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FORSCHUNGSZENTRUM

Integration of Experimental Facilities

A joint effort for establishing a common knowledge base in experimental work on hydrogen safety

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ICHS-3, September 16-18, 2009, Ajaccio (France)

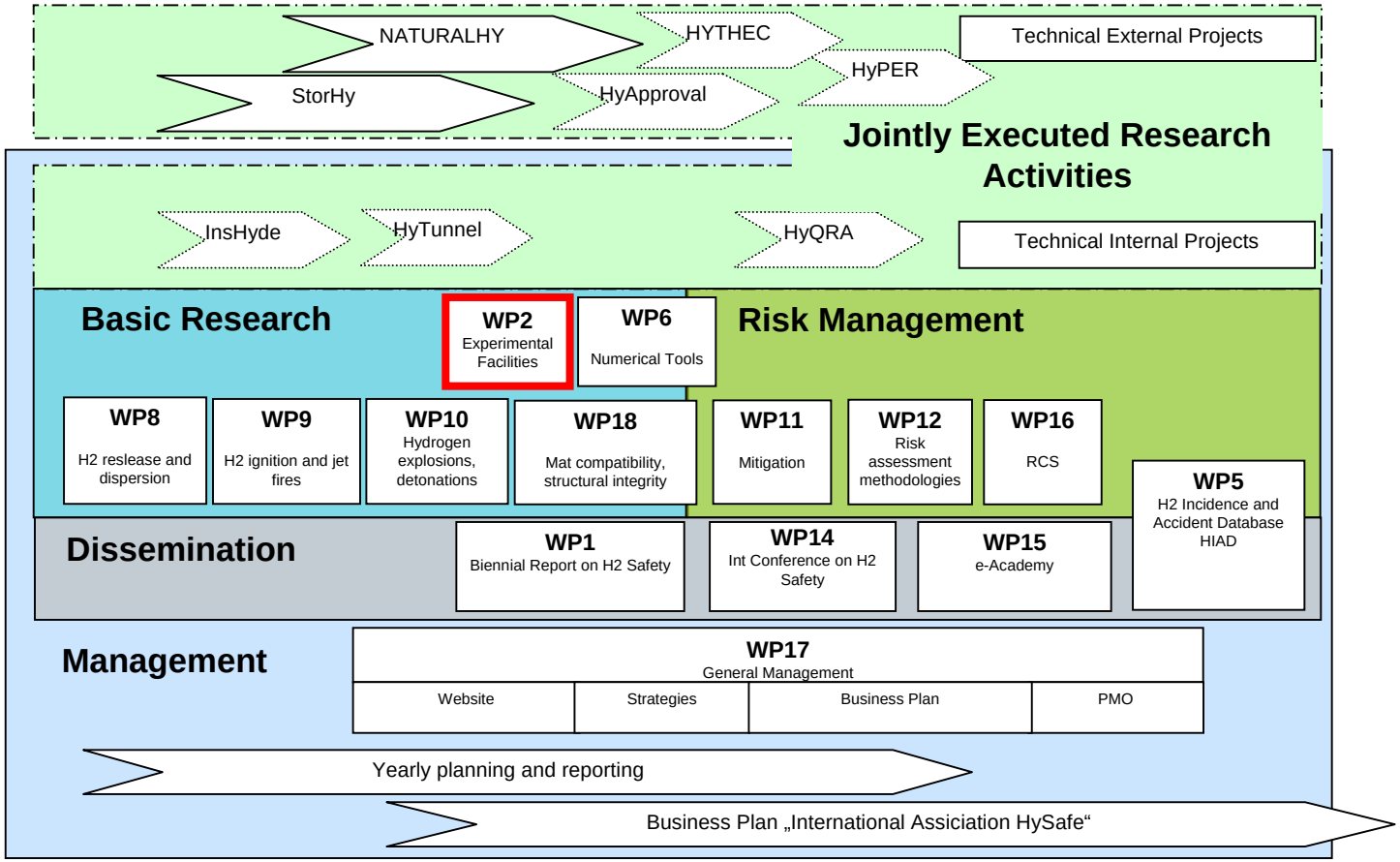
Scope

- Introduction to IEF
- Partners and Facilities in IEF
- Communication and Knowledge Base
- Outlook: IEF in IA HySafe

