DC in the Netherlands

Current OS

WE ARE DCIFYING THE WORLD

MAKING DC SYSTEMS BY CONNECTING SOURCES & LOADS

DC SYSTEMS

DIRECT CURRENT BV

HELLAS RECTIFIERS BV

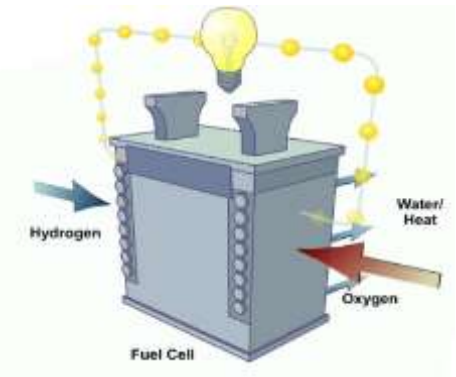
FEMTOGRID ES BV

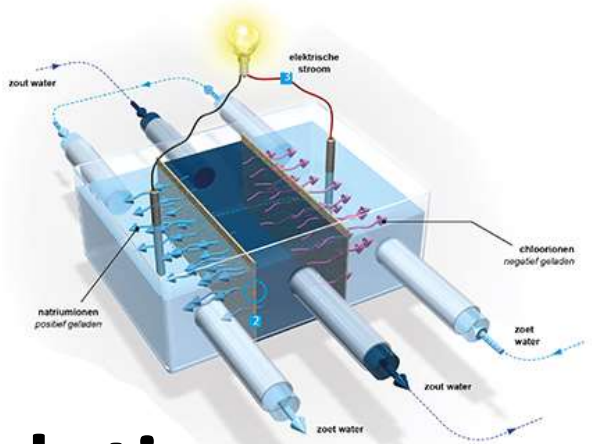
We are already live in a DC world

Why DC

Direct Current BV

Everything we ❤ and 👍 is **DC**





DC brings fun, comfort, clean and sustainable solutions

Contact
Harry@dc.expert

Me

DC SYSTEMS

ACTIVITY

Owner of the following Companies:

- DC. Systems LtD
- Direct Current LtD
- Hellas Rectifiers LtD
- Amstel Rectifiers LtD
- Femtogrid ES LtD
- DC Hortilighting LtD
- DOE-DC LtD

Foundations

- Founder of the DC Foundation
- Founder of Current/OS Foundation

DC Foundation

BACKGROUND

Skills

- Started in 1988 as a DC entrepreneur. Building and creating DC systems for industrial application
- Energy systems
- Power Electronics
- High Current technology up[to 30kA
- ICT firmware/software
- Grid regulations
- DC System integration
- DC Applications
- DC Industrial processes
- DC and corrosion

COMMISIONS

Commissions

- IEC LVDC SyC CAG1, CAG2, WPG1 Convener AhG1 LVDC Syc in the IEC for use case the last mile
- SyC LVDC liaison officer for TC8-WG9
- IEC TC 61200 PT101/102 TC64
- Convener Working group DC TC64 (NEN 1010) NPR9090
- Member electrical infrastructure of the Dutch Democrats D66
- CIGRÉ SC 6.31 MVDC distribution

CV

- Protecting the Dutch Water defense against corrosion
- Green deal

  Enabling a outdoor DC grid
- Universities

  Active in the TU/Delft supporting the faculty DC and storage

European Business Awards for the Environment
Runner up

Green Deal
AWARD WINNER 2016

I'm Dyslectic, so forgive me for spelling mistakes

DC SYSTEMS

DC SYSTEMS

- **Contact**
  info@dc.systems
  +31(0)850-444 000
  Oosteinderweg 127C
  1432 AH Aalsmeer
  The Netherlands
- Support
  support@dc.systems
- Sales
  sales@dc.systems
- Purchase
  purchase@dc.systems
- Invoices
  invoices@dc.systems

DIRECT CURRENT

- R&D
  Safety, Protection, system dynamics, infrastructure, negative side effects, business cases, power electronics
- Product design
  Drivers, interfaces, protection, converters
- System integration
  Buildings, Outdoor services, Distribution Grids, Greenhouses
- Creating use cases

HELLAS RECTIFIERS

- Manufacturing
  Address
  Fuutlaan 12E1
  5613AB Eindhoven
  The Netherlands
- Rectifiers
  In the range from 1 … 30kA
  - Cathodic Protection
  - Electrochemical
  - SMPS up to 10kW @ 500A
- Active frontends
  In the range from 6kW … 1MW

FEMTOGRID

- R&D on solar
  Safety, Optimizing power, Fire protection, cables and connection systems
- Micro converters
  For 350V and 700V DC grids

Why grids are important

DC SYSTEMS

- The electricity grid is one of the most value assets the society owns
- It give us:
  - Energy
  - Hygiene
  - More dense society
  - It’s the fundament of the economy
  - Solution to sustainable systems
  - Economics

  - We have to protect is and make it simple as possible
  - It’s not about the business case only but it’s about our continuity in life.

nieuws

NIEUWS

VOLVO INTRODUCEERT VANAF 2019 ALLEEN NOG 'ELEKTRISCHE AUTO'S'

Na vijftig jaar gaat Nederland afscheid nemen van aardgas

Wilko Stark, vice-president strategie bij Daimler. © RV Daimler AG

'Elektrisch rijden wordt binnenkort de kern van Mercedes'

BMW komt komende jaren met 25 modellen elektrische auto's

DO 7 SEPTEMBER, 20:15 ECONOMIE

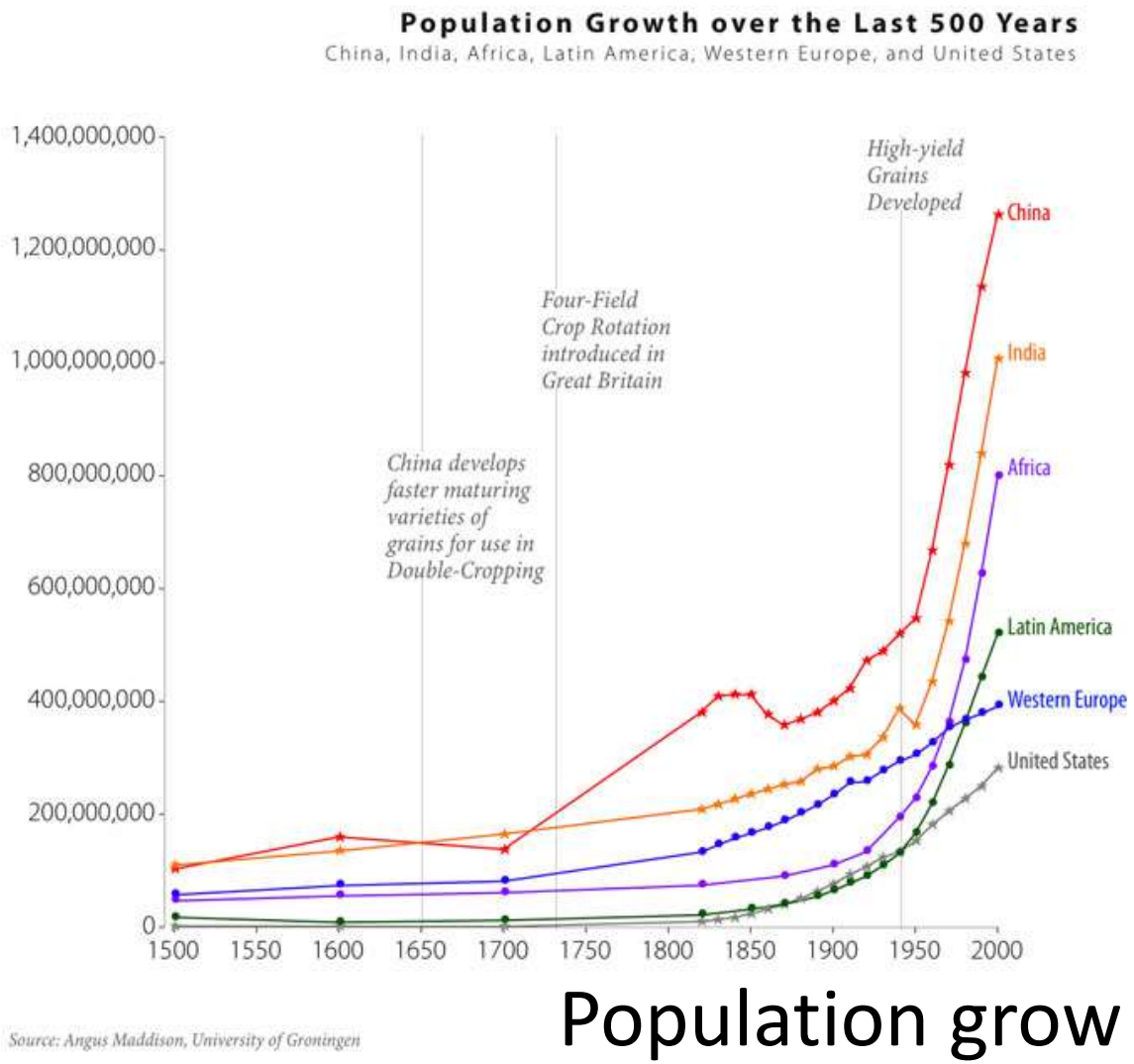
Volkswagen steekt 70 miljard euro in elektrisch rijden

