e-Refinery

Towards sustainable production of chemicals and fuels

Electrochemische productie van brandstoffen en chemicalien

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OUR CLIMATE IS CHANGING

+0.85°C

*Average temperature **increase** from 1880 to 2012*

-1.7km

*Arctic's sea ice **loss** every decade since 1979*

+19cm

*Average sea level **rise** from 1901 to 2010*

+50%

*Greenhouse gas emissions **rise** than 1990*

-5%

*Grain yields **decline** per 1°C increase*

+400%

Increase of natural disasters since 1970

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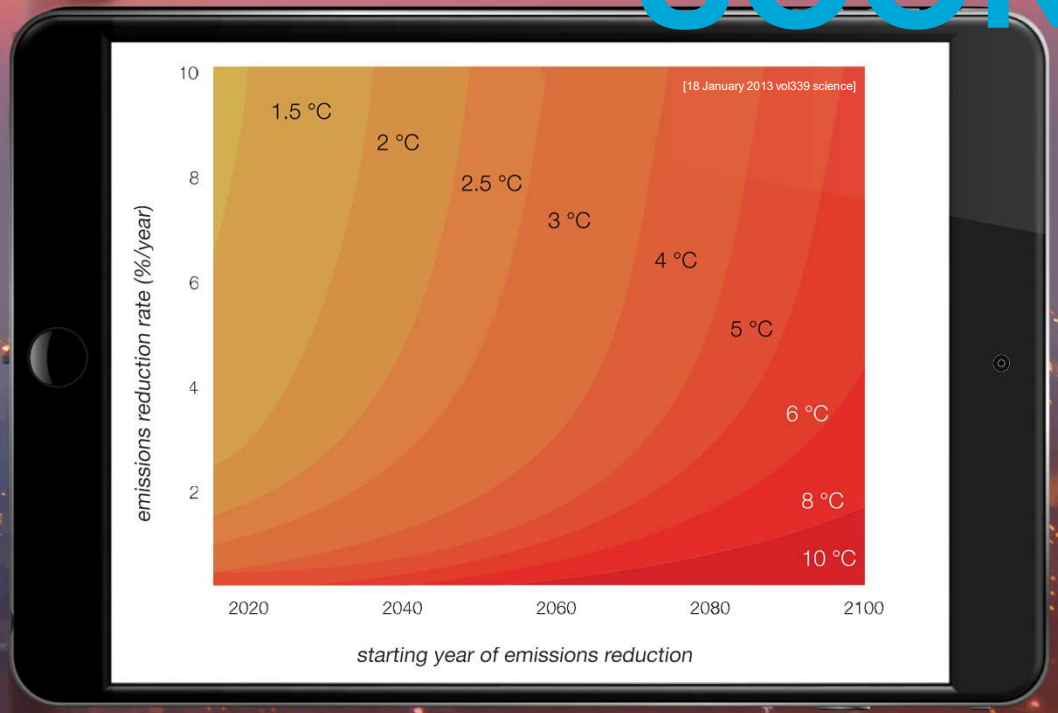
Ref: *United Nations Sustainable Development Goals Climate Action*

REDUCTION OF WORLD CO_2 EMISSION NEEDS TO START SOON...



EVERY YEAR WE WAIT,
THE CHALLENGE
GETS TOUGHER

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Stocker, Science 339, 280–282 (2013)

TARGETS TO REDUCE CO_2 EMISSION

PARIS2015
COP21·CMP11

Paris Agreement

limit the increase to 1.5°C
in 2050 relative to 1990 levels.

Klimaat-akkoord

Dutch ‘Klimaat akkoord’

49% CO_2-reduction of CO_2 emission
in 2030 and 95% in 2050 relative to 1990 levels.

