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Technical end economic viability of hydrogen road vehicles in Valencia, Spain

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Abstract
Decarbonising the automotive industry is important in improving air quality by reducing emissions. As one of the main promising alternatives to achieve this, hydrogen technologies are emerging. This paper will analyse the hydrogen automotive market, studying the economic and functional feasibility of implementing a plan to introduce hydrogen vehicles in society. The necessary supply is estimated, as well as the green production of the required hydrogen through the investigation of a plant to produce this gas using solar energy. This way, a vision of the future of hydrogen technologies applied to automation and its possible introduction to society will be obtained.
Keywords
hydrogen vehicles, electrolysis, fuel cell, FCEV, solar energy.

1. Introduction

The decrease in the impact of automotive pollution on our planet by reducing vehicle emissions (*Zalacko et al., 2021*) is unquestionable. Decarbonisation will be key to achieving this (*Torok et al., 2014*). In this sense, one of the most promising and increasingly viable solutions is the implementation of hydrogen cars (*Zöldy, 2009*). These vehicles use fuel cells that convert hydrogen into electricity, emitting no polluting gases. Moreover, hydrogen is a renewable and abundant resource on our planet, which makes it a sustainable option in the long term (*Szendrő, Csete, Török, 2012*). However, despite the advantages of hydrogen cars, their implementation presents significant challenges, such as the need for infrastructure for hydrogen production, storage, and distribution or willingness to use (*Andrejszki et al., 2015*) or safety-related questions (*Ágoston and Madleňák, 2021*). Therefore, this paper will analyse the hydrogen automotive market, studying the economic and functional feasibility of implementing a plan to introduce hydrogen vehicles. The necessary supply and the green production of the required hydrogen will be explored by investigating a plant to produce this gas using solar energy in Valencia, Spain. This way, a vision of the future of hydrogen technologies applied to automation and its possible introduction to society will be obtained.

2. Data and methods

2.1. Plans description

This paper focuses on the Spanish city of Valencia, where the data show that there will be 1.3 million vehicles in 2021 and an average of 32,000 new registrations annually (*Statistical Portal of the Valenciana, 2021*). An introduction plan is devised to analyse the implementation of the hydrogen vehicle in this location. A certain percentage of the new vehicles registered annually will be assumed to be hydrogen vehicles, starting with 1 % during the first year and contemplating three different levels according to the plan's acceptance (*Szabó et al., 2021*). The medium-rate plan with an increase of 1.5 % per year, the high-rate plan, where the percentage of new vehicles registered each year will be assumed to be hydrogen-fuelled. Moreover, the very high-rate plan, where the same will be done by 2 %. With these plans, more than 16 000 hydrogen-powered vehicles would be obtained in the case of the average acceptance of the plan, and more than 41 000 vehicles in the most favourable case, with a very high rate. In the next *Table 1*, the plan numbers are shown.

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Table 1. Introduction plan description

Total cars at Valencia	1293340
New registered cars at valencia	32386

YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
0,5%	1,5%	2,5%	3,5%	4,5%	5,5%	6,5%	7,5%	8,5%	9,5%
0,5%	2,0%	3,5%	5,0%	6,5%	8,0%	9,5%	11,0%	12,5%	14,0%
0,5%	2,5%	4,5%	6,5%	8,5%	10,5%	12,5%	14,5%	16,5%	18,5%
New H_2 cars									
162	486	810	1134	1457	1781	2105	2429	2753	3077
162	648	1134	1619	2105	2591	3077	3562	4048	4534
162	810	1457	2105	2753	3401	4048	4696	5344	5991
Total H_2 cars									
162	648	1457	2591	4048	5829	7935	10364	13116	16193
162	810	1943	3562	5668	8258	11335	14898	18946	23480
162	988	2544	4903	8147	12362	17646	24107	31861	41039

2.2. Hydrogen supply calculation

The necessary supply of hydrogen for implementing the plan in the society must be calculated, for which two parallel calculations have been performed so that the result has been obtained following two different procedures.

