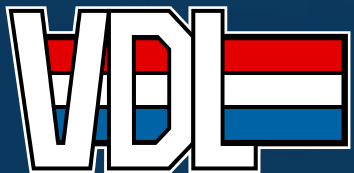


Waterstofnet 10 jaar

14-11-2019

VDL

RUUD BOUWMAN



KRACHT DOOR SAMENWERKING



Facts & figures



104 COMPANIES



SPREAD ACROSS
20 COUNTRIES



TURNOVER
€ **6,0** BILLION

PROFIT
€ **180** MILLION



>16,000 EMPLOYEES



84% EXPORT
to **105 COUNTRIES**



COMPANY ACTIVITIES
DIVIDED AMONG **4 DIVISIONS**



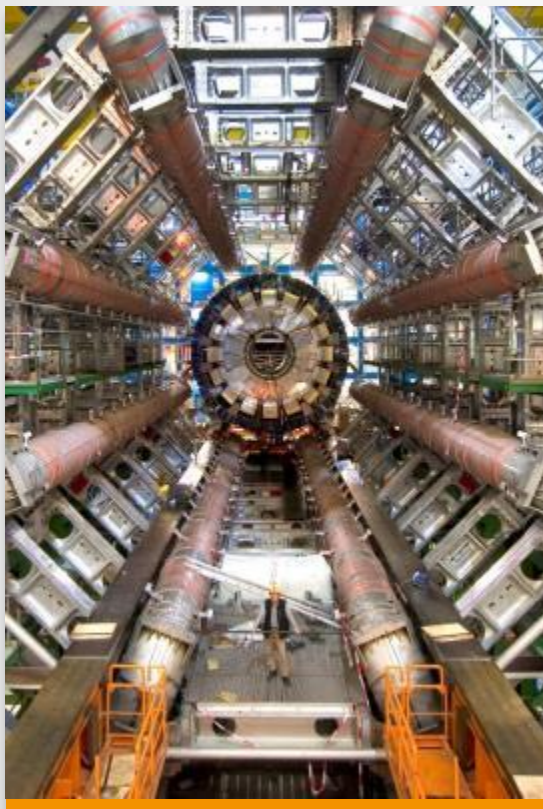
STRONG BALANCE SHEET POSITION
SOLVENCY **58%**



>1,400,000 M²
PRODUCTION SURFACE AREA



Highlights



Subcontracting



Car Manufacturing

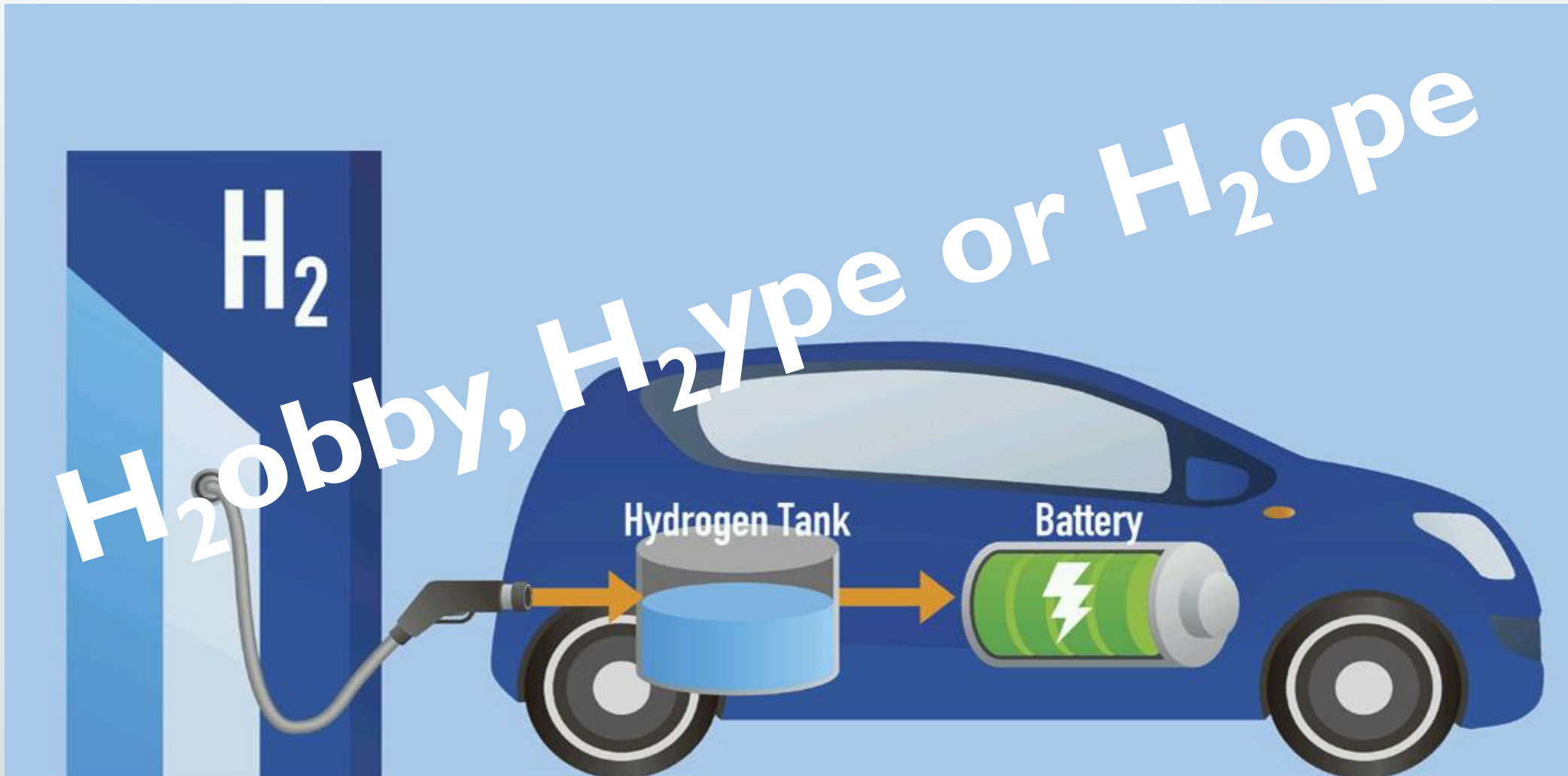


Bus & Coach



End Products

H₂ Hobby, H₂ype or H₂ope



H₂obby 1998 - 2013

