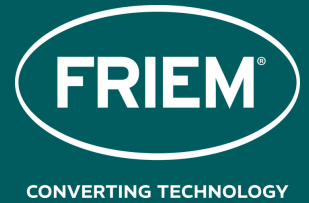


White Paper



# FRIEM PSU: SOLUTIONS FOR HYDROGEN PRODUCTION FROM DESIGN TO DELIVERY



# GREEN HYDROGEN IS NOT JUST ABOUT ELECTROLYSERS

## ACCELERATING HYDROGEN PROJECTS FROM FID TO OPERATIONAL

### Why power conversion determines project success

**Green hydrogen** is expected to play a **key role** in the **energy transition**, with strong growth projected by 2030.

Despite this momentum, the industry is still facing **structural challenges**. The cost gap with fossil-based hydrogen remains significant, regulatory frameworks are evolving slowly, and project deployment is progressing at a slower pace than initially expected.

As a result, the main issue is no longer whether projects are announced, but whether they can be **delivered efficiently**. Many projects struggle to move efficiently from **Final Investment Decision (FID)** to **full operation**.

### THE CHALLENGE

Moving from **engineering** to **commissioning** remains one of the most critical phases for hydrogen projects.

In many cases, systems validated during design do not fully reflect real operating conditions. Testing environments cannot always replicate full load behavior, and issues often emerge only once the plant is installed.

When this happens, late-stage modifications become necessary, increasing costs and impacting timelines. In complex projects, even a single delay can trigger a cascading effect across the entire execution phase.

This makes achieving **reliable, efficient, and on-time operation** a key challenge for project developers.

### THE FRIEM APPROACH

FRIEM supports **hydrogen projects** across the **entire lifecycle**, from early engineering to long-term operation.

To address these challenges, power conversion must be properly engineered from the early project stages, ensuring **full alignment** between the **Power Supply Unit (PSU)**, the **electrolyser**, and **plant requirements**.

The **PSU** is a critical part of the plant, directly connecting the electrical network to the electrolyser and defining how efficiently power is converted into hydrogen. Its **design** directly impacts **efficiency**, system **stability**, and overall plant **performance**.

For this reason, the **PSU must be designed as an integral part of the process, not as a standalone component**.

## ENGINEERING - DESIGN DRIVERS

From a **PSU perspective**, hydrogen production costs depend on three key factors:

- **Best PSU Match (CAPEX)**

Proper PSU sizing and configuration ensure a competitive investment and avoid unnecessary complexity.

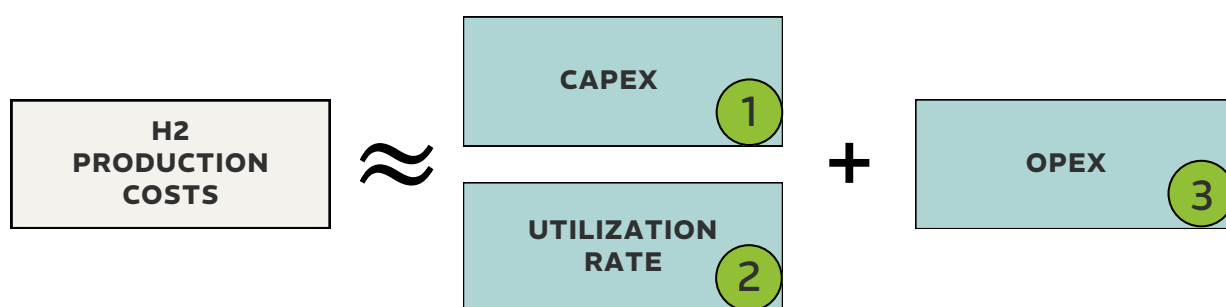
- **Reliability (Utilization Rate)**

Stable operation of the PSU is essential to maximize plant availability and hydrogen production.

- **Efficiency (OPEX)**

High conversion efficiency and reduced maintenance requirements lower operating costs over time.

Each of these elements must be **carefully balanced** during the design phase to ensure optimal project performance.



