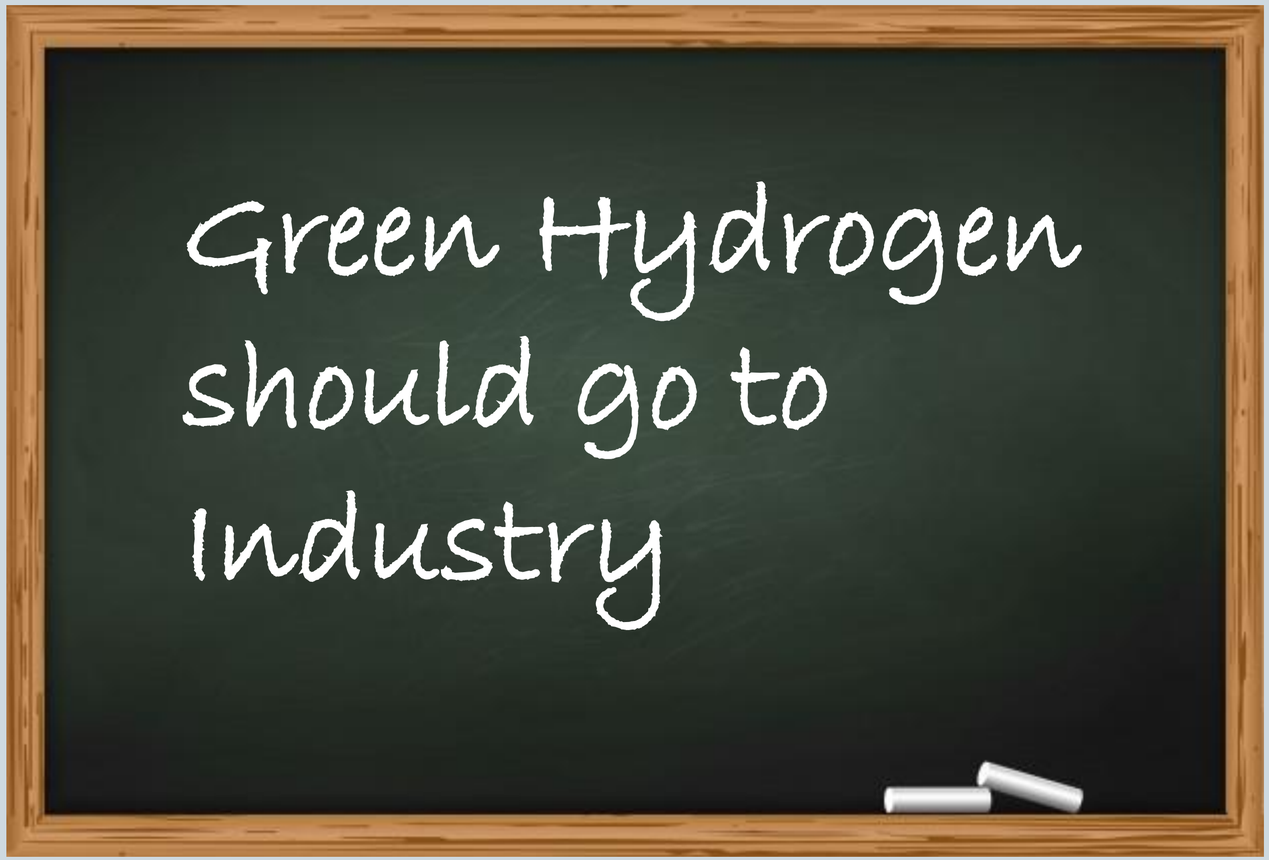
Hydrogen In Industry

Jasper Paauwe
30 september 2020

Something to think about



Together with our customers, we plan and design the communities and cities of the future

In Europe and around the world

Sweco in numbers

- **#1** on the European market
- Leading position in **6** markets
- **17.000** employees
- **1.750** employees in The Netherlands
- Net sales **EUR 1.9 billion**

Local expertise and international strength

- Local expertise is vital in order to plan and design our future cities in an insightful way.
- International strength gives access to the right expertise for every situation.

