

Luxinnovation Hydrogen logistics for territorial mobility



21 February 2019

COPYRIGHT: HINICIO





About Hinicio





Hinicio in a nutshell



STRATEGY CONSULTANTS SPECIALISED IN SUSTAINABLE ENERGY AND TRANSPORT

Founded in Brussels in 2007

Active in Europe, Latin America and Asia.



Multidisciplinary integrated approach

TECHNOLOGY



MULTIDISCIPLINARY APPROACH AND TEAM

- Engineers
- Economists
- Energy and transport policy experts
- Operating as a virtual team
- 9 nationalities
- Clients in 19 countries in Europe, Latin America and Asia
- Offices in Brussels, Paris, Bogota, Buenos Aires and Shanghai



Introducing HINICIO: we brings a 360° view on the hydrogen industry at the local, national and international level

- HINICIO is a strategic consultancy specialized in hydrogen and fuel cells, widely recognized as a leader in Europe in this area.
- 80+ assignments on hydrogen and fuel cells since the creation of the company in 2007, including several landmark study at the European level.
- Unmatched experience at every step of the value chain on all aspects:
 - Technology
 - Economy
 - Business Cases
 - Markets
 - Strategy
 - Public policy and regulation
 - □ Social acceptance, etc.

An international view and network



Countries covered by HINICIO's recent studies on hydrogen

Production	T&D et storage	Fuel cell applications	End-clients	Public sector	Investors and donors
			LA POSTE		VELVO GROUP VENTURE CAPITAL SOJITZ CONTRACTOR Fouriertransform
	HySA Catalysis	PowerCell Fuel Cell Europe CIRCUIT DE SPA FRANCORCHAMPS	ArcelorMittal SCOTLAND	RhôneAlpes	



Introduction to hydrogen



6



H2 pops up as an energy carrier for storing renewables





Worldwide H2 markets – It is not a new market

INDUSTRY & MARKET SHARE	KEY APPLICATIONS	SUPPLY SYSTEM	H2 DEMAND per YEAR	
General Industry 1%	 Semiconductor Propellant Fuel Glass Production Hydrogenation of Fats Cooling of electrical Generators 	 Small on-site Tube trailers Cylinders Liquid H2 	LOW >0.4 Mtons	
Metal Working 6%	 Iron Reduction Blanketing gas Forming gas 	CylindersTube trailers	MEDIUM 2 Mtons	
Refining 30%	 Hydrocracking Hydrotreating 	 Pipeline Large On-site 	14 Mtons	
Chemical 63%	 Ammonia Methanol Polymers Resins 	 Pipeline Large On-site 	HIGH 29 Mtons	



Overview of Power-to-gas





Mobility business case for P-2-G at regional level









Mobility Demand on a regional level





Semi-centralized supply chain allows to deliver hydrogen to a region-wide HRS network and other small consumers

Supply chain for H2 mobility application





System dimensioning: starting from the demand





Main components of a semi-centralised Power-to-Gas system

	H2 production & conditioning Production 1 MW The second se	€/kgH2 ◀ Storage and transport	kgH2 Distribution	Consolidated Business Case
CAPEX	M€	M€	X	M€
OPEX	k€/yr	k€/yr	x	k€/yr
H2 cost €/kg	€/kg _{H2}	€/kg _{H2}	€/kg _{H2}	
Revenues	-	-	X	k€/yr

Image: Hinicio



H2BCase by HINICIO: Dimensioning, optimizing and simulating your hydrogen supply chain



Images: Hinicio H2BCase model



14 scenarios assessed: France Vs Germany, 2015 versus 2030

Deverseler	Scenario													
rarameter	1 - Ref	2	3	4	5	6	7	8	9	10	11	12	13	14
Country	France		(Germany										
Year of electrolyser commissioning	2015			2020	2030						2030		2030	
Initial/Final H2 Mobility demand (kg/d)	100/325	100/ 163					No H2 mobility sales		100/ 163				200/650	
Electricity price duration curve or cost	France 2014		Germ. 2014	Germ. 2020	Germ. 2030					26% of wind el. Cost France	100% of wind el. cost France	17% of wind el. Cost Germ.	100% of wind el. cost France	
Grid charge	France 2015		Germ	nany 2015	5 rates									
CSPE (€/MWh)	Electrint. 0.5					19.5								
H2 injection price (€/MWh)	90 (FIT)				55.8			No inject.	No inject		55.8		55.8	
Electrolyser capex (M €/ MW)	1,9				0.55						0.55		0.55	
Electrolyser efficiency/stack lifetime	66%/4y				75%/ 10y						75%/ 10y		75%/ 10y	
Public subsidy on investment costs														25%



Scenario Nbr	1 (Ref)
Country	France
Year of electrolyser commissioning	2015
Initial/Final H2 Mobility demand (kg/d)	100/325
Electricity price duration curve	France 2014
Grid charge	France 2015 rates
CSPE (€/MWh)	Electro-int. 0.5
H2 injection price (€/MWh)	90 (FIT)
Electrolyser capex (M €/ MW)	1,9
Electrolyser efficiency/stack lifetime	66%/4y