### Best PSU match

- 1 Competitive CAPEX means selecting the “right” PSU

### Reliability

- 2 Avoiding downtime and ensuring stable and safe conversion of MWH to H2

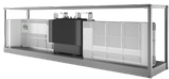
### Efficiency

- 3 Lowering OPEX by maximizing efficiency, and reducing maintenance needs

## FINDING THE BEST MATCH

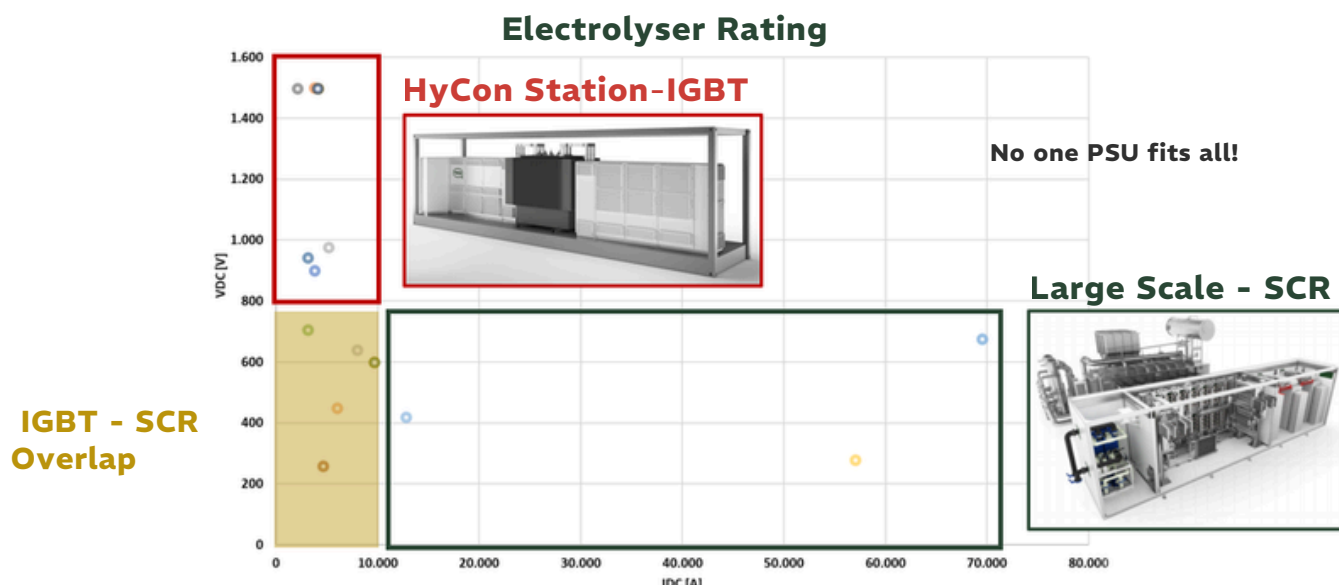
**No one PSU fits all.** Different technologies, such as **IGBT** and **SCR**, offer distinct advantages and must be selected based on **project-specific requirements**, including electrolyser type, operating curve, and grid conditions. **Selecting the right technology** is essential to ensure **optimal performance** and **long-term reliability**.

### SELECTING THE RIGHT TECHNOLOGY

|                           | Containerized SCR                                                                 | HyCon Station                                                                     | Large Scale SCR                                                                    | 2-levels HyCon                                                                      |
|---------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Product                   |  |  |  |  |
| Electrolyser technology   | PEM, pressurized alkaline                                                         | PEM                                                                               | Alkaline                                                                           | Pressurized alkaline                                                                |
| Rated DC Voltage          | Up to 750 V                                                                       | Up to 1500 V                                                                      | Up to 700 V                                                                        | Up to 800 V                                                                         |
| Rated DC current          | Up to 10 kA                                                                       | Up to 6,5 kA                                                                      | Up to 70 kA                                                                        | Up to 12 kA                                                                         |
| Semiconductors            | Thyristors, 2 to 3 inches                                                         | IGBT (3 or 2 levels) AFE                                                          | Thyristors, 2 to 4 inch                                                            | IGBT (2 levels) AFE                                                                 |
| Power Quality Integration | Static Harmonic filters                                                           | Not required                                                                      | STATCOM + Harmonic filters                                                         | Not required                                                                        |
| DC Voltage Control        | Thyristors + NLTC                                                                 | IGBT control                                                                      | OLTC + thyristors                                                                  | IGBT control                                                                        |
| Pulse                     | 12                                                                                | -                                                                                 | Multipulse                                                                         | -                                                                                   |

**Other ratings available upon request**

## ENGINEERING - DESIGN DRIVERS



## MANUFACTURING EXCELLENCE

**Modular design**, robust **supply chain** management, and **lean production** processes, allow FRIEM to ensure **reduced lead times**, **scalability** and consistent quality across projects.

