FUEVA

EUROPEAN FUEL CELL VEHICLES TECHNOLOGY VALIDATION

HarmonHy Final Conference

4th of October 2006

Brussels

Overview

Project partners

ika INSTITUT FÜR KRAFTFAHRWESEN AACHEN RWTH

PSA PEUGEOT CITROËN

VOLVO

CENTRO RICERCHE FIAT

Ford Research & Advanced Engineering

RENAULT

Start: 01.01.2003
Duration: 42 month
Budget: 2 M€
EU contribution: 1,2 M€

Overview

Project structure

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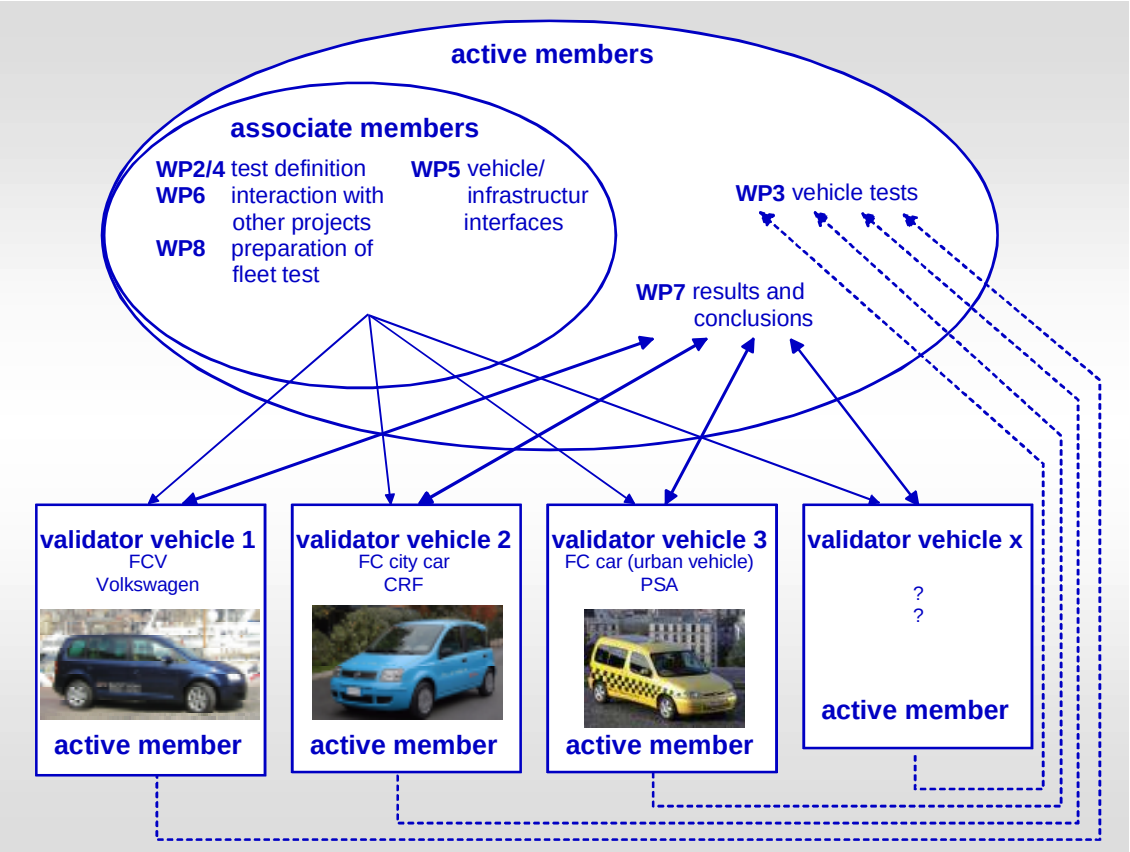
Main Tasks:

- Modification of regulations, codes and standards for usage with FCV with focus on fuel consumption measurement
- Preparation of test equipment
  for performing the various measurement methods at different locations
- Vehicle measurements
- Refinement of the proposed documents
- Verification of measurement methods, also possible in cooperation with other European/International projects



WP 2

Standards and Regulations in the scope of the project

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	European Regulation	ECE Directive	Status
Fuel Consumption H_2	R101	80-1268	V
Fuel Consumption LH_2 & CO_2 emissions	R101	80-1268	V
Emissions	R83-05	70-220	D
Start up time & energy cons.	(R 101)	70-220	V
Maximum & 30 min power	R85-84	80-1269	V
Maximum Electrical power (FC system + Battery)	----------	New draft	V
Range with fuel + Battery	(R 101)	----------	V
Range with fuel	(R 101)	----------	D

Status : Validated, Draft, Not Achieved, Not Modified

WP 2

H2 measurement methods

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- **Electric current method**: the hydrogen consumption is calculated by measuring the output current of the fuel cell stack
- **Pressure temperature method**: the hydrogen consumption is calculated by measuring the pressure and the temperature of the gas in the high-pressure fuel tank before and after the test, calculating the change in the number of moles of gas in the storage by applying the measured values of p and T to the state equation
- **Weighing method**: the hydrogen consumption is calculated by measuring the weight of the high-pressure fuel tank before and after the test procedure
- **Flow volume method**: the amount of hydrogen supplied to and consumed by a fuel cell vehicle is measured by a flow meter, which will be installed in the H_2 feed pipe in between an external fuel supply source and the vehicle

Main issues:

