



spark

deCarbonized **Hydrogen**

Exec Summary

Spark is pioneering a new way to produce de**Carbonized hydrogen: methane plasmalysis**, which has (1) **low electrical consumption** and (2) co-produces **solid carbon**, a valuable industrial material.



Spark brings :

- A **worldwide-unique, patented technology: Nanopulsed Plasmalysis**, which optimizes efficiency.
- Competitive hydrogen **as a substitute to natural gas** to decarbonize industrial heat.
- Sustainable solid carbon **avoiding CO₂ emissions** due to traditional solid carbon manufacturing.
- Modular units directly at the consumption site

1 - SPARK's team: from lab to industry - 11 people team



Erwan Pannier

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



Co-founder & CTO
Science

- **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
Business

- **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
Industry

- **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.

2 - The challenge: how to source clean, on-site and affordable H₂



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

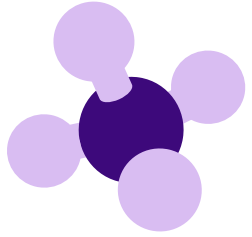
6 250 TWh
1/4 of worldwide electricity production
needed in 2030 for hydrogen production
target with **water electrolysis**



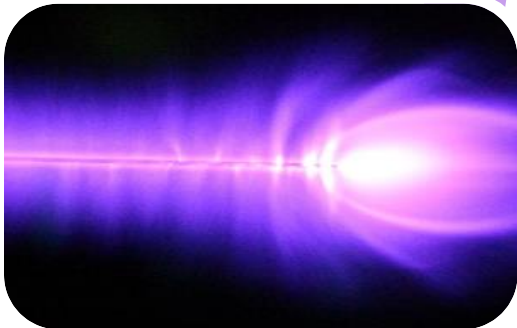
Transport costs are important

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

3 - A new way for H₂: plasmalysis



(3kgC / kgH₂ produced)



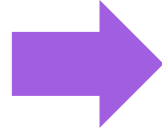
Cold Nanopulsed Plasma (*"Lightning in a box"*)
a **world-unique**, patented technology,
converts methane into hydrogen and valuable
solid carbon **without CO₂ emissions** and **low
electricity input**



4 – Clean hydrogen to decarbonize hard-to-abate industrial heat

Spark offers **competitive hydrogen**, produced directly at the consumption site, as a **substitute to natural gas to decarbonize hard-to-abate industrial heat**.

CH₄-POWERED FURNACE



SPARK H₂

+

UPGRADED BURNERS & RE-USE FURNACES*



Gas is already available

- **Low cost** (5x less electricity than electrolysis, solid carbon valorization)
- **Low carbon footprint** (client's premium prices, ESG quotes, ...)
- **Non-intrusive in the process** (low CAPEX, modular & plug-and-play)

