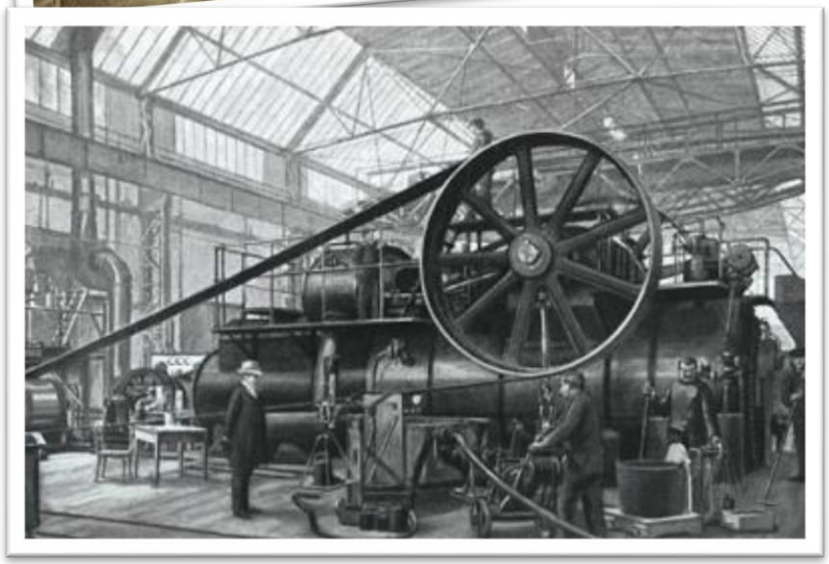
Choose certainty.
Add value.

HYDROGEN AND FUEL CELL
-
TO STRENGTHEN THE VALUE CHAIN AND ADDED VALUE IN GERMANY

Presented by Tom Elliger
2014-10-23

Content

Our heritage: 148 years of business success



1866 Establishment of a Mannheim-based steam boiler inspection association by 21 operators and owners of steam boilers, with the objective of protecting man, the environment and property against the risk emanating from a new and largely unknown form of technology

1910 First vehicle periodic technical inspection (PTI)

1926 Introduction of the “TÜV mark / stamp” in Germany

1958 Development of a Bavaria-wide network of vehicle inspection centres in the late 1950s

1990s Conglomeration of TÜVs from the southern part of Germany to form TÜV SÜD and the expansion of business operations into Asia

2006 Expansion of services in ASEAN by acquiring Singapore-based PSB Group

2009 Launch of Turkey-wide vehicle inspection by TÜVTURK

Today TÜV SÜD continues to pursue a strategy of internationalisation and growth


Today, TÜV SÜD stays true to its founding principle of **protecting people, environment and property against the adverse effects of technology.**

TÜV SÜD in numbers: Growing from strength to strength

1	One-stop technical solution provider
150	years of experience
800	locations worldwide
1,900	million Euro in sales revenue 2013
20,200	employees worldwide

Note: Figures have been rounded off.

Technical expertise & broad industry knowledge

Testing & product certification

Chemical, physical, mechanical, electrical and environmental testing and product certification.

Inspection

Product, system, building, plant and infrastructure inspection.

Knowledge services

Safety, quality, risk, environmental protection and regulatory advisory.

Auditing & system certification

Audits system certification in a variety of fields including quality, safety, energy, IT security, social compliance and environment.

Training

Training in work safety, technical skills, management systems and executive programs.

