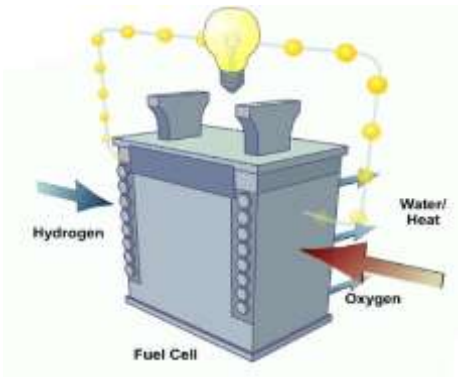
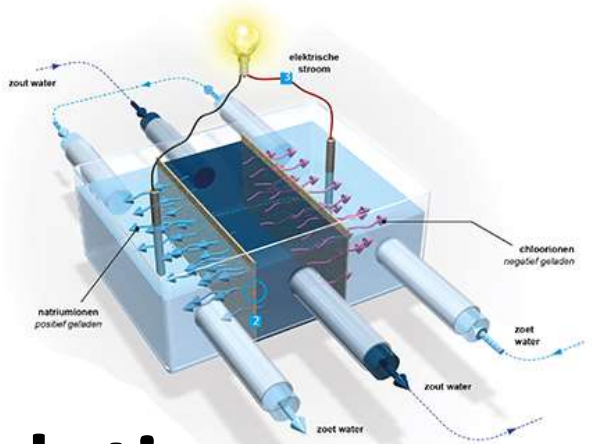
We are already
live in a DC world

Why DC

DIRECT CURRENT BV

Everything we ❤ and 👍 is **DC**





DC brings fun, comfort, clean and sustainable solutions

To make the DC future

About me and the mission

DC SYSTEMS

Direct Current

Femtogrid Energy

Hellas Rectifiers

Amstel Rectifiers

- 29 years history as DC **Entrepreneur** (started in 1988)
  - Production of high current rectifiers up to 30kA (owner of Hellas Rectifiers BV). More than 30.000 rectifiers build. Delivery worldwide in the following markets: Electronics, Connectors, Solar, Cathodic Protection, Electrolysis and Chargers.
  - Mission to make a DC world. R&D (owner of Direct Current BV), DC Competence Center.
  - SMPS rectifiers (owner of Amstel Rectifiers BV), SMPS since 1998 in CP, plating and electrolysis.
  - Solar, wind & blue energy inverters, MPPT & R&D (owner of Femtogrid Energy Solutions BV).
  - DC Light lease in the greenhouses "main share holder of DC Hortilighting BV"
  - Independent DC promotor (founder and chairman of the DC Foundation).
- DC **Pilots**: Agricultural Grow Lights, Public Lighting, Housing, Offices, DC Smart Grid.
- **Education**: Power Electronics, Energy and IT.
- Driver and **motivator** of DC systems.
- Close **relationship** with technical universities, grid operators, energy supplier and the large enterprises.
- **Politic** active in D66 working group electrical infrastructure.
- Green Deal with the **government** to make DC possible in the Netherlands.
- **Standards:** Chairmen in the local standards "TC64 DC" NEN 1010 DC workgroup and member of LVDC IEC workgroup SEG 4 LVDC and SEG 6 LVDC grids. (official member in the in the DC System Comity of the IEC)
- Member of the **CIGRÉ** workgroup SC 6.31 MVDC distribution
- Sets the standard in **±350Vdc** and **±700Vdc** LVDC active grids.

DC Foundation

European Business Awards for the Environment

Runner up

Green Deal

AWARD WINNER 2016

I'm Dyslectic, so forgive me for spelling mistakes

DC forced without noticed

Hidden Society Road map

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European Union forcing, Economic drive by manufactures and Globalization:

- Standard connector for small devices. Market answered with USB-C
- Efficiency of small rotating machines. Market answer BLCD (DC motors)
- Reduction of Vacuum cleaner power consumption. Market answer DC powered cleaning robots
- Saving in lighting. Market answer DC powered LED + communication
- Reduction to CO_2 in mobility. Market answer DC powered Electrical Cars
- More sustainable energy production. Market answer DC solar energy production
- Smart grids. Market answer with DC storage, and Controllability of DC devices

AC is disappearing and replaced by DC

What is going on

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- There are no more serious AC devices
  - Motors are connected to variable speed drives

- But more new DC devices that have big impact
  - Electric cars
  - Batteries
  - Solar
  - Wind
  - ICT
  - LED

Everything become solid state (electronics)
Electronics need DC to work
GAN theoretical limit 1cm² 120kW switch @1W

DC Timeline

History and we are just beginning

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Economy is based on rotating machines AC