Metallurgy
Cement
Glass
Chemical

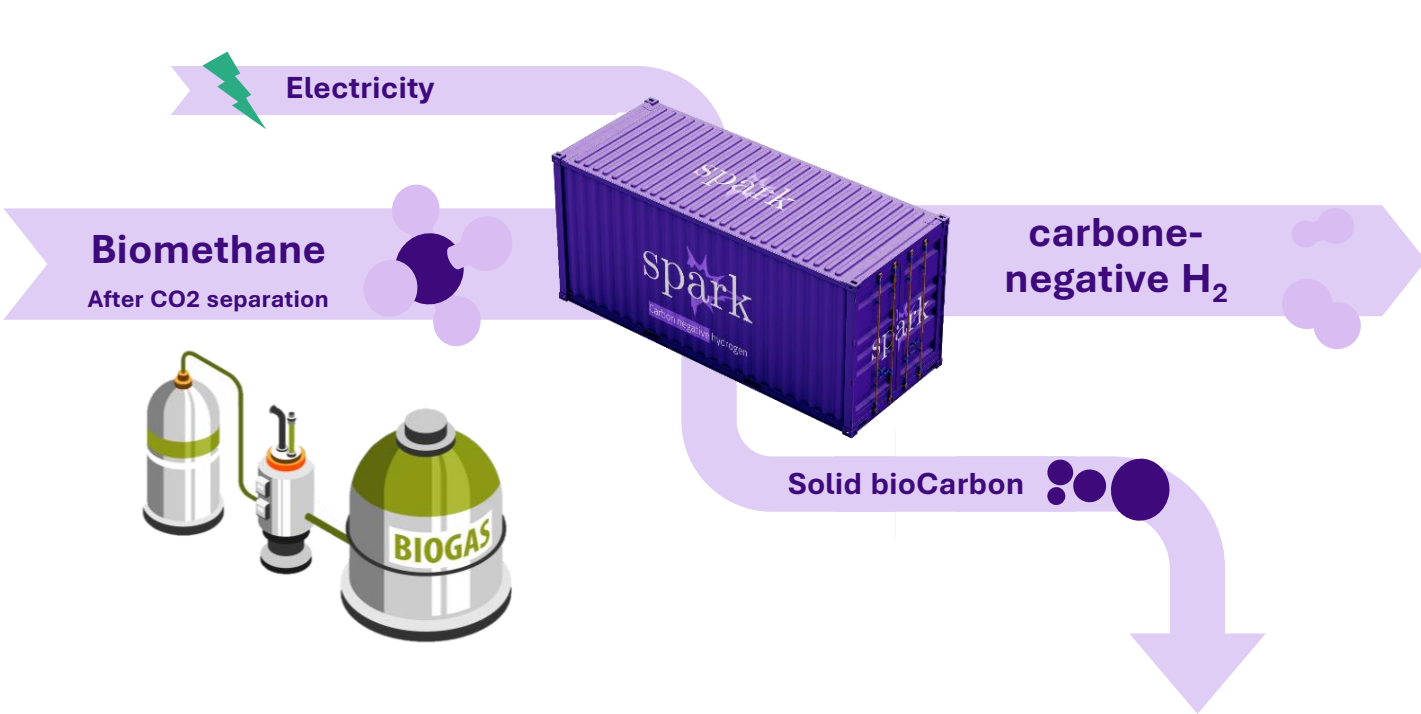
Typical Client :

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

Spark :

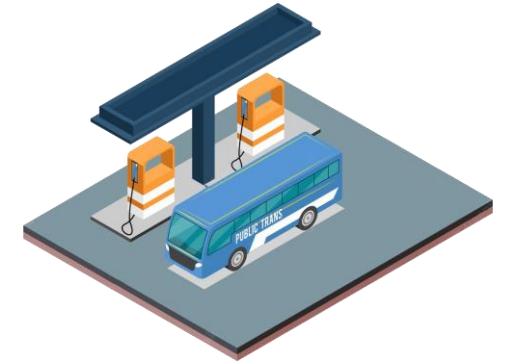
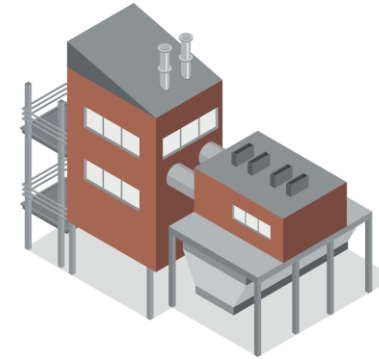
Modular, Plug-and-play production units
Start and stop

5 - Plasmaplalysis boosts biomethane's decarbonizing effect tenfold



Distributed industrial usages

Local use in internal logistics



A negative carbon footprint for hydrogen
BioPlasmaplalysis boosts the decarbonizing effect of biomethane tenfold, by sequestering carbon in solid form.

Solid bioCarbon production and valorization
for industrial usages

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



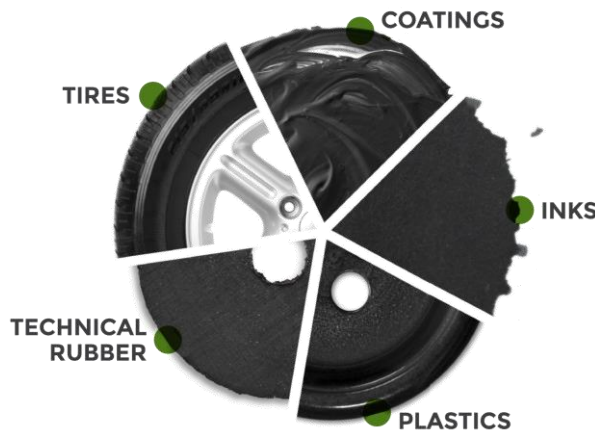
3kg C / kgH₂ produced

Solid Carbon / BioCarbon

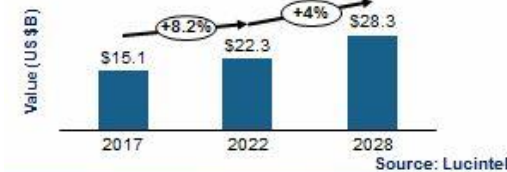
Solid carbon valorization drive down hydrogen cost

