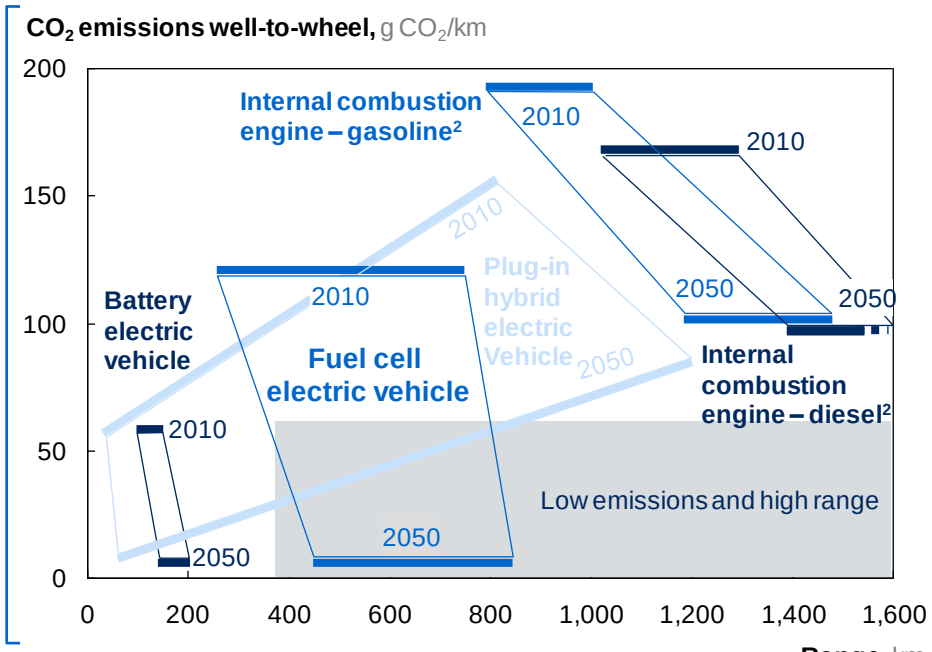
Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Hydrogen, Fuel Cell and Battery Electric Drives – Federal Market Preparation Programs in Germany, Status Quo & Outlook

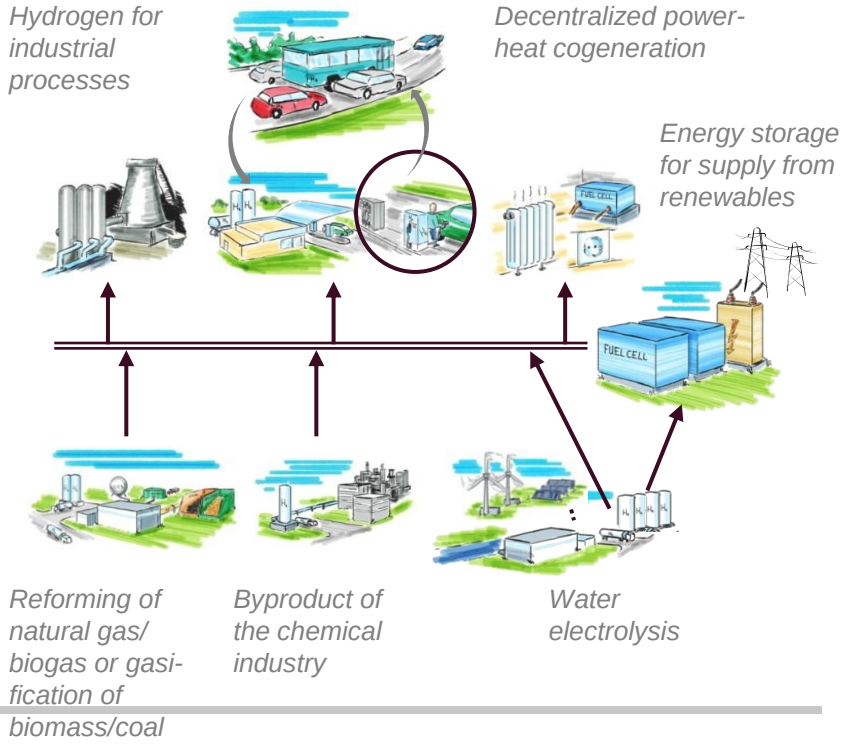
Dr. Klaus Bonhoff| General Director
NOW GmbH National Organization Hydrogen and Fuel Cell Technology

Fuel Cell Vehicles and Hydrogen from Renewable Energy Sources are Key Elements of an Integrated Sustainable Energy System

Fuel Cell Vehicles using hydrogen from renewable energy sources are needed to **decarbonize the transportation sector**

