

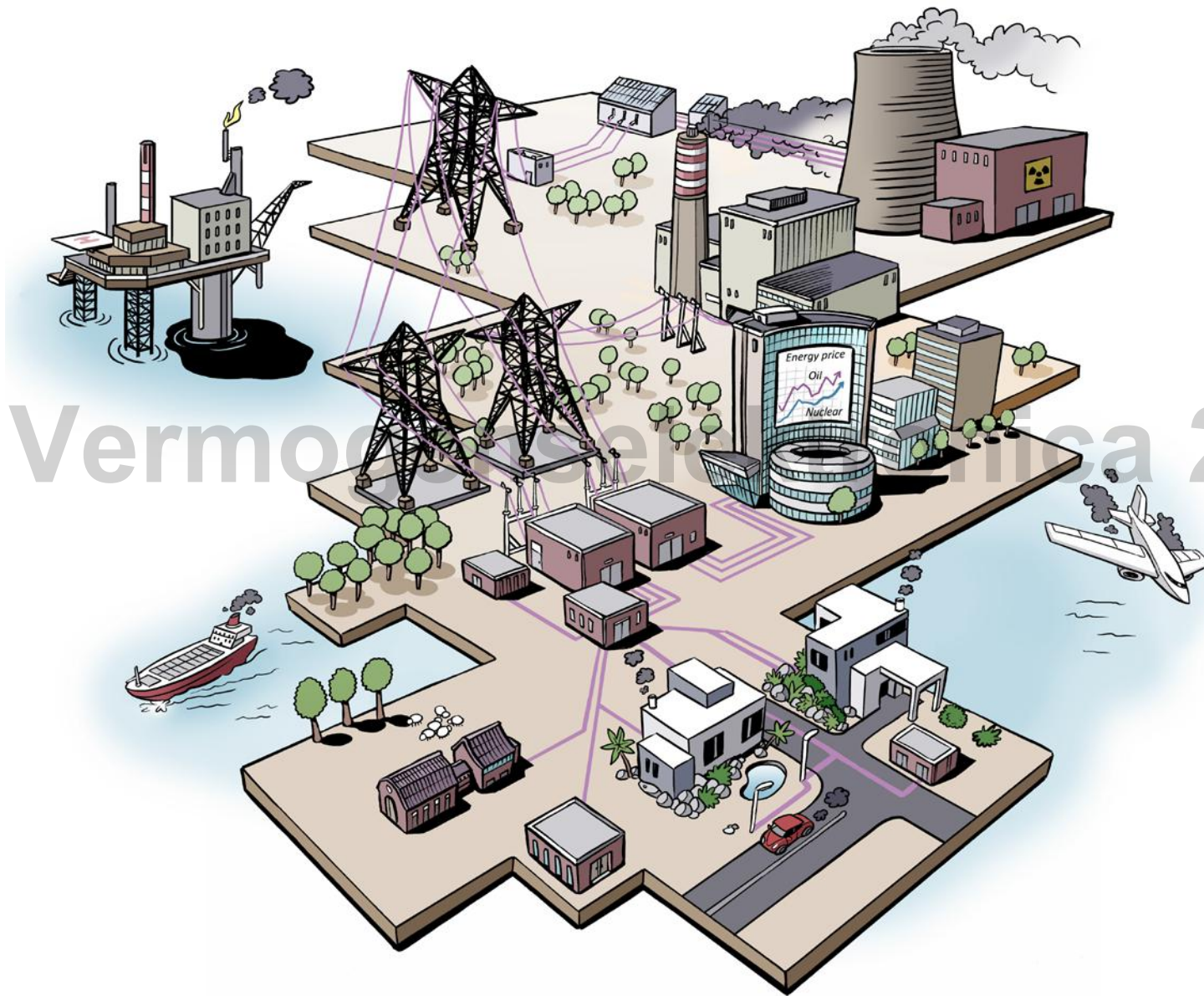
# ‘How direct will the future electricity be?’

## Vermogenselektronica 2017

prof.dr.ir. P.Bauer

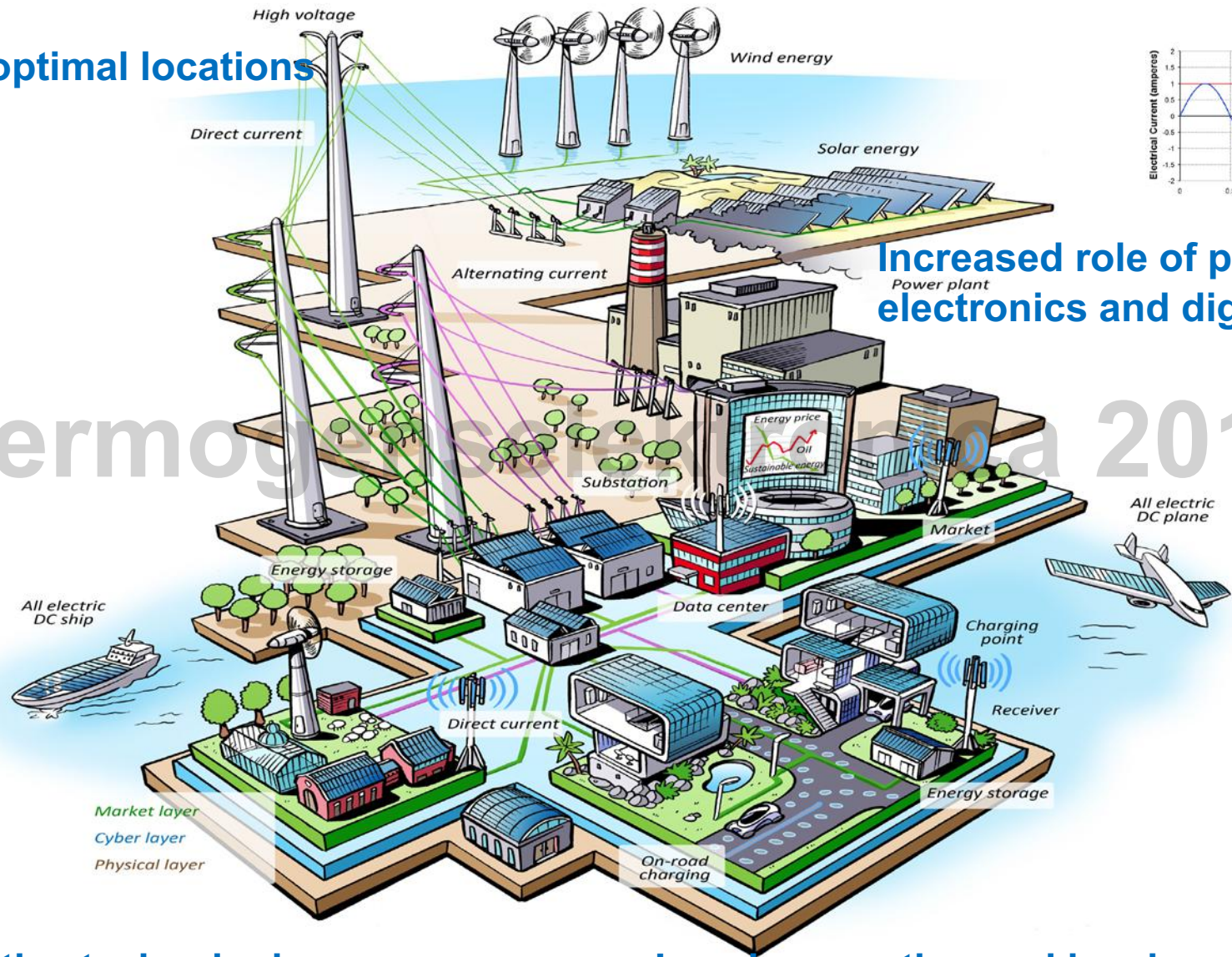
Hoogleraar DC Systems, Energy Conversion & Storage

20 juni 2017



Vermogen & Energie 2017

RE at optimal locations



Increased role of power electronics and digitalization

Vermogen 2017

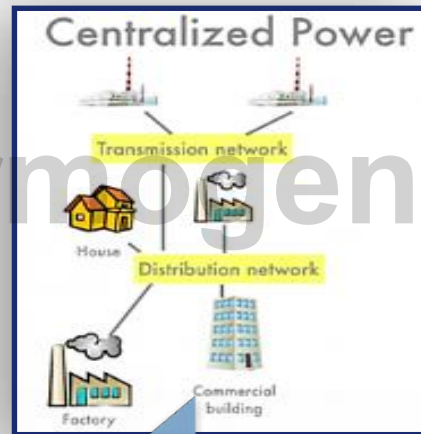
Disruptive technologies

Local generation and local consumption

## ‘How direct will the future electricity be?’

- Renewable energy at optimal locations such as wind offshore in the north sea and solar in the south connected via HVDC
- Local generation and local consumption - Smart cities, Evs and storage
- Increasing role of Power Electronics and Digitalization in all voltage levels,

# Renewable Energy at Optimal Location and Clean Local Power



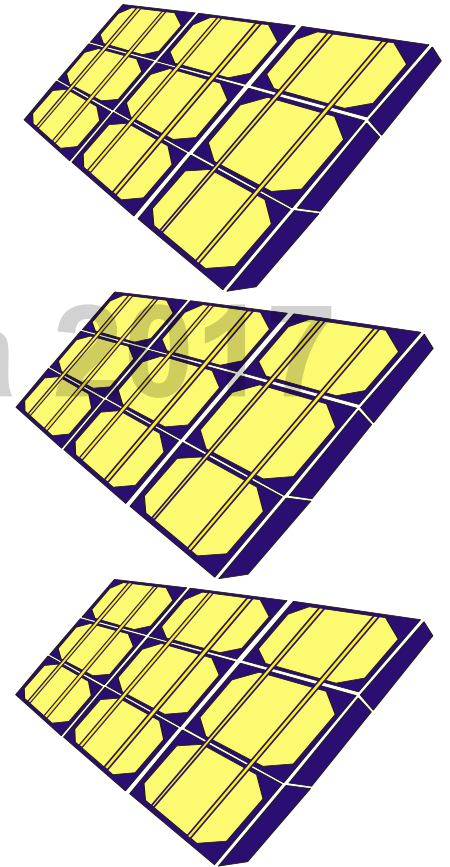
Source: Friends of Supergrid

Yesterday

Tomorrow

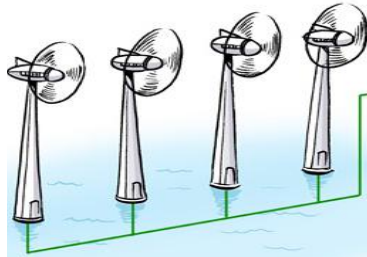
Adapted from: <http://www.ilsr.org>

# Energy for Netherlands ?

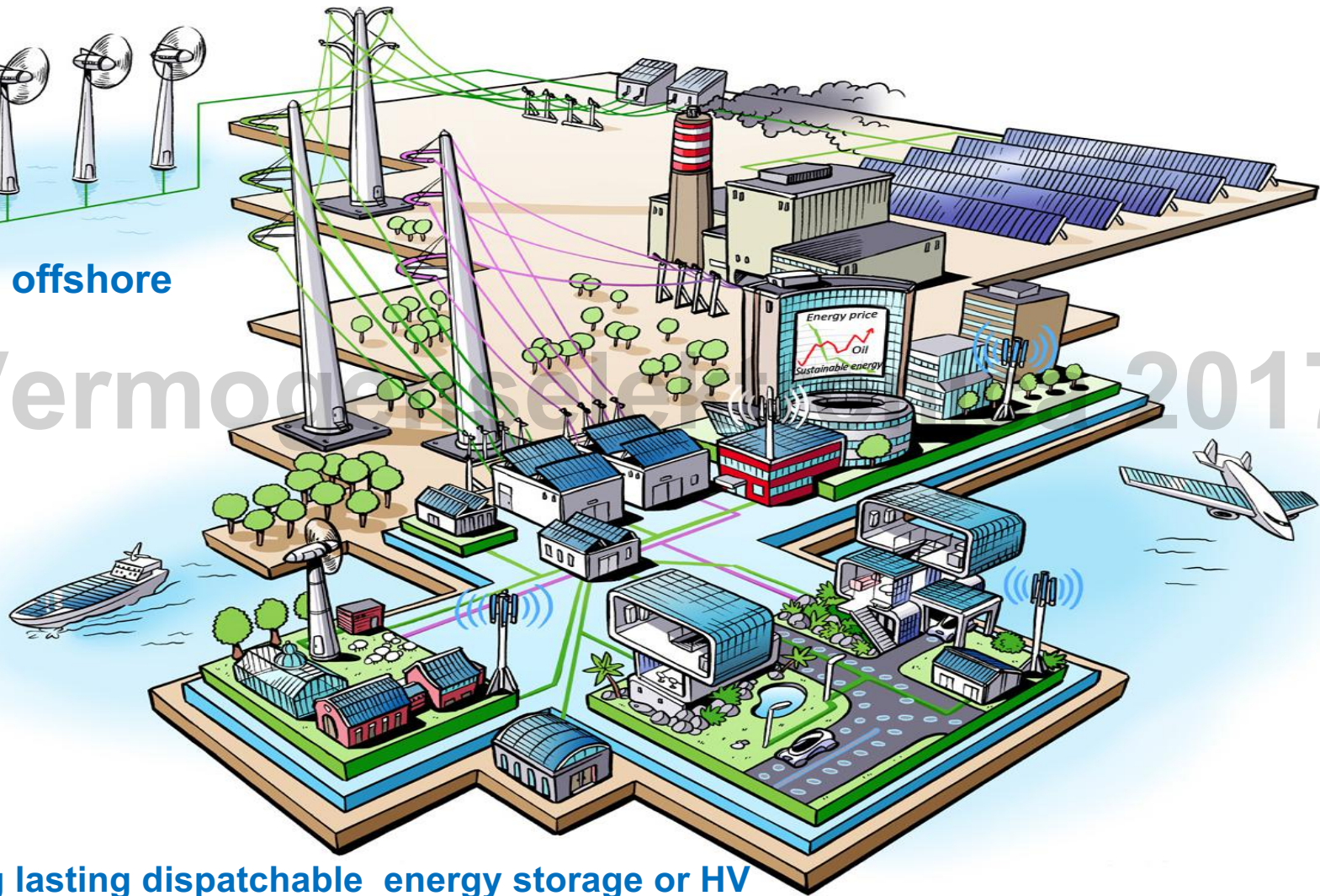


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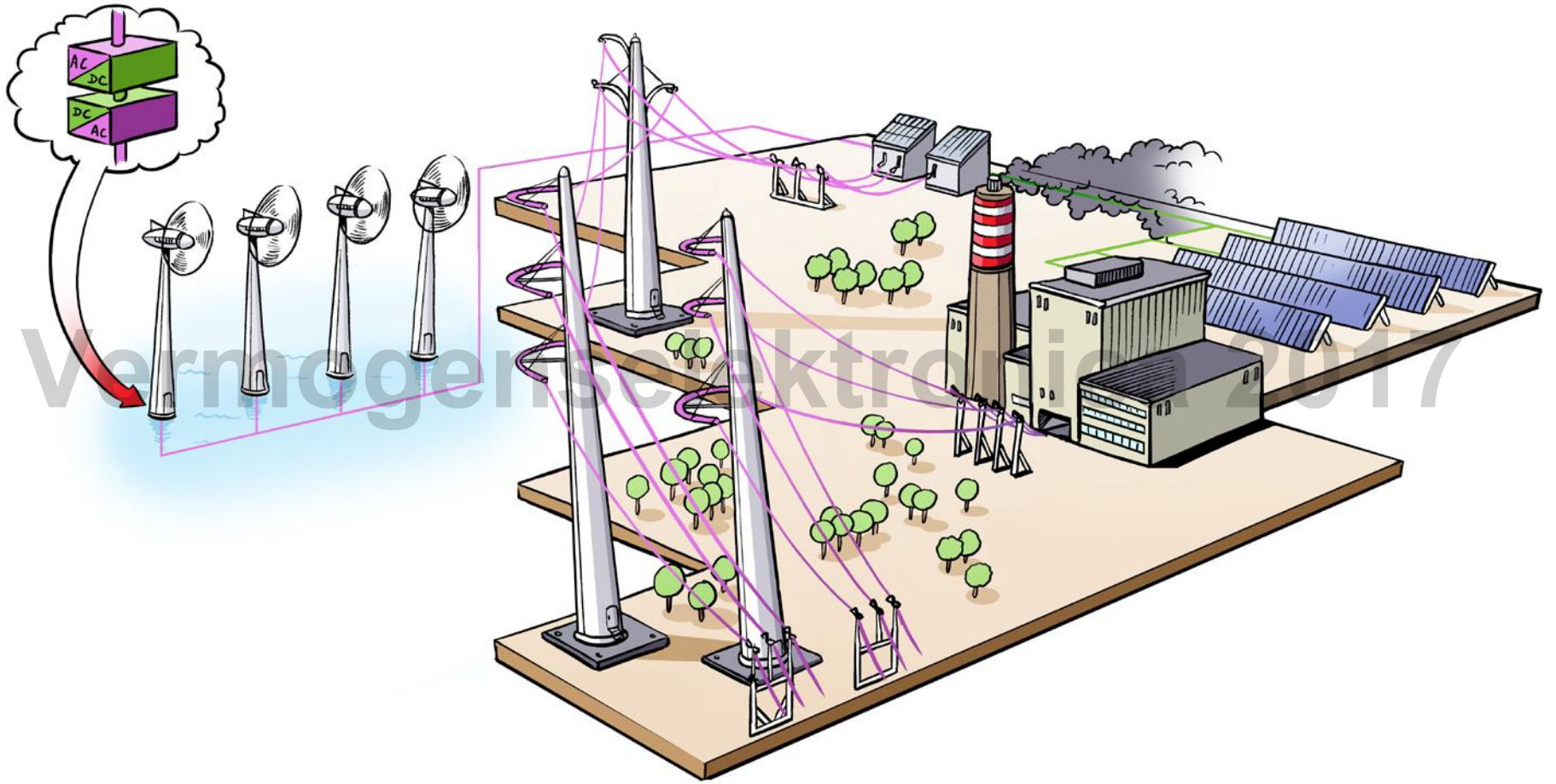
## RE at optimal locations



