Opportunities within the domain of energy research

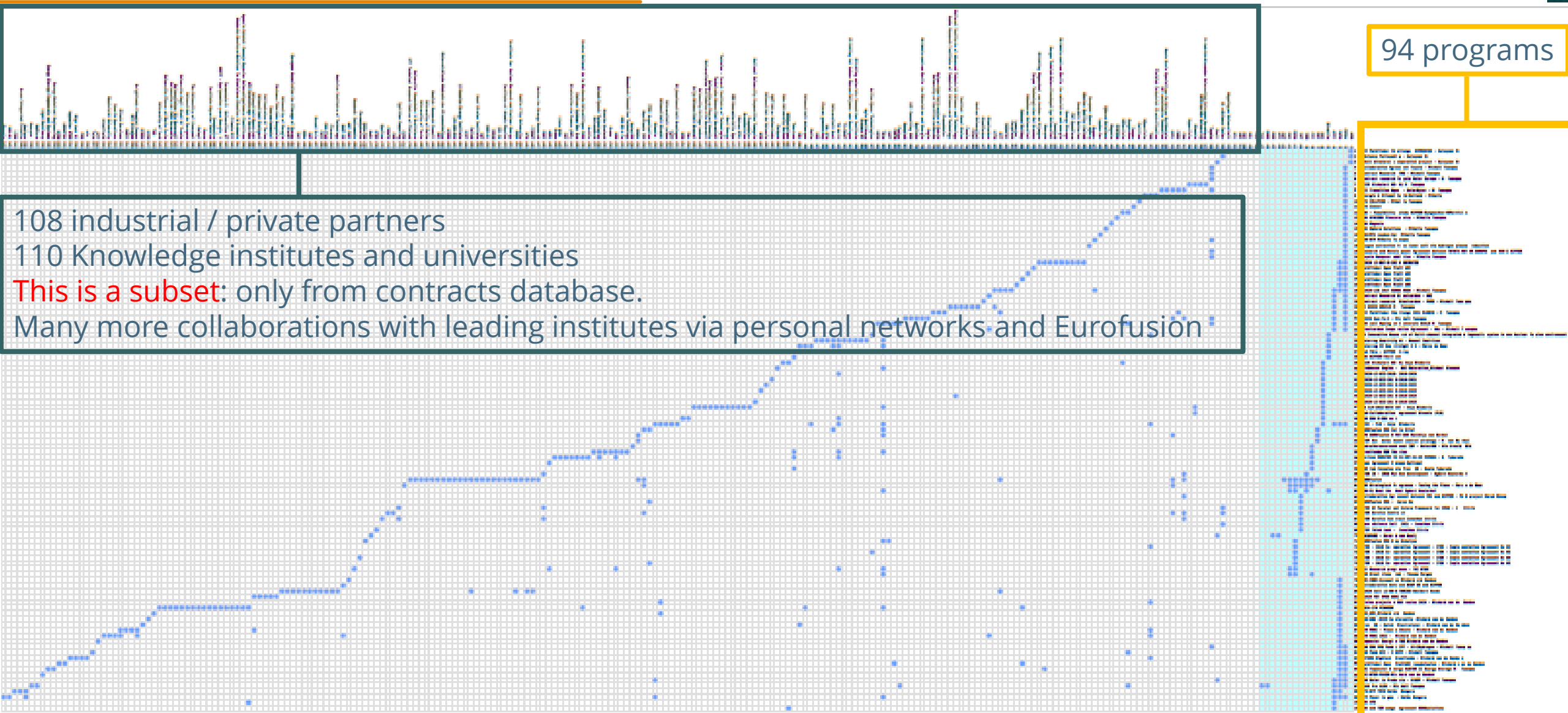
Co-evolution, Technology Transfer, start-ups, and Spin-Outs

Marco de Baar

DIFFER

NWO

What is our (inter)national role?



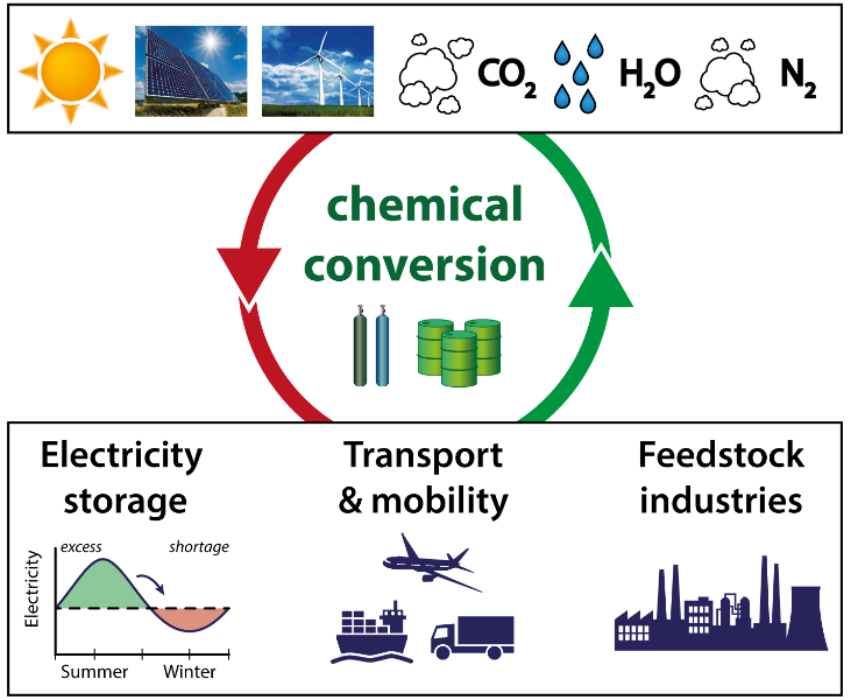
94 programs

108 industrial / private partners
110 Knowledge institutes and universities
This is a subset: only from contracts database.
Many more collaborations with leading institutes via personal networks and Eurofusion