First, the starting point was a database for the consumption of traditional fuels for the fleet of private vehicles in the different provinces of Spain (*Statistical Portal of the Valenciana*, *2021*. Thus, knowing the diesel and gasoline consumption for a year based on 2021 consumption, the total supply needed to provide autonomy to all vehicles in Valencia was calculated. From this, the" hydrogen energy equivalent could be estimated, calculating the necessary hydrogen supply for vehicles in Valencia. Then, the necessary quantities for the different plans can be obtained.

Secondly, it is calculated by estimating the average distance travelled and the number of vehicles in Valencia. It is known that the average distance travelled by a private vehicle in Spain is 12562.9 km/year, and there are a total of 1 293 340 vehicles in the province of Valencia (*Statistical Portal of the Valenciana*, *2021*. Thus, the quantities of traditional fuels needed to supply the entire fleet of Valencian vehicles could be calculated.

To transform the equivalent energetic quantity between traditional fuels and hydrogen, the consumptions and densities of both fuels for a given distance were calculated (*Eq 1*), obtaining a ratio of 5.6913 kg of traditional fuel for each kilogram of hydrogen. So, the required supply of hydrogen for each plan and each year can be calculated. In *Table 2*, this process is described, and following the equation, the equivalence of both fuels is calculated.

Table 2. Energetic equivalence between conventional fuels and hydrogen.

	Comsumption (l/100km)	Density (kg/l)	Consumption (kg/100km)
gasoline	6	0.832	4.992
diesel	4.50	0.75	3.375
HC	5.0649	0.78	3.98
H_2	-	-	0.7

$$Consumption\ ratio = \frac{HC\ consumption}{H_2\ consumption} = \frac{3{,}98}{0{,}7} = 5{,}6913 \quad (1)$$

In this way, the quantities needed to supply 100% of the vehicles in the province of Valencia if they were hydrogen cars are obtained in both ways, getting very similar results and with a deviation of 2.19 %, being these 111 302 t of H_2 with the CORES data analysis calculation and 113 625 t with the other calculation method. Given the closeness between the two methods, from now on, the author proceeded with the calculations considering the values obtained from the CORES data.

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After this, from these values, the supply for each plan and each year will be calculated following Eq (2), and the results are shown in *Table 3:*

$$Annual\ H_2\ consumption = Consumption\ 100\%\ H_2\ cars * \frac{Total\ H_2\ cars}{Total\ cars\ Valenica} \tag{2}$$

Table 3. Hydrogen demand in Valencia, Spain

YEAR 1	Total H_2Cars	H_2 amount(kg)	H_2 amount/day
0.5%	162	13935	38
0.5%	162	13935	38
0.5%	162	13935	38
YEAR 2			
1.5%	648	55741	153
2.0%	810	69677	191
2.5%	972	83612	229
YEAR 3			
2.5%	1457	125418	344
3.5%	1943	167224	458
4.5%	2429	209030	573
YEAR 4			
3.5%	2591	222965	611
5.0%	3562	306578	840
6.5%	4534	390190	1069
YEAR 5			
4.5%	4048	348384	954
6.5%	5668	487737	1336
8.5%	7287	627090	1718
YEAR 6			
5.5%	5829	501672	1374
8.0%	8258	710703	1947
10.5%	10687	919733	2520
YEAR 7			
6.5%	7935	682832	1871
9.5%	11335	975474	2673
12.5%	14736	1268116	3474
YEAR 8			
7.5%	10364	891862	2443
11.0%	14898	1282052	3512
14.5%	20905	1799053	4929
YEAR 9			
8.5%	13116	1128763	3093
12.5%	18946	1630435	4467
16.5%	28339	2438824	6682
YEAR 10			
9.5%	16193	1393534	3818
14.0%	23480	2020625	5536
18.5%	37165	3198315	8763