Zero Emission History (No Battery)

Conclusions:

Electrical (Public) Transport
within 5-15 years is feasible
Also for bigger vehicles >24m

-Not one-solution-

- 1-Combination of Battery technology
(Power+Recuperation)
and H₂ technology
(Range+Flexibility)
- 2-For Zero-Emission PT, FULL integration
between vehicle and operation is needed

Experiences with H₂ vehicles
in Public Transport



29 Februari 2013
Ruud Bouwman

Actions (Modularity):

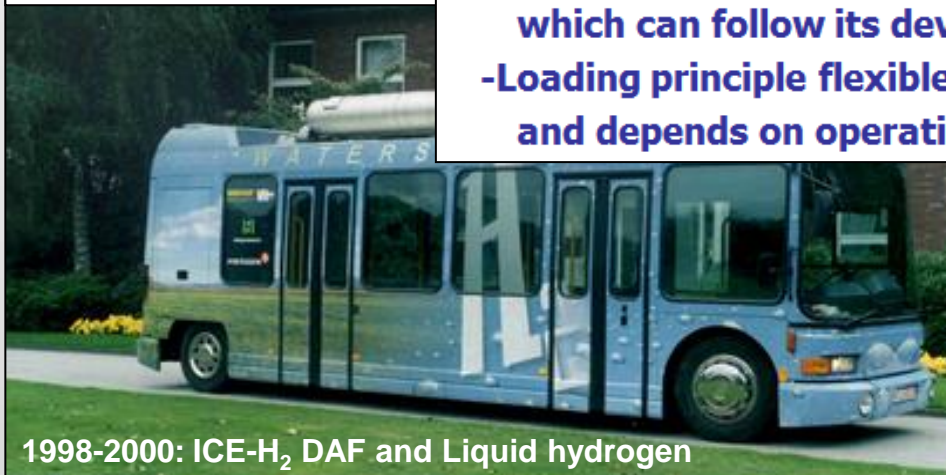
- Electrical vehicle,
optimise on weight-volume-price
- Energy-storage as module,
which can follow its developments
- Loading principle flexible
and depends on operation