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

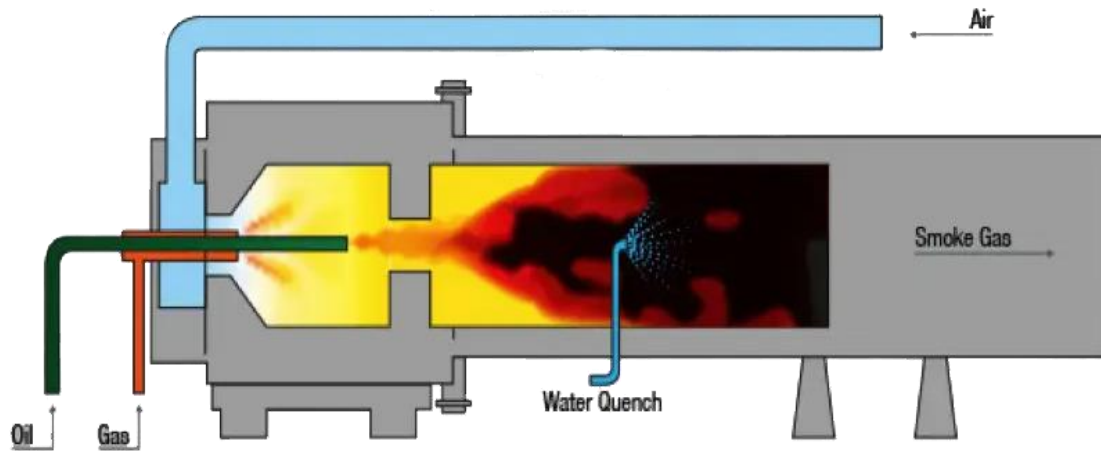
Application	Grade	Function	End Use Industry
<ul style="list-style-type: none"> Tire Rubber Non-Tire Rubber Plastics Ink Coatings Others 	<ul style="list-style-type: none"> Commodity Carbon Black Specialty Carbon Black 	<ul style="list-style-type: none"> Reinforcement Coloring (Pigmentation) Conductivity 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.

6 – Solid Carbon 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

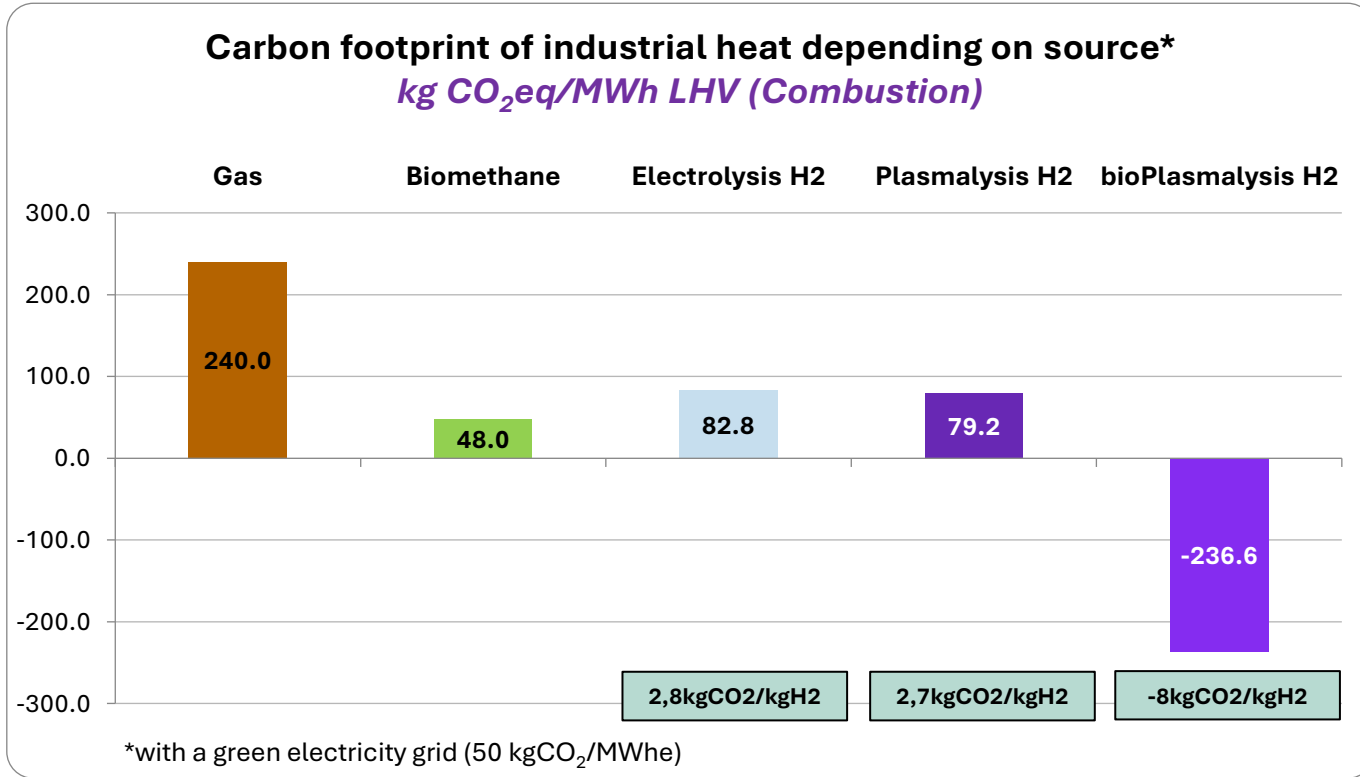
Spark technology cleanly dissociate methane to **produce hydrogen and solid carbon**



