Vlaamse overheid

AGENTSCHAP ONDERNEMEN

ROADMAP STUDY
POWER-TO-GAS (PTG) VLAANDEREN

Main results and conclusions (Final version)

Webinar, 26.10.2016

Denis THOMAS, EU Regulatory Affairs and Business Development Manager
Renewable Hydrogen , Hydrogenics Europe NV

AGENDA

1. **Introduction**
2. P2G business models
3. Role of the government
4. P2G roadmap for Flanders
5. P2G Cluster: the right vehicle for the execution
6. Conclusion & discussion

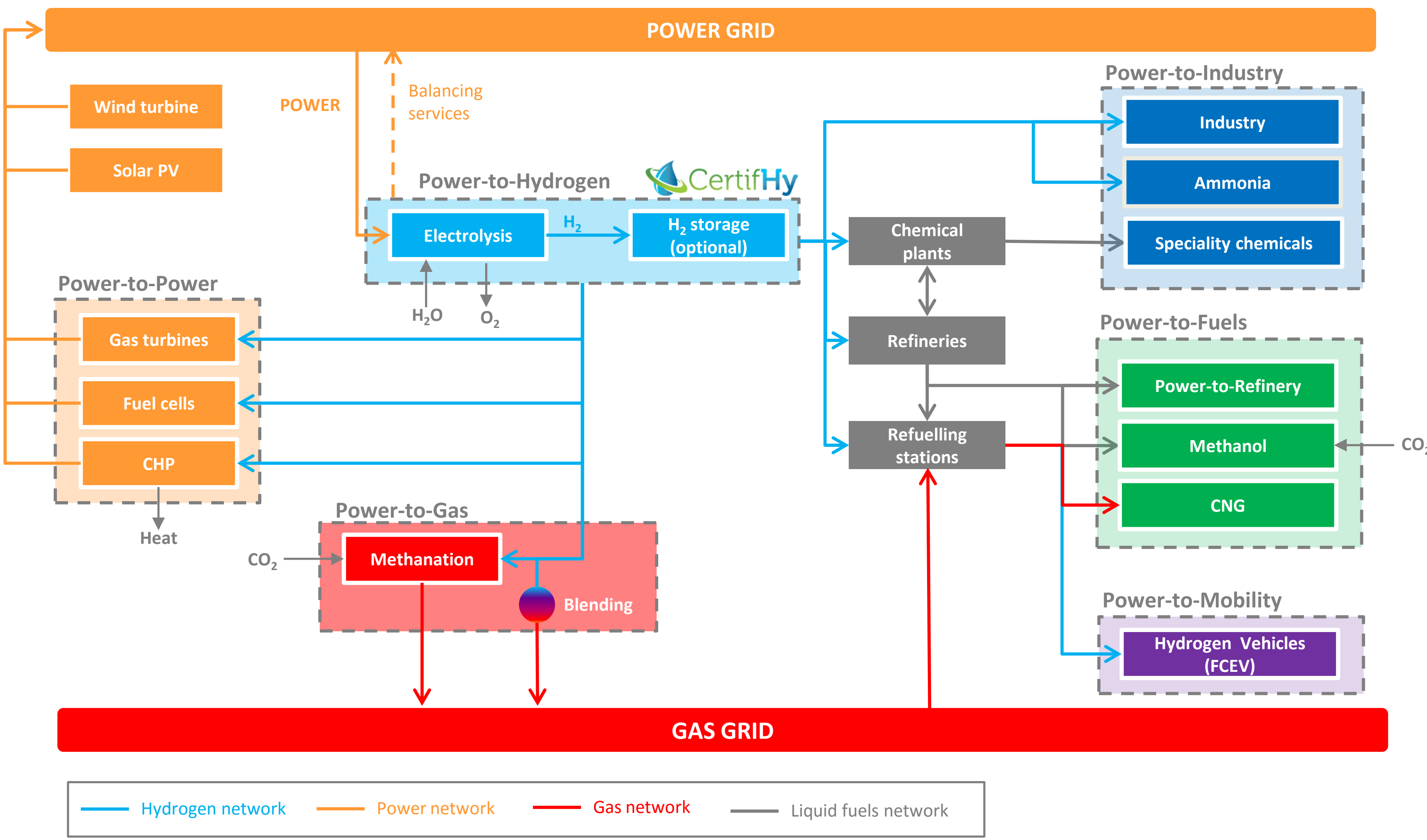
POWER-TO-GAS ROADMAP FOR FLANDERS
IN A NUTSHELL

- Duration: 14 months (01/10/2014 - 31/01/2016)
- Funding : Flemish Region, Belgium
- Project partners:
- Coordinator: Hydrogenics

POWER-TO-GAS ROADMAP FOR FLANDERS
OBJECTIVES

- Analyze the **actual and future status of Power-to-Gas (PtG) in Flanders** (technology, economics, legal framework, market opportunities)
- Study various PtG **business cases** and identify **early markets**
- Elaborate a **roadmap** which will serve as the backbone for the actions of a **Power-to-Gas Cluster** in Flanders
- **Prioritize the actions** in order to create a **PtG framework** for the development of projects in Flanders and abroad
- Indentify potential **demonstration projects** in Flanders

GREEN HYDROGEN
IN POWER, GAS, TRANSPORTATION AND INDUSTRY SECTORS



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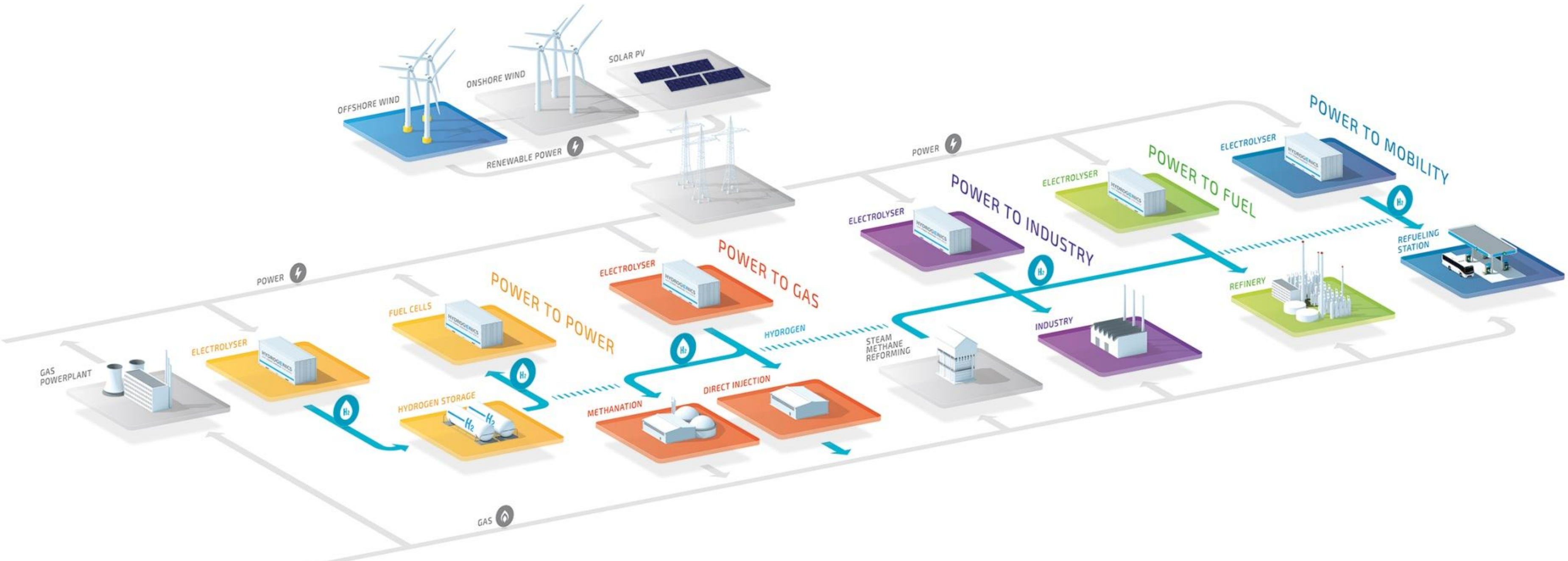
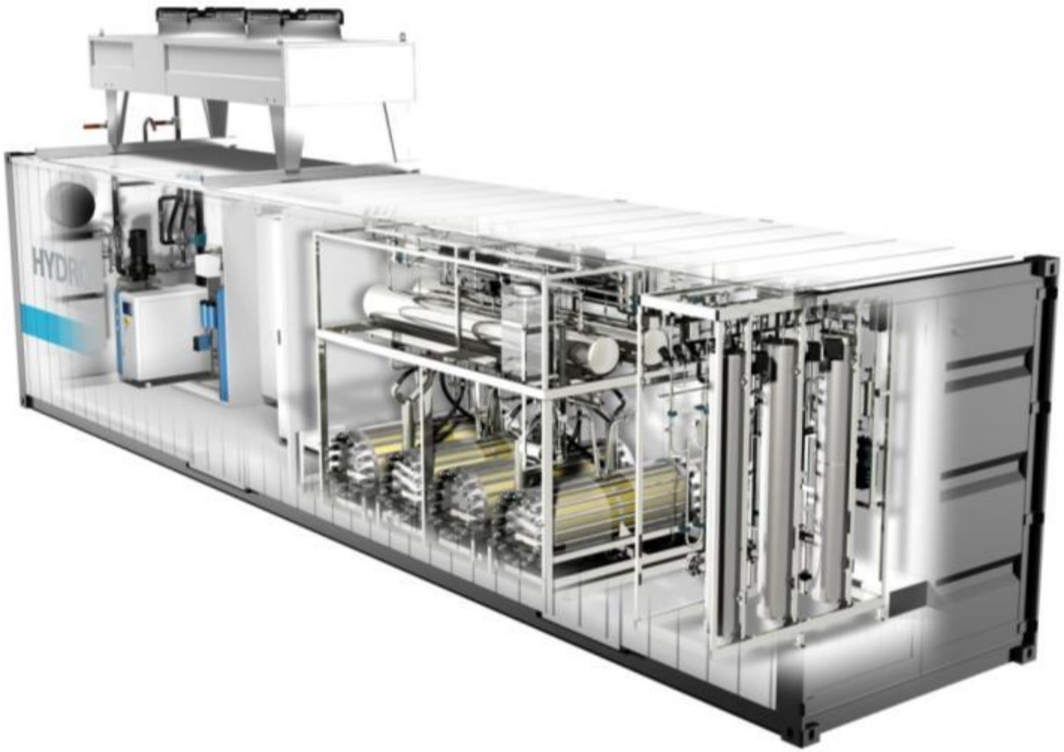
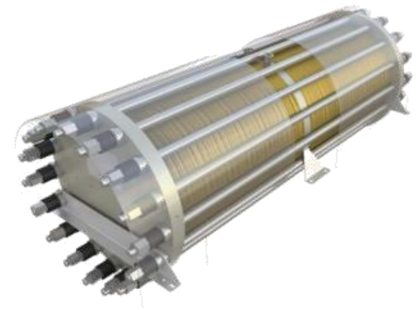


THE ELECTROLYSER
THE CENTRAL PIECE OF ALL POWER-TO-GAS APPLICATIONS





Made in Flanders ©

GLOBAL HYDROGEN MARKET

Main data source: The Hydrogen Economy, M. Ball, 2009

Production

Steam Methane Reforming

48%

Crude oil cracking

30%

Coal gasification

18%

H2 by-product

3%

Water electrolysis

1%

Storage / Transport / Distribution

H_2

Hydrogen pipeline infrastructure in the EU

- Air Liquide (NL-BE-FR): 810 km
- Air Liquide (GER): 240 km
- Linde (GER): 150 km

NB: 5 % is merchant hydrogen (free market), onsite production represents 95%

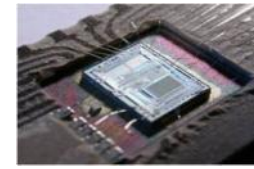
End-use (global market in 2013: +/- 100 billion €)

INDUSTRY : protecting atmosphere (H_2/N_2), hardening of metals — 6%

Float glass

Metallurgy

Semi-conductors



CHEMISTRY & REFINERIES: C, H, O, Amonia — 93%

Fertilizers


50%

Refineries


43%

OTHERS: cooling agent, hardening of oil, power generation, mobility — 1%

Electrical power plants

Food industry

FCEV

Production → **Storage / Transport / Distribution** → **End-use** (global market in 2013: +/- 100 billion €)

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OVERVIEW
CALCULATED P2G BUSINESS CASES

Case	Size electrolyser	Typical application	Reference product
POWER-TO-INDUSTRY			
$PtH_{2\ (large)}$: Power-to-Hydrogen (large scale)	100 MW	H_2 as feedstock in large industry (Ammonia production or refinery)	H_2 produced with onsite SMR from CH_4 or H_2 delivered by pipeline
$PtH_{2\ (small)}$: Power-to-Hydrogen (small scale)	1.2MW	H_2 as feedstock in small to medium size industry	H_2 delivered by tube trailers trucks
POWER-TO-GAS			
$PtH_{2\ (blend)}$: Power-to-Gas (direct injection)	15 MW	Direct injection of hydrogen in gas grid	Natural gas from gas grid
$PtCH_4$: Power-to-Gas (methanation)	15 MW	Transformation H_2 into SNG and injection in gas grid	Natural gas from gas grid
POWER-TO-MOBILITY			
$PtFCEV_{(cars)}$: Hydrogen Refuelling Station for cars	500 kW	Hydrogen as a fuel for FCEV (cars)	Diesel
$PtFCEV_{(buses)}$: Hydrogen Refuelling Station for buses	2.2 MW	Hydrogen as a fuel for FCEV (buses)	Diesel
POWER-TO-FUELS			
$PtCH_3OH_{\ (fuel)}$: Power-to-Methanol (as a fuel)	50 MW	Partial substitution of diesel with bio-methanol produced from H_2 and CO_2 in a methanolisation process.	Diesel
POWER-TO-POWER			
$PtP_{\ (small)}$: Power-to-Power (small scale)	500 kW	Hydrogen-based electrical energy storage in medium-sized industry with own renewable energy production (*prosumer*)	Power from the grid
$PtP_{\ (large)}$: Power-to-Power (large scale)	400 MW	Hydrogen-based electrical energy storage (at utility scale)	Power from the grid

BUISNESS CASES
BUILDING BLOCKS

- RES development in Belgium towards 2050
- **Power price duration curve for Belgium**
- Grid fees
- Electrolyser + cell stack replacement model
- Methanation
- Hydrogen storage and compression
- Hydrogen refueling Station + Mobility (buses and cars)
- Methanolisation
- Fuels cells
- Hydrogen prices
- CO_2 prices
- Ancillary services
- Prosumer model (self-consumption)
- Societal benefits
- Physical and Property data

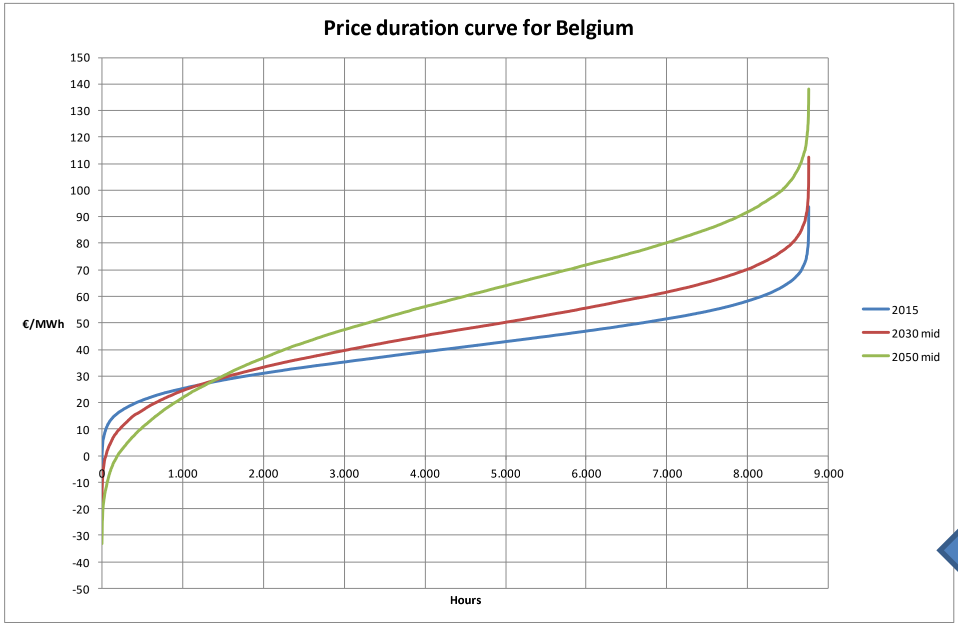
Grid connected systems, green/renewable hydrogen certification via guarantees of origin certificates (cf. www.certifhy.eu)

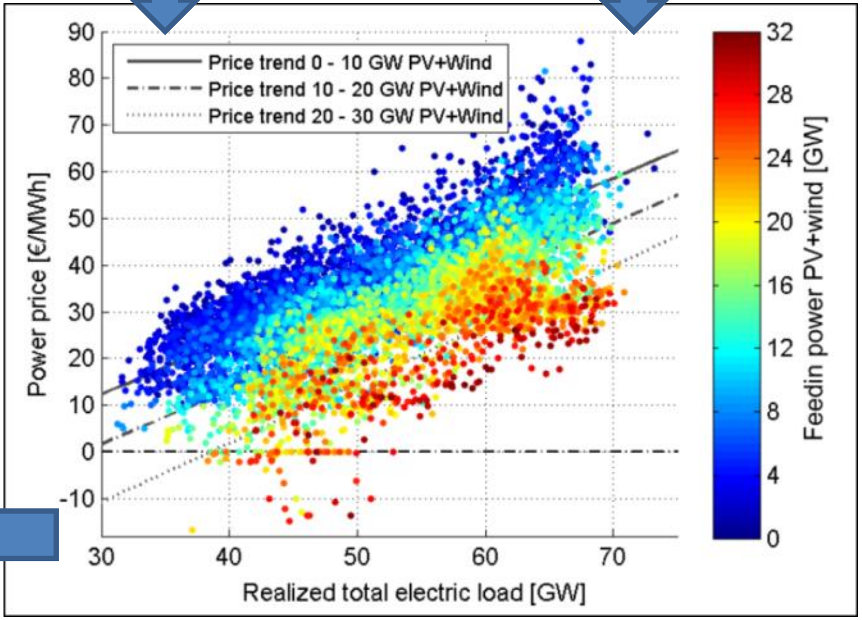
ELECTRICITY PRICE 2015-2030-2050
ASSUMPTION

- Based on a German model
- Use the correlation between power price, RES production (wind + solar) and power demand
- Back-up power assumed with gas fired power-plants

