



FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

NET-Tools

**Novel Education and Training Tools based
on digital applications related to Hydrogen
and Fuel Cell Technology**

Prof h.c. Olaf Jedicke

**Karlsruher Institute of
Technology (KIT)**



www.h2fc-net.eu

Olaf.Jedicke@kit.edu

Programme Review Days 2018

Brussels, 14-15 November 2018

PROJECT OVERVIEW



- **Call year:** 2016
- **Call topic:** H2020-JTI-FCH-2016-1; FCH-04-1-2016 Novel Education and Training Tools
- **Project dates:** 01.03.2017 – 28.02.2020
- **% stage of implementation 01/11/2018:** 45 - 55 %
- **Total project budget:** 1.596.007,50 €
- **FCH JU max. contribution:** 1.596.007,50 €
- **Other financial contribution:** not yet identified (*part of specific deliverable: business plan*)



PROJECT OVERVIEW



- **Partners:**
- **Karlsruher Institute of Technology (*Germany*)** member HER
- **PersEE (*France*)** member HE
- **National Center for Scientific Research "DEMOKRITOS" (*Greece*)** member HER
- **University of Ulster (*United Kingdom*)** member HER
- **Danmarks Tekniske Universitet (*Denmark*)** member HER
- **Institute of Electrochemistry and Energy Systems (*Bulgaria*)** member HER
- **Universita Degli Studi di Perugia (*Italy*)** member HER
- **Element Energy Limited (*United Kingdom*)** member HE



PROJECT SUMMARY



- **NET-Tools, Novel Education and Training Tools based on digital applications related to Hydrogen and Fuel Cell Technology**
- **Objectives**
 - Education and training e-tools dedicated to FCH relevant themes (MAWP addendum 2018)
 - Education and training for students and professionals (MAWP addendum 2018, NIP)
 - Interaction and interconnection with relevant projects (MAWP, NIP)
 - Informal platform for any stakeholder, public, politicians (MAWP)
- **Global positioning vs international state-of the art**
 - Linchpin and network for FCH relevant educational materials and contents, practical e-tools, RCS (databases), PNR and safety aspects
- **Application and market area**
 - Education and training, provider of database and specific content, managing of lectures and schools (summer and winter schools), flying teachers

