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كما أتوجه بخالص الشكر SONATRACH وشركةENAFOR واخص بالذكر والتقدير الجميع عمال شركة

المهندسين " خالد" و"الصبري" و" الربيع" على جميع مساهماتهم ومجهوداهم المبذولة من اجل إثراء هذا العمل

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أبي الغالي أطال الله في عمره رزقه جنته؛

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الخير

الطالب:

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Dédicacions

(بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ)

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List of Acronyms

symbol	Acronyms
ATR	**Autothermal Reforming**
BDV	**Blowdown Valves**
CCGT	**Combined Cycle Gas Turbine**
CO_2	**Carbon Dioxide gas**
CH4	**Methane gas**
EIS	**Environmental Impact Study**
ESD	**Emergency shutdown system**
GHG	**Green Hydrogen**
H2	**Hydrogen gas**
H2O	**the water**
HBK	**Haoud Berkaoui**
HS	**Hazard study**
OSH	**Occupational Safety and Health**
POX	**Partial Oxidation**
PLC	**Programmable Logic Controller**
SDV	**Shut-Down Valves**
SIF	**Safety Instrumented Functions .**
SIS	**Safety Integrity Level**
SIL	**Safety Instrumented systems**
SMR	**Steam Methane Reforming**

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General Introduction

1. General Introduction

At a time when the use of fossil fuels is declining, the world is witnessing the emergence of other sources of alternative energy, which will be capable of restructuring human civilization and which will also cause a major change in the nature of financial markets and economic, social conditions. and the most prominent of these sources is hydrogen. Accordingly, we are on the cusp of an economic and energetic revolution. and this revolution basis Hydrogen.

Current research in the field of energy aims to try to change the reliance on non-renewable fossil energy sources to reliance and work with renewable energy sources, which are widely available, inexpensive and characterized by being environmentally friendly. Researchers have concluded that the best source of this energy is hydrogen as It is the most abundant element in the universe, (but it does not exist in nature in free form, but rather exists in the form of compounds combined with metals and other elements, as the most common element that contains hydrogen is water, and there are other sources, most of which are organic materials), and it can be said It is a fuel that does not produce any polluting emissions, and it also has the highest calorific value per unit mass of compared to all energy sources available on Earth.

Hydrogen can be produced from a variety of feedstock's. These include fossil resources, such as natural gas and coal, as well as renewable resources, such as biomass and water using renewable energy sources (such as sunlight, wind, waves or hydropower. and this type is called green hydrogen). A variety of techniques can be used to produce this gas, the most important of which are chemical, biological, analytical, photochemical, and thermo chemical techniques. Each technology includes a set of different stages that depend on development. Each technology provides unique opportunities, benefits and challenges. And the production of hydrogen gas depends on several points, the most important of which are the availability of raw materials, the development of the technology used, the costs necessary for production, and market requirements.

In order to ensure that hydrogen production is carried out in the best way, it must be ensured that the safety and security system used is effective and works in the best possible way and the safety and security system is an essential element for the success of any industrial facility, and it is considered one of the most important systems that industrial facilities rely on, because of its many benefits at various levels, including the protection of lives and property, so that it reduces the risks of accidents and injuries, maintains the safety of workers and employees, and contributes to increasing Productivity and efficiency so as to provide a safe and comfortable work environment, and contribute to improving the facility’s reputation before official bodies and society. It enhances the confidence of customers and investors.

for achieve an effective safety and security system in industrial facilities, it is necessary to ensure that clear plans and policies for safety and security are developed.

The aim of this work is to clarify and demonstrate how to produce green hydrogen while ensuring that the production process takes place under conditions and a high level of industrial security and safety.

In order to cover all aspects of the research, the following problem must be presented:

What is the best security and safety system through which we can ensure that thegreen hydrogen production process is carried out safely?

In order to cover this problem, we must answer these questions:

- What is hydrogen and what are the methods of producing it?
- What are the basic elements that make up an industrial safety and security system?
- What is the industrial safety and security system necessary to ensure the safe production of green hydrogen?

Chapter 01:

The Hydrogen and its production methods

Chapter 01:The Hydrogen and its production methods

1. Introduction

One of the things that is making a big noise in the world at the present time is environmental issues, due to the great importance that the environment has, which in turn suffers from several dangers, most notably climate change and the increasing demand for energy, which poses a serious threat to our lives and the life of our planet. In this regard, several solutions have emerged, including: not relying on fossil fuels, which are considered the traditional source of energy and cause many negative effects on the environment and human health. Instead, we must rely on clean energy sources, the most important of which is green hydrogen, which stands out as a promising alternative for achieving a balance between our energy needs and protecting our planet. Given the great importance of this source, it is necessary to rely on it better and on a larger scale in all production facilities.

The importance of green hydrogen must be recognized by all parties, from ordinary citizens to government officials. We must work to cooperate at all levels with individuals, governments, and influential organizations to protect our planet by using this clean gas in all areas of production in all fields.

2.What is the Hydrogen?

Hydrogen is a chemical element with the symbolH2. It is a colorless, odorless, and non-toxic gas. It is lighter than the elements found in nature and its volumetric mass is $\rho = 0.09 g / l$. It is about 14 times lighter than air, and it has a great ability to spread in the atmosphere. Its atomic weight is 1.0079 and its isotopes are deuterium and tertium. However, it exists in combination with other elements. Hydrogen is not a major source of energy. However, it becomes an attractive and important carrier of energy when separated from other elements using energy sources. Hydrogen is supposed to be a clean fuel for energy in the future, especially for the purposes of storage and energy transmission. The storage capacity of hydrogen energy is excellent because calculations show that each kilogram of hydrogen contains approximately 33KWh of energy [1].

3.A look at the history and future of Hydrogen production

Several technologies are already available in the marketplace for the industrial production of hydrogen. The first commercial technology, dating from the late 1920s, was the electrolysis of water to produce pure hydrogen. In the 1960s, the industrial production of hydrogen shifted slowly towards a fossil-based feedstock, which is the main source for hydrogen production today.

In Figure (1.1), a future hydrogen pathway is illustrated. Large-scale hydrogen production is probable only in the longer term. In the short and medium term, the production options for hydrogen are first based on distributed hydrogen production from the electrolysis of water and on the reforming of natural gas and coal. Larger centralized hydrogen production plants are more likely to be introduced at a later stage. These plants will probably be based on biomass or fossil fuels with CO_2 capture and storage. [2]

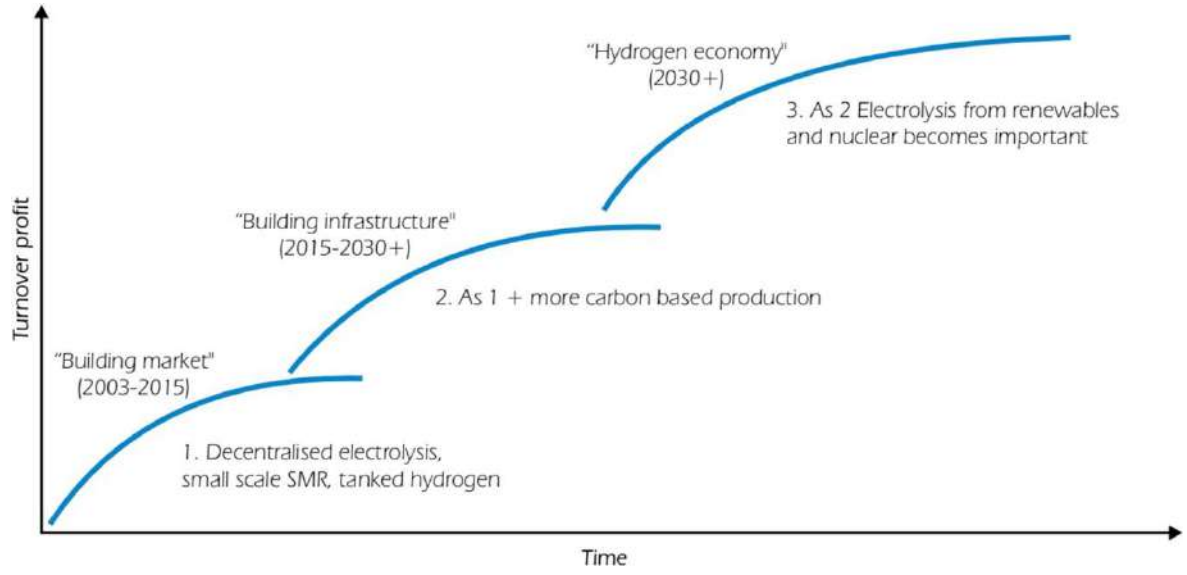

Figure (1.1): Main hydrogen pathways: the long-term perspective [2].

4. Advantages To using Hydrogen

Hydrogen has several advantages, and this is due to the great importance it is given. we mention some of this advantage below:

- A safe energy source that contributes to reducing oil imports in non-oil countries, by using local resources to produce hydrogen, which leads to energy independence.
- It is characterized by sustainability by taking advantage of renewable energy sources, as hydrogen can be produced from renewable energy sources.
- It does not pollute the environment because it is characterized by almost no carbon production, as hydrogen can replace fossil fuels to provide electrical energy and transportation fuel.
- The economic importance is that hydrogen can form global energy markets in the future.

Therefore, hydrogen is a clean energy carrier accepted worldwide as it is an independent source and contains a high percentage of energy per mass compared to other fuels as shown in the following table there is a comparison between hydrogen and different types of fuel as an energy source [3].

Table (1.1): Comparison between hydrogen and different types of fuel as an energy source.

Fuel	Energy content (MJ/Kg)
Hydrogen	120
Liquefied natural gas LNG	54,4

Coal	27
Car gasoline	46,4
Car diesel	45,6
Ethanol	29,6
Methanol	19,7

We note from the table that the type of fuel that contains the highest stored energy is hydrogen. this is due to the fact that the hydrogen atom contains a significant amount of energy that can be liberated from reactions and thus can be exploited.

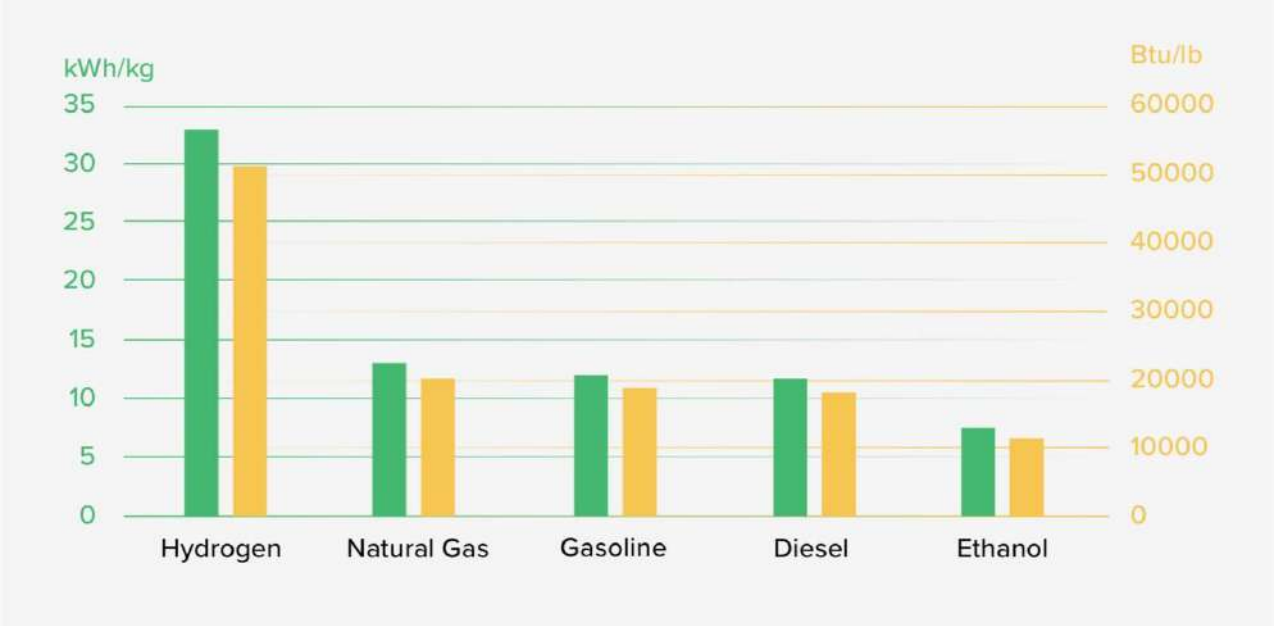

Figure (1.2):Comparative Energy Content of fuels [4]

5. Disadvantages of Hydrogen

As we mentioned previously, hydrogen has several advantages, but it also has several disadvantages, which we summarize in the following points:

- **Storage and transportation:** Hydrogen is a very light gas, making it difficult and expensive to store and transport in large quantities. It requires high pressure or special containers to keep it from dissipating, unlike gasoline or natural gas which can be stored in tanks at ambient pressure.
- **Production:** Currently, most hydrogen is produced through a process called steam reforming of natural gas, which generates greenhouse gas emissions. For hydrogen to be a truly clean fuel source, it needs to be produced using electrolysis powered by renewable energy sources, but this method is still in its early stages and can be expensive.
- **Infrastructure:** There is a lack of infrastructure for hydrogen, including refueling stations for hydrogen fuel cell vehicles. This makes it inconvenient for widespread adoption.
- **Cost:** Due to the challenges mentioned above, hydrogen is a more expensive fuel source compared to gasoline or diesel.

- **Safety:** Hydrogen is highly flammable and explosive. While safety systems are built into hydrogen technologies, leaks can still be a concern.

6. Hydrogen colors and types:

Currently, 96% of hydrogen is produced from fossil fuels via carbon-intensive processes either by Steam Methane Reforming (SMR) without Carbon Capture, Utilization, and Storage (grey hydrogen) or coal gasification (black hydrogen). The GHG emissions and approach in the production process give hydrogen its color. [5]

Green hydrogen:

Green hydrogen is produced through the electrolysis of water in an electrolyzer, powered by electricity produced from renewable sources such as hydro, wind or solar. Provided that the inputs of electricity only come from renewable energy sources (and if desalinated water needed, powered 100% by solar and wind), the GHG emissions during the production process are equal to zero.[5]

Grey hydrogen and Black hydrogen:

Grey hydrogen production uses natural gas while Black hydrogen uses coal as a primary source. The transformation process, called Steam Methane Reforming (SMR) uses oxygen from water steam in a heat chamber to separate methane (CH_4) and produce H_2. However, the process remains highly pollutive as it generates >9kg of CO_2 for every kilogram of hydrogen produced.[6].

Blue hydrogen:

Blue hydrogen follows the same process as grey hydrogen, but the carbon emitted during production is captured with a Carbon dioxide capture and storage process to reduce CO_2 emissions. The EU's framework refers to blue hydrogen as fossil-based hydrogen with carbon capture.[5]

Yellow hydrogen:

Yellow hydrogen is obtained by electrolysis from the electric energy of mixed origin that could be from nuclear or waste-to-hydrogen. Also, it could be via gasification of waste. [5]

Turquoise hydrogen:

Turquoise hydrogen uses natural gas or biomass as energy input via pyrolysis to produce hydrogen in an endothermic process while solid carbon is obtained as a by-product. While pyrolysis for biomass is a relatively dirty process from an environmental point of view, the pyrolysis process via natural gas can be interesting, provided that the energy comes from renewable sources. [7]

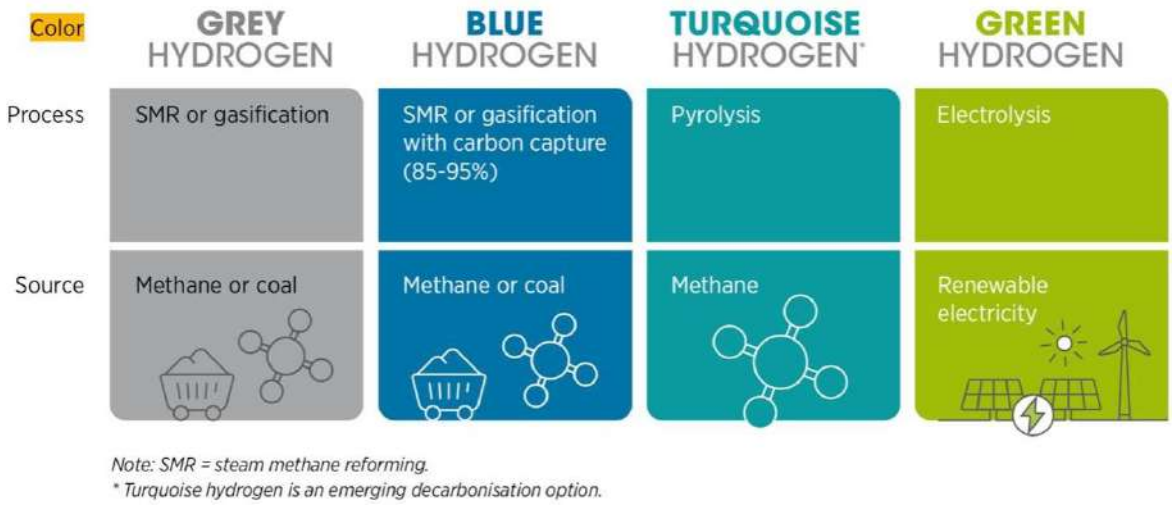

Figure (1.3): A figure showing the source and process of producing each type (color) of hydrogen [5]

7. Sources of hydrogen production

Hydrogen can be produced from a variety of sources, as shown in Figures ((1.4)and (1.5)), which show several diverse paths for hydrogen production, as it can be produced from materials rich in it, such as coal, natural gas, biomass, and water The importance of these paths in fuel production is that they can be produced locally without relying on external sources.[8]

