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# 95% LESS IRIDIUM SMOLTEK HYDROGEN

## Iridium Shortage - No Longer an Issue in Hydrogen Industry

SMOLTEK HYDROGEN is an advanced material science company and address the climate change with deep knowledge in nanotechnology. Iridium is used in PEM electrolyzers that produce green hydrogen. It is extremely scarce, so we developed a new material with 95% less iridium. We use nanotechnology and build with atoms and molecules; competition use ink and screen printing. Some try more advanced technologies, but we have not found any other company or university with a durable and scalable solution. Our material might therefore be the only way to avoid that iridium shortage delays the scale up of PEM electrolyzers.

# IRIDIUM SHORTAGE → GREEN HYDROGEN DELAY

The manufacturing and development of PEM electrolyzers is critical for the new fast-growing green hydrogen industry. However, the limited availability of the catalyst material iridium will prevent the scale up of PEM electrolyzers – unless the iridium problem finds its solution.

### Fossil Free Steel Works



### Shipping Solar Energy from Deserts



### Fertilizers from Green H2



### Synthetic Fuels for Marine Area



### Balancing Intermittent Energy



### Fuel Cells When Batteries Unsuitable



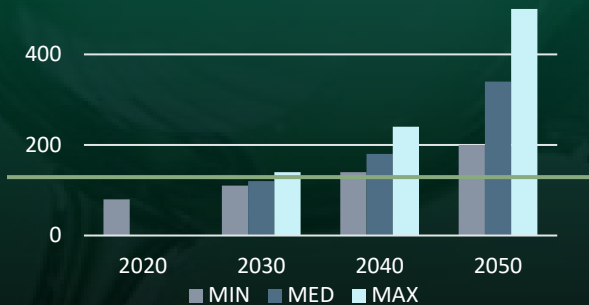
**PROTON EXCHANGE MEMBRANE (PEM) ELECTROLYZERS** use electricity to split water into hydrogen and oxygen. PEM electrolysis is easy to start and stop, and therefore better suited for solar and wind power, compared to the traditional alkaline electrolyzers. As an example, with PEM technology wind energy can be stored from windy days to later when it is better needed. A PEM electrolyzer cell consists of several layers of expensive materials, where the noble metal iridium is positioned on the anode side of the cell, between a layer of titanium and the membrane. There is not enough of iridium to meet the future demand, unless the hydrogen industry manage to use significantly less iridium for same output. Smoltek has solved this and place iridium on the titanium and not the membrane. Noone else has a solution for this. Competition still try to solve the problem by depositing iridium on the membrane, while Smoltek use nanotechnology to build a very unique surface, where iridium then is positioned. Industry forecasts predict the iridium loading to reach 0.8 mg/cm<sup>2</sup> in 2030, but already in 2024 Smoltek reach same performance with only 0.2 mg/cm<sup>2</sup> and expect to bring it down to 0.1 mg/cm<sup>2</sup> in a near future. **GREEN HYDROGEN** means hydrogen produced with electricity from fossil free sources.



# HUGE MARKET GROWTH

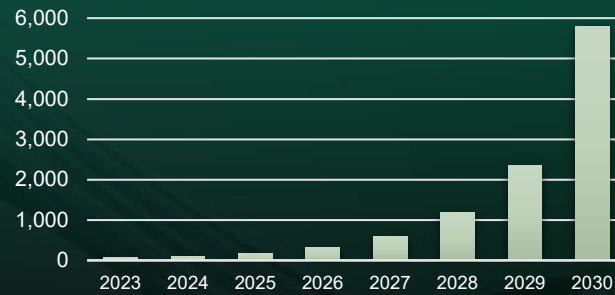
PEM electrolysis to see significant growth as it is crucial for scaling up green hydrogen.

HYDROGEN DEMAND (Mt)\*\*



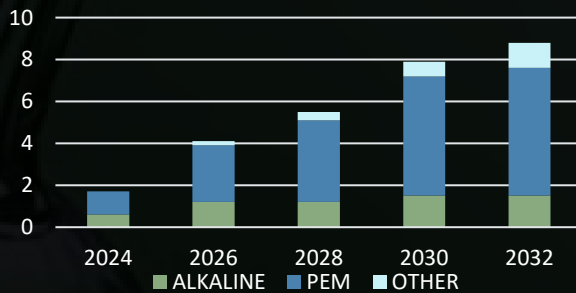
The fast growth of hydrogen demand is expected because fossil free hydrogen is one of the keys to reach Net Zero

TOTAL ADDRESSABLE MARKET (EURm)