Tangible economic benefits for your business

Increase

Market access

Productivity & profits

Brand reputation

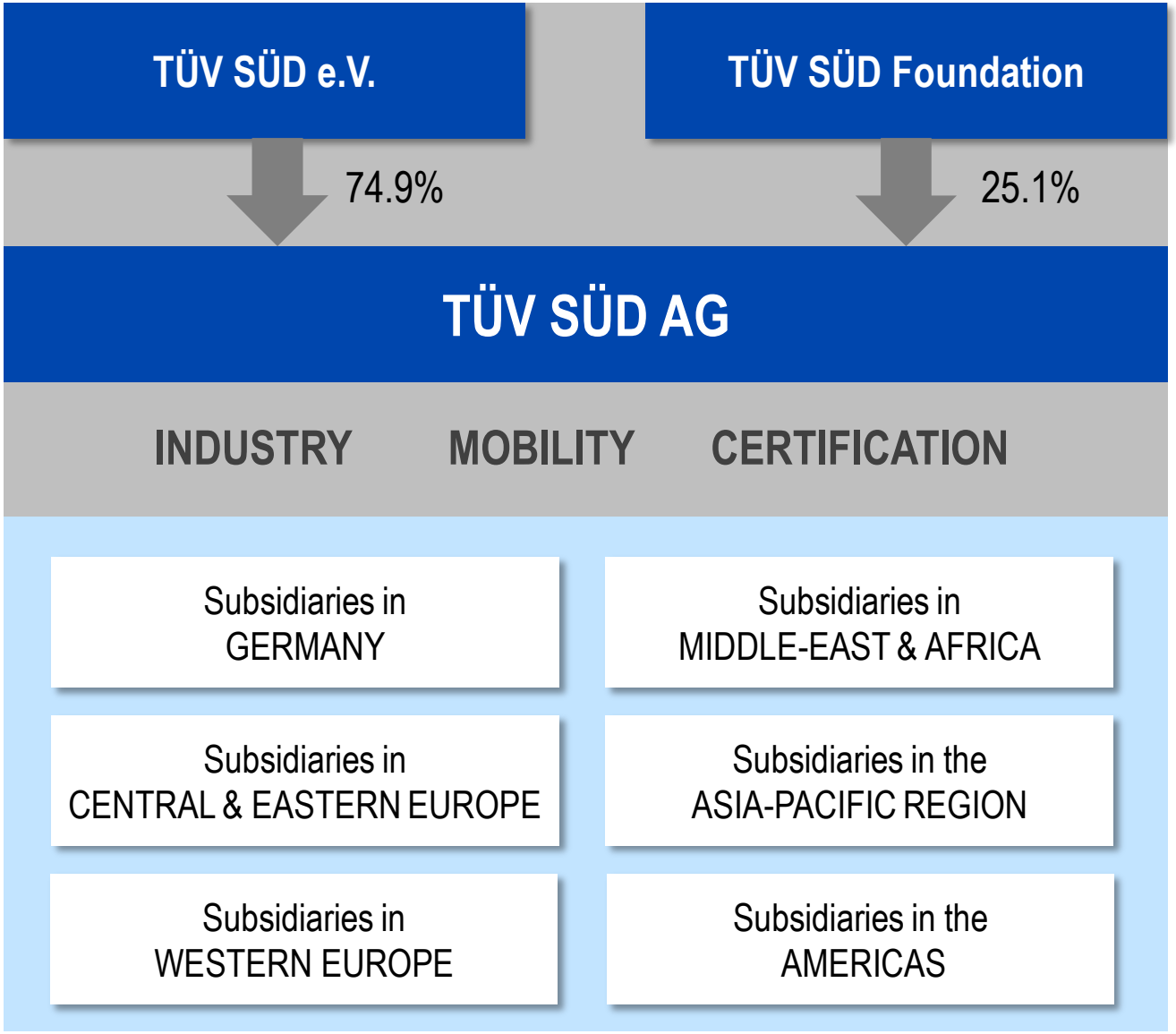
Decrease

Costs & inefficiencies

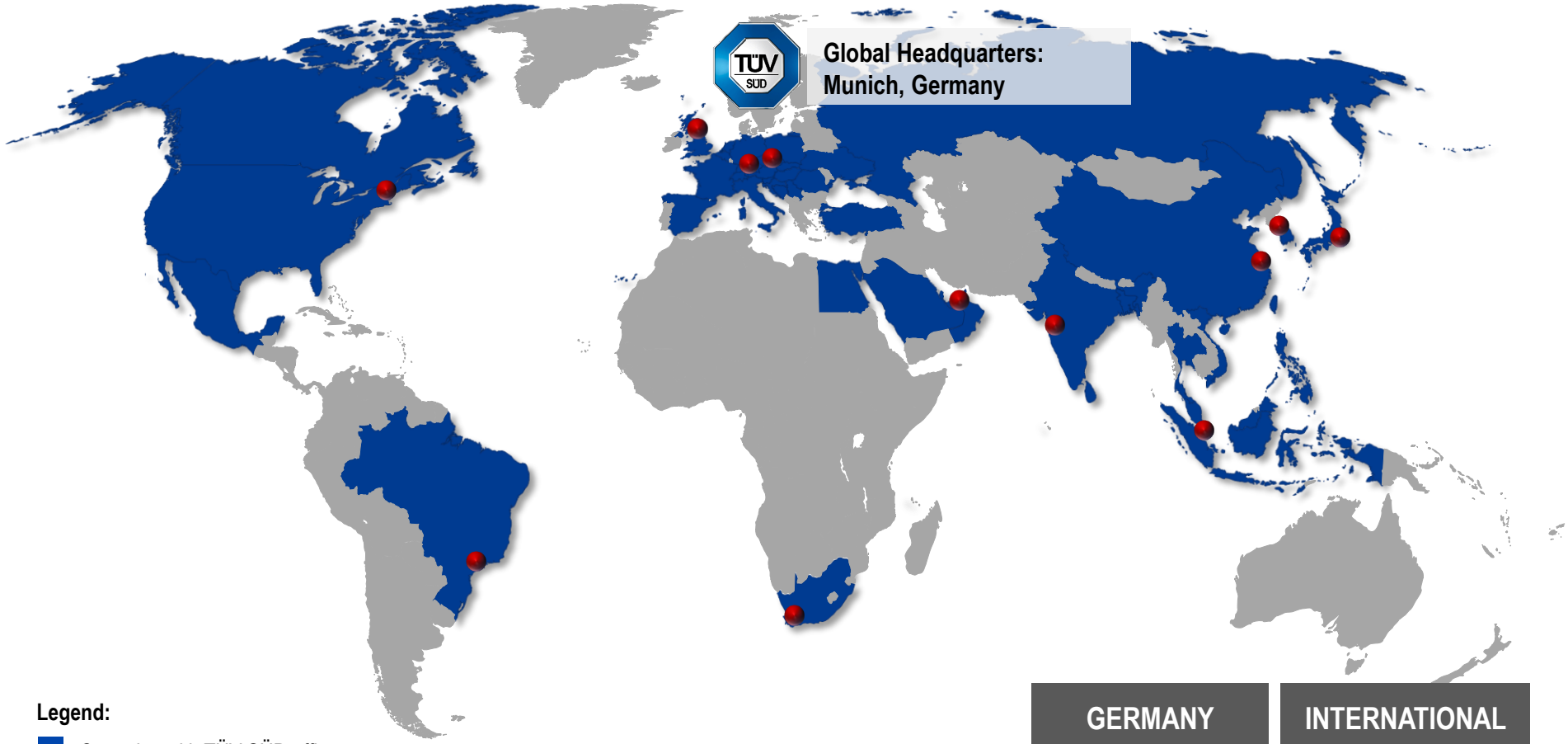
Time to market

Business risks

Independence and impartiality



Global expertise. Local experience.



Legend:

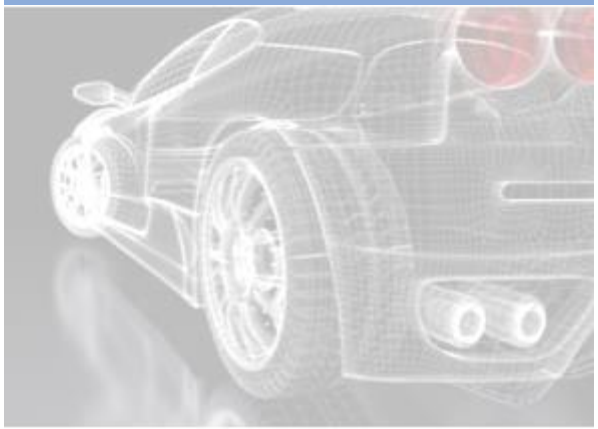
- Countries with TÜV SÜD offices
- Regional headquarters

Note: Figures have been rounded off.

GERMANY	INTERNATIONAL
Euro 1,190 mio 10,400 staff	Euro 750 mio 9,800 staff

TÜV SÜD Business Segment - Industry

Mobility



- Services for
  - automotive suppliers and Original Equipment Manufacturers (OEM)
  - repair shops and car dealerships, leasing companies and fleet management companies
  - government transport authorities
  - private vehicle owners

Industry

- Services for investors, operators and equipment manufacturers
  - of Chemical, Oil and Gas Industry
  - Power and Energy Industry, include Nuclear, Conventional and Renewables
  - Manufacturing & industrial machinery Industry
  - Rail and Infrastructure Industry
  - Real Estate

Certification

- Services for
  - industrial equipment and material manufacturers
  - manufacturers and suppliers of consumer products
  - medical device manufacturers and health care providers
  - manufacturers and operators of telecommunication and IT equipment

TÜV SÜD Industry – Main Activities

Plant Engineering

Steam- and Pressure Engineering

Energy and Technology

Environmental Engineering

Civil Engineering

Electrical and Building Services Engineering

Lift and Cranes

References: Dubai Eye

References: Dubai Eye

Project Volume: 2 Million $

Run Time:
2 years since May 2013

Services:
Concept and Design Inspection
for Structure, Terminal Building,
Fundaments (Wheel and Building)
together with Wallace Whittle

Wheel Size: 250 m
(Highest Ferris Wheel of the world!)

Investment, Wheel: ca. 250 Million $
Investment, overall: ca. 1 Billion $

King Abdullah Financial District - International

King Abdullah Financial District - International

Project Volume: 1.8 Million $

Run Time:
January 2013 – February 2015

Services:
- Quality Inspection of execution of construction works
- international and local construction supervision
- own testing as well as review of test reports

Investment, overall: ca. 16 Billion $

SAMSUNG Semiconductor Plant in China and Korea

SAMSUNG Semiconductor Plants, China and Korea

Project Volume:
Suwon, Korea: 11 Mio $
Xi'an, China: 5 Mio $

Run Time:
Korea: 12 Months (till 2014-08-31)
China: 6 Months (till 2014-02-28)

Services:
TÜV SÜD supports with QA / QC Services for the facilities in China and Korea

Investment Korea: ca. 7 Billion $
Investment China: ca. 13 Billion $

Content

Political background for the transition to renewable energies

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

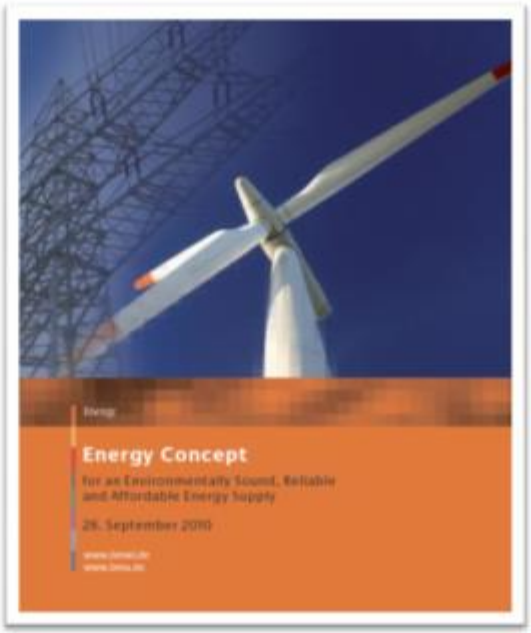
- **Climate protection:**
  Global responsibility for the next generation.

- **Energy security:**
  More independency from fossil fuels.

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

Political Climate and Energy Targets for Germany

- **Reducing GHG across all sectors (1990 baseline):**
  40% by 2010 ➔ 80% by 2050
- **Share of renewable energies of the gross final energy consumption:**
  18% by 2020 ➔ 60% by 2050
- **The share of renewable energies for the electric power supply:**
  40-45% by 2025 ➔ 55-60% by 2035
- **Reducing primary energy consumption:**
  20% by 2020 ➔ 50% by 2050.
- **Increase of Energy productivity:**
  2.1% per year compared to final energy consumption.
- **Decrease of electricity consumption (baseline 2008):**
  10% by 2020 ➔ 25% by 2050
- **Compared to 2008, heat demand in buildings** is to be reduced by 20% by 2020, while primary energy demand is to fall by 80% by 2050.



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

Preparing Hydrogen and Fuel Cell Markets

Transportation (54%*)

- H_2 production and infrastructure
- Expanding vehicle fleets and hydrogen infrastructure starting from key regions

Stationary Applications (36%*)

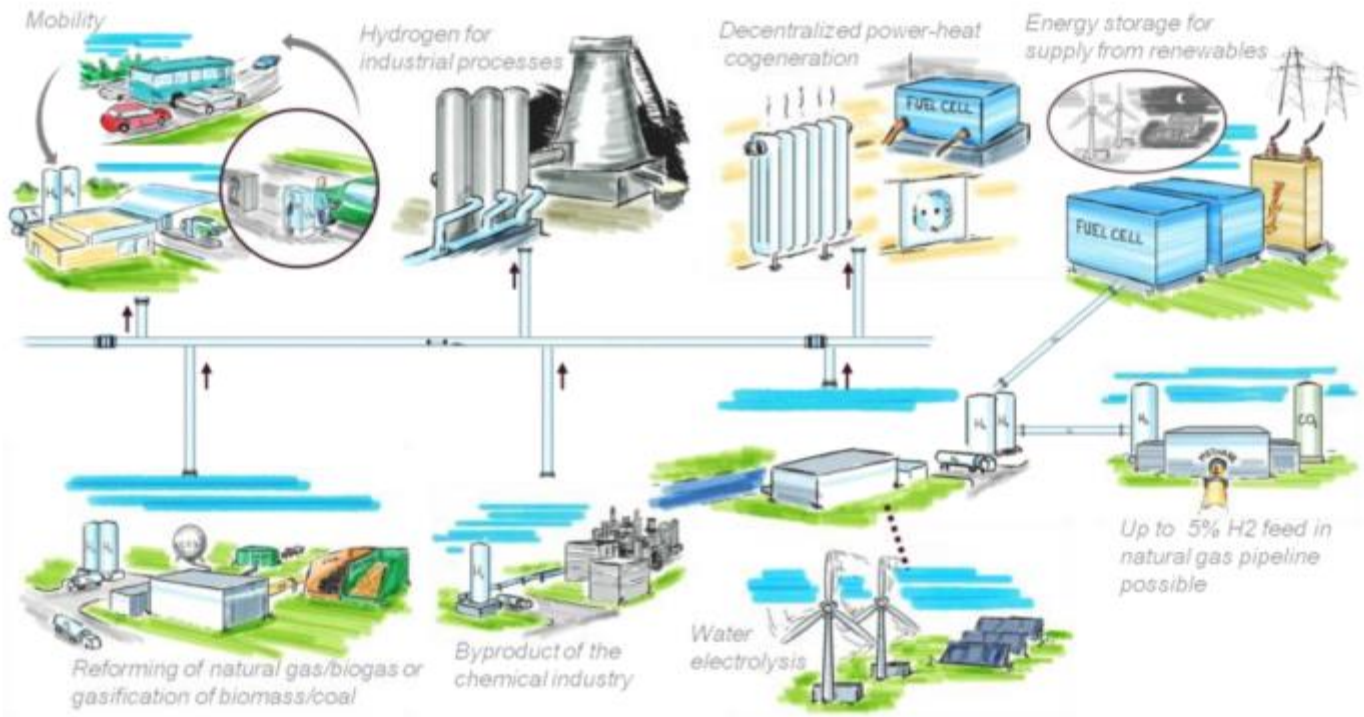
- Micro CHP for residential use
- Industrial gensets for CHP and trigeneration