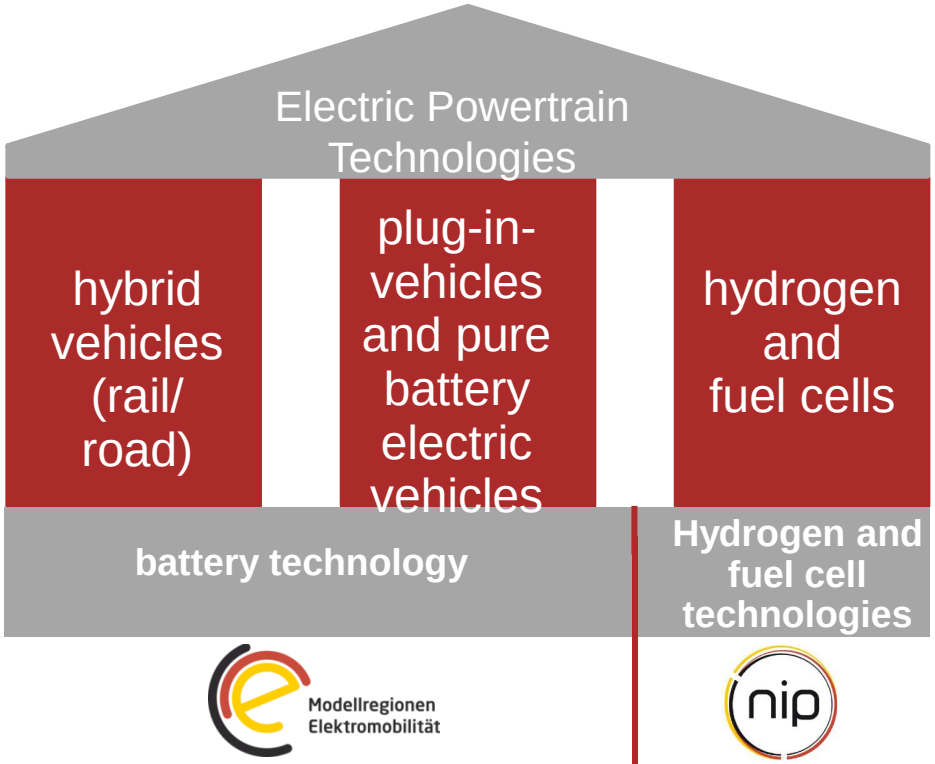


hydrogen produced from renewable power sources is needed to **stabilize the power grid**



Market Preparation for Eletro-Mobility

Three pillars of electrifying the powertrain



500 mio. € budget (2009-2014);
- Incl. 150 mio. € BMVBS (2009-2011)
- ~ 100 mio. € (2011-2014)

1,4 bn. € budget (2007-2016)
- incl. 700 mio. € federal funding: BMVBS (500 mio. €) and BMWi (200 mio. €)

batteries

and

hydrogen / fuel cells

are

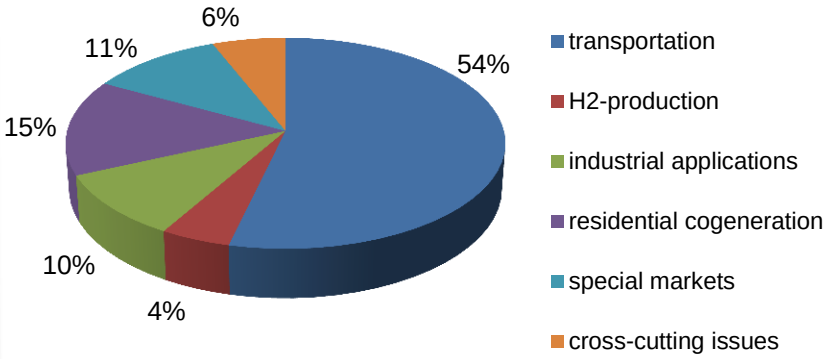
key technologies for a sustainable mobility

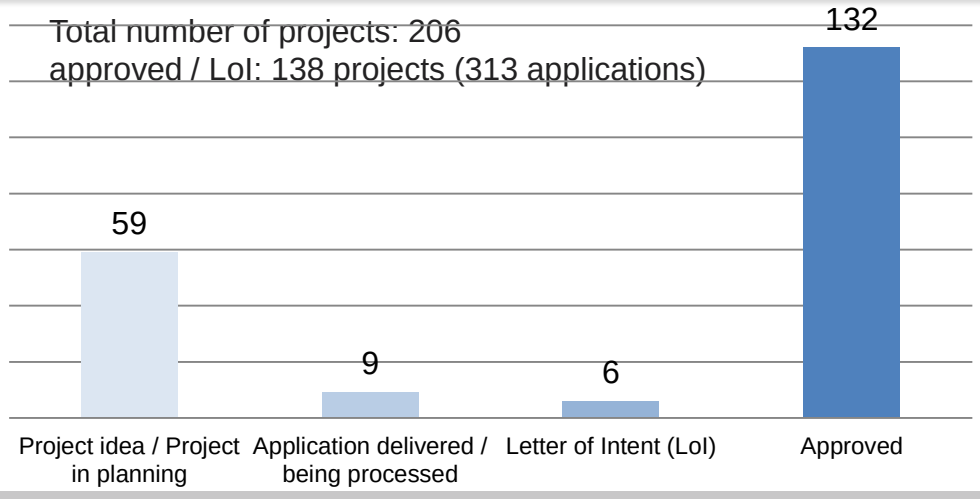
National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)

