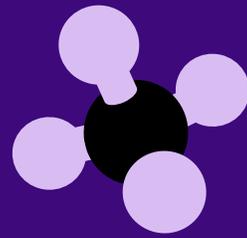


spark

deCarbonized Hydrogen

Exec Summary



Spark is pioneering a new way to produce de**Carbonized hydrogen: methane plasmalysis**, which has **low electrical consumption** and co-produces **solid carbon**, a valuable industrial material.

Spark offers :

- Competitive hydrogen **as a substitute to natural gas** to decarbonize industrial heat.
- Sustainable solid carbon **avoiding CO₂ emissions** due to traditional solid carbon manufacturing.

Hydrogen is produced directly at consumption site thanks to a **unique worldwide, patented technology: Nanopulsed Cold Plasma**, which optimizes energy efficiency.

EVOLEN'UP



RISE
CNRS
INNOVATION



1 - SPARK's team: from lab to industry



Erwan Pannier

Engineer at Centrale Paris '14
(top2 France)
Ph.D Plasma Physics Paris-
Saclay '19 / Invited St.
Researcher Stanford University



Co-founder & CTO

- **Developed the cold pulsed plasma technology** for energy applications through his Ph.D at Paris-Saclay & as invited researcher at Stanford
- Lead Spark's Lab program (0.55 m€, 5 people), built the Lab prototypes, won the 2022 French Innovation Prize i-Lab Prize (+0.5m€)



Patrick Peters

20+ years of experience in
Management, Finance &
Biz dev in the environment
and energy sectors



Co-founder & CEO

- **CEO Biogas subsidiary of Suez**
150 employees
€45m invested in green energy
- **CEO Adionics (lithium extraction)**
Lithium positioning, raised €12m,
scaled the team from 10 to 30 and
deployed 3 industrial pilots.



Alban Reboul Salze

20+ years of experience in
Industrial project
management & Biz dev in
the oil & gas sector



Co-founder & COO

- **Engineering and Construction Department Manager at TotalEnergies**
Industrial project management (1 to 225 MUSD, 10 to 600 people)
- **COO Haffner Energy**
Structuring and scaling operations to industrial level (30 people)

+ 8 very talented Engineers & Business people .

1 - SPARK's team: from lab to industry

Industrial Advisor



Alain Honnart

Former Industrial Director at Vallourec (Oil, Gas & Nuclear)

Extensive Industrial Network & Strong Experience in industrial Innovation



Jean Yves Le Goux

Former Director at Suez Industrial Solutions & Caisse des dépôts Projets Industriels
Technical expert, thermal, solid gas filtration, technological development



Christophe Laux

Professor Paris Saclay & CentraleSupélec

Inventor of the nanopulsed cold Plasma Technology



Khaled Hassouni

Professor CNRS

World-specialist in plasma-assisted carbon production (nucleation, diamond synthesis, etc.)

Marketing Advisor



Geoffroy de Grandmaison

Former Marketing Director at Vallourec, Faurecia, Wabtec

Strong Experience in industrial marketing, market study and innovation.

Board of Advisors



Charles-Henry Choël

Partner Asterion Ventures

Financial, management and international experience. Investor and Board Advisor of Klaro, Bocoloco, Urbyn, Aktio...



Amaury Bierent

CEO Optyma & Ovive

Experience in industrial water treatment and waste-to-energy projects. Investor and Board Advisor of Waga, Lhyfe and Tryon environnement.



Benoit Galland

Former Director Akuo Energy

Experience in the energy and agri-food sectors (+250m€ projects). Investor and Board Advisor Polyfly, Rapidle...

...

+ Business Angels

Experienced in Industrial Hydrogen, Energy Reglementations, Oil & Gas, Project Financing, Industrialization, HR Growth, etc.