SWECO NETHERLANDS

Jasper Paauwe
Process Engineer

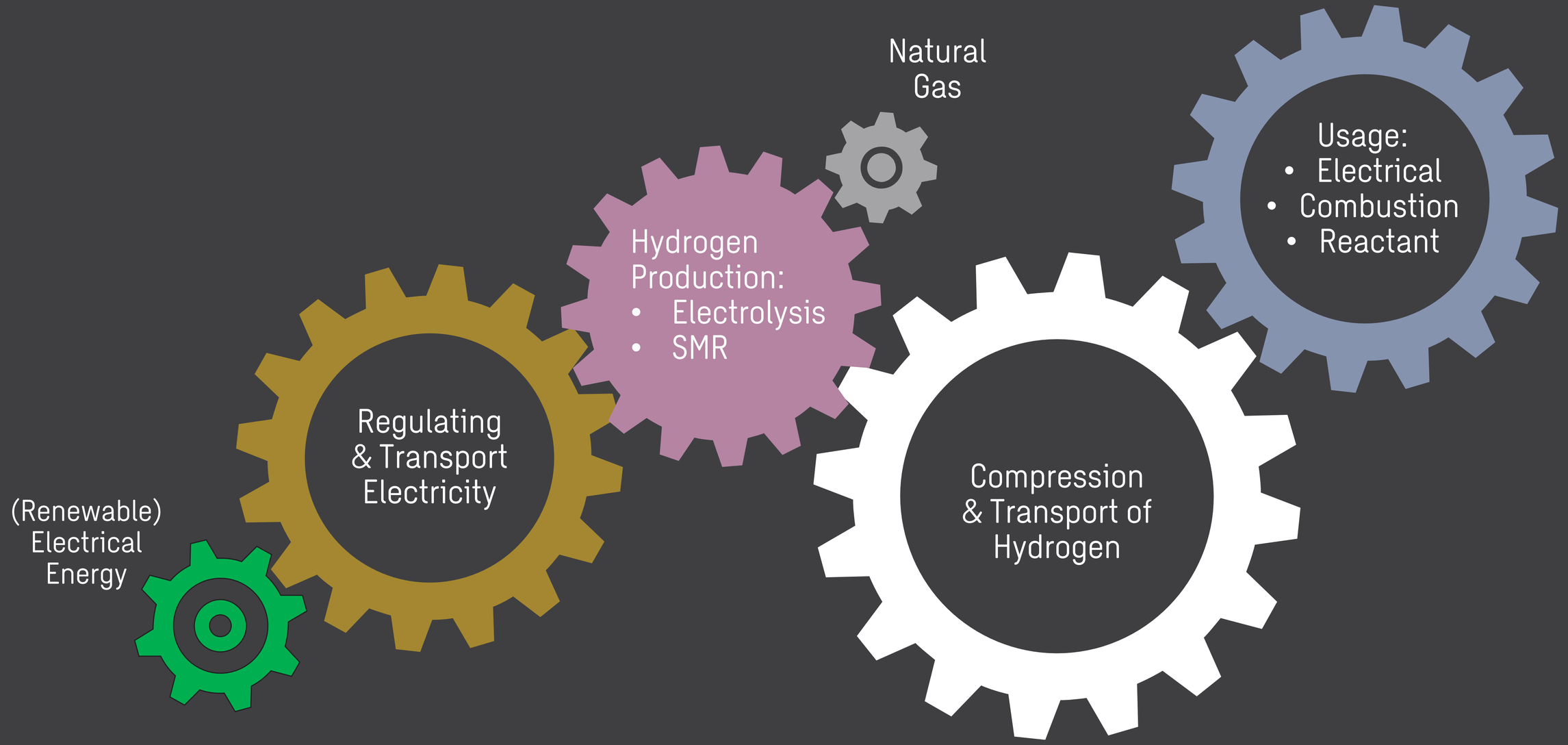
Department of Industry

University of Groningen:
- MSc. Chemical Engineering
- MSc. Chemistry

Some clients:
Gasunie, Avebe, Nouryon, PPG, DGR, Teijin, Vermillion, ThermoFisher, Plixxent, EEW, Damco Aluminium - Aldel

HYDROGEN & INDUSTRY

The Hydrogen Chain



Not every link is as effective

Each part of the chain adds losses

Renewable Electricity

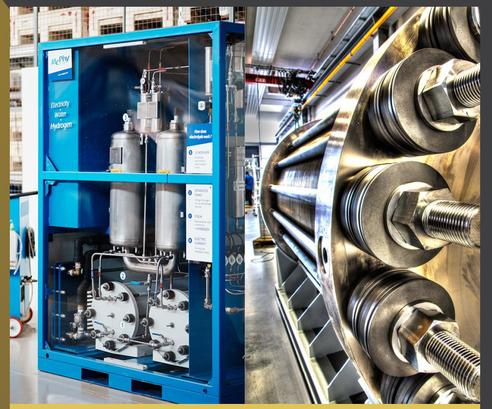
Efficiency solar panels:
- ~ > 20 %

Efficiency wind turbine:
- ~ > 50 %

Electrical Transmission

- Transformers
- Transmission lines

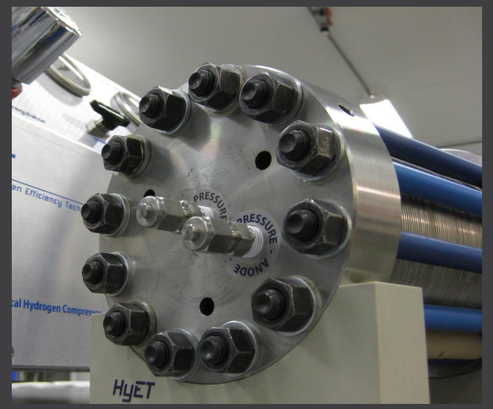
- Efficiency depending on distance travelled



Electrolyzer
H_2 production

Different technologies
PEM and Alkaline:

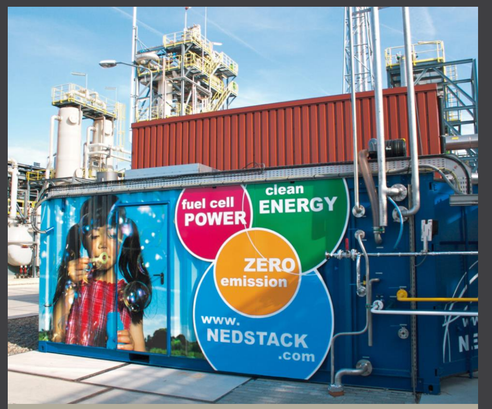
- Efficiency ~ 75 %
- 1kg H_2 = ~ 50 kWh



Hydrogen Compression

Mechanical compression
- Efficiency ~ > 70 %

Electrochemical compression
- Efficiency ~ > 80 %



Fuel Cell Coversion

Different technologies
PEM:
- Efficiency ~ > 50 %

SOFC:
- Efficiency ~ > 60 %
  - + heat recovery

Industry

Different locations in the hydrogen chain

Energy Demand

Requires Energy :

- Heat
- Electricity

Energy Generation

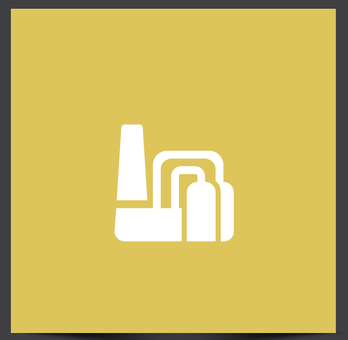
Produces Energy:

- Heat
- Electricity

Chemistry Usage

Hydrogen being used in the process:

- Synthesis
- Reduction
- Treatment
  - desulphurization



Chemistry Production

Hydrogen as a by-product:

- Electrolysis
- Syngas production
- Cracking

Energy Generation

Produces Energy:

- Electricity

Gasunie Zuidwending

At the location Zuidwending Gasunie produces hydrogen by electrolysis. Sweco was involved in the expansion of the hydrogen infrastructure in the design and wrote the specifications of various components necessary.