Measurement range, accuracy and dynamics (strongly depending on the method)

WP2

Benchmarking of H2 measurement methods suitable for H2 FCV

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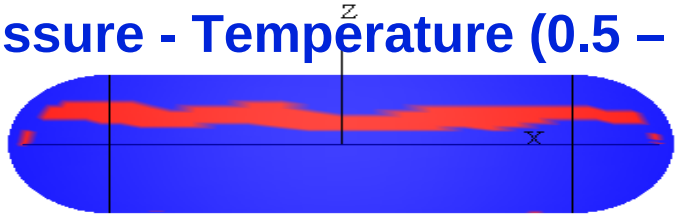
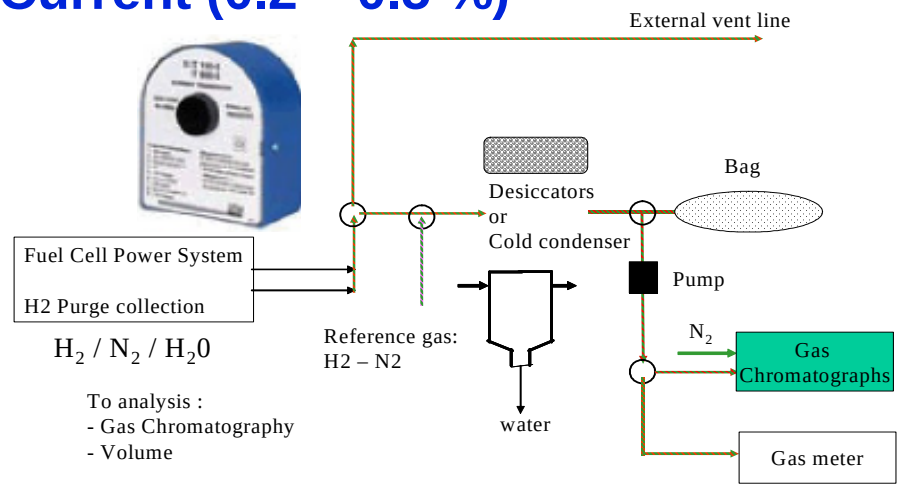
Pressure - Temperature (0.5 – 1%)



Redlich-Kwong Equation <-> Van der Waals

Current (0.2 – 0.5 %)

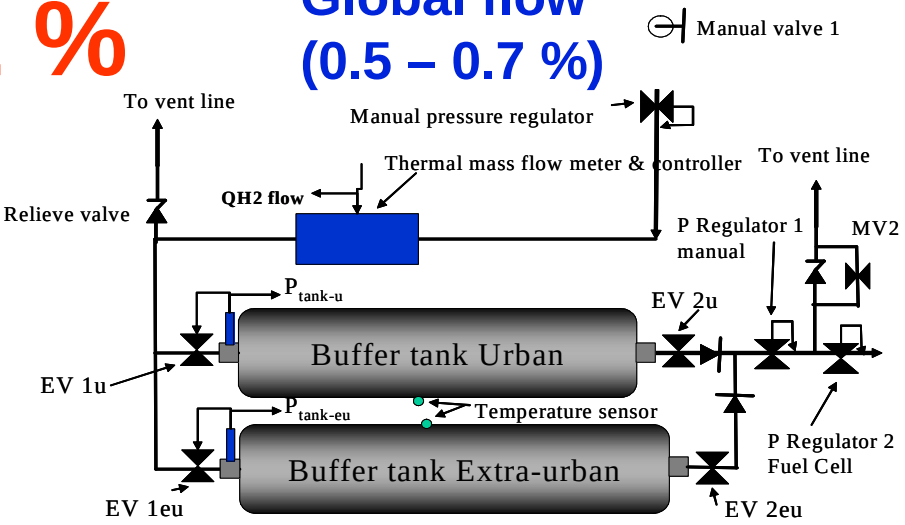


Weight (0.2 – 0.5 %)

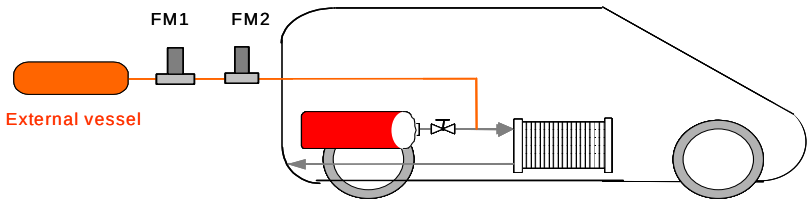
Accuracy Target:

Error < 1 %

Global flow (0.5 – 0.7 %)



Instantaneous flow rate (0.9 – 1.3 %)



WP3

Hydrogen Measuring Rack (I)