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Renewable Energy
is the SOLUTION
WHY?
www.AskWhyWhyNot

OPTIONS
THE INDUSTRY

Increase energy efficiency

Implement Carbon Capture and Storage

Use sustainable heat

Use Biomass as feedstock

MOBILITY SECTOR

Electric driving

H_2

Hydrogen driving

e:Refinery

Indirect route water electrolysis & thermochemical process

Direct route CO_2 & N_2 conversion

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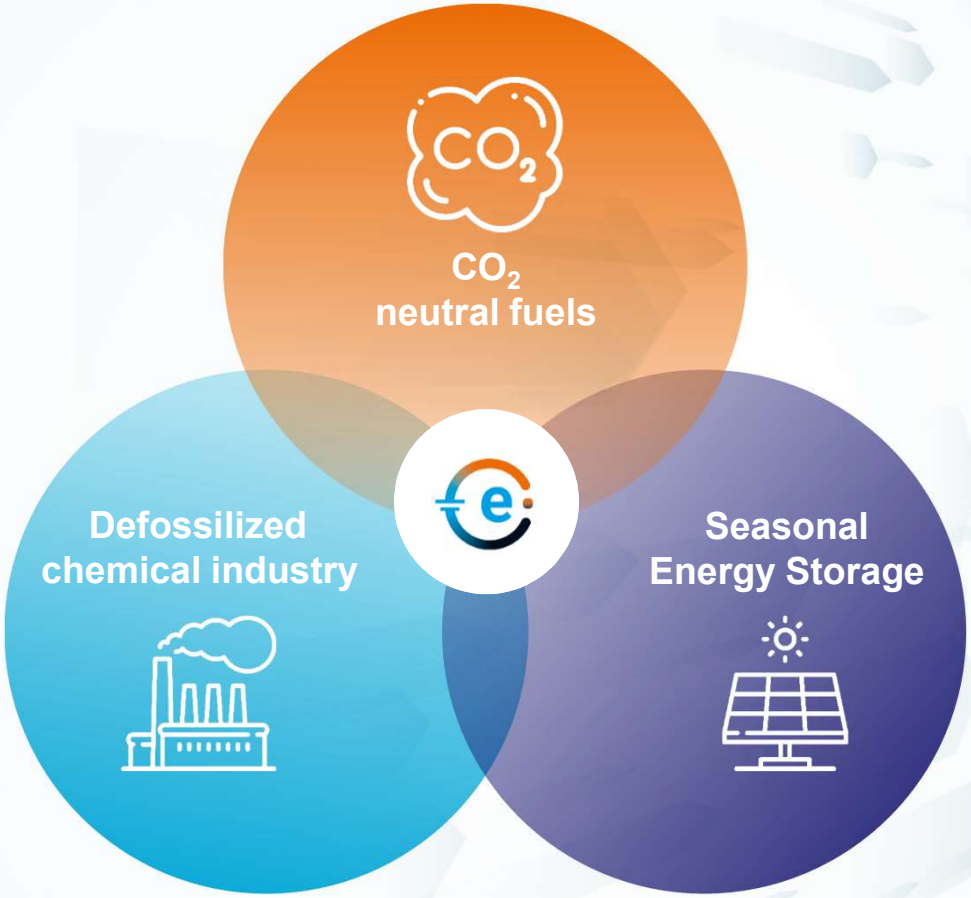
e-Refinery addresses three interconnected challenges