Chemiepark Delfzijl

For clients on the cluster Chemiepark Delfzijl and surroundings, Sweco provides site based engineering services. These projects start often as feasibility studies, leading to basic and detail engineering projects. Sweco offers maintenance engineering, commisioning and construction management services.

Nouryon, Groningen Seaports and various other partners envision a hydrogen backbone. With various parties like Nouryon Sweco has a long term relation and framework agreement.

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Energy Demand

Requires Energy :

- Heat
- Electricity

Chemistry Usage

Hydrogen being used in the process:

- Synthesis

Neste / Neste Engineering Solutions
Sweco has a longstanding co-operation during 40 decades with Neste in, oil refining and petrochemicals. Assignments include all fields of engineering and design and project services.

Several OSBL engineering assignments including cooling water and electrical systems.

Various engineering assignments for refinery hydrogenation units including high pressure hydrogen systems.

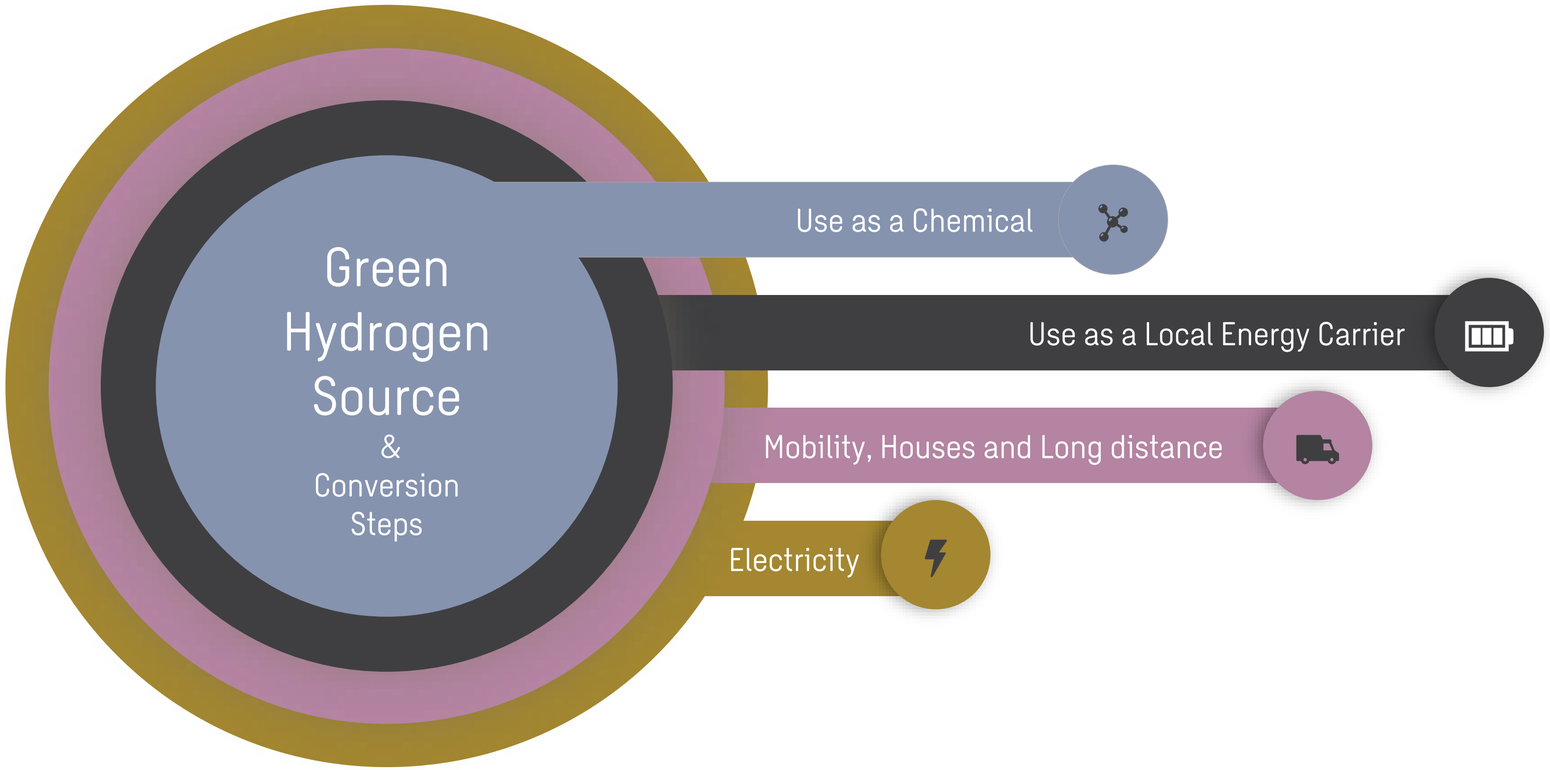
Chemistry Production

Hydrogen as a by-product:

- Electrolysis

Kemira, Joutseno
New sodium chlorate plant, EPCm assignment. Electrolytic process producing sodium chlorate from sodium chloride. Hydrogen is a by-product.