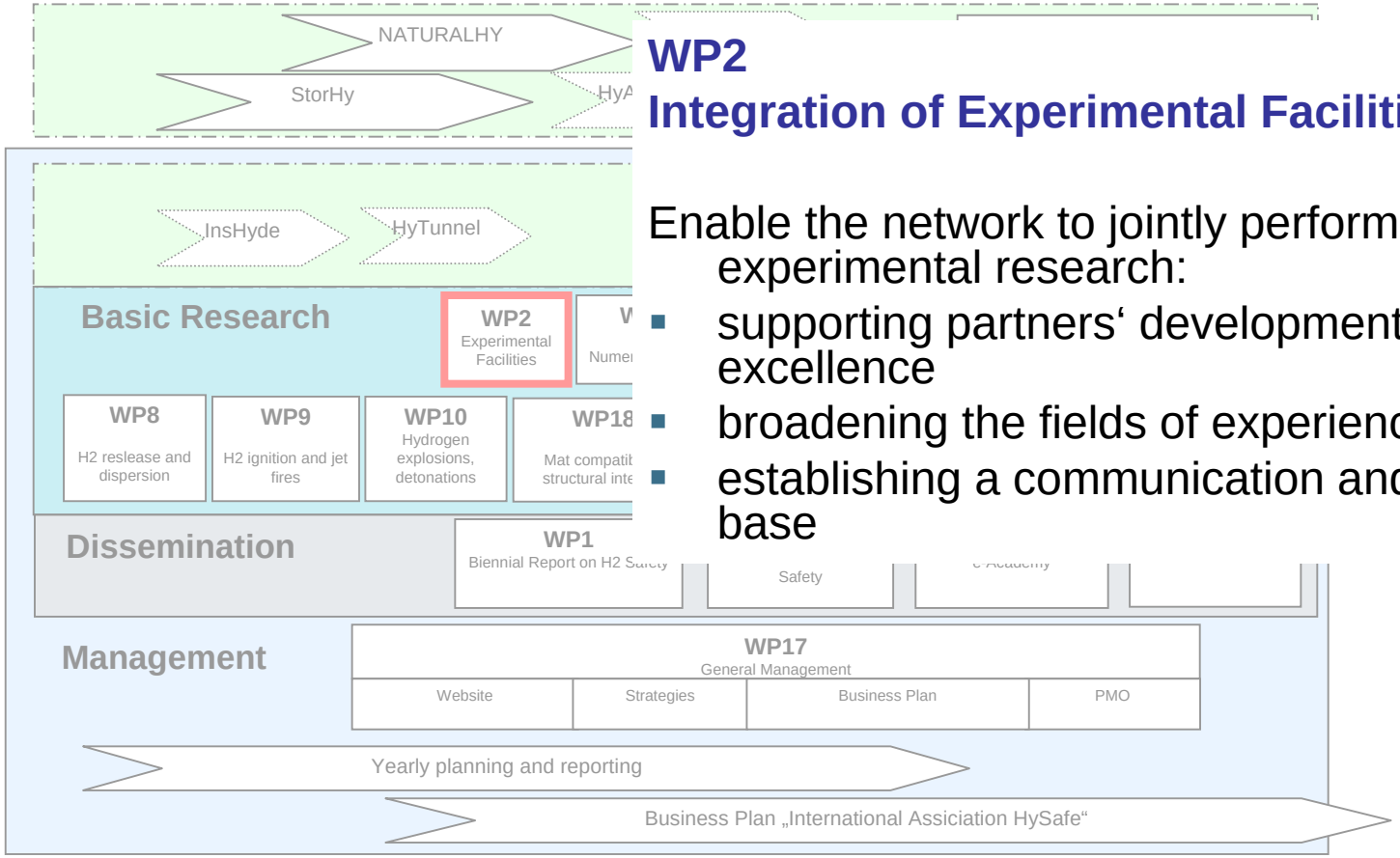
Introduction | HySafe

- The introduction and commercialisation of hydrogen as an energy carrier of the future makes great demands on all aspects of safety.
- In the frame of the 6th European Framework Programme, the HySafe Network of Excellence (NoE) has been aiming at the integration of the European research activities in the area of hydrogen safety and to disseminate the knowledge and achievements in order to support the safe and efficient introduction and commercialisation of hydrogen as an energy carrier of the future.
- Funding period: March 2004 - February 2009

Introduction | HySafe



Objectives of IEF

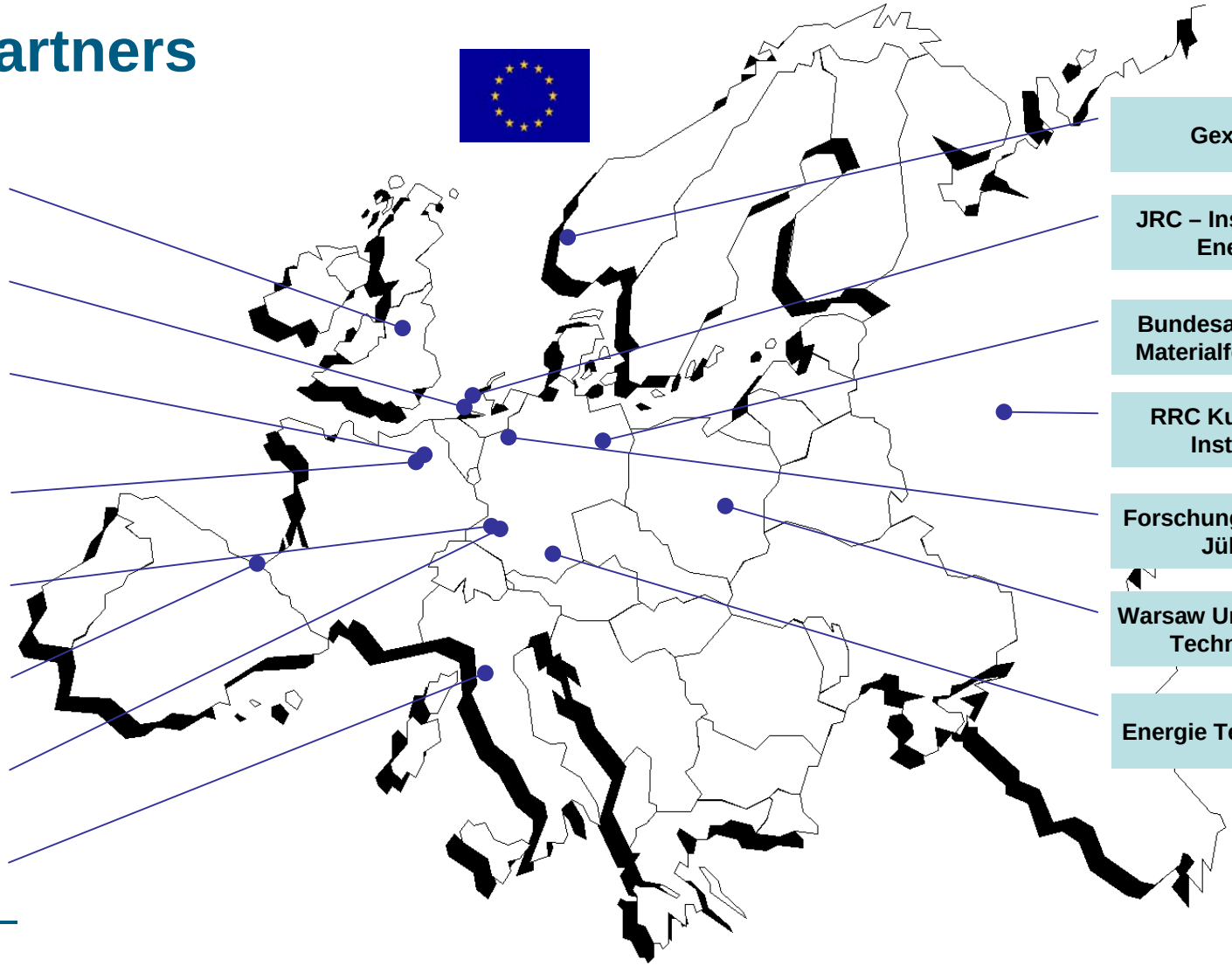


WP2
Integration of Experimental Facilities (IEF)

Enable the network to jointly perform high level experimental research:

- supporting partners‘ development of excellence
- broadening the fields of experience
- establishing a communication and knowledge base

IEF Partners



- Health and Safety Executive
- TNO Defence, Security and Safety
- Institut National de l'Environnement Industriel et des Risques
- Commissariat à l'Energie Atomique
- Forschungszentrum Karlsruhe
- INASMET-Tecnalia
- Fraunhofer-ICT
- Università di Pisa
- GexCon
- JRC – Institute for Energy
- Bundesanstalt für Materialforschung
- RRC Kurchatov Institute
- Forschungszentrum Jülich
- Warsaw University of Technology
- Energie Technologie