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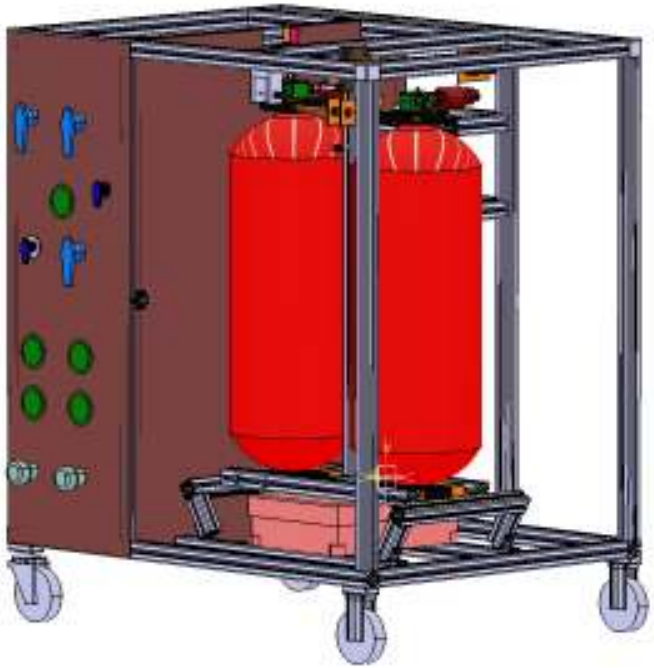

Mobile Rack:
HxBxL: 1380x920x1200

WP3

Hydrogen Measuring Rack (II)

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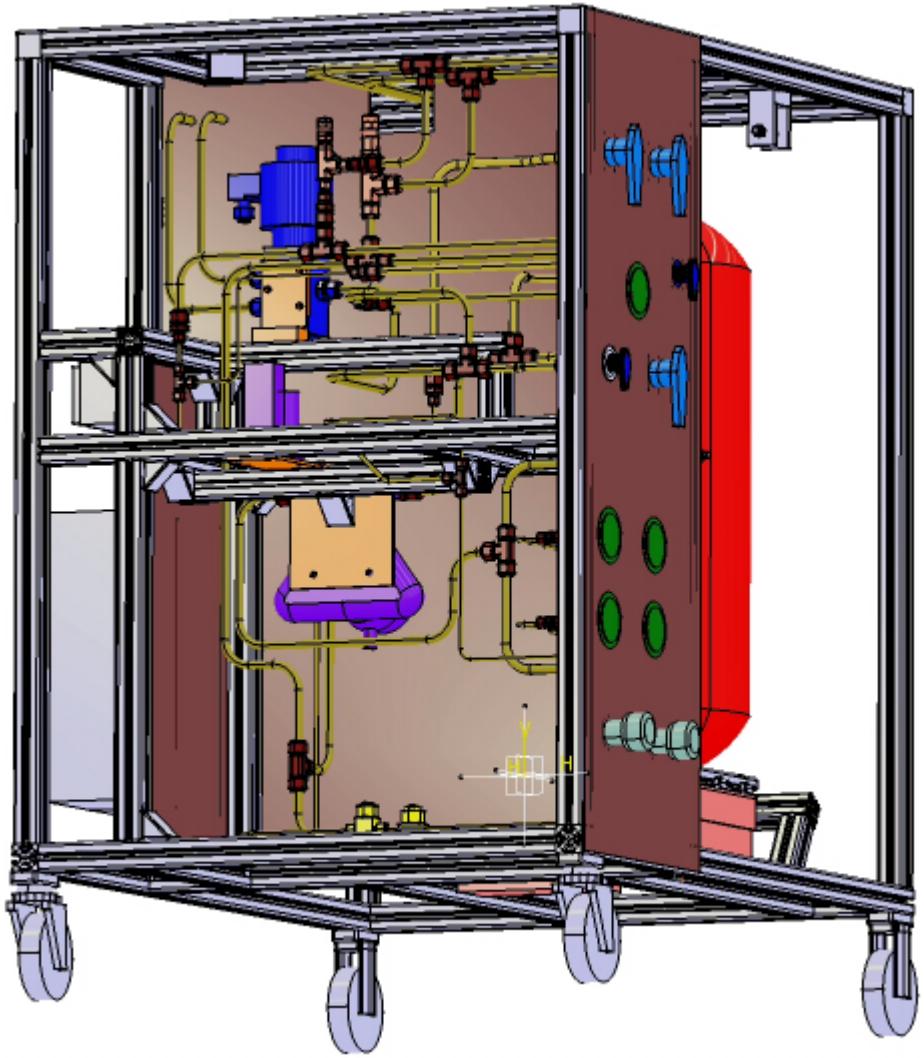