Economy is based on:
standing still is moving forward

now

1880

1947

Pre DC age

AC age

DC age

2000 year

130 year

moving time age

War of currents

Electronic revolution
solid-state change

Future

Alessandro Volta

André-Marie Ampère

Edison

Tesla

Westinghouse

John Bardeen

Transistor

Ambition

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We want a DC world

- 1.2 Billion people without energy access, green field for DC
- All new applications are DC, all lighting will be DC
- The future is based on DC

DC solutions

We are designing and realizing

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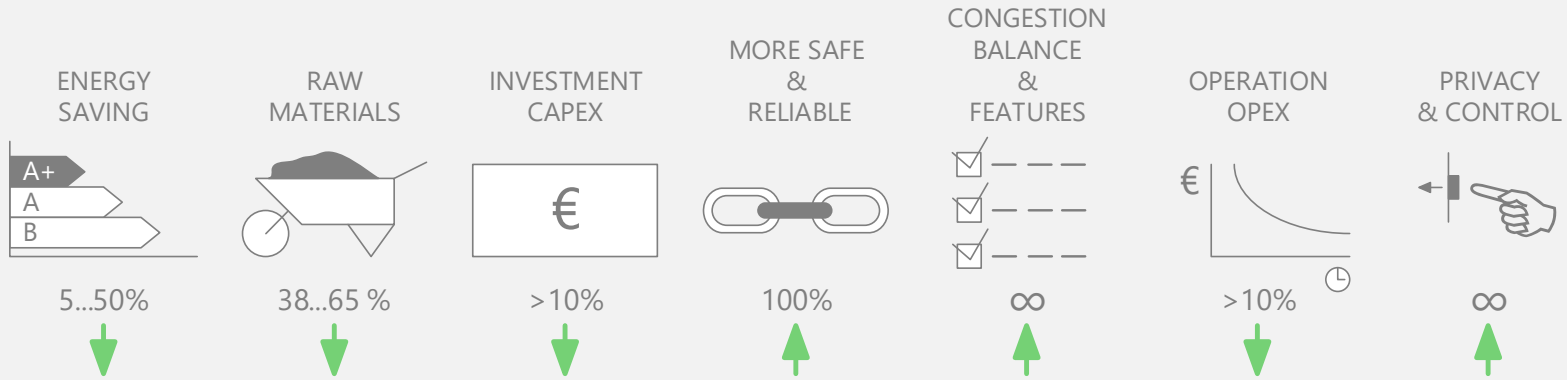
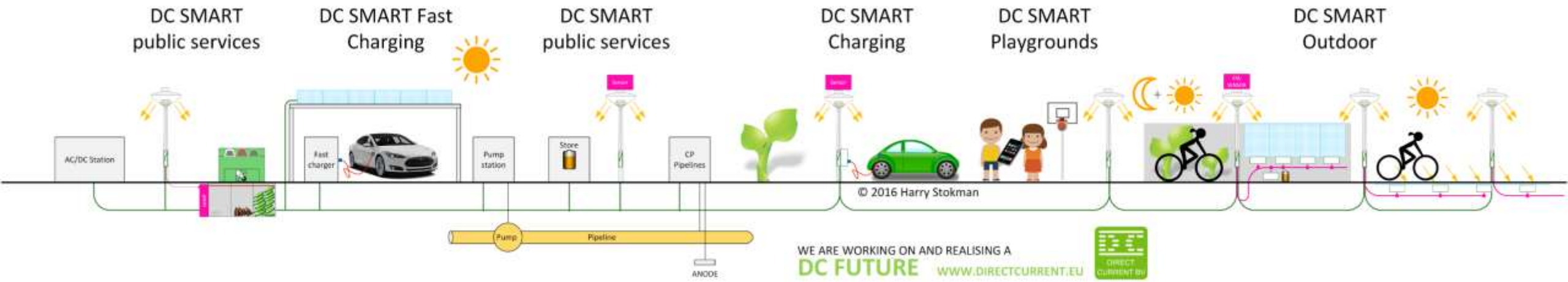
- DC smartest grids
- DC Smart cities
- DC Smart greenhouses
- DC Smart homes
- DC Smart offices
- DC Smart manufacturing

EFFECTS OF DC COMPARED TO AC GRIDS

WWW.DIRECTCURRENT.EU



WE ARE ALREADY LIVING IN A DC WORLD WITHOUT REALIZING IT



DC Pilots

DC show cases

- 1500X Public lighting on DC networks
- Grow light greenhouse Vreeken Bouvardia
- Full DC office installation in progress
- DC Flex house
- DC USB-C

