Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Overview of Fuel Cell and Hydrogen Developments in Germany

7th IPHE H2igher Educational Round | Grenoble | 30.12.2015

Dr. Hanno Butsch| Head of International Cooperation
National Organisation Hydrogen and Fuel Cell Technology (NOW)

Policy Goals in Europe for Renewable Energies in the Energy System and for Road Transport

EU Climate Targets

	GHG Reduction (vs. 1990)	Share of renewables	Energy Efficiency
2020	20 %	20 %	20 %
2030	40 %	≥ 27 %	27 %
2050	?	?	?

Climate Targets - Transport

Reduce GHG emissions of <u>transport</u>

- 20 % (vs. 2008)

- 60 % (vs. 1990)

Source: Weissbuch KOM(2011) 144
(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:DE:PDF)

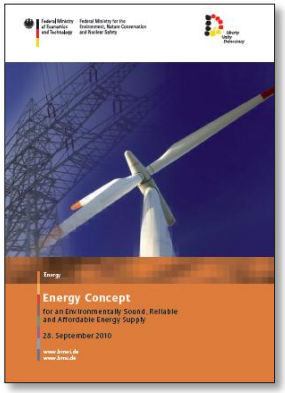
Policy Goals in Germany for Renewable Energies in the Energy System and for Road Transport

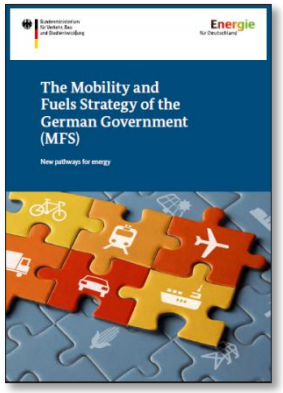
National Climate Targets

	GHG Reduction (vs. 1990)	Share of renewables	Energy Efficiency (vs. 2008)
2020	40 %	18 %	20 %
2050	85-90 %	60 %	50 %

Climate Targets - Transport

Reduce final energy consumption of transport (vs. 2005)
- 10 %
- 40 %





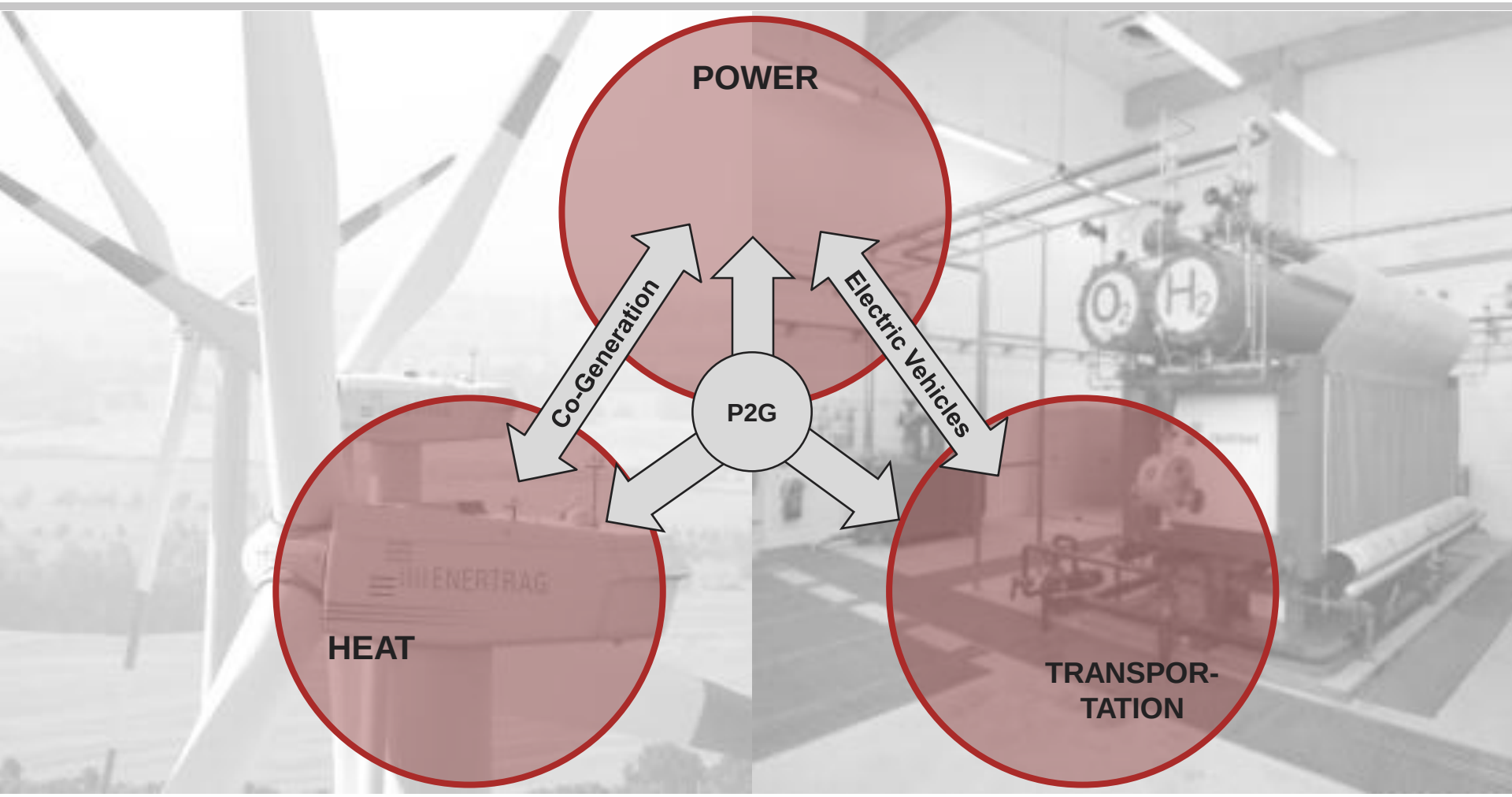
Three reasons why it is inevitable to change the energy system in Germany and Europe:

Climate protection:
Global responsibility for the next generation.