2 - The challenge: how to source clean, on-site and affordable H₂ for industries and refuelling stations



Today's H₂ production is not environmentally friendly

10 T CO₂ / T H₂
produced with current process
(steam methane reforming)



Electrical alternatives require huge power

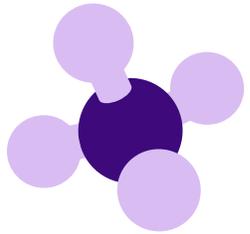
6 250 TWh
¼ of worldwide electricity production
needed in 2030 for hydrogen production target with **water electrolysis**



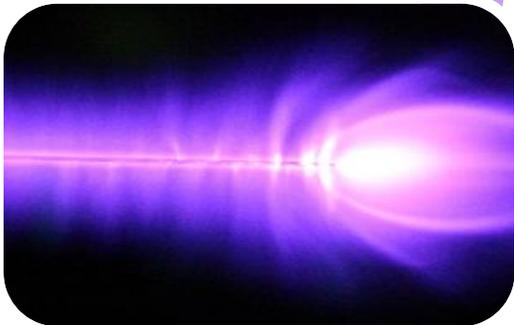
Transport costs are important

70%+
of the global H₂ cost for decentralized consumption are **distribution costs**

3 - A new way for H₂: plasmatolysis



(3kgC / kgH₂ produced)



Cold Nanopulsed Plasma (*"Lightning in a box"*)
a **world-unique**, patented technology,
converts **methane** into **hydrogen** and **valuable solid carbon** without CO₂ emissions.



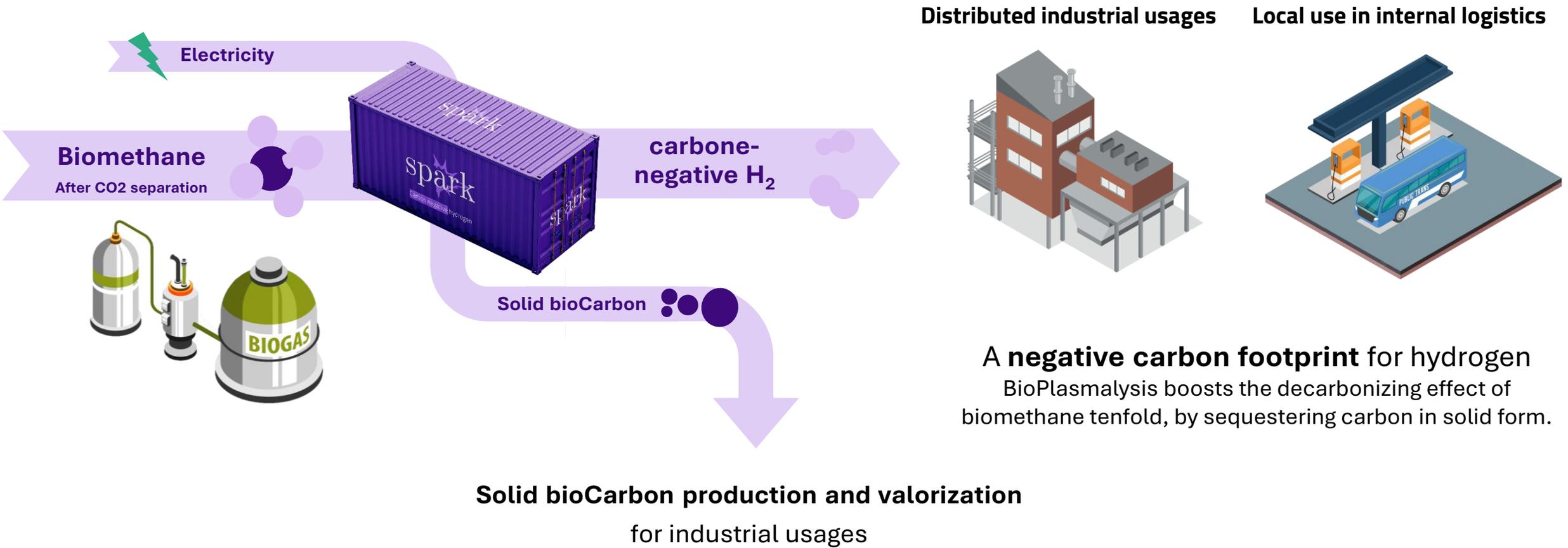
5x less electricity than electrolysis



Zero CO₂ emissions



5 - Plasmalysis boosts biomethane's decarbonizing effect tenfold



Typical Client :
Methanization plant

Spark :
Modular for all sizes of plants
Deployment of an CH-5 industrial pilot in Q1 2024