6kg CO₂ avoided/kgH₂ produced
with Spark technology

Today's decarbonized innovation

6 – Two products = Two simultaneous decarbonation



+

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

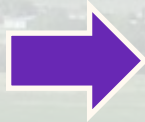
8 kgCO₂/kgH₂ permanently stored*

+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)

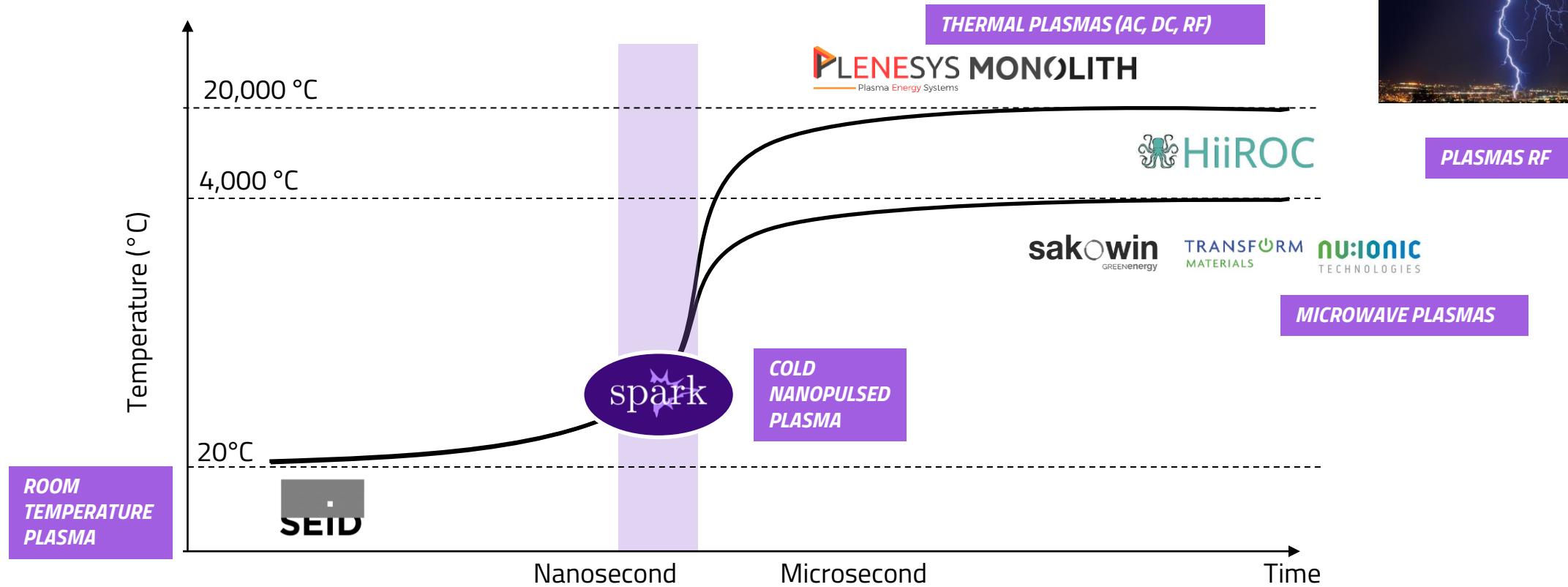
Thermal plasma was energy inefficient but Monolith mitigated heat losses by scaling : they reached 25 kWh/kg H₂ at industrial size (half the consumption of an electrolyzer)

