



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

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Teaching Fuel Cell and Hydrogen Science and Engineering Across Europe within Horizon 2020



- Development of Course Curricula
- Harmonisation of Course Curricula
- Development of Course Content
- Development of Course Materials
- Compilation to cc
- Complementary L

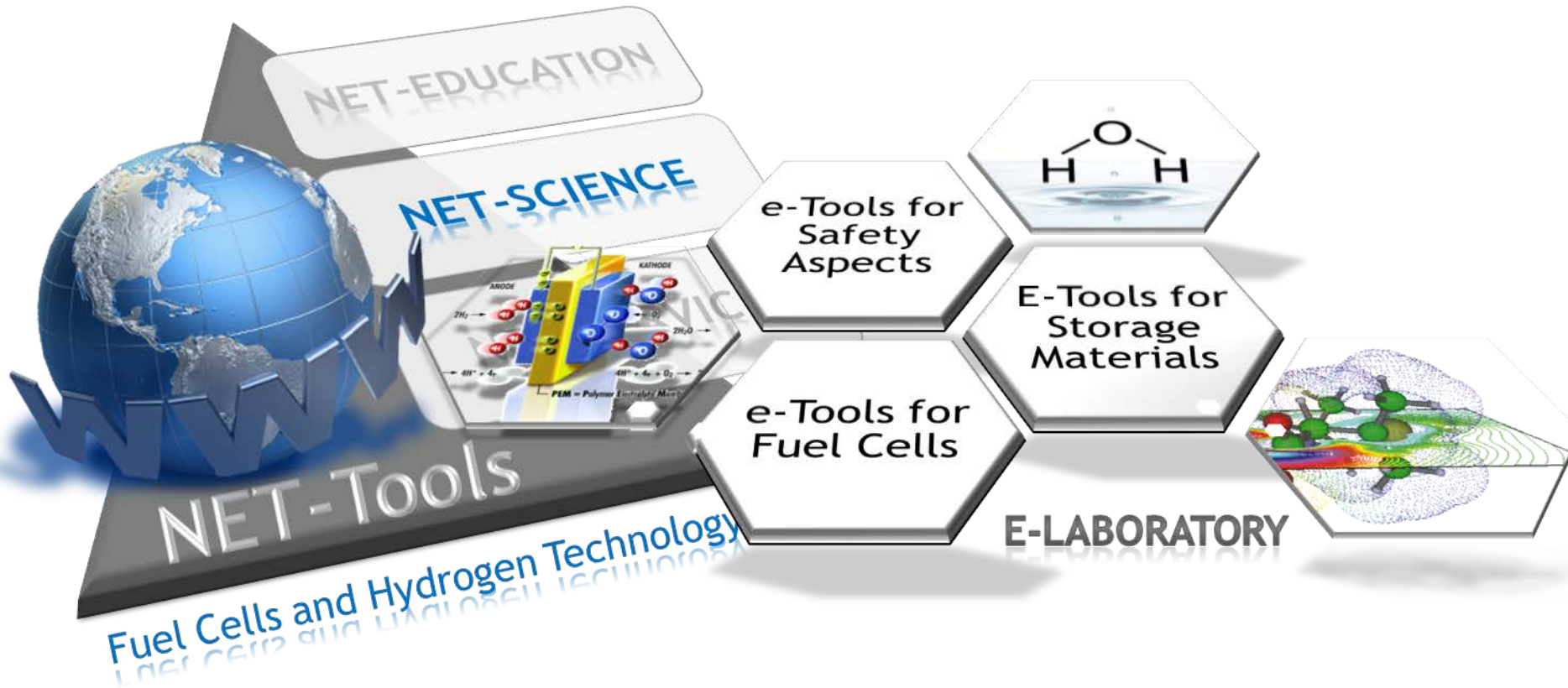
LMS

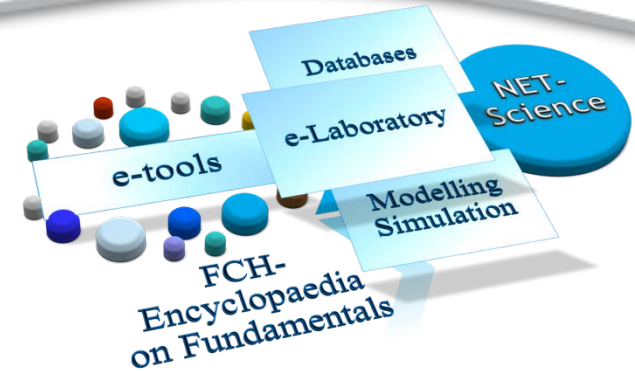


- Development of e-Platform
- Development of e-Tools
- e-Laboratory
- (engineering tools and scientific tools)
- e-Education
- e-model lectures
- Database
- Business concept