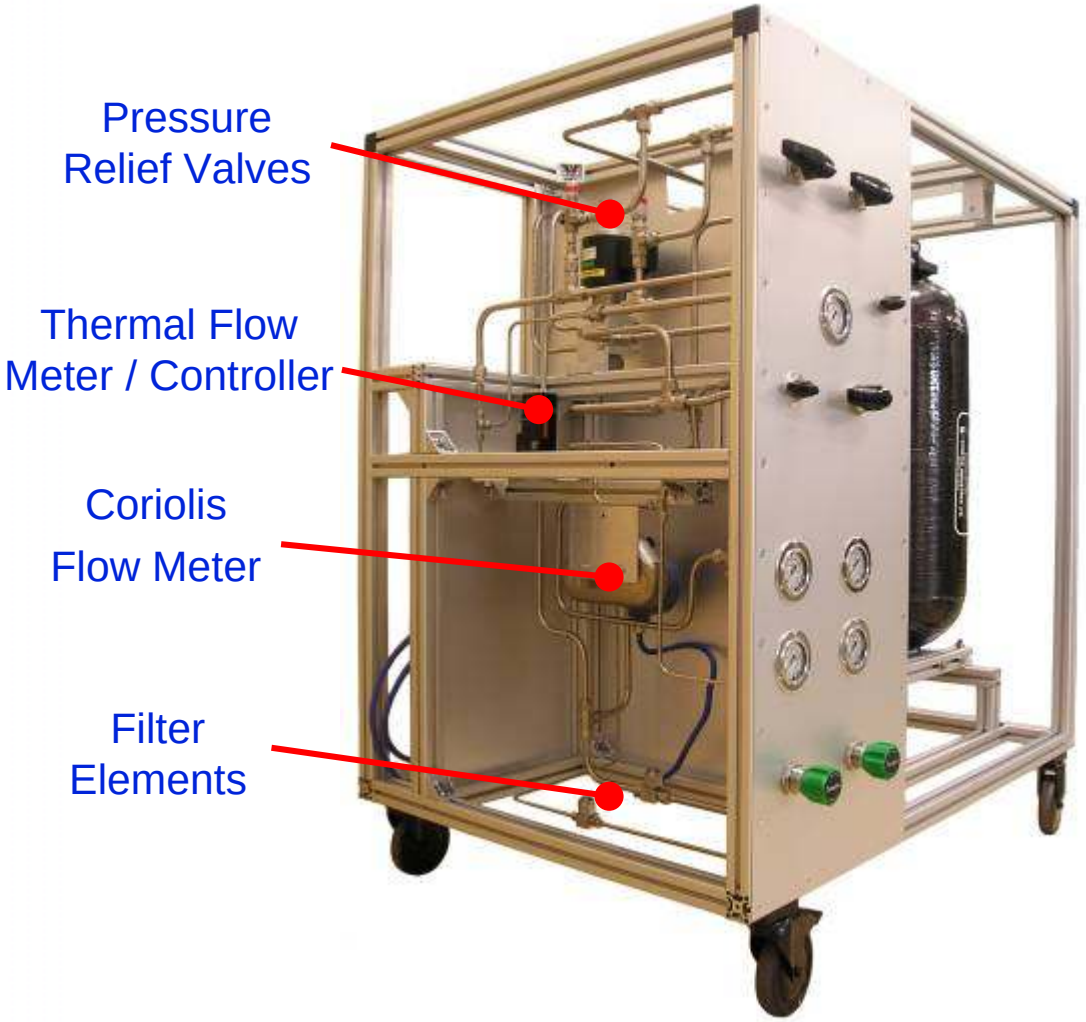

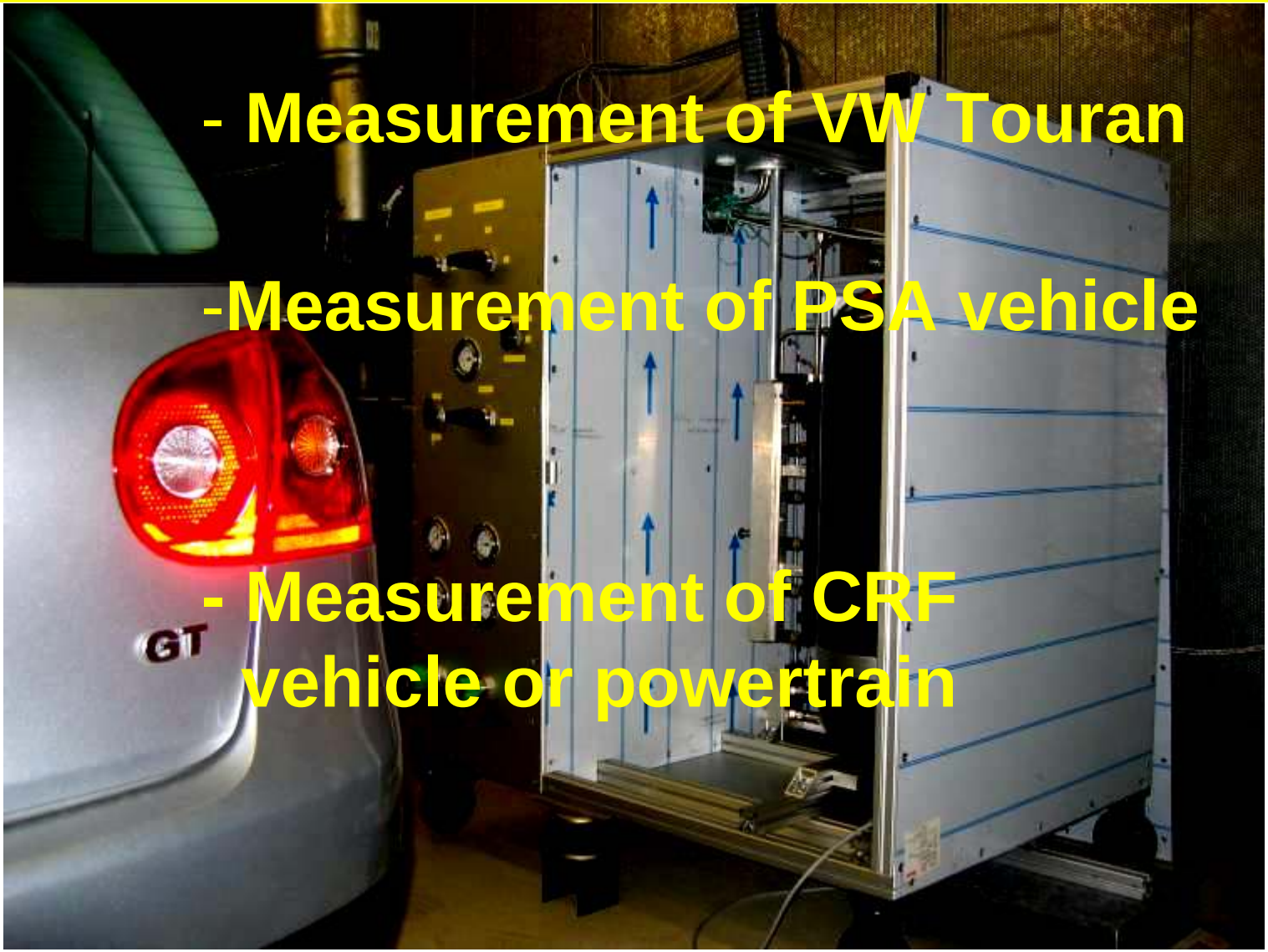
- Measurement of VW Touran
-Measurement of PSA vehicle
- Measurement of CRF vehicle or powertrain
GT