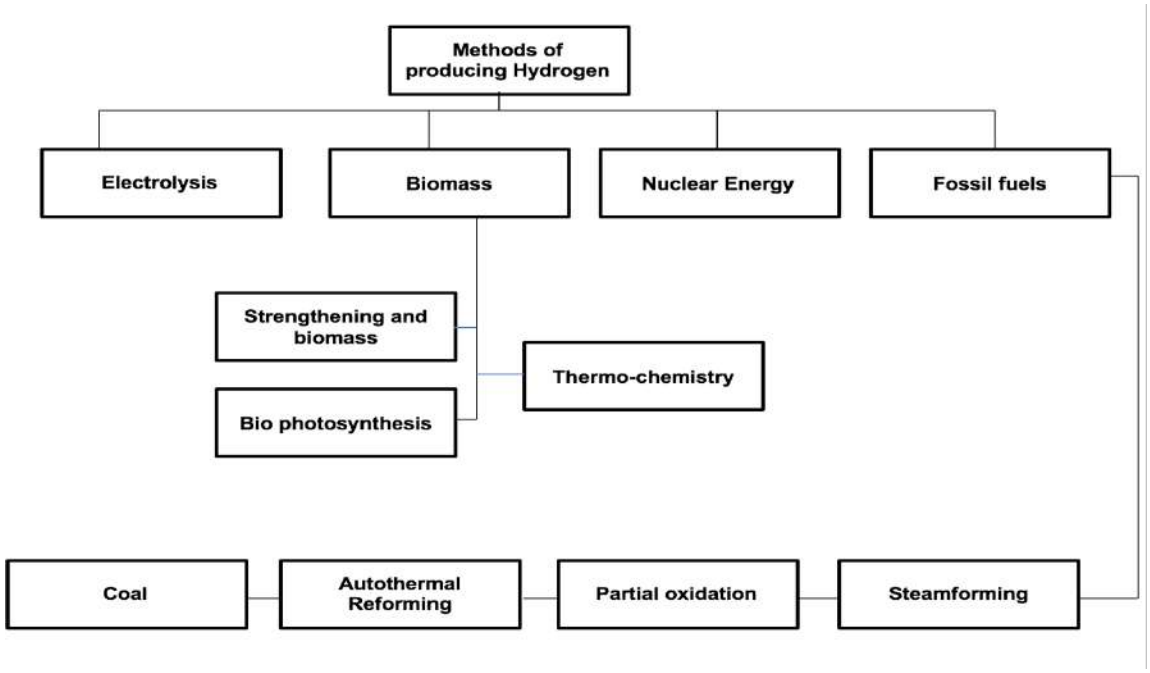

Figure (1.4):Scheme of the main energy sources for hydrogen production.[8]

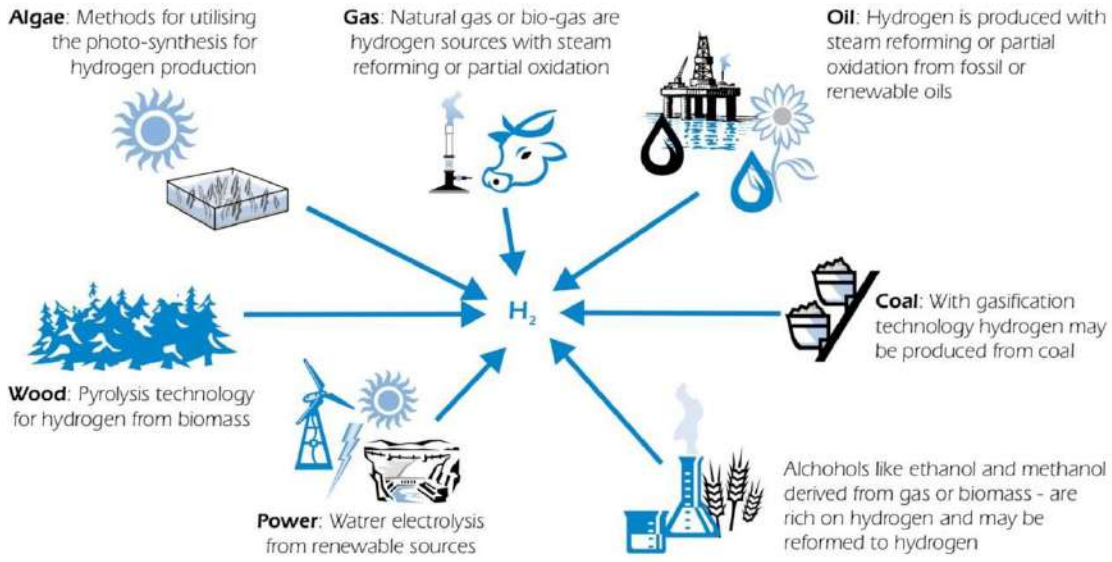

Figure (1.5):Some feedstock and process alternatives [2]

HYDROGEN FROM FOSSIL FUELS

Hydrogen can be produced from most fossil fuels. The complexity of the processes varies. Since carbon dioxide is produced as a by-product, the CO2 should be captured to ensure a sustainable (zero-emission) process. The feasibility of the processes will vary with respect to a centralized or distributed production plant.

Production from natural gas

Hydrogen can currently be produced from natural gas by means of three different chemical processes:

- ● Steam reforming (steam methane reforming – SMR).
- ● Partial oxidation (POX).
- ● Autothermal reforming (ATR).

Steam reforming

Steam reforming involves the endothermic conversion of methane and water vapour into hydrogen and carbon monoxide…, The heat is often supplied from the combustion of some of the methane feed-gas. The process typically occurs at temperatures of 700 to 850 °C and pressures of 3 to 25 bars. The product gas contains approximately 12 % CO, which can be further converted to CO_2 and H_2 through the water-gas shift reaction….[2]

$$CH_4 + H_2O + heat \rightarrow CO + 3H_2$$

$$CO + H_2O \rightarrow CO_2 + H_2 + heat$$

Partial oxidation

Partial oxidation of natural gas is the process whereby hydrogen is produced through the partial combustion of methane with oxygen gas to yield carbon monoxide and hydrogen …. In this process, heat is produced in an exothermic reaction, and hence a more compact design is possible as there is no need for any external heating of the reactor. The CO produced is further converted to H2 as described in equation ….[2]

$$CH_4 + {}^1/_2O_2 \rightarrow CO + 2H_2 + heat$$

Autothermal reforming

Autothermal reforming is a combination of both steam reforming and partial oxidation. The total reaction is exothermic, and so it releases heat. The outlet temperature from the reactor is in the range of 950 to 1100 °C, and the gas pressure can be as high as 100 bar. Again, the CO produced is converted to H_2 through the water-gas shift reaction. The need to purify the output gases adds significantly to plant costs and reduces the total efficiency. [2]

Each of the processes mentioned above has several advantages and at the same time several challenges that can be summarized in Table 2

Table (1.2): Advantages and challenges that characterize the processes of producing hydrogen from fuel

The processus	Avantages	Challenges
steam methane reforming	▪ It has High efficience ▪ Low émissions	▪ High production costs (production units are expensive) ▪ System available for production is complex. ▪ It relates to the quality and characteristics of the gas
Partial oxidation and	▪ It is characterized by its acceptable size (small) ▪ Löw production costs ▪ It has a simple	▪ Low efficience ▪ The hydrogen produced requires a purification process

Autothermal reforming	production system	▪ Environmentally harmful waste (emissions from burning)

Production from coal

7.2.1Gasification

Gasification is a thermal process that converts biomass or coal into a mixture of gases (first Oxide and carbon dioxide in addition to hydrogen) and other compounds, and this is through the application of pressure and heat in addition to water vapor, where special metals or membranes can separate the hydrogen from this gas, and additional hydrogen can be generated through the reaction of CO with water vapor. To form hydrogen and carbon dioxide.[9]

from coal

It is an available and relatively inexpensive local resource. It is important to note that hydrogen can be produced directly from coal by gasification, instead of using coal-generated electricity to produce hydrogen, which requires this process to flow at a high temperature, as the coal (carbon) is converted) to carbon monoxide and hydrogen gas.[10]

$C + H\,O + heat \rightarrow CO + H$

Since this reaction is endothermic, heat must be added, as is the case in the process of re-evaporating methane and converting CO into CO2 and H2, through a chemical reaction between water vapor and carbon monoxide, as we discussed previously, where the carbon dioxide that It is produced as a second product of coal and must be captured and stored in order for gas emissions to be almost non-existent.[10]

After producing hydrogen from coal and it becomes mature, we find it more complex compared to producing it from natural gas, but the cost of the resulting hydrogen is higher, so it must be used as an energy source due to its great abundance in the world. [10]

Capture and storage of CO_2

Carbon dioxide is a major exhaust in all production of hydrogen from fossil fuels. The amount of CO_2 will vary with respect to the hydrogen content of the feedstock. To obtain a sustainable (zero- emission) production of hydrogen, the CO_2 should be captured and stored. This process is known as de-carbonisation. There are three different options to capture CO_2 in a combustion process: [2]

- **Post-combustion.** The CO_2 can be removed from the exhaust gas of the combustion process in a conventional steam turbine or CCGT (combined cycle gas turbine) power plant. This can be done via the "amine" process, for example. The exhaust gas will contain large amounts of nitrogen and some amounts of nitrogen oxides in addition to water vapour, CO_2 and CO.
- ● Pre-**combustion.** CO_2 is captured when producing hydrogen through any of the processes discussed above.
- ● Oxyfuel-**combustion.** The fossil fuel is converted to heat in a combustion process in a conventional steam turbine or CCGT power plant. This is done with pure oxygen as an oxidiser. Mostly CO_2 and water vapour are produced in the exhaust or flue gases, and CO_2 can be easily separated by condensing the water vapor.

The captured CO_2 can be stored in geological formations like oil and gas fields, as well as in aquifers, but the feasibility and proof of permanent CO_2 storage are critical to the success of de-carbonization.[11]

Biomass to Hydrogen:

Biomass has great potential to produce hydrogen while some CO2 emissions. This hydrogen can be produced from biomass in several ways, such as gasification (to produce CO2 and H2), and this hydrogen requires a purification process. There are several stations in the world that operate with biomass gasification, dedicated to producing hydrogen by mass photolysis and the use of some microalgae or some bacteria. And microorganisms by analyzing organic compounds produced by bacteria. Where hydrogen is used or transported through a network of pipes. Scientists and developers are striving to make an effort in this field in order to reach an advanced and acceptable level in producing hydrogen from biomass.

In biomass conversion processes, a hydrogen-containing gas is normally produced in a manner similar to the gasification of coal, as in equation…Biomass gasification is an R&D area shared between H2 production and biofuels production. Gasification and pyrolysis are considered the most promising medium-term technologies for the commercialization of H2 production from biomass. A typical flow sheet for the production of hydrogen from biomass is presented inFigure4. In terms of its energy requirements, the drying of biomass might not be justifiable; therefore, other pathways based on wet biomass are being sought as well. Biomass feedstocks are unrefined products with inconsistent quality and poor-quality control. The production methods vary according to crop type, location and climatic variations. [2]

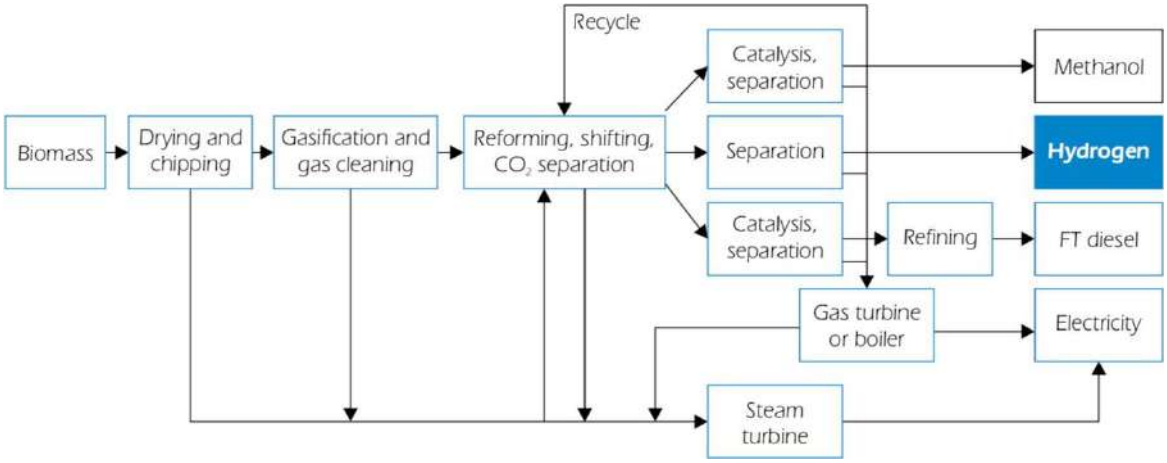

Figure (1.6) Generic flow sheet for methanol, hydrogen or diesel production via biomass gasification. [2]

Several developments are needed to improve the economics of production processes and the logistics of handling a biomass feedstock:

- Feed preparation and identifying the characteristics of feedstocks that will allow the technologies to develop.
- Gasification of biomass. This is not specific for hydrogen, but relates to general biomass and renewables pathways and research.
- Raw gas handling and clean-up.
- Interface issues and system integration. One should also investigate the relationship between the production scale and the fuel quality requirements and tolerances that can be accommodated for the respective technologies.[2]

From nuclear energy

This energy is characterized by the consumption of little electricity, which requires an increase in heat flows. In recent years, researchers have studied the so-called nuclear reaction, meaning that hydrogen can be produced without producing any emissions that affect global warming. The production of hydrogen by electrolysis is subject to poor performance, but it can be A solution that must be applied while thinking about other solutions that are more important in the long term, such as the electrolysis of water, but not in the traditional way. This reaction requires a temperature of about 850 degrees Celsius in addition to electricity, and its reserve is usually limited, so nuclear energy must be studied from However, nuclear technology must be developed in the future.[12] As the following figure shows:

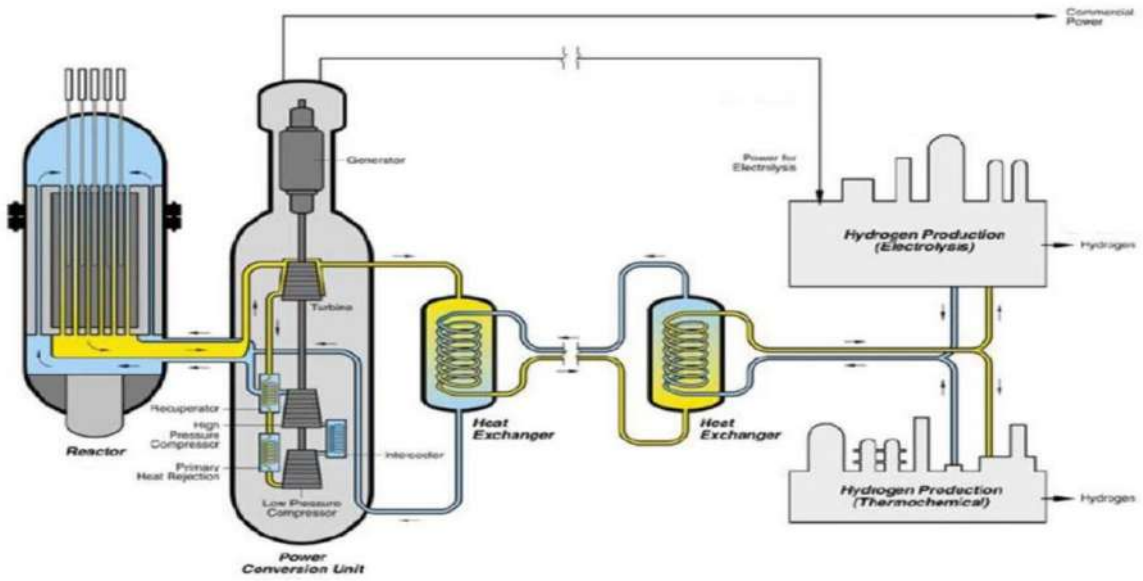

Figure (1.7): shows the method of producing hydrogen with nuclear energy.

Thermal method

This method is used to produce hydrogen by thermal decomposition of water. This is done in two ways:

- We expose water to high temperatures exceeding 2500 degrees Celsius, and the water disintegrates into oxygen and hydrogen. To ensure the production of a significant percentage of hydrogen requires a high temperature, in addition to providing materials that can withstand this temperature, and this process is mostly undesirable, and it is expensive and not easy, as the following figure shows:

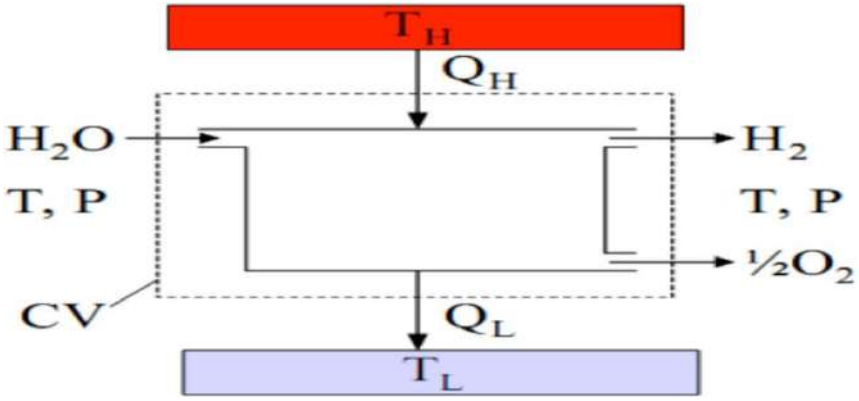

Figure (1.8): shows the method of producing hydrogen with Thermal method**.2**

We heat the water at a temperature of about 5000 degrees Celsius using the plasma arc process, so the water disintegrates into the products: H_2O, OH, O_2, O, H_2, H. The percentage of hydrogen production from the mixture is estimated at about 50% of its volume, and this process is considered very expensive. Compared to other methods of producing hydrogen.[12]

HYDROGEN FROM SPLITTING OF WATER

Water electrolysis

The electrolysis of water is a process in which water is separated into two elements, oxygen and hydrogen, using electricity, as the total energy required for the electrolysis of water increases slightly with temperature, which leads to a decrease in the electrical energy required, and it is a unit called an electrolysis device. The electrolyte is an electrical cell consisting of two different electrodes (anode and cathode) connected to the medium. The water that is analyzed must be as pure as possible because impurities remain in the device and accumulate over the course of the electrolysis.[8]

- As for the anode: it is the one in which oxidation occurs and it is also called the anode.
- As for the cathode: it is the one where the return process occurs and it is also called the cathode electrode.

