

FLYWHEEL FOR INNOVATION

TNO innovation
for life

TNO.NL

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FAVORIEETE
WERKGEVER
AWARDS

18

Lennart van der Burg

› HOW DO WE MAKE OUR LIVES

MORE SUSTAINABLE?



› HYDROGEN

THE KEY TO THE ENERGY TRANSITION

› Waterstof krijgt een systeem functie

OUR AMBITION

The ambition of the ECN part of TNO is to accelerate the energy transition together with knowledge institutions, companies and governments

WHY HYDROGEN?

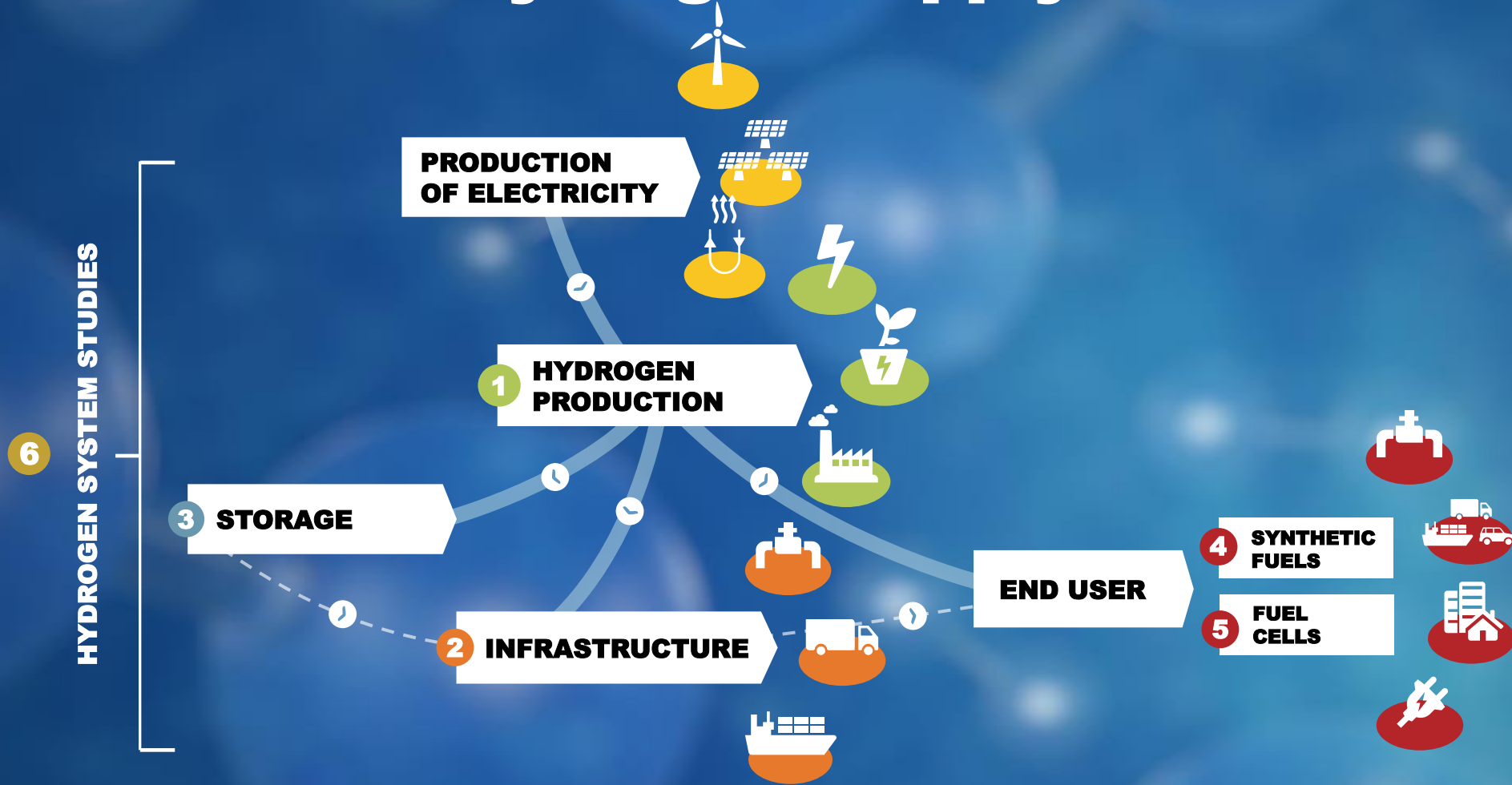
Hydrogen can be seen as an enabler for the transition towards renewable energy:

- 'Unlock' renewable energy
- Providing long term (seasonal) storage capability complementing intrinsically intermittent solar and wind
- Providing carbon neutral energy for heavy duty transport
- Providing a carbon free source of (high temperature) heat

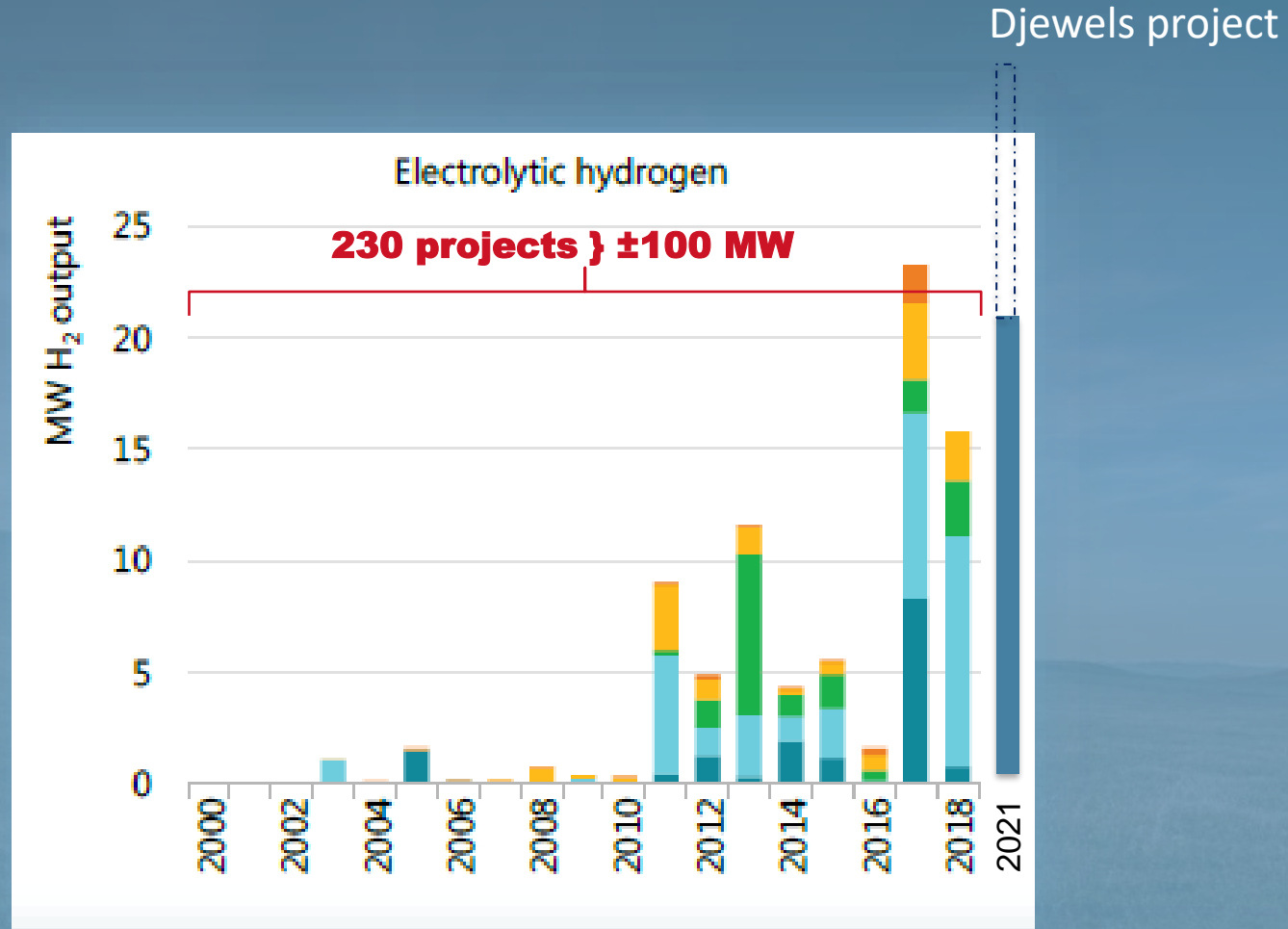
WHAT WE DO?