3x meer elektra verbruik

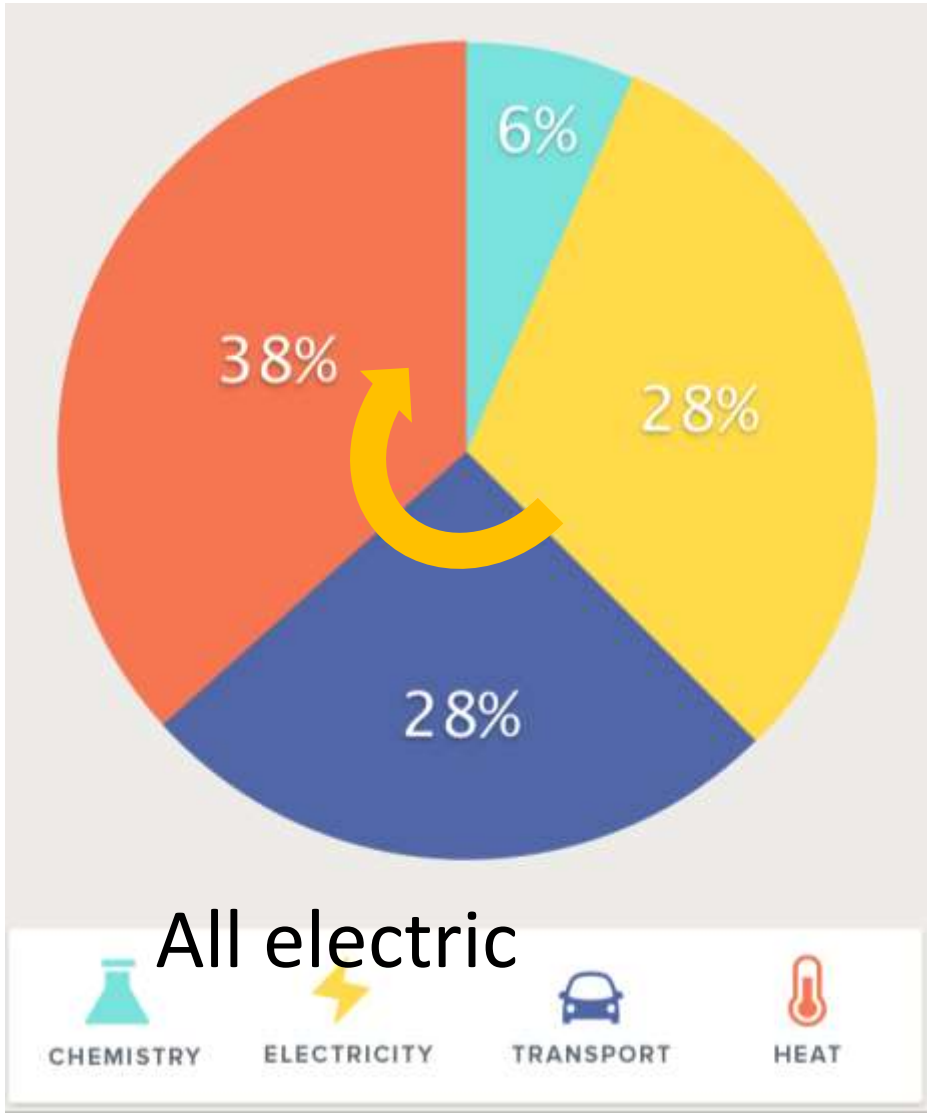
Net aanpassing minimaal 7 .. 10 jaar

De groei gaat harder dan gedacht.

