Safety in Motion

Hydrogen safety risk challenges for new projects in CEPSA

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Agenda

Safety in Motion

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02 Green Hydrogen projects overview

03 Technology chosen

04 Safety Risks Challenges Electrolysis

05 Tools for facing Safety Risk challenges

06 HSE safety in motion projects strategy

CEPSA and the energy transition in a glance

CEPSA aims to become a reference **for sustainable energy transition and** mobility in Spain and Portugal within the framework of its **POSITIVE MOTION strategy**

CEPSA plans to invest **€3 billion in Europe's largest green hydrogen project.** Two new plants with a **capacity of 2GW** and a production of **300,000 tons of green H2** located in “Campo de Gibraltar” and “Palos de la Frontera.”

An Agreement with the **Port of Rotterdam to create** the first green hydrogen corridor **between southern and northern Europe**

By 2050, **it aims to achieve zero net CO2 emissions** within its Sustainability Plan

Construction of the largest 2G biofuel plant in Southern Europe together with Bio-Oils, as part of its commitment to decarbonization and innovation.

Hydrogen Portfolio projects

Status

Onuba Project – H2 Electrolyzers

- **Key Figures:**
  - Project involves the construction of a **400 MW** capacity of renewable hydrogen in La Rabida.
  - **100 MW** of PEM technology and **300 MW** of Alkalyne technology.
- **Technology:** Thyssen Nucera (ALK) & Siemens (PEM) selected OEMs
- **Partnership:** Fertiberia & Alter Enersun
- **TIC:** 770 M€

Timeline

May 24	Oct 24	Q1 25	Q3-26	
Gate 2	FID	Const.	Commissioning	RFSU

Tharsis Project – e-Methanol

- **Key Figures:**
  - Project involves the construction of a Green MeOH with a target production of **300 kt/y**.
  - **170MW** of renewable hydrogen + supply from hydrogen ring in Huelva.
- **Technology:** Tender for technology selection of H_2 and MeOH completed and short-listed
- **Partnership:** C2X