Special Markets (10%*)

- IT, telecommunications
- Logistics, leisure and tourism markets

* distribution according to the National Development Plan

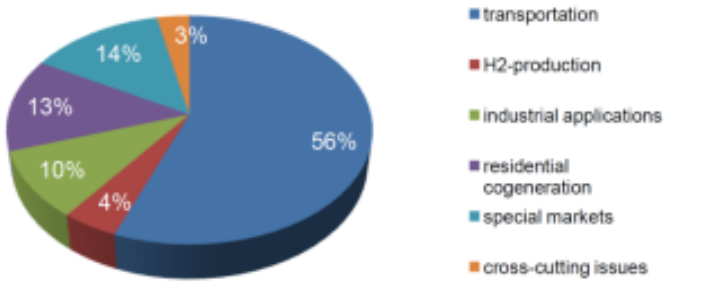
NIP Programm - Why hydrogen?

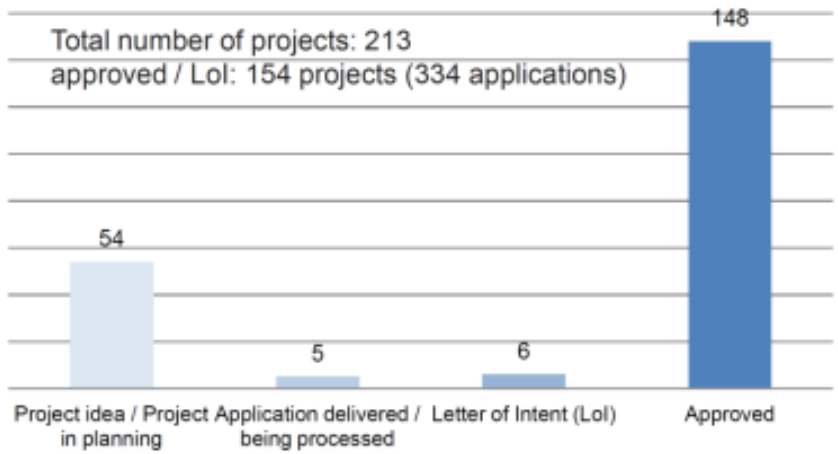


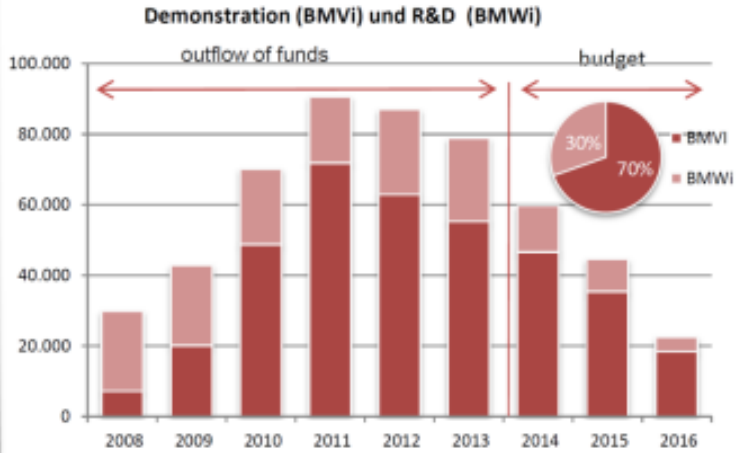
National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP)

BMVI-funding Status 12/2013

program area	Budget k€	funding k€ LoI & approved k€	In discussion €k
transportation	579.058	276.755	238.361	38.394
H2-production	44.002	21.795	14.792	7.003
industrial applications	91.302	47.667	29.904	17.764
residential cogeneration	140.171	65.557	55.063	10.494
special markets	137.767	67.219	51.700	15.518
cross-cutting issues	31.777	16.299	6.824	9.475
innovative drive systems	15.439	7.411	7.411	-
product line	**1.039.516**	**502.703**	**404.055**	**98.648**







NIP - Integrated Approach for Market Preparation

Technology	Application	Markets
• components • subsystem • systems + products	• cost • reliability • lifetime	• customer acception • safety • approval processes

Bosch:
Hydrogen Gas
Injector HGI

FCCT:
Gas Diffusion Layer
(GDL)

Linde:
Ionic H2-Compressor

CEP

callux

Praxistest Brennstoffzelle fürs Eigenheim

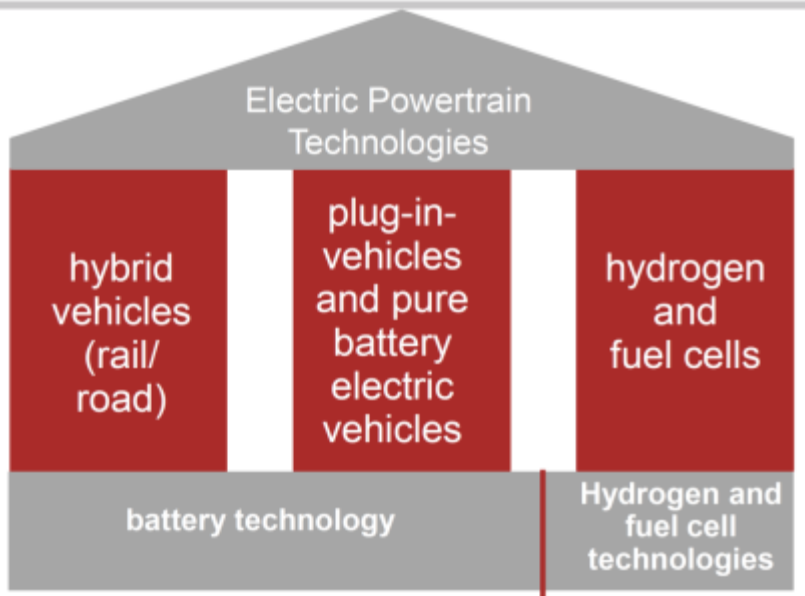
clean power net

NOW

7

Market Preparation for Eletro-Mobility

Three pillars of electrifying the powertrain



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

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

batteries
and
hydrogen / fuel cells

are
key technologies for a sustainable mobility

NOW

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:
  - about -10 % until 2020 of energy consumption
  - about -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 an key issue to reach the targets!**

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

➔ **Further increase of RE then planned.**

➔ **Large scale storage for Hydrogen is inevitable.**

Clean Power for Transport Directive General

Targets of the directive:

- Solve the "Chicken-and-Egg-Problem" = Energy/Fuel– Powertrain – Infrastructure, Safety for investment into alternative power trains due to availability of infrastructure.
- Establishment of an EU market for alternative fuels and power trains.
- Enforcements of the the EU's innovation and competitiveness

CPT-directive covers specific infrastructure requirements for the following fuel options:

- Power for BEV's as well as charging opportunities for ships in habors.
- Hydrogen
- Methane (CNG and LNG: for street traffic and maritime applications)

Key elements of the CPT-directive:

- Member states(MS) have to develop national implementation plans (NIP); no specific guidelines for infrastructure by the directive: MS have to decide within their NIP about a „appropriate number" for „Charging/H2/LNG&CNG"-infrastructures
- Establishment of binding technical standards and specifications for the interconnection between „Fuel / Vehicle / Infrastructure". Motivation/Target: Interoperability und anti-discriminatory availability of infrastructure.

