



**Teaching FCH Technologies in a
Masters' Course across Europe**

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Partners



**UNIVERSITY OF
BIRMINGHAM**



EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



**Ulster
University**



Grenoble **INP**



TU Delft
Delft
University of
Technology



ULB
UNIVERSITÉ
LIBRE
DE BRUXELLES



**UNIVERSITY OF
CHEMISTRY AND
TECHNOLOGY
PRAGUE**



Technical
University of
Denmark



DTU



KIT
Karlsruher Institut für Technologie











Linking to previous activities ...



Interactions with projects funded under EU programmes

- TrainHy – MSc course based on syllabus developed by TrainHy
- HySafe – Hw safety module from HySafe
- KnowHy – blended learning and CPD approach



Interactions with national and international-level projects and initiatives

- IPHE – Educational Activities – represented by Jürgen Garcke on Advisory Board
- EPSRC Supergen H2FC Hub – use of Educational Portal
- T.I.M.E. network – network partners



Interactions with private projects and initiatives

- JESS – Joint European Summer School – cooperation on module development and delivery



The Need



2012										
Application area	Unit	Est. annual production		Market value (M€)	CAGR	Number of companies involved		Employment		
		Unit	Value			SMEs	Large companies	Workers	Technicians	Engineers
Fuel cell electric vehicles	#	100	5	---	10	8	250	750	1500	
Hydrogen refuelling stations	#	20	20	---	10	5	133	133	133	
Hydrogen Production	ton	895	9	---	15	5	447	447	447	
Stationary fuel cells	#	50	2	---	18	5	83	83	83	
Early markets - forklifts	#	300	4	---	18	6	25	25	25	
Early markets - power generation	#	500	1.2	---	18	5	25	25	25	
TOTAL			41				964	1464	2214	

2020										
Application area	Unit	Est. annual production		Market value (M€)	CAGR 2012-2020	Number of companies involved		Employment		
		Unit	Value			SMEs	Large companies	Workers	Technicians	Engineers
Fuel cell electric vehicles	#	100 000	3 000	45%	5	12	12 500	6 250	6 250	
Hydrogen refuelling infrastructure	#	150	135	12%	3	7	750	750	750	
Hydrogen Production	ton	145 447	1 164	32%	10	10	4 848	4 800	4 800	
Stationary fuel cells	#	50 000	625	45%	10	7	5 000	5 000	5 000	
Early markets - forklifts	#	10 000	100	21%	10	8	417	417	417	
Early markets - power generation	#	20 000	28	22%	10	7	208	208	208	
TOTAL			5 052	30%			23 723	17 425	17 425	

2030										
Application area	Unit	Est. annual production		Market value (M€)	CAGR 2020-2030	Number of companies involved		Employment		
		Unit	Value			SMEs	Large companies	Workers	Technicians	Engineers
Fuel cell electric vehicles	#	500 000	12 500	7%	2	15	62 500	31 250	31 250	
Hydrogen refuelling infrastructure	#	300	420	3%	3	7	2 250	1 125	1 125	
Hydrogen Production	ton	425 635	3 405	5%	5	10	11 350	11 237	11 237	
Stationary fuel cells	#	150 000	1 500	5%	5	8	11 250	5 625	5 625	
Early markets - forklifts	#	30 000	240	5%	5	8	1 000	1 000	1 000	
Early markets - power generation	#	30 000	42	2%	5	8	500	500	500	
TOTAL			18 107	7%			88 850	50 737	50 737	



Objectives

- establish a blended learning MSc course to be delivered by a network of European universities
- offer CPD and public educational materials and certified professional courses based on the course material
- develop virtual and distance access to laboratory facilities
- map pathways to accreditation in various European countries
- support universities in implementing the scheme or elements thereof on their own Learning Management Systems
- support research project and exam implementation
- build a post-project entity (Charity IASBL) that will continually support the further development of the teaching material



The TeachHy Syllabus

12 months taught programme (potentially 18 or 24 months)

7 mandatory modules:

1. Thermodynamics, electrochemistry, chemistry
2. Introduction to fuel cells
3. Hydrogen (production, storage, handling), fuels (P2G, P2X)
4. Characterisation methods
5. Fuel cell modelling tools and control
6. Lab Work (virtual lab)
7. Hydrogen and fuel cell safety



