Hydrogen Tool Users Guide

GRANT AGREEMENT 700092

STATUS: DRAFT / FINAL DRAFT / **FINAL**

PUBLIC

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Version	Date	Revised by
01	14/11/19	Alfonso Bernad
02	23/06/20	Alfonso Bernad Jesús Simón

Content

1 OBJECTIVES

This document has been created to help the user of HydrogenTool to understand how it works and how it should be used.

For any queries about the HydrogenTool please, contact with the following mail under the topic [Hydrogen Tool Query]

Contact mail: abernad@hidrogenoaragon.org

REMARK

The Hydrogen Tool is based on macros and Excel. Sometimes, as function of the inputs, the tool will use certain minutes to obtain the results. Please, be patient and do not close the windows until the results screen appears.

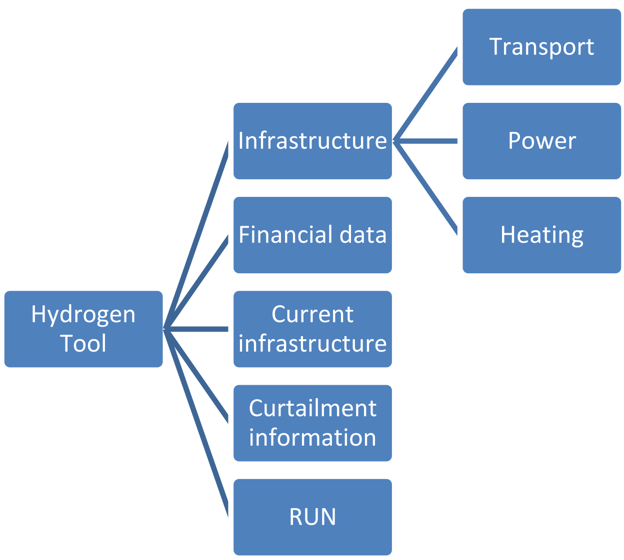
If error messages appears during the execution of the Hydrogen Tool, it is recommended to close the excel sheet without saving changes, and open it again.

2 HOW TO USE THE TOOL?

The first step to use the HydrogenTool is to launch it. The tool has been created in an Excel based environment. To launch the tool, it is needed to open the HydogenTool Excel file and once the use of external macros has been accepted, the user has to click the button "Launch Hydrogen Tool Application".

Launch Hydrogen Tool Application

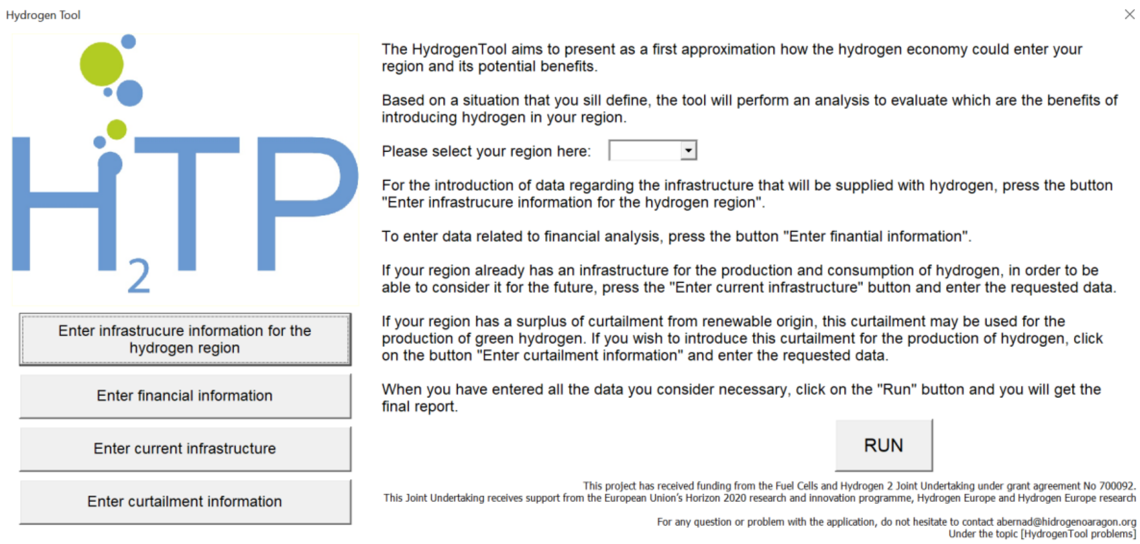
The HydrogenTool has been structured with the following data inputs windows.



The tool operates by means of user defined inputs values that must be entered in the system. It is recommended to review all the screens in order to introduce data. If a value is not introduced by the user, the tool assigns a default value. The following section explains each window by presenting its design and explaining the inputs and/or buttons the window has.

2.1 Hydrogen Tool window

This window is the initial one. It provides a general description of the tool and allows the user to navigate to other windows and to start the computation. It is important in this screen to select also the country to which the region belongs.



Input Name	**Definition**	**Default Value**
Region	The selection box allows the user to enter the country. This value defines from an internal database the value of the minimum wage used for the personnel costs and the duration of the winter used for the estimation of the heating requirements. The list of countries is as follows: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Norway, Switzerland and North Macedonia	Belgium

Button Text	Function
Enter infrastructure information for the hydrogen region	Launch the Infrastructure window
Enter financial information	Launch the Financial data window
Enter curtailment information	Launch the Curtailment information window
Enter current infrastructure	Launch the current infrastructure window
RUN	Launch the computation and presents the results

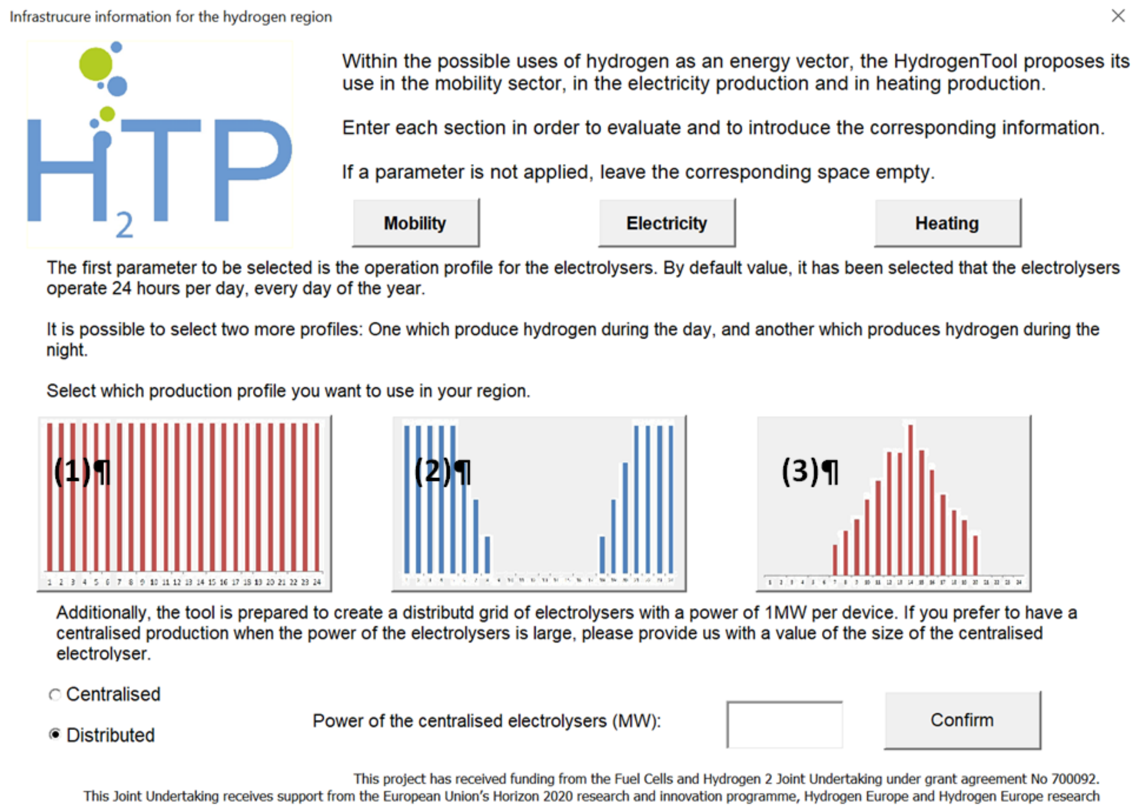
2.2 Infrastructure window

This window aims to obtain the data needed to model hydrogen demand and how to meet it. The user is able to enter three different sections to introduce specific data: Mobility, Electricity and Heating.

