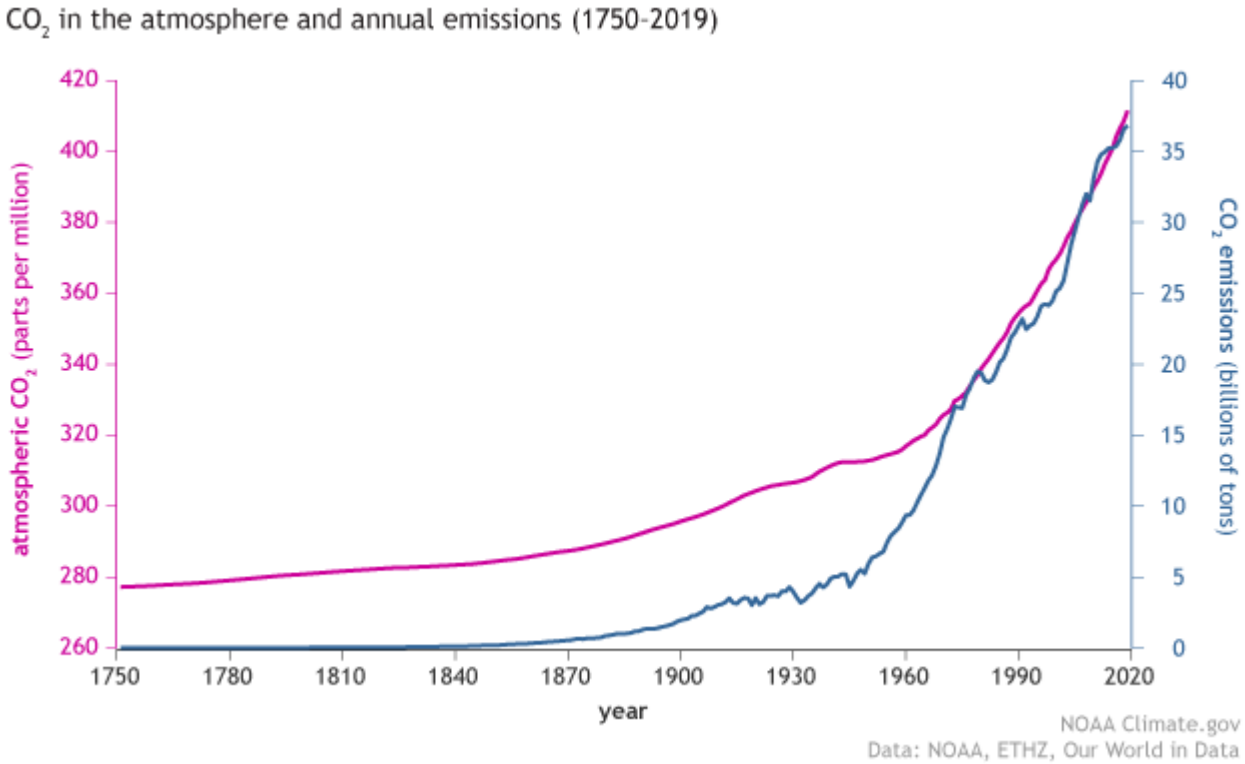
Renew CO_2

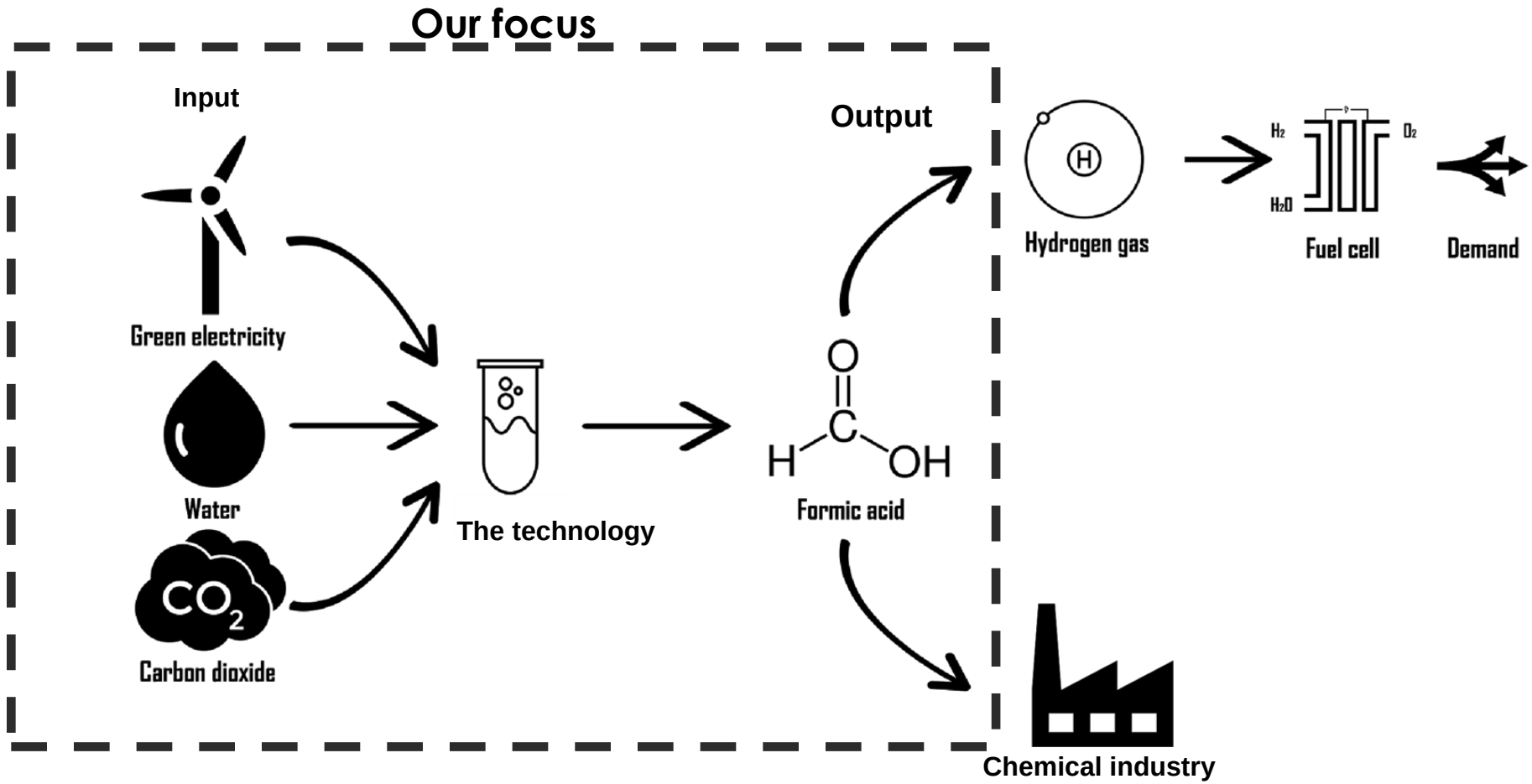
The problem

- CO2 emission is rising
- CO2 needs to be captured and stored
- Rising temperature and climate change



Graphically presented: rising CO_2 concentration in atmosphere (purple) and rising CO_2 emission(Blue).