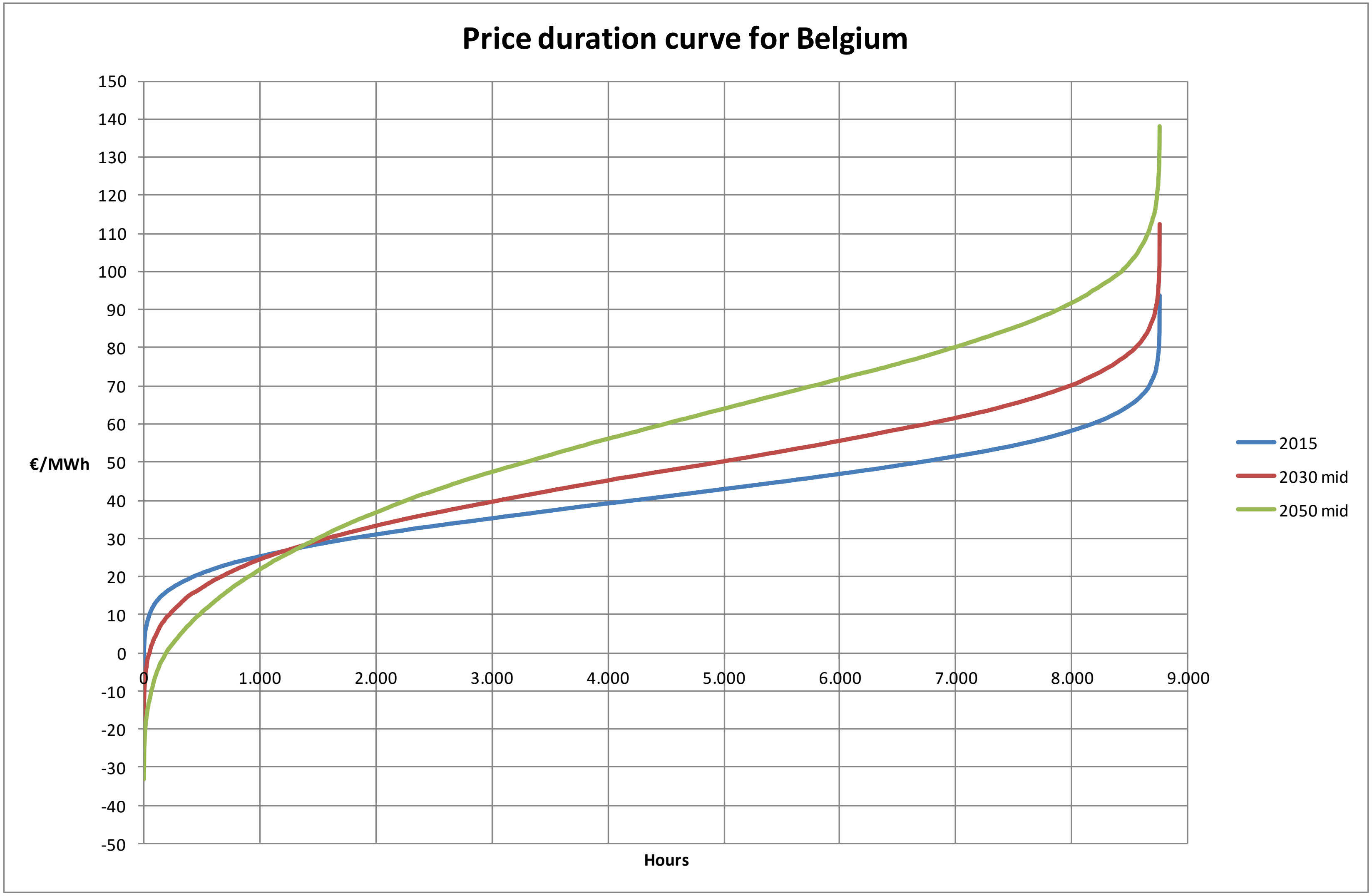
Installed capacity in BELGIUM	Onshore wind	Offshore wid	PV
End 2014	**1.246**	**712**	**3.105**
2030	4.678	3.522	4.800
2050	7.213	7.687	10.000

Use of historical data 2014 for Belgium: BELPEX prices + wind + solar

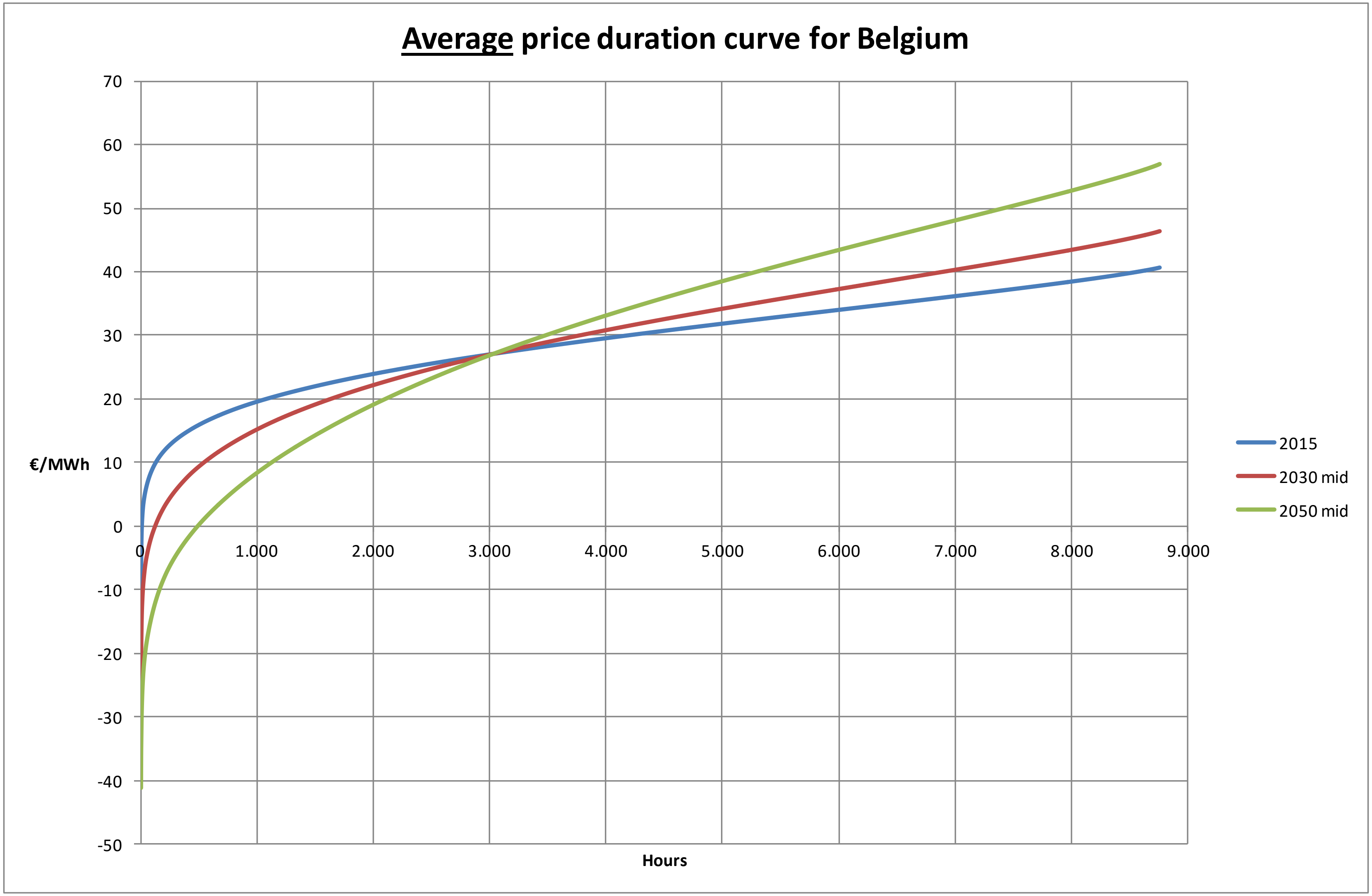




ELECTRICITY PRICE 2015-2030-2050
ASSUMPTION



ELECTRICITY PRICE 2015-2030-2050
ASSUMPTION



ELECTRICITY PRICE 2015-2030-2050
ASSUMPTION

Average price (from power price curve)

+ supplier margin (5-20%)

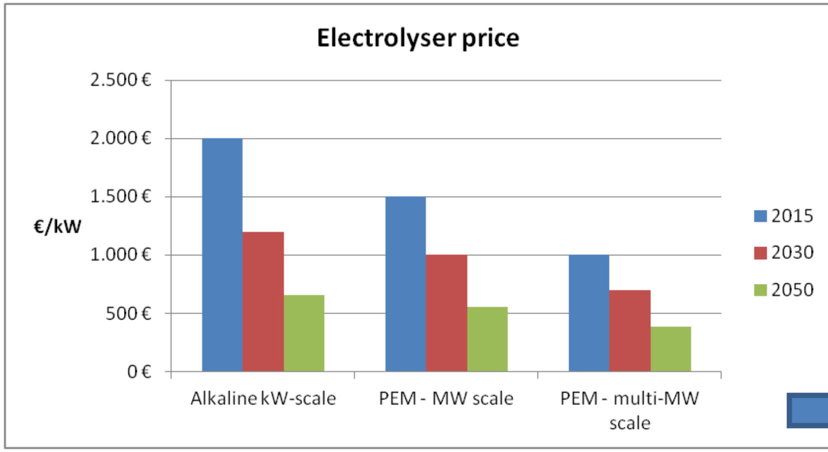
+ grid fees (→ grid connection +consumption)

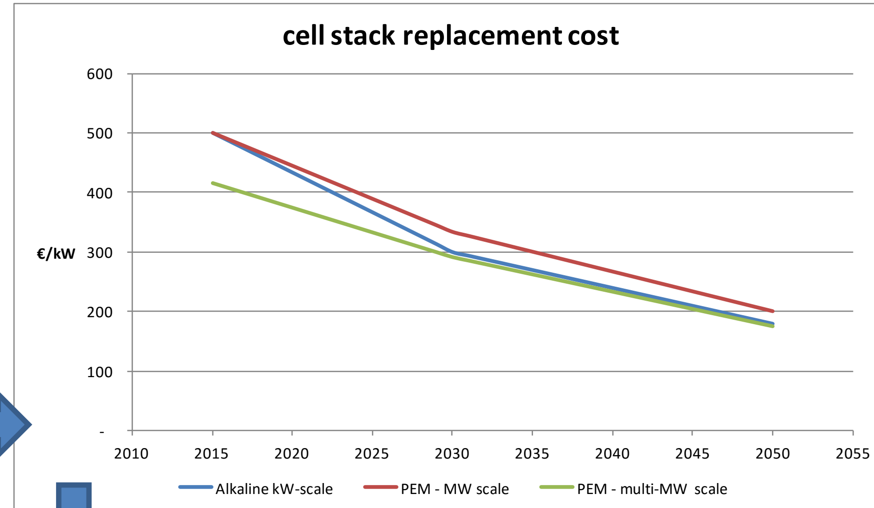
TOTAL ELECTRICITY PRICE

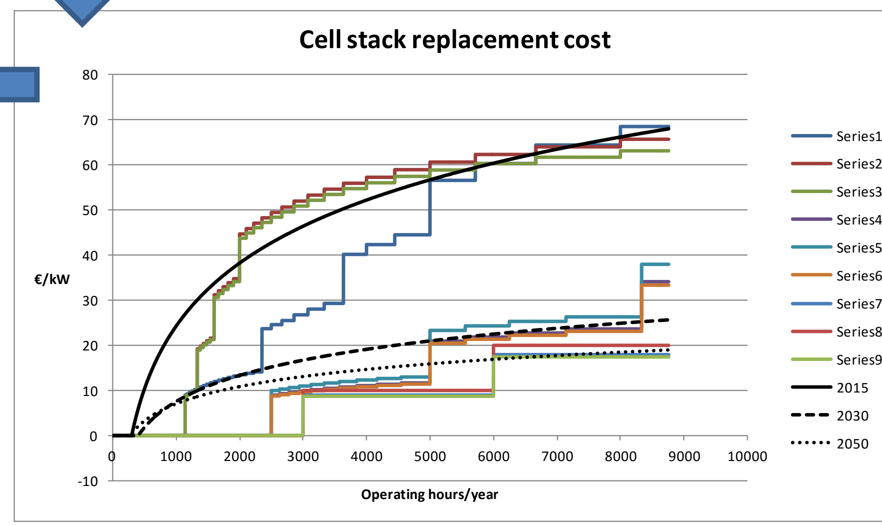
ASSUMPTIONS
ALL ELECTROLYSERS

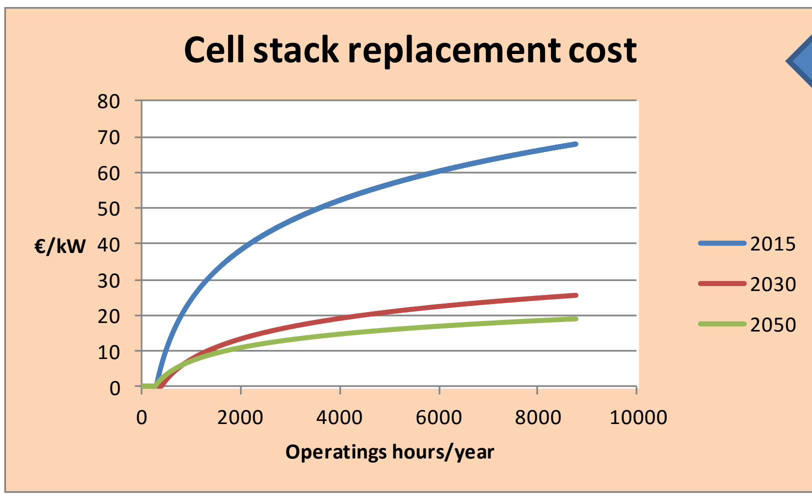
Item	*Unit*	2015	2030	2050
Alkaline kW-scale				
H_2 nominal production capacity	*Nm³/h*	60	300	300
Efficiency	*kWh/Nm³ H_2*	5,2	5,1	5
Electrical power	*kW*	312	1.530	1.560
Output pressure	*barg*	10	60	60
Water consumption with R/O	*liter / Nm³ H_2*	1,3	1,3	1,3
Price	*€*	624.000	1.836.000	1.029.600
Price/kW - SYSTEM	*€/kW*	2.000	1.200	660
OPEX	*€/kW/year*	80	64	56
Expected cell stack expected lifetime	*hours*	60.000	60.000	60.000
Cell stack cost / electrolyser cost		30%	30%	30%
PEM - MW scale				
H_2 nominal production capacity	*Nm³/h*	200	200	200
Efficiency	*kWh/Nm³ H_2*	5,2	5,1	5
Electrical power	*kW*	1.040	1.020	1.040
Output pressure	*barg*	30	30	30
Water consumption with R/O	*liter / Nm³ H_2*	1,3	1,3	1,3
Price	*€*	1.560.000	1.020.000	572.000
Price/kW - SYSTEM	*€/kW*	1.500	1.000	550
OPEX	*€/kW/year*	60	48	42
Expected cell stack expected lifetime	*hours*	40.000	50.000	60.000
Cell stack cost / electrolyser cost		40%	40%	40%
PEM - multi-MW scale				
H_2 nominal production capacity	*Nm³/h*	3120	3120	3120
Efficiency	*kWh/Nm³ H_2*	5	4,9	4,8
Electrical power	*kW*	15.600	15.288	15.600
Output pressure	*barg*	30	30	30
Water consumption with R/O	*liter / Nm³ H_2*	1,3	1,3	1,3
Price	*€*	15.600.000	10.701.600	6.006.000
Price/kW - SYSTEM	*€/kW*	1.000	700	385
OPEX	*€/kW/year*	40	32	28
Expected cell stack expected lifetime	*hours*	40.000	50.000	60.000
Cell stack cost / electrolyser cost		50%	50%	50%

ELECTROLYSERS & CELL STACK REPLACEMENT
ASSUMPTIONS 2015-2030-2050









ANCILLARY SERVICES
ASSUMPTION : IDEM 2015

Type	Name	Connection required	Direction	Symetry	Reaction time	Duration	Reservation	Average price in 2015 (€/MW/h)	Activation fee	Type of activation	Via aggragators
R1	Primary reserve	ELIA >36 kV	UP and DOWN	Symetrical	15 sec	15 min	Monthly auction	28,37	no	Automatic	no
R2	Secondary reserve	ELIA	UP of DOWN	Asymetrical	7,5 min	unlimited	Monthly auction	10,6	yes	Automatic	no
R3DP	Tertiary reserve - Dynamic profile	ELIA Distribution grid	UP	Asymetrical	15 min	2 hours	Annual	3,07		Manual	yes

Required total volumes of ancillary services:

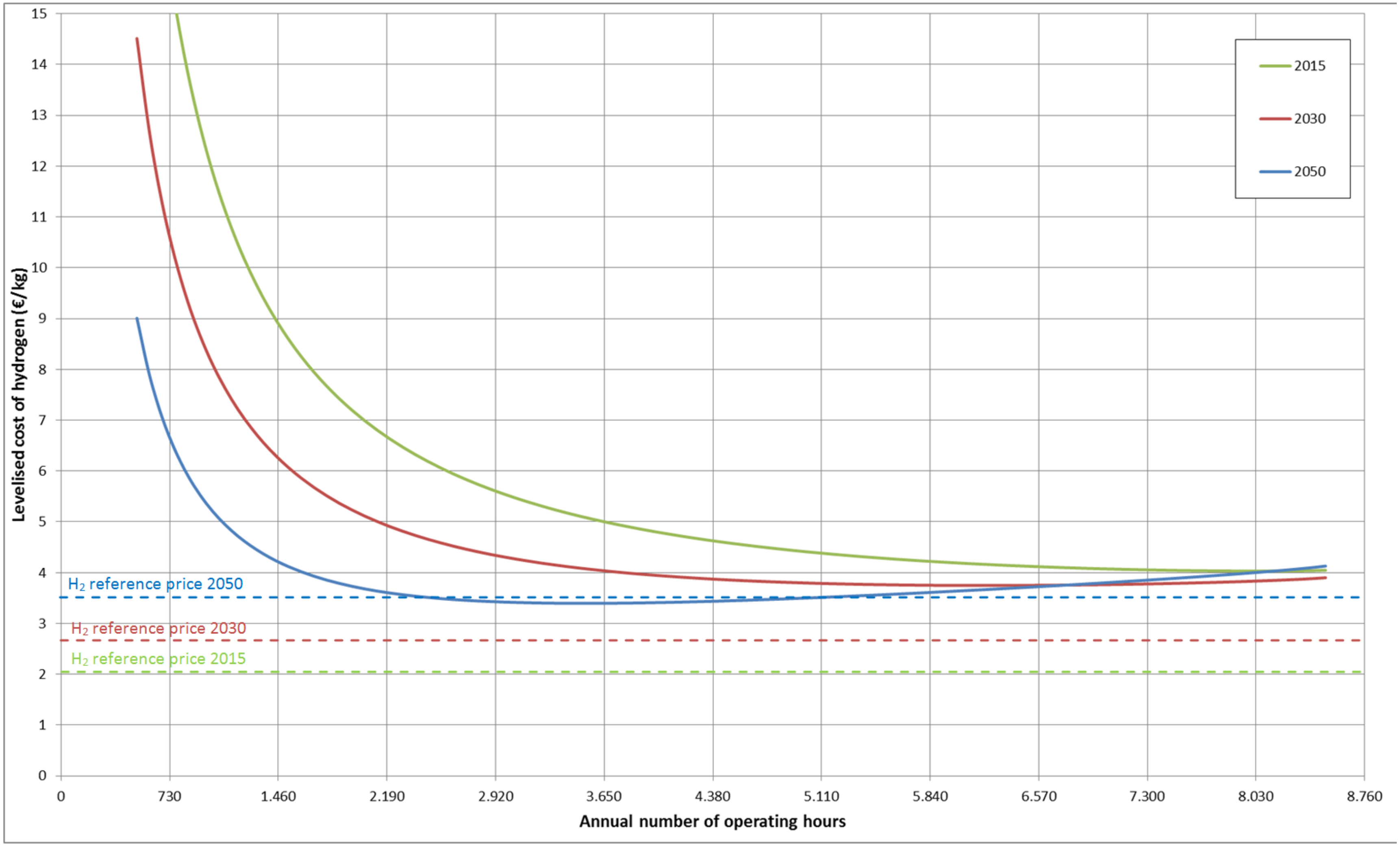
	Required total volumes for year 2015 [MW]
Primary Frequency Control (0s - 30s) *R1 – symmetrical – 200mHz*	83 MW
Secondary Frequency Control (30s – 15min) *R2 – symmetrical*	140 MW
Tertiary Frequency Control (15min) *R3 production (PROD) + dynamic profile (DP)*	400 MW
Tertiary Frequency Control *From interruptible clients (ICH)*	261 MW

POWER-TO-INDUSTRY (LARGE SCALE)
BRIEF DESCRIPTION

- Large scale electrolyser providing a part of the need for hydrogen :
  - 100 MW
  - 20.000 Nm^3/h, ~1.8 t H_2/h
- Connection to ELIA HV grid
- Industrial activity is already consuming hydrogen in large quantities (refinery, amonia production)
- Existing onsite SMR unit or hydrogen pipeline connection (= back-up)
- Type of ancillary services: R2 (secondary reserve)

