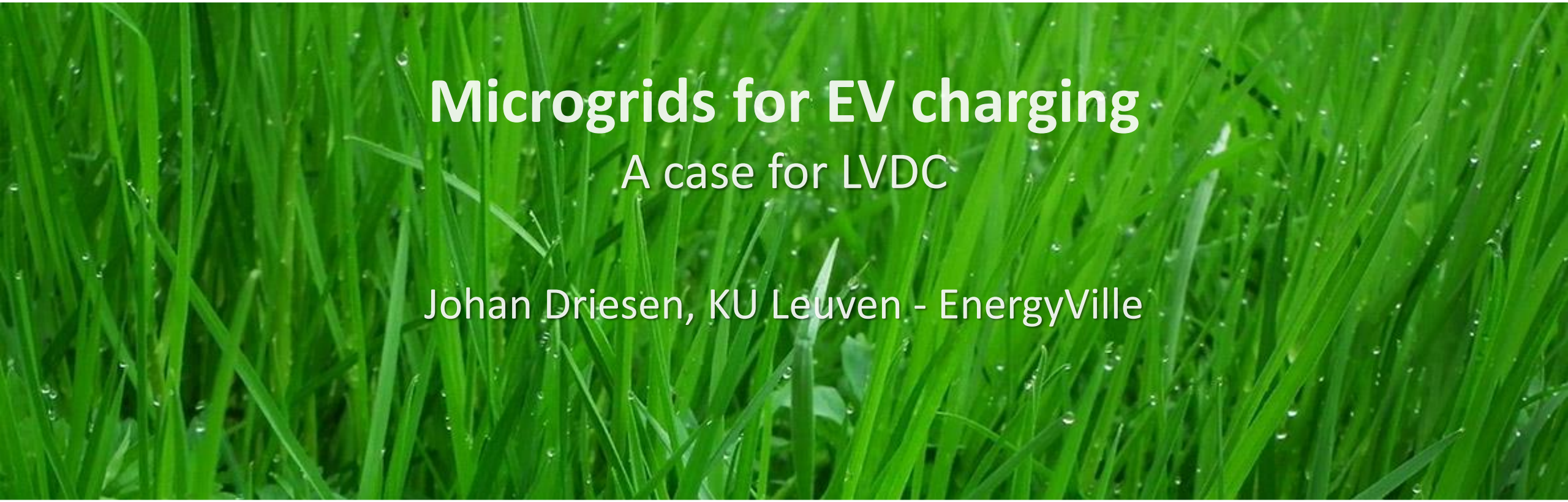


Microgrids for EV charging

A case for LVDC

Johan Driesen, KU Leuven - EnergyVille

The Energy Transition

The European Perspective

Transitions have always happened

And there was always resistance …

Ik blijf wie ik ben.

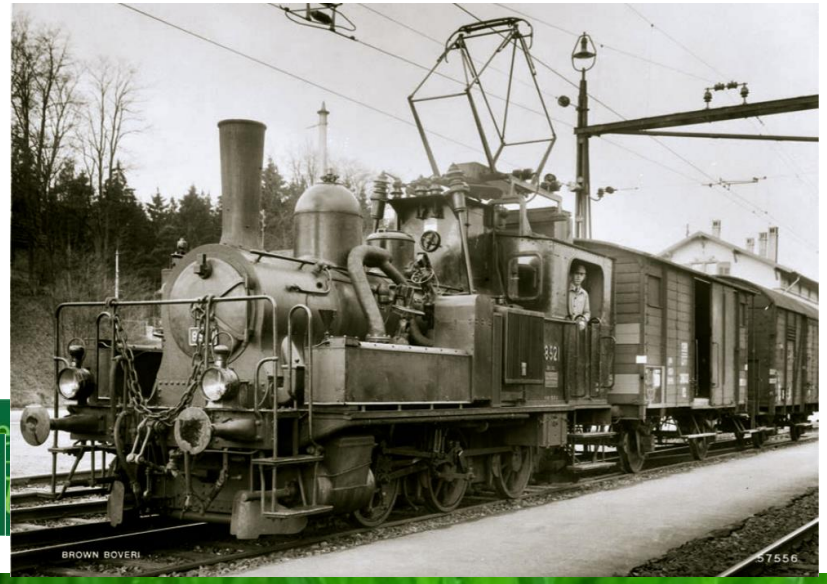
'Ik was er helemaal niet vóór … die omschakeling op aardgas. Per slot van rekening jagen ze je maar op kosten. Dit afgekeurd, dàt afgekeurd en de pijp afgekeurd. En in de bus een briefje: zorg er zelf maar voor! Dat kostte me handen vol geld'. Deze verzuchting is van mevrouw D. J. de Jong, Cattenhagestraat 11a in Naarden. Velen voelen het net zo. Waarom blijft zij bij gezellig kolen stoken?

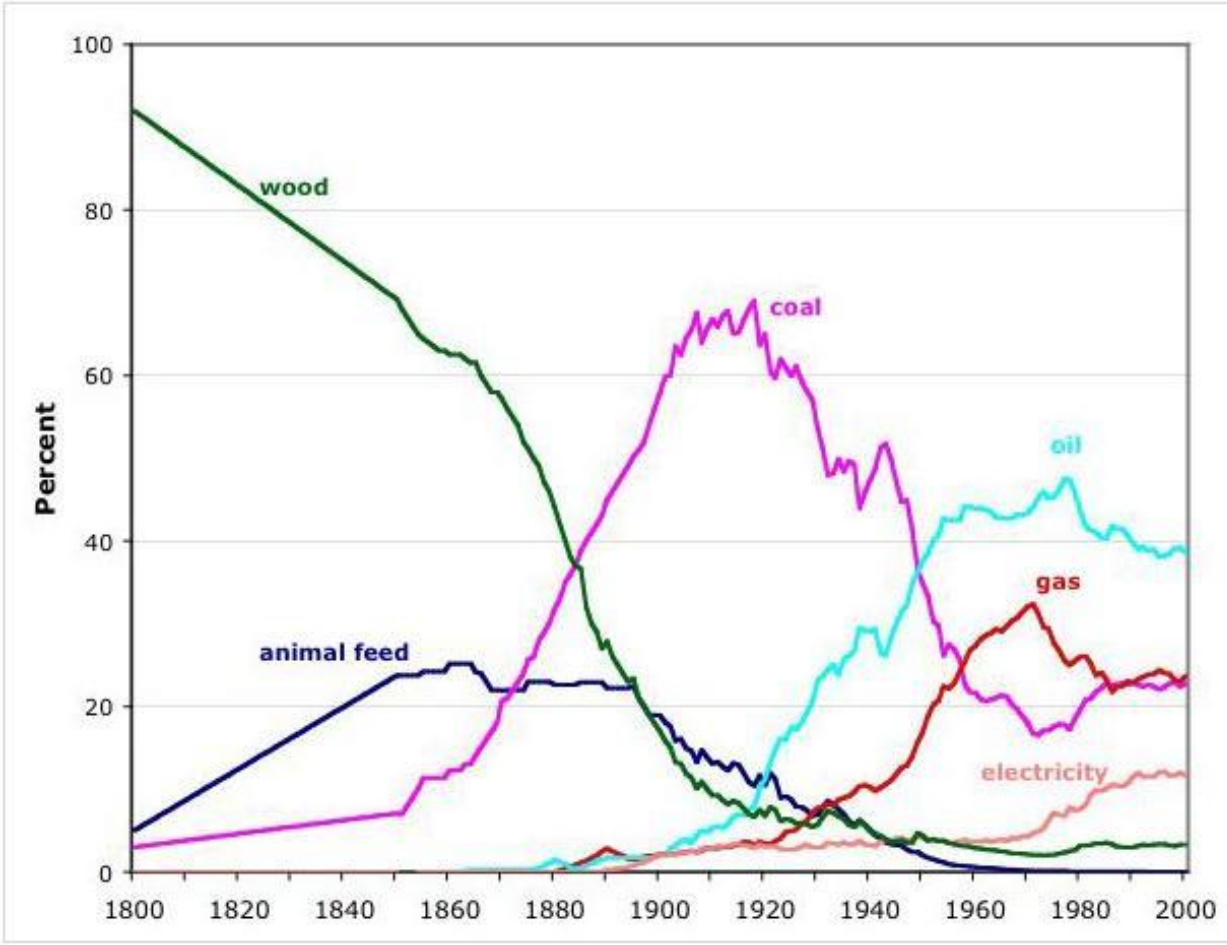
'Dat zal ik u zeggen. Het bevalt mij al niet met koken, laat staan met stoken! En ik wil graag klant blijven. Zoals ik altijd geweest ben. Klant van een kolenhandelaar, die wéét wie ik ben als ik opbel. Echt klánt - en geen verbruiker nummer zoveel. Een naamloze. Met ambtelijk gedoe. Bovendien: in de kamer waarin je leeft kan je niet zonder echte stralingswarmte. Warmte waar wat aan te *beleven* is !' U hoort het: leefwarmte. Van kolen!