DIFFER Solar Fuels
Renewable energy → chemicals and fuels

Clean conversion: CO_2-neutral fuels and chemistry

- Seasonal and regional energy storage
- Energy dense fuels for long haul transport and mobility
- Sustainable feedstock for green industry



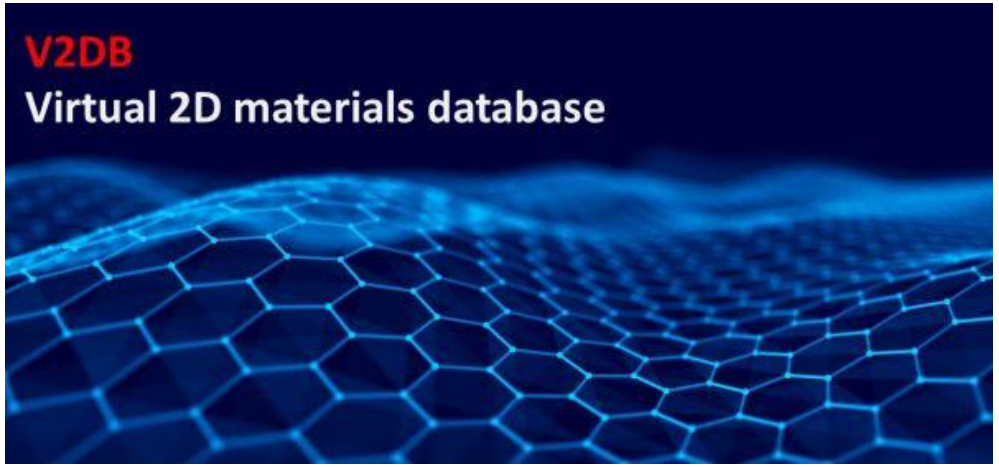
Technological challenge

Renewable fuels and chemicals cheaper than fossil equivalents. Example: electrolysis benchmark of > 6 €/kg H_2

→ Research on novel materials, processes and systems to reach < 1 €/kg H_2 in 10-15 years

NWO-Shell CSER
Computational design of hybrid photocatalysts for solar fuel generation

The virtual design of two dimensional material based photocatalysts that can selectively and efficiently catalyze H_2O, CO_2, and N_2 reduction



Partners:

DIFFER

Products:

Software for virtual 2D material design,

Database of 2D materials,

Publications

NWO-LIFT: Air2Hydrogen
“Water neutral” photoelectrochemical hydrogen production

Scope:

“Water neutral” photoelectrochemical (PEC) hydrogen production

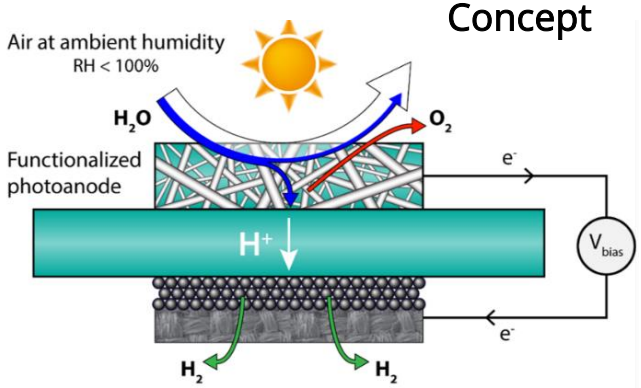
- Alternative device and photoelectrode architecture
- Material functionalization for capturing water from ambient air

Partners:

DIFFER, Toyota

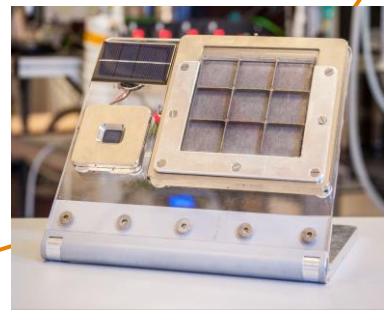
(via NWO ENW PPS fund)

Concept



Toyota Mirai fuel cell car - 2014

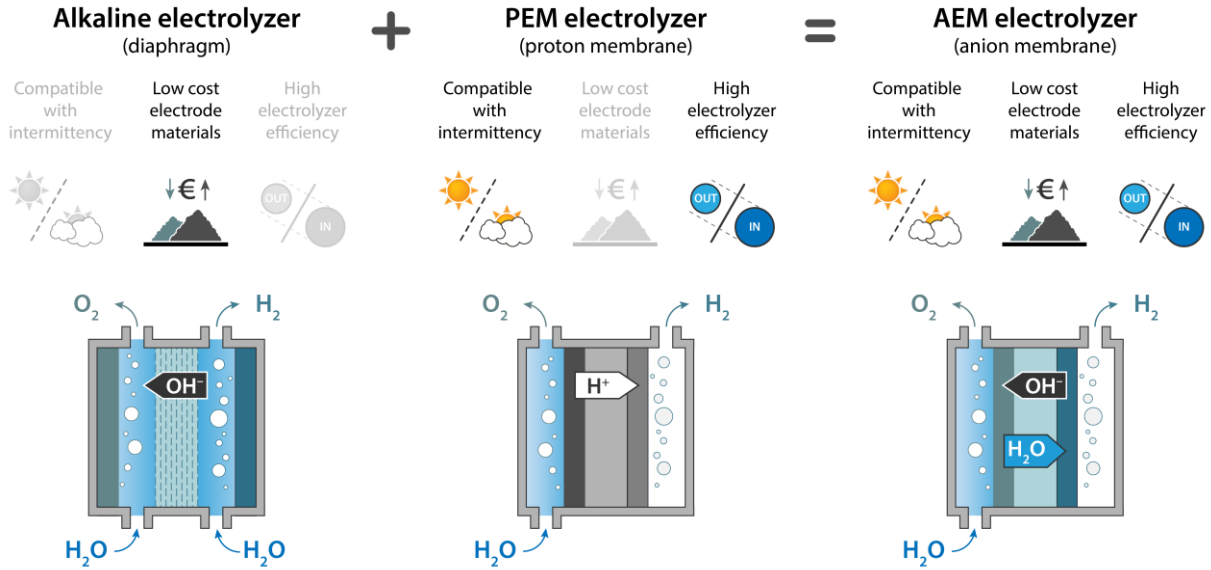
- *Green hydrogen*
- *Gas phase PEC operation*



Prototype cell

ECCM-NWA: SCALE project
Next-generation water electrolysers: from lab to industry

Prepare basic science for next-generation of anion exchange membrane (AEM) water electrolysers, by bringing emerging materials from “lab to the industry”.