Starting point and boundary conditions

	nuclear	natural gas
Private Research Organisation	~100 facilities from lab scale to large/full scale	
Governmental Research Organisation		
European Research Organisation		
Industry		
University		

- identify best expertise of the partners
- identify gaps
- promote exchange of expertise and know-how

Strategy

- identify best expertise of the partners
- identify gaps

  → documentation and categorisation of facilities and equipment

- promote exchange of expertise and know-how

Documentation of facilities and instruments

109 experimental facilities

- Descriptions
- Fact sheets
- On-line version (internal)

Health and Safety Executive

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Forschungszentrum Karlsruhe

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Forschungszentrum Jülich

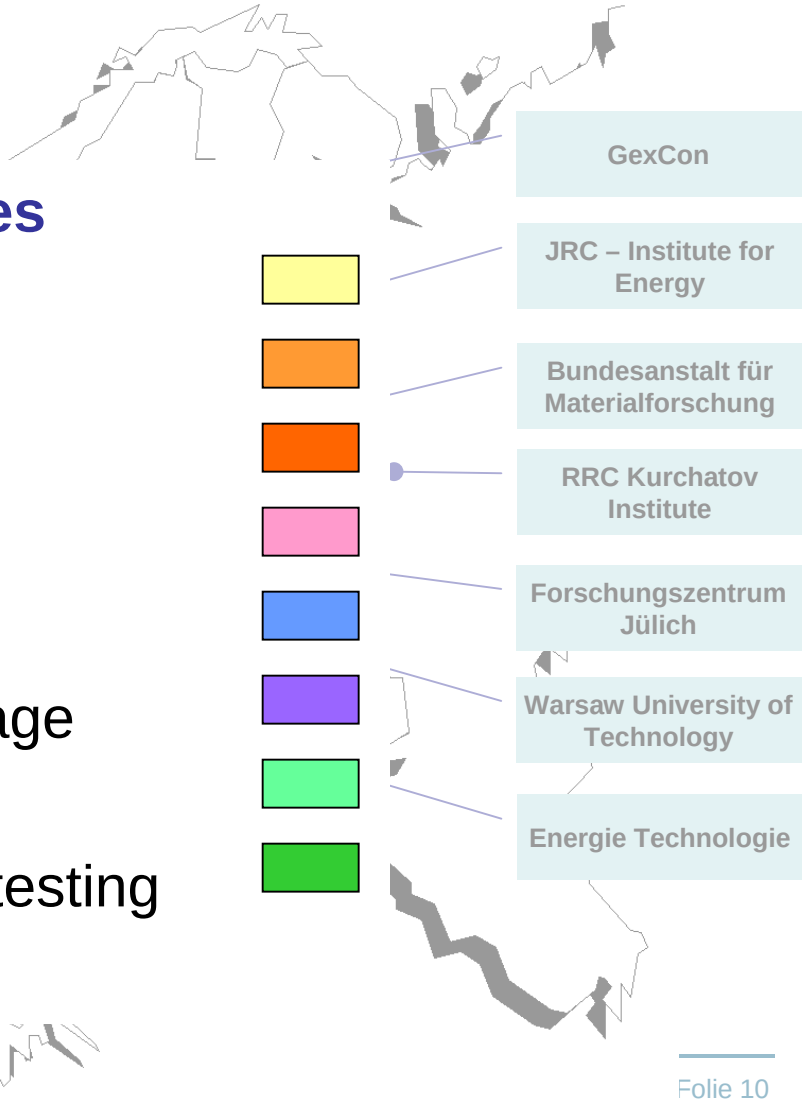
Warsaw University of Technology

Energie Technologie

Categorisation of facilities

109 experimental facilities

- Gaseous release
- Dispersion
- Ignition
- Combustion/explosion
- Liquid release
- Explosion of liquid storage
- Mitigation
- Equipment and device testing



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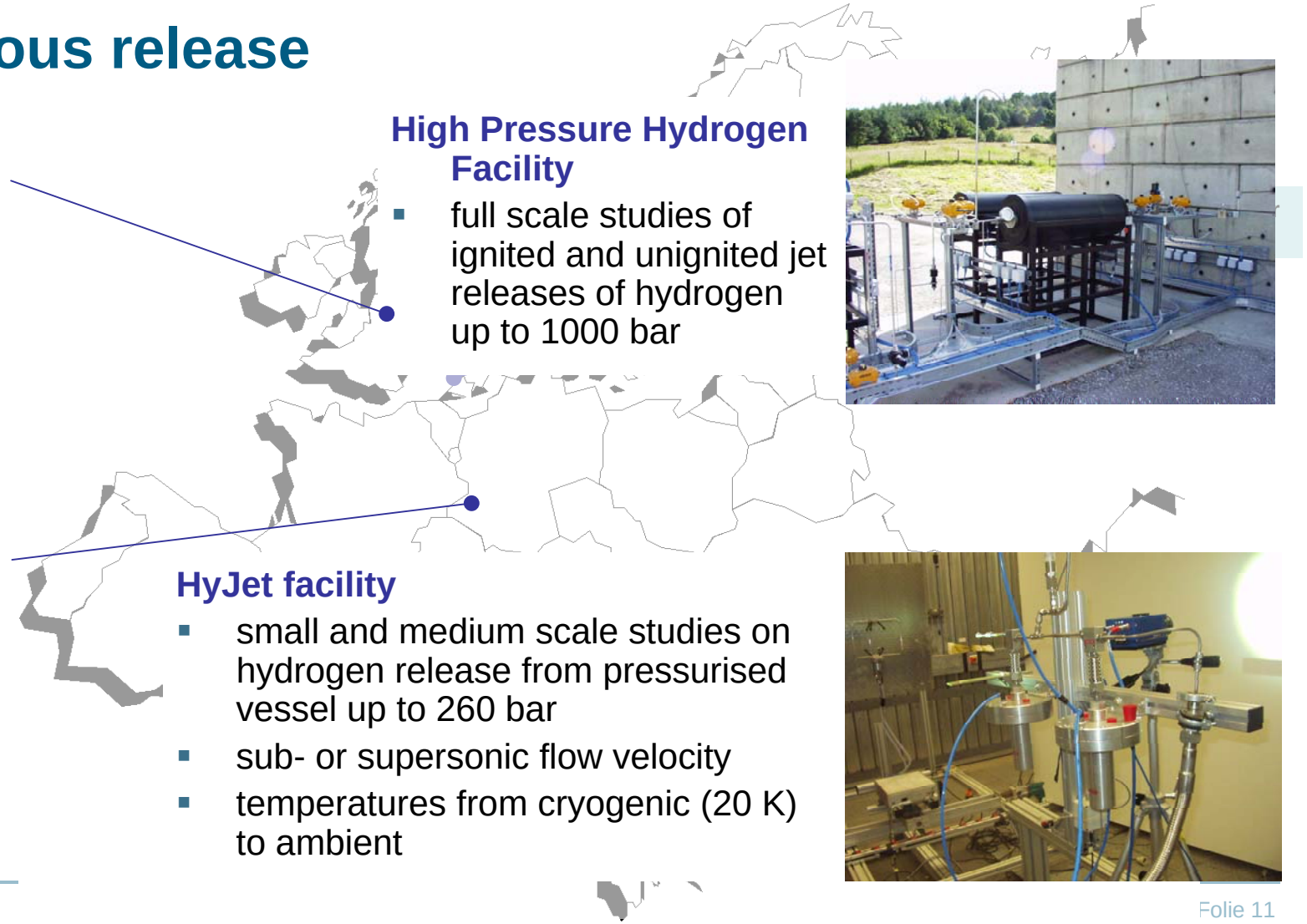
Energie Technologie