5 – Valorization of solid (bio)Carbon



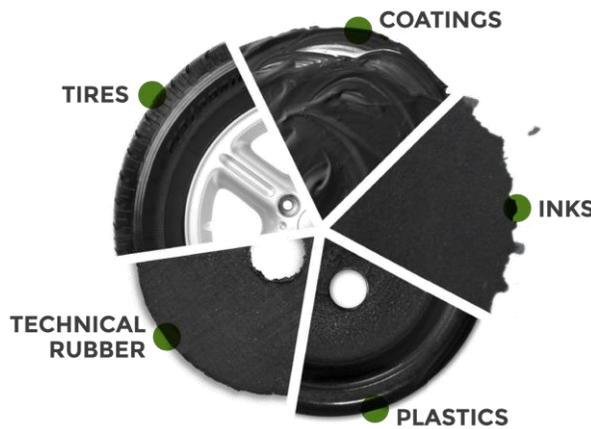
3kg C / kgH₂ produced

Solid Carbon / BioCarbon

Solid carbon valorization drive down hydrogen cost

deCarbonized H₂

Solid carbon plays a **vital role in various industrial applications**.
Solid (bio)carbon **offsets the hard-to-abate emissions** of carbon-intensive sectors.



Trends and Forecast for the Global Carbon Black Market (US \$B) (2017-2028)



Top Companies in Carbon Black Market

- Cabot Corporation
- Orion Engineered Carbons
- Birla Carbon
- Sid Richardson Co
- Philips Carbon Black

Opportunities for Specialty Carbon Black by Application, Grade, Function, and End Use Industry

Application	Grade	Function	End Use Industry
<ul style="list-style-type: none"> Tire Rubber Non-Tire Rubber Plastics Ink Coatings Others 	<ul style="list-style-type: none"> Commodity Carbon Black Specialty Carbon Black 	<ul style="list-style-type: none"> Reinforcement Coloring (Pigmentation) Conductivity UV Protection Others 	<ul style="list-style-type: none"> Transportation Industrial Building and Construction Printing and Packaging Others

Solid carbon generates an **additional revenue stream** allowing a low pricing on H₂.

5 - Use case 1: decarbonation of industrial heat processes

Spark can produce hydrogen for medium-temperature processes (using natural gas) in search of decarbonation solutions **reusing their existing infrastructure**

CH₄-POWERED FURNACE



SPARK H₂

+

UPGRADED BURNERS & RE-USE FURNACES*



- **Low cost** (5x less electricity than electrolysis, solid carbon valorization)
- **Low carbon footprint** (client's premium prices, ESG quotes, ...)
- **Re-use natural gas burners** (low CAPEX, modular & plug-and-play)
- **Equivalent to biomethane combustion** in terms of overall carbon footprint

Typical Client :

12t Aluminium Pilot Furnace = 1.8t H₂/day
150t Aluminium Furnace = 10 – 12t H₂/day

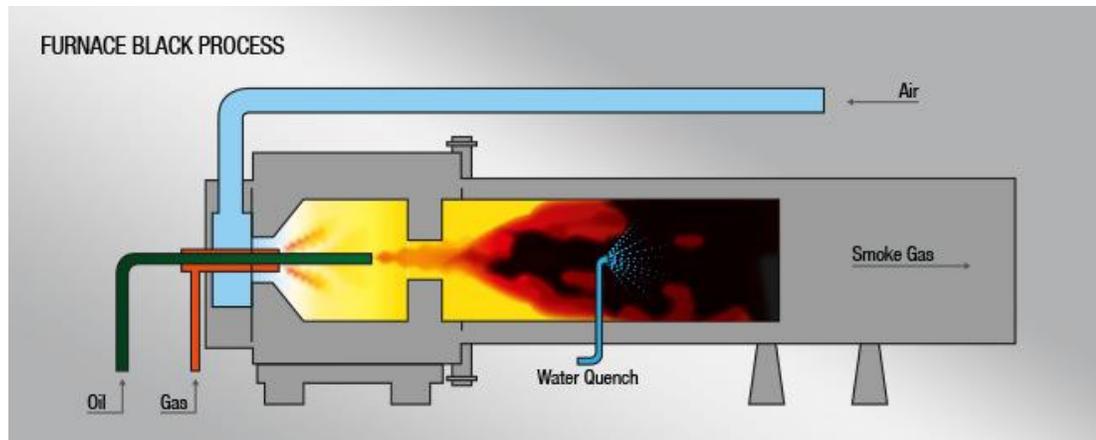
Spark :