Future and challenges



Population grow

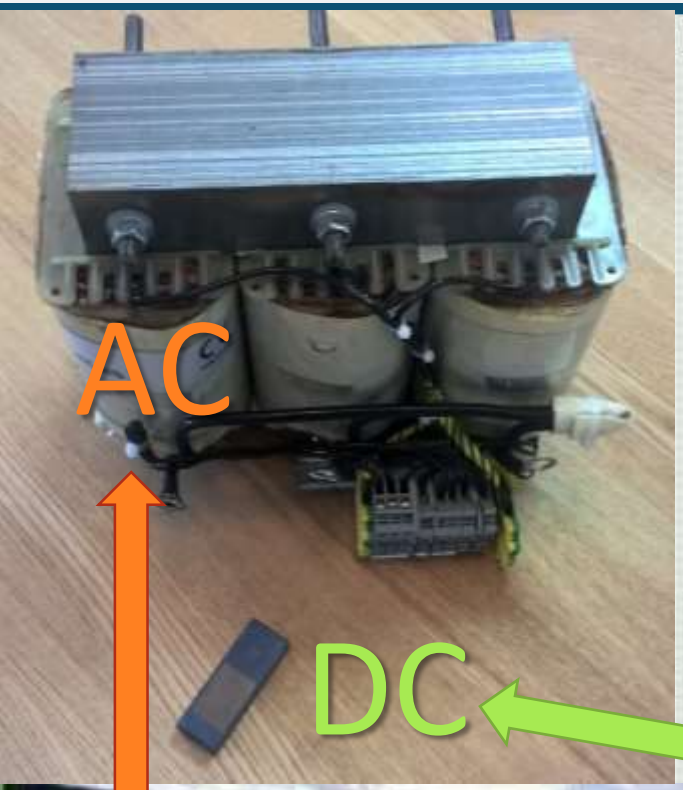


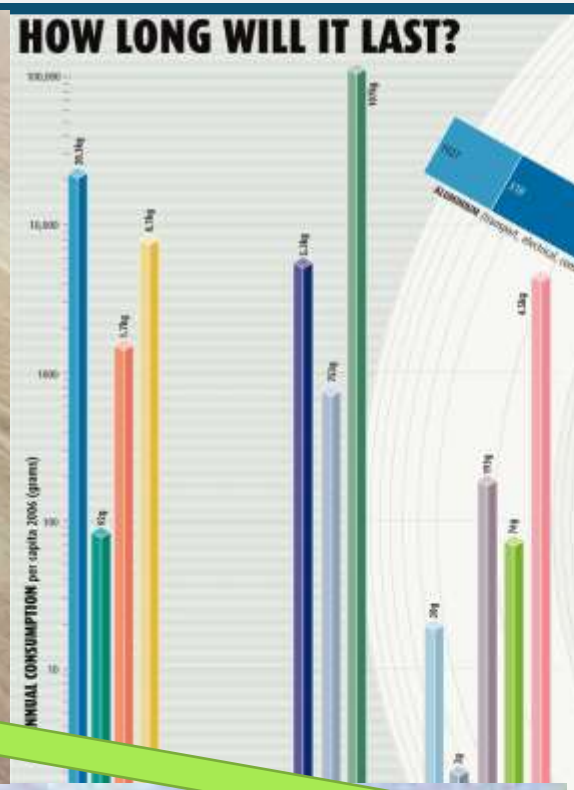
All electric

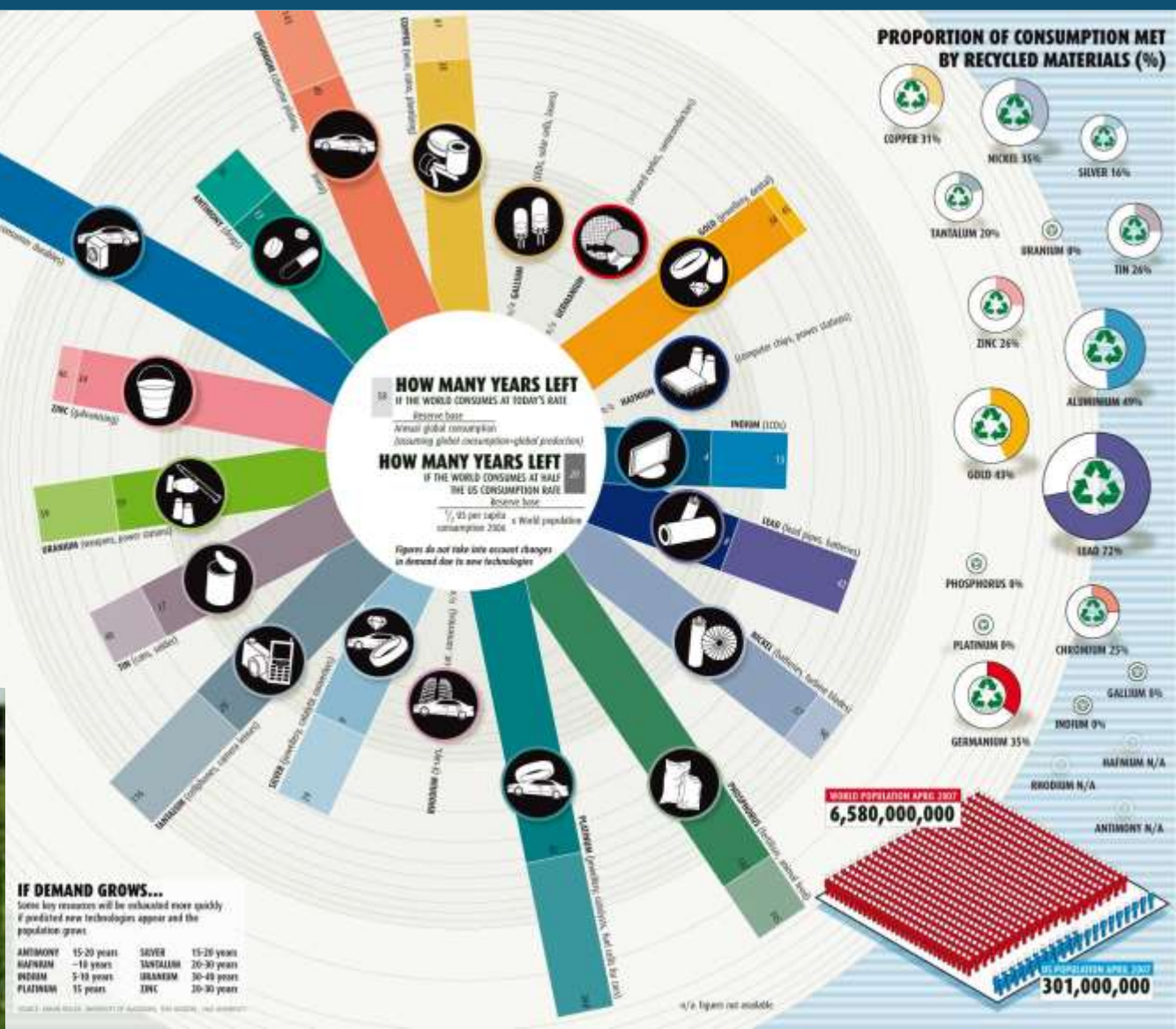
Copper
38 to 61 year

Raw materials and DC

DC SYSTEMS







In the end everything is solved

Gold

Cooperation

Oil

Create issues

Sand

Solve them

Gold - Oil - Sand age

It’s all about sand.

Everything is also possible in AC

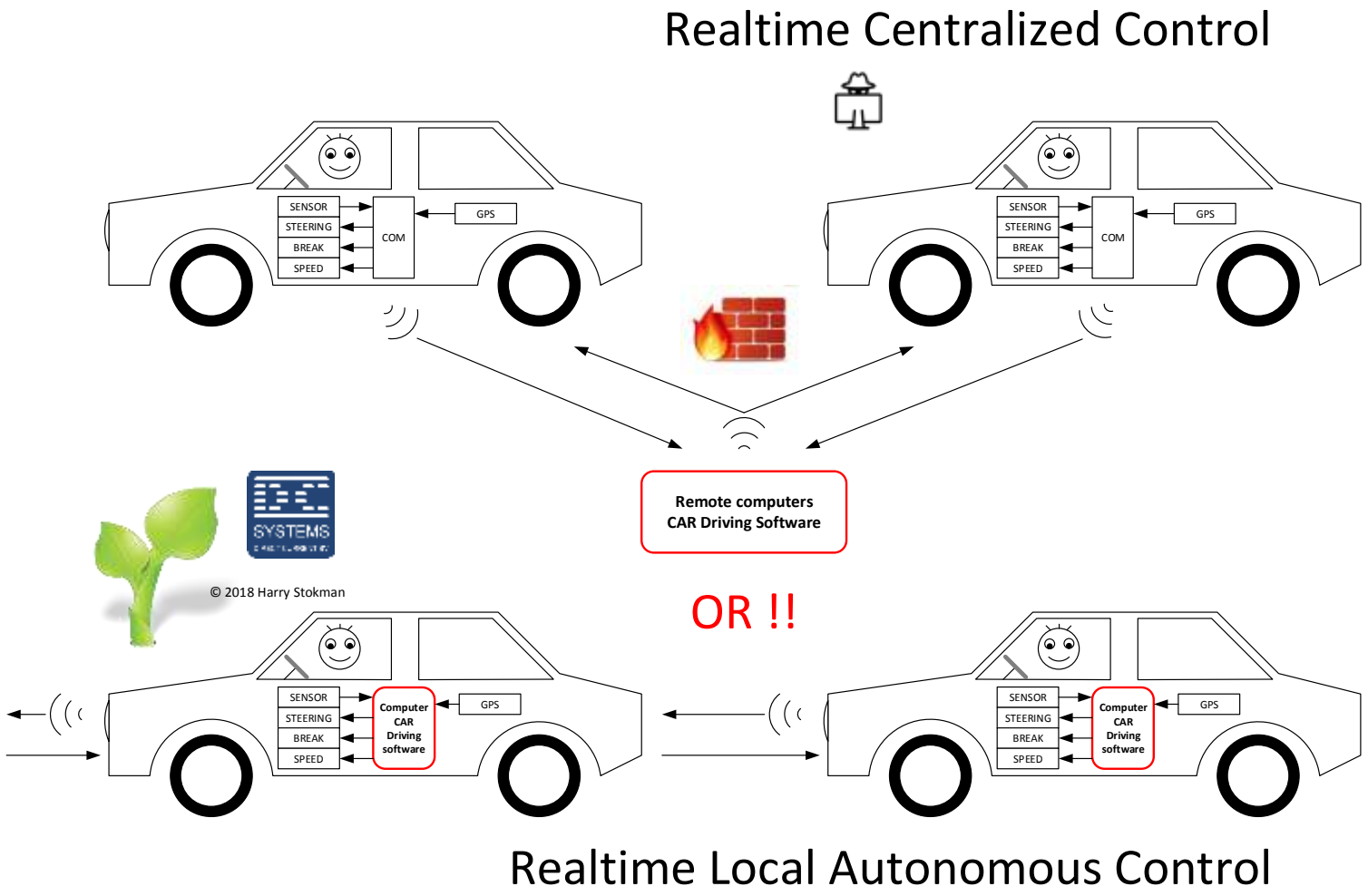
DC SYSTEMS

- **The discussion is not**
  - **Efficiency**
  - **Can not be done in AC**

It’s not all about system efficiency, but about an efficient system.

- But it makes more sense to do this in DC because
  - It’s about reduction of complexity
  - It’s about reliability
  - It’s about a full electronic system
  - It’s about predicting the system
  - It’s about raw materials
  - Having a high share of renewables in the system
  - It’s about increasing power levels in the last mile or application with smaller connections

Control AC vs DC



Smart grid

- Trust
- Privacy
- Availability
- Autonomous

The other society in development
DC connecting worlds together

DIRECT CURRENT BV

DC SYSTEMS

1,2 Billon people without electrical access

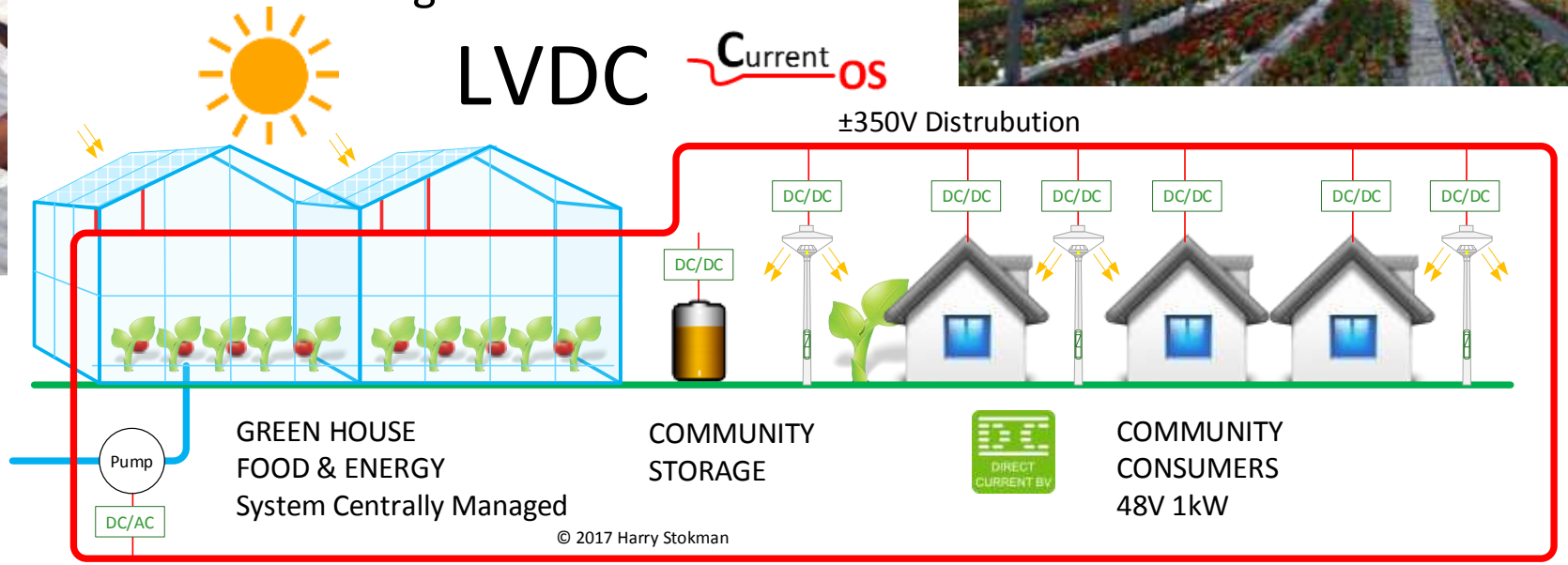
- Energy
- Food
- Water reduction
- Greenhouses
- Direct Current
- Electrical cooking