Timeline

Sept 24	Q1 26	Q1 27	Q4-28	Q2-29
Gate 2	FID	Const.	Commissioning	RFSU

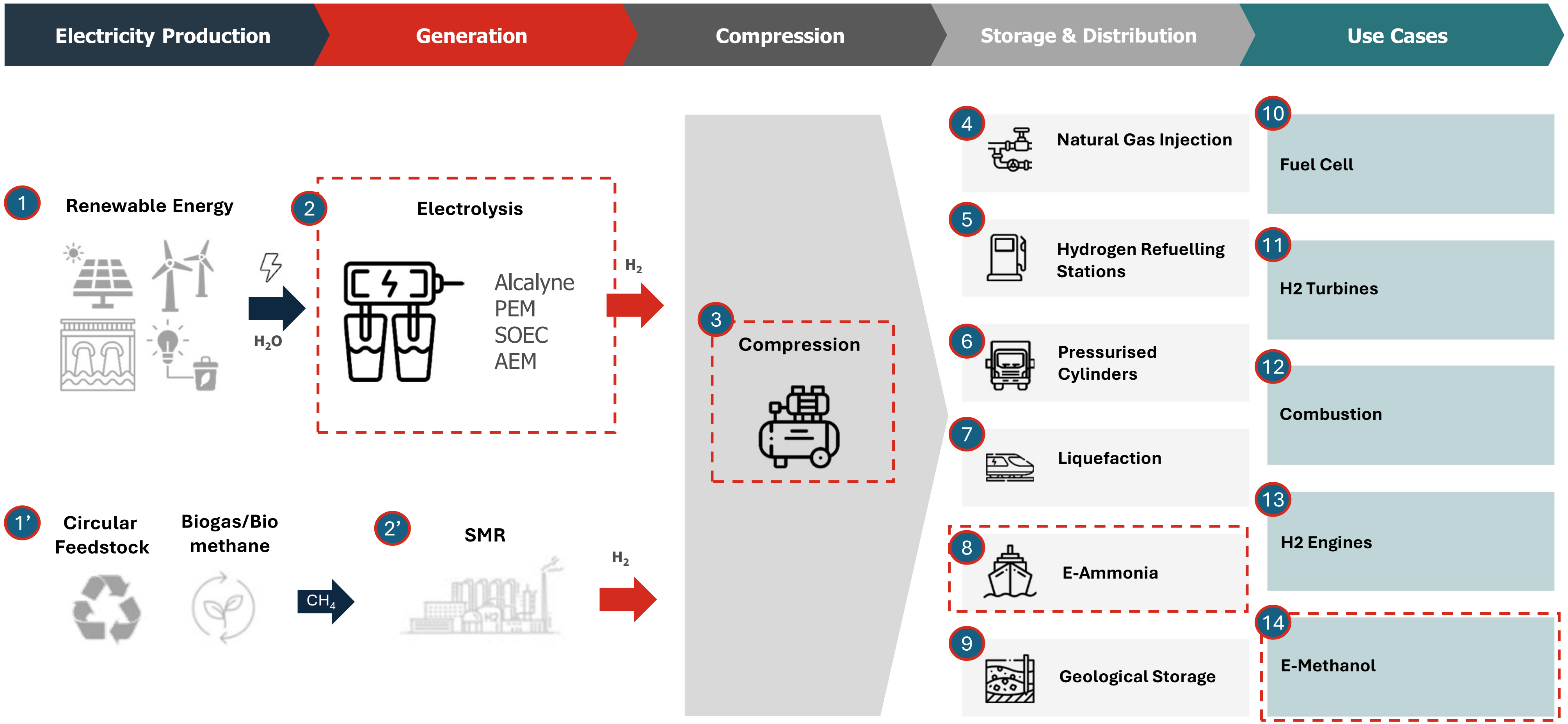
Carteia Project – e-Ammonia

- **Key Figures:**
  - Project involves the construction of a green ammonia plant (600 ktpy) and a renewable hydrogen plant (1GW) in San Roque.
  - Two conceptual cases 600 ktpy green ammonia + 1GW. In case 300 ktpy and 500 MW
- **Technology:** Tender for technology selection of H_2 and NH_3: Bids under evaluation
- **Partnership:** Yara

Timeline

April24	Q1 25	Q4 25	Q2-26	Q4-28
Gate 1	G2	FID	Const	RFSU

Green H2 | Value Chain Technologies



Electrolysis | Technologies Comparison

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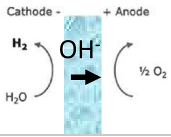
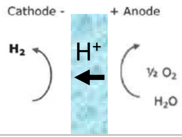
	SMR	Alcaline	PEM	SOEC	AEM
Description	**Steam Methane Reformer** Main industrial technology (5000-200 000m^3/h)	**Mature Technology** The most common technology worldwide	**Emergent TEchnology** Installed in Renewable projects due to its flexibility.	**TRL 7 Innovation** High Potential due to high efficiency ratio's. First demo plants 2-3MW.	**Research & Development** High Potential because of flexibility & lower cost (without critical materials)
Scale (MW) (0-50 / 50-300 / > 300)	> 300	50-300	0-50	none highlighted	none highlighted
Temp Oper. (ºC)	– (0–1000)	60 - 80 (0–1000)	50 - 80 (0–1000)	650 - 1000 (0–1000)	50 - 80 (0–1000)
Efficiency	75 - 85 (0–100)	63 - 70 (0–100)	56 - 60 (0–100)	74 - 81 (0–100)	55 - 70 (0–100)
Useful life (h[x1000])	270 (0–300)	60 - 90 (0–300)	30 - 90 (0–300)	10 - 30 (0–300)	5 - 10 (0–300)
CAPEX (€/W)	0,53 – 1,07 (0–3)	0,45 – 1,25 (0–3)	0,98 – 1,6 (0–3)	2,5 – 4,98 (0–6)	0,6 – 1,5 (0–6)
Surface (m^2/MW)	– (0–100)	95 (0–100)	48 (0–100)	20 - 50 (0–100)	30 - 50 (0–100)