Gaseous release



Health and Safety Executive

High Pressure Hydrogen Facility

- full scale studies of ignited and unignited jet releases of hydrogen up to 1000 bar

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HyJet facility

- small and medium scale studies on hydrogen release from pressurised vessel up to 260 bar
- sub- or supersonic flow velocity
- temperatures from cryogenic (20 K) to ambient

Dispersion

INERIS-100 m³ chamber

- large scale investigations with flammable gases
- flame propagation rates in various configurations
- stratification of gases and diffusion

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GARAGE facility

- dispersion of buoyant gas (He) in an enclosure representing a full scale private garage incl. tilting door, back door, vents and ventilation
- local time resolved concentration measurements (mini-katharometers)
- optical diagnostics for velocity measurements (LDA, PIV)

Dispersion - SBEP

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Experimental data from both experiments have been used in numerical benchmarks on the physical phenomena associated to the short and long term mixing and distribution of hydrogen releases in confined spaces (SBEP-V3 and SBEP-V21).

Ignition

1.25 m³ Explosion Bomb

- studies on hydrogen ignition, flame propagation and quenching
- mixtures consisting of hydrogen, air, nitrogen, oxygen, argon, helium or carbon dioxide.

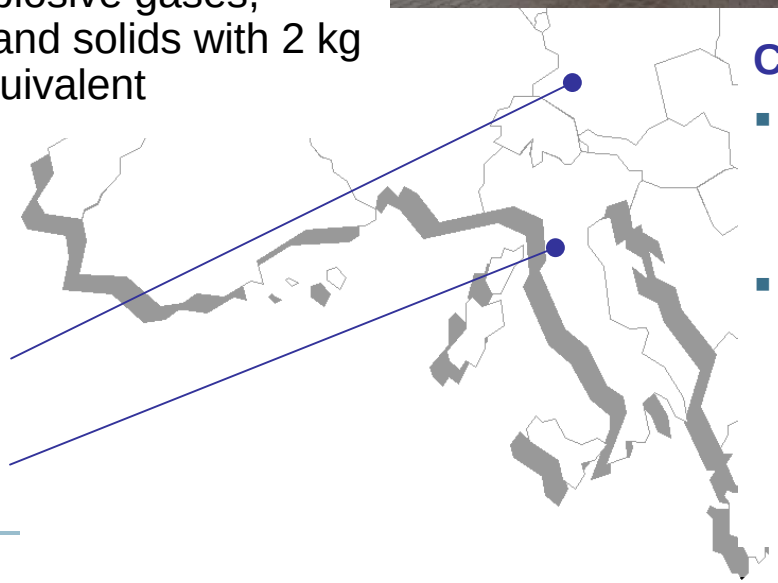
Combustion/Explosion (1)

Closed detonation room

- 45 m³ detonation chamber built of reinforced concrete with additional 20 mm steel inliner and remote controlled door
- detonation experiments with explosive gases, liquids and solids with 2 kg TNT equivalent

CVE facility (27 m³)

- vented explosions in hydrogen-air atmospheres with uniform or non uniform initial conditions
- two sides of the chamber entirely covered with glass panes (upper and one lateral side) in order to view and record the flame's shape propagation



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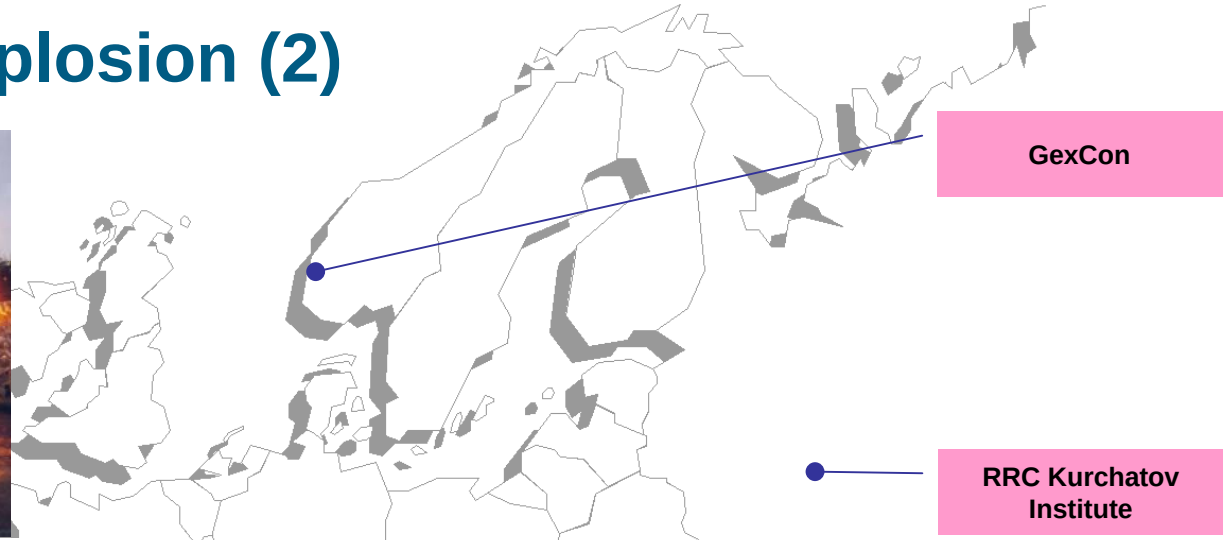
Combustion/Explosion (2)