1999: H₂ Trailer



2013: FC Hydrogenics Range Extender



1998-2000: ICE-H₂ DAF and Liquid hydrogen



2010-2014: FC Ballard Phileas Cologne



2010-2014: FC Ballard Phileas Amsterdam



H₂ype 2013 - now

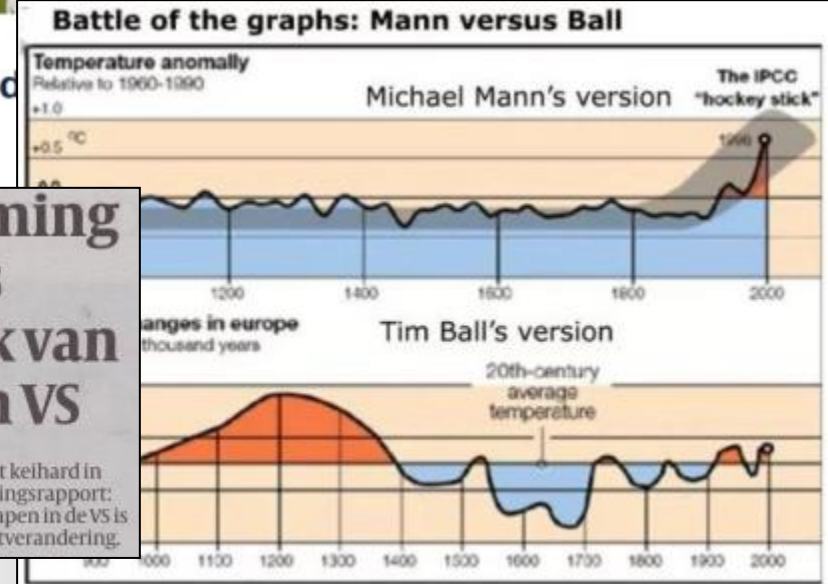
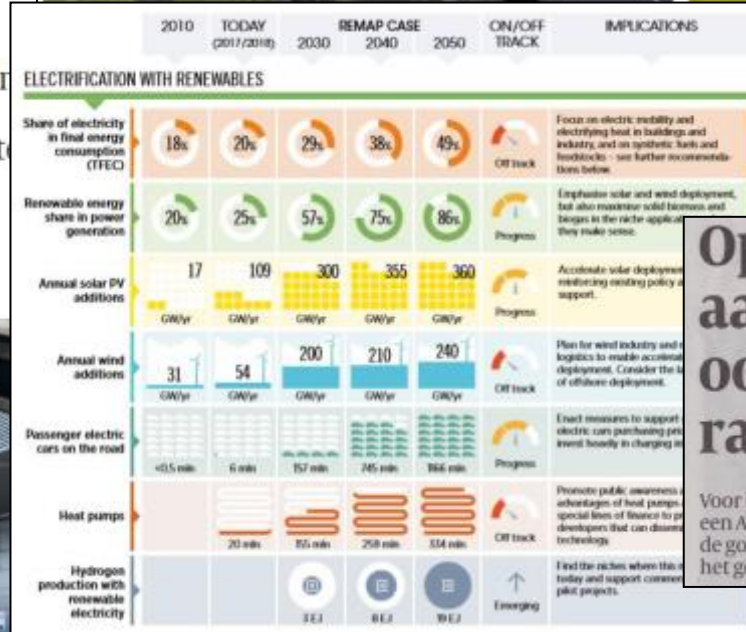
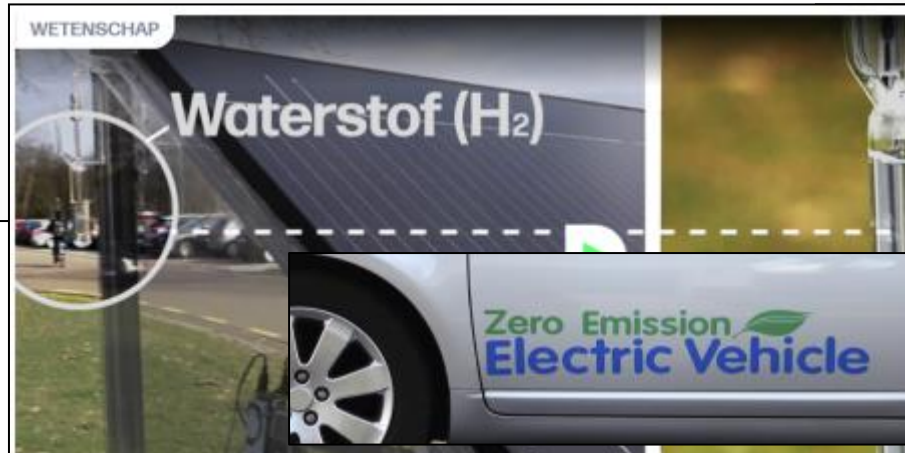
Zero Emission-CO₂-H₂

Internet

Nederlands bedrijfsleven wil inzetten op groene waterstof

'Waterstof essentiële bouwsteen energietransitie' - hij spreekt voor zich, de titel van het manifest waarin bedrijven, organisaties en universiteiten stellen dat groene waterstof een grote rol moet krijgen in het aankomende Klimaat- en Energieakkoord. Joris Thijssen, directeur van Greenpeace, overhandigde het vrijdag tijdens een conferentie over het onderwerp aan minister Wiebes van Economische Zaken en Klimaat.

Niels Waarlo 2 juni 2018, 11:59



Opwarming aarde is oorzaak van rampen VS

Voor het eerst staat het keihard in een Amerikaans regeringsrapport: de golf aan natuurrampen in de VS is het gevolg van klimaatverandering.



