E&M COMBUSTIÓN

HYDROGEN COMBUSTION SYSTEMS FOR THE DECARBONIZATION OF THE INDUSTRY

WHITEPAPER

Hydrogen: change of energy model in industry
Combustion prospects and challenges

GREEN HYDROGEN

Produced by electrolysis of water using renewable energy

GRAY HYDROGEN

Sourced from coal and natural gas. Generate CO2 emissions

BLUE HYDROGEN

From natural gas with carbon capture and storage

01

There are several technologies of hydrogen generation that can make this fuel a solution not only ecological but profitable in the short term

Executive summary

We face a new challenge in the coming years in the transformation of our energy model. Decarbonization is presented as a fundamental element in our lives, not only for the improvement of the environment but also as a new way of understanding industrial relations and improving our production processes. The element that will contribute to this change in the energy model is called Hydrogen.

Several hydrogen generation technologies can make this fuel not only an ecological solution, but also profitable one in a short period of time. All these technologies come together in the same point of consumption: the combustion of hydrogen. For this reason, research and improvement of hydrogen combustion is presented as a fundamental aspect in the value chain of this element. E&M Combustion contributes with its grain of sand to this hydrogen combustion technology, with the development, manufacture and installation of hydrogen combustion systems increasingly efficient and ecological.

A great challenge that we face in this first phase, in which we have not yet built new power plants or industrial plants for the use of hydrogen as an energy source, is the adaptation of existing plants to this new fuel less polluting than its predecessors.

Iñigo Béjar González · General Manager of E&M Combustión

01. Energy model change
Introduction to the theoretical framework

We face a new challenge in the coming years in the transformation of our energy model. Decarbonization is presented as a fundamental element in our lives, not only for the improvement of our environment, increasingly deteriorated, but as a new way of understanding industrial relations and improving our productive processes from another more global point of view and not simply of economic profitability, based on the saving of fuel costs. The element called to contribute to this change in the energy model, and possibly also geopolitical, is called hydrogen.

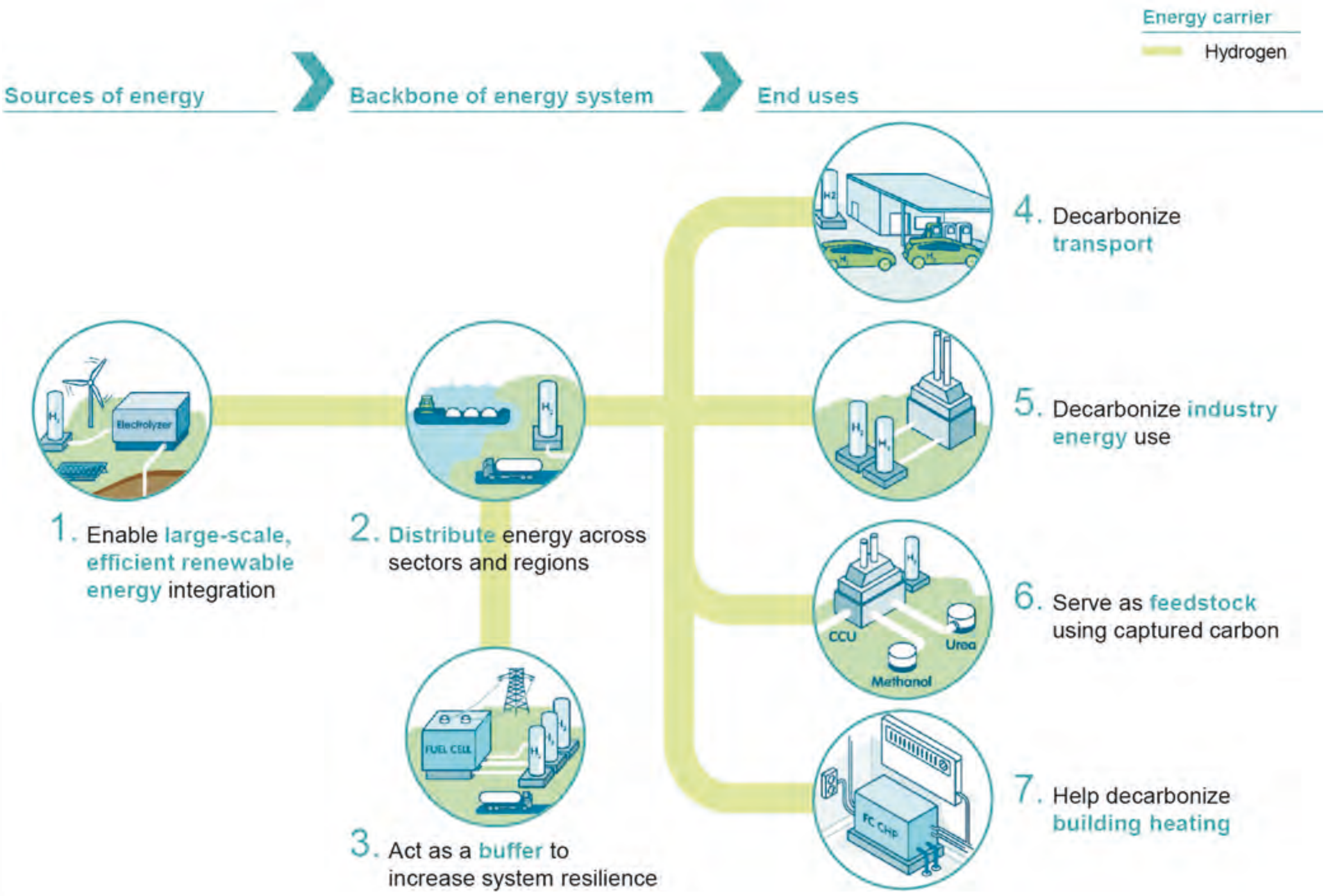
Throughout history, energy transformations have resulted in changes in societies who have lived them and the relationships between people themselves. The evolution that occurs with the use of coal, especially during the 18th and 19th centuries, completely transformed society. The charcoal began to illuminate the cities, allowed the creation of the railroad, etc. In fact, today it is still a fundamental element for the electricity generation in many parts of the planet.