- 6 programs
- 50+ projects
- Various research groups & key experts
- Multiple facilities
- Over 40 years of Hydrogen research

Research in hydrogen supply chain



GREEN HYDROGEN IS THE FUTURE



Industrial feedstocks

Vehicles

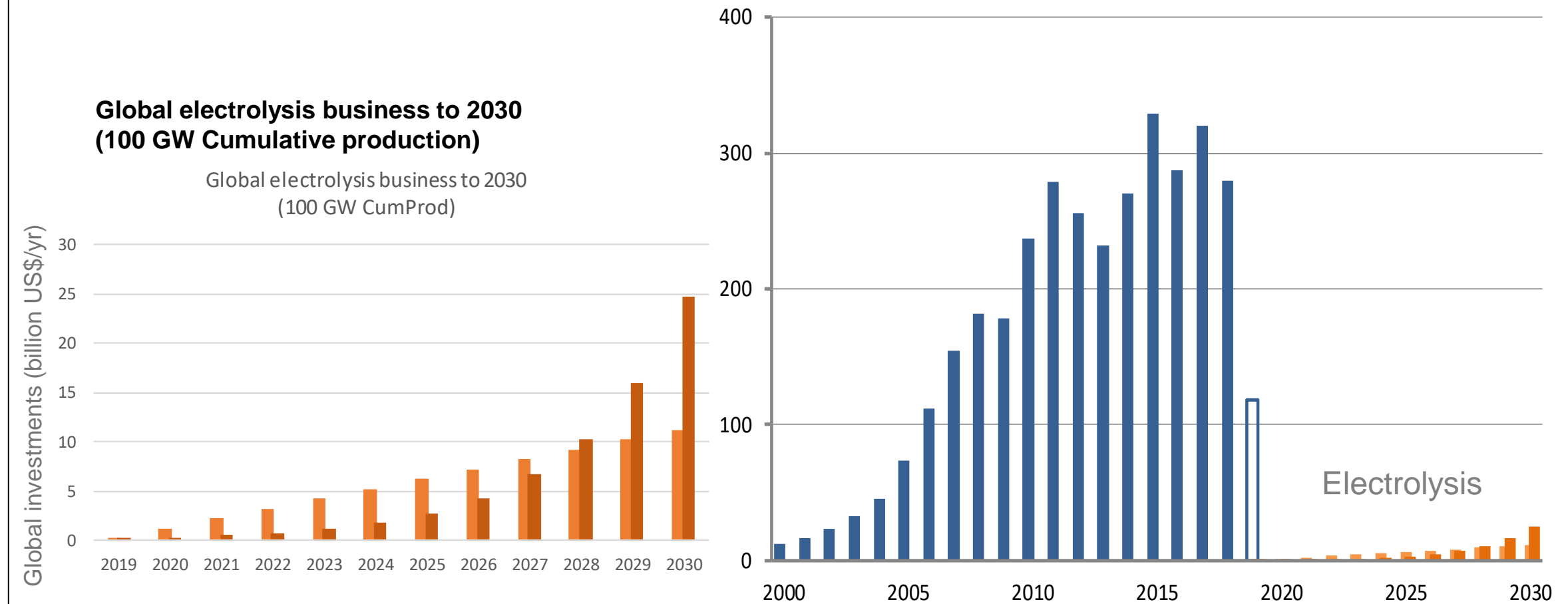
Gas grid injections

Electricity storage

Heat

ELECTROLYSE LOOPT 20 JAAR ACHTER OP ZONE ENERGIE

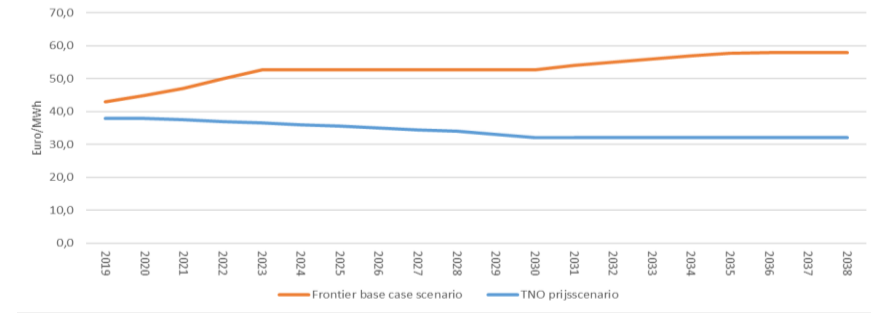
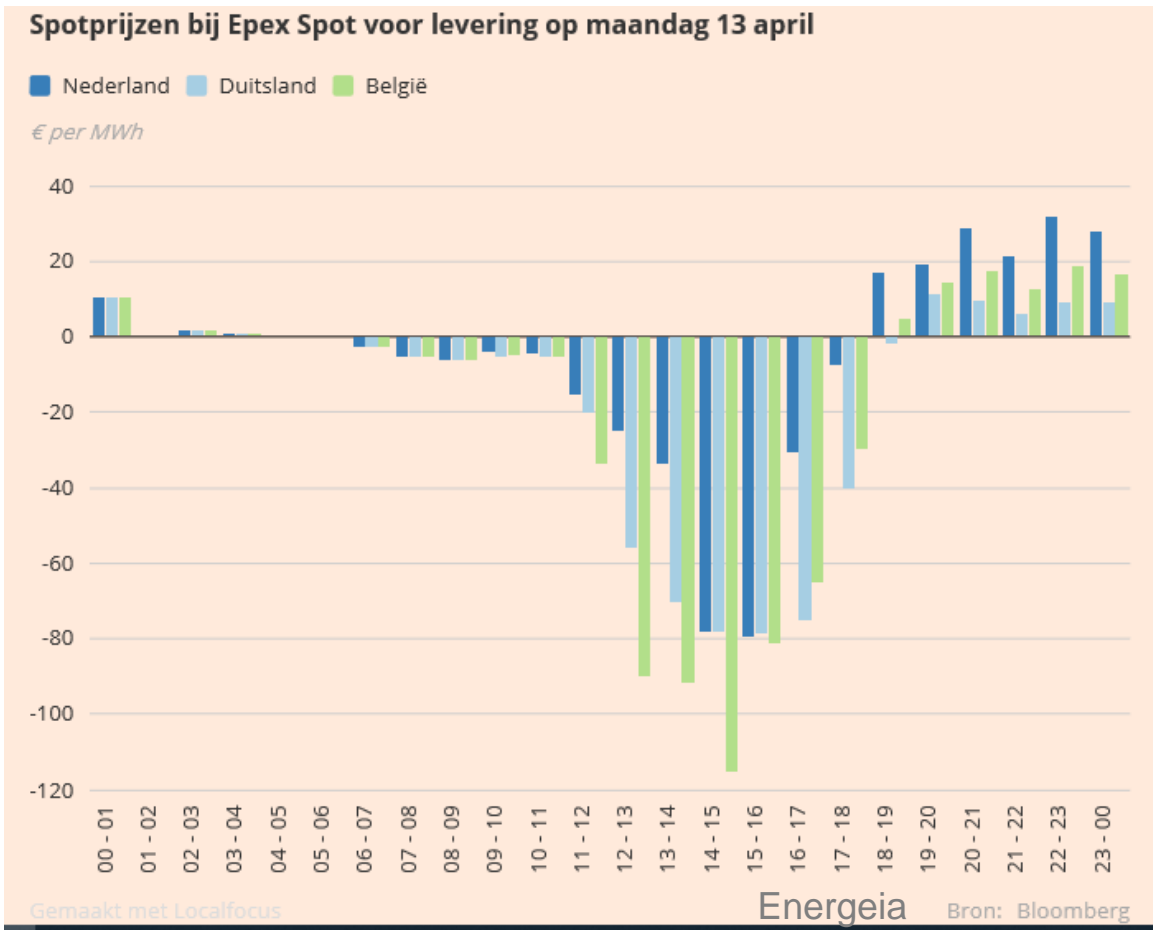
Global Investments Non-hydro Renewables