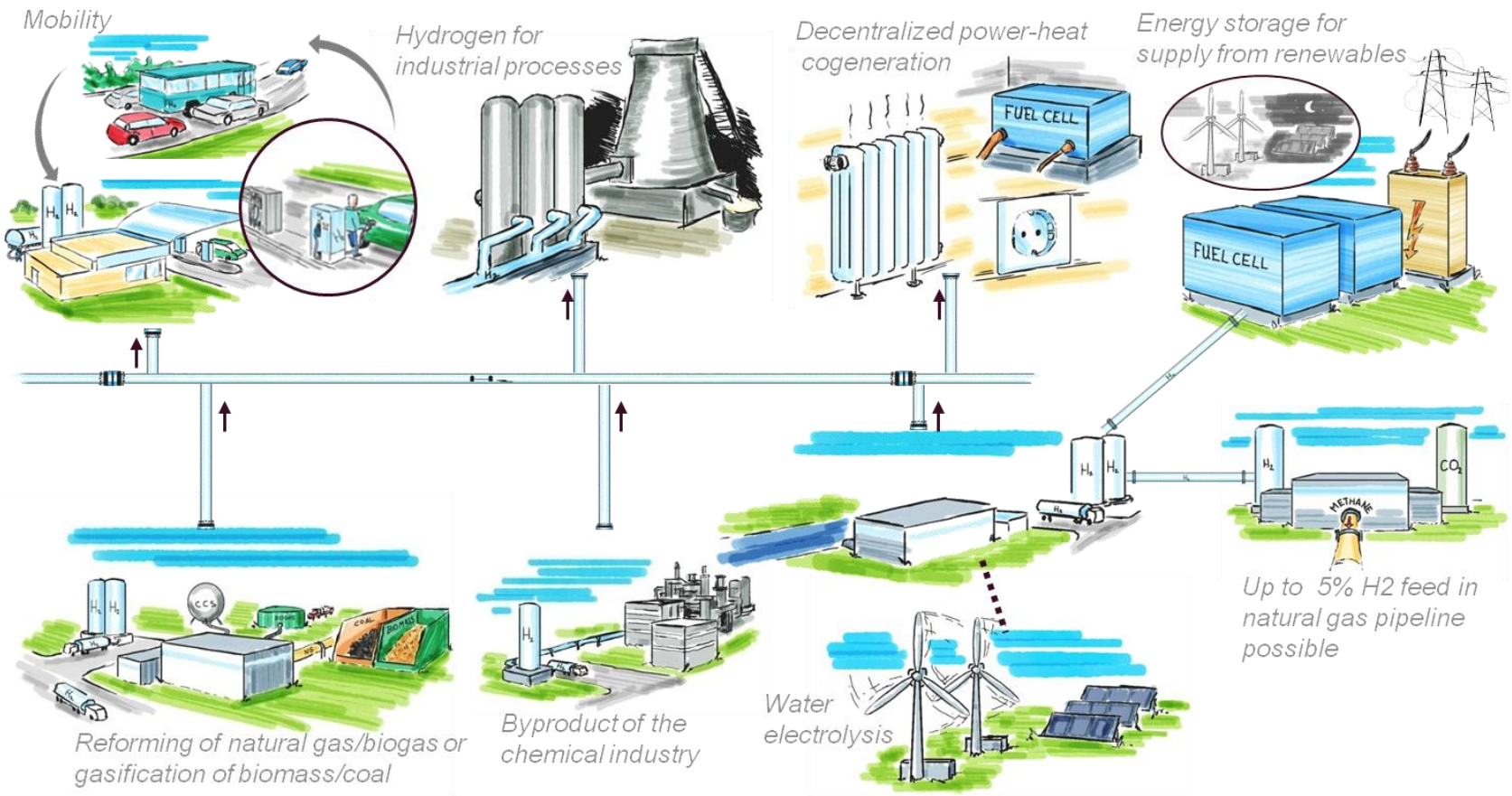
Energy security:
More independency from fossil fuels.

Securing the economy:
Creating new markets and jobs through innovations.

Creating an inter-sectoral energy system is crucial to achieve the European and German Targets

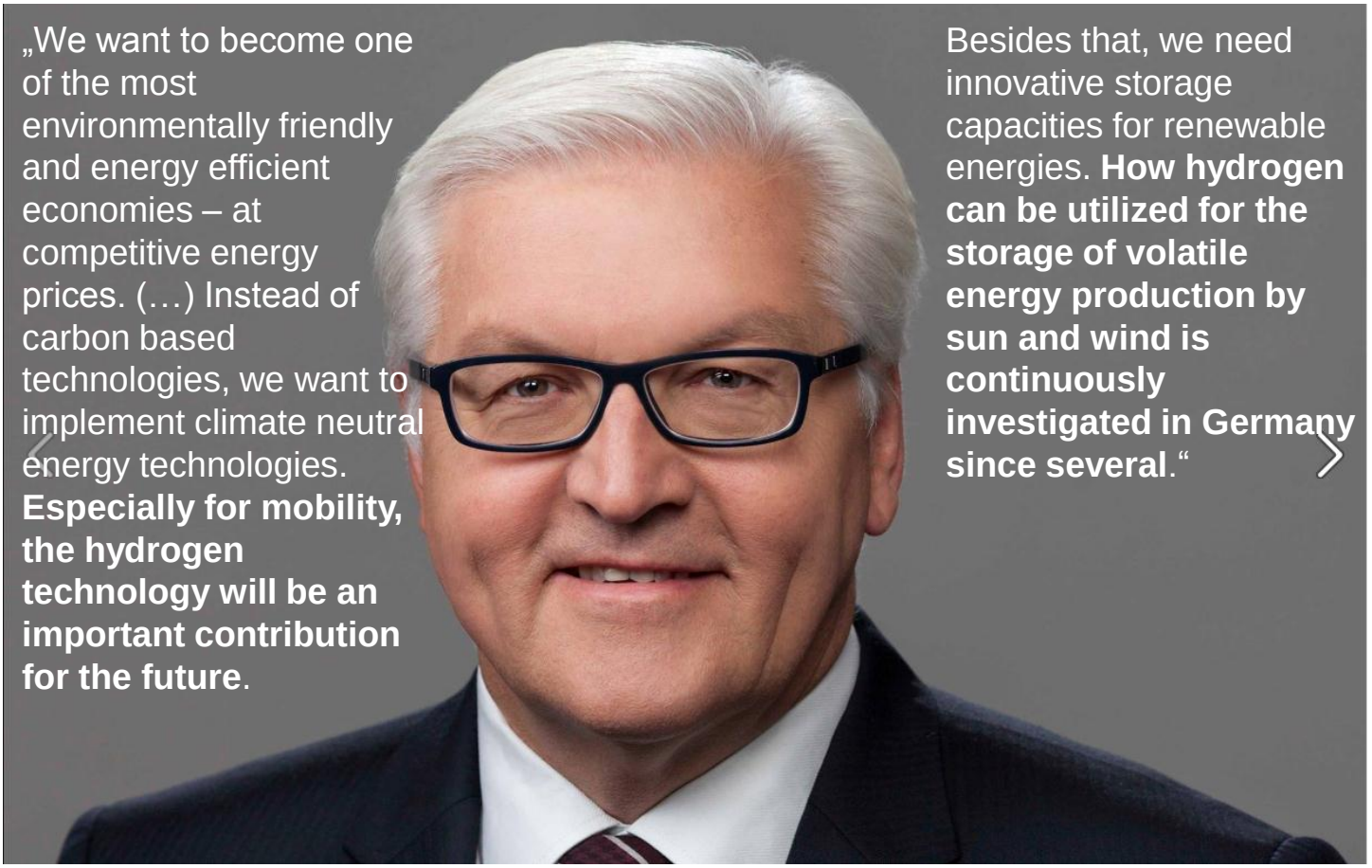


NIP Programm - Why hydrogen?



Statement from Frank-Walter Steinmeier, Foreing Minister of the Federal Republic of Germany

8. Oktober 2015



House of Logistics & Mobility - HOLM
Gestern · Bearbeitet ·

Außenminister #Steinmeier #spd über #H2 , #wasserstoff und #mobilität : "Wir wollen eine der umweltschonendsten und energiesparsamsten Volkswirtschaften werden – bei wettbewerbsfähigen Energiepreisen. (…) Anstelle von kohlenstoffbasierten wollen wir klimaneutrale Energietechnologien einsetzen. Gerade für die Mobilität wird Wasserstofftechnologie in Zukunft einen wichtigen Beitrag leisten können.