General Aim (graphical overview)

To develop, realize, promote and provide a common e-platform





- ✦ Development of an e-Laboratory Platform
subdivided into:
 - ✦ e-Engineering Toolbox
 - Modelling and simulation of FCH related technical aspects
 - Guidelines and brief handbooks of e-tools
 - ✦ e-Science Toolbox
 - Modelling and simulation of FCH relevant phenomena
 - Database of results received from done experiments
 - Database related CFD programming (validation and verification of codes)
 - Guidelines
 - ✦ Database
 - Repository of done experiments and results
 - Guidelines and handbooks

e-Engineering (samples of tools)

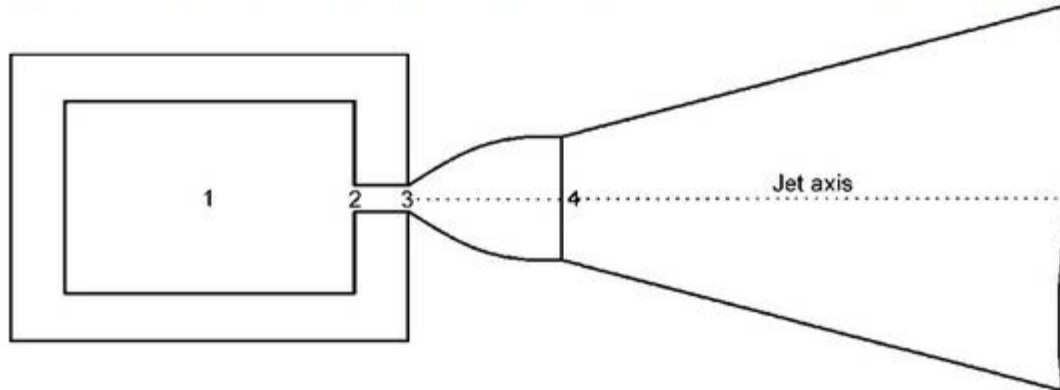


e-Engineering	Renewable energy system (RES) tools	1. Design and optimization of hybrid RES-hydrogen systems	Simulation of SOFC based on natural gas as fuel
	Fuel cells (FC) tools	1. Simulation of SOFC based on natural gas as fuel	
		2. Energy balances and hydrogen costs for various electrolysis techniques	
		3. Cell and stack models for both fuel cells and electrolysis	Cell and stack models for both fuel cells and electrolysis
		4. Thermo-mechanical models to predict lifetime of high temperature FCs and electrolysis	
	Storage tools	1. Storage material properties	
		2. gProms thermal design of storage tanks optimization (http://www.psenterprise.com/gproms.html).	
	FC integrated into CHP tools	1. Simulation of FC system integrated into mCHP application, including electrolyser operation	
		1. Under-expanded jet parameters model	Forced ventilation system parameters
		2. Adiabatic and isothermal model of blowdown of storage tank dynamics	Adiabatic and isothermal model blowdown of storage tank dynamics
		3. Flame length correlation and three hazard distances for jet fires	
	Safety engineering tools	4. Continuity law for concentration dynamics hydrogen surrounded and under expanded jets and vented jet based distances	
		6. Passive ventilation in an enclosure with one vent: uniform hydrogen concentration	
		7. Mitigation of uniform mixture deflagration by venting technique	
		8. Forced ventilation system parameters	Calculation of upper limits of hydrogen inventory in closed space
		9. Blast wave propagation	
		10. Effect of buoyancy on decrease of hazard distance for unignited releases	
11. Pressure peaking phenomenon for ignited releases			
12. Upper limit of hydrogen inventory in closed space			
13. Mitigation of localised non-uniform deflagration by venting			
14. Blowdown time as a function of storage pressure, volume, and TPRD diameter			
15. Radiation from hydrogen fireball after high-pressure hydrogen tank rupture in a fire			
16. Effect of buoyancy on hazard distances for jet fires			
17. Calculation of choked flow for stagnation conditions in vapor, liquid or supercritical regimes.			

Cyber Laboratory

Underexpanded jet parameters

The model describes parameters in an underexpanded jet through characteristic stages of its development - in reservoir (1), orifice (2), and effective nozzle diameter (4). The model is based on Abel-Noble equation of state for hydrogen; conservation equations for mass and energy; assumption that at state (4) (so called "effective nozzle diameter") pressure is equal to the ambient one and velocity is equal to the local sound speed. The model does not account pressure losses in the nozzle (between states (2) and (3)).