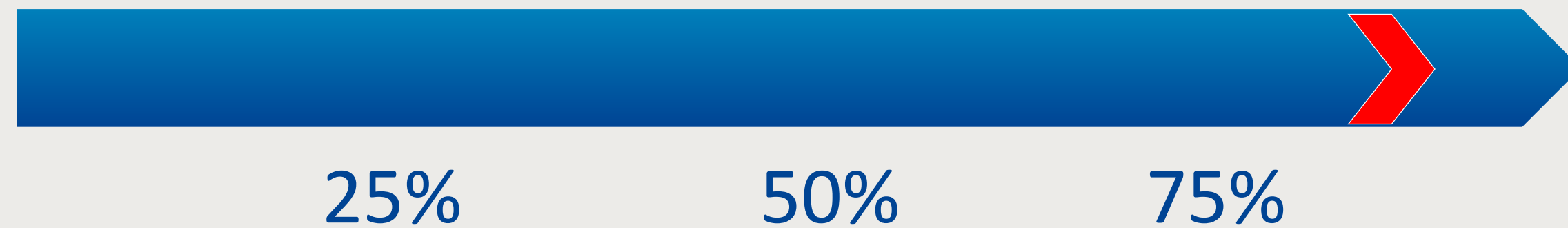


PROJECT PROGRESS/Technical Infrastructure



Technical Infrastructure

0



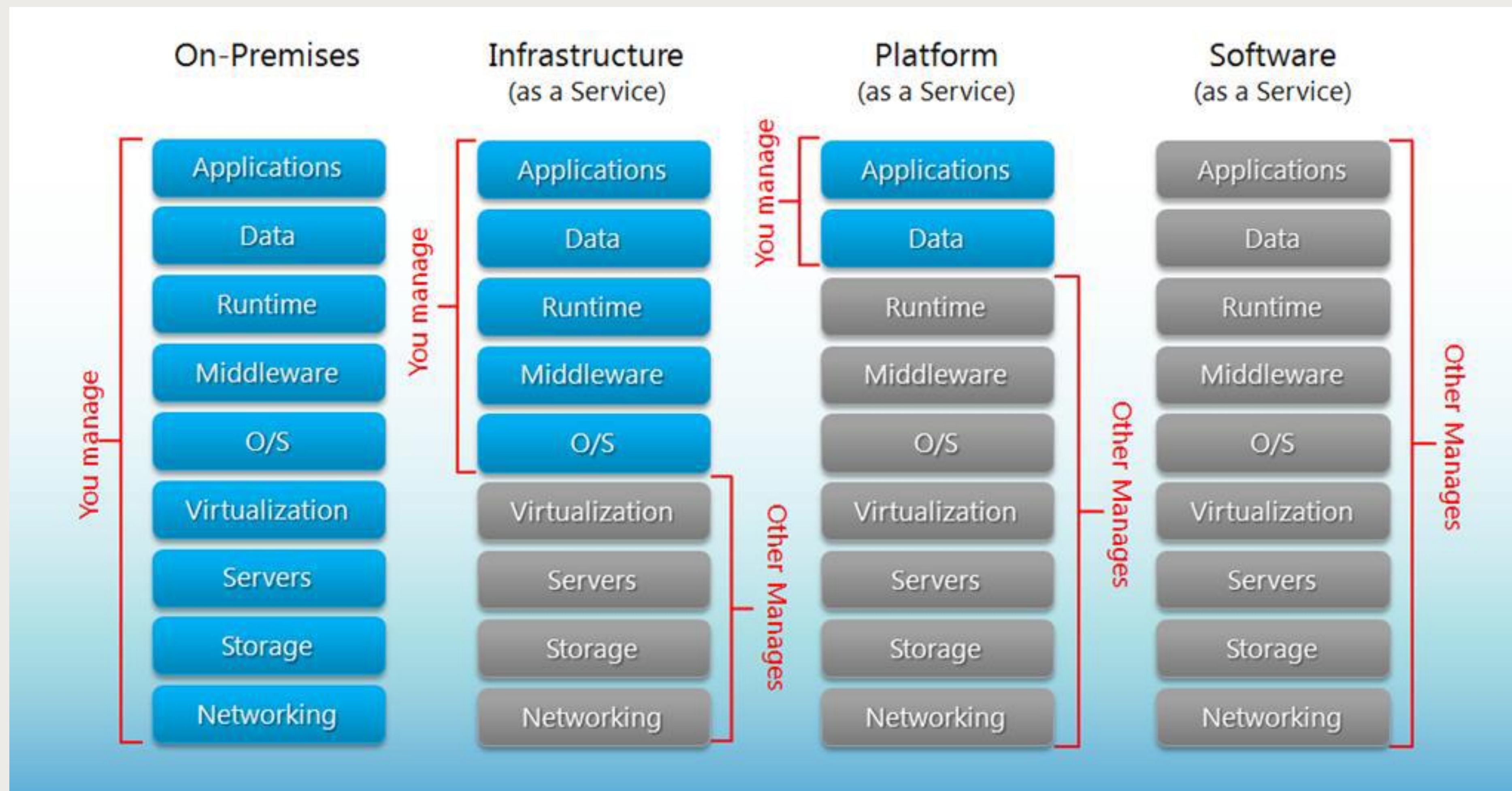
1

- **Open source based e-infrastructure** dedicated to FCH knowledge and science able to connect existing knowledge and easily integrate or support the development of new ones
 - Server based solution planned but discarded due to costs, practical maintenance and software updates
 - Project plan changed to implement e-learning and e-laboratory via approved open source platforms also cloud based
- **NET-Tools website** works as linchpin to interconnect all open source platforms and activities
 - Project plan changed to implement NET-website (runs as NET-platform) via approved open source platform
- Interfaces adapted (lectures and users) to different target audience, e.g. students and professionals (e-education)
- **Implementation of e-learning** platform (LMS) at open EdX
- **Implementation of digital e-laboratory** workspace (distinguished between e-science and e-engineering)
- Reinstallation of **databases** at NET-Tools website, e.g. SUSANA database



