



The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

EMPIR Programme

15NRM03

Hydrogen

Metrology for sustainable hydrogen energy applications

WP4 Creating Impact

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Frédérique Haloua

Final & Stakeholder Advisory Board meeting
21 May 2019, VSL, Delft

Create impact for all relevant stakeholders from industry, manufacturers, standardisation committees and the scientific community

ISO/TC 197 Hydrogen technologies

ISO/FDIS 14687	Hydrogen fuel quality- Product specification
ISO 16111	Transportable gas storage devices - Hydrogen absorbed in reversible metal hydride
ISO/FDIS 19880-8	Gaseous hydrogen - Fuelling stations - Part 8: Fuel quality control

CEN/TC 268/WG5 Specific hydrogen technologies applications

CEN/CLC JTC 6 Hydrogen in energy systems

CEN/CLC SFEM – Sector Forum Energy Management → WG Hydrogen last plenary meeting ... yesterday

ISO/TC 197 - ISO/TC 158 JWG 7

ISO/FDIS 21087	Gas analysis - Analytical methods for hydrogen fuel - Proton exchange membrane (PEM) fuel cell applications for road vehicles
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Activity number	Description	Partners
A4.1.1	Stakeholder Advisory Board established	VSL, all partners
A4.1.2	Project homepage established with a public and restricted sections	LNE, all partners
A4.1.3	Conferences	VSL, all partners
A4.1.4	Peer-reviewed publications	LNE, all partners
A4.1.5	Publications for a more general, non-expert public	VSL, all partners
A4.1.6	International workshop	VSL, all partners

Activity number	Description	Partners
A4.2.1	Training session during the workshop (A4.1.6)	LNE, all partners
A4.2.2	Stakeholder workshop	VSL, all partners
A4.3.1	Exploitation plan: Feed the standardization processes of revision of standards ISO 14687 and 16111 Report at ISO level	LNE, all partners
A4.3.2	Intellectual property right	LNE, all partners
A4.3.3	Continuous flow of information on progress and results will be disseminated to standardisation TCs	LNE, all partners

Months	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
Activities	June-16	July-16	August-16	September-16	October-16	November-16	December-16	January-17	February-17	March-17	April-17	May-17	June-17	July-17	August-17	September-17	October-17	November-17	December-17	January-18	February-18	March-18	April-18	May-18	June-18	July-18	August-18	September-18	October-18	November-18	December-18	January-19	February-19	March-19	April-19	May-19	
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Attend project meetings, access project progress reports (in a restricted part of the project webpage)

Give advice and stimulate/catalyse dissemination

SAB was formed within three months after the start of the project.

Should consist of at least five active members with different backgrounds and nationalities → up to 16 people in the SAB 👍

SAB gather once a year



	Date	Host
1 st	7 November 2016	LNE, Paris / web conference
2 nd	30 November 2017	LNE, Paris / web conference
3 rd	7 – 8 November 2018	Joint with the International workshop at Air Liquide R&D Centre Campus Innovation Paris
4 th	21 st May 2019	VSL (Delft) joint with the final meeting of the project

<http://projects.lne.eu/jrp-hydrogen/>

Project website is updated!

Public section

- Description of the project
- Contact details
- News/upcoming/past events
- Presentations at conferences
- Links to articles published
- Place for interested parties to register