Partners:

TU/e

Fontys University of Applied Sciences

Institute for Sustainable Process Technology

syngaschem BV synthesis gas chemistry fundamental research projects

vsparticle

veco precision metal

TOYOTA

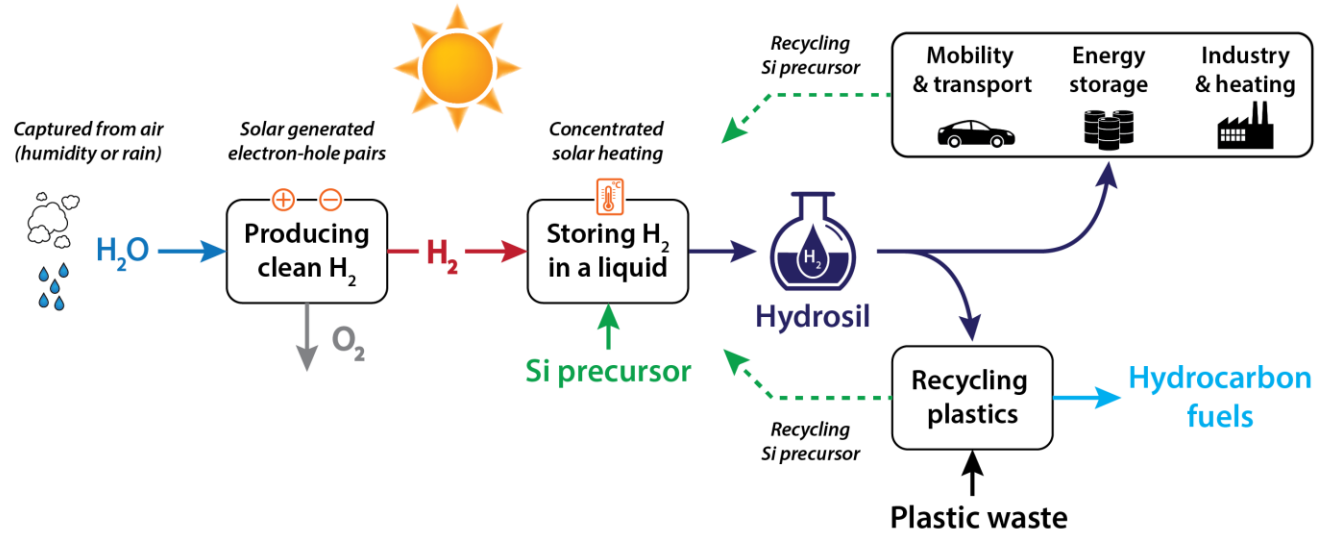
FORTH INSTITUTE OF CHEMICAL ENGINEERING SCIENCES

Granted:	09/2020
Kick-off:	Q2 2021
DIFFER:	Project coordinator

https://www.differ.nl/news/SCALE

H2020: Sun-to-X project
Solar energy for carbon-free liquid fuel

Use solar energy to produce the carbon-free, non-toxic, energy-dense, liquid fuel "Hydrosil" with very good long-term stability and applicable in the transport and energy sectors.



Partners:

Granted: 12/2019
Kick off: 09/2020

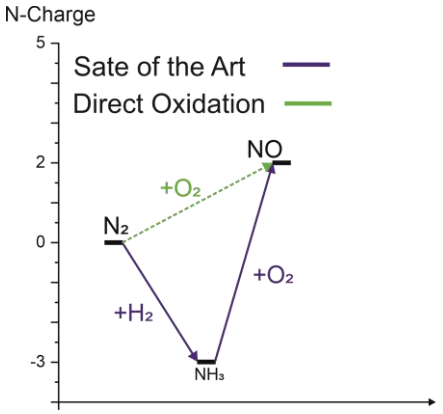
DIFFER: WP3 leader

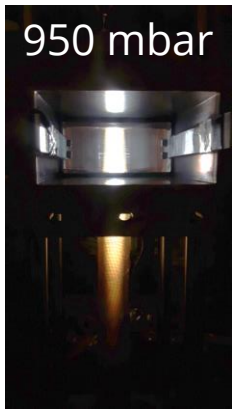
https://sun-to-x.eu

Industrial collaboration
Green N_2 fixation: direct oxidation of Nitrogen to Nitric Oxide

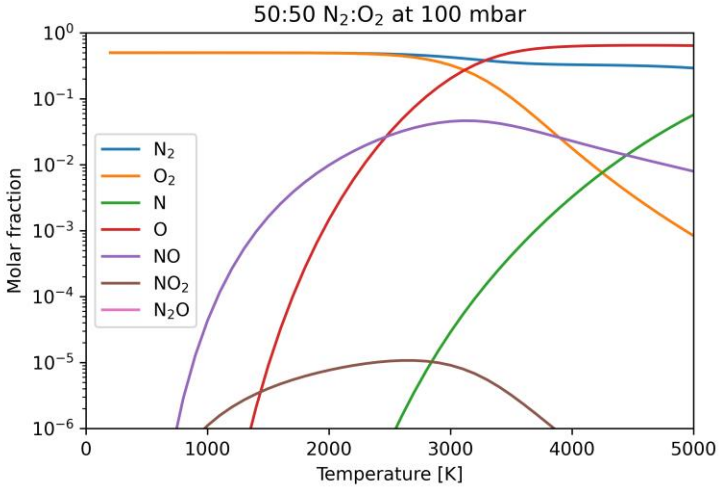
Next Generation “Birkeland-Eyde” Process:

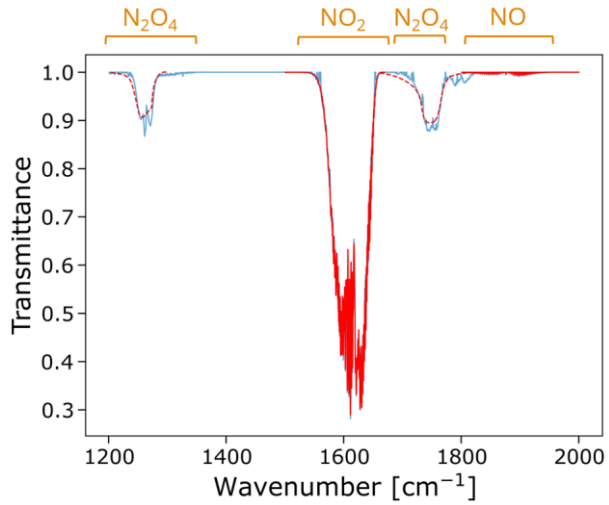
- Replace fossil-fuel based ammonia production (NH3) with nitrogen oxides (NO)
- NO can be produced directly from air and electricity using high temperature plasma





Partners:

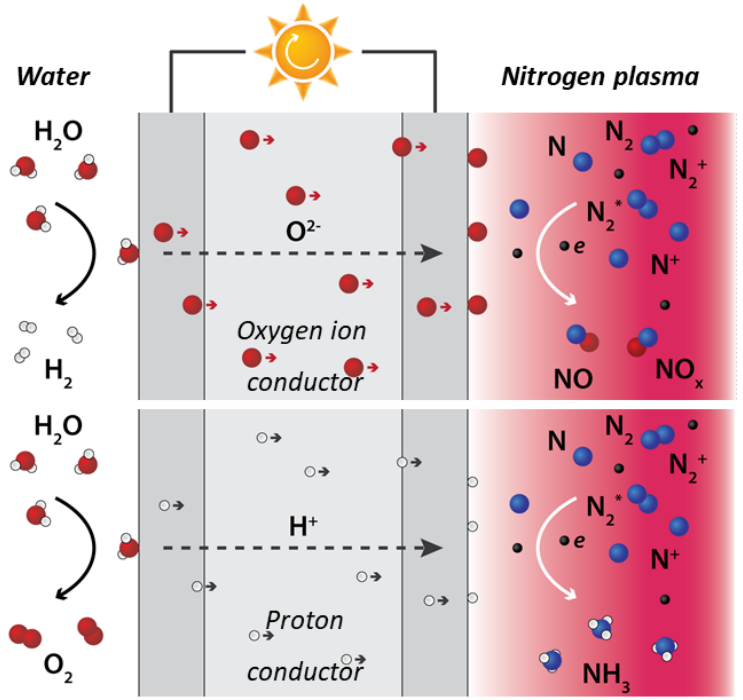




RVO / ISPT project
Green N_2 fixation: direct oxidation of Nitrogen to Nitric Oxide

Plasma aided electrochemical nitrogen fixation to nitric oxide or ammonia (basic precursors for fertilizers).

- Demonstrated plasma activation with water electrolysis for green fertilizers.
- Base for H2020-ORACLE: <u>all electric</u> and <u>no CO_2 emissions</u>



Partners:

ISPT Institute for Sustainable Process Technology

OCI NITROGEN

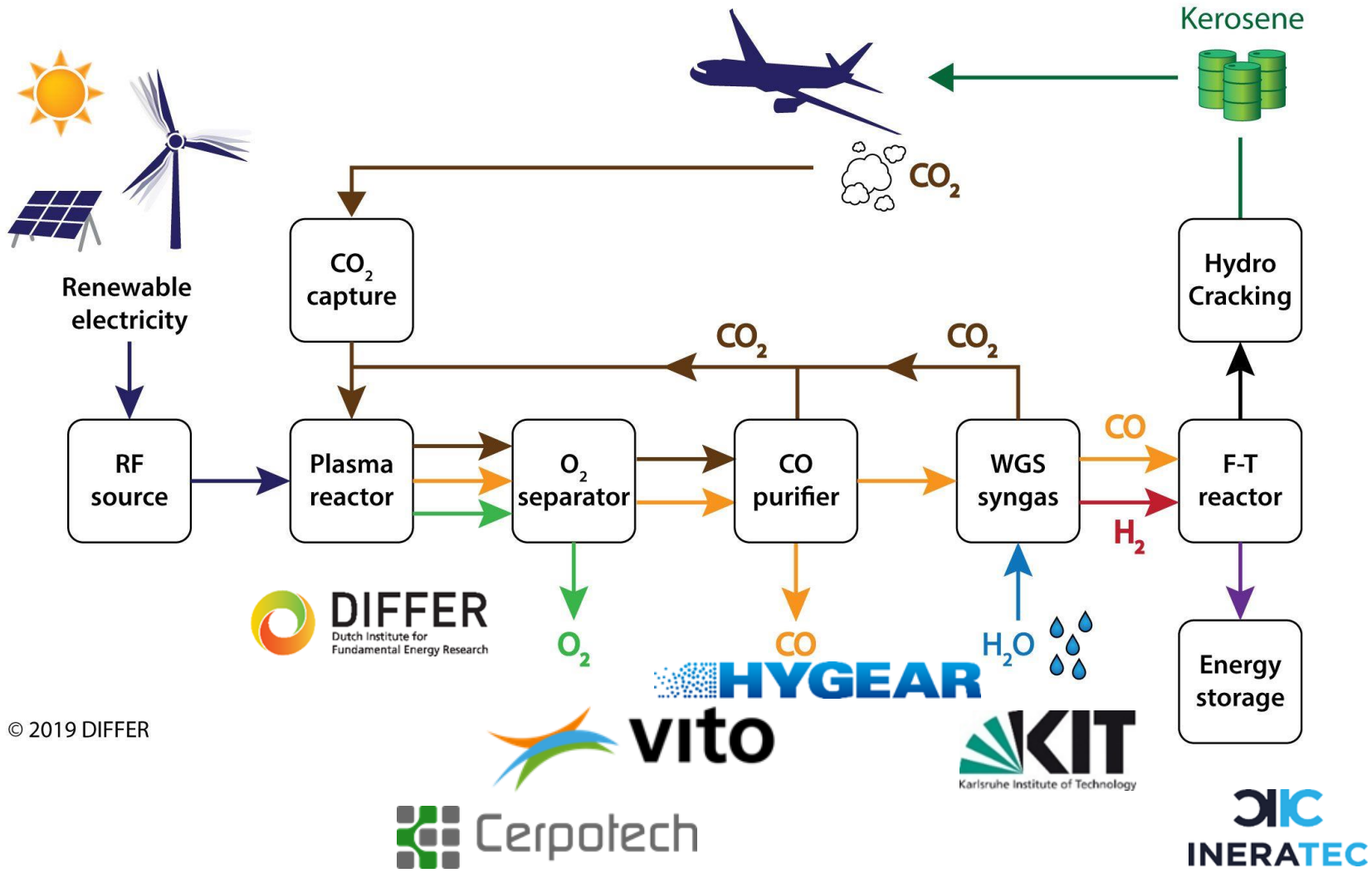
YARA

Vopak

Nouryon

Granted:	01/2018
Finish:	03/2021
DIFFER:	Project coordinator

EU - KEROGREEN concept



1. CO_2 split by plasma reactor into products CO_2, CO, O_2
2. O_2 separated out electro-chemically
3. CO content purified
4. CO and water form syngas by Water Gas Shift reaction
5. Fischer-Tropsch reactor synthesize hydrocarbons
6. Hydrocracking optimize kerosene content
7. CO_2 re-emitted into the atmosphere by combustion
8. Direct Air Capture of CO_2 emitted
9. CO_2 neutral circle is closed

This project has received funding from the European Union's Horizon 2020 Research and Innovation

DIFFER's role in the **Nuclear Fusion ecosystem**

Participation in scientific programmes
Design of High End instruments
PWI, (modelling for) Advanced Control
EF-GA, F4E-GB, F4E-TAP, STAC, ITPA

International scientific infrastructure

- Governmental Nuclear Fusion programmes
- Nuclear Fusion start-ups

In-house scientific infrastructure

- Magnum, IBF,
- Materials for energy facility

Geo-return

DIFFER institute

ILO

Industry

Co-evolution,
Technology Transfer,
Spin-outs

Universities

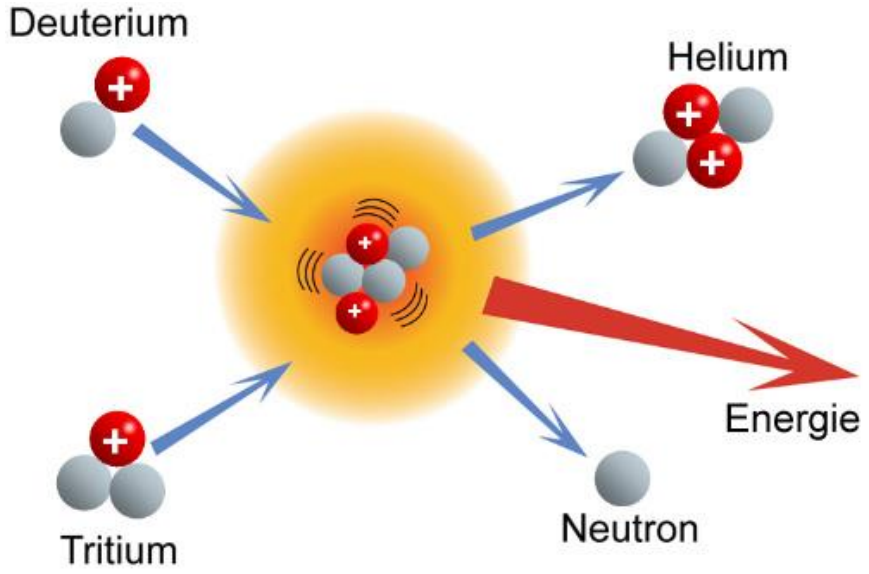
Nuclear fusion reaction(s)

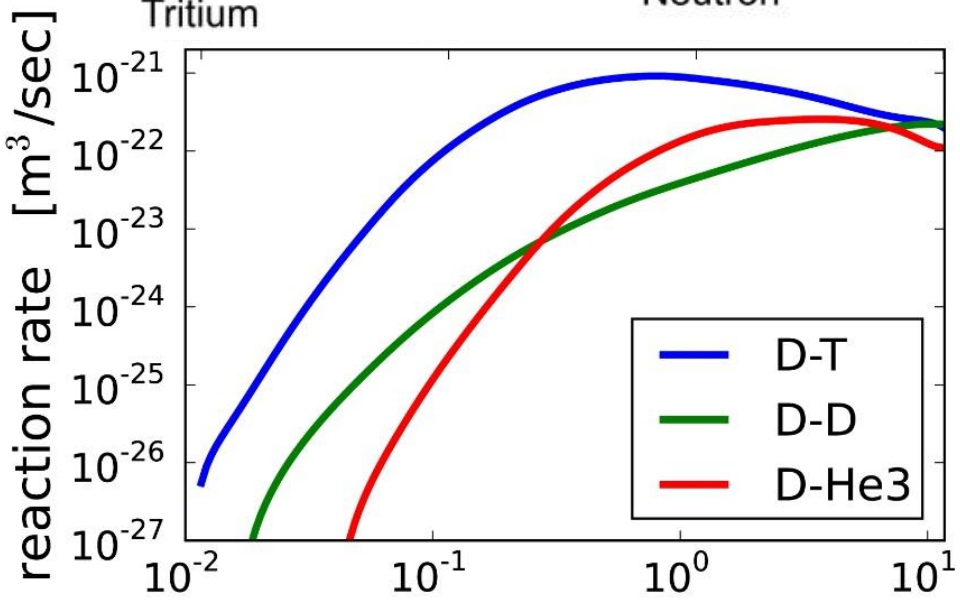
$D + T \rightarrow {}^4He + n + 15\ MeV$