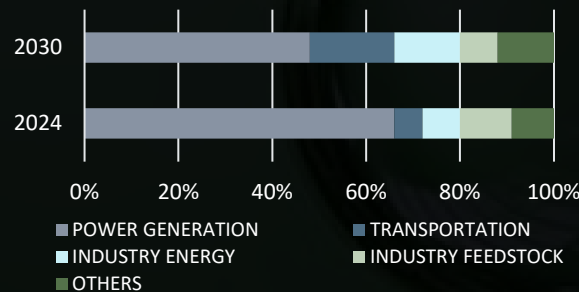


Smoltek Hydrogen's total addressable market defines as 10% of the global electrolyzer market\*\*\*

ELECTROLYZER MARKET (USD Billion) \*



PEM ELECTROLYZER APPLICATIONS\*



## PEM vs. ALKALINE ELECTROLYZERS

Advantages of PEM vs alkaline outweigh most of its challenges

	PEM	Alkaline
Integration with Renewables	<b>Excellent</b>	Moderate
Advantages	High efficiency Fast response High purity	Low-cost operation Well-established
Challenges	Cost Durability Scalability	Lower efficiency Moderate purity
Applications	Filling Stations Industry	Industry Power

\* Source: PEM Electrolyzer Market Size, Share & Growth Analysis – 2032 (gminsights.com)

\*\* Based on data compiled by Price Waterhouse Cooper

\*\*\* For coated titanium transport layers - other business models are possible. 10% is a highly uncertain internal estimation based on limited available sources.

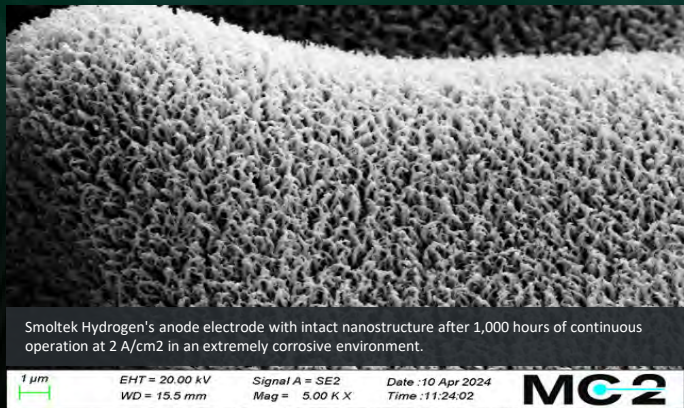
# READY FOR TAKE-OFF

Sales potential is huge. Time-to-market is crucial. Scale-up plan is ready.

To execute the growth strategy Smoltek seeks industrial and financial partners for credibility, capital & synergies.

## SUCCESSFUL DURABILITY TEST

1,000-hour durability test completed March 2024



The test shows that 0.2 mg/cm<sup>2</sup> is enough for the hydrogen production. Next step is 0.1 mg/cm<sup>2</sup>

## CUSTOMER DIALOGUES ONGOING

Contacted by giants

Testing activities with a handful of the leading energy and automotive corporations

Screening sample evaluations

- Iridium reduction in electrolyzers
- Contact resistance in fuel cells

Larger samples

- Scaling up of volumes and sizes planned in accordance with customer's product development project phases
- Lab equipment being upgraded to A4 size

## SCALE-UP PLAN READY TO BE IMPLEMENTED

Next Step - Order the new chamber

- A new chamber has been designed together with AGC\*
- To be used to verify that the AGC equipment is the right choice and to specify the pilot plant

Pilot Plant - Lab-coaters for A4 size

- Specify the volume line
- Customer samples for tests and industrialization

Integrated turn-key production line

- AGC to design, build, and install the production line, including running it for 6 months at their own premises (training staff, ramping up, producing on behalf of Smoltek)

\* AGC is a coating specialist with a background in coating glass for eg skyscrapers

## NEWS

[Smoltek's material successfully passed a 1,000-hour test with only 0.2 mg of iridium per cm<sup>2</sup>](#)

[Smoltek inaugurates inhouse hydrogen laboratory](#)

[International electrolyzer manufacturer will evaluate Smoltek's carbon nanofibers](#)

[Together towards 0.1 mg iridium/cm<sup>2</sup>](#)

[Towards mass production of Smoltek Hydrogen's cell material](#)

[Smoltek founder Shafiq Kabir returns to the company to scale up production processes](#)

# DEEP KNOWLEDGE

Founders, senior scientists and experts with deep scientific and industrial background in deep tech development.



**Ellinor Ehrnberg PhD**  
**Founder and President Smoltek Hydrogen AB**

Over 30 years of experience from various global roles in business, innovation, strategy and M&A at SKF, Husqvarna, Mölnlycke, RISE and Arthur D Little. Unique competence in bringing radical innovation to market in large complex organizations. PhD Chalmers 1996 - Technological Discontinuities & Industrial Dynamics



**Fabian Wenger PhD**  
**Founder and VP Technology Smoltek Hydrogen AB**

Broad variety of industries combined with deep knowledge in advanced material science - a unique platform for groundbreaking innovations. Senior technology positions at Qamcom, Emerson, SiRF, Saab Ericsson Space, Switchcore, Ericsson. PhD in Theoretical Solid-State Physics, 1995.