Additionally in this section, information about the production is asked. First, the production profile is requested by the tool. Three different profiles are available:

- **(1) Full load production**: a production profile where the hydrogen is produced 24 hours per day by a full load operating electrolyser. This is the default option
- **(2) Night production**: This profile aims to represent night production.
- **(3) Day production**: This profile aims to represent daytime production.

Two production methodologies are available inside the model. Distributed production assumes that the maximum power of each electrolyser is 1 MW per unit, and for each electrolyser, there will be an independent facility with its own storage and compressors. Centralised production allows the user defining the size of the minimum unit of electrolyser. With this value, the total power required will be shared between units of the defined size and the possible rest of power is feed by 1 MW electrolysers. With this option, the amount of production points decreases.



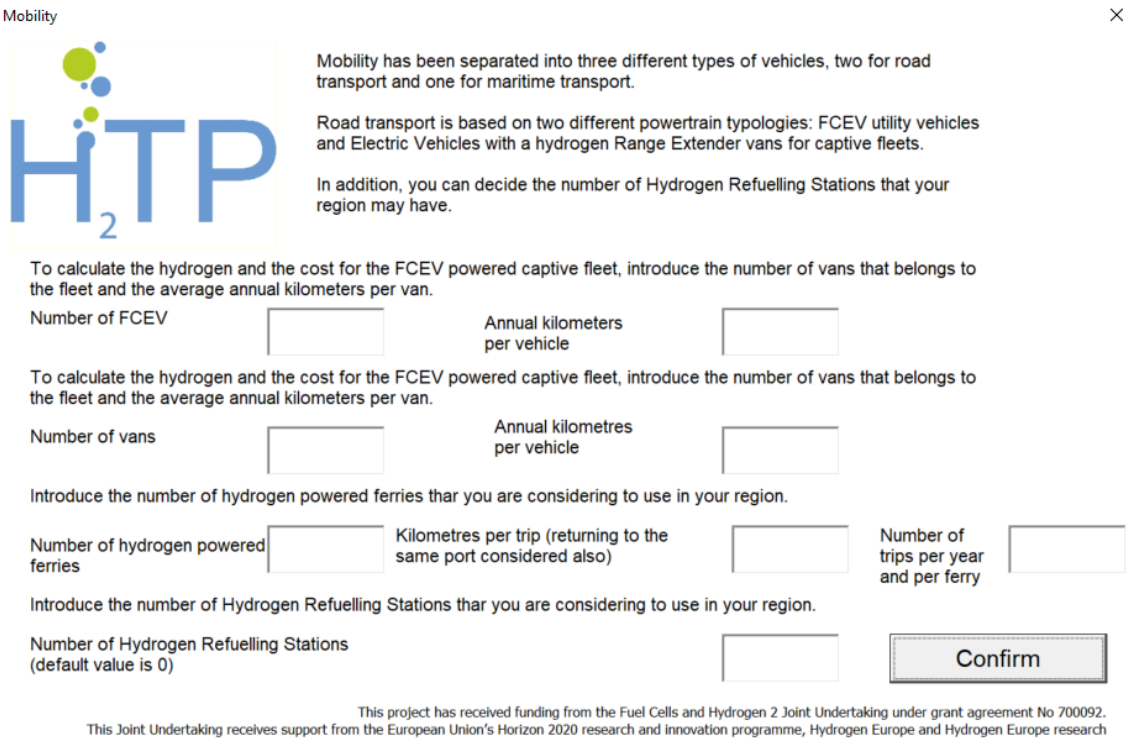
Input Name	**Definition**	**Unit**	**Default Value**
Power of the centralised electrolysers	If the user wants to minimize the amount of electrolysers, it is possible to centralise the production in higher power groups. The user enters the power of the large electrolysers and the model will be calculated according to this data.	MW	1

Button Text	**Function**
Mobility	Launch the Mobility window
Electricity	Launch the Electricity window
Heating	Launch the Heating window
Full load profile	Introduce in the system the profile of hydrogen production related to the full load production profile (1)
Night profile	Introduce in the system the profile of hydrogen production related to the night production (2)
Day profile	Introduce in the system the profile of hydrogen production related to the day production (3)
Confirm	Save the data and return to the previous window

2.2.1 Mobility window

This window focuses its information on the use of hydrogen for transport, using fuel cells. The user can enter here information for:

- **Utility vehicles powered by hydrogen**: These vehicles are Fuel Cell Electric Vehicles, from commercial brands. These vehicles may be used by citizens or by the administration of the region.
- **Electric vehicles with a hydrogen range extender:** Vans which may be used in captive fleets as the postal service fleet.
- **Hydrogen powered ferries**: This tool allows introducing also maritime transport. By introducing the number of ferries, and information about the usual trip and the number of trips, the hydrogen demand is estimated.
- **Hydrogen Refuelling Stations**: This field represent the refuelling points the region is planning to have for hydrogen **road** vehicles. The maritime sector will use specific infrastructure that the model has linked with the number of ferries, due to it, the hydrogen refuelling station for ferries should not be introduced in this field.



Mobility

Mobility has been separated into three different types of vehicles, two for road transport and one for maritime transport.

Road transport is based on two different powertrain typologies: FCEV utility vehicles and Electric Vehicles with a hydrogen Range Extender vans for captive fleets.

In addition, you can decide the number of Hydrogen Refuelling Stations that your region may have.

To calculate the hydrogen and the cost for the FCEV powered captive fleet, introduce the number of vans that belongs to the fleet and the average annual kilometers per van.

Number of FCEV | Annual kilometers per vehicle

To calculate the hydrogen and the cost for the FCEV powered captive fleet, introduce the number of vans that belongs to the fleet and the average annual kilometers per van.

Number of vans | Annual kilometres per vehicle

Introduce the number of hydrogen powered ferries thar you are considering to use in your region.

Number of hydrogen powered ferries | Kilometres per trip (returning to the same port considered also) | Number of trips per year and per ferry

Introduce the number of Hydrogen Refuelling Stations thar you are considering to use in your region.