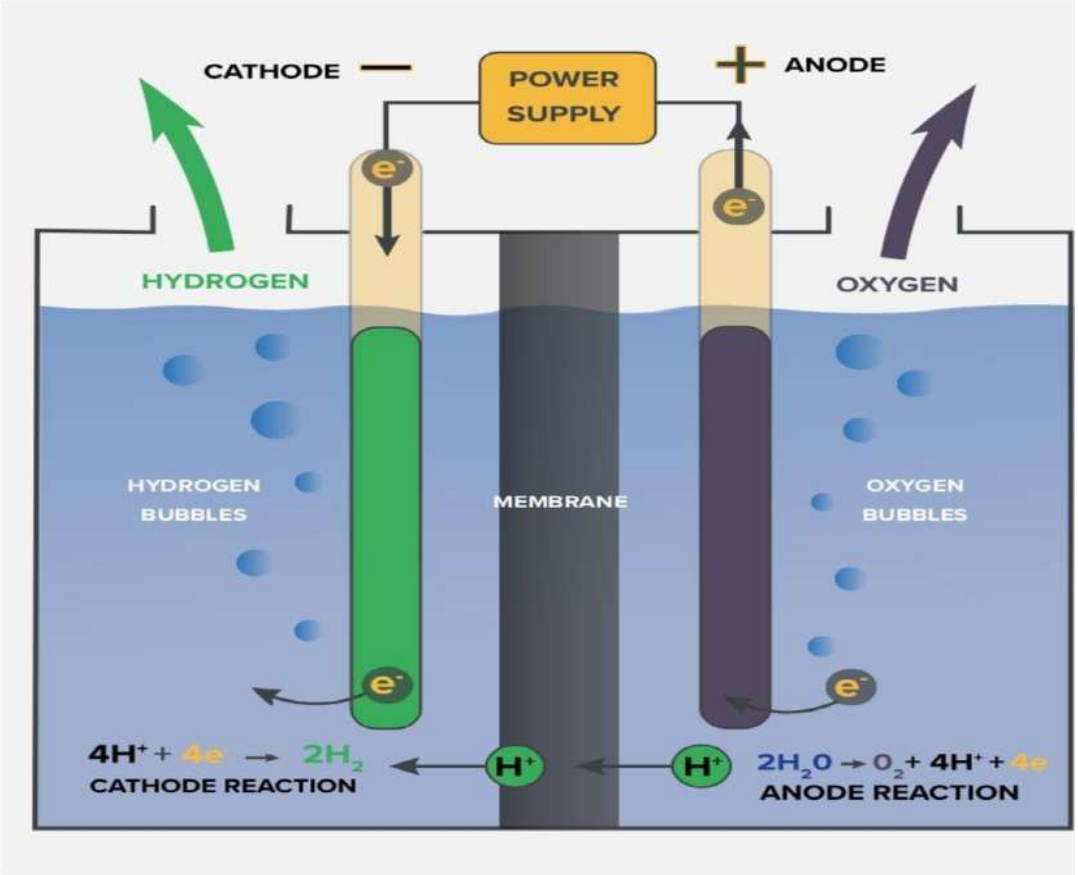

Figure (1.9): Electrolysis reaction, productivity, and efficiency

The electrodes of this electrical cell are often inert, as they work to increase the path of electrons as they combine hydrogen ions with electrons at the cathode to form hydrogen gas.[9]

The production of hydrogen using the method of electrolysis of water is considered one of the most important and best methods for producing hydrogen. This is due to several advantages that characterize this method, among which we mention that it is the most common method for producing hydrogen in the world and that it does not produce any pollutants or any emissions, and it is also characterized by its relatively low cost. The method of producing hydrogen through electrolysis of water can be explained with the following chemical equations:

H_2O + electrsity energy $\rightarrow$ H_2 + 1/2 O_2

Equations occurring inside the electrolysis cell:

- Electrolysis of water: $4H_2O \rightarrow 4H^+ + 4OH^-$
- Anode: $4OH^- \rightarrow O_2 + 2H_2O + 4e$
- Cathode: $4H^+ + 4e \rightarrow 2H_2$
- The sum of the cathode and anode processes: $2H_2O \rightarrow 2H_2 + O_2$

The following picture shows the principle of producing hydrogen through the electrolysis of water, where water is separated into two compounds, hydrogen and oxygen

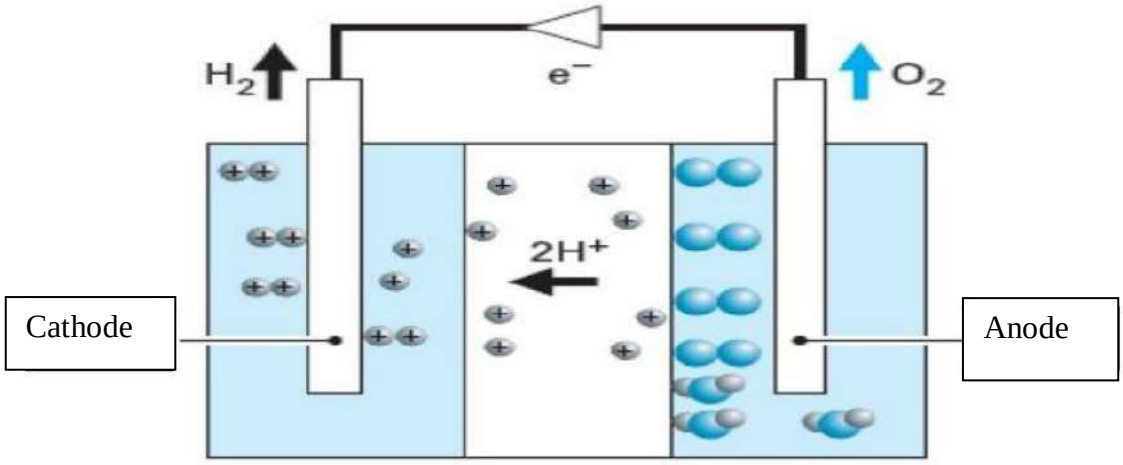

Figure (1.10): A drawing showing a water electrolysis cell

In addition to this cell, there may be a need for other subsystems in the electrolysis process, such as cooling systems and power extensions. There may also be a need for an external compressor in order to transfer the hydrogen to the required pressure. This installation generally consists of several devices. Electronics connected in series and parallel [8]

7.6.2Alkaline Electrolysis

This technology is considered the oldest and most widely used, and therefore it is valid. It is carried out using an aqueous solution of potassium hydroxide, which varies in concentration

and temperature. This solution is preferred because it is considered essential in the conduction of ions and improves the control of chlorides and sulfate impurities.[13]

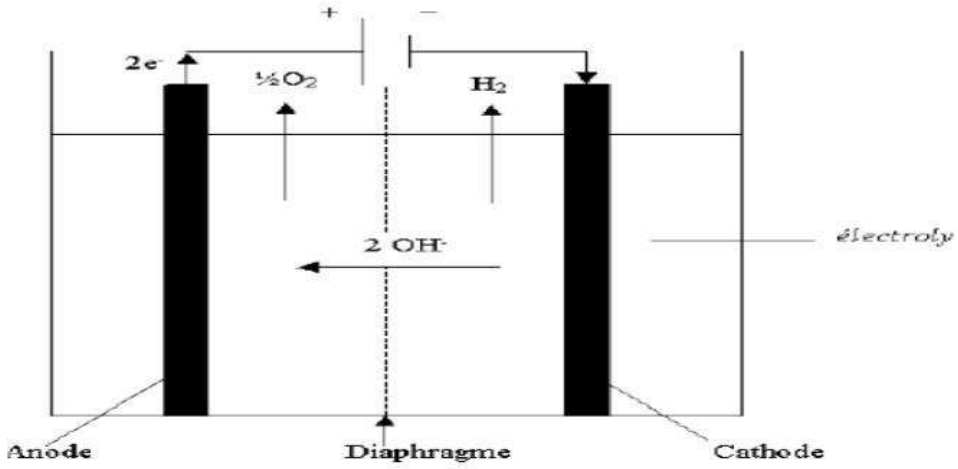

Figure (1.11): A diagram showing the analysis of alkaline electrophoresis.[14]

Acid electrophoresis analysis

This type of electrolysis involves a proton-permeable membrane. This membrane usually consists of pure sulfuric acid polymers, whose electrodes work to stimulate metals that facilitate their penetration. The analysis of water into oxygen and the electrons and protons takes place at the anode, where the protons migrate through the membrane to the cathode, where It is reduced to hydrogen molecules, where the electrons migrate through the external circuit to the cathode. This technology is considered successful, and this process can be performed at atmospheric pressure. This is considered a type of electrolysis as a source of renewable energy, and it is better than alkaline electrolysis, as we notice a difference in Electrical energy In addition, electrolysis is the best way to produce hydrogen..[15]

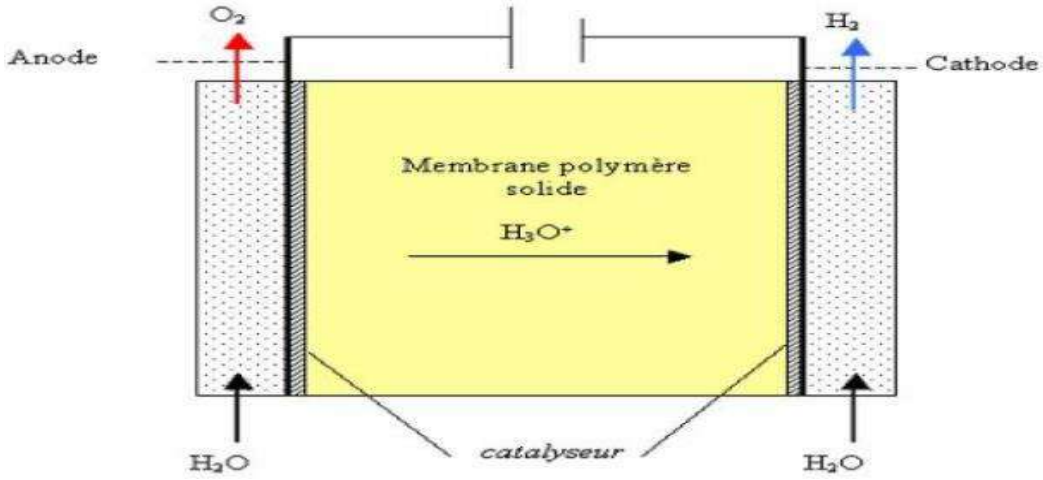

Figure (1.12): A diagram showing the analysis of acid.[14]

High Temperature Electrolysis

This technology is a result of the development of fuel cells, and most importantly, it provides electricity and heat in order to maintain the required high temperature, as this type of electrolysis aims to compare it to a solar system or a nuclear reactor with high temperatures.

This technology is considered similar to alkaline electrolysis, but it uses water vapor instead of liquid water, as this method is currently studying the production of hydrogen with oxygen as a by-product, and in the future, it may be more effective than water electrolysis, because some of the energy required for the reaction can be saved. Heat is less expensive than electricity and more efficient.

It is not possible to compare with hydrocarbon chemical conversions, as these reactions depend not only on their efficiency, but also taking into account the amount of emissions. Therefore, all thermal energy sources are not chemical CO2, including geothermal energy sources, nuclear reactors, and solar collectors [16]

Photometric analysis of water

Photolysis of water is a method in which water is analyzed with the electricity resulting from a photocatalystwith semiconductors, as the photovoltaic cells are immersed in water and exposed to sunlight, whereby water is analyzed into oxygen and hydrogen only. This can be done with photovoltaic or photoelectric devices, and there are four stages. Main features of this method:

- The painting must be exposed to sunlight.
- The oxidation process takes place at the anode to produce oxygen molecules.
- Hydrogen ions and electrons move from the anode to the cathode.
- Hydrogen ions decrease to form hydrogen molecules at the cathode

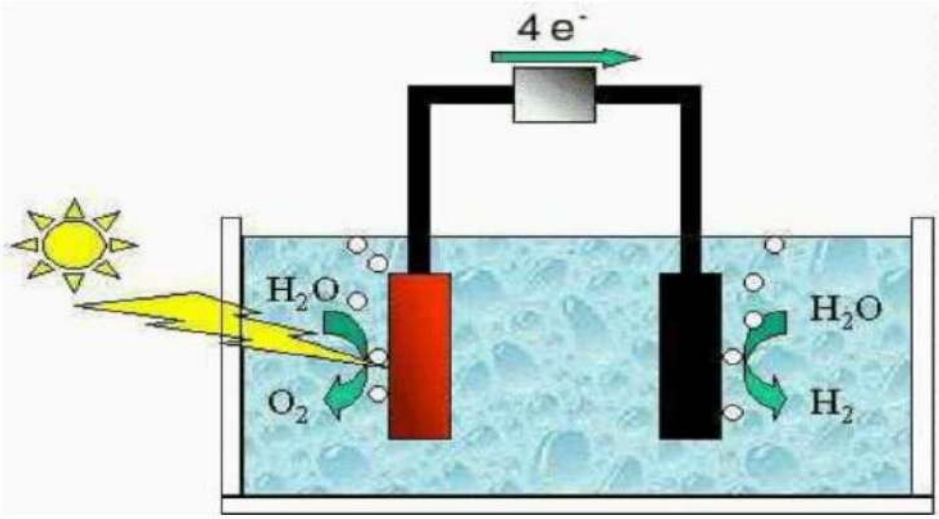

Figure (1.13): A diagram showing the photometric analysis of water.

The benefits of this method are the direct production of hydrogen, and the costs of this method are considered to potentially increase in terms of general efficiency. Finally, the most important technological barrier in this method is completed in the semiconductor industry, and on the other hand, it is capable of absorbing solar photons.[16] [17]

8. Green hydrogen

What is the Green hydrogen?

hydrogen created from renewable energy sources such as solar, wind, hydropower, biomass, biogas, and municipal waste. [4]

Green hydrogen is produced through the electrolysis of water in an electrolyzer, powered by electricity produced from renewable sources such as hydro, wind or solar. Provided that the inputs of electricity only come from renewable energy sources (and if desalinated water needed, powered 100% by solar and wind), the green hydrogen emissions during the production process are equal to zero. [5]

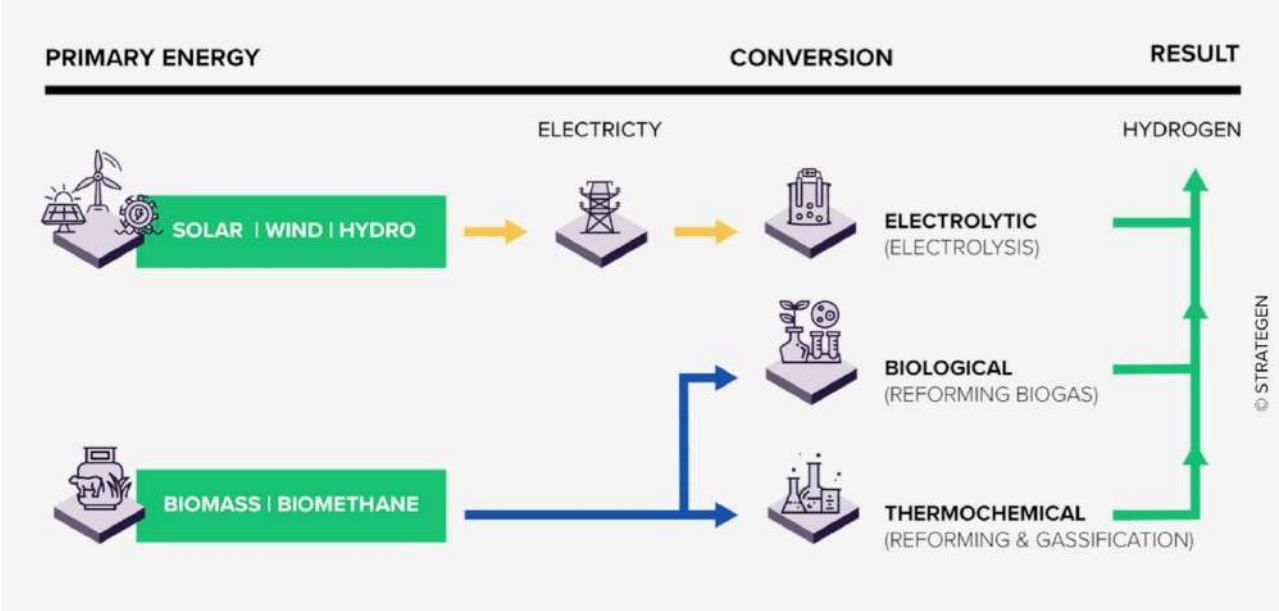

Figure (1.14): Illustration of how green hydrogen is produced [4]

Advantages and disadvantages of Green hydrogen

Green hydrogen has several advantages that may develop in the future, as well as several disadvantages that are currently being studied in order to find solutions to reduce or eliminate them. Among the advantages and disadvantages we mention the following:

Advantagesof Green hydrogen

- Sustainability: Green hydrogen gas is a renewable energy, so as long as there is renewable energy such as wind or solar energy, we have the opportunity to produce this gas, meaning it is a sustainable source.
- A source of clean energy: Green hydrogen does not emit polluting gases either during combustion or during production.
- Storability: Green hydrogen is easy to store, and this contributes to giving us opportunities to use it later for other purposes and at any time.
- Great usability: Green hydrogen can be converted into electricity or synthetic gas and used for domestic, commercial, industrial or mobility purposes.

disadvantagesof Green hydrogen

- The problem of high energy consumption: The production of green hydrogen requires more energy than other types of fuel, especially electrical energy.
- Occupational safety and security: Hydrogen is considered a highly dangerous element and has a high flammability. Therefore, comprehensive occupational safety and security measures must be taken to prevent leakages, explosions, and fires that may be caused by the production or use of green hydrogen gas.
- Production cost: Green hydrogen production suffers from the problem of high production costs compared to the cost of producing other gases.

