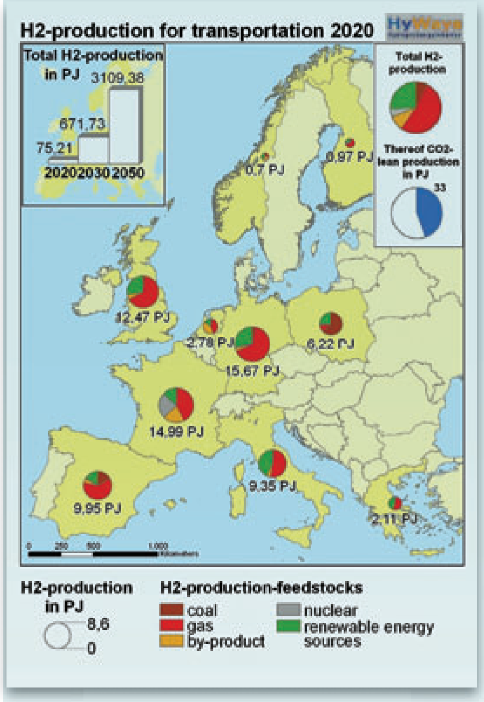
NATURALHY

HyWays - Towards a validated European Hydrogen Roadmap

HyWays is an integrated project, co-funded by research institutes, industry and by the European Commission (EC) under the 6th Framework Programme. HyWays will combine technology databases and socio-/techno-/ economic analyses to evaluate selected stakeholder scenarios for future sustainable hydrogen energy systems. This will lead to recommendations for a European Hydrogen Energy Roadmap reflecting country specific realities in the participating member states.



Main characteristic of this Roadmap is that it reflects real life conditions by taking into account not only technological but also institutional, geographic and socio-economic barriers and opportunities as being representative for the different Member States. Therefore this Roadmap will be based on inputs from European industry, research institutes and government agencies, and backed up with the best-available data. It will describe systematically the future steps to be taken for large-scale introduction of hydrogen as an energy carrier in the transport and power market and as storage medium for renewable energy. It will result in an action plan for the implementation of the European Hydrogen Energy Roadmap. Moreover, it will describe the effects and impacts of this introduction on the EU economy, society and environment. It will propose concrete policy measures, priorities in technology development and training/education.

In Phase I HyWays assessed individual roadmap contributions from the six member/associate states France, Germany, Greece, Italy, Norway and the Netherlands. These countries are characterised by different energy mixes, demand situations and end uses. All comprise natural gas in different pecularities.

In early 2005, HyWays and NaturalHy agreed to not only exchange technical or economic data and results but also to consider the integration of hydrogen-to-natural-gas admixture energy chains in depth. For this purpose HyWays will carry out well-to-wheel analyses to assess the potential role of these NaturalHy specific processes in future energy markets. In order to render this effort as pragmatic as possible two Member States (France and The Netherlands) have suggested to specifically integrate these chains into their portfolio of other hydrogen energy chains. NaturalHy in turn will provide specific datasets and structural information allowing to integrate these chains in the various techno-economic and emissions models.

In Phase II HyWays has added 4 new Member States (Finland, Poland, Spain and the UK). The methodology has been extended for the infrastructure analysis. Phase II will conclude the project with a European Roadmap by synthesizing across all 10 countries and an Action Plan with recommendations from the stakeholders.

To avoid that any premature data leak out of the assessment process all relevant project partners have signed a Confidentially Agreement in mutual interest. With this document the project liaison is fully operational. Finally, HyWays and NaturalHy partners meet at different occasions exchanging general and specific views. ❖

Ulrich Bünger, Ludwig-Bölkow-Systemtechnik GmbH,
HyWays responsible for the NaturalHy project liaison

UPCOMING EVENTS

Second NATURALHY-workshop: 30 May 2007 (Amsterdam, please see the project website **www.naturalhy.net**)

11-13 September, 2007 International Conference on Hydrogen Safety (ICHS), San Sebastian, (Spain).
Theme: "Safety of Hydrogen as an Energy Carrier".