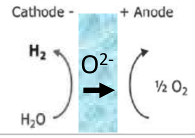
Alcaline:



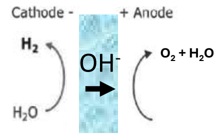
PEM:



SOEC:



AEM:



Electrolysis | Technology Selection

15 OEMs have been analyzed and benchmarked by following criteria:

- Price
- Safety
- Financial capacity
- Maturity of technology
- Experience
- Local content
- Efficiency
- Innovation roadmap
- Service agreements (LTSA and guarantees)

Alkaline

- John Cockerill
- thyssenkrupp
- McPhy (Driving clean energy Forward)
- Hydrogen pro
- nel
- sunfire
- PH2 Peric Hydrogen

PEM

- ohmium
- SIEMENS energy
- plug
- Cummins
- PH2 Peric Hydrogen
- nel
- ITM POWER (Energy Storage | Clean Fuel)

Solid Oxide Electrolysis (SOEC)

- Bloomenergy
- sunfire
- TOPSOE

✓ SOEC and AEM technologies are promising & good projections, still not sufficiently mature for short-term and large scale project.

✓ PEM and Alkaline technologies selected

Electrolysis | Degradation Principles

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Degradation of stacks occurs as a result of chemical reactions, corrosion, and mechanical stress.

Stack degradation during lifetime **is not guaranteed by OEMs** due to:

- Dependency on several external parameters as operating profile, especially start-ups and shutdowns per year (e.g.: non continuous Renewable energy availability).
- Lack of real operating data for 80,000 hours (typical stack lifetime) in industrial environment, the degradation rate is just an OEMs´estimation.

Typical values estimated for overall alkaline and PEM technologies are between 1% to 1,5% degradation /8000 h in continuous operation.

Major Hydrogen Accidents

1985 Posgrum, Norway.
Explosion due to a H2 leak at an ammonia plant.
Two deaths and significant material damage.

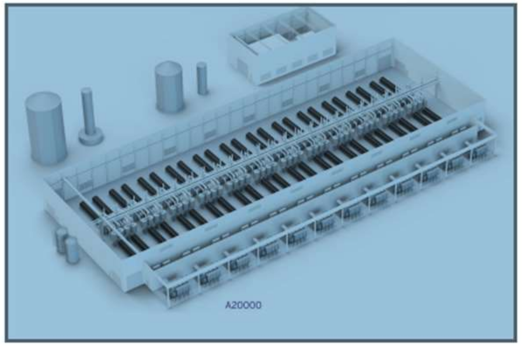
2019 Gangneung, South Korea
Explosion of a mixture of O2 and H2 in a tank downstream of the electrolysis process.
Two dead and six injured.

2019 Sandvika, Norway
Explosion in a tank at a hydrogen station.
No deaths and two people injured.

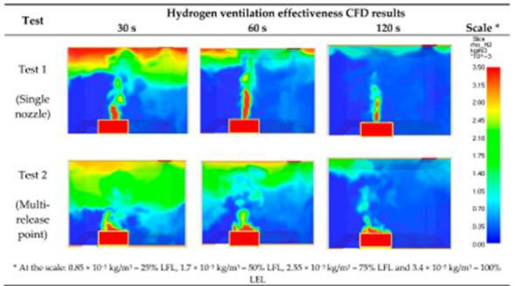
Lessons learned from serious hydrogen gas explosion accidents