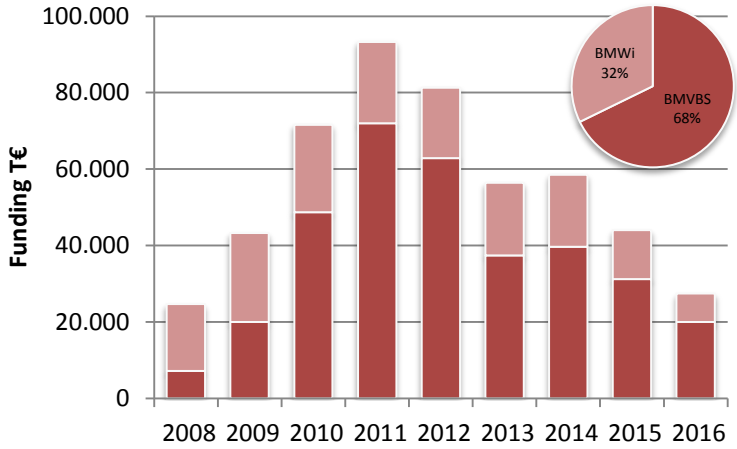
BMVBS-funding Status 01/2013

Total Budget:1,4 billion €
2007-2016

program area	LoI & approved k€	In discussion €k	total k€
transportation	226.306	46.075	272.380
H_2-production	15.040	8.537	23.577
industrial applications	33.623	16.858	50.480
residential cogeneration	58.347	16.074	74.421
special markets	34.116	21.586	55.701
cross-cutting issues	18.976	11.664	30.640
product line	**386.407**	**120.793**	**507.200**







NIP -
Integrated Approach for Market Preparation

Technology
- components
- subsystem
- systems + products

Application
- cost
- reliability
- lifetime

Markets
- customer acception
- safety
- approval processes

Bosch:
Hydrogen Gas
Injector HGI

CEP
Clean Energy Partnership
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie
nip

FCCT:
Gas Diffusion Layer
(GDL)

callux
nip
Praxistest Brennstoffzelle fürs Eigenheim
Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Linde:
Ionic H2-Compressor

clean power net
Brennstoffzellen in Industrie und Business

NOW
Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

The Clean Energy Partnership

- A public-private partnership founded in Dec. 2002 as a joint initiative between the government and industry under the lead management of the Federal Ministry of Transport and Traffic
- The aim is to think, research and act across industries for a zero-emissions future with hydrogen cars and buses
- The CEP is the biggest demonstration project in Europe in the field of hydrogen technology, and the lighthouse project of the National Hydrogen an Fuel Cell Technology Innovation Programme (NIP) in the transport sector.
- The NIP is coordinated by NOW GmbH (National Organisation for Hydrogen and Fuel Cell Technology).

Gefördert durch: Bundesministerium für Verkehr, Bau und Stadtentwicklung

Koordiniert durch: NOW

Clean Energy Partnership – FCV Fleet

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Fuel Cell Vehicles from different OEM`s

- 80 Daimler B-series F-CELL
- 20 Opel Hydrogen4
- 8 Volkswagen Touran, Caddy, Tiguan HyMotion, Audi Q5-HFC
- 5 Toyota FCHV
- 2 Honda FCX Clarity
- Hyundai recently joined the CEP
- 7 Fuel Cell Busses (Evobus) in Hamburg

+3225011616



Daimler AG, Ford Motor Company and Nissan Motor Co., Ltd., have signed a unique three-way agreement to accelerate the commercialization of fuel cell electric vehicle (FCEV) technology.

STUTTGART, Germany (Jan. 28, 2013)

The goal of the collaboration is to jointly develop a common fuel cell electric vehicle system while reducing investment costs associated with the engineering of the technology. Each company will invest equally towards the project. The strategy to maximize design commonality, leverage volume and derive efficiencies through economies of scale will help to launch the world's first affordable, mass-market FCEVs as early as 2017.

Together, Daimler, Ford and Nissan have more than 60 years of cumulative experience developing FCEVs. Their FCEVs have logged more than 10 million km in test drives around the world in customers' hands and as part of demonstration projects in diverse conditions. The partners plan to develop a common fuel cell stack and fuel cell system that can be used by each company in the launch of highly differentiated, separately branded FCEVs, which produce no CO2 emissions while driving.

The collaboration sends a clear signal to suppliers, policymakers and the industry to encourage further development of hydrogen refueling stations and other infrastructure necessary to allow the vehicles to be mass-marketed.

BMW Group and Toyota Motor Corporation Deepen Collaboration by Signing Binding Agreements

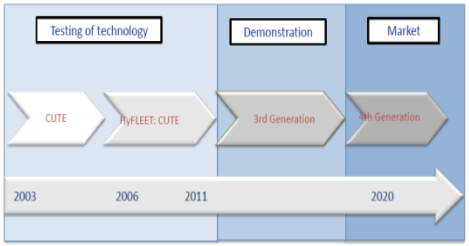
Nagoya/Japan, 24 January 2013

BMW Group and Toyota Motor Corporation (TMC) are pursuing their successful strategic long-term cooperation in the field of sustainable mobility today by signing binding agreements aimed at long-term collaboration between the two companies for the joint development of a fuel cell system, joint development of architecture and components for a sports vehicle, and joint research and development of lightweight technologies. These agreements follow a memorandum of understanding signed in June 2012.