Our project


Our focus
Input
Green electricity
Water
Carbon dioxide
The technology
Output
Formic acid
Hydrogen gas
Fuel cell
Demand
Chemical industry

The team

The people behind the project

Left to right: Eileen (Mechanical engineering), Luka (Applied physics), Daan (Mechanical engineering), Tobias (Chemistry) & Cris (Chemistry)

Recently joined

Eloy (Applied sciences)

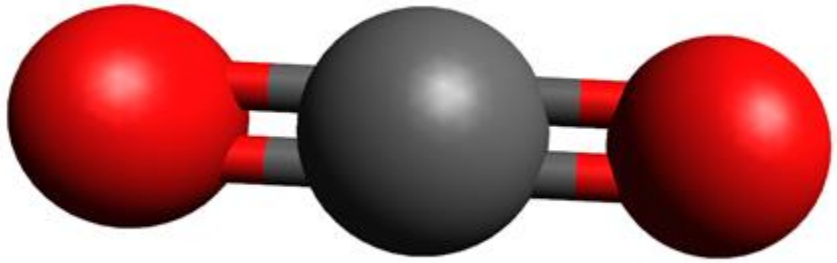
Sjoerd (Applied sciences)

Luke (Applied sciences)

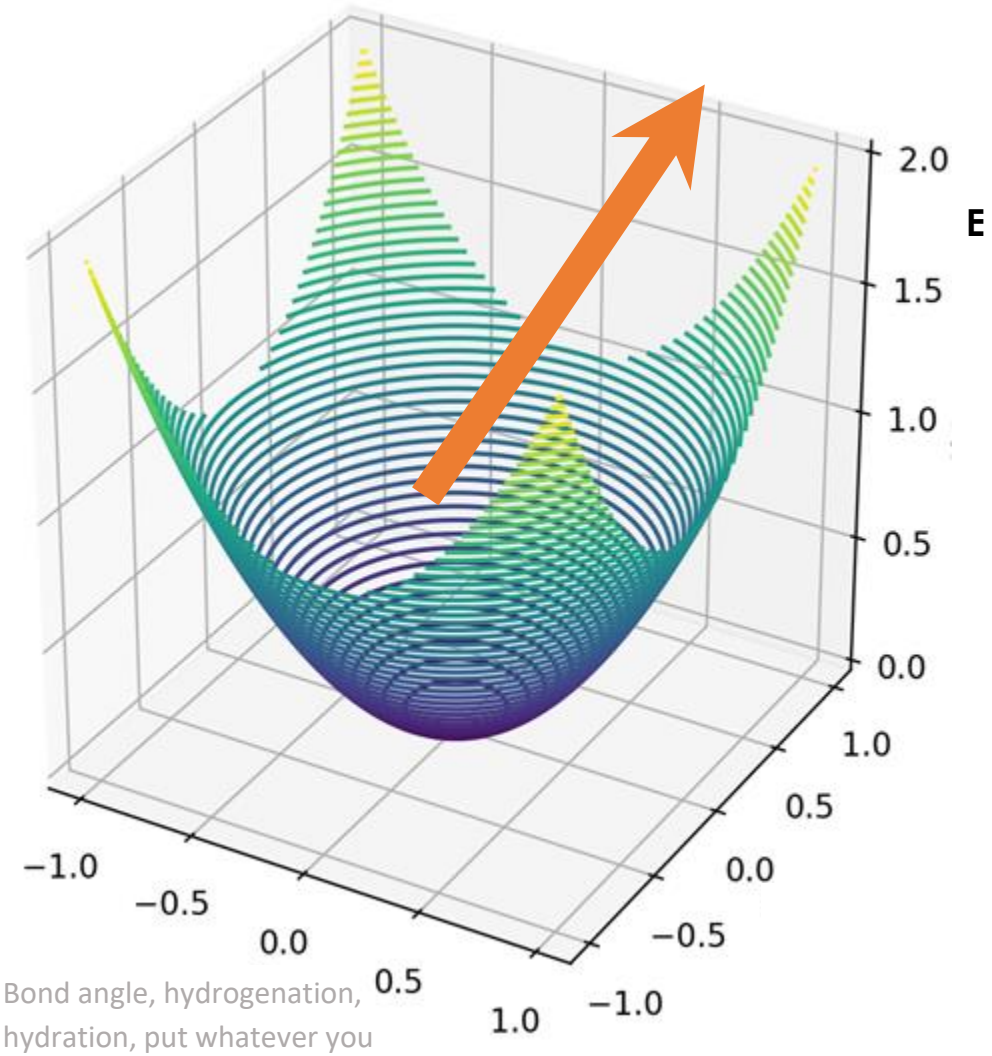
Why is CO_2 a problem?

Enthalpy of formation of greenhouse gases:

- $\Delta H_f(\mathbf{CO_2})$ = -393.5 kJ/mol
- $\Delta H_f(\mathbf{CH_4})$ = −74.8 kJ/mol
- $\Delta H_f(\mathbf{N_2O})$ = 82 kJ/mol
- $\Delta H_f(\mathbf{O_3})$ = 142.7 kJ/mol