15-19 June, 2008 the 17th World Hydrogen Energy Conference (WHEC) 2008,
Brisbane Convention and Exhibition Centre, Queensland Australia

CONTACT US

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NATURALHY

"Preparing for the Hydrogen Economy by Using the Existing Natural Gas System as a Catalyst"
Project Contract No.: SES6/CT/2004/502661

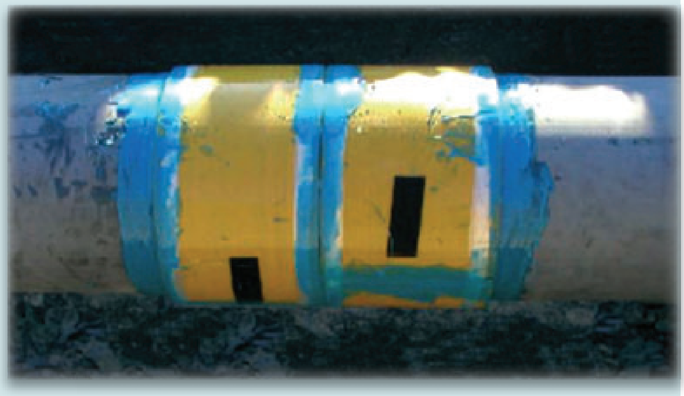
NATURALHY is an Integrated Project funded by the European Commission's Sixth Framework Programme (2002-2006) for research, technological development and demonstration (RTD)

Integrity Management of Hydrogen Transportation Pipelines

Integrity management

The aim of integrity management (IM) can be defined as providing "…the information for an operator to effectively allocate resources for appropriate prevention, detection, and mitigation activities that will result in improved safety and a reduction in the number of incidents."

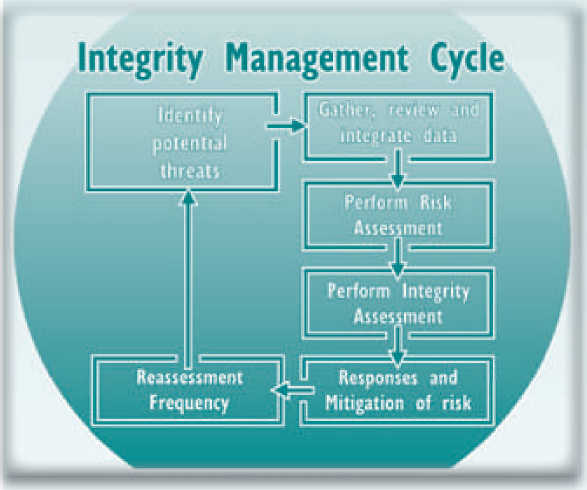
"…a process that an operator of a pipeline system can use to assess and mitigate risks in order to reduce both the likelihood and consequences of incidents." (Source: ASME B31.8s)



Clock Spring repair of a steel pipeline

To run a proper integrity management is essential for the safe and effective operation of a pipeline system. The currently applied integrity management for natural gas pipelines fulfils these obligations.

In order to prepare the existing natural gas grid for the transportation of hydrogen rich gasses it is important to ensure that a suitable integrity management is available beginning from the first day of the hydrogen transportation. The development of an IM considering the effect of hydrogen is necessary as this promising energy carrier can have an unwanted and perceptible influence on the material properties of steel.



General flow chart of the integrity management cycle (source: Report "Integrity Management and the Naturalhy Project")

The aim of the WP4 (Integrity) in the Naturalhy project is to provide a specification for an integrity management tool (IMT). The specification to be developed will meet the needs raised by the challenge to transport hydrogen in the existing pipelines, which were constructed to carry natural gas. Furthermore, the effect of introducing hydrogen on the costs for operating the integrity management will be investigated.

It was decided to develop a specification instead of a compiled software tool as a specification provides the flexibility to be used by pipeline operators across Europe independently of the software environment of the single companies.

