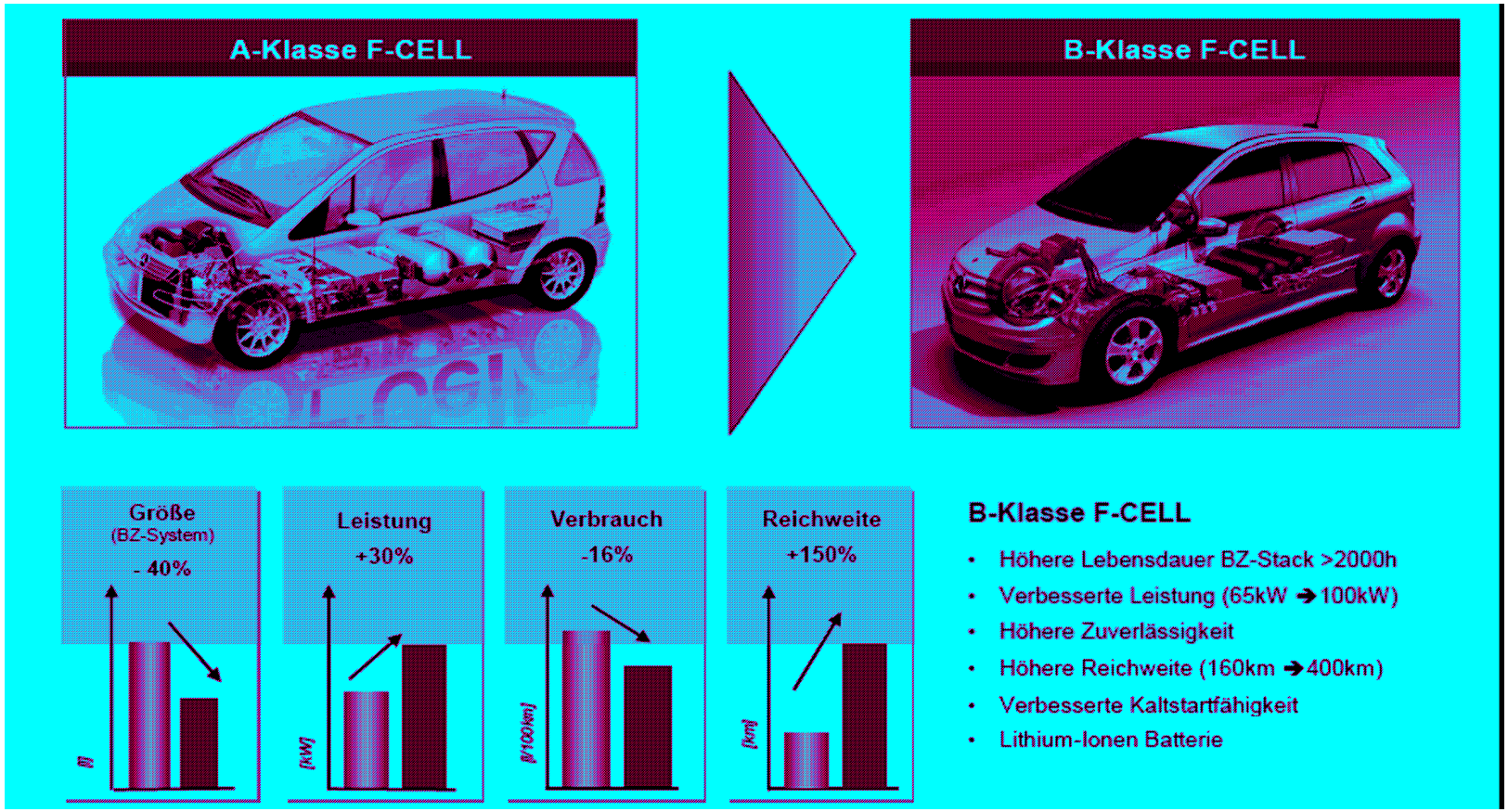
Stärken

- Kurze Betankungszeit und hohe Reichweite
- Brennstoffzellenantrieb auch für größere PKW und Nutzfahrzeuge anwendbar
- Keine Treibhausgas-Emissionen
- Effiziente Nutzung von Energie
- Unabhängigkeit vom Rohöl
- Dynamik und Komfort mit dem Elektroantrieb
- Geringe Geräuschentwicklung

Herausfor-derungen

- Hohe Komponentenkosten
- Umweltfreundlich hergestellter Wasserstoff
- H2-Infrastruktur noch nicht vorhanden