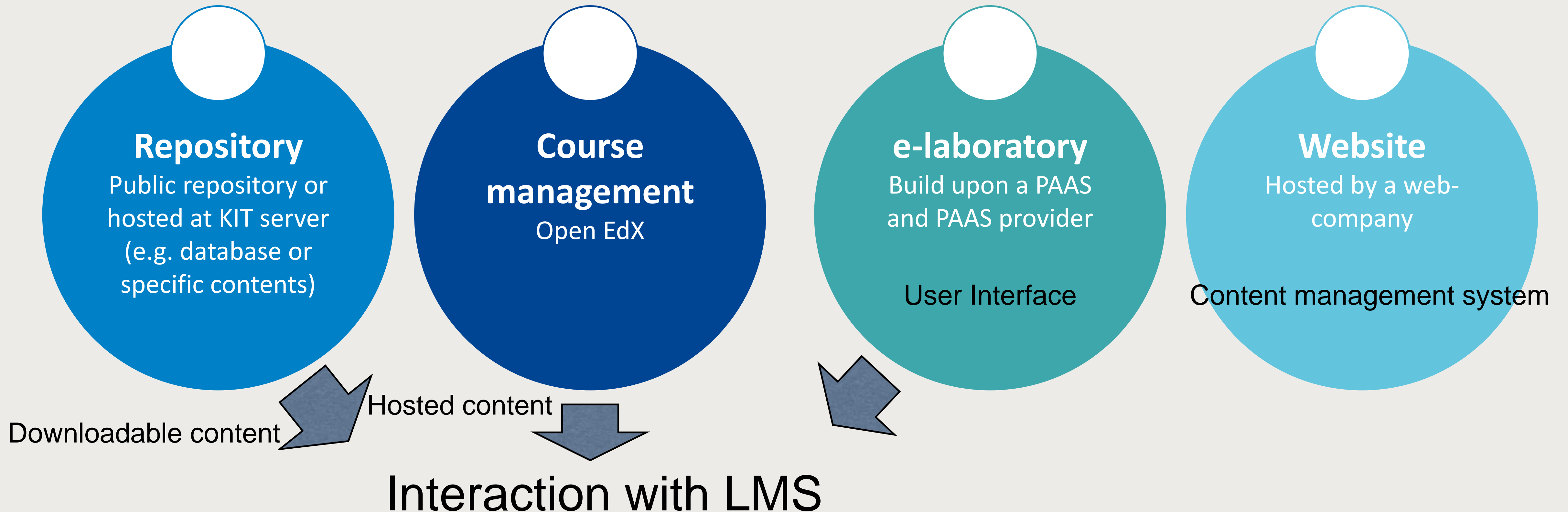
Technical Architecture and Composition

Overview of opportunities to the technical infrastructure

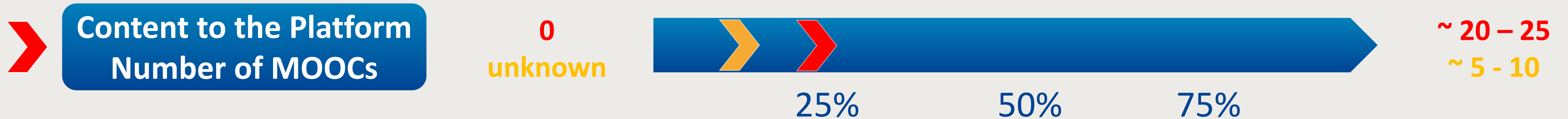


Practical Structure and Interconnection

Overview of opportunities to the technical infrastructure



PROJECT PROGRESS/Compiling and development of e-educational content materials and MOOCs



- **Consolidation of existing e-education** and e-knowledge (courses, lectures, modules)
 - Surprisingly less e-content (already provided under open access) could get investigated
 - **Demand** of providing e-learning materials must get investigated more detailed
 - **Quality assurance and IPR** to be implemented simultaneous to new engagements of external participants
- Three main **lectures planned** to be prepared as example course (e-learning content):
 - Use of Hydrogen (dedicated to Fuel Cells only)
 - Hydrogen Production (all methods including storage)
 - Hydrogen Handling (transportation etc.)
- Development of **novel training** delivery method together with new digital practices (interconnection with e-laboratory)
 - Strategy to follow up this academic pretension and targets less defined “how”
- **Engagement** with and gaining traction from the wide FCH community, companies and universities