## Wind offshore

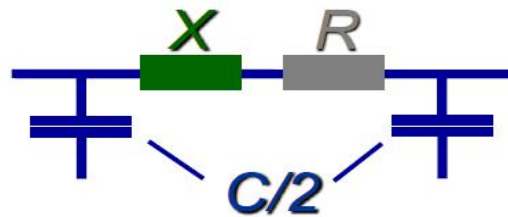
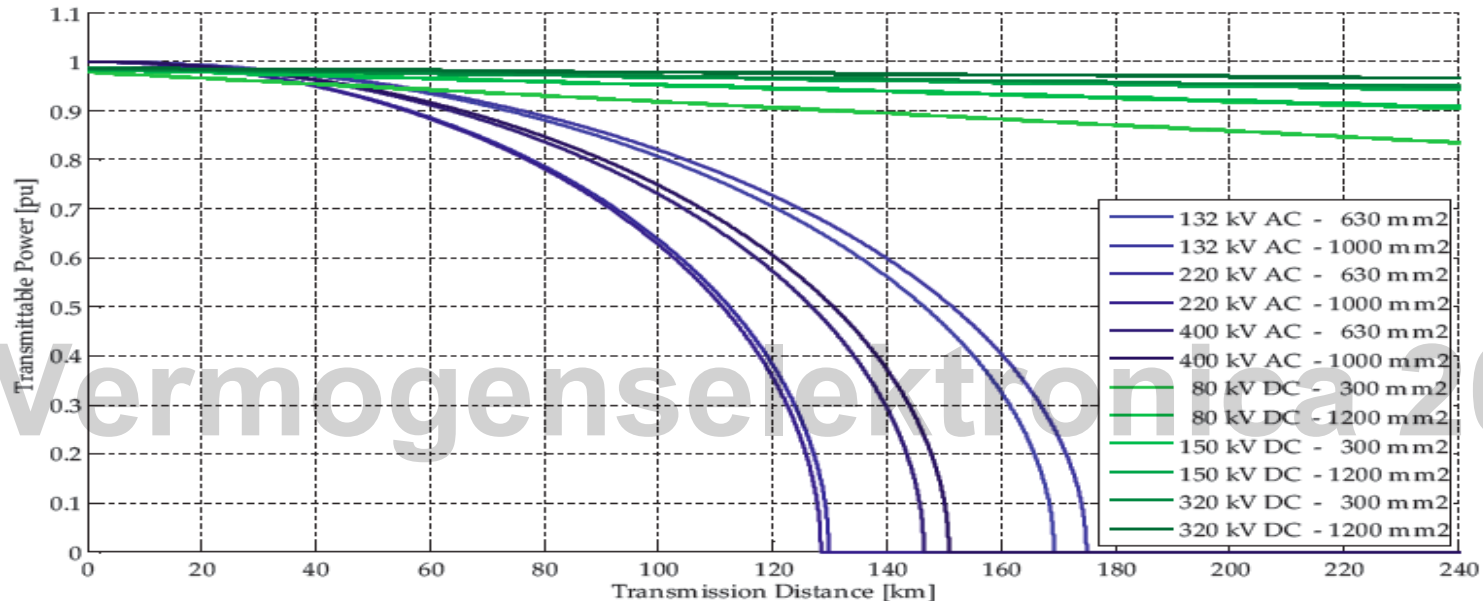


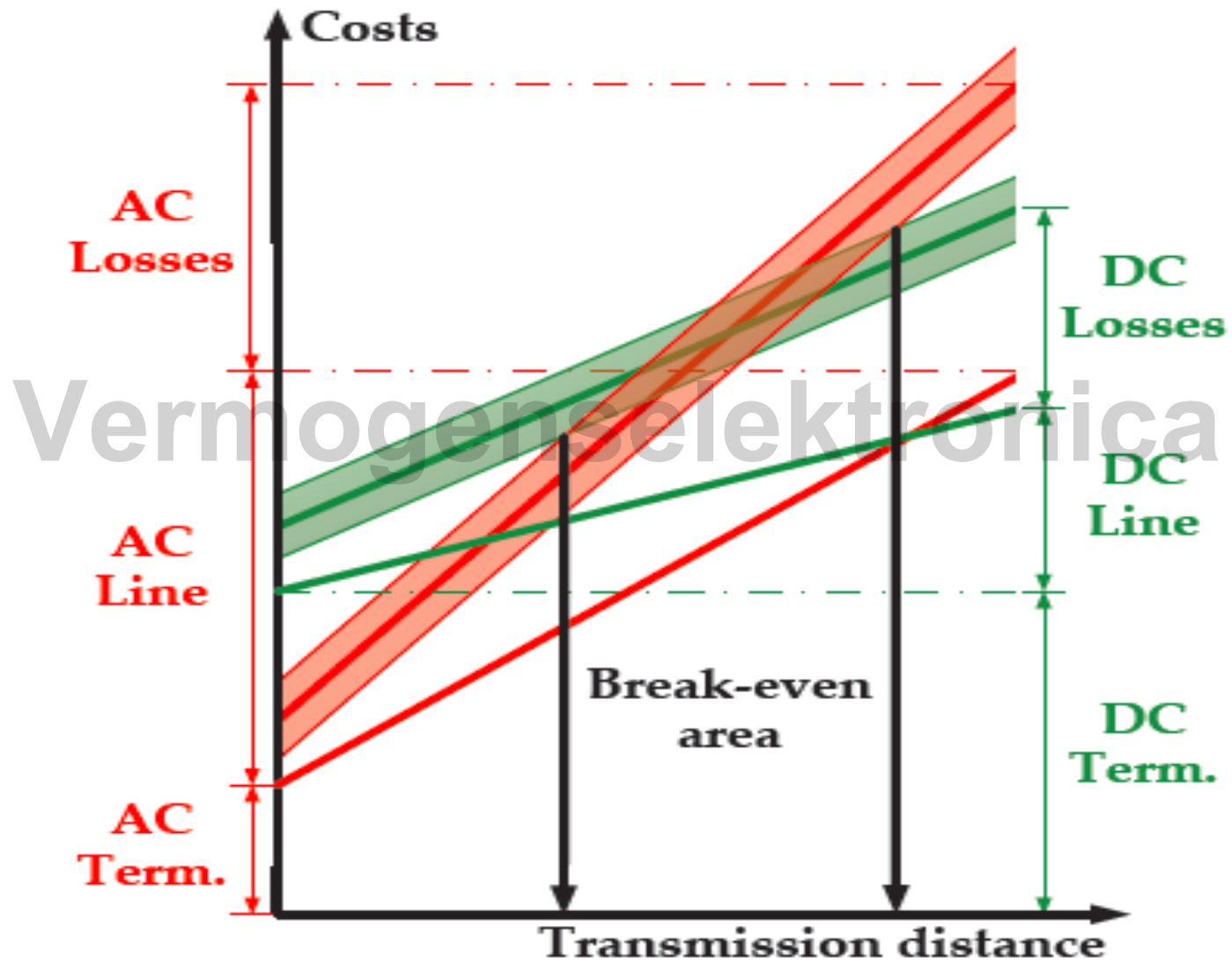
Long lasting dispatchable energy storage or HV lines



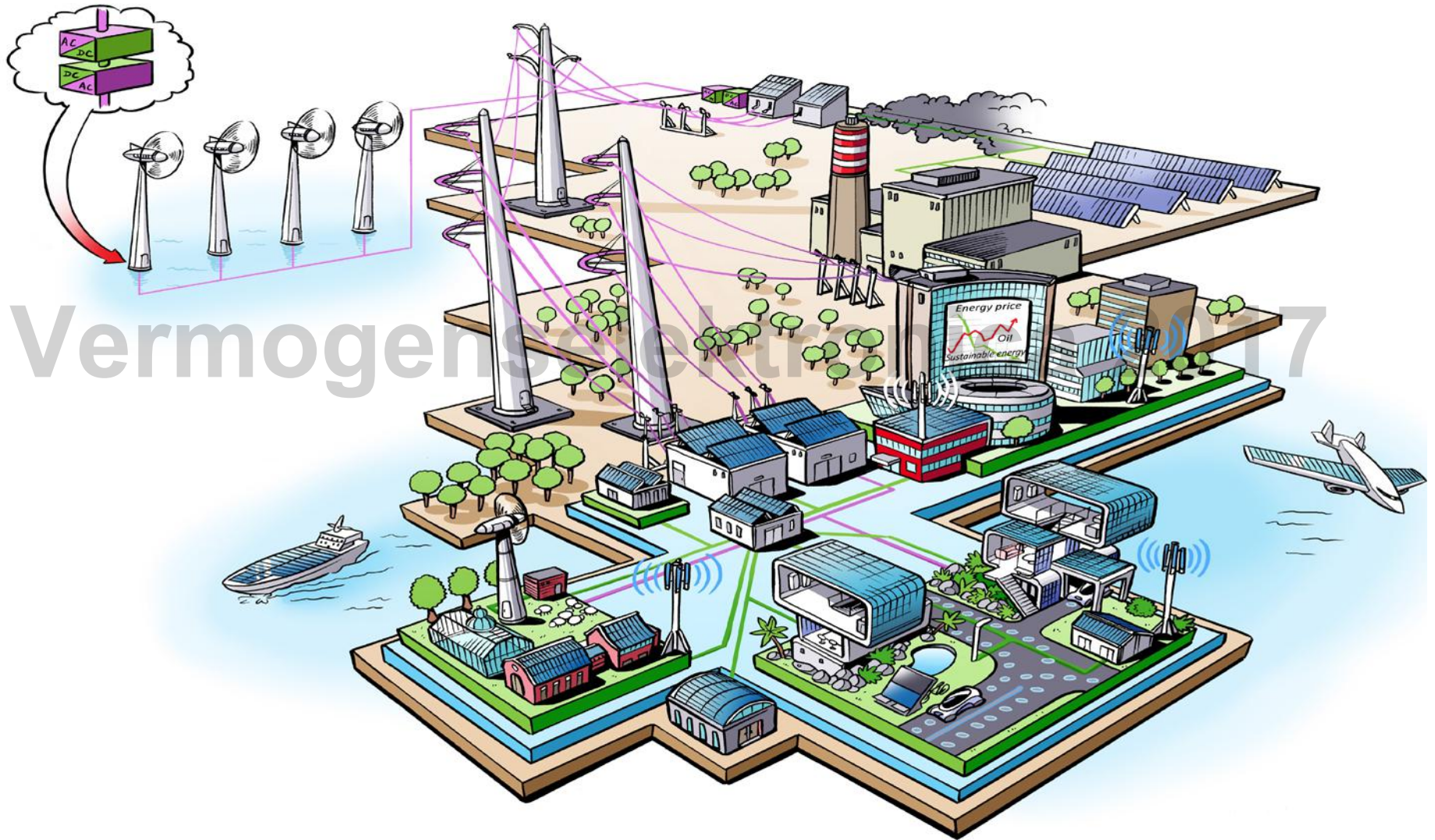


# AC versus DC HV cable





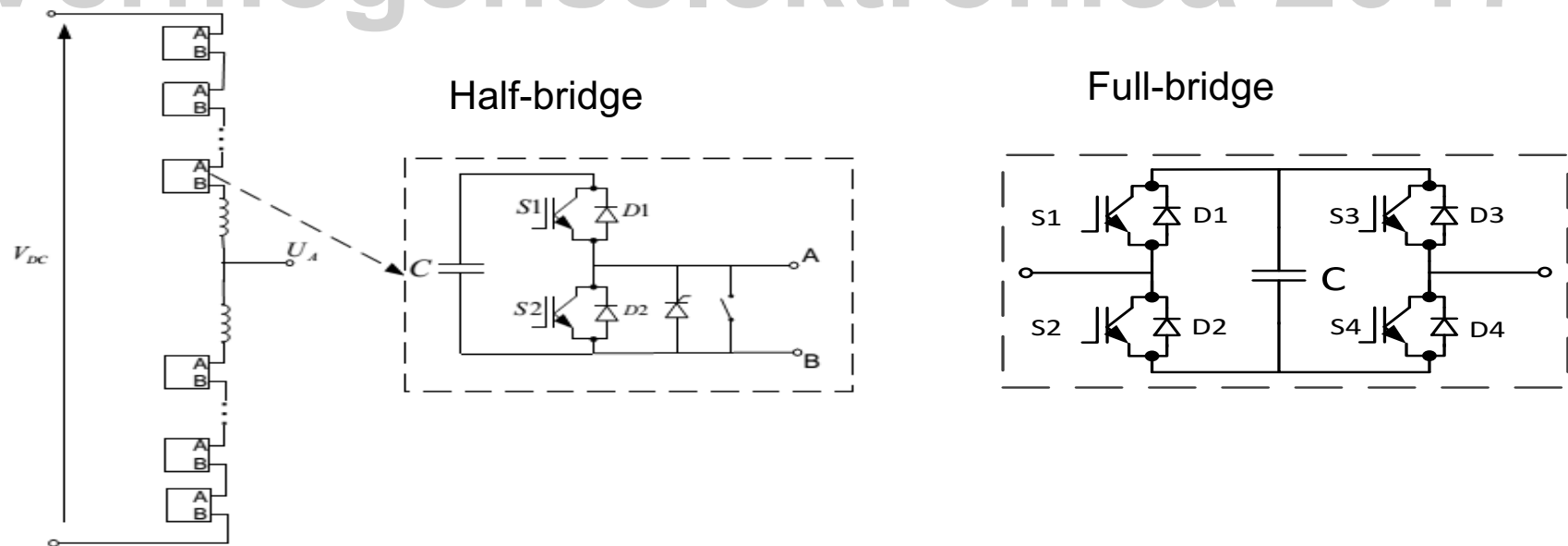
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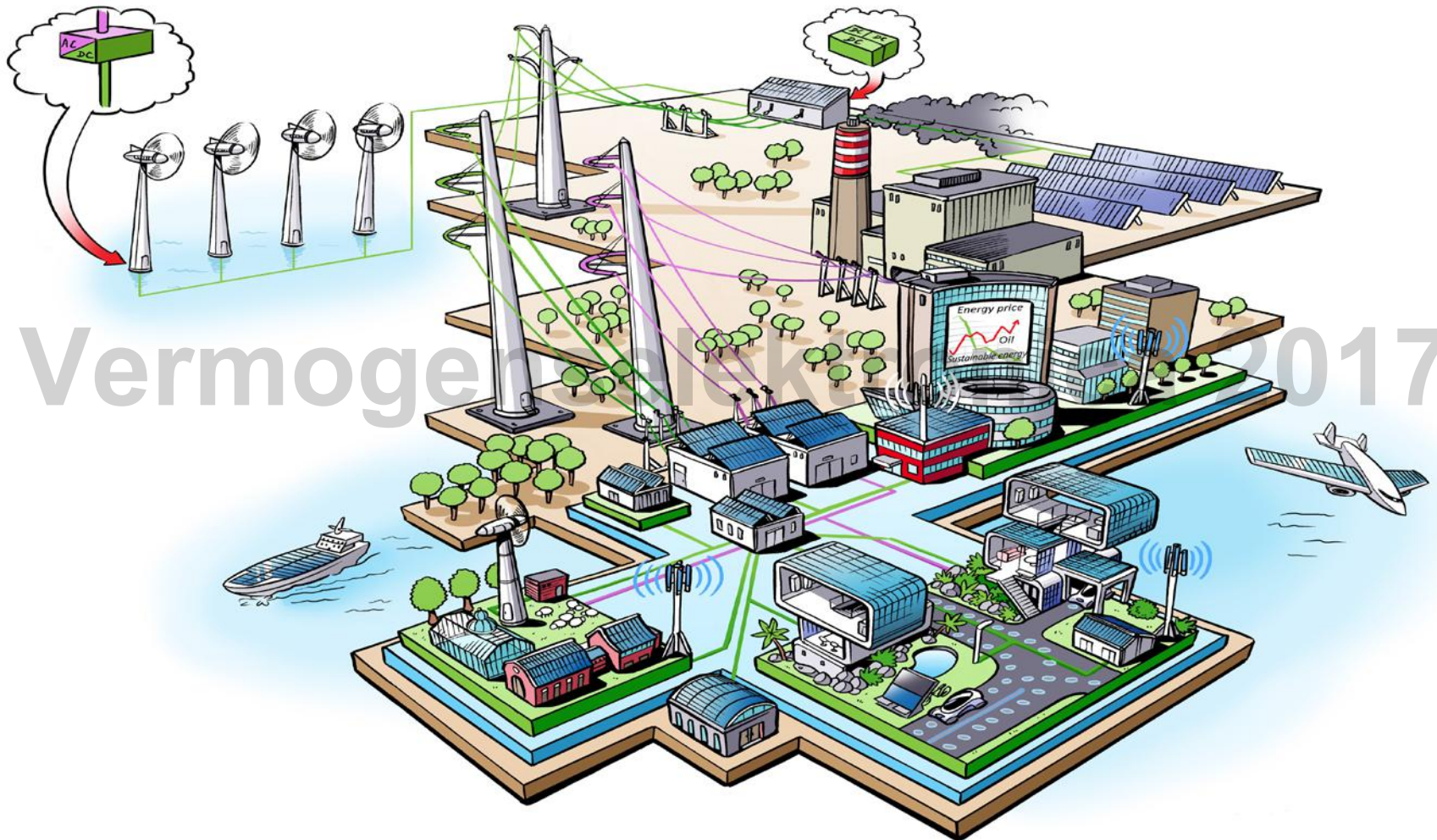