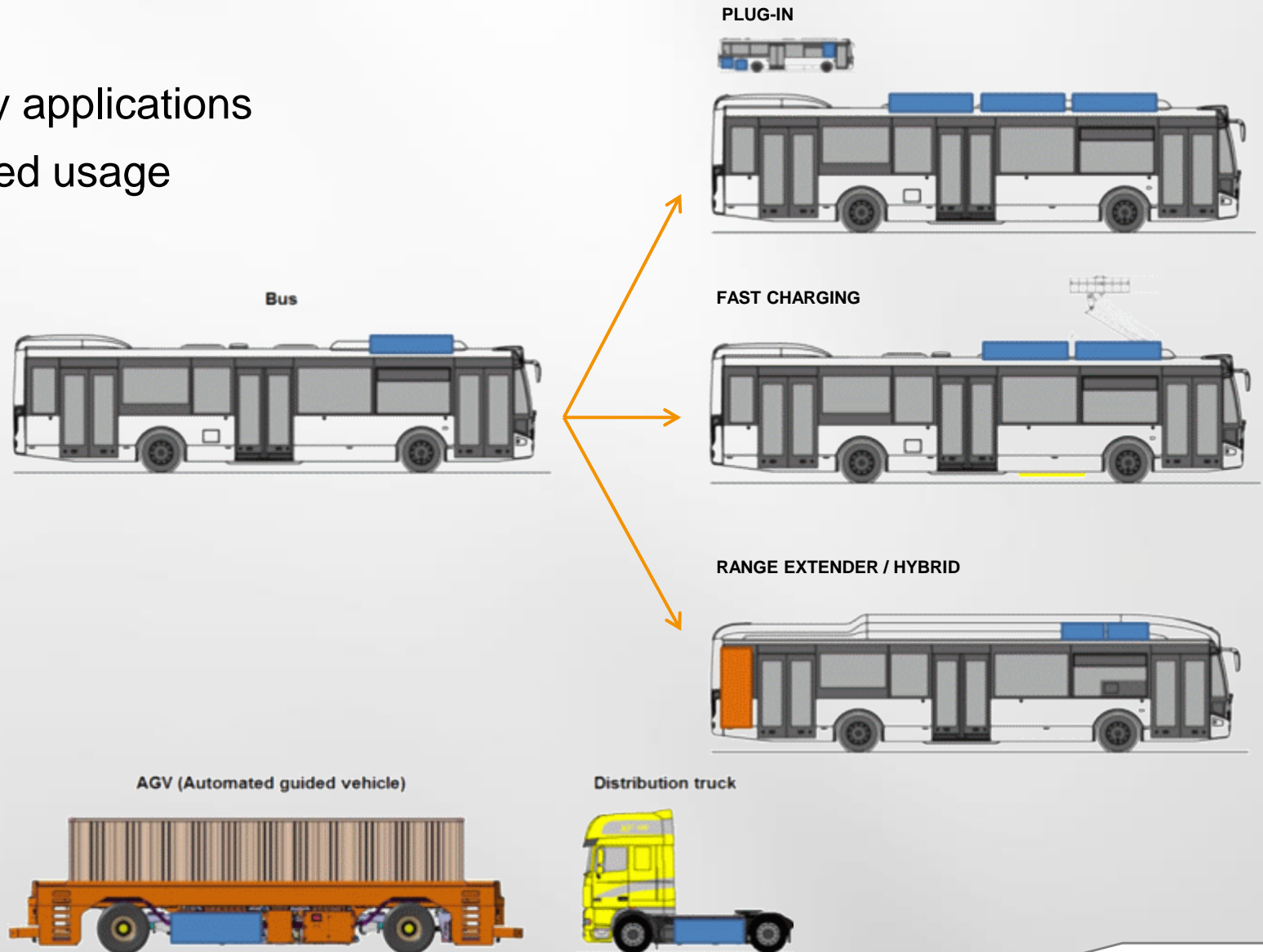
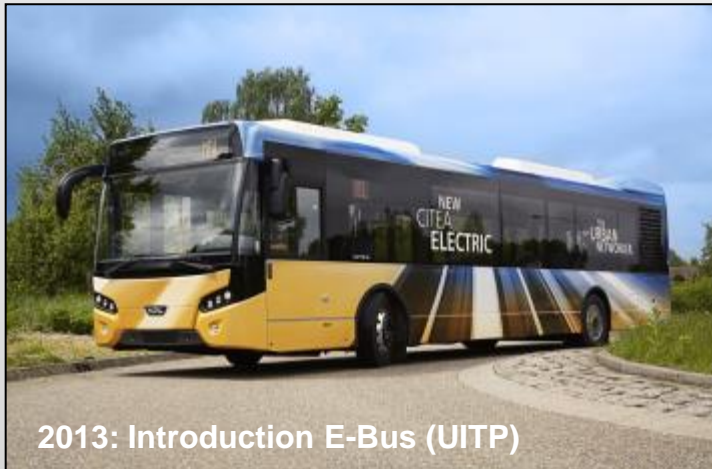
NASA admits that climate change occurs because of changes in Earth's solar orbit, and NOT because of SUVs and fossil fuels

08/30/2019 / By Ethan Huff

H₂ype: VDL Strategy on Zero Mobility (2013 - now)

Flexibility through modular design

- Modular system – for all heavy duty applications
- Configuration depending on intended usage
 - Small battery – fast charging
 - Big battery – slow charging
 - Range extender possibilities
- Heavy Duty
- TCO @ ICE level



VDL Zero Emission products

Battery Electric for Public Transport, Distribution, Storage.....



City ZE-bus



Distribution ZE-truck



ZE-AGV



Energy Storage Systems
(kW)



> 800 E buses

AIMING FOR ZERO.