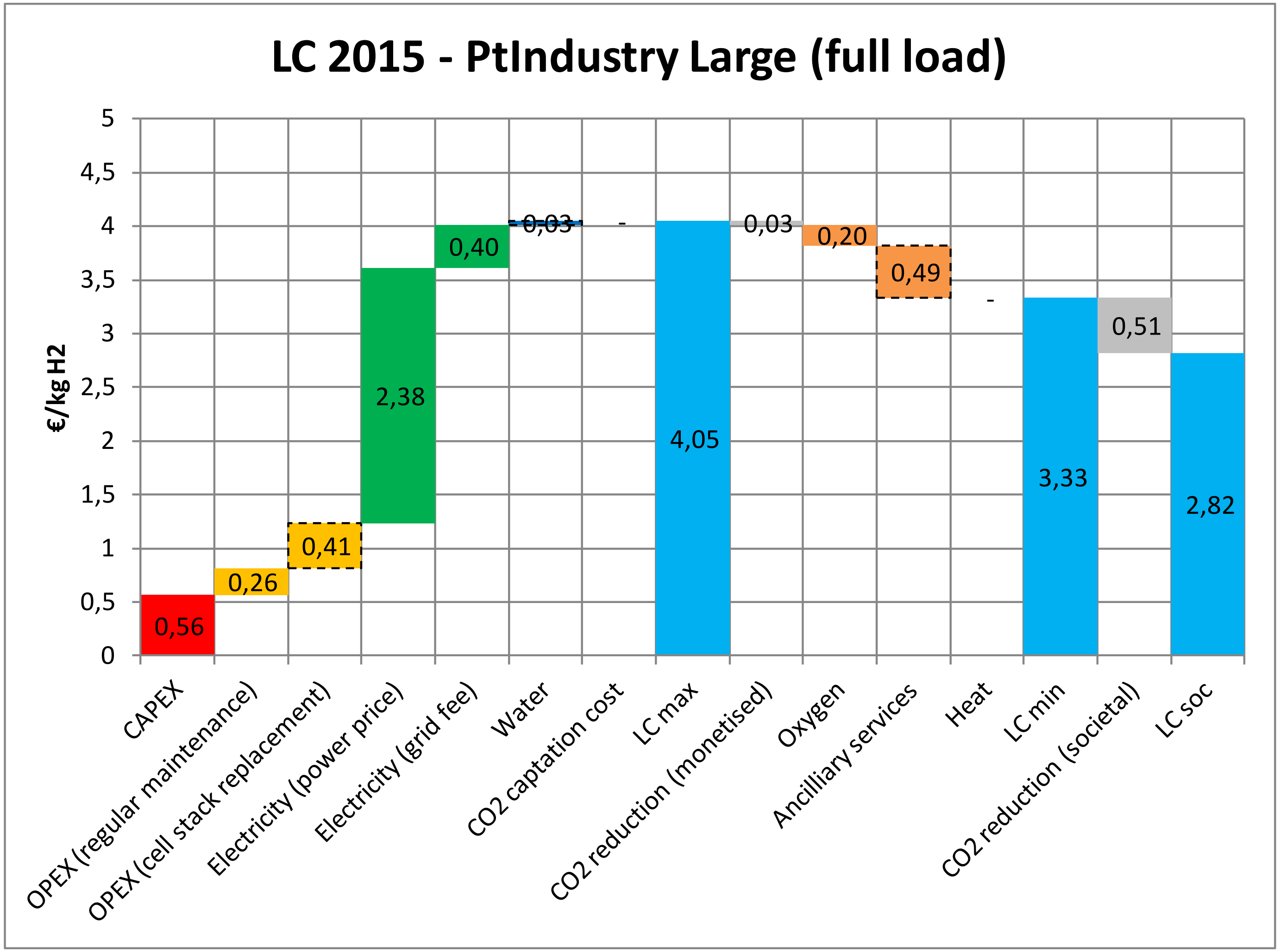
POWER-TO-INDUSTRY (LARGE SCALE)

LC_{MAX} VS OPERATING HOURS

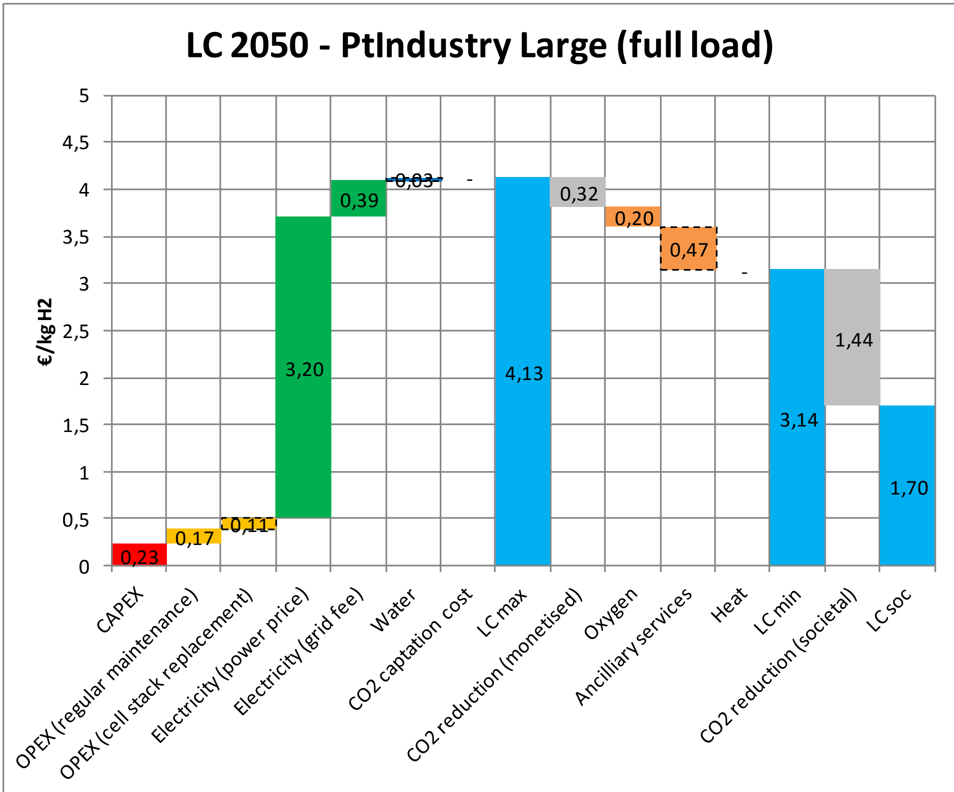


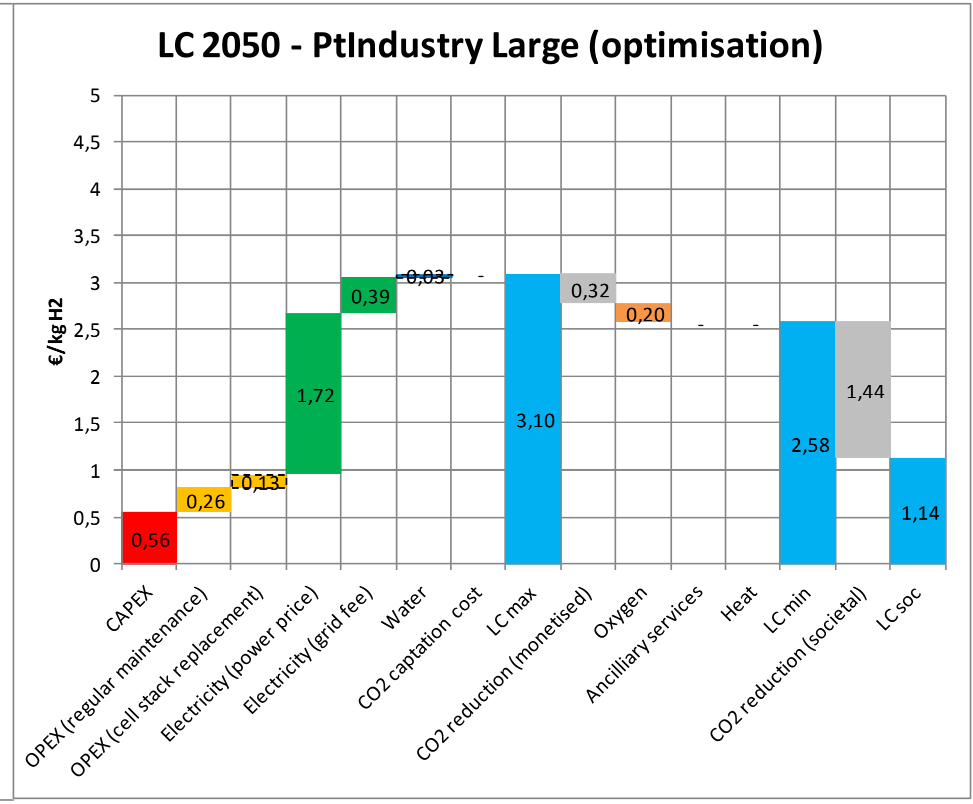
POWER-TO-INDUSTRY (LARGE SCALE)

WATERFALL GRAPH: LC_{MAX}, LC_{MIN}, LC_{SOC}



POWER-TO-INDUSTRY (LARGE SCALE)
WATERFALL GRAPHS: FULL LOAD VS OPTIMISATION

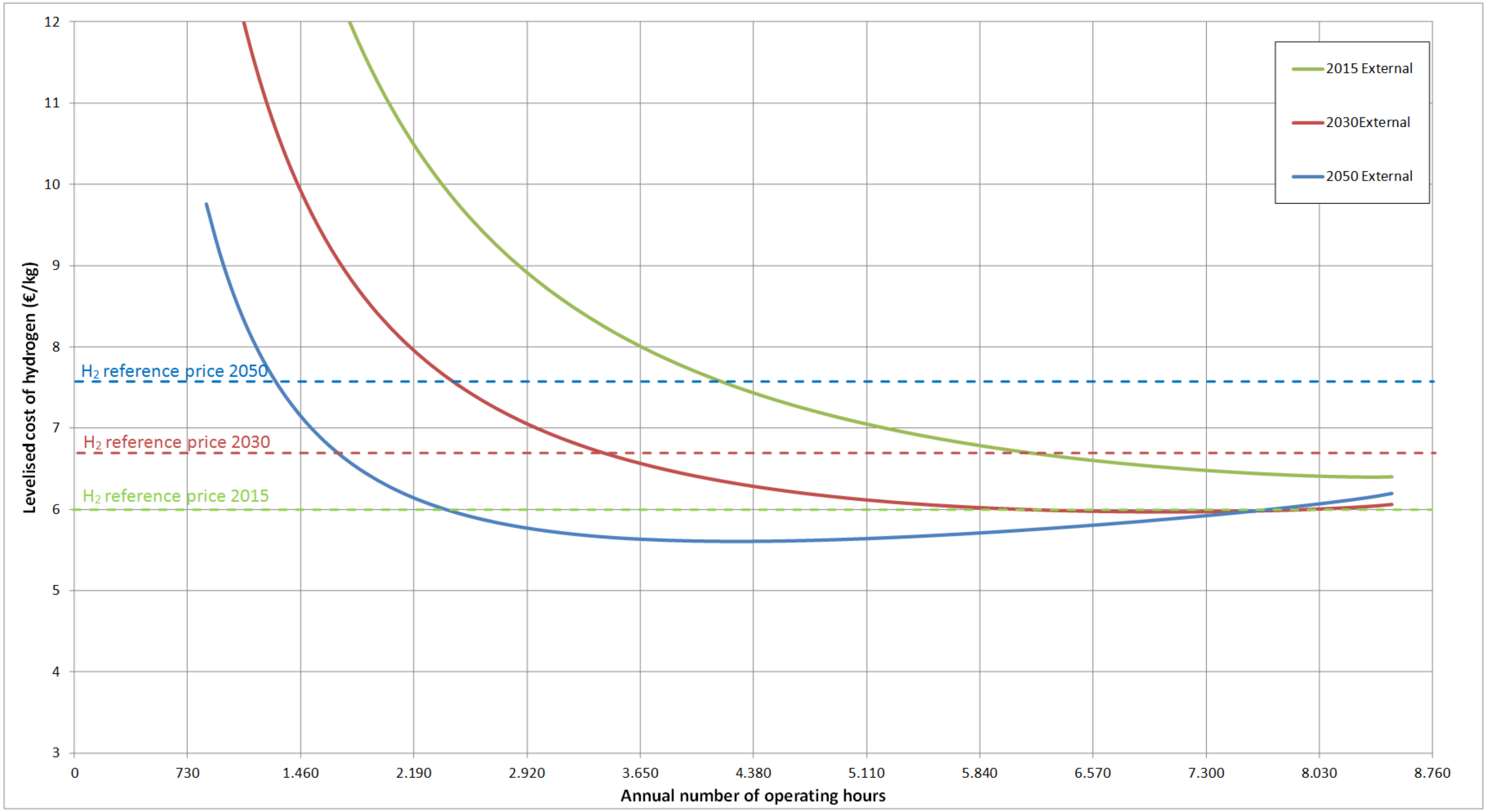




POWER-TO-INDUSTRY (SMALL SCALE)
BRIEF DESCRIPTION

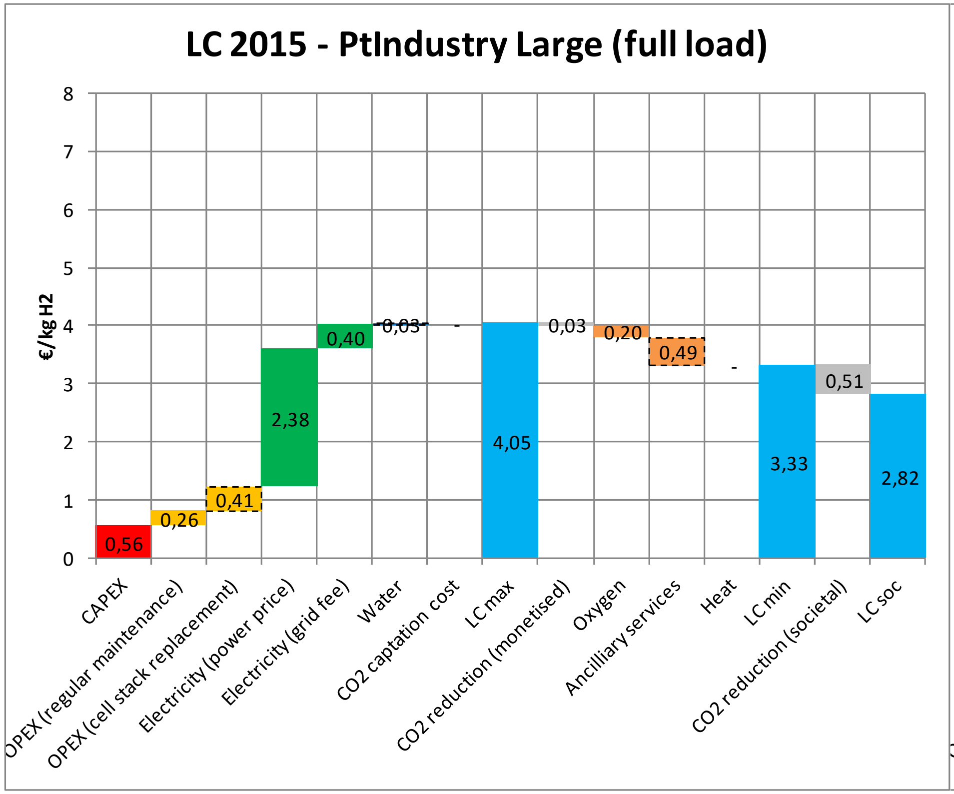
- Small scale electrolyser providing a part of the need for hydrogen
  - 1,2 MW
  - 230 Nm^3/h of hydrogen
- Connection to MV (10/12/15 kV) grid
- Industrial activity is already consuming hydrogen supplied via tube trailers (steel, glass, oil&fat)
- 48 hours hydrogen storage has been added for back-up
- Type of ancillary services: R3DP (tertiary reserve)

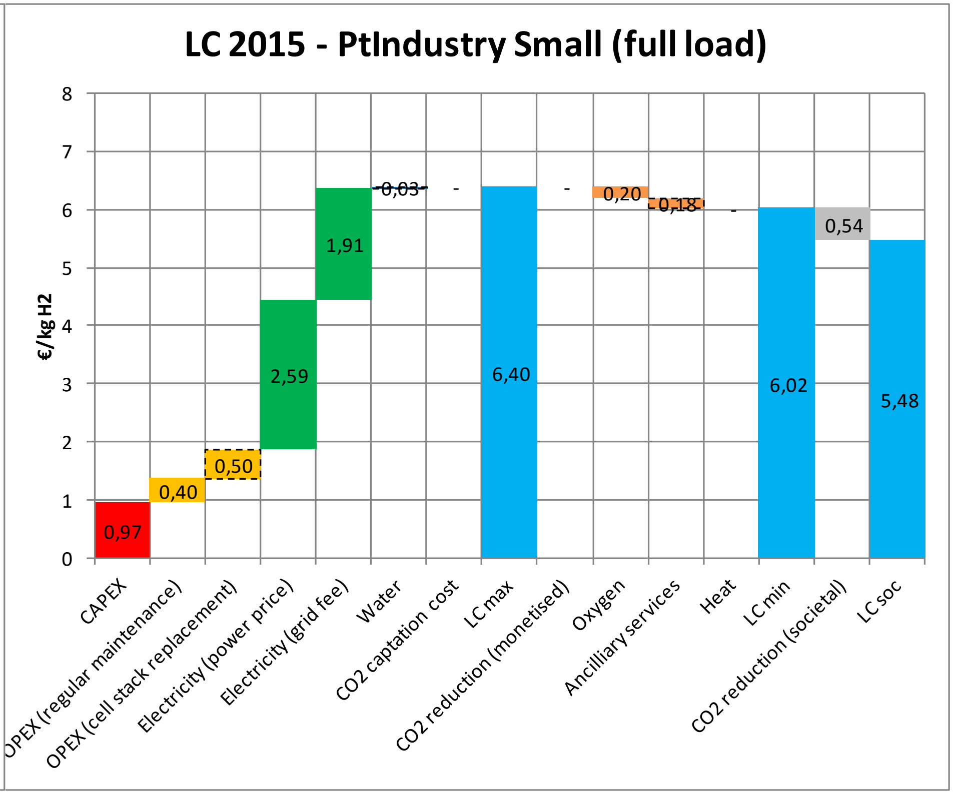
POWER-TO-INDUSTRY (SMALL SCALE)
LCOH+ VS OPERATING HOURS



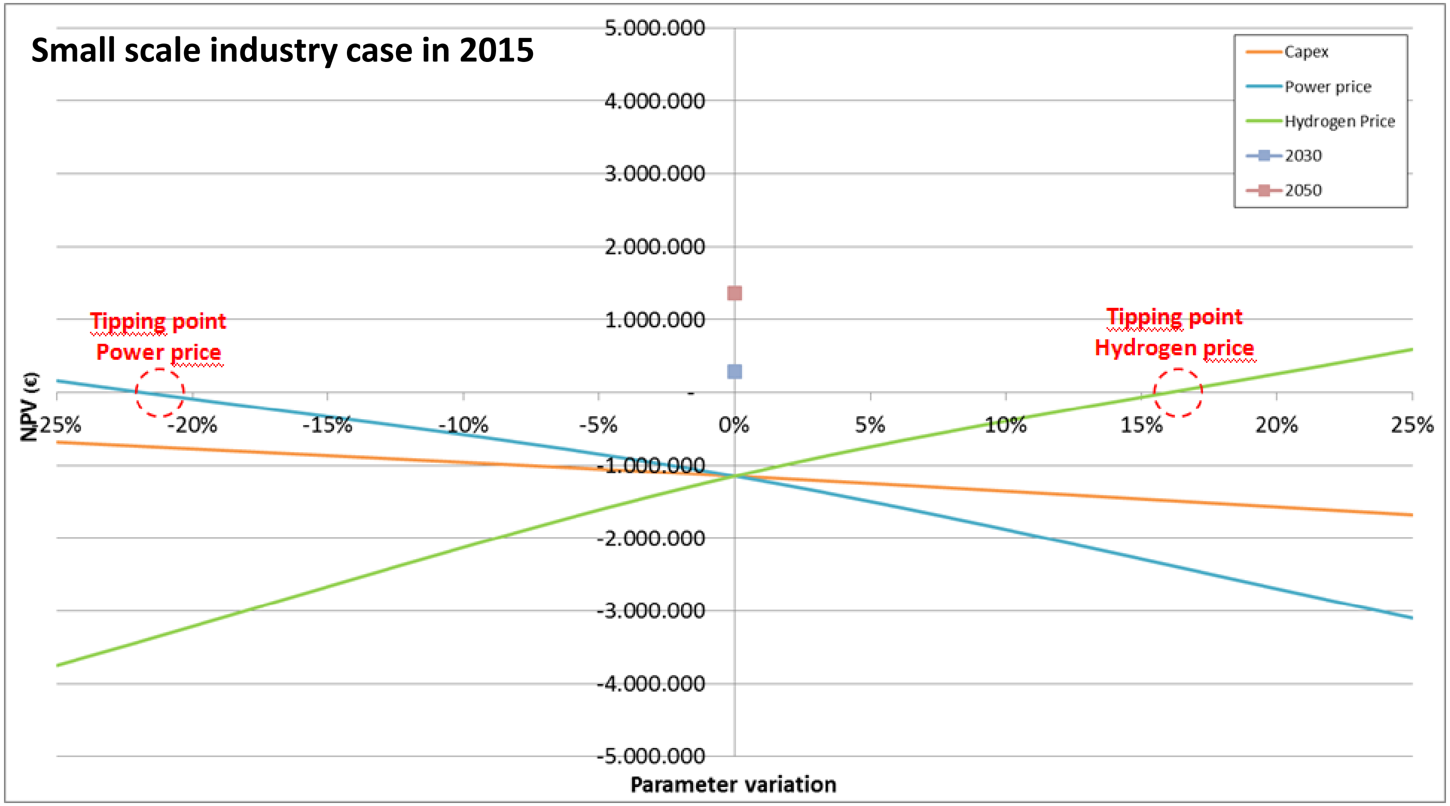
POWER-TO-INDUSTRY

WATERFALL GRAPH : SMALL VS LARGE





POWER-TO-INDUSTRY (SMALL SCALE)
SENSITIVITY ANALYSIS AND TIPPING POINTS



	2015		2030		2050	
	Requirement	Actual value	Requirement	Expected value	Requirement	Expected value
Power price (all-in)	< 60,8 €/MWh	77,82 €/MWh	< 88,4 €/MWh	84,16 €/MWh	< 116,2 €/MWh	95,76 €/MWh
Avoided purchasing cost of hydrogen	> 6,99 €/kg	6,00 €/kg	> 6,47 €/kg	6,71 €/kg	> 6,46 €/kg	7,60 €/kg
CAPEX	< 0,77 M€	2,13 M€	< 1,87 M€	1,53 M€	< 2,62 M€	1,00 M€