# Multilevel modular converters

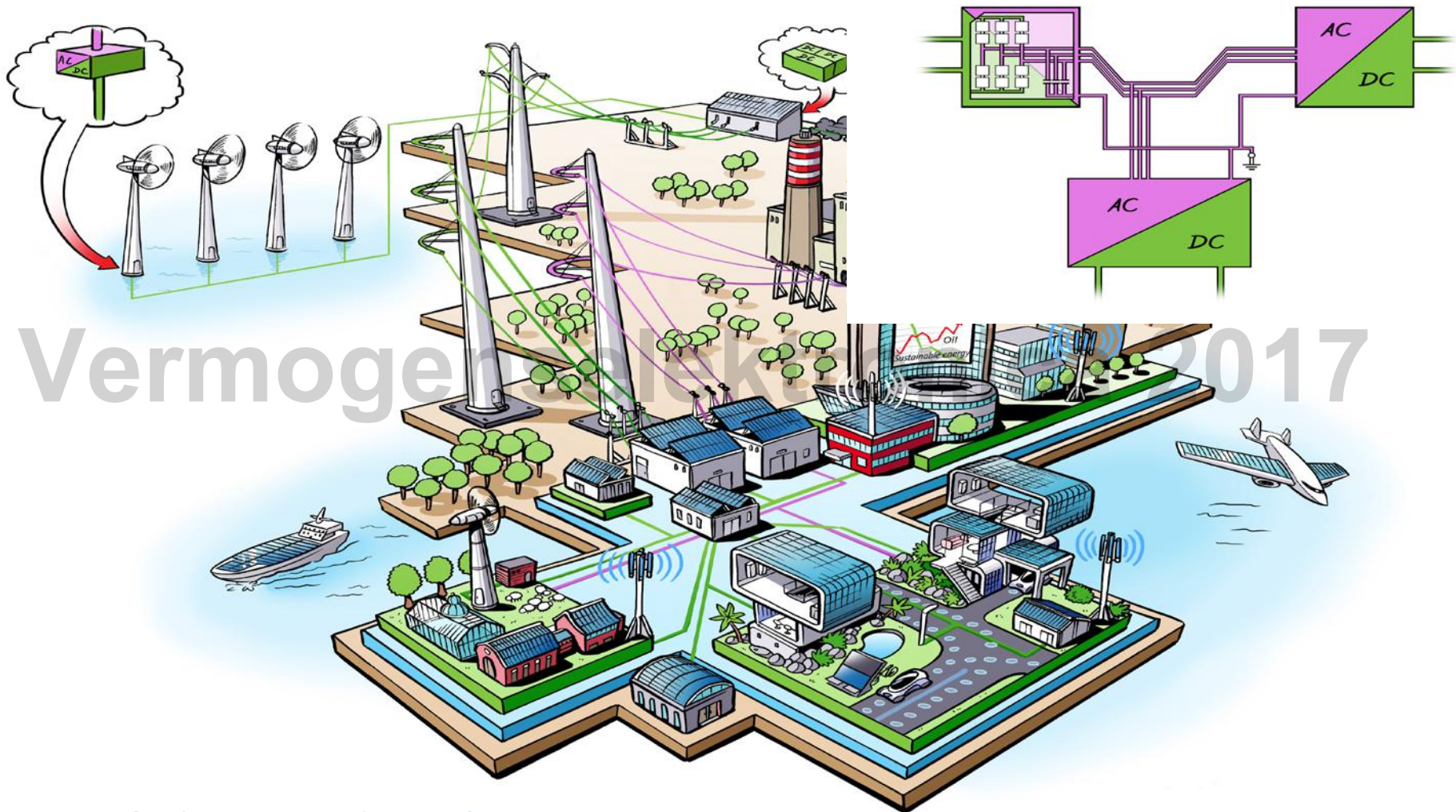
- The Multilevel Modular Converter (Marquardt, 2002)
- Major step forward for high-power converters
- Direct substitute for VSC 2-level technology (>20 years in HVDC)
- Based on series connection of converter cells (submodules)

## Main Submodule Topologies



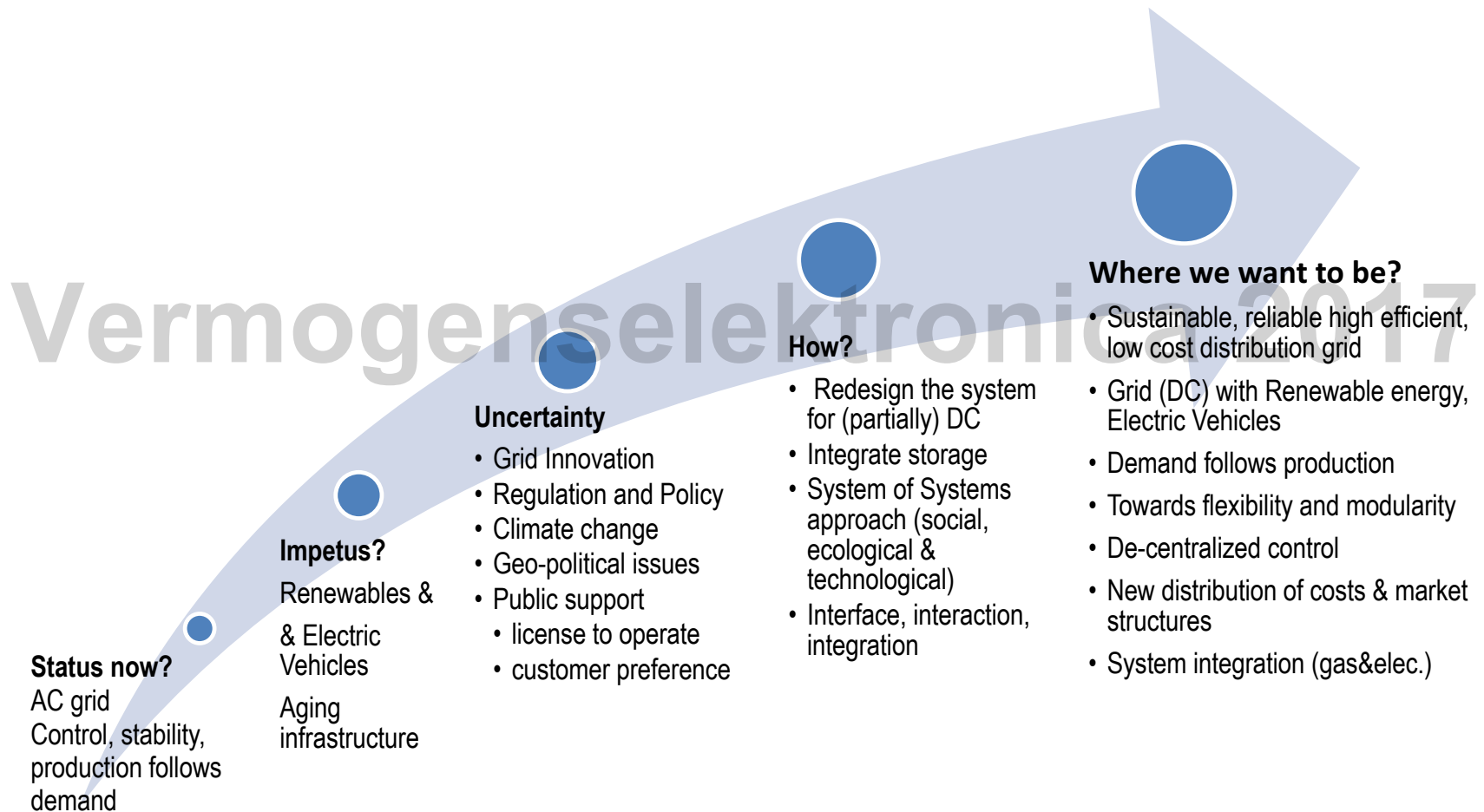


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# Multiterminal DC

# How direct will the future electricity be ?



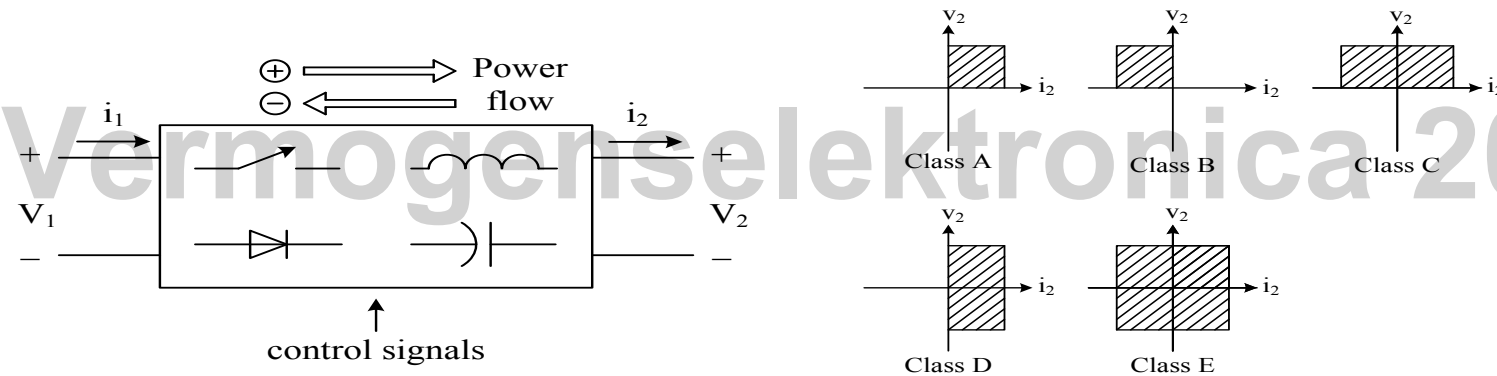
## Why DC distribution ?

- All Renewable Energy and Storage essentially DC
- Higher system efficiency
- Lower overall investment costs
- Higher System controllability (stability, resonances)
- Potential for long distance transmission
- Higher reliability
- Greater power per conductor
- Higher voltages possible

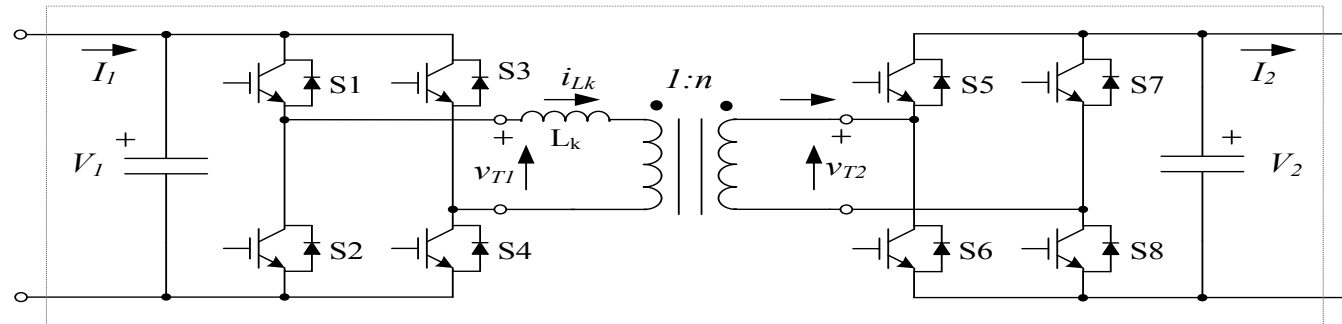
What about the transformer



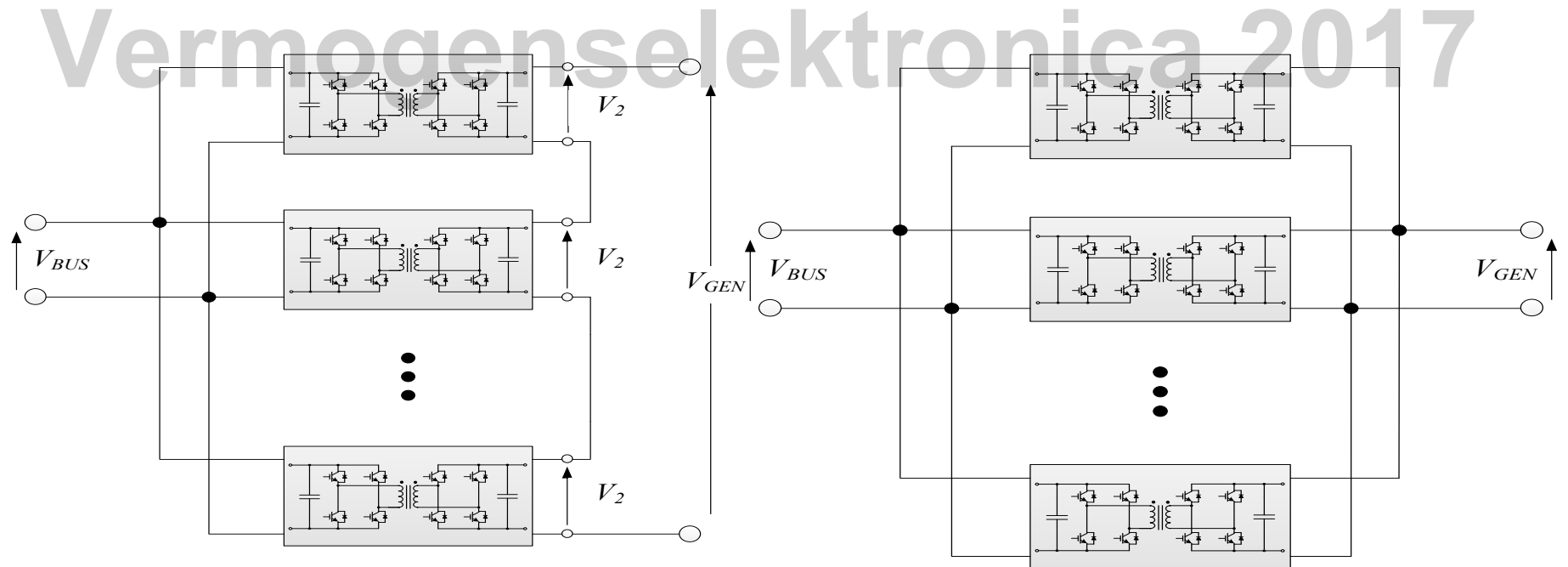
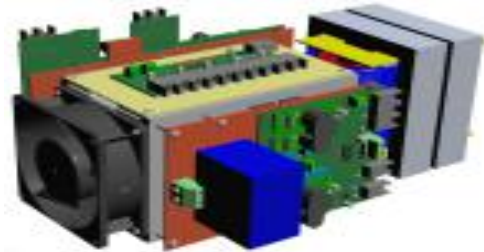
# DC-DC Converter – Electronic transformer Edison's missing link