After the Second World War, oil took over. From petroleum derivatives we obtain the most of the products that we use today, such as plastics, detergents, synthetic fabrics, gasoline for automobiles, etc. The transformation that this has brought about in the past century is obvious. Also during mid of that century, the massive use of natural gas in the industrial application and electricity generation began, an option less polluting than the previous two and preferred choice in many countries until the arrival of the renewable energy.

Decarbonization is presented as a fundamental element in our lives. The fuel to contribute to the change in the energy model is called Hydrogen

Finally, at the beginning of this century a large part of the international community seems to be clear that it will be the renewable energies those that mark the energy future of the planet in the medium and long term. Many of these are not still profitable, although they are necessary to avoid the destruction of the planet. Especially in Europe it has been bet clearly through this energy generation route. The question that arises is what do we do until these energies are more profitable and we can tackle a complete transformation to energy such as wind, photovoltaic and solar. Everything indicates that the answer to this question is hydrogen.

Hydrogen can play 7 roles in the energy transition



Source: Hydrogen Council

0.2 Hydrogen combustion

Research and improvement of hydrogen combustion is presented as a fundamental element in the chain value of this element. There are several technologies of hydrogen generation - some of them revolutionary, in which E&M Combustión plans to participate as strategic partner- who can make hydrogen a solution, not only ecological, but also profitable in a short time. They all end mostly at the same point of consumption. This point of consumption is the combustion of this hydrogen.

E&M Combustión wants to contribute with its grain of sand to this technology through the development, manufacture and installation of hydrogen combustion systems increasingly efficient and ecological. Although from the economic point of view it may seem an element not too relevant in the installation of a complete hydrogen generation plant, it is relevant from the point of view of its final application in the electricity generation plants, industry, etc. That is why all the steps taken to improve this technology will be associated with a great social benefit.

A great challenge that we have to face is that, logically, we will not initially have the capacity to build new power plants or industrial plants for the use of hydrogen as an energy source, which will also be done, but the normal thing is to use the current plants and adapt them to this new fuel. The success in the transformation of these facilities that currently use natural gas, fuel oil, diesel or coal for its use with hydrogen, will mean a success as a society with this new alternative energy source that is much less polluting than the previous ones. It is therefore essential to contribute and develop an efficient combustion technology and the least polluting possible of this fuel. E&M Combustión already has experience in this field and expects to contribute in the coming years in an active and leading way in the improvement of these facilities and the possible energy transformation that is presented to us.

From a technical point of view, we have to take into account some factors that will be essential in the transformation of these existing plants to the use of hydrogen combustion, and especially to its application to the boilers of electricity generation plants. We initially establish a table with the characteristics of hydrogen in gas form.

Concept	Values
1. Density:	0,0899 kg/Nm3 (gas) 0,0708 kg/l (liquid)
2. Lower calorific value:	2.580 Kcal/Nm3
Higher calorific power:	3.050 Kcal/Nm3
3. Explosion limits:	4,0 - 75,0 % (H2 concentration in air)
4. Detonation limits:	18,3 - 59,0 % (H2 concentration in air)
5. Specific heat capacity:	Cp=14,199 KJ/(kg•K) Cv=10,074 KJ(kg•K)
6. Diffusion coefficient:	0,61 cm2/s