Modular, Plug-and-play production units
Start and stop

6 – Carbon black is currently produced using oil and gas

Spark sustainable solid carbon is produced **without combustion**, avoiding CO₂ emissions associated with traditional solid carbon manufacturing and further **reducing the carbon footprint of the overall process.**

Current carbon black production is based on **burning oil and gas** and is **highly CO₂ emitting**



2kg CO₂/kg Carbon Black produced
with traditional production methods

Past polluting methods

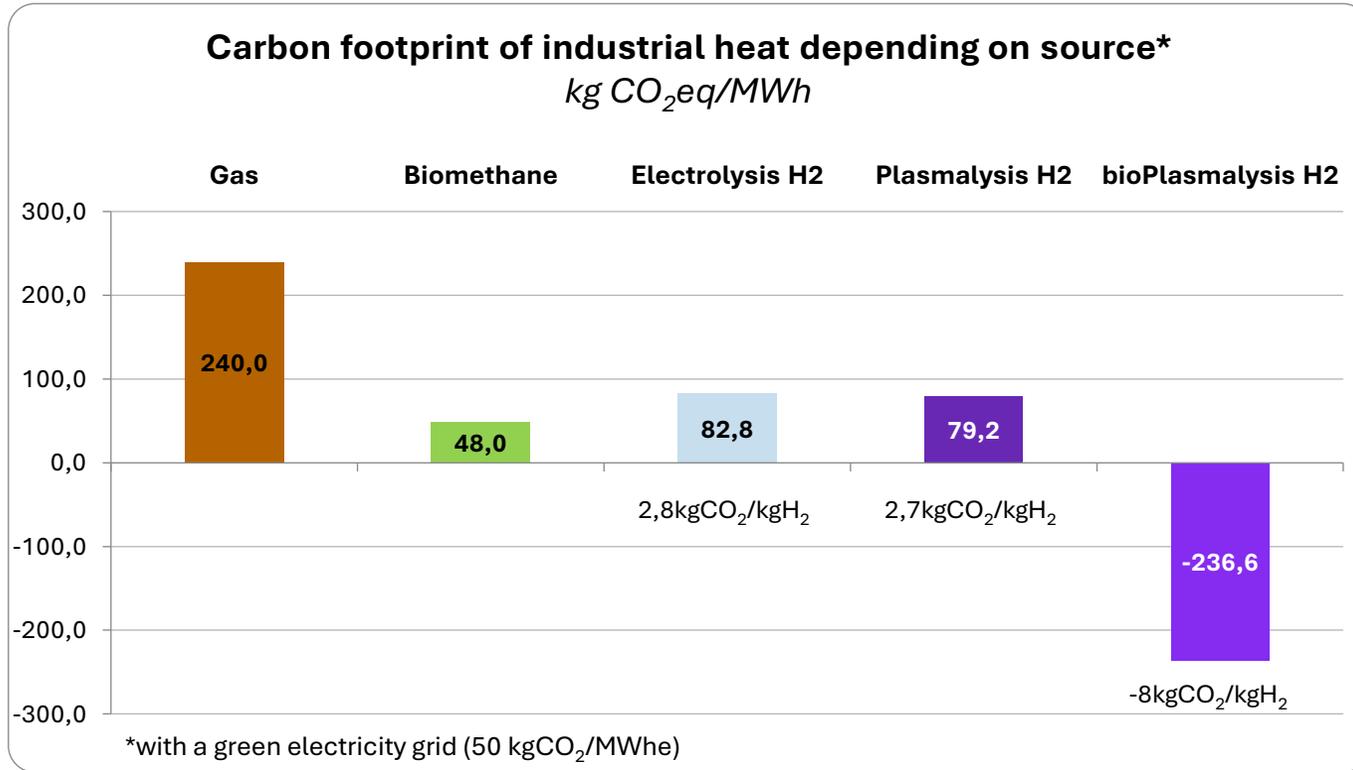
Spark technology cleanly dissociate methane to **produce hydrogen and carbon black**