## FROM TESTING TO OPERATION

FRIEM support continues **beyond commissioning**, ensuring reliable operation, performance optimization, and system **availability over time**.

## ADVANCED TESTING & VALIDATION

A **step-by-step validation** approach is applied to verify PSU performance before installation:

- **Simulation** to predict real operating conditions
- **Module test** to reduce FAT failure and rework risk.
- Factory Acceptance Tests (**FAT**)
- Site Acceptance Tests (**SAT**)

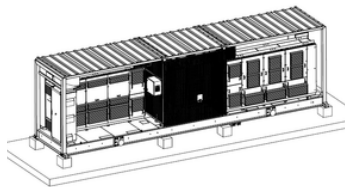
**This reduces uncertainty and prevents costly late-stage modifications.**



## PSU DEPLOYED - DIFFERENT PROJECTS, DIFFERENT NEEDS

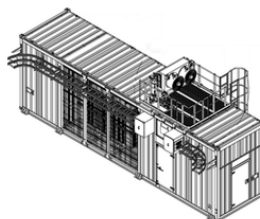
### IGBT PSU for 5MW PEM Electrolyser

- Location: Brazil
- PSU rating: 3.75 kA - 1,500 V
- Unit: 1
- Oil filled transformer. Skid with integrated retention bund
- 40 feet container for plug and play solution
- Power factor higher than 0.97



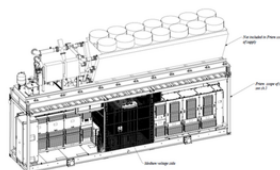
### Thyristor PSU for 5MW PEM Electrolyser

- Location: Crete
- PSU rating: 2x3, 75 kA - 710 V - 12 pulse
- Units: 1
- 24 kV switchgear inside the container
- Oil filled transformer
- 40 feet container for plug and play solution
- Harmonic filter to reach 0.95 power factor



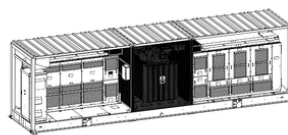
### IGBT PSU for 5MW PEM Electrolyser

- Location: Germany
- PSU rating: 2x3, 1 kA - 940 V
- Unit: 1
- Oil filled transformer with integrated retention bund
- 40 feet container for plug and play solution
- Electrolyser heat exchanger installed on top of the skid
- Power factor equal to 0.98

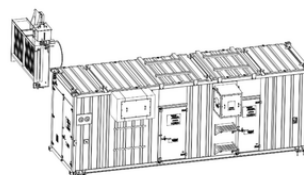


**IGBT PSU for 5MW PEM Electrolyser**

- Location: Romania
- PSU rating: 3.75 kA - 1,500 V
- Units: 11
- Oil filled transformer. Skid with integrated retention bund
- 40 feet container for plug and play solution
- Power factor higher than 0.97