Full EPCm scope, all utility systems including cooling water, electrical systems and hydrogen handling.



Use as a Chemical

Direct use of hydrogen produced by electrolysis does not require changes in the process and does not add extra conversions with loss in efficiency

Use as Local Energy Carrier

Replacing natural gas to achieve high temperatures. Converting excess energy to hydrogen for on-site use.

Mobility, Houses and Long Distance

Replacing diesels in mobility for heavy transport. Transport across the country in pipelines and giving houses access to hydrogen grid.

Electricity

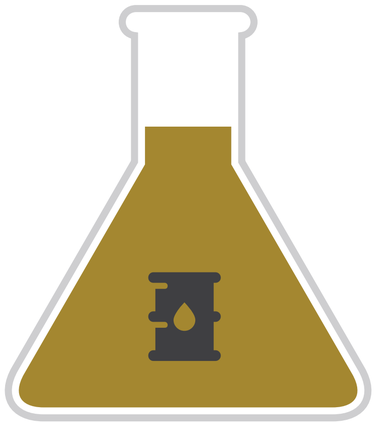
Converting green hydrogen to electricity on demand for industrial and residential use. Conversion with fuel cell technology.

Three essential parts of a Successful Energy Strategy

Minimize

Consumption

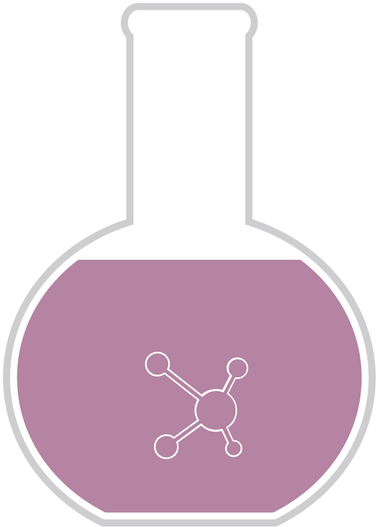
First step is to reduce het energy demand by process integration and reducing overall energy losses



Replace

With Sustainable Alternatives

The remaining energy demand should be as much as possible replaced by other more sustainable alternatives



Reduce

Negative Impact

Use fossil fuels as efficiently and clean as possible

High Temperatures & Hydrogen

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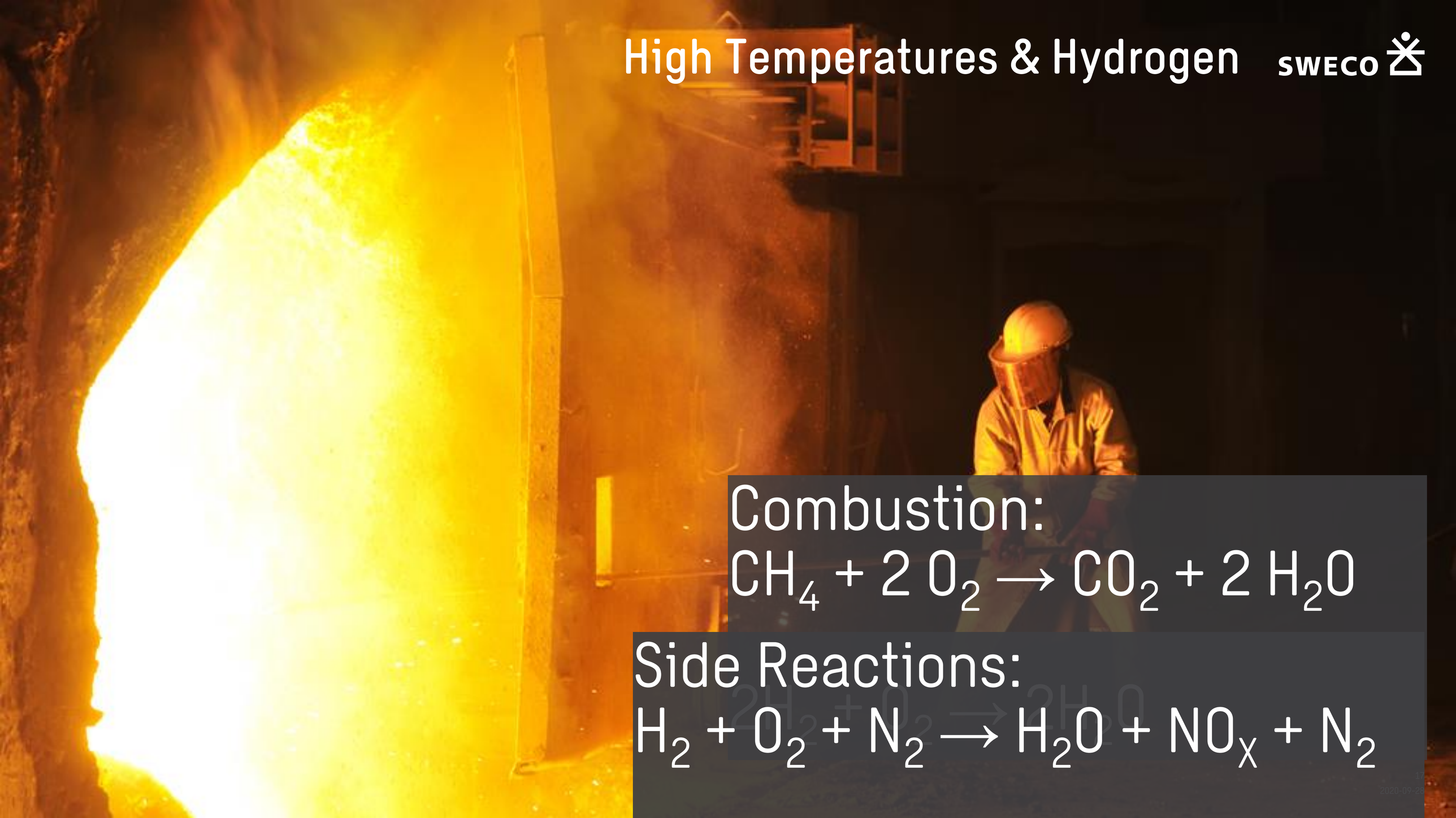