Balance

LVDC

Current OS

±350V Distrubution



IEC

Electricity access

More than a promise: LVDC

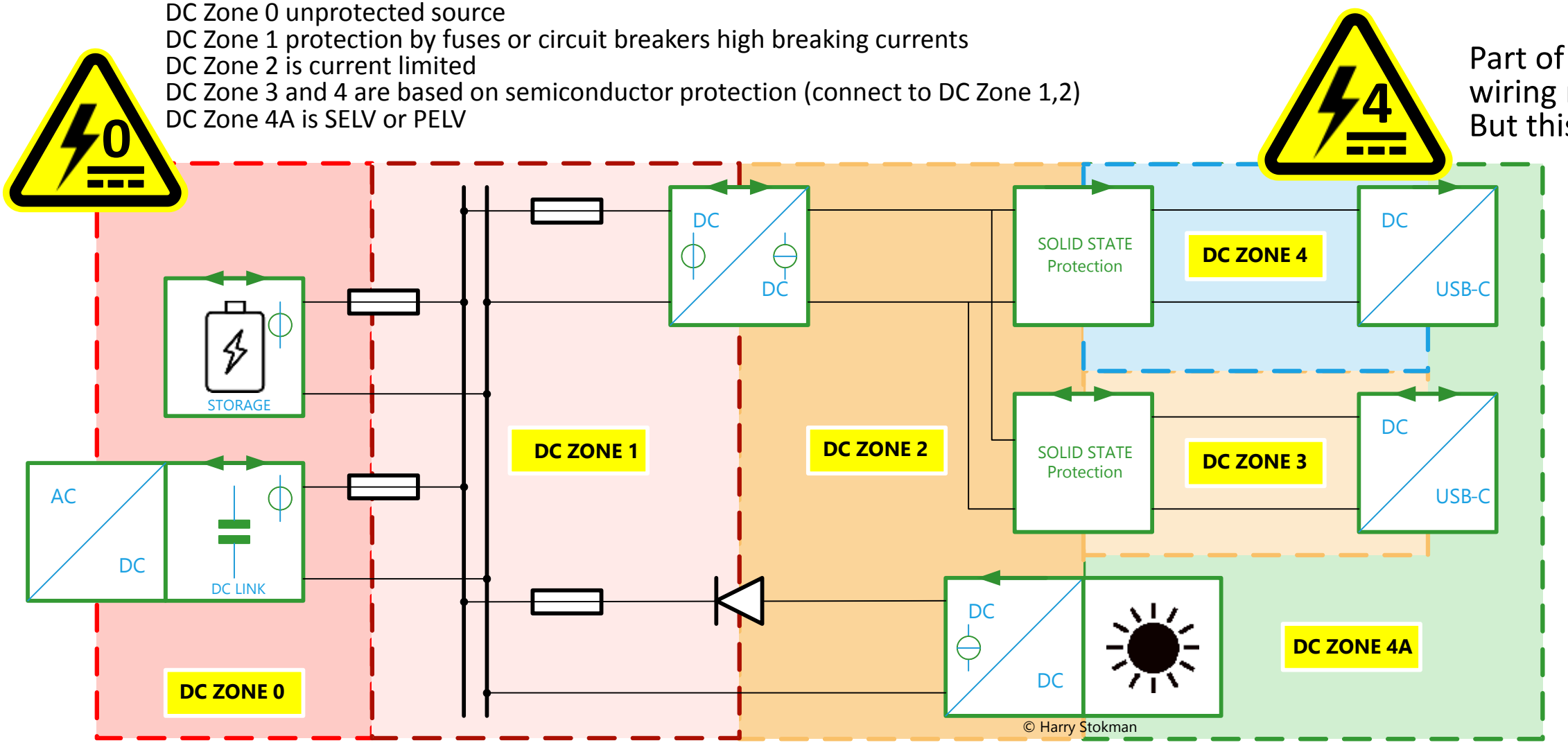
DC in Standards

- IEC TC 8 WG9 LVDC distribution Selecting the voltage levels
- IEC TC 64 PT101/102 Guidelines for developing countries up to 1500V
- IEC TC23E working on DC RCD
- IEC LVDC System Committee coordination between the different TC's
- TC64 DC Workgroup (NEN1010) result NPR 9090 In the Netherlands
  - 350/700V DC as advised standard,
  - Risk labels DC Zones
  - Grounding structures

Safety DC zones

DC Zone 0 unprotected source
DC Zone 1 protection by fuses or circuit breakers high breaking currents
DC Zone 2 is current limited
DC Zone 3 and 4 are based on semiconductor protection (connect to DC Zone 1,2)
DC Zone 4A is SELV or PELV

Part of the Dutch wiring regulations
But this is not all



Effects of DC

Yesterday

Now

Projects where we are involved

- DC Flex house (Renovation and DC)
- DC in lofts
- DC in Buildings ABN and Pulse TU/delft faculty building and construction
- DC in streetlighting
- DC in tunnels
- DC in football station Amsterdam Arena
- DC public service bus
- DC in the last mile
- DC and cooling combined with solar
- DC in greenhouses and last mile
- DC and charging EV and electric busses connected to the Metro traction
- DC in industries 4.0
- MVDC roundabout in the chemical industry

DC Homes

- DC Lofts Strijp-s Eindhoven, 50kW central DC installation where multiple apartment owners are connected, USB-C, Batteries & Solar
- DC-Flexhouse where we working on renovation existing homes
- Prime Energy roofs Heat Pump, PV, ventilation and windows integrated. Safety and reduction of construction.
- DC Grid for student houses Delft just started
- DC grids in holyday parks

Possibly by

Rijksdienst voor Ondernemend Nederland

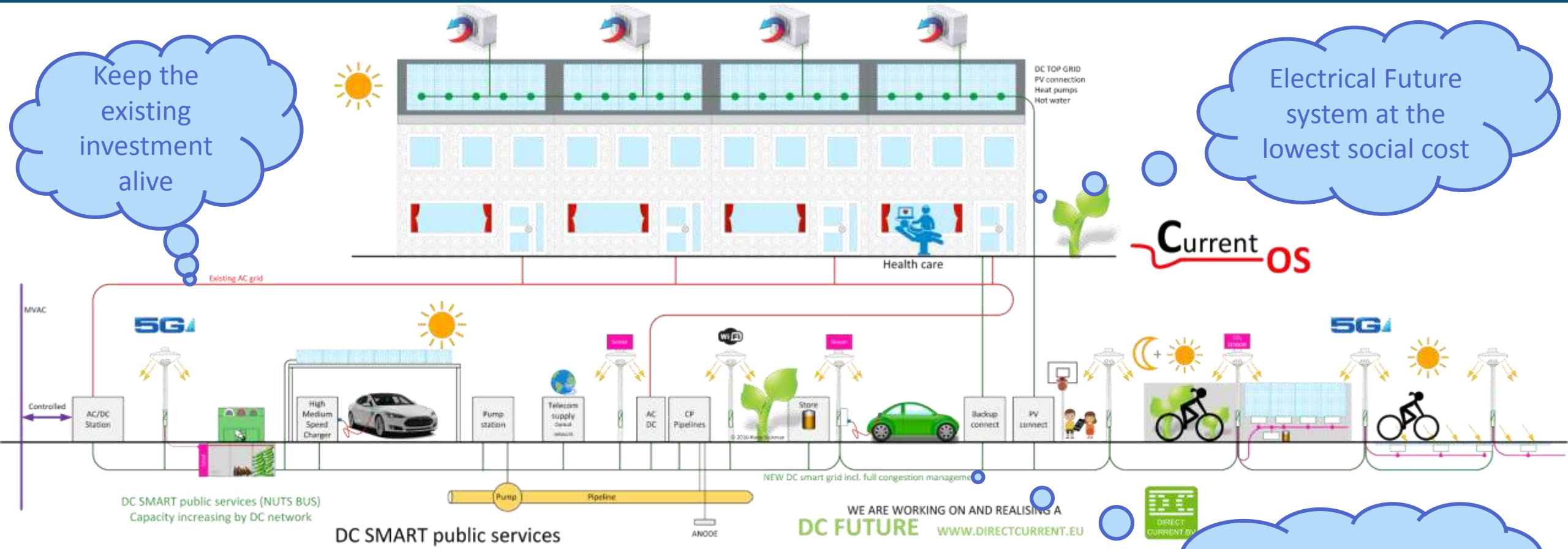
DC Outdoor lighting

- Outdoor (we started this because it’s innocent, but can be expanded)
  - 90 km Public lighting installed in the Netherlands with as result:
    - More than 50 new projects moved into prospect state (business case)
    - Now we talk about bringing other application to the public service grids
    - Enabling new services and possibilities where nobody has thought about