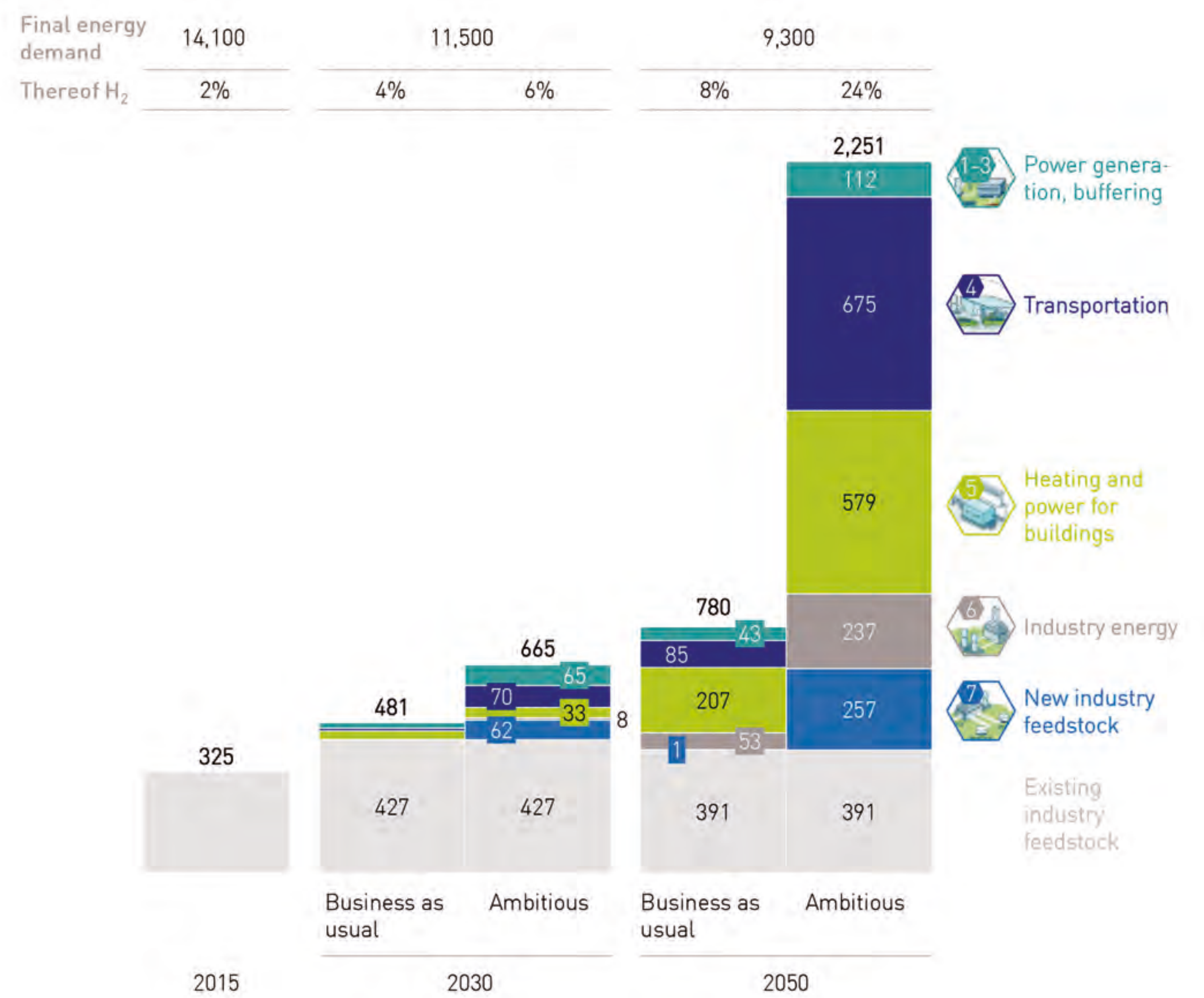
The first relevant data that we observe in this table is its calorific value. The calorific value of hydrogen in gas form compared to other fuels is low, so it must be borne in mind that it will be necessary to redesign and adapt the supply pipes to the consumption points. If we establish the comparison for example with natural gas, normally the low calorific value ranges between 8,500 to 9,100 Kcal / Nm3. We can observe, by therefore, there is a flow difference of approximately 3 to 3.5 times in relation to natural gas to be able to achieve a similar heat transfer. This fact also requires the replacement of combustion equipment by others that are capable of handling this flow, in addition to other characteristics that we will cite below.

For the design of combustion equipment we have to take into account the low density of this gas. Although the design of the hydrogen nozzles and injectors are similar to those of other gases, we must not exceed high gas velocities at these injection points. The flame propagation speed of hydrogen is approximately 8 times higher than that of natural gas, therefore it is not advisable to use high speeds for flame formation. It is also important for burner design to calculate the possible speed of a backfire.

Another aspect to consider is that the flame temperature achieved with hydrogen is higher than that achieved with natural gas. The stoichiometric flame temperature with a gas, with a percentage of H2 of 99% is 1,985 ºC, which is approximately 170 ºC more than with natural gas. It is therefore necessary to study the adaptation of the flames in the different boiler combustion chambers or thermal generation equipment to see the consequences of a higher flame temperature.

There are solutions to lower this flame temperature as we will see later, but initially we have to start from this premise to avoid a deterioration of combustion chambers due to an excessive heat transfer radiation. Likewise, a control of the flame geometry is essential to avoid damage to the interior of these chambers or in the steps of tubes of boilers or generators.

Hydrogen could provide up to 24% of total energy demand by 2050



Source: Hydrogen Roadmap Europe Report

03. Solutions to polluting emissions

There is a widespread misconception which is to consider that hydrogen, or more specifically combustion hydrogen, does not produce polluting particles; in short, it does not generate polluting gas emissions of the so-called greenhouse effect. This is a very widespread mistake since we continually talk about the word decarbonization with respect to hydrogen and this term is correct because hydrogen allows us to eliminate the CO2 emission. If we do not have carbon present in the combustion reaction, obviously we are not going to produce it in gases. Hence, CO2 is not emitted when hydrogen is burned, but NOx is emitted, which is another of the known as greenhouse gases. This gas is especially harmful to health.

In fact, the formation of NOx in the combustion of hydrogen is one of the factors on which it will be necessary to work in the coming years to be able to reduce their creation. The reason for the increased formation of nitrogen oxides comes from the higher flame temperature of hydrogen. As we have already said before, the adiabatic flame temperature of hydrogen is about 170 ºC higher than that of natural gas, which favors the formation of thermal NOx. Estimated NOx emissions values in a normal burner is about 210 - 240 mg / Nm3. This value is considered without the use of any specific technology for the reduction of NOx emissions from this gas. This value for example exceeds the values allowed by the Union European for medium and high power installations.

Emission regulations are governed by two Directives in the European Union right now. It's about the directive 2010/75/EU, applicable to combustion plants of more than 50 MW thermal, and the directive 2015/2193/EU, affecting medium combustion plants with a power between 1 and 50 MW thermal. The emission values that mark these two regulations are as follows (emission values are calculated for a temperature of 273.15 K, a pressure 101.4 KPa and 3% excess oxygen):

Directive 2010/75/EU · Emission limit values (mg/Nm³) for NOx and CO for gas fired combustion plants

Concept	NOx	CO
Combustion plants firing natural gas with the exception of gas turbines and gas engines	100	100
Combustion plants firing blast furnace gas, coke oven gas or low calorific gases from gasification of refinery residues, with the exception of gas turbines and gas engines	200 (4)	-----
Combustion plants firing other gases, with the exception of gas turbines and gas engines	200 (4)	-----
Gas turbines (including CCGT), using natural gas (1) as fuel	50 (2) (3)	100
Gas turbines (including CCGT), using other gases as fuel	120	-----
Gas engines	100	100

Notes:

(1) Natural gas is naturally occurring methane with not more than 20 % (by volume) of inerts and other constituents.