- Hydrogen **burns quickly** and can generate clouds that can cause **a devastating explosion with high pressures** (Porsgrunn (1985) and Sandvika (2019))
- **Fragments** constitute a significant hazard to glass, compressor hood wall structure, etc.
- **Fires often follow the explosion:** risk of tank rupture, collapse/meltdown of the structure

- **Internal leakage, cross leakage** and air intrusion in hydrogen-containing equipment can cause serious damage. Internal explosion and equipment rupture (Gangneung (2019))
- We need to better understand the transition from deflagration to detonation mechanism. We can achieve a transition to detonation in less than 1 m
- Hydrogen leaks can self-ignite (extremely flammable gas)



Picture source: NEL



Source: *Energies* **2021**, *14*(13), 4029; https://doi.org/10.3390/en14134029

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Hazards and risks of hydrogen: “Crossover gas” phenomenon

Danger of formation of flammable oxygen-hydrogen mixtures downstream (storage tanks -> 2019 Gangneung, South Korea)

Causes	Safeguards
Design deficiencies in the process: absence of catalytic burner	Robust design. Have catalytic burners
Lack of oxygen detectors	Install oxygen detectors
Poor operating strategy	Establish operational safety windows
	Understand deeply the mechanisms that cause the “gas crossover” phenomenon
	Risk Assessment (HAZOPs) focusing **in transient operations**

Source: Center for Hydrogen Safety Conference Proceeding 2019 *"Review: Hydrogen Tank Explosion in Gangneung, South Korea"*

Desing phase

Operate and Maintain

Gas tank explosion at Norsk Hydro (1969 and 1987). Oxygen separator drum explosion at Laporte (Ilford, UK, 1974)

Hazards and Risks of hydrogen: Venting_Flaring

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Danger of formation of flammable mixtures of oxygen and hydrogen, causing large explosions

Causes

- Connecting the hydrogen from electrifiers to the venting and purging network, and gas recovery (Refineries case)
- Electrifiers cannot be certified as Ex devices according to ATEX regulations

Safeguards

- Have an **independent venting system for Hydrogen** one for low pressure and another for high pressure
- Continue **gas inert injection** (N2) in the flare system
- Design the pipeline so that it can **structurally withstand an explosion**
- ATEX requirements can be met **with good ventilation** (dispersion models)

Desing phase

Operate and Maintain

Study in particular the venting of hydrogen **during start-up and shutdown of equipment (transient operations)**

Other identified risks and safeguards

Risks

Hydrogen processing equipment is typically contained in buildings with the risk of leakage, formation of an explosive atmosphere and ignition.

In addition**, the equipment cannot be certified as Ex devices** according to ATEX regulations.

Safeguards

Good ventilation

Early detection and mitigation of potential hydrogen losses (need to study the proper dispersion of hydrogen emissions)

Have **competent personnel** to operate these technologies

Desing phase

Operate and Maintain

Hydrogen Safety

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Cepsa as a key player in technical forums

BEQUINOR — Develop **technical guidelines** to achieve the highest levels of safety

Concawe — Sessions **addressing major challenges** associated with production, storage and distribution

CCPS (Center for Chemical Process Safety) — Lessons learned from projects

What are we doing…?

Pilot plants
Focus in transition operations

Digital twins
Major hazards scenarios simulation

Training & awareness

Risk hazard analysis / Strong MoC system

Asset integrity in all the project lifecicle

During construction and operation

- Design
- Construction & Commissioning
- Operate & Maintain
- Emergency Response

Start Strong, Stay Strong…

in hydrogen projects

One integrated team with shared safety vision, raising risk awareness of **employees and contractors** from the start

How do we build the safest plants?