6kg CO₂ avoided/kgH₂ produced
with Spark technology

Today's decarbonized innovation

6 – Carbon Intensity of Plasmalysis: a doubly virtuous path



Avoidance of CO₂ emissions due to the production and valorization of clean solid carbon

2kg CO₂ avoided / kg C(s) produced
 → 6kg CO₂ avoided / kg H₂ produced



Global impact

Nanopulsed Plasmalysis

3,3 kgCO₂/kgH₂ avoided

Nanopulsed bioPlasmalysis

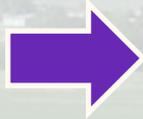
8 kgCO₂/kgH₂ permanently stored*

+6 kgCO₂/kgH₂ avoided

*If carbon's end-of-life is not combustion.

7 – Spark improves a proven concept ...

Monolith Materials were the first to industrialize a **plasmalysis process (2012+)** using **thermal plasma**



2012 – MinesParistech
(France)

Prototype – **20 kg/day H₂**

86 kWh/kg H₂*

2014 – Redwood City – **200 kg/day H₂**

2020 – **12 t H₂/day** **Economically viable size**

25 kWh/kg H₂ – \$100m investment

+1B\$ granted by the Department of Energy (DOE)

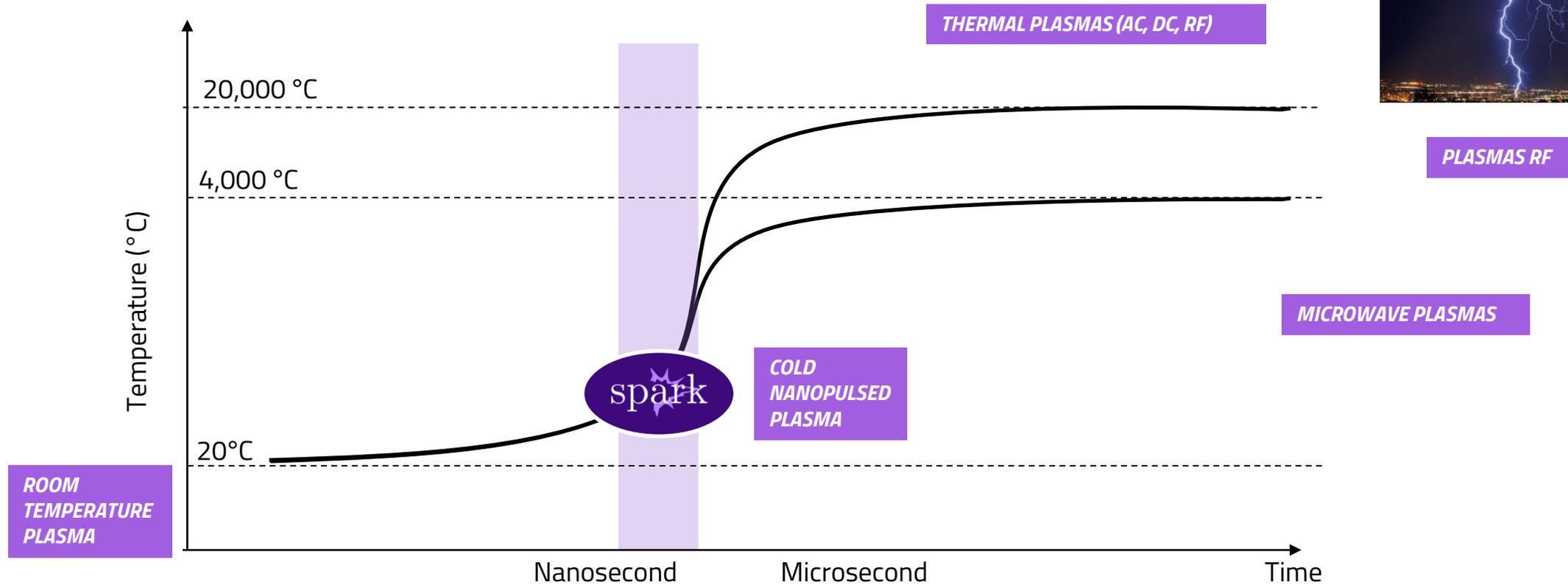
Thermal plasma was energy inefficient but Monolith mitigated heat losses by scaling : they reached 25 kWh/kg H₂ at industrial size (half the consumption of an electrolyzer)