Furthermore, BMW Group and TMC also today signed a binding agreement to commence collaborative research on lithium-air batteries, a post-lithium-battery solution. This agreement marks the second phase of collaborative research into next-generation lithium-ion battery cells that commenced in March 2012.

Signing of the contract for the cooperation between BMW Group and Toyota Motor Corporation in Nagoya/Japan on 24 January 2013 ...

Why Fuel Cell Buses?



Strategic approach

- Long term strategy for safe energy supply duly focussed on decreasing availability of fossil fuels
- First Mover: Better perception for public transport
- Protection of revenues („Eco-Bonus“)
- Introduction of new technology only doable step by step
- Sufficient time for education and on-the-job training
- Set up of workshops and refuelling infrastructure subsequently to benefit from technical optimization
- Which storage technology allows vehicle use up to 20 hours per day?
- How can productivity losses in line service be avoided?
- High launching costs still more economic than a direct later implementation!

Framework Conditions

External

- Implementation of EU clean air regulations in national law
- Transition towards renewable energy
- Buses up to 14 years in use: Long term strategy for safe energy supply
- Growing rate of „environmentally orientated customers“ (no captive riders)
- Consideration of socio-economic developments in mobility
- Future availability and cost of fossil fuels

Internal

- Introduction of new technology can only be done step by step
- Sufficient time for education and on-the-job training
- Make use of technical optimization in workshops and refeuelling infrastructure
- Storage technology to allow for up to 20 hours per day
- Avoid productivity losses in line service
- Launching costs high but more economic than a latter direct implementation

The New Fuel Cell Hybrid Bus

New generation with fuel cell hybrid system

- Recuperation system saves energy
- Higher efficiency
- More driving comfort due to low noise system and smooth acceleration
- Optimized availability
- Longer life cycle

Fuel Cell Bus (CUTE)

Technical Data	
Capacity	205 kW for < 15-20 Sec.
Range	180 - 220 km
HV-Battery	--
Hydrogen Consumption	20 – 24 kg / 100 km
Max. Efficiency	48 %
Number of passengers	23 + 49 = 72

Fuel Cell Hybrid Bus

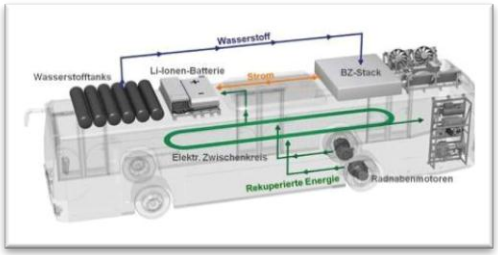
Technical Data	
Capacity	220 kW for < 15-20 Sec.
Range	> 250 km (planned)
HV-Battery	Li-Ion, 180 kW permanent
Hydrogen Consumption	8 kg / 100 km
Max. Efficiency	58 %
Number of passengers	25 + 50 = 76

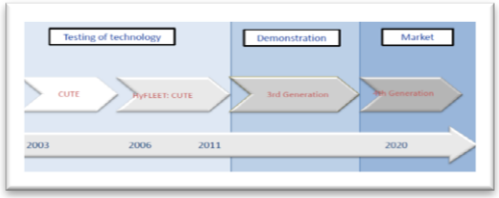
FC Buses in Hamburg

Gefördert durch: Bundesministerium für Verkehr, Bau und Stadtentwicklung

Koordiniert durch: NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

hySOLUTIONS Driving Innovation for Hamburg





Current status

- 4 Hybrid-FC buses in operation, option for another 3 buses
- 2 x 70 kW FC modules, 35 kg hydrogen on board
- 350 kilometres range
- Guarantee 12,000 hours or 5 years (40,000 h necessary)
- Very comfortable, quiet, good drivability
- Appreciable fuel reduction compared with last bus generation from 22 kg/100 km to 8 kg/100 km
- Up to 250 km/day in line service
- In total ~ 68,000 km up to now since August 2011

Next steps

- 3 more vehicles in 2013, next generation by 2017
- Masterplan for implementation of technology with manufacturer
- Only low emission buses to be purchased from 2020
- Depot for low emission buses in planning

Future FC Buses?