CO_2 is a thermodynamic sink

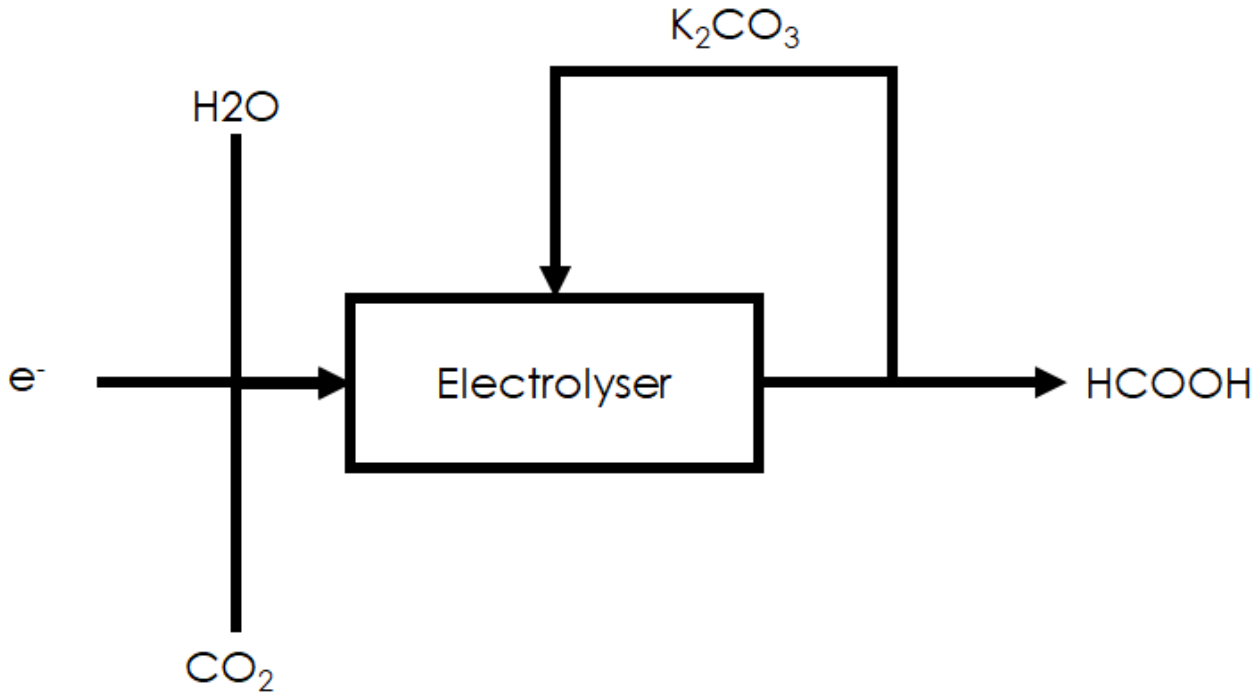


Bond angle, hydrogenation, hydration, put whatever you want on these axes

Any process transforming CO_2 requires some form of energy as input

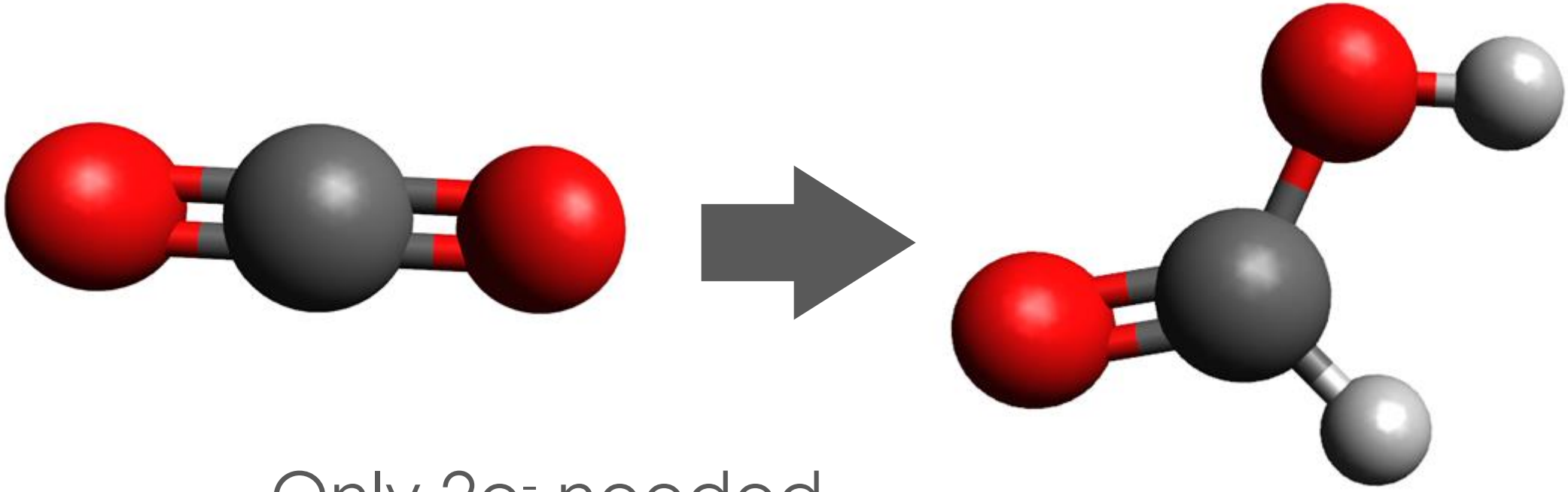
[1]

Why electrical energy



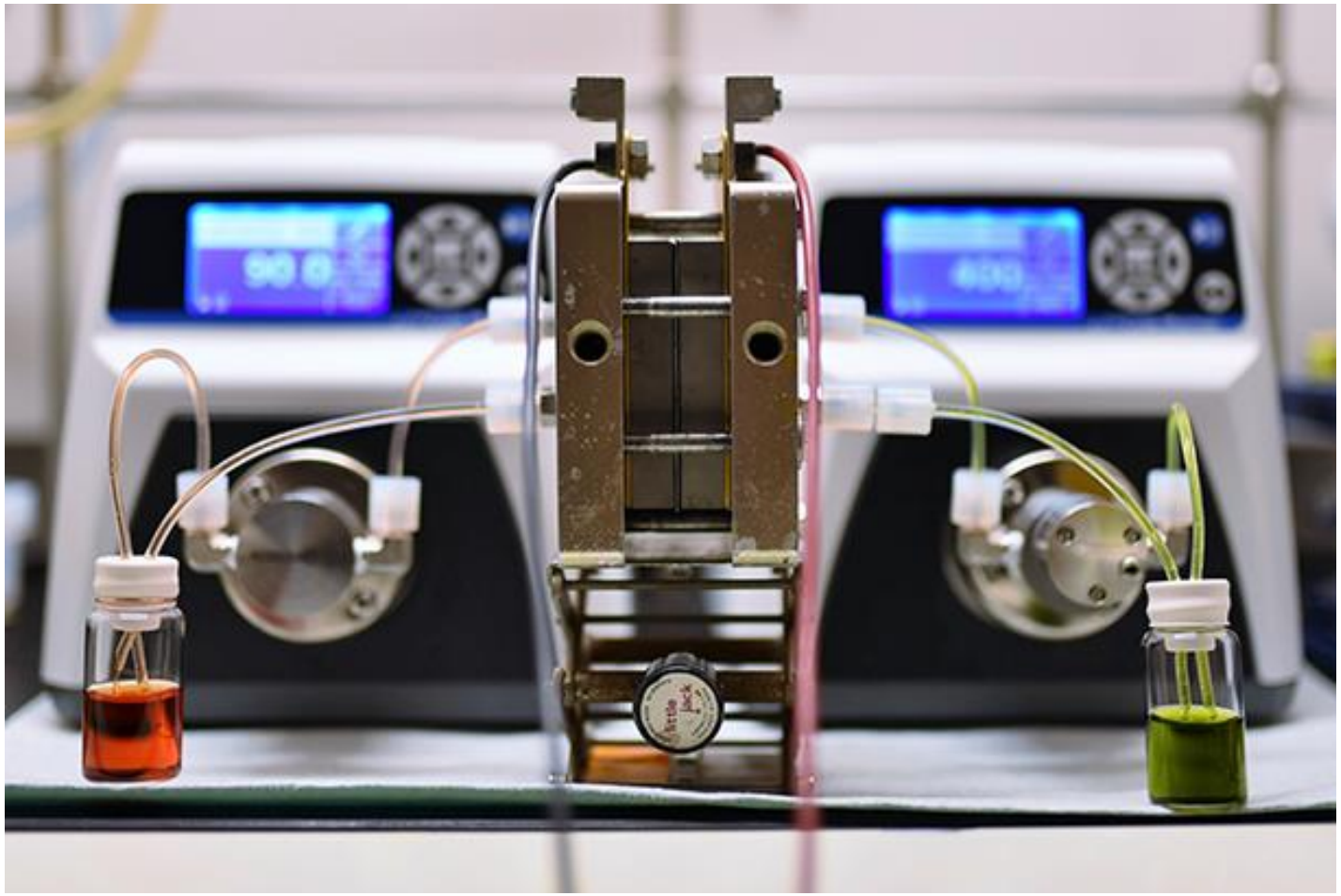
- **No efficiency loss** from energy conversion
- Process at **ambient T** and P
- **No toxic**/ environmentally harmful **chemicals**
- (almost) **no** unwanted **side-products**

Why formic acid?