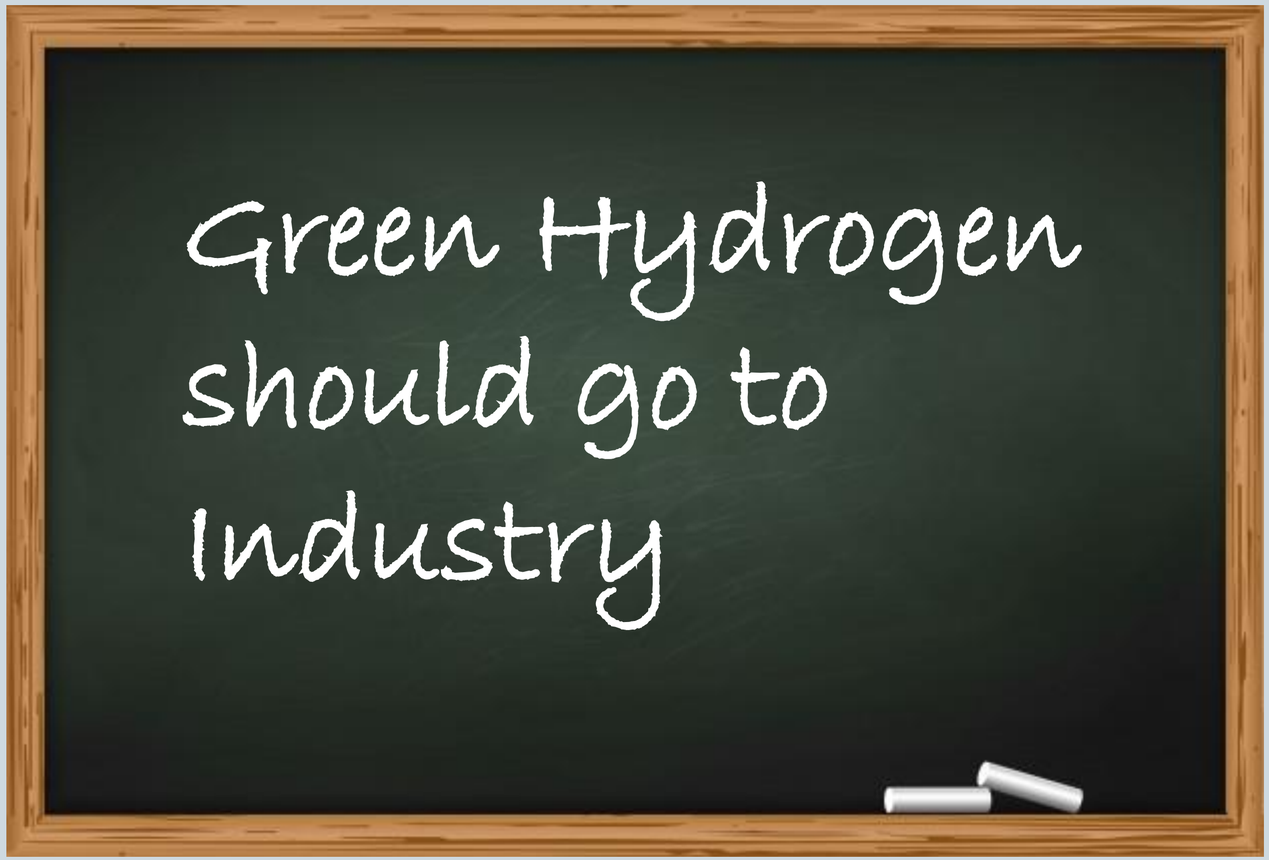
Combustion:

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

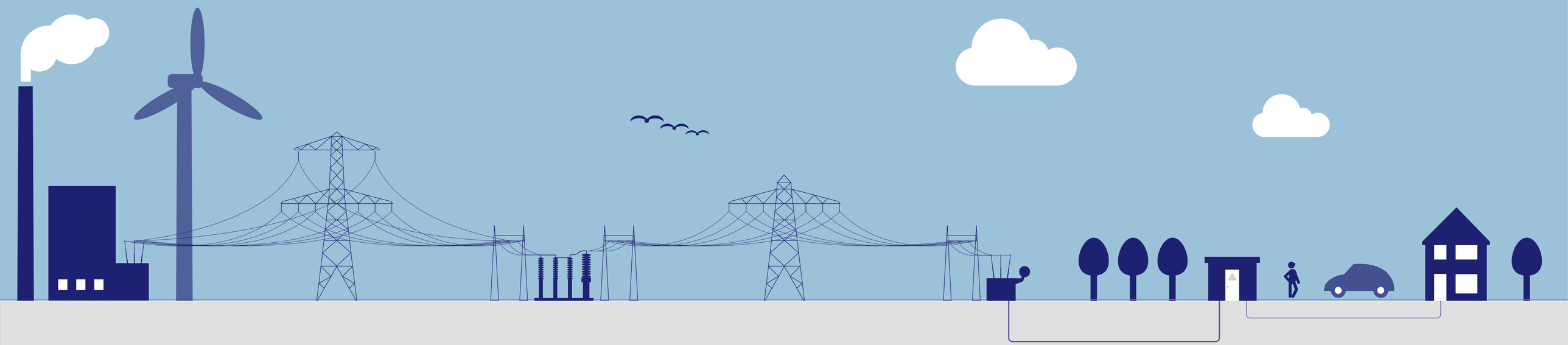
Side Reactions:

$$H_2 + O_2 + N_2 \rightarrow H_2O + NO_X + N_2$$

Something to think about



Example – Electricity in The Netherlands



High voltage lines

Local high voltage lines

Underground medium voltage lines

Underground lines

TenneT

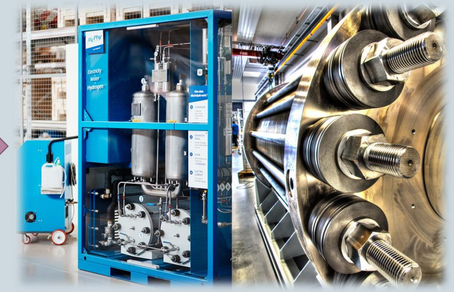
Regional grid owners

Hydrogen / Electricity

Electricity

Electricity

Electricity



Hydrogen

Hydrogen

Hydrogen

Hydrogen

Hydrogen

Electricity

Heat

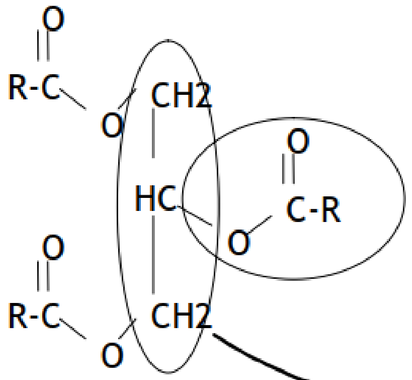
Example Hydrogen Use in Industry

CH_4

H_2

Simplified NExBTL Process Chemistry

Feedstock



Triglyceride, R = nC

Reactions & Products

H2 — Catalyst

R'-CH2-CH3 + 2 H2O (A)

R'-CH3 + CO2 (B)

R'-CH3 + CO (C)

NExBTL biodiesel, R' = (n-1)C

H2 — Catalyst

CH3-CH2-CH3

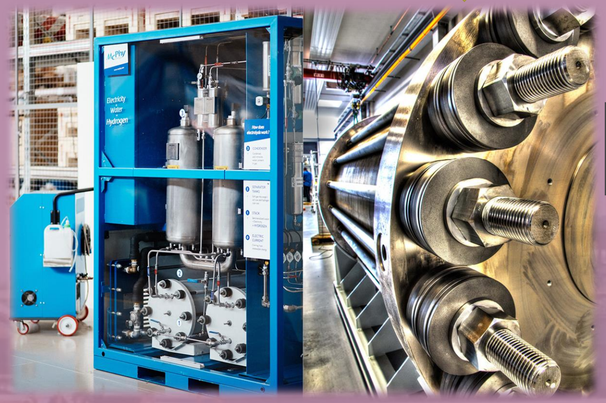
Propane (fuel gas)

NExBTL is a stabile and pure hydrocarbon!

Figure 2: The new Neste Oil's NExBTL Renewable Synthetic Diesel Technology to produce a second generation renewable diesel.

Replacing the Hydrogen's Origin

Electricity



H_2

Simplified NExBTL Process Chemistry

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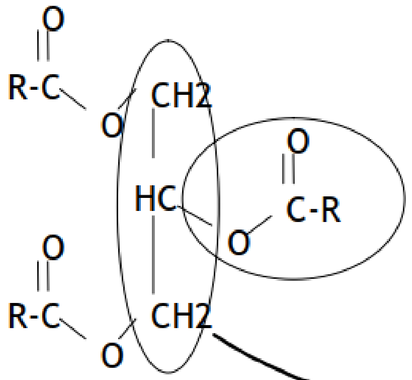

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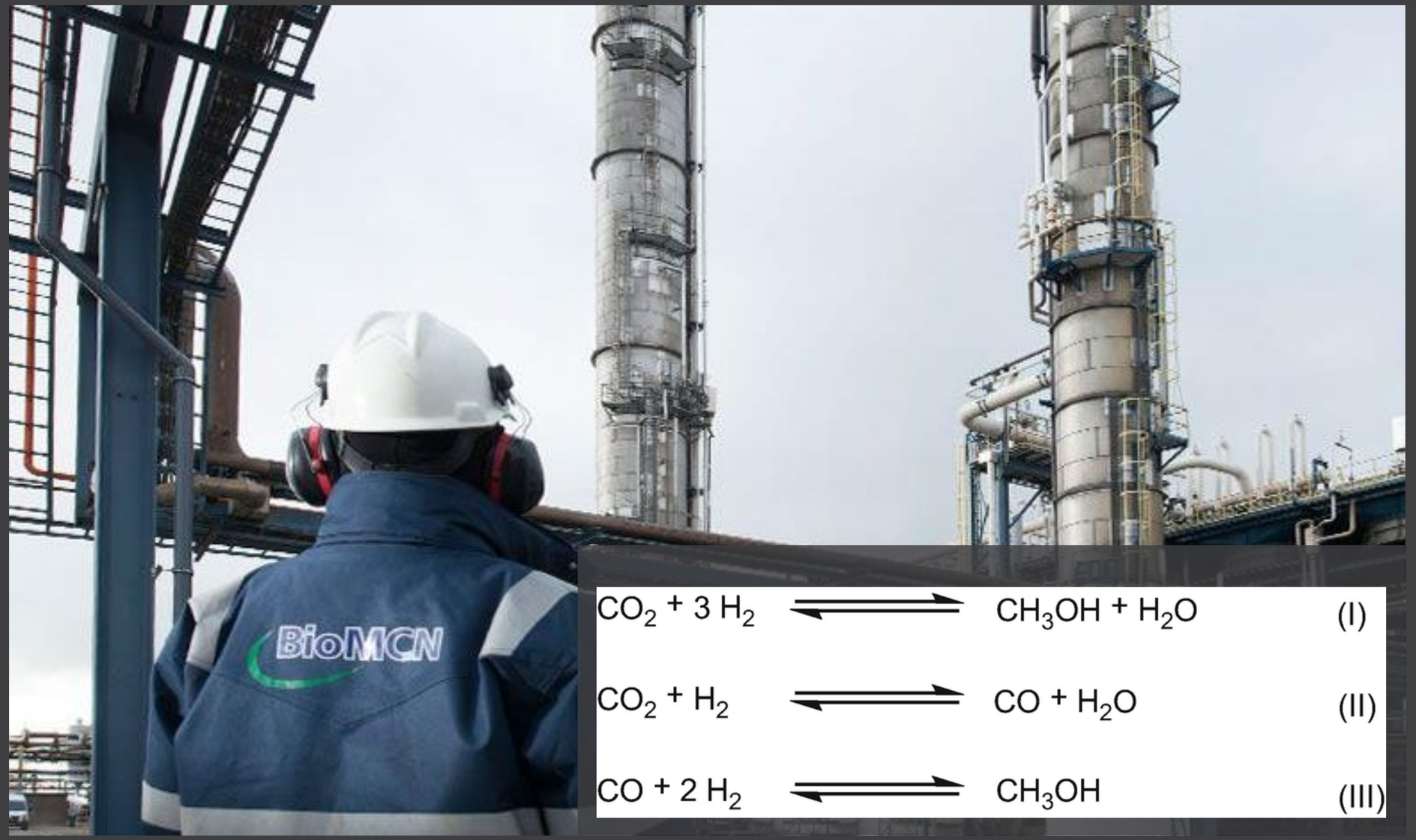
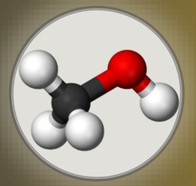