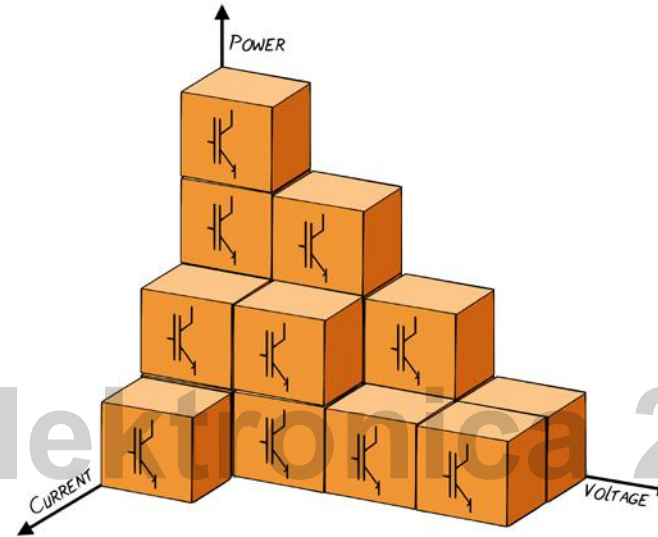
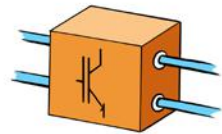
DAB module



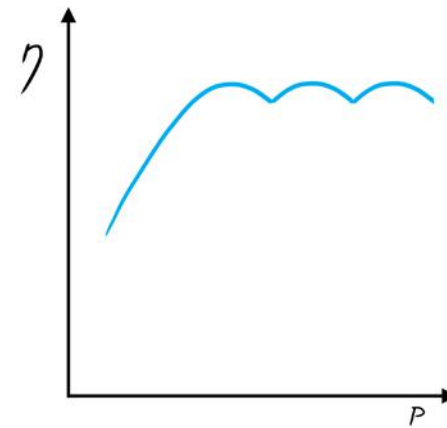
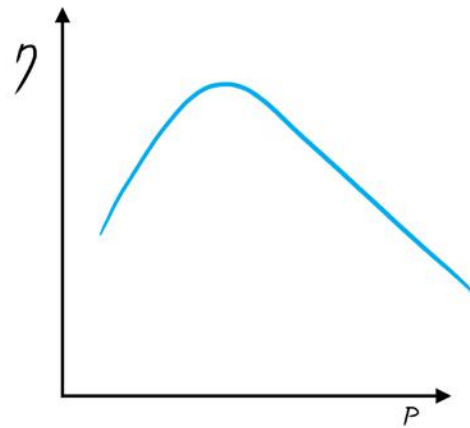
# Series -parallel



# Modularity



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# Roadmap for DC Systems

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## DC Nanogrids

- Radial DC feeders (lighting)
- Devices, protection, stability

## DC Nanogrids V2.0

- Bidirectional power flow
- PV and storage
- DC house nanogrid
- PV charging systems of EVs
- DC ready devices and USB power delivery
- Enable demand response

## DC microgrids / DC links

- Towards local generation local use (storage, EVs)
- Cellular concept
- Sizing (optimization)
- Protection, grounding
- Stability of DC grids
- Optimal power flow
- Demand side management
- Data over power line
- Power management
- Markets
- Enabling Blockchain

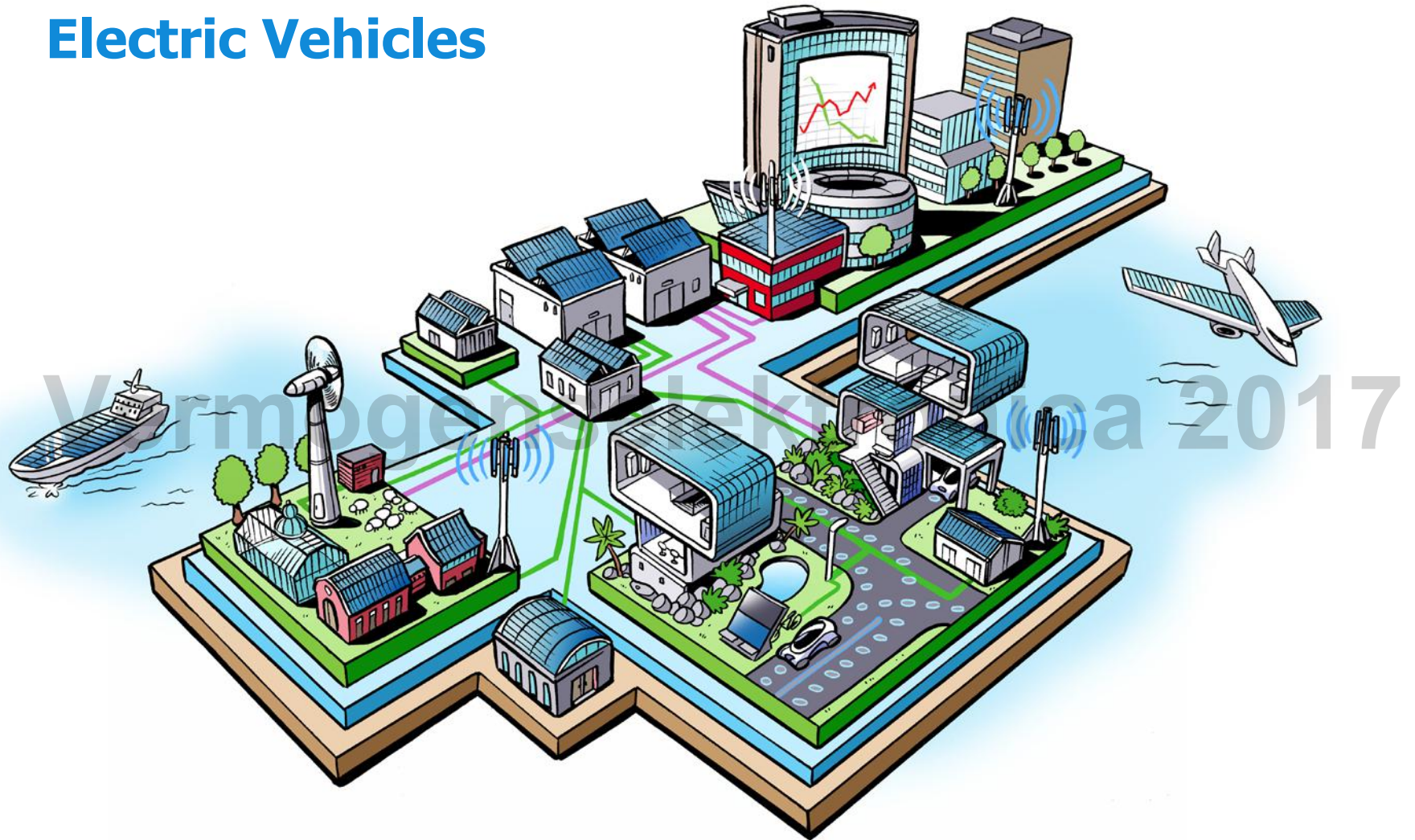
## Radial DC grids

- Connecting DC microgrids
- Refurbishing the system for (partially) DC infra
- Modular converters with integrated protection
- Integrated control market approach
- Integrating cells/microgrids
- Interface, interact, integrate

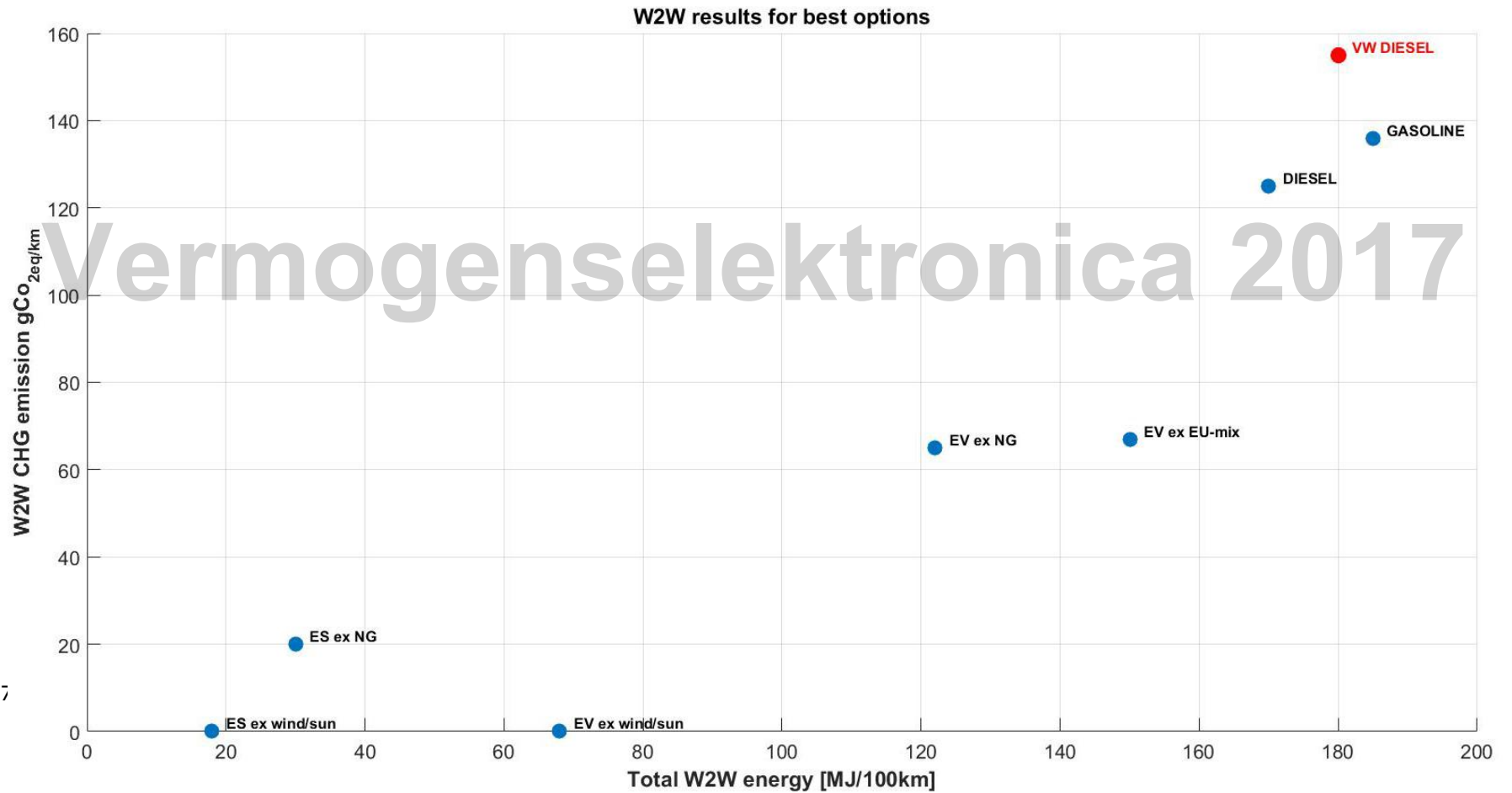
## Meshed DC distribution grids

- Sustainable, reliable, high efficient, low cost DC distribution grid with renewable energy, and electric vehicles
- Flexibility and modularity
- Decentralized control
- New distribution of costs, market and usage structures
- Integration of multiple energy carriers (gas&elec.)

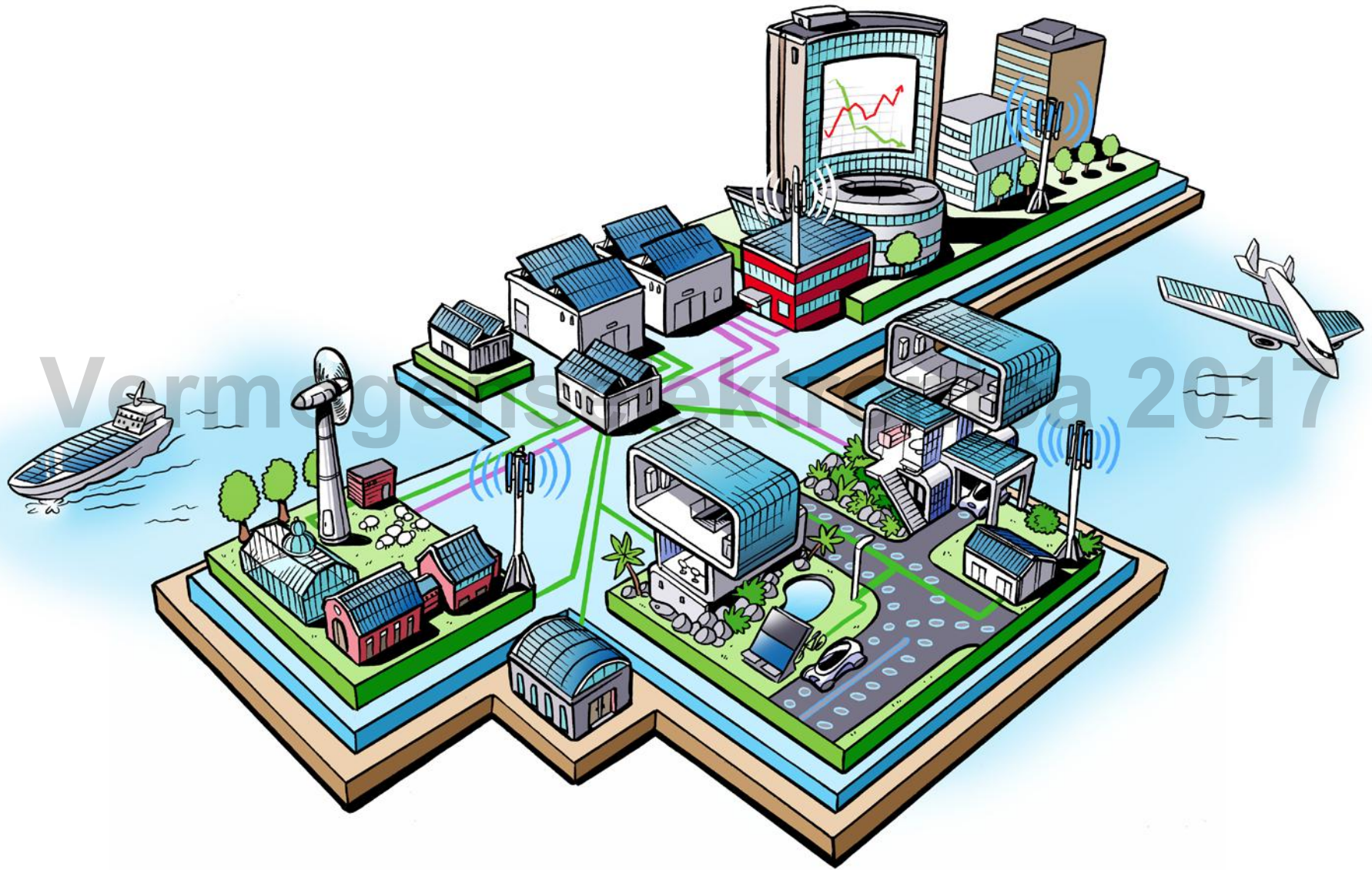
# Electric Vehicles



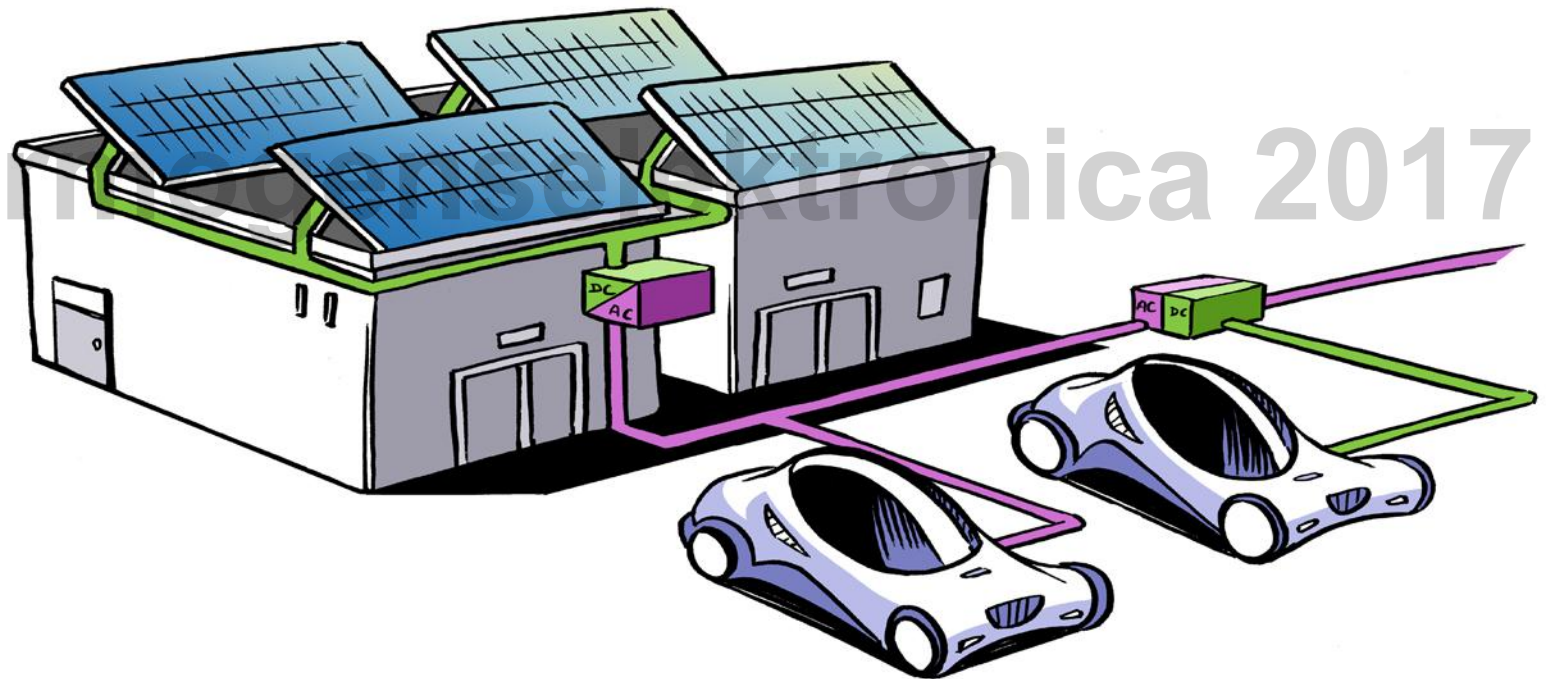
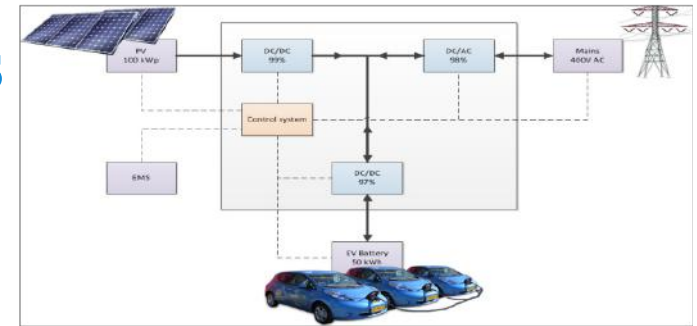
# Implication on CO2 emissions