DC Public service bus
Second grid

Keep the existing investment alive

Electrical Future system at the lowest social cost



Enable new services DSO, Healthcare, mobility

Bipolar DC grids running on ±350Vdc and 700Vdc for last mile replacement

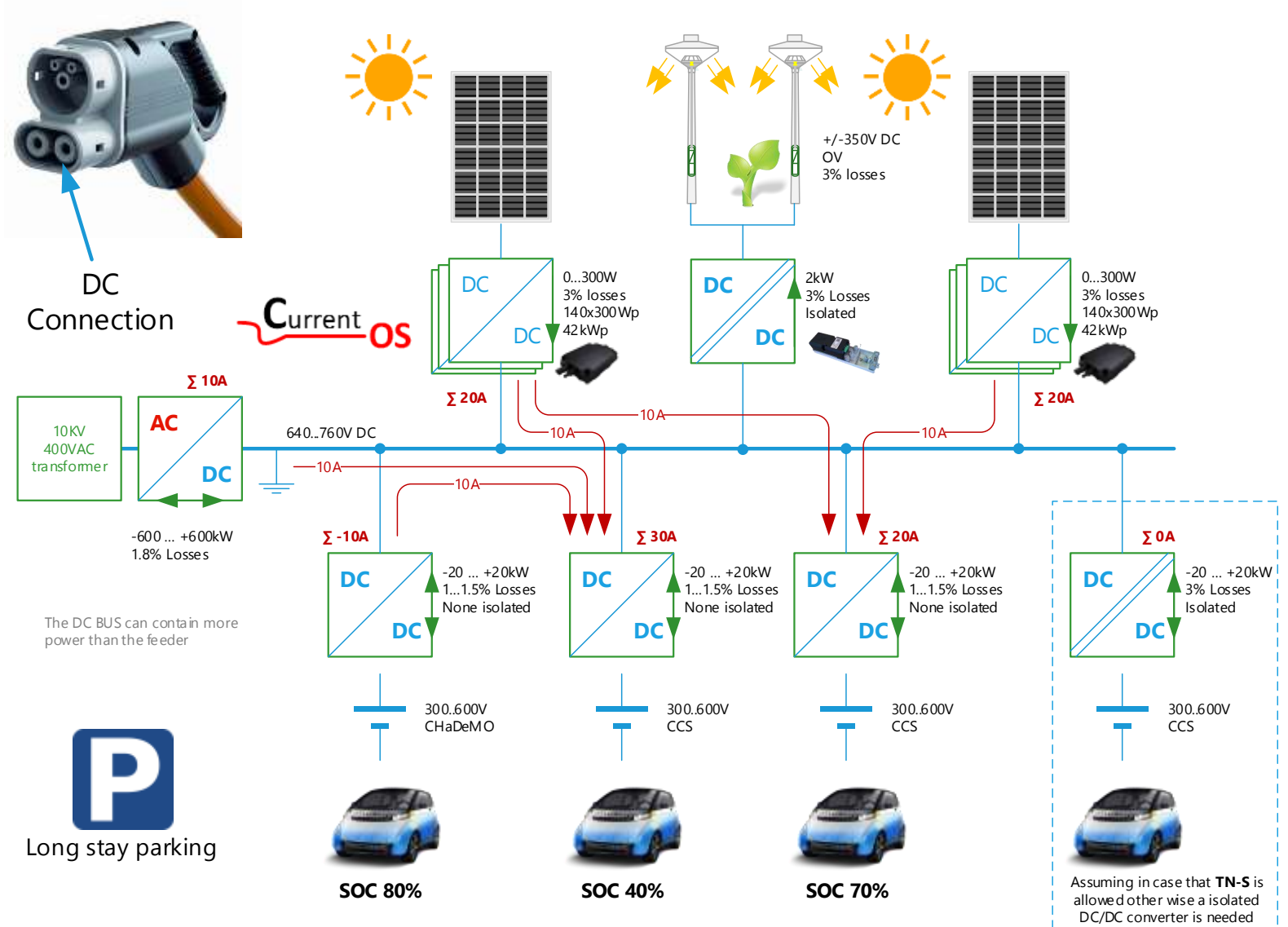
Current OS

ABN·AMRO Bank

DC SYSTEMS

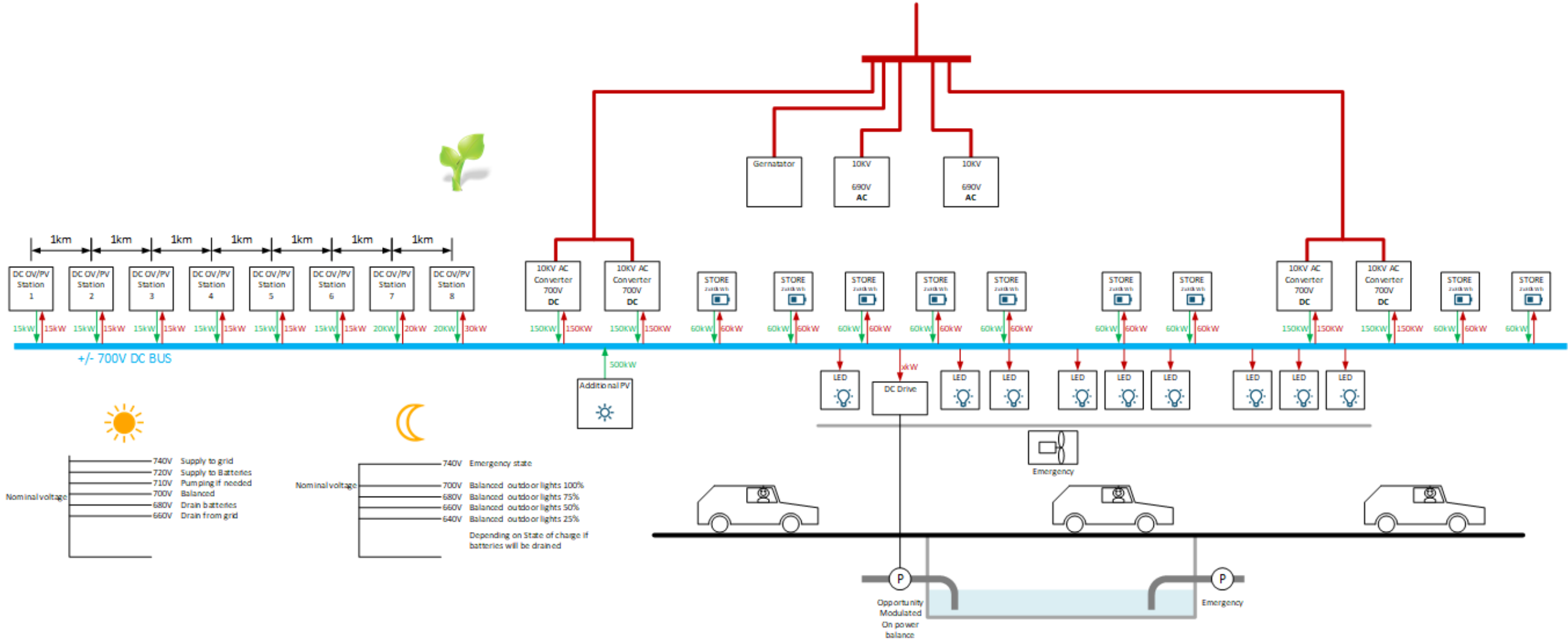
- 3x 50kW Active Front Ends. Driving 150kW DC bus managed by the Current/OS protocol
- 535x 280W panels connected to DC micro converters
- 15x 16A/350V Current Routers protection
- 30kW LED lighting directly to DC
- 10kW Ventilation directly to 350V
- 6x 2500W AC 230V from the 350V DC
- Current/OS congestion
- Connection
  - 48x USB-C 100W
  - 48x USB-A
  - 48x 350V 10A sockets