Achievements

- Good development progress, optimization potentials widely known
- Support for political motivated energy transition
- Synergies regarding energy supply (storability, use of erratic energy from renewable sources) with political change in overall energy policy
- Easier to handle than other innovative powertrains (battery, trolley etc.)
- Spill-Over effects from passenger cars

Challenges

- No clear indication on reduction of costs
- Roadmap to market viability of manufacturer's (milestones, timeline) not clear
- Price of hydrogen, market strategy of relevant industry
- Storage of big volumes of hydrogen
- Insufficient communication to / awareness at decision-makers and public

Clean Energy Partnership – Hydrogen Refueling Stations (HRS)

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie

Hamburg, Bramfelder Chaussee Shell

Hamburg, HafenCity Vattenfall/ Shell

Hamburg, Cuxhavener Str. Total

Düsseldorf, Air Liquide

Under construction

Stuttgart, EnBW

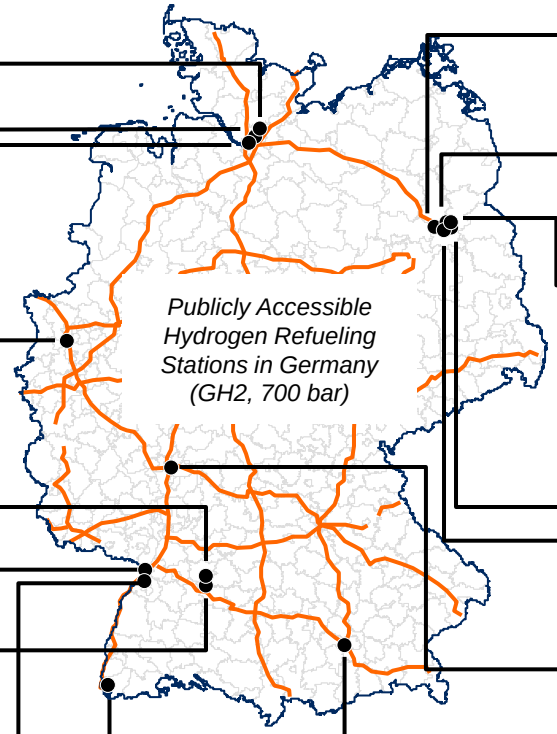
Stuttgart, Airport OMV

Karlsruhe, ENBW

Under construction

Karlsruhe, KIT

Freiburg, FhG ISE



Berlin, Heidestraße Linde/Total

Berlin, Heerstraße Total

In planning stage

Berlin, BBI Total

Berlin, Holzmarktstraße Linde/Total/ Statoil

Berlin, Sachsendamm Shell

Frankfurt (Höchst), AGIP

Munich, Detmoldstraße Total *(only LH2)*

Key achievements

- Safety of stations proven
- Refueling standards agreed
- Storage and compressor technology tested
- H_2 supply chain tested
- Bugs of station technology eliminated

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Germany to expand nationwide network of hydrogen filling stations from 15 to 50 by 2015

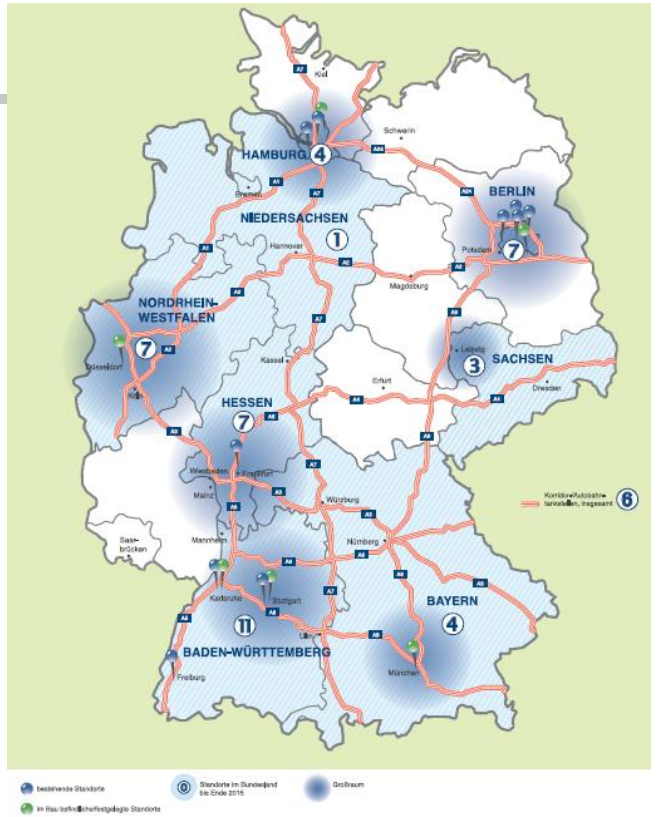
June 20, 2012

- **joint Letter of Intent to expand the network of hydrogen filling stations in Germany**
  - signed by the German Ministry of Transport, Building and Urban Development (BMVBS) and several industrial companies
  - part of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)
  - overall investment more than €40 million (US$51 million)
- **market-relevant testing of filling-station technology**
- **ensure a needs-driven supply for fuel cell vehicles**
- **coordination by NOW GmbH in the frame of the Clean Energy Partnership (CEP)**

Federal Ministry of Transport, Building and Urban Development

Clean Energy Partnership CEP

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (nip)