Clean Power for Transport Directive
Impact for the Hydrogen Technology

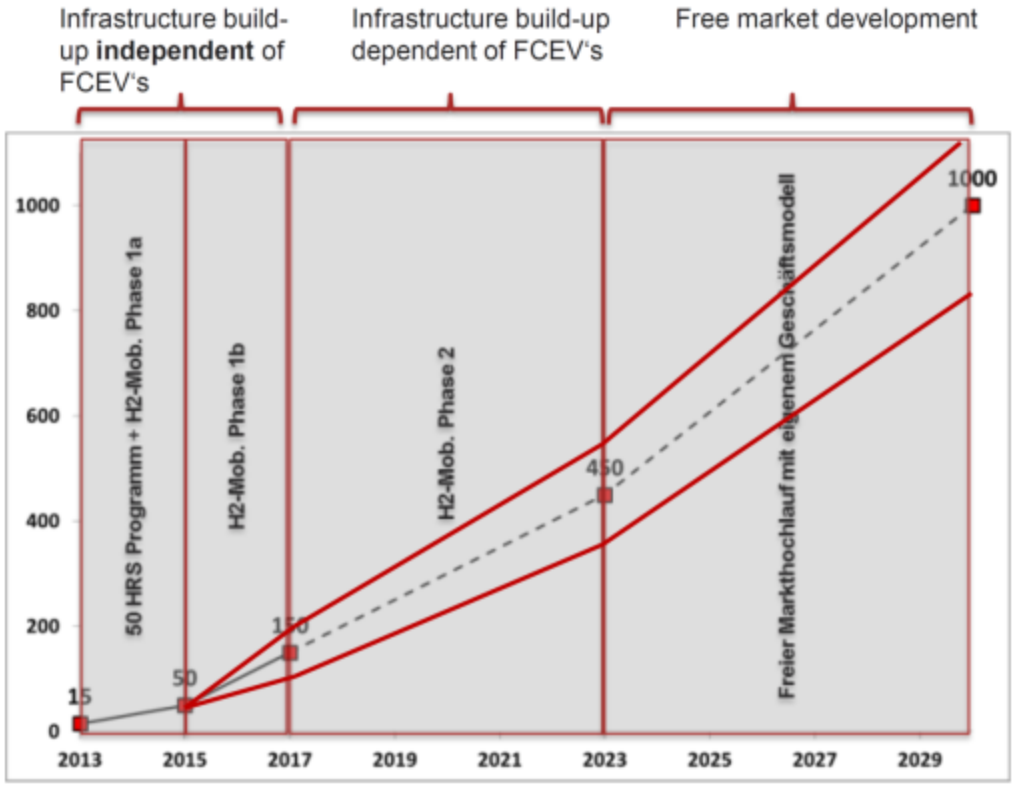
- Integration of the directive into national laws: 24 month after empowerment (expected: mid of 2014)
- H2-Infrastructure: 31.12.2025 (just for MS which will use the H2 option)
- Relevant Standards:
  - The **hydrogen purity** dispensed by hydrogen refuelling points shall comply with the technical specifications included in the **ISO 14687-2** standard.
  - Hydrogen refuelling points shall employ **fuelling algorithms** and equipment complying with the **ISO/TS 20100** Gaseous Hydrogen Fuelling specification.
  - **Connectors for motor vehicles** for the refuelling of gaseous hydrogen shall comply with the **ISO 17268** gaseous hydrogen motor vehicle refuelling connection devices standard.
- Transition period for all fuel options: 36 month after empowerment of the directive all new or renewed fuel infrastructure has to follwe the mentioned standards.

➔ Council has approved the directive.

Phased approach to a profitable commercial infrastructure ramp-up

	R&D and demonstration	Market preparation and validation	Commercial ramp-up
When? Who?	▪ Since 2006 ▪ NOW / CEP	▪ For the next 5 - 10 years ▪ H_2 Mobility and NOW / CEP	▪ Around 2020 ▪ H_2 Mobility and free market
Goals	▪ HRS technology up and running ▪ Costs significantly reduced	▪ Proof of HRS, FCEV technology, and H_2 supply chain ▪ Customer acceptance of FCEVs ▪ Attractive business case for next phase	▪ Scaled nationwide HRS network to enable FCEV mass take-up ▪ Profitable, high-growth business

Timeline HRS infrastructure build-up H2-Mobility including 50 HRS Program



Until 2015:
- 50 HRS are securely financed by NIP.

2015 - 2017:
- Build-up of a preliminary overcapacity of HRS as basis for an independent market development by H2 Mobility
- Build up is not related to (certified) FCEV numbers

2017 - 2023:
- Roll-out of HRS network will depend on (certified) FCEV numbers (internal H2-Mobility allocation key)

In-depth analysis investigating the potential development of a hydrogen infrastructure in Germany

H_2 Mobility

H_2 Mobility setup	H_2 Mobility business case (joint study)	H2 Mobility business and implementation plan (joint study)	Negotiations for founding joint entity	Market preparation and validation

Main achievements			H_2 Mobility coalition objectives	
Memorandum of understanding for H_2 Mobility signed Sep 10, 2009 in Berlin	Consistent HRS and FCEV ramp-up scenarios for Germany agreed	Design of joint entity structure outlined	Negotiate joint entity agreement	Start HRS rollout in Germany via the CEP
		Business case calculated and implementation plan outlined	Win (new) H_2 Mobility members as investors	Synchronize HRS rollout with FCEV ramp-up

Partner:

DAIMLER, TOTAL, AIR LIQUIDE, OMV, Linde, Shell

Associated Partner:

NISSAN, BMW GROUP, HYUNDAI, KIA MOTORS, Volkswagen, TOYOTA, HONDA, Intelligent Energy, NOW

NOW

21

23. September 2008

Goals of the project

Preparation for the launch of natural gas-powered Fuel cell for heating

- Demonstration and support of development of technical maturity to **marketable products**
- Develop **supply chains** by binding orders for large numbers
- Increase awareness among the **public**
- Development of concepts for integration into the **supply structures**
- **Training** / development of the market partners
- Validation of **requirements** against **market** and customers
- Promotion of **value added** in Germany

callux (nip)

Die Callux-Projektpartner

Energieversorgungsunternehmen:

EnBW, E.ON, EWE ENERGIE,
MVV Energie, VNG

- installieren und betreiben bereits seit Jahren Brennstoffzellen-Heizgeräte,
- können gemeinsam eine Installations- und Betriebserfahrung von über 400 Anlagen aufweisen.

Kindertagesstätte in Oberderdingen
(Baden-Württemberg)

Hersteller:

Baxi Innotech, Hexis, Vaillant

- in Deutschland tätige Know-how-Träger in der Entwicklung von Brennstoffzellen-Heizgeräten
- Technologie: PEM und SOFC (1 kW_{el})
- weisen mehrjährige Betriebserfahrung mit hunderten von Anlagen auf

Projektkoordinator:

Zentrum für Sonnenenergie- und Wasserstoff-Forschung

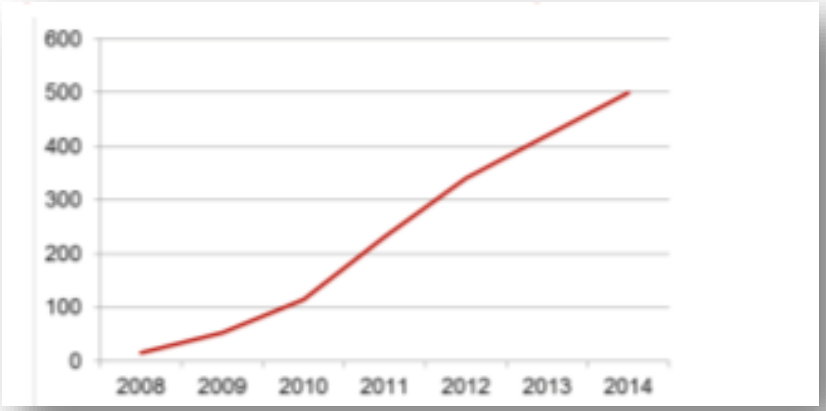
- umfangreiche Erfahrungen in der Bearbeitung und Abwicklung von Förderprojekten

Einfamilienhaus in Ötisheim
(Baden-Württemberg)

- **WP1: Market Partner**
  - Develop a training module for Qualification of service personnel
- **WP2: Market Research**
  - Analysis of specifications and special barriers for a direct market entry
- **WP3: Infrastructure**
  - Development of a standardized interface for communication of fuel cell heating with energy management systems
- within the consortium
- **WP4: Communication**
- **WP5: Scientific Support**
  - Joint discussion of scientific issues related to the implementation as out put of the evaluation of the practical test
- **WP6: Project Coordination**
  - Project Coordinator ZSW

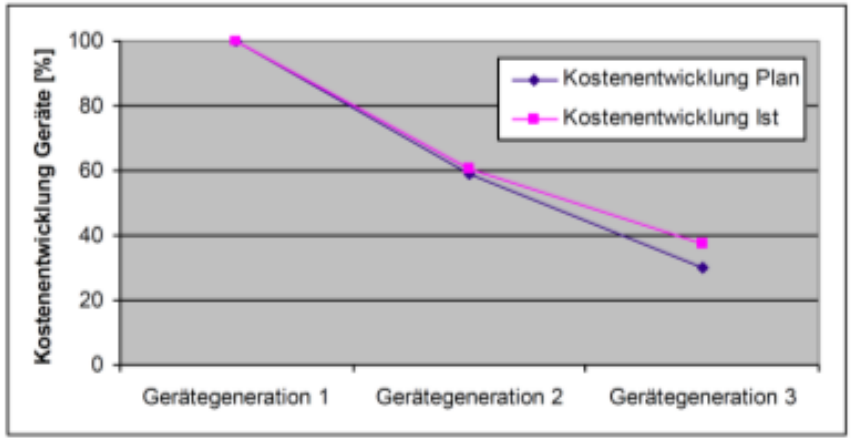
Some numbers – up to now

Advised fuel cell heating
(cumulative installations)



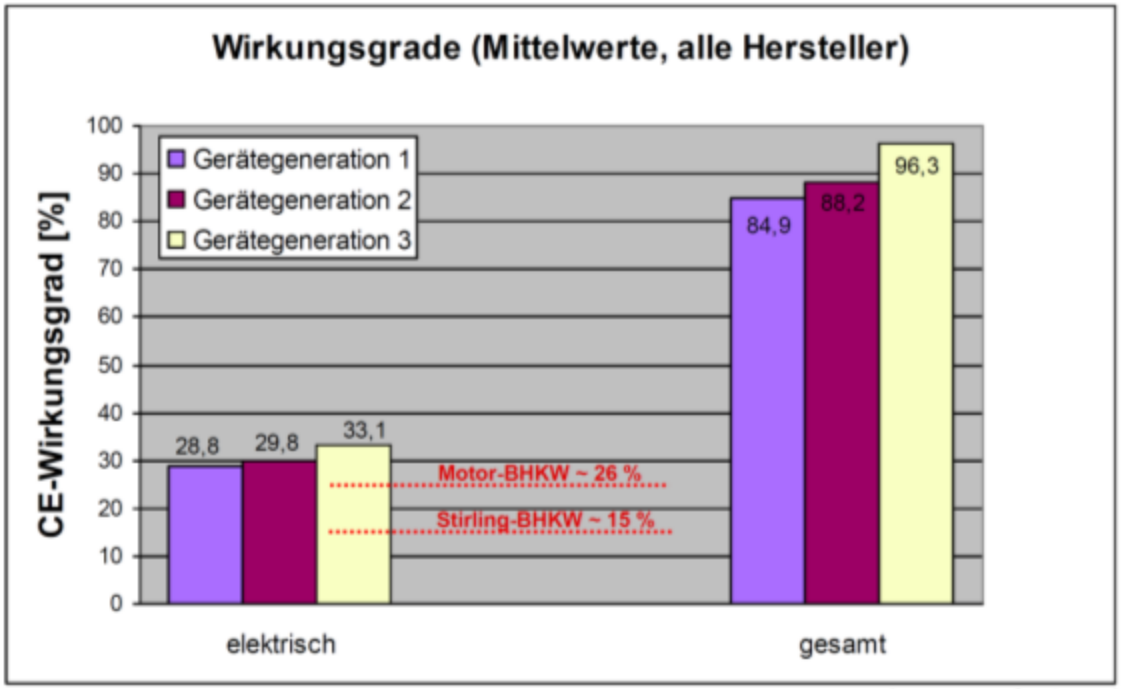
By 2014, approximately 500 fuel cell heating appliances are installed and in operaton.