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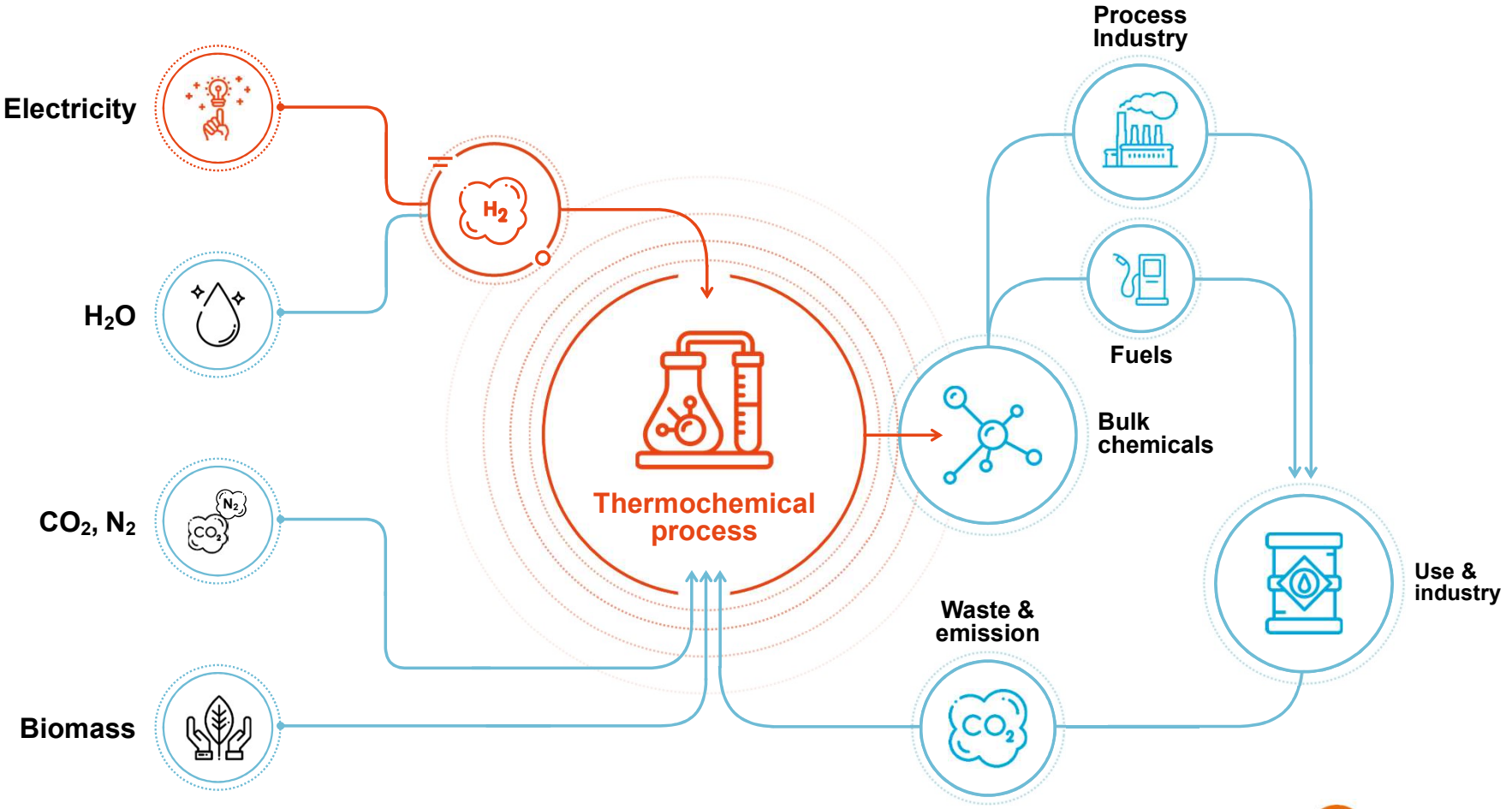
The indirect route