(2) 75 mg/Nm³ in the following cases, where the efficiency of the gas turbine is determined at ISO base load conditions:

i) Gas turbines, used in combined heat and power systems having an overall efficiency greater than 75 %.

ii) Gas turbines, used in combined heat and power systems having an overall efficiency greater than 75 %.

iii) Gas turbines for mechanical drives.

(3) For single cycle gas turbines not falling into any of the categories mentioned under note (2), but having an efficiency greater than 35 % – determined at ISO base load conditions – the emission limit value for NOx shall be 50xη/35 where η is the gas turbine efficiency at ISO base load conditions expressed as a percentage.

(4) 300 mg/Nm³ for such combustion plants with a total rated thermal input not exceeding 500 MW which were granted a permit before27 November 2002 or the operators of which had submitted a complete application for a permit before that date, provided that the plant was put into operation no later than 27 November 2003.

■ **Directive 2015/2193/EU** · **Emission limit values (mg/Nm³) for new medium combustion plants other than engines and gas turbines**

Pollutant	Solid biomass	Other solid fuels	Gas oil	Liquid fuels other than gas oil	Natural gas	Gaseous fuels other than natural gas
SO2	200 (1)	400	----	350 (2)	----	35 (3) (4)
NOx	300 (5)	300 (5)	200	300 (6)	100	200
Dust	20 (7)	20 (7)	----	20 (8)	----	----

Notes:

(1) The value does not apply in the case of plants firing exclusively woody solid biomass.

(2) Until 1 January 2025, 1 700 mg/Nm³ in the case of plants which are part of SIS or MIS.

(3) 400 mg/Nm³ in the case of low calorific gases from coke ovens, and 200 mg/Nm3 in the case of low calorific gases from blast furnaces, in the iron and steel industry.

(4) 100 mg/Nm³ in the case of biogas.

(5) 500 mg/Nm³ in the case of plants with a total rated thermal input equal to or greater than 1 MW and less than or equal to 5 MW.

(6) Until 1 January 2025, 450 mg/Nm³ when firing heavy fuel oil containing between 0,2 % and 0,3 % N and 360 mg/Nm³ when firing heavy fuel oil containing less than 0,2 % N in the case of plants which are part of SIS or MIS.

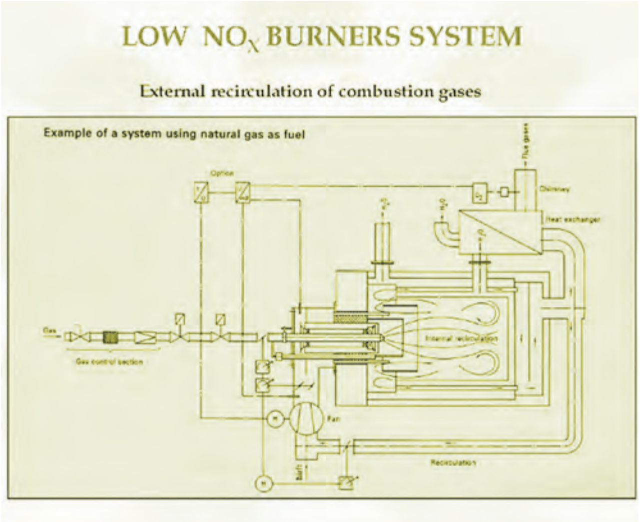
(7) 50 mg/Nm³ in the case of plants with a total rated thermal input equal to or greater than 1 MW and less than or equal to 5 MW; 30 mg/Nm³ in the case of plants with a total rated thermal input greater than 5 MW and less than or equal to 20 MW.

(8) 50 mg/Nm³ in the case of plants with a total rated thermal input equal to or greater than 1 MW and less than or equal to 5 MW.

These values apply to new combustion plants. In the case of existing facilities, the regulations for medium-sized combustion facilities establish another level of emissions, although it is reasonable to think that if we are going to transform any existing plant to hydrogen, the values should be taken considering it as a new facility. At this time there is no explicit regulation on hydrogen in terms of emissions that it will surely have to be established in the next few years. In any case, if we analyze the values of the current European regulations, it is possible to think that the section that would apply to hydrogen is that of gaseous fuels other than natural gas. Therefore, if we transform an installation and include a new burner, the NOx emission limit will be 200 mg / Nm3, which is the one set forth in the aforementioned section for gaseous fuels other than natural gas.

We are faced with the situation that it is very possible that current burners, without the application of any NOx emission reduction system, exceed this value set by the existing regulations.

NOx formation in the hydrogen combustion is one of the factors on which we will have to work in the next few years



03.01 Gases recirculation

Up • Gas Recirculation Fan

Bottom · Preheater gas recirculation outlet of the boiler
Source: E&M Combustión

Current technology for NOx reduction is mostly based on gases recirculation for the reduction of the flame temperature, and the consequent decrease in thermal NOx. This gas recirculation can be internal or external. (*See emission reduction article*). From E&M Combustion we bet on the realization of a system of external gases recirculation as the most effective method for reducing nitrogen oxides.

If we recirculate a quantity of combustion gases of approximately 15-20% of the total gases emitted by the generator, we can reduce emissions even below 100 mg / Nm3, which would correspond with current emission limits corresponding to a new natural gas facility.

By applying this gas recirculation technology, we are also able to lower the flame temperature, and consequently, reduce the heat transmitted by the flame radiation. As we have already mentioned previously, one of the problems that we can face when transforming current installations, which have been calculated for other fuels, is their thermal resistance at the temperature of a hydrogen flame. It could be the case that the end of the combustion chamber of a boiler or the welds of the pipes were damaged in a short period of time because the heat emitted by the hydrogen flame is higher than that emitted by natural gas or other fuels, precisely due to since these equipments have not been thermally calculated taking into account this factor. In short, the recirculation of gases would allow us to obtain more friendly flame temperatures for the equipment already on the market and guarantee a higher life time without having to reduce, for example, their thermal power.