Steps towards the integrity management for the hydrogen service

The first step in order to develop an IM for

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EDITORIAL

With this fifth Newsletter on the NATURALHY-project we would like to continue to inform you about our project, which investigates the potential of the existing natural gas system for the delivery of hydrogen. As a first logic step of the transition towards the hydrogen economy, this project focuses on the delivery of hydrogen/natural gas mixtures. The addition of hydrogen to natural gas affects the chemical and physical properties of the gas and will have an impact on the safety aspects related to the transmission, distribution and en use of the gas. In the main article of this issue we further focus on the NATURALHY-research programme directed to the quantification of this impact in particular related to the management of the integrity of the pipeline system. We also have items on two other initiatives in the transition field: the HYWAYS-project about the development of a European Roadmap to the hydrogen economy, and a project in preparation that will be coordinated by the Wuppertal institute about using the existing hydrogen infra-structure in the Nord Rhine Westphalia area to supply the early market for hydrogen applications. If you have any questions or would like to discuss certain aspects of the NATURALHY-approach with us, than please react through our website www.naturalhy.net.

The project coordination team
Gjalt Tiekstra,
Folkert Koopman
and Klaas Bos

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the hydrogen transportation in natural gas pipelines is to identify the defects that might be existing in the pipelines. This has been done in the task "Knowledge of realistic defects". The results of this task comprise a broad overview of the existing defects in natural gas pipelines, the needed prerequisites for the defect establishment, the growth rates and possible mitigation actions.

Furthermore, a first hydrogen impact analysis on the existing defects was done showing that sharp defects are more severe than blunt defects. The sharp ones cause higher stresses in the material and, as far as they are located at the inner pipe wall, they can allow the hydrogen to enter the material due to plastic deformation in the crack tips.

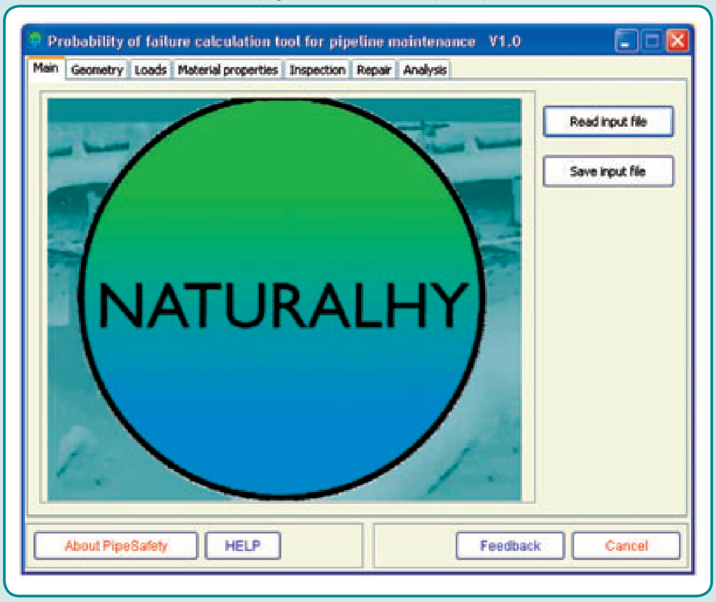
Beyond this, an adopted procedure for the classification of defects was developed. The aim of the classification is to sort the defects according to their location, dimension, complexity, shape and, if requested, further details (e.g. radius). This procedure should especially help to gain knowledge about blunt defects with small sizes, which are also able to introduce significant stresses to the pipeline.

Having identified all realistic defects that might be available in the pipelines it is necessary to isolate the most severe ones. As mentioned above, the sharp defects (mostly cracks) introduce a significant stress to the pipeline and are considered as critical.

Beyond the type, it is very important to know the critical defect sizes. As cracks can growth over the time (cracks = time dependent defects) the knowledge of the crack growth rate in a certain time frame can provide the critical defect size, which should not be exceeded at the beginning of the period under review.

In order to obtain reliable information about critical crack sizes several investigations were performed in the frame of the task "Assessment of critical defect sizes". The work done comprises a sensitivity analysis showing the impact of hydrogen on the acceptable defect size over the whole lifetime of selected pipelines. A second sensitivity analysis (numerical) is underway to extend the results on more cases. Furthermore a tool, which can estimate the probability of failure (POF) of single defects and whole pipelines is available as a draft version and will be further developed in 2007. The main difference between the POF tool and the sensitivity analysis is that, in the tool, the distributions

Main page of the POF-tool "PipeSafety"



of the pipe and crack geometry, the loads and the material properties are considered instead of fixed case-parameters.