Development of costs for a Fuel cell system
(averages over all manufacturers)



During the project,
the equipment costs were reduced by about 60% (investment).

efficiency
(averages over all manufacturers)



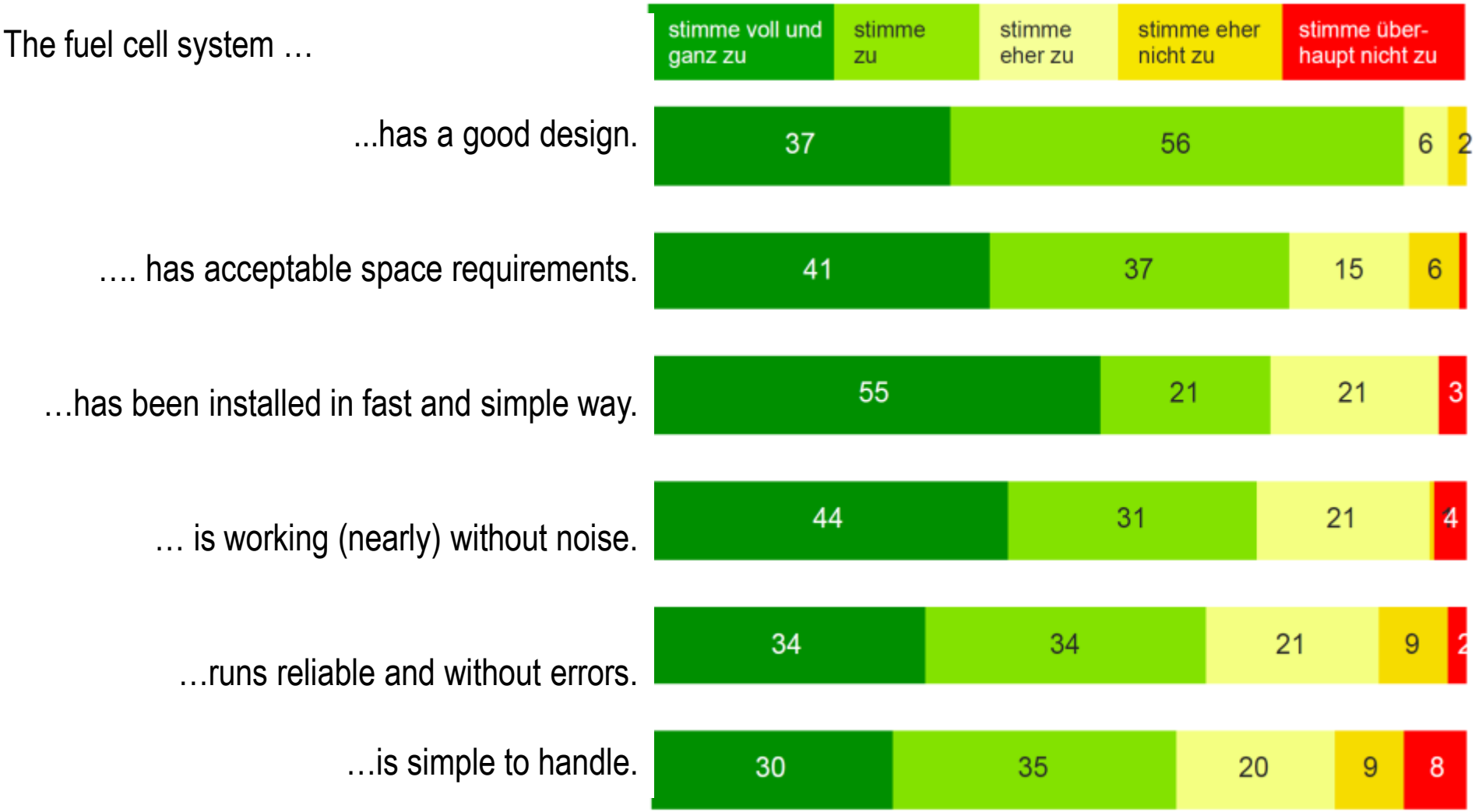
bezogen auf unteren Heizwert, H_u

The efficiencies have successively been increased:

el. efficiencies - > 33%

overall efficiencies > 96%.

Some results - up to now



Befragung von Callux-Feldtestkunden im Juni 2013.

- Significant **reduction** of device dimensions and **weight** (up to 50%)
- Confirmation **low emissions** and **noise**
- **Increasing ease** for installation in the existing building services
- Significant **reduction in maintenance** operations
- **Increase** the **annual operating** hours by demand modulation
- Increase the **power to heat ratio**
- Stack **maturities of approx. 10,000 h** detected in the 2-year field tests
- Further **reduction** of the **stack degradation** rates up to <0.2% per 1000 h

SOFC / PEM Systems used for

callux (nip)
Praxistest Brennstoffzelle fürs Eigenheim

Brennstoffzellen-Heizgerät von Hexis: Galileo 1000 N

KWK-Teil	
Typ	Festoxid-Brennstoffzelle (SOFC)
Leistung (el/th)	1,0 kWel / 1,8 kWth
Modulation	100-50 %
Brennstoff	Erdgas, Bioerdgas
el. Wirkungsgrad (Hi)	30-35 %
Gesamtwirkungsgrad	95 %
Integriertes Zusatzheizgerät	
Typ	Brennwertgerät
Leistung	4-20 kW
Normnutzungsgrad	109 % (η_sN bei 40/30°C)
Gesamtgerät:	
Gesamtwirkungsgrad	> 95 % (nach EN 50465 bei VL/RL 60/40°C)
Größe (cm), BxTxH	62 x 58 x 164
Gewicht	ca. 170 kg
Gehäuse	lackiert, vollgekapselt
Erdgasdruck	20-25 mbar (EN 437)
Elektrischer Anschluss	230 V/ 50 Hz
Betriebsart	wärmegeführt, Energiemanager geregelt, Steuerung auch über Fernzugriff

Brennstoffzellen-Heizgerät von Baxi Innotech: GAMMA PREMIO

KWK-Teil	
Typ	Niedertemperatur PEM-Brennstoffzelle (70°C)
Leistung (el/th) [1]	max. 1,0 kW_{el} / 1,87 kW_{th}
Modulation	ca. 100 – 40 % P_{el}
Brennstoff	Erdgas, Bioerdgas
el. Wirkungsgrad (Hi)	34,1 %
th. Wirkungsgrad KWK	62,0 %
Gesamtwirkungsgrad	96,1 % (Leistungsmessung TÜV Rheinland)
Integriertes Zusatzheizgerät	
Typ	Brennwertgerät
Leistung	3,5-20 kW
Normnutzungsgrad	109 % (η_sN bei 40/30°C)
Gesamtgerät	
Größe (mm), LxBxH	600 x 600 x 1515
Gewicht	ca. 235 kg
Gehäuse	lackiert, vollgekapselt
Erdgasdruck	20 / 25 mbar (EN 437)
Elektrischer Anschluss	230 V / 50 Hz
Betriebsart	stromgeführt, wärmegeführt, Energiemanager geregelt, zentral gesteuert (virtuelles Kraftwerk)

[1] Typ H-Gas

Brennstoffzellen-Heizgerät von Vaillant:

Typ	Festoxid-Brennstoffzelle (SOFC)
Leistung (el/th)	max. 1,0 kWel / 2,0 kWth
Einsatzbereich	Einfamilienhaus
Brennstoff	Erdgas, Bioerdgas
el. Wirkungsgrad (Hi)	31 %
Gesamtwirkungsgrad KWK	87 %
Gerätedaten	
Größe (mm), LxBxH	600 x 625 x 986
Gewicht	ca. 150 kg
Gehäuse	lackiert, voll gekapselt
Erdgasdruck	20-25 mbar (EN 437)
Elektrischer Anschluss	230 V/ 50 Hz
Betriebsart	wärmegeführt, Energiemanager geregelt, Steuerung auch über Fernzugriff
Externes Zusatzheizgerät	
Typ	Brennwertheizgerät
Leistung	je nach Bedarf konfigurierbar
Normnutzungsgrad	109 % (η_sN bei 40/30°C)

Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

For further details please contact

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National Organization Hydrogen and Fuel Cell Technology

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download: www.now-gmbh.de

Content

H_2-application - fuel cell system certification

- Different types of fuel cell applications, e.g.:
  - Stationary use
  - Portable use
  - Vehicle applications
  - Fuel cell modules (e.g. stack)
  - Micro fuel cell systems

- There are different RCS for the European, American and Asian market, e.g.:
  - European Directives e.g. 97/23/EC, 2006/42/EC, 2004/108/EC, 94/9/EC, 79/2009/EC
  - IEC 62282 (Europe, worldwide)
  - ANSI/CSA FC (North America)
  - JIS C (Japan)

➢ ***Challenge:*** How is it possible to consider every single requirement for the different worldwide markets at the product design stage for manufacturing and operation?

