Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

# Policy and Market Environment for Electrolyzers in Germany

IEA ANNEX 30 Electrolysis Meeting | MEGASTACK Workshop |
Herten, Germany | April 20-21, 2015 |

Dr. Oliver Ehret | Programme Manager Hydrogen Provision |
National Organization Hydrogen and Fuel Cell Technology |

# Environmental Policy Goals


**reduce *overall* GHG emissions**
(1990 baseline)
40% by 2020 ➔ 80%-95% by 2050

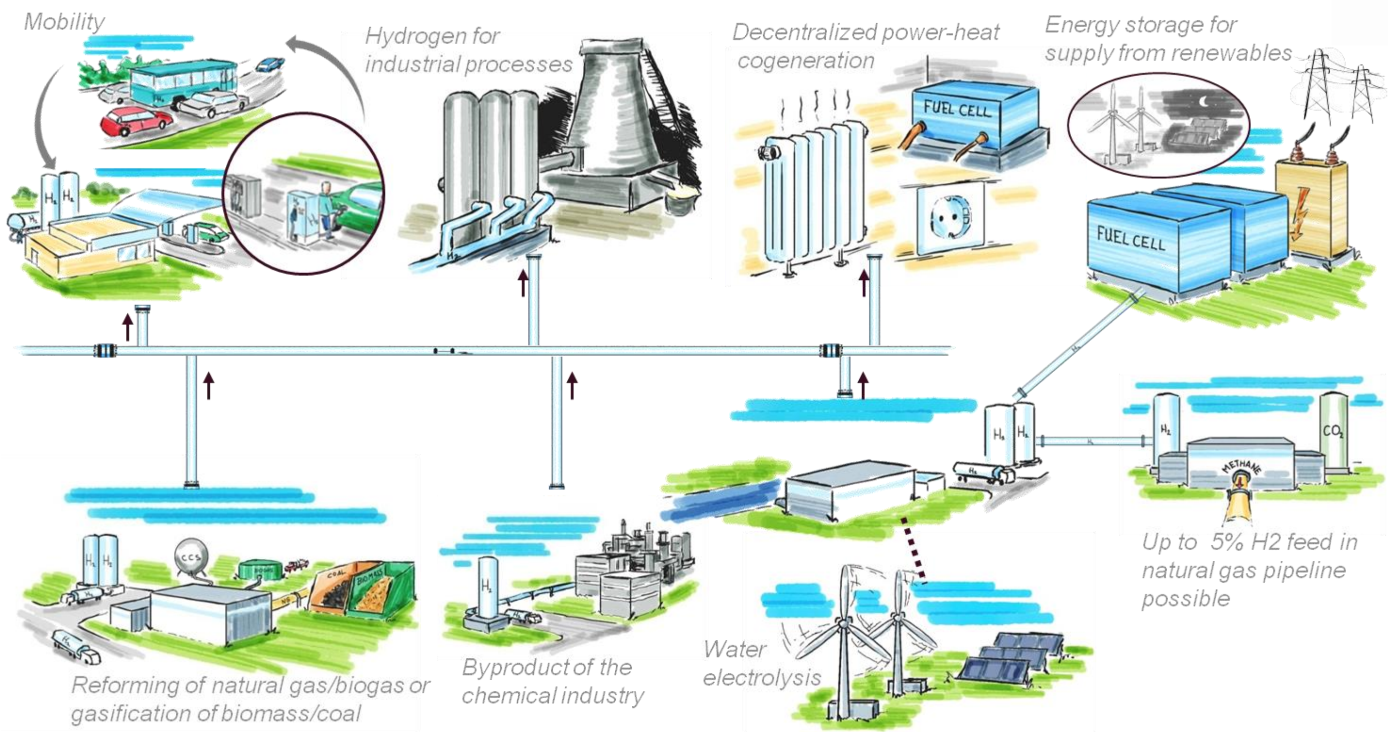
**increase share of renewable energies in final energy consumption**
18% by 2020 ➔ 60% by 2050