Spark uses a new, first-principle approach to cancel losses already at small scale using a **cold plasma**.

*Fulcheri et al 2022. doi.org/10.1016/j.ijhydene.2022.10.144

8 - ... with a new approach: nanosecond-control of temperature

The transition between a cold gas and a thermal plasma (e.g. lightning) spans over merely few nanoseconds.



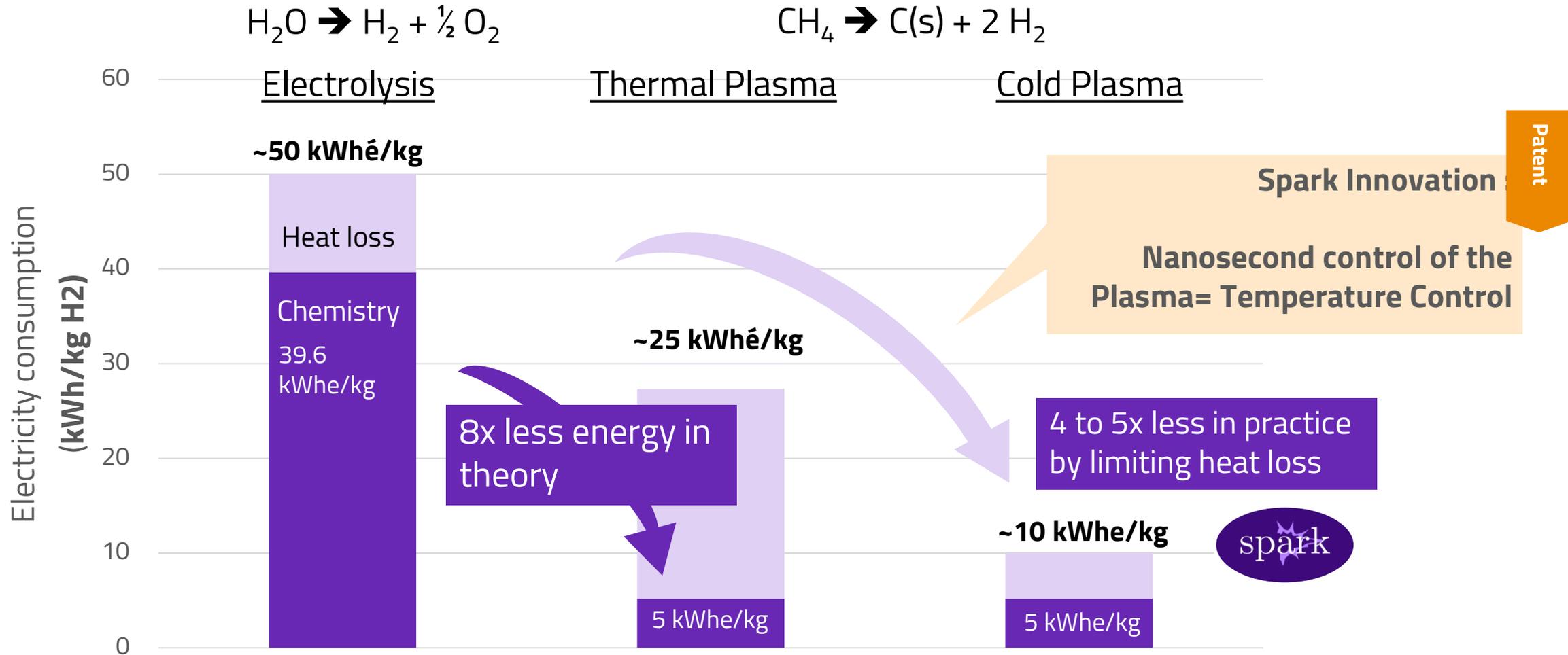
Temperature too low: the reaction is too slow, hydrogen is not produced and energy is lost: **inefficient**.