Restricted section

- For project partners
- Communication within project



The screenshot shows the project website homepage with a navigation menu (Home, The project, Workpackages, Partners, Tools / publications, Member Space, Contact). The main content area features the 'Hydrogen' logo and a headline: 'Hydrogen, as an energy source, is a clean and storable solution that could meet the worldwide energy demands.' Below this is a news section with a red stamp that reads 'Live until at least end of 2019!'. The news items include: 'The new European policy objectives in the transport and energy sectors defined in the Horizon 2020 Research and Innovation programme encourage the decarbonisation of the transport sector in order to reduce the green-house gases effect.', 'The overall objective of the Hydrogen project is to address the standardisation needs in the hydrogen-energy sector that meet the requirements of the European Directive on the deployment of Alternative Fuels Infrastructure 2014/94/EU in order to bring forward the standardization in R&D related to metrology.', 'The project aims at supplementing the revision of two ISO standards that are currently too generic to enable a sustainable implementation in the fast emerging sector of hydrogen fuel and at contributing to the elaboration of two new standards.', 'Revisions of these two ISO standards (ISO 14687:2012 Hydrogen fuel - Product specification - Part 2: Proton exchange membrane (PEM) fuel cell applications for road vehicles and ISO 16111:2008 Developing transportable gas storage devices - Hydrogen absorbed in reversible metal hydrides) are stated in the business plans of ISO/TC 197 Hydrogen technologies and CEN/TC 268 Cryogenic vessels and specific hydrogen technologies applications.', 'The two new standards currently in elaboration within the ISO/TC 197 standardization activities are ISO 21087 Hydrogen fuel - Analytical methods - Proton exchange membrane (PEM) fuel cell applications for road vehicles and ISO 19880-8 Gaseous hydrogen - Fueling stations - Part 8:'. On the right side, there is a 'NEWS' section with items: 'Press-release: Impact of hydrogen impurities on fuel cells', 'Workshop at Air Liquide R&D Centre: November 7 & 8, 2018', 'Hydrogen quality: publication in International Journal of Hydrogen Energy, April 2018', and 'Upcoming events'.

CONFERENCES

23 presentations/ posters




HySPaC CNRS

FCH2 TECHNICAL CONFERENCE

PITTCON CONFERENCE & EXPO

WHTC PRAGUE 2017

GAS Analysis 2019

m6 congresos de metrología

WHEC 22nd WORLD HYDROGEN ENERGY CONFERENCE 2018 Rio de Janeiro

EPEC 2019

Fluid flow measurement 10th international symposium

CIM2017 18th INTERNATIONAL METROLOGY CONGRESS

CONGRESO IBEROAMERICANO DE HIDROGENO Y PILAS DE COMBUSTIBLE

iber conappice 2017

HYPOTHESIS XII SIRACUSA 2017 ITALY

CIM2017

CIM2019

→ 2 upcoming conferences in 2019 (CIM 2019, GAS2019)

Annex 1 v2.0: “In the course of the project, at least 3 open access peer-reviewed publications”

- T. Bacquart, A. Murugan, M. Carré, B. Gozlan, F. Auprêtre, F. Haloua, T.A. Aarhaug - *Probability of occurrence of ISO 14687-2 contaminants in hydrogen: principles and examples from steam methane reforming and electrolysis (water and chlor-alkali) production processes model*, Int. J. of Hydrogen Energy, Vol. 43 (2018) pp. 11872-11883, <https://doi.org/10.1016/j.ijhydene.2018.03.084>

open access

- Influence of trace amounts of NH₃, HCl and C₄Cl₄F₆ impurities in hydrogen stream on PEM fuel cell performance over a long term test, I. Profatilova, F. Fouda-Onana, T. Bacquart, A. Rojo, F. Haloua, P.-A. Jacques

open access?

31 May 2019

- Hydrogen fuel quality from two main production processes: steam methane reforming with pressure swing adsorption and proton exchange membrane water electrolysis, T. Bacquart, A. Murugan, S. Bartlett, N. Moore, A. Morris, B. Gozlan, M. Carré, G. De Reals, G. Doucet, F. Laridant, E. Gernot, F. Auprêtre, A. Rojo, K. Arrhenius, A. Fischer, S. Persijn, F. Haloua


open access acted

Annex 1 v2.0: “At least 4 other publications for a more general, non-expert public”

Where	Title	Authors
Proceedings ISFFM	Development and validation of traceable methods for the measurement of hydrogen absorbed in metal hydride tanks	O. Büker, B. Delobelle, O. Gillia, R. Pérez, F. Haloua
Proceedings Iberconappice	Presentación del proyecto de metrología: 15NRM03 Hydrogen	R. Perez, F. Haloua, J. Simon, V. Gil
Proceedings Spanish Congress of metrology	Desarrollo de la Infraestructura Metrológica para Aplicaciones Sostenibles de Hidrógeno	A. Rojo, D. del Campo, T. Fernandez, JJ Segovia
Proceedings CIM 2017 and special issue in a peer-reviewed journal	<i>Metrology for hydrogen energy applications: a project to address normative requirements</i>	F. Haloua, T. Bacquart, K. Arrhenius, B. Delobelle, H. Ent
	Measurement, Science and Technology, vol. 29 (2018) pp. 034001 (6pp), https://doi.org/10.1088/1361-6501/aa99ac	
Special issue in IJHE following WHEC 2018	Hydrogen sampling procedure for transport (hydrogen refuelling station and production process) – Impact of the sampling on the final amount fraction of water, oxygen and nitrogen in hydrogen	T. Bacquart, N. Moore, A. Morris, N. Hart, T.A. Aarhaug, O. Kjos, F. Aupretre, T. Colas, F. Haloua, B. Gozlan, A. Murugan