2.3. Hydrogen supply production

Once the needed hydrogen for implementing each plan has been calculated (*Table 3)*, the problem of how to produce this hydrogen was investigated. To produce it, electrolysis has been selected as the most optimal process for this investigation due to its green and sustainable character. In addition, it is necessary to analyse which method best suits the project's requirements to produce the energy needed for the electrolysis process. For this, the production of the energy necessary for the hydrogen production process from solar energy was chosen, given the favourable characteristics of the Valencia location and the sustainable nature of this process. The best way to combine this is in a solar hydrogen production plant, so knowing the production needed to supply the hydrogen demanded by the FCEV (Fuel Cell Electric Vehicle - FCEVs are a type of vehicle that uses compressed hydrogen gas as fuel to generate electric power via a highly efficient energy converter, a fuel cell. The fuel cell directly transforms hydrogen into electricity to power an electric engine.) introduction plans can start with the sizing of the plant to know its approximate size. For this, the energy needed to produce one kilogram of hydrogen is known, which is 50 kWh, and knowing the efficiency (ε) of the solar panels, which is 0.21, and the average irradiance in Valencia of 5.23 kWh/m^2, we can calculate approximately the size of solar panels and power needed to supply the hydrogen supply. The calculations needed are given in the 3,4,5 and 6 equations:

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$$Electrolysis\ energy(kWh) = \frac{Electrolysis\ energy}{kgH_2} * H_2\ amount = 50 * H_2\ amount \quad (3)$$

$$Solar\ energy(kWh) = \frac{Electrolysis\ energy}{\varepsilon} = \frac{Electrolysis\ energy}{0{,}21} \quad (4)$$

$$Area(m^2) = \frac{Solar\ energy}{solarradiation\ vlc} = \frac{Solar\ energy}{5{,}73} \quad (5)$$

$$Instalated\ power(kW) = Solar\ radiation\left(\frac{kW}{m^2}\right) * \ \varepsilon * size\ of\ solar\ panel = 5.23 * 0{,}21 * size\ of\ solar\ panel \quad (6)$$

Following these steps, *Table 4* shows the results of the estimated plant size and power:

Table 4. Size and power estimation for the plant.

YEAR 1	kWh(electrolysys)	kWh(sun)	area(m2)	powinst(MW
0.5%	1909	9090	1738	0.37
0.5%	1909	9090	1738	0.37
0.5%	1909	9090	1738	0.37
YEAR 2				
1.5%	7636	36361	6952	1.5
2.0%	9545	45451	8690	1.8
2.5%	11454	54541	10429	2.2
YEAR 3				
2.5%	17181	81812	15643	3.3
3.5%	22907	109083	20857	4.4
4.5%	28634	136354	26071	5.5
YEAR 4				
3.5%	30543	145444	27810	5.8
5.0%	41997	199985	38238	8.0
6.5%	53451	254527	48667	10.2
YEAR 5				
4.5%	47724	227256	43452	9.1
6.5%	66813	318159	60833	12.8
8.5%	85903	409061	78214	16.4
YEAR 6				
5.5%	68722	327249	62571	13.1
8.0%	97357	463602	88643	18.6
10.5%	125991	599956	114714	24.1
YEAR 7				
6.5%	93539	445422	85167	17.9
9.5%	133627	636317	121667	25.6
12.5%	173715	827212	158167	33.2
YEAR 8				
7.5%	122173	581776	111238	23.4
11.0%	175624	836302	159905	33.6
14.5%	246446	1173550	224388	47.1
YEAR 9				
8.5%	154625	736310	140786	29.6
12.5%	223347	1063558	203357	42.7
16.5%	334086	1590884	304184	63.9
YEAR 10				
9.5%	190895	909024	173810	36.5
14.0%	276798	1318085	252024	52.9
18.5%	438125	2086311	398912	83.8

After obtaining the power required for the plans to introduce the hydrogen vehicle in Valencia, this research was continued by designing a hydrogen production plant using solar energy with a power of 10 MW, which, as shown in *Table 4*, will be possible to supply the hydrogen required for the plan during the first five years in the case of the medium rate plan or four years in the other two cases.

2.4. Solar plant design for hydrogen production

The following points of the paper will analyse the technical and economic feasibility of a plant of this power to cover the designed plan. First, an analysis of the plant's annual production is carried out in a fictive location, in La Pobla de Vallobona, a small town in Valencia with a largely rural area. The following values are extracted on the solar irradiance measured as a monthly average (*Figure 1)*:

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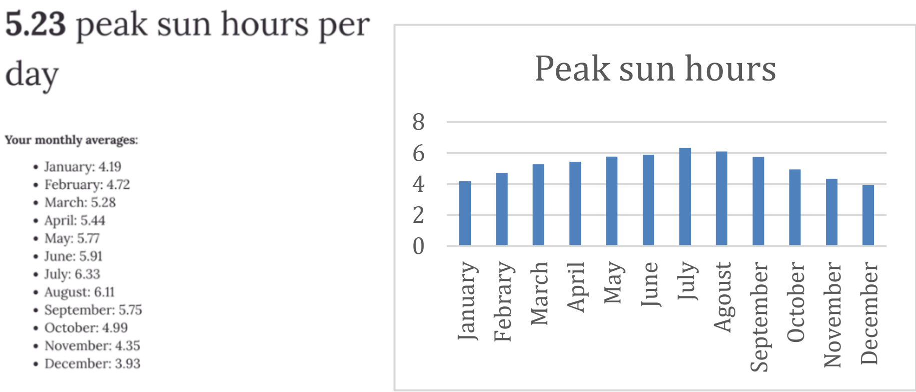

Figure 1. Monthly solar irradiation study.

Based on these data and having an installed capacity of 10 MW, the plant's maximum possible hydrogen production can be calculated. This will occur during July, with the maximum length of irradiation (*Eq. 7*):

$$Kg\ of\ H_2 = \frac{6{,}33*10000}{50} = 1266\ kg/day \tag{7}$$

To know the productive capacity of the planned hydrogen plant, the monthly production is calculated in the same way as in the previous section, analysing each month separately because the average monthly irradiation is variable. Thus, there will be months like winter in which the production will be lower. The next figures represent these calculations *(Figure 2)*:

	Peak sun hrs	H_2 kg
January	4.19	25978
Febrary	4.72	26432
March	5.28	32736
April	5.44	32640
May	5.77	35774
June	5.91	35460
July	6.33	39246
Agoust	6.11	37882
September	5.75	34500
October	4.95	30690
November	4.35	26100
December	3.93	24366
Average	5.23	31817
Total	62.73	381804

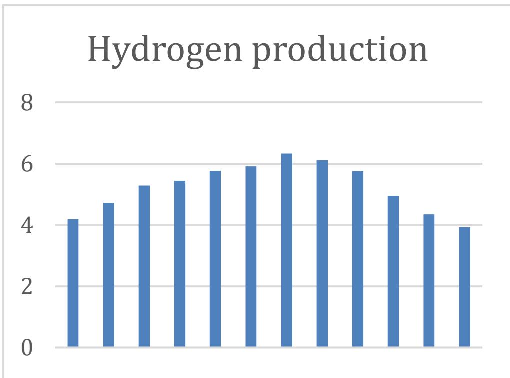

Figure 2. Hydrogen production estimation of the plant in Valencia, Spain

Therefore, with a 10 MW plant, approximately 381 t H_2 will be produced yearly.

2.5. Installation components

Thus, we already know certain technical requirements about the plant's production that will be important for further design. Further on, the most important and necessary components for the implementation of the plant will be described, and through the analysis of their cost, the author can approximate the economic viability of the implementation of this plant to supply the plan.

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First, to cover the selected power, solar modules must be installed, for which the 545 W JA Solar Mono PERC model has been selected, as it is most commonly used in Sapin nowadays. To reach 10 MW power, 18 349 solar panels should be installed. Thus, the total area of solar panels will be 47 500 m^2. Secondly, to produce hydrogen, an electrolyser is required. This is the device with which we can carry out the electrolysis process, which consists of separating the hydrogen and oxygen molecules in water using electricity. Different electrolysers exist, such as alkaline electrolysers, proton exchange membrane electrolysers (PEM) or solid oxide electrolysers (SOEC). For this plant, the PEM electrolysers have been selected because of their benefits, which include the production of high-purity hydrogen and ease of cooling, and better performance with renewable energies due to their variable nature. To suit the size of our plant, the EL600N electrolyser from H2B2 has been selected with the following technical specifications:

Hydrogen gas production:

Max. nominal hydrogen flow: 600 Nm^3/h (1,290 kg/day)

Hydrogen flow range: 10–100 %

Operating pressure: 15–40 bar (217–580 psig)

Hydrogen purity (before gas purification): > 99.9 %; < 25 ppm O_2; H_2O saturated

Hydrogen purity (after gas purification): 99.999 %; < 5 ppm O_2; < 5 ppm H_2O

Electrical requirements:

Power (BoP + Stacks): 3,100 kW

Stack consumption: 4.7 kWh/Nm^3 H_2

AC power consumption (BoP + stack): 5.1 kWh/Nm^3 H_2

Feed water requirements:

Consumption: < 1 L/Nm^3 H_2

Temperature: +5 ºC to + 40 ºC (+41 ºF to +104 ºF)

The compressor is another vital element for the installation because it transports the hydrogen at high pressures, higher than 700 bar, the pressure required in the hydrogen stations for vehicles. Two compressors, one low-pressure and one high-pressure, will be applied to achieve this. This way, the low-pressure compressor will raise the pressure to 160 bar and the high-pressure compressor to 900 bar. Therefore, the path that the hydrogen will follow in its compression process will start at the beginning of the electrolyser, from where it will be conducted to the low-pressure compressor, and after the compression process, it will be stored in the low-pressure tank at 60 bar. After this, the hydrogen will pass to the high-pressure compressor and will be stored in the high-pressure tanks, from where it can be distributed to the different hydro line plants in the province of Valencia. Thus, the equipment applied must have the above pressure requirements. In addition, the compressor must be able to work with a hydrogen flow higher than the maximum flow provided by the electrolyser, so we must look for a compressor that operates correctly with the flow required. The Hyperbaric brand was selected for this: model 1KS 50 for the first stage of compression and model 1KS 95 for the second stage, as it is widely used in Spain. Thus, two compressors will be needed for the low-pressure stage due to the high hydrogen flows and one for the high-pressure stage. Another main installation component is the low-pressure tank, where the hydrogen is stored after the first compression stage. To calculate its capacity, the daily hydrogen production must be estimated. Assuming production at 100% of the electrolyser capacity to obtain an upward estimate, which will not occur because the solar energy obtained in the most favourable month is not enough for that production level, a value of 1290 kg of H_2 per day is obtained. Since the pressure at the outlet of the first compression stage will be 160 atmospheres, the required tank volume can be obtained by following *Eq. 8*:

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$$V = \frac{n*R*T}{P} = \frac{m*R*T}{M*P} \frac{1290*0.082*298}{0.002*160} = 98507.6\ l \quad (8)$$

where

- V is the volume [l];
- m is the hydrogen mass [kg];
- R is the ideal gas constant [atm-l/k-mol];
- T is the temperature of hydrogen [K];
- M is the molecular mass of H_2 [kg/mol];
- P is the hydrogen pressure [atm].

For this volume, the LH 100H tank manufactured by LAPESA SL will be installed with the following technical specifications:

- Nominal volume [m^3] =100
- Outer diameter D [mm]=3 000
- Overall length L [mm]=15 350
- Unladen weight [ton]=34.7

Finally, the last component that will be considered for the economic estimation of the project will be the high-pressure tank, where the hydrogen will be stored and ready for distribution. For this purpose, the required dimensions of the tank are calculated in the same way as in *Eq. 7*, obtaining a value of 17 512.5 l.

After that, the LH 25H model is selected with the following technical data:

- Nominal volume [m^3] =25
- Outer diameter D [mm]=2 200
- Overall length L [mm]=7 850
- Unladen weight [ton]=10.1

Now, the main components of the solar hydrogen production plant are known, and the economic analysis can be performed.

3. Results and discussion

3.1. Economic viability analysis.

In order to be able to make the feasibility study of this project, the different types of costs that the implementation of the hydrogen production plant would carry and the income generated by the sale of the hydrogen at the different points of distribution and sale to the public must be analysed.

Firstly, the different fixed costs will be collected, mainly the investment in the equipment necessary to construct the hydrogen production plants. In addition, other fixed costs will be the purchase of the building and the land. These costs are represented in *Table 5*:

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Table 5. Fixed costs.