Sufficient and controlled temperature for a **fast and efficient** reaction

Temperature too high: material stress and heat losses: **inefficient reaction**

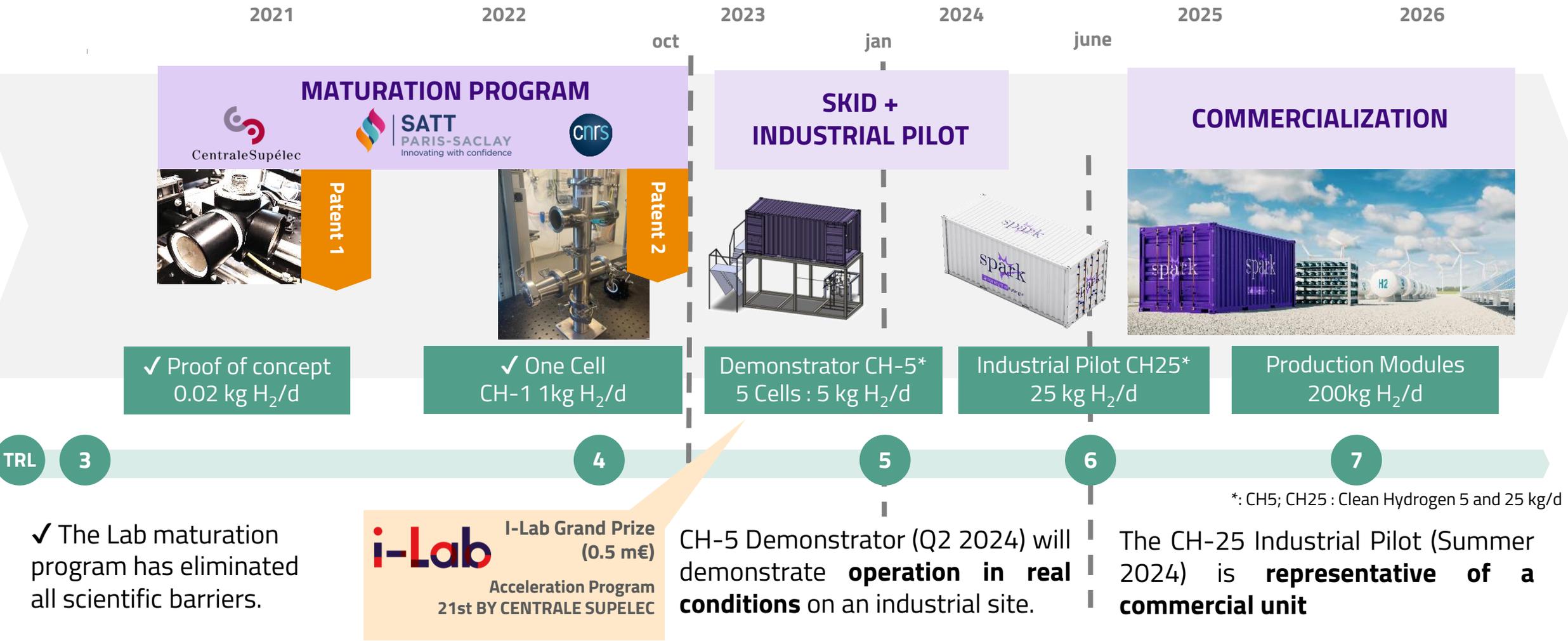
Spark's nanopulses are a **unique technology** that allows to control the temperature in the plasma to obtain the optimum between fast reaction & low heat losses.

8 - ... with a new approach: nanosecond-control of temperature



Temperature control brings us closer to the theoretical minimum of 5 kWh/kg H₂. Spark aims for 10 kWh/kg (4 to 5 x less than electrolysis).