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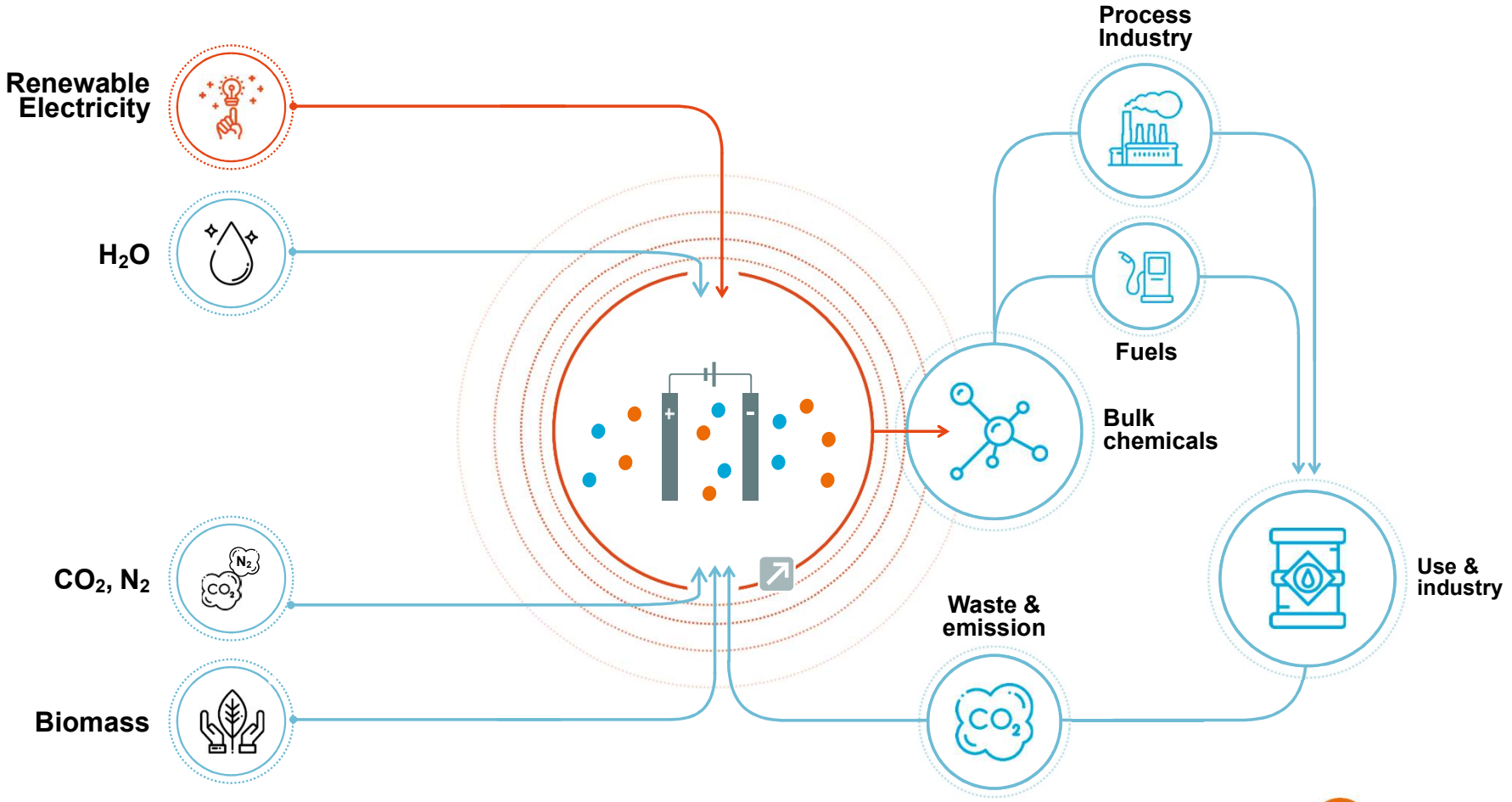
The direct route



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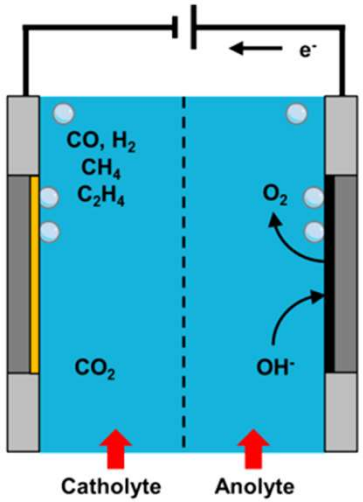
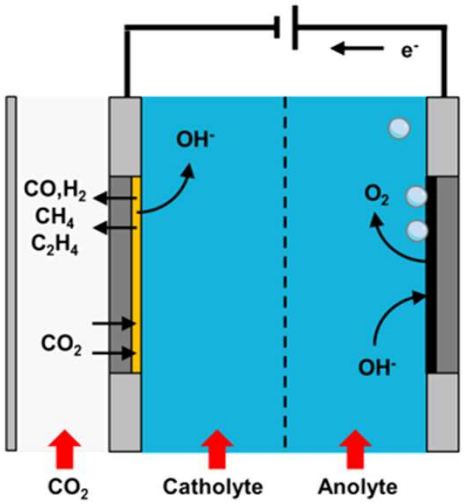
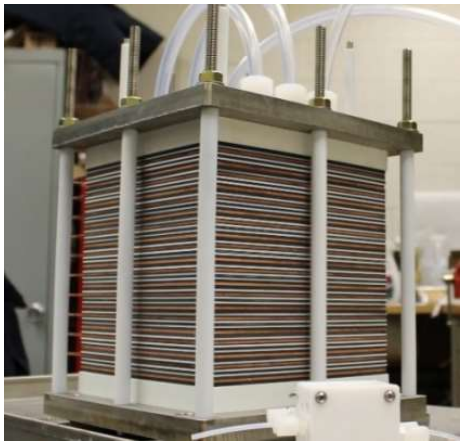
How does such a device look like?