**Shafiq Kabir PhD**  
**VP Volume Processes Smoltek Hydrogen AB**  
**Founder of Smoltek**

Founded Smoltek based on PhD thesis in Microtechnology and Nanoscience 2005. After having built up a solid technology platform of patents, recipes and lab resources he now brings the nanofabrication out from the clean room and scales it up to industrial sizes and volumes in close cooperation with leading suppliers



**Xin Wen PhD**  
 Senior Nanotechnology Scientist

PhD in Material Science 2020  
 Metallic catalyst synthesis and microstructure study



**Reka Simon-Balint MSc**  
 VP Quality & Project Management

EHS & Reliability



**Bastien Penninckx MSc**

Nanotechnology  
 Engineer



**John Schack**

Nanotechnology Master Student



**Emma Rönmark**  
 Board Member

CCO Liquid Wind: Electro-fuels from green hydrogen



**Sankar Sasidharan PhD**  
 Industrial Postdoc WISE & CTH

PhD in Chemistry 2015  
 Composite and Coatings for Functional Applications.



**Edit Helge PhD**

European Patent Attorney  
 QIPR



**Amin Saleem PhD**

Senior Nanotechnology  
 Scientist, Smoltek Semi



# THE IRIIDIUM PROBLEM

Iridium is expensive, rare, necessary. And impossible to decrease without game-changing new technology expanding the surface area 10 – 30 times, making it possible to coat the *titanium substrate* instead of the *membrane* – **CCS** instead of **CCM**.

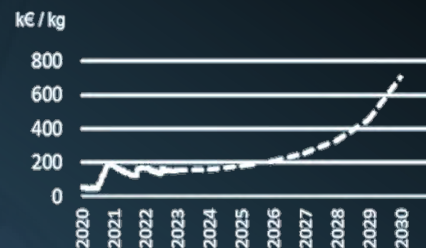
## IRIDIUM PROBLEM - TOO SMALL SUPPLY

### IRIDIUM SHORTAGE

- Only 9 tonnes / yr
- Produced in Russia & South Africa, no other sources
- No other catalyst material is a realistic alternative

### IRIDIUM PRICE INCREASE

150 to 700\*\* EUR/g



Source: Report Linker – Global Iridium Industri

### IRIDIUM PROBLEM – HIGHEST ON AGENDA

#### NECESSARY PRECONDITION

[Sciencedirect](#) Necessary precondition – dramatic reduction of iridium catalyst loading in PEM electrolysis cells

#### NO GUARANTEE

[Hydrogeninsight](#) Will there be enough iridium available to meet the rising demand from PEM electrolyzers? ... none are guaranteed to solve the problem

#### MAJOR RISK

[Hydrogentechworld](#) The problem of iridium scarcity poses a major risk to the development of a large electrolyzer market.

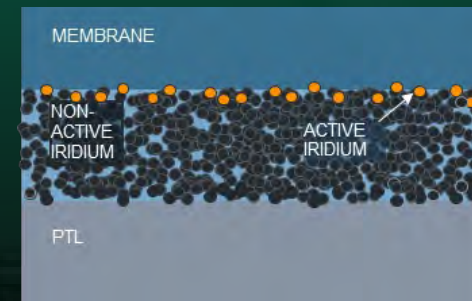
#### ACUTELY FOCUSED

[Guidehouseinsights](#) Within the hydrogen industry, material sourcing concerns are most acutely focused on iridium.

#### POTENTIAL BOTTLENECK

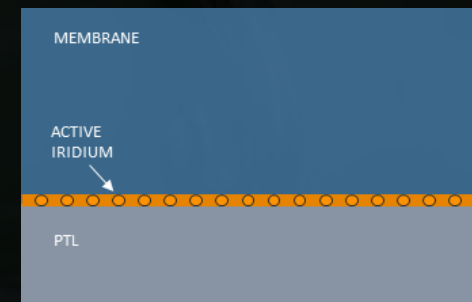
[H2-tech](#) With iridium supply a potential bottleneck, companies are actively working on ways to reduce the requirement for iridium

## CCM - Catalyst Coated Membrane - TOO THICK LAYER



- Traditional technology: The large 3D surface is based on ink with iridium, filled with water
- Difficult to reduce iridium since thinner ink layer gets too fragile and lower iridium density is not conductive enough

## CCS - Catalyst Coated Substrate - TOO SMALL AREA



- CCS is a promising approach, and technologies are available for coating a thin iridium layer. But the surface area is too small
- Necessary to expand the surface area 10 – 30 times, so that CCS can be used