Daimler: Entwicklungsfortschritte 2004 ➔ 2009



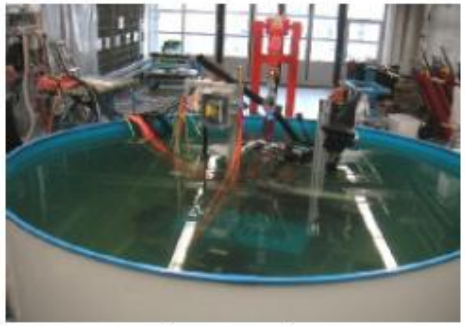
Product Development & Operations

NUCELLSYS

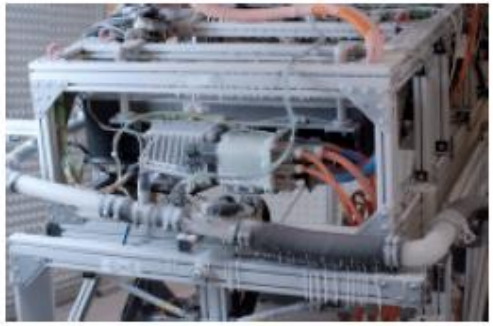
Automotive Testing

Crashtests

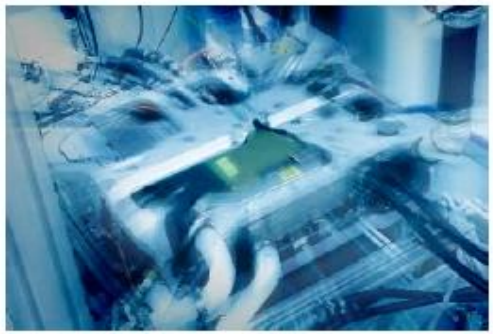
Shower watering during operation



Immersion during operation

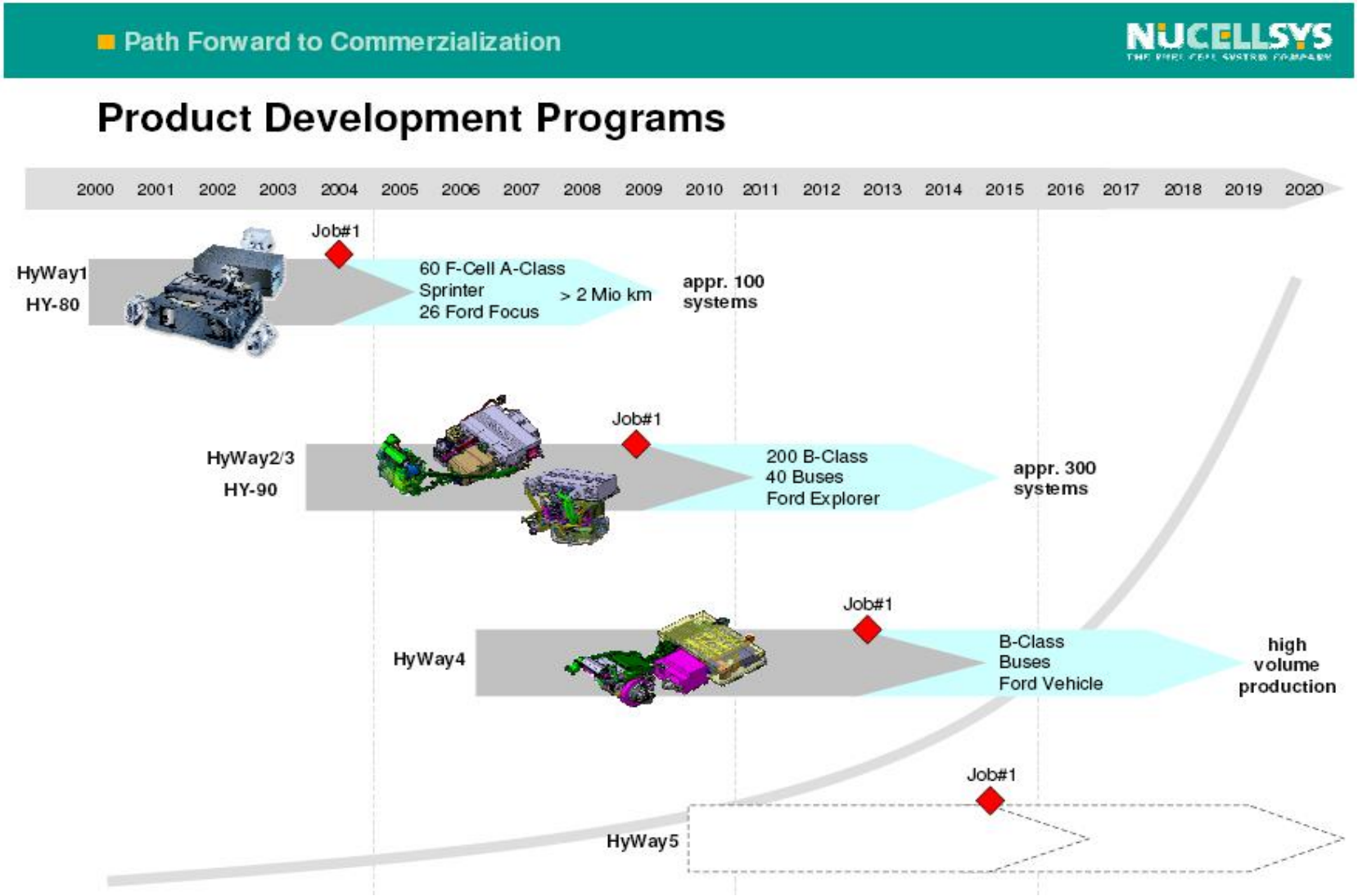


Climate Testing



Vibration Testing

EMC Testing


Path Forward to Commerzialization
NUCELLSYS
Product Development Programs
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
HyWay1
HY-80
Job#1
60 F-Cell A-Class
Sprinter