20/06/2017

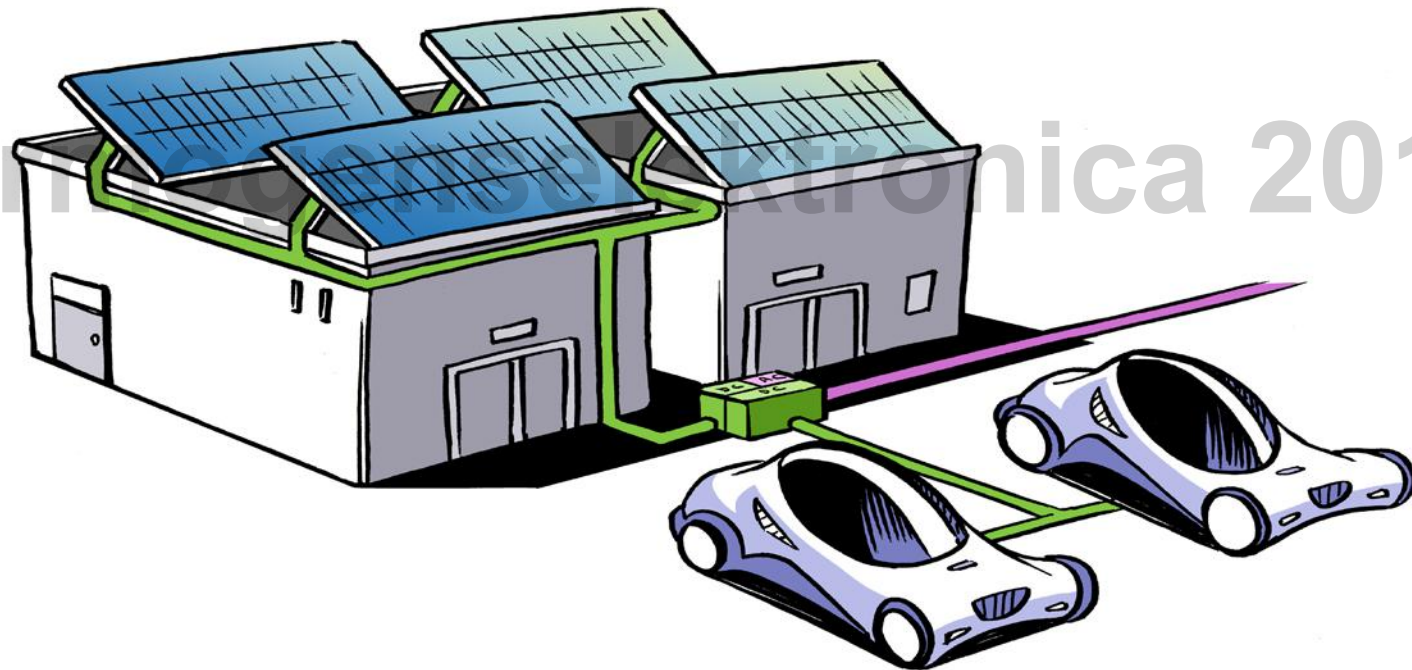


# PV Charging of Electric Vehicles



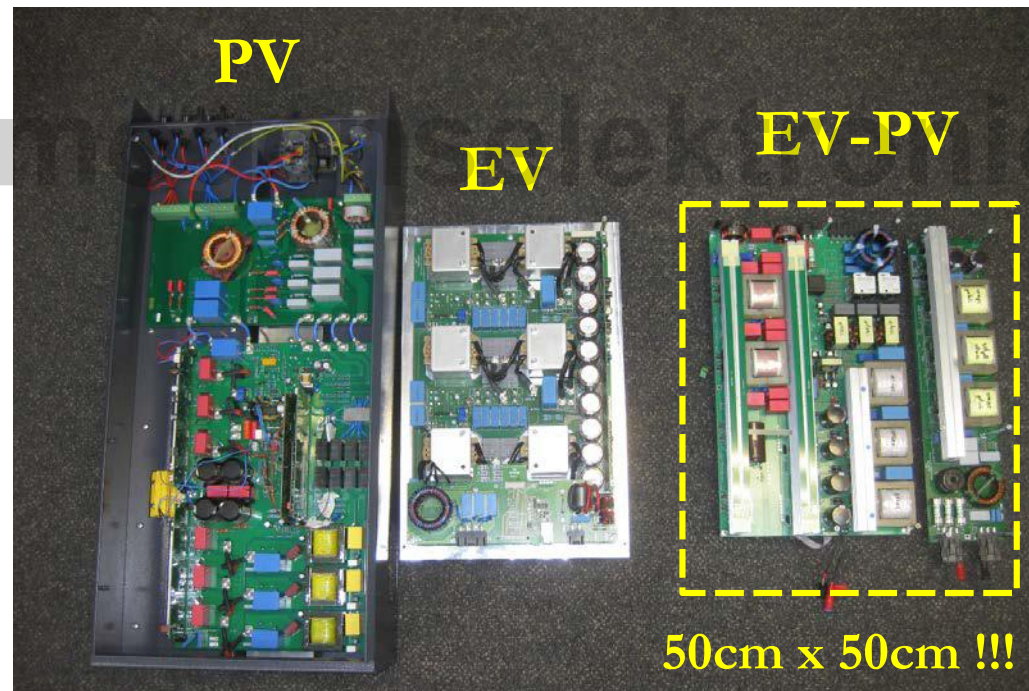


# PV Charging of Electric Vehicles

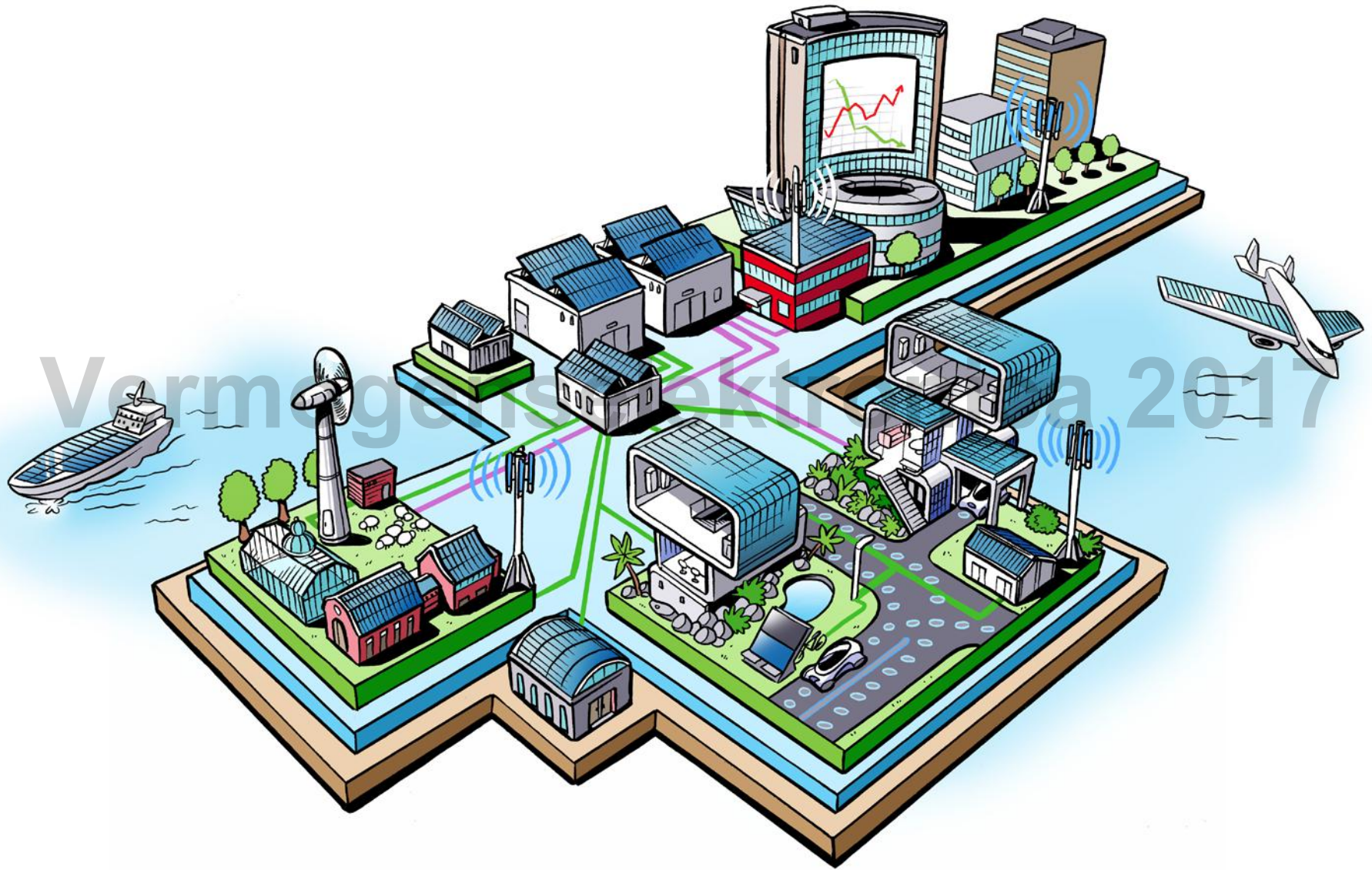


# 10kW EV-PV power converter

- Higher power density
  - Higher efficiency
  - Bidirectional EV charging
- SiC MOSFET
  - SiC diode
  - Powdered alloy inductors

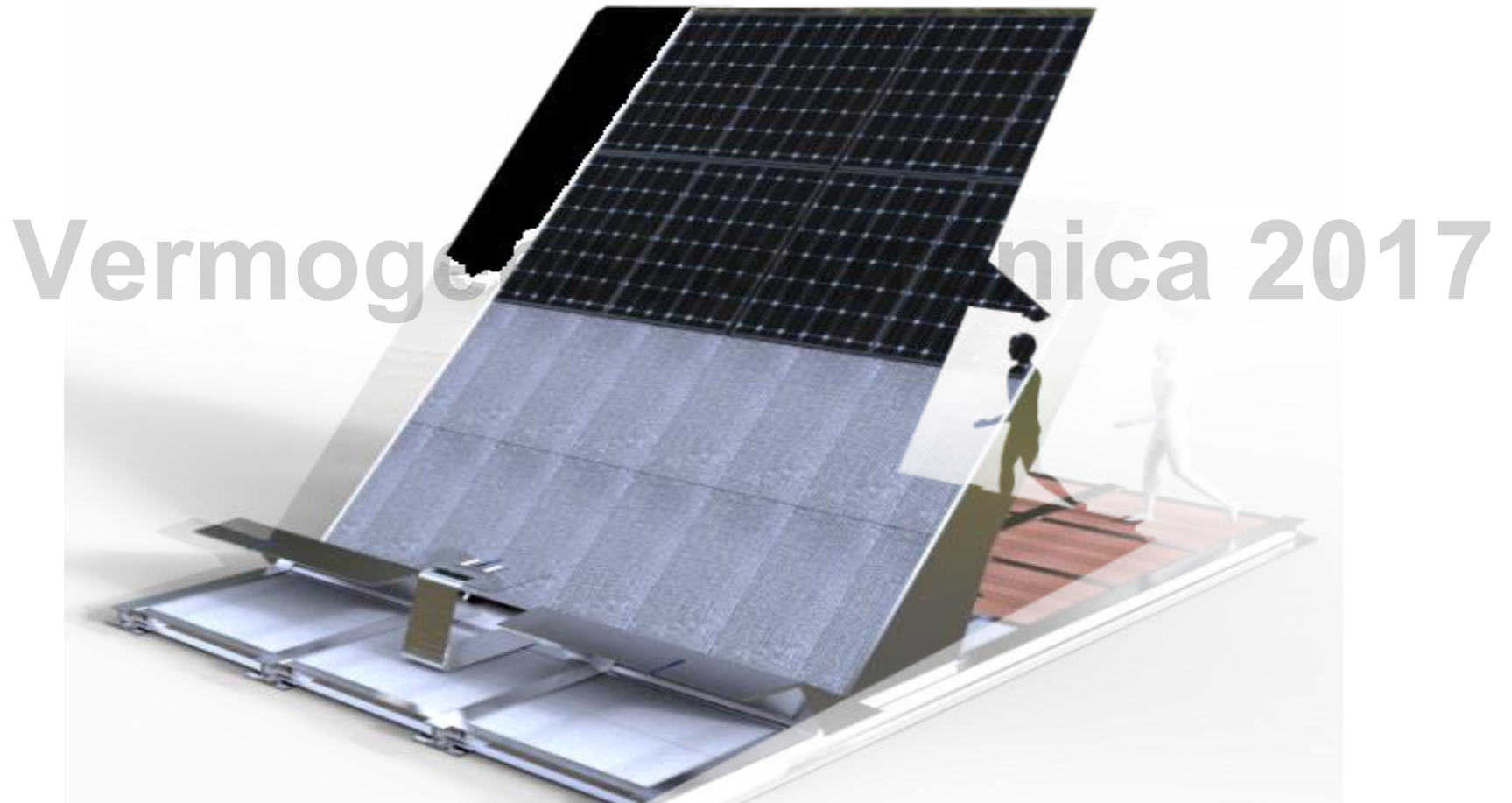


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## PV for smart cities applications

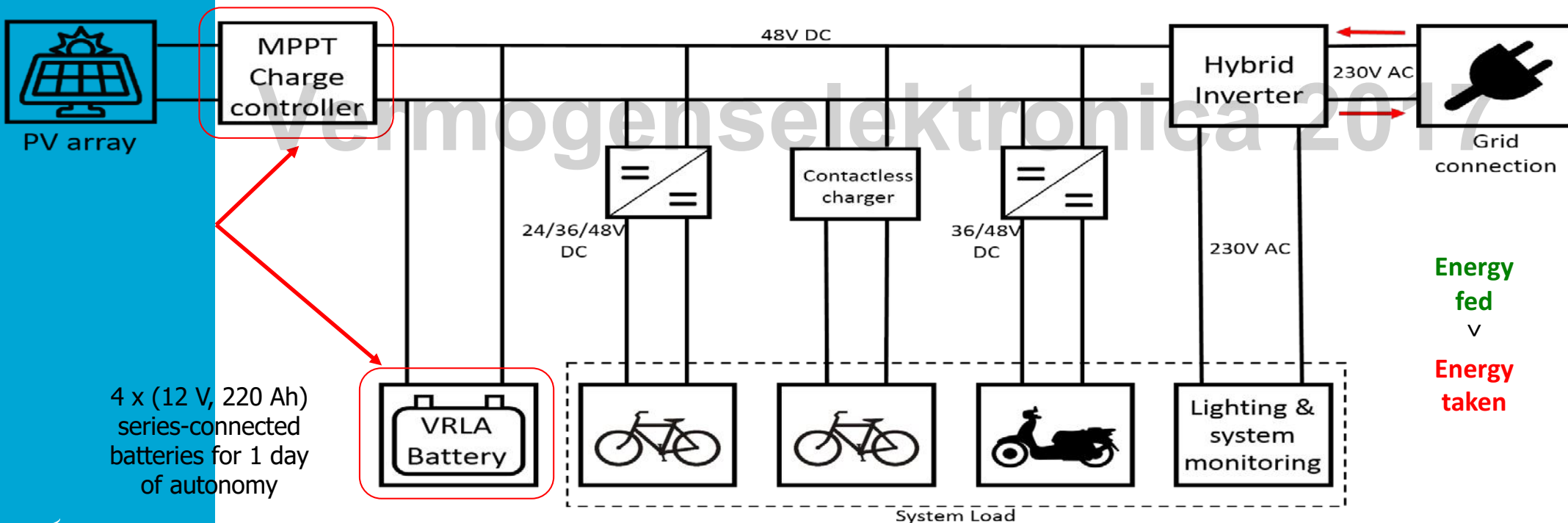
### Solar Powered Electrical Bike and Scooter Charging Station