POWER-TO-INDUSTRY
MAIN CONCLUSIONS

Power-to-Industry: small scale (2 MW)

- Depending on the actual price of hydrogen for small industrial hydrogen consumer (function of the delivery distance and the hydrogen demand volume), onsite hydrogen production from electrolysis can already be **competitive** (~7 €/kg) with hydrogen delivered by tube trailers trucks from a central SMR unit.

Power-to-Industry: large scale (100 MW)

- Large scale electrolysers **could generate in the future** (2030-2050) **cheaper hydrogen** than onsite SMR units (or hydrogen delivered via pipeline) if they can operate during the cheapest power price hours.

POWER-TO-GAS
BRIEF DESCRIPTION

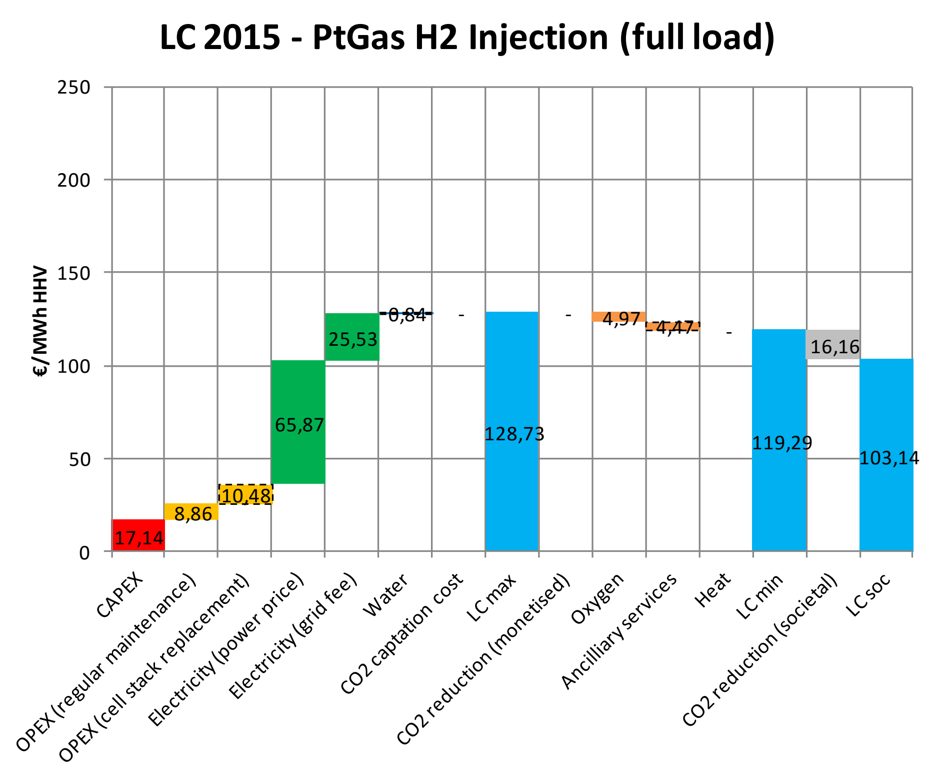
Direct injection

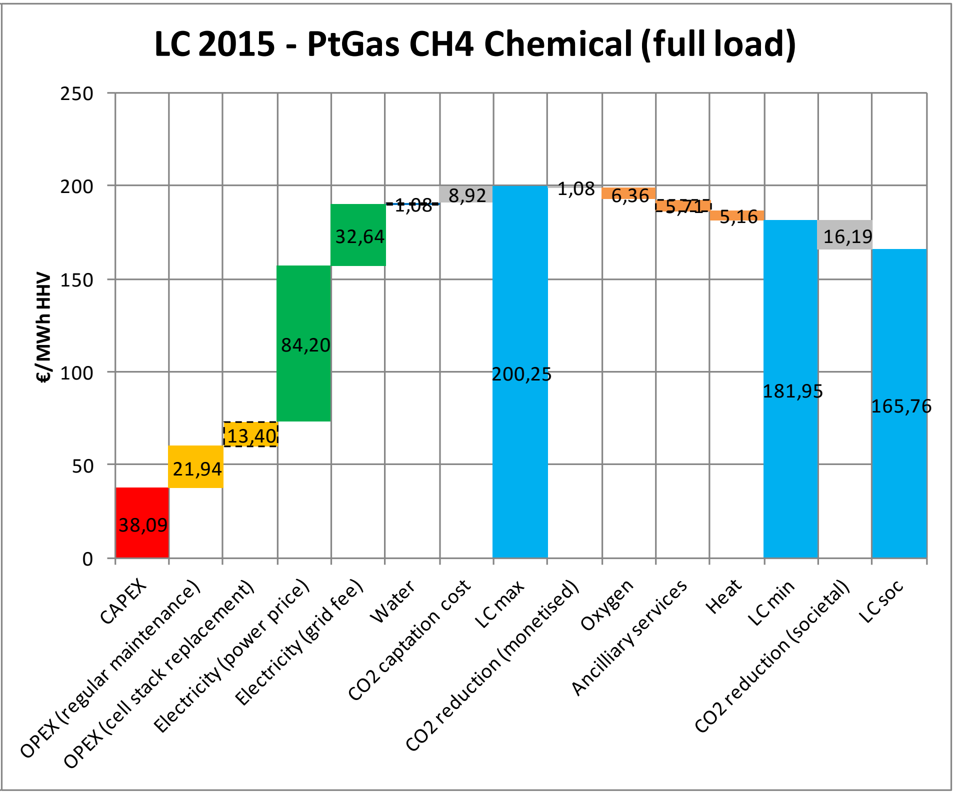
- Medium scale electrolyser: 15 MW
- Compression up to 70 bar
- Injection into the transportation gas grid
- Gas injection facility included
- Connection to MV grid
- Type of ancillary services: R3DP (tertiary reserve)

+ Methanation

- All hydrogen is used in a methanation process to produce Synthetic Natural Gas (SNG or CH_4)
- CO_2 source : ~1.5 ton of CO2 per hour (50 €/t)

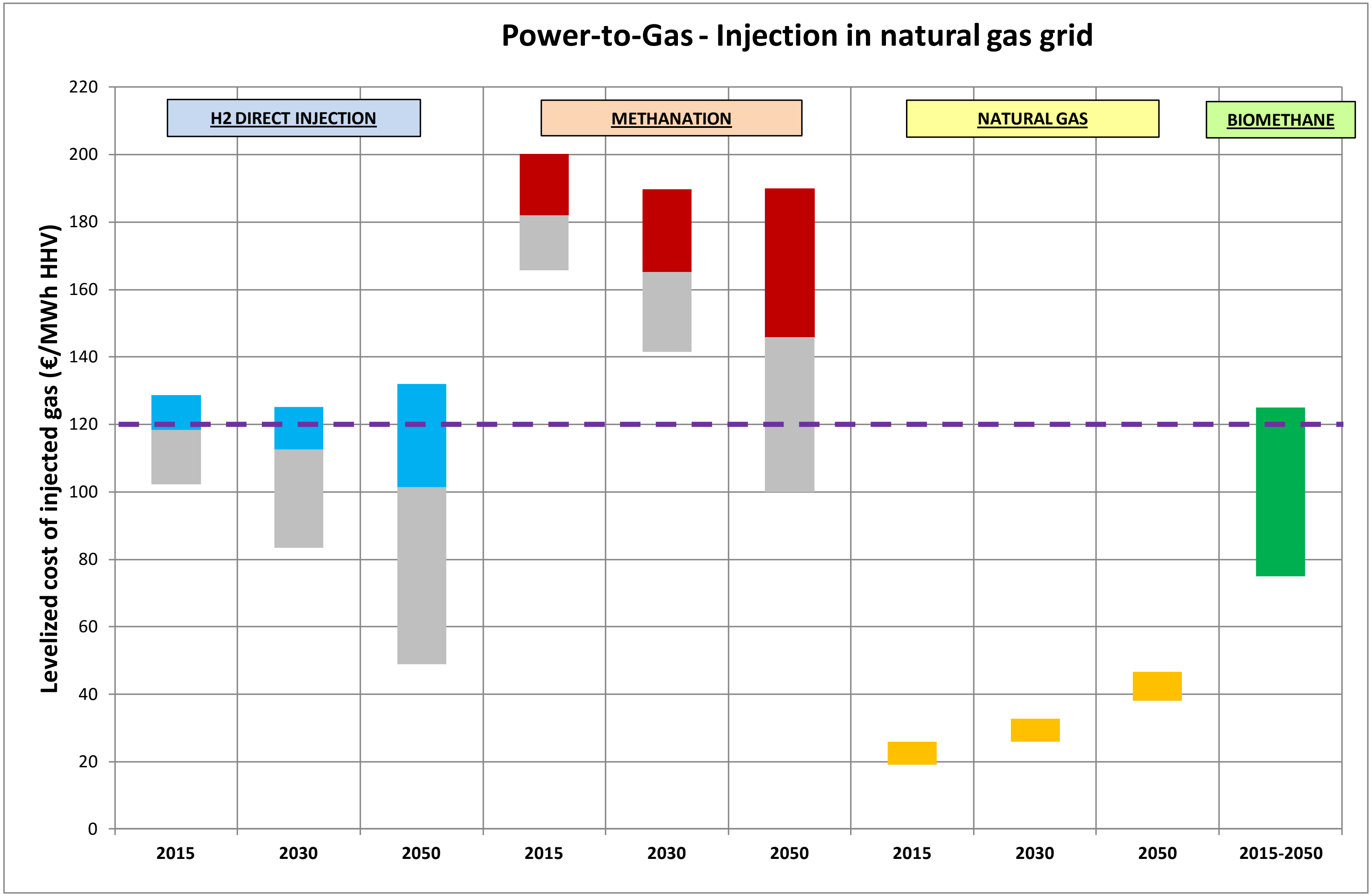
POWER-TO-GAS
DIRECT INJECTION VS METHANATION





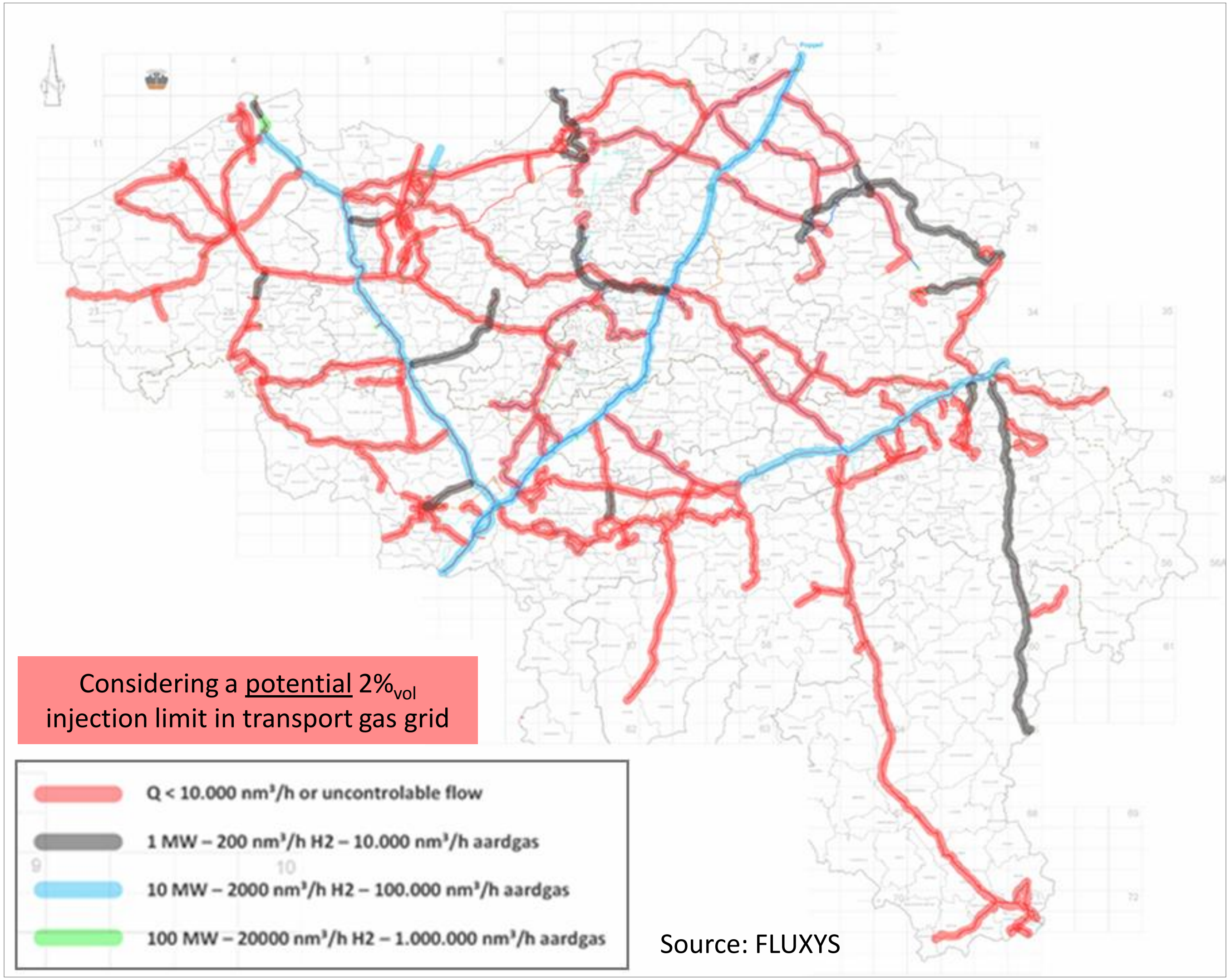
- Main difference is explained by the efficiency of the methanation reaction (max 78%: $H_2 + CO_2 \rightarrow CH_4 + H_2O$) and additional capex/opex for methanation unit

POWER-TO-GAS
DIRECT INJECTION, METHANATION, BIOMETHANE



POWER-TO-GAS

POTENTIAL IN BELGIUM FOR DIRECT INJECTION



Source: FLUXYS

POWER-TO-GAS
MAIN CONCLUSIONS

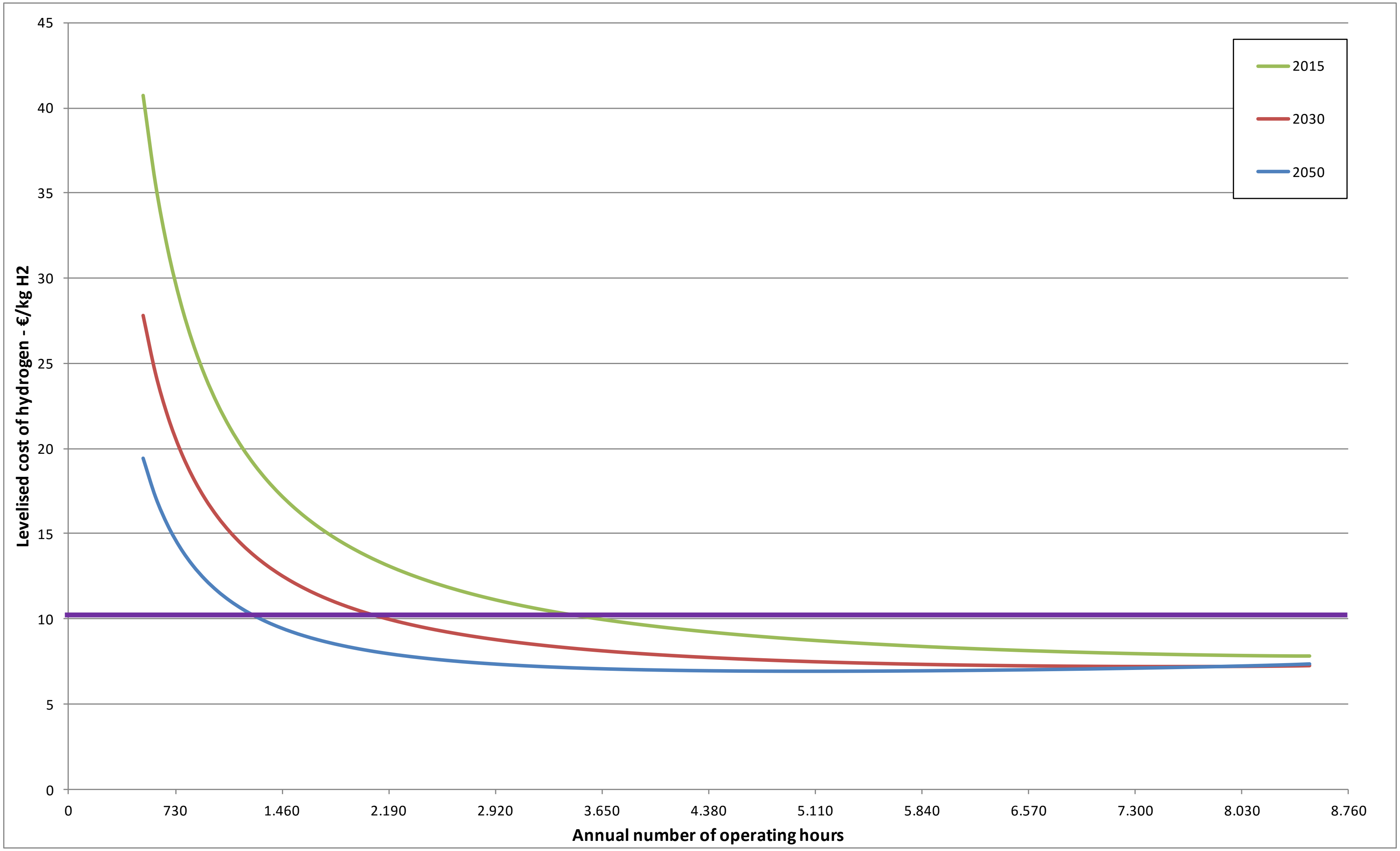
- P2G options remain **more expensive than natural gas**.
- **Only a few options are available to green the gas** transported and/or distributed in our gas grids: mainly biomethane.
- **Direct injection** of hydrogen in gas grids (~125 €/MWh) seems already competitive today with some biomethane feed-in tariffs existing in France or Germany (75-125 €/MWh). If such Power-to-Gas projects could benefit from these feed-in-tariffs in Belgium, it would be a sufficient incentive to have a business case for the direct injection of hydrogen in gas grids.
- If we want to convert hydrogen (H_2) to **synthetic methane** (CH_4) by using carbon dioxide (CO_2), we have additional costs and efficiencies which bring the costs in the range of 150-200 €/MWh, which makes it difficult to justify today. But if we want to decarbonise fully the gas distributed and transported in our grids in the future, this is definitely an option to be considered taking into account the limitation of existing gas grids for hydrogen.

POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 25 BUSES/DAY : BRIEF DESCRIPTION

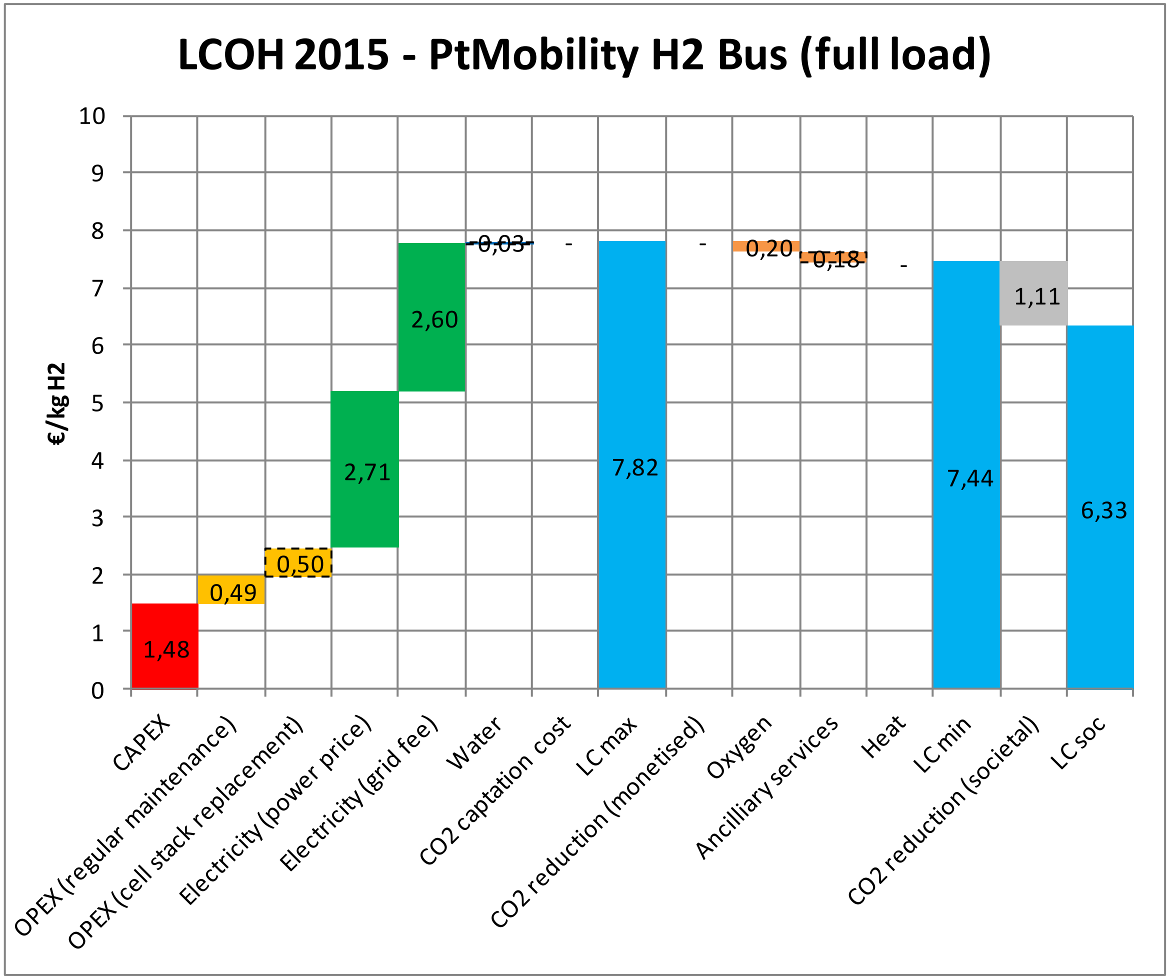
- Medium scale electrolyser:
  - 2.2 MW, 900 kg/day
- Compression up to 450 bar
- 12 hours storage in pressure tanks
- Dispensing included
- Connection to transfo LV grid
- Type of ancillary services: R3DP (tertiary reserve)
- Implementation in an existing refueling station

- Not constraint as been assumed on fueling planning (back-to-back…)

POWER-TO-MOBILITY: HYDROGEN REFUELING STATION
25 BUSES/DAY : LCOH+ vs OPERATING HOURS



POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 25 BUSES/DAY: WATERFALL GRAPHS

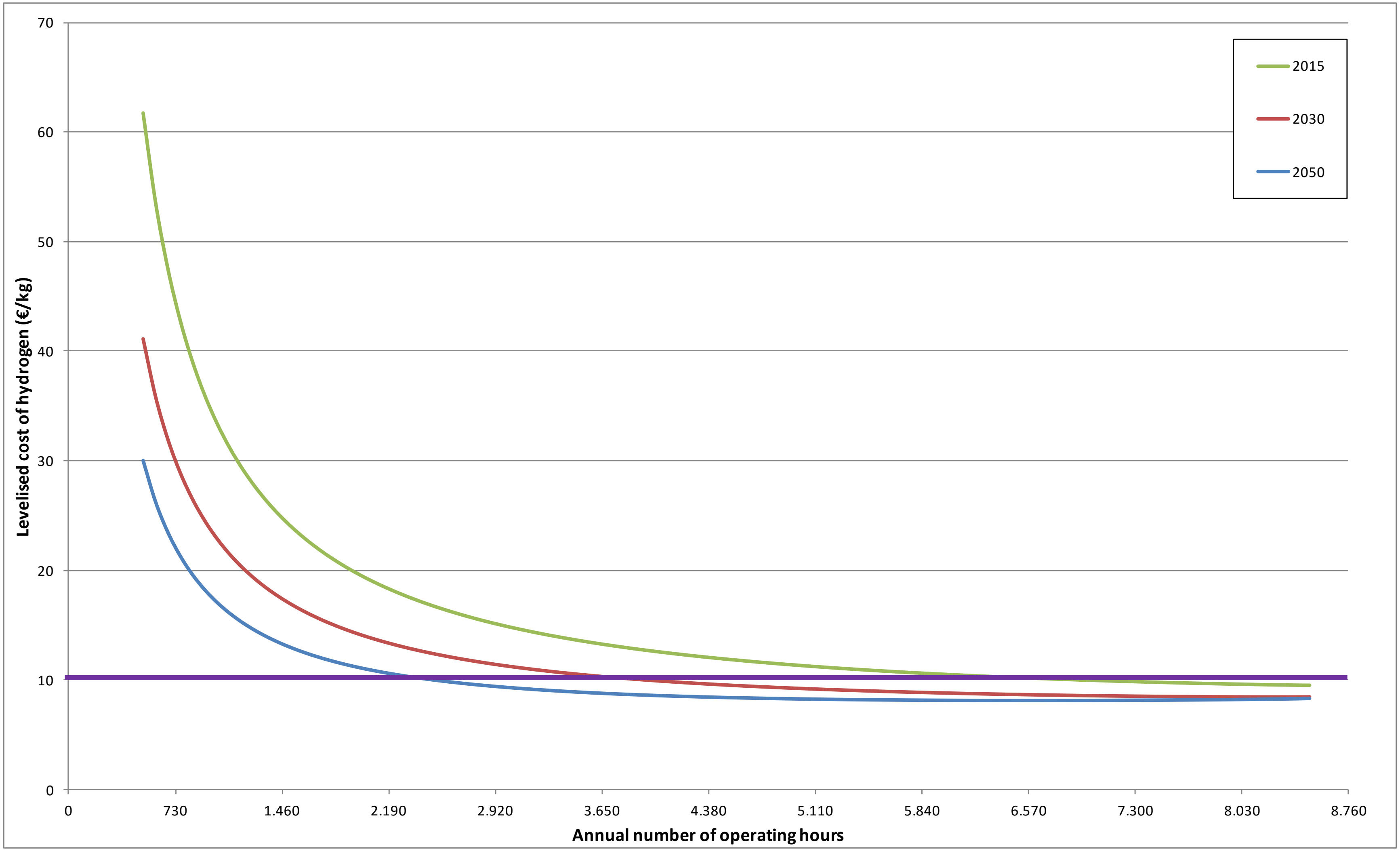


POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 50 CARS/DAY : BRIEF DESCRIPTION

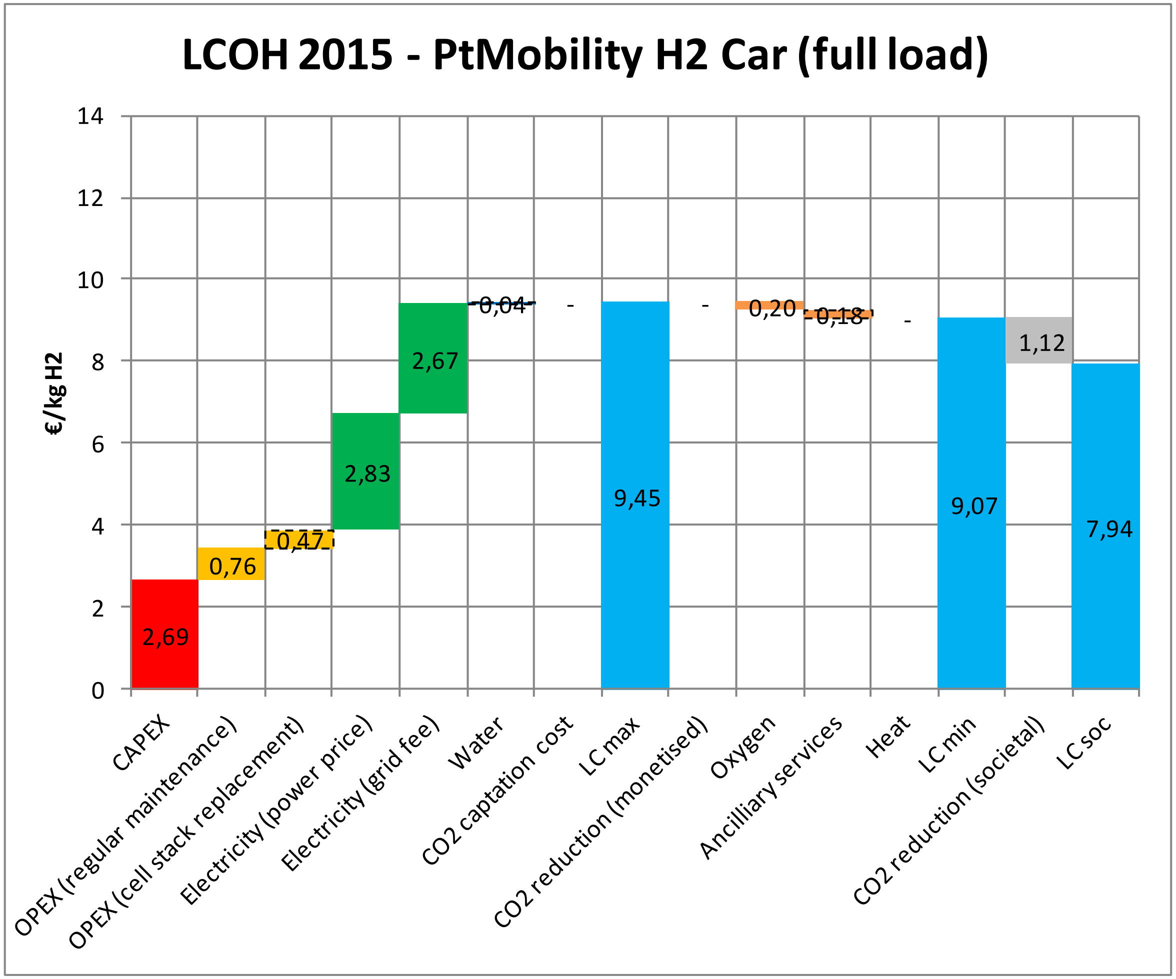
- Small scale electrolyser:
  - 0.5 MW, 200 kg/day
- Compression up to 900 bar
- 12 hours storage in pressure tanks
- Dispensing included
- Connection to transfo LV grid
- Type of ancillary services: R3DP (tertiary reserve)
- Implementation in an existing refueling station

- Not constraint as been assumed on fueling planning (back-to-back…)

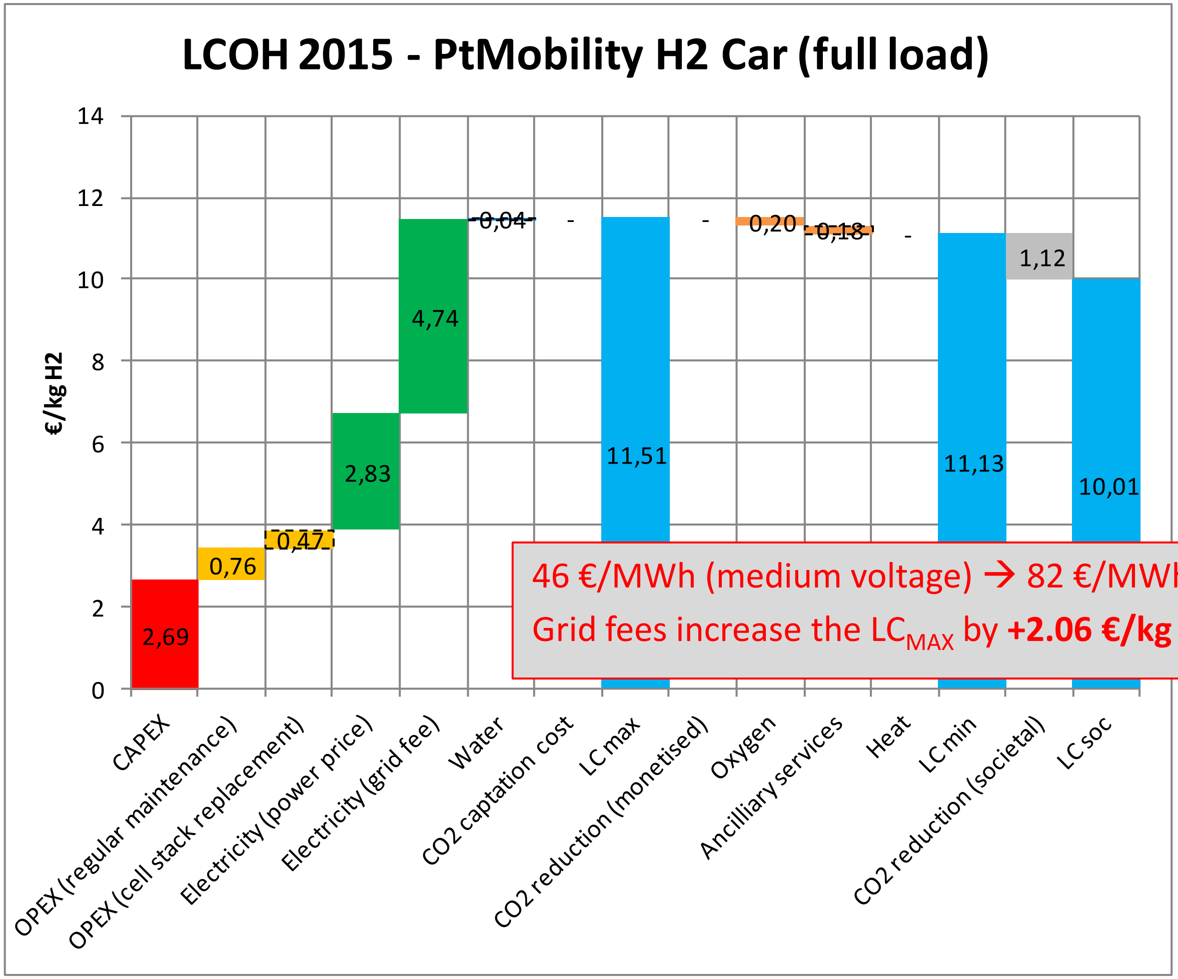
POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 50 CARS/DAY : LC_{MAX} vs OPERATING HOURS



POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 50 CARS/DAY : WATERFALL GRAPHS



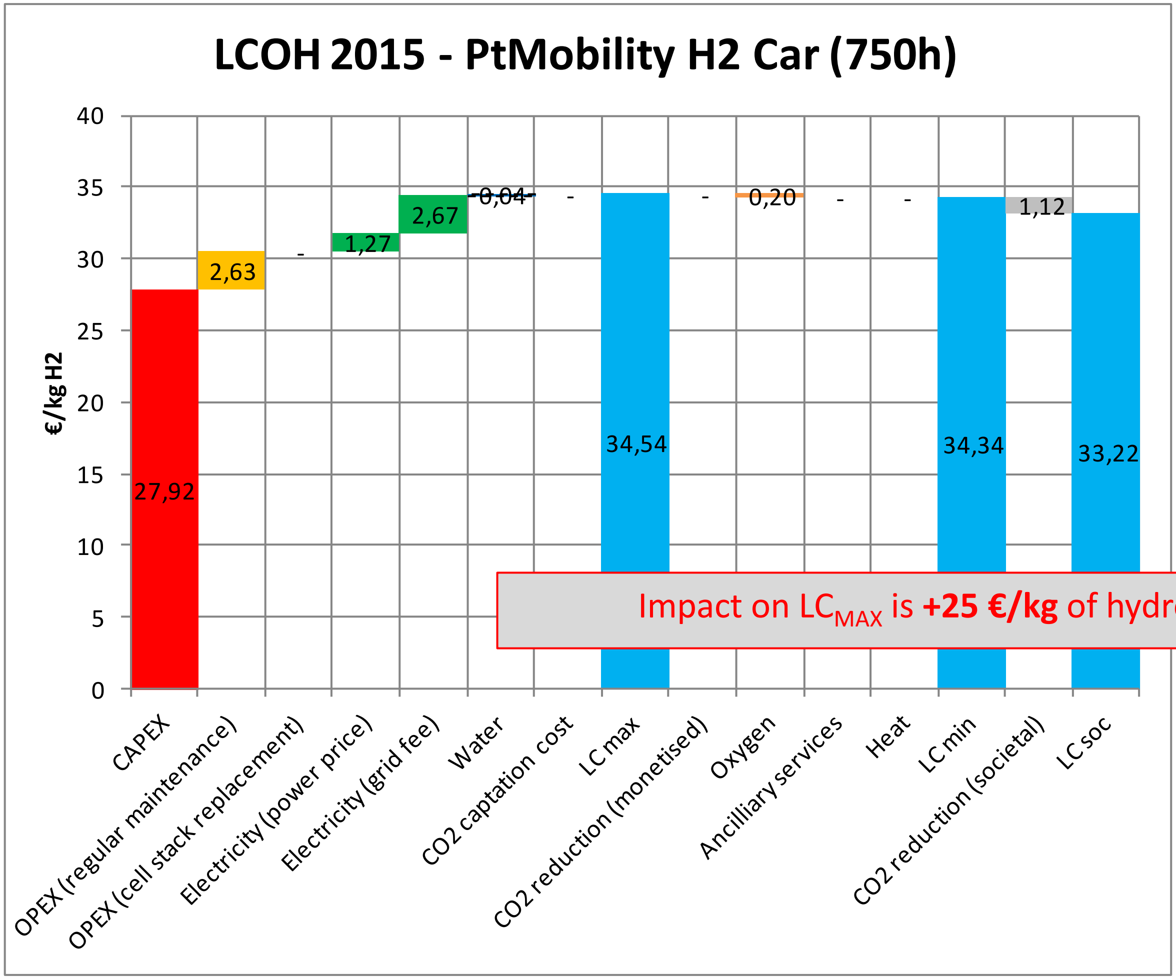
POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 50 CARS/DAY : WHAT IF CONNECTION AT LOW VOLTAGE ?