26 Ford Focus
> 2 Mio km
appr. 100
systems
HyWay2/3
HY-90
Job#1
200 B-Class
40 Buses
Ford Explorer
appr. 300
systems
HyWay4
Job#1
B-Class
Buses
Ford Vehicle
high
volume
production
HyWay5
Job#1

HySYS: Fuel Cell System Components

Air supply

Current Technology:
Screw-Compressor

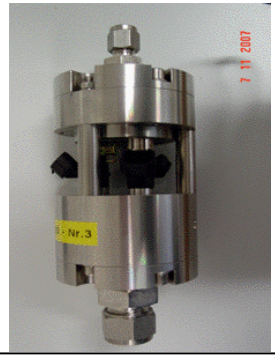
Innovative Technology:
Electrical Turbocharger

- High Efficiency
- Low Cost, volume& weight
- High Dynamic response
- Noise reduction

Hydrogen supply line

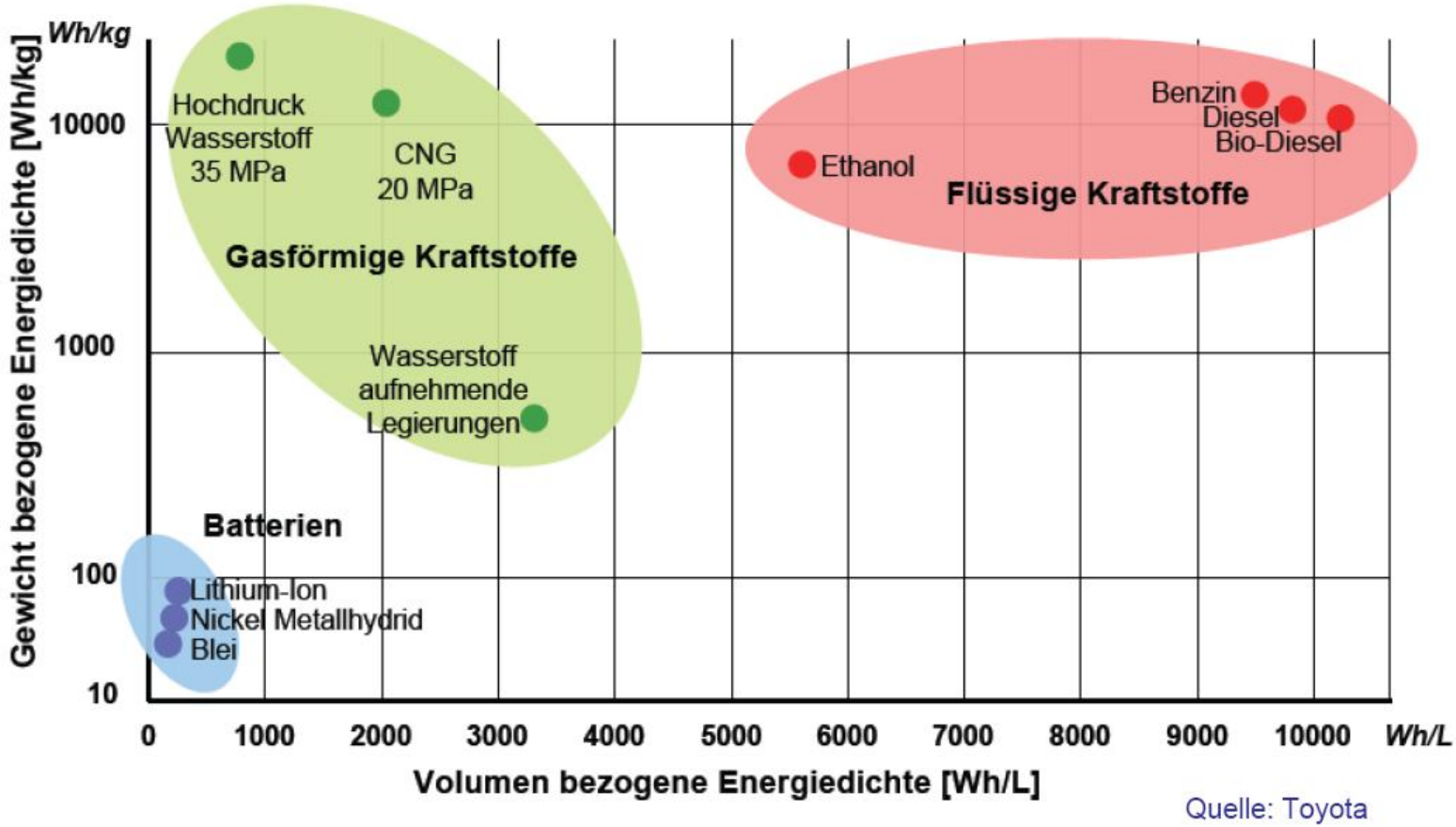
Current Technology:
standard H2 line with pressure regulator valves