Hydrogen production by exploiting renewable energy sources

There are several methods for producing hydrogen that are characterized by high efficiency and productivity. One of these methods for producing hydrogen is a method of electrolysis of water using electrical energy produced from renewable energies such as wind and solar energy, which are considered among the most important sources of renewable energies currently exploited in the hydrogen production industry, which in this case is called with green hydrogen

From wind energy

This wind system can produce electricity and exploit surplus electrical energy to produce hydrogen by electrolyzing water. This source is considered environmentally friendly and an alternative energy source as it does not produce any emissions or any polluting gases. The following figure shows a symbolic diagram which It is called the "wind-hydrogen system."[18]

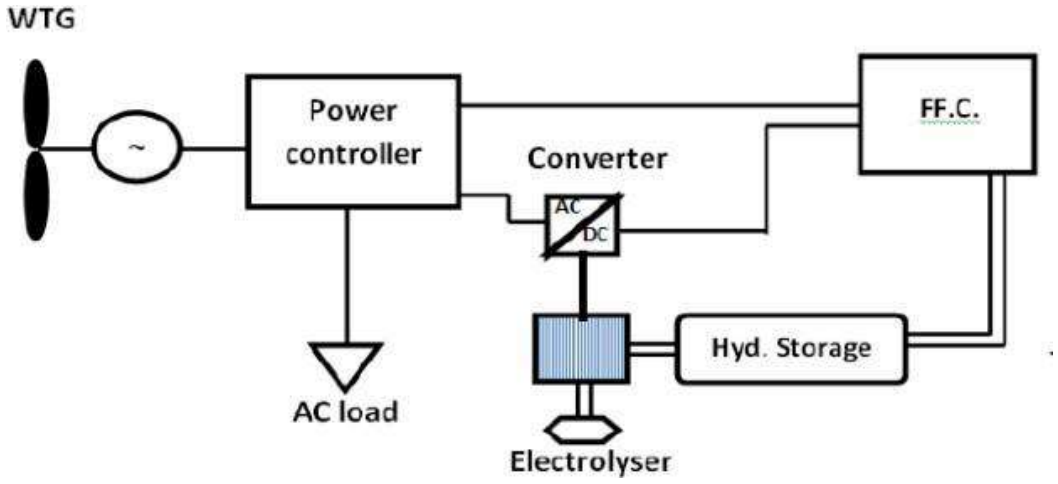

Figure (1.15): Symbolic diagram of the wind-hydrogen system

From solar energy

Water electrolysis is considered one of the most common methods for producing hydrogen. We exploit and use solar energy in the electrolysis process, and it is one of the most cost-effective methods and the most environmentally friendly. This method is considered one of the simplest methods for producing hydrogen, as this method includes: Several stages, including [19]

- Photovoltaic module: It is a panel consisting of photovoltaic materials that convert solar energy into electrical energy. In general, these materials are conductors or semiconductor compounds.
- Air conditioning system: What is meant by this system is the form of the signal emanating from the optical unit

- Electrolysis system: It is a group of cells consisting of two electrodes and immersed in the electrolyte solution and connected to the power supply, where we add a conducting chemical to the water.

Energy can be provided to operate these systems either by means of a photovoltaic unit or by means of additional energy, and this additional energy can be traditional or be either wind energy or geothermal energy.

Green Hydrogen Safety

Hydrogen is a safe, non-toxic, and reliable fuel with 70 million tons produced and consumed each year around the world. From a safety perspective, a molecule of "green" hydrogen is indistinguishable from normal hydrogen, and can be treated simply as hydrogen gas (H2). [4]

Safety benefits of hydrogen as a fuel source

- Hydrogen is a non-toxic, colorless, and odorless gas that does not threaten human or environ- mental health if released into the environment
- Hydrogen is much lighter than air (14x lighter) and about 57x lighter than gasoline vapor, so
- it dissipates rapidly when it is released. This allows for rapid dispersal of the fuel in the case of a leak.
- Hydrogen combustion is more rapid than com- bastion of other fuels. A hydrogen cloud will burn within seconds, and all the energy of the cloud will be released.
- Safety features are designed and engineered into hydrogen systems and managed by govern- ments as well as regulated in accordance with expert third-party international hydrogen safety standards. [4]

The Role of Hydrogen in the Global Energy Transition

The main trends of the energy transition are the accelerated deployment of emission-free technologies, the digitalization of energy processes and the decentralization/democratization made possible by RE. What role can hydrogen play in the interdependent energy transition of the global economy? Green hydrogen is the missing link to the decarbonization of all sectors. Hydrogen has the potential to become the fuel molecule that powers a clean global economy. It can be used as a substitute for fossil fuels as clean industrial feedstock in a large variety of applications – from heavy transport to steelmaking – and produces no pollution at the point of consumption. Being a CO2-free energy carrier, H2 is clean, sustainable and flexible: it can be transported over long distances and it has high energy when compressed or liquefied; it produces clean power and fuel and it has safety similar to natural gas or petroleum. Hydrogen is expected to meet from 24% of the world energy needs by 2050 with an annual sale of H2 worth of USD 700 billion and billions more in sales of end- use equipment. More bullish and very recent estimates foresee an addressable global market of up to USD 11.7trillion. [5]

9.Hydrogen storage

One of the biggest challenges facing the hydrogen industry (especially green hydrogen) is the process of storing this hydrogen. Several research projects have emerged to invent new methods for storing hydrogen. The current methods for storing this important gas can be divided as follows

Storing hydrogen as a gas

The method of storing H2 in the form of gas is considered one of the simplest and most common technologies. This process is carried out inside tanks, containers and gas cylinders. Light-weight composite tanks have been developed to withstand pressures of up to about 850 bar, and the maximum filling pressure has been achieved. Containers are about 1094 bar, as there are other ways to store hydrogen as a gas, such as refrigerant gas, where gaseous hydrogen is cooled at low temperatures, which improves the energy density of the gas. [20] In short, this method depends on the pressure of hydrogen gas

Hydrogen pressure

The process of compressing hydrogen is similar to the process of compressing any gas, and hydrogen is usually compressed at a pressure of about (25-200) bar, and this is in the case of storing it in cylindrical tanks with small capacities within the limits. However, if hydrogen is used in a wide range, it is compressed under 50l high pressures and It is stored in thick-walled tanks, most of which are in cylindrical shape. Carbon or aluminum composite tanks are considered one of the most effective technologies, as these tanks are able to withstand high pressures of approximately 700 bar[21]

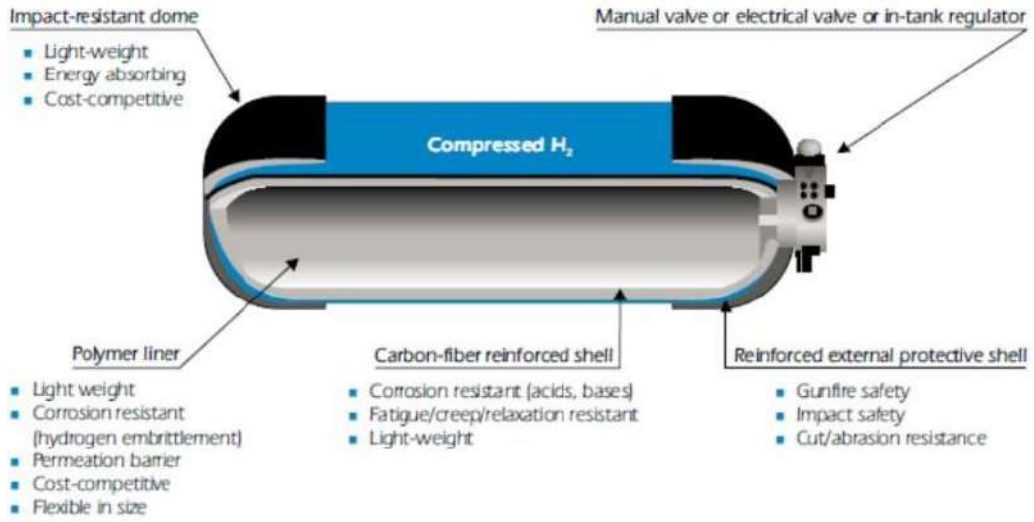

Figure (1.16): shows a model of a composite tank for storing hydrogen gas under pressure

Storing hydrogen in liquid form

The second most widely used storage method after compressed gas is to store hydrogen as a liquid. Hydrogen can also be stored in the form of a cryogenic liquid at a temperature below zero (-253). or it is stored as a component in other liquids such as solutions ($NABH_4$) or organic liquids 58. So, this method depends on the gas temperature, that is, it depends on the process of cooling the gas [22]

Liquid hydrogen cooling

Hydrogen is stored in refrigeration vessels, also known as chillers. These vessels are double-walled with insulation between the walls. This insulation is important in order to reduce heat flow. Liquid nitrogen is also used as an inert to further reduce heat transfer. This liquid hydrogen is characterized by a high storage density at relatively low pressures, in addition to that its stored energy is much better than compressed hydrogen, but a large amount of energy is needed in the liquefaction process, as this energy required for liquefaction is estimated, while 10 kwh/kg[23]

10. Uses of hydrogen

The use of hydrogen is considered an important issue in implementing sustainable development policy, as it can be the link between different types of energy and it can also be an alternative to diesel fuel or an alternative to natural gas. Hence, the combustion of hydrogen in engines or its use in fuel cells does not lead to any Polluting gas emissions.[24]
Hydrogen can be used in internal combustion engines and fuel cell vehicles, and it can also be an effective way to store energy from renewable sources, as the sub-uses of hydrogen today depend on: [25]

- Chemical industry: It is used in large quantities in the production of ammonia, which is considered the raw material in the fertilizer industry.
- Food and pharmaceutical industry: in the hydrogenation of oils, fats, cosmetics, and others.
- Petrochemical industry: oil refining, methanol production, etc.
- Electronic industry: production of semiconductors, optical fibers, etc.
- It has a higher thermal conductivity ability than any other gas.
- It is used in rocket fuel.
- It is used to cool electric generators, where hydrogen is used as a high-performance cooling medium.
- It is used in nuclear reactors as nuclear fuel.
- It is used to generate thermal energy by direct burning in thermal stations.
- It is used to generate electrical energy using fuel cells, which is a modern technology

The consumed percentage of hydrogen produced globally is currently estimated at approximately 50% in ammonia production, 37% in oil refining, 8%in methanol production, and the rest in other uses. [8]

11. The Hydrogen Economy

Hydrogen economy, synonymous with sustainable energy, refers to the situation where the whole energy system of a country is solely based on hydrogen. It can also be defined as an economy in which hydrogen is the primary energy carrier along with electricity. Hydrogen has great technical, economical, and societal appeal as a viable solution to decarbonize economies by the year 2030. The eventual successful outcome of a hydrogen economy is contingent on the general public. The hydrogen economy being accepted by the world market is not only dependent on its commercial and practical viability but also on the safety in widespread usage. The realization and development of hydrogen-based economies have been difficult and challenging tasks due to the substantial investments needed. Hydrogen has always had the potential to be significant, but the challenges of establishing hydrogen economies all over the world have hindered progress. This is mainly because the production, storage, transportation, distribution, and utilization sectors in the hydrogen economy all have challenges that need to be addressed while maintaining strategic policy support. In the transportation sector, for example, the debate over whether hydrogen fuel cell vehicles or hydrogen refueling infrastructure should come first has stymied progress toward using hydrogen as a transportation fuel. The transition to using hydrogen as the primary fuel in global economies will fundamentally change energy systems all over the world while reducing atmospheric greenhouse gas emissions. Hydrogen's sustainability, cleanliness, and versatility support a smooth transition to the hydrogen economy from the current global economy dominated by fossil fuels.[26]

12. Conclusion

In this chapter, we provided an explanation of hydrogen gas, which is considered one of the most important gases used in the world. This is due to the large energy it stores and the ability to be used in several fields, and that it is an environmentally friendly gas in that it does not emit carbon emissions during its use. In this chapter, we also touched on methods for producing hydrogen, with a focus on the method of producing green hydrogen using the process of electrolysis of water using electrical energy produced from renewable sources such as wind and solar energy. We also mentioned in this chapter methods for storing and using hydrogen in the world.

We have come to the conclusion that hydrogen gas is one of the most important clean energy sources in the world and has several advantages and uses and can compete with traditional energy sources in the near future.

Chapter 02:

Security and safety system in industrial facilities

Chapter 2: Security and safety system in industrial facilities

1. Introduction

Among the most important things that are of great importance and interest to companies and facilities is the efficiency of the occupational security and safety system, as it is one of the pillars of building a strong company or industrial facility characterized by continuity, as this system guarantees the safety of companies and facility workers and their partners and also guarantees the safety of production and work equipment, which is sometimes estimated at millions of dollars.

The occupational security and safety system varies from one company to another depending on the activity of that company and its policy. The occupational security and safety system consist of several elements and related systems aimed at ensuring the security of the workers and equipment of the company and the facility and ensuring the protection of the environment. In this chapter, we will address an explanation of the occupational security and safety system for companies and establishments, with an explanation of the components of this system, which is of great importance to all companies and industrial establishments.

2. Basic concepts

Safety and security system

The safety and security system are a group of systems, equipment (machines), methods and means that relate and unite together in order to achieve and provide occupational safety and security in companies and establishments. It also aims to attempt to remove or reduce dangers in order to provide a suitable working environment for workers and industrial machines.

The set of these systems varies from one company and company to another depending on the activity, policy and capabilities of the company, and these systems are considered complementary to each other. For example, about these systems that constitute the occupational security and safety system, we mention a danger study and an impact study, a Safety Integrity Level system, and a detection and extinction system.

Industrial safety

Industrial Safety is a multi-disciplinary approach to developing and ensuring compliance with regulatory agencies, safe working practices, and maintaining the health and well-being of those employed in a particular occupation or workplace. Strategies to accomplish these goals maintain a strong focus on injury prevention through hazard identification, prevention and controls; education and training; audits and inspections; engineering modifications, and enforcement. And industrial safety depends primarily on risk assessment and control. and the use of occupational accident statistics is one of the most important aspects of industrial safety to better understand the sectors most affected by accidents, in order to take safety precautions, especially in the industrial field. [27]

Chapter 2:Security and safety system

Industrial Safety is measures or techniques implemented to reduce the risk of injury, loss and danger to persons, property or the environment in any facility or place involving the manufacturing, producing and processing of goods or merchandise.[28]

Industrial hazard

Industrial hazard may be defined as any condition produced by industries that may cause injury or death to personnel or loss of product or property.[29]

Occupational safety and health

Occupational safety and health (OSH) are generally defined as the science of the anticipation, recognition, evaluation and control of hazards arising in or from the workplace that could impair the health and well-being of workers, taking into account the possible impact on the surrounding communities and the general environment. This domain is necessarily vast, encompassing a large number of disciplines and numerous workplace and environmental hazards. A wide range of structures, skills, knowledge and analytical capacities are needed to coordinate and implement all of the "building blocks" that make up national OSH systems so that protection is extended to both workers and the environment. [30]

Danger

A danger is defined as a chemical or physical condition that has the potential to harm people, facilities or the environment. Danger is a situation which has, in itself, a certain potential to cause damage to people and property [31]

Risk

Risk Probability that the potential for harm is reached under the conditions of use and/or exposure. [32]

risk is when there is the possibility of a (risk) event, where the consequences are quantitively known. What industry does is to manage the risks by implementing risk mitigation strategies. These strategies reduce the likelihood of an event occurring[33]

Industrial accidents

Industrial accidents are technological accidents that take place during industrial processes, most often within the confines of factories. It is well known that industries implement on a large scale a host of dangerous products and processes presenting risks of accident and illness. [34]

Risk assessment

Risk assessments are part of the risk management process and are included in the Management of Health and Safety at Work Regulations. A risk assessment is the process of identifying what hazards currently exist or may appear in the workplace. A risk assessment defines which workplace hazards are likely to cause harm to employees and visitors.[35]

Classified installation

Classified installation: any fixed technical unit in which one or more activities appear in the nomenclature of classified installations as set by the regulations in force[36]

classified establishment

Classified establishment: the entire area containing one or more classified installations and which is the responsibility of a natural or legal person, public or private, who owns, operates or causes to be operated the establishment and the classified installations which fall under it.[36]

A classified establishment is considered to be: any industrial, commercial or artisanal establishment or installation, public or private, any activity or related activity and any process, which may present causes of danger or disadvantages with regard to the protection of safety, the health or convenience of the public, the neighborhood or the staff of these establishments, the health and safety of workers as well as the human and natural environment. [37]

3. The security and safety system objectives

The occupational security and safety system consist of a group of systems, and therefore the objectives of this system are the set of objectives of those systems that constitute it, which differ from one activity to another and from one company to another, but in general the objectives of the occupational security and safety system can be summarized in the following points:

- **Providing protection:** Ensuring the necessary protection for all workers and industrial equipment and reducing risk factors in all stages of the industrial facility's operation while providing integrated protection for the environment.
- **Occupational disease problems:** The occupational safety and security system works to reduce the incidence of occupational diseases by providing safe and appropriate working conditions.
- **Reducing the risk of injuries and accidents at work.**
- **Providing complete and continuous prevention:** such as preventing and combating fires and other danger elements, and working to develop modern preventive methods.

- **Efficiency and productivity**: Helping to increase the levels of work efficiency and production in the company and the worker who feels safe and secure in his work provides better and more to his company.
- **Quality:** The occupational security and safety system allows for a work environment that encourages creativity and improves the quality of work that the company has achieved by using modern technologies to increase the efficiency of productive hands while ensuring their protection and safety.
- **Professional training and culture:** by ensuring good and continuous training for workers to work in safety while involving them in the occupational security and safety system.

Note: It should be noted that the elements and components of the security and safety system applied by industrial institutions vary from one institution to another, and this is due to the institution's policy and its view towards security and safety. The elements and components of

the security and safety system are many and different, and in this chapter we have limited ourselves to only the most important elements, which are the basis of any security and safety system Industrial.

4. Environmental Impact Study and Hazard Study

Before starting the completion of any project or industrial facilities that fall within the classification of classified establishments or Classified installation, the employer or the entity concerned with this facility must submit and provide a hazard study(HS) along with Environmental Impact Study(EIS)for the project.

The study of hazard and the study of the impact is one of the main components of the occupational security and safety system in establishments. This is due to the great importance that these studies carry in the field of occupational safety, as they provide information about the effects and damages that may result from the project or industrial establishments on workers or the environment.

The impact studies :

The impact study is a mandatory document stipulated by law, and the project cannot be started without it. This is because of its great importance, as it is one of the foundations for achieving a strong system of occupational security and safety. This study is submitted to the relevant authorities for evaluation and approval is given to the project owner to start his project if all the environmental guarantees contained in this study are met.

What is the impact study?

An environmental impact study (EIS) is a process that, at the beginning of planning, identifies and assesses the risks of environmental impacts arising from the planned project. The impact study identifies measures that can be adopted to address negative environmental impacts or reduce them to acceptable levels in advance. Therefore, the impact study represents a proactive and preventive approach to managing and protecting the environment. [38]

What is the environmental impact assessment?