03.02 Mix with natural gas

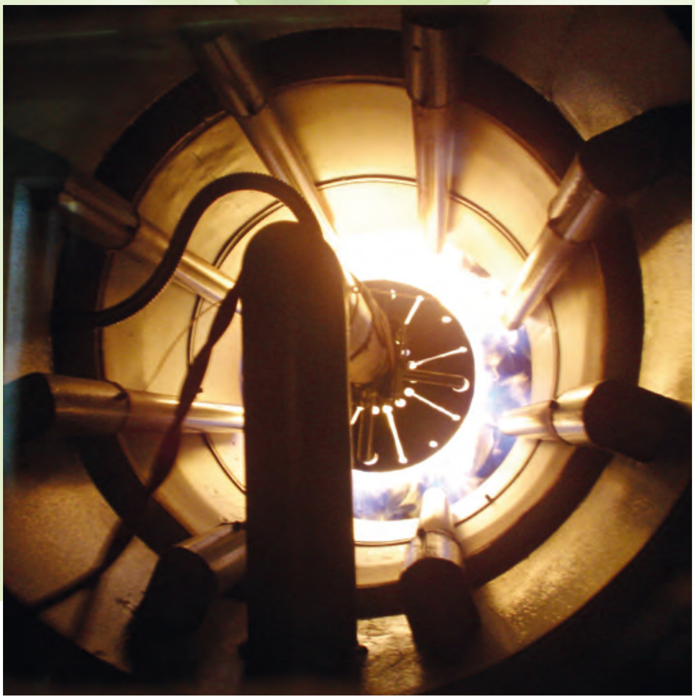
Another alternative that E&M Combustion has already tested, and which may be a very viable mode of operation for the future, is to mix hydrogen gas with 15-20% natural gas. The advantages that this mixture gives us are basically the following:

- The mixture would be enriched by increasing the calorific value of this mixture and achieving a more stable and efficient combustion.
- NOx emissions will be reduced, since the emissions obtained with natural gas are inferior to hydrogen. Thermal NOx production decreases with the combustion of natural gas since its flame temperature is lower.
- Flame detection is improved, which is one of the problems generated by hydrogen combustion and which we will deal with later in a special chapter.

The mixture of natural gas and hydrogen can be done in two ways. The first one is a mixer designed for this purpose. E&M Combustion has already tested this solution with positive results. It basically consists of the manufacture of a manifold designed for the realization of this mixture, in which control valves are installed that maintain the proportion of the mixture in a constant way. This manifold is placed before the inlet to the burner valve train.

Another solution for this mixture is to carry it out in the burner itself, using for example the gas in the central part to give more flame stability, and to distribute the hydrogen in other points of the head. The burner would be prepared for the admission of two fuels through two different gas trains, one for each fuel, with two independent regulating valves.

This is a solution that we can consider for the future in facilities where natural gas is already being used.



04. Flame detection

As we have already mentioned earlier in this writing, one of the challenges that we are going to face with the Hydrogen is the invisibility that the flames of this fuel present with respect to the spectrum of vision of the human eye. In fact, it could be the case that a fire occurred due to the combustion of hydrogen and that, in the case of occur during the day, it would go unnoticed. Even if it weren't for the temperature, we could go over a fire generated by combustion of hydrogen and we simply do not realize that there is a flame in this place. Hydrogen itself is colorless and odorless at this point. One question that arises from this reflection is that we will probably have to add some additive to hydrogen to make it perceptible to humans as It is made with natural gas, because in the event of a leak, and what is more dangerous, in the event of a combustion in full sunlight day, humans would not be able to detect it.

This has a very simple explanation. The hydrogen flame generates a flame spectrum outside the detection ranges of the human eye. In fact, hydrogen flames have a very low emissivity, that is, they radiate very little in the infrared spectrum.

This also creates a challenge and is that the proximity to a hydrogen flame can generate a false sensation of heat, precisely because of its low emissivity in the infrared, when what is going to happen is that it is going to emit a large amount of ultraviolet radiation, which could cause severe radiation burns.

The conclusion to this brief introduction that we have made about flame detection is that we are going to face hydrogen combustion in boilers where we are not going to see the flames from the outside, except by using specific systems for them. These systems will be special polarized crystals or specific thermal imaging cameras for their detection. This will generate complications for the adjustment of the equipment inside the combustion chambers. As mentioned before, it is essential to study the flame dimensions with precision.

For the safety of the burners, it is necessary to use special flame scanners that work in that ultraviolet spectrum in which the gas flame is emitted and also that are capable of detecting the flickering of the flame. Flickering is nothing more than the fluctuations that occur in a flame. These fluctuations are due to the fact that the oxygen aspirated in and the current fuel are burning, simultaneously aspirating in new oxygen and new fuel. They are like little flickers or fluctuations. Therefore, it is interesting that the flame scanners, apart from adjusting their measurement to the UV spectrum with the highest emissivity of hydrogen combustion, also capture the flickering of the flame as double security.

As we have also mentioned in this article, another challenge that makes the flames more invisible is the recirculation of gases. Previous experience with natural gas already shows us that from 25% gas recirculation, flames become increasingly invisible to the human eye and even special flame scanners themselves have greater difficulties in detecting them. We have to bear in mind that this factor, which can be very useful and effective for reducing emissions, can possibly generate a problem with flame detection. Without a doubt this will be another of the challenges that we are going to find in hydrogen combustion plants. From E&M we are committed to installing several sensors in the burners as a safety measure and sensors that are calibrable and adjustable in different spectra and also that are capable of detecting flickering.