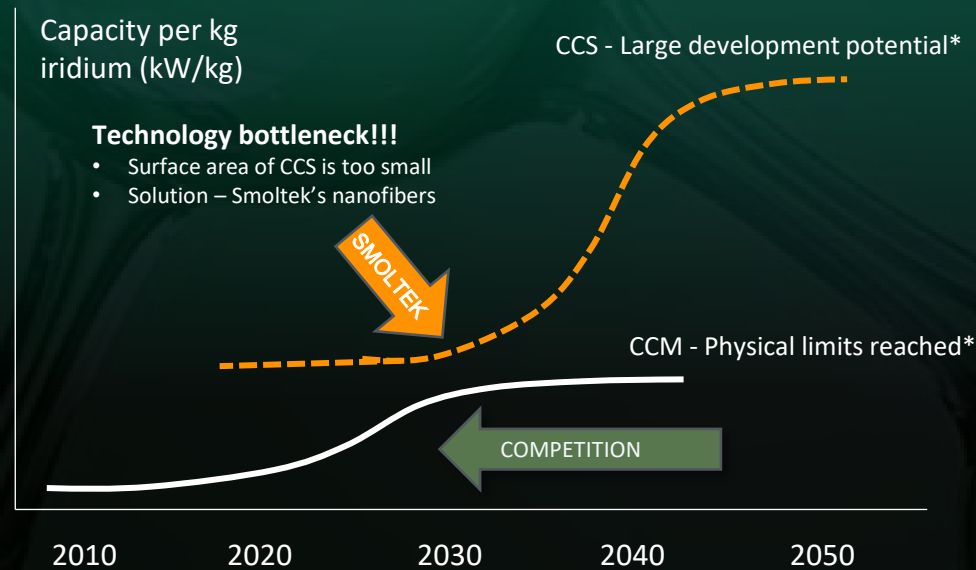
**New technological regime urgently needed to increase surface area 10 – 30 times.**

# THE NANOFIBER SOLUTION

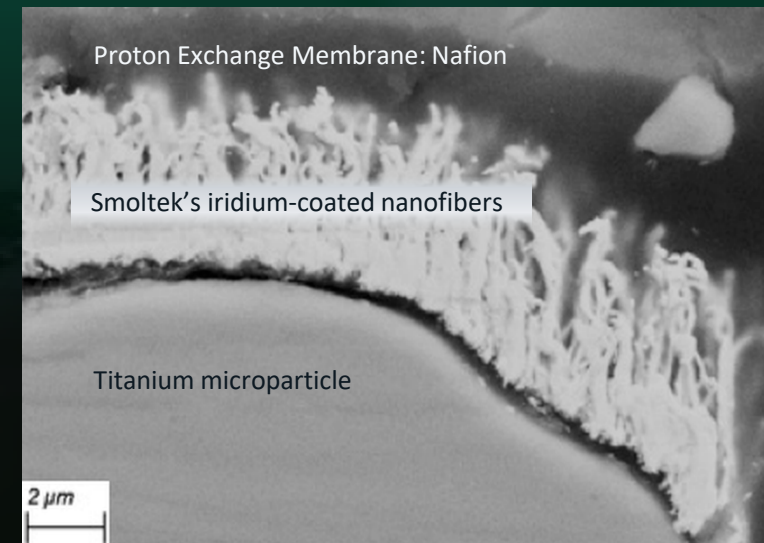
Smoltek's disruptive technology enables the long-wanted breakthrough for CCS, as the path to ultra-low iridium loading.