**reduce primary energy consumption (increase energy efficiency)**
20% by 2020 ➔ 50% by 2050

**goals for *transport***
reduce final energy consumption (vs. 2005)
10% by 2020 ➔ 40% by 2050

**electrification of drive trains (FCEVs, BEVs) crucial for reaching targets**

# Market Opportunities for Hydrogen: Production & Use, Applications & Initiatives



# NOW GmbH manages NIP and BMVI Research Activities on Electric Mobility

set up 2008

NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

nip

implementation

PtJ Projektträger Jülich Forschungszentrum Jülich

2007

National Innovation Programme Hydrogen and Fuel Cell Technology
- market preparation
- R&D & demonstration
- public + private sector €700 m. each

➢€1.4 billion

2016

Federal Ministry of Transport and Digital Infrastructure

Federal Ministry for Economic Affairs and Energy

coordination

Modellregionen Elektromobilität

2009

- BMVI research and demonstration activities on Electric Mobility
- battery vehicles

2016

Federal Ministry of Transport and Digital Infrastructure

# Hydrogen as a Fuel and Energy Storage in the NIP


need to **integrate large and growing volumes of fluctuating energies in stationary and transport energy sector!**

vast expansion of **wind power** turns wind into **main source of energy for $H_2$ fuel production**

- key technology large-scale electrolysis
- need for demonstration of wind-$H_2$-systems
- studies required


$H_2$ based on **biomass** also relevant; though potentials are limited

# Hydrogen Vehicles and Infrastructure: Clean Energy Partnership

Clean Energy Partnership CEP

Ein Projekt im Nationalen Innovationsprogramm Wasserstoff- und Brennstoffzellentechnologie nip

CEP I Berlin : Demonstration Project 2003-2008

- **17 hydrogen / fuel cell vehicles** (Ø)
- **2 public hydrogen retail stations**

CEP II: Lighthouse Project 2008-2010

- enlargement: **Hamburg, North Rhine-Westphalia , Baden-Wuerttemberg**
- growth and modernization of **FCV fleet** (cars and buses)
- construction and operation of **new HRS**
- 48 % of project costs borne by NIP, 52 % by companies

CEP III: Market Preparation 2011-2016

- **Hessia** joined as additional region
- corporate membership grew to **20 firms** (2015)
- new generation **vehicles** and **infrastructure**
- over **100 fuel cell cars and busses, 17 HRS** (2015)
- at least **50 % renewable $H_2$ production** (2015)


# Wind & Solar Hydrogen in the CEP



February 2012: HRS Hamburg HafenCity commissioned by Vattenfall and Shell

March 2012: HRS in Freiburg opened by Fraunhofer ISE

March 2013: HRS in City of Stuttgart commissioned by EnBW


April 2012: ENERTRAG Hybrid Power Plant supplies wind $H_2$ to TOTAL HRS in Berlin for first time


May 2014: opening of multi-energy refueling station at Berlin airport by Total and partners

