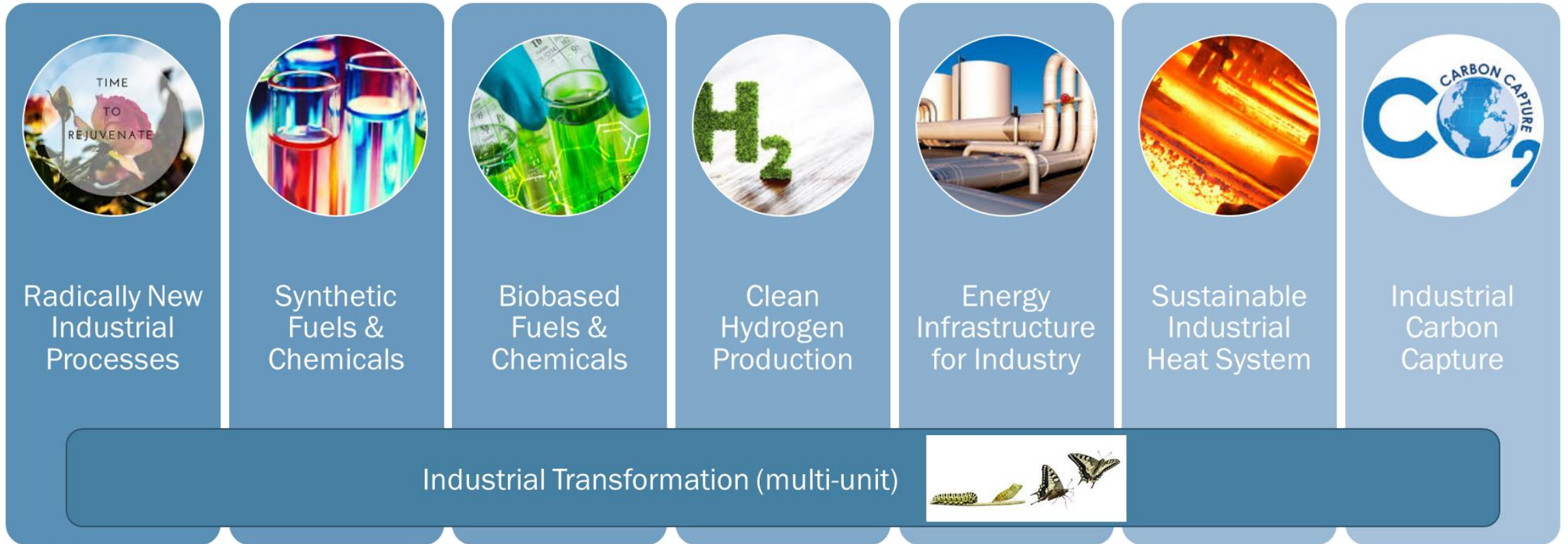




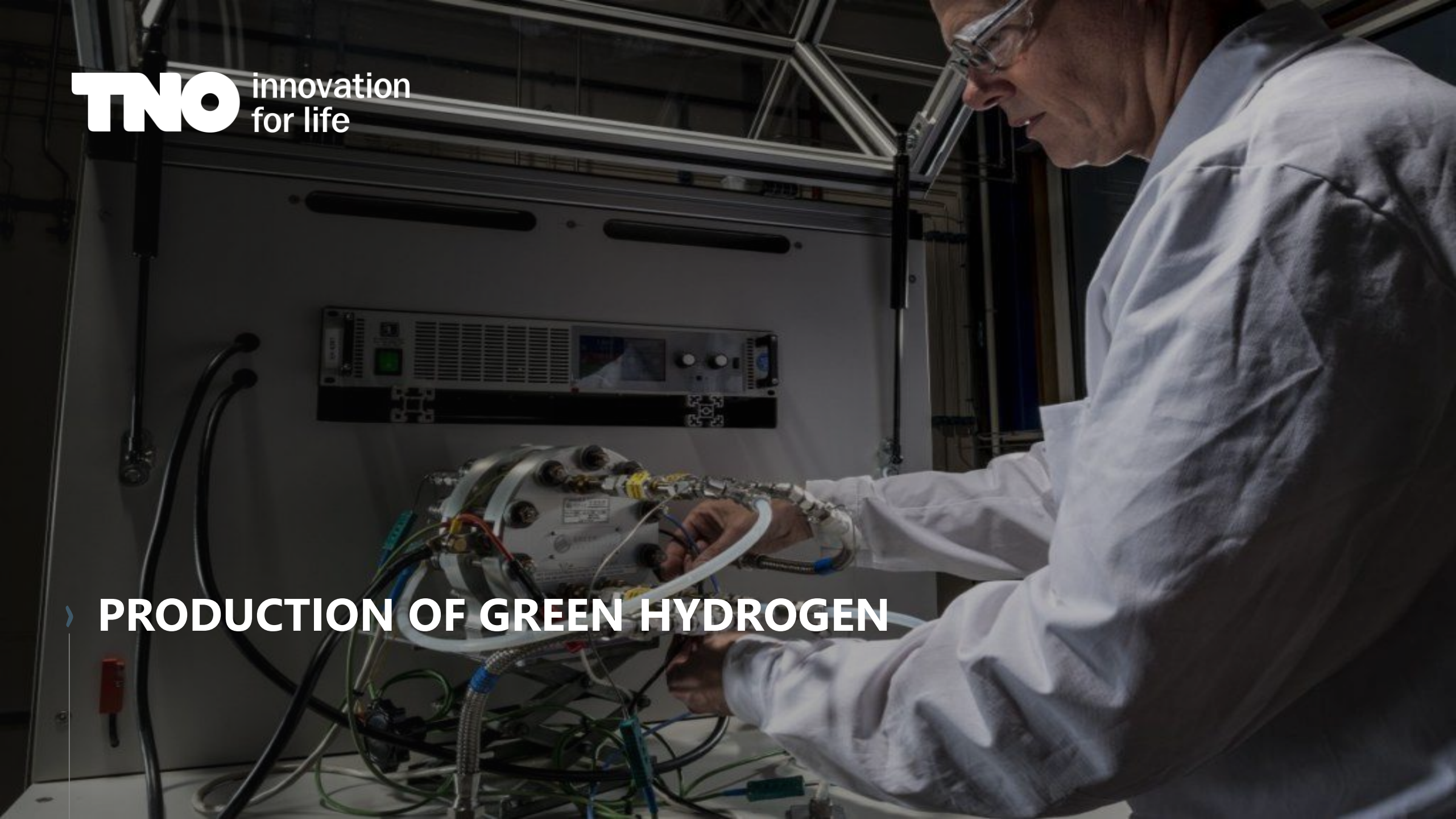
› **SUSTAINABLE TECHNOLOGIES FOR INDUSTRIAL PROCESSES**
IN A NUTSHELL | M.SARIĆ

TOWARDS CO₂ NEUTRAL INDUSTRY

CONTRIBUTION OF STIP TO THE PMC-CLUSTERS OF THE ROADMAP

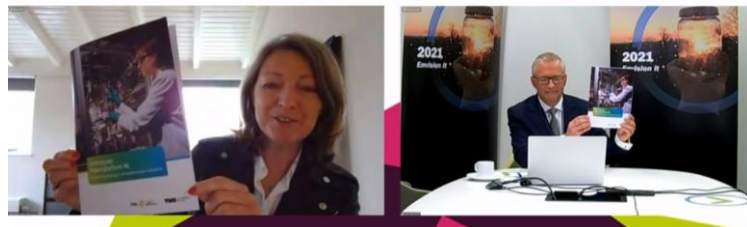


› **PRODUCTION OF GREEN HYDROGEN**



TNO POSITION ON GREEN HYDROGEN PRODUCTION

- › Internationally Orientated. Top 3 player in Europe on Electrolysis
- › Initiated strong industrial ecosystems across supply chain (North Sea Energy, Voltachem)
- › Building a strong network of national high tech companies (**Electrolyzer producers platform NL**)
- › R&D one of the **technology leaders** in the field of PEM and SOE
- › **Facilities:** state of the art across value chain (Faraday lab, Hydrohub, Fieldlab, Switch, PoShydon, Holst)
- › IP portfolio in development
- › Potential to build **strong collaboration between Netherlands and Germany** for the High-Tech industry



THE DUTCH ELECTROLYZER STRATEGY

STRATEGIES TO POSITION THE NETHERLANDS IN THE NEXT DECADE

4 strategies

Product innovation

› Support Dutch companies to become active in the electrolyzer supply chain (Dutch technology inside)