**BREAKTHROUGH FOR COATED SUBSTRATES** enabled with unique nanofibers

**SMOLTEK'S NANOFIBERS** create a very large surface area, where an ultra-thin iridium layer is deposited



\* Conceptual diagram to illustrate a possible scenario

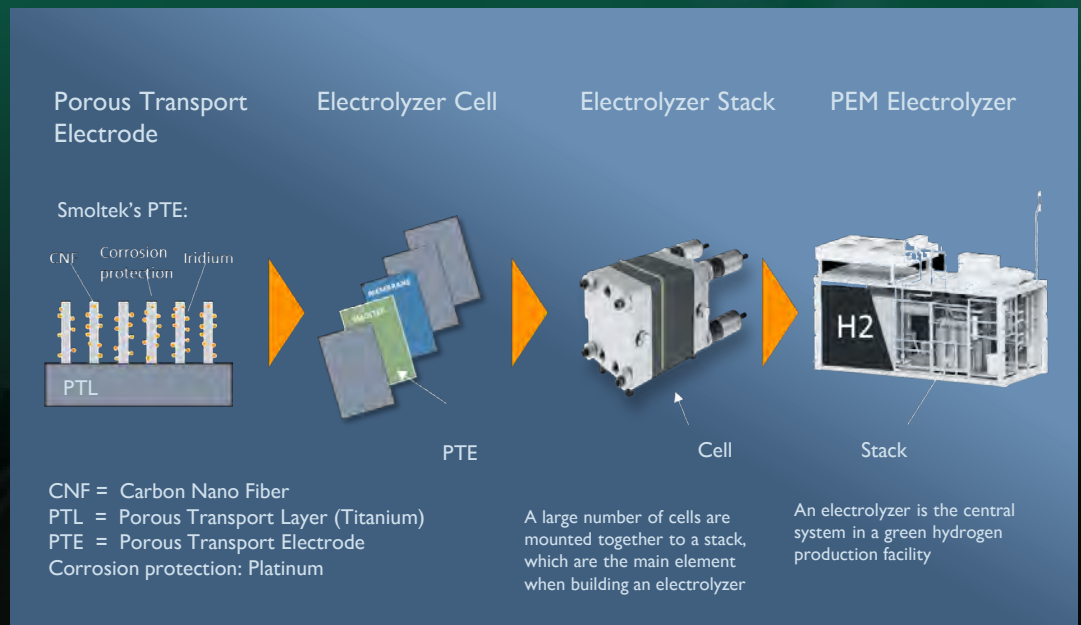
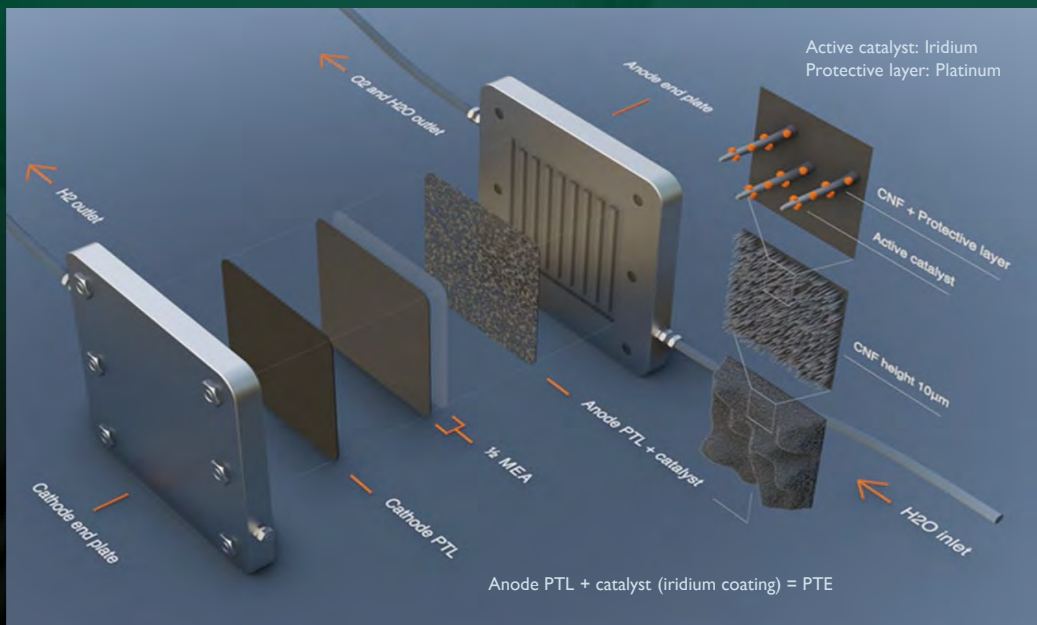


**STANDARD APPROACH** is to develop new coatings for the membrane (CCM). To reach ultra-low loading, all particles must be active, i.e. in contact with both water and electric current. This is only possible if the iridium is deposited on the electrode (CCS), but then the surface area is far too small. This is what Smoltek Hydrogen has solved.

**COMPETITION** In January 2024 a team of recognized researches published a thorough technology review on reducing iridium in PEMWE. Based on a large number of studies their conclusions tell us that our solution – *nanostructure on the PTL* - is the necessary way forward and that a commercial solution does not exist. [Design of PEM water electrolyzers with low iridium loading - Clifton Wang, Keonhag Lee, Christopher Pantayatiwong Liu, Devashish Kulkarni, Plamen Atanassov, Xiong Peng, Iryna V. Zenyuk, 2024 \(sagepub.com\)](#) Review of competing technologies by Smoltek March 2024, including links to 40 main references, is available upon request

# UNIQUE PRODUCT – 0.1 MG/CM<sup>2</sup>

Smoltek has developed a porous transport electrode (PTE), where nanofibers are used to expand the surface area, before the thin iridium layer is deposited on the structure. The product is planned to have 0.1 mg per cm<sup>2</sup> iridium.



For a future large industrial partner, a potential market share of 30% would bring a highly interesting business scenario.

**MARKET SHARE:** The scenario of 30% market share is NOT a sales target or forecast for Smoltek Hydrogen. It is what we see as a reasonable target for an industrial partner: our solution solves an urgent matter and should be made available to as large part of the users as possible. But a market leader of an industrial market seldom reaches more than one third of the market, since customers normally do not accept to depend on only one supplier.