# Additional HRS in the CEP


March 2015: opening of Shell HRS with on-site PEM-electrolysis in Hamburg


**Goal for early 2016: 50 HRS facilitate FCEV commercialization**

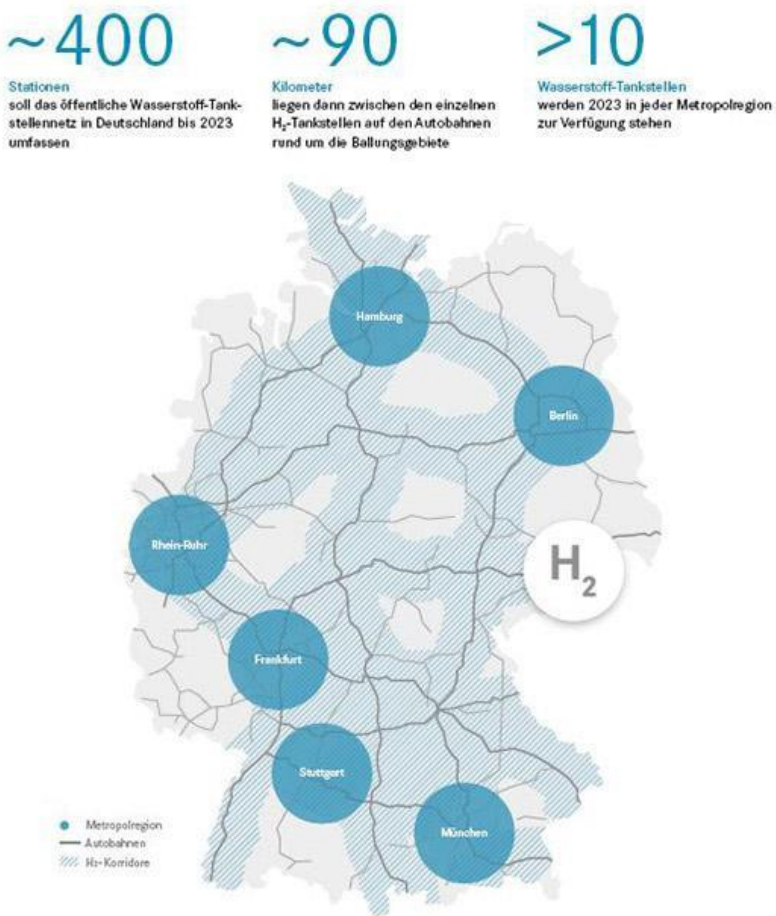
# $H_2$ Mobility Action Plan up to 2023

30th September 2013:

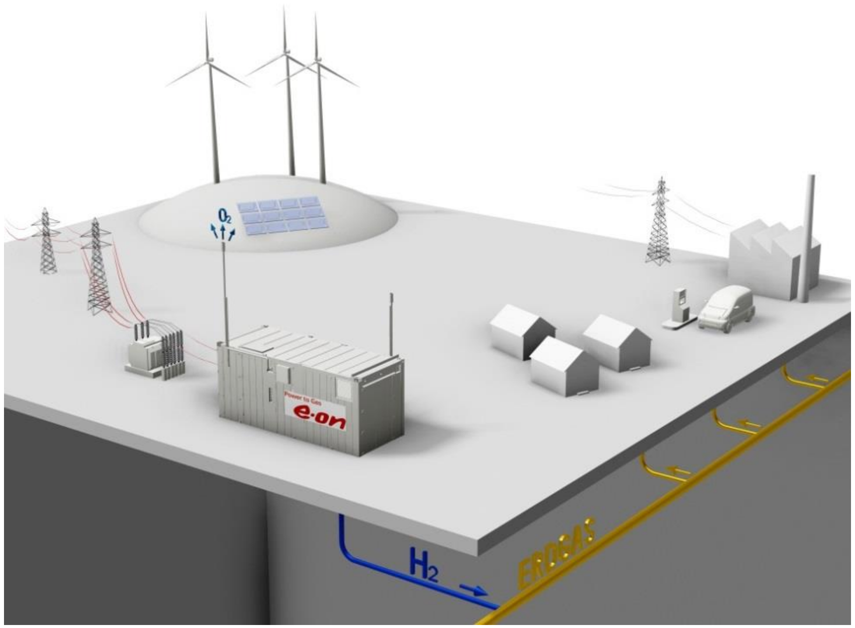
**Air Liquide, Daimler, Linde, OMV, Shell** and **Total** agree on an action plan for the construction of a hydrogen refueling network in Germany

**Targets:**

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



# Demonstration Project KompElSys: Power-to-Gas for Hamburg





- 1MW PEM-electrolyzer
- injection of $H_2$ into natural gas grid
- budget 13,789 Mio. €
- 11-2012 to 06-2016

ground-breaking ceremony June 2013

e·on | HYDROGENICS SHIFT POWER | ENERGIZE YOUR WORLD | SolviCore Fuel Cell Technologies | DLR Deutsches Zentrum für Luft- und Raumfahrt | Fraunhofer ISE

# Wind Hydrogen Project RH2-WKA

**Renewable Hydrogen- Werder/Kessin/Altentreptow**

## Demonstration of Wind-$H_2$-System

- conception, construction and operation
- electricity supply for wind power plants at times of calm
- planned budget 9,426 Mio. € (later reduced)
- 10-2009 to 07-2015

WIND-projekt

WiWa

completed plant


commissioning of plant September 2013

# Study on Water Electrolysis

Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Program NOW Workshop

**Water Electrolysis: Status and Potential for Development**

9 May 2011

Berlin


main study results:

both **alkaline** and **PEM-technology** are **promising** but require further R&D and demonstration