Sources: investment data: BNEF; and Kramer and Haigh, Nature, 462, 568-9 (2009)

TOP 5 KOSTEN (1/5)

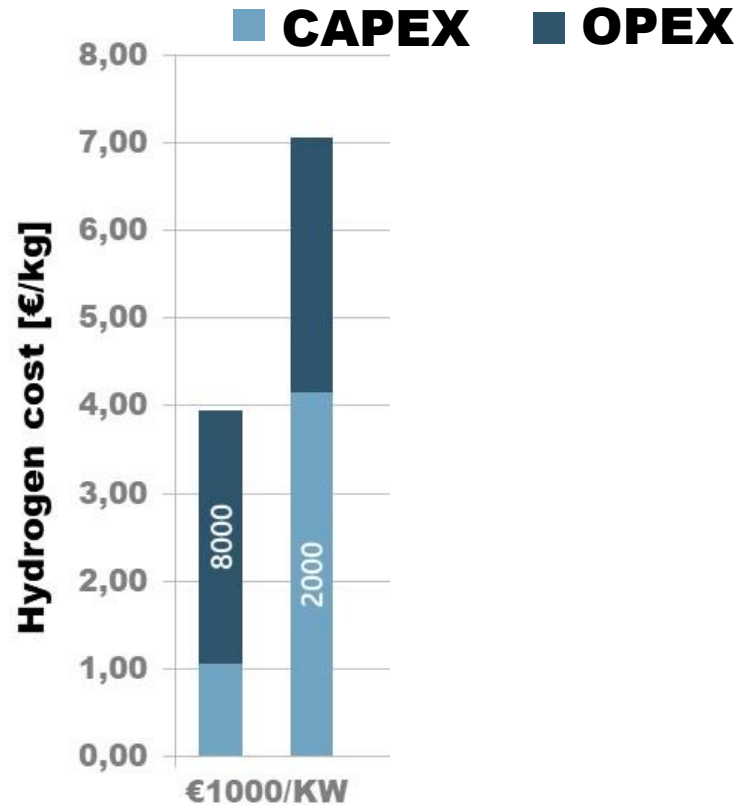
PRIJS ELECTRICITEIT BEPAALT PRIJS KG WATERSTOF



Prijs scenario's elektriciteit

Gemiddeld rendement hele levensduur 58 kWh/kg H2

VOLLASTUREN ZIJN BEPALEND, ZEKER BIJ KOPPELING ZON EN WIND



Two major costs:

› Electrolyser costs (CAPEX)