WP3

Information on measuring equipment (e.g. accuracy, practicability, …)

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- Demanded / specified accuracy:
  - p/T method 1 %
  - Weighing method 1 %
  - CMFM method 1 %
  - TMFC refill method 1 %
- Achieved / calculated accuracy (for 120 g H2):
  - p/T method +/- 200 mbar pressure x temp.- error
  - Weighing method 0,4 % (~0,5 g, in optimal case)
  - CMFM method 0,35 % (0,8%) x response error
  - TMFC refill method 0,5 % x +/- 200 mbar pressure

WP4

Definition and preparation of field tests

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- ***Overall goal:***
  Development of assessment criteria for FCV road operating performance and other customer relevant data on test tracks and public roads.
- ***Examples for road operating performance:***
  Maximum and continuous speed, acceleration, hill starting ability, speed uphill, airborne noise levels, etc..
- ***Examples for customer relevant assessment data:***
  Pre-starting time, passenger compartment noise levels, etc..

WP4

Customer relevant assessment criteria

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1. Technical data:

Vehicle & component technical assessment data mainly based on FUERO templates.

- *Electric motor & transmission*
- *High power traction battery system*
- *Fuel cell system*
- *Hydrogen tank system*
- *High & low voltage DC/DC-converter*
- *Power steering*
- *Climate control system*
- *Passenger cabin heating device*
- *Other comfort auxiliaries*

2. Operational requirements:

Mainly inputs from car manufacturer, who deliver cars for testing.

- *Environmental operating conditions and requirements*
- *Safety requirements*
- *Maintenance requirements*
- *Pre- / starting process requirements*
- *Shut-down process*
- *Refuelling requirements*
- *…*

3. Performance data:

Measurement data according already established revised standards and regulations for FCEVs, performed at proving grounds.

- *Pre-starting process*
- *Shut-down process*
- *Fuel consumption*
- *Range*
- *Top and 30-minutes speed*
- *Acceleration performance*
- *Braking performance*
- *…*

4. Comfort & handling assessment:

Mainly subjective assessment during field testing activity, checklist has to be established.

- *Power steering*
- *Heating & climate control system*
- *Seating comfort*
- *Noise outside & passenger compartment*
- *Instrumentation*
- *Handling during driving*
- *Safety impression*
- *…*

WP5

Hydrogen infrastructure, refuelling stations and common interfaces

Activities

- Hydrogen quality
- Hydrogen availability
- Refuelling stations
- Connectors and nozzles

Hydrogen quality chart by FC manufacturer

	Ballard	NUVERA FC Inc	Ford / DC	ISO 14687 - JEVA	Anuvu Inc	Anuvu Inc	UTC FC
H2 purity (%)	99.995	99.9995 (5.5 type)	99.9	99.99	99.5	99.95	
O2 (ppm)	ns	1	1 vpm	ns	ns	ns	
H2O (ppm)	ns	2	50 (liquid)	not to be condensed	ns	ns	
N2 (ppm)	ns	2	200	ns	ns	ns	
HC (ppm)	ns	0	1	0,01 µmol/mol (HCHO 0,04)	ns	ns	
CO (ppm)	ns	0	2	0,2 micromol/mol	5	ns	
CO2 (ppm)	ns	0	2	ns	ns	ns	
H2O vapor (%)	ns	ns	0.1		ns	ns	
S compounds	ns	ns	1	0,0002 micromol/mol	0	ns	
NH3 (ppm)	ns	ns	0.01	?	ns	ns	
He (ppm)	ns	ns	200	ns	ns	ns	
Ar (ppm)	ns	ns	200	ns	ns	ns	
Particles (ppm)	ns	ns	10	fueling station requirements	ns	ns	
Max Part. size (µm)	ns	ns	10	ns	ns	ns	
Oil	ns	ns	ns	ns	0	ns	