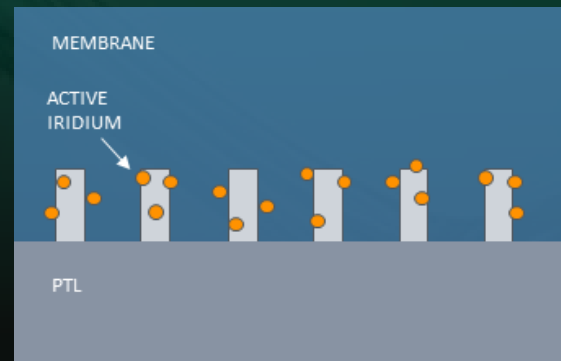
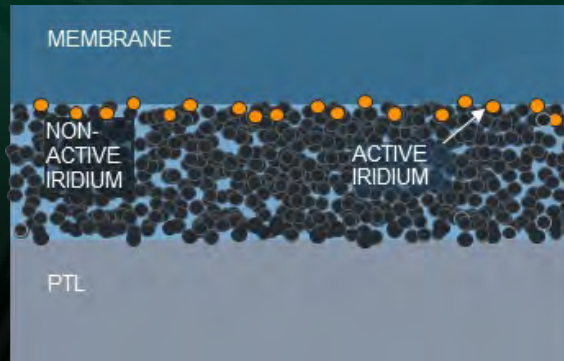


# 95% LESS IRIDIUM

**CUSTOMER VALUE:** The most important value created when only using 0.1 mg Iridium per square centimeter is that the limited supply of iridium is no longer a road-blocker for scaling up the PEM electrolyzer industry.

## SAME OUTPUT\* WITH 95% LESS IRIDIUM

All the black iridium particles are of no use, since they do not reach the membrane



## ALREADY FAR BEYOND THE 2030 TARGET

### IRIDIUM LOADING

	<i>mg/cm<sup>2</sup></i>
Smoltek's target	0.1
Smoltek 2024	0.2
Standard today**	2.0
Standard 2030E**	0.8

### Industry standard

Iridium loading	2.0 mg/cm <sup>2</sup>
Output	2A/cm <sup>2</sup>

### Smoltek

Iridium loading	0.1 mg/cm <sup>2</sup>
Output	2A/cm <sup>2</sup>

IRIDIUM SHORTAGE → No Longer An Issue

\* Output means how much hydrogen that is produced, which corresponds to the current density measured as A/cm<sup>2</sup>

\*\* Source: Fraunhofer 2021, Cost forecast for low-temperature Electrolysis – technology driven bottom-up prognosis for PEM and Alkaline water electrolysis systems: “Modern MEAs have a catalyst loading of about 2 mg/cm<sup>2</sup> on the anode side and about 1 mg/cm<sup>2</sup> on the cathode side. Currently, intense research and development focusses on the reduction of catalyst loadings for new MEA generations by approximately 40-60%. Iridium in particular is a critical raw material and could be a bottleneck for a multi-GW electrolysis industry”

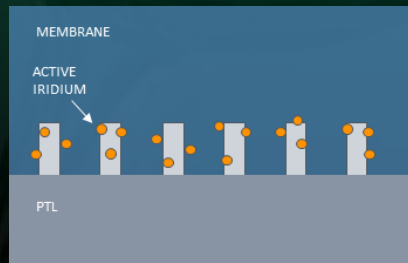
# LOWER COSTS

**NOTE: UNCERTAIN  
COST ESTIMATIONS**

**CUSTOMER VALUE** The cost of Smoltek’s basic configuration is about 5.000 EUR/m<sup>2</sup> lower than the industry standard in 2030. If longer fibers are used even more costs can be cut, e.g. 3 times longer fibers for 3 times higher H2 output.

## BASIC

Short fibers 2A/cm<sup>2</sup>



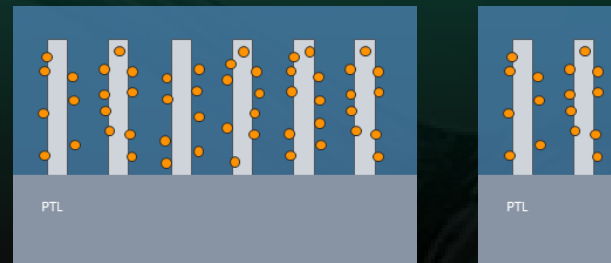
**NORMAL OUTPUT**

5.000 EUR/m<sup>2</sup> cheaper cell vs std.

## COMPACT

Long fibers → High density 6A/cm<sup>2</sup>

Different ways of utilizing the compact material



**3 TIMES MORE OUTPUT**

vs Smoltek basic & Standard

**3 TIMES SMALLER**

Same output

50% cheaper electrolyzer vs. standard

## RADICAL COST DIFFERENCE vs standard solution

2030 kEUR/m <sup>2</sup>	Standard Solution	Smoltek BASIC 3um	Smoltek COMPACT 10um
Cell	17	12	3
Balance of Plant	11	11	11
PEM Electrolyzer	28	23	14