Environmental impact assessment is a procedure that allows us to learn about the foreseeable impacts that a project will have on the environment. It is a preventive tool which aims to protect the environment and which is part of a sustainable development approach. The environmental impact assessment aims to help promoters understand and evaluate the impacts of their project and to promote its integration into its environment.[39]

The content of the impact study

- Presentation of the project promoter, the name or company name as well as, where applicable, their company, their possible experience in the area of the planned project and in other areas;
- Presentation of the design office;
- Analysis of possible alternatives of the different project options by explaining and basing the choices made in economic, technological and environmental terms;
- Delimitation of the study area.
- Detailed description of the initial state of the site and its environment, particularly its natural resources, its biodiversity, as well as the land, maritime or hydraulic spaces likely to be affected by the project
- Detailed description of the different phases of the project, in particular the construction phase, the operation phase and the post-operation phase (dismantling of the installations and restoration of the premises);
- Estimation of the categories and quantities of residues, emissions and nuisances likely to be generated during the different phases of project implementation and operation (in particular waste, heat, noise, radiation, vibrations, odors, smoke.).
- Evaluation of the foreseeable direct and indirect-, short-, medium- and long-term impacts of the project on the environment (air, water, soil, biological environment, health, etc.)
- Cumulative effects that may be generated during the different phases of the project;
- Description of the measures envisaged by the promoter to eliminate, reduce and/or compensate for the harmful consequences of the different phases of the project;
- Environmental management plan which is a monitoring program for mitigation and/or compensation measures implemented by the promoter;
- Financial impacts allocated to the recommended measures.[39]

Objectives of the impact study

The great importance of an impact study is due to the set of objectives it achieves. These objectives include the following:

- **The relationship of the project to the environment**: The impact study provides a detailed look at the relationship of the facility and the industrial company with the environment, so that it presents all the positive or negative impacts that the project may cause.
- **The nature of the impacts:** The impact study provides a clear picture of the impacts resulting from industrial facilities, allowing us to reach solutions to protect our environment.
- **The relationship of the project's impacts with the industrial area**: Often the impact of industrial facilities collides with the impact of another facility, which may cause an environmental disaster. Therefore, an impact study allows organizing the locations of companies according to their impact on each other.
- **Means of protecting the environment**: After analyzing the types of impacts emanating from industrial facilities, which were presented to us through an impact

study, and from it we can suggest the best means of protection in order to preserve the environment.

- **Environmental statistics:** The total statistics for impact studies provide us with a general overview of the rate of pollution and the rate of progress in protecting the environment in all parts of the country, and from it we can determine the best environmental policy.

Procedures for approval of impact studies

- Submission of the file to the Wilaya Environment Directorate.
- Examination and establishment of the decision to take into consideration
- Opening of the public inquiry.
- Establishment of approval or rejection of the impact notice by the wali.
- Transmission of the impact study file to the ministry.
- Establishment of approval of the impact study.[39]

Note: An impact study is often associated with environmental audit, which is one of the foundations for building a strong system for occupational security and safety. In the following element, we will provide an overview of environmental audit as a serving element for the efficiency of the impact study.

Environmental audit

What is the environmental audit?

The environmental audit is a planning tool that has been used to optimize the integration of the company into its environment. It aims to identify, describe and evaluate the effects of the company on the environment in the broad sense, that is to say on the physical, biological and human components of this environment. As it makes it possible to integrate environmental considerations into the various production operations and makes it possible to develop the necessary mitigation measures to minimize the negative effects of any production operation and optimize its positive impacts.[39]

The objectives of environmental audit

- Comply with environmental legislation and regulations.
- Carry out a self-assessment of the state of the environment in the company.
- Propose measures aimed at reducing possible nuisances generated by the company's various installations
- Saving raw materials, energy and water resources.[39]

Environmental audit process

1. Preparation

• Human resources.

• Technical and material resources.

• Logistical resources.

2. Realization

• Document review:

- Verification of the management system and environmental management.

- Critical review of procedures, forms and environmental policy.

- Assessment of regulatory compliance: regulatory monitoring and

application of regulatory texts.

• Interview with managers and on-site staff.

• Site inspection: throughout the life cycle of products from raw material to finished product and waste.

- Production facilities and equipment even oil wells.

- Workshops and work premises.

- Stores and storage location for products.

- Waste storage areas.

- Quagmires.

- Flares and sources of atmospheric emissions.

- Sources of emission of discharges onto the ground.

- Emission sources of liquid discharges.

- Others.

• Companion to measurements and analyzes of discharges

- Analysis of liquid discharges.

- Analysis of discharges onto the ground.

- Measurements of atmospheric emissions.

3. Report

• Drafting of the report according to the requirements of regulatory texts.

• Writing non-technical summary and action plan.

4. Tracking

Environmental audit approval procedures

- Examination of the environmental audit at the level of the environmental department or at the level of the Ministry of the Environment.
- Approval of the audit by the wail or by the Minister of the Environment.[39]

Hazard Study

What is the hazard study?

The hazard study is required when submitting an operating authorization application file. It is also at the heart of any risk management approach. An in-depth knowledge of the dangers linked to the activity and its environment allows the reduction of risks at source, through the use of the safest technologies and the implementation of appropriate safety measures and the information of the authorities concerned. Knowledge of risks allows responsible authorities to judge the environmental acceptability of the company by considering safety and the proposed management measures.[39]

What is the Accident scenario?

An accident scenario is the schematization of the sequence of a set of events leading to the occurrence of an accident. The different sequences and logical links in this sequence arise from the risk analysis procedure. Overall, the description of several scenarios can lead to the same accident.

Objectives of the hazard study

The set of objectives of the hazard study includes the following:

- Giving a clear and complete overview of all the hazard (the dangers) that may be caused by industrial facilities
- Determine the best means of industrial security and the best means and systems for protecting workers and industrial equipment
- Providing a complete picture of major accident scenarios, including providing measures and precautions so that these major accidents will not be repeated (such as an explosion accident and a huge fire accident)
- providing a very knowledgeable and organized intervention plan in order to protect workers and the environment and reduce accident damage as much as possible
- Explaining all means of security and safety and clarifying the necessary procedures to be taken before and after the accident for the owner of the industrial facility and for his workers.

The importance of the Hazard Study

A hazard study (HS) is essential for industries presenting a high risk, it allows:

- Identify the targets and issues linked to the site integrating the operation (urban area, drinking water supply catchments, etc.).
- Identify internal and external sources of aggression;
- Reduce risks and evaluate the performance of safety barriers;
- Choose the actions best suited to your site, particularly economically;
- Control identified Hzarde.
- Manage accidental and incidental situations (internal intervention plan IIP).

- Preventively, inform the local public of the actions to take in the event of an alert/accident.[40]

Stages of the Hazard Study

- ❖ The dangerous phenomena associated with the industrial activity of the studied industrial facility must first be identified and known. to do this, the body responsible for studying the risk must provide a description of the installation and its environment, in addition to the products used.
- ❖ Explaining the sources of various risks in all their details, whether they are internal, such as a specific process or activity, or external, such as natural risks in general, such as earthquake risks.
- ❖ evaluation the likelihood of risks and accidents occurring and their seriousness, as well as the size of the areas that could be affected if these accidents occur.
- ❖ Establishing the most important and best industrial safety and security technologies available to reduce these risks from the source, if possible, with the commitment of industrial facilities and companies to implement them.
- ❖ Develop methods and an emergency plan, which will be implemented in the event of an accident and the event failure of preventive safety means.

Hazard study approval procedures

- ❖ Examination of danger studies by the intersectoral commission for examination and approval of danger studies at the level of the wilaya or at the level of the Ministry of the Environment.
- ❖ Establishment of the approval decision by the wali or jointly by the Minister of the Environment and The Minister of the Interior, Local Authorities and Regional Planning. [39]

Note: The study of danger is always accompanied by the simulation of a dangerous phenomenon, as the latter allows us to give an overview of the incidents of a dangerous phenomenon and the extent of the impact that it may cause. In the next element, we will provide an overview of the dangerous phenomena and their simulation.

The simulation of a dangerous phenomenon

Chapter 2:Security and safety system

Dangerous phenomena are phenomena that result in the release of a large amount of energy and effects. This energy results from the interaction or transformation of dangerous materials and causes damage and losses to targets of a different nature (such as humans, the environment, and devices).And it's are events that can cause harm to humans or the environment due to industrial systems, installations and facilities, and these phenomena result in serious thermal, energy and toxic effects.

What is the dangerous phenomenon?

Dangerous accident phenomena are those which release large amounts of energy or substances and which may inflict damage on people or goods. They are categorised by their probability of occurrence, their intensity and their likely dynamic kinetic behaviour. [41]

What is the Simulation of dangerous phenomenon?

Simulating dangerous phenomena is a powerful tool to better understand these dangerous phenomena, and provides us with an integrated view that allows predicting the behavior of these phenomena in the future. This technology is used in various fields. Andone of the most important softwires used in simulating dangerous phenomena is the ALOHA and FAST software.

Type of the dangerous phenomenon

Fire: Self-sustaining, uncontrolled combustion that may last for a long time and spread to other locations. The study of this phenomenon is based on the fire triangle: the simultaneous presence of a combustive (oxygen), a combustible product and a source of inflammation. The type of fire depends on the nature of the combustible, which may be in solid (warehouse or forest fire), liquid (oil slick fire) or gas form (torch fire caused by a pipe leak). Although related, fireballs are treated separately due to their distinctive characteristics: very short duration, flame projections, etc. [41]

Explosion: Sudden oxidation or decomposition producing an increase in temperature, pressure, or both simultaneously. There are two main types of explosion: physical (a burst tire, a change in the physical state of material) and chemical (combustion, substance decomposition reactions). For explosions involving powder or gas combustion, a distinction is made between deflagration (the flame produced by the explosion spreads at a speed lower than the speed of sound, around several meters per second) and detonation (the flame produced by the combustion spreads at a speed higher than the speed of sound, in the range of several kilometres per second). An explosion can transition from a deflagration to a detonation. [41]

Atmospheric dispersion as a dangerous phenomenon: the path in time and space of a cloud of particles emitted into the atmosphere (aerosols, gases, dust) which are harmful to humans or to the environment. The dispersed cloud may be composed of smoke from a fire or substances with flammable and toxic properties (ammonia, chlorine, etc.) Dispersion depends on the release conditions (mode of emission, type of substance, etc.), meteorological conditions (wind, temperature, etc.), and the surrounding environment (topography, presence of obstacles, etc.). [41]

The effects of dangerous phenomenan

The effects of dangerous phenomena fall into 4 categories.

- Thermal effects, linked to the combustion of a flammable product or an explosion
- Mechanical effects, caused by the high-pressure shock wave from an explosion
- Projection effects, which are indirect effects of the formation and movement of debris and fragments from an explosive shock wave
- Toxic effects which result in the inhalation of a toxic chemical substance following a leak at a site. [41]

Advantages of simulation dangerous phenomenon

Simulating hazardous phenomena offers several advantages:

- It allows you to understand the behavior of complex and dangerous phenomena,
- Providing a picture of the targeted dangerous phenomenon and the extent to which its apparent effects may reach
- It allows you to test various scenarios in order to strengthen security and safety.
- It helps improve the decision-making process, especially in the field of occupational security and safety.
- It is used in planning and prevention in order to provide the best protection for workers and the environment.
- Provides an overview of the type, quantity and efficiencies of safety barriers

Note: All information mentioned in the above item (Environmental Impact Study and Hazard Study) is derived from and compatible with Algerian legislation and laws, so Algerian legislation and laws is the source of that information.

5. Safety barriers

The industrial safety barrier is one of the most important elements of occupational safety, as it separates pedestrians, workers, automatic and even manual machines to avoid accidents and aims to provide a completely safe work environment. Security barriers are necessary to continue the development and progress of the industrial company and to work safely and securely.

What is safety barrier

A safety barrier can be defined as any instrumental, mechanical or procedural device making it possible to prevent or reduce the probability of occurrence of a feared event or to limit its consequences. - A security barrier under its different names (security system, defense system, elements for risk management, etc.) designates all the elements necessary and sufficient to ensure one or more security functions. This term brings together technical, organizational, instrumental, mechanical or procedural devices making it possible to prevent the occurrence of a feared event or to reduce its effects.

What is the barrier system?

Chapter 2:Security and safety system

It is a system that has been provided and installed to ensure several functions of that barrier (prevention - detection - monitoring - avoidance - restriction), and the barrier system describes how to achieve and implement that function. A barrier system can provide many barrier functions (for example, security system equipped with SIS devices).

What is the barrier element?

It is one of the components of the safety barrier or is a subsystem that is not sufficient in itself to perform the function of a barrier and may contain multiple redundant elements that are used in systems other than the security and safety system.

Main functions of a safety barrier

the security and safety functionsit is a set of procedures, techniques and elements that must be provided and installed in the facilities' work systems (production system and storage system, for example) in order to reach and achieve an acceptable level of security and safety. Controlling risks in facilities and achieving complete and adequate safety functions is considered the most important element in installing these barriers.

It can be said that security and safety functions revolve around the following elements:

Prevent - detect - Control- avoid - limit

Specific security functions can be ensured by using technical security barriers, organizational barriers, or by using both. The same function can be provided by several safety barriers.

- Prevent function: It is done by identifying the source that may cause an accident and reducing the possibility and extent of the seriousness of this accident. This function aims primarily to provide prevention. It should be noted that this function does not make the occurrence of accidents impossible, so protection must always be provided (periodic monitoring, inspection, and maintenance and installation maintenance).
- Detection function: It aims to detect elements and sources that may be the cause of accidents. Accidents cannot be controlled by using this function alone, but must be linked to other functions such as the control or limit function (a flammable gas detection system was installed in the production facility)
- Control function: This function aims to control, control, and monitor changes in the basic elements and settings of the work (for example, temperature control and pressure control), and as an example of the control function (opening a line to the flame to relieve pressure on the equipment).
- Avoid function: The avoidance function aims to prevent accidents from occurring, that is, to make them impossible and make the possibility of their occurrence non-existent. This function generally refers to deep modifications of fixtures and provides substantially safer operation. (such as replacing a used gas in the device with air or nitrogen).

- ❖ Limit function: It aims to "reduce" and "Limit" the sources and causes of accidents by analyzing the consequences and outcomes of an accident in order to reduce its seriousness and reduce the probability of its occurrence. This function is often applied to the source of the incident (for example, determining the leak time or flow rate).

Classification of safety barriers

Safety barriers can be classified into two categories, based on the following criteria:

- Classification according to the function of the barrier (prevention barrier, protective barrier)

- Classification according to the nature of the barrier (technical barrier, human and organizational barrier).

Classification according to the function of the barrierPrevention barrier:

This type of barrier aims to prevent or reduce the possibility of accidents occurring, and it focuses on basic prevention elements. For example:

- upkeep and maintenance program.- Employee training program.

- Smoke detector.- Self-closing valve.

Protection barrier:

A protective safety barrier helps reduce the consequences of the feared event. For example: powder extinguishing system.

- Fire extinguishers.- Fire wall.

- Emergency plan.- Evacuation procedure.

Classification according to the nature of the barrier

Depending on the nature of the safety barriers, the following can be distinguished:

- Technical security barrier

- Human and organizational security barriers

Technical safety barrier

A technical security barrier is divided into three categories:

- The passive safety device

- The active safety device

- Safety instrumented systems.

- ❖ **The safety devices**

In general, the safety device is a unitary, autonomous element, intended that aims to achieve safety. There are two types of safety devices:

A- The passive safety device

Passive devices are devices that do not require any mechanical system, no human work (except maintenance-type intervention), no technical procedure, and no external power source to perform their function. As an example, we find:

- Containment walls- Mechanical or thermal protection screens.

- Reservoir dams- Flame retardant

- Fire resistant- Retaining bowl- Flow reducer

B – The active safety device

Active devices are devices that use mechanical devices (lever) to perform their function. This category includes relief valves and flow limiting valves. They may require an external power source to operate. like:

- Safety valve- Valve check

- Double break valve- Overflow valve

Human and organizational security barriers

Human activity is defined as the process or action that opposes the chain of events likely to lead to an accident (this is prevention) or which reduces its consequences (this is protection)

The organizational safety barrier consists of a set of procedures and regulations integrated into the company's management system that reflect the series of events that are likely to cause an accident, for example:

- Work procedures (work permit)

- Audits, inspections, etc.

- HSE induction

- Training and awareness of employees

Safety instrumented systems (SIS)

Performance standards for safety barriers

In order to obtain the best occupational safety and security system, industrial facilities and companies must choose and install the best safety barriers in order to ensure the availability and continuity of security and safety. The efficiency of these barriers must be evaluated by the

facilities in order to know the extent of safety and security provided by these used barriers, and this will be According to several criteria, including the following:

- **Independence from human intervention**: This depends on the nature of the relationship between the safety barrier and the workers. The more the barrier does not require human intervention (workers), the better. That is, the extent of the barrier's dependency on workers must be known.
- **Responding to a request:** The barrier's response must be immediate and complete in order to ensure safety. When an accident occurs, all safety barriers must respond.
- **Response time:** The time that elapses between the activation of the barrier and the complete completion of the safety function. It is defined by the safety barrier designer.
- Reliability: The extent to which barriers can withstand and endure during and after an accident
- **Efficiency:** The safety barrier must provide the best expected result in order to provide protection and protection for workers and the environment
- **Implementation time:** The time to implement the barrier for the required order is one of the most important criteria for evaluating barriers. The faster the implementation time, the better.
- **Resources required:** This depends on the extent to which the required capabilities and resources are provided for the safety barrier to provide the best result.

6. Safety instrumented systems (SIS)

And SIS is an automated system designed to protect people, equipment, and the environment from hazardous situations. It monitors critical process variables and takes pre-programmed actions when those parameters exceed safe limits.

What is the Safety instrumented systems (SIS)?

Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s). A SIS is usually having a number of safety functions with different safety integrity levels (SIL) so it is best avoid describing it by a single SIL. [42]

A safety instrumented system (SIS) is a system that contains control elements, sensors, and logic solvers to monitor parameters and values of processes within a plant and ensure that they remain within defined limits. In case those limits are violated, safety instrumented systems deploy a series of actions to take the process to a safe state. Safety conditions in a plant must be clearly defined and must be followed closely by the employees. SIS ensures that in case the safety of certain processes is compromised, appropriate action is triggered to mitigate risk and make those processes safe again [43]

Example: Automatic detection and extinguishing (fire) system

The importance of Safety Instrumented Systems

(SIS) comes from the added value they bring. They drastically help reduce risks on and around the site, keeping company assets, people, and the environment safe. There are many

catastrophes that can occur at operational sites that deal with heavy machinery and chemicals. These can range from fires to leaks that could lead to explosions. [44]

Safety Instrumented Systems' primary purpose is to bring dangerous processes to a safe state in pre-determined hazard scenarios. Moreover, Safety Instrumented Systems keep people within and near the operational site safe. Unfortunately, failure can never be fully prevented, and risks can never be fully eliminated from the equation. Because of this, it is important to always examine the possible catastrophes, and have safeguards in place, so that even in the event of an incident, the damage is minimal and handled to limit the effects to a tolerable level. [44]

The Main Components of Safety Instrumented Systems

Safety instrumented systems are independent from the process control system, and include three main components: sensors, logic solver, and the final element.