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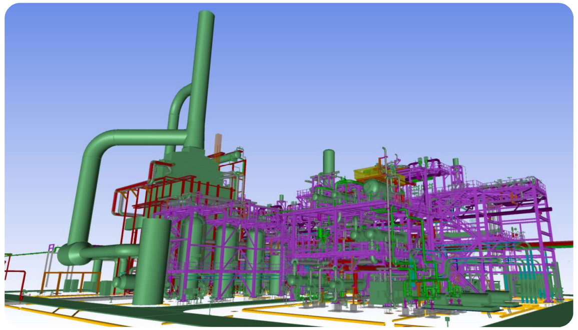
Establish Asset Integrity → **Safeguard Asset Integrity** →

Design



- **Risk identification** and register
- **Risk assessments** (HAZOP, QRAs) to ALARP
- **SCE** identification

Contruction & Commissioning

- Critical interface: **front line supervision**
- Life **critical activities**
- Design **verification**

Operate & Maintain

- **Permit to work** and **emergency response** systems
- **Shift handover**
- Deploy **maintenance** and **inspection** philosophy

Safety in Motion during project transitions…

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Organizational change

Different risk profile (occupational H&S - process)

Simultaneous Operations **(SIMOPS)**

Communication and coordination between teams

HSE Plans for each project phase

Area segregation with physical barriers

Focus Areas HSE Plan: Actions

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Leadership & Culture

- HSE **incentive** program
- Senior management/sponsors **involvement**
- **One team program approach with contractors**
- **Start Strong, Stay Strong**

Communication

- Share **HSE bulletins**
- Complete and **roll out HSE** policy and objectives **to all staff**
- Develop and **implement effective communication** process

Training & Competencies

- Develop **HSE training matrix** for HSE critical positions
- Approve **contractors HSE training plans**
- Develop **HSE onboarding program** for HVO project team

Risk Management & HEMP Processess

- Review and maintain the **high potential risks** and **hazards register**
- Develop and implement **span of control procedure**
- Develop **risk awareness** program

Target, plans, procedures and practices

- Ensure **SIMOPS** and **MOPO** are developed
- Implement **OPS** program
- Ensure **medical evacuation response** plan is developed and maintained
- Ensure compliance with **EIA** approval conditions

Management review & audit

- **HSE Audit** plan: monitor progress on monthly basis
- **HSE performance** management review meetings
- **Quarterly contractor performance** review

Vision

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1. People as a priority by offering them **training** and **resources** to act with **leadership**.