**STANDARD** means using traditional solutions with 0.8 mg/m<sup>2</sup> iridium and calculated with the higher iridium price of 2030

**COMPACT** configuration might have shorter lifetime or be less efficient – more research needed

Data is highly uncertain and are based on a series of very rough estimations and internal calculations. Main sources:

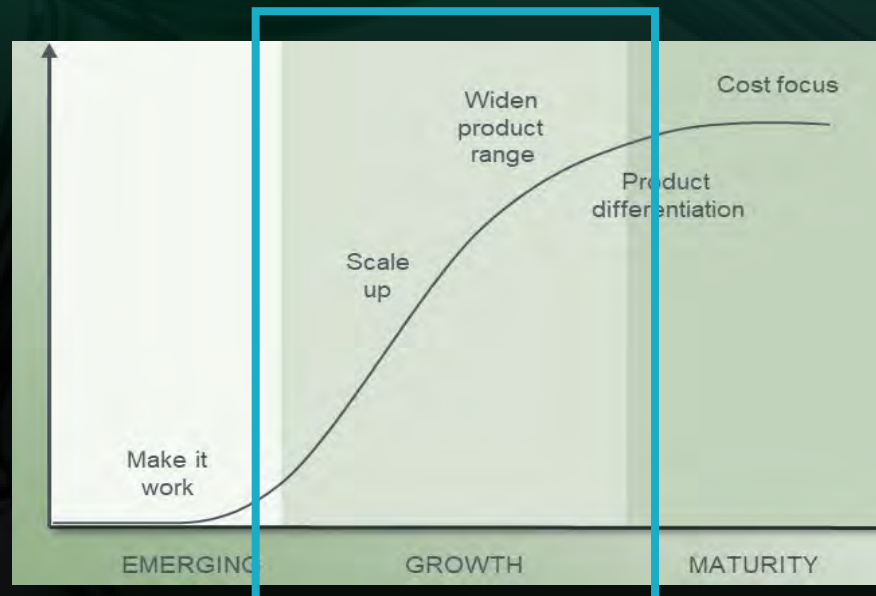
- Fraunhofer 2021: Cost forecast for low-temperature Electrolysis – technology driven bottom-up prognosis for PEM and Alkaline water electrolysis systems.
- BCC Research 2022: LLC FCB059A Global PEM Electrolyzer and MEA Component Market
- Iridium price forecasts: Indexed predictions by Digital Coin and day prices from Metal Daily

# FASTER SCALING UP

**CUSTOMER VALUE:** The electrolyzer industry is racing for market shares through GIGA-watt factories, which is why smaller stacks with same capacity provide a significant competitive advantage.

## FAST-GROWING INDUSTRY

In the fast-growing electrolyzer industry, fast scaling up is of higher importance than manufacturing cost.



## THREE TIMES FASTER SCALING UP

With three times higher current density a three times smaller electrolyzer deliver the same power to the user.

## UNIQUE PRODUCT PERFORMANCE

With a current density of 6 A/cm<sup>2</sup>, unique electrolyzers can be developed:

- Cheaper hydrogen production facilities
- Smaller foot-print with same capacity
- High capacity at standard size

## UNIQUE COST POSITION

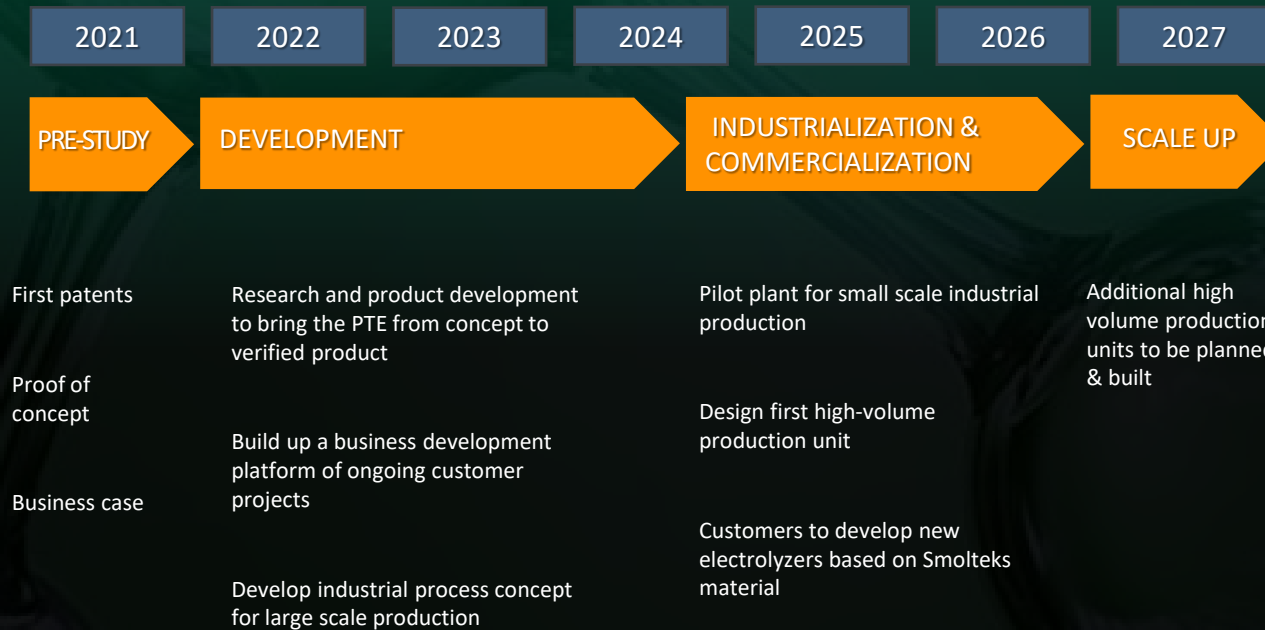
An electrolyzer built with the compact PTE has three times lower manufacturing costs of the stacks, and a total manufacturing cost of about 50%.