**electrolyzer manufacturers** and **users** presented

discussion showed:

growing demand for hydrogen as a **fuel, energy storage, industrial gas** and **natural gas addition** likely to create **market pull**

**prospects** for overcoming technology challenges thus regarded **good**

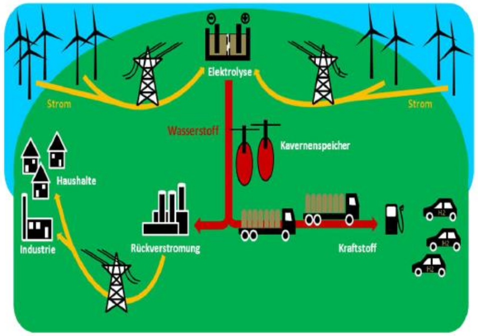
# Study: Integration of Wind-Hydrogen-Systems in the Energy System

NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Ergebnisvorstellung der NOW-Studie

**Integration von Wind-Wasserstoff-Systemen in das Energiesystem**

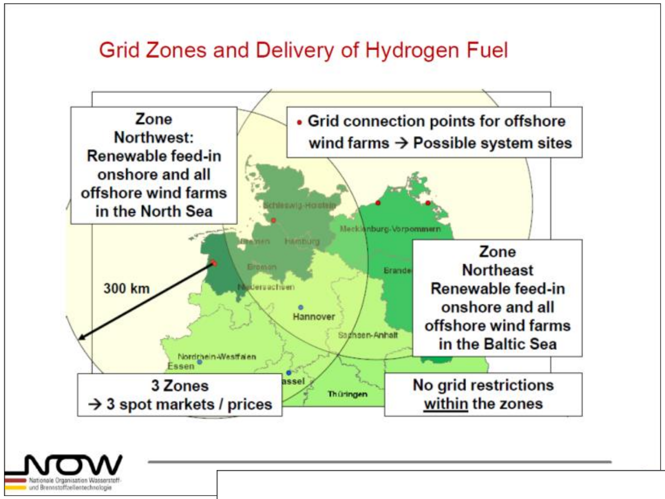
28. Januar 2013
Berlin

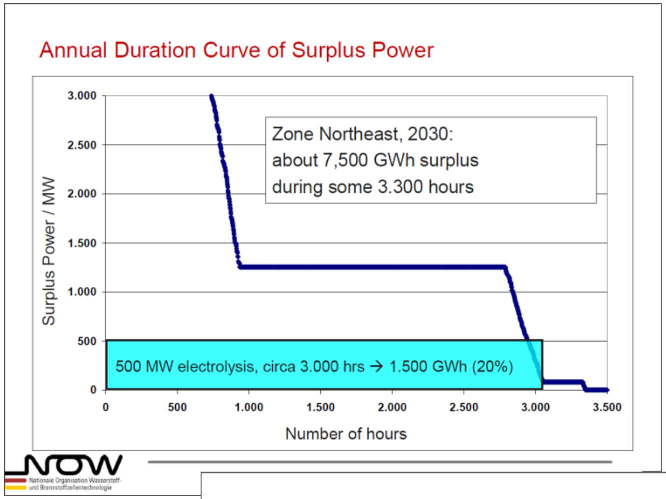


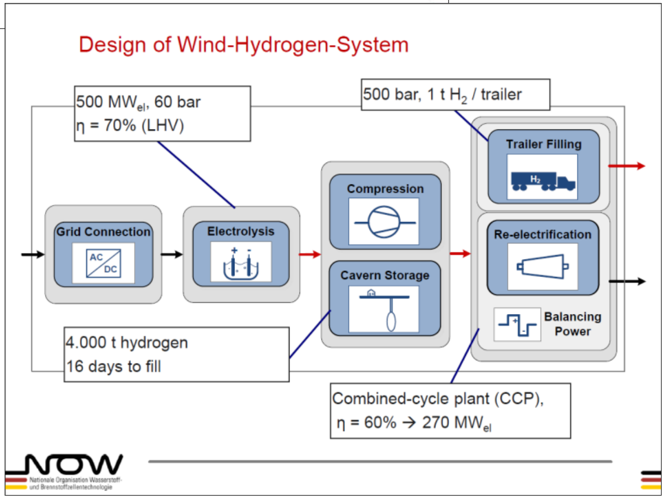

PLANET GbR | IFEU Institut für Energie und Umwelt e.V. | fachhochschule lübeck PROJEKT-GMBH | KBB Underground Technologies | Fraunhofer ISI