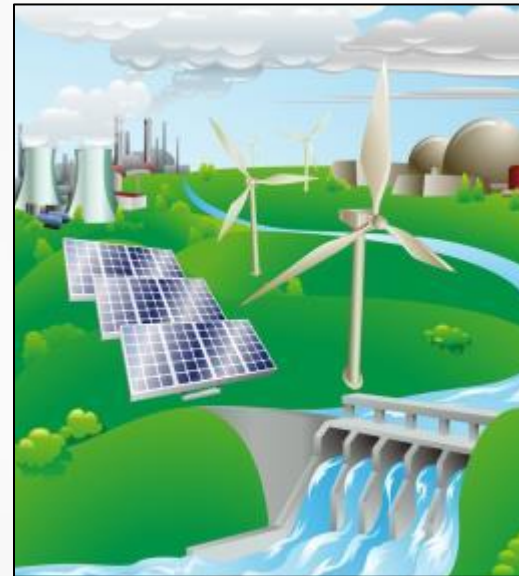
H₂ope 2019 -

Zero Emission Breakthrough

Challenges:

- ZE-Energy Generation
- ZE-Energy Storage (Static – Mobile)
- ZE-Energy Transport
- ZE-Energy Use
 - Industrial
 - Residential
 - Transport (f.e. Hydrogen)