# STRATEGY & ACHIEVEMENTS

Detailed road-map can be shared when nondisclosure agreement is signed, but below is an overview. More information on the achievements are to be found at [smoltek.com](https://smoltek.com) as various publications.

## STRATEGIC PLAN



## ACHIEVEMENTS

### PERFORMANCE

- Same amount H2 produced with 80% less iridium (2023)
- Successful 1000-hrs test (2024)
- The verified results open up for large scale communication to potential customers

### CAPABILITIES

- CNF technology platform & patents
- Patents for electrolyzers
- Unique catalyst coating method
- Manufacturing concepts

### ADVANCED RESOURCES

- Laboratory facilities (fabricate & test electrolyzer cells, incl. lifetime tests +1000hrs)
- Partners & network (potential customers, suppliers, experts, and academia)
- Leading senior scientists in nanotechnology and electro chemistry (all in all 7 PhD:s)

# HIGH REVENUE AND PROFIT POTENTIAL

An outstanding cost leadership position on a fast-growing market allows for aggressive pricing to gain market share, while at the same time enjoying good earnings.

ILLUSTRATIVE EXAMPLE –  
NOT A PLAN OR FORECAST

EXAMPLE	2027	2028	2029	2030
Price vs competition	70%	80%	90%	90%
Gross margin	45%	45%	48%	54%

NOTE: Data in the sheet is highly uncertain, and does not represent any forecast or plan, but is only used as an example to illustrate a future scenario. The numbers are based on a series of very rough estimations, come from internal calculations, and are based on several assumptions and sources. Main sources: Fraunhofer 2021, Cost forecast for low-temperature Electrolysis – technology driven bottom-up prognosis for PEM and Alkaline water electrolysis systems; BCC Research 2022: LLC FCB059A Global PEM Electrolyzer and MEA Component Market; Iridium price forecasts, Indexed predictions by Digital Coin and day prices from Metal Daily.

# KEY INVESTMENT HIGHLIGHTS

Unique opportunity to invest in a cutting-edge PEM electrolyzer technology company with huge growth potential.



Pioneer in nanotechnology for green hydrogen

- Solved the iridium problem – manage to reduce by 95%
- Global pioneer using nanotechnology to solve iridium shortage issues connected to green hydrogen
- Partnerships with global leaders to offer the world's most cost-effective iridium solution for PEM electrolyzers



Unique and patented disruptive technology cut iridium cost by 80%

- Opening up a paradigm shift and thereby able to decrease the need for nobel metal iridium by 95%
- Technology breakthrough based on unique nanotechnology and strong application engineering
- IP are covered by strong and resilient patent families



Highly attractive market supported by sustainable megatrends

- Extremely high growth expected in markets for green hydrogen, electrolyzers, and cell materials
- The global electrolyzer market is driven by changing to a fossil free future end reduced CO2-footprint
- Clear customer value due to the expected price increase of iridium from 150 to 700 EUR/kg



Appealing and tangible growth story with strong trajectory

- The go-to-market strategy in place, and major energy and automotive companies are evaluating the new material
- Clearly defined scale-up strategies supported by ongoing collaboration with equipment suppliers
- Appealing growth story with extremely strong revenue and profit potential



Highly experienced management team

- Highly skilled and experienced management team and board, with extensive experience in the field of nanotechnology, electro chemistry and in commercializing new technologies



# TRANSACTION BACKGROUND

- In order to accelerate its growth and become a substantial player in the PEM cell material industry, Smoltek Hydrogen intends to invite new investors to become shareholders in a very innovative high-tech company and to benefit from the strongly growing green hydrogen market.
- Smoltek Hydrogen AB is today a fully owned subsidiary of Smoltek Nanotech Holding AB, a public company listed at the Spotlight Stock Market in Stockholm.
- This presentation only contains information that has been publicly communicated.



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