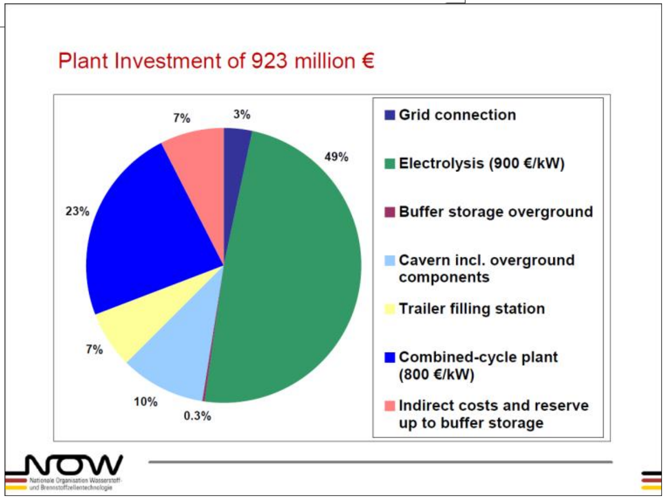
- Volume 'excess' wind power in Germany 2030?
- Technology and costs wind-hydrogen-systems?
- Best options for $H_2$ transport and stationary use?

# Central Issues Investigated



# Results: Revenues Required to Break Even in Different Scenarios

| Case | "Less fuel" | "Standard Northeast" | Investment electrolysis 700 €/kW | Investment electrolysis 500 €/kW | Price driven electrolysis operation |
|---|---|---|---|---|---|
| Electrolysis full load hrs | 3.052 | 3.052 | 3.052 | 3.052 | 5.600 |
| Tonnes $H_2$ per year | 32.044 | 32.044 | 32.044 | 32.044 | 59.100 |
| Share for power plant | 38% | 7% | 7% | 7% | 39% |
| | Specifc Revenue to break even [€/kg $H_2$ fuel] | | | | |
| Spot market price | 3,71 | 2,92 | 2,50 | 2,08 | 2,06 |
| 40 €/MWh | 6,80 | 5,00 | 4,58 | 4,16 | |
| 80 €/MWh | 9,90 | 7,08 | 6,66 | 6,24 | |

**Color Key**

Green:

wind-$H_2$ competitive at fuel market

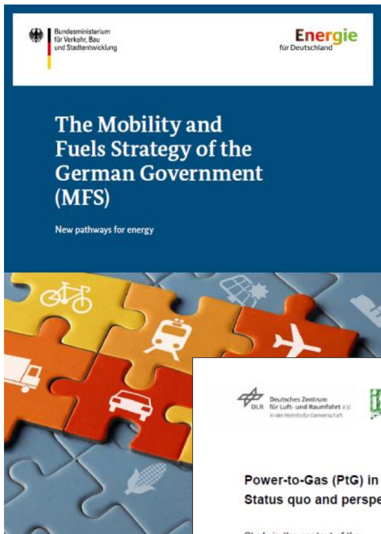
Gold:

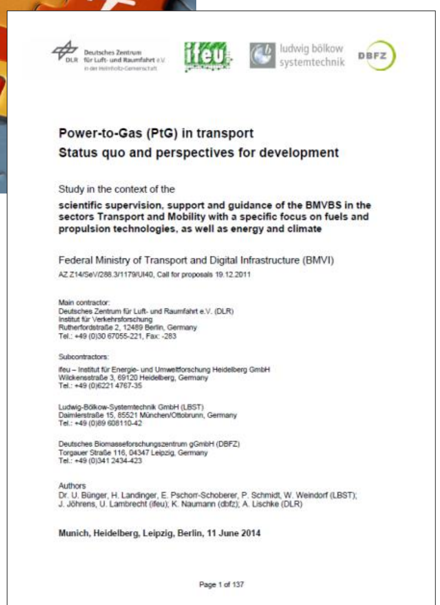
wind-$H_2$ cheaper than $H_2$ from natural gas