Demonstration

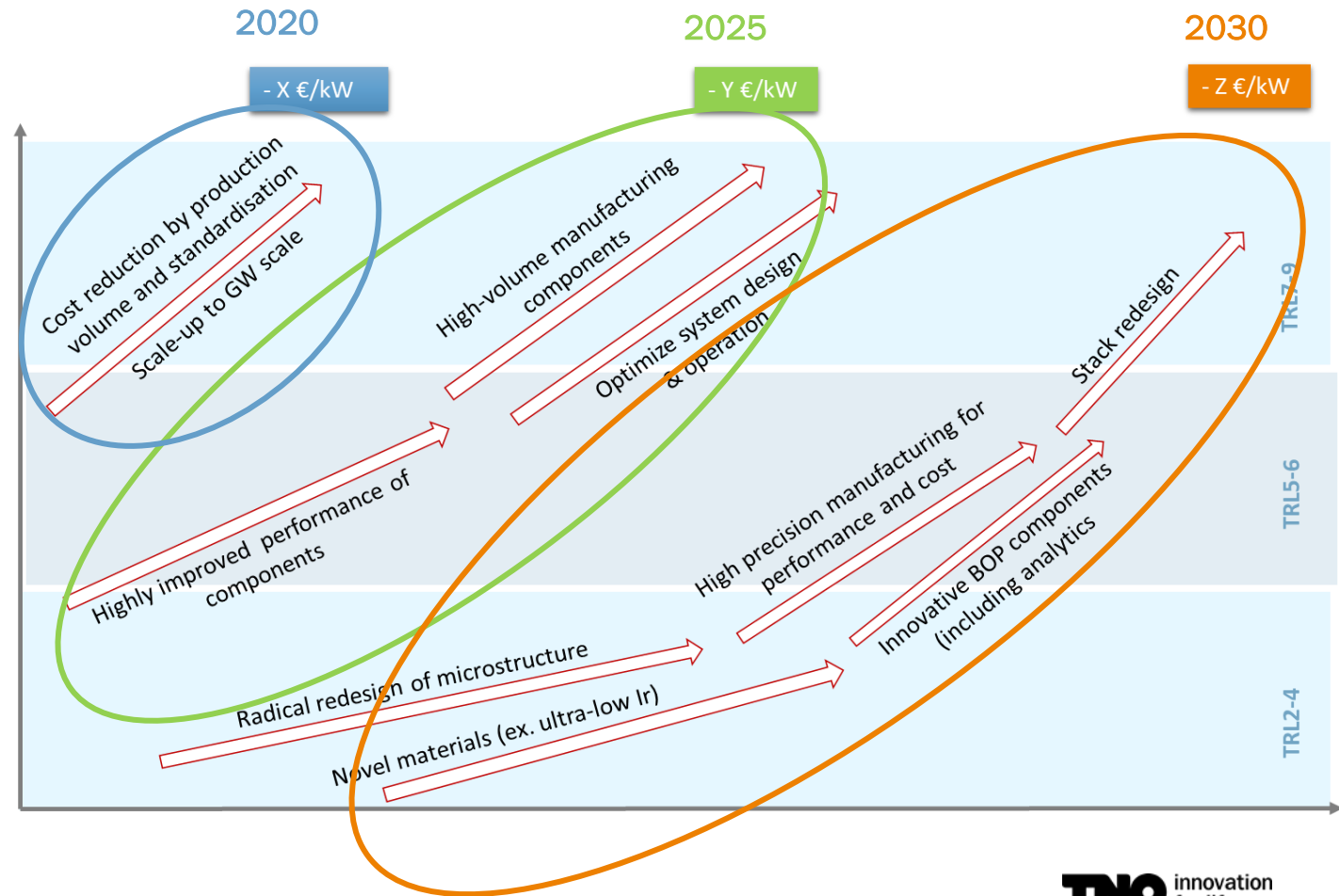
› Support industry clusters with transition to CO₂ free production processes based on green hydrogen

Process innovation

› Developing High-volume & high precision production equipment (and assembly in the NL)

System innovation

› Developing next generation Electrolyzer technology (become an OEMer for specific application i.e. offshore)