Knowing the critical defect types and sizes, it is possible to prove whether the currently used inspection tools are able to detect and identify these defects. The state of the art of the tools used today is described in the results of task "Current inspection performance".

The test of a magnetic flux tool (MFL), which represents the standard for natural gas pipeline inline inspection, in a pipe with artificial defects will reveal if there is need for performance improvement or not.

The knowledge of critical defects and their growth rates is the base for setting up inspection intervals, which ensure a pipeline observation providing enough time for taking mitigation actions before pipeline failures can occur.

As the material properties of steel will be influenced by hydrogen in an unwanted way, the inspection intervals be will shortened in comparison to the natural gas service as long as the sensitivity of the inspection tools will be the same and no other mitigation actions are introduced. An approach for reducing the effect of hydrogen on the properties of pipeline steel is to add very small quantities of oxygen to the gas. This option will be investigated by performing fatigue tests in the WP3 (Durability). The results of the investigations can be applied on the prediction of crack growth in pipelines by using the POF tool.

Regarding the mitigation actions (mainly repair or renewal of pipes or pipe sections), two main strategies exist: the batch and the defect wise repair. Applying the batch wise repair procedure, all detected defects, which need mitigation in a period will be repaired at the same time. Using the second procedure, defect wise repair, defects will be repaired according to their maturity. The decision, which of the strategies is the most convenient one will be addressed in the task "Integrity management tool".

Also, the mitigation actions, especially the currently applied repair technologies, have to be reviewed before hydrogen can be put into the system. This will be done in the frame of the task "Repair adoptions". The work is focussed on the repair technologies "Clock Spring", "Metallic Sleeve" and "Weld Deposit".

The evaluation of the suitability of the technologies "Metallic Sleeve" and "Clock Spring" for the hydrogen service is based on numerical modelling and, for the latter one, validated by burst tests. The preliminary results show that at least the "Clock Spring" repair (the investigation of the metallic sleeves is still underway) is suitable for repairing of hydrogen transportation pipelines.

The test of the repair technology "Weld Deposit" is still in progress and results are expected according to the planning in October 2007.

Dr. Gert Müller-Syring, DBI Gas- und Umwelttechnik GmbH

Partners in WP4 Integrity

The following partners are involved in WP4:
BP Gas Marketing Limited (UK), Computational Mechanics International Ltd (UK), DBI Gas- und Umwelttechnik GmbH (D), N.V. Nederlandse Gasunie (NL), Gaz de France (F), GE PII Limited (UK), IGDAS Istanbul gas distribution CO.INC. (TR), Instituto de Soldadura e Qualidade (P), Statoil New Energy – Hydrogen (N), Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (NL), Total S.A. (F), TÜrkiye BIlimsel ve Teknik Arastirma Kurumu (TR).
Since May 2006 WP4 "Integrity" is lead by DBI (Gas- und Umwelttechnik GmbH). ❖

Opening up early markets and using existing infrastructrues – elements of a hydrogen energy strategy for North-Rhine Westphalia

Being a major energy region in Europe, the Federal State of North-Rhine Westphalia (NRW) takes a leading position in developing hydrogen energy solutions as one element of future energy systems. In order to direct resources to the most promising options, however, the various technology pathways and market applications have to be assessed carefully. Taking this into account, an energy systems view on future hydrogen markets was linked with the existing industrial potential in NRW (market players and competences) in order to detect and assess most suitable target areas for public-private partnerships. Acknowledging the need to bundle forces, focal points of action in NRW have been identified by the state government.

Within a first "technology phase" up to 2020/2030 the focus of the NRW hydrogen and fuel cell strategy is set on preparing hydrogen and fuel cell technologies for early markets, that offer favourable conditions to introduce these new technologies at a premium price and achieve early commercialisation. Linked by a transition phase, a much later third "energy policy phase" after 2020 will mark the entry in a large-scale hydrogen utilisation, mainly in road transport.