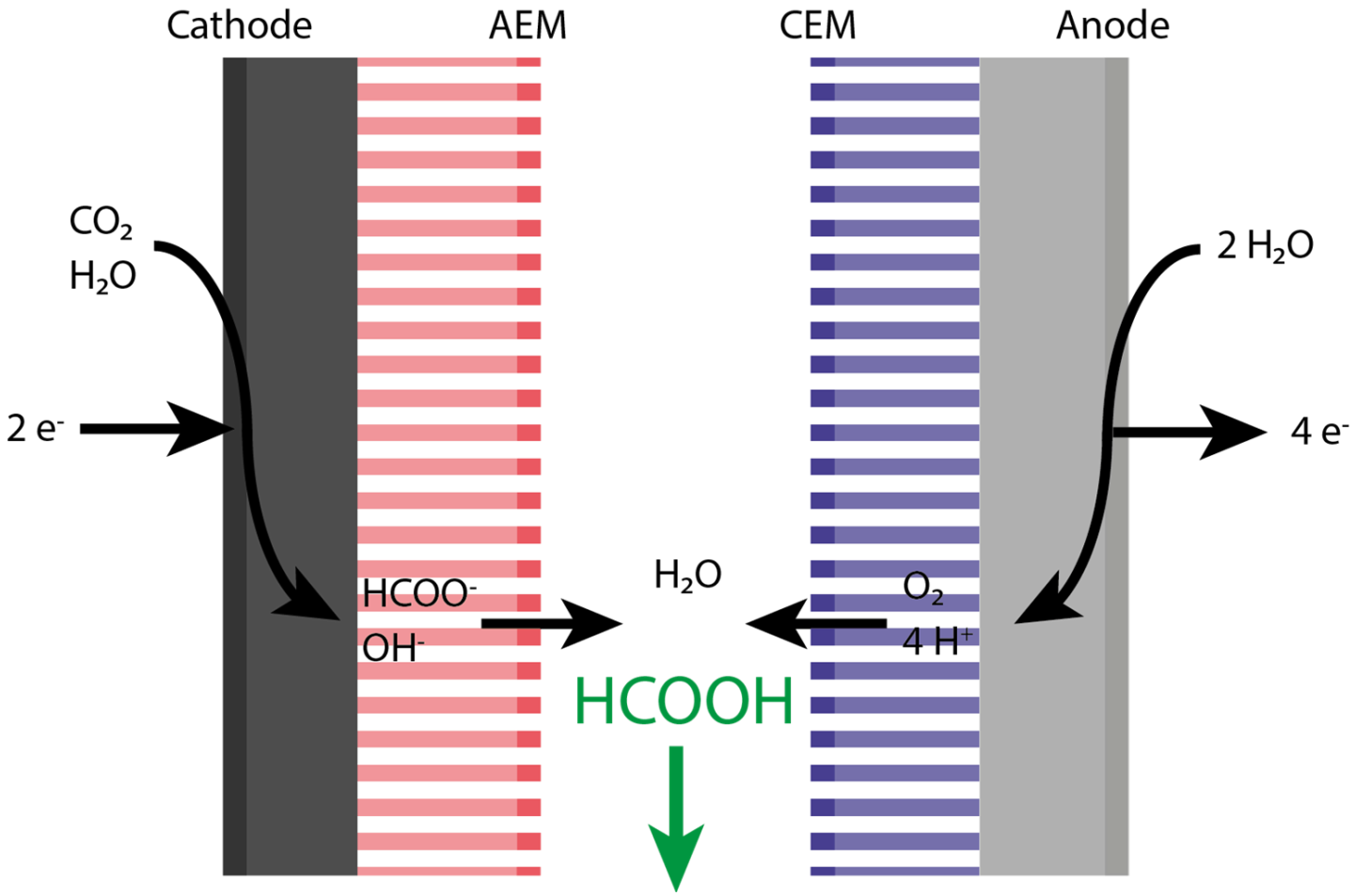


Only $2e^-$ needed

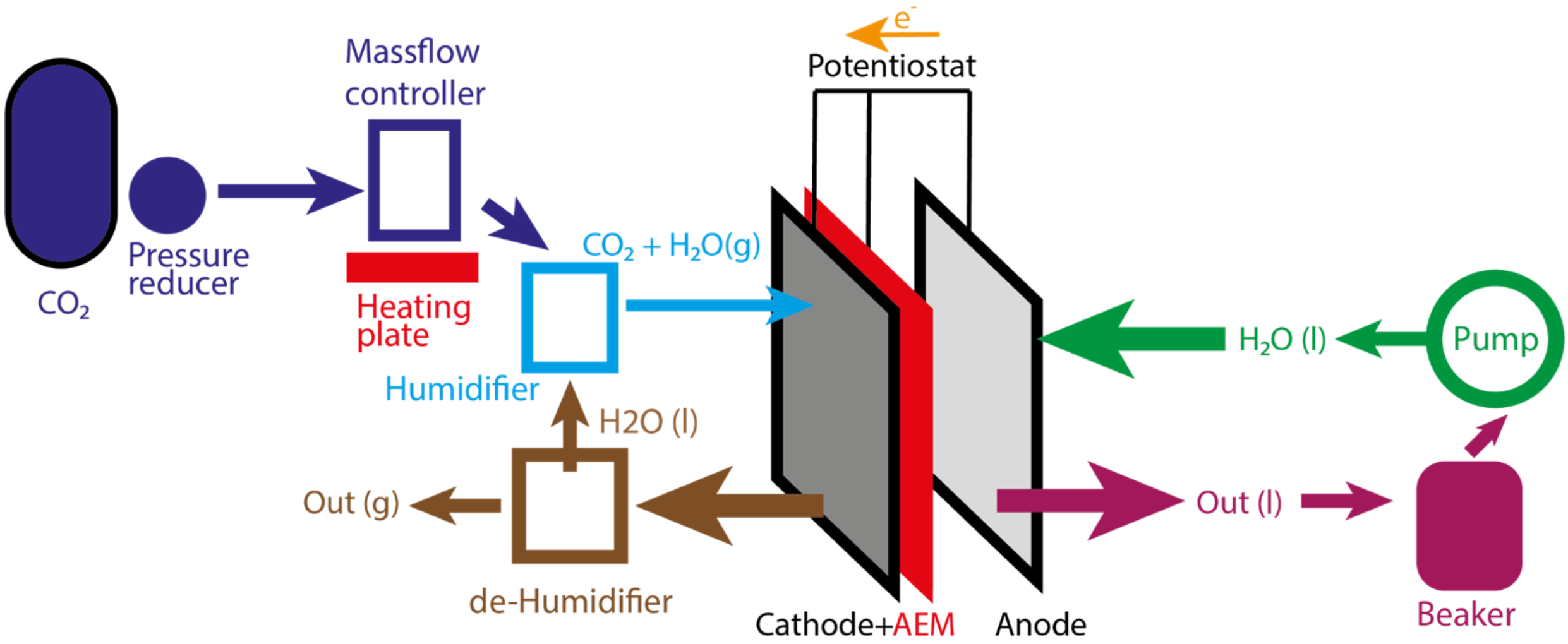
Constructing the cell



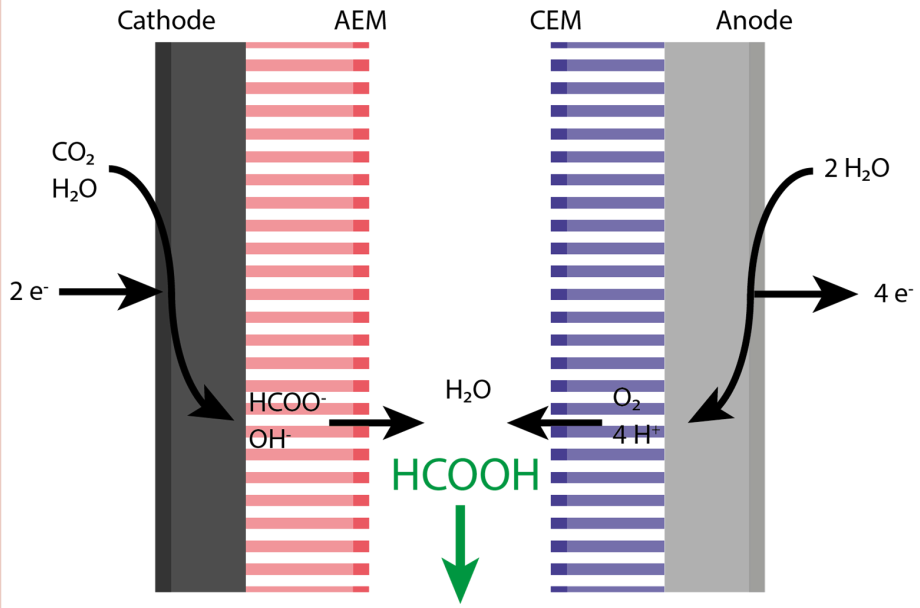
Cell design: Reducing resistance

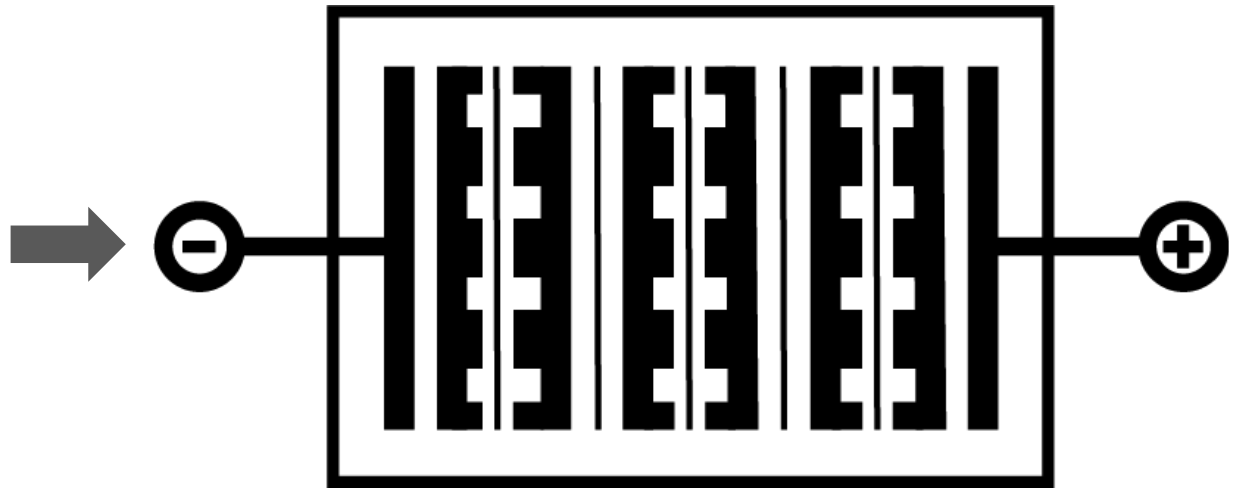


Prototype reactor



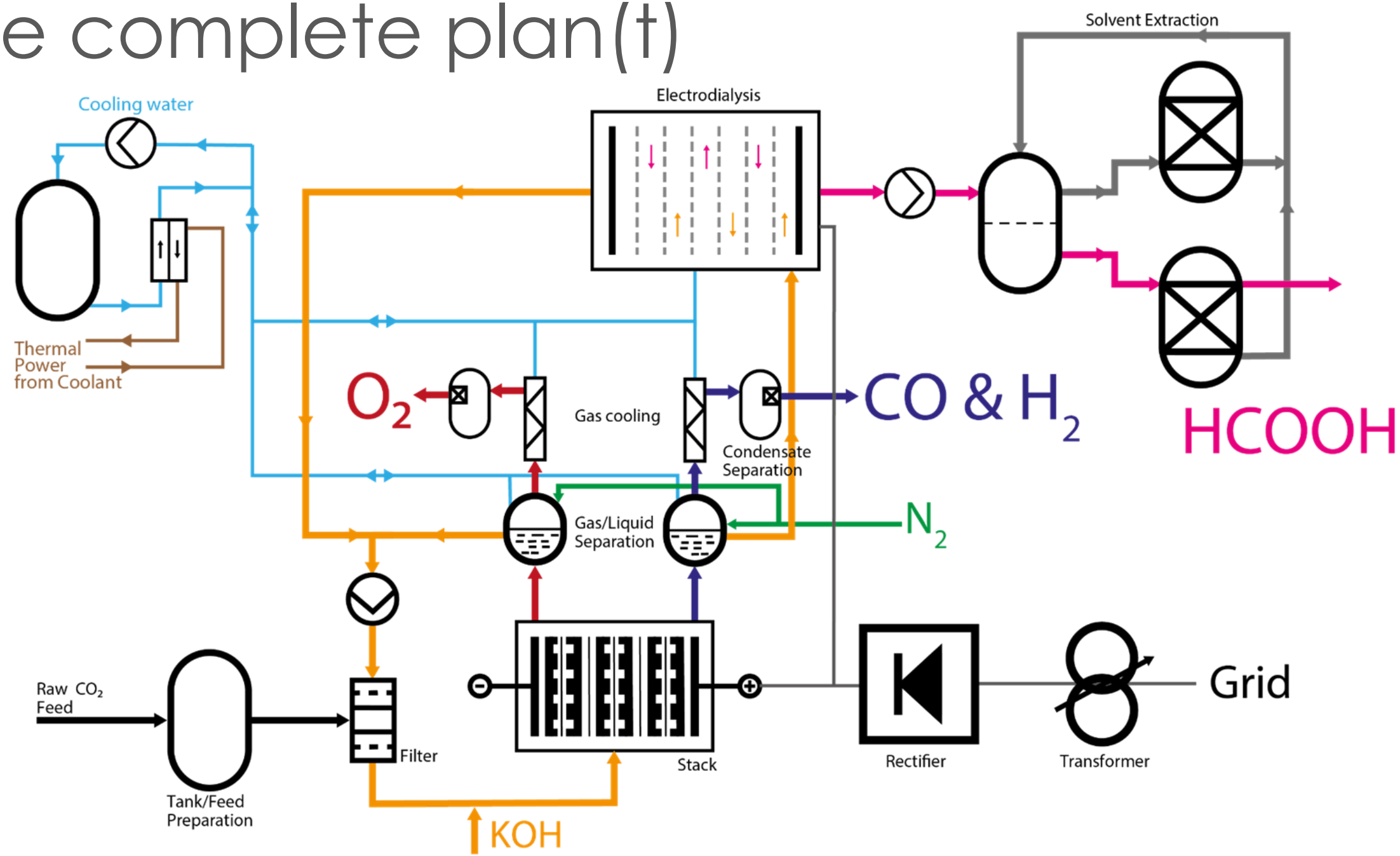
From prototype to production



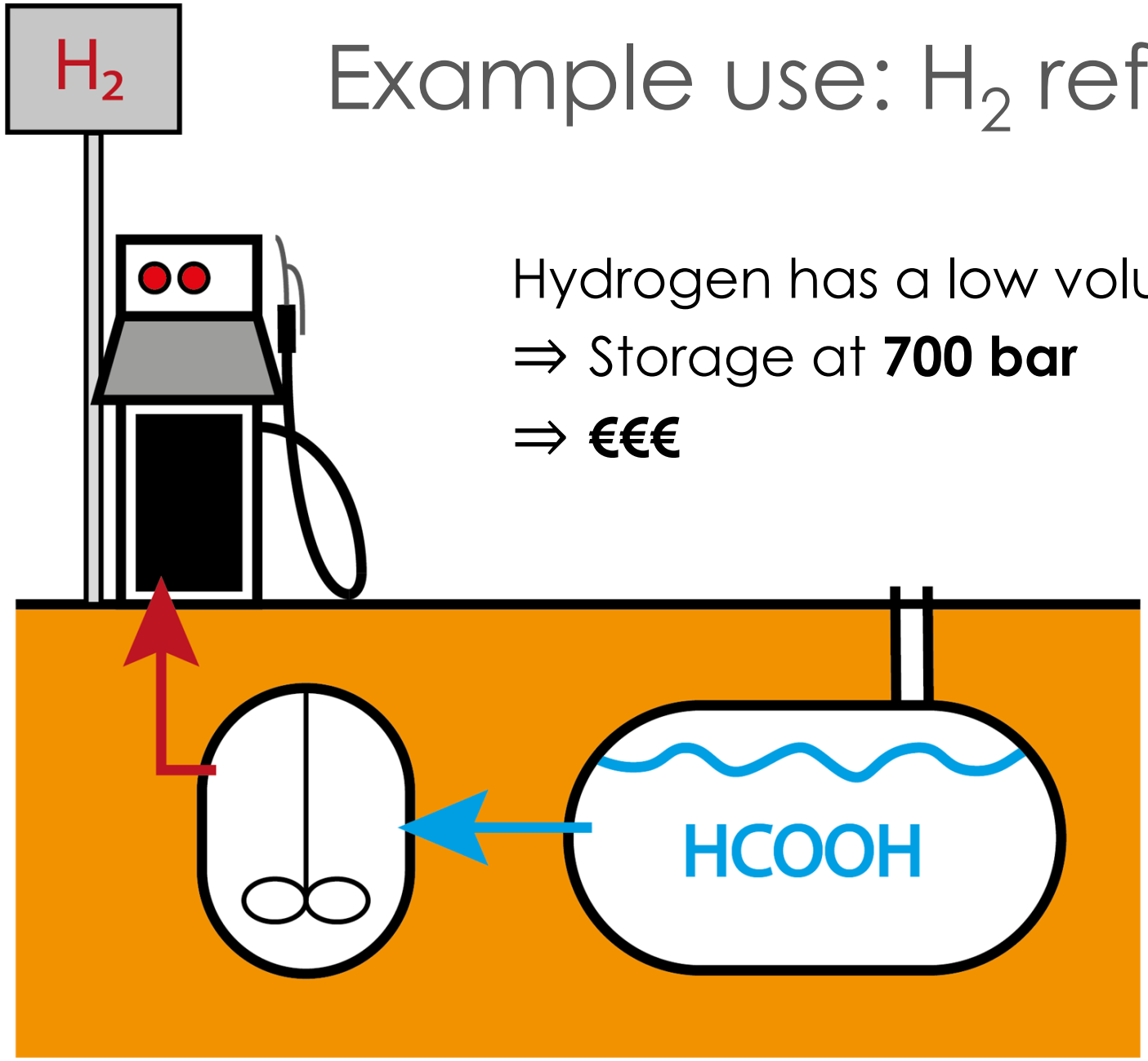


Chain ~**200 cells** after each other, connected to **one current source** (DC)

The complete plan(t)