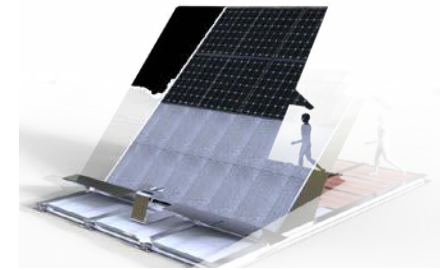
# PV for smart cities applications

## Solar Powered Electrical Bike and Scooter Charging Station

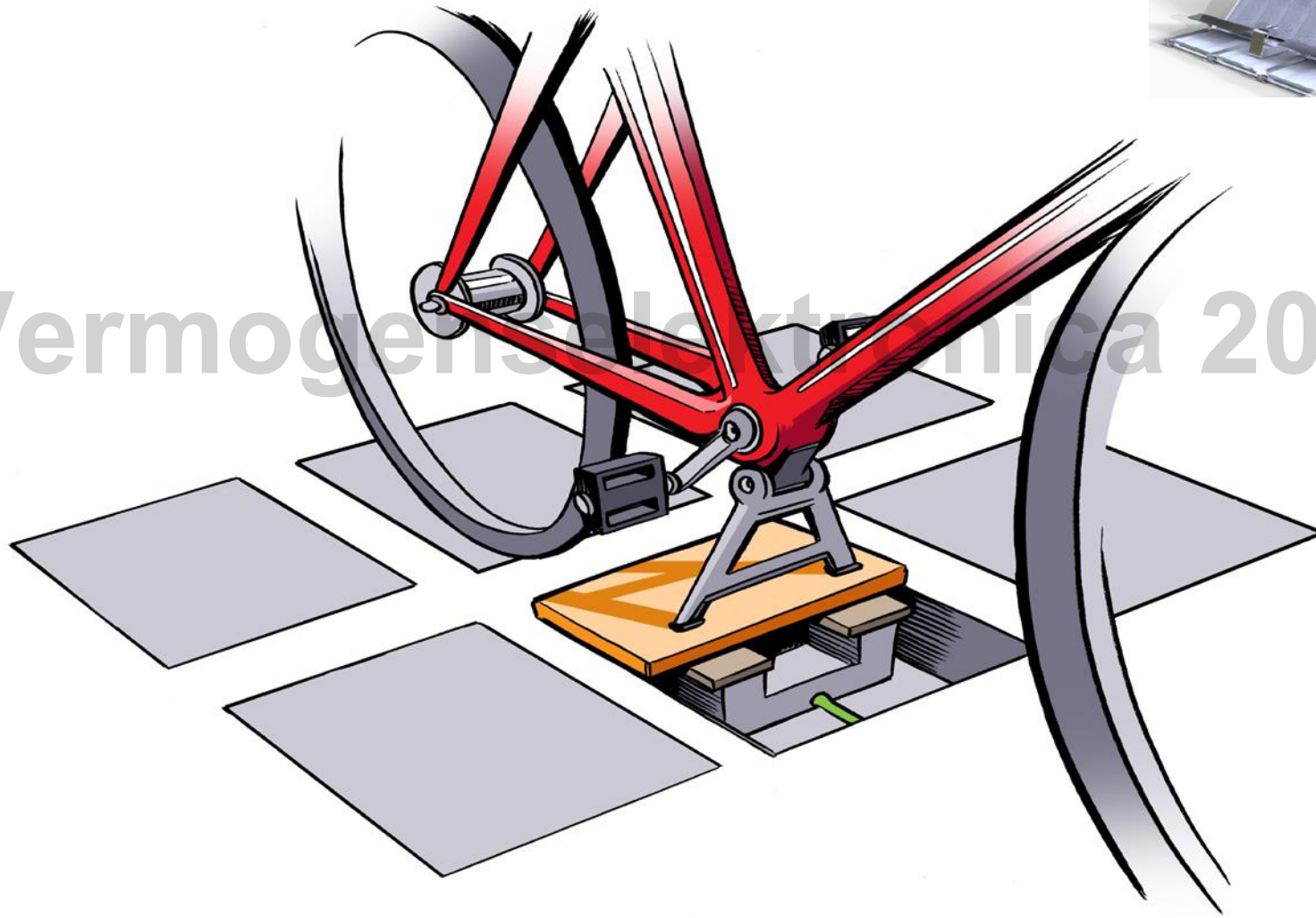
System topology



## Wireless bike charging V1.0

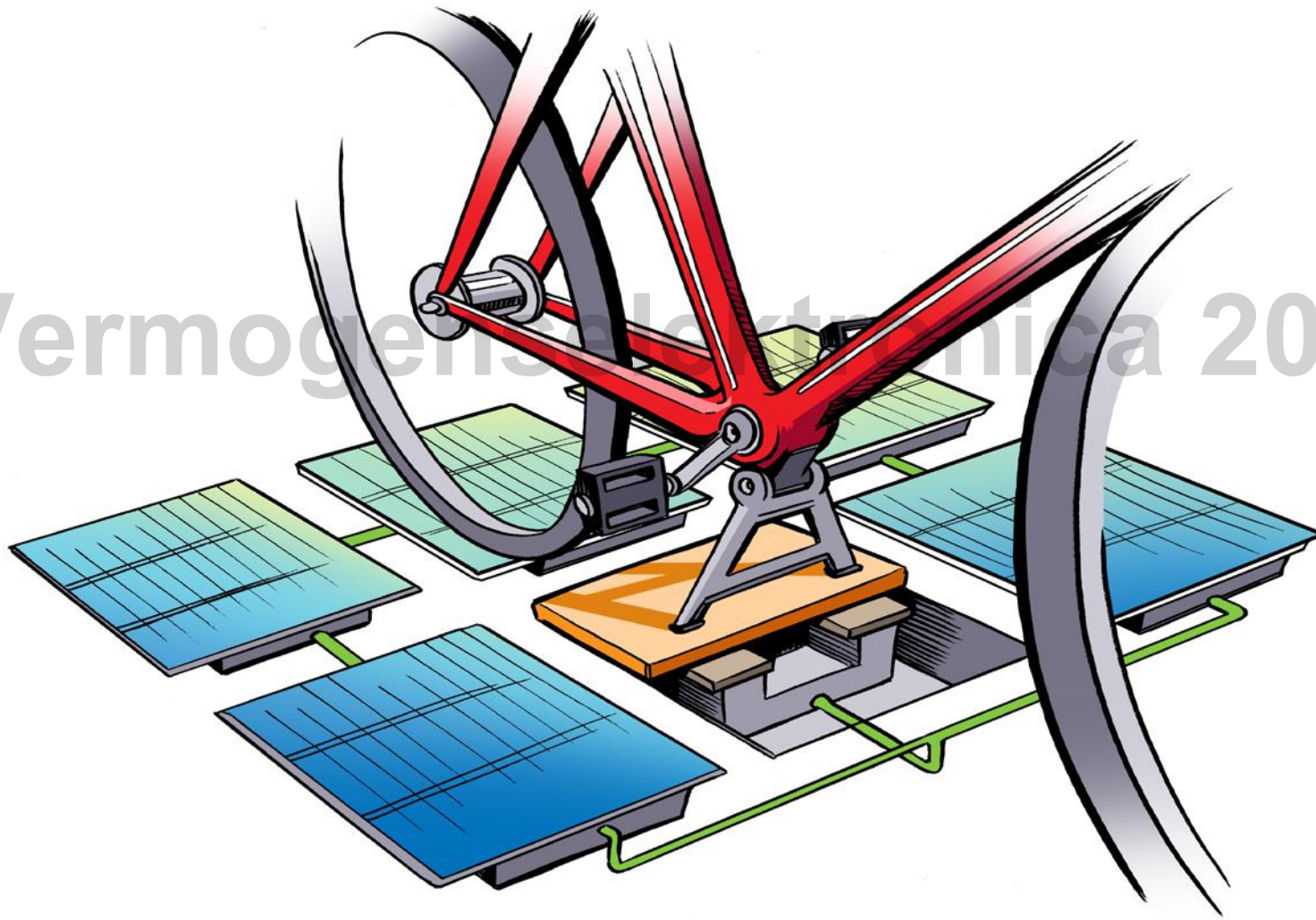


Vermogens电子技术 2017



## Wireless bike charging V2.0

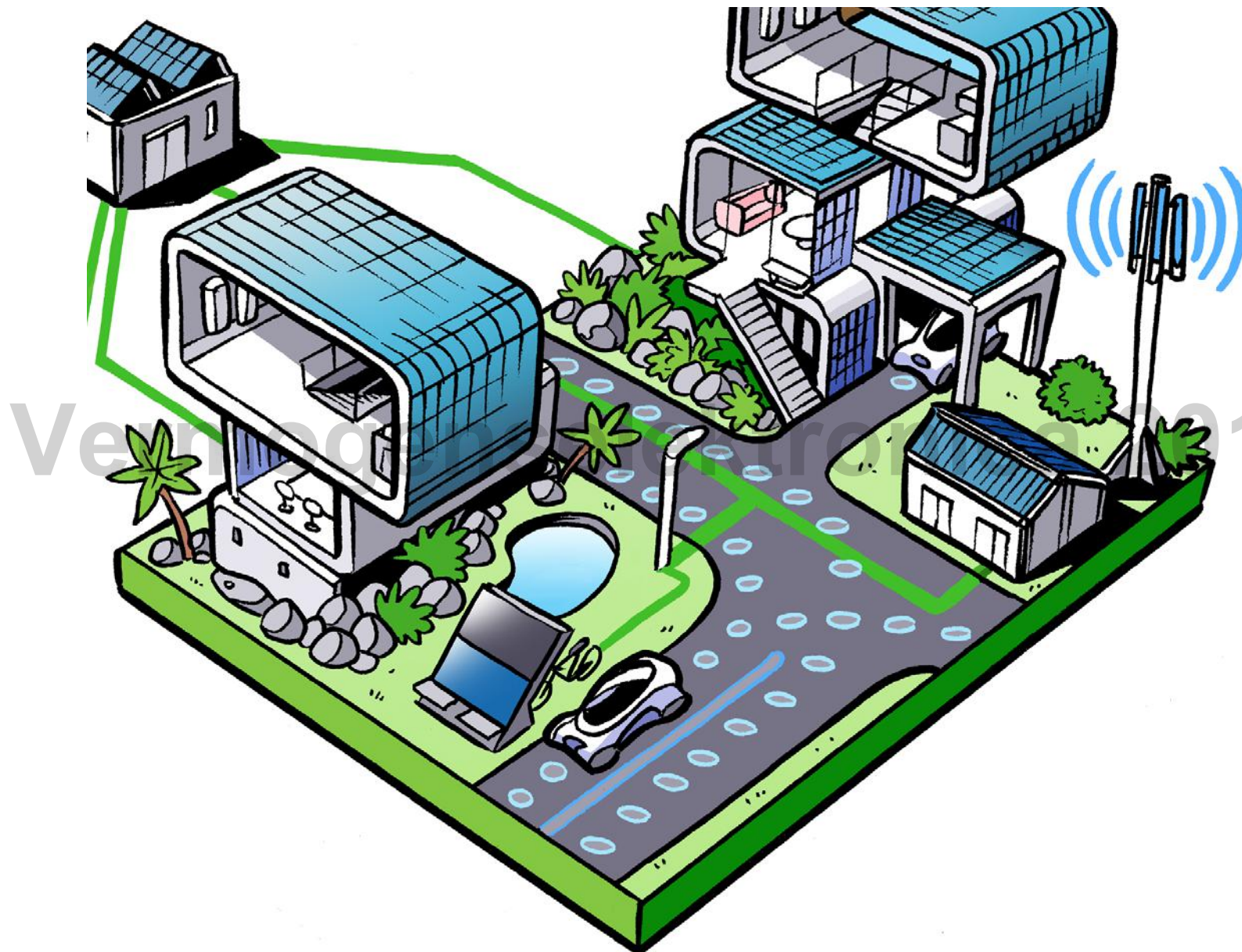
Vermogens elektronica 2017