168 m³ open geometry

- studies on explosions in open, congested geometries
- variable geometry congestion
- suitable for explosion tests in homogeneous gas clouds with limited hydrogen concentration or for non-homogeneous (leak-generated) gas mixtures

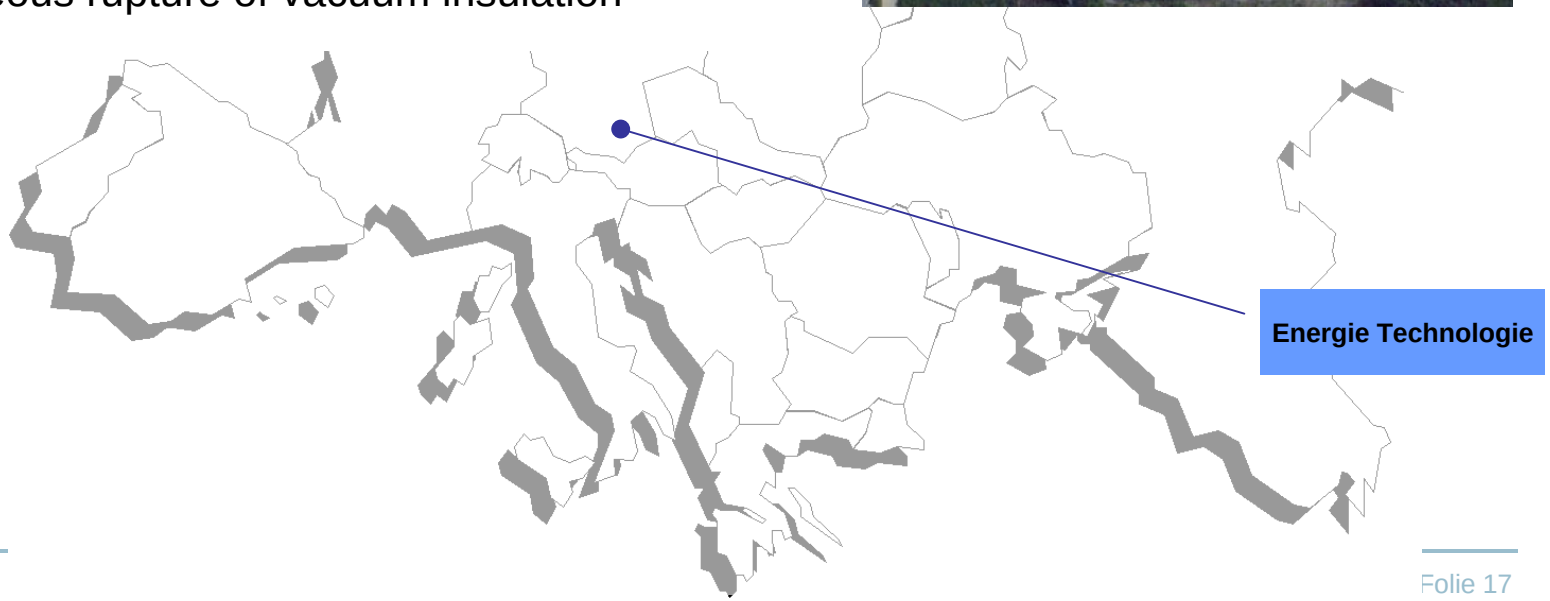
Torpedo facility

- large scale studies on turbulent combustions and detonations, and on scaling and venting effects
- internal diameter of 520 mm at a length of up to 50 m
- max. initial pressure of 3 bar

Liquid release and explosion of liquid storage

Hydrogen testing facilities

- In 2007, the consortium was joined by company ET which is operating facilities on LH2.
- LH2 vacuum insulation rupture rig:
  studies on the behaviour of a LH2-car tank under spontaneous rupture of vacuum insulation



Mitigation

Gas Explosion Chamber

- large scale testing of constructions that can reduce or protect against explosion overpressures
- venting devices: venting areas from ~ 2 to 5 m²
- explosion resistant constructions:
  max. explosion overpressure of 1 bar

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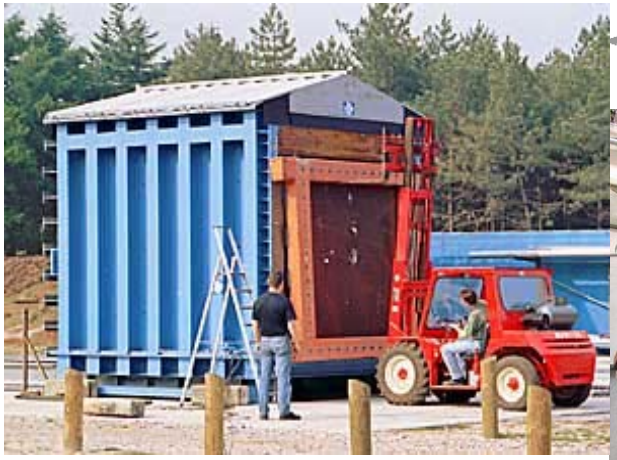