- Highest reaction rate
- ^4He: 3,5 MeV
- n: 14.1 MeV

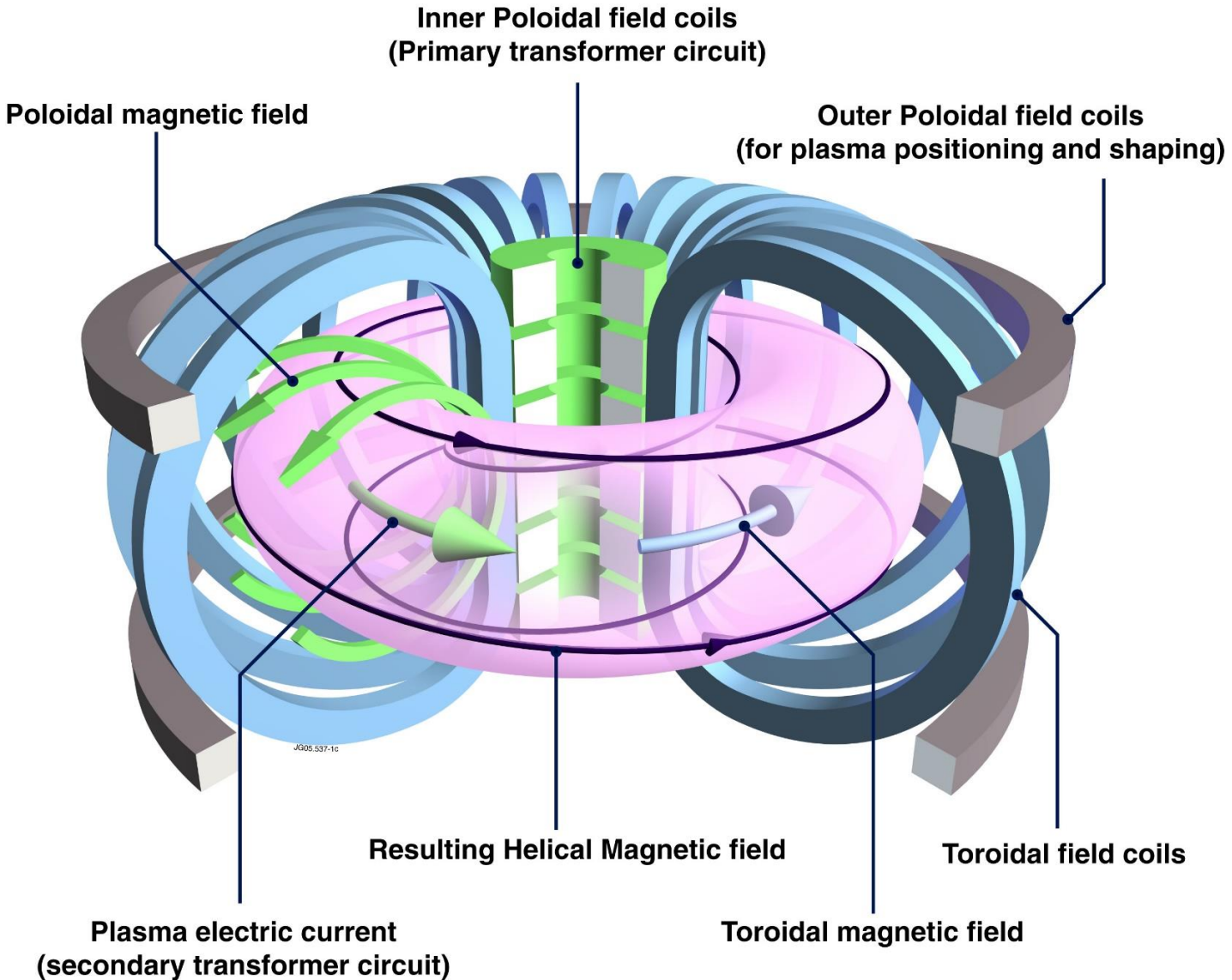
$n\ T\ \tau_E > 5 \times 10^{28}\ m^{-3}\ K\ s$