# Vermogenanalyse 2017

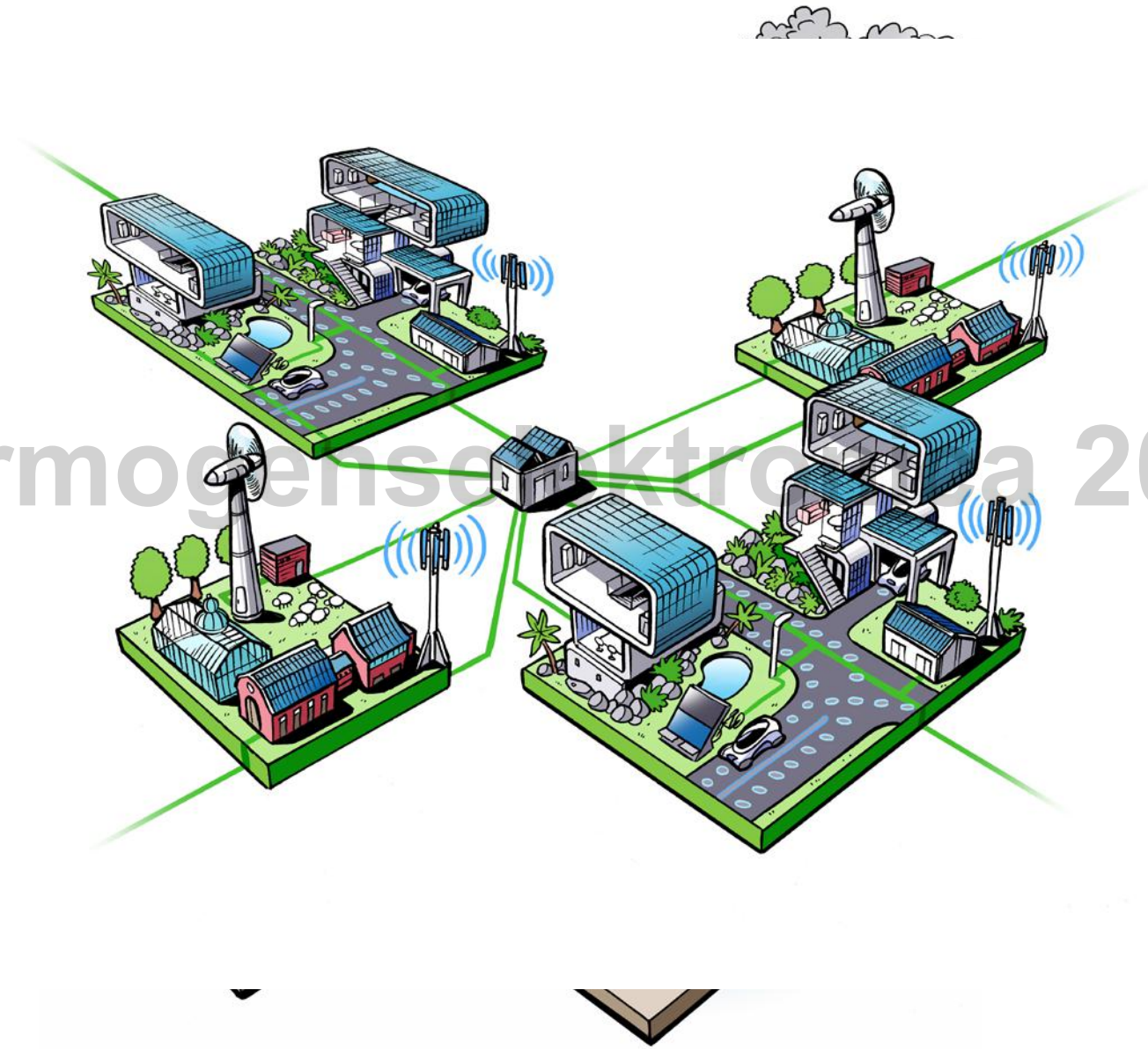




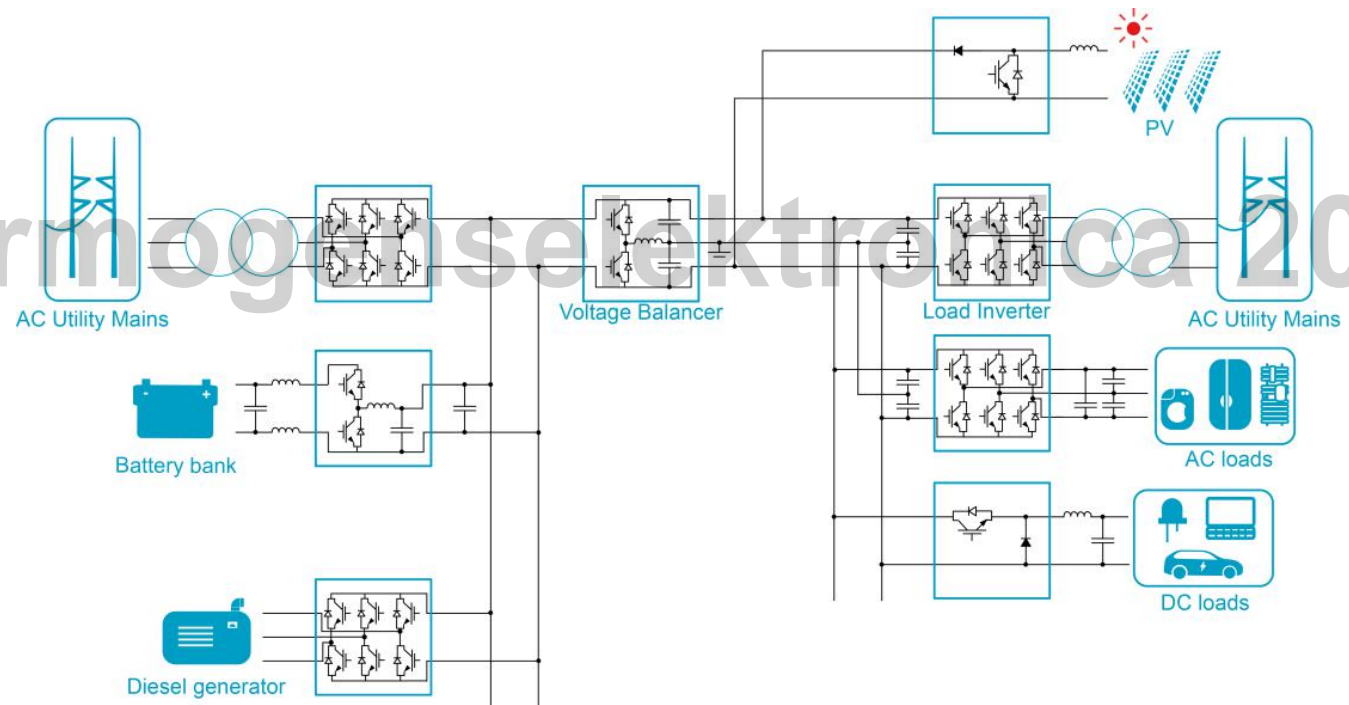


Vereniging 2017

# Vermogensselectie 2017

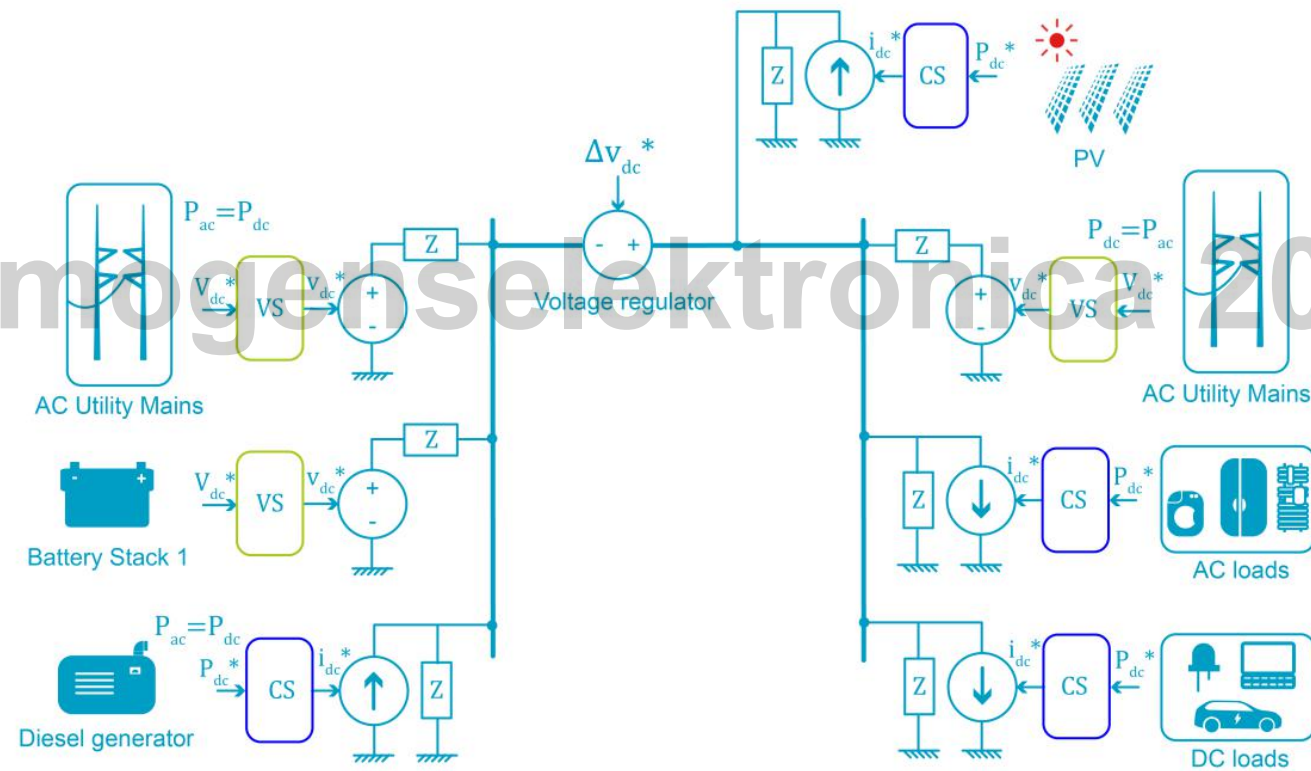


# Bipolar Single-Bus



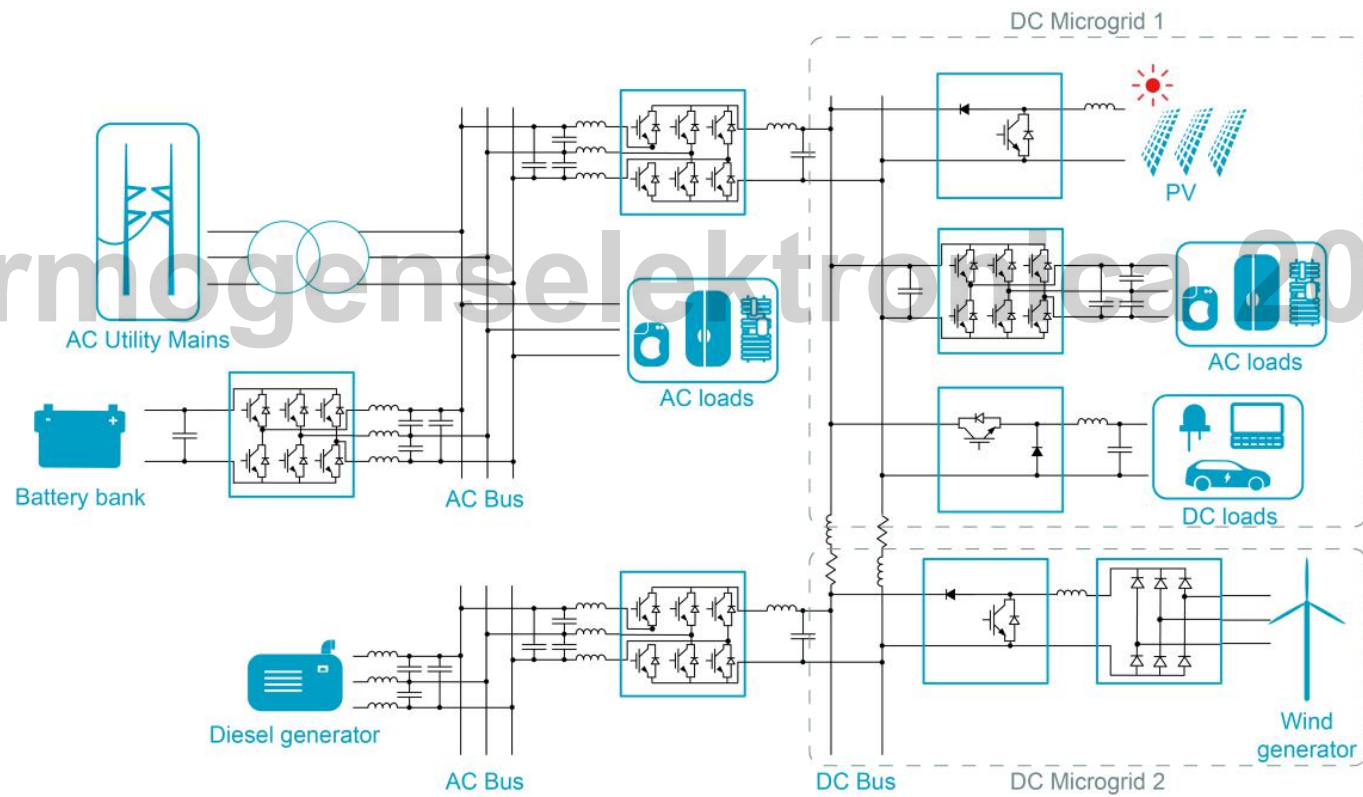
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# Bipolar Single-Bus



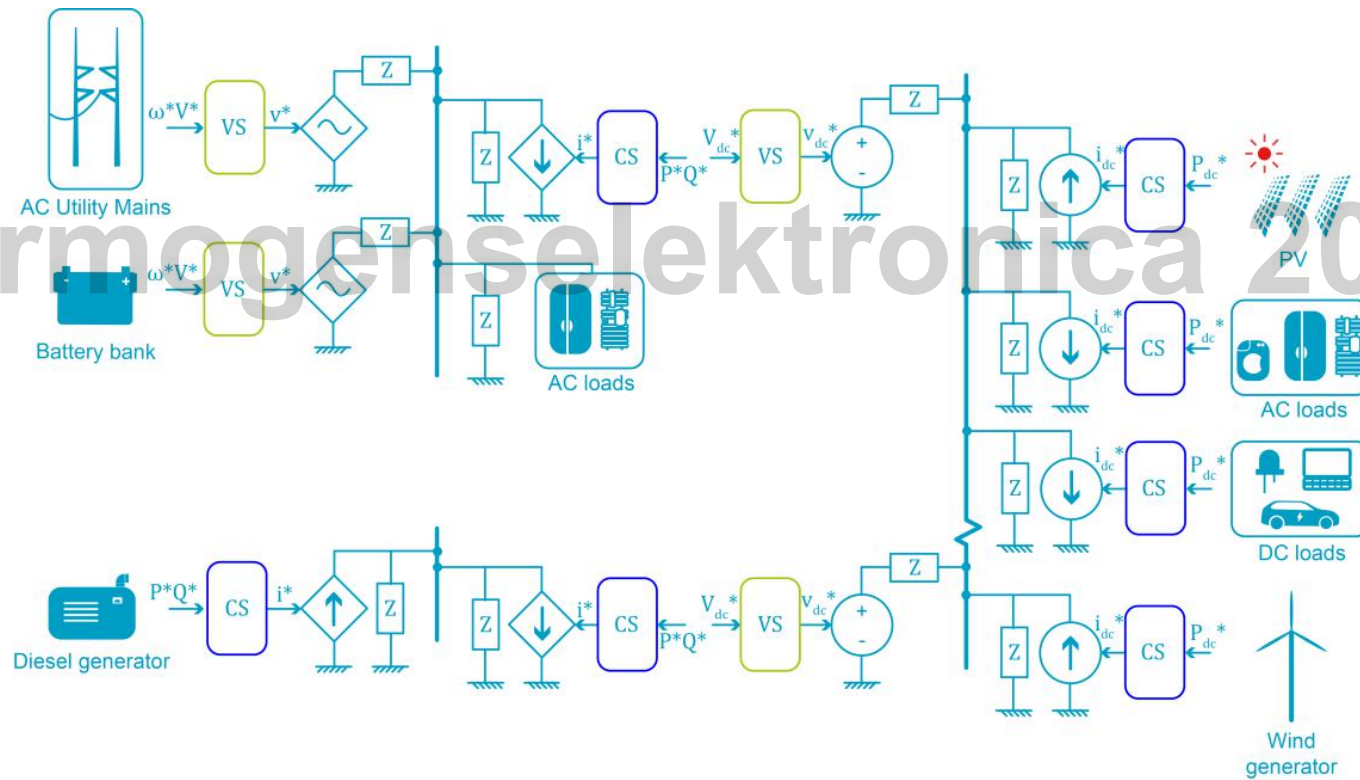
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# HYBRID AC DC