Annex 1 v2.0: “At least 4 other publications for a more general, non-expert public”

- Popular science magazines
- Branch-related journals
- Newspapers

- Updating **Wikipedia page** on hydrogen purity
- https://en.wikipedia.org/wiki/Hydrogen_purity → Stefan
- News on *Hydrogen platform* (in Dutch, upcoming) at <https://opwegmetwaterstof.nl/> → Stefan
- Publication issue of an article from *NPL Meeting European regulations for hydrogen quality*, Thomas Bacquart, 4 june 2018, <https://www.gasworld.com/meeting-european-regulations-for-hydrogen-quality/2014778.article> → Thomas
- « L’avenir des piles à combustible passe par l’analyse de la qualité de l’hydrogène, D. Chauvel, directeur commercial at AP2E and E. Smith, commercial hors France chez AP2E, MESURES 901, janvier 2018, <http://www.mesures.com/archives/dossiers/item/14872-l-avenir-des-piles-%C3%A0-combustible-passe-par-l-analyse-de-la-qualit%C3%A9-de-l-hydrog%C3%A8ne> → AP2E, one collaborator
- « Quel impact des polluants de l’hydrogène sur les PAC ? » A press-release on CEA website
 → Irina

Annex 1 v2.0: 4.1.6: “**Dissemination of the project results to a larger audience.** The duration of the workshop will be **one to two full days** and will include presentations and poster sessions. **Personal invitations (around 20)** will go to representatives from the hydrogen production, sampling, analysis fields, including the manufacturing industry and standardisation bodies, and researchers in metrology in this area. This workshop will be broadly advertised in advance through the existing networks of the consortium partners.

Proceedings and presentations that result from this workshop will be made available on the project web site.”

Annex 1 v2.0: 4.2.1: “During the international workshop (A4.1.6) LNE together with all partners will organise a **training session, based on the results of WP1, WP2, and WP3.** The aim is to train the participants on **understanding the real risks of contaminants found in hydrogen samples,** including their **effects on fuel cell systems,** and on **optimised analytical protocols to implement ISO 14687-2.** The targeted attendees will be the stakeholder group and industrial partners. **Between 20 and 30 delegates** is targeted. The training material will focus on hydrogen purity methods and the relevant ISO standards (e.g. ISO 14687-2 and ISO 16111).

All training documents will be posted online on the project webpage.”



A4.1.6 International Workshop & A4.2.1 Training sessions



7 & 8 November 2018

at

Air Liquide R&D Centre Campus Innovation Paris

Hydrogen

EMPIR EURAMET

Metrology for sustainable hydrogen energy applications

Workshop

LinkedIn

Air Liquide

7 & 8 November 2018

Air Liquide, R&D Centre - Paris-Saclay
1 Chemin de la Porte des Loges, Les Loges-en-Josas
78354 Jouy-en-Josas, France



AIR LIQUIDE will host the workshop at new premises of R&D Centre. Visits of the Hydrogen Refuelling Station and laboratories are planned.

TRAINING SESSION – 7 November PM

This session will lead to practical information from the scientific activities of the project and actual results to supplement standards on their elaboration or revision path. What perspective towards a broad and easy use of hydrogen emphasising end-user expectation?

Attendance is limited, so **REGISTER NOW!**

- 1 - Free entrance for both days
- 2 - Program and Registration at: <http://projects.ine.eu/jrp-hydrogen/workshop/>
- 3 - Contact: bruno.gozlan@airliquide.com frederique.haloua@ine.fr
- 4 - Deadline for registration: **October 5, 2018**

WORKSHOP SESSION – 8 November all day

The workshop will tackle among others the hydrogen vehicle market, the challenges of hydrogen production, the hydrogen impurity analytical methods, the impurity risk assessment for the marketed and future generation of fuel cells and the measurement methods for hydrogen mass in storage tanks. Cross-cutting themes for hydrogen as the standardization role and sampling will be addressed.