Zo is het! GEZELLIGE MENSEN STOKEN

KOLEN

de Volkskrant van MAANDAG 5 OKTOBER 1964





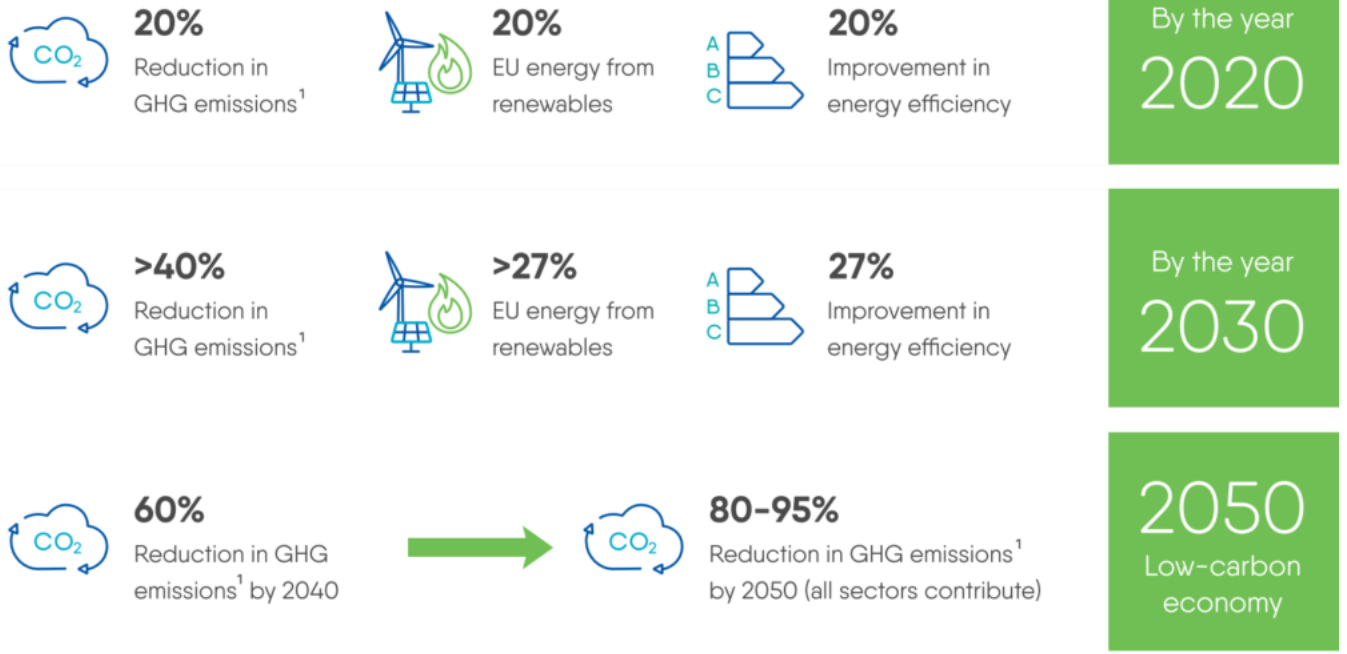
21st century: Energy Transition

- In
  - For the climate
  - For the market
  - For (energy) independence

  - Programmes: Fit-for-55, RePowerEU,

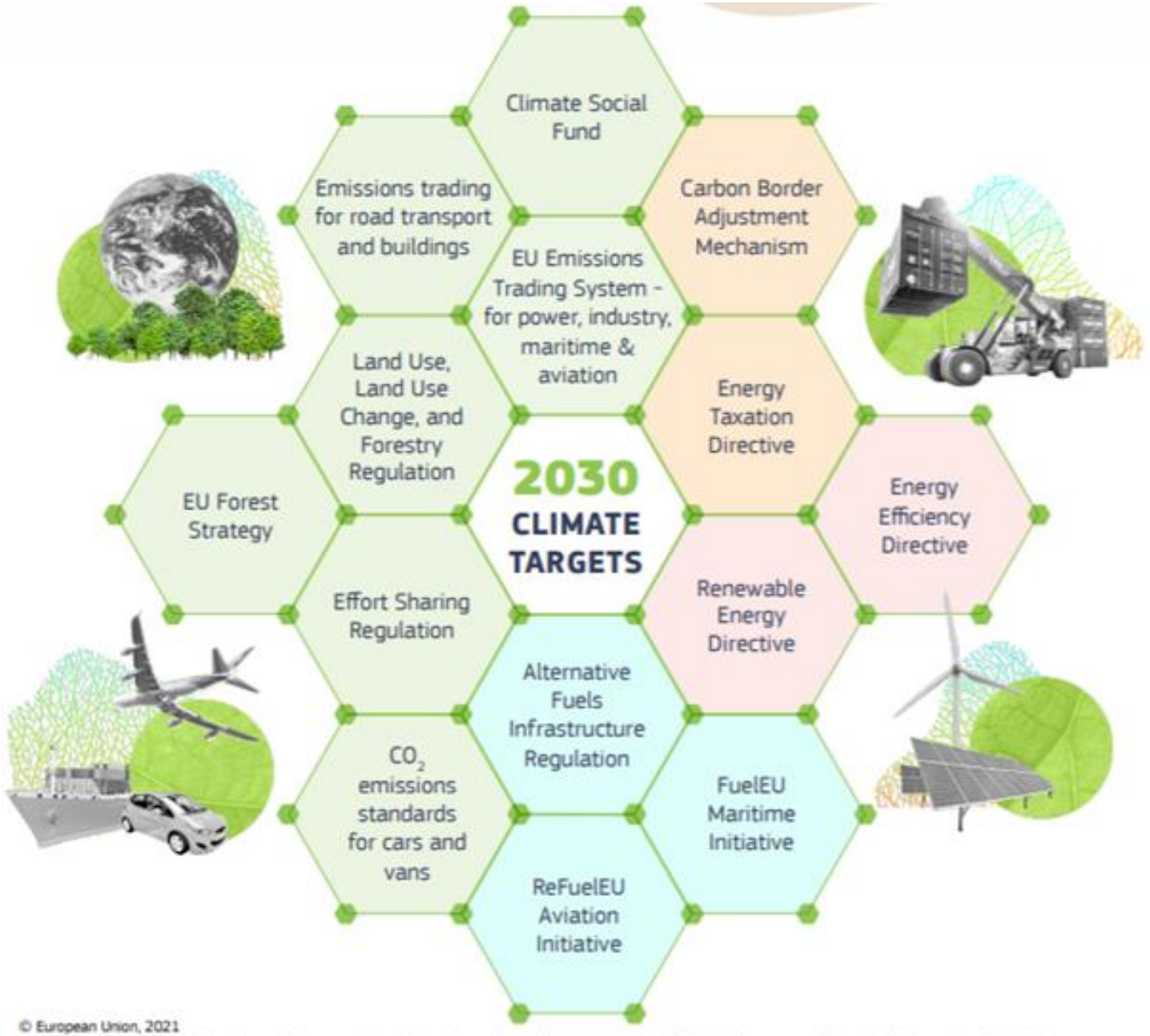
- The rest of the world…
  - Still 840 Million people without power
  - China: transition towards less pollution
  - US: transition thanks to (fracking) gas and cheap renewables
  - Local renewables cheapest source for developing nations

- 2022: US LNG export, gas prices outbid “poor countries”, …



Tougher goals: Fit-for-55

- GHG -55% by 2030
- A package of directives showing the implementation roadmap
- Expansion of the ETS system (=a hidden carbon tax)
- “Just Transition”
  - Distributive justice
  - Procedural justice
  - Recognition justice

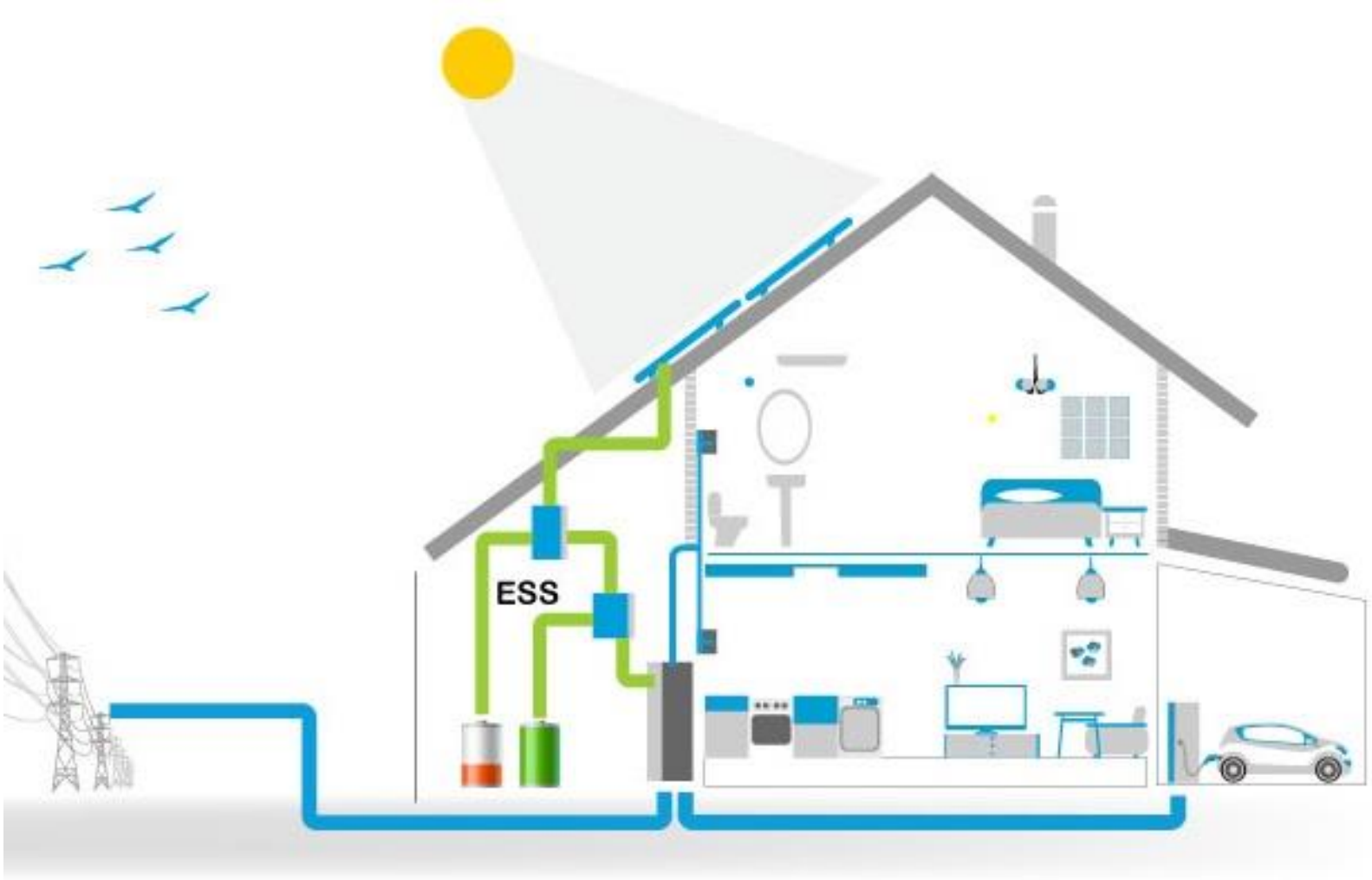


The interest in (LV)DC

A transition in the background?