Number of Hydrogen Refuelling Stations (default value is 0)

Confirm

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This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe research

Input Name	Definition	Unit	Default Value
Number of FCEV	The user defines the number of Fuel Cell Electric Vehicles. The vehicles used in this work are utility vehicles.	Unit	0
Annual kilometres	The user defines the annual kilometres that a utility vehicle is going to perform.	Km	0
Number of vans	The user defines the number of electric vehicles (vans) with a hydrogen range extender that are going to be used in the region.	Unit	0
Annual kilometres	The user defines the annual kilometres that a range extended vehicle is going to perform.	km	0
Number of ferries	The user defines the number of hydrogen powered ferries that the region is going to have.	Unit	0
Kilometres per trip	The user defines the distance in kilometres that the ferry covers in each trip.	km	0
Number of trips per year and per ferry	Number of trips that each ferry covers per year.	Unit	0
Number of HRS	The user defines the number of Hydrogen Refuelling Stations that the region is going to have.	Unit	0[1]

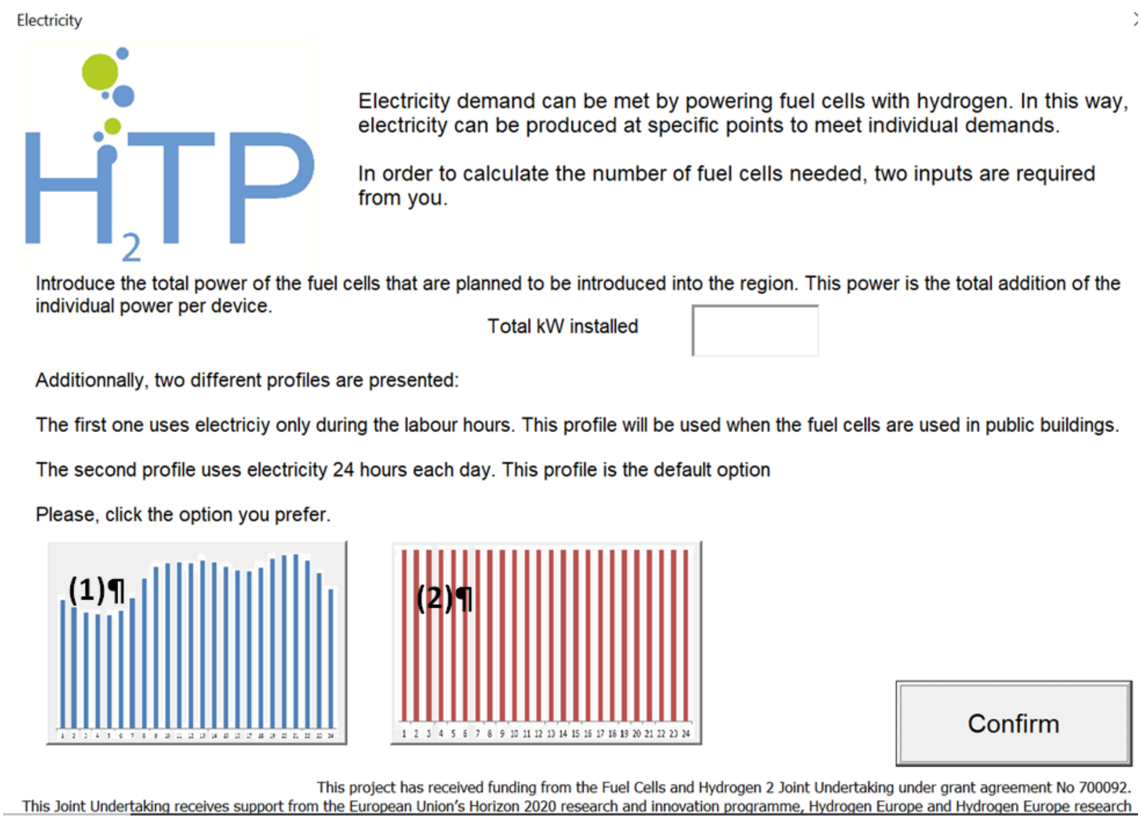
Button Text	Function
Confirm	Save the data and return to the previous window

2.2.2 Electricity window

Another use of hydrogen is the electricity production by fuel cells. The user has to introduce in the tool the total power of fuel cells that are going to be installed in the region for electricity production purposes and also, the electricity demand profile. The options for the profile are:

- **(1) Common electricity distribution**: This profile has been created according the electricity demand of Spain, based on information obtained from E-SIOS [1] and considering that the fuel cell operates in fractions of its nominal power.
- **(2) Full time full load electricity production**: This profile considers a full load use of the fuel cell 24 hours per day, the 365 days of the year.

[1] If any road vehicle has been defined previously, the tool introduces automatically at least one hydrogen refuelling station.

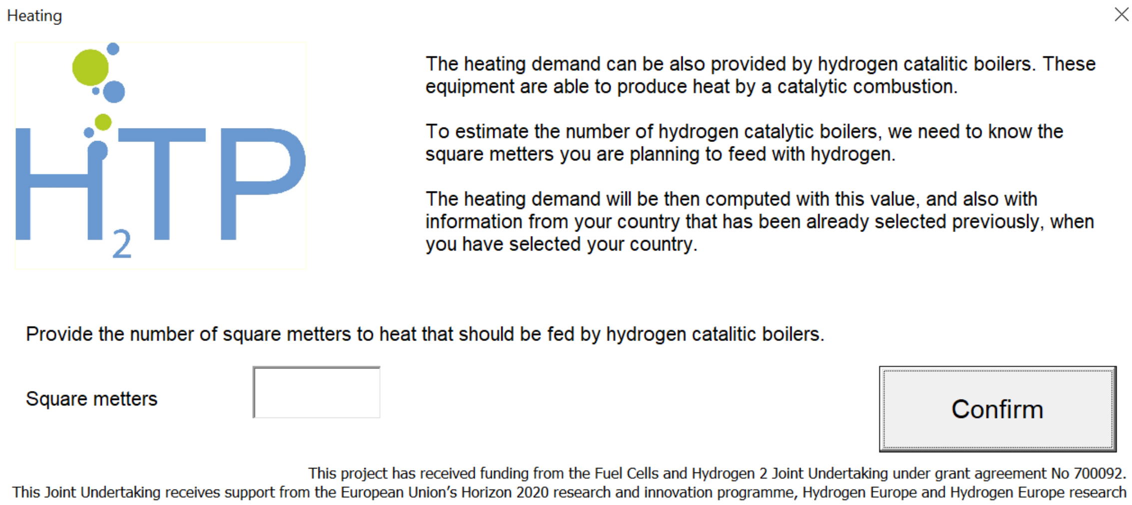


Input Name	Definition	Unit	Default Value
Total power of fuel cells	The user defines the total power of fuel cells that are going to be feed by hydrogen in the region. These fuel cells will be used for electricity production purposes. The hydrogen demand of these fuel cells will be calculate with this data.	kW	0

Button Text	Function
Common electricity distribution scheme	Introduce in the system the profile of electricity demand feed by hydrogen following the **Common electricity distribution scheme**
Full time full load electricity production	Introduce in the system the profile of electricity demand feed by hydrogen following the **Full time full load electricity production**.
Confirm	Save the data and return to the previous window

2.2.3 Heating window

Hydrogen has also the option of feeding hydrogen catalytic boilers to produce heat. As long as the user has previously defined the country where the region belongs to, the model has inside a database that allows estimating the heating demand per square meter in the region. The model requires the number of square meters that will be heated by hydrogen, in order to estimate the number of devices needed and the hydrogen demand.