at T between 150 – 200 MK





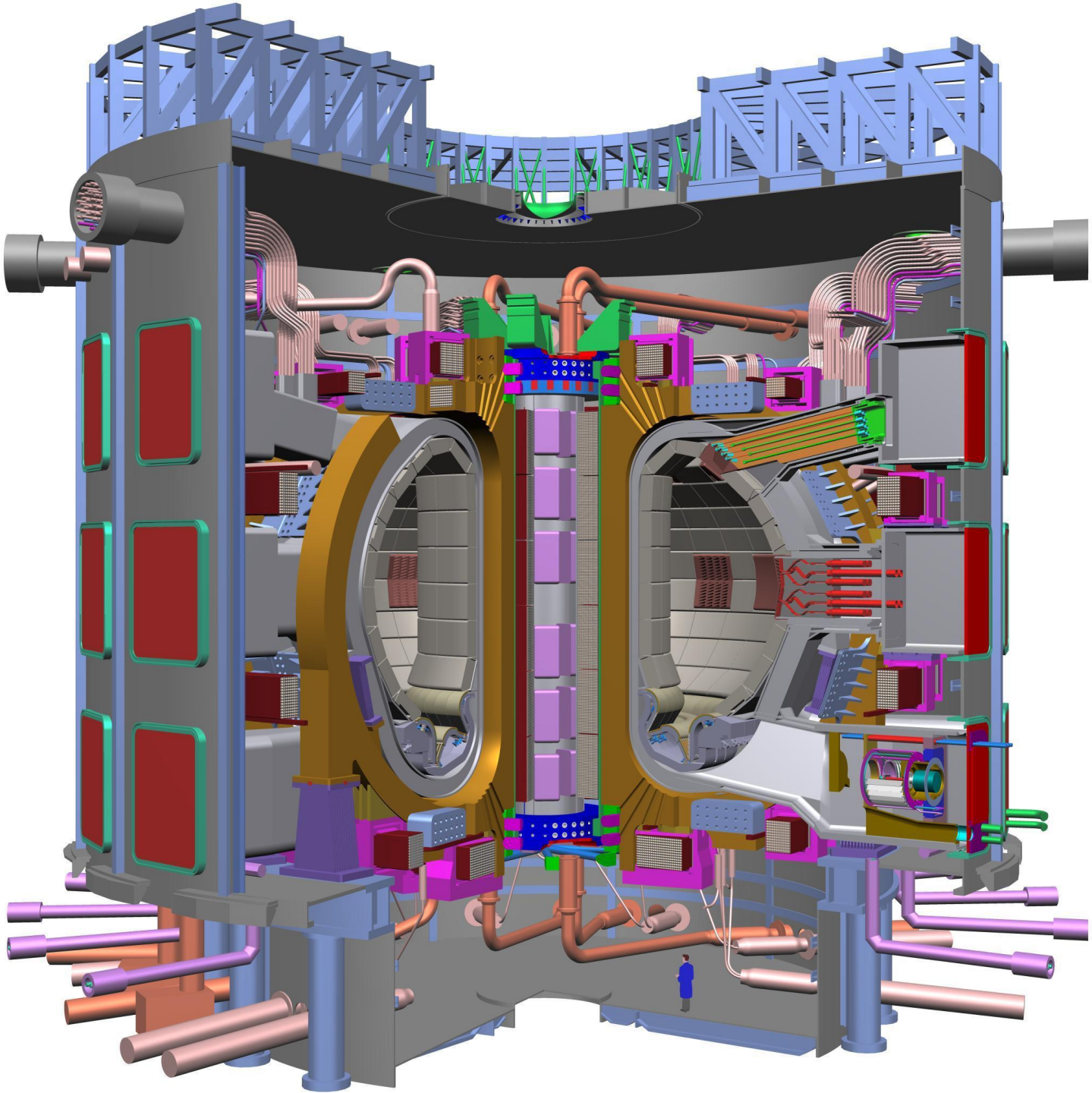
Our work-horse: The Tokamak



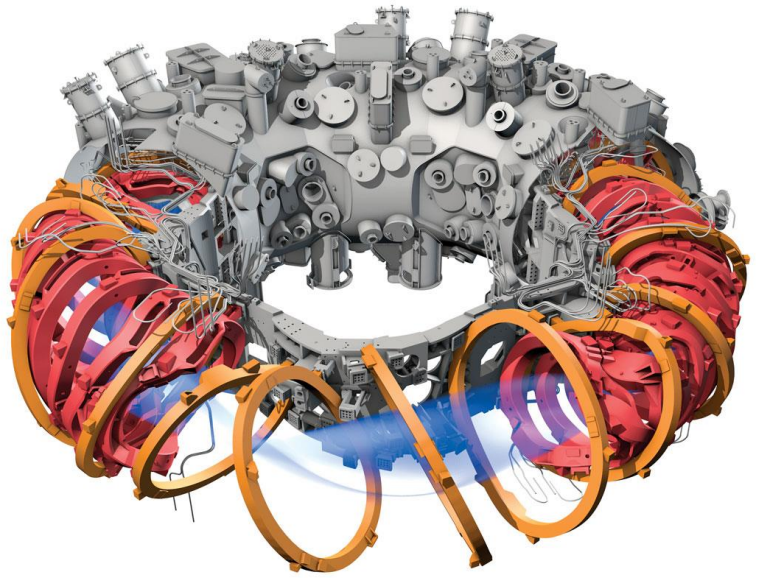
ITER

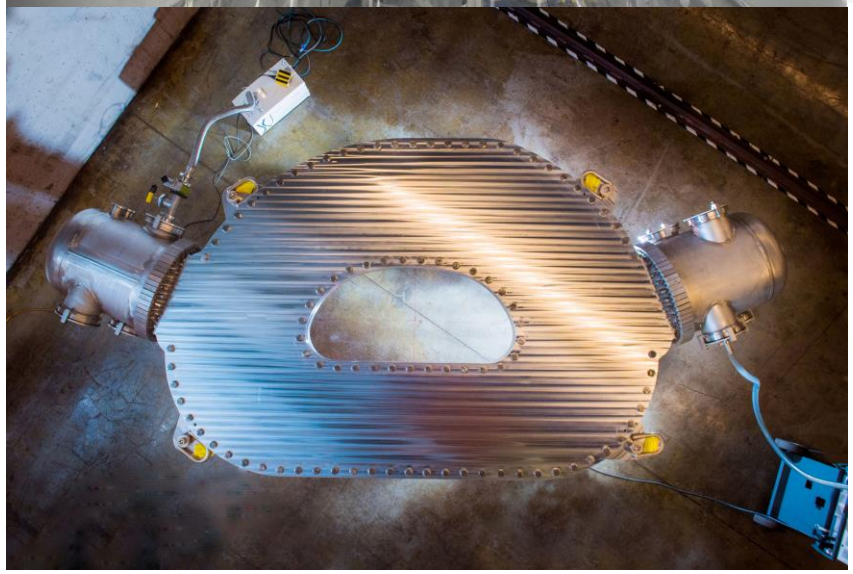
Physics:
Alpha-heating
Confinement
MHD
Exhaust: Plasma-atomic-molecular-metal