Daneben benötigen wir innovative Speicherkapazitäten für erneuerbare Energien. Wie Wasserstofftechnologie zur Speicherung der unbeständigen Energieerzeugung durch Sonne und Wind eingesetzt werden kann, wird bereits seit Jahren erfolgreich in Deutschland erforscht."

http://www.fh-brandenburg.de/

https://www.facebook.com/

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

Politics		Industry

BMVI / BMWi / BMBF / BMU

€ 500 million + **€ 200 million** + **€ 700 million**

for demonstration | for R&D | Co-financing by the industry

€ 1,4 billion

2007-2016

- Preparing hydrogen & fuel cell markets
- Focus on R&D combined with everyday demonstration

- Hydrogen & fuel cells driven by applications and markets: transport, stationary energy supply, special markets

Cooperation and integration for the market preparation: Showcase projects within the NIP

Mobility/Transport: Operation of FCEV (buses and cars) and deployment of 50 hydrogen refueling stations in Germany

Stationary: Almost 500 installed fuel cell heatings in the field of residential energy

Stationary: Testing of fuel cell systems for the electricity supply on board of ships

Special markets: Secure or/and off grid electricity supply systems at more than 250 locations

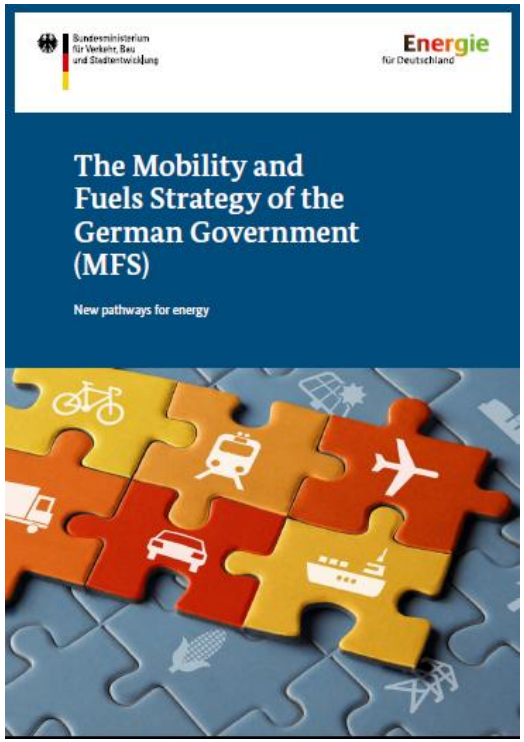
Fuel Cell Vehicles (cars and busses) and Hydrogen Stations

Political Framework for the Transport Sector

- Share of transport in final energy consumption nearly 30%
- Tripling of energy consumption in transport since 1960, even five-fold increase in road traffic

- Goals of the German Energy Concept (2010) for Transport:
  - -10 % until 2020 of energy consumption
  - -40 % until 2050 of energy consumption (vs. 2005)

The Mobility and Fuels Strategy of the German Government outlines the way how to achieve these objectives



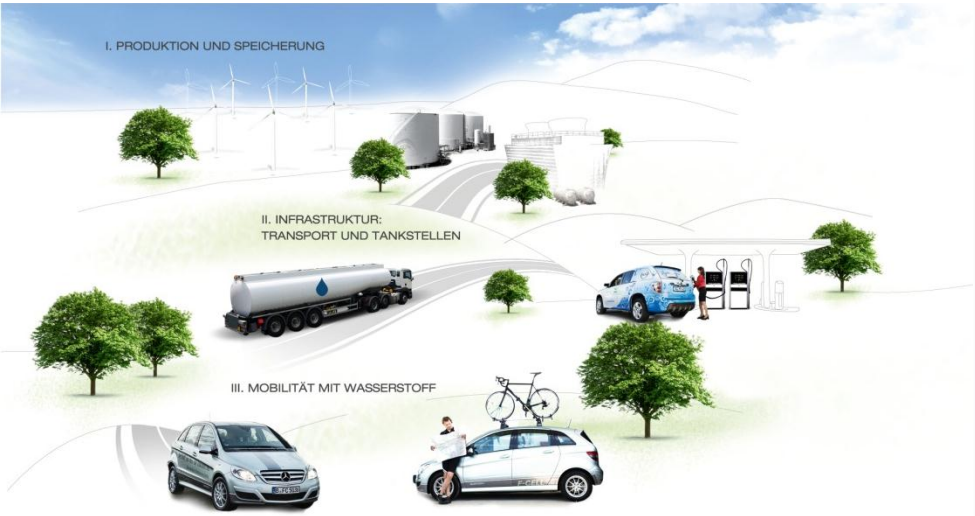
➔ **Electrification of the drive train (BEV's and FCEV's) is a key issue to reach the targets**

➔ **Targets only achievable with PtG-H2 and PtG-Methane**

➔ **Further increase of renewable energies beyond current planning is needed**

➔ **Large scale storage for hydrogen is inevitable**

The Clean Energy Partnership



AIR LIQUIDE | BMW Group | BVG
DAIMLER | EnBW | Ford
GM | Opel | HOCHBAHN | HONDA The Power of Dreams
HYUNDAI | THE LINDE GROUP Linde | SIEMENS
Shell | TOTAL | TOYOTA
SSB | VATTENFALL | VOLKSWAGEN AKTIENGESELLSCHAFT

funded by: Federal Ministry of Transport and Digital Infrastructure
coordinated by: NOW

Clean Energy Partnership – More than 100 vehicles

Mercedes-Benz is on track to launch its first commercially available hydrogen fuel cell model within the next two years.

23.11.2015

http://www.autocar.co.uk/car-news/new-cars/mercedes-benz-glc-get-hydrogen-fuel-cell-power-2017

Mercedes-Benz GLC to get hydrogen fuel cell power in 2017

Mercedes confirms it’s readying a hydrogen fuel cell version of its mid-sized SUV

Thomas Weber, Mercedes’ head of research and development, told Autocar the company had finalised the engineering parameters for the new model, which is rumoured to be based around the recently introduced GLC.

“We are targeting a combined range for the fuel cell and battery of up to **600km** [373 miles], along with a refuelling time for the hydrogen tanks of three minutes,” Weber said.

The new model is set to be called the **GLC F-Cell**. It is scheduled to be unveiled at the Frankfurt motor show in 2017 and reach showrooms the following year. It’s expected to be offered to customers in selected markets on either a monthly lease or outright purchase programme. The price is expected to be around £50,000.

Competitors for the GLC F-Cell include the recently introduced Toyota Mirai and Honda FCV Clarity. A further hydrogen-propelled rival is expected to come from BMW, which recently confirmed plans to launch its first fuel cell model by 2020.