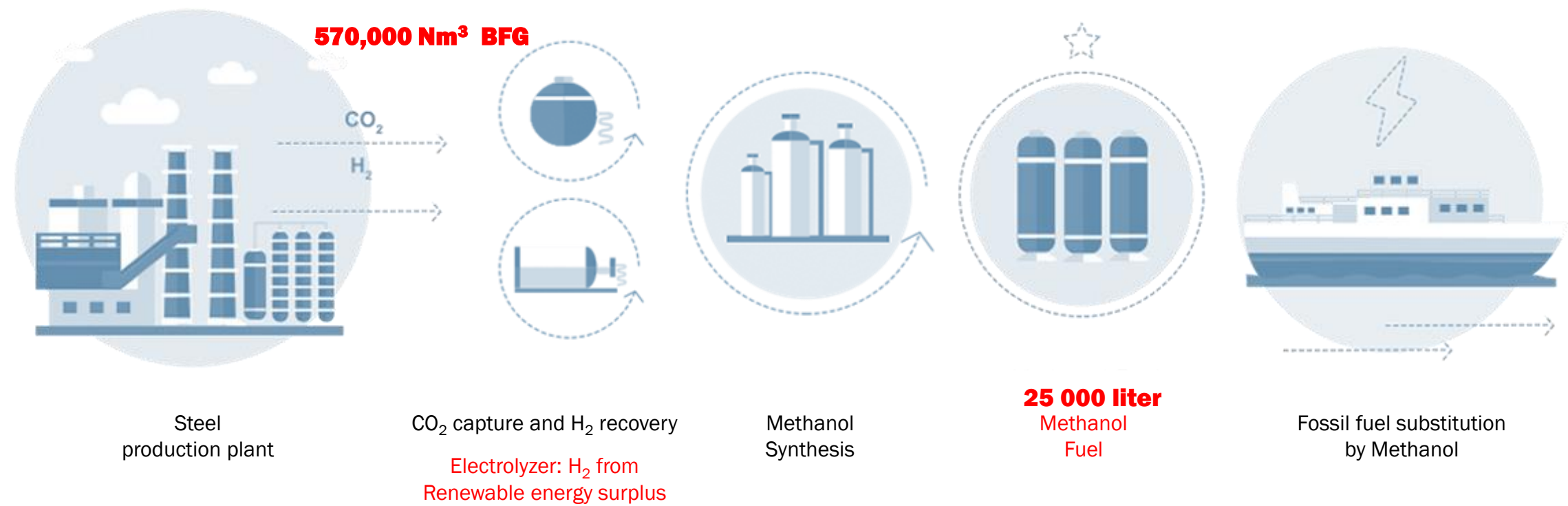


› **SYNTHETIC FUELS**



CO₂ UTILIZATION TO METHANOL WITH SEWGS

- › Methanol essential energy vector, chemical feedstock in circular carbon economy
- › CO₂ separation and methanol synthesis