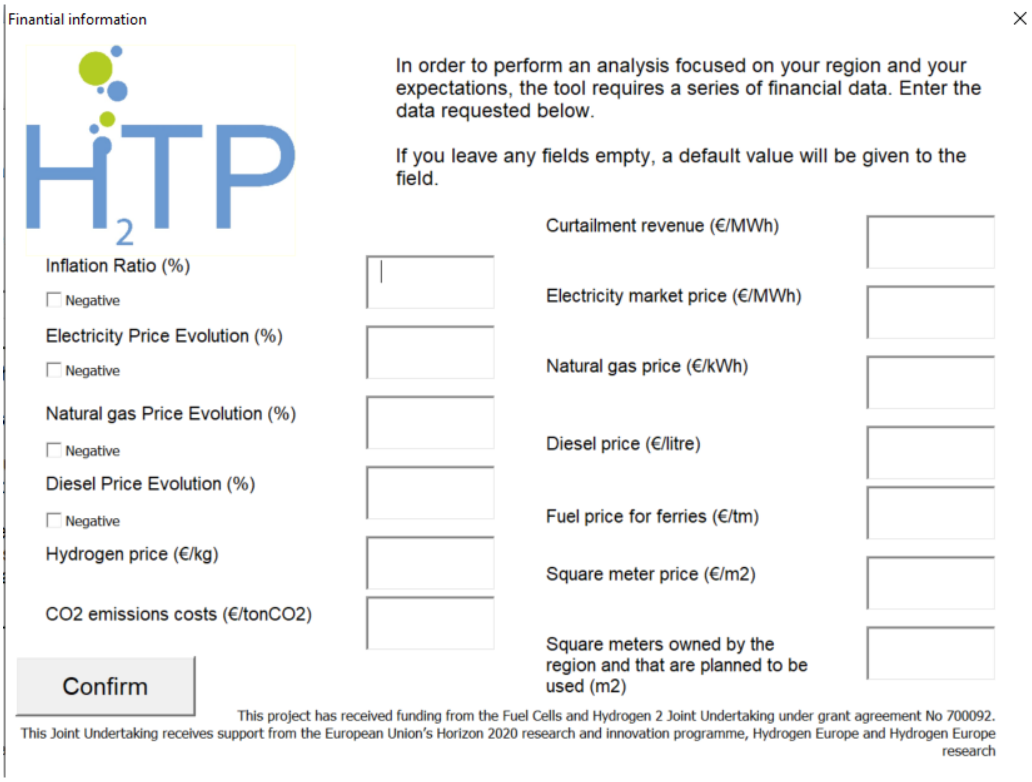


Input Name	Definition	Unit	Default Value
Square meters	If the user decide to use hydrogen for heating applications, thanks to hydrogen catalytic boilers, the amount of square meters that are going to be heated are required. This value, and other information linked to the region are inputs for the computation of hydrogen catalytic boilers for the region and the amount of hydrogen required.	m^2	0

Button Text	Function
Confirm	Save the data and return to the previous window

2.3 Financial data window

The Financial data window has as main objective to collect data from the region, in order to estimate the costs and saving thanks to hydrogen in the region. Inflation, and the evolution of the electricity, natural gas and fuels price has to be introduced in % (considering annual evolution) and the prices has to be introduced in the unit presented by the tool. Moreover, other parameters as the CO_2 emissions costs have to be defined.



Input Name	Definition	Unit	Default Value
Inflation rate	Sustained increase in the general price level of goods and services in an economy over a period of time. Information can be found in the Eurostat database. [2] Link: https://ec.europa.eu/eurostat/databrowser/view/tec00118/default/table?lang=en **NOTE:** If the other percentages are left empties, the value for the electricity price evolution, the diesel price evolution and the natural gas evolution will be fixed equal to the inflation rate defined by the user. **NOTE**: If the user wants to define a negative value of the inflation rate, the check box next to "Negative" must be marked.	%	0
Electricity price evolution	Sustained evolution in the electricity price over a period of time, if different than the inflation rate. **NOTE**: If the user wants to define a negative value of the evolution, the negative check box must be marked.	%	0
Natural gas price evolution	Sustained evolution in the natural gas price over a period of time, if different than the inflation rate. **NOTE**: If the user wants to define a negative value of the evolution, the negative check box must be marked.	%	0

Input Name	Definition	Unit	Default Value
Diesel price evolution	Sustained evolution in the diesel price over a period of time, if different than the inflation rate. **NOTE**: If the user wants to define a negative value of the evolution, the negative check box must be marked.	%	0
Hydrogen price	Introduced the price that the user wants to use to sell hydrogen.	€/kg	0
CO_2 emissions costs	This value is used to calculate the cost of the CO_2 emissions covered by the model. Information about this value is available in commodities indexes. Example given in Market Insider [3] Link: https://markets.businessinsider.com/commodities/co2-european-emission-allowances	€/tonCO_2	0
Curtailment revenue	Revenue obtained thanks to the use of electricity provided by curtailment.	€/MWh	0
Electricity market price	Electricity price. Information about this value is available in the Eurostat database. Please, check the units properly. [4] Link: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_205&lang=en	€/MWh	0
Natural gas price	Natural gas price. Information about this value is available in the Eurostat database. Please, check the units properly. [5] Link: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_203&lang=en	€/kWh	0
Diesel price	Diesel price. Information about this value is available in databases. Please, check the units properly. Information available in GlobalPetrolPrices [6] Link: https://www.globalpetrolprices.com/gasoline_prices/	€/l	0
Fuel price for ferries	Maritime fuel price. The tool has been created to use Maritime Gasoil (MGO). Information about this value is available in databases. Please, check the units properly:[7] Link: https://shipandbunker.com/prices/emea	€/ton	
Square meter price	Square meter price.	€/m^2	0

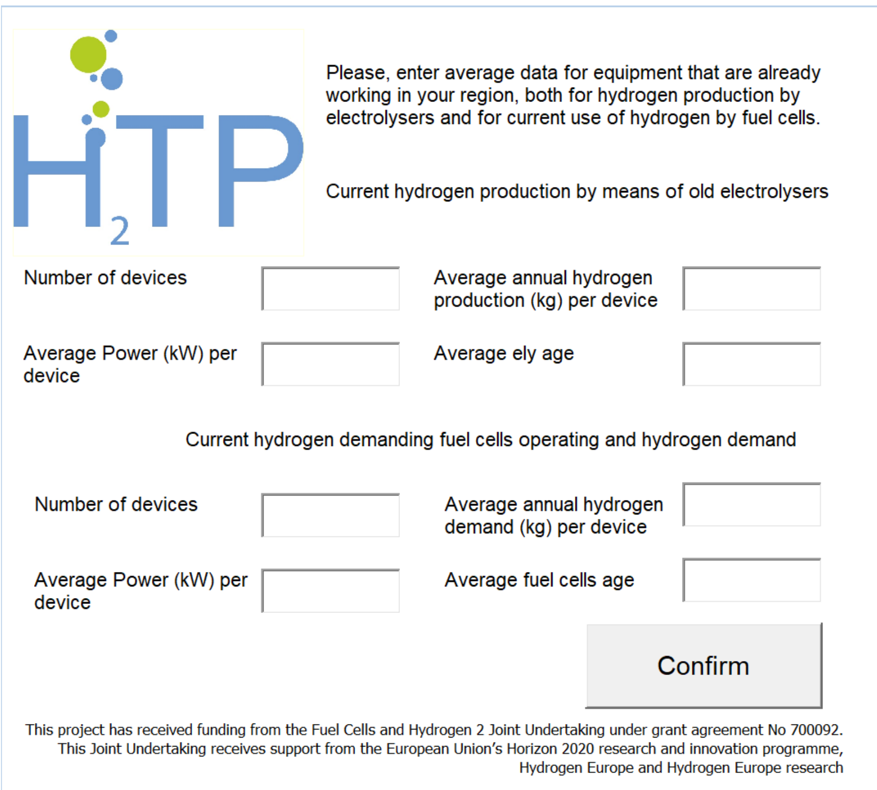
Input Name	Definition	Unit	Default Value
Square meters owned by the region and that are planned to be used	If the region has available a defined amount of square meters that are going to be used for the hydrogen infrastructure, the introduction of this value will assume that these meters are already purchased and the total costs of land use are reduced accordingly with this value.	m^2	

Button Text	Function
Confirm	Save the data and return to the previous window

2.4 Current infrastructure window

This window aims to collect information of an existing hydrogen infrastructure in the region. In order to do so, information about exiting electrolysers and old fuel cells is requested by the tool.