Red:

wind-$H_2$ not competitive

# Hydrogen and Fuel Cells in the German Mobility and Fuels Strategy (MFS)



Deutsches Zentrum für Luft- und Raumfahrt e.V. | ifeu | ludwig bölkow systemtechnik | DBFZ

**Power-to-Gas (PtG) in transport**
**Status quo and perspectives for development**

Study in the context of the

**scientific supervision, support and guidance of the BMVBS in the sectors Transport and Mobility with a specific focus on fuels and propulsion technologies, as well as energy and climate**

Federal Ministry of Transport and Digital Infrastructure (BMVI)
AZ Z14/SeV/288.3/1179/UI40, Call for proposals 19.12.2011

Main contractor:
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**Munich, Heidelberg, Leipzig, Berlin, 11 June 2014**

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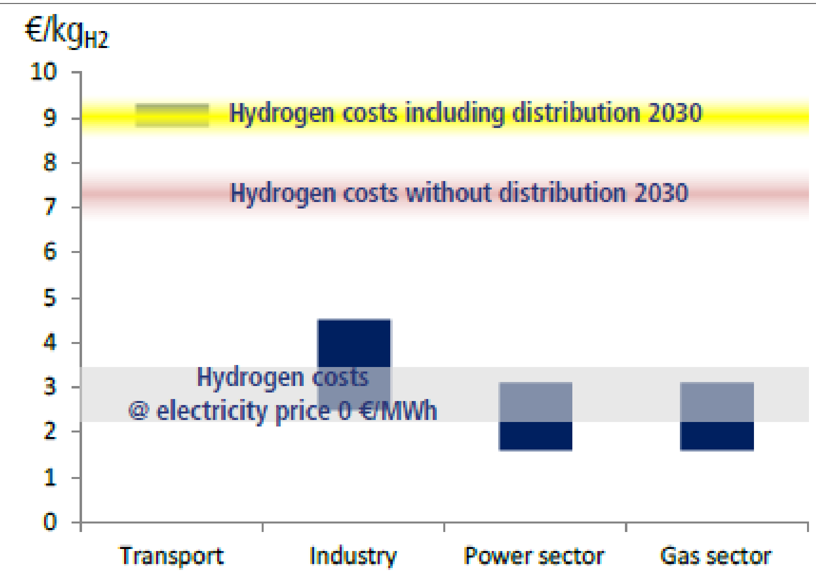


**Figure 14: Hydrogen production costs for 2030 and cost ranges for competing solutions by market sector from Table 2**

# Strategic Planning for Electrolyzer Roll-Out Beyond 2016

Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

**Hydrogen and fuel cell technologies – key pillars of the energy transition 2.0**

Further development of the
National Innovation Programme for Hydrogen and Fuel Cell Technology
(NIP)

Nationales Innovationsprogramm
Wasserstoff- und
Brennstoffzellentechnologie

Berlin, June 2013

Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

- Fuel cells for electric vehicle drives and hydrogen infrastructure for comprehensive, emission-free mobility, with
  - more than 500 public hydrogen fuelling stations nationally,
  - over half a million fuel cell cars on the road and
  - 2,000 fuel cell buses in line service operation within the public transport system
- Hydrogen generation from renewable energies and integration in the energy system as a link between sustainable mobility and energy supply
  - 1,500 MW capacity electrolysers for the generation of hydrogen from renewable energies
  - definition and implementation of successful business models for power to gas
  - development of hydrogen storage mechanisms to store renewable electricity
- Fuel cells for stationary energy supply using decentralised cogeneration in house and building supply, industry and a secure power supply for public safety communication systems, telecommunications, etc.
  - more than a half a million fuel cell heating appliances in operation
  - more than 1,000 MW fuel cell CHP installations in operation
  - more than 25,000 secure power supply installations in place

# Policy and Market Prospects for Electrolyzers


**Production and use of renewable $H_2$ may facilitate achievement of Energy Concept and MFS goals**

- by cutting GHG and other emissions
- integrating RES in transport and stationary sector
- reducing primary energy consumption
- facilitating electrification of drive trains

**Hydrogen may serve various markets**

- transport fuel (fuel cell vehicles)
- stationary energy storage (e.g. grid injection, caverns)
- industrial processes (e.g. refineries)