Reference:

- Free eBook: V. Molokov "Fundamentals of Hydrogen Safety Engineering", www.BookBoon.com, October, 2012

INPUT VALUES

Units for pressure input:

[bar]

Pressure in tank:

700 [bar]

Temperature in tank:

240 [K]

Orifice diameter:

2 [m]

Ambient pressure:

650 [bar]

RUN

The calculation can last for a few seconds. If you want to start a calculation, click twice on the update button for it.

Temperature of the environment [K] 288.4000000000000

pressure of the environment [Pa] 101325.00000000000

jet exit diameter [m] 0.12000000000000000

```

#####
# INCLUDE PARAMETERS OF ENVIRONMENT
# T = temperature of the environment / K
#T = 288.40
T=ind
# p = pressure of the environment / Pa
#p = 101325.0
p=ind
# rho = density of environment / kg/m3
rho = Rho(p,R_gas,T)
#####
# INCLUDE JET PARAMETERS
# d_j = jet exit diameter / m
#d_j = 0.12
d_j=ind
#####
# SET GAS TO HYDROGEN
Ea = Ea_H2
Tmax = Tmax_H2
Mpec = Mpec_H2
alpha = alpha_H2
Ra = Ra_H2
# H2_1d
V_j = 1224.20
rho_j = 0.04
omega = 20.40

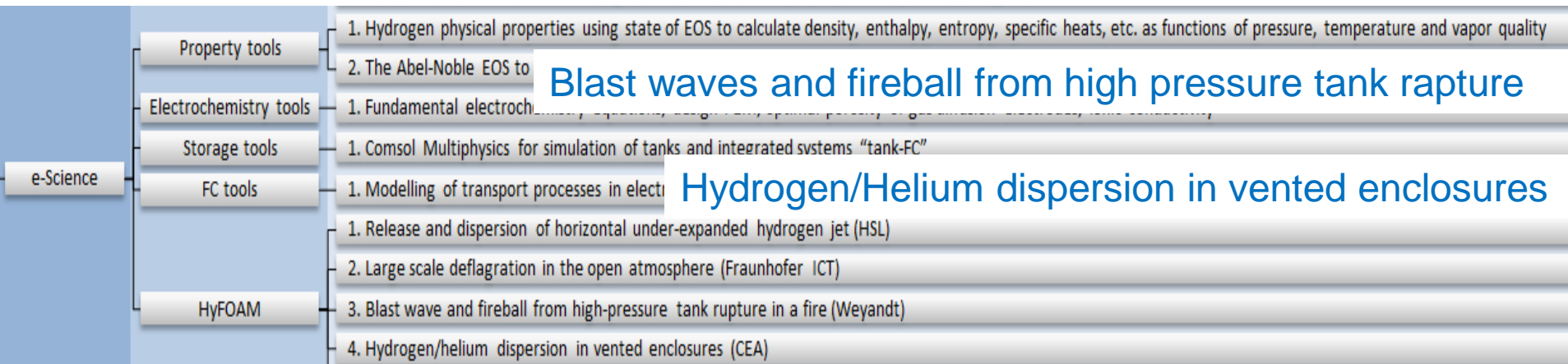
Fr_f = V_j * d_j**0.5 / (rho_j / rho)**0.25 / ((Tmax/T - 1.0) ** 0.5 * d_j)**0.5
#print "Fr_f = ", Fr_f

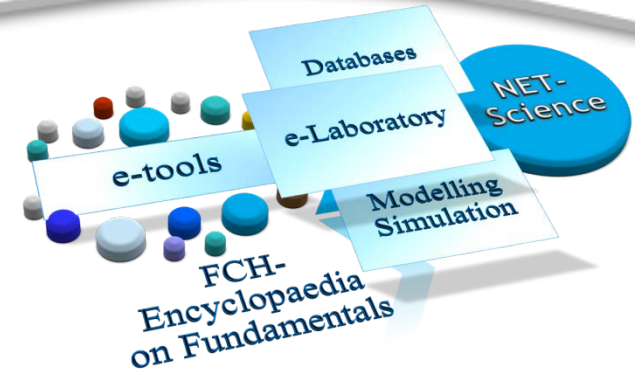
# l_star = 0.10
l_star = 10.0 * Fr_f**0.4 / (1.0 + 0.07 * Fr_f**2)**0.2
diseq
l_star = 20
#print "l_star = ", l_star

L_vis = l_star * d_j * sqrt(rho_j / rho) / Ea
#print "L_vis = ", L_vis, " m"
                    
```

Thermo-physical properties of Hydrogen

Release and dispersion phenomena





- ✪ Development of an e-Educational Platform
subdivided into:
 - ✪ e-Learning
 - Conventional Learning Management System (LMS)
 - Technical features to support users concerning communication, planning, exchange of documents, etc.
 - Quality assurance (probably review)
 - Guidelines
 - ✪ e-Repository of FCH relevant information
 - Database
 - Documentations
 - e-books ?
 - Guidelines