Innovative Technology:
Fully automated H2 line with
Hydrogen Metering Device
- dual stage pressure reduction
- flexible regulating FC stack pressure
- fail safe with failure recovery
- improved lifetime of FC system



Market Segments

Energiedichten von Kraftstoffspeichern im Vergleich

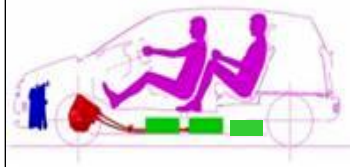
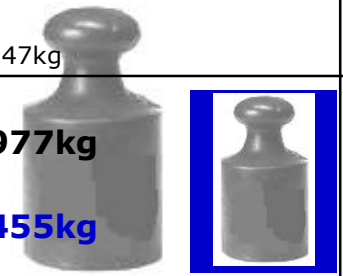


Quelle: Toyota

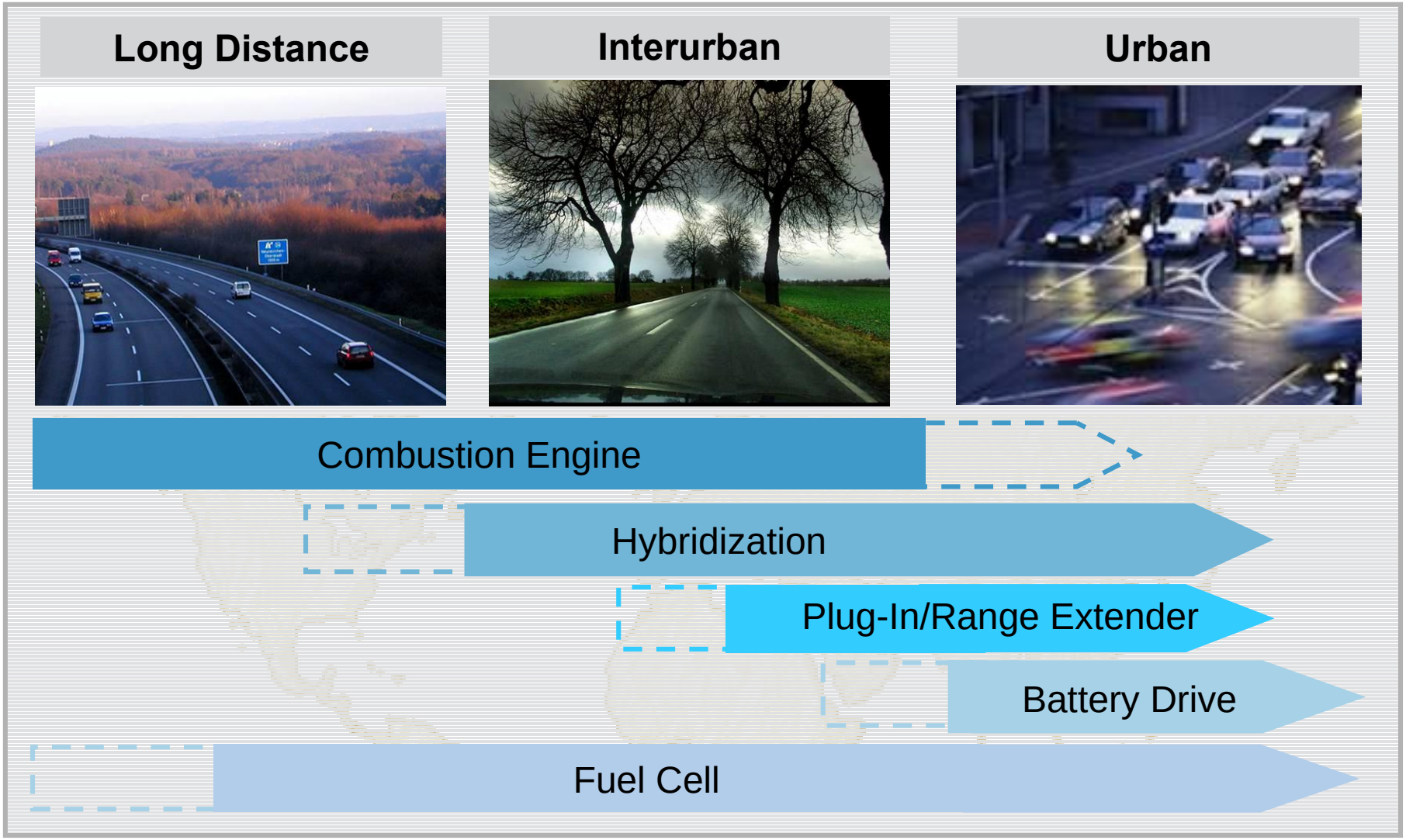
Mass and Volumes of drive train for a range of 500km (B-Class in NEDC)

Drive Train	Diesel	Plug-In (Range-Extender)	E vehicle	FC vehicle
Positioning in vehicle				
Energy storage and mass	Tank 45kg	Tank, battery (14,6 kWh) 180kg E-Range from battery = 70km	Battery (100 kWh) 830kg	H2-Tank, battery (1,4kWh) 131kg E-Range from battery = 2-5km
Energy conversion and mass	ICE, transmission 215kg	E-Motor, transmission, converter ICE, generator, converter 275kg	E-Motor, transmission, converter 147kg	E-Motor, converter, transmission, HV DC/DC FC System (HW4) 276kg
Drive train mass	**257kg** 	**455kg** 	**977kg** 	**407kg** 
Drive train volume	125 l	319l	1000 l	480l

Mass and Volume of drive train for a range of 500km (B-Class in NEDC)

Drive Train	Diesel	Plug-In (Range-Extender)	E vehicle	FC vehicle
Positioning in vehicle				
Energy storage and mass	Tank 45kg	Tank, battery (14,6 kWh) 180kg E-Range from battery = 70km	Battery (100 kWh) 830kg **Batterie (40kWh =200km)** **330kg**	H2-Tank, battery (1,4kWh) 131kg E-Range from battery = 2-5km
Energy conversion and mass	ICE, transmission 215kg	E-Motor, transmission, converter ICE, generator, converter 275kg	E-Motor, transmission, converter 147kg	E-Motor, converter, transmission, HV DC/DC FC System (HW4) 276kg
Drive train mass	**257kg** 	**455kg** 	**977kg** **455kg** 	**407kg** 
Drive train volume	125 l	319l	**500l**	480l