Internet

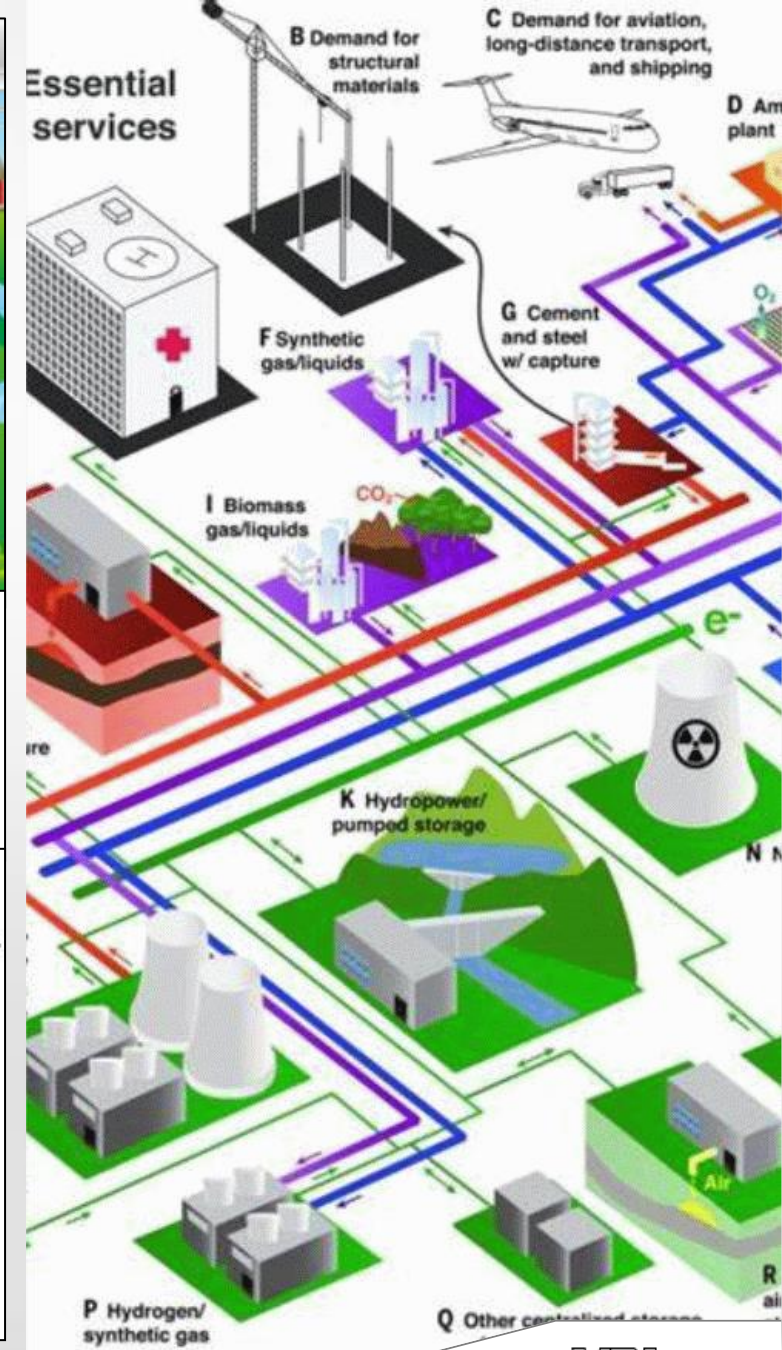


Cable versus pipeline cost

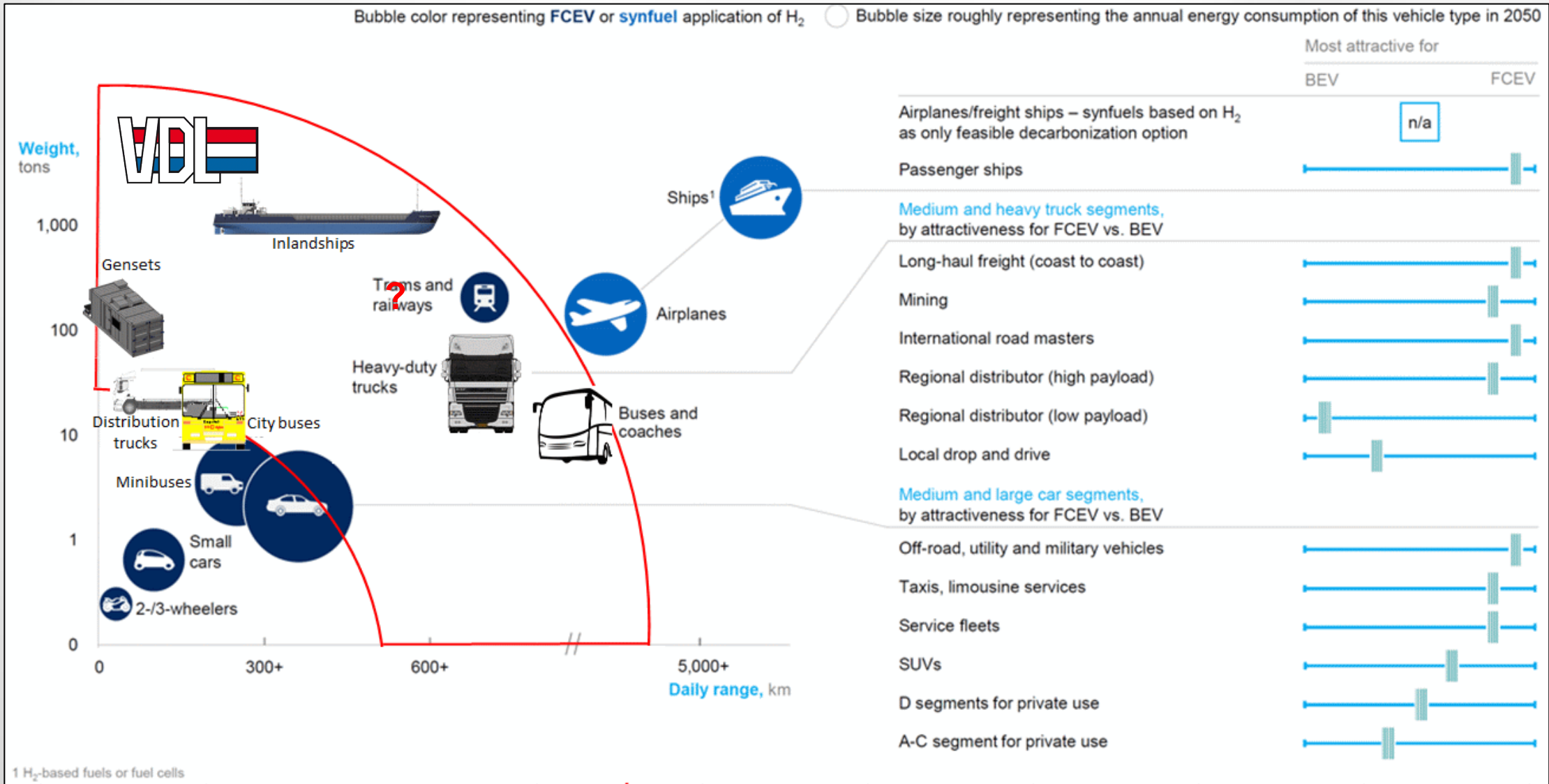
	Cable (BritNed)	Pipeline (BBL)
Capacity	1 GW	15 GW
Construction Cost	€ 500 mln	€ 500 mln
Volume (year)	8 TWh	120 TWh