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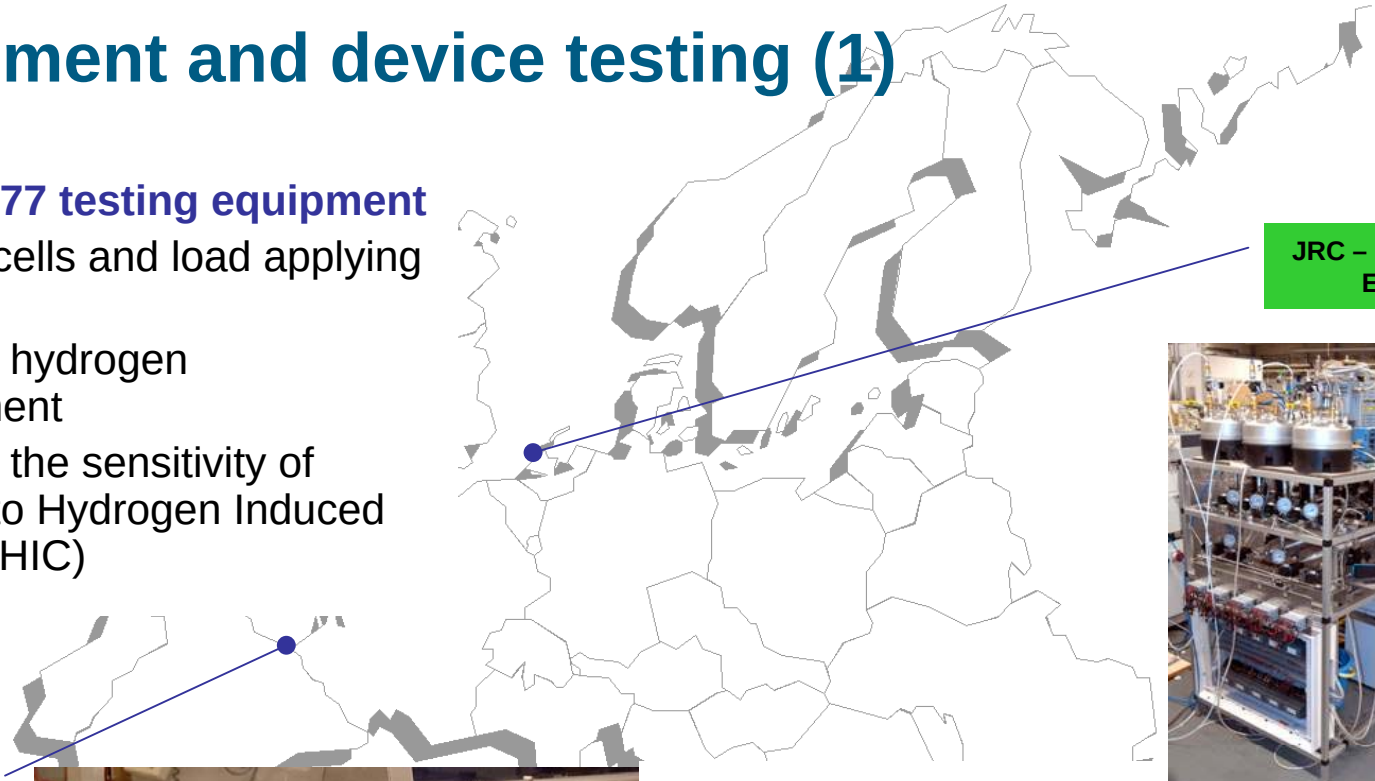
REKO-1 facility

- testing of catalyst elements for hydrogen recombination under well defined conditions
- commercial catalysts and in-house developments

Equipment and device testing (1)

NACE TM 01-77 testing equipment

- corrosion cells and load applying rings
- studies on hydrogen embrittlement
- studies on the sensitivity of materials to Hydrogen Induced Cracking (HIC)



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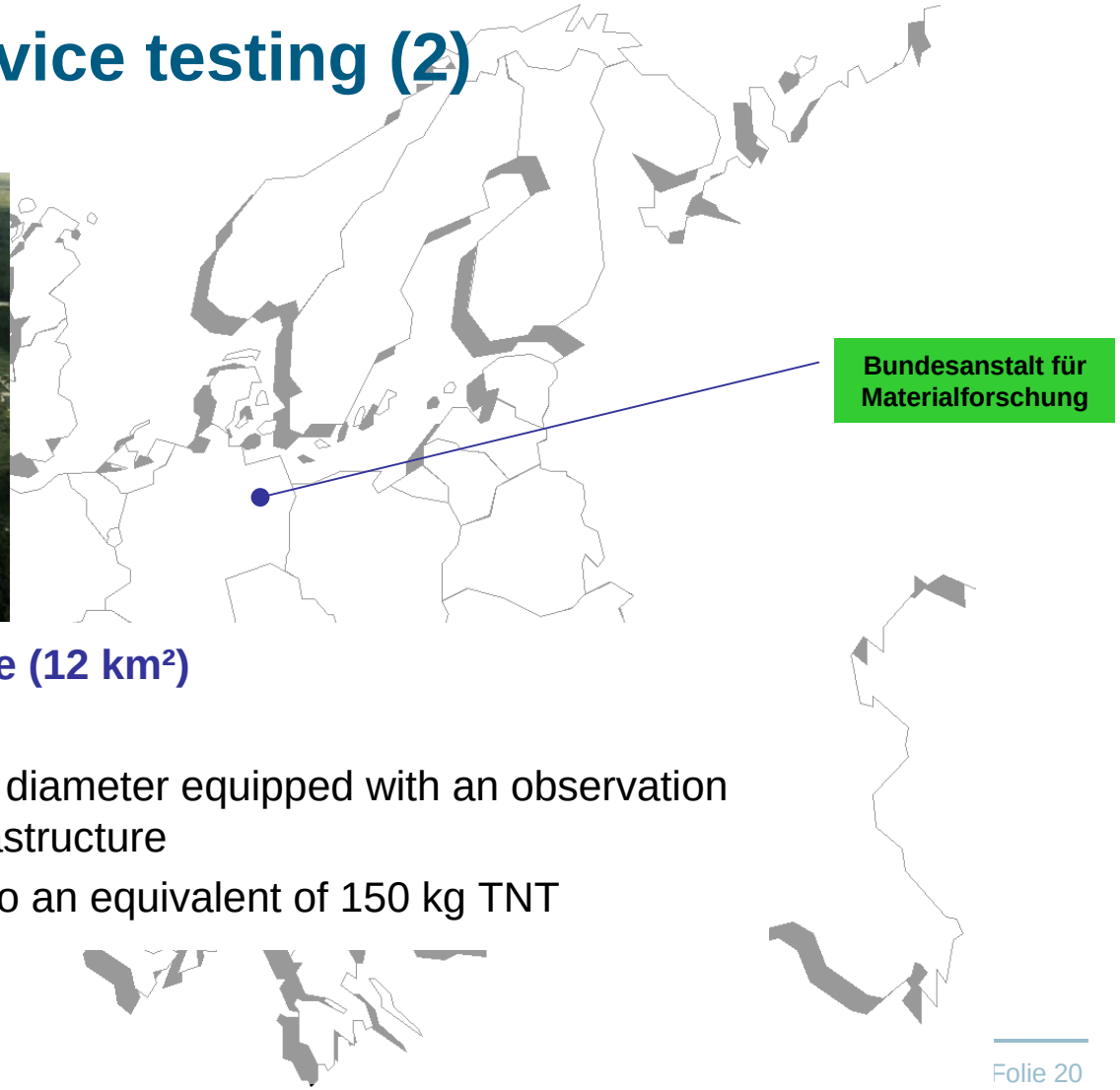
SenTeF

- temperature range - 50 to +130ºC
- pressure of 0.5 to 1.3 bar
- gas handling and environmental control system (complex gas/vapour mixtures, variable temperature, variable pressure, variable humidity).