Prosumers, in smart homes, take centre stage in the energy transition

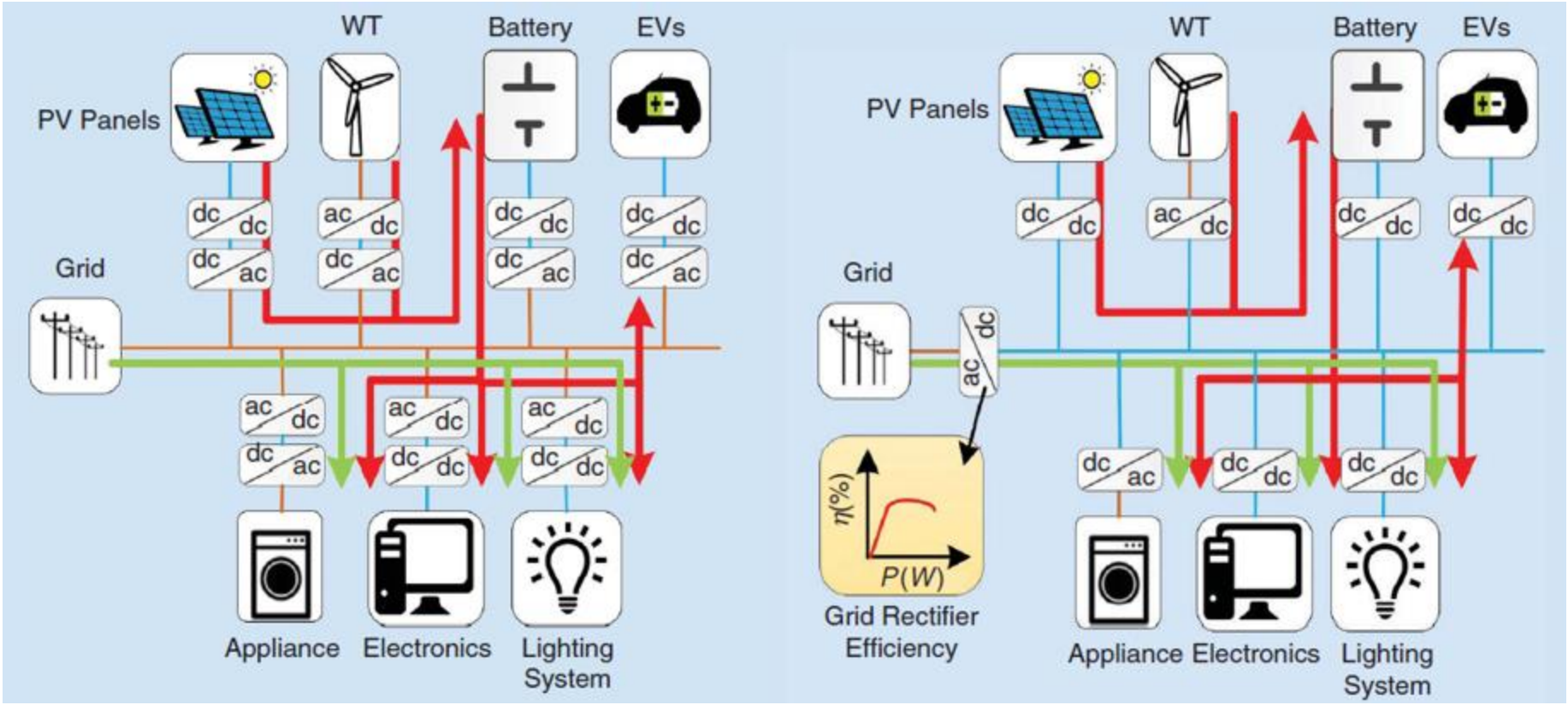
- Automatisation, domotics
- Smart contruction: isolation, daylighting, …
- Smart energy systems: PV, battery, heat pump, flexible loads, …



Introduction

AC grid

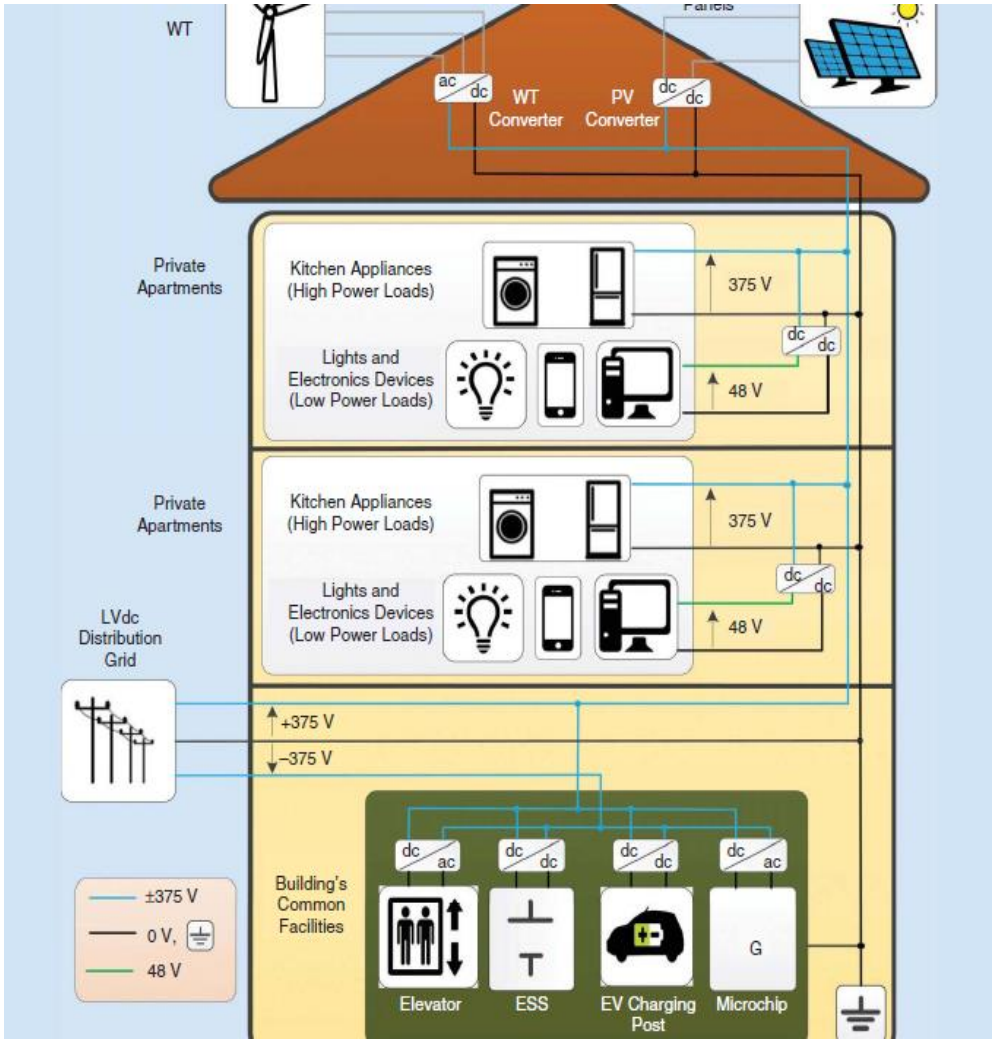
DC grid



[1]

Advantages of LVDC technology in a nutshell

- Increased level of compatibility
  - Efficiency gains (5-15%pt savings)
  - Easy storage integration
  - Upfront cost savings (-30%)
  - Material resource savings
  - Reliability improvement
- Increased power transfer capability (voltage level dependent)
  - Upfront cost savings
  - Material resource savings



LVDC research at EnergyVille

Vision and Mission

Vision

At EnergyVille, we strongly believe that **bipolar LVDC grids** will play an essential role in **commercial buildings and districts** to **facilitate** the integration of on-site renewable generation and energy storage at a **lower total cost of ownership**.