Partners:



Hydrogen 15NRM03

EMPIR EURAMET

November 7-8
Welcome

International Workshop
Metrology for sustainable hydrogen energy applications

LABORATOIRE NATIONAL DE METROLOGIE ET D'ESSAIS LNE

R&D TV - Campus Innovation Paris

Air Liquide creative oxygen

Dutch Metrology Institute

15NRM03 project – Final & SAB meeting, 21 May 2019, VSL, Delft



A4.1.6 International Workshop



7 November PM: TRAINING SESSION

8 November: WORKSHOP SESSION

13:30 – 13:40 Welcome and Opening *Air Liquide*

9:30 – 9:40 Welcome and Opening *Air Liquide*

13:40 – 14:15 Short introduction of the EMPIR Metrology Programme and presentation of the *Hydrogen* project *F Haloua, LNE*

9:40 – 10:00 Towards sustainability: The current status and future outlook of fuel cell vehicles in Toyota *V Mattelaer, Toyota*

14:15 – 14:40 Role of Standardization *ME Crozet, AFNOR*

10:00 – 10:20 Standards to promote hydrogen mobility *H Barthélémy, CEN TC 268 Chair*

15:00 – 16:15 Parallel sessions

- Room 1:** Hydrogen purity measurements according to ISO 14687-2 and risk assessment for fuel cells *T Bacquart, NPL*
- Room 2:** Analytical methods review for hydrogen quality control according to ISO standards *O Büker, RISE*
- Room 3:** Mass measurements of hydrogen absorbed in metal hydrides and the revised ISO 16111 *D Perreux, MAHYTEC*

10:20 – 10:40 Sampling and analysis of hydrogen from refuelling stations in Europe *TA Aarhaug, SINTEF*

10:40 – 11:00 How to ensure H₂ quality without increasing H₂ analysis cost? *M Carré, Air Liquide*

11:00 – 11:20 COFFEE BREAK

16:15 – 16:35 COFFEE BREAK

11:20 – 11:40 Impact of key impurities on fuel cell degradation *I Profatilova, CEA*

16:35 – 17:35 Air Liquide facilities visit – Parallel sessions (Hydrogen Refuelling Station or Laboratories) *Air Liquide*

11:40 – 12:00 Check of risk assessment of impurities in hydrogen for fuel cells, based on analytical data *M Carré, Air Liquide*
F Auaprêtre, AREVAH2GEN

17:35 – 17:50 End of day 1 & Closing remarks *Air Liquide*

12:00 – 12:20 Impurities found in real hydrogen production samples *T Bacquart, NPL*

19:00 Possibility to join the Workshop dinner at a restaurant in Versailles (supported by each attendee)

12:20 – 12:40 Analytical method development for the most challenging impurities *S Persijn, VSL*

12:40 – 13:40 LUNCH

13:40 – 14:00 Hydrogen storage: Measurement methods for hydrogen mass in storage tanks *D Perreux, MAHYTEC*