The existing equipments are going to operate under the same regime, what means that the model estimates that the annual average demand or production will be maintained in the next years. The model is prepared also to introduce the possible replacements needed during the years of study.

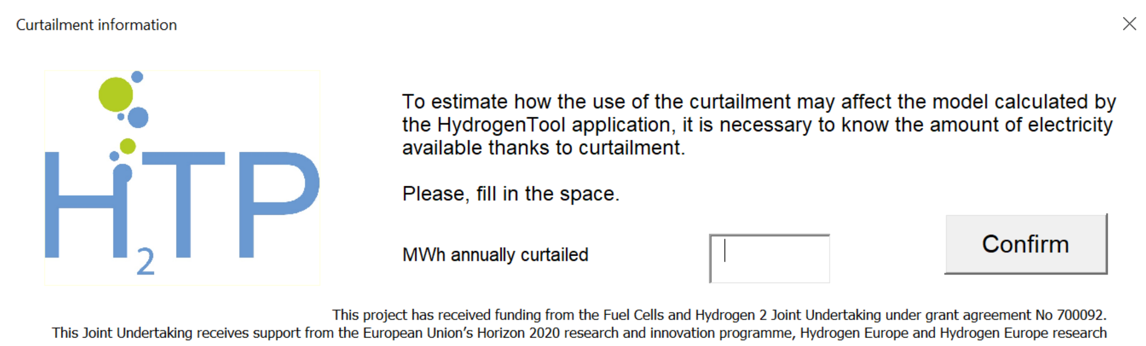


Input Name	Definition	Unit	Default Value
Number of devices	Number of existing devices operating in the region.	Number	0
Average annual hydrogen production	Annual production of hydrogen by the existing devices operating in the region per device. The total production will be the value of this value multiplied by the number of devices.	Kg	0
Average power per device	Average power per device of the existing devices operating in the region.	kW	0
Average Ely age	Average age of the devices. Information needed for the replacement.	years	0
Number of devices	Number of existing devices operating in the region.	Number	0
Average annual hydrogen demand	Demand needed of hydrogen by the existing devices operating in the region.	Kg	0
Average power per device	Average power per device of the existing devices operating in the region.	kW	0
Average FC age	Average age of the devices. Information needed for the replacement.	years	0

Button Text	Function
Confirm	Save the data and return to the previous window

2.5 Curtailment information

The user can benefit from curtailment electricity, and thanks to it, reduce the operation costs of the model. The information required is the MWh that the region may use from curtailment.

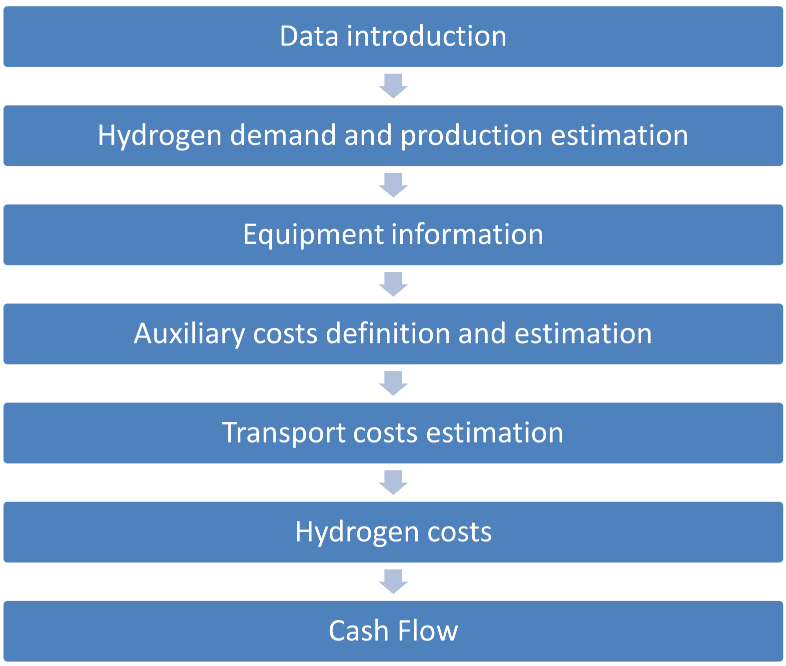


Input Name	**Definition**	**Unit**	**Default Value**
MWh annually curtailed	Amount of electricity that the region is going to use from curtailment	MWh	0

Button Text	**Function**
Confirm	Save the data and return to the previous window

3 COMPUTATION STEPS

The model follows the flow diagram presented below to obtain the results.



3.1 Data introduction

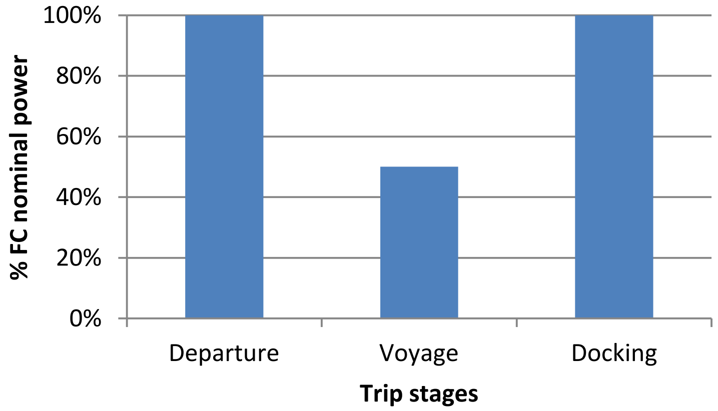
The user needs to introduce the data into the tool. Remember that if a field is left empty it will take the default value.

3.2 Hydrogen demand and production estimation

The next step, once the data has been introduced in the tool, is the estimation of the demand and production of hydrogen. The model firstly estimates the amount of hydrogen demand that the user has introduced with the input data.

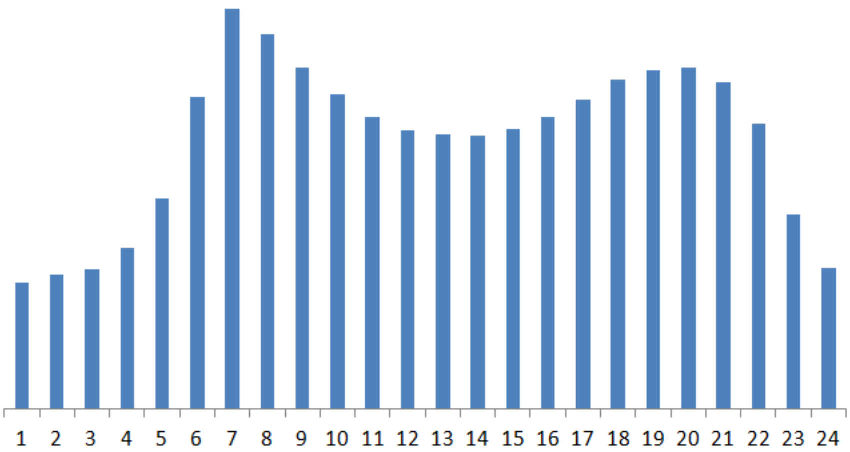
The road transport estimates the amount of hydrogen based on the amount of kilometres that the vehicles are going to cover per year. The maritime transport estimates the hydrogen demand needed based on the following assumptions:

- The fuel cell that powers the ferry operates at its nominal power at the departure and docking stage. The fuel cell operates for the rest of the trip at a 50 % of its nominal power.
- The departure and the docking stage are estimated as the 20 % of the total trip distance, being the 80 % assumed to correspond to the 50 % of the load.
- The ferries modelled in the tool belong to the Ro-Ro typology and the fuel cell that moves them has been modelled with 700 kW of nominal power.
- An onboard storage of hydrogen (1000 kg, 250 bar) has been introduced in each ferry. In the port, there is a storage unit (500 kg, 250 bar) to feed each ferry introduced by the user.
- Ferries velocity has been set as 16 knots.