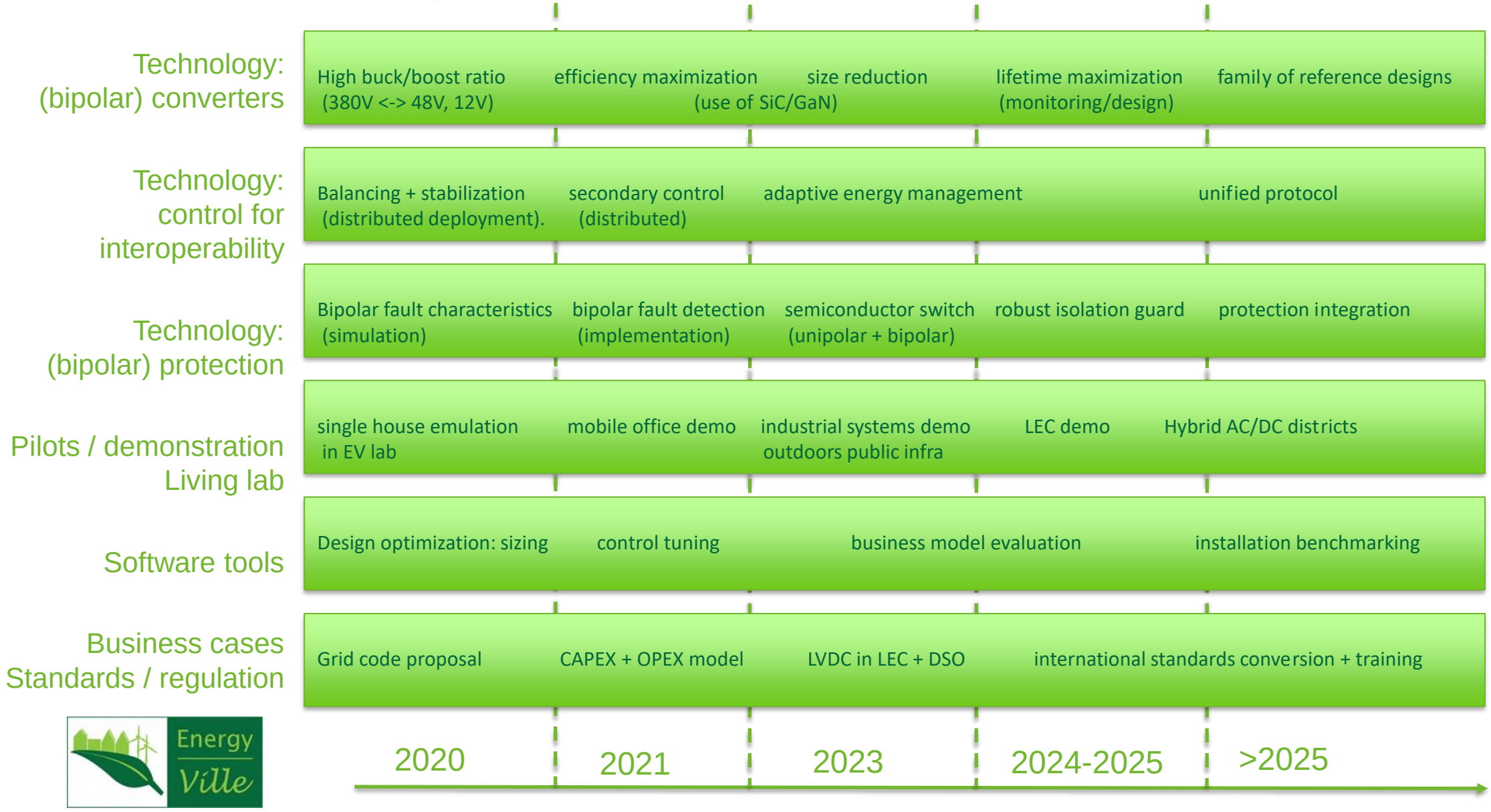
Mission

Our mission is to provide and further develop device- and system-level expertise on LVDC networks regarding the primary functionalities encompassing voltage control, protection, network configuration and interoperability.

Key challenges

- System-level voltage stability
- Protection of LVDC systems
- Converter design & interoperability
- Training
- Standardization

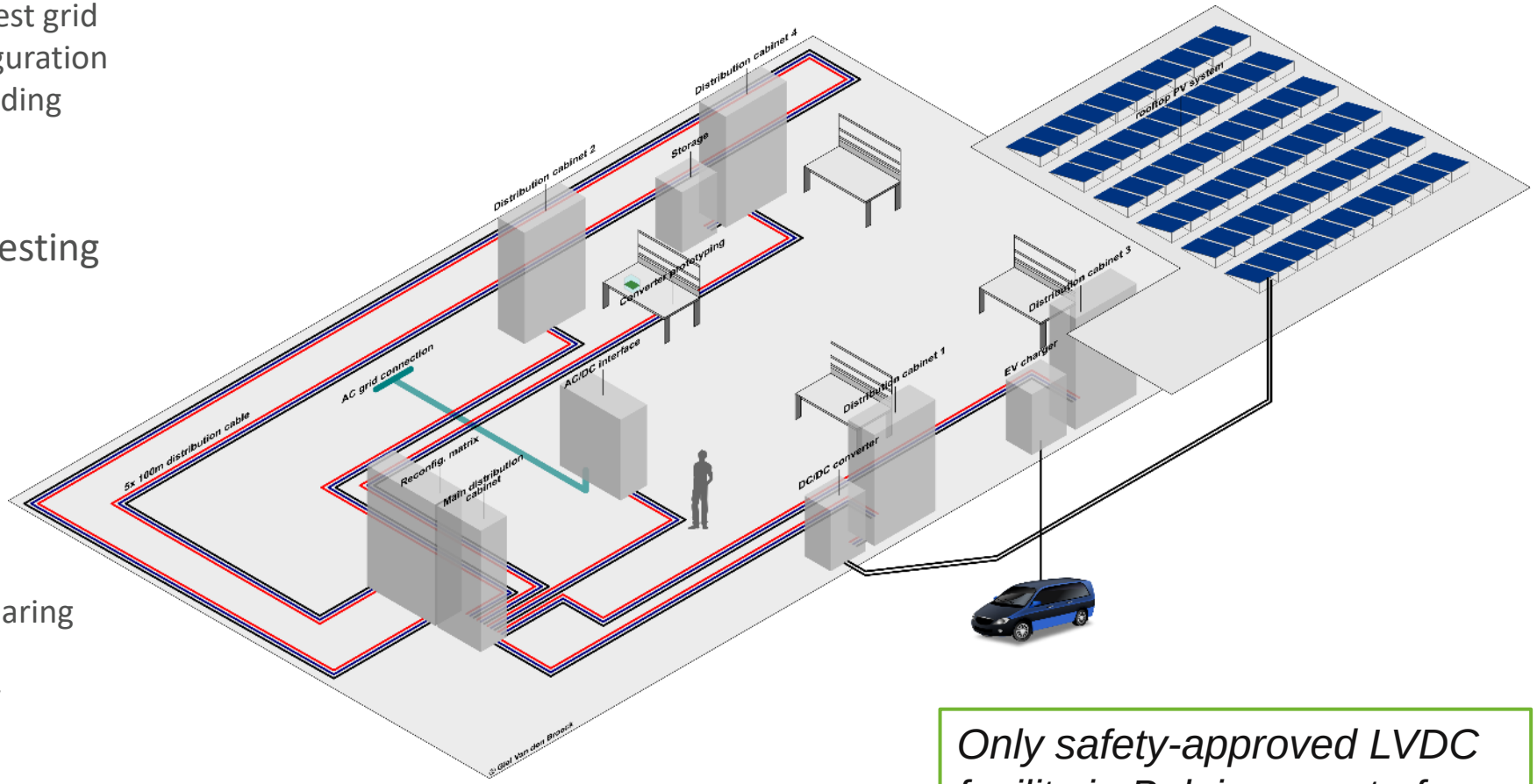
LVDC roadmap 2020-…



Low-voltage DC test facility

A ±500V bipolar DC test grid

- **Reconfigurable** lab infrastructure
  - 100 kW up to ±500V DC test grid
  - Unipolar and bipolar configuration
  - TN-S grounding or IT grounding
- Power flow monitoring
- Voltage measurements
- Power electronic converter testing
- Connected to other labs
  - Rooftop PV test site
  - Battery laboratory
  - EV Parking
- Connection to EV2 building ("DC LEC")
- Tests
  - Voltage stability - power sharing
  - Protection systems
  - Equipment interoperability
  - Efficiency assessment