demonstrated in industrially relevant environment (TRL6), for 1500 h

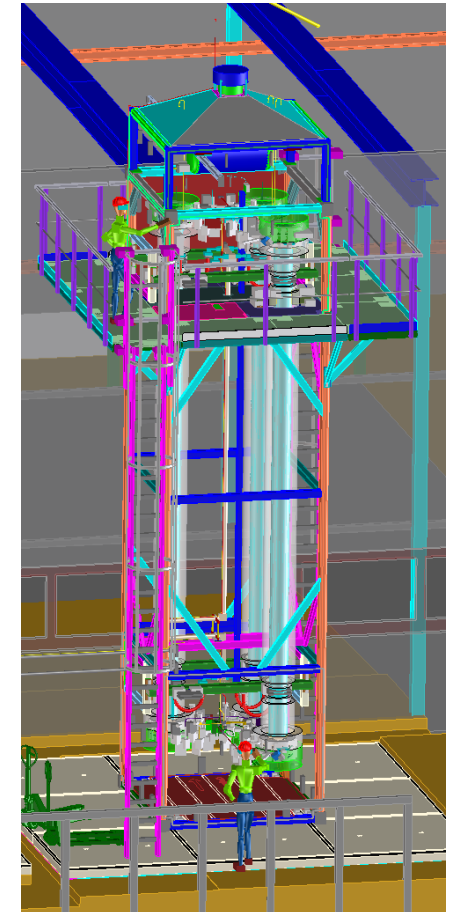
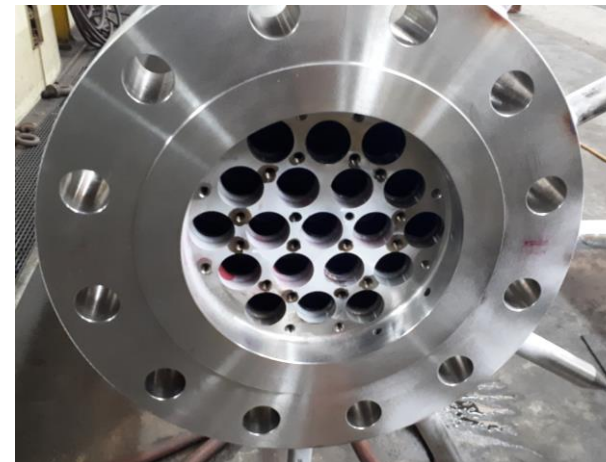
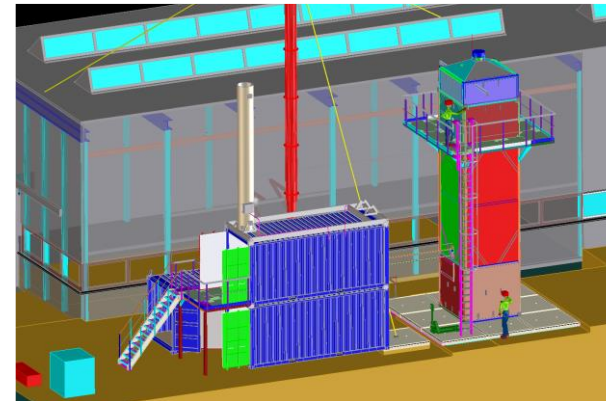
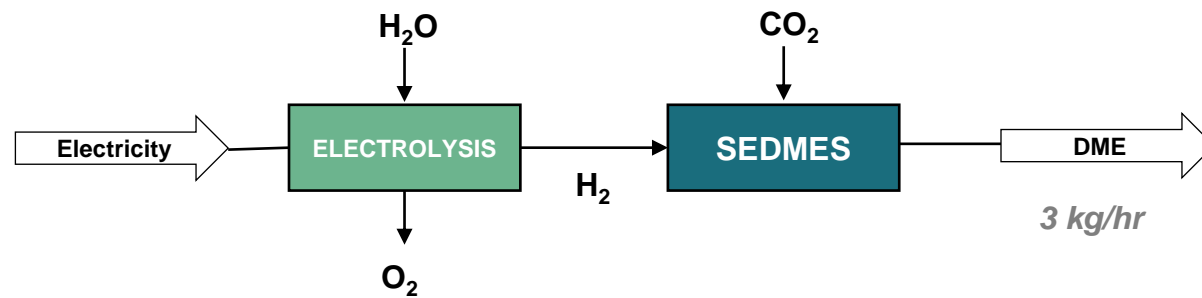