- **Sensor**

The sensors are mounted on machines, cables, and valves, and are used to detect any abnormal deviations. Sensors are often the first point in safety instrumented systems, and can categorize deviations as low-level or high-level.

- **The Logic Solver**

The logic solver or a programmable logic controller (PLC) is a component that takes data from the sensor, evaluates it, and then issues a command. For instance, if the sensor detects high voltage in one of the cables, higher than the predetermined levels, the logic controller will immediately issue a command to close the element.

Logic solvers are specialized devices that are often installed in rough conditions, so they usually have a hard casing. Multiple processing units are installed to execute the logic while ensuring the integrity of the system.

- **Final Element**

The final element is the last guard within a safety instrumented system, and plays a critical role in maintaining the overall safety of the entire system. It acts upon the command issued by the logic solver by terminating connections, opening or closing valves, or taking relevant steps to take the process to a safe state. [43]

Understanding Safety Instrumented Functions

Safety instrumented systems take into account discrete functions throughout the facility. These are known as Safety Instrumented Functions (SIF).

Data from the sensors for each SIF is entered into the system, and the logic solver then determines acceptable SIS outputs for each SIF. These acceptable outputs must meet Safety Integrity Level (SIL) targets. [43]

Note: Definition of Safety Instrumented Function: A set of equipment intended to reduce the risk due to a specific hazard (a safety loop). Its purpose is to

1. Automatically taking an industrial process to a safe state when specified conditions are violated;

2. Permit a process to move forward in a safe manner when specified conditions allow (permissive functions);

3. Taking action to mitigate the consequences of an industrial hazard. It includes elements that detect an accident is imminent, decide to take action, and then carry out the action needed to bring the process to a safe state. Its ability to detect, decide and act is designated by the safety integrity level (SIL) of the function. [42]

Manual safety action system

Manual safety systems are mixed barriers with technical and human components: the operator interacts with the technical elements of the safety system that he monitors or acts on. For example, placing a safety valve in the safety position by manual actuation of an emergency stop button following the detection of a gas leak during a monitoring round is considered to be a system with manual safety action

7. Safety Integrity Level(SIL)

The Safety Integrity Level (SIL) is one of the most important systems and elements of the security and safety system, as it aims to reduce the risks provided by the safety function, or aims to determine the target level for reducing risks. The Safety Integrity Level (SIL) has a close relationship with the Safety Instrument Function (SIF).

There are four SIL levels, from the least reliable SIL 1 to the most reliable SIL 4. The applicable SIL is determined based on a number of quantitative factors as well as qualitative and professional factors.

Definition of the Safety Integrity Level

Safety Integrity Level - A quantitative target for measuring the level of performance needed for safety function to achieve a tolerable risk for a process hazard. Defining a target SIL level for the process should be based on the assessment of the likelihood that an incident will occur and the consequences of the incident.[42]

SIL levels:

As mentioned previously, SIL has four levels, each of which has increasing stringency in terms of its ability to reduce risks:

SIL 1 (Low): Used in less severe risk situations, where a single failure may not cause serious consequences. (For example, preventing overflow in a low-pressure tank)

SIL 2 (Medium): Applies to scenarios with the highest potential damage, but low frequency of occurrence. (For example, turning off a non-critical pump)

SIL 3 (High): Performed for operations with potentially serious consequences, and failures may be more frequent. (For example, emergency shutdown system for flammable gas pipeline)

SIL 4 (Very High): The most stringent level, intended for high-risk situations that could lead to catastrophic outcomes. (For example, a rupture prevention system in a nuclear reactor)

SIL is a relative level of risk reduction provided by a safety function. SIL ratings correlate to the frequency and severity of hazards. They determine the performance required to maintain and achieve safety — and the probability of failure. there are four SILs — SIL 1, SIL 2, SIL 3, and SIL 4. The higher the SIL, the greater the risk of failure. And the greater the risk of failure, the stricter the safety requirements. [45]

Table (2.1): A table showing the Safety Integrity Levels [45]

Safety Integrity Level	**Probability of Failure on Demand**	Risk Reduction Factor
SIL 4	$\geq 10^{5}$ to $<10^{4}$	100,000 to 10,000
SIL 3	$\geq 10^{4}$ to $<10^{3}$	10,000 to 1,000
SIL 2	$\geq 10^{3}$ to $<10^{2}$	1,000 to 100
SIL 1	$\geq 10^{2}$ to $<10^{1}$	100 to 10

The importance of SIL

1. The SIL helps ensure that the SIS can perform its safety function effectively when needed.
2. Reduced Risk: By having a SIS with proper SIL, the potential for accidents and injuries is greatly reduced.
3. Regulatory Compliance: Many industries have regulations mandating the use of SIS with specific SIL levels for specific processes.
4. Improving Safety Culture: A focus on SIL demonstrates a commitment to safety within a facility.
5. Giving a good image and high status to establishments and companies in competitive markets
6. Raising the level of the security and safety system to the highest possible level

SIL requirements

Several factors affect the required SIL for an SIS, including:

- The severity of the potential hazard, the level of damage that could occur if the SIS system fails to operate.
- Frequency of hazardous events, the number of times dangerous situations may arise.
- Exposure to employees, the possibility of people being present when the hazard occurs.
- Environmental impact: potential damage to the environment in the event of a failure of the SIS system.

- The safety policy followed and relied upon by the industrial facility
- The financial budget provided by the company and allocated to the SIS and SIL system

Note: The emergency shutdown system (ESD) is one of the most important parts of the CIS and SIL system, which does a great job in ensuring protection for the facility and workers. Below is some information about the emergency shutdown system (ESD)

8. Emergency shutdown system:

Definition of emergency shutdown system (ESD)

Emergency Shutdown System (ESD) are specialized highly reliable control systems forhigh-risk industries like Oil and Gas, Nuclear Power or other Environments with explosion risk.Their purpose is to protect personnel, plant, and the environment in case the process goes beyond the control margins. [46]

The objectives of the emergency shutdown system (ESD)

Its primary function is to automatically shut down the equipment or the entire process if a dangerous situation occurs. This helps prevent accidents, injuries and environmental damage.

The previous main goal is achieved by achieving the following goals provided by ESD:

- The ESD system ensures priority control of the process equipment required to switch the process to safe mode.
- Collect and process electrostatic discharge (ESD)-related information about process parameters and equipment status
- Detection and alarm in emergency situations and process deviations beyond pre-set limits
- Automatic shutdown of production facilities (or a separate piece of equipment) in case of deviation of parameters (e.g., pressure and temperature) from pre-set limits or manual shutdown by the operator
- Manage alarms and notifications
- Preventing repeated operation of production facilities (or a separate piece of equipment) until the cause of the shutdown is removed or a forced unlock is performed[46]

Importance of Emergency Shutdown System (ESD)

Safe shutdown systems play a vital role in ensuring workplace safety and protecting the environment and It acts as a fail-safe mechanism, taking over and halting processes when human intervention is too slow or impossible.

Typical ESD system components

1. Dedicated process transmitters
2. Logic Solver
3. Shut-Down valves (SDV), Fail to Close type. The purpose of this valve is to isolate.

4. Blowdown valves (BDV), Fail to Open type. The purpose of this valve is to depressurize.

In practice the plant is usually divided into several isolable units that can be depressurized and isolated.[46]

Functions of Emergency Shutdown (ESD) System

- Shut down of part systems and equipment
- Isolate hydrocarbon inventories
- Isolate electrical equipment
- Prevent escalation of events
- Stop hydrocarbon flow
- Depressurise / Blowdown
- Emergency ventilation control
- Close watertight doors and fire doors
- May alternatively form part of the fire/gas detection and protection system.[46]

9. Automatic detection and extinguishing (fire) system

Fire safety is a critical concern in various environments, and the implementation of effective fire suppression systems is essential to prevent the spread of fires and protect lives and property. Automatic fire suppression systems have emerged as a reliable and efficient solution, providing numerous benefits in early fire detection, rapid response, and minimizing the potential damage caused by fires. [47]

What is the automatic detection and extinguishing (fire) system

Automatic detection and extinguishing (fire) system is a system that can detect and extinguish, or contain, a fire without having to rely on human intervention. In their simplest form, these systems have a means of detection, actuation and delivery. [48]

Fully automatic fire suppression systems take away the need to depend on a person to discover and tackle a fire. Within seconds of a fire occurring, the detection system detects the radiant heat from the fire, automatically actuates the system and delivers the extinguishing agents straight into the heart of the fire. [48]

Note: The automatic fire detection and extinguishing system is an example of the application of the SIS system. Therefore, it is of great importance to the income of industrial facilities and is therefore one of the foundations of a strong industrial safety and security system.

9.2.Types of Automatic Fire Detection Systems

Automatic fire detection systems can incorporate a range of detection technologies depending on premises and exact requirements. [49]

- **Photoelectric or Optical**

These detectors work by sending pulses of light into a sensor chamber at regular intervals. If smoke particles enter the chamber, they scatter the light onto a receptor that triggers a signal to be sent to the control panel. They don't work well in dusty environments, and are best for detecting smouldering fires. [49]

- **Heat Alarms**

These simple detection systems trigger an alarm once a certain temperature is reached, making them better for locations that are dusty or steamy. Often, they don't provide warning as early as other types of detection, though, so it's best to use them in combination. [49]

- **Video Detection**

This type offers a wide coverage so performs well in large areas like warehouses. They work by using software to analyse each frame of video they capture, using an algorithm that can identify smoke patterns in pixels. [49]

- **Aspirating**

An aspirating system is typically able to identify fire faster than any other. This is because it sucks air into its central detection unit using a network of pipes, rather than waiting for smoke particles to drift into it. The air is then tested much like a photoelectric detector. [49]

The benefits of Automatic detection and extinguishing (fire) system

The automatic detection and extinguishing system has several advantages and benefits that can be summarized in the following points

- **Immediate Fire Detection**

Automatic fire suppression systems are equipped with advanced fire detection technology that enables immediate fire detection. These systems utilize sensors, such as smoke detectors, heat detectors, or flame detectors, to identify the presence of a fire. The early detection capabilities of automatic systems allow for rapid response, ensuring that fires are addressed in their initial stages minimizing the risk of escalation. [47]

- **Rapid Fire Suppression**

Once a fire is detected, automatic fire suppression systems swiftly suppress the flames. These systems are designed to automatically activate fire suppression measures, such as sprinklers, foam suppression, or gaseous suppression agents. The quick response of these systems helps to control and extinguish fires before they can spread and cause significant damage, providing a higher level of safety and protection. [47]

- **24/7 Protection**

One of the significant advantages of automatic fire suppression systems is their ability to provide round-the-clock protection. These systems are always active and ready to respond to fire incidents, even in unoccupied or after-hours environments. Continuous monitoring and immediate response ensure that fires are addressed promptly, reducing the risk of extensive damage and potential loss of life. [47]

- **Minimization of Property Damage**

Automatic fire suppression systems play a crucial role in minimizing property damage. By quickly suppressing fires, these systems limit the extent of the fire's spread and the resulting damage. They help protect valuable assets, equipment, and infrastructure, reducing financial losses and minimizing disruptions to business operations. The investment in an automatic suppression system can lead to significant cost savings in the long run. [47]

- **Safety in Unmanned Areas**

Automatic fire suppression systems provide a vital safety mechanism in environments where human presence is limited or non-existent, such as data centers or storage facilities. These systems can detect and suppress fires even in unoccupied areas, mitigating the risk of fire-related incidents when human intervention may be delayed or unavailable. Automatic fire suppression ensures that potential fires are addressed promptly, protecting valuable assets and minimizing downtime. [47]

- **Compliance with Safety Regulations**

Automatic fire suppression systems often fulfill regulatory requirements and compliance standards. Implementing an automatic suppression system helps ensure compliance with local fire codes and safety regulations, avoiding potential penalties and legal issues. [47]

Note: It should be noted that among the most important elements of the security and safety system are the means of protection and intervention. The most important objective that this element can achieve is to provide protection (after the occurrence of industrial accidents). As an example of the means of protection and intervention, we mention:

- the anti-fire network that aims to control To fight fires by using pressurized water, the range of this network reaches all sensitive points within the industrial facility.
- Manual intervention means such as fire extinguishers.
- Individual and collective protection equipment that for protect workers and prevent the impact of dangerous accidents

10. Conclusion:

Finally, the industrial safety and security system is one of the foundations for building a strong industrial company or facility, and this is due to the great importance it is given. The industrial safety and security system consists of the integration of a group of systems, elements, and devices that aim to achieve a qualitative leap in the level of industrial security and safety within the facility, and thus it is It aims to raise the level of safety and the facility's workers and equipment and protect the environment. The importance of the industrial security and safety system must be understood and recognized by all the facility's frameworks, and continuous work must be done to develop and raise the level of the permanent security and safety system in the industrial facility.

Chapter 03:

Installing a security and safety system in a green hydrogen production facility

Chapter 03: Installing a security and safety system in a green hydrogen production facility

1. Introduction

In order to obtain the necessary information in order to complete this work, we lurked in the Sonatrach company, thanks to which we were able to obtain several pieces of information that enabled us to reach the results of this work. At the beginning of this chapter, we will present an introduction to this petroleum company, especially its branch Haoud Berkaoui HBK. Then we will present the results of this work entitled Installing a security and safety system in a green hydrogen production facility.

2.presentation of companies:

Geographic location of the region:

The Haoud Berkaoui region represents one of the ten (10) main hydrocarbon-producing areas of the Algerian Sahara. On the RN°49 road known as oil tankers linking Ghardaïa to Hassi Messaoud, and 35 km southwest of Ouargla, a crossroads indicates the presence of an oil field, this is the region of Haoud Berkaoui. The Haoud Berkaoui region is located 100 km west of Hassi Messaoud at an altitude of 220 m and located 770 km south of the capital (Algiers), it is very important because of its share of hydrocarbon production. our it extends from the southeast of Ghardaïa to the extreme Boukhazana field, near the Touggourt road. To date, 100 wells are in operation, spread across all fields, including 73 gas-lift wells and 27 eruptive wells. Cumulative production since the beginning is 86 million m3, for total reservoirs in place of 472 million m3. All quantities of recovered oil and gas are transported to the various production centers in the region. There are two main production centers located in Haoud Berkaoui (HBK) and Guellala (GLA) and three satellite centers in Benkahla (BKH), Guellala Nord-Est (GLA-NE) and Draa Et-Tamra (DRT).

Figure (3.1): An image showing the geographical location of Sonatrach Haoud Berkaoui (HBK)

The fields in haoud barkaoui:

- Haoud-Berkaoui fields
- Benkahla fields
- Guellala fields

History of the region:

The regional management of Haoud Berkaoui is located in the commune of Rouisent, 25km from the capital of the wilaya of Ouargla, the region was managed by Hassi Messaoud from 1965 to 1976 and here is the main outline of its history. In 1976 the Haoud Berkaoui region became autonomous. The discovery of peripheral fields took place between 1963 and 1984. In the space of 30 years, the region has developed considerably thanks to various discoveries and investments.

HSE policy:

The HAOUD BARKAOUI A health, safety and environment policy aims at the following objectives:

- Zero damage and zero accidents
- Zero effect on the environment, whether in the Algerian Republic or throughout the world
- Employee awareness
- Zero occupational illness

3.Installing a security and safety system in a green hydrogen production facility

In order to install a strong industrial safety and security system in any facility or industrial institution, it is necessary to fully and comprehensively understand the activity and process by which this industrial facility depends and operates.

Before choosing the best safety elements that make up the security and safety system, the activity and process of the industrial facility must be divided into sections and then Understand and analyze the way each department works, understand the dangers that that department deals with and the critical points and parts in it that may cause an accident or disaster in some cases, and then choose the best appropriate means, techniques and safety systems in order to make the level of industrial safety and security suitable for workers and the environment.

In our case, it is necessary From understanding the process of producing green hydrogen and analyzing the equipment involved in the process of producing this dangerous gas. In this work, we counted all the basic devices and components that are considered the basis of producing green hydrogen, and we divided the production process into several sections in order to install the best industrial security and safety system for a production facility Green hydrogen. Below we will analyze the process of producing green hydrogen and study the possibility of producing it at Sonatrach Company Haoud Berkaoui while ensuring the best industrial security and safety system that ensures the production process runs in complete safety.

Explain the process of producing green hydrogen

The green hydrogen production plant that we will study in this work relies on the use of abandoned and unused water resulting from crude oil processing waste by Sonatrach Company to produce green hydrogen, which is considered one of the most important types of clean fuel in the world, using electrolysis of that water. The production process takes place in the following sections Which we will explain:

The first section: Producing electricity through a small production station that relies on renewable energy. This is done by producing it using solar panels or air turbines (renewable energy), and then converting the electricity to direct current if it is produced by air turbines, or leaving it as it is if it is produced by panels Solar power (the electricity used in the water electrolysis device is in the form of a direct current). The electricity is then stored in a room containing large capacity batteries. This room has the optimal conditions for storing electricity in batteries.

The second section: Filtering unused water and converting it into water that can be used in the electrolysis process using special types of filters that guarantee raising the purity of the water to 90/ . Then storing it in a tank inside the factory and inserting this tank into the fireproof network (so we can put out the fire by using this emergency stored water)

Section Three: Producing green hydrogen using a water electrolysis machine. We use the water stored in the tank (Section Two) and clean electricity previously produced from renewable sources. In this section, we obtain oxygen and hydrogen, which must be stored in a safe way. It

should be noted that one of the problems facing The high temperature of water electrolysis machiner , the problem of the purity of the water used, the problem of the amount of electricity used, and the problem of blockage in the path of produced gases that may cause an industrial disaster, so continuous monitoring and periodic maintenance must be provided for this device.

Section Four: Storage of hydrogen and oxygen. This is done by compressing them using a compressor device or condensing them and storing them in special tanks. Note: Due to the high risk of storing hydrogen, the method of transporting it with natural gas is highlighted due to Sonatrach owning natural gas transmission lines.