PROJECT PROGRESS/Development of e-tools to the e-laboratory



Content to the Platform Number of e-Tools

0
0



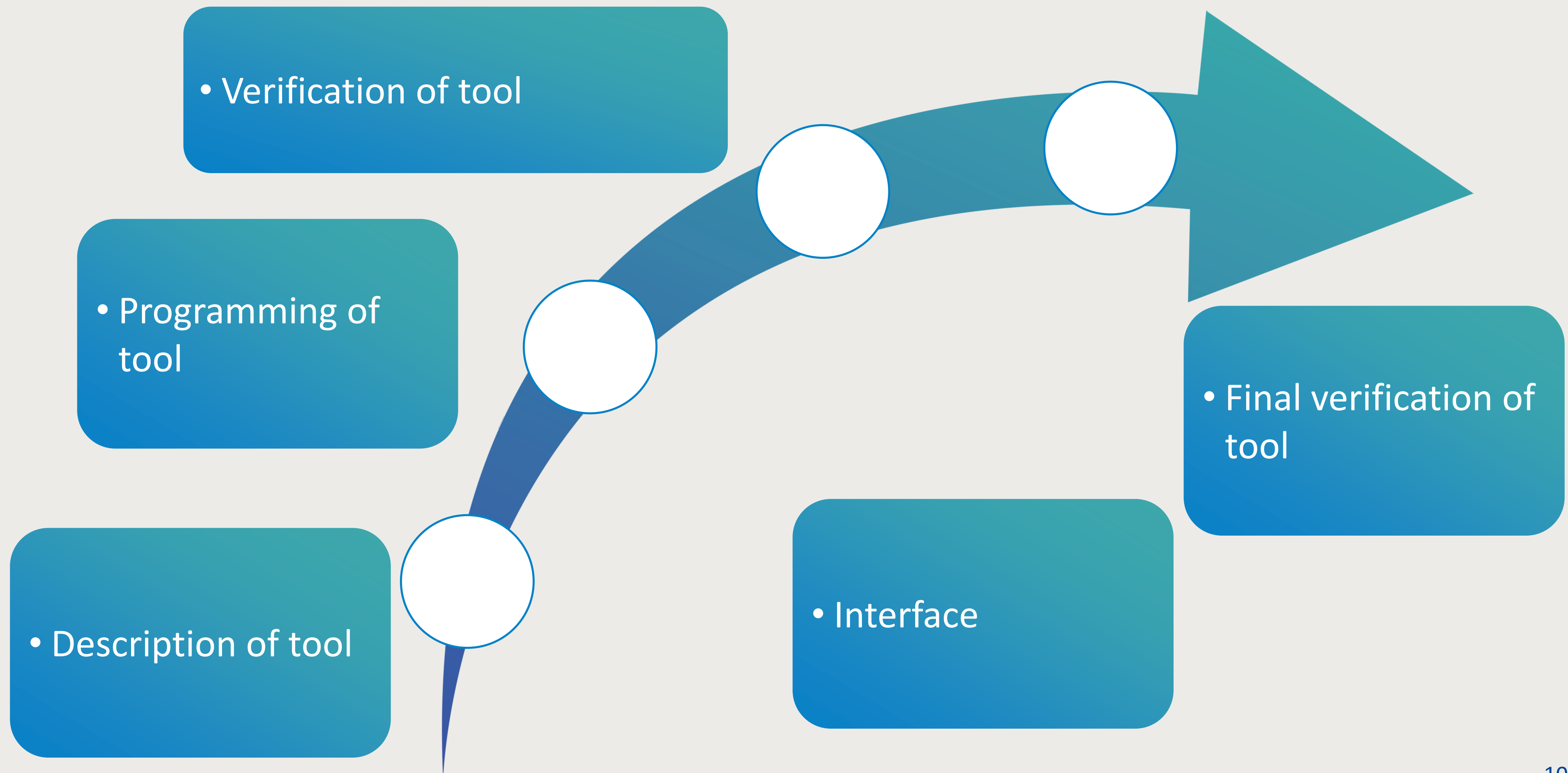
~ 20 - 25
~ 10 - 15

- **Consolidation of existing e-tools** and e-knowledge
 - Surprisingly less e-content (already provided under open access) could get investigated
 - **Demand** of providing e-learning materials must get investigated more detailed
 - **Quality assurance and IPR** to be implemented simultaneous to new engagements of external participants
- **e-laboratory** distinguished in:
 - **e-engineering tools** (for practical teaching and learning and pre-evaluation)
 - **e-science tools** (to support research e.g. modelling and simulation)
- **Engagement** with and gaining traction from the wide FCH community, companies and universities