The hydrogen demand for electricity considers the profile introduced by the user and calculates the hydrogen needed to feed the power previously defined with the profile selected.

To estimate the hydrogen demand for heating purposes, the hydrogen catalytic boilers are calculated with the inputs and the database information. Moreover, there are two different winter profiles: One winter with only 4 months of heating demand, and another with 6 months of heating demand. The daily profile in both cases is the following one, based on information raised from [8]:



Once the hydrogen demand has been estimated, the model determines the number of electrolysers that are needed. The model has been programmed to always be able to produce enough hydrogen demand to supply the demand and in order to do it, the model increase the number of 1 MW units while the condition is not overcome.

Due to the fact that the hydrogen production is not variable in the 1 MW units there will always be an extra amount of hydrogen produced. With this hydrogen, the region has an extra amount of hydrogen to commercialise.

NOTE: The model is designed assuming that **ALL** the hydrogen produced will be sold, with the hydrogen being sold firstly to meet the user-defined demand. The surplus of hydrogen is assumed to be sold at the same price to third parties as an example, industries.

3.3 Equipment costs

The model estimates, with the investment cost and the maintenance and operational costs, the annual amount of money needed. All the investments are made in year 0. Replacements are calculated considering the expected useful life of the different hydrogen demand equipment.

Additionally, the model estimates the amount of electricity needed for the hydrogen production. The model has been defined to firstly use the curtailment electricity available in the region and only purchase electricity from the power grid when there is not enough electricity available from the curtailment. The costs are calculated thanks to the introduced user data.

The hydrogen consumption has been estimated and in order to estimate the annual savings thanks to the use of hydrogen, the annual savings of natural gas, electricity from the grid, diesel for vehicles and fuel are estimated. With this information and with the costs introduced by the user, the model defines the monetary annual savings that the hydrogen infrastructure has compared with a normal situation with current technologies.

At the same time, and thanks to the CO_2 price defined by the user, the tool estimates the cost of the CO_2 emissions of the model without hydrogen, and these costs are also considered as savings in the model.

3.4 Auxiliary costs definition and estimation

The infrastructure has been estimated accordingly with the demand. Firstly, the model estimates the number of consumption points and with this information, the amount of hydrogen storage points.

The storage of hydrogen will be done at 250 bar of pressure in all the consumption points with the exception of the hydrogen refuelling station. The hydrogen refuelling station has storage of 450 bar (to refill vehicles with 350 bar of operative pressure as the range extender) and another of 900 bar for the utility vehicles (if the user has introduced this vehicles). The hydrogen storage in ferries is done in land.

The hydrogen storage in the production points has been size with a capacity enough for a month of production. The size of each storage unit has been defined as:

- Monthly storage for the production site storage (250 bar)
- 50kg for the storage of hydrogen in HRS(450 bar and 900 bar to refill both cars and vans) and next to end users for heating and electricity (250 bar)
- 500 kg for the storage of hydrogen in ports for the ferries (250 bar)

Once the amount of equipments has been defined, the tool estimates the number of trips that the distribution vehicles have to address to fill the storages with enough hydrogen to cover the annual hydrogen demand per point.

For the compression infrastructure needed, the model considers two different compressors [9]. The number of low pressure compressor has been defined in order to compress the annual hydrogen production in the production points and also the hydrogen needed to recompress in the hydrogen refuelling stations due to the defined transport conditions. The number of high pressure compressors has been defined in order to be able to compress the hydrogen demand for the commercial vehicles.

Compressor pressure	**10 to 450 bar**	**450 to 900 bar**
Maximum compression per hour (kg)	10,788	10,788
Compression energy (kWh/kg)	5,56	2,22

The number of hydrogen dispenser has been adjusted according to the number of hydrogen refuelling stations, providing two nozzles for each station, and with the number of ferries that the user has introduced.

With all this information, the model estimates the investment costs of compressors, and storages, and also the operational costs for the compression.

The model also estimates the land use of the infrastructure and estimates the square meters that the model needs. With this input, and the square meter price, the model calculates the cost of the land needed. If the user has defined square meters owned by the region, these square meters are eliminated for the costs calculation.

Finally, the model estimates also the amount of employees needed for this infrastructure, setting one employee per hydrogen refuelling station and one for the ferries infrastructure. With this number, and the annual minimum wage per country that the database has, the personnel costs are also estimated.

3.5 Transport costs estimation

The model has defined a road transport for hydrogen, as the one used under the frame of the BigHit project (Grant Agreement 700092). Due to it, a maximum amount of 500 kg per vehicle can be transported per day.

The maximum distance that a transport is going to cover is an area of 1960 km^2 (assuming that the vehicle will cover a circle of 50 km), and the amount of trips performed by the total hydrogen transport fleet is calculated to fit with the amount of storage needed.

With the amount of trips, and the average kilometres per trip, the model estimates the transports costs.

3.6 Hydrogen costs

The user has to introduce a price for hydrogen, in order to estimate if the model is profitable or not. Nevertheless, the model estimate the hydrogen levelized cost as it follows:

$$LCoH_2 = \frac{(CAPEX + OPEX)}{kg\ H_2\ produced}$$

Under the CAPEX definition the prices included are:

- Electrolysers' price and replacement of stacks for the study length (20 years)
- Land use for electrolysis power plant
- Storage for the production plant
- Compression stages for the production plant
- Transport vehicles

Under the OPEX definition it is included:

- Price for electricity over the study length
- Benefits from the curtailment use over the study length
- Compression cost
- Distribution costs

The total amount of hydrogen produced is considered for the cost definition, even if not all the hydrogen is going to be used by the model defined by the user. As it has been explained, this hydrogen surplus may be traded and be an alternative income source and due to it, the surplus of hydrogen has been considered.

3.7 Cash Flow

Finally, the model estimates the cash flow for the **global** model considering the costs and present the results file based on the following scenarios:

NEEDED HYDROGEN LCoH2 +MONETARY SAVINGS
Hydrogen traded corresponds to the hydrogen consumption of the region. The price is estimated with the LCoH2 price calculation. The cost of fossil fuels that is saved thanks to the use of hydrogen is also considered in this scenario as a benefit.

NEEDED HYDROGEN LCoH2 +MONETARY AND CO2 SAVINGS
Hydrogen traded corresponds to the hydrogen consumption of the region. The cost of fossil fuels that is saved thanks to the use of hydrogen is also considered in this scenario as a benefit. The CO2 emissions price is also considered in this scenario.

ALL HYDROGEN COMMERCIALISED AT LCoH2 PRICE+MONETARY AND CO2 SAVINGS
All hydrogen produced is traded. The price is the LCoH2 estimated by the tool. CO2 price and fossil fuel savings are also considered.