Fixed costs			
Equipment [€]	**Units [€]**	**Unit price [€]**	**Amount [€]**
Solar panels 545W JA Solar Mono PERC	18349	216.24	3967788
Electrolyzer EL600N H2B2	1	10000000	10000000
Compressor 1KS50	2	500000	1000000
Compressor 1KS95	1	600000	600000
Low-pressure tank	1	98900	98900
High-pressure tank	1	253100	253100
Land and warehouse purchase	1	300000	300000
		Total	16219788

In addition, the different variable costs of the installation must also be considered. These include the costs for the water supply of the electrolyser, and an average water price of 1.97 €/m^3 will amount to 15,000 €. A small percentage of the project's direct costs must be established destinated to the complementary direct costs, which include concepts that are difficult to quantify. Thus, we will establish 1% of direct costs. Also, indirect costs are execution costs not attributable to specific work units but to the whole or part of the project. For these, we establish 4% of the direct costs. An example of these costs would be plant maintenance. The Budget for Material Execution and the Investment Budget can be calculated by applying the different standardised rates *(Table 6):*

Table 6. Investment budget.

Equipment [€]	Units [€]	Unit price [€]	Amount [€]
Solar panels 545W JA Solar Mono PERC	18 349	216	3 967 788
Electrolyzer EL600N H2B2	1	10 000 000	10 000 000
Compressor 1KS50	2	500 000	1 000 000
Compressor 1KS95	1	600 000	600 000
Low-pressure tank	1	98 900	98 900
High-pressure tank	1	253 100	253 100
Land and warehouse purchase	1	300 000	300 000
Water yearly supply	20	750	15 000
Equipment and material budget			16 234 788
Complementary direct costs (1%)			162 348
Indirect costs (4%)			649 392
(1)Budget for Material Execution (1)			17 046 527
(2) Overhead Expenses (0,13*1)			2 216 049
(3) Industrial Profit (0,06*1)			1 022 792
(4)Contract execution budget (1+2+3)			20 285 367
(5)Value added tax (0,21*4)			4 259 927
(6)InvestmentBudget (4+5)			24 545 294

The hydrogen plant's income will come from selling hydrogen to the different hydrogen sales points. Thus the selling price of a kilogram of hydrogen must be known. Due to the current uncertainty about the price of hydrogen, to investigate the feasibility, instead of setting a specific price, it was calculated from what price our project starts to be profitable. Graphically this can be understood as the intersection between the cost and benefit curve, and the point of the intersection is called the break-even point. We must draw both curves from the data to translate this to the present case. First, the cost curve can be approximated to the fixed costs since the variable costs only include the water supply, and their cost is insignificant to the investment budget. So the cost will be represented by a straight line with the value of the investment cost. In addition, due to the lack of data on the residual value of the installation components, we will be in the most unfavourable situation to avoid failing the feasibility study, and we will take the residual values of the acquired equipment as 0. Second, the income curve is studied. This has a higher complexity since the selling price of hydrogen, as mentioned above, is very uncertain for the coming years. It is expected that with economies of scale, it will be reduced considerably. Therefore, we cannot determine the slope of the income curve and plot the situation to find the break-even point.

Due to this, the minimum average selling price of hydrogen will be calculated so that the investment is recovered in the 20 years of the project's useful life. It will be studied if it fits with the predictions that exist or, on the contrary, it is an unreal price, and therefore the project of the construction of the plant to supply green hydrogen for the plan of introducing vehicles would not be viable.

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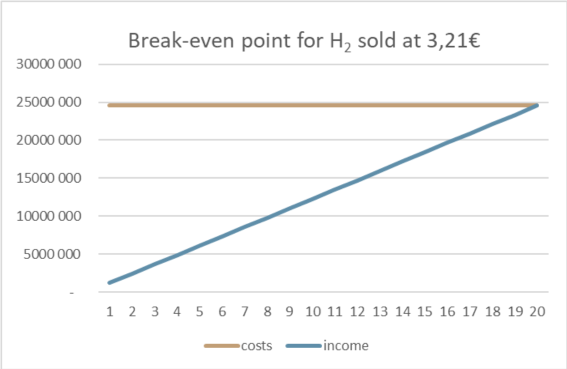
After these calculations, we obtain an average selling price of hydrogen of 3.21 €, from which the investment will be recovered in 20 years. The following graphs represent the break-even points for a price of 3.21 €/kg H_2 and 5 €/kg H_2, with the amount in € on the y-axis and the years since start-up on the x-axis. 100% production capacity of the plant is assumed, so 381 t H_2 are produced each year *(Figure 3)*:



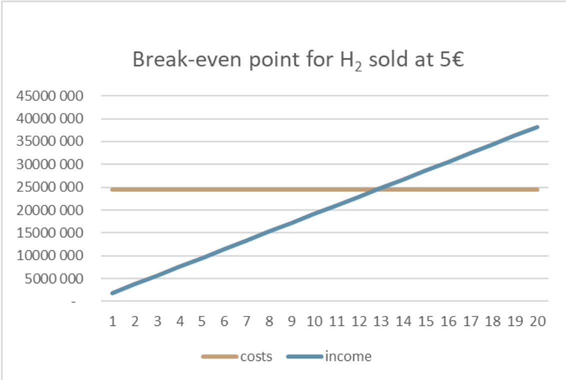


Figure 3. Break-even point graph for H_2 price of 3.21 and 5 €.

As can be seen in the first graph, if the plant operates at 100 % and the average selling price of hydrogen during the investigation period is 3.21 €, the investment will be recovered in year 20, while if the price of H_2 is increased to 5 €, the investment will be recovered in year 12, and the useful life of the plant will end with an approximate profit of 15 million €. Considering the hydrogen market and the predictions we found about its price in the future, we can see that currently, its selling price is 8 to 10 €. However, due to economies of scale, there will be a considerable reduction in the prices of fuel cells and storage tanks, which will bring about a 70 % reduction in the cost of hydrogen production over the next ten years. A comparative analysis between hydrogen and other conventional fuels can be analysed to get a different perspective on the selling price of hydrogen and whether it would be attractive to the market. For this, the costs of the equivalent amount of energy in terms of autonomy in both cases and the percentage difference between the two prices will be the energetic equivalent in terms of the autonomy of 1 kg of H_2 is 7.2965 litres of traditional fuels and setting an average price of 1.795 €/l, the total price for this amount of energy is 13.1 €, a value much higher than that obtained for hydrogen in the study, which put its selling price of that amount of energy between 3.21 and 5 €. In percentage terms, hydrogen would give us a 62 % cheaper energy to power vehicles. This saving can be observed more clearly when the price is analysed as a function of the kilometres travelled. Acting in this way, the price for travelling 100 km with an H_2 vehicle and considering a high consumption value for hydrogen vehicles, would oscillate between 3.21 and 5 € due to the range of sales prices with which we have been working in this study while using conventional fuel would be 9.1 €/100 km.

3.2. Environmental viability analysis.

The benefits of implementing the studied plan can also be addressed from an environmental point of view. For this, when analysing the reduction of pollutant emissions, only the previous emissions of vehicles with conventional fuels should be calculated since the saving will be 100%. The analysis of environmental data on vehicle emissions during the year 2021 proves that vehicles emit an average of 2.45 kg of CO_2 per litre of fuel, so knowing the litres of fuel that will be saved with the implementation of the plan can be known the savings of CO_2 emissions into the atmosphere. After these simple calculations, we obtain values of a reduction of CO_2 emissions close to 200 000 megagrams after the 10-year duration of the plan. Lastly, the economic value of these emissions can be determined. The price of CO_2 emission allowances during 2021 reached an annual average of 53.55 €/t, so we multiplied this value by the calculated emissions to obtain the economic value of 10 710 000 €.

4. Conclusion

In conclusion, after studying the sustainable plan for introducing hydrogen vehicles in the province of Valencia, it has been possible to show the strong advantages that the implementation of hydrogen technologies can bring to the automotive industry, and the barriers are to be dealt with. A proposed plan covers the sale of hydrogen vehicles and the calculation of the required hydrogen fuel supply for the sustainable production of hydrogen fuel, showing the necessity of the progressive electrification of the automotive market and the consequent evolution of hydrogen production systems to supply this change in the market. After this study, the feasibility of this project has become clear after analysing the approximate investment cost of a fully green hydrogen production plant, the implementation of which will be a key point in the course towards sustainable hydrogen. Also, the economic and environmental benefits of this change in the vehicle market have been discussed, and the beneficial character of introducing the studied plan has been evidenced. In addition, it must be emphasised the stage of development of the hydrogen market and how economies of scale will make hydrogen prices even more competitive. This is a technology whose future will undoubtedly be very promising.

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