DC and Parking



- 60 … 600 Charging points power between 500W…10kW bidirectional start with 60 chargers
- Simple infrastructure
- Vehicle to grid
- High Safety systems can be easy disconnect for work
- Realtime congestion management
- 300x DC Public lighting 30kW
- Direct PV integration 1MW peak
- Small grid connection <600kW direct connected to the DC grid from the DNO.
- Ring grid structure

DC in Tunnels



DC and football

DC Greenhous status

- 1.5MW DC grow light blocks of 150kW @ 700V DC (tested for 1 year)
- Next step 1 MW HPS integration directly to the 700V DC grid (during 2018)
- In progress with the grid operator grounding issues and at some point move the DC connection to the grid operator (Alliander) (end of 2017)
- In progress PV installation connected to the main AC/DC station (begin 2018)

Manny hordes to take and taken

- Grounding AC and DC
- Main protection
- Active case, fall back scenario is mandate
- Converter station grid operator ready
- Limited budget for realization
- Hybrid breakers and Solid-state breakers
- Grid codes
- Installers acceptance

DC and Corrosion

- Corrosion is a underestimated issue we have more then 50 year knowledge in this area.
- We are protecting the Netherlands. The Dutch water defense systems **“The Delta works“** are protected by our DC systems
- And we are very proud that our system helps the Dutch to keep their feet dry

The Why (voltage level)

Why 350V DC (320V…380V range)

- With ± 30VDC Droop the limit for direct touch disconnect time = 2.5 millisecond. So can be used in Home applications. In line with the IEC60479-2
- Clear number not confused by AC voltage levels in hybrid cases
- Multiple grounding possible
- Similar design criteria's as 230V AC
- Lifetime improvement with 600/650V semiconductors
- In case for bipolar ±350V DC the 700V DC levels is available for larger power devices

±350V DC use this for locations where direct touch protection is needed.

Why 700V DC (640 … 760V range)

- Isolation windings in motors is in the safe range
- Clear number not confused by AC
- ± 60VDC droop
- Multiple grounding possible
- Similar design criteria's as 480V AC
- Lifetime improvement with 1200V semiconductors and capacitors
- In case for bipolar ±700V DC the 1400V DC levels is below the 1500V DC border this enable full range of the voltage band to use

Standardized in the Netherlands in the TC64 application paper in the Dutch NEN1010 practical guide

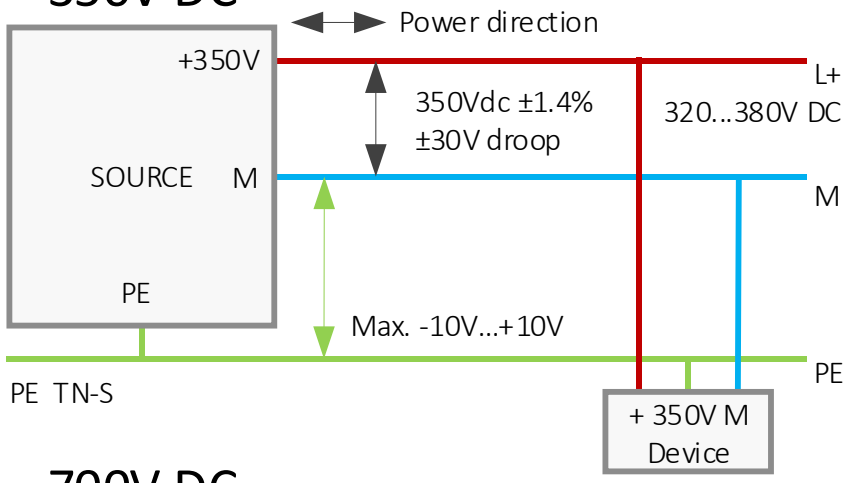
Questions need to be answered for selecting the correct voltage level

The voltage level including the droop ranges is defined by the:

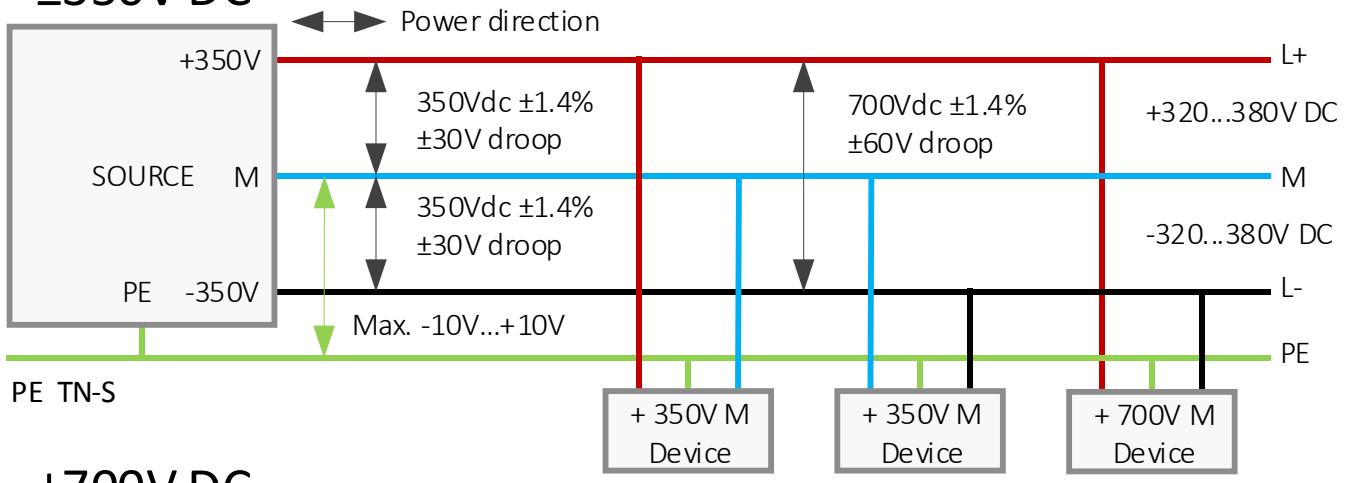
- Grounding system
- Direct touch protection
- Distribution efficiency
- Full replacement of existing AC solutions in many applications
- Must work in all applications, with compatibility
- Clearness in hybrid systems
- Arcing
- Corrosion
- And many more small items that are common overlooked

DC system voltages

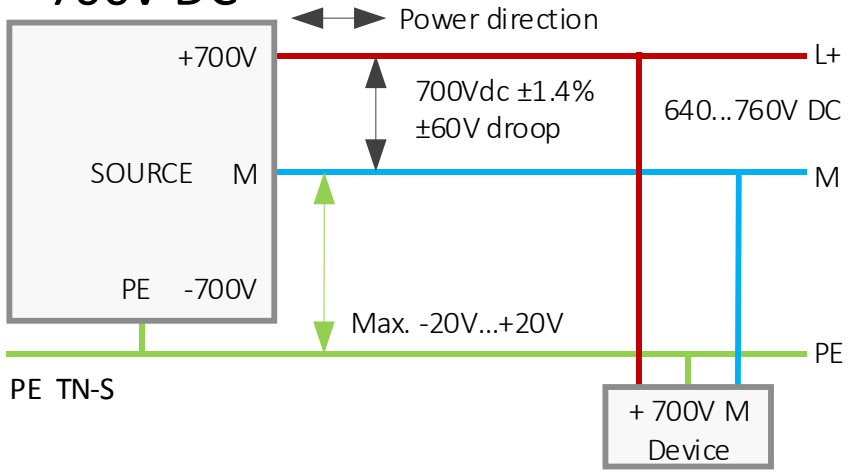
350V DC



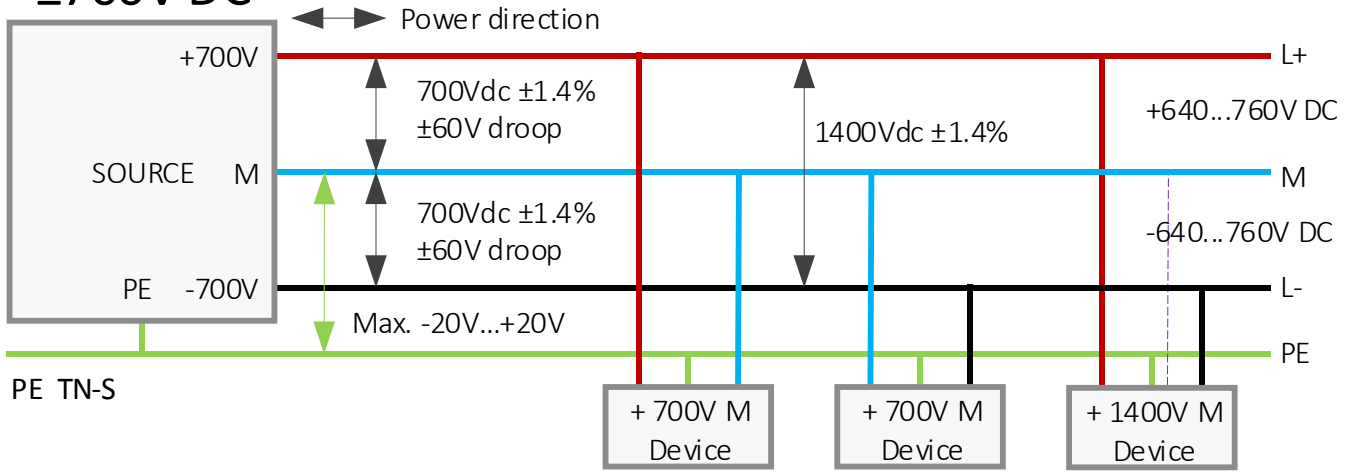
±350V DC



700V DC



±700V DC



DC and Direct Touch

- Additional protection (protection against direct contact) still possible for 350 VDC nominal 320…380V including droop with a overshoot to 400 VDC.
- Pictures below according to NEN NPR 9090 Wiring regulations in the Netherlands