AC world

Current situation AC 3x400Vac

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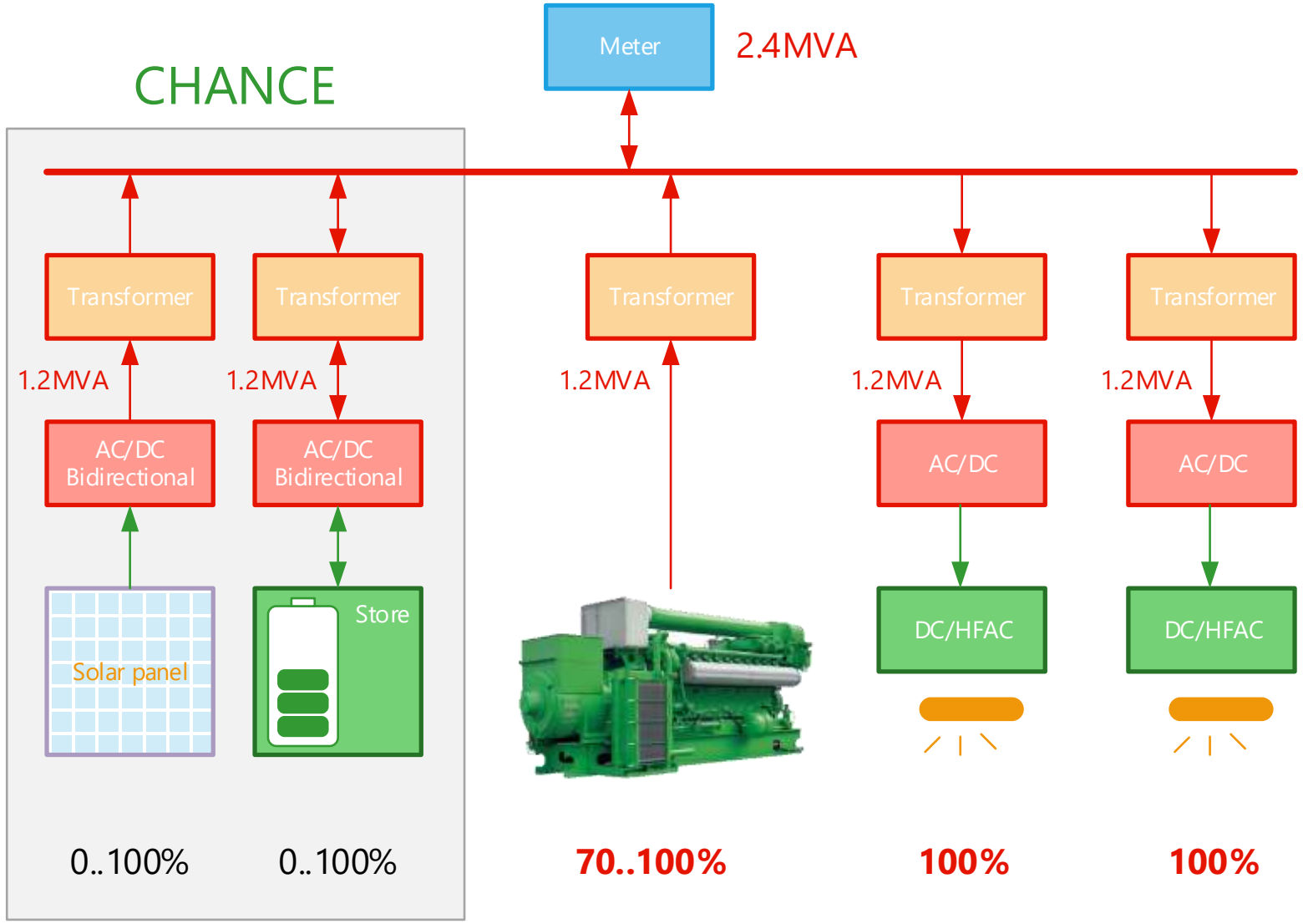
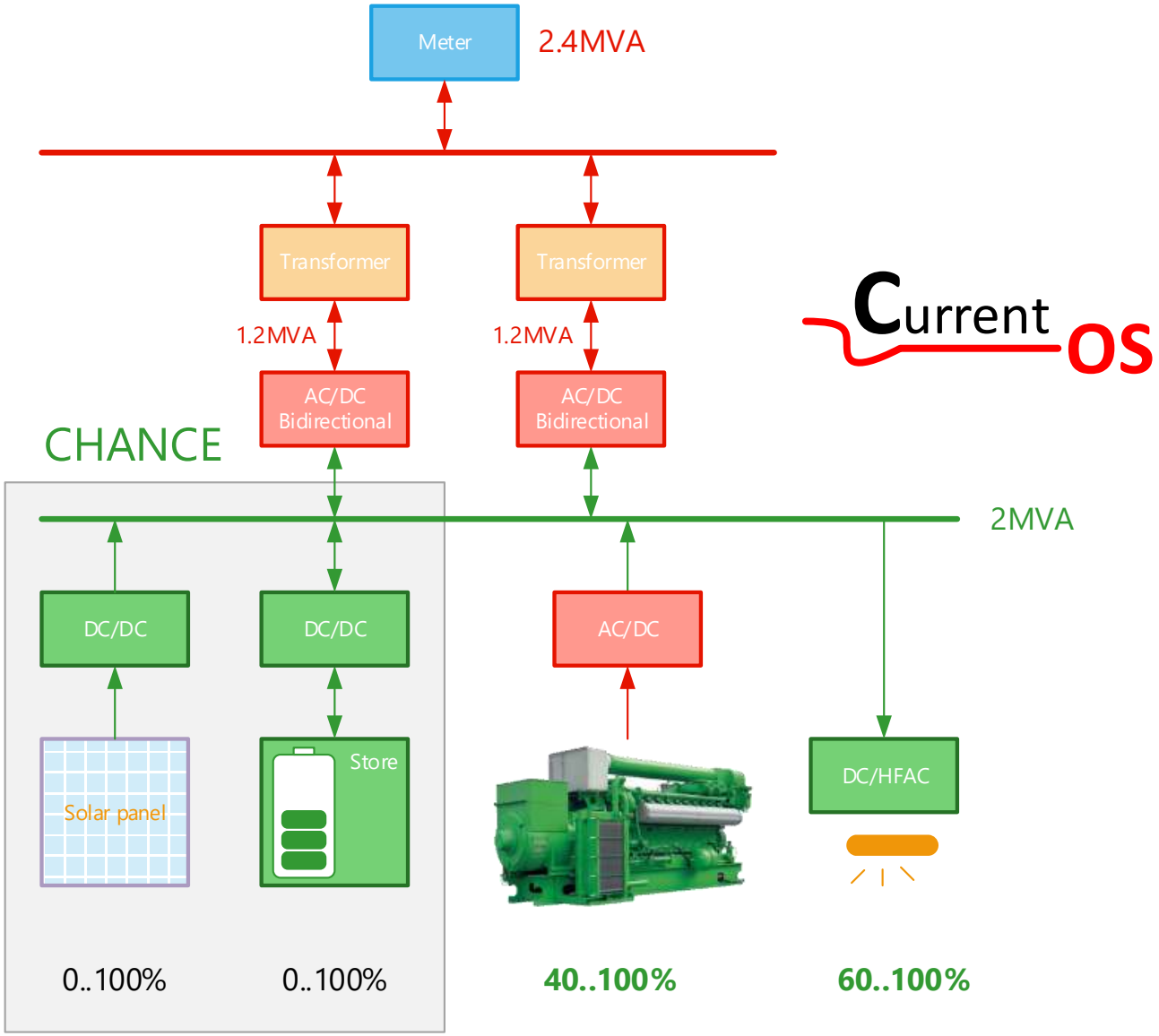