Ad van Wijk

Surface needed to produce all the world's energy 556 EJ = 155.000 TWh

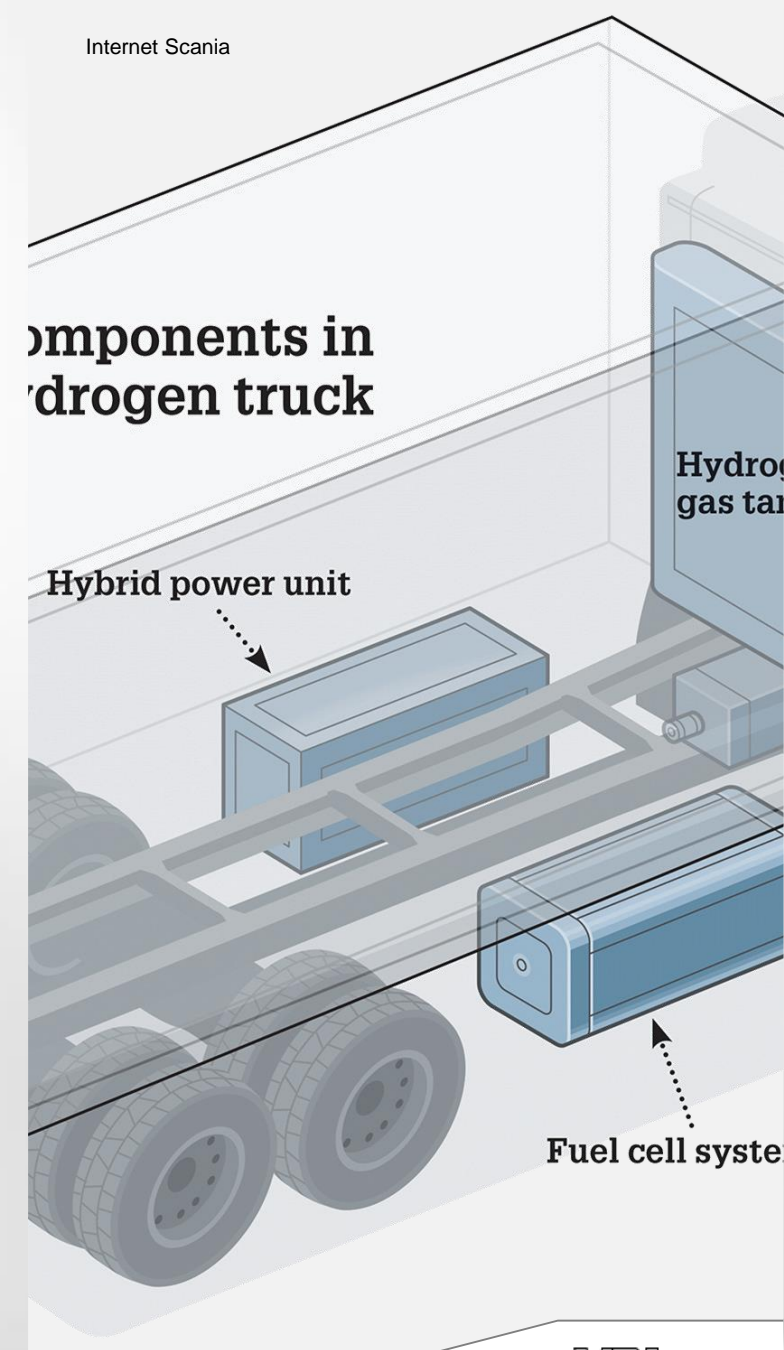


ZE-Energy (Hydrogen) Use in Transport (EU reports)



VDL Strategy on Hydrogen

- Hydrogen as Range Extender
- Hydrogen for Heavy Duty (>3.5ton) and Long Range/Haul
 - Regional Bus and Coach
 - Long Haul Truck
 - GenSet (Multi-Purpose)
- Hydrogen TCO comparable with current TCO's
- VDL as FC system assembler and integrator



VDL Zero Emission Hydrogen RE products

Hydrogen Range Extender for Regional Transport, Coach, Long Haul Transport,



Regional ZE-Bus



ZE-Coach (Future)



Long-Haul ZE-Truck



Energy Storage Systems

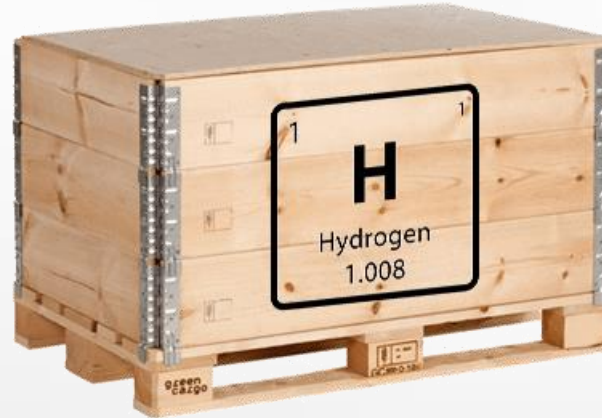
But for HD transport:

TCO too high (without subventions):

1. FC system price is too high
2. Hydrogen price is too high

Density storage too low

- 1 ltr Dsl = 29.0 ltr Battery
- 1 ltr Dsl = 12.5 ltr H₂@350bar
- 1 ltr Dsl = 9.3 ltr H₂@700bar
- 1 ltr Dsl = 5.3 ltr LH₂



GOAL (1/3):

- 1/3 Price /kW and /kg
- 1/3 Volume system
- 1/3 Weight system

Goal TCO Hydrogen = <3-4 Euro/kg

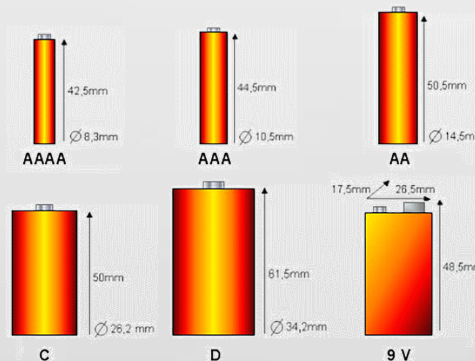
Solution: **Increase Hydrogen demand**

- Economy of Scale
 - Blue/Green Hydrogen
- Other Hydrogen production methods

Goal TCO FC system = <600-800 Euro/kW

Solution: **Standard Sized (Modular) FC module**

- Economy of Scale
 - Increase in sales, markets and applications.
 - Easier logistics for parts and services
 - Justification of investments in manufacturability
- Fair competition