ALL HYDROGEN TRADED AT USER DEFINED PRICE +MONETARY AND CO2 SAVINGS
Hydrogen traded corresponds to the total possible production of the region. The price is the one defined by the user. CO2 price and fossil fuel savings are also considered

4 RESULTS INFORMATION

Once all the data has been introduced in the model, the tool calculates the results and provides a summary in the excel file and in a separated pdf report that can be saved by the user.

If a sensitivity analysis is desired, in order to study how the solution of the model evolves as function of different parameters, the user only has to follow the next procedure:

- Close the pdf report.
- Click in the HydrogenTool_Introduction sheet and
- Click in Launch Hydrogen Tool.

All the values will be maintained and the user only needs to change those who will be varied for the sensitivity analysis.

The results window presents the following information to the user.

H2TP

This tool has been created to allow a first approach to the techno-economic viability of hydrogen valleys projects. However, the results are preliminary and each case will require a detailed study at both the engineering and investment levels.

The tool makes a series of assumptions that may differ from the final case of application. These assumptions are found in the manual and can be consulted with the designers by email.

The creators of the tool are not responsible for the use made of it, nor for the results obtained through it. It is recommended to always consult with agents in the hydrogen sector when looking for more detailed information.

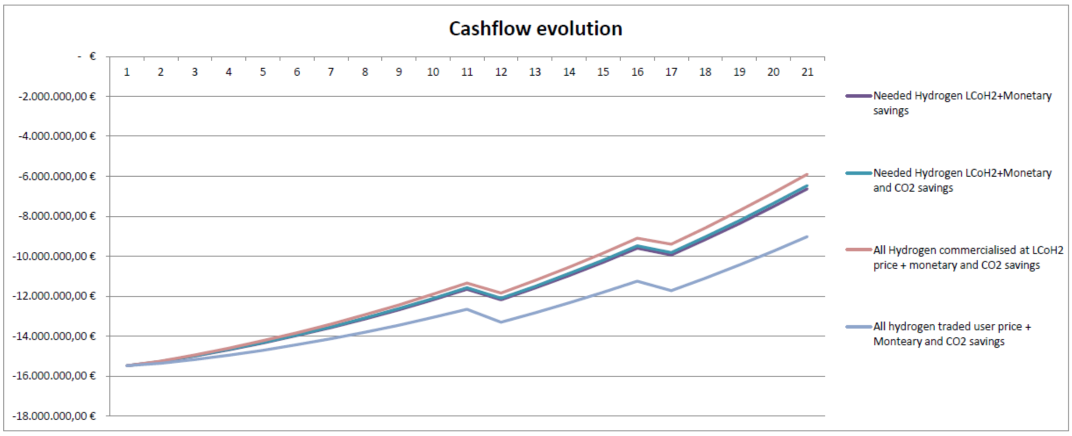
GENERAL OVERVIEW

Demand		Unit
Power of Electrolysers	1000	kW
Power of Fuel Cells for electricity	160	kW
Number of Hydrogen Boilers	0	number
Utilitary vehicles	10	number
Range Extended Vehicles	10	number
Ferries	2	number

Financial data		Unit
Inflation rate	3%	
Electricity Price	114	€/MWh
Natural Gas Price	0	€/kWh
Curtailment Revenue	0	€/MWh
Gasoline price	1,741	€/l
Maritime fuel price	300	€/ton
Square meter price	118	€/m2

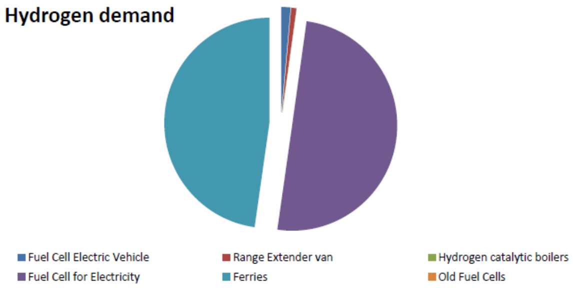
	Electrolysers	Unit	Fuel Cells	Unit
Number of Old Devices	0	Number	0	Number
Production/Consumption	0	kg H2	0	kg H2

In this first section the tool present the data introduced by the user and at the same time, the electrolysis installed capacity that the tool has estimated to fulfil the hydrogen requirements.



This graph present, based on the scenarios presented in section 3.7, how the cash flow of the global model evolves.

NOTE: The cash flow has been estimated considering the overall costs of the model: CAPEX and OPEX for vehicles, particular storages and all the costs that the model has.



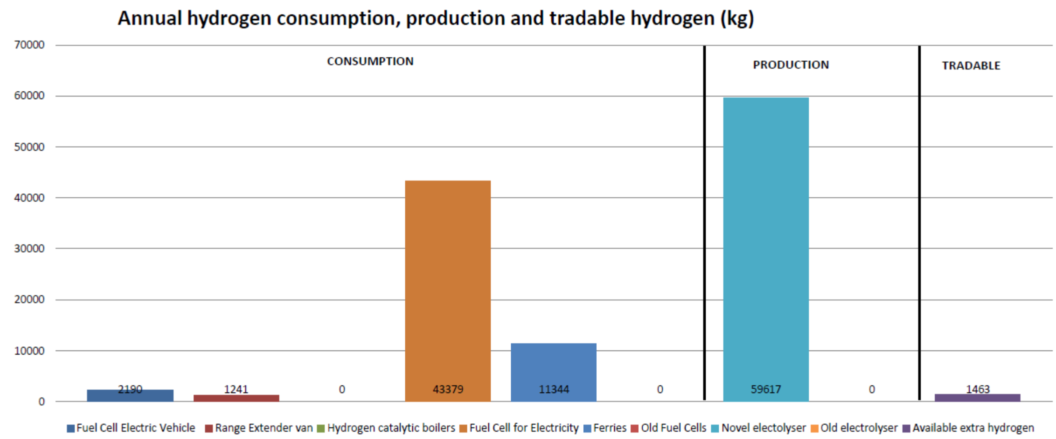
HYDROGEN PRODUCTION AND CONSUMPTION OVERVIEW

Annual Hydrogen Demand		Unit
Fuel Cell Electric Vehicle	2190	kg H2
Range Extender van	1241	kg H2
Hydrogen catalytic boilers	0	kg H2
Fuel Cell for Electricity	43379	kg H2
Ferries	11344	kg H2
Old Fuel Cells	0	kg H2
Total	58154	kg H2

Annual Hydrogen production		Unit
Total Hydrogen production	59617	kg H2
Hydrogen demand to the region	58154	kg H2
Surplus of hydrogen	1463	kg H2

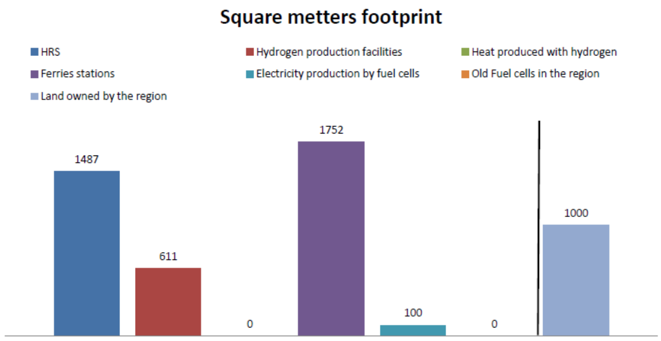
REMARK : The present model used seeks to maximize the benefit of the region. Therefore, hydrogen production will always be higher than the infrastructure needs. With this remaining hydrogen, the region has a resource to market, in order to obtain greater economic benefits from the hydrogen territory. This remaining hydrogen can be used also to increase the use of the region, decreasing thus even more the CO2 emissions and empowering the hydrogen territory.