THE E2C PROJECT

CO₂ UTILIZATION TO PRODUCE DIMETHYL ETHER

www.voltachem.com/e2c

- › 3 shell-and-tube reactors of 7.5 m and 150 L each
- › TRL6 demonstration





› **SUSTAINABLE INDUSTRIAL HEAT SYSTEMS**

› SUSTAINABLE INDUSTRIAL HEAT SYSTEMS

HEAT IS HOT!

MISSION

Develop knowledge and technology to support industry in the transition to a sustainable, carbon neutral, heat system.

PROGRAM LINES

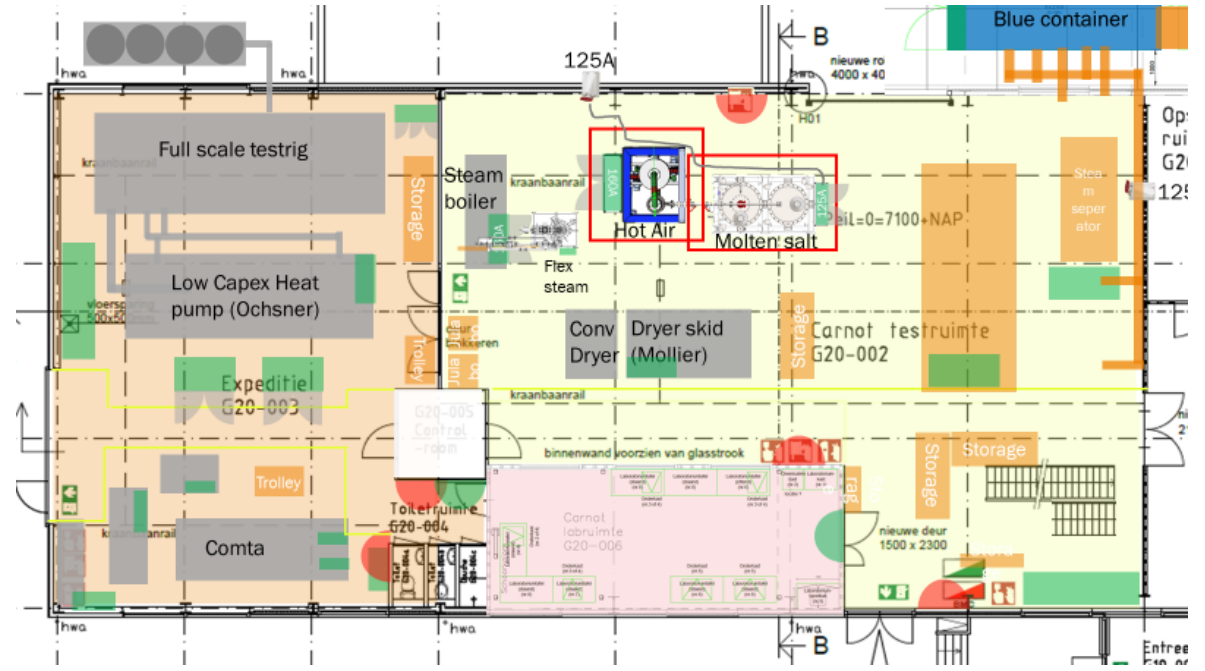
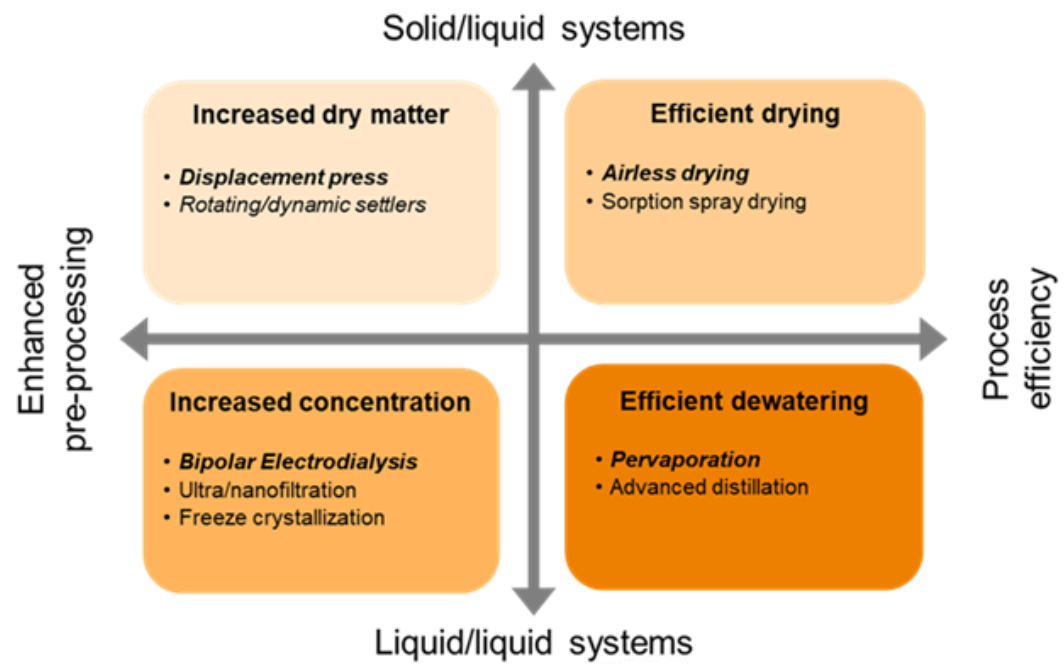
- › Eliminate or reduce heat demand – Energy efficient separation
- › Sustainable heat production
- › Recover and re-use of heat – Heat pumps
- › System analyses and integration