Global hydrogen demand

Industry Sector	Key Applications
Chemical	Ammonia · Polymers · Resins
Refining	Hydrocraking · Hydrotreating
Iron&Steel	Annealing · Blanketing gas · Forming gas
General Industry	Semiconductor · Propellant fuel · Glass production Hydrogenation of fats Cooling of generations

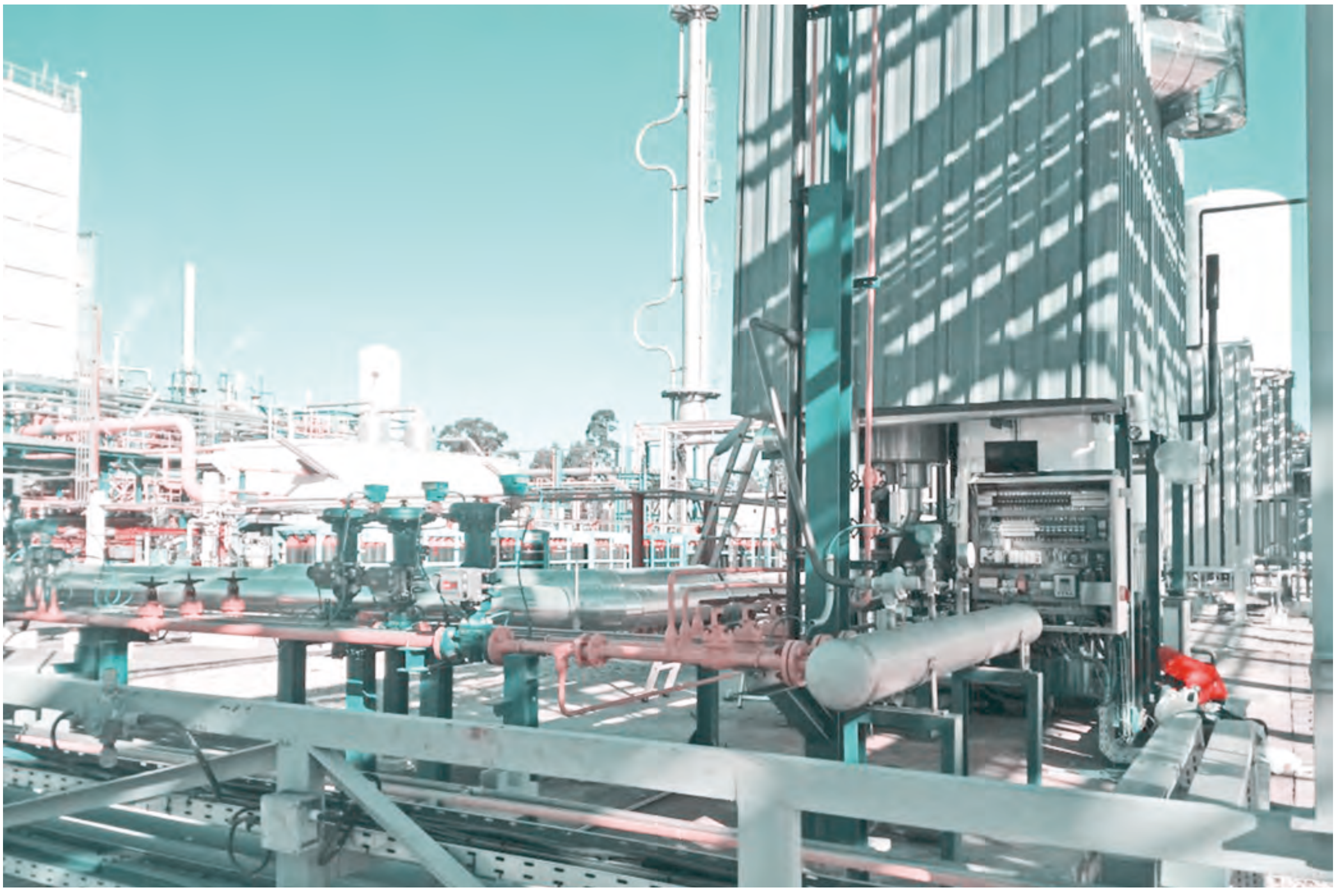
04. Hydrogen safety / Leaks

There is a tendency to think that hydrogen is more dangerous and explosive than other types of gases, such as natural gas. The reality is that studies show that this is not the case, therefore there is no more fear of hydrogen than other types of gases, although this does not mean avoiding taking all the security measures that are necessary in the facilities, and in the part that affects us, in the lines of safety valves of the combustion installations.

The first thing to say about hydrogen is that the molecule of this gas is much smaller than that of other fuels, so its ability to leak in pipes and valve joints is greater than with other fuels, such as it could be natural gas. In fact, the studied probability of hydrogen leaks ranges from 1.3 to 2.8 times higher, for example, than that of natural gas. On the other hand, as we have already seen, the LHV of hydrogen is from 3 to 3.5 less than natural gas, so in the total calculation we can affirm that with a natural gas leak more energy is released than with one of hydrogen.

On the other hand, the speed of propagation of hydrogen is approximately 2.9 times that of natural gas. Taking into account the difference in LHV we return to the conclusion that the energy released by natural gas is slightly higher in this case too.

Another aspect to take into account is that hydrogen reduces its risk of explosion if it is in open spaces or well ventilated. The hydrogen molecule is much lighter than air and other fuels, for so if a leak occurs, it will tend to rise rapidly and disperse very quickly. This makes in the event of a hydrogen leak, the probability of this combustion is very small since that the time to which it is exposed with the heat source is much less. The degree or energy of ignition of hydrogen is also similar to natural gas, so there is no penalty in this section.