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.



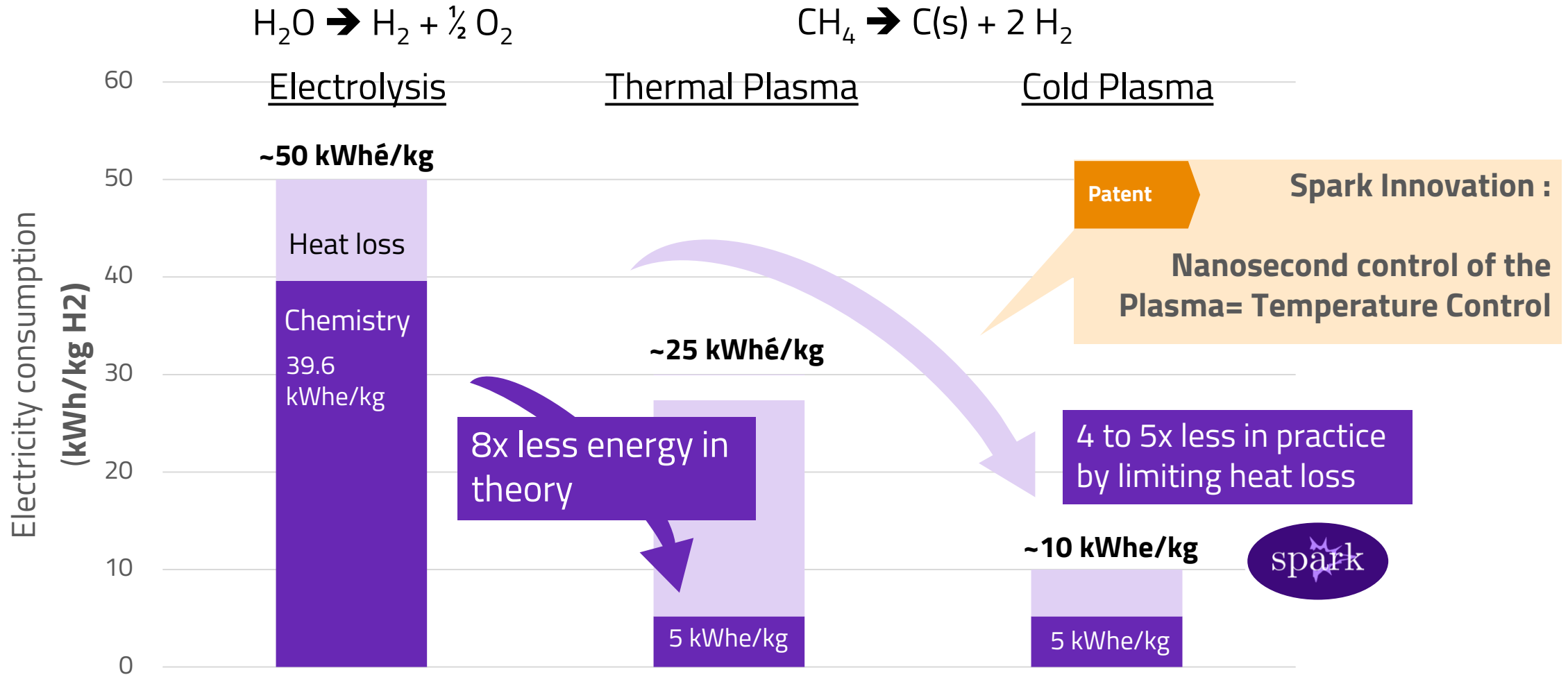
Temperature too low: the reaction is too slow, hydrogen is not produced and energy is lost: **inefficient**.