› **ENERGY EFFICIENT SEPARATION**

DRYING AND DEWATERING

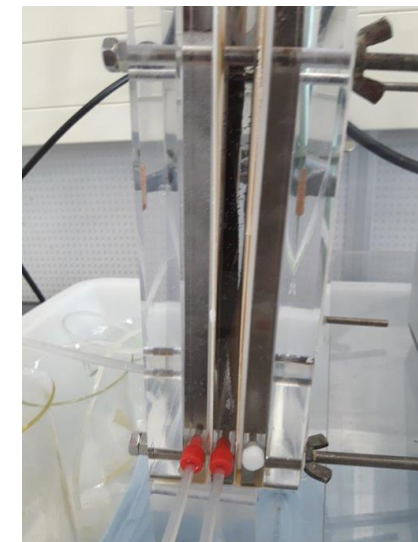
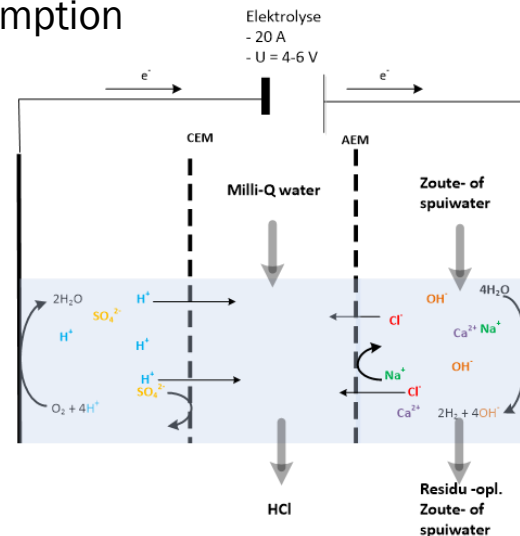
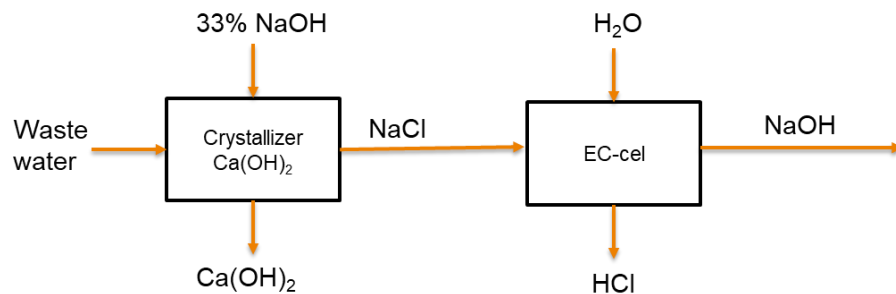
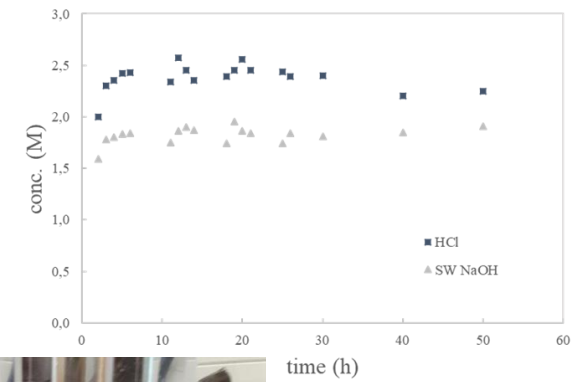
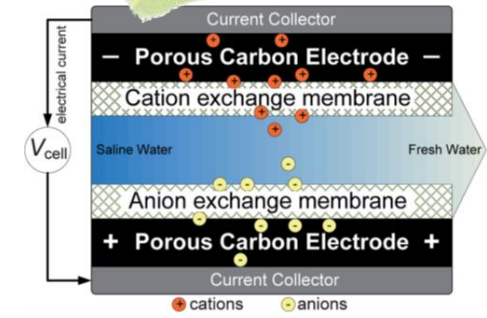
SECOND TITLE OF THE SLIDE



ELECTRO SEPARATION

RECOVERY OF PRODUCTS FROM WASTE STREAMS

- › **MCDI = Membrane capacitive deionization:** Remove ions (salts, (organic) acids, bases) from process streams, thereby enabling the reuse of these streams.
 - › Use of biomass (biorefining) based process streams; e.g. improved fermentation processes
 - › Concentration of e.g. CO₂ or NO₃ in water, combined with electrochemical conversion
- › **Electrochemically-driven production of chemicals from waste to**
 - eliminate waste disposal and
 - reduce water consumption
 - › Electrode ionisation for HCl and NaOH production
 - › Phosphate recovery as valuable fertilizer product