1-10 cm² Area

10-400 cm² Area

'Stack'

'Stack of stacks'

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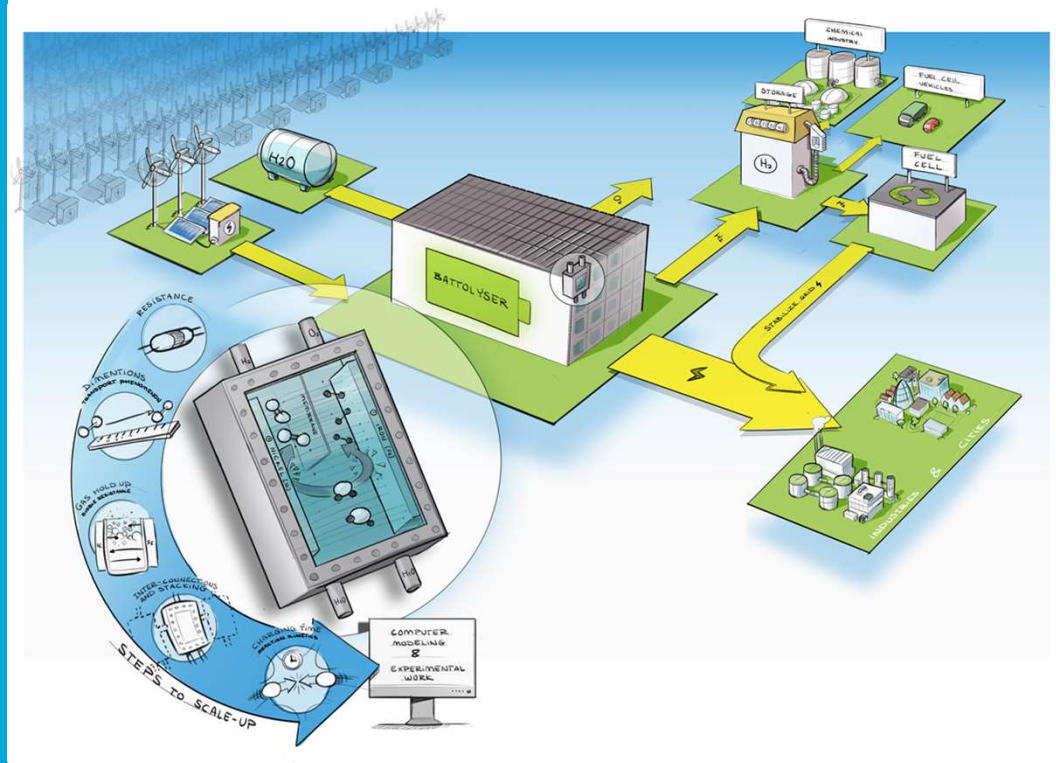
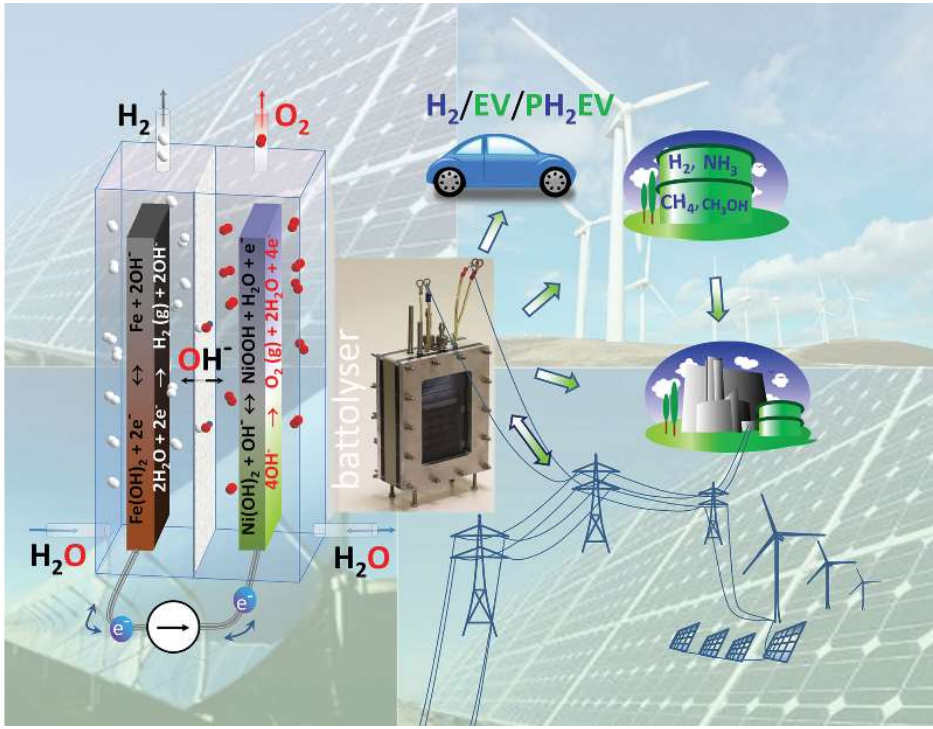
Battolyser: an integrated battery and electrolyser