$$CO_2 + 3\,H_2 \rightleftharpoons CH_3OH + H_2O \quad (I)$$

$$CO_2 + H_2 \rightleftharpoons CO + H_2O \quad (II)$$

$$CO + 2\,H_2 \rightleftharpoons CH_3OH \quad (III)$$



Methanol

In Delfzijl BioMCN will start to produce methanol based on green hydrogen.
The hydrogen will be supplied from the DJEWELS project Electrolyzer

Green Hydrogen should go to Industry

- High demand
- Less conversion steps
- Systems close together
- Use without modifications
- Start building H_2 Supply
- Highest Impact per €

Steps Forward
- Making Connections

DISCUSSION & QUESTIONS

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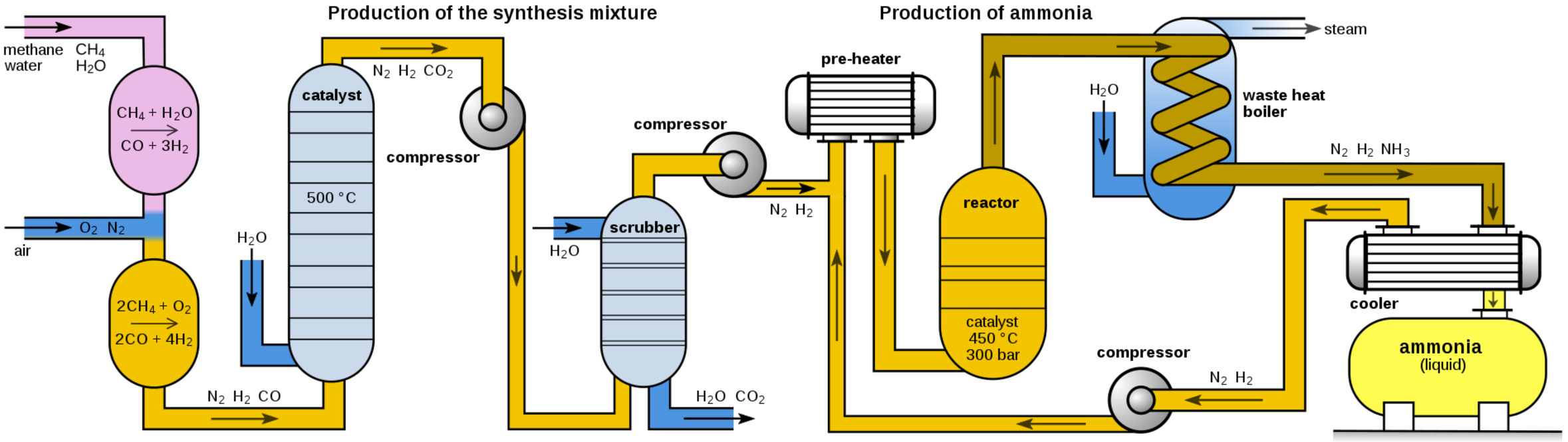
Extra Example: Haber Bosch

Famous Hydrogen Intensive Process



Francis E Williams

Sweco is Europe's #1 in engineering & architecture

Whatever Industry challenges our customers face, you can count on us to solve them... as the most respected knowledge company in the fields of engineering, environment and architecture.