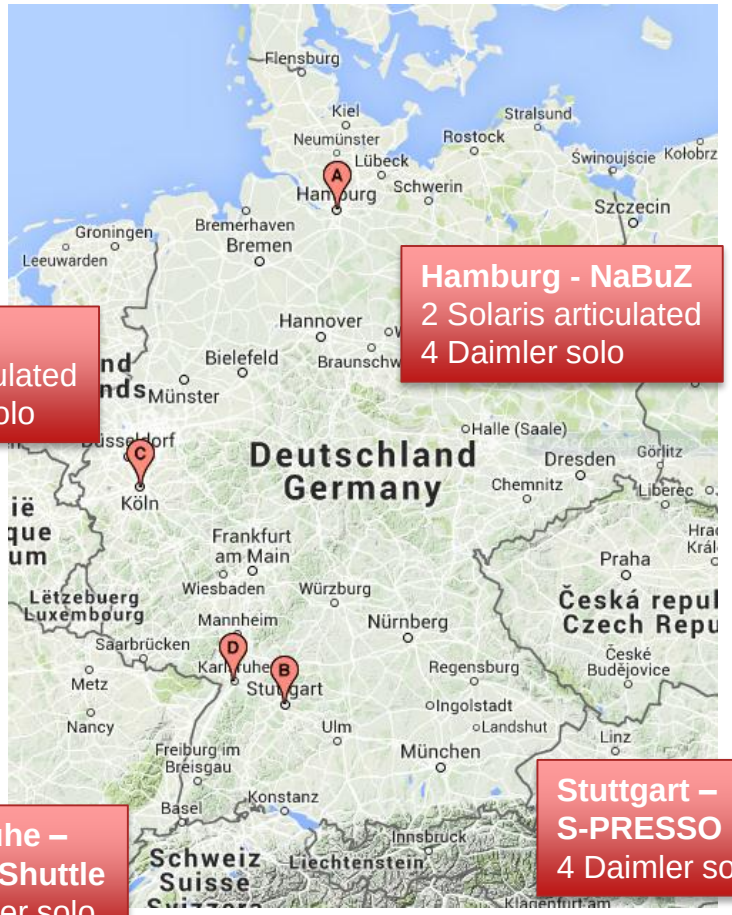
Despite basing earlier fuel cell prototypes on the B-Class, Weber said the continued high cost of the fuel stack makes a hydrogen fuel cell model commercially viable only in higher classes.

He said: **“The technology has matured greatly in recent years, with improved packaging and efficiency, but it remains in its infancy and is still quite expensive by conventional driveline standards.”**

Among the components planned to appear in the new model is a new fuel cell stack. As in the earlier B-Class F-Cell prototype, it is planned to be mounted in the space usually dedicated to the GLC’s combustion engine.