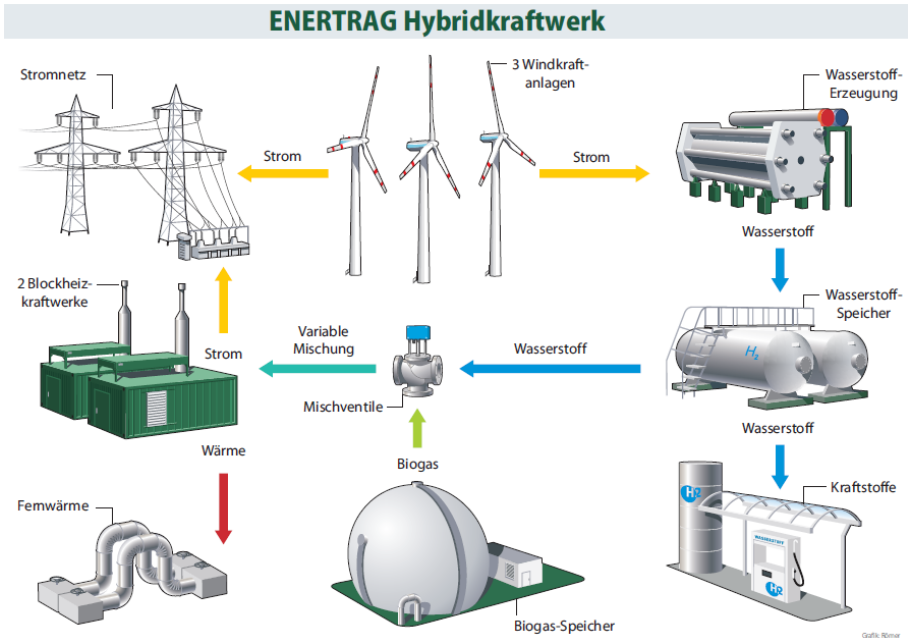


„To facilitate market introduction [of fuel cell vehicles] we need a hydrogen station network covering and connecting the metropolitan regions.“

Dr. Peter Ramsauer, Federal Minister for Transport, Building and Urban Development

Demonstrating Wind-Hydrogen for Mobility

hydrogen as part of an integrated energy system ⟹ **renewable hydrogen as a fuel**



Enertrag: Hybrid Power Plant

Total: Refueling Station at Heidestr., Berlin
First delievery of wind-hydrogen on April 18th, 2012

Major Global Infrastructure Activities

UK H_2 Mobility

- Phase 1 accomplished

H2-Mobility France

- In preparation

TEN-T

Scandinavian Hydrogen Highway Partnership

- 45 HRS / 2015
- 500 cars / 2015

H_2 Mobility

CEP

- a total of 100 HRS (50 within the CEP) / 2015
- 5000 cars / 2015

H2 SWISS MOBILITY

- 10-15 HRS

USA (California)

- 68 HRS till 2015
- 5000 FCEVS till 2015

Japan

- 1000 HRS till 2025
- 1 Mio. FCEV‘s till 2025

South Korea

- 500 HRS till 2020
- 50.000 FCEV‘s till 2020

China

- 5 HRS till 2015
- 1.000 FCEV‘s till 2015

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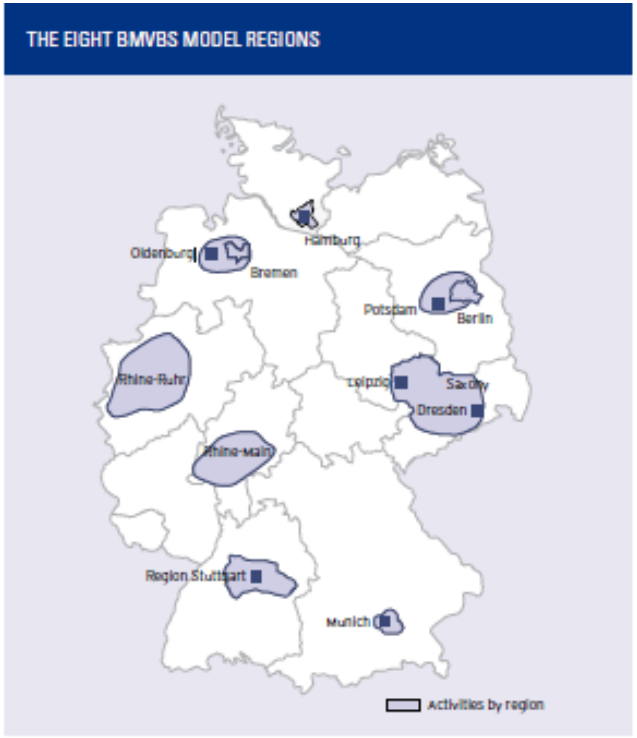
Goals and Implementation of the Model Regions

A program funded by BMVBS
Part of the stimulus package of the German government (2009-2011) and beyond