Example use: H_2 refueling



Hydrogen has a low volumetric energy density

⇒ Storage at **700 bar**

⇒ **€€€**

Formic acid can be stored in conventional tanks

⇒ **Easy integration**

Why is no one doing this?

The answer is **money**, of course. Here's a quick estimate

Even in the ideal case we can't beat Thermodynamics:

Minimum energy in $\Delta G_r \cong$

300 kJ/mol

Ideal electric terms $E_{cell} \cong$

1.55 V

Electricity costs 170 €/ton formic acid

(dutch industrial electricity costs)

Market price of formic acid is 360 €/ton

A few words on €

Reality isn't this easy. We need to consider
Overpotentials
(catalyst inefficiencies ≅ 0.9V)
and **Transport resistances** (membrane resistance ≅ 0.6V)

State of the art cells run at $E_{actual} \cong$ 3.05 V

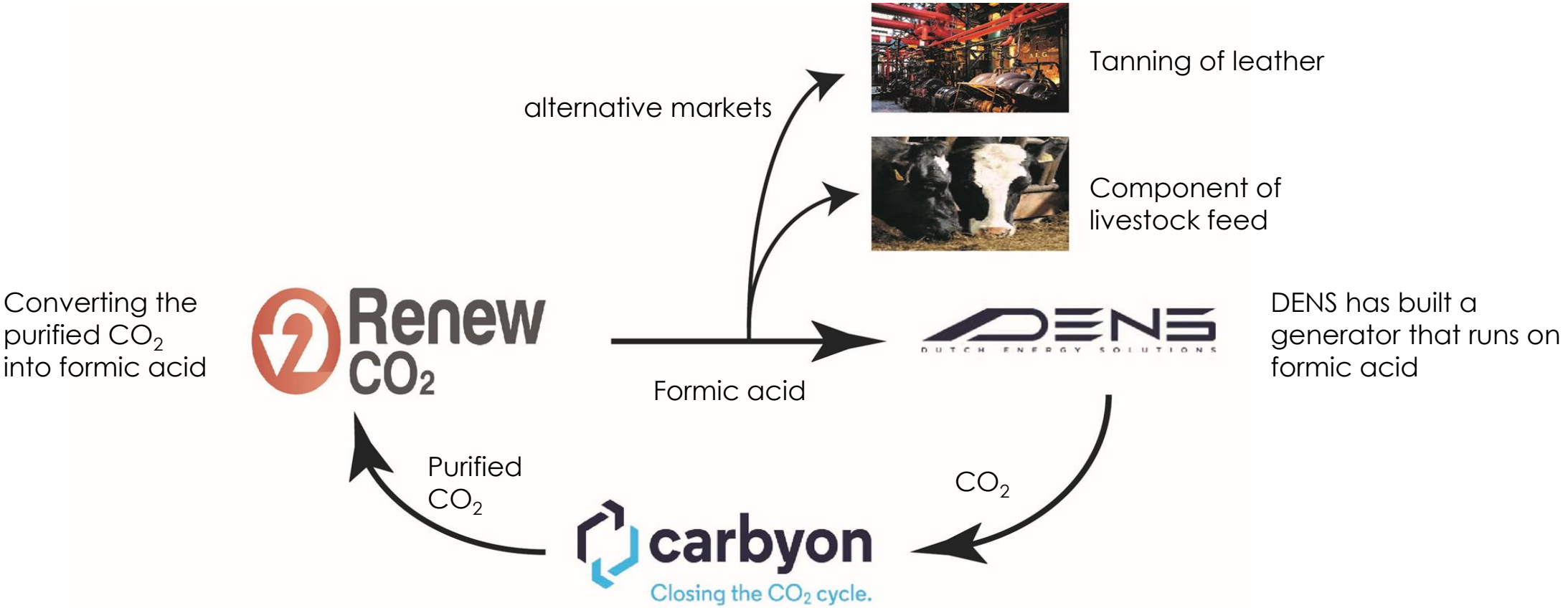
Energy efficiency $\Phi =$ 1.55/3.05 = **0.5**

Current electricity costs are 340 €/ton

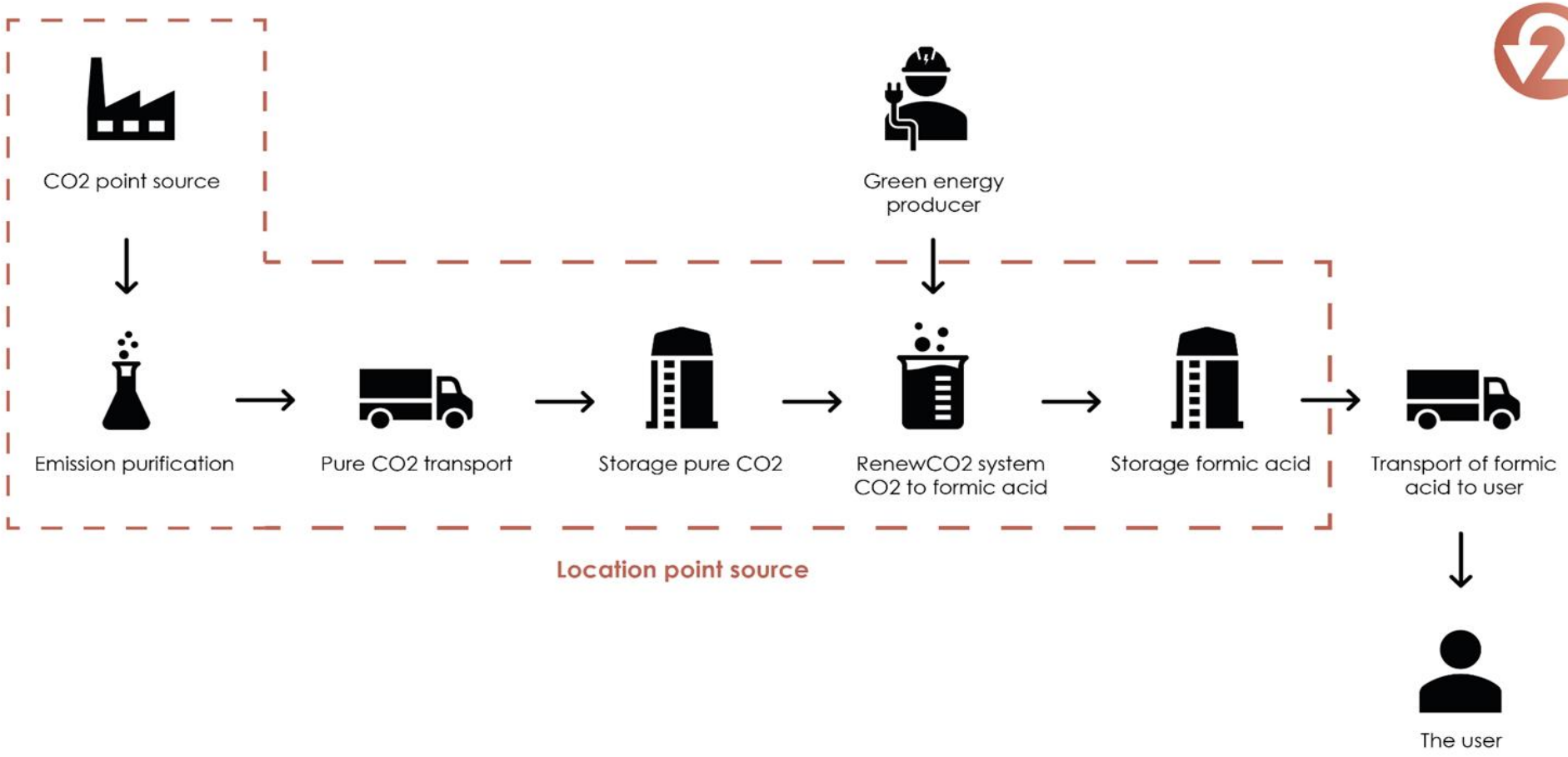
⇒ Better catalyst and cell design is necessary!