Clean Energy Partnership – 16 buses in public transport

Köln
2 APTS articulated
2 Van Hool solo



Hamburg - NaBuZ
2 Solaris articulated
4 Daimler solo

Karlsruhe – KIT-H_2-Shuttle
2 Daimler solo

Stuttgart – S-PRESSO
4 Daimler solo

50 HRS Program
Plan and Status Quo

PLAN

STATUS

https://cleanenergypartnership.de/kundenbereich/h2-tankstellen/

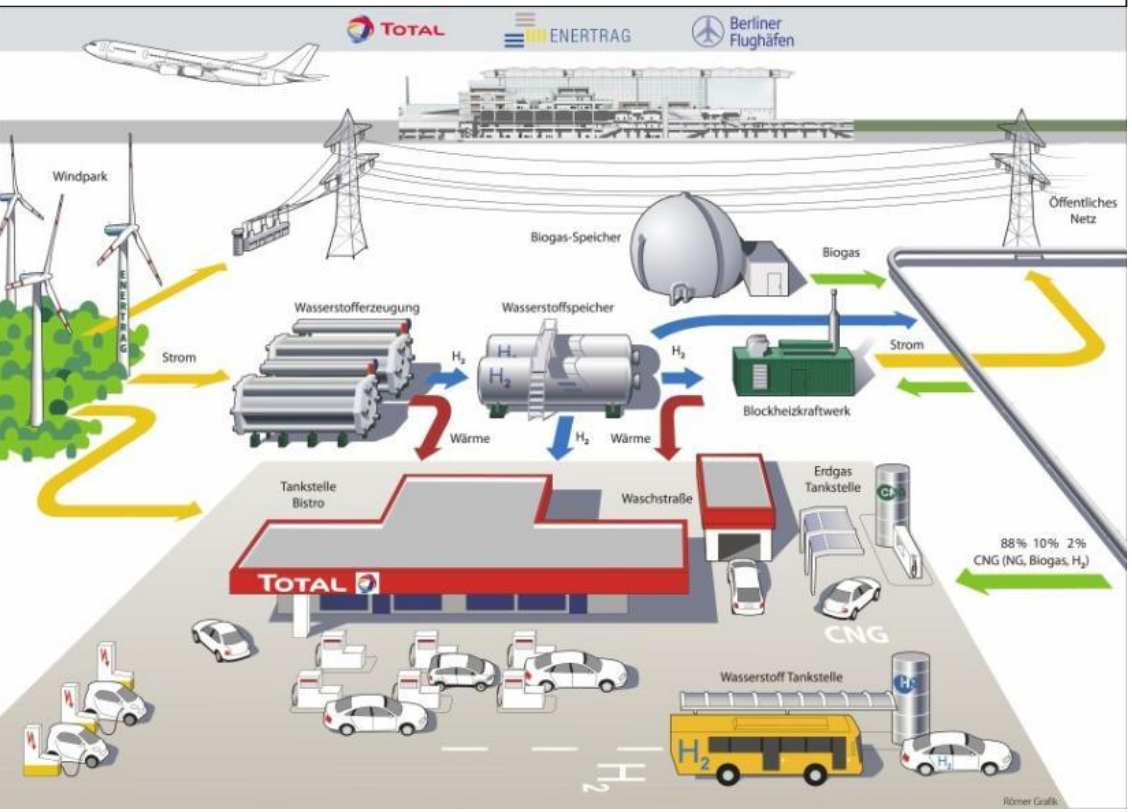
Hydrogen Station Deployment

demonstrating Wind-Hydrogen for transportation

Clean Energy Partnership CEP

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie (nip

hydrogen as part of an integrated energy system



Total: multi-energy fuelling station

refueling renewable power

Total Refueling Station at Berlin-Schoenefeld
Opening on May 23th, 2014

50 Hydrogen Refuelling Stations for Germany – Latest News

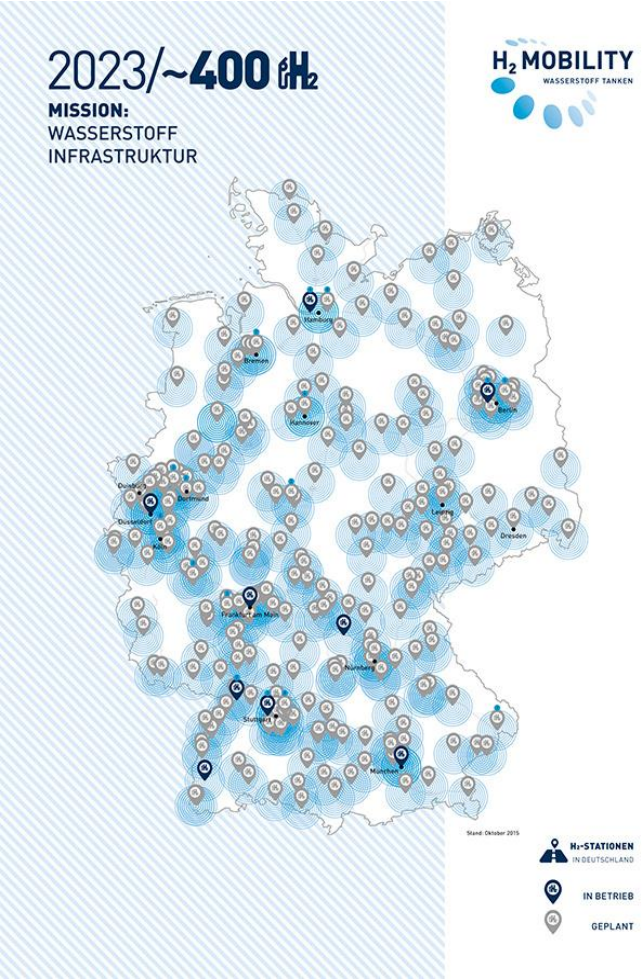
Geiselwind, 04.05.2015
GERMANY'S FIRST HYDROGEN FILLING STATION ON THE AUTOBAHN OPENS

H2-Mobility action plan until 2023

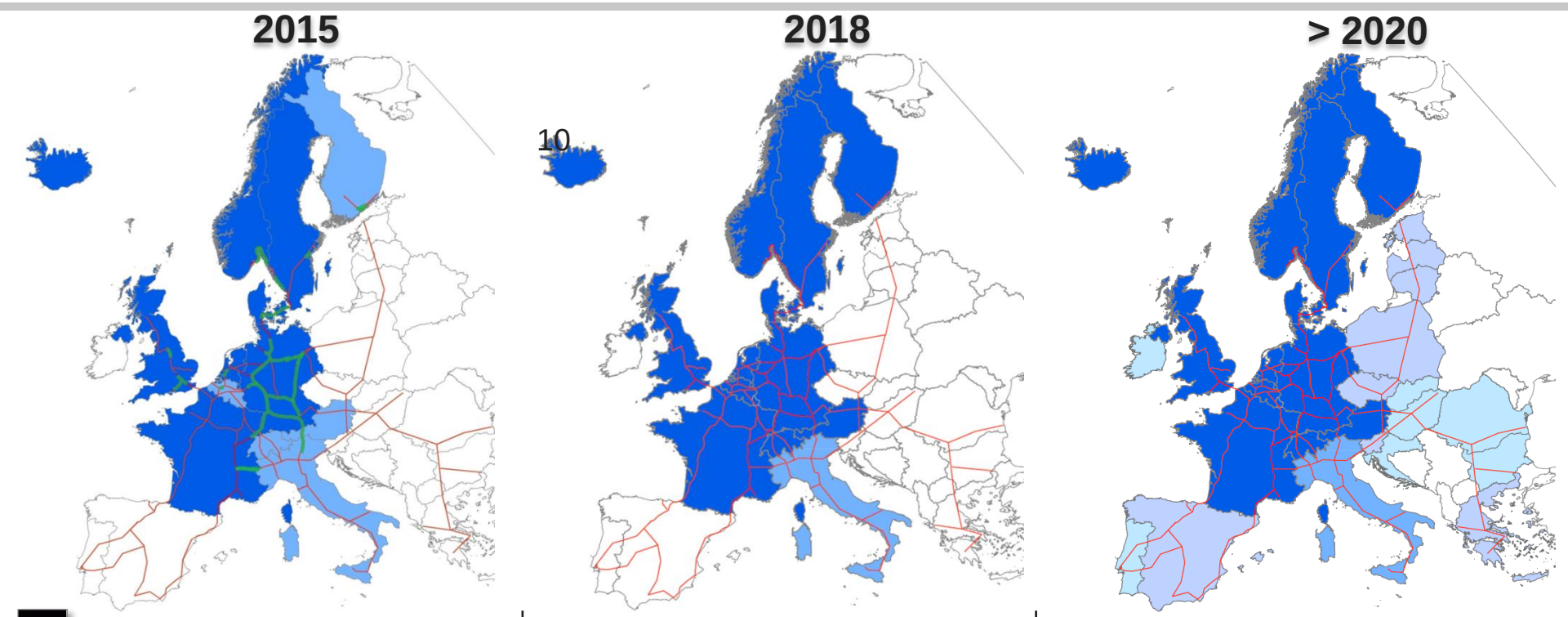
Air Liquide, Daimler, Linde, OMV, Shell and Total agree on an action plan for the construction of a hydrogen refueling network in Germany.

Targets:

- **400 HRS** until **2023** (100 HRS until 2017).
- **350 mio. €** investment.
- Max**. 90 km** distance between two HRS at the motorway.
- **10 HRS** in each metropolitan area.



Scenario for the development of an EU HRS infrastructure



	2015	2018	> 2020
	50	100	400
	2 – 4	10	20
	~5	~5	40
	9	30	70
	10	30	40

Nations with H_2Mobility initiatives
Nations with some activity and/or H2Mobility initiatives starting
Nations without H_2Mobility initiatives

DIRECTIVES OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

22th October 2014: Alternative Fuels Infrastructure Directive (2014/94/EU)

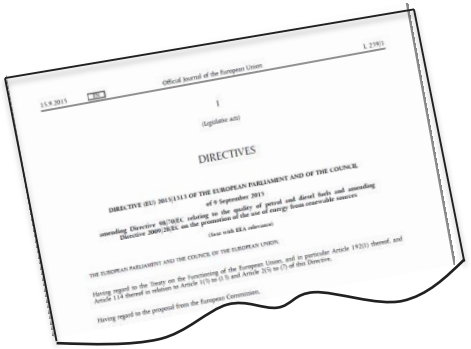

PRESS
EN
Council of the European Union
PRESS RELEASE
ST 13660/14
PRESSE 487
Brussels, 29 September 2014

Clean fuel infrastructure rules adopted by the Council

The Council today adopted a directive on building up minimum infrastructure for alternative fuels across the EU (PE-CONS 79/14; statements: 13287/14 ADD 1).

'Under the directive, each member state has two years to draw up an alternative fuel deployment strategy and send it to the Commission. These strategies or "national policy frameworks" will set out the country's national targets for putting in place new recharge and refuelling points for the different types of "clean fuel", such as electricity, hydrogen and natural gas, as well as relevant supporting actions.'