46 €/MWh (medium voltage) → 82 €/MWh (low voltage)

Grid fees increase the LC_{MAX} by **+2.06 €/kg** of hydrogen !

POWER-TO-MOBILITY: HYDROGEN REFUELING STATION 50 CARS/DAY : WHAT IF ONLY 750 OPERATING HOURS ?



Impact on LC_{MAX} is **+25 €/kg** of hydrogen !!!

POWER-TO-MOBILITY: HYDROGEN REFUELING STATION
MAIN CONCLUSIONS

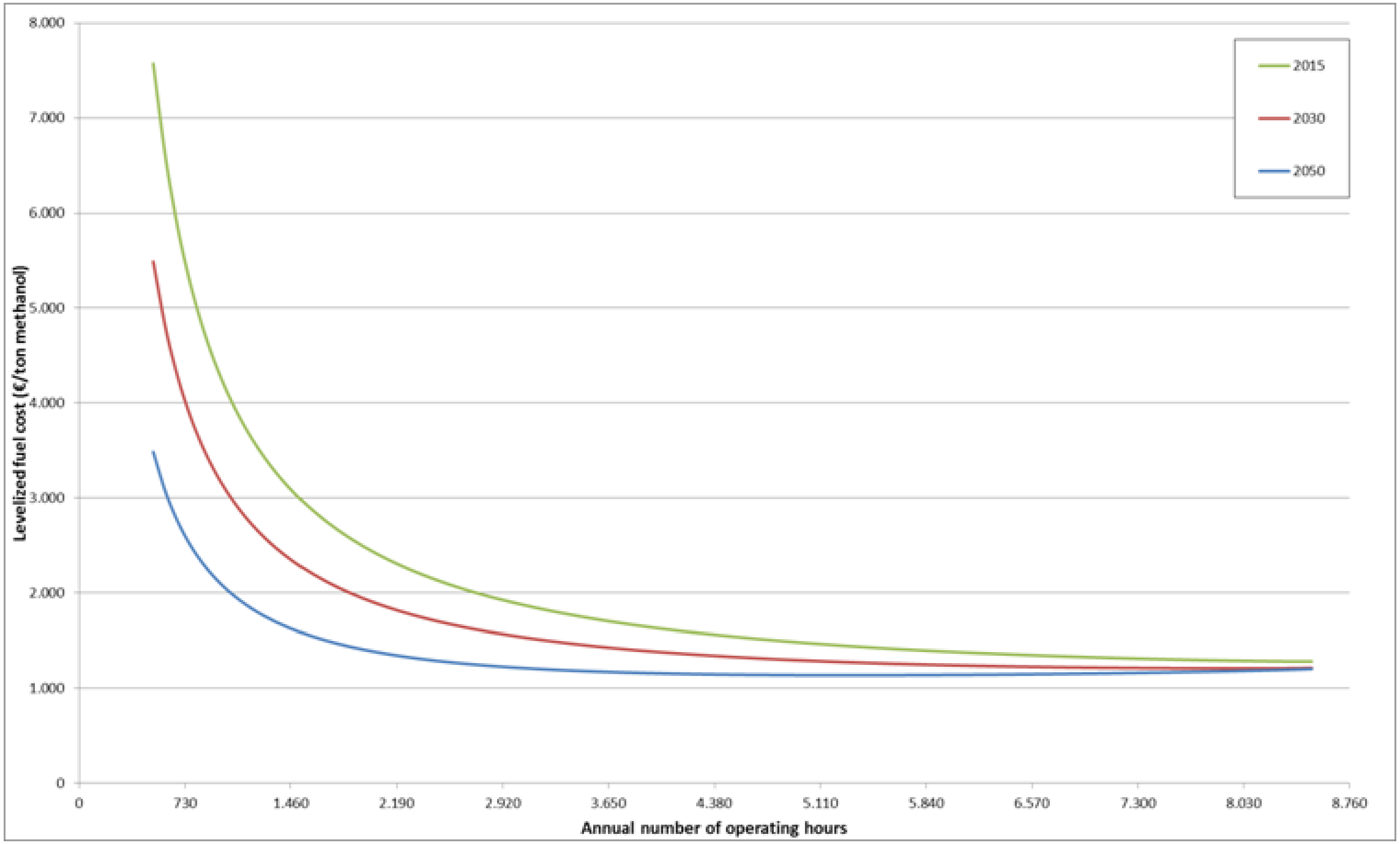
- LC_{MAX} for the HRS can fall below the 10€/kg landmark if the utilization of the HRS (and electrolyser) is generally above 25%
- Important to secure the hydrogen demand for future HRS with captive fleets (buses, corporate cars, forklifts...)
- The direct use of hydrogen in FCEV will become more competitive than diesel on the medium term (2030) already on a fuel cost basis for a 100 km distance.
- The location of the HRS should be adequately chosen in order to minimize the fees associated to the grid connection.
- If grid fees are removed on the power consumed for the hydrogen production in HRS , the LC_{MAX} would approach the 5,5-6 €/kg

POWER-TO-FUELS: METHANOL
BRIEF DESCRIPTION

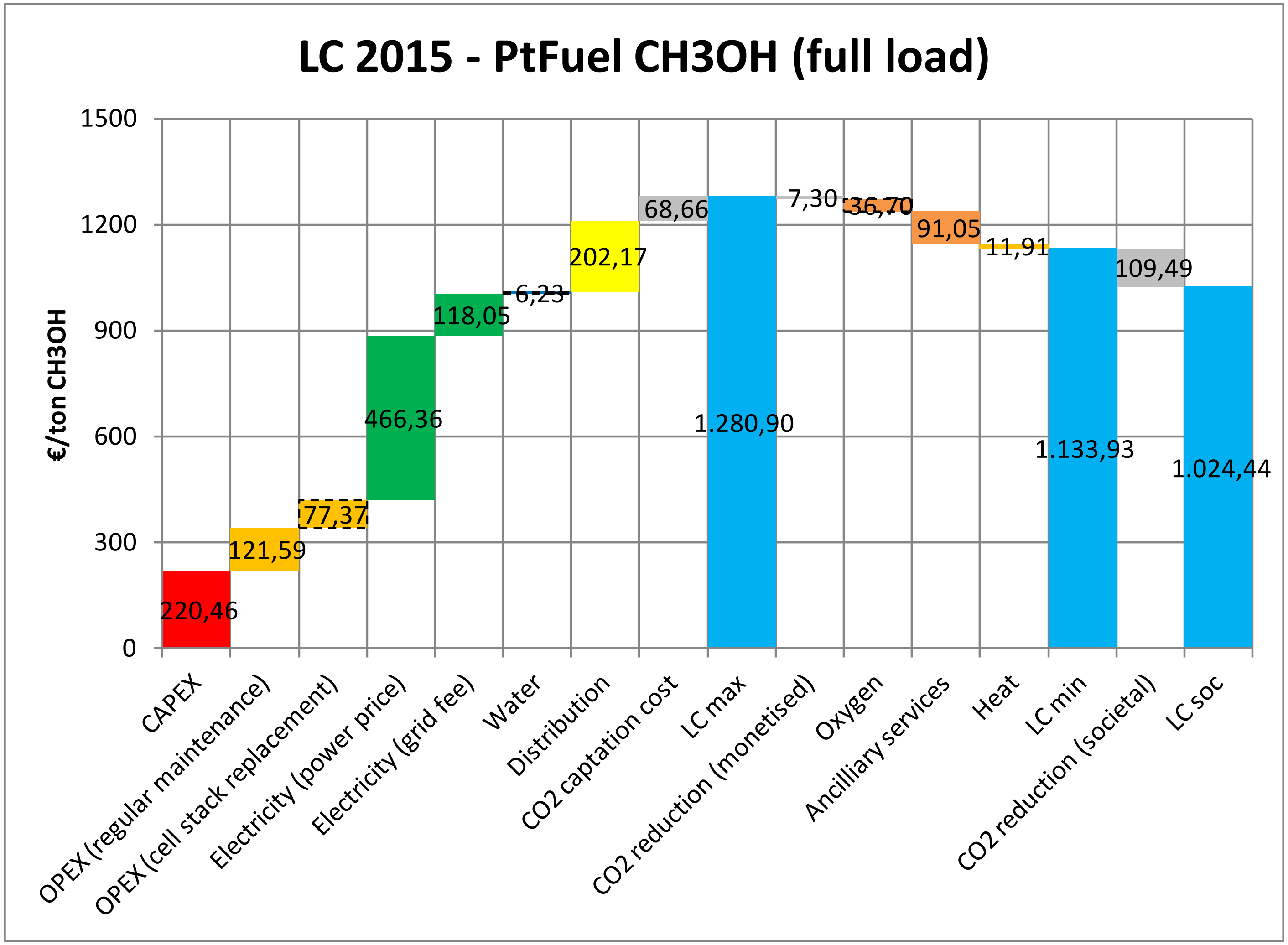
- Large scale electrolyser:
  - 50 MW
  - 10.000 Nm³/h, ~0.9 t H_2/h
- Methanol output of 40.000 tons/year
- CO_2 source : ~6.6 tons of CO2 per hour (50 €/t)
- Connection to ELIA HV (transfo) grid
- New activity on existing industrial site
- Type of ancillary services: R2 (secondary reserve)

POWER-TO-FUELS: METHANOL

LC_{MAX} vs OPERATING HOURS

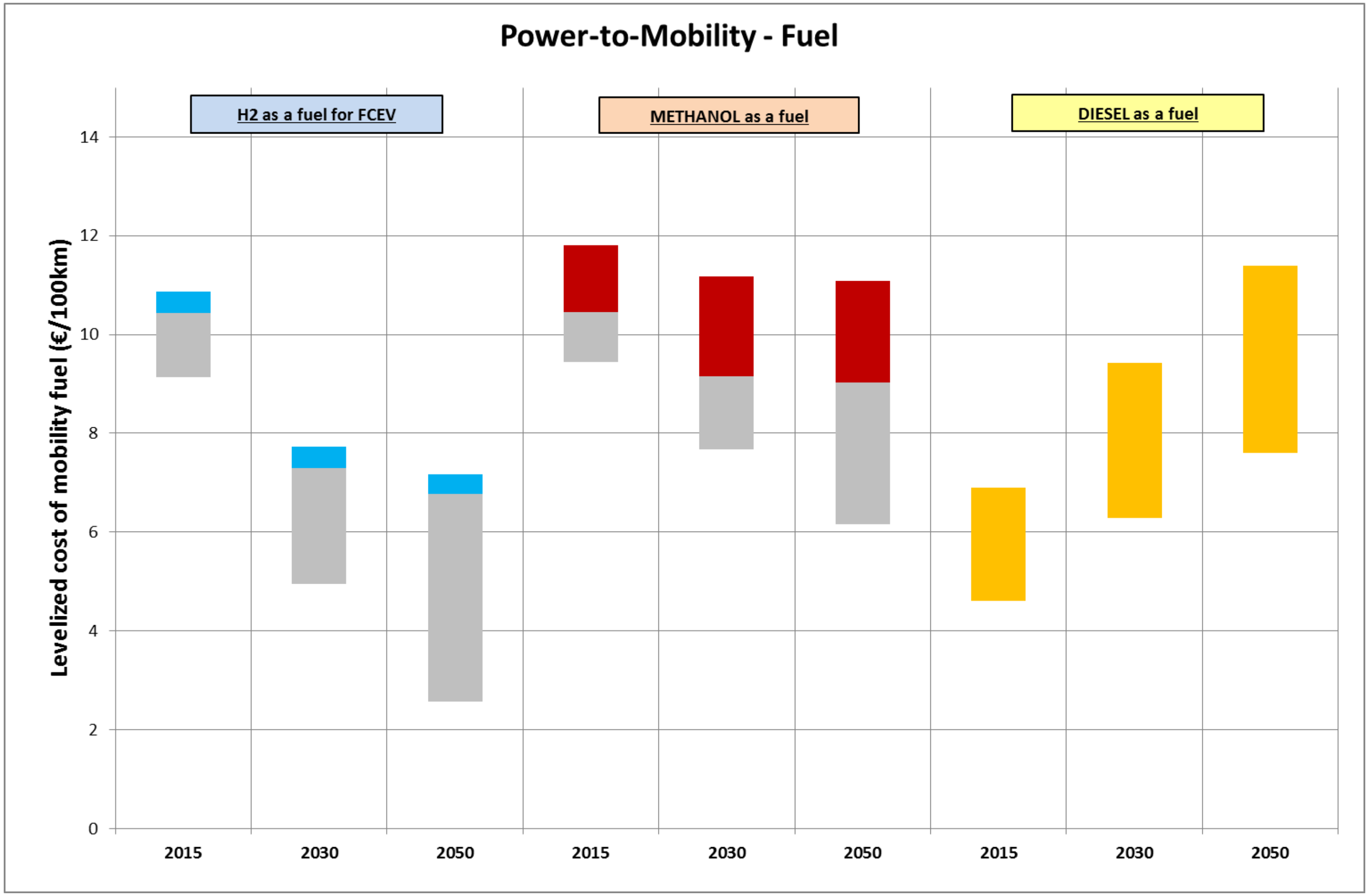


POWER-TO-FUELS: METHANOL
WATERFALL GRAPH



POWER-TO-FUELS/MOBILITY: COMPARISON BETWEEN HYDROGEN, METHANOL AND DIESEL

Fuel cost comparison for 100km and expected development until 2050 between methanol and diesel



POWER-TO-FUELS
MAIN CONCLUSIONS

- 10% biofuels in Belgium by 2020 mainly through bio-diesel and bio-ethanol (1st generation biofuels).
- Opportunity with the EU Fuel Quality Directive to comply with the 10% target with 2nd generation (or Advanced) biofuels
- Several alternatives are possible (among others):
    1. Partial substitution of diesel with bio-methanol (Power-to-Methanol)
    2. Direct use of green hydrogen in refineries
- We expect bio-methanol to become competitive with diesel around 2030 already.
- Direct use of green hydrogen in refineries was not in the scope of the P2G roadmap but should be further studied.

POWER-TO-POWER: HYDROGEN BASED ENERGY STORAGE
BRIEF DESCRIPTION

- Small scale
  - In medium-sized industry with own renewable energy production (*prosumer model = avoiding injection*)
  - Electrolyser: 500 kW
  - Fuel cell: 120 kW
  - Compression and storage at 200 bar

- Large scale
  - At utility scale (price arbitrage: buying when cheap power is available, selling when power price is high)
  - Electrolyser: 400 MW
  - Fuel cell: 80 MW
  - Compression and storage at 200 bar

POWER-TO-POWER: HYDROGEN BASED ENERGY STORAGE
RESULTS FROM SIMULATIONS

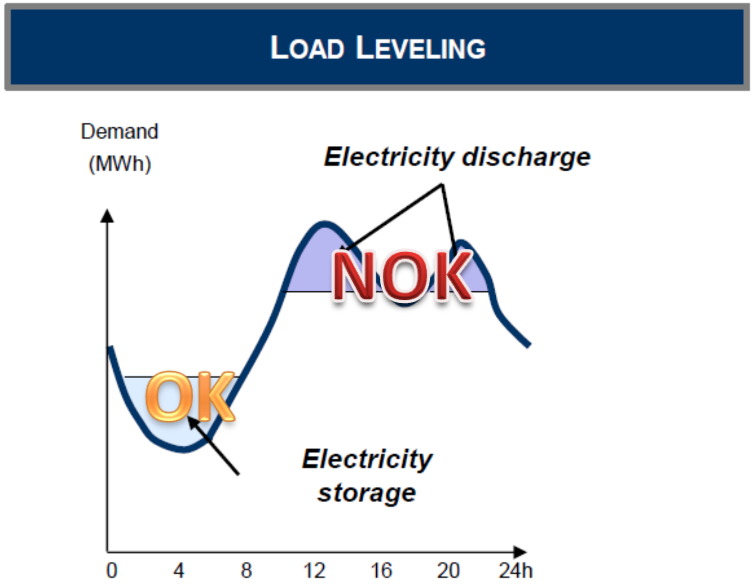
	2015	2030	2050
Small scale	770 €/MWh	440 €/MWh	336 €/MWh
Large scale	570 €/MWh	518 €/MWh	245 €/MWh

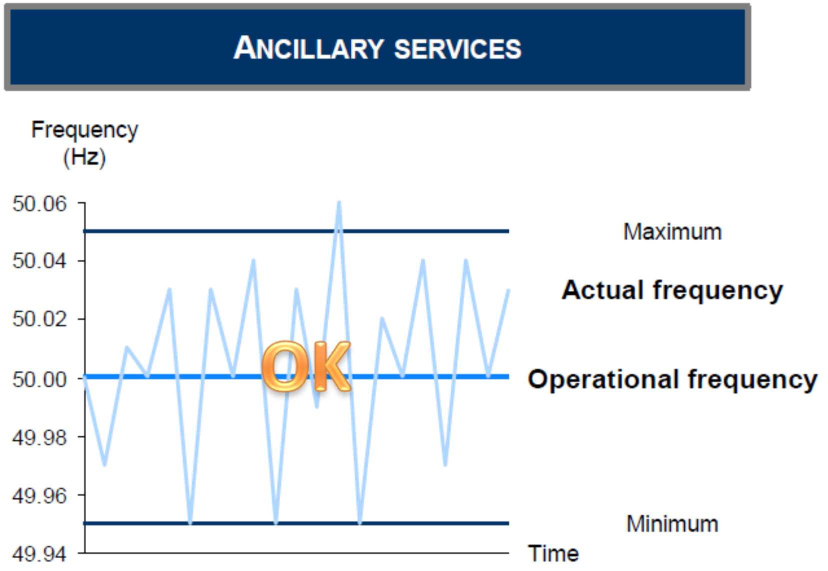
	2015	2030	2050
Batteries NaS	+/- 140 €/MWh		
Batteries Li-Ion	+/- 160 €/MWh	+/- 80 €/MWh	+/- 65 €/MWh
Pumped Hydro Storage (Coo)	+/- 85 €/MWh		
Pumped Hydro Storage (Energy Atoll)	+/- 85 €/MWh		

Table 2: Summary of indicative cost of energy storage (power-to-power)

- Main explanations:
    - Expensive capex (electrolyser + fuel cell + H_2 storage)
    - Low round trip efficiency
    - Low amount of operating hours
    - Electricity price spread no sufficient