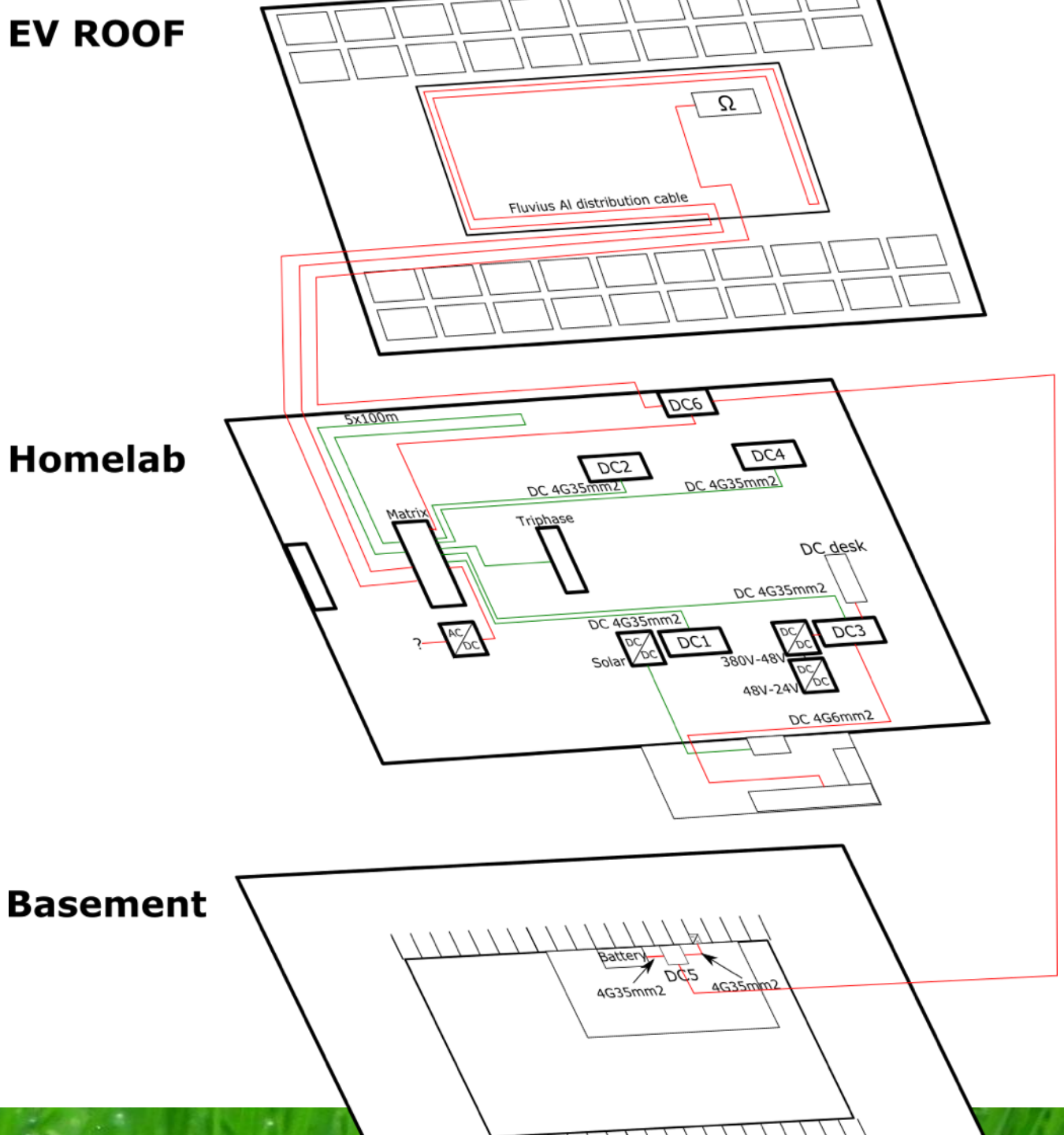


Only safety-approved LVDC facility in Belgium, part of "sandbox regulatory regime"

EnergyVille Demonstrator

Layout

- Setup across 3 levels of EnergyVille1
- Addition of Al distribution cable
- Expandable DC grid to office rooms
- Expandable DC EV charging



Green: Existing Cables
Red: New Cables

Electric Mobility

Challenge: integration of charging

What is wrong in this picture?

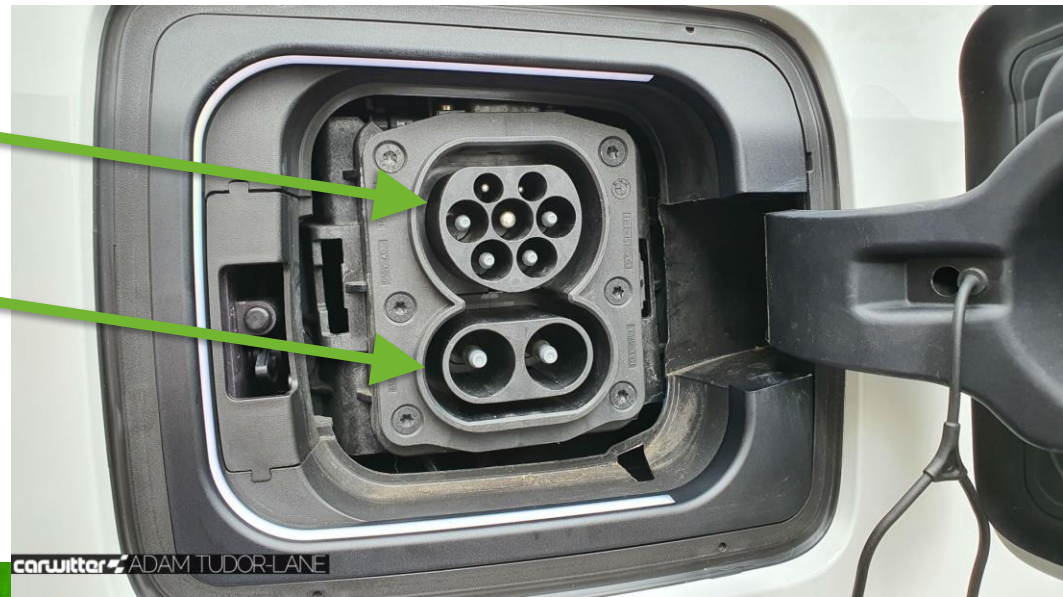
How to charge?

AC

- Up 22 kW
- AC single/three-phase on grid
- Power can be modulated
- E.g.: 200 kWh battery: 9h charging

DC

- 50 – 350 kW
- DC 400 – 800 (– 1250V); needs rectifier
- For high-power or “opportunity charging” (e.g. along high-way) ?



Large-scale EV charging architecture (from AC to DC) – ICON Hume project

➢ AC based architecture (low power)

Advantages: mature protection devices, standardized metering, etc.

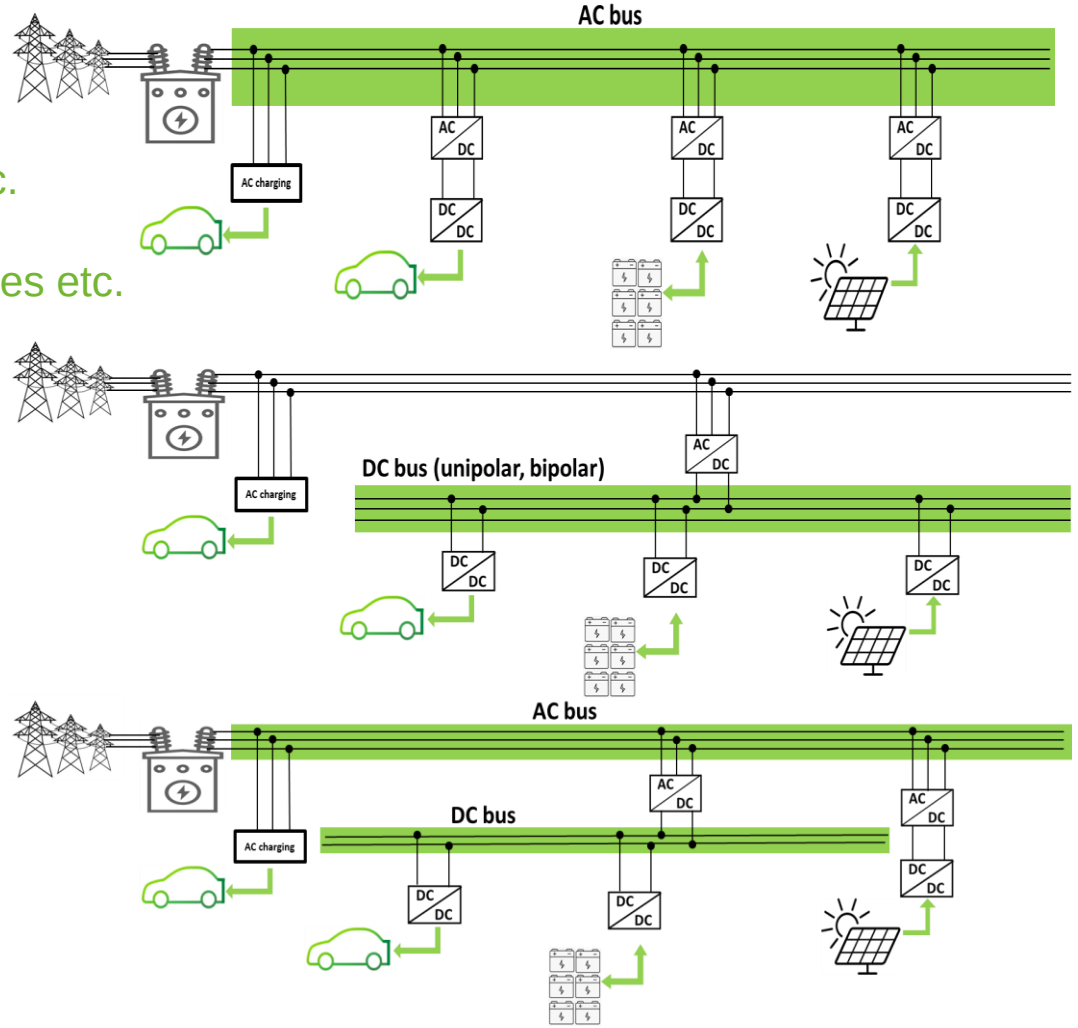
Challenges: complex control, more conversions, power quality issues etc.