Hydrogen refilling stations worldwide

Location	Continent	country / state	Picture	Fuel type	Project	Dates in operation	H2 production mode	production rate
Cairo	Africa Egypt	egypt			GEF and UNDP FC bus		Electrolytic Hydrogen	
Mobile station	North America	USA		GH2	DYNETEK			
Mobile station	North America	USA		GH2	POWERTECH			
Mobile station	America	Arizona		GH2	FORD	2002	Electrolyser Stuart Energy	24 kg / day
Phoenix	North America	Arizona		GH2, CNG & blend	DOE; Arizona public service, Veh. Testing Center - Part of DOE Field Ops Program	2001	PEM electrolyser Proton Energy's HOGEN	
Sao Paulo	South America	Brazil			GEF, UNDP FC bus, GOB, Sao Paulo state			
Auburn	North America	California		GH2	CAFCP; Pacific gas & electricity	Mid 2004	High Performance Steam NG Reforming (HPSR by Ztek)	17 L / h
Chula Vista (mobile station)	North America	California		GH2	City of Chula vista	2003	Electrolyser CFP 1350	36 Nm3/h - 3kg/h - 60kg/day
Davis	North America	California		GH2	Davis H2 bus; California university; Toyota	2003 June	Delivery LH2 by truck from Air Products and Chemicals (APCI)	20 kg /day
Detroit	North America	California			Ford - BP			
Diamond Bar	North America	California		GH2	South Coast Air Quality Management (SCAQMD) HQ	2004 august	Stuart Energy Station (SES-f)	
El Segundo	North America	California		GH2	Xerox; DOE; UC Riverside; Matrix engineers; City West Holywood; Kaiser engineering; SCAQMD; CAN	1995-1997	Electrolyser from solar energy	
Irvine	North America	California		GH2	UC Irvine; SCAQMD; Toyota FCV	2003 June	Delivery LH2 by truck from Air Products	20 kg /day
Irvine	North America	California		GH2	UC Irvine; NFCRC; Toyota FCV	ordered in 2004		small scale SES-f
Los Alamos	North America	California		LH2	Los Alamos National Laboratory	1979	Delivery LH2	
Los Angoles (Airport)	North America	California		GH2	PRAXAIR; BP, DOE, SCAQMD	october 2004	Natural gas steam reforming	150 kg / day
Oakland	North America	California		GH2	Chevron Texaco; AC Transit	2005 August	Natural gas steam reforming	150 kg / day
Orlando	North America	California			Ford - BP			
Oxnard	North America	California		LH2	BMW; Emission test center	2001 July	Delivery LH2 by truck from APCI	

Specifications of refilling nozzles, by manufacturer

Name of manufacturer	WEH GmbH		OPW GmbH	
	Hydrogen fuelling nozzles			
Product name	TK15 (1), TK16 (4), TK25 (1) (2)		CW3600	CW5000
Material	Corrosion resistant steel		316L stainless steel	
Max pressure (bar)	250	350	248	345
Min flow rate	ns	ns	2000 SCFM @ 3600 psid	
Temperature range	-40℃ to 80℃	-40℃ to 80℃	-40℃ to 8 5℃	-40℃ to 85℃
Weight (g)	ns	ns	1520	
Compatibility	250 - 350	350	LW3600	LW5000
	Hydrogen fuelling receptacles			
Product name	TN1, TN5 (3)		LW3600	LW5000
Material	Corrosion resistant steel		316L stainless steel	
Max pressure (bar)	250	350	248	345
Min flow rate	ns	ns	2000 SCFM @ 3600 psid	
Temperature range	-40℃ to 80℃	-40℃ to 80℃	40℃ to 1 20℃	-40℃ to 120℃
Weight (g)	ns	ns	230	
Compatibility	250	250 – 350	CW3600	CW5000
Contact information	http://www.weh.com		https://www.opw-fc.com/	
Notes	1 TÜV approval for hydrogen 2 TK15 & TK16 are designed for cars and TK25 for buses 3 TN 1 for cars and TN5 for buses 4 TÜV certificate of conformity with SAE J2600 - H35 standard on 09-09-2004			

WP5

Information on fuel qualities and receptacles

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Manufacturer	Walther	Nitto Kohki		WEH		OPW	
	Hydrogen fuelling nozzles						
Product name	HG-400	HHV-3S-H25-L-G, HHV-3S-H35-L-G		TK15[1], TK16[4], TK25[1] [2]		CW3600	CW5000
Material	Stainless steel 1.4404/1.4571 or similar	SUS304		Corrosion resistant steel		316L stainless steel	
Max pressure (bar)	700 (max. 875)	250	350	250	350	250	345
Min flow rate	ns	Cv value 1.3		ns	ns	56 m^3/min @ 250 bar	
Temperature range	-40℃ to 85℃	-20℃ to 70℃		-40℃ to 80℃	-40℃ to 80℃	-40℃ to 85℃	-40℃ to 85℃
Weight (g)	1400	3000		ns	ns	1520	
Compatibility	ns	ns	350	250 - 350	350	LW3600	LW50
	Hydrogen fuelling receptacles						
Product name	HG-400	HHV-3P-BI3/8-3500, -5000		TN1, TN5 [3]		LW3600	LW50
Material	Stainless steel	SUS316		Corrosion resistant steel		316L stainless steel	
Max pressure (bar)	700 (max 875)	250	350	250	350	250	345
Min flow rate	Ns	Cv value 1.3		ns	ns	56 m^3/min @ 250 bar	
Temperature range	-40℃ to 80℃	-20℃ to 70℃		-40℃ to 80℃	-40℃ to 80℃	-40℃ to 120℃	-40℃ to 120
Weight (g)	310	335		ns	ns	230	
Compatibility	ns	250	ns	250	250 – 350	CW3600	CW50
Contact information				http://www.weh.com		https://www.opw-fc.com/	
Notes	[1] TÜV approval for hydrogen [2] TK15 & TK16 are designed for cars and TK25 for buses [3] TN 1 for cars and TN5 for buses [4] TÜV certificate of conformity with SAE J2600 - H35 standard on 09-09-2004						

- SAE J2600 → ISO 17268
- SAE J2601
- Revised ISO 17268 ?