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Studies show that hydrogen is no more dangerous and explosive than other types of gases

We therefore conclude, with this safety introduction, that the greatest risk of leaks that an explosion with hydrogen can occur in confined spaces where there is no ventilation, since in open spaces there is no greater risk than with other gases. We recommend including hydrogen detectors in these types of spaces to avoid these risks.

In the combustion part, the risk of leaks affects the design of the gas pipes. The first thing we have to have in account is that the joints of the pipeline with the valves must be flanged and use special joints to minimize the risk of leakage. It is important to do an intensive leak check during the installation. We have observed that the risk of leakage is higher with hydrogen, although the risk of explosion is lower. Likewise the burners internally, they must use special gaskets to avoid possible leaks of this gas.

Explosion-proof ATEX regulations

To minimize the risk of explosion, another alternative would be to manufacture the burner and the gas lines with elements that comply with the ATEX explosion proof regulations. E&M Combustion has been successfully carrying out this type of manufacturing for many years for different sectors such as petrochemicals, refineries, etc., and it is one of the proposals that we will need to be made before each hydrogen installation. Actually we have already seen that hydrogen is not more dangerous than natural gas, but there is a social perception in this sense, so everything we do to avoid accidents and eliminate this perception will benefit the development of this technology itself.

Within the ATEX regulations, hydrogen is included in group IIC. Apart from a study in greater detail for each specific plant, our suggestion is to place the equipment that is installed in the combustion equipment and in the safety valve lines associated with it within the classification zone 1, and group IIC . It would be enough to install equipment with EExd flame proof classification suitable for group IIC to be covered against any contingency regarding the possibility of deflagration in case of leaks.

Burner adapted to the ATEX explosion proof regulations.
Source: E&M Combustion

05. Pipe design

Another point that we are going to face, especially in existing plants, is the modification or redesign of the pipes in case these plants are operating with other gaseous fuels. The main factor for making these changes necessary is the flow difference to achieve the same thermal emission, due to the difference in the L.H.V. of gas comparing it, for example, with natural gas. Apart from this section, we have to take into account the possible corrosion that hydrogen can cause in the pipes. This phenomenon is known by the name of embrittlement.

Hydrogen embrittlement is a type of corrosion in which atomic hydrogen diffuses into the material and deposits on the reticular structure of the metal. Hydrogen undergoes molecular recombination, particularly in defects and grain limits in the material. The increase of associated volume can lead to internal pressure high and consequently internal tensile stresses, which makes the material brittle and creates cracks (called hydrogen-induced cracking).

Three factors can affect the embrittlement of carbon steel in pipes by hydrogen:

- The temperature we have in the pipeline.
- The working pressure of hydrogen.
- The O2 content of hydrogen.

One of the factors to avoid that we have embrittlement in the pipes is to work at pressures that are not too high, or at least that the transfer of that hydrogen to the pipes where the safety valves of the burners are located, are not carried out at too high pressures. Normally working at low pressures we will not have corrosion problems from hydrogen.

06. Conclusion

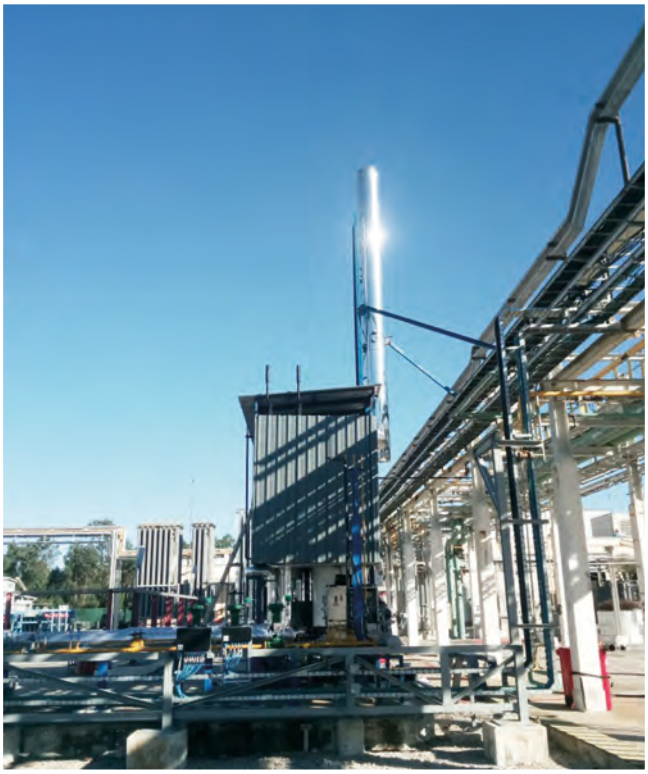
It is foreseeable that in the coming years we will face the transformation of numerous facilities that now consume other types of fuels due to the use of hydrogen or mixtures with other gases, with hydrogen as the main fuel. New electricity or hot water generation plants are also going to be created using hydrogen. In this sense, E&M Combustión is positioned as a leading company in this sector and aims to provide basic support in accompanying customers to the incorporation of this new fuel in their industrial processes. The experience and guarantees of a reliable combustion equipment with this new fuel is essential, and advice on this matter is indispensable.

This article has tried to explain some of the changes or challenges that hydrogen is going to introduce in the design and manufacture of combustion equipment and its application within industrial plants, but we always recommend a detailed study of each installation to evaluate the best solution in each specific case. Our team of professionals is always at your disposal to help you in this new model of energy transition.

02

E&M Combustion

The best choice
in industrial burners and
combustion equipment



A technical solution for every industrial need

E&M Combustion's mission is to create industrial burners to meet its customer's requirements, with the contribution of technical and specific solutions for Industrial Combustion processes. So, the company develops Innovative Combustion Technologies in order to offer cutting-edge knowledge of energy efficiency and reduction of polluting emissions, contributing to the sustainable development of our environment.