CE 0036

- **Low Voltage Directive:** Directive 2014/35/EU
- **Electromagnetic Compatibility Directive:** Directive 2014/30/EU
- **ATEX Directive:** Directive 2014/34/EU
- **Lifts Directive:** Directive 2014/33/EU

- **Simple Pressure Vessels Directive:** Directive 2014/29/EU

- **Measuring Instruments Directive:** Directive 2014/32/EU
- **Non-automatic Weighing Instruments Directive:** Directive 2014/31/EU
- **Civil Explosives Directive:** Directive 2014/28/EU

- **Pressure Equipment Directive:** Directive 2014/68/EU

H_2-application - fuel cell system certification

TÜV SÜD certification

IEC 62282
Fuel Cell Technologies

(EU) 79/2009
Hydrogen-powered motor vehicles

94/9/EC
"ATEX Directive"

ECE R100
Electric safety

2004/108/EC
Electromagnetic Compatibility

2006/42/EC
Industrial Machinery Directive

97/23/EC
Pressure Equipment Directive

ANSI/CSA FC 1-2004
Stationary Fuel Cell Power Systems

2006/95/EC
Low Voltage Directive

H_2-application - fuel cell system certification

Steps of the certification process

1. Evaluation of relevant risks to determine the necessary protection devices
   Basis:
   - deterministic safety concept,
   - FMEA (Failure Mode and Effects Analysis)
   - HAZOP (Hazard and Operability Study) etc.

Safety concept

- Pressure (to high, to low)
- Temperature (to high, to low)
- Fluid (reverse flow, wrong media)
- Explosion Protection

Documentation review

2. Evaluation of functional safety requirements for safety-related components based on e.g. IEC 61508, IEC 61511 (SIL)

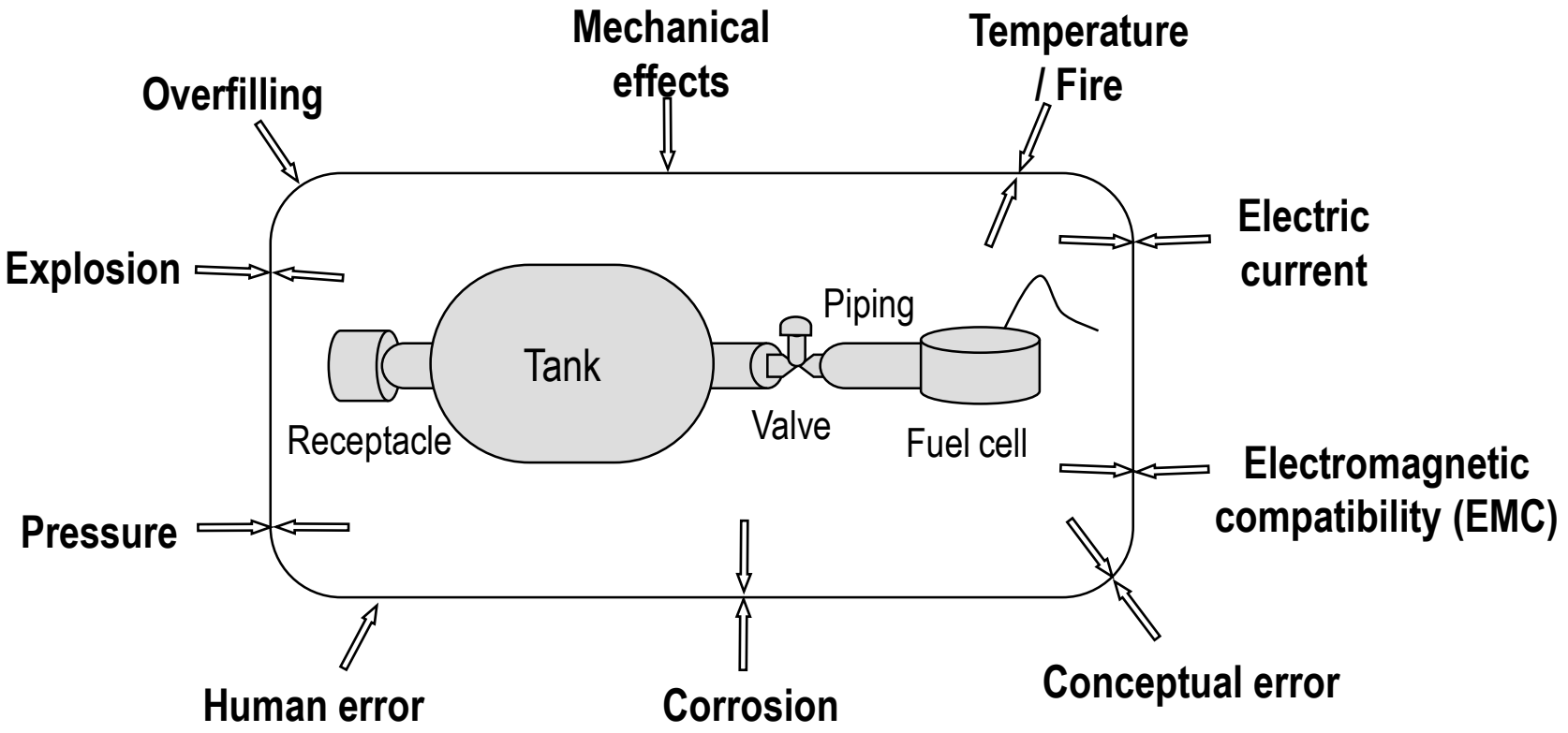
product testing
Proof of concept - verification

- Pressure test
- Leakage tests
- Steady-load test
- Lack of oxygen
- Error current
- Wind- and shock test
- Drop test
- Operating instructions