Section Five: Transporting green hydrogen through special tanks or pipes for transporting green hydrogen gas. This section contains a large proportion of dangers and The best safety means must be provided in order to provide safe transport of this gas.

Note: In what comes , we will try to suggest the best occupational security and safety system that provides an acceptable level of security and safety in every section of green hydrogen production.

Information about Sonatrach green hydrogen production facility

It is worth noting that Sonatrach Haoud Berkaoui Company does not own a factory or facility to produce green hydrogen, but Sonatrach Haoud Berkaoui Company possesses all the material, human and logistical capabilities to build and operate a facility to produce clean green hydrogen gas. Below is some information and capabilities that Sonatrach Haoud Berkaoui Company possesses that allow it to produce a significant amount of green hydrogen gas:

Table (3.1): A table showing some of Sonatrach capabilities to produce green hydrogen

Necessary capabilities	**The possibilities it will provide**
Space needed to build facilities	Sonatrach Haoud Berkaoui owns a large area allocated for industrial activity, some of which can be used to establish a factory to produce green hydrogen. These areas appear in the following image. Determining the best area to build the facility requires a special study, which we will conduct in the following:
The amount of water available	Sonatrach Haoud Berkaoui Company owns a significant amount of unused water resulting from the treatment of crude oil and wastewater treatment. This treated water has a purity rate of up to 80%, and this percentage can be increased further. The amount of this water is estimated at the following: ▪ Crude oil treatment water: estimated from 25,000 m^3 to 30,000 m^3 ▪ Sewage treatment water: estimated from 2500 m^3 to 3000 m^3

Electrical energy	Sonatrach Haoud Berkaoui is located in the state of Ouargla, which has great potential to produce electrical energy from renewable sources such as solar and wind energy.
Storage	Given the great experience that Sonatrach Haoud Berkaoui has in storing materials and gases produced through its activities, storing green hydrogen gas, despite the danger of storing it, may not pose a problem for Sonatrach.
Transport	Sonatrach Haoud Berkaoui has great capabilities that enable it to ensure the transportation of green hydrogen gas, whether through storage tanks or natural gas transportation pipelines.

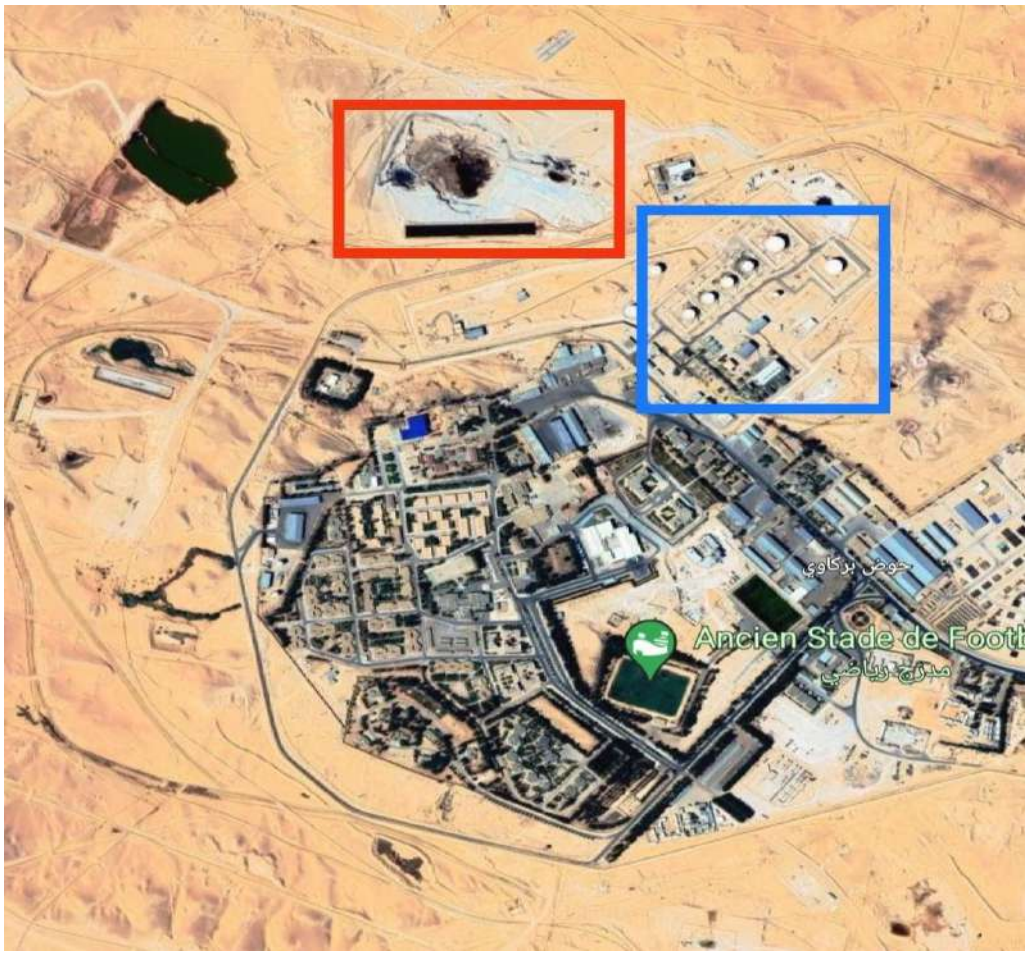

Figure (3.1): A satellite image showing the location of Sonatrach Haoud Berkaoui industrial activity

The image represents a satellite snapshot of the Sonatrach area and company, with the red frame representing the water treatment plant produced from crude oil, as well as the tank for that water. The blue frame represents the area of Sandarac's industrial activity, where crude oil and natural gas are processed. It is a very dangerous area. The activity of the green hydrogen production facility must not interfere with that area, so as not to cause an industrial disaster.

Note: all the information about the hydrogen production process, including temperature, the amount of electricity, and the pressure ratio, that we will need in our study. We will choose the average of each element.

Impact study and hazard study

hazard study:

In a green hydrogen production facility, two major scenarios can be distinguished: fire and explosion. So in the following we will try to analyze and study these two phenomena, each of which is a serious disaster for workers and the environment.

Note: In the following study, we focused on the dangerous scenario aspect only from the hazard study. Our study It is part of the complete risk study for the green hydrogen production facility and responsible for creating this study completely and reliability is a study office specific to this activity.

Explanation of the formation of the scenario and its cause:

1- **Fire scenario:** As we know, green hydrogen gas is a gas highly susceptible to ignition from the simplest spark, and the green hydrogen production facility is almost never devoid of green hydrogen gas in its atmosphere, so the rate of formation of this scenario is very large, so the best methods and means of prevention and protection must be put in place. In order to prevent the formation of this scenario dangerous.

2-**explosion scenario**, it should be noted that the green hydrogen production facility is an environment suitable for explosions, as it meets all the conditions for an explosion, and the largest area that provides this scenario is the storage area and the gas pressure area. As before, the best means of prevention and protection must be put in place in order to Prevent this dangerous explosion scenario from occurring

Security and safety measures and means:

After understanding the main reason behind the formation of dangerous scenarios in the green hydrogen production facility, we can take the best industrial security and safety means and measures. The best way to provide industrial security and safety is to isolate the causes of these scenarios, and since the scenarios are similar in causes and danger, the safety means and measures are the same and it is suitable for almost every scenario that may arise in a green hydrogen production facility. The following are some industrial security and safety methods and measures that are compatible with this facility:

1- Prevention:

A suitable location must be chosen to establish this industrial facility, and this is what we will study in the following items.

- Installing the SIS system in all production departments.
- Relying on SIL in order to raise the level of industrial safety.
- Establishing the best safety barriers, making sure to have at least two barriers in each part of the production departments.
- Making sure to provide good training and training for workers from In order to deal with dangerous scenarios.
- Providing means of prevention and safety of excellent quality and reliability.
- Establishing a good security and safety policy that the facility will follow, placing the level of safety at the top of its objectives.

2- Protection:

All means of individual and collective protection must be provided, with all Production departments with fireproof network, self-extinguishing system and fire extinguisher. In order to control the consequences of dangerous scenarios that may occur

Impact study:

In the green hydrogen production facility, there is almost no industrial waste. This is due to the clean and environmentally friendly sources on which all production departments rely. However, it should be noted that if the Emergency Shutdown System is activated, the amount of green hydrogen produced will be released into the air and burned, and therefore an impact study must be submitted in this case in order to settle the situation towards the Ministry of Environment to place the facility within its legal framework. Water filter waste and human waste must be taken into account, for which a complete waste management system must be provided or included within the waste management process approved by Sonatrach.

Green hydrogen storage and transportation:

It is worth noting that there are two ways in which a green hydrogen production facility can operate

The first method is to produce green hydrogen, then store it in gas bottles or a spherical tank, then transport it and market it. This method depends on compressing or condensing this dangerous gas.

The second method is to transfer green hydrogen directly through natural gas pipelines. This method depends on raising the pressure of green hydrogen to the same pressure passing through natural gas pipelines.

In order to know the best method in terms of industrial security and safety, we have prepared the following table, which represents some of the pros and cons of each method.

Table (3.2): A table showing a comparison of the Advantages and disadvantages of both green hydrogen transport methods

The method	Advantages	disadvantages
The first method	**1-** Ease of stopping the production process at any time **2-** Controlling the quantity produced according to the targeted level of security and safety **3-** Not taking into account the problems and dangers of natural gas pipelines **4-** Ease of Determine the level of danger available in the facility by knowing the amount of gas stored, which facilitates the placement of security barriers	**1-** The high level of risk that exists in a private facility, the storage department **2-** The financial cost is large in storing and cost security barriers **3-** Permanent explosion source **4-** Serial industrial accidents: the explosion of one of the gas storage bottles necessarily means the explosion of the rest of the bottles and the storage tank **5-** Difficulty of control in the event of an industrial accident The problem of human error in storage or transportation
The second method	**1-**High level of industrial security and safety with a low level of risk **2-**The cost is low **3-**The percentage of human error is very small, as this road is operated by special machinery **4-**Eliminate the source of danger by transporting this dangerous gas directly after production. **5-**Easily activate the emergency stop system by placing a valve at the beginning of the connection to the natural gas pipeline	**1-**The problem of the return of natural gas to the green hydrogen production department, which causes an industrial disaster **2-**The danger of natural gas pipeline explosion **3-**The cost of separating hydrogen from natural gas after transporting it

As we can see from the table, the best method in terms of providing an acceptable level of industrial security and safety and reducing the level of risk is the second method in which green

hydrogen gas is transported in natural gas pipelines. This is due to the many advantages that serve industrial security and safety in the green hydrogen gas production facility.

The amount of energy resulting from dangerous phenomena:

In order to study and know the amount of thermal energy that can occur in the event of a dangerous phenomenon, especially the phenomenon of explosion, we have used the T.N.T Equivalent Method, which will provide us with the amount of energy released from an explosion in the green hydrogen storage section of the TNT unit, that is, how much an explosion will result of energy compared to TNT. This study helps us choose the best security and safety methods in order to raise the level of industrial safety in this facility.

After using the TNT Equivalent Method, we obtained the following results:

After research, we found that in order to produce 1 kilogram of green hydrogen gas, we need 9 to 20 liters of water[50]. Sonatrach can provide an amount of 22,500 (which is estimated at 2,250,000 liters) of water at least in one month. After a calculation process in the optimal conditions, and assuming that all the targeted amount of water is treated in a period of one month, we find that the green hydrogen production facility produces an estimated 225,000 kilograms of green hydrogen per month. In the case of storage, this produced quantity of green hydrogen is a very large quantity and must be determined and reduced (for example, 5,000 kilograms are stored only per week) in order to maintain an acceptable and controlled level of risk. and The production process must be made It is compatible only with the safe quantity allowed to be stored and which does not pose a danger to the workers, the facility and the environment. Or the green hydrogen must be transported immediately after its production in pipes in order to avoid this problem.

We will now calculate the amount of corresponding to the amount of hydrogen produced:

TNT Law: **r = (M1) x 4690 / (M2 x Q)**

M1: equivalent mass of TNT in Kg

M2: mass of product considered between LEL and LSE in Kg

Q :heat of combustion of the gas KJ / kg

4690 KJ / Kg: combustion heat of TNT

M1x4690: decomposition energy of TNT

We know that the Explosion yield for green hydrogen is estimated at 50%, and that the amount of heat for the combustion of green hydrogen gas is estimated at 141860 KJ / kg . [51]

Note: explosion yield: in a non-confined environment r=10/.and explosion in a confined environment r=10/ or r=50/ if tank works under pressure

after applying the method we find:

$$r = (M1) \times 4690 / (M2 \times Q)$$

$$(M1) = (M2 \times Q) \times r / 4690$$

Energy corresponds to the exploitation of all the amount of water in production

$$(M1) = 225{,}000 \times 141860 \times 0.5 / 4690 = 3402825 \text{ KJ}$$

Energy corresponding to a safe amount of storage

$$(M1) = 5{,}000 \times 141860 \times 0.5 / 4690 = 75618 \text{ KJ}$$

We also note that it is necessary to determine and reduce the safe amount of storage in order to reduce the level of risk and raise the level of security and safety in the facility.

Choosing a place to build the facility:

In order to choose the best and most appropriate place to build a green hydrogen production facility in terms of security and industrial safety, we used the Aloha program, which is one of the best programs for creating simulations of dangerous phenomena, which will present us with the dangerous areas that will be damaged in the event of an industrial accident represented by a fire or an explosion caused by green hydrogen gas. After working on the Aloha program, we obtained the following results that we will study:

SITE DATA:

Location: HAOUD BERKAOUI .ALGERIA, ALGERIA
Building Air Exchanges Per Hour: 1.30 (unsheltered single storied)
Time: May 28, 2024 2256 hours ST (using computer's clock)

CHEMICAL DATA:

Chemical Name: HYDROGEN
CAS Number: 1333-74-0 Molecular Weight: 2.02 g/mol
PAC-1: 65000 ppm PAC-2: 230000 ppm PAC-3: 400000 ppm
LEL: 40000 ppm UEL: 750000 ppm
Ambient Boiling Point: -423.1° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA:

Wind: 14 miles/hour from ESE at 3 meters
Ground Roughness: urban or forest Cloud Cover: 0 tenths
Air Temperature: 39° C Stability Class: D
No Inversion Height Relative Humidity: 5%

SOURCE STRENGTH:

Leak from hole in spherical tank
Flammable chemical is burning as it escapes from tank
Tank Diameter: 14 meters Tank Volume: 1,437 cubic meters
Tank contains gas only Internal Temperature: 0° C
Chemical Mass in Tank: 25,845 kilograms
Internal Press: 200 atmospheres
Circular Opening Diameter: 6 meters
Flame Length: 227 yards Burn Duration: 20 seconds
Burn Rate: 498,000 pounds/sec
Total Amount Burned: 56,220 pounds

THREAT ZONE:

Threat Modeled: Thermal radiation from jet fire

Red : 440 yards --- (10.0 kW/(sq m) = potentially lethal within 60 sec)

Orange: 619 yards --- (5.0 kW/(sq m) = 2nd degree burns within 60 sec)

Yellow: 956 yards --- (2.0 kW/(sq m) = pain within 60 sec)

The result:

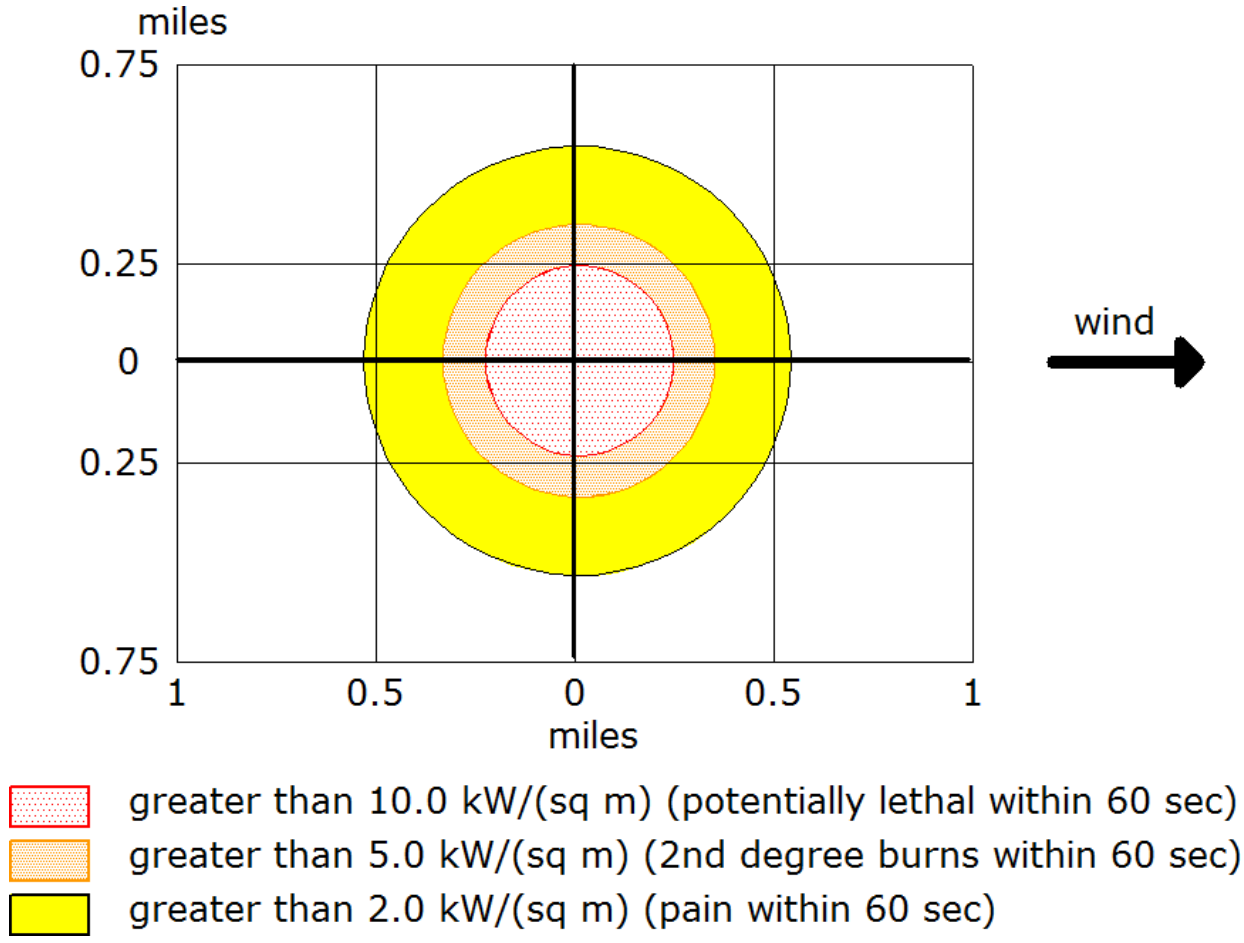

Figure (3.3) **:**A Figure showing the expected size of the explosion circle with stored hydrogen gas

Discuss the results:

It is worth noting that the results of the simulations can change with changing data. Changing the amount of stored hydrogen and how it is stored gives other results. As we note, the danger zone in red is approximately 400 meters, so there must not be any activity, even small, on the part of another facility within the diameter of this circle. In order to raise the level Safety is greater. There must be no industrial activity for any other facility near the yellow zone, which is estimated at approximately 880 meters, so that the green hydrogen production facility does not affect other companies..

