Industrial transformation to carbon neutrality

Clean hydrogen and solid, sustainable carbon for industry

Climate change

Fast transition is needed

Battery industry is developing rapidly

Existing solutions?

Renewable energy production?

The supply of critical materials?
Hycamite’s solution: TCD* Process

* TCD – Thermo Catalytic Decomposition (of methane or biomethane)
Why Hydrogen?

Hydrogen can be used to decarbonise many different industries and applications:

- **Heat/power**
- **Metals production**
- **Chemical/industrial processes**
- **Upgrading biomass**
- **Ammonia / Fertilizer**

**Chemical Conversions**:

- $H_2 + CO/CO_2 \rightarrow CH_4$ (Methanation)
- $H_2 + CO/CO_2 \rightarrow CH_3OH$ (Methanol synthesis)
- $H_2 + CO/CO_2 \rightarrow e-Diesel, e-Kerosene$ (e-Diesel, e-Kerosene)

**Alternative Fuel**:

- Fuel cell's, internal combustion engines
Company established 2020
- Personnel: 16
- Location: Kokkola, Finland
- Status: Growing fast from pilot scale to industrial scale (TRL 5-6)

Matti Malkamäki
Founder and Chairman

Laura Rahikka
Founder and CEO

Henrik Romar
R&D Director

Natascha Skog
HR & Marketing Manager

Susanna Rönnqvist
CFO

Niina Grönqvist
Founder and Commercial Director

Jussi Kukkula
Project Manager

Laura Rahikka
Founder and CEO

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Niina Grönqvist
Founder and Commercial Director

**COMPANY**

**Team**

- **Plant project**
  - Management of the industrial scale pilot plant project

- **Technology**
  - Process development
  - New product development
  - Application know-how

- **HR & Marketing**
  - HR and education
  - Marketing and communication

- **Finance**
  - Finance, financial admin
  - Investments
  - Business development
  - Stakeholders

- **Commercial**
  - Business development of hydrogen and carbon products
Business model – sales of the output and ownership of plants via SPV

1) SPV – Special Purpose Vehicle

**Stakeholders**

**Hycamite**
- IP / Tech know-how.
- Business development, cooperation agreements.
- Plant operations.

**Hycamite production sites**
- Sites close to local H₂ customers.
- Long supply agreements especially on the hydrogen.
- Operations from the Hycamite, maintenance and service locally.
- Financing through SPV’s.

**Special purpose vehicle**
- Financing of the plants via asset investors.
- Fixed and safe returns.

**Revenue streams, customers**

**High value-added carbon**
- Strategic partners, special products.

**Hydrogen**
- Local, industrial customers that use the H₂ either as a fuel or as a raw material.
- Long supply agreements.

**Commodity carbon**
- Regional customers with long supply agreements.
- Carbon traders.

**Carbon emissions trading**
- Where possible.
SCIENTIFIC BACKGROUND

Commercialising Top European Research

Roots of the technology at the University of Oulu

Catalyst development
• Reduces energy consumption of TCD process
• Enables special high quality carbon products

Expertise on carbon product applications
• Advantage compared to hydrogen competitors
• Enables unique position in the market

Process technology innovations
• Energy savings through heat exchange, product stream differentiation, catalyst regeneration, and several other innovations

Hycamite has full freedom of operation
• Preliminary patent landscape completed

Regarding Hycamite technology, following scientific publications have been published by our researchers:
• 42 Scientific publications
• 4 Dissertation defence (PhD)
• 5 Master of Science Thesis (Technology and Chemistry)
• 3 Bachelor of Science Thesis (Technology)

Left: Stability of standard catalysts. Right: stability of one of the Hycamite catalysts. Note, the drops indicate manual shutdowns, no catalyst was changed. The performance of the Hycamite’s catalyst in this test remained practically unchanged after 7 hours of testing when the other catalysts lose their activity in minutes.
Sustainable Carbon as a secondary product supplementing the sales

Carbon nanotubes (CNT)
Carbon nanofibers (CNF)
Amorphous carbon → activated carbon
Graphite

PRODUCTS - CARBON

- Battery industry
- Electric vehicles (supercapacitors)
- Catalysts

- Lightweight materials for automotive and aerospace industry
- Water treatment
- Pharmaceutical purification
- Industrial applications
## Comparison of different hydrogens

There are many ways to produce hydrogen. Here a quick third party overview.

<table>
<thead>
<tr>
<th></th>
<th>SMR(^1) (Grey H(_2))</th>
<th>SMR with CCS(^2) (Blue H(_2))</th>
<th>Electrolysis (Green H(_2))</th>
<th>Hycamite TCD (Clean or Turquoise H(_2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low or no CO(_2)</td>
<td>✗</td>
<td>✗ / ✓</td>
<td>✓</td>
<td>✓ / &lt;0</td>
</tr>
<tr>
<td>No need for additional, massive power generation capacity and thus rapidly scalable</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Possibility to load-following production and thus no or only a small need for storage facilities</td>
<td>✗ / ✓</td>
<td>✗ / ✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>No need of rare earth metals in the production units</td>
<td>✓</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Additional revenue from carbon sales</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Estimated costs EUR per kg H(_2)</td>
<td>1.47 – 3.90</td>
<td>1.91</td>
<td>2.37</td>
<td>0.91</td>
</tr>
</tbody>
</table>

1) SMR – Steam Methane Reforming  
2) CCS – Carbon Capture and Storage
Business development – Scaling up requires partners

- Research
- Engineering
- Component providers
- Hydrogen customers
- Feedstock providers
- Carbon customers

Demo plant engineering
Small scale pilot & labs
Demo plan building
Customers
Demo plant in operation

Own plants on industrial sites next to the customer
Financed via SPV

2021  2022  2023  2024
Contact us – It is time to act NOW!