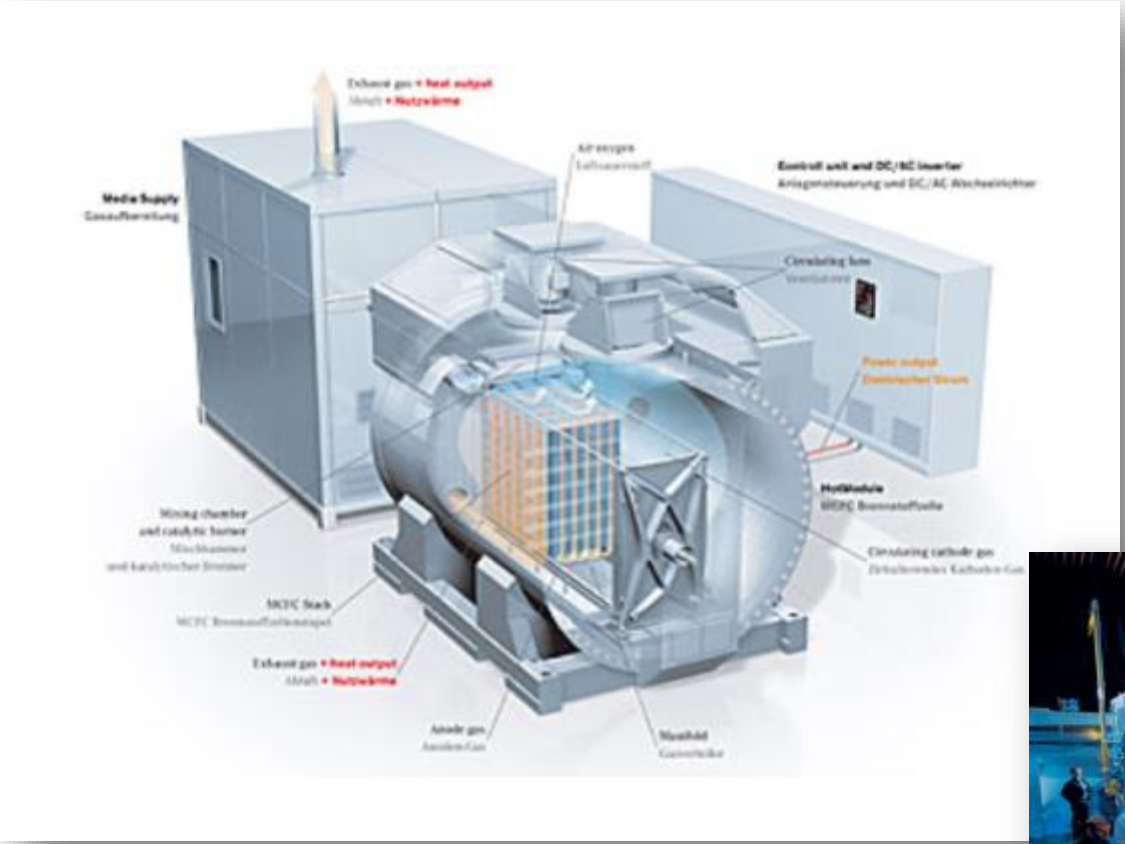
Testing of a specimen

3. Realization of the safety concept
   Verification of 1 and 2 and proof of documentation

Aspects of the safety concept



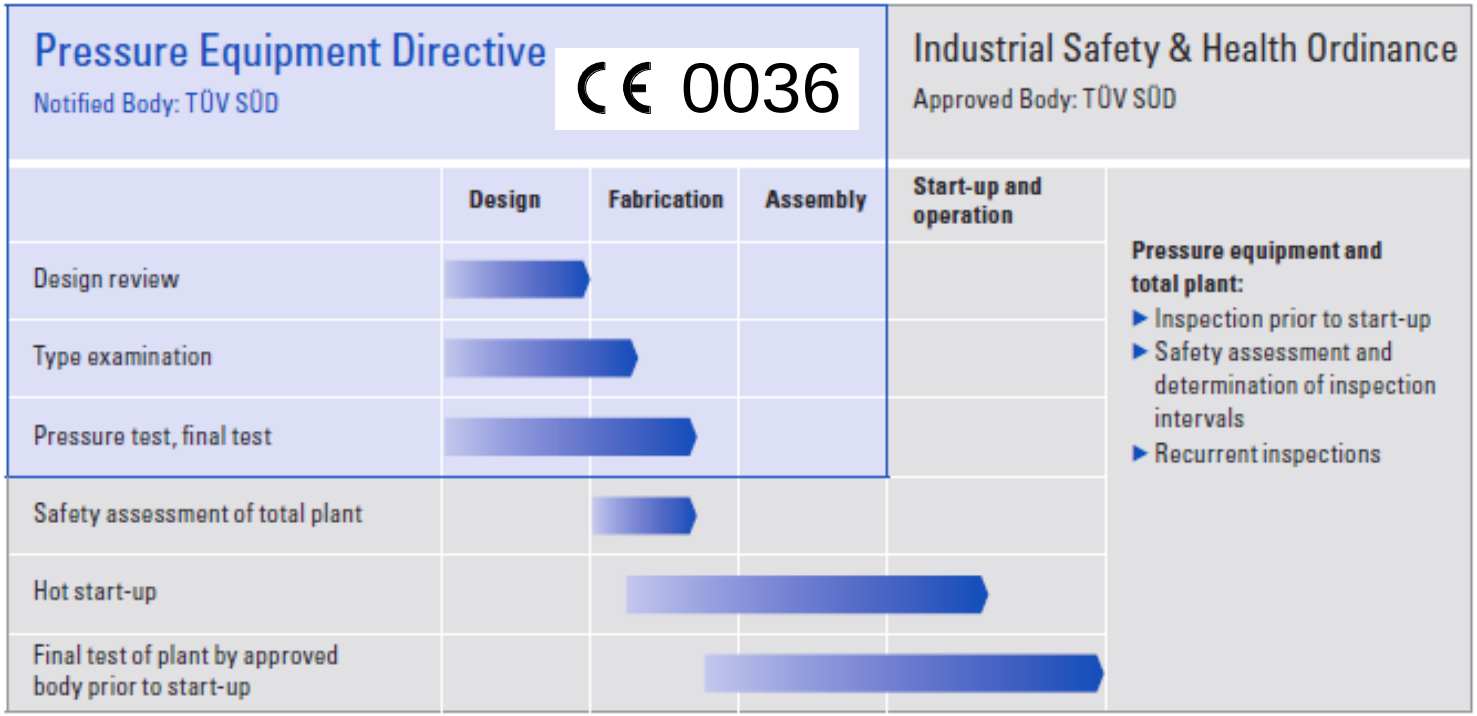
Complex systems – stationary application



Hot Module, MTU Onside Energy

TÜV SÜD services for manufacturing and operation

manufacturing → operation



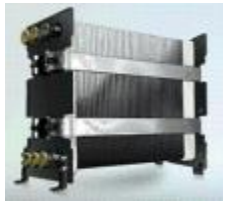
Hydrogen Refueling Stations (HRS)

Who cares for the correct interface between vehicle and HRS?

Vehilce with fuel cells

Storage Systems
Testing and Certification

Components
Testing and Certification



Fuel Cell Stack / – system
Testing and Certification, Safety,
EMC and Efficiency

Vehicle Integration
Explosion / Fire and mechanical Protection,
Electric and Battery Safety

H_2-mobility - Component certification (EU, China, USA etc.)

Daimler

Daimler

Toyota

BMW

e1

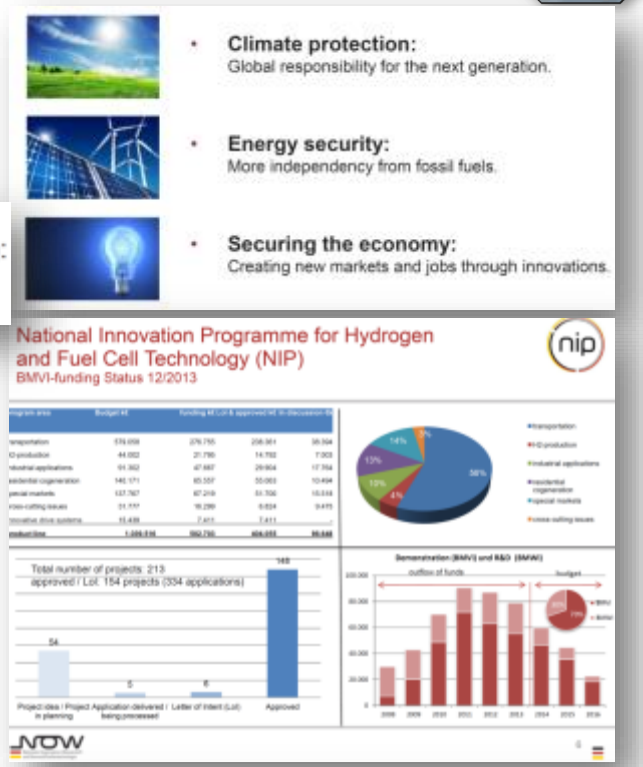
- Cylinders – Type I, II, III, IV
- Automatic valves
- Manual valves
- Pressure regulator
- Injection nozzle
- Flexible fuel line
- Pressure / temperature sensor
- Pressure gauge
- Electronic control
- Connecting parts

Content

Conclusions

- Political Goals are adressed clealy within Germany
- German Government sets NIP in place:
  (National Innovation Programme for Hydrogen and Fuel Cell Technology)

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



- different application do need different ways of **governmental and industry support**
  - financial funding
  - technical issues
  - communication platforms to synchronize technical issues (e.g. interface FCV-HRS)

and there is a **need for standardization**, where **industry** must be in the **driver seat** to adress early markets

with support of an independent **third party** TÜV SÜD

Thank you for your attention!

One-stop testing, inspection, certification and training solutions for business success

Presented by Tom Elliger

Choose certainty.
Add value.

Back-up

Choose certainty.
Add value.

Process plants – examples central Eastern Europe – TÜV SÜD activities

Rafness, Noretyl , Norway
Plant: Ethylene Cracking Furnace
Completion: 2015, BG PED

Dscherschinsk (Region Nischni Nowgorod)
Plants: Air Separation Units
Completion: 2014

Swinoujscie, Poland
Plant: LNG
Completion: 2013, BG PED

Nishnekamsk (Republic Tatarstan)
Plant: Hydrogen plant
Completion: 2015

Atyrau, Kazakstan
Plant: Petrochemical complex –
ASU, Ethan craker, Polyethylen and Gas pipeline
Completion: 2016-2017

Tuepras, TK

Togliati, Oblast Samara
Plant: H2/NH3 piping / Steam Reformer
Completion: 2015

- Industrial Gases
- Healthcare
- Engineering division

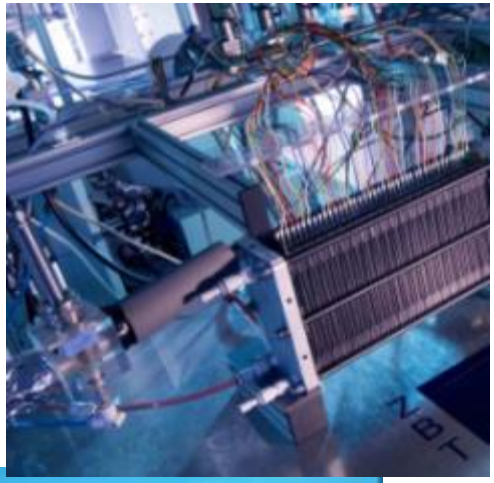
Testing facilities – for fuel cells

TÜV SÜD cooperates with external accredited testing facilities/laboratories for testing of fuel cell systems/modules, high pressure equipment, hydrogen etc.

Testing according to IEC 62282-2

(accredited laboratory EN ISO/IEC 17025)

- The testing facility offers separate enclosed testing areas in order to guarantee technical confidentiality
- Three modular, reverse-traceable test-stands for fuel cells with a power range from 200 Wel up to 20 kWel are available
- Testing of fuel cell modules with either pure hydrogen or with hydrogen mixtures
- Ability to test 5-cell up to 100-cell stacks
- Optional air or water cooled modules
- Inspections up to 900 Ampere and 100 Volt
- Up to 6 bar operational pressure
- Operation under either pure feed gases or gas mixtures for anode and cathode sides
- Operation under differing climatic conditions



Testing facilities – for fuel cells

High pressure testing with Hydrogen / CNG
(accredited laboratory EN ISO/IEC 17025)

- climate chambers for sample conditioning **from -60 °C to 200 °C**
- testing with **hydrogen**, CNG and other gases up to **200 MPa**

- ***Component testing***

Functional tests with compressed gas

- ***Permeation measurement***

  Gases H_2, He, CH_4
  Single cylinders & complete systems

- ***Burst testing***

  Components or complete tanks
  Combination with high-speed cameras

- *Validation and certification testing*

  Leak and function testing
  Development support

- ***Fuel cell testing***

  Operation under extreme ambient conditions
  Gas tightness of single components or complete systems
  Destructive tests
  Durability

Testing facilities – for fuel cells

High pressure hydrogen / cryo compressed hydrogen testing
(accredited laboratory EN ISO/IEC 17025)

- *Tests beyond certification limits*
  Pressures > 87.5 Mpa
  Temperatures < - 60°C > +85 °C
- *Gas cycle tests with*
  chemically/mechanically pre-damaged tank systems
- *Thermal shock testing*
  quick tank system temperature changes
  extreme gas pre-conditioning
- *Measurement of substantial leaks*
- *Emission (permeation + leakage)*
  measurement during draining and filling
  emission measurement during gas cycle tests continuously
- *O-ring tests*
  gas tightness at various temperatures
- *Long-term exposure to hydrogen*
  max. pressure 100 MPa
  max. temperature 300 °C
- *Hydraulic burst tests*
- *Ignition of released hydrogen gas*






H_2-infrastructure - filling stations

Hydrogen refueling stations

Europe‘s larges HRS, Hamburg, 2012

OMV Stuttgart Airport, 2010

Mobile HRS, Linde, 2006

Flexible location , H2logic, 2011

Sustainable Hydrogen Applications

Who cares for the correct interface between vehicle and HRS (hydrogen filling station)?