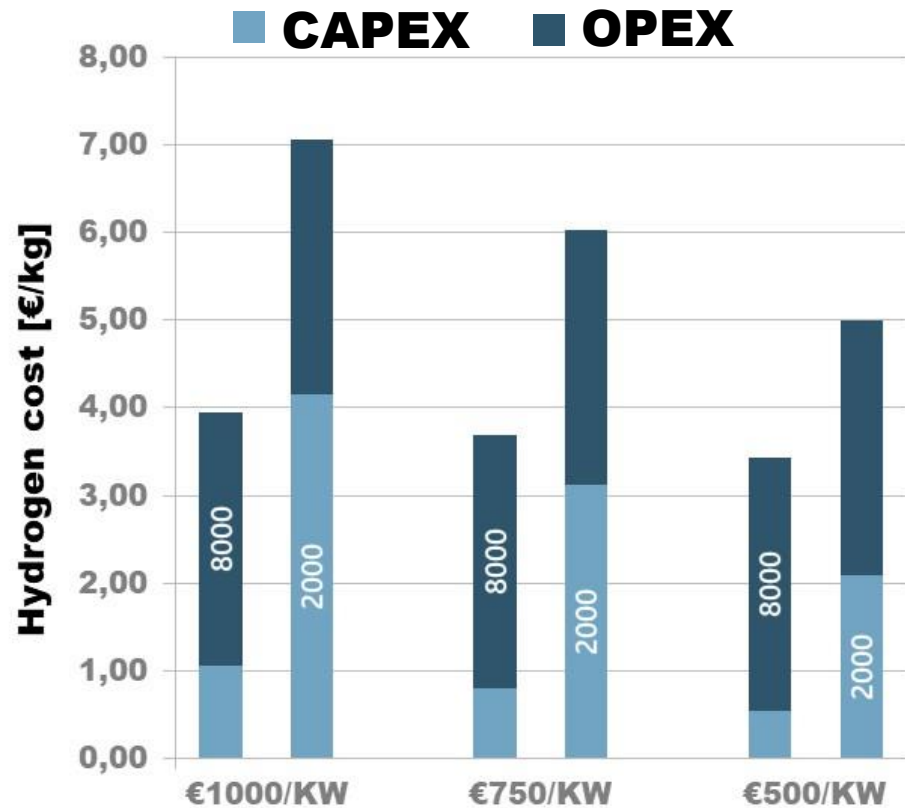
› Electricity costs (OPEX)

Base case (BC)

Investment cost	1000 €/kW
Depreciation	15% /year
O&M	2% /year
Electricity price	50 Euro/MWh
Operating hours	8000 hours
Efficiency	60%

TOP 5 KOSTEN (3/5)

BIJ < 50% TIJD OPERATIONEEL CAPEX KOSTEN DOMINANT



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› Electrolyser costs (CAPEX)

› Electricity costs (OPEX)

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KOSTEN TRANSPORT EN OPSLAG AFHANKELIJK VAN LOKALE AFNAME






PV-panelen agrarisch gebied

Negatieve businesscase
NPV -0.25 mln euro, IRR 6%

Case 1



-  Lokale gebruikersvraag: klein
-  Transportkosten: hoog (niet lokaal)
-  Willingness-to-Pay: hoog






Grootschalig zonnepark

Negatieve business case
NPV -12.1 mln euro, IRR 5%

Case 2



-  Lokale gebruikersvraag: groot
-  Transportkosten: hoog (niet lokaal)
-  Willingness-to-Pay: laag






Energiehub bedrijventerrein

Positieve businesscase
NPV +1.4 mln euro, IRR 20%

Case 3



-  Lokale gebruikersvraag: klein
-  Transportkosten: laag (lokaal)
-  Willingness-to-Pay: hoog



Industriële waterstof

Positieve businesscase
NPV +2.3 mln euro, IRR 9%

Case 4



-  Lokale gebruikersvraag: groot
-  Transportkosten: laag (lokaal)
-  Willingness-to-Pay: laag



ONTWIKKELKOSTEN (O.A.DEVEX) % AFHANKELIJK VAN PROJECTOMVANG

Project ontwikkelkosten relatief hoog door o.a.

- Organiseren lokale H2 afname
- Onbekendheid technologie
- Netaansluiting / inpassing
- Vergunningen – leges
- Beperkte ervaring; van eerste pilot projecten naar opschaling



TNO werkt aan Learning community voor lokale waterstof projecten

Hydrogen

TNO innovation
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