Equipment and device testing (2)



Open Air Test Site Horstwalde (12 km²)

- various test installations
- explosion test site of 400 m diameter equipped with an observation shelter and other basic infrastructure
- fire and explosion tests up to an equivalent of 150 kg TNT

Strategy

- identify best expertise of the partners
- identify gaps

  ⇨ documentation and categorisation of facilities and equipment

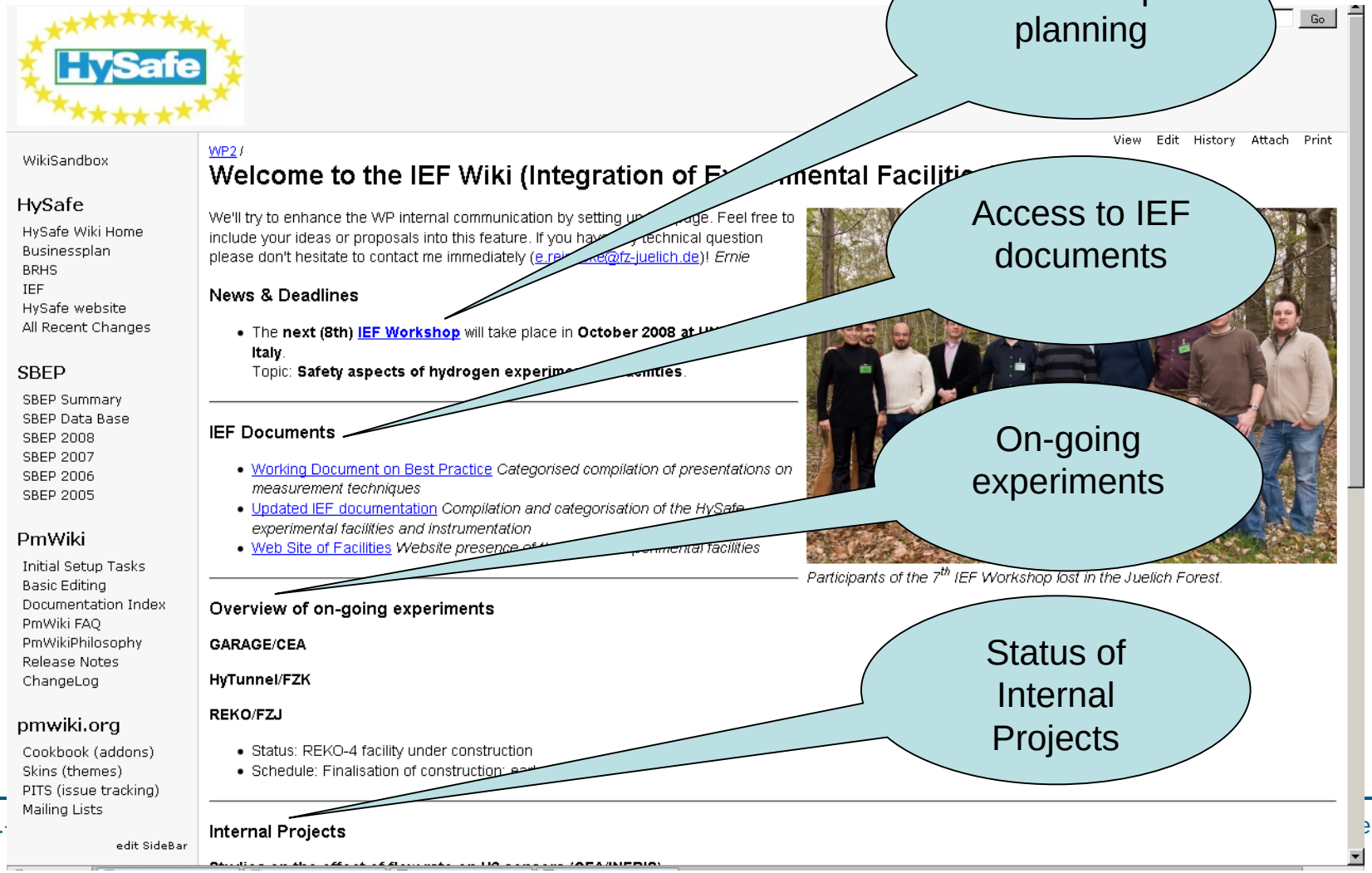
- promote exchange of expertise and know-how

  ⇨ IEF Workshops
  IEF Wiki
  IEF Working document on best practice

IEF Workshops

5-6 July, 2005 Fh-ICT, Germany	Hydrogen concentration measurements
16-17 November, 2005 INERIS, France	Temperature and heat flux measurements
5-6 April, 2006 HSL, UK	Velocity measurements in gases and flames
10-11 October, 2006 CEA, France	Dynamic pressure measurements
12-14 March, 2007 ET, Germany	Data acquisition systems
25-27 September, 2007 WUT, Poland	Optical measurement techniques
22-24 April, 2008 FZJ, Germany	Software for data analysis and presentation
20-22 October, 2008 UNIPI, Italy	Safety aspects of hydrogen experiments in facilities