Test and certification of 70 MPa cylinder (Type 4)

Special test facilities

Test and certification of 70 MPa cylinder (Type 4)

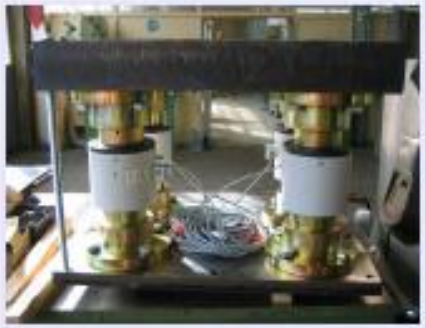
Special test facilities

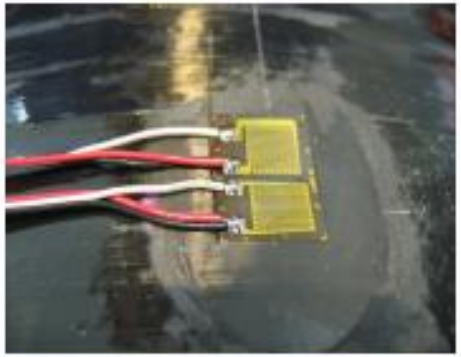
Technical Data:

max. drop weight: 2.5 t
max. drop height: 7m
Adjustable positioning
Remote-controlled activation
Tests with flammable gas possible

Measurement equipment:

Acceleration sensor
Inner-tank pressure
Strain gauge
Ambient pressure
High-speed camera
Infra-red camera
etc.





Training and education of personnel

level of qualification - safe hydrogen handling

Führungskraft Im wasserstofftechnischen Umfeld	**Fach-verantwortung der durchgeführten HV-/ H_2-Tätigkeiten in ihrem Bereich**	vEFK 5
H_2 befähigte Person 4	**(eigen-) vera ntwortliche Tätigkeiten am HV-/ gasführenden System**	EFK 4 (optional 4 AuS)
H_2 befähigte Person Für festgelegte Tätigkeiten 3	**Festgelegte Arbeiten an HV-/ gasführenden Systemen**	EFKfft 3
H_2 unterwie-sene Person 2	**Allgemeine Arbeiten an elektrifizierten / gasführenden Fahrzeugen (nicht am HV/H2-System)**	EUP 2
H_2 Basis Mit Fahrberechtigung 1	**Elektrifiziertes / gasführendes Fahrzeug fahren und bedienen**	EL Mit Fahrberechtigung

EL Elektrotechnischer Laie EFKfft Elektrofachkraft für festgelegte Tätigkeiten AuS Arbeiten unter Spannung
EU

The Clean Energy Partnership

Fields of Activities:

- Hydrogen Production
  Technical improvement of electrolyzers, compressors and storage technologies.
- Infrastructure
  Technical improvement of refueling technology and deployment of an initial HRS infrastructure.
- Mobility (Cars and Busses)
  Technical improvement of the FC System and running demonstration fleets.

50 HRS for Germany

- **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 (BMVI) 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)
- **coordination by NOW GmbH in the frame of the Clean Energy Partnership (CEP)**

Federal Ministry of Transport, Building and Urban Development

Current Status:

- Location planning of the 50 HRS has been finalized.
- Currently there are application for funding for 23 HRS, the remaining 12 HRS are in the planning phase.
- The majority of the HRS will be operated by H2-Mobility after the funded project time frame has ended.
- About ~110 FCEV's are currently on the road.

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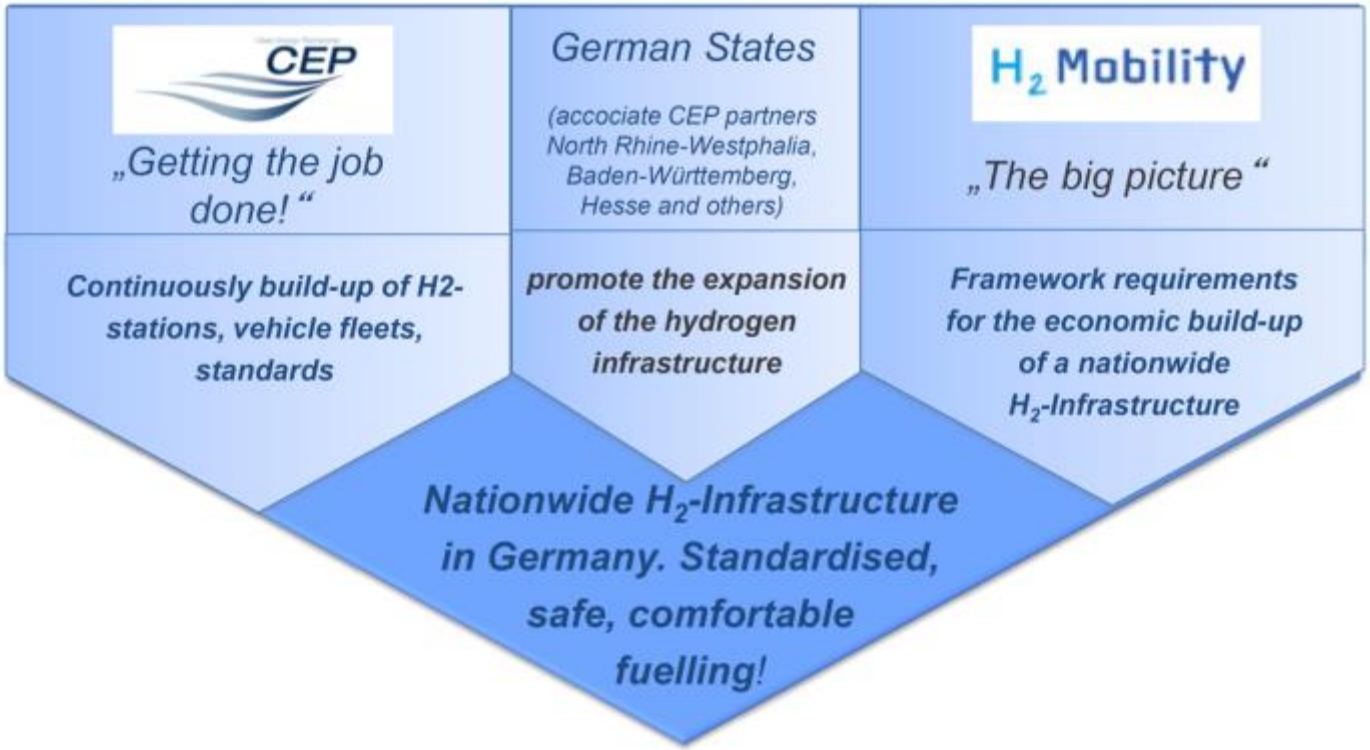
CEP & H2 Mobility – Expansion of the filling station network in Germany



NOW

H2-Mobility action plan until 2023

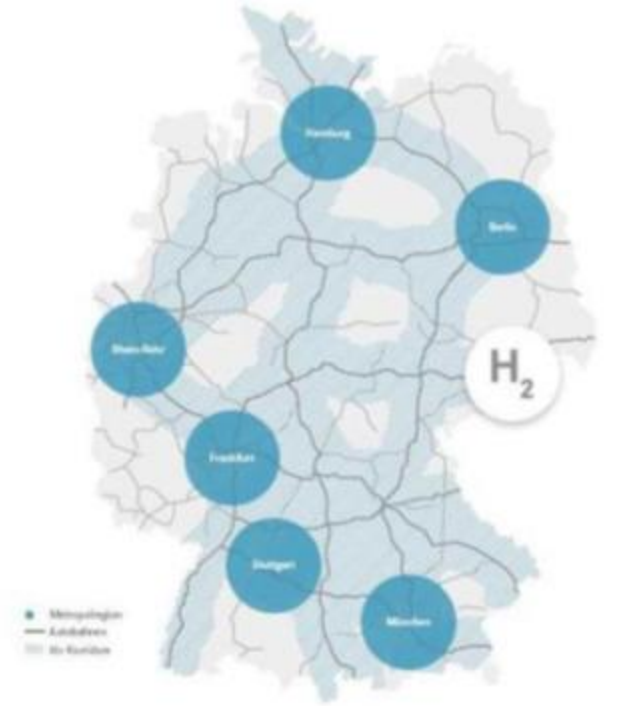
H_2 Mobility

DAIMLER TOTAL AIR LIQUIDE OMV Linde SHELL

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.



H_2 Mobility

NOW