POWER-TO-POWER: HYDROGEN BASED ENERGY STORAGE
MAIN CONCLUSIONS

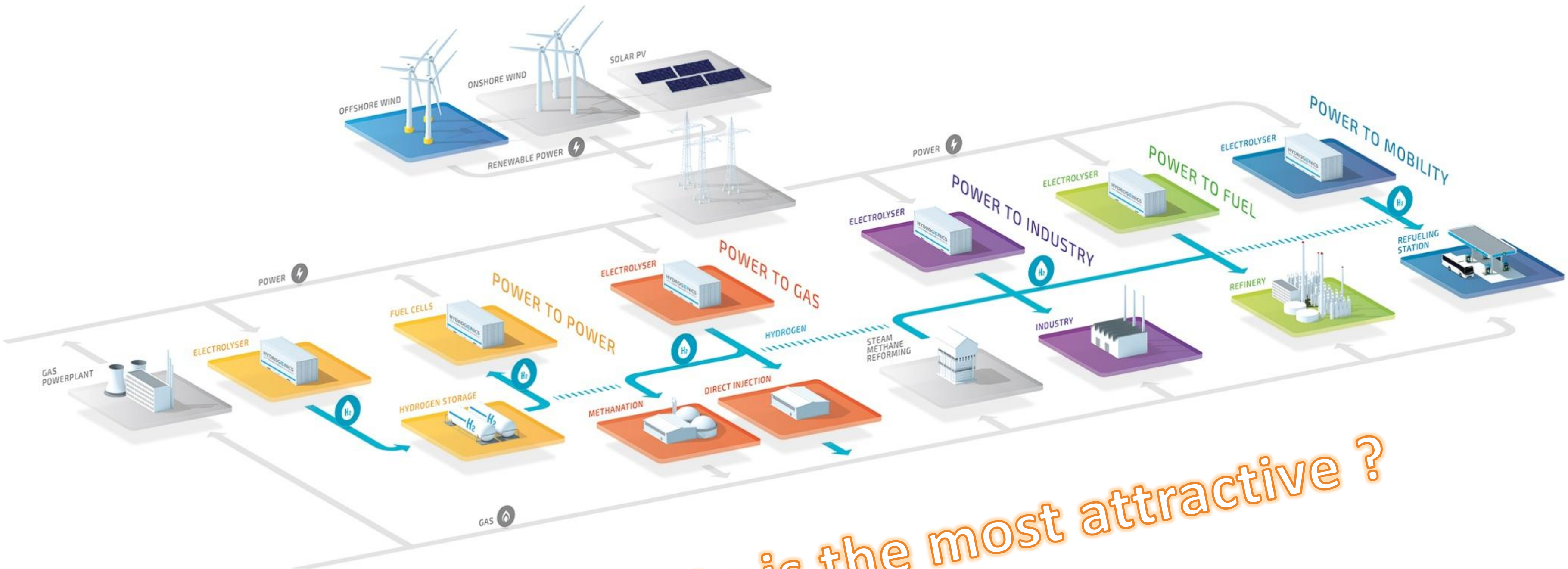




Source: SBC Energy Institute Analysis based on IRES Proceedings 2012

- Electrolysers with highly dynamic operation capabilities can offer services to the ancillary market
- Hydrogen offers large storage capabilities for the power sector, however re-electrification is not seen as the most interesting option in the short term (high capex, low round-trip efficiency) expect under specific conditions (remote locations, islands, off-grid systems)

GREEN HYDROGEN
IN POWER, GAS, TRANSPORTATION AND INDUSTRY SECTORS

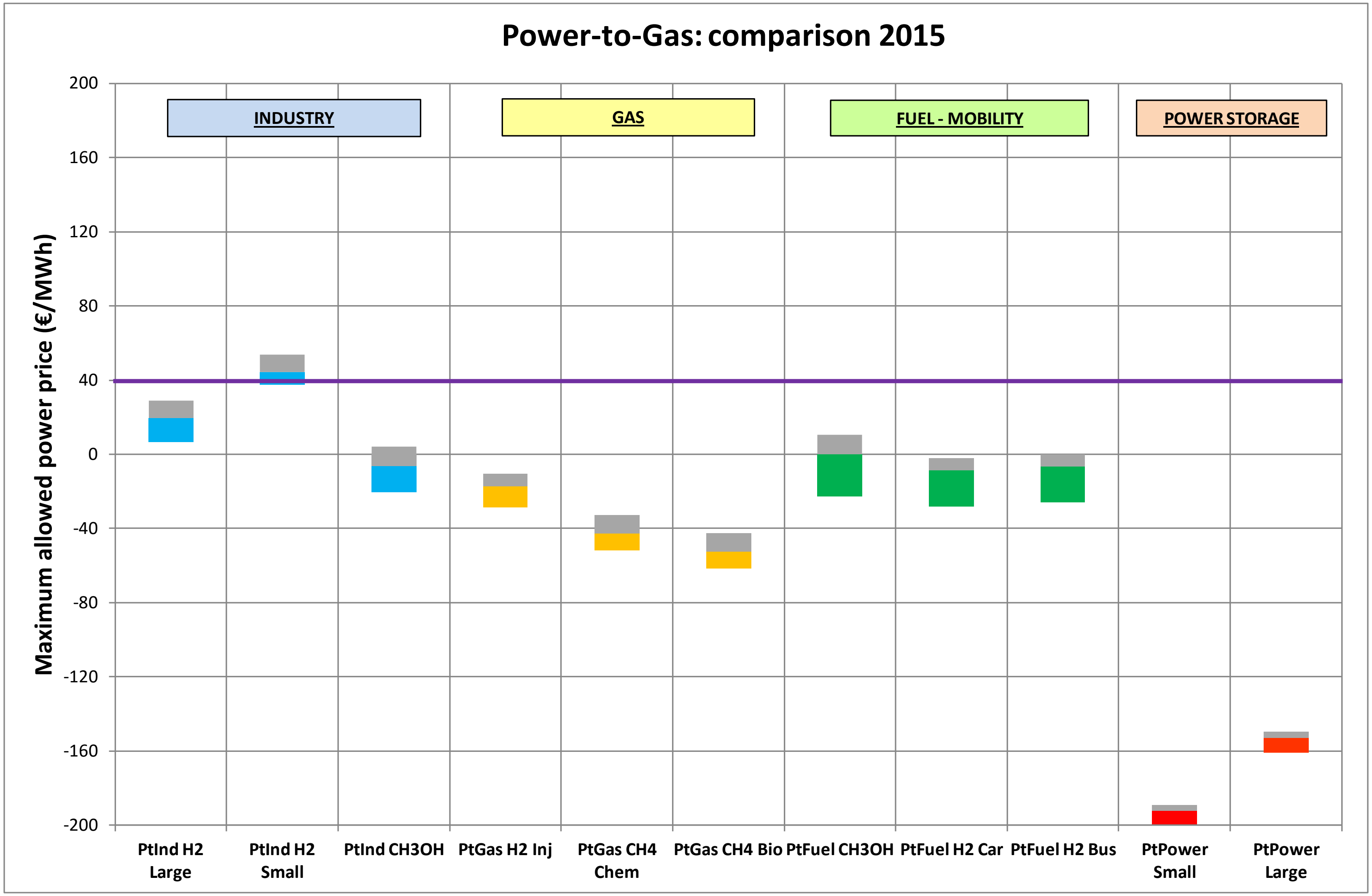


Which route is the most attractive ?

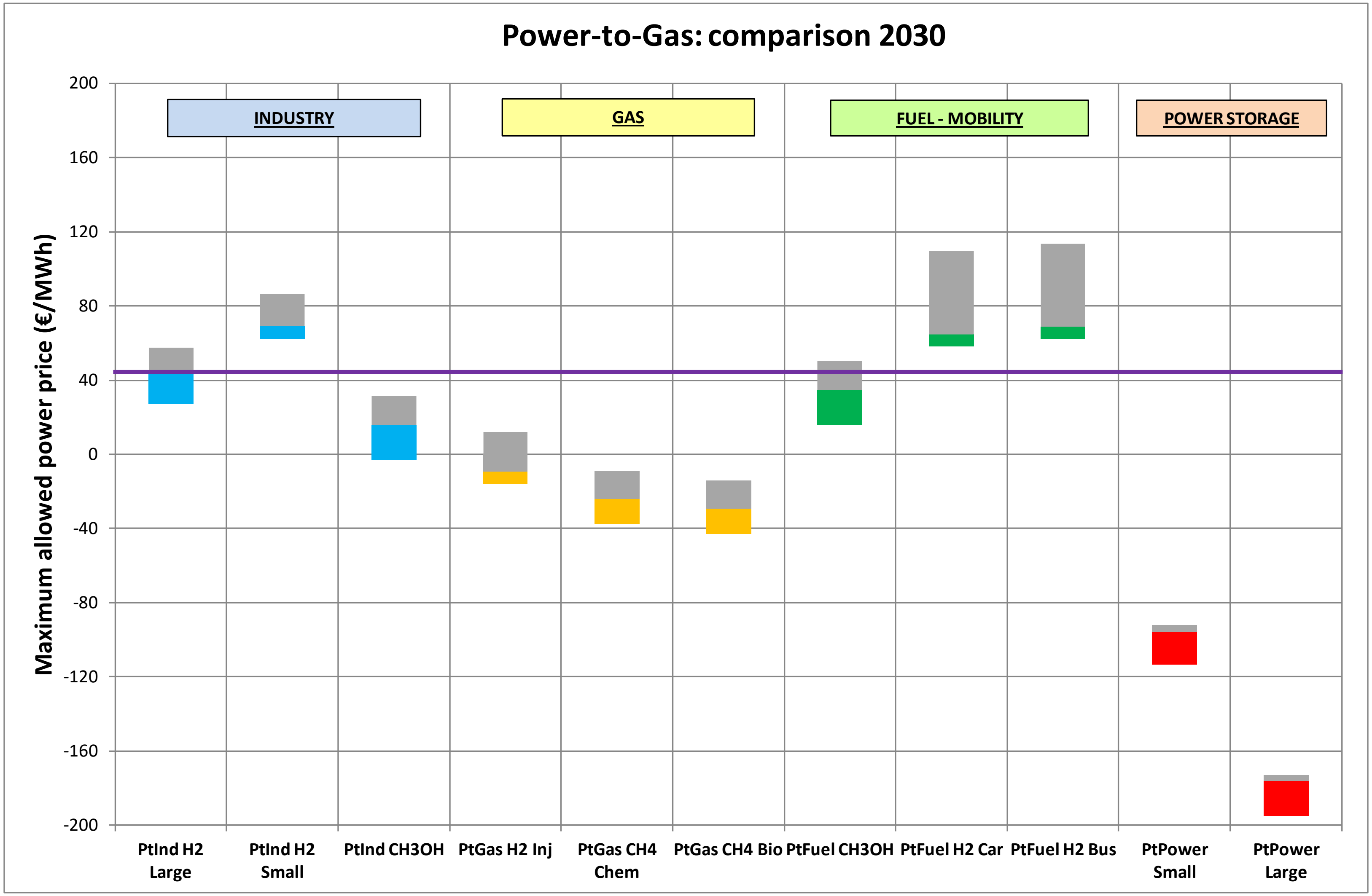
CASES COMPARISON 2015-2030-2050
« HOT » MAP

	2015	2030	2050
Power-to-Industry - small scale			
Power-to-Industry - large scale			
Power-to-Gas - direct Injection			
Power-to-Gas - synthetic natural gas (methanation)			
Power-to-Fuel - methanol			
Power-to-Mobility - HRS for cars			
Power-to-Mobility - HRS for buses			
Power-to-Power - small scale			
NB: This table refers to the analysis of the different business cases in a 'business as-usual' scenario assuming no fundamental policy changes.			

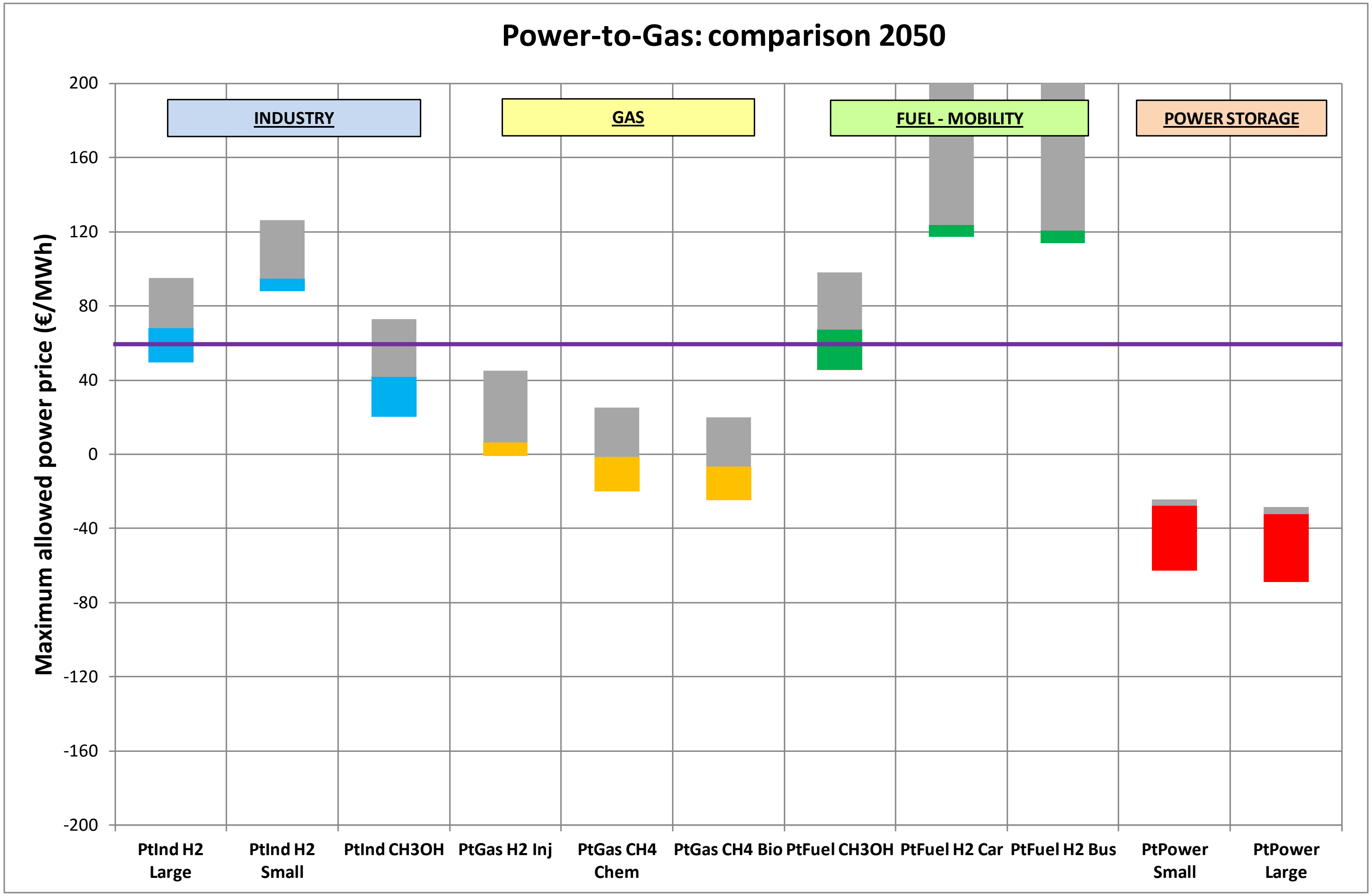
CASES COMPARISON 2015
ALLOWABLE POWER PRICE FOR BREAK-EVEN



CASES COMPARISON 2030
ALLOWABLE POWER PRICE FOR BREAK-EVEN



CASES COMPARISON 2050
ALLOWABLE POWER PRICE FOR BREAK-EVEN



GENERAL COMMENT
ON THE BUSINESS CASES

- The simulations for 2030 and 2050 are based on conservative assumptions and should be interpreted as <u>indicative figures</u> in a ‘business-as-usual’ electricity market.
- **Fundamental changes are expected** in the energy market in the near, medium and long-term mainly driven by environmental and energy policies in all sectors.
- Fundamental changes are expected in the power, gas, industry and transport markets of which the effects on the P2G business cases can’t be predicted
- **If more ambitious (or disruptive) policies are put in place, this will impact positively all P2G business cases** (higher CO_2 price, more renewables, clean transport, green gases...)

AGENDA

1. Introduction
2. P2G business models
3. **Role of the government**
4. P2G roadmap for Flanders
5. P2G Cluster: the right vehicle for the execution
6. Conclusion & discussion

ROLE OF THE GOVERNMENT
TO SUPPORT A P2G MARKET UPTAKE

Why ?

- Environmental and energy policies pursue generally the 3 following objectives:
  - **fight climate change** (through CO_2 reduction measures in the power, gas and transport sectors),
  - **improve energy security of supply** (reduce dependency from countries outside de EU)
  - **improve air quality** (especially in urban areas)
- H_2 and P2G technologies answers positively all 3 objectives
- Strong industry in presence with additional job creation potential in Flanders and export possibilities

ROLE OF THE GOVERNMENT
TO SUPPORT A P2G MARKET UPTAKE

A supportive regulatory framework is needed including:

- Removal of existing barriers mainly due to the absence of specific legislation addressing H_2 and P2G
- Creation of a real status for 'Energy storage'
- Setting up a green hydrogen certification mechanism
- Continued introduction of H_2 and P2G in transport legislation
- Provision of a financially attractive environment (pull and push measures) to stimulate investments in H_2 and P2G in Flanders

Other actions are needed

- Supporting the roadmap execution and the P2G cluster
- Supporting the market preparation phase and 1st market introduction phase adequately
- Showing the example (ex: FCEV fleets for ministries)
- Communication, awareness and education