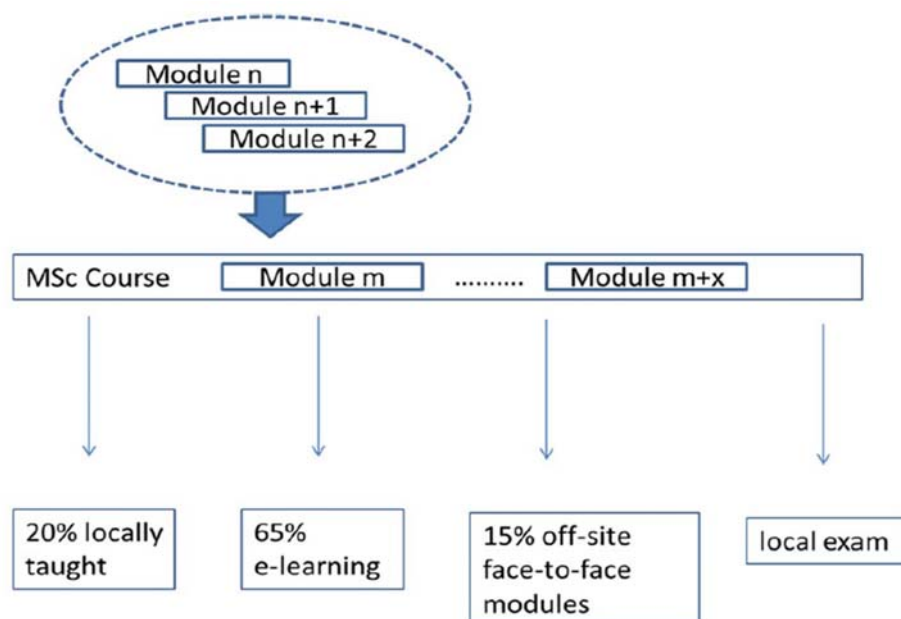
The TeachHy Syllabus (2)

5 optional modules (out of 10):

1. Environmental analysis, life cycle analysis
2. Low temperature fuel cells (materials, stacks, thermodynamics, electrochemistry, chemistry)
3. High temperature fuel cells (materials, stacks, thermodynamics, electrochemistry, chemistry)
4. Low temperature systems
5. High temperature systems
6. Advanced characterisation
7. High temperature chemistry for SOFCs/SOEs
8. Fuel cell electric vehicles
9. Politics, markets, regulation, codes and standards
10. Energy system and storage
- A1. Advanced modelling