We will now provide an example of a safe and sound location where it is possible to build a green hydrogen production facility:

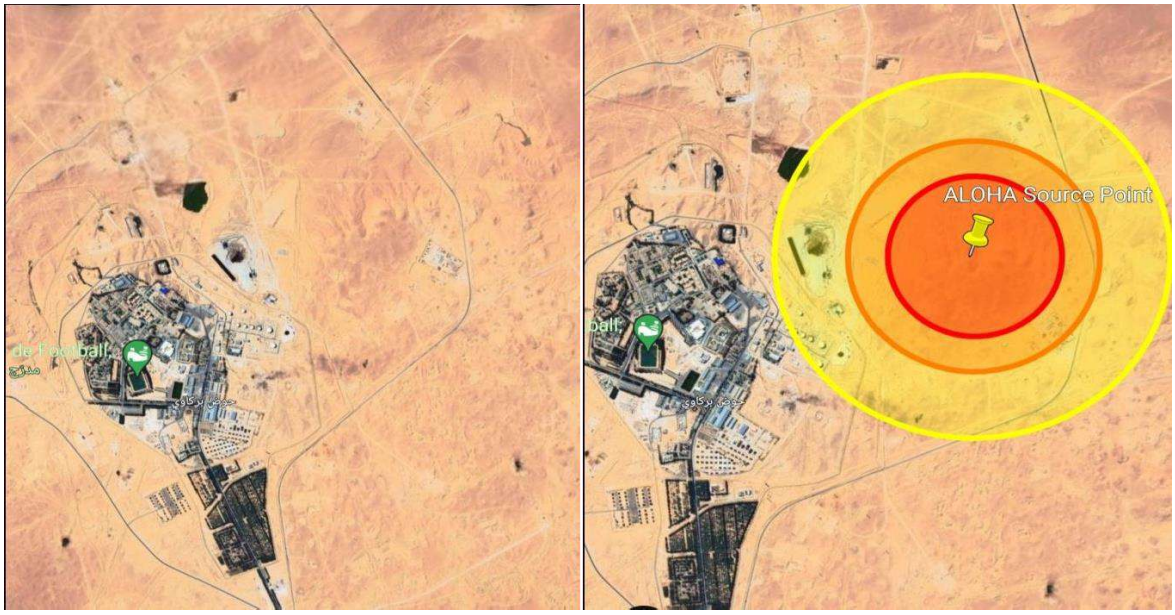

Figure (3.4) **:**A Figure showing a simulation of the danger zones of a green hydrogen production facility before and after a dangerous phenomenon occurs

Note: As we said previously, the amount of stored hydrogen must be reduced to the maximum possible amount in order to raise the level of industrial safety. We proposed 5,000 kilograms. In these simulations, we assumed storing 5 times the proposed amount, i.e. about 25,000 kilograms, in order to raise the level of safety given by these simulations.

Reasons for choosing the location:

Choosing the best place and area to place the green hydrogen production facility is one of the most important steps in adopting a strong security and safety system. After using the Aloha program, we arrived at choosing the previous area. It is a very good area to establish a green hydrogen production facility and this is due to several reasons, the most important of which are:

- the presence In the safe zone: The chosen area is located at the appropriate distance from Sonatrach industrial activity area, and this allows for no harmful mutual influence between the two areas.
- Joint intervention: In the event of an accident occurring in the green hydrogen production facility, Sonatrach protection and intervention teams, which have experience, can , from helping and protecting the facility.
- Reducing the impact: The chosen area is far from points of life and points of human activity at an appropriate distance, which allows them not to be affected by the activity of the facility or to be affected by accidents that may occur in the facility.
- Possibility of transportation in pipes: As we mentioned previously. The best way after producing hydrogen is to transport it directly in natural gas pipelines, and

Sonatrach possesses the technology and an effective network of pipelines and choosing a safe area near Sonatrach is a positive step.

- Seeking help from Sonatrach: The chosen area is close to Sonatrach, which facilitates the transfer of industrial safety methods and expertise. and Sonatrach owns one The best safety systems and one of the best industrial security and safety policies.

safety barriers:

After understanding the green hydrogen production process and understanding and analyzing all the sections that go through the production process, we can suggest the best and most effective security barriers for each section, through which we aim to raise the level of the security and safety system to the highest possible level. Below are some security barriers for each section in table:

Table (3.3): A table showing the safety barriers for each section of green hydrogen production

section	Technical barriers	Human and organizational barriers
The first section: Producing electricity	1-Smoke and heat detectors for fire prediction 2-Carbon dioxide self-suppression system in the battery room 3-Fire extinguisher and fire network 4-Means of protection from electricity 5-Provide SIS 6-Providing an alternative for every method and device 7-Surveillance means and alarms 8-Means of dealing with high currents	1-Good and integrated training and awareness for workers 2-A work permit is required before any work 3-safety cheek list 4-Continuous monitoring and permanent maintenance 5-An internal intervention plan IIP and an emergency safety plan
The second section: Filtering unused water	1-Level detector 2-Provide SIS 3-Safety valves 4-Providing an alternative for every method and device 5-Surveillance means and alarms	1-Good and integrated training and awareness for workers 2-A work permit is required before any work 3-safety cheek list 4-Continuous monitoring and permanent maintenance

Section Three: Producing green hydrogen	1-Smoke and heat detectors for fire prediction 2-Self-extinguishing system with water 3-Fire extinguisher and fire network 4-Level detector 5-Provide SIS 6-Safety valves 7-Providing an alternative for every method and device 8-Surveillance means and alarms	1-Good and integrated training and awareness for workers 2-A work permit is required before any work 3-safety cheek list 4-Continuous monitoring and permanent maintenance 5-An internal intervention plan IIP and an emergency safety plan
Section Four: Storage of hydrogen and oxygen.	1-Smoke and heat detectors for fire prediction 2-Self-extinguishing system with water 3-Fire extinguisher and fire network 4-Level detector 5-Provide SIS 6-Safety valves 7-Providing an alternative for every method and device 8-Surveillance means and alarms	1-Good and integrated training and awareness for workers 2-A work permit is required before any work 3-safety cheek list 4-Continuous monitoring and permanent maintenance 5-An internal intervention plan IIP and an emergency safety plan
Section Five: Transporting green hydrogen	1-Fire extinguisher and fire network 2-Safety valves 3-Providing an alternative for every method and device 4-Surveillance means and alarms	1-Good and integrated training and awareness for workers 2-A work permit is required before any work 3-safety cheek list 4-Continuous monitoring and permanent maintenance 5-An internal intervention plan IIP and an emergency safety plan

Note: If the method of transporting green hydrogen gas is used with natural gas, the safety barriers remain the same as the safety barriers for the storage method mentioned in the

table above. It is necessary to add one of the safety barriers in this method, which is a single-path valve to prevent the return of natural gas to the facility in case Pumping and pressure system failure

Safety instrumented systems (SIS)

In view of the major risks that threaten the green hydrogen production facility, it is necessary to provide a SIS in all sections of that facility. This is due to the great importance it has as an element capable of raising the level of security and safety within the facility. Installing a SIS in a facility has several advantages, including reducing human errors and reducing dependence on the human factor in the field of protection and safety of devices. SIS can be installed in almost all sections of a green hydrogen production facility, especially the hydrogen production section and the storage section. Any change in the basic elements and settings of those sections exposed by special detectors (which may cause harm to the facility) triggers a series of reactions that It aims to return those sections to their basic state of safety. As an example of SIS, we will study the installation of one of its most important elements, which is the fire detection and self-extinguishing:

Installing a The fire detection and self-extinguishing :

The fire detection and self-extinguishing system is one of the most important elements of safety barriers and one of the best elements of the industrial safety and security system in the industrial field in general and the field of green hydrogen production in particular. This important system can be installed in almost all departments of the facility except for the water filtration department and a little in the transportation department. It must be installed in the production and storage departments. In the clean electricity production department, it must be installed in the battery room and in the processing room, with carbon dioxide gas used as an extinguishing agent in order to preserve undamaged devices. Below we will present precautions and recommendations that must be taken into consideration:

- The type of extinguishing agent must be determined after special and careful study, especially in the section on storing renewable electricity in batteries, so the appropriate material must be used in each section.
- The duration of activating a system must be determined precisely. An appropriate period must be given for the evacuation of workers, and it must be appropriate so that the fire does not spread further
- Permanent and ongoing maintenance must be provided for the self-fire detection and extinguishing system
- All elements of the system must be constantly simulated and tested. And an appropriate period, it must be tested every six months
- Elements of the self-fire detection and extinguishing system must be provided with high quality, reliability and effectiveness

- ❖ Suitable, good and special training must be provided for facility workers in order to deal with this important system in the industrial security and safety system and in facility.

Note: With regard to SIL, security and safety must be included and involved in all production operations and departments. And each of the devices included in the formation of a green hydrogen production facility must participate in the overall safety process of the facility. The appropriate type of SIL that the facility will be exposed to must be chosen. As a suggestion from us, it is preferable to use SIL4 due to the disastrous consequences and effects that may be caused by an industrial accident in the facility.

Emergency Shutdown System

Emergency Shutdown System is one of the foundations of a strong security and safety system within industrial facilities. It aims to protect the facility and workers by stopping all operations and sections of the facility producing green hydrogen for a period. With the activation of a series of procedures that work to remove all elements and causes that could cause an industrial accident. Below we will explain how the emergency shutdown system installed in the green hydrogen production facility works:

1. Errors or malfunctions occur in one of the facility's departments, especially the production and storage department
2. Identify defects and Malfunctions and classify them according to their damage and consequences. If this defect may harm the lives of workers or cause the destruction of the facility, this system must be activated.
3. Activate the Emergency Shutdown System manually and automatically at the same time. This is to reduce errors
4. Trigger an audio and visual alarm
5. Cutting off electricity to the facility. Except for safety and protection devices and means, such as the detection and self-extinguishing system.
6. Close all supply valves and open and close all safety valves according to the specificity of each device in all production departments.
7. Empty the tanks and burn the gas in air (Sonatrach burner system can be used)
8. Closing the valve responsible for preventing gas return in case of using piped transportation
9. Turn off and empty all devices containing hydrogen gas or hazardous materials
10. Evacuate all workers and put intervention teams on standby to protect the facility

Note: It should be noted that the Emergency Shutdown System is one of the components of the SIS system, just like the fire detection and self-extinguishing system, so several recommendations and requirements must be made for it. These recommendations are the same as those for the self-fire detection and extinguishing system, so they must be reviewed in the previous item.

4. General recommandations:

There are several points that must be taken into consideration. These points are recommendations that must be implemented and developed in order to ensure that the level of security and safety within the green hydrogen production facility is high and characterized by effectiveness. Below are some recommendations:

- Care must be taken to provide security and safety tools, means and barriers of high quality, reliability and effectiveness
- Studies offices with experience and capabilities must be used in order to provide all necessary safety studies in the facility
- Work to resolve the situation and remain permanent within the state's legal framework. It is necessary to work with the state's decrees and laws and not violate them, especially in the field of industrial security and the environment.
- Before starting any work or making any changes in the facility or its organizational systems, an effective and integrated study must be drawn up that studies all aspects of the work and changes.
- A fully defined, reliable and effective emergency plan and internal intervention plan must be provided.
- All workers and equipment must be involved in the industrial safety and security system and policy
- A strong industrial safety and security policy must be adopted through the participation and encouragement of higher bodies in the facility, represented by the chief official for industrial safety and security.
- It is necessary to provide continuous and permanent maintenance and monitoring of all devices and sections of the green hydrogen production facility.
- Experience must be gained by seeking help and studying previous problems and incidents, whether in the facility or other facilities, to ensure that they are not repeated in the future.
- It is necessary to provide environmental and security inspections and audits in the facility
- Training and awareness must be provided to workers on all means, measures and systems of industrial security and safety

5. Conclusion:

In conclusion, the industrial safety and security system stands out as one of the most important basic systems in a green hydrogen production facility due to the great importance it has in this type of facility. A set of complete and reliable studies must be provided before deciding to install one of the industrial safety and security systems. Algeria, and especially Sonatrach, has huge potential to produce green hydrogen, but work must be done to install and develop the best industrial safety and security systems in green hydrogen production facilities.

General conclusion:

Finally, given the great importance and status that green hydrogen gas enjoys in Algeria, which is taking tremendous steps to control its production technologies and in the world, we have created this work that studies the installation of a security and safety system in a green hydrogen production facility. Care must be taken to generalize its production in the future, as it is considered a suitable alternative to fossil fuels and environmentally friendly. Care must be taken to produce this important gas safely by ensuring the provision of an industrial security and safety system that consists of several elements, means and systems. In order to ensure that hydrogen production is carried out In the best way, that is, in a safe way, you must ensure that the industrial safety and security system used is effective, reliable, and works in the best possible way. The safety and security system is considered an essential element for the success of any project or industrial facility, and it is considered one of the most important systems that industrial facilities rely on, because of its benefits and advantages. Many at various levels, including protecting workers and equipment, so as to reduce the risks of accidents and injuries, maintain safety for workers and employees, and contribute to increasing productivity and efficiency in a way that provides a safe and comfortable work environment at all levels, and contributes to improving the facility's reputation before official bodies and society. It enhances customer and investor confidence.

To achieve an effective system of safety and security in industrial facilities, it is necessary to ensure that clear plans and policies are put in place for safety and security. Our work aims to highlight the importance of the industrial safety and security system and its components that aim to raise the level of industrial safety in a green hydrogen production facility that relies on the exploitation of the resulting unused water. From Santrach's crude oil processing activity, for example.

The results obtained in this work are generally valid for all green hydrogen production facilities in any region in Algeria, but it is necessary to raise and improve the level of the industrial safety and security system further in order to ensure continuous development in industrial safety and security in all facilities in the future..

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Abstract of this work :

ملخص

يعد هذا العمل بمثابة دراسة لتثبيت نظام امن والسلامة الصناعية في منشاة إنتاج هدروجين اخضر بحيث قمنا بالتطرق إلى الهدروجين وطرق إنتاجه مع شرح كافي لكل طريقة ،ومع التركيز على الهدروجين
االخضر وعملية إنتاجه في الفصل االول.وتطرقنا إلى شرح لنظام االمن والسلامة الصناعية داخل الشركات والمنشات الصناعية .ومع التركيز على شرح أهم العناصر واالنظمة التي يتكون منه نظام امن والسلامة صناعية قوي في المنشات في الفصل الثاني. أما بالنسبة للفصل الثالث فحاولنا اقترح أفضل نظام امن والسالمة الصناعية الصالح لمنشاة إنتاج
هدروجين االخضر في الجزائر .وركزنا في هذا الفصل على شرح عملية إنتاج الهدروجين الخضر مع دراسة تقريبية إلمكانية إنشاء منشاة إنتاج هدروجين اخضر تعتمد على استعمال المياه الناتجة من معالجة البترول
الخام.وقمنا بالتركيز كذلك على جميع أنظمة والوسائل والتدبير العناصر التي تحتاجها تلك منشاة من اجل بناء وتبني نظام امن وسالمة صناعية قوي يتميز بالفاعلية والموثوقية العالية.

Abstract:

This work is considered a study to install an industrial security and safety system in a green hydrogen production facility. We have discussed hydrogen and its production methods with a sufficient explanation of each method, with a focus on green hydrogen and its production process in the first chapter. We have touched on an explanation of the industrial security and safety system within companies and industrial facilities. With a focus on explaining the most important elements and systems that make up a strong industrial security and safety system in facilities in the second chapter.

As for the third chapter, we tried to propose the best industrial safety and security system suitable for a green hydrogen production facility in Algeria. In this chapter, we focused on explaining the green hydrogen production process with an approximate study of the possibility of establishing a green hydrogen production facility based on the use of water resulting from processing crude oil. We also focused on It includes all the systems, means, management, and elements that an establishment needs in order to build and adopt a strong industrial safety and security system that is characterized by effectiveness and high reliability.

Résumé :

Ce travail est considéré comme une étude visant à installer un système de sécurité et de sûreté industrielle dans une installation de production d'hydrogène vert. Nous avons discuté de l'hydrogène et de ses méthodes de production avec une explication suffisante de chaque méthode, en mettant l'accent sur l'hydrogène vert et son processus de production dans le premier chapitre. Nous avons abordé une explication du système de sécurité et de sûreté industrielle au sein des entreprises et des installations industrielles. En mettant l'accent sur l'explication des éléments et des systèmes les plus importants qui constituent un système solide de sécurité industrielle et de sûreté dans les installations dans le deuxième chapitre.

Quant au troisième chapitre, nous avons tenté de proposer le meilleur système de sûreté et de sécurité industrielle adapté à une installation de production d'hydrogène vert en Algérie. Dans ce chapitre, nous nous sommes concentrés sur l'explication du processus de production d'hydrogène vert avec une étude approximative de la possibilité d'établir une installation de production d'hydrogène vert basée sur l'utilisation de l'eau résultant du traitement du pétrole brut. Nous nous sommes également concentrés sur Il comprend tous les systèmes, moyens, gestion et éléments dont un établissement a besoin pour construire et adopter un système de sûreté et de sécurité industrielle solide, caractérisé par son efficacité et sa grande fiabilité.

الكلمات المفتاحية
الهيدروجين ,الامن, النظام الأمني ,انتاج الهيدروجين ,محطة إزالة الزيت

Key words :

Hydrogen ,security ,system, hydrogen productio, threshold station

Les mots cles :

Hydrogene, securite ,systeme de securite , production de l’hydrogene ,station de d’hsuillage