- Educational materials
 - Course materials
 - Survey of existing course materials

- Specific Courses (Master Courses) in collaboration with **TeachHy**
 - Course Curricula (University level)
 - Content descriptions (based on modules)
 - Specific educational course materials
 - List of European Universities providing the master course (faculties, professors, lectures, etc.)
 - Access for students and teachers (lectures)

- e-Learning for Industrial Use
 - Typical industrial demands
 - Industrial level (technicians and engineers)
 - Facing industrial problems



H2FC
EUROPEAN RESEARCH INFRASTRUCTURE



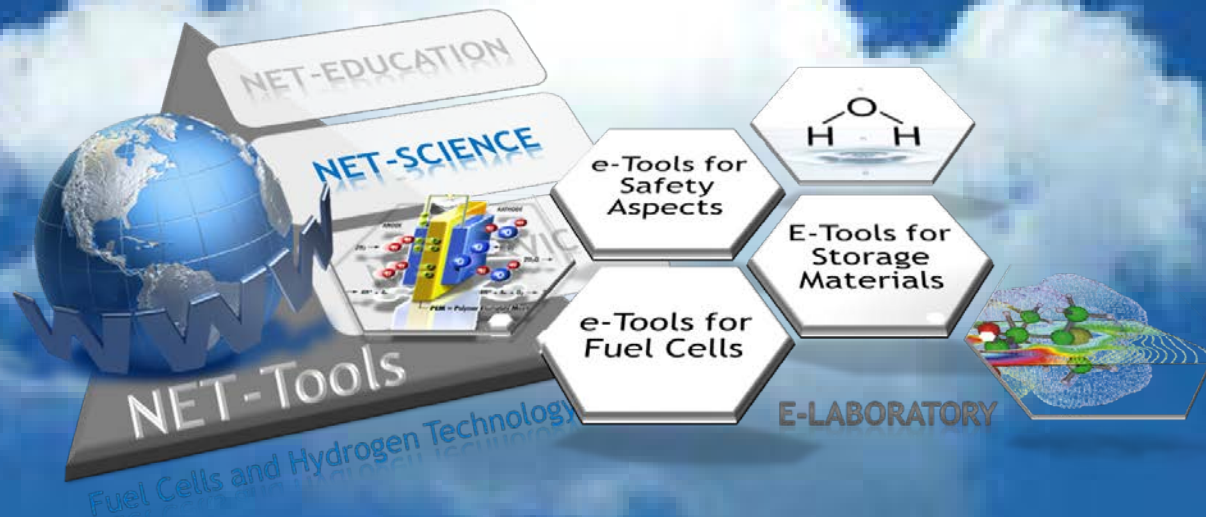
- ✦ Expert Workshop (2018)
 - Stakeholders from Industry
 - Stakeholders from Academia
 - Advisory Board Members
 - Others
- ✦ Two Educational Schools (2018 and 2019)
 - To enrol and test NET-Tools e-platform on practical level (in operando)
 - Feedback for further improvement and development
- ✦ Flying Teachers
 - To enrol and test the acceptance of new teaching strategy in combination with NET-Tools
 - H2FC (Research Infrastructure Project)
- ✦ Newsletter

Development and compilation of specific e-tools















Development of e-Laboratory (scientific and engineering basis)

Development of e-Education (repository and LMS)

Development of e-Platform (cloud based) to provide e-Laboratory and e-Education under free access



TO PROVIDE an EUROPEAN DIGITAL PLATFORM to the FCH Community

Acronym	KIT coordinator leader WP 1	Membership
	Karlsruher Institute of Technology GERMANY (KIT) Research Organisation	
Acronym	PersEE leader WP 2	
	PersEE FRANCE Small and Medium Enterprise (SME)	
Acronym	NCSR	
	National Center For Scientific Research DEMOKRITOS GREECE University (Higher Education)	
Acronym	UU leader WP 3	
	University of Ulster UNITED KINGDOM University (Higher Education)	
Acronym	DTU leader WP 4	
	Danmarks Tekniske Univeritet DENMARK University (Higher Education)	
Acronym	IEES leader WP 5	
	Bulgarian Academy of Science BULGARIA Institute of Electrochemistry and Energy Systems University (Higher Education)	
Acronym	UNIPG	
	Università Delgi Studi di Perugia ITALY University (Higher Education)	
Acronym	EE leader industrial advisory board	



NET-TOOLS

e-tools for
education in
modern

FCH-technology

Created by Olaf Jedicke