Our place in the market

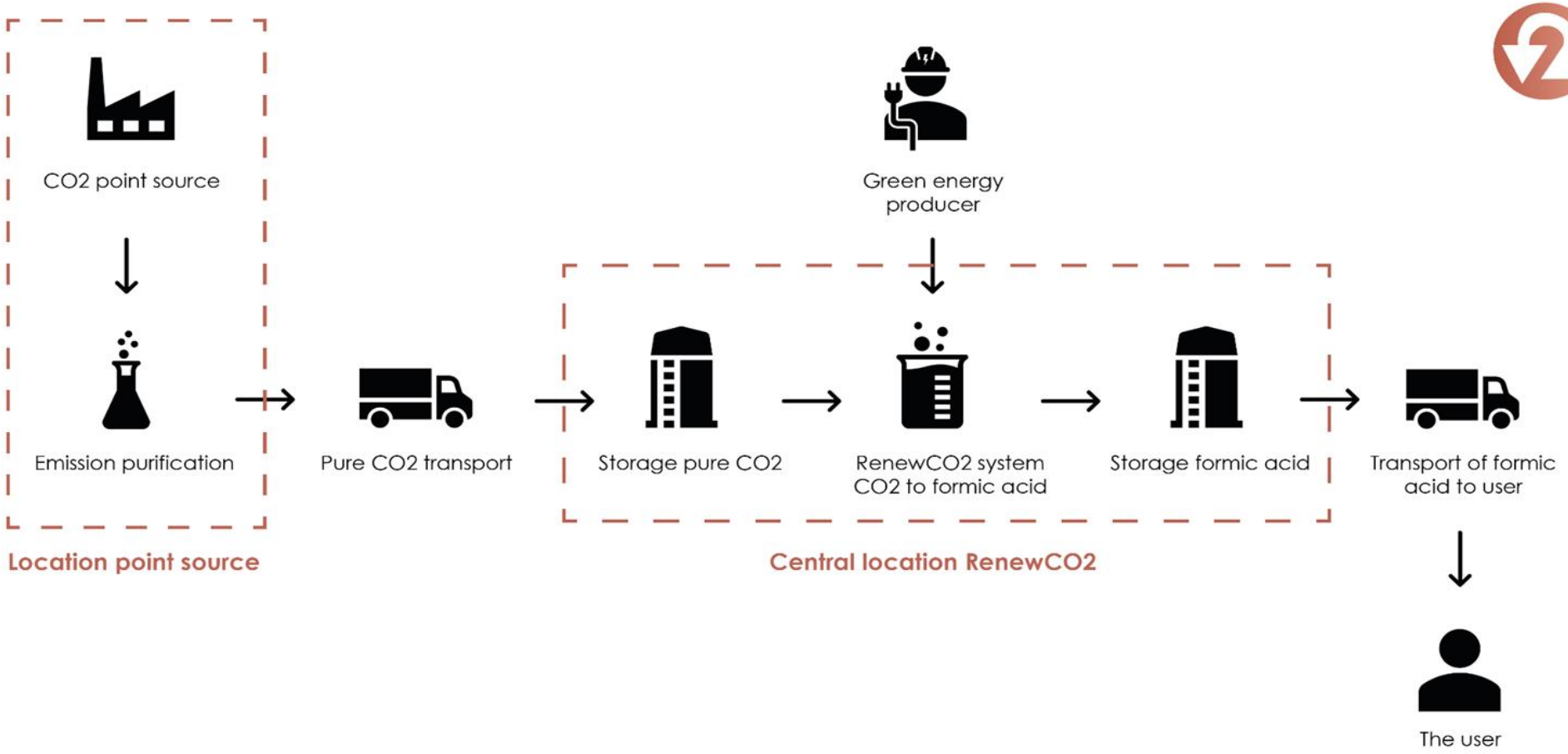
- The missing part of the energy circle



Chain 1


CO2 point source
Green energy producer
Emission purification
Pure CO2 transport
Storage pure CO2
RenewCO2 system CO2 to formic acid
Storage formic acid
Transport of formic acid to user
Location point source
The user