2. Recognize and **communicate** to employees their job well done.

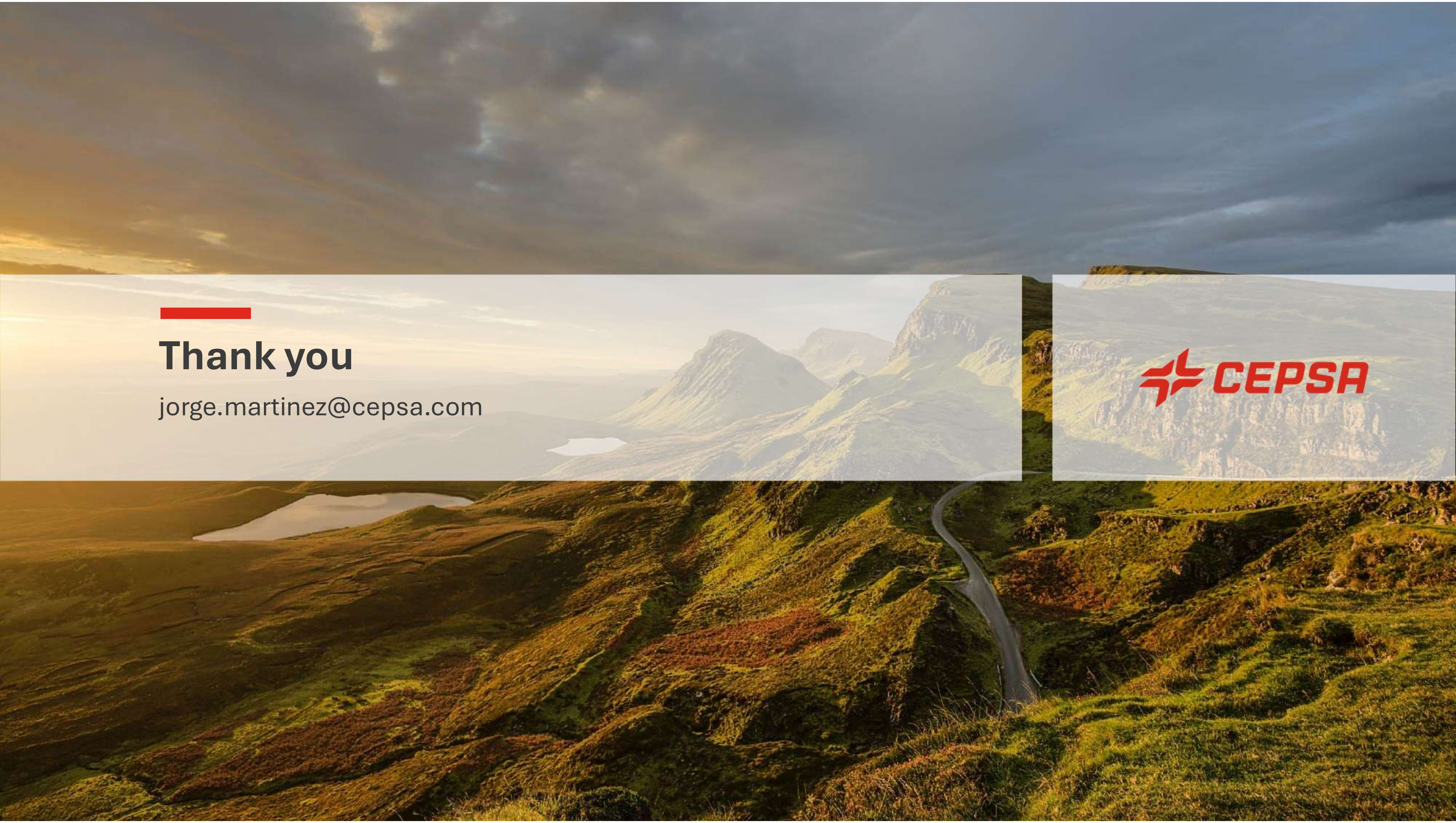
3. All the people involved in the project are **willing to speak up.**

4. Co-creation of a positive and collaborative work environment where everyone feels inspired and motivated.

5. Implementation of digital tools to ensure the **highest safety standards**.

6. Cepsa and contractors act as one team.


Safety in Motion
Start Strong
Stay Strong
CEPSA
Nuestro compromiso:
Somos un equipo unido para la construcción y puesta en marcha del proyecto más seguro de España, la planta de biocombustibles líder del sur de Europa.
Todos somos líderes en Seguridad. Tenemos un compromiso personal e incondicional con el bienestar de nuestros trabajadores.
La seguridad es una condición previa. Evaluamos todos los riesgos antes de comenzar cualquier trabajo. Actuamos con valentía ante situaciones inseguras.
Celebramos nuestros éxitos, reconocemos los esfuerzos y promovemos el aprendizaje continuo.
¡Nuestros equipos están orgullosos de trabajar en el proyecto HVO!



Thank you

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Hydrogen Projects in Cepsa 2030

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ONUBA (Huelva)

In collaboration with Fertiberia, renewable hydrogen and ammonia will be produced with **400 MW of electrolysis capacity**

→ 300 MW → Alcalyne (75%)
→ 100 MW → PEM (25%)

Green MeOH (Huelva)

A **methanol plant** with a production of 45 t/h and **170 MW capacity** will be built

Green H2 (Huelva)

Hydrogen production of **36 kt/y from biogas** (steam reformer) to feed the new HVO plant

CARTEIA (Algeciras) Green Ammonia

A 600 ktpy renewable ammonia plant and **1GW** renewable hydrogen production will be produced in San Roque