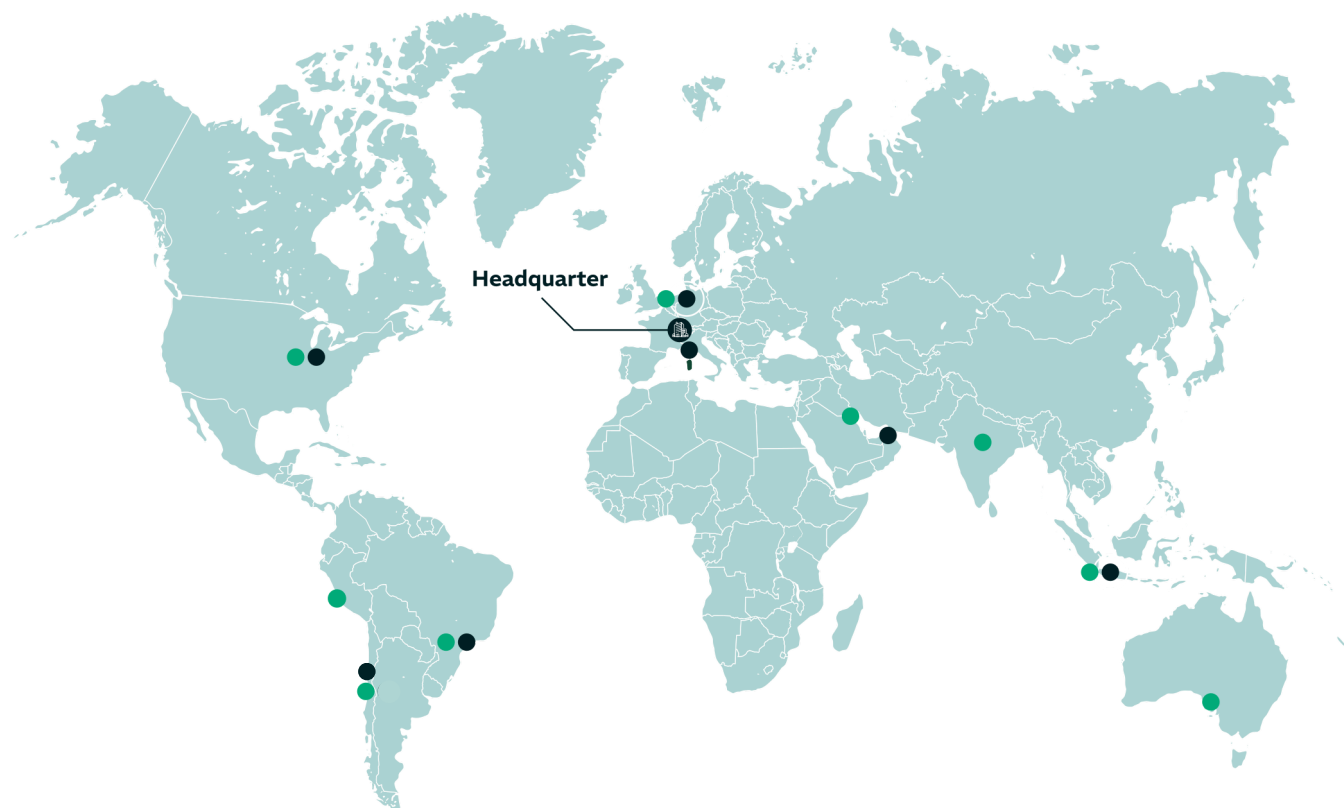
**Thyristor PSU for 2MW PEM Electrolyser**

- Location: Spain
- PSU rating: 3,1 kA - 707 V - 12 pulse
- Unit: 1
- Dry-Type transformer
- 30 feet container for plug and play solution
- Harmonic filter to reach 0.95 power factor



# FRIEM CONVERTING TECHNOLOGY SINCE 1950

## Service Centres and Offices



### ● Locations

MILAN HQ | GENOA | COLUMBUS | CHICAGO  
SAO PAULO | JAKARTA | SANTIAGO | BONN | DUBAI

### ● Service Centres

MILAN | COLUMBUS | SAO PAULO | JAKARTA | NEW DELHI  
LIMA | SANTIAGO | ADELAIDE | DAMMAM | BONN

## ABOUT FRIEM

FRIEM is an **Italian technology manufacturer** founded in 1950, **specializing in the design and production of electrical converters for special applications.**

The company ranks among the world's top four players in **current rectifiers for large-scale industries and green hydrogen production.**

As a key enabler of the energy transition, **FRIEM supplies power conversion systems for high-capacity electrolysis plants and is recognized as a European leader in this field.**

In April 2022, Fondo Italiano d'Investimento, through FITEC, acquired a minority stake to support FRIEM's growth and investment strategy.

**FRIEM is part of FRIEM Group, a global industrial group specializing in high-power energy conversion.**

Today, **FRIEM Group** generates approximately €60 million in production value—over 90% of which comes from international markets in collaboration with leading global partners—boasts 2.5 GW of installed capacity, and employs more than 180 people.

The Group comprises the parent company FRIEM S.p.A., headquartered in Segrate (Milan), and subsidiaries in the United States (FRIEM America Ltd), Brazil (FRIEM Brazil), Chile (FRIEM Chile), Germany (FRIEM Germany), and the commercial offices FRIEM Indonesia and FRIEM Dubai. It also includes **DynAmp** (USA), a manufacturer of high-current DC measuring systems, and **Poseico** (Italy) specialised in power semiconductors and power converters.

## **FRIEM S.p.A.**

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