Procedure and Structure Development of e-tools

Development of e-laboratory and e-Tools



Planning of e-tools

Graphic to demonstrate complexity of development (not to read in details)



		Tools	Description	Programming	Verification	Interface	Final verificat	
e-Laboratory	e-Engineering	Renewable energy system (RES) tools	1. Design & Optimisation of hybrid RES – Hydrogen autonomous power systems for isolated communities and sites.	NCSRDM18	NCSRDM18	NCSRDM19	M20	NCSRDM20
		Fuel cells (FC) tools	1. Simulation of SOFC based on natural gas as fuel	DTU M23(12,7)	M24	M14	M15	M25
			2. Energy balances and hydrogen costs for various electrolysis techniques	DTU M25(11,6)	M26	M13	M14	M27
			3. Cell and stack models for both fuel cells and electrolysis	DTU M15(10,5)	M16	M12	M13	M17
			4. Thermo-mechanical models to predict lifetime of high temperature FCs and electrolysis	DTU M19(9,4)	M20	M11	M12	M21
		Storage/Separation tools	1. Storage material properties estimation and performance assessment based on a "materials-by-design" multi-scale approach; a. Hydrogen Storage in Carbon-based Materials, b. Hydrate equilibrium pressure of H2 mixtures, c. Hydrate-based separation of the binary mixture H2+CO2	NCSRDM12	NCSRDM16(12)	NCSRDM17(13)	M17(14)	M18(14)
		FC integrated into CHP tools	1. Simulation of FC system integrated into mCHP application, including electrolyser operation	UNIPG M2	M4	M8	M10	M10
		Safety engineering tools	1. Jet parameters model	UU M2	M7	M8	M10	M10
			2. Adiabatic and isothermal model of blowdown of storage tank dynamics	UU M2	M8	M9	M10	M10
			3. Flame length correlation and three hazard distances for jet fires	UU M3	M8	M9	M10	M10
	4. Similarity law for concentration decay in hydrogen expanded and under-expanded jets and unignited jet hazard distances		UU M4	M9	M10	M11	M11	
	5. Pressure peaking phenomenon for unignited releases		UU M3	M9	M10	M11	M11	
	6. Passive ventilation in an enclosure with one vent: uniform hydrogen concentration		UU M1	M4	M6	M10	M10	
	7. Mitigation of uniform mixture deflagration by venting technique		UU M4	M14	M15	M16	M15	
	8. Forced ventilation system parameters		UU M5	M15	M16	M16	M17	
	9. Blast wave from high-pressure rupture without and with combustion		UU M14(12,10)	M15	M16	M16	M17	
	10. Effect of buoyancy on decrease of hazard distance for unignited releases		UU M6	M10	M11	M12	M12	
	11. Pressure peaking phenomenon for ignited releases		UU M6	M17	M18	M18	M18	
	12. Upper limit of hydrogen inventory in closed space		UU M7	M8	M9	M10	M10	
	13. Mitigation of localised non-uniform deflagration by venting		UU M8	M16	M14	M15	M15	
14. Effect of buoyancy on hazard distances for jet fires	UU M14(12,8)		M15	M16	M17	M17		
15. Calculation of fireball diameter for rupture in a fire of a stand-alone and an under-vehicle hydrogen storage tanks	UU M9		M14	M15	M16	M16		
16. H2 properties and Tank Blowdown	NCSRDM24		NCSRDM24	NCSRDM25	M26	NCSRDM26		
e-Science	Property tools	1. Normal Hydrogen thermo-physical properties using the NIST-EoS, (Helmholtz free energy based)	NCSRDM17	NCSRDM17	NCSRDM18	M19	NCSRDM19	
		2. The Abel-Noble EOS to calculate CGH2 mass in a volume at particular pressure and density	UU M9	M16	M17	M18	M18	
	Electrochemistry tools	1. Fundamental electrochemistry equations, design PEM, optimal porosity of gas diffusion electrodes, ionic conductivity: a. Electrochemical potential; b. Nernst equation; c. Faraday laws of electrolysis; d. Butler-Volmer equation; e. Tafel equation; f. Ionic conductivity g. Levich equation	IEES M4	M17	M18	M19	M19	
	Storage tools	1. Comsol Multiphysics for simulation of hydrogen production and FCH technologies; a. Methane steam reformer; b. Solid Oxide Fuel Cell (SOFC)	NCSRDM12	NCSRDM12	NCSRDM13	M14	NCSRDM14	
	FC tools	1. Modelling of transport processes in electrodes and electrolytes:	DTU M21(12,4)	M22	M18	M19	M23	
	HyFOAM	1. Release and dispersion of horizontal under-expanded hydrogen jet (HSL)	UU M13	M17	M18	M18	M18	
		2. Large scale deflagration in the open atmosphere (Fraunhofer ICT)	UU M16	M16	M18	M18	M18	
		3. Blast wave and fireball from high-pressure tank rupture in a fire (Weyandt)	UU M25	M25	M27	M27	M27	
		4. Hydrogen/helium dispersion in vented enclosures (CEA)	NCSRDM17	M17	M19	M19	M19	
		5. Vented deflagration (FM Global)	NCSRDM26	M26	M27	M27	M27	