➢ DC based architecture (low + high power)

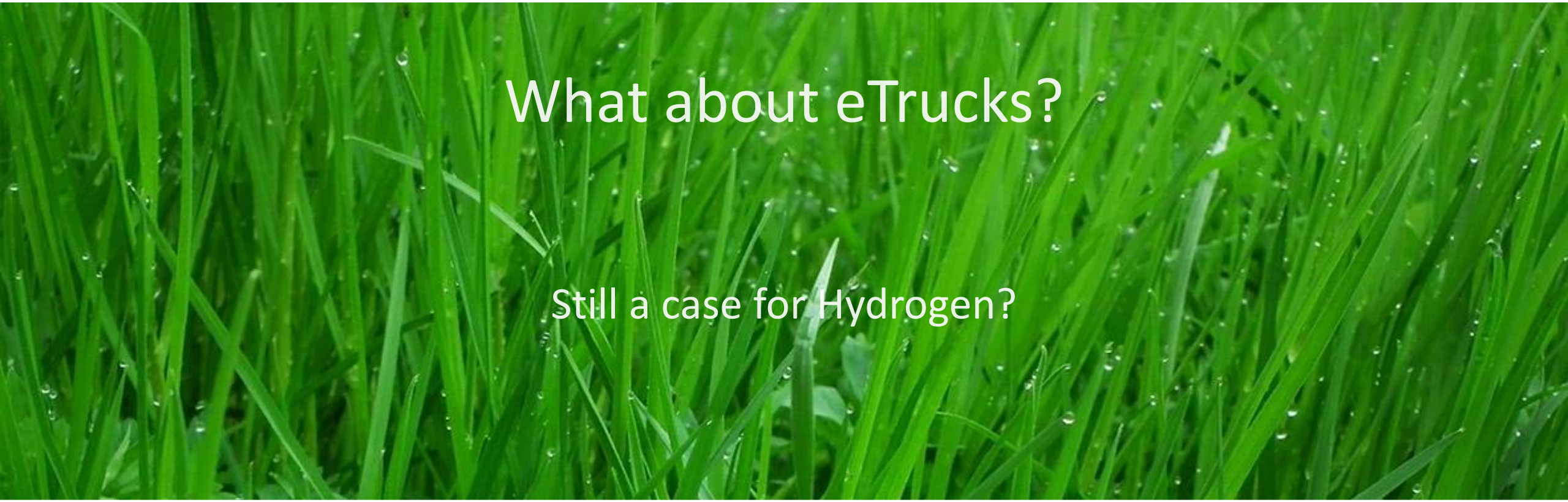
Advantages: simple control, less conversions, more power with less conductors (bipolar DC), less power quality issues etc.

Challenges: complex protection, non-standardized metering, capacitive nature, etc. + efficiency?

➢ AC and DC based architecture



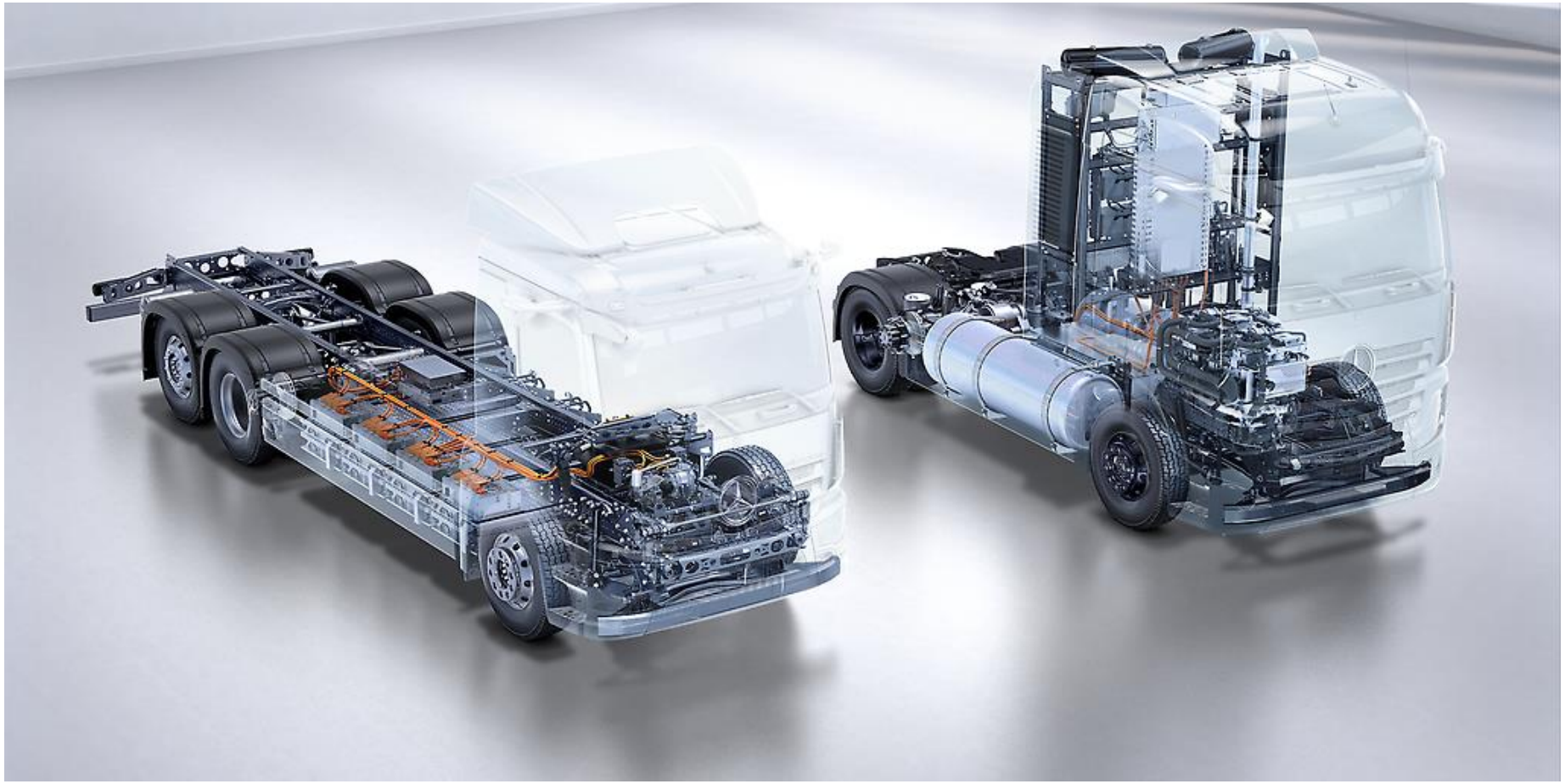
What is the most suitable architecture for public charging (office, commercial sites, hotel etc…)?



What about eTrucks?

Still a case for Hydrogen?

Modern “clean” truck technologies

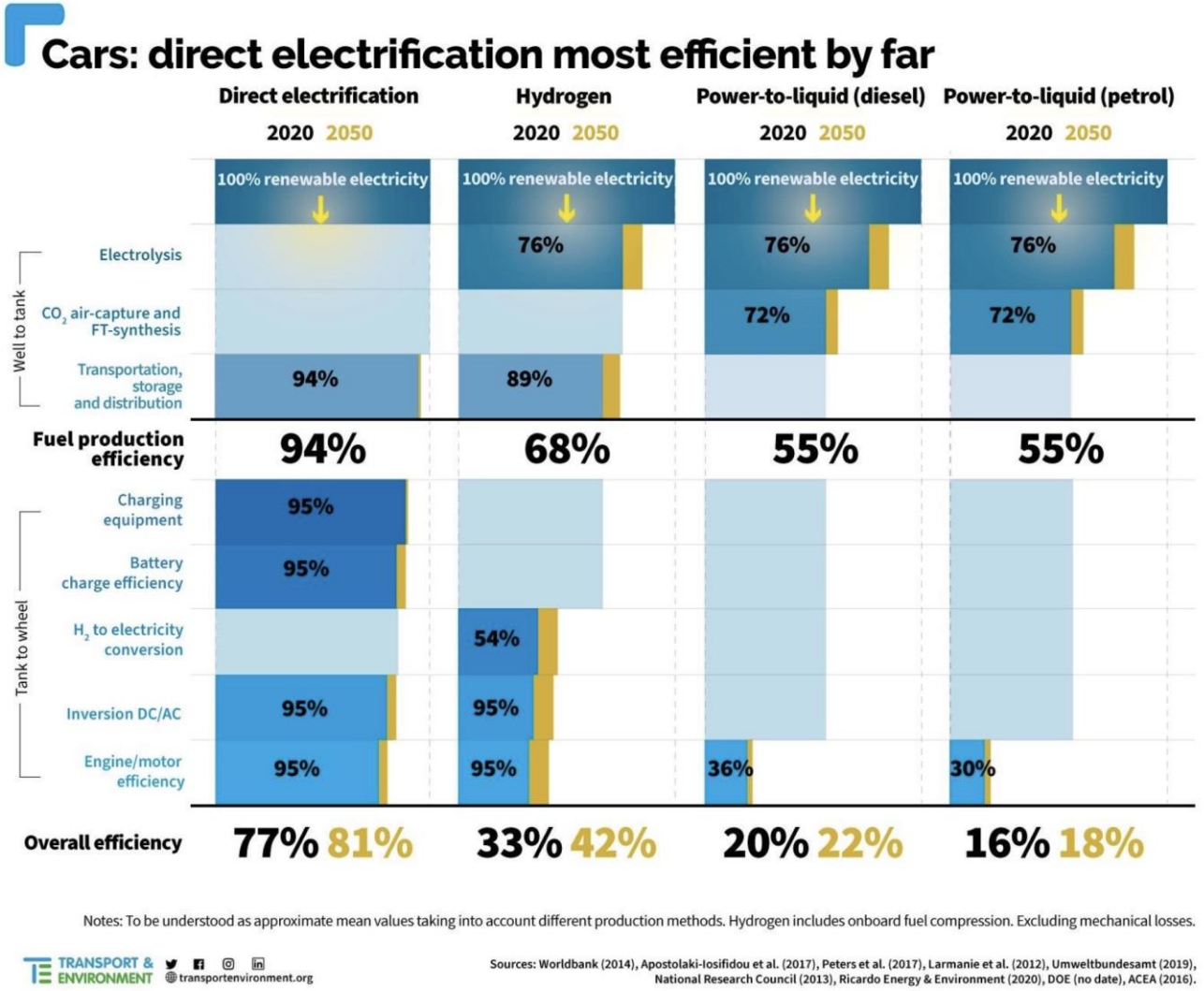


Daimler

Battery-electric powertrain (**BEV**)