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

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

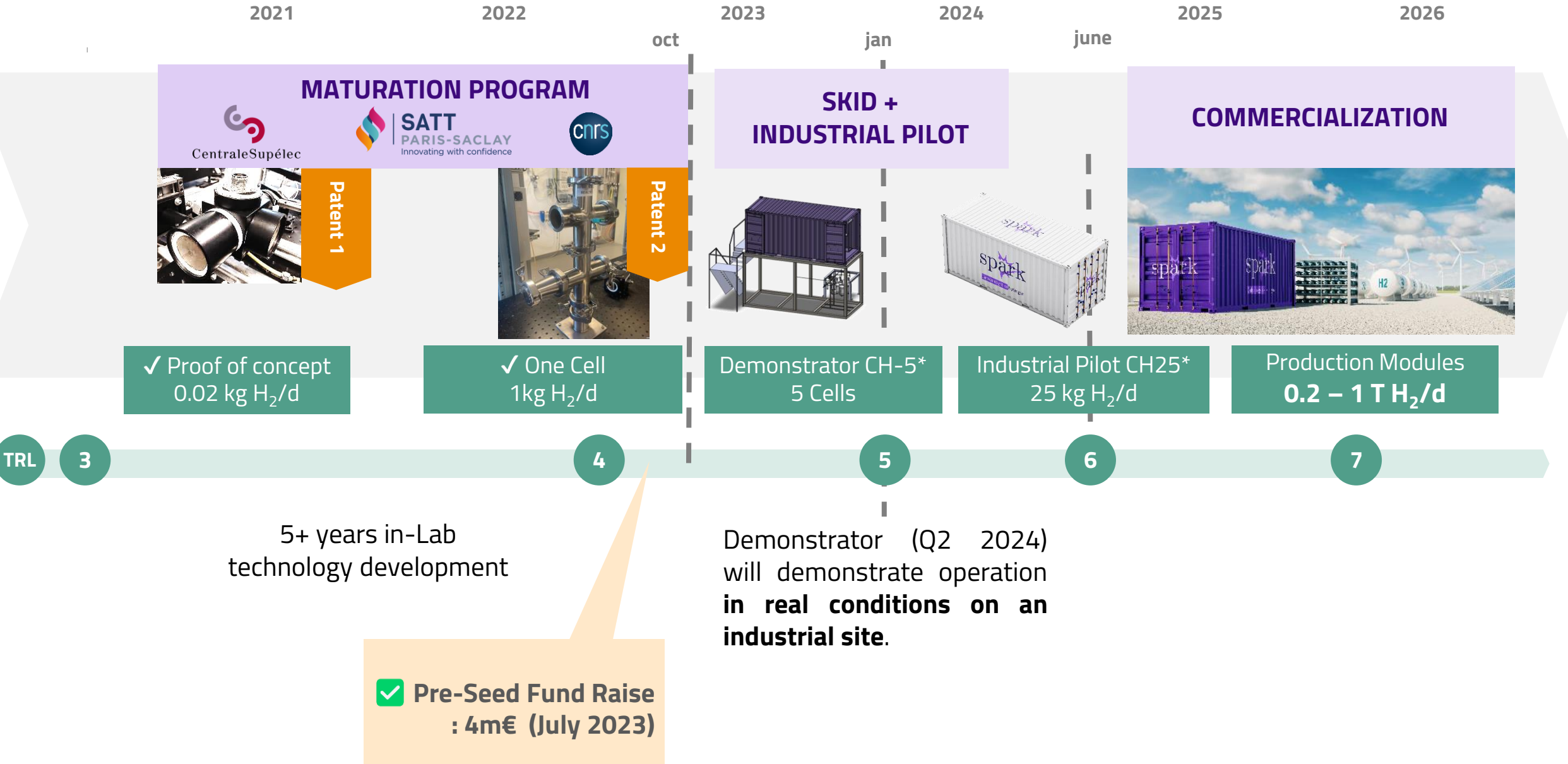
Spark's nanopulses are a **unique technology** that allows to control the temperature in the plasma to obtain the optimum between fast reaction & low heat losses.