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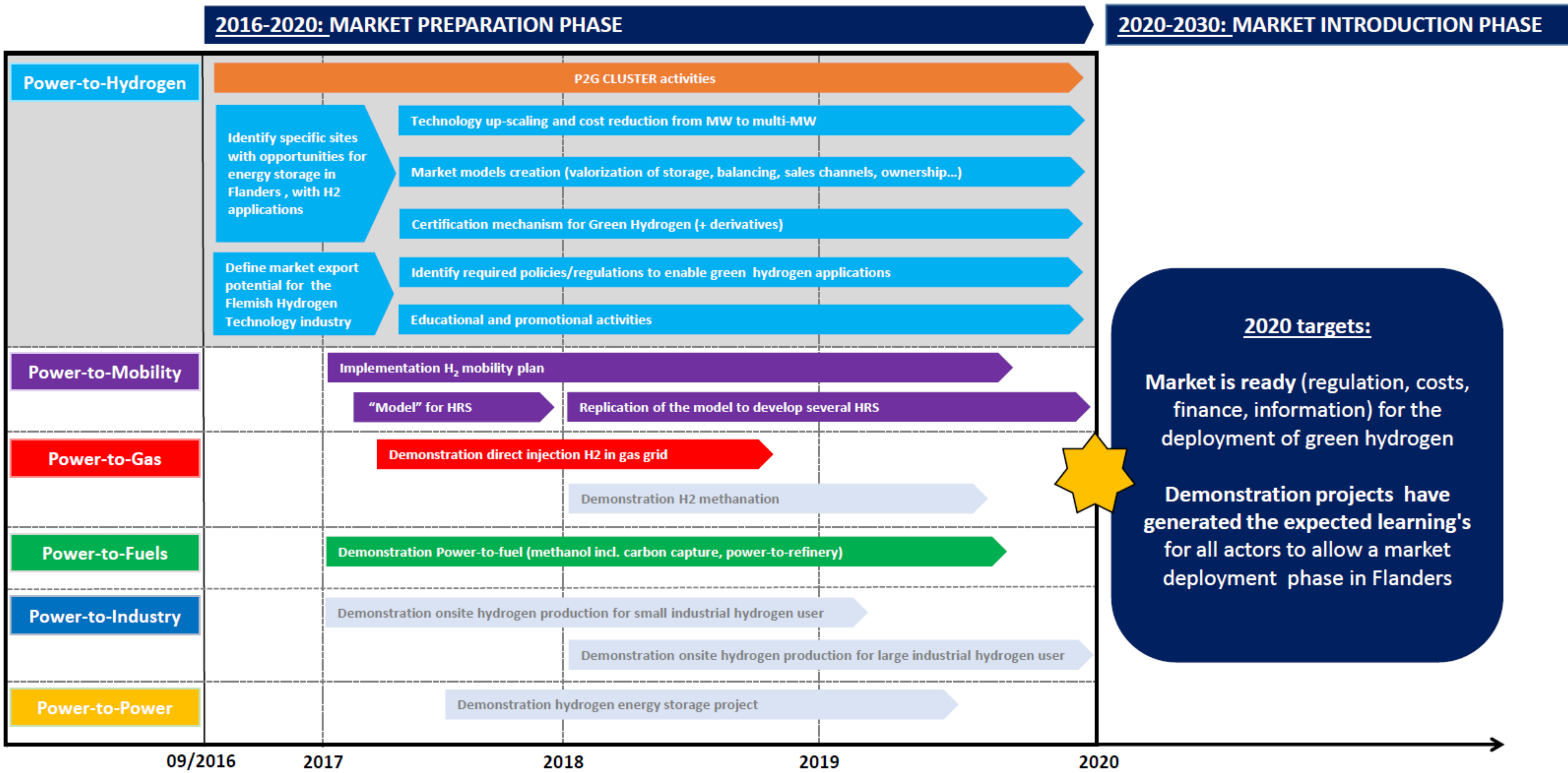
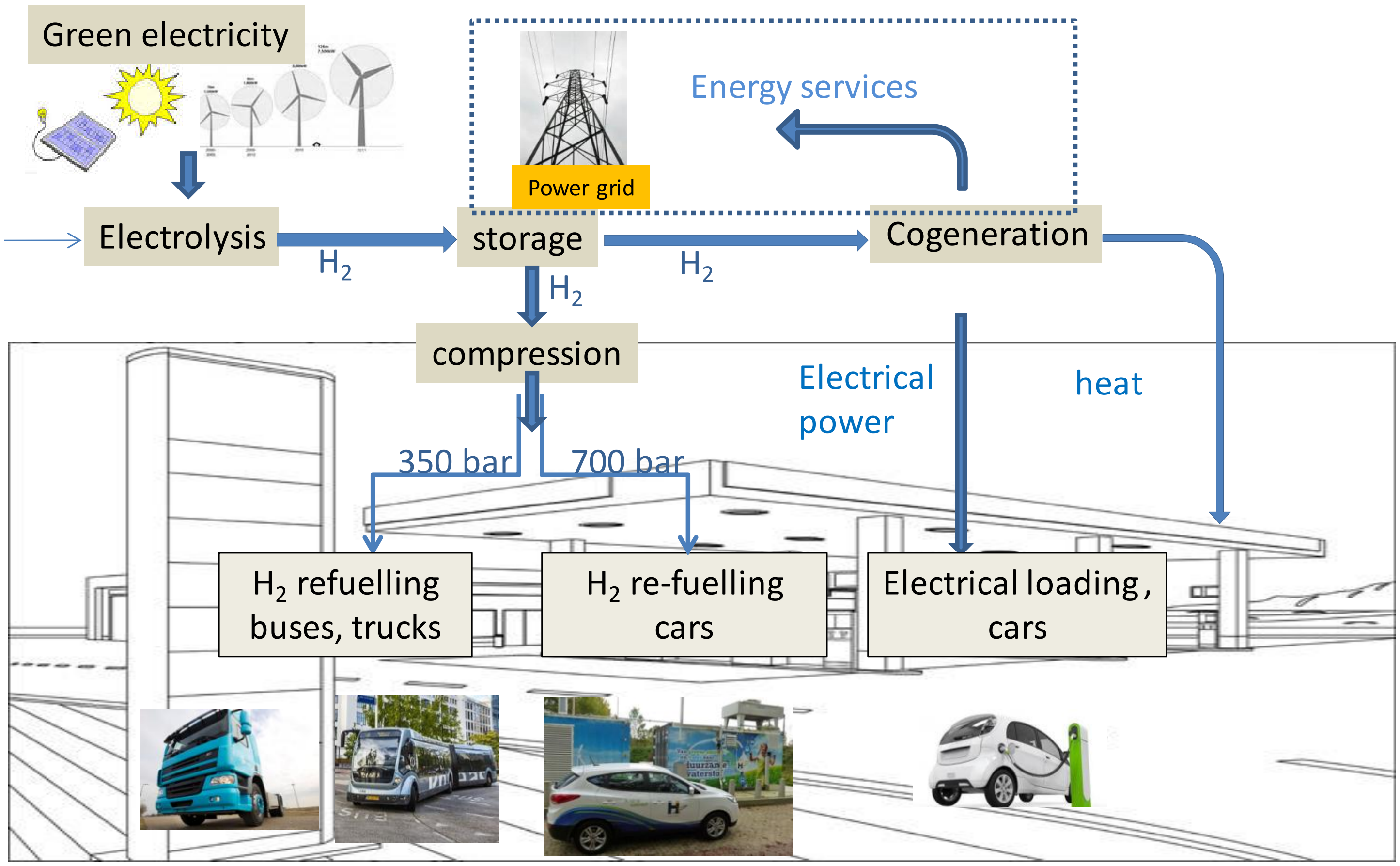
P2G ROADMAP FOR FLANDERS



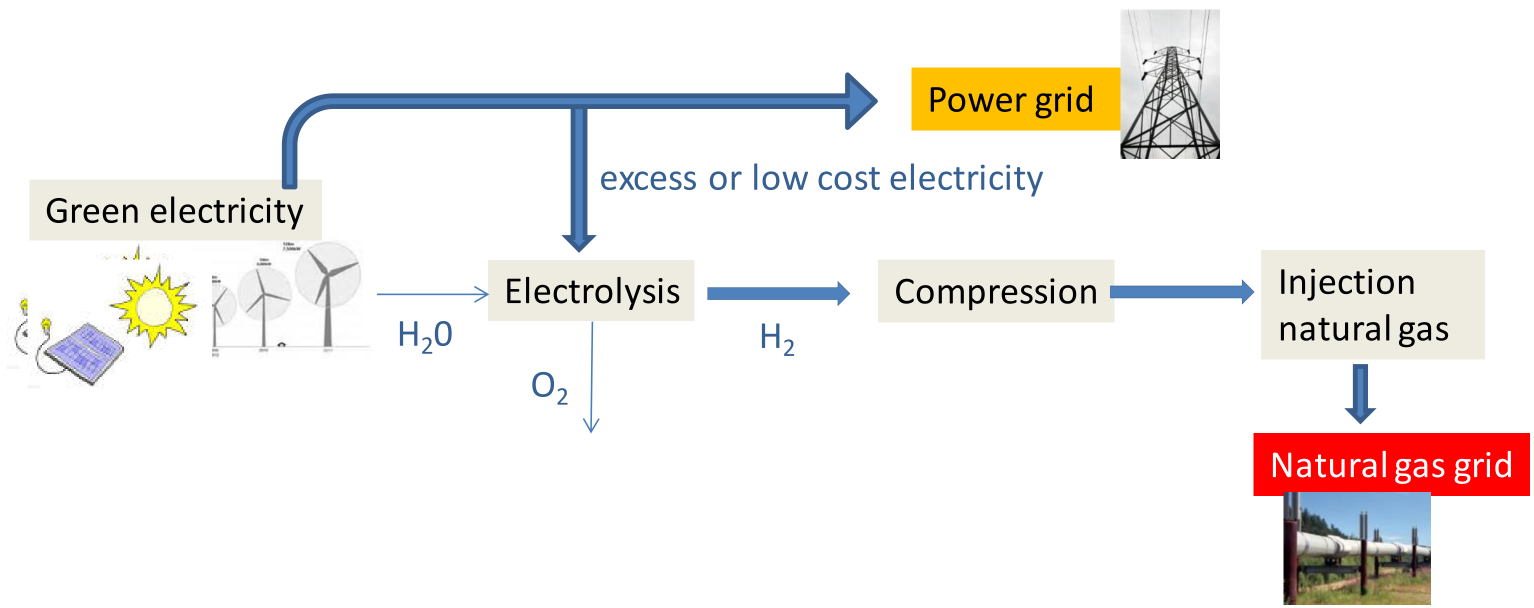
P2G ROADMAP FOR FLANDERS
THE NEED FOR DEMONSTRATION PROJECTS

- To initiate adequately the market preparation phase, **demonstration projects are seen as key** to:
  - Crystallize the energy of the actors on specific and representative projects
  - Increase the general expertise (technical, economical, legal…) of all stakeholders
  - Push for the development of new regulation
  - Raise awareness on these concepts by showing real reference examples

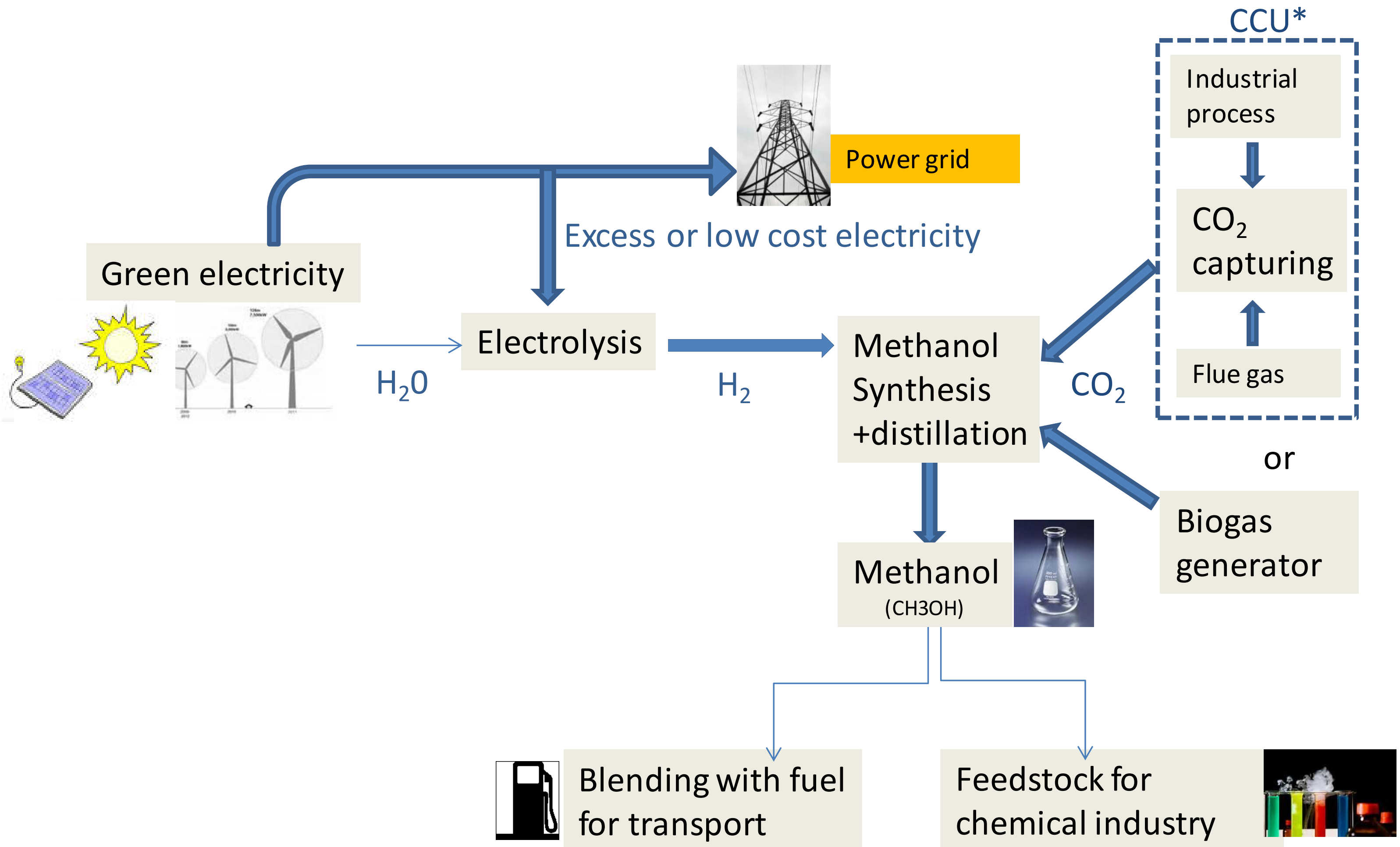
P2G ROADMAP FOR FLANDERS
POWER-TO-MOBILITY DEMONSTRATION PROJECT



P2G ROADMAP FOR FLANDERS
POWER-TO-GAS DEMONSTRATION PROJECT



P2G ROADMAP FOR FLANDERS
POWER-TO-FUEL DEMONSTRATION PROJECT



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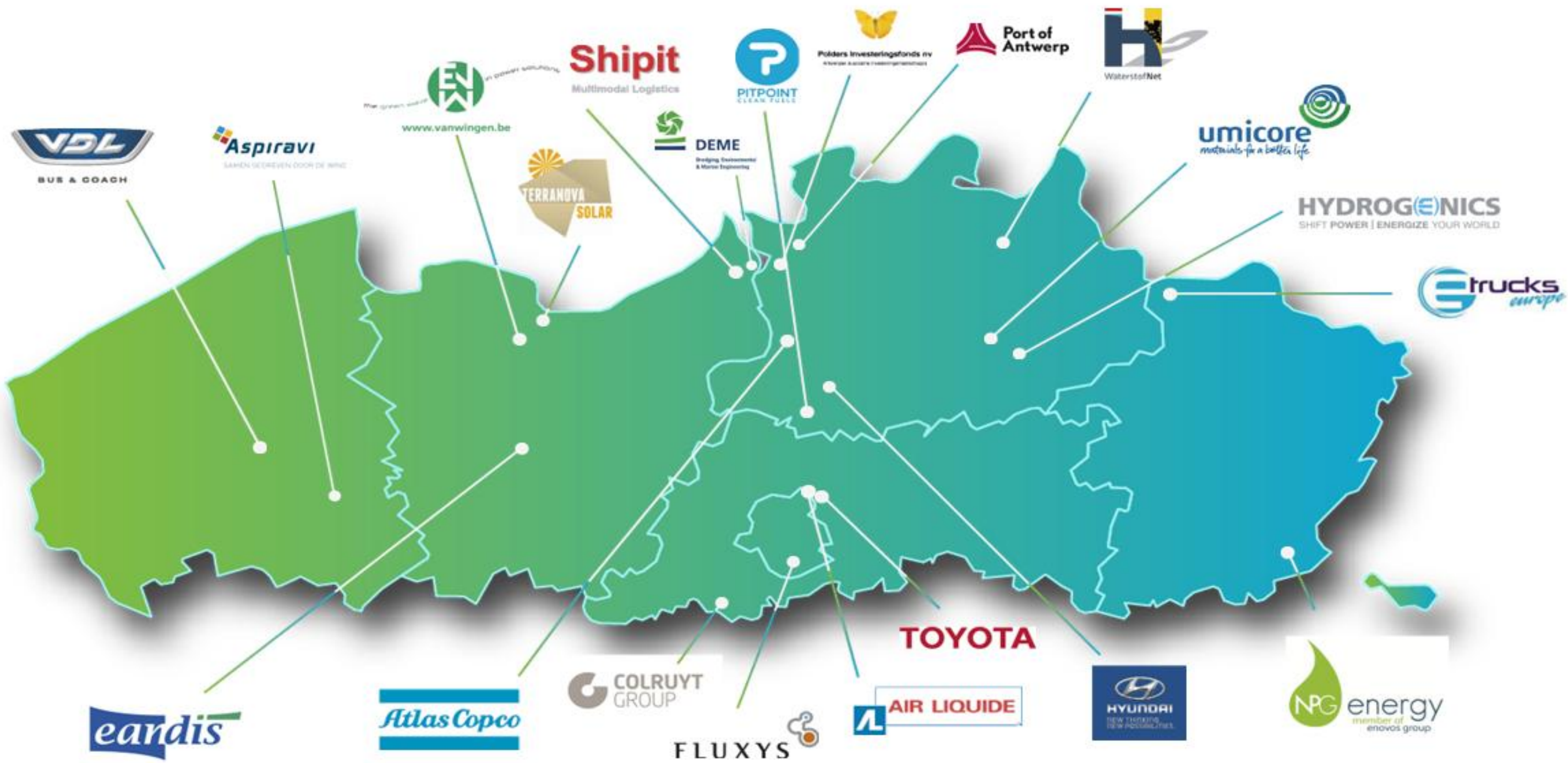
POWER-TO-GAS CLUSTER



Renewable energy producers → Electrolysis → H_2 compression, storage and transport → Grid operators → System integrators → Hydrogen users

Supporting actors (gas measurment, reasearch institutes, consultancy)

POWER-TO-GAS CLUSTER
OBJECTIVES AND ACTIVITIES

- Development of **demonstration projects** around P2G in Flanders
- Elaboration of **creative business models**
- **Collaborative knowledge platform** on P2G concepts
- Acting for favorable regulation for P2G
- **Profiling of Flemish industry** in European P2G market
- Act as a **representative / first contact point** of the P2G industry in Flemish/Belgian energy strategy
- Representation of Flanders in **international P2G events**

Contact person: Isabel François, WaterstofNet,

isabel.francois@waterstofnet.eu

www.power-to-gas.be

P2G CLUSTER
6 WORKING GROUPS

Power to Mobility

H_2 refueling stations/users

Power to Gas

H_2 injection in gas grid

Power to Fuel

$H_2 + CO_2 \rightarrow$ methanol

Smart energy management systems

Grid-balancering

H2 demand

Fuel cell or combustion engine?

Offshore Electrolysis ?

Storage

H_2 for maritime applications

H_2 or methanol in ships

Off-shore wind

Large scale energy storage

Certification

be green

“Gree” H_2, gas, methanol..

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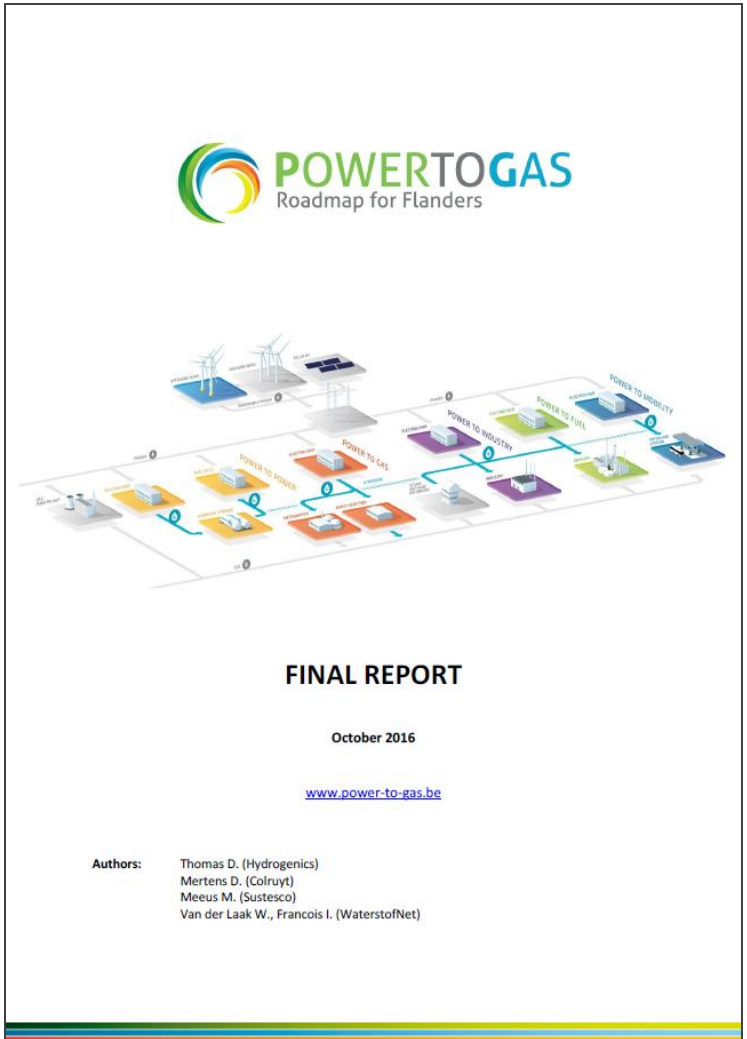
P2G ROADMAP FOR FLANDERS
FINAL REPORT IS AVAILABLE



POWERTOGAS
Roadmap for Flanders

FINAL REPORT

October 2016

www.power-to-gas.be

Authors: Thomas D. (Hydrogenics)
Mertens D. (Colruyt)
Meeus M. (Sustesco)
Van der Laak W., Francois I. (WaterstofNet)

http://www.power-to-gas.be/roadmap-study

- This roadmap was a 1st essential step to:
  - confirm the P2G opportunity
  - identify the challenges and priorities
  - increase awareness on the topic
- The creation of a P2G cluster was the 2nd step to start the implementation of the roadmap with a broad industry involvement
- **Political commitment and support will be essential for future steps !**

QUESTION & ANSWERS

THANK YOU FOR YOUR ATTENTION !

More info: www.power-to-gas.be

Project coordinator
Denis THOMAS
Renewable Hydrogen - EU Regulatory Affairs and Business Development Manager
Hydrogenics Europe NV
Mobile: +32 479 909 129
Email: dthomas@hydrogenics.com