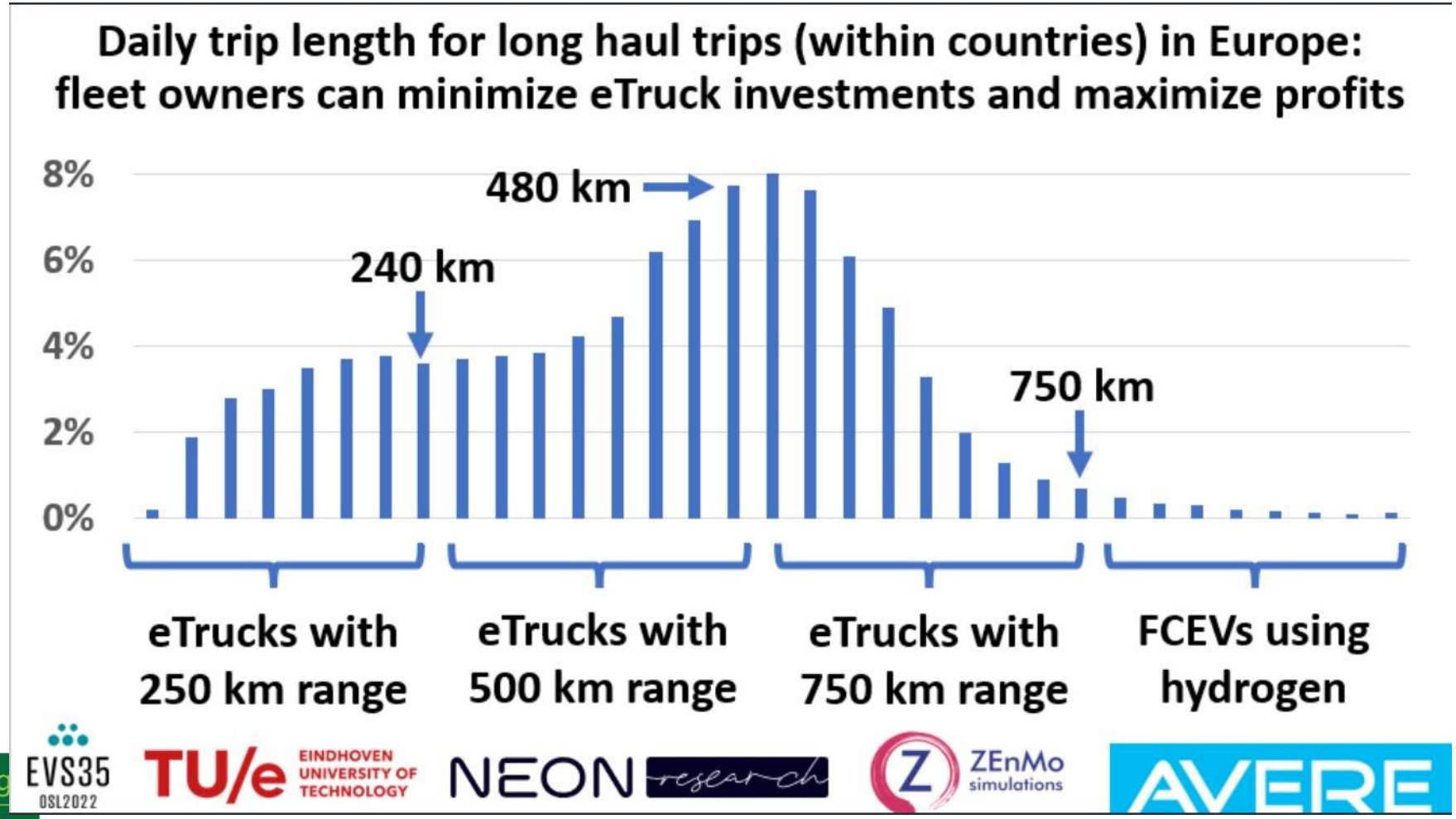
Hydrogen-electric powertrain using fuel cells (**FCV**)

“Well-to-wheel” efficiency of vehicles: put your system boundaries wide enough



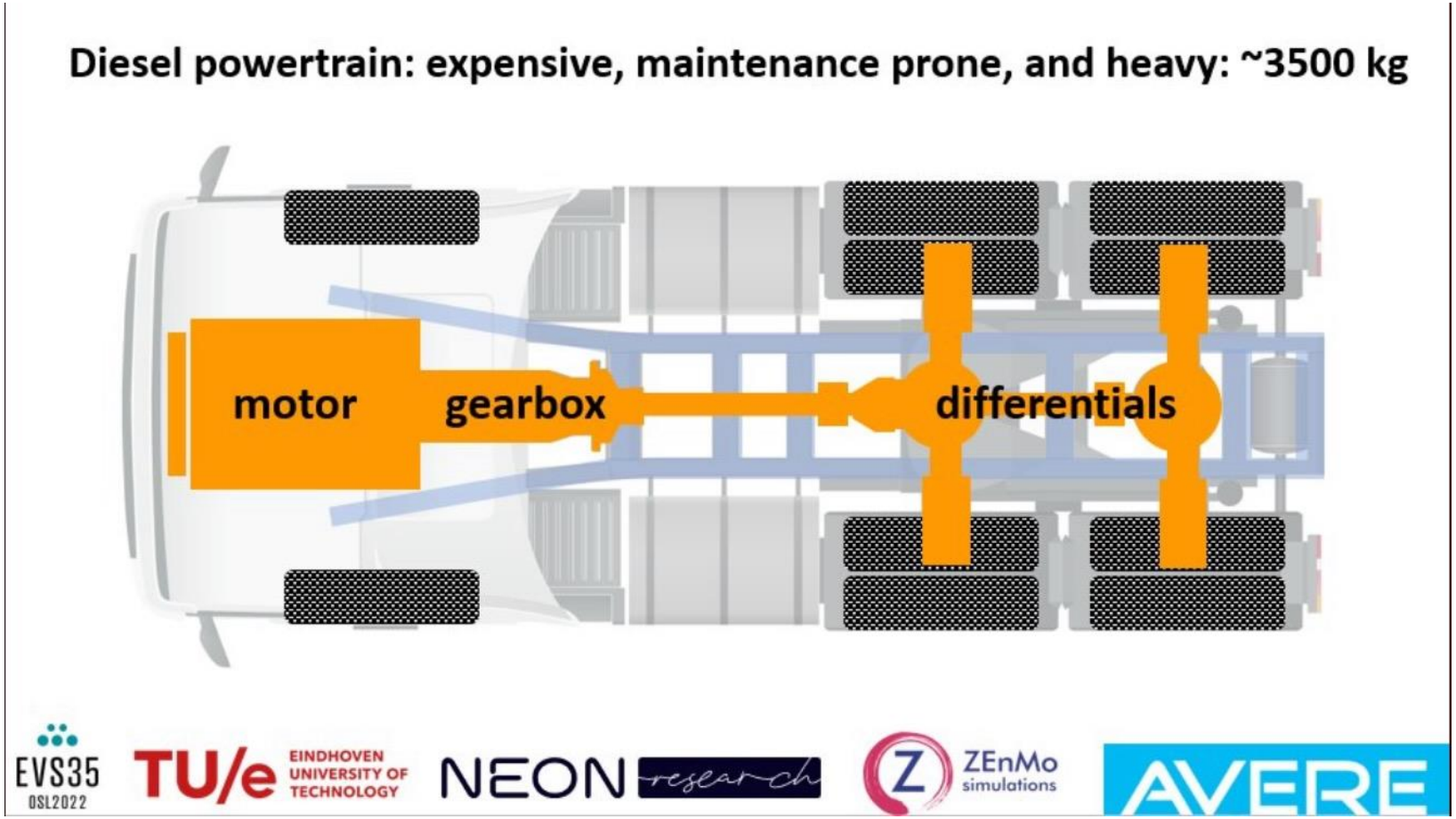
Energy Ville

Future fleets?