WP5

Hydrogen refuelling stations

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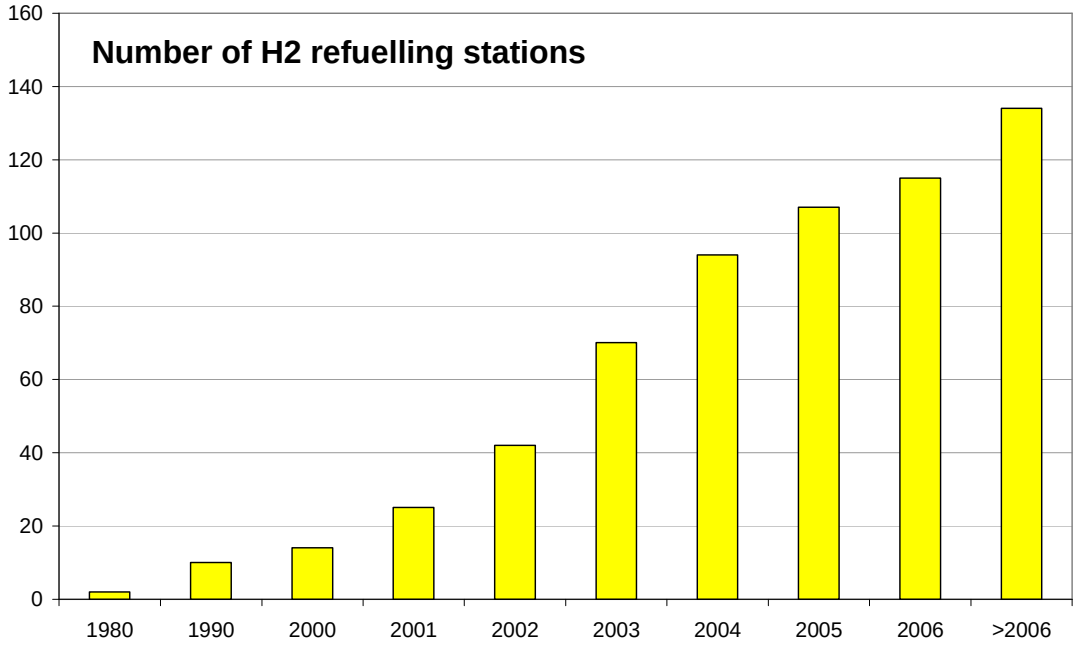