15th September 2015: Directive 2015/1513 for the amendment of Directives 98/70/EC (FQD) and 2009/28/EC (RED)


15.9.2015 EN Official Journal of the European Union L 239/1

I

(Legislative acts)

DIRECTIVES

DIRECTIVE (EU) 2015/1513 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 September 2015 amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending Directive 2009/28/EC on the promotion of the use of energy from renewable sources (Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof, and Article 114 thereof in relation to Article 1(3) to (5) and Article 2(3) to (7) of this Directive,

Having regard to the proposal from the European Commission,

RED: *[…] the share of energy from renewable sources in all forms of transport in 2020 is at least 10 % […]*

FQD: *[…] require suppliers of fuel or energy to reduce by at least 6 % by 31 December 2020 the life cycle greenhouse gas emissions per unit of energy of fuels used in the Union by road vehicles, non-road mobile machinery, agricultural and forestry tractors and recreational craft when not at sea. […]*

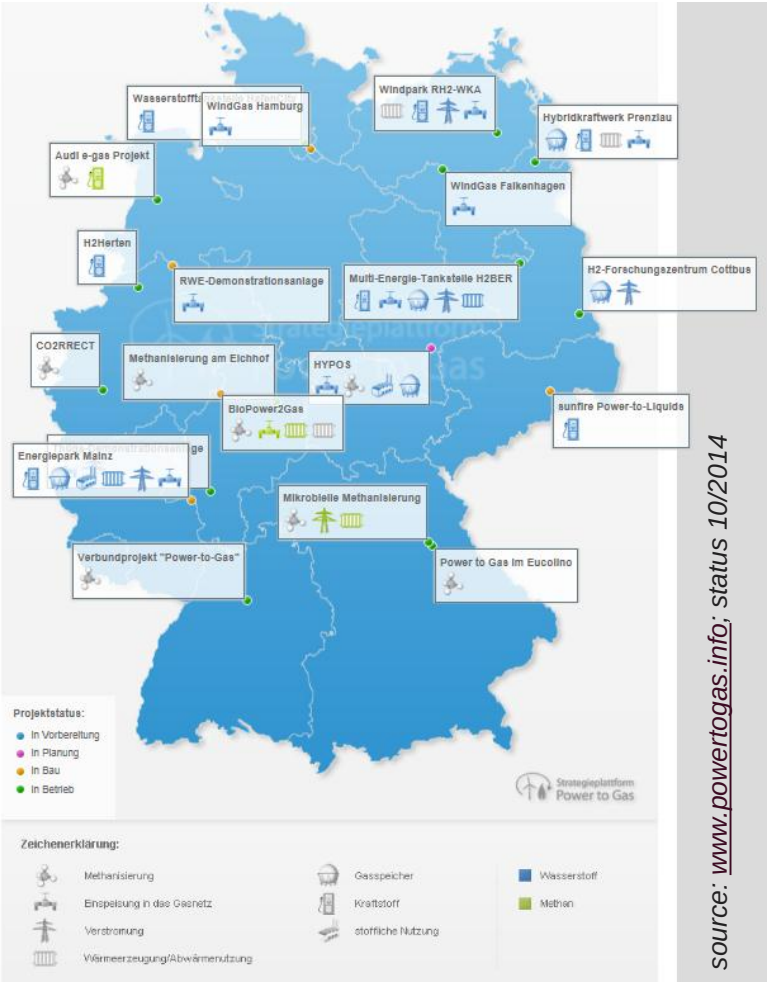
"renewable liquid and gaseous transport fuels of non-biological origin" means liquid or gaseous fuels other than biofuels whose energy content comes from renewable energy sources other than biomass, and which are used in transport;"

Hydrogen Production from Renewable Energies

stabilizing the grid in the power sector and providing a renewable fuel to the transportation sector

Power-to-Gas

Demonstration Projects in Germany



source: www.powertogas.info; status 10/2014

Co-generation with Fuel Cell Systems

efficient decentralized supply of power and heat in homes

Fuel Cell CHP Technology offers Multi-Purpose Solutions

Conversion of fossil power generation system

Grid expansion

Combined Heat & Power-Technology with highest electric efficiency

Opportunities for integration into virtual power networks

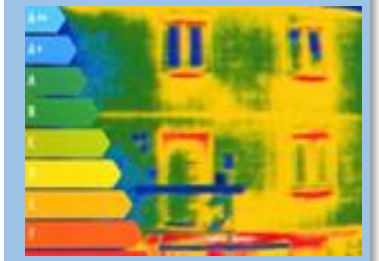
Ease pressure on and help stabilizing electricity grid through de-central operation

Predestined for flexible use and leveling out fluctuating renewable energies

Operation with biogas or SNG

Much higher efficiency compared to non-coupled heat and power production

Expansion of REN



Increases in energy efficiency

Fuel cell CHP appliances offer ideal building blocks for future energy systems due to their efficiency, flexibility and de-central deployability

Lighthouse project CALLUX - overview

Focus:

- **Research and Development**
- **Training (craftsmen)**
- **Operating experience**
- **Market research**
- **Cost reduction**
- **Reliability increase**