A.Hoekstra

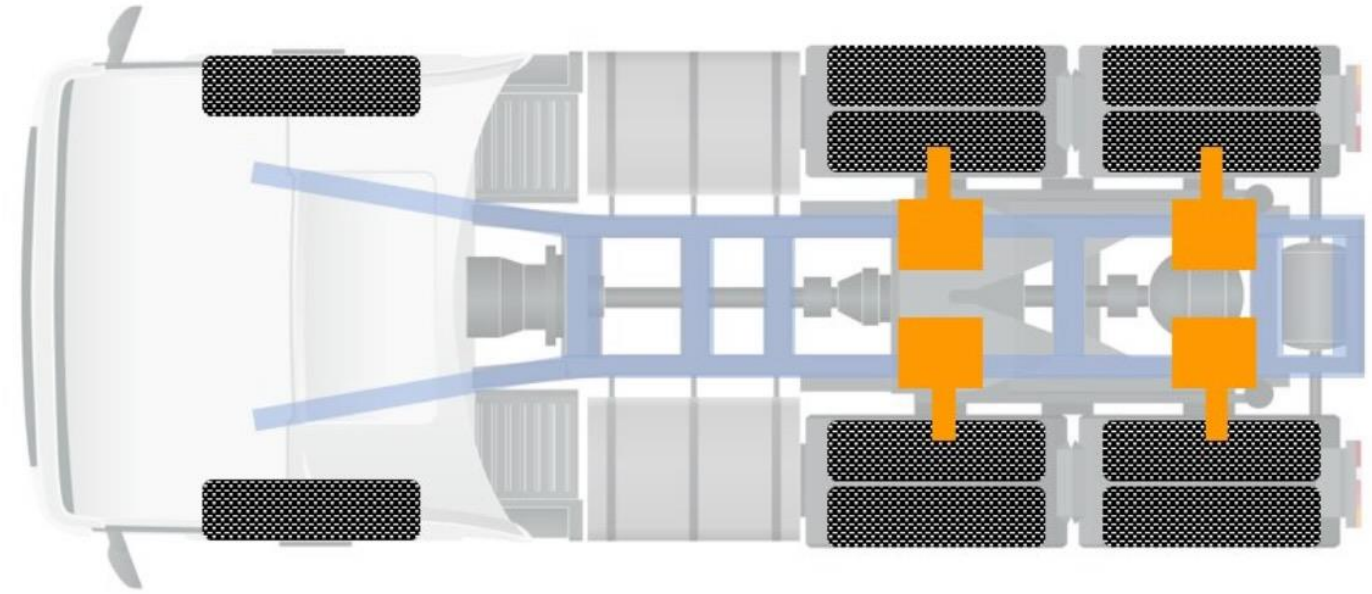
Generations of e-truck



A.Hoekstra

Generations of e-truck

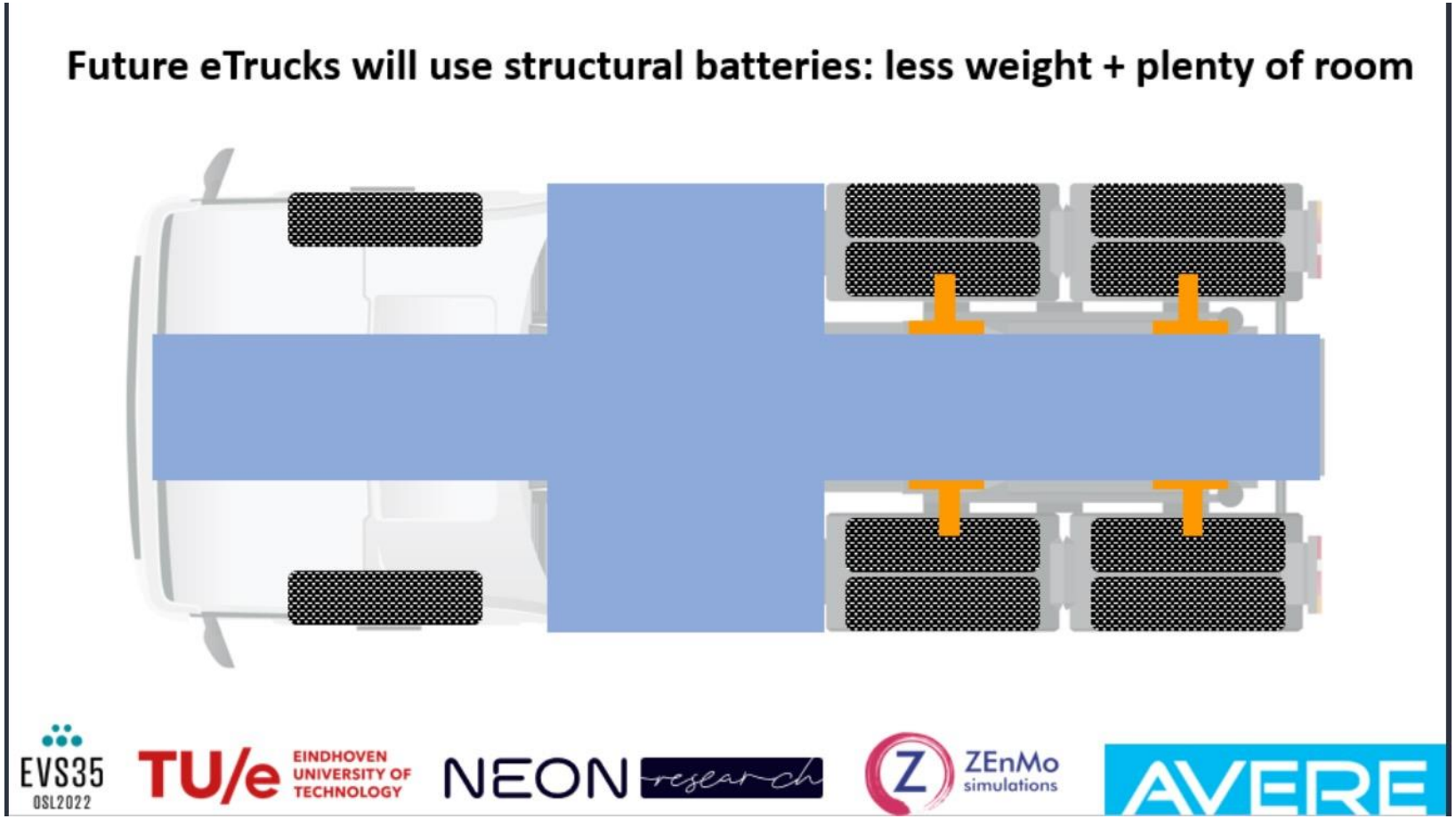
Real electric truck: motors close to the wheels is all that's left



EVS35 OSL2022 TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY NEON research ZEnMo simulations AVERE

A.Hoekstra

Generations of e-truck



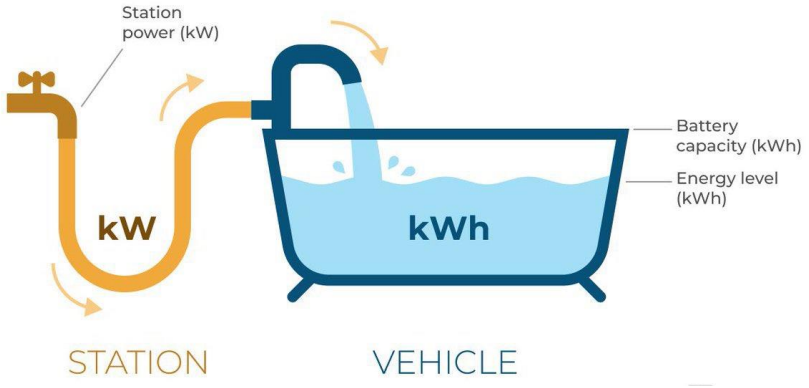
A.Hoekstra

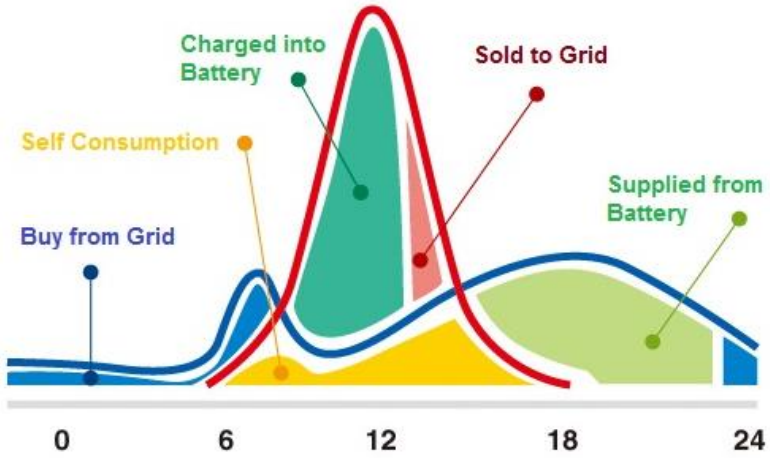
Specific for (heavy) trucks: MCS

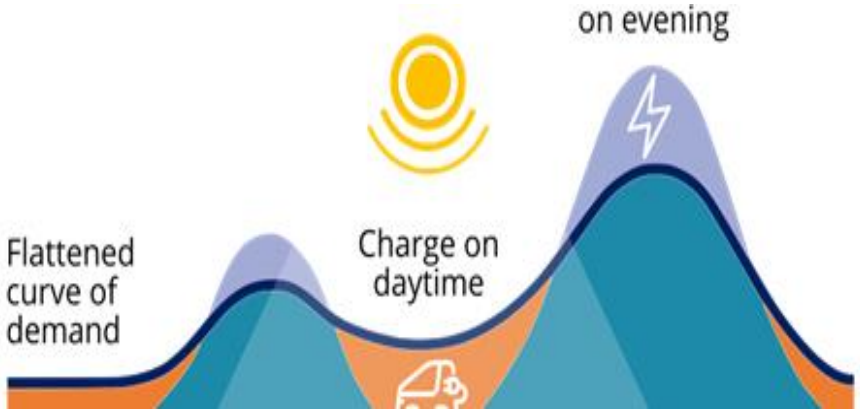
- Megawatt Charging System (MCS)
  - Max 1.250 V & 3.000 A (DC)
  - Power: 1 - 2 - 3,75 MW

Integration of charging on site

- Charging need
  - Energy: how much kWh is needed
  - Power: how fast is it needed (kW)
- When ?
  - Flexibility from truck
    - Overnight?
    - During reloading between round?
    - Predictable?
  - Flexibility from source
    - Self-consumption is cheapest + low-risk
      - Direct
      - Indirect (battery needed)
    - Remaining power from grid
      - Peak?
      - Contract?
- V2G (bidirectional): is there a business case?
- Regulatory challenge







Sustainable logistic centres: the case for a microgrid?

- Without eTruck
  - Maximal PV on roof
    - Problem with weak roofs?
  - PV: towards E-W orientations
  - Problem with distribution grid: bottleneck!
  - Passive, limited self-consumption
    - Activate flexibility
      - E.g. flexible cooling load
      - Consider battery unit?

- eTruck ready
  - Which charging profiles?
    - Truck rotation
    - Truck scheduling
  - AC (low-power) and/or DC (high-power) ?
    - Case for LVDC microgrid technology
  - Batteries to *increase* self-consumption
    - Day: PV – Night: charging
    - Peak power management
    - Battery capacity (spare) can be contracted for grid services

Some final thoughts

Energy transitions happen all the time.
We always win in the end.

- System thinking: look at the bigger picture
- Individual optimum vs. collective optimum
- New technologies help integration
- New business models are needed
- Don’t forget to communicate, create trust


Thank You