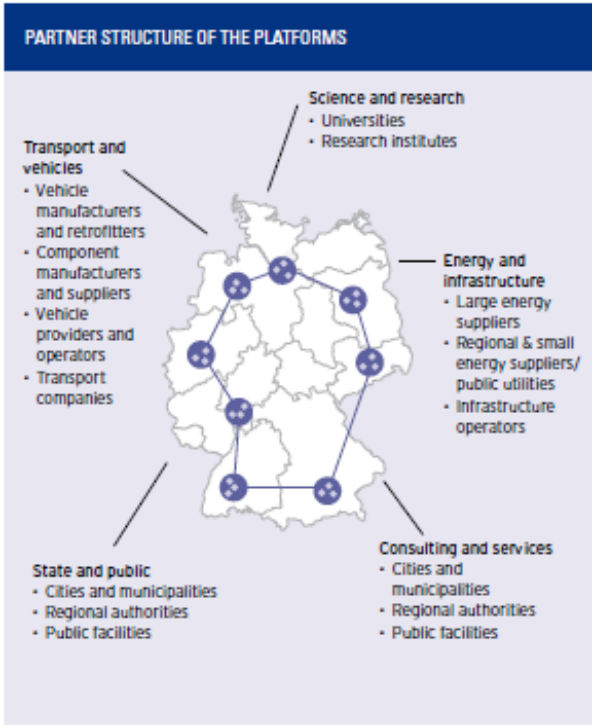


Goals

- Experience from day-to-day operation as a basis for commercialization

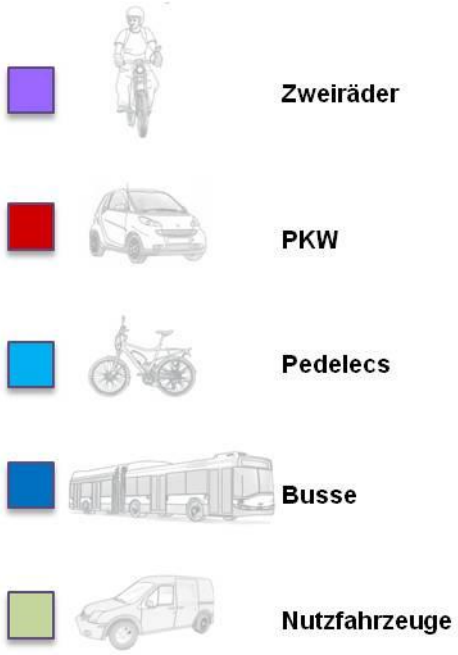
Implementation

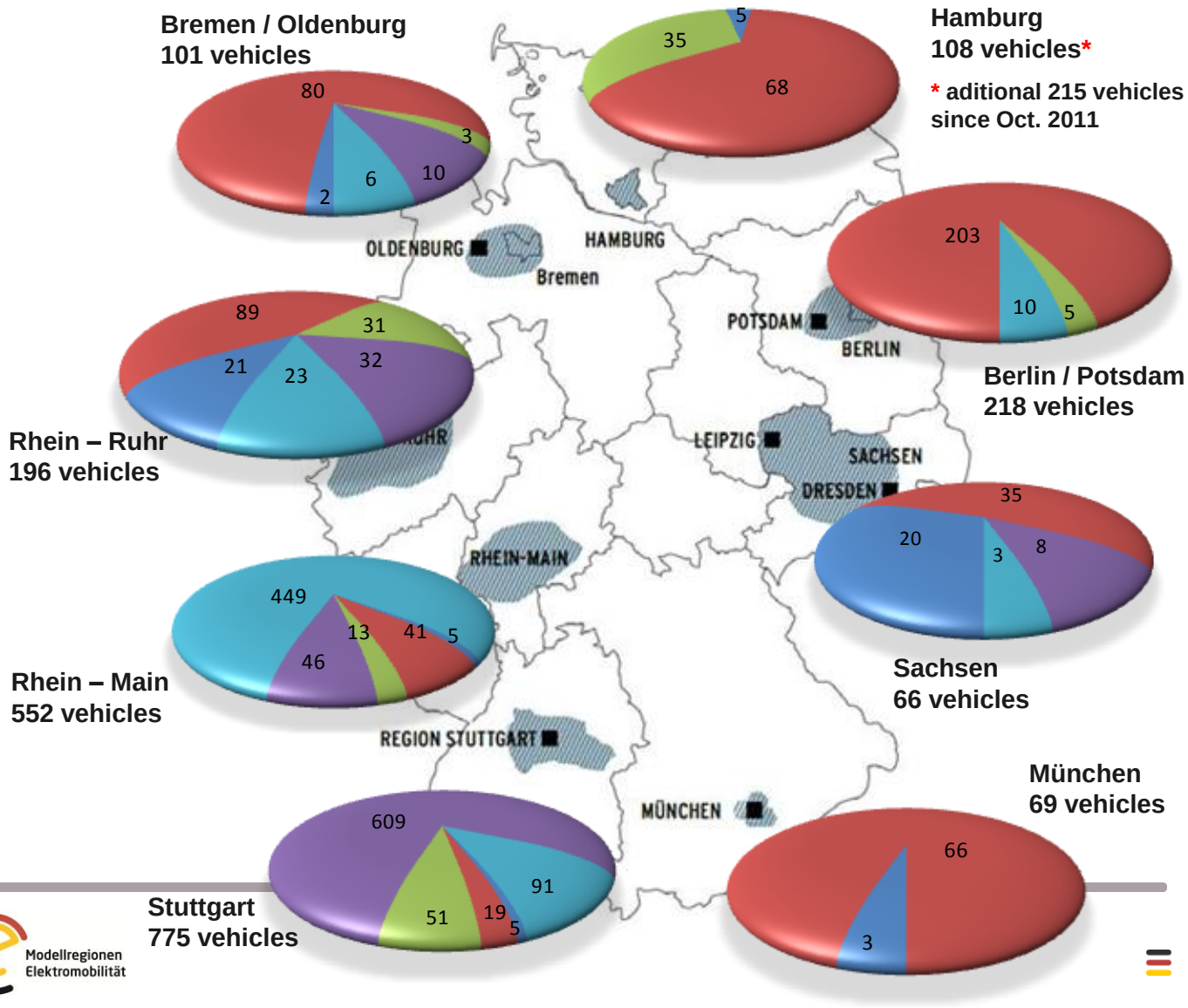
- Integrated mobility concepts focused in regional clusters (local networks)
- National-wide exchange of experiences in topic-specific plattforms