Beside the development of attractive products e.g. in the field of light transport or remote power supply, however, the question of hydrogen supply for these applications emerges.

Taking into account the relatively slow growth of hydrogen energy consumption in absolute terms, one has to think about least cost solutions for the early transition phase. One option in this regard is exploring synergies with the already existing industrial hydrogen system in place.

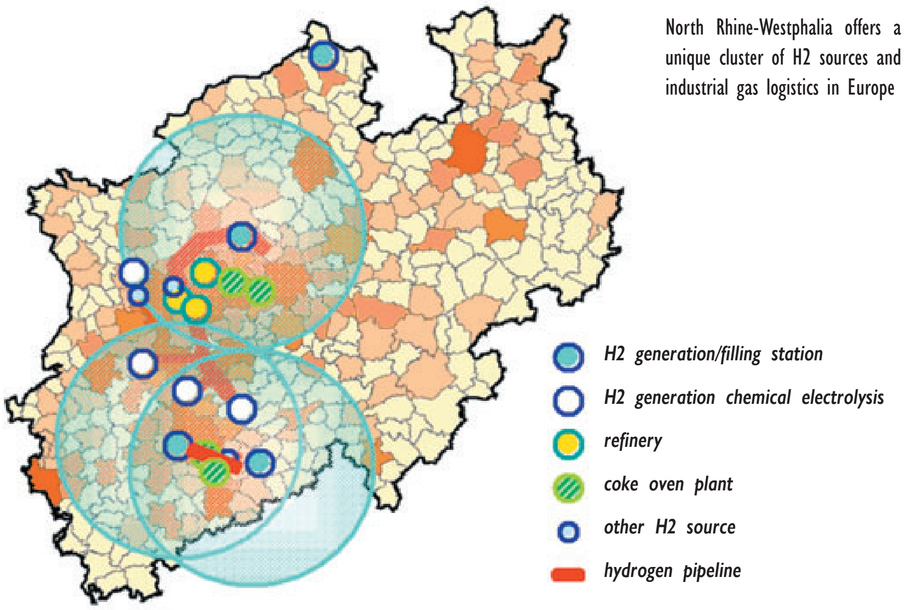
In the European roadmap study HyWays, for example, an important role was assigned to the use of industrial surplus hydrogen. Estimating the total availability of waste hydrogen in Germany at 2.500 GWh, one half of these capacities alone (1.250 GWh) are located in NRW. Related sources are mainly chemical industry and refineries. Being the industrial core of Germany, the region is characterised by a European-wide unique hydrogen infrastructure inlcuding more than 215 km of H2 pipeline networks. The NRW pipeline has a diameter of 168-273 mm and is operated by Air Liquide with a pressure of 3 MPa (30 bar). A comparable hydrogen network – operated as well by Air Liquide – can be found in the French-Belgian-Dutch cluster of chemical industries around Antwerpen. Total length is 330 km, operation pressure is in the range of 6,5-10 MPa (65-100 bar). Interestingly, the gap between both clusters is a distance of less than 100 km which offers prospects for a trans-border link in the future.

But how to use the existing well-established infrastructure of industrial hydrogen production – that is the largest in Europe - as the starting point to supply early markets at competitive costs?

A series of open issues and problems have to be analysed in order to get a better picture on the actual contribution of these sources to early market supply such as:

- the quality of waste hydrogen and related costs of upgrading and handling
- the competing uses for chemical feedstock or energy purposes and the prospects for the market dynamics of industrial hydrogen
- the availability and appropriateness of infrastructures such as grids and distribution networks for early market demand
- the existence of "hydrogen-ready" sites and infrastructures e.g. from former uses such as town gas distribution with higher hydrogen contents
- the integration of industrial hydrogen supply schemes with other solutions such as mobile filling stations, decentralised hydrogen production on-site, etc.

As one part of the on-going initiatives, the hydrogen and fuel cell network NRW will discuss these questions more thoroughly during the next year and results can be expected for next spring 2008.



North Rhine-Westphalia offers a unique cluster of H2 sources and industrial gas logistics in Europe

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