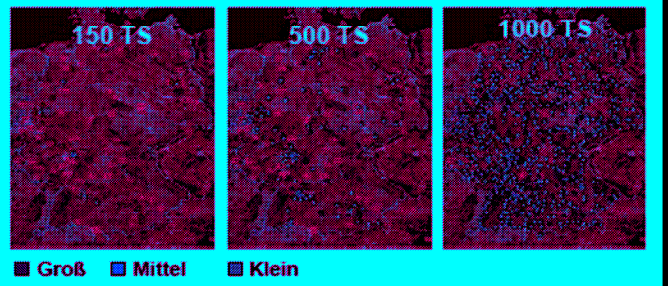
Daimler: Optimal Mobility Scenario



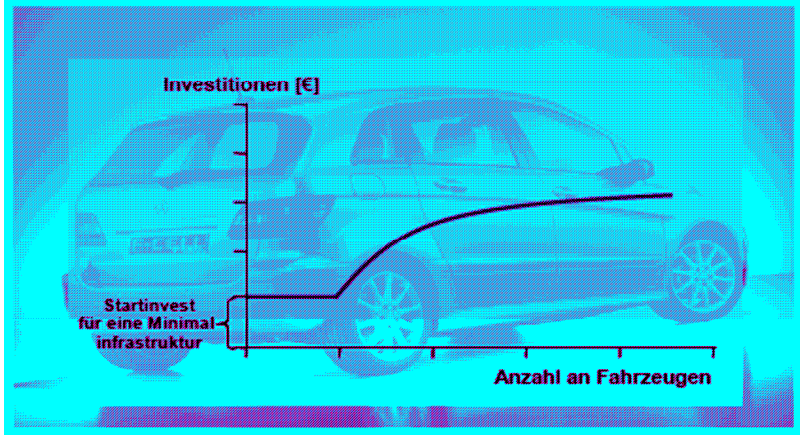
Hydrogen

Aufbau einer H2-Infrastruktur in Deutschland

- Die Demo-Infrastruktur ist nicht ausreichend für die geplante Kommerzialisierung von Brennstoffzellenfahrzeugen
- Für eine volle Kundenakzeptanz ist ein flächendeckendes und ausreichendes Tankstellen-Netz notwendig
- Eine detaillierte betriebswirtschaftliche Analyse des Aufbaus einer H2-Infrastruktur in Deutschland wurde erarbeitet



Aufbau H_2-Infrastruktur



⇨ H_2-Infrastruktur benötigt Anfangsinvestitionen

Machbarkeitsstudie: H2-Infrastruktur

Ergebnis

- Flächendeckender Aufbau einer H2-Infrastruktur in den nächsten ca. 10 Jahren (1.000 Tankstellen in Deutschland)
- Für den Aufbau sind Investitionen von weniger als 2 Milliarden € notwendig

Aktivitäten

- Bestimmung von Möglichkeiten den Business Case positiver zu gestalten, z.B. Subventionen für H2 und / oder H2-Tankstellen
- Durchführung einer Analyse, um die Anforderungen für den Aufbau von 1.000 Tankstellen zu bestimmen
- Übertragung des Business Case auf andere Märkte

Energiespeicher für Regenerative Energieerzeugung

Pumpspeicher Geesthacht

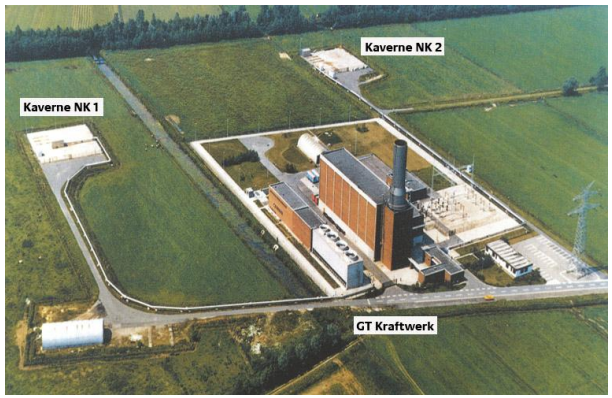
Quelle: www.elbetreff.de

V = 3,3 Mio m³

H = 83 m

E_{Nutz} = 600 MWh

Druckluftspeicher Huntorf



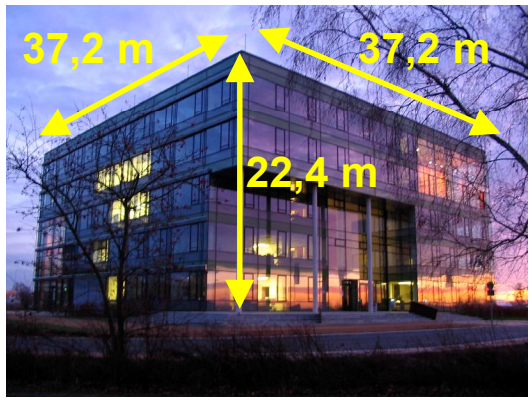
Quelle: www.thema-energie.de

V = 0,3 Mio m³

p = 50-70 bar

E_{Nutz} = 580 MWh

„H_2-Speicher MFC“ (Dimension)