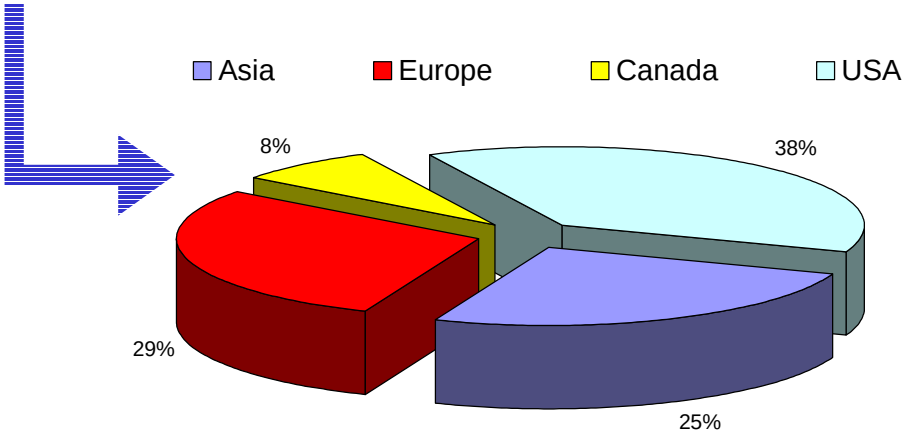

WP6

FUEVA cooperation
Internal and external links

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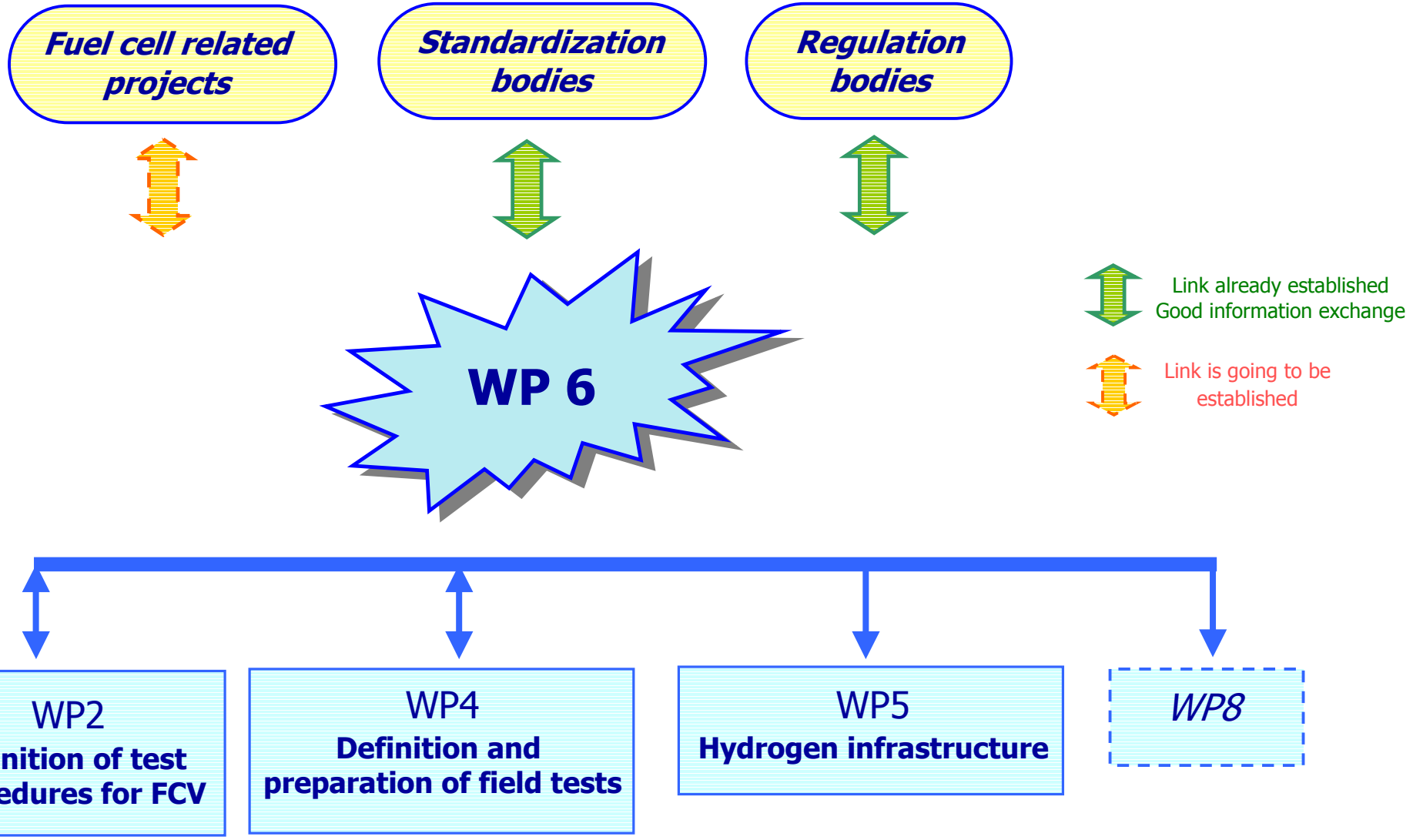

WP8

Benefits of FUEVA for « European Fuel Cell Vehicle Partnership with fleet demonstration »

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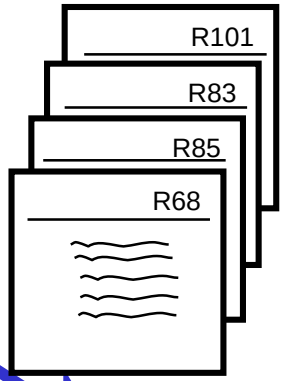
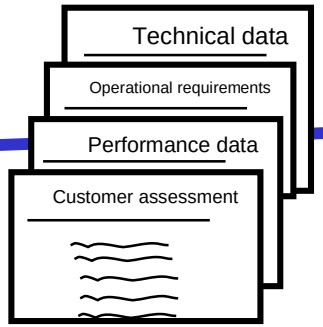
FUEVA

Regulations
for Fuel cell vehicle



Test bench for H2
Consumption measurements

Data base for
customer assessment



Hylights

- CUTE
- HyChain
- Zero Regio
- HySys
- Roads2HyCom
- …

Dissemination

Who can get which information?

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- Modified / Amended Standards and Documents available for:
  - Other EC projects (Zero Regio, HySYS, Roads2HyCom, Hylights, HarmonHy, etc.)
  - OICA
  - EUCAR
  - ACEA
  - ISO TC 197
  - ....
- Final report in a public version giving an overview of the tasks tackled in the FUEVA Project and possible contact persons for getting information, documents, etc.
- Presentation of results on workshops, conferences, public events, etc.

Test bench activity (WP2)	Regulation	European Directive	ECE Status
Fuel Consumption H_2	R101	80-1268	V
Fuel Consumption Liquid & CO_2 emissions	R101	80-1268	V
Emissions	R83-05	70-220	D
Start up time & energy	(R 101)	70-220	V
Maximum Power & 30 min	R85-84	80-1269	V
Maximum Electrical power (FC system + Battery)	----------	New draft	V
Range with fuel + Battery	(R 101)		
Range with fuel	(R 101)		

Status : Validated, Draft, Not Achieved, Not

RC&S

Customer evaluation questionaire

Manufacturer		Volkswagen		
Vehicle		VW Touran HyMotion		
Picture				
Basic Platform		VW Touran		
Basic System Configuration		Fuel Cell Hybrid Vehicle		
Drive Train Configuration		Front Wheel Drive		
Dimensions LxWxH	[mm]	4391x1794x1635		
Curb Weight	[kg]	1975		
Total Weight	[kg]	2300		
Passengers		4		
Power Steering				
Individual Classification		worth	normal	excellent
Brake System				
Individual Classification		worth	normal	excellent
Air Conditioning				
Individual Classification		worth	normal	excellent
Passenger Cabin Heating System				
Individual Classification		worth	normal	excellent
Seating Comfort				
Individual Classification		worth	normal	excellent
Noise Inside				
Individual Classification		worth	normal	excellent
Noise Outside				
Individual Classification		worth	normal	excellent

Thank you for your attention.

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e-mail: schuessler@ika.rwth-aachen.de