Type	I_n [A]	$I_{\Delta n}$	Standard values of break time at a residual operating direct current equal to [ms]			
			$I_{\Delta n}$	2 $I_{\Delta n}$	3 $I_{\Delta n}$ < 1 A	1, 2, 5, 10, 20, 50, 100A
General	Any value	≤ 80 mA	40	10	2,5	see NEN 1010:2015 table 41.1

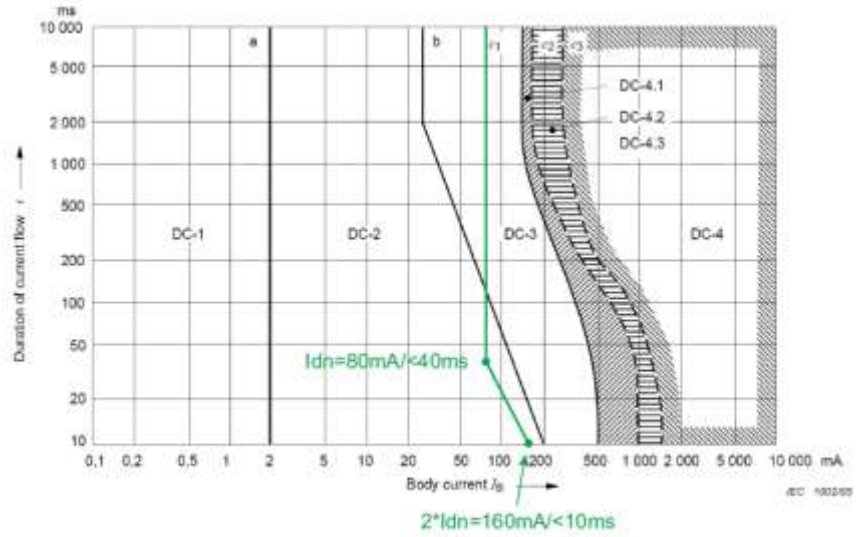
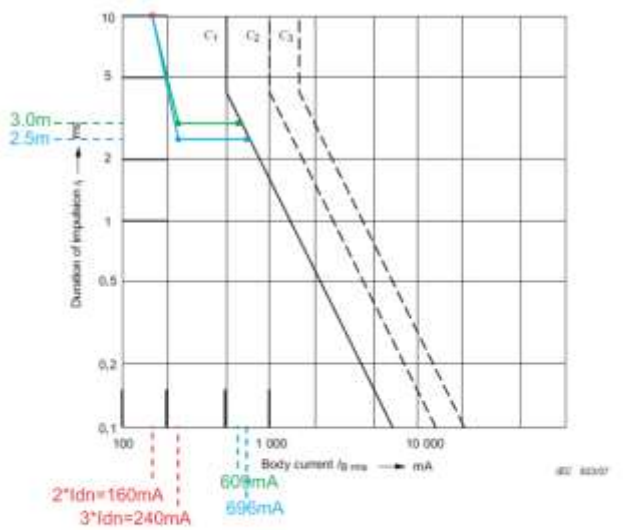


Figure 22 – Conventional time/current zones of effects of d.c. currents on persons for a longitudinal upward current path (for explanation see Table 13)

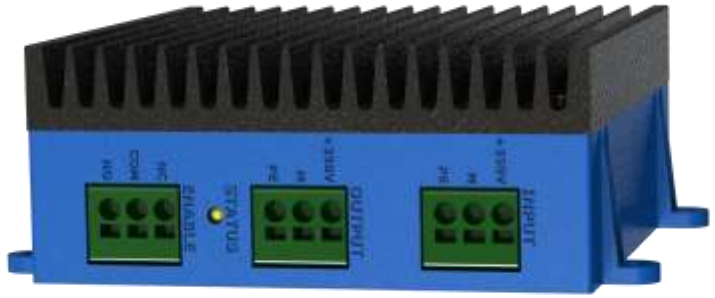


green, below C1: no fibrilation up to 350V/3.0ms (at 575 Ohms body impedance)
blue, below C1: no fibrilation up to 400V/2.5ms (at 575 Ohms body impedance)

Figure 20 of IEC TS 60479-2:2007
for duration<10ms, body current>160mA

Safety is in our tradition
The first historical safety shoes ☺

Current/OS Interface to DC grids



- 2kW 6A 350VDC
- Connect Devices that can work on DC to the Current/OS
- Safe connection for devices
- No inrush currents

Manny devices can work directly on DC but not according the DC protocol.

DC Current Router (protection) 16A (100A version in Q4-2018)

DC protection in greenhouses

- 16A Solid-state Breaker <8us short detection
- RCD 1…80mA 0.1sec for 80..500mA <0.025sec (IEC 60479-2)
- G3 powerline communication for parametering
- RS485 SCADA control (MODBUS)
- kWh meter
- Congestion management
- Priority structure
- No inrush current
- Black start protocol
- Protection of the incoming DC
- Arc detection
- <12W losses @16A / 700Vdc incl. housekeeping and communication
- DC Zone 3 and 4 operation

DC Micro converter

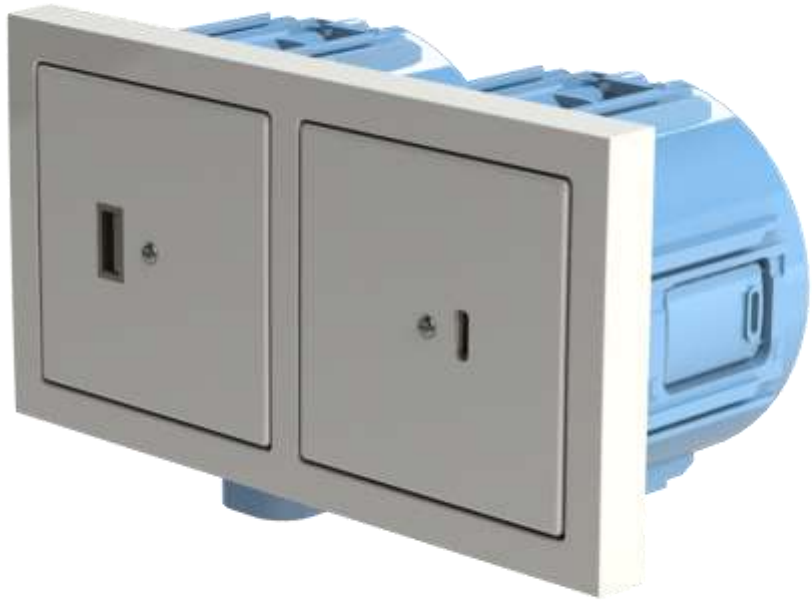
Features

- Superior performance due to Maximum Power Point Tracking (MPPT) on each PV panel
- Superior MPPT efficiency >99.9%
- Electrical efficiency (97%, peak) and (95.8% euro)
- Parallel software architecture
- PV panel add-on
- Power rating 300/310W nominal, 310/330W peak
- 60/72 and 96 Cells versions (55V or 85V max input voltage)
- Droop control
- 350Vdc, 380Vdc available and 700Vdc expected in 2017
- Patented 48Vdc safety system
- PV panel level monitoring
- Monitoring level safety
- Solves the negative system impact of:
  - shading conditions
  - module mismatch
  - aging mismatch
  - soiling mismatch
  - temperature variance

USB-C 350VDC

- Wall enclosure
- >97% efficiency
- 100W max USB power
- USB-C socket up to 20V 5A (100W)
- USB-PD power protocol
- USB-A socket 5V 1.5A
- 350Vdc input voltage
- Current/OS 350Vdc compatible