Architects – 1,300

Power & Energy Engineers – 2,000

Structural Enginners – 2,000

Infrastructure & Civil Engineers –4,000

Industry & Process Engineers –2,400

MEP Engineers –2,200

Water & Environment Engineers –3,100

Development IT & Social Analysis –2,000

Project Management –2,000

Industry & Process Engineers ~ 2,400

Services	Capabilities
• Project management • Master planning • Feasibility & concept • Permits, MER, safety report • Basic engineering • EPCm – Detailed engineering – Procurement – Construction management – Commissioning & Qualification • CE-certification • Safety management • Energy & environmental management and consultancy • Managed services • Optimisation • Decommissioning	• Process technology, process knowledge • Building and civil techniques • Piping / equipment engineering • Building Technical installations • Mechanical & electrical engineering • Instrumentation & automation • Construction management and buildability • Commissioning and qualification • 3D Laser scanning & industrial surveying. • Site based managed engineering services. • Procurement. • Energy design & power distribution. • Water Treatment. • AIM: Asset Information Management. • Environmental management & consultancy. – Energy management and CO_2 reduction – Coordination, permitting & policy – Water purification and production – Soil remediation

With 2,400 employees focusing upon industry and process engineering,
we build our industrial services around Plant Life Cycle (MOC),
multidisciplinary EPCm projects and Asset Information Management. Our specialists manage your projects within time and budget, from its first concept through basic and detailed engineering and construction management resulting in safe, effective and resource efficient production facilities.

Sweco has delivered framework contracts with a wide range of chemical companies for the purpose of executing MOC projects (Management of Change). We are equally involved in complex shutdowns or large EPCm projects.

Sweco is Europe's #1 in engineering & architecture

Whatever the Industrial challenges our customers face, you can count on us to solve them... as the most approachable and committed partner with recognised expertise.

Sweco Undertook Engineering Design and construction management Jannssen (NL)

Sweco undertook masterplanning and engineering design VOPACK (NL)

Plant design - Sweco's industry engineers deliver efficient, resource-saving design services in the energy and industrial sector. We combine detailed expertise with an wholistic perspective to sustainable competitiveness solution for our customers. Our experts work with the design of mechanics, piping, electricity and automation for major construction and renovation, to minor additions and alterations. From We work with our customers throughout the entire project helping them to manage a project from feasibility study through to decommissioning.

Process engineering - Many of our customers work continuously to improve their industrial processes. They set high standards for energy and resource efficiency and reduced environmental impact. Sweco helps them reduce costs while also promoting a more sustainable society.
Our experts have extensive experience and broad-based expertise in chemical engineering, energy technology and energy efficiency improvements, and work in the majority of industrial branches. With an overall perspective and leading-edge expertise, we conduct feasibility studies and manage projects that optimise industrial processes. Our services also include technical calculations such as computational fluid dynamics, mass and energy balances, combustion technology, flue-gas treatment and industrial risk analyses.

Sweco developed a new sodium chlorate plant (EPCm assignment) for Kemira (FI)

Sweco helped ABB increase production process capacity in polish facilities (PL)

Sweco designed a safer and more reliable power station for Toatal Raffinaderij (BE)

Logistics - With good logistics, a company can maximise its capacity. But for Sweco it's also a matter of helping our customers exceed their customers' expectations. With innovative solutions and the latest technology, we help identify improvement opportunities. Efficient logistics requires an in-depth understanding of the business, so a close collaboration with the customer is needed. We share our expertise as part of the project, and have found a key success factor is combining the roles of project manager and logistics expert in one person. We optimise production facilities, warehousing & distribution flows with extensive experience in both automated & manual solutions. We test different solutions by simulating and visualising the operations before taking decisions.

Sweco is providing process advice for the expansion of 3 Sodra Plup Mills (SE)

Sweco designed and supervised the delivery of a self-powered WWTW (UK)

Sweco helped Unilever realize a new R&D Centre for liquid food (PL)

Sweco helped Anglian Water deliver £3bn investment while saving £60m pa. (UK)

Electricity and automation - Sweco's industry specialists design tomorrow's electricity and automation systems. We work with our customers to create resource-efficient, smart and reliable solutions by taking overall responsibility for planning and design. Whether the project is a major investment in new construction or the renovation or minor alteration of an existing building, our experts are at your disposal. We help with the entire chain, from feasibility study, requirements analysis, procurement and co-ordination through installation and start-up.
We design robust solutions for electricity supply, intelligent power plants with efficient control systems & designing measurement technology for automatic control & surveillance systems

Over several years Sweco helped Frankfurt Airport develop it´s capacity(DE)

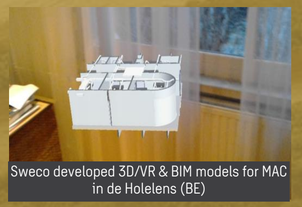
Industrial electronics - Sweco's innovative product development within industrial electronics and telecommunications creates smart new solutions for our customers. For example, we've developed software for sawmills that makes maximum use of raw materials, and precise measurement systems for heavy vehicles that reduce wear and tear and environmental impact.

By combining software, electronics, industrial design, and mechanical and project management, we help our customers develop products and solutions that save resources and reduce costs through smarter utilisation.

Our experts possess broad-based and comprehensive expertise and we work closely with our customers to develop sustainable solutions – from idea to reality.

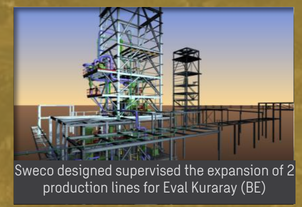
Sweco designed Trinseo's new BREEAM Excellent office in Hoek (NL)

Sweco helped improve Mars production process – on time and budget (UK)



Sweco developed 3D/VR & BIM models for MAC in de Holelens (BE)

Sweco undertook land-use & construction planning for SCA pulp mill expansion (SE)



Sweco designed supervised the expansion of 2 production lines for Eval Kuraray (BE)

Sweco worked in EPCm projects for INEOS to improve process and facilities (BE)

Key clients include - 3M, Akzo, ArcelorMittal, ATPC, Boreal Bioref, Borealis, Electrabel, Gassco, G, Ineos Oxide, Ineos Phenol, Janssen Pharmaceutica, Kemria, Kuraray EVAL Europe, Metsä Group, Mondo, Pfizer Nestle, Total Olefins, Stora Enso, Trinseo, Umicore, UPM and many, many more.

SWECO