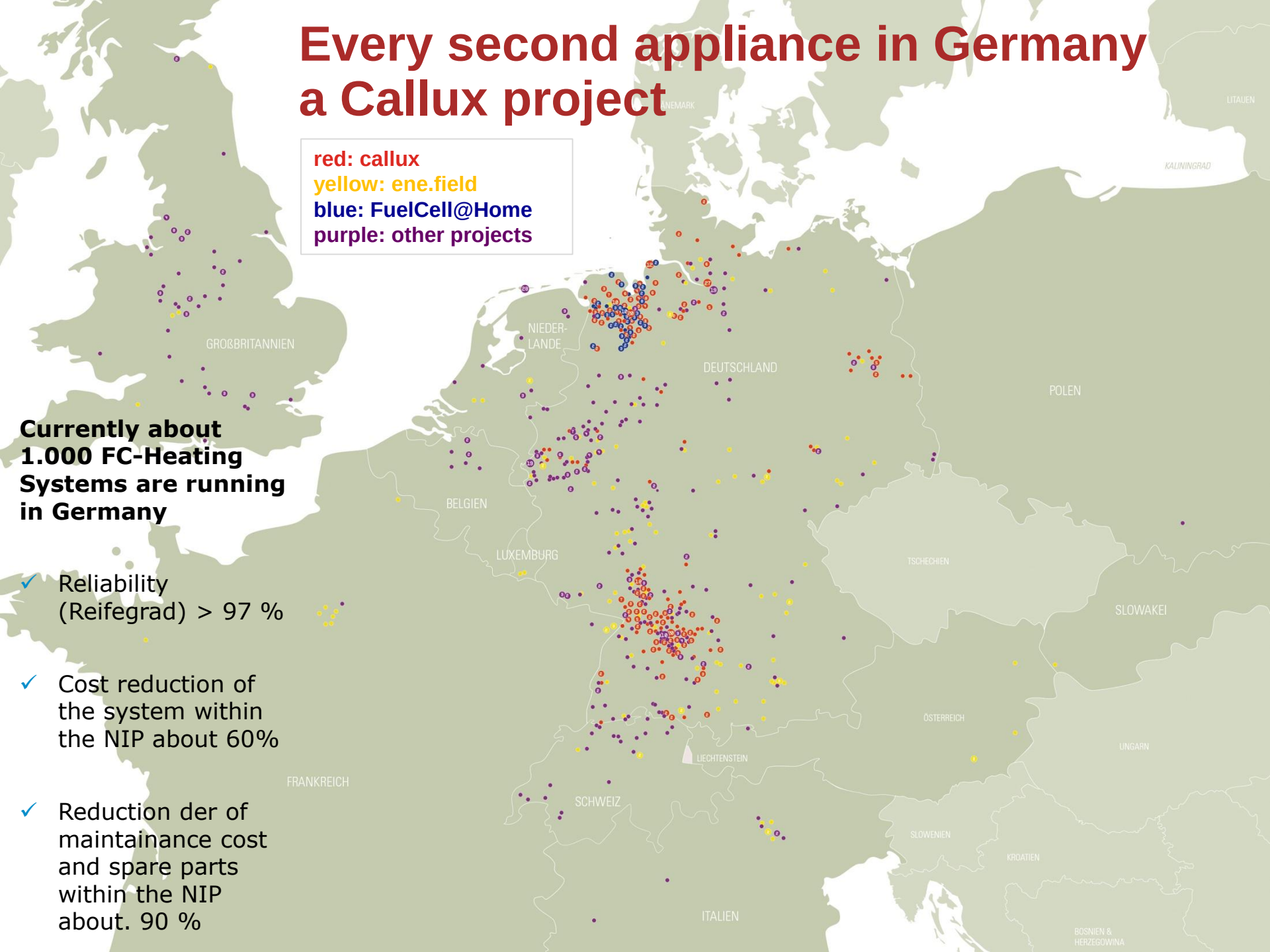
http://www.callux.net

Research & Development → Demonstration / Field Trials / Markt Preparation → Commercial Ramp Up → Mass Market

CALLUX

Every second appliance in Germany a Callux project

red: callux
yellow: ene.field
blue: FuelCell@Home
purple: other projects



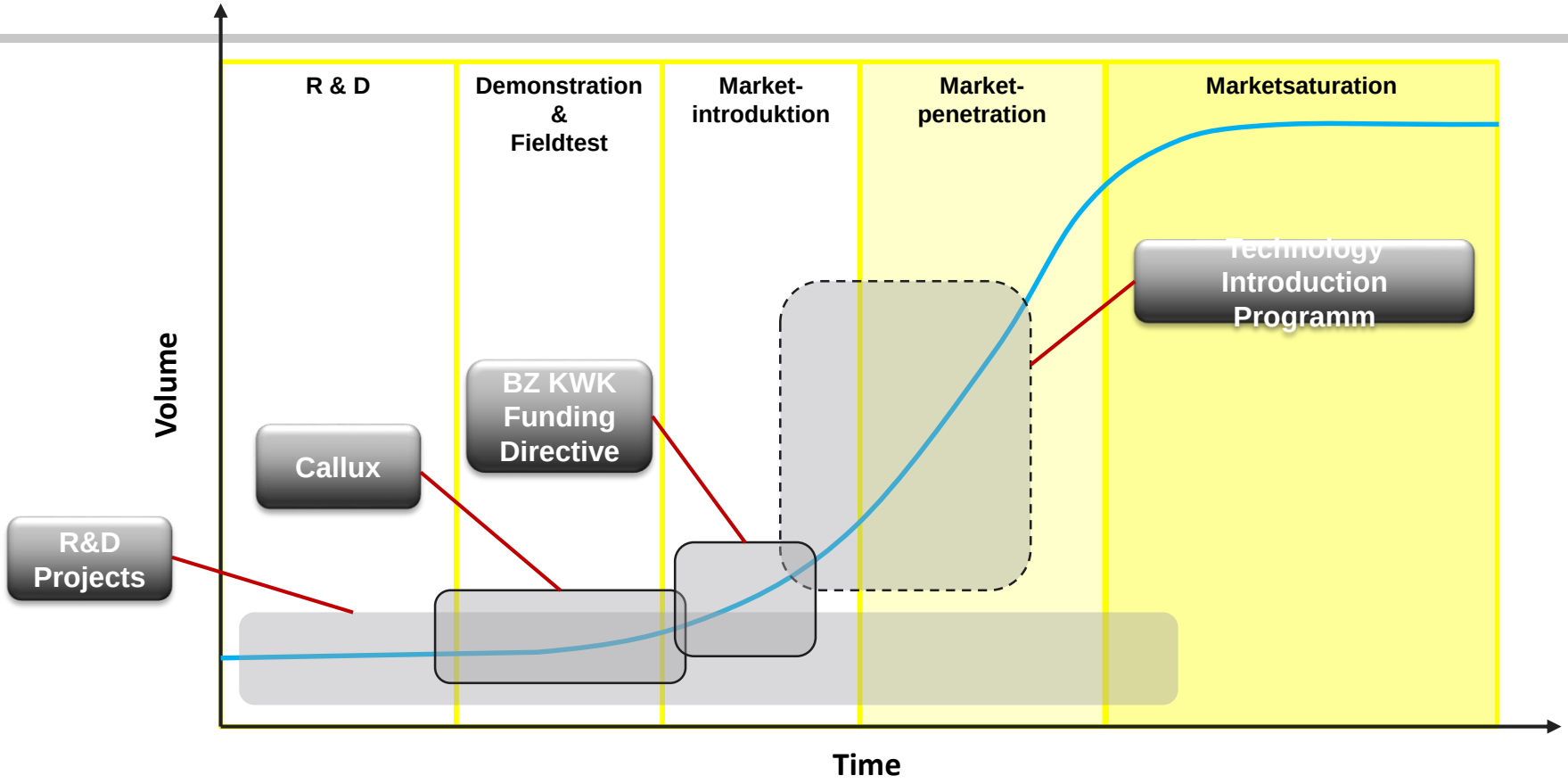
Currently about 1.000 FC-Heating Systems are running in Germany

- ✓ Reliability (Reifegrad) > 97 %
- ✓ Cost reduction of the system within the NIP about 60%
- ✓ Reduction der of maintainance cost and spare parts within the NIP about. 90 %