**Economic interests crucial to market introduction**

- transport market seems most attractive
- but there is keen interest also in other applications
- potential cross-sectoral synergies and scale effects exist
- lifting potential should improve overall business case

## Template for the Task Forces (TFs) of the CEN/CENELEC SFEM WG HYDROGEN

**SFEM Working Group Hydrogen**

Contact : Françoise de Jong (NEN)
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Email : francoise.dejong@nen.nl

### Template for the Task Forces (TFs) of the CEN/CENELEC SFEM Working Group HYDROGEN

| | |
|---|---|
| Date of document | 2015-03-03 |
| Expected action | for reaction from the TF members |
| Due Date | **2015-03-27** |

### 1. Introduction

The new Working Group under SFEM, is jointly convened with the Joint Research Centre (JRC), to provide CEN/BT and CENELEC/BT with concrete proposals on the way forward to address standardization needs in this emerging field.

The scope of work should be large enough to properly map hydrogen-energy related issues and challenges as well as existing standardization initiatives, needs and gaps in a holistic way. According to the manner of working within SFEM for such a mapping exercise, we expect to prepare a "strategy" document with priority topics and issues about innovation and standardization.

Following communication to both CEN and CENELEC BTs, the objectives and main expectations of this new WG on Hydrogen are :

- Map all current relevant standardization activities and the relevant links with European and international standardization work programs (e.g. ISO/TC 197 "Hydrogen technologies");
- Identify the relevant existing test methods and issues related to metrology.
- Make an inventory of the existing projects in this field in Europe and elsewhere, such as for instance: Althytude and GRHYD in France, the GERG -European Gas Research Group-managed projects, etc.;
- Identify and prioritize main research needs and standardization gaps.
- Establish contact with additional relevant stakeholders from gas sector, grids, electric supply, mobility (including Alternative fuel issues), etc. and, if needed, propose the organization of seminars and workshop in specific hydrogen-related areas in order to consult, and attract, existing and new stakeholders;
- Link with the Fuel Cells and Hydrogen Joint Undertaking (FCH-JU) and take into account the outcomes of the projects managed by them, aiming to reduce the production cost of fuel cell systems, increase the energy efficiency of production of hydrogen and



DOCUMENT CEN/CLC SFEM
WG HYDROGEN N0027
Date : 2015-03-03

demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems;
- Consider input from JRC and other relevant EC Services (e.g. DG RTD, DG ENER and DG ENV) including any policy development relating to standardization.

### 2. Scope of work and Organization

The scope of work was globally elaborated with the help of the WG experts during the WG kick-off meeting, held in Brussels last February 9th, 2015, taking into account the outputs of the JRC-EARTO-CEN/CENELEC workshop on "Putting Science into Standards: Power-to-Hydrogen and HCNG", held in Petten last October 21st – 22nd, 2015, as well as FCH-JU expectations from industry and innovation.

During the kick-off meeting, it was agreed to regroup the main issues under 5 Task Forces :

- TF 1: Electricity grid connection.
- TF 2: Electrolyzers and hydrogen storage.
- TF 3: HCNG, gas infrastructure and applications.
- TF 4: Hydrogen infrastructure and applications.
- TF 5: Cross cutting
  Terminology, Regulation/Legislation/Certification, Safety/Security, Metering/Testing/Monitoring, Interfaces to the grid (connectivity), R&D needs; gap analysis, International dimension, Identification of involved stakeholder communities.

### 3. Composition of the TFs

During the kick-off, experts showed their interest in joining actively the above defined TFs. However, other experts are still welcomed to join one or several TFs, in order to complete the expertise and skills of the group.
As of today, the expression of interest in joining the Task Forces are the following :

- TF 1: Electricity grid connection:
  - ✓ Fabian Auprêtre
  - ✓ Bernard Gindroz
  - ✓ John Newton
- TF 2: Electrolyzers and hydrogen storage:
  - ✓ Fabian Auprêtre
  - ✓ Fabian Burggraf
  - ✓ Gonzalo García Jiménez
  - ✓ Robert Judd
  - ✓ Michael Lang
  - ✓ John Newton
  - ✓ Szymon Obrębowski
  - ✓ Thomas Steenberg
  - ✓ Manfred Waidhas

Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

# Thank you very much!

NOW GmbH
National Organization Hydrogen and Fuel Cell Technology

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