Risks and Challenges



Major Risk (during project)

- Keep educational materials attractive
- Hold the lines to external participants and instructions (guidelines)
- Quality assurance and content management
- Intellectual property rights

Major Risks (beyond the project)

- Running empty of resources to operate and maintain NET-Tools platform
- To cover expenses of running platform especially LMS at EdX open source
- Insurance of quality to the content, visibility and support to content providers and users



Communications Activities



Expert Workshop



Project Flyer

Project Website



List of potential Stakeholders

Social Media

Visit us:



This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 736648.

This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research.



Project e-Newsletter 3rd Issue



Educational Schools Flying Teachers Publications

Communications Activities



Czech Hydrogen Days Prague 2018

ECF Naples 2017

Expert Workshop Trentino 2018

EHEC Malaga 2018

WHEC Rio de Janeiro 2018

Hands on Training Webinar 2018



Novel Education and Training Tools based on digital Applications related to Hydrogen and Fuel Cell Technology

Karlsruhe Institute of Technology
Institute of Nuclear- and Energy Technologies (INET)
Olaf Jedicke; Giovanni Cinti⁽¹⁾; Evelina Slavcheva⁽²⁾
[EFC 2017; Naples 12th – 15th December 2017]
⁽¹⁾ University of Perugia (Italy)
⁽²⁾ Bulgarian Academy of Science (Bulgaria)

Novel Education and Training Tools based on digital Applications related to Hydrogen and Fuel Cell Technology

Karlsruhe Institute of Technology
Institute of Nuclear- and Energy Technologies (INET)
Olaf Jedicke; Giovanni Cinti⁽¹⁾; Evelina Slavcheva⁽²⁾
[Czech Hydrogen Days 2018; Prague 13th – 15th June 2018]
⁽¹⁾ University of Perugia (Italy)
⁽²⁾ Bulgarian Academy of Science (Bulgaria)

Proceedings of EFC2017
European Fuel Cell Technology & Application Conference - Piero Lunghi Conference
December 12-15, 2017, Naples, Italy

EFC17191

NET-TOOLS, AN E-INFRASTRUCTURE TO COMPILE AND PROVIDE E-LEARNING CONTENT TO THE FCH-COMMUNITY

O. Jedicke*, G. Cinti**, E. Slavcheva***
*Karlsruher Institute of Technology, Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldsdorfer (Germany)
**University Perugia, Piazza Dell' Università 1, 06123 Perugia (Italy)
***Bulgarian Academy of Science, Institute of Electrochemistry and Energy Systems, Acad G Bonchev Street BL 10, 1113 Sofia (Bulgaria)

Abstract - Internet technologies, large-scale computing and digital storage resources, data search/retrieval tools, mobile devices, social media and their high uptake among different groups of people have profoundly changed the way knowledge is created, communicated and how it can be further deployed. The digital information technology has made possible a radical transformation of the nature of science and innovation independent from scientific themes. New digital tools and also a new research culture make it possible to perform today's education in a different way and drive research more efficiently by their communication and dissemination. However, to realize new types of education, science and research which are more harmonized, more global and collaborative and especially closer to the demands of all kind of FCH-community, a continuous development and provision of respective e-tools must get provided to support education and development on digital basis. NET-Tools project fosters exactly this aim by developing of new e-tools for e-education and e-science.