• Ms. Laura Rahikka, CEO
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• Ms. Niina Grönqvist, Commercial Director
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• Mr. Matti Malkamäki, Chairman
  • [matti.malkamaki@hycamite.com](mailto:matti.malkamaki@hycamite.com)
Thank you!
# Methane pyrolysis (cracking/splitting) for turquoise hydrogen production

## Third party based comparison on different turquoise (clean) hydrogens

<table>
<thead>
<tr>
<th>Process shown</th>
<th>Plasma Pyrolysis</th>
<th>Fluidised Bed</th>
<th>Moving Carbon Bed</th>
<th>Molten Metal or Molten Salt</th>
<th>Hycamite</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monolith Materials</td>
<td>Hazer</td>
<td>BASF</td>
<td>TNO or C-Zero</td>
<td>Hycamite TCD Technologies</td>
</tr>
<tr>
<td>Hydrogen content at reactor outlet</td>
<td>~ 95%</td>
<td>~ 92%</td>
<td>~ 92%</td>
<td>Up to 95%</td>
<td>~ 92%</td>
</tr>
<tr>
<td>Carbon production</td>
<td>Carbon black as powder or granules</td>
<td>80 – 95% graphite encapsulating catalyst dust particles</td>
<td>Carbon black as powder or granules</td>
<td>Carbon black as powder or granules</td>
<td>• Graphene, nanotubes, nanofibers • Graphite like carbon</td>
</tr>
<tr>
<td>Catalyst required</td>
<td>No</td>
<td>Iron oxide granules</td>
<td>Carbon bed</td>
<td>• Molten 27% Nickel - 73% Bismuth • Molten Manganese Chloride</td>
<td>Own development</td>
</tr>
<tr>
<td>Heating mechanism</td>
<td>Direct heating with plasma</td>
<td>Indirect heat applied around the reactor</td>
<td>Electrodes to heat the carbon bed and indirect heat applied around the reactor</td>
<td>Indirect heat applied around the reactor or electrodes to heat the melt in a separate vessel</td>
<td>Indirect heat + own heat management</td>
</tr>
<tr>
<td>Reactor temperature</td>
<td>2 000 °C</td>
<td>900 °C</td>
<td>1 000 to 1 400 °C</td>
<td>Depends on melt, 650 to 1 100 °C</td>
<td>Depends on desired carbon, 600 to 800 °C</td>
</tr>
<tr>
<td>Reactor pressure</td>
<td>Close to atmospheric pressure</td>
<td>Close to atmospheric pressure</td>
<td>Close to atmospheric pressure</td>
<td>Up to 5 bar</td>
<td>Close to atmospheric pressure</td>
</tr>
<tr>
<td>Major disadvantages</td>
<td>Energy inefficient, produces only carbon black</td>
<td>Produced carbon difficult to separate from porous iron catalyst</td>
<td>Reactor clogging not solved, produces only carbon black</td>
<td>Produced carbon difficult to separate from catalyst, produces only carbon black</td>
<td></td>
</tr>
</tbody>
</table>

Partially courtesy of sbh4 consulting GmbH.
Demand for sustainable carbon

**Drivers**

- Environmental regulation pushing non-ecological production methods.
- Companies eager to **decrease** their carbon footprint.
- Willingness for self-sufficiency and shorter logistics chains create demand for carbon production in Europe for crucial industries such as battery industry, electronics, solar and wind power construction.

**Prices and market sizes**

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite</td>
<td>500 – 1 600[^i]</td>
<td>2 892 (current) [^iii]</td>
<td>16.13 bn → 31.55 bn[^i]</td>
</tr>
<tr>
<td>Graphene</td>
<td>150 000[^iv]</td>
<td>1 → 12[^iv]</td>
<td>60 M → 620 M[^iv]</td>
</tr>
<tr>
<td>Carbon nanotubes (SWCNT)</td>
<td>2 000 000<a href="est.">^iv</a></td>
<td>0.005 – 0.26[^iv]</td>
<td>0.1 – 5.2 bn[^iv]</td>
</tr>
<tr>
<td>Activated carbon</td>
<td>1 400 – 2 300</td>
<td>2 700 – 3 900[^v]</td>
<td>2.8 bn – 4 bn</td>
</tr>
<tr>
<td>Carbon black</td>
<td>1 500 – 2 100[^av.]</td>
<td>14 000 – 18 000[^i] (est.2025)</td>
<td>18.5 bn → 24 bn[^i]</td>
</tr>
</tbody>
</table>

**Hycamite Advantages**

- Hycamite offers an alternative to imported carbon products. We deduct or even remove the dependency of the overseas providers with a local, yet sustainable and clean product.
- Hycamite focuses now on the carbon use in electronical appliances, such as batteries. The need for batteries is growing and we have the access to test our products directly with the UniOulu laboratories that are well-known and renowned R&D partner within the industry.
- Global increase of steel production due to growing urbanization and rising demand for graphite for production of lightweight aircraft materials are expected to augment the graphite market outlook.
- In addition, Hycamite develops high-value-added carbon allotropes such as carbon nanotubes and carbon nanofibers, which have huge potential in demanding applications.

[^i]: Frost&Sullivan,[^ii]: Expert Market Research,[^iii]: Mordor Intelligence,[^iv]: IdTechEx,[^v]: prnewswire

NB. Prices are average prices/ranges of different qualities, thus the market size seem not to be equal to the market price and size.
Miten - Innovaatio

- Katalyytti
- Katalyyttiperhe, kuinka katalyytti toimii yleisellä tasolla
  - Tuotetaan energiatehokkaasti vetyä ja haluttua hiiltä