This section presents the annual hydrogen consumption and the annual hydrogen production. As this document already has explained, the tool always fulfil the hydrogen demand, and due to it, there will be always a surplus of hydrogen that could be used for trading, acting as a source of income.



This graph presents how the hydrogen consumption is shared among the several uses, from which typology (novel or old) electrolyser has been produced and also which is the surplus of hydrogen that can be traded.

LOGISTICS AND INFRASTRUCTURE OVERVIEW

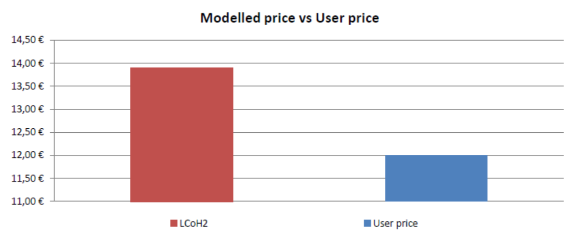


REMARK REGARDING LOGISTICS

The logistics for the model has been designed according to the model used in the BigHit project. The transport is done in trucks and compressed hydrogen is carried from one point to another according to the total demand. Vehicle and transport costs have been included in the model.

This graph aims to present to the user which is the footprint needed for the overall model. Thanks to this graph, the user will be able to estimate the required space per application needed.

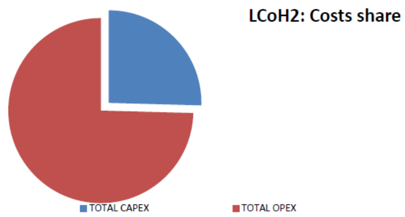
ECONOMIC OVERVIEW



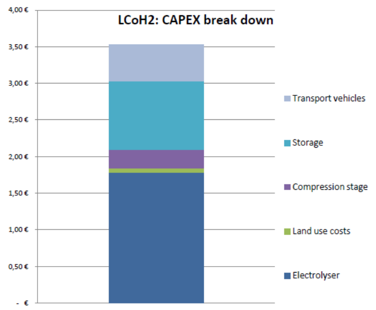
What is the meanning of LCoH2?

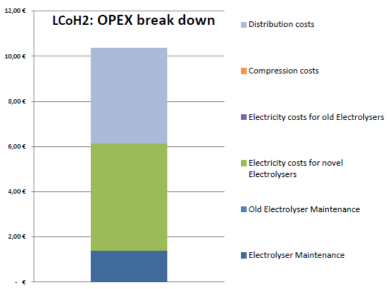
The calculations of the LCoH2 value correspond to the result of adding the value of the CAPEX and the OPEX during the life of the project and dividing this value by the amount of total hydrogen produced.
This value enables to estimate the real cost of hydrogen.

Hydrogen price		Unit
LCoH2	13,89 €	€/kg H2
Hydrogen price defined by user	12,00 €	€/kg H2

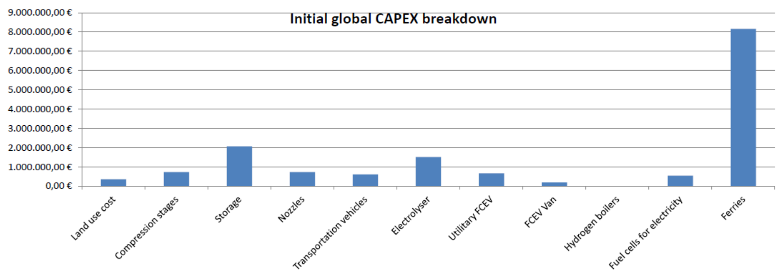


This section presents the economic overview of the model.





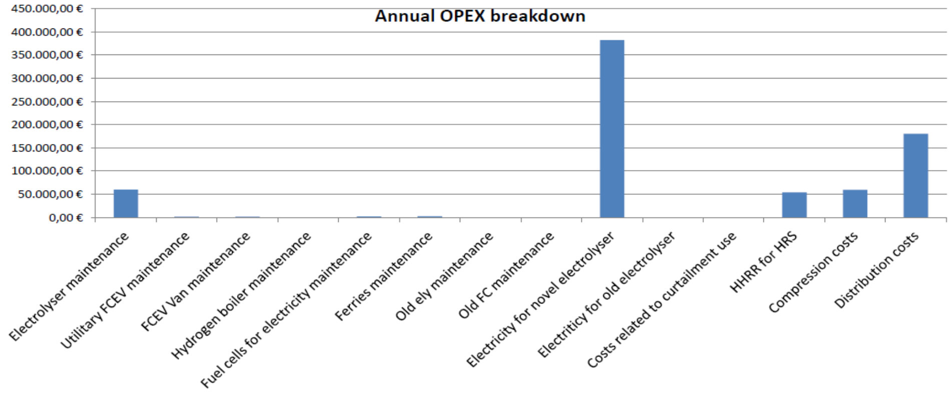
CAPEX			
Equipment	13.194.596 €	Auxiliary costs	4.448.480 €



The graphs presented in this section aims to present the breakdown of the LCoH2 costs obtained from the model. This information provides useful information as far as the user will be able to see which are the most cost consuming parts of the LCoH2 and it will allows identifying critical improvements.

Moreover, the global CAPEX breakdown of the tool is presented in order to give information about the most important contributing factors. The annual OPEX breakdown is also presented in the report as shown below these lines.

OPEX	
Maintenance	1.879.685 €
Operation	12.517.126 €



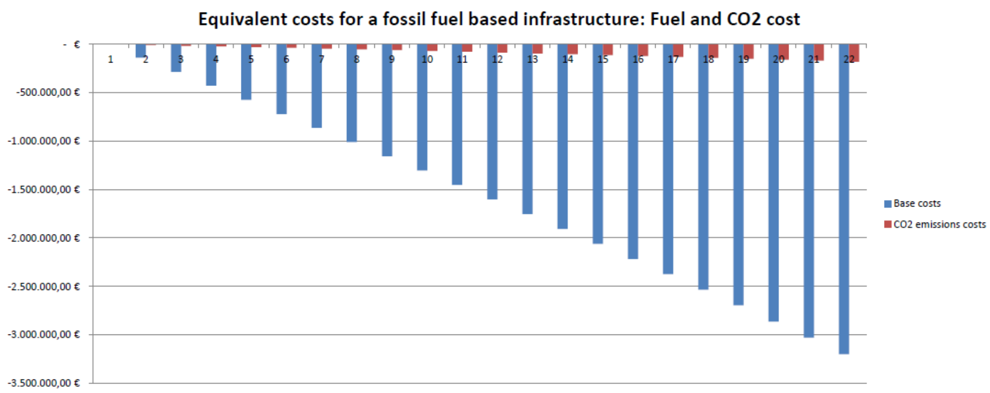
Finally, the model aims to present which are the cost and CO_2 emissions savings thanks to the use of hydrogen. Based on the estimation of the equivalent fuel consumptions, the price and the CO_2 that is neither used nor emitted to the atmosphere is present.

COMPARISON WITH FOSSIL FUEL BASED INFRASTRUCTURE

Annual Savings		Unit	Monetary value (€)	CO2 Emissions (kg)
Gasoline FCEV	15330	litres	26.690 €	4139
Gasoline RE	15330	litres	26.690 €	4139
Natural Gas Boiler	0	kWh	0 €	0
Electricity from grid	650430	kWh	74.149.020 €	254318
Maritime diesel	31410	tons	9.423.069 €	9423

Initial EU ETS price (€/tonCO2)
25

Final EU ETS price (€/tonCO2)
37,5



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