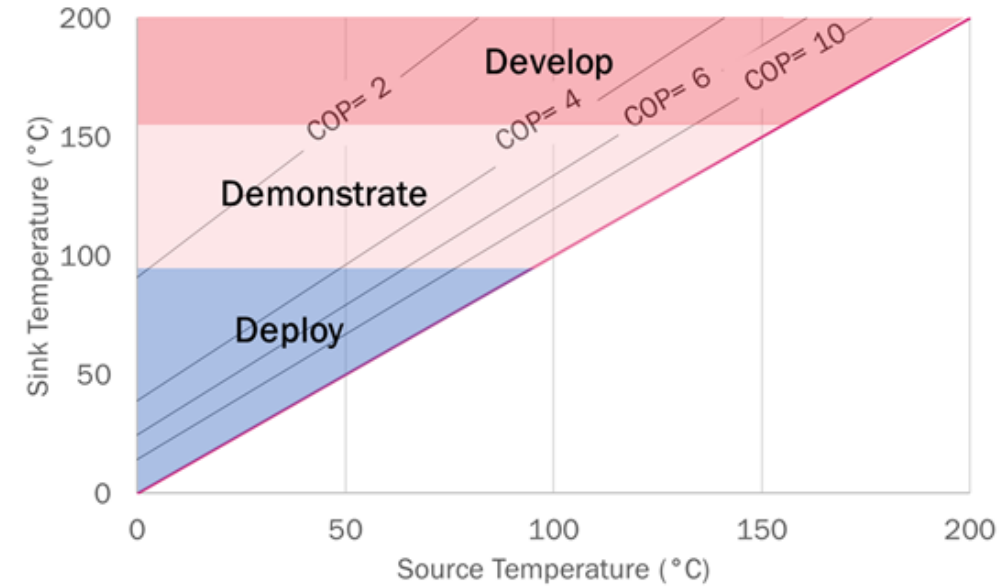
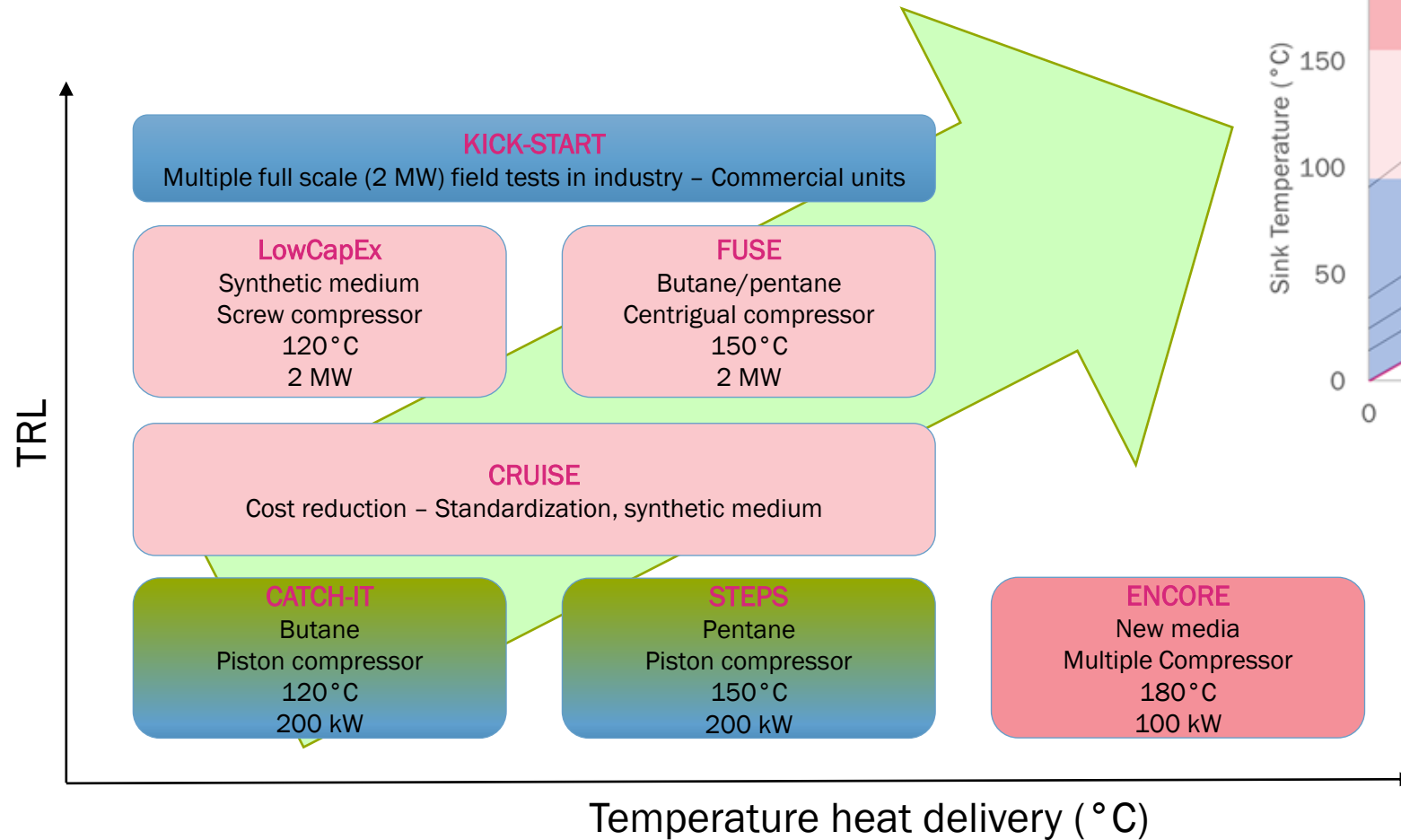


time (h)

› **HEAT PUMPS**

A large industrial refinery or chemical plant is shown at sunset. The sky is a deep orange and yellow, with thick plumes of white steam or smoke rising from various towers and pipes. The foreground is dark, showing the complex structure of the facility with many vertical distillation columns and horizontal pipes. The overall scene conveys a sense of industrial activity and energy.

COMPRESSION HEAT PUMP TECHNOLOGY DEVELOPMENT TNO ROADMAP





› **THANK YOU FOR
YOUR TIME AND ATTENTION**

TNO innovation
for life