9 - ... 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 : 2 pilots towards commercial scale

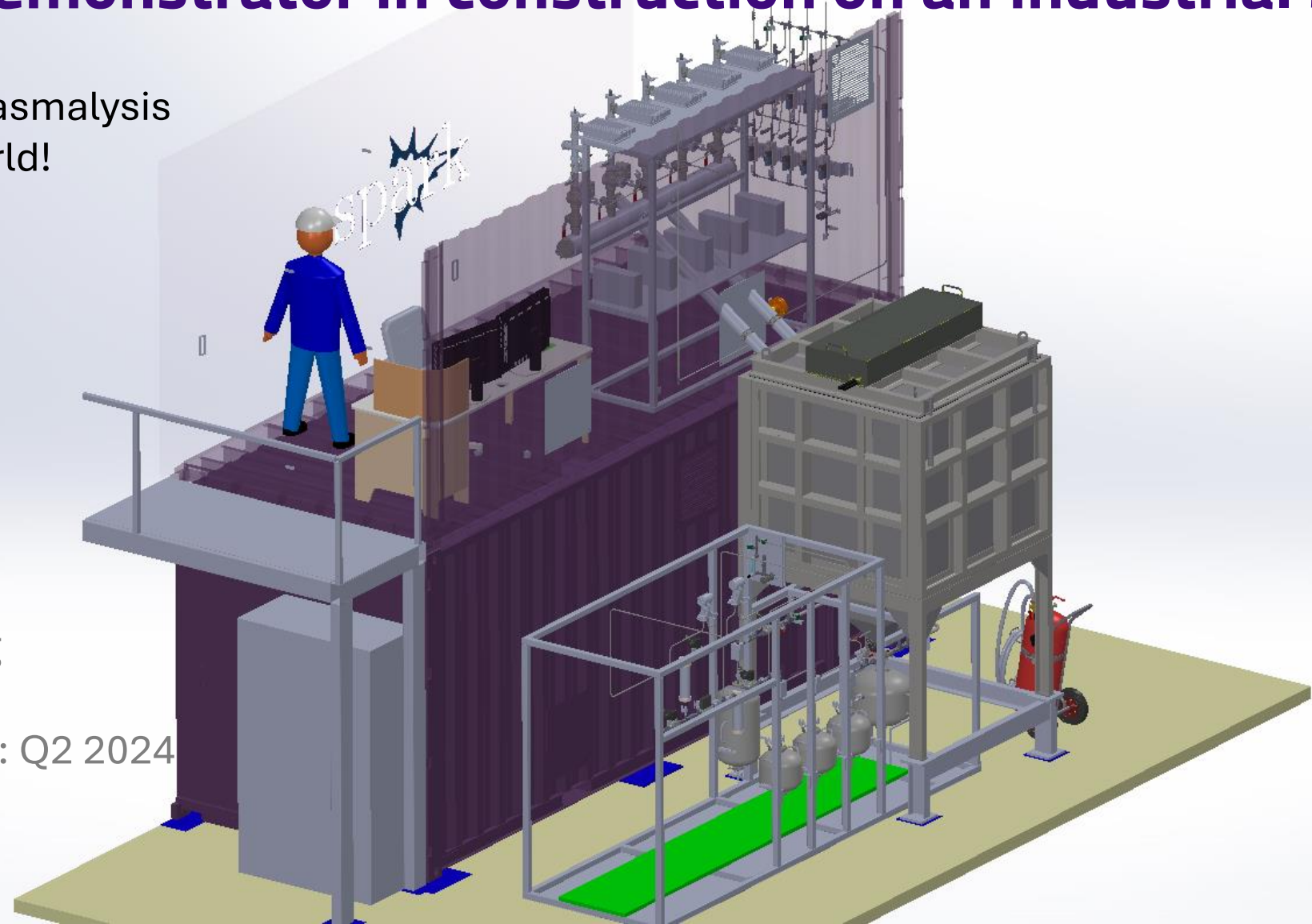


Demonstrator (Q2 2024) will demonstrate operation in real conditions on an industrial site.

✓ Pre-Seed Fund Raise : 4m€ (July 2023)

Q1 2024 : 1st Demonstrator in construction on an industrial site

✦ First Nanopulsed Plasmaprolysis Demonstrator in the world!



Construction : on-going

Factory Tests : Q1 2024

Client Site deployment : Q2 2024

Our Next Step :

Pilot Operation + larger Fund raise Q4 2024 to design our **~1T/day** commercial unit in 2025

spark

Let's meet!



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