BMVBS Eight Model Regions (2009-2014)

Almost 2,200 battery-electric vehicles in day-to-day operation





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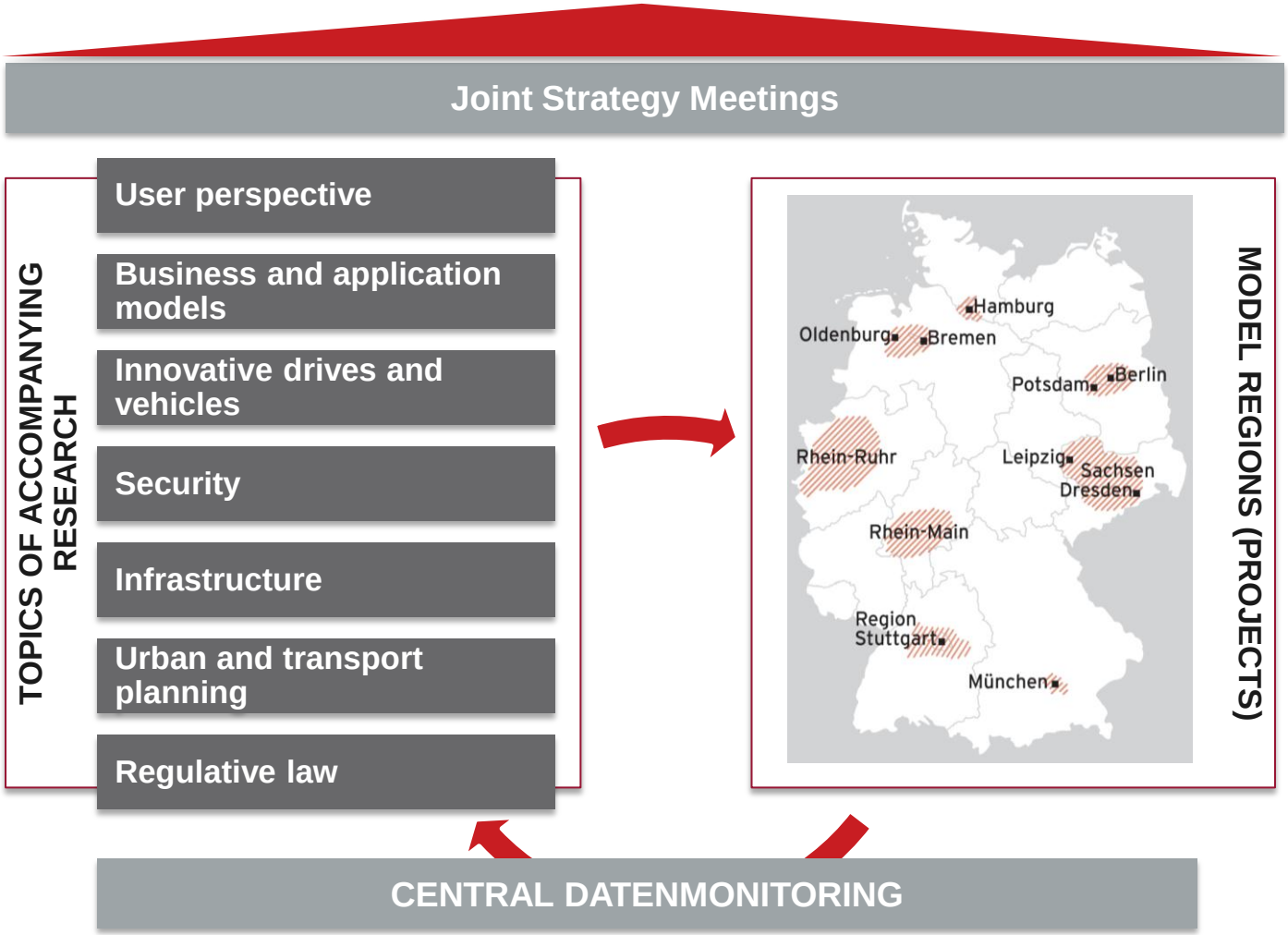
Modellregionen Elektromobilität

Model Regions (2011-2016)
Knowledgetransfer through accompanying research



Programm Scope

- About 20 new projects started in 2011
- About 40 projects to start in 2012

- At least 200 partners (incl associated partners) from research, utilities, municipalities and with automotive background

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Modellregionen Elektromobilität

THANK YOU!