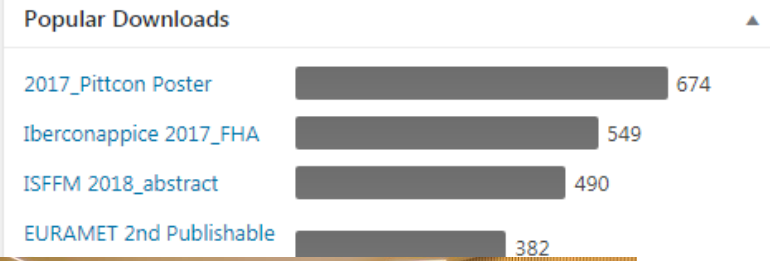
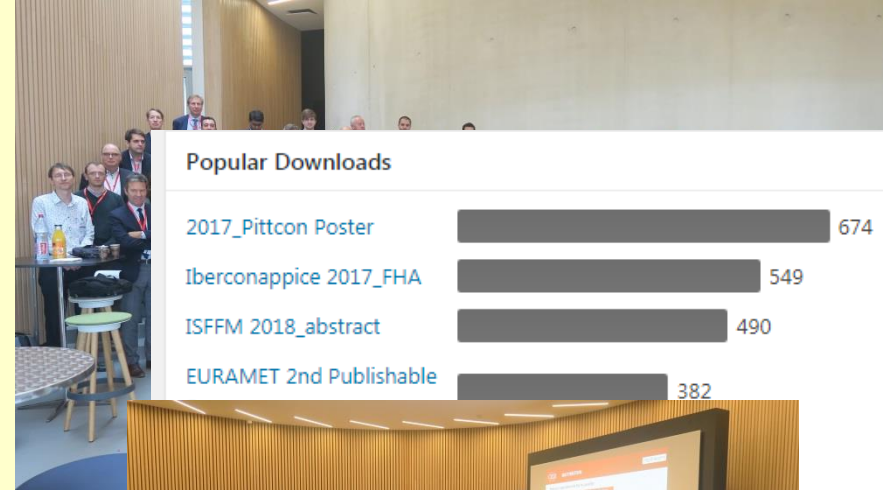
14:00 – 14:15 Closure of the Workshop: follow-up of the actions / feedback from the audience / additional information *F Haloua, LNE*

14:15 – 15:15 Air Liquide facilities visit – Parallel sessions (Hydrogen Refuelling Station or Laboratories) *Air Liquide*

Success Story!

Thanks to all for the large advertising done

- Around 100 people attending the International Workshop!
- BtoB discussions
- 3 Training courses (most popular!)
- Visit of Air Liquide facilities (laboratories and HRS – Bus and vehicles)
- Talks of external speakers (Toyota, SINTEF, Chair CEN/TC 268, AFNOR)



An exploitation plan was elaborated at project start (reviewed/updated during each project meeting)

Focus points:

- *To give strategic advice at technical board meetings of ISO TCs*
- *To support/assist the standardisation process to revise standards ISO 14687-2 and ISO 16111*
- *To report twice at ISO-level (**Mid-term & end of the project**)*

- LNE, NPL, VSL, MAHYTEC participated to national mirror committee of ISO TC 197 (AFNOR, BSI, NEN) and to CEN/CENELEC SFEM WG Hydrogen
- Air Liquide, AREVAH2GEN, CEA, NPL, MAHYTEC are involved in the working groups of ISO TC 197
- AP2E company, collaborator of the 15NRM03 project, used one project output (bibliography document 2.1.1) for a commercial use by sending it to prospective customers in order to align their technique (identified in the document) as the most relevant

23 Contributions to standardization meetings



To obtain the 21 hydrogen samples around Europe

Type of collaboration	Project partners involved in the collaboration	Others involved in the collaboration	Date of collaboration	Funding source	Additional comments
Sharing of technical facilities	NPL, Air Liquide, AH2GEN	Site A	2017	Other European sources	Hydrogen production sites
	NPL, CEM	Site B	2017		
	NPL, CEM	Site C	2017		
	NPL	Site D	2018		
	LNE	Site E	2019		

Target reached and exceeded !

Targeted Programmes of EMPIR

Year	Calls	Additional calls
2014	Industry	Research Potential, SIP
2015	Health, SI Broader Scope	Pre-normative, Research Potential, SIP
2016	Environment, Energy	Pre-normative, Research Potential, SIP
2017	Fundamental, Industry	Pre-normative, Research Potential, SIP
2018	Health, SI Broader Scope	Pre-normative, Research Potential, SIP, Networks
2019	Environment, Energy	Pre-normative, Research Potential, SIP, Networks
2020	Fundamental, Industry	Pre-normative, Research Potential, SIP, Networks

Selected Research Topic	Titre	Partners
g01	Metrology for decarbonising the gas grid	NPL , CEM, VSL, RISE, LNE, LNE-LADG, ...
g05	Metrology for hydrogen vehicles 2	NPL , CEM, RISE, LNE-LADG, VSL, ...
g07	Metrology for hydrogen advanced storage solutions	LNE , CEM, NPL, VSL, RISE, LNE-LADG, PTB, BAM, CMI, VTT, ...

Thank you all for the success of the project and to have made it possible !

Hydrogen