Chain 2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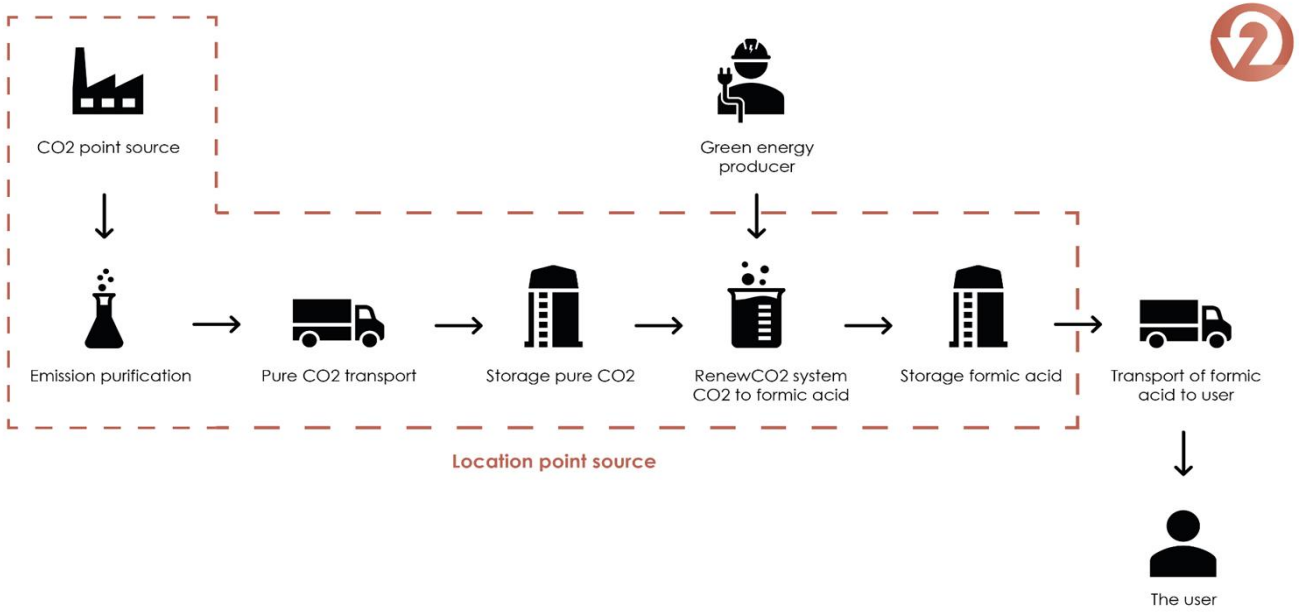
Chain 1 or 2?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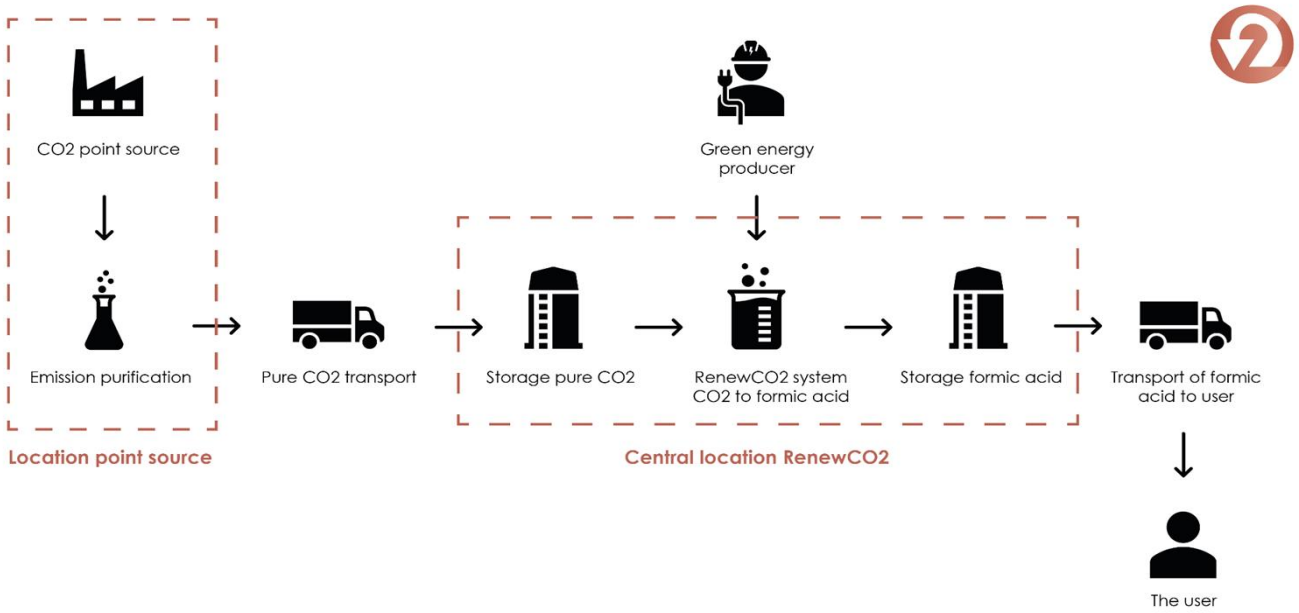
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Our idea on the chains

- A central location
  - Easier to distribute the produced formic acid
  - Enough space to setup factory
  - Easier for heavy industry

- Disadvantages
  - CO_2 needs to be transported

Roadmap

2018

Spin off from team fast. Researching possibilities to convert CO2 into formic acid

2019

Research in the technology of electrolysis. Registered in the Dutch Chamber of Commerce

2020

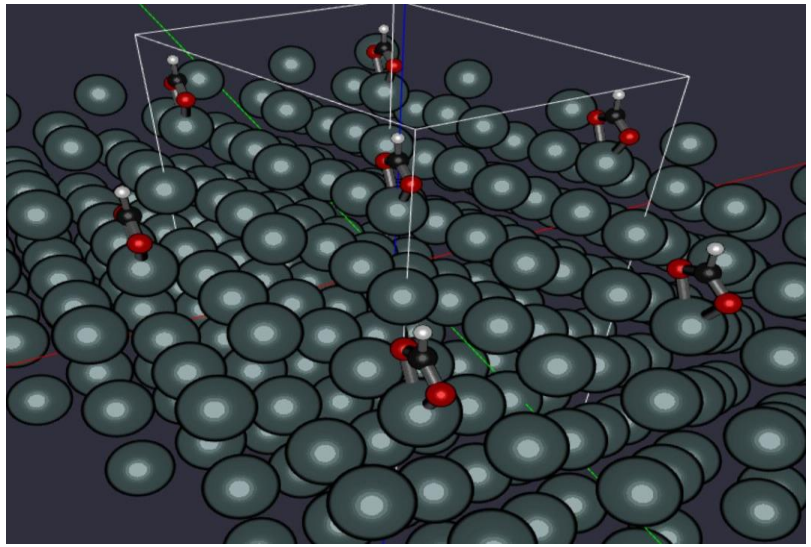
Validating our research with experiments. Building POC.

2021

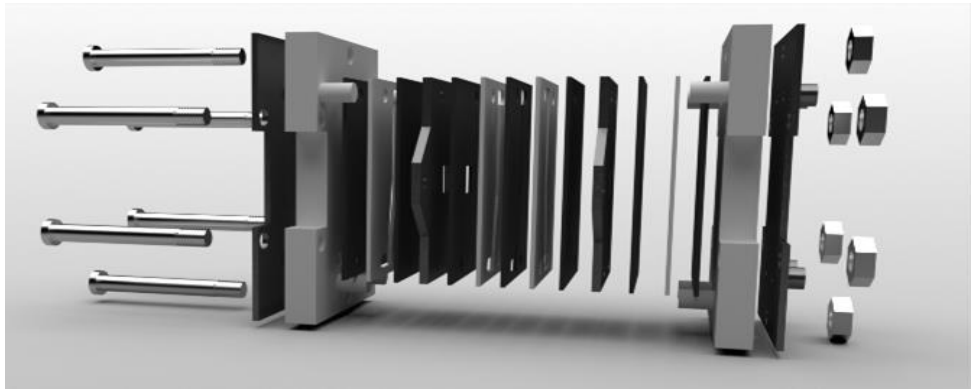
First working prototype with reasonable efficiency. Aiming to produce a full scale device.

Where are we now

- Enlargement of visibility
  - Braventure
  - Innovation origins
  - Innovation space
  - Future visions
  - Social media
- Setting up experiment plan
- Modelling of kinetics and transport in our system



Adsorbate state of $HCOO^-$ on Sn



Detailed drawing of first prototype

Progress Non-Technical

- Subsidy
  - MRE subsidy handed in
  - CE3 subsidy received
- Business plan
  - Market validation: The Future
  - TMC and Innovation Guru
- TU/e Contest
  - Top 20 selection

Technical planning

Devising three possible experimental setups

Fit transport model to experimental data

Development of Flow Cell prototype

Q3

Q4

Q1

Microkinetic model of In_2O_3 system

Combine multiscale model for system analysis

Network

Potential partners to close energy cycle

DENS
DUTCH ENERGY SOLUTIONS

carbyon
Closing the CO_2 cycle.

Better e

Advice/experts in different fields

SNE

HONORS ACADEMY

TU/e

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

innovation Space

TU/e EIRES

TMC PEOPLE DRIVE TECHNOLOGY

Advice for subsidies

The Future
DRIVEN BY INNOVATION

TU/e Collaboration

Advisors/coaches

- Mark Cox & Steven van Huiden
  - Business and managing advice
- Han van Kasteren
  - Honors academy coach
  - Personal development
- Boudewijn Docter
  - Coaching in market research

PhD (candidates)

- Tim Wissink
  - Experimental setup
- Francesco Cannizzaro
  - Kinetic modelling
- Ria R. Sijabat
  - Transport modelling

Assistant professor

- Ivo Filot
  - Kinetic modelling








Discussion

''Formic acid is the fuel of the future''

Contact

If you want to know more, visit our website:
https://www.teamrenewco2.com/

Or our social media:

https://www.linkedin.com/company/renewco2tue/

@teamrenewCO2

https://www.facebook.com/Renew-CO2-106719361018841

Email: renewco2@gmail.com