V = 0,43 Mio Nm³ H_2

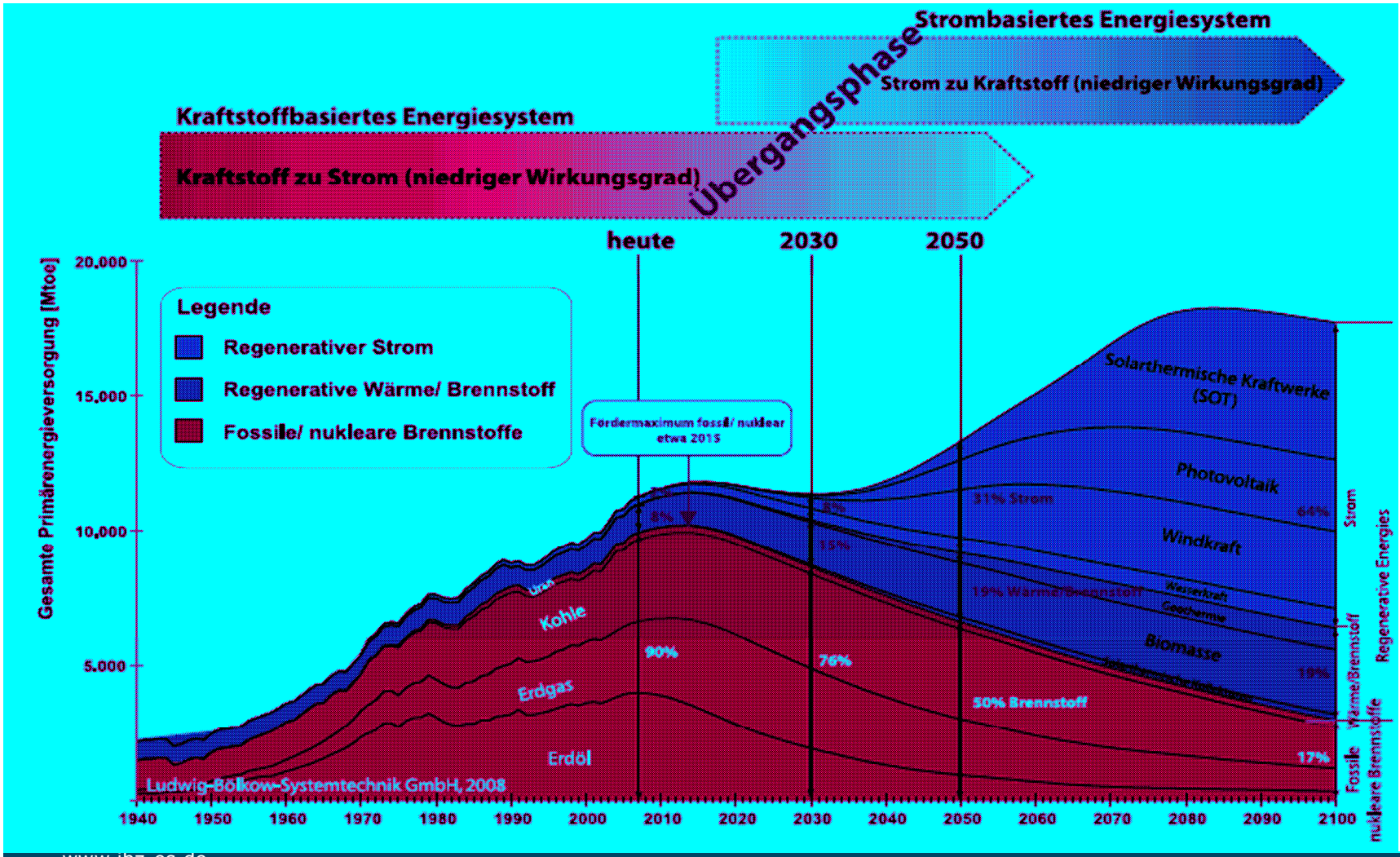
= 10.361 m³ H_2 @

p = 50 bar

E_{Nutz} = 600 MWh

Final Remarks

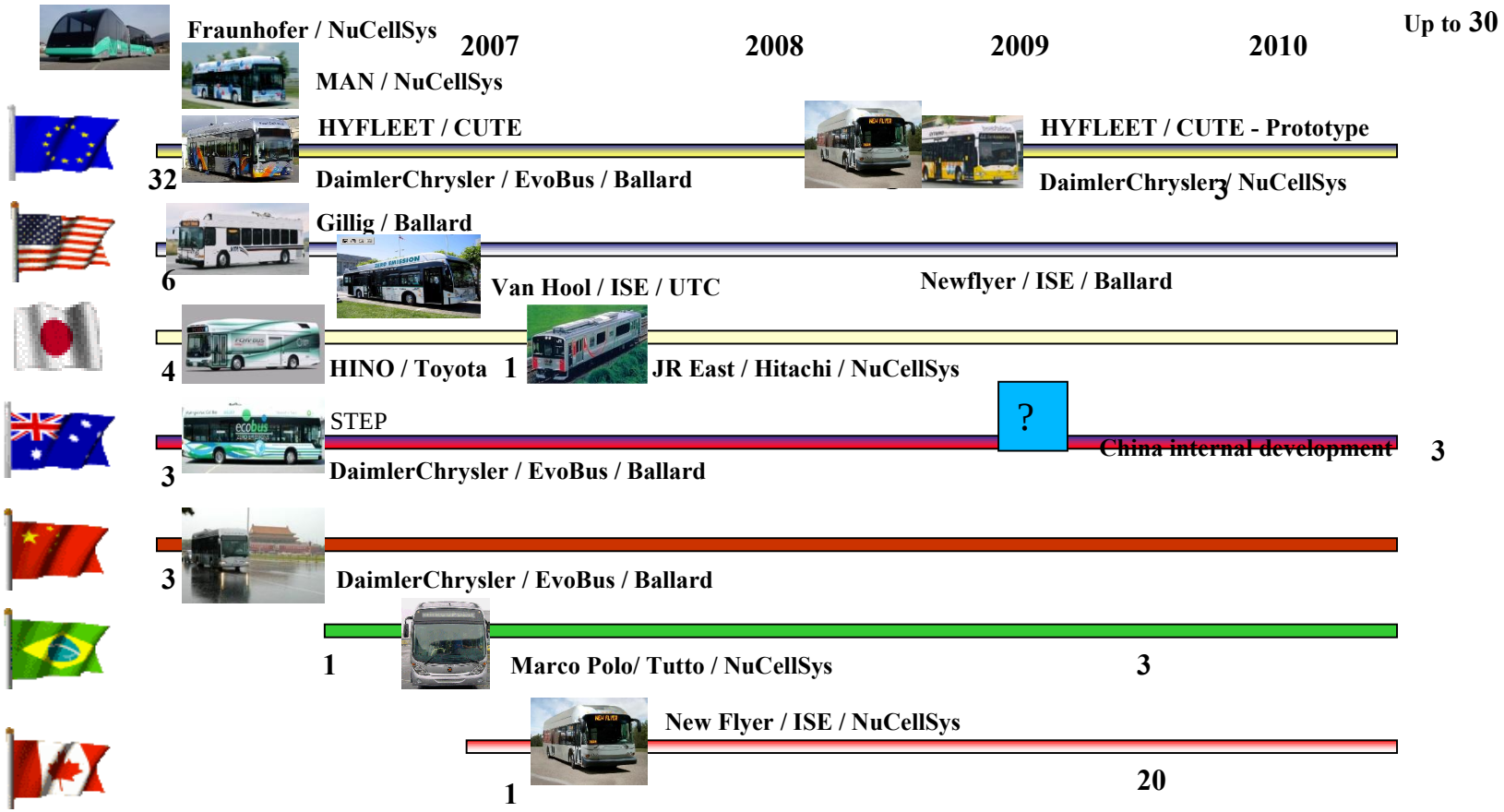
Energieszenarien Deutschland 2009➔ 2100



"Ist die Zukunft der Brennstoffzelle schon vorbei?"

- *Brennstoffzellenantriebe haben das Potential, den Verbrennungsmotor im breiten Segment des Individualverkehrs, des Öffentlichen Personennahverkehrs und des Verteilerverkehrs zu ersetzen.*
- *Der Verbrennungsmotor wird insbesondere im Überlandverkehr und dort vor allem beim Nutzfahrzeug auch längerfristig eine dominante Rolle spielen.*
  Mit Blick auf die begrenzte Verfügbarkeit von Biokraftstoffen sollten diese für dieses Segment des Überlandverkehrs reserviert bleiben, um die resultierende CO2-Belastung durch diese Fahrzeuge gering zu halten.
- *Mit batterieelektrischen Fahrzeugen kann sich ein so heute nicht existierendes neues Marktsegment der ausgeprägten Stadtfahrzeuge entwickeln, ergänzt durch Zwei- und Dreiräder.*
- *Der Wasserstoff wird neben dem elektrischen Strom ein wichtiger Energieträger in einem auf einen hohen Anteil erneuerbarer Energien basierenden Stromversorgungs-system werden, was seine zusätzliche Nutzung als Kraftstoff gesamtwirtschaftlich sehr attraktiv macht.*

Fuel Cell Bus Projects 2004 to 2010



Muito obrigado

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