Index Terms - Digital Education, Digital Science, e-Tools

I. NOMENCLATURE
FCH: Fuel Cells and Hydrogen
NET-Tools: Project funded by FCH-JU 2.0

II. INTRODUCTION
NET-Tools project extends the scope in providing digital educational materials and new e-tools for courses and e-learning and supplying these to the European lecturer and student's community. The supply of high quality teaching and learning material is essential in building the vast human resources needed for the further development and maintenance of FCH-technologies, infrastructures and institutions expanded meanwhile to very different areas. The university type material developed within the project shall be usable for specific target groups (e.g. FCH-industry, junior researchers, regulators, first responders) but also schools since the curriculum structure is generally valid. To provide e-tools and educational materials to the respective community the integrated architecture of the NET-Tools digital platform is conceived based on detail understanding of distributed multilevel knowledge transfer processes in selected generic cases. Specific features of the platform shall consist on the development of an advanced virtual networking space with a large flexibility in integrating different types of applications able to be tailored based on the needs of the FCH community and sustainable development problems in order to make learners adaptable to changing contexts.

III. NET-TOOLS PLATFORM
The overall concept of NET-Tools is, to realize and develop a specific e-platform as a linchpin concerning education in FCH technologies. The main target of NET-Tools is to develop and provide a European source for international collaboration and exchange of knowledge and teaching materials between providers and users arising from academia and industry. Based on open source software and components, the e-platform will be usable for free (during the course of the project at least) to everybody. Target groups are students, technicians, engineers, lecturers at academic and industry side, public etc. The e-

e-Infrastructure to compile and provide e-Learning Content and Engineering Tools

Project Objectives

- To establish an open source based e-infrastructure (NET-Tools Platform) dedicated to provide FCH knowledge and science under open access
- To establish an open source based e-infrastructure able to interconnect with existing knowledge and integrate or support further development of e-tools and knowledge
- To provide e-Learning materials for self-studies via an Learning Management System
- To develop novel training delivery method together with new digital practices
- To provide e-Laboratory as a workspace for practicing based on science and results arising from science
- To consolidate existing e-education and e-knowledge
- To engage with and gain traction from a wide community of companies and universities

Type of targeted groups	Expected result through CAD activities	Means to achieve expected results
Hydrogen producers		
Energy producers	Promote platform functionalities/ Provide expert knowledge in their domain	Participation in trade fairs, social media, project website, cooperation with other EU platforms
Engineering companies involved in the design of machinery for FCH		
Academia with expertise in FCH		Participation in trade fairs, conferences, social media, project website, cooperation with other EU platforms
Associations in FCH		
General public	Promote platform functionalities/ Provide knowledge and more info regarding FCH	Participation in trade fairs, conferences, social media, project website, cooperation with other EU platforms

Expected Results

- Technical realisation of e-infrastructure and its sub-platforms (e-Learning (LMS) and e-Laboratory)
- Development of e-tools and educational materials in cooperation with Industry and Academia
- Establishment of interconnections and network for further development and elaboration

NET-Tools Hands-On Session

Dear Reader

1st online hands-on session in use of the e-Laboratory 27th June 2018

Collaboration Activities



HySafe



Herve Barthelemy, Thomas Jordan, Marco Carcassi, Jay Keller
International Association for Hydrogen Safety HySafe

The focal point on integrated research and information for hydrogen safety



Czech Hydrogen Days 2018
Praha 13/15 June 2018



UNIVERSITY OF
BIRMINGHAM

**New Programme of Study and e-Learning Tools for
Educating in Fuel Cell and Hydrogen Technologies**



Robert Steinberger-Wilckens
Centre for Fuel Cell & Hydrogen Research
University of Birmingham



EXPLOITATION PLAN/EXPECTED IMPACT



Exploitation

- NET-Tools as open access
- Newsletters, flyers and presentations on respective events
- Educational Schools (demonstrative)
- Workshops and communication to raise engagements

Impact

- European linchpin to educational materials and content on different level
- Online education and training of e.g. engineers and technicians
- e-tools for pre-evaluation and calculation of project realization
- Database and collection of knowledge





FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

NET-Tools

**Novel Education and Training Tools based
on digital applications related to Hydrogen
and Fuel Cell Technology**

Prof h.c. Olaf Jedicke

**Karlsruher Institute of
Technology (KIT)**



www.h2fc-net.eu

Olaf.Jedicke@kit.edu

Programme Review Days 2018

Brussels, 14-15 November 2018