- H2Mobility market consumes 1/3 of electrolyser capacity in year 1 (1MW electrolyser 100 kg/day 100 FCEV/REX or 4 busses) and increases to full electrolyser capacity in year 10.
- Electrolyser plant considered to be benefiting from "electro intensif" regime (low grid / tax fees).
- Available capacity permitting, H2 is produced for injection into the Gas Grid when marginal costs of H2 production are lower than Feed-In-Tariff (assuming €90/ MWh) to achieve increase revenue streams during market take-off phase of FCEV.
- No charges applied to the electricity consumed for producing the hydrogen injected into the gas grid



1 MW semi-central Power-to-H2 system - Revenues and Costs (CAPEX depreciated)



<u>Revenues:</u>							
1.	H2Mobility: €8 / kg @ 200 bar @ HRS						
2.	H2 injected @FIT: €90/MWh						
3.	Primary reserve: €18/MW/h						



1 MW semi-central Power-to-H2 system - Revenues and Costs (CAPEX depreciated)





1 MW semi-central Power-to-H2 system - Revenues and Costs (CAPEX depreciated)





Fixed Costs:

- 1. H2 Mobility: electrolyser O&M (3% +3% of CAPEX) & Fixed part of Grid fee & Trailer & Storage @ HRS O&M
- 2. Injection: Electrolyser O&M (3% +3% of CAPEX) & Fixed part of Grid fee
- Depreciation of Electrolyser + Stack Replacement + Compressor & Injection Skid
- 4. Depreciations of Trailer & Storage @ HRS



Scenario 1 - Reference - Results



1 MW semi-central Power-to-H2 system - Revenues and Costs (CAPEX depreciated)

→ Injection into the Gas Grid and System Services complements revenue streams during "valley of death" of FCEV market.

→ Its contribution to margin decreases as hydrogen mobility market takes off.



Table: Hinicio

France 2015 – Higher H2 Mobility demand from year 1

Parameter	1 - <u>Ref</u>		
Country	France		
Year of electrolyser commissioning	2015		
Initial/Final H2 Mobility demand (kg/d)	100/325		
Electricity price duration curve or cost	France 2014		
Grid charge	France 2015		
CSPE (€/MWh)	Electr int. 0.5		
H2 injection price (€/MWh)	90 (FIT)		
Electrolyser capex (M €/ MW)	1,9		
Electrolyser efficiency/stack lifetime	66%/4y		

H2Mobility market consumes 1/2 and 2/3 (instead of 1/3 base scenario) of electrolyser capacity in year 1 (1MW electrolyser – 165 and 216 kg/day – 165/216 FCEV/REX or 6/8 busses) and increases to full electrolyser capacity in year 10.

Demand year 1: 165 kg/d



Demand year 1: 216 kg/d





France 2030 - Assumptions

Devenueder		13		
rarameter	1 - <u>Ref</u>			
Country	France			
Year of electrolyser commissioning	2015	2030		 Electrolyser technology costs of 2030
Initial/Final H2 Mobility demand (kg/d)	100/325	200/325		 Securing 2/3 of maximum electrolyser capacity from the start
Electricity price duration curve or cost	France 2014	wind el. cost France		Upfront purchase of the production of renewable generation capacity at projected.
Grid charge	France 2015			full cost (Eur 60 / MWh, cfr ADEME
CSPE (€/MWh)	Electr int. 0.5			projections)
H2 injection price (€/MWh)	90 (FIT)	55.8		Caloric Value of H2 ~ Natural Ga (37.8 £ (M/W/b) of: 154 pourvoque min
Electrolyser capex (M €/ MW)	1,9	0.55		2030) + Carbon tax of 90€/t CO2
Electrolyser efficiency/stack lifetime	66%/4y	75%/ 10y		



Scenario 13 – France 2030 - Results



1 MW semi-central Power-to-H2 system - Revenues and Costs



- <u>From a technical standpoint</u>, **Power-to-Gas is one promising option in our portfolio towards the energy transition** in order to simultaneously integrate more intermittent renewables and decarbonize road transport **thanks to responsiveness of the PEM electrolysis technology**
- <u>From an economic standpoint</u>, **Power-to-Gas appears as a credible option in the mid-to-long term** for the supply of low carbon hydrogen at the local level in low electricity marginal cost environments. **The business case could potentially fly with no public support if** an adequate (and long expected...) carbon pricing environment is put in place and regulatory barriers are dealt with to allow injection into the gas grid and participate in system services and balancing.



This presentation builds on the results of the study "Short term and long term opportunities to leverage synergies between the electricity and transport sectors through power-to-hydrogen"

HINICIO and LBST would like to thank **Fondation Tuck** for supporting this study under its **The Future of Energy** programme





<u>Your contact person:</u> Louis Lammertyn Manager Benelux - China Email: Louis.Lammertyn@hinicio.com Tel: +32 2 211 34 11



visit our website www.hinicio.com