- Next steps for 2017
  - Domotica
  - Current/OS Power Line Communication
  - Overbooking possible
  - Power delivery device to DC grid power flow UPS function
  - Distributed batteries
  - Highspeed Ethernet



Active frontend

- Safe DC grid bidirectional
- Isolation transformer
- Activate from the DC but
- In case of batteries UPS function
- Autarky mode OFF grid in case of batteries
- Emergency mode
- Constant Power factor = 1
- In Modules of 50kW
- 50/100/150kw Versions
- 350Vdc or 700Vdc versions
- Connection for PV systems
- Integrated System controller (ARC)
- Current/OS (voltage & communication
- In case of multiple modules it puts itself in cascade mode. Auto stepping in steps of 50kW
- Routing PV power directly to load
- IGBT based (SiC versions 2018 for improved version)
- Width 1.2m+ (modules * 0.4m)
- Height x Depth 2m x 0.6m
- 48Vdc Safety bus for PV system
- Intern or External MS-SQL database for logging
- Power monitoring

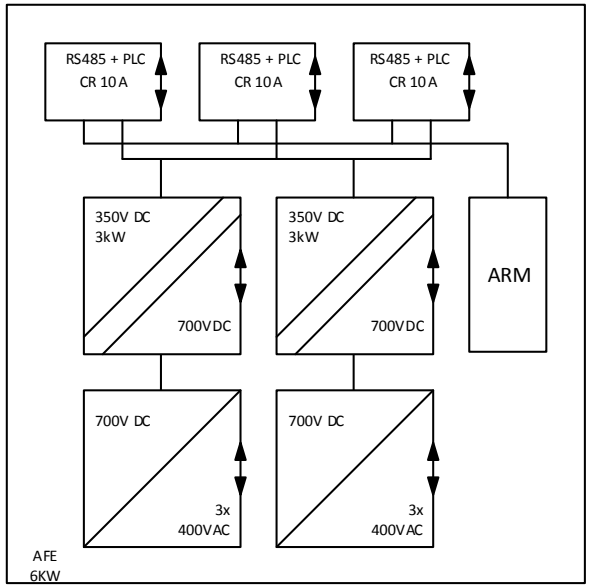
350V model

- Up to 30 current routers
- Losses 3.5kW/50kW
- Direct connection to DC micro converters for PV up to 500 panels
- Direct connection for USB-C and LED drivers.
- PV panel to Load 97%
- PV panel to grid 91%

700V model

- Up to 30 current routers
- Losses 2.6kW/50kW
- Direct connection to DC micro converters for PV up to 500 panels
- 150kWh batteries
- PV panel to Load 97%
- PV panel to grid 92%

AC/DC Bidirectional Converter Primality Q4-18

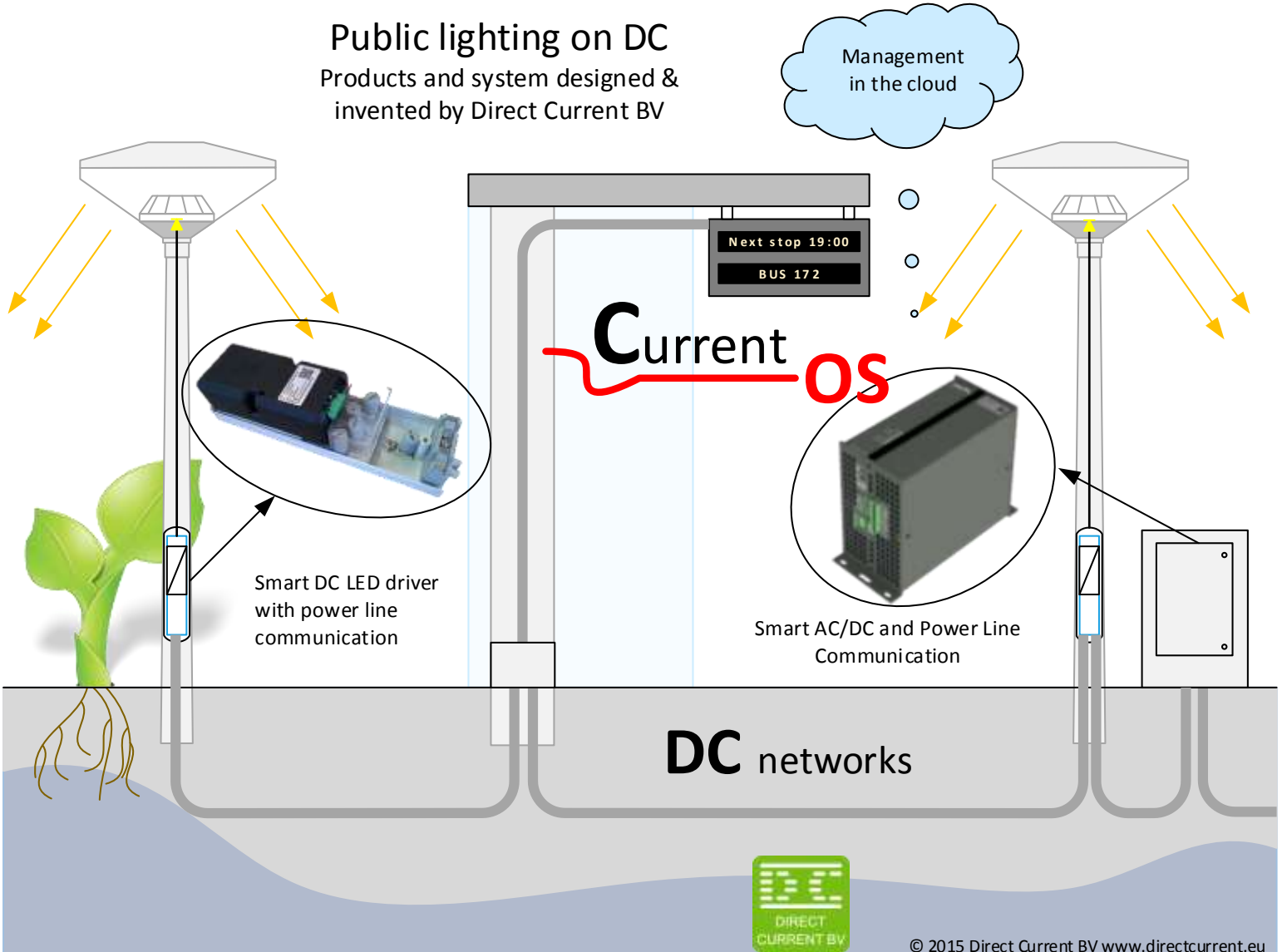


- Power 6kW (2x3kW)
- Voltage +/-350V DC
- 3x (2x10A) Current router
- 3x RCD
- Galvanic isolated by bidirectional DC/DC converters
- 600x220x250 mmm (HxWxD)
- 3x Zone 3 or Zone 4 Connections
- 1x AC Input Bidirectional
- Galvanic isolated DC from AC
- TN-S(CDD) grounding
- ARM Linux running Domoticz
- Power line communication
- 3x RS 485 for Zone 3 sources
- AC Protection
- Current/OS implemented
- 3x isolation switch
- 6kW natural cooling but fan needed when ambient is higher than 45 degrees
- Design lifetime 200K hour
- Overall efficiency 97.5% <40W housekeeping and active no load losses

Battery Connection
Primality Q4-18

- Power 6/8kW
- Voltage 700V DC
- 1x16A Current router
- 1x Zone 3 Connection
- TN-S(CDD) grounding
- RS 485 for Zone 3 sources
- Current/OS implemented
- 3 phase Buck Boost Max 15A battery current natural cooling
- Efficiency 99.1%
- CAN BMS Interface
- SOC optimized based on state of grid
- Easy to combine multiple batteries in one system

DC Public Lighting



Example: We have installed more than 1800 Public Lights of 60W More than **90km** in the Netherlands in cooperation with Eleq, Lightwell, Luminext and CityTec based on:

- ±350Vdc Grids
- Earth fault protection 1..30mA adjustable
- Cable quality and state is known
- Lighting protection
- Arcing detection
- Corrosion protection
- Fully controlled
- Smart grid (Current/OS)
- Power Line Communication G3 protocol connected to the cloud
- No Breaking Current needed for protection
- Cable length > 2km
- HVAC transmission lines area

DC and Processes

- IP67 Anodized housing and highly chemical resistance coating
- >97% efficiency
- 100% Digital using DSP's
- Extremely low EMC
- RS485 Modbus (next step Power line communication)
- Full control by fieldbus
- Firmware can be updated
- Under and Over alarms
- Contact Failure Detection
- Auto Low Voltage
- Low product damage at shorts
- Arc prevention
- Coulomb counter (As, Am, Ah)
- Calibration during process
- PIN code to lock parameters
- Machine Builder Coding
- 700Vdc Current/OS interface
- 8V/100A or 16V/50A

Capacitive Grounding blocks for large DC systems