Mulder, F.M. et al., *Energy & Environmental Science*, **2017**, 10, 756.


TO CHANGE EVERYTHING IT TAKES EVERYONE
CLIMATE
ACTION

The e-Refinery approach

COMMUNITY

Networking and
Knowledge sharing

Multi-level

Multiscale

Multidiscipline

From basic research
to industrial scale

Integrating TRLs

INTEGRATION

ACCELERATION

Fail fast through
quick feedback

Mitigate failure
up the value chain

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Scales

Micro
design of the electrosynthesis process

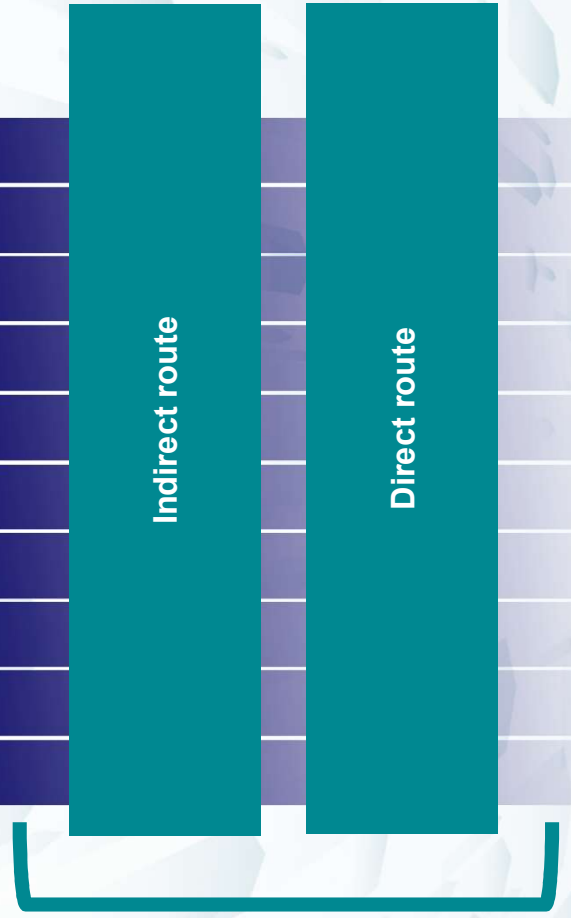
Meso
engineer the reactor and process system design

Macro
assessment of the transition to e-Refinery

Disciplines

- Power Engineering
- Catalysis
- Electrochemistry
- Materials science
- Transport Phenomena
- Reactor Engineering Process Intensification
- Process & Control
- Separation Technology
- Energy Technology & System Engineering
- System Integration & Societal Embedding

Research lines



Parallel and synergetic development

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Research goals for 2025

Indirect route

Electro-thermochemical

100 kW

thermal bench scale set-up of an efficient reactor for continuous methane production from CO_2 and H_2

Direct route

Electrochemical

100 kW

system for the conversion of CO_2 into the base chemical ethylene, ca 40 kg/day

Bio-electrochemical

100 kW system to the conversion of CO_2 into the base chemical hexanoic acid ca. 100 kg/day

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Questions?

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