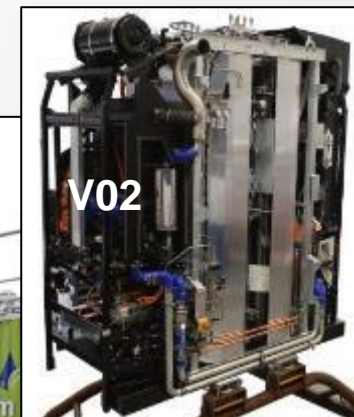


Goal Density storage = >50kgH₂m⁻³ (DOE)

Solution: R&D

- 1 ltr Dsl <= 4.2ltr H₂@.....
 - HCOOH
 - MeBH₄
 - NH₃
 -

Standard Sized (Modular) FC system V01 and V02



V01: Interreg IV-A



V02: 3EMotion and H2Share



V02: Giantleap



V02: Interreg 2.0

Standard Sized (Modular) FC system V03

From an independent FC system V02 to a Plug-In FC system V03

FC system V02



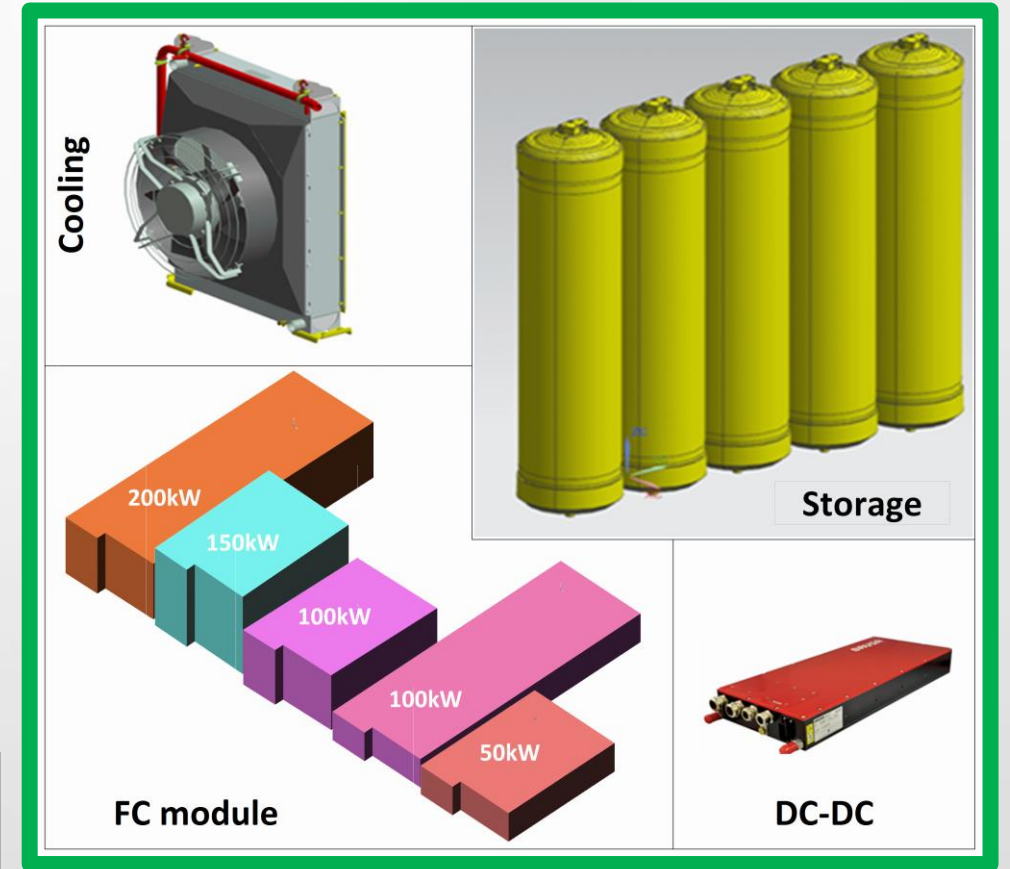
Totally integrated



GOAL (1/3):

- 1/3 Price /kW and /kg
- 1/3 Volume system
- 1/3 Weight system

FC system V03 (4 units)



Standard Sized Plug-In (Lego-Blocks)

FC system V03 HD applications

For example RE for:

Minibus and/or GenSet(s)

50kW,

50-1.000kW,

Etc.

Regional Bus and Coach

100kW,

150kW,

Etc.

Truck DayCab and SleepCab

100kW,

200kW,

Etc.

Hydrogen Range Extender for Heavy Duty and Long Haul (x 1/3):
Standard Sized (Modular) FC module / system (Energy module)
Focus on Hydrogen storage

THANKS FOR YOUR ATTENTION