Besides the use of traditional fuels, E&M Combustión undertakes its own designs of industrial burners and combustion systems to adapt increasingly frequent cases in which the energy resource used involves lean gases, recycled oils and other types of alternative fuels, like hydrogen. Our designs also consider the possibility that a single burner may be used for several types of fuels simultaneously or alternatively.

Our R&D&I department collaborates with combustion technology centres in different countries. This means we are working with a top-tier team of researchers, allowig us to share information and pursue several lines of search. The final outcome is the pooling of different options for improvement, which are embodied in a highly satisfactory and innovative product for the customer.

The reduction of emissions has been a constant of E&M Combustion since its creation. We continue to develop and improve our Low NOx technology, achieving ever better emission results in our industrial burners.

Some references of our equipment

Hydrogen burner for a chemical plant

Hydrogen burner model JBD-3500 GHC0 for a plant in the chemical sector in Portugal. Duobloc equipment, with double air register and reduced NOx emissions, prepared to overcome high overpressures in the combustion chamber. It can operate on a mixture of three fuels: hydrogen, natural gas, and CO. Hydrogen added to other types of fuel helps to significantly optimize the combustion systems of standard fuels.

Multi-fuel burners

Mixed industrial burners to operate at the PT Global Dairi Alami plant in Java. Farm with 6,000 head of cattle, associated with the dairy production factory and the biogas generation itself. JBM 4,500-G2LO burners, with a power of 450 -4500 KW and reduced Low NOx emissions. The equipment use the biogas generated in the facility itself as fuel. They can work only with natural gas, with diesel, or with mixtures of natural gas-biogas and with diesel-biogas, depending on the availability of the client.

Ultra Low NOx burners

Ultra Low NOx burners in the district heatings of Luan Chuan and Beichen (China), with an emission level of less than 30 mg of nitrogen oxide (NOx) per cubic meter at 3%, with a flue gas recirculation system. In Luan Chuan, E&M Combustion has developed a JBD 70,000 burner, which operates with natural gas, and a flue gas recirculation (F.G.R.) system. In Beichen, the burner is a JBD 40,000 model with a Combustion Gas Recirculation (F.G.R.) system to improve environmental protection.

Hot gas generators

Hot gas generators are compact combustion chambers used in a large number of industrial applications, such as drying processes in the food industry, cement manufacturing or the mineral drying, wood industry, etc. These units produce gases at different temperatures starting from the combustion of different fuels such as natural gas, diesel, fuel oil, etc. The

internal combustion chambers are covered with refractory to withstand temperatures up to 1500ºC. For this reason, they have a robust structure that is resistant to this type of industrial applications. There are different types of chambers, with single or double shell that makes the heat losses through them quite low. Various types of burners are used to generate these hot gases, the most common are the pressurized air burners for liquid fuels and gases and duct burners for gases.

ATEX burners for potentially explosive areas

Supply of 28 ATEX burners for four refineries of the Indian state company ONGC. The equipment will operate in Indirect Bath Heaters, used in heating applications to reduce oil viscosity and improve process fluidity.

Designed according to the requirements of zone 1, according to the ATEX Directive, ATmosphere EXplosive, which describes the type of equipment allowed to work in this type of zone.

Combustion equipment for solar thermal power plants

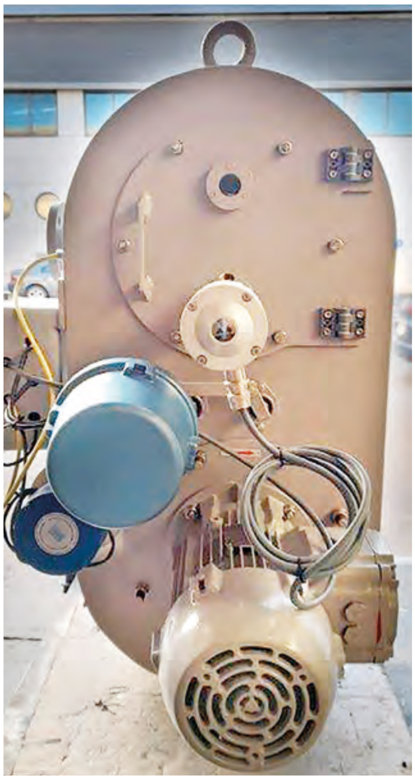
Supply of five units of combustion equipment for the Ashalim solar thermal power plant, in Israel, with a capacity of 121 MW. Contribution to this project of three industrial burners, model JBD-60,000-G, working with natural gas, and another two JBD-60,000-GLO burners, working with diesel and natural gas. All of them operate with air preheated to 250ºC and with a gas recirculation system (F.G.R.) to reduce Nox emissions below 100 mg / Nm3, at the combustion of natural gas.

Transformation of coal installations to natural gas

Project for the transformation of a thermal installation from coal to natural gas in a textile plant in China. Transformation of a 30-ton coal boiler to clean energy, and several 10 to 15-ton fuel oil boilers, with a temperature of 100º C.

Combustion equipment for the optimization of cement plants

Installation of combustion equipment in cement plants in the United States, Poland and Montenegro. Designed to operate in hot gas generators intended to optimize the cement drying process. Compact monoblock burners JBM-HP-100-G-Ex and JBM-HP-150-G-Ex, with a power of 1,675 KW and 936 KW, respectively, for the projects in Poland, manufactured under ATEX regulations. The Montenegro plant will have a compact monoblock burner JBM-HP-100-G, with a power of 1,177 KW; and a compact monoblock burners, with a power of 17,500 kw in the United States installation.



E&M COMBUSTIÓN

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