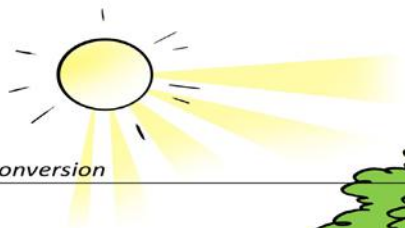


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# HYBRID AC DC



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Energy conversion

Robot

Direct current

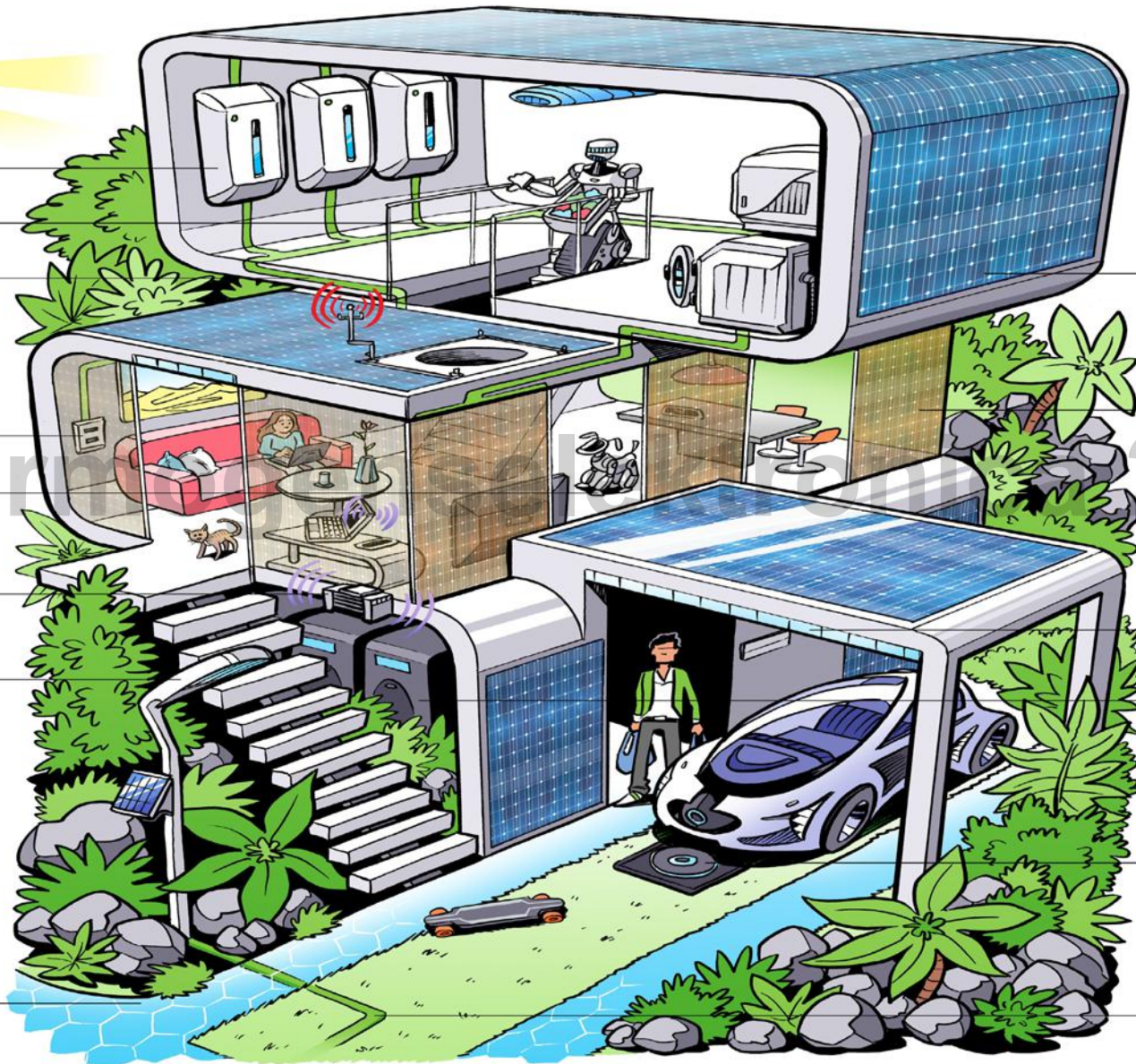
USB charge/  
data

Robo-dog

Contactless  
energy point

Street lights

Solar road



Delivery service

Integrated  
solar panels

Semi transparent  
solar panels

LED  
lights

Energy storage

Charging point

Direct current

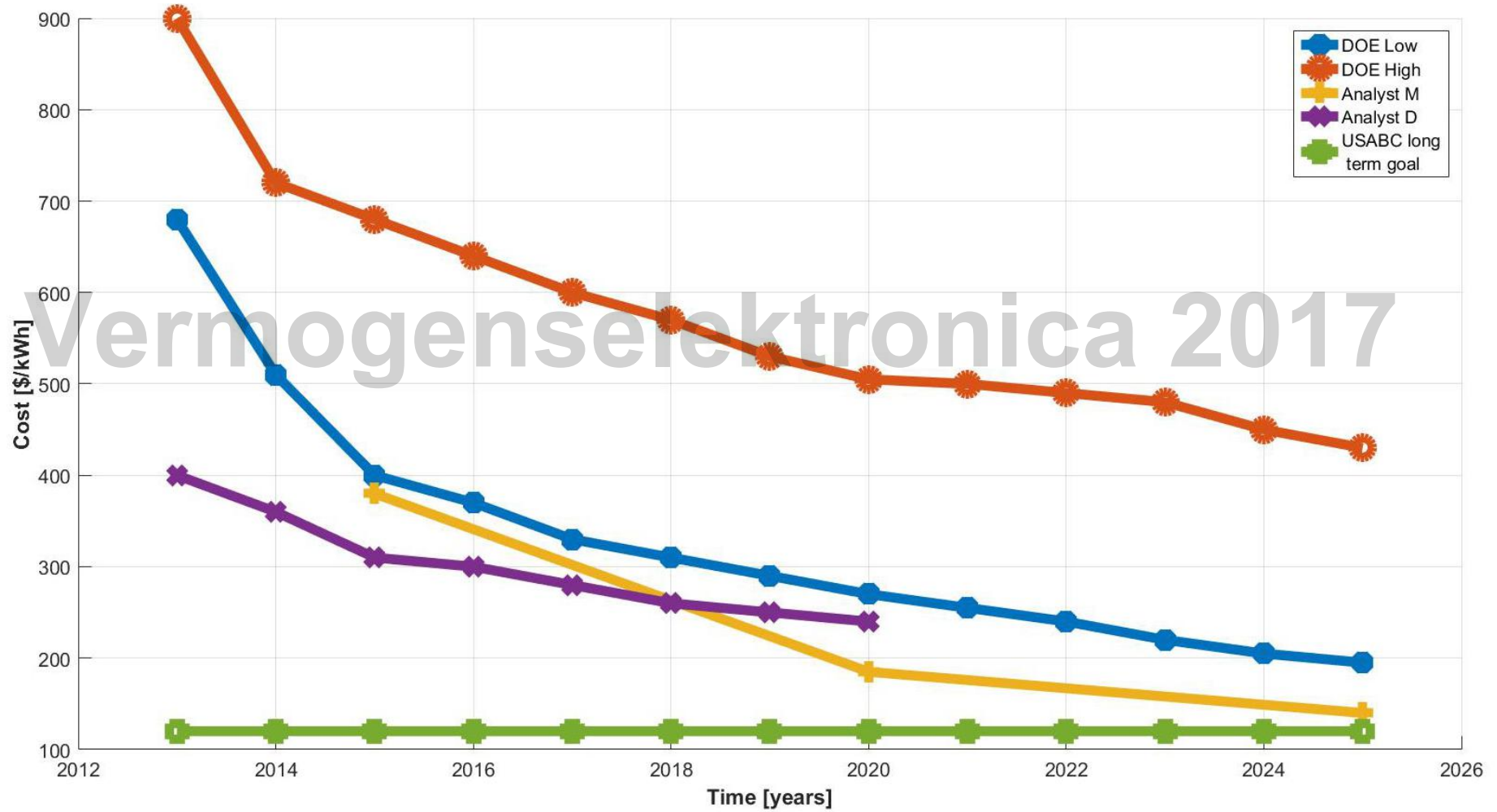
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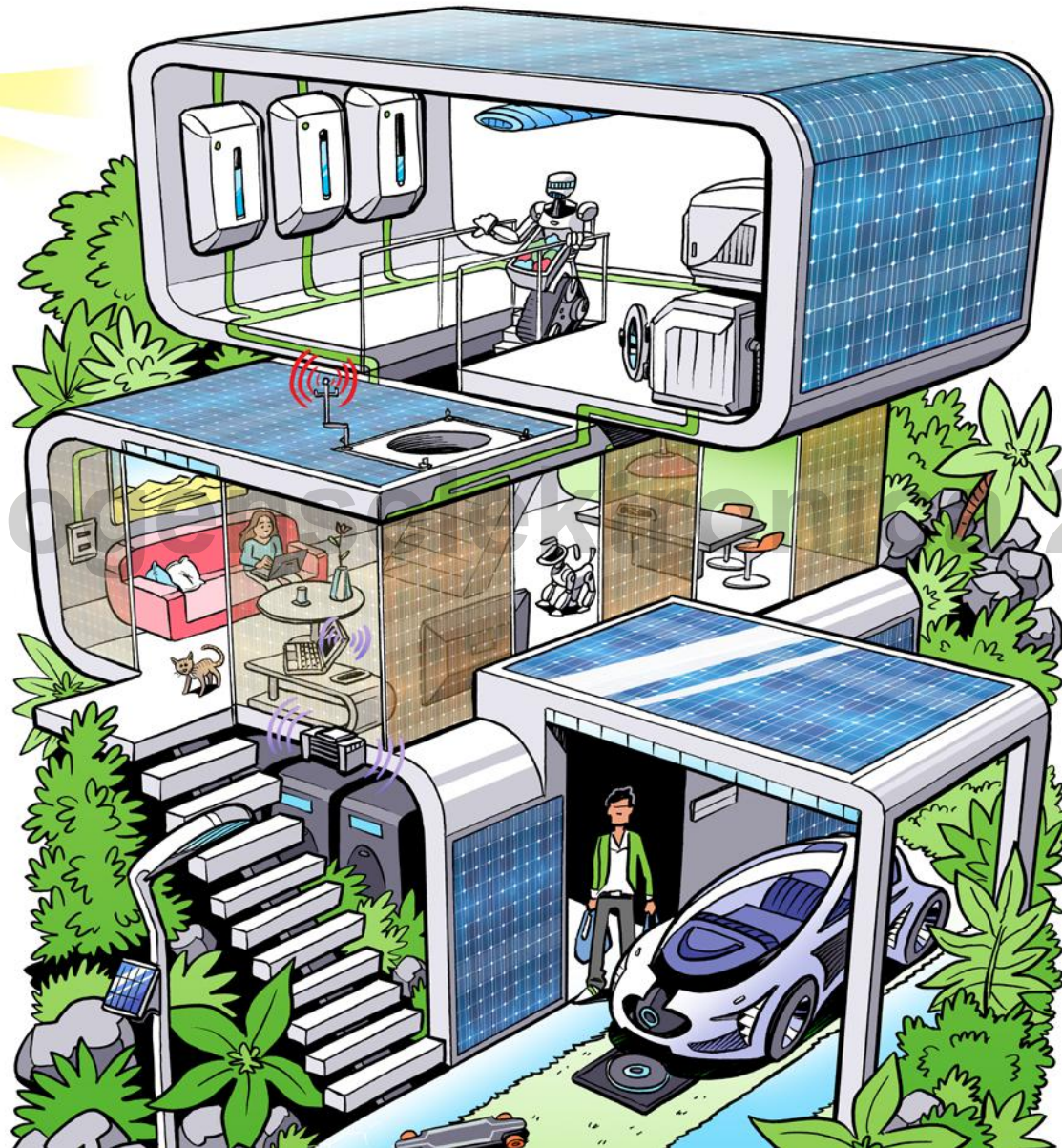
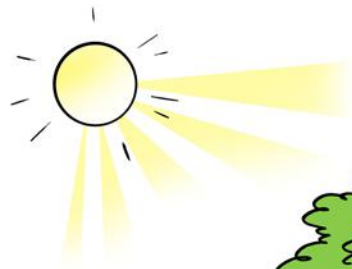
Congestion management  
Frequency control in case  
Local voltage problems  
Transient stability  
Reliability problem





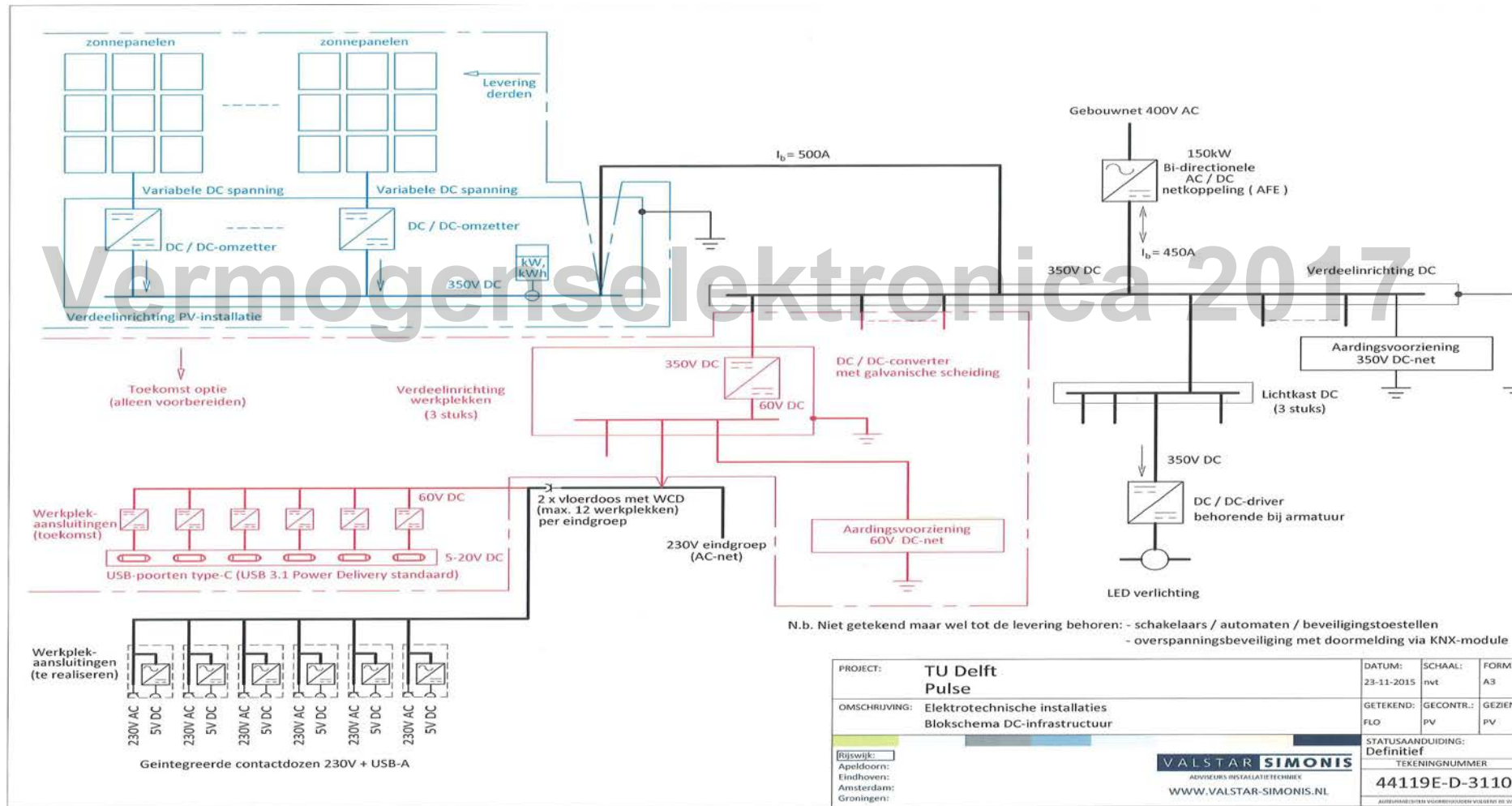
# Storage – key solution

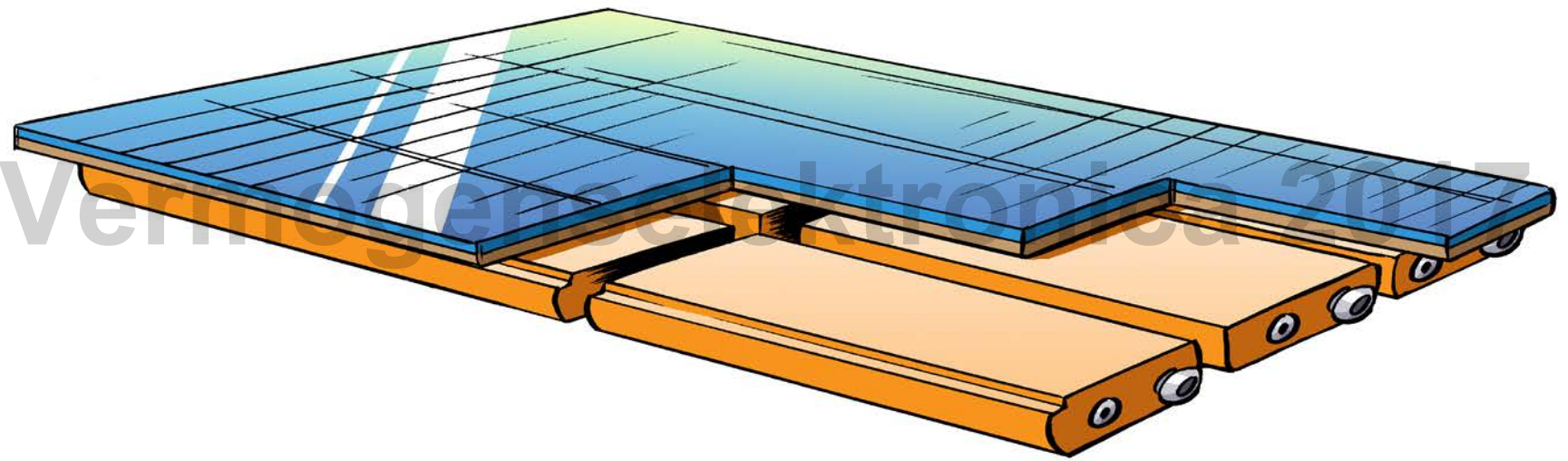




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# PULSE BUILDING TU DELFT





A word cloud featuring the phrase "thank you" in numerous languages. The words are arranged in various sizes and orientations, with "thank you" being the largest and most prominent in the center. Other large words include "gracias", "merci", "danke", "tesekkür ederim", "obrigado", "dziękuje", "sukriya", "terima kasih", and "mercí". Smaller words include "спасибо", "謝謝", "ngiyabonga", "barkaa", "welalin", "tack", "misaotra", "matondo", "paldies", "grazzi", "mahalo", "tapadh leat", "хвала", "asante", "manana", "obrigada", "murakoze", "tenki", "djere dieuf", "tau", "mochchakkeram", "дякую", "mamnun", "sulpáy", "go raibh maith agat", "chnorakaloutioun", "gratias ago", "gracies", "sagolun", "kop khun krap", "taiku", "arigatō", "takk", "dakujem", "trugarez", "najs tuke", "merci", "mercé", "merci", "dhanyavadagal", "shukriya", "didi madloba", "kam sah hamnida", "rahmat", "tanemirt", "rahmet", "diolch", "dhanyavadagal", "shukriya", "mercé", "merci", "didi madloba", "kam sah hamnida", "rahmat", "tanemirt", "rahmet", "diolch", "dhanyavadagal", "shukriya", "mercé", "merci", "didi madloba", "kam sah hamnida", "rahmat", "tanemirt", "rahmet", "diolch", "dhanyavadagal", "shukriya", "mercé", "merci".