Stationary System Suppliers

									
Hersteller	**Buderus**	**Ceramic Fuel Cells**	**Elcore**	**Hexis**	**Junkers**	**SenerTec**	**SOLIDpower**	**Vaillant**	**Viessmann**
Typ	SOFC	SOFC	HT-PEM	SOFC	SOFC	NT-PEM	SOFC	SOFC	NT-PEM
Leistung (el/th)	0,7/0,62 kW	1,5/0,61 kW	0,3/0,7 kW	1,0/1,8 kW	0,7/0,62 kW	0,7/0,96 kW	2,5/2 kW	0,8/1,5 kW	0,75/1 kW
Thermische Leistung des Zusatz-brenners	7,3-24 kW	extern, individuell wählbar	Paketlösungen: 5,1-22,8 kW / 6,8-36,7 kW, oder extern, individuell wählbar	7-21 kW	7,3-21,8 kW	4,8-20 kW	extern, individuell wählbar	5,8-27 kW	5,5-19 kW
Speicher	Warmwasserspeicher 75 l, Pufferspeicher 135 l	extern, individuell wählbar	Paketlösungen: 500 l, oder extern, individuell wählbar	extern, individuell wählbar	Warmwasserspeicher 75 l, Pufferspeicher 135 l	Pufferspeicher mit Frischwasserstation 300 l	300 l, optional	extern, individuell wählbar	Warmwasserspeicher 46 l, Pufferspeicher 170 l
Elektrischer Wirkungsgrad	45 %	bis zu 60 %	32 %	35 %	45 %	bis zu 37 %	50 %	33 %	37 %
Gesamt-wirkungsgrad	85 %	bis zu 85 %	104 %	95 %	85 %	93 %	90 %	92 %	90 %
Abmessun-gen in mm (B x T x H)	1200 x 600 x 1800	600 x 660 x 1100	600x550x105	620 x 580 x 1650	1200 x 600 x 1800	Brennstoffzelleneinheit: 453 x 727 x 1053 Systemtechnik: 650 x 1065 x 1800	630 x 830 x 170	599 x 693 x 1640	1085 x 595 x 1998
Gewicht in kg	Gesamtsystem 304 kg in Modulbauweise, max. Modulgewicht 112kg	ca. 200	115	210	Gesamtsystem 304 kg in Modulbauweise, max. Modulgewicht 112kg	115 kg (Brennstoffzellenmodul) max. Modulgewicht 120 kg	350	150	290 (Brennstoffzellenmodul 125) (Spitzenlastmodul 165)
Feldtests, Kooperationen, Demonstra-tionsprojekte	ene.field (EU), Kleinserie in Kooperation mit Energieversorgern	abgeschlossen	ene.field (EU), verschiedene Partner aus der Ener-giewirtschaft und dem Hausbau	Callux (DE), Pharos (CH), ene.field (EU)	ene.field (EU)	enefield (EU), Callux (DE)	ene.field (EU)	Feldtest in Callux (DE), Kleinserie in ene.field (EU)	Januar 2013 Pretest; Juli 2013 bis März 2014 großer Feldtest
Markt-ein-führung	2016	erfolgt (2012)	2014	Ende 2013	2016	2016	2016/2017	2016/2017	April 2014
Kontakt	www.buderus.de	www.ceramicfuelcells.de	www.elcore.com	www.hexis.com	www.junkers.com	www.derdachs.de	www.solidpower.com	www.vaillant.de	www.viessmann.com

Funding µCHP



Typical Innovation- and Diffusion process for new technologies

Fuel Cells Systems for Back-up Power and Remote Locations

reliable power supply at any time

What is CPN?
Networking for innovative applications

Clean Power Net is an open german wide network of solution providers and users for fuel cells for backup power and off-grid applications

Branches:

Information Technology

Telecomunication

Industrial process automatisation

Industrial control centers

Traffic control

Energy supply / Distribution networks

Applications:

UPS / Backup / Generator replacement

Smart-Grid

Remote / off-grid power supply
(Mobile base stations)

UPS for power supply switching stations
(High voltage – middle voltage – low voltage)

Virtual power plants for tertiary power
(Minutenreserve) and peak power shaving

Efficient, intelligent, climate friendly and reliable energy supply with fuel cells

CPN
Projects

NIP-financed UPS- / backup and off-grid projects

Status Quo:

- 14 projects
- Approx. 300 fuel cells in field tests and demonstrations
- 7 further projects are applied for and are under review with NIP-financing

Project details @ www.cleanpowernet.de

Fuel cell powered industrial truck application in the BMW plant Leipzig

Current Status

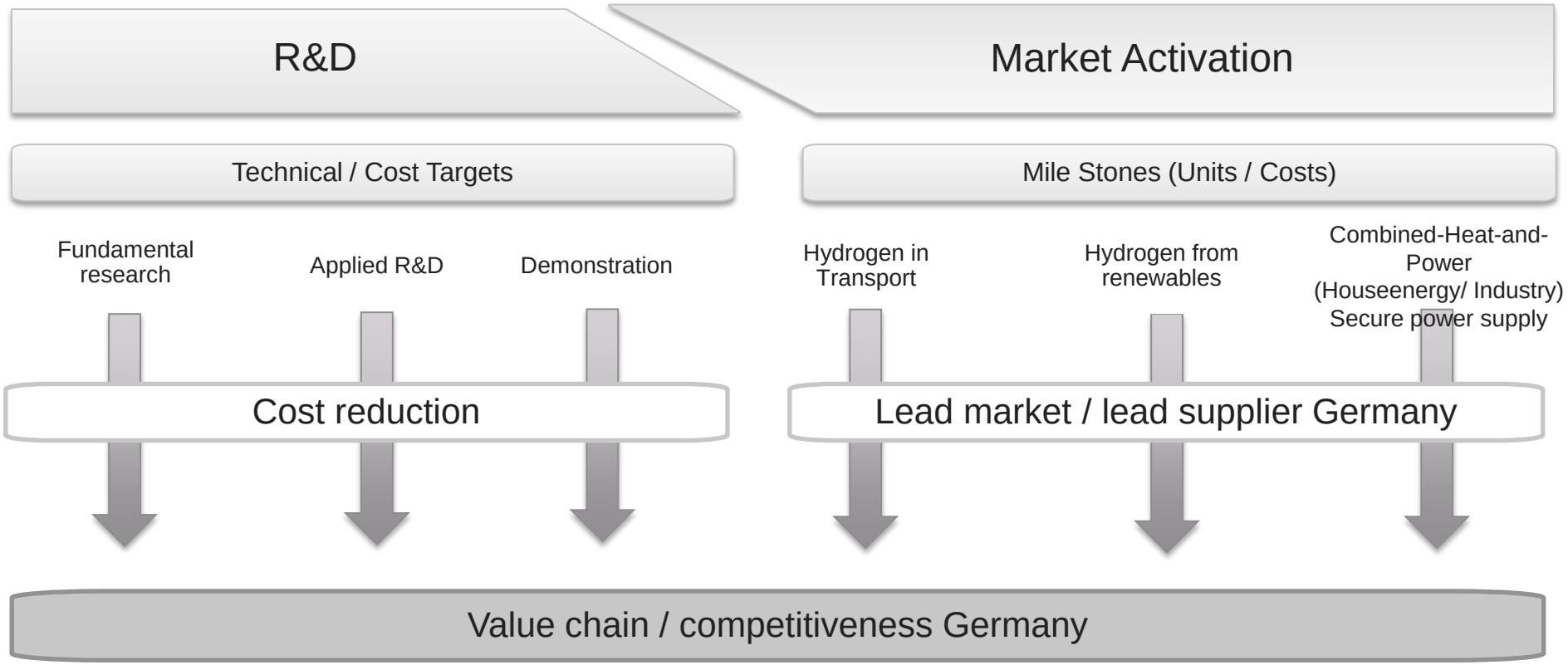
- Germany's first indoor fueling-station
- Carbon-fiber-body-shop production supply with 5 f-cell forklifts & 6 f-cell tuggers at BMW plant Leipzig
- Guidelines for using f-cell powered industrial trucks
- Evaluation of ecological and economic sustainability in progress

More Information

- www.h2intradrive.de

Continuation of the National Innovation Program Hydrogen and Fuel Cell Technology 2016-2026

Program Structure



Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Thank you very much!

download:
www.now-gmbh.de

Dr. Hanno Butsch
Head of International Cooperation

NOW GmbH
National Organization Hydrogen and Fuel Cell Technology