10 – Development plan



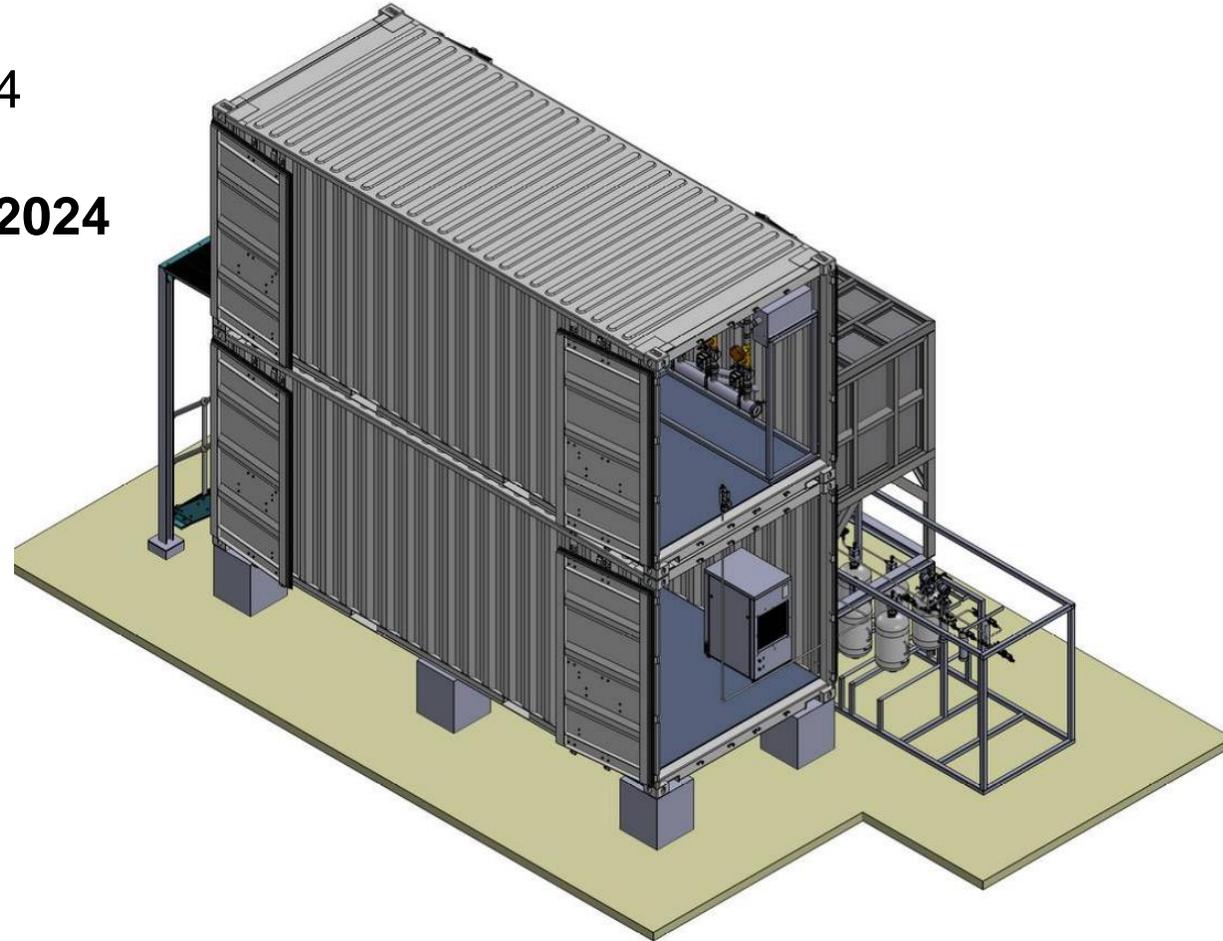
Industrial Demonstrator : CH-5 « Clean Hydrogen Five »

First Nanopulsed Plasmaplysis Demonstrator in the world!

Factory Tests : March 2024

Client Site deployment

on an industrial site: **Q2 2024**



Next Pilot will pave the way for our **200 kg – 1T/day** commercial unit in 2025

spark

Let's meet!



www.spark-cleantech.eu



contact@spark-cleantech.eu



[@spark_cleantech](https://www.linkedin.com/company/spark_cleantech)