IEF Wiki


Workshop planning
Access to IEF documents
On-going experiments
Status of Internal Projects
HySafe
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All Recent Changes
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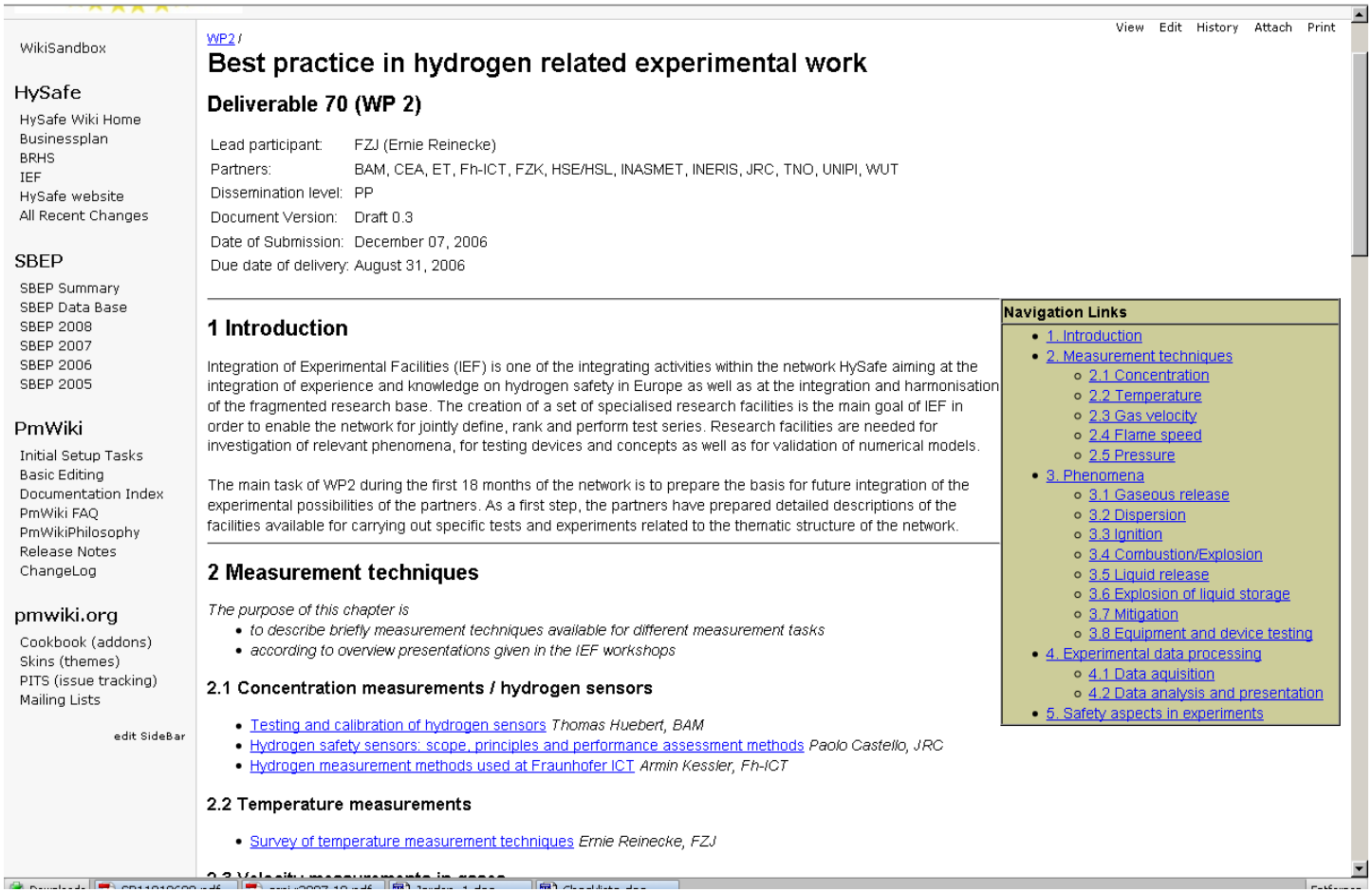
WP2 /
Welcome to the IEF Wiki (Integration of Ex mental Facilitie
We'll try to enhance the WP internal communication by setting up ge. Feel free to include your ideas or proposals into this feature. If you hav technical question please don't hesitate to contact me immediately (e.rei ke@fz-juelich.de)! Ernie
News & Deadlines
The next (8th) IEF Workshop will take place in October 2008 at U Italy.
Topic: Safety aspects of hydrogen experim ilities.
IEF Documents
Working Document on Best Practice Categorised compilation of presentations on measurement techniques
Updated IEF documentation Compilation and categorisation of the HySafe experimental facilities and instrumentation
Web Site of Facilities Website presence of experimental facilities
Participants of the 7th IEF Workshop lost in the Juelich Forest.
Overview of on-going experiments
GARAGE/CEA
HyTunnel/FZK
REKO/FZJ
Status: REKO-4 facility under construction
Schedule: Finalisation of construction: ear
Internal Projects

IEF Working document on best practice



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WP2 /

Best practice in hydrogen related experimental work

Deliverable 70 (WP 2)

Lead participant:	FZJ (Ernie Reinecke)
Partners:	BAM, CEA, ET, Fh-ICT, FZK, HSE/HSL, INASMET, INERIS, JRC, TNO, UNIPI, WUT
Dissemination level:	PP
Document Version:	Draft 0.3
Date of Submission:	December 07, 2006
Due date of delivery:	August 31, 2006

Navigation Links

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  - 3.3 Ignition
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  - 3.5 Liquid release
  - 3.6 Explosion of liquid storage
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- 4. Experimental data processing
  - 4.1 Data aquisition
  - 4.2 Data analysis and presentation
- 5. Safety aspects in experiments

1 Introduction

Integration of Experimental Facilities (IEF) is one of the integrating activities within the network HySafe aiming at the integration of experience and knowledge on hydrogen safety in Europe as well as at the integration and harmonisation of the fragmented research base. The creation of a set of specialised research facilities is the main goal of IEF in order to enable the network for jointly define, rank and perform test series. Research facilities are needed for investigation of relevant phenomena, for testing devices and concepts as well as for validation of numerical models.

The main task of WP2 during the first 18 months of the network is to prepare the basis for future integration of the experimental possibilities of the partners. As a first step, the partners have prepared detailed descriptions of the facilities available for carrying out specific tests and experiments related to the thematic structure of the network.

2 Measurement techniques

The purpose of this chapter is

- *to describe briefly measurement techniques available for different measurement tasks*
- *according to overview presentations given in the IEF workshops*

2.1 Concentration measurements / hydrogen sensors

- Testing and calibration of hydrogen sensors *Thomas Huebert, BAM*
- Hydrogen safety sensors: scope, principles and performance assessment methods *Paolo Castello, JRC*
- Hydrogen measurement methods used at Fraunhofer ICT *Armin Kessler, Fh-ICT*

2.2 Temperature measurements

- Survey of temperature measurement techniques *Ernie Reinecke, FZJ*

Conclusions

- IEF has provided basic support for jointly performed experimental work in NoE HySafe.
- IEF documentation on facilities and instrumentation has helped categorising the experimental capabilities of the partners.
- IEF communication and knowledge base (Workshops, Wiki, Working document on best practice) has supported an intensive know-how exchange among the partners.

Outlook – IEF in IA HySafe

- IEF documents provide an excellent basis for the continuation of joint activities in the framework of IA HySafe.
- Two activities are expected to become basic part of future activities:
  - series of workshops on experimental work in hydrogen safety
  - joint studies on challenging measurement tasks: know-how on specific measurement techniques

    ⇒ joint studies on mini-katharometers for hydrogen concentration measurements

Thank you for your attention !