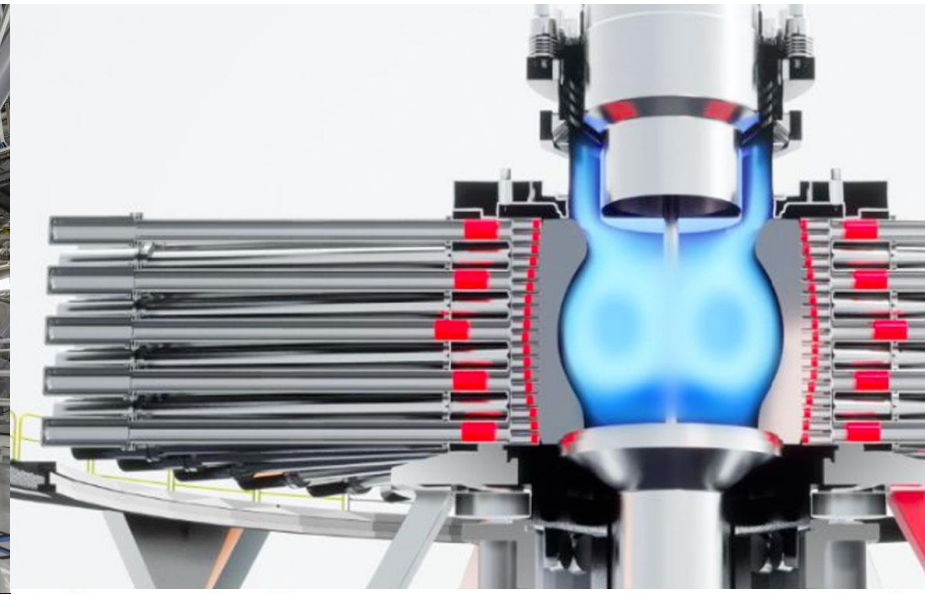
Technology:
Super conducting magnets
Reactor maintenance
Heating systems
Diagnostics
Systeem-, and control
Tritium breeding
System Engineering



Alternative approaches to Fusion (hand-picked)







Microsoft signs power purchase deal wit nuclear fusion company Helion

By Timothy Gardner

In total over 33 Fusion start-ups. Top 5 in terms of cash:

1. CFS	US	2.0G$	
2. TAE	US	1.2G$	
3. HELION	US	0.5G$	
4. GF	Ca / UK	0.3G$	
5. Tokamak Energy	UK	0.1G$	
• STEP	UK	?	Public-private

We are open to work with all new developments that we consider realistic and teams that we consider competent

• CFS	US	2.0G$	Materials, Control, Instrumentation
• TAE	US	1.2G$	
• HELION	US	0.5G$	
• GF	Ca / UK	0.3G$	Instrumentation
• Tokamak Energy	UK	0.1G$	Materials
• STEP	UK	?	Control
• BEST	Ch	?	Diagnostics, Systems Engineering, Control

Fusion Energy research projects
Spin-outs and Technology Transfer with academia and industry

Focus on materials, instrumentation and control, and models for operation of nuclear fusion reactors

- Validation of ITER Material Mix and Development of complex material solutions for DEMO
- Models and instruments for control of thermal, particle, momentum and radiative distributions
  - HEATING SYSTEMS at high Toroidal Fiel
- Tractable models for turbulence, plasma transport and plasma scenarios optimization
- Operation of fusion facilities, including world leading experimental facility Magnum-PSI

Single **Dutch beneficiary** in the EUROFUSION program

- Representing Affiliated Entities: TU/e, UT, and FuseNet
- Initiating research programs for development of technology development and valorization for ITER

→ **CO-EVOLUTION** with companies and industries to establish instruments, but direct valorization difficult due to nuclear fusion time scales.

→ **So far: SPIN-OUTS** and **TECHNOLOGY TRANSFER** and to lesser extend **GEO-RETURN**

DIFFER institute
Prominent position in the innovation ecosystem

- Solar Fuels department is co-evolving TODAY new processes and innovations for the electrification of industry with a wide variety of industrial partners
- Fusion Energy department involved in technology transfer and spin-outs.
- Present Georeturn from large European facilities helps Dutch companies to innovate

Present DIFFER research infrastructure is used by academia and industrial partners

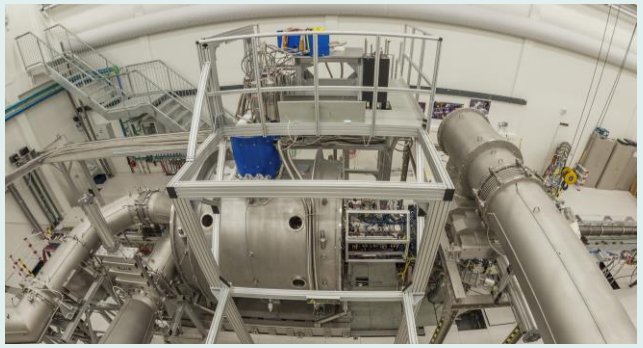
→ Future facilities to be **co-evolved** with industrial partners

→ Operated as **user facilities** for (inter)national academic and industrial teams

; -) Not all nuclear start-ups do fusion
With NRG, RID and French Nuclear Industry we support Thorizon

EUROfusion, 50 international partners, TU/e, TUD, ASML…
New developments: re-entry research, flower industry, FONTYS

Plasma Facilities



Ion Beam Facility

DICE		RID, NRG, nuclear industry
Plasma		UM, TU/e, TUD, UL, Fontys, industrial partners
LiMeS		EUROfusion, TU/e, Industrial partners

PLD	Open Ion Beam	X-Ray Facility
UT, RUG, TU/e TSST, ASML, TUD, Leiden AMOLF, ARCNL	Electro-catalysis, Electrolyser companies, Cancer therapy, Life sciences	TU/e, TUDelft, UA, RUG, UGent, VDL, KMSKA, Erasmus MC, Agfa Healthcare, ASML… AMOLF, SRON, ARCNL

LSI Materials

LSI Technology

Groeifonds Hydrogen

Groeifonds Nucleair en Thorizon

DIFFER has prominent position in the innovation ecosystem

Valorization lies at the heart of our science: Co-evolution, Technology Transfer and Spin-outs

Marco de Baar

DIFFER