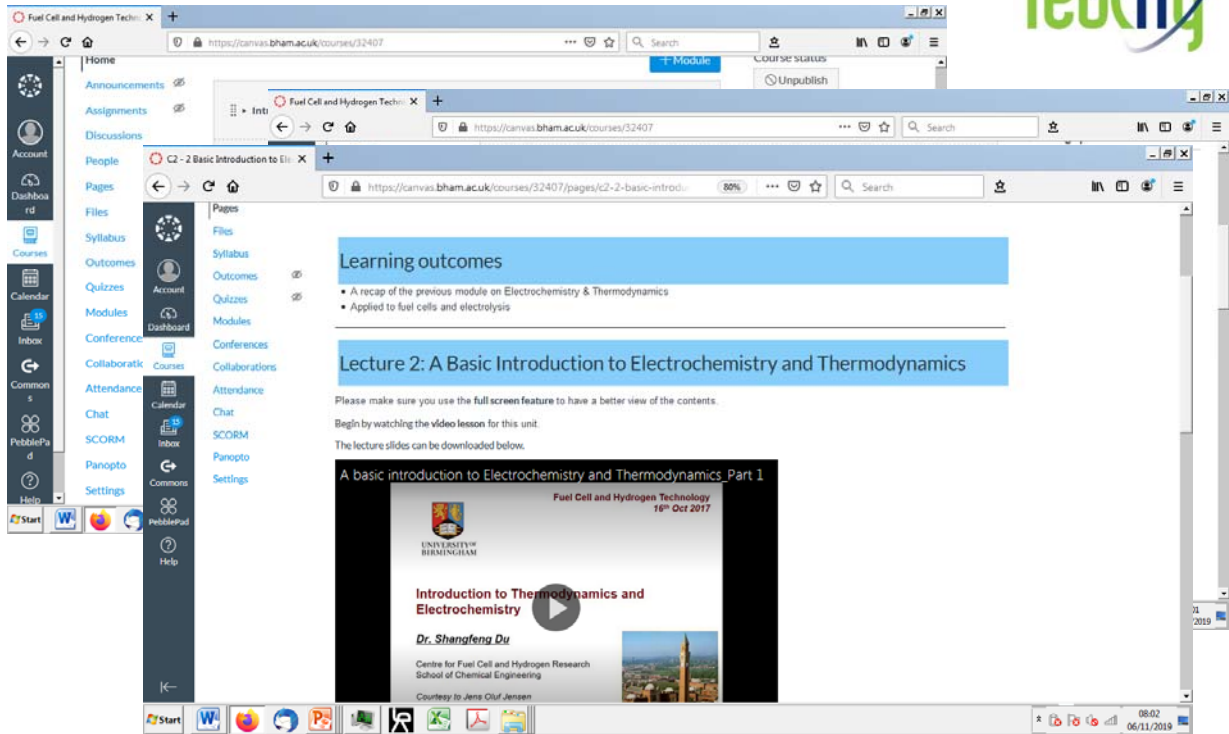


Choose & Mix

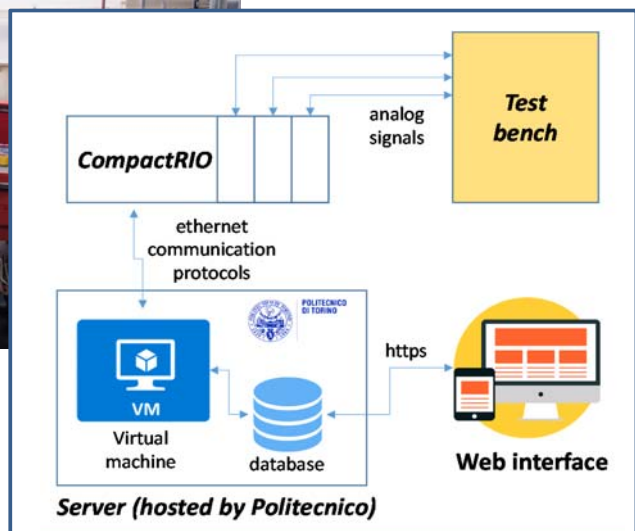
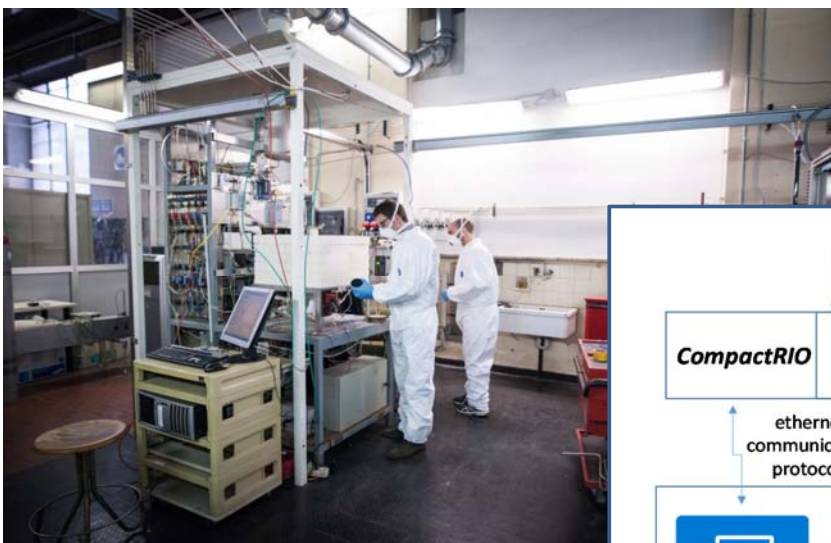




Prototype Implementation on CANVAS LMS



The Remote Lab Experience



- any participating university can 'buy' into the network
- currently on a 'tit for tat' basis – you take, you give (e.g. by translating material)
- later as a sustainable business model
- from the modules available an individual MSc course can be built,
deciding what to deliver locally (face-to-face) and what online
- organise lab work locally (or in collaboration with other uni) and exam
- locally/nationally accredit the course
- participate in student / staff exchanges

Critical Issues

Accreditation procedures

- diversity of accreditation models at universities
- reluctance of university administrations to accept external contributions
- 'ownership' of modules

Financial issues

- divergence of university financing models and tuition charges
- reluctance of funding of educational activities – under-funding, considerable unpaid and unrecognised university input
- depending on cooperation model the annual license fees will be around 7 500 €



How can Universities get Involved?

- many universities cover single topics in FCH in courses such as Physics, Chemistry, Materials Sciences, Chemical & Mechanical engineering etc.
- within the EU only one (!) university offers an FCH MSc degree
- many universities can cover about ~30% of the necessary lecturing material and capacity
- a number of 50 to 200 university courses are needed to cover the HR demands by 2030
- TeachHy will help to build individual MSc courses, based on the TeachHy material, deciding what to deliver locally (face-to-face) and what online
- partnering universities will organise research project, exams, and lab work locally (or in collaboration with other uni's)
- TeachHy will operate as a Charity post-project, collecting license fees to continuously update, develop and adapt the educational material

Training Technicians



- programme of technician training in blended learning mode
- combination of e-learning content, use of simulation tools ('serious games') and background reading
- followed by lab-work session and an exam
- modules : Micro Fuel Cells, Combined Heat and Power Generation, Fuel Cell Based Generators, Fuel Cells for Transport Applications, Hydrogen Production and Handling



Upcoming events:

4th Degradation Workshop –
online **5 May 2021**

Fuel Cell Systems Workshop –
18/19/20 May 2021, Bruges,
Belgium / online

JESS 2020 – Joint European Summer School,
06 to 11 & 13 to 18 Sept 2021,
Athens
www.jess-summerschool.eu



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Thank you for your Attention!

Any Questions?



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