DC world

DC Version 700Vdc



- Uitdagingen
- Motor fabrikant moet mee werken om de WKK verder te kunnen optimaliseren bij variabel toerental
- Weinig bekent omdat WKK altijd 1500RPM draait
- Is onderdeel van het DEI project DOE-DC
- Kans voor 2e leven tuinbouwbedrijven

Icon project ABN on 350Vdc

- 150kW Solar panels on 350Vdc
  - 535X DCMC 300W
- USB-C 100W connectors on 350Vdc
  - 48x DC USB-C 100W
- 150kW AC/DC bidirectional converter
  - AFEF-350V-150kW-3-400V-O
- 230Vac 2.5kW from 350Vdc
  - AFEN-350V-2500W-1-230V
- 400kWh second live batteries Planned connected by DC/DC tot the 350Vdc link
- 30kW LED lighting in 350Vdc
- DC Current Routers 14x 5.5kW(16A)
  - CRN-350V-16A-1P-350V-T

DC Protection

DC IS SAFE

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Current OS

DC protection in greenhouses

- 16A Solid-state Breaker
- <8us short detection
- RCD 1…30mA
- G3 powerline communication
- RS485 SCADA control
- Current/OS
- kWh meter
- Congestion management
- Priority structure
- No inrush current
- Protection of the incoming DC
- Arc detection
- <12W losses @16A / 700Vdc incl. housekeeping and communication

DC generation

DC micro converter

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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

Current os

femtogrid energy solutions

DC Connection

350VDC USB-C Wall Socket

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- 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

AC to DC

AFE 150kW offices use

- 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)
- 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
- 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 92%

700V model

- Up to 30 current routers
- Direct connection to DC micro converters for PV up to 500 panels
- 150kWh batteries
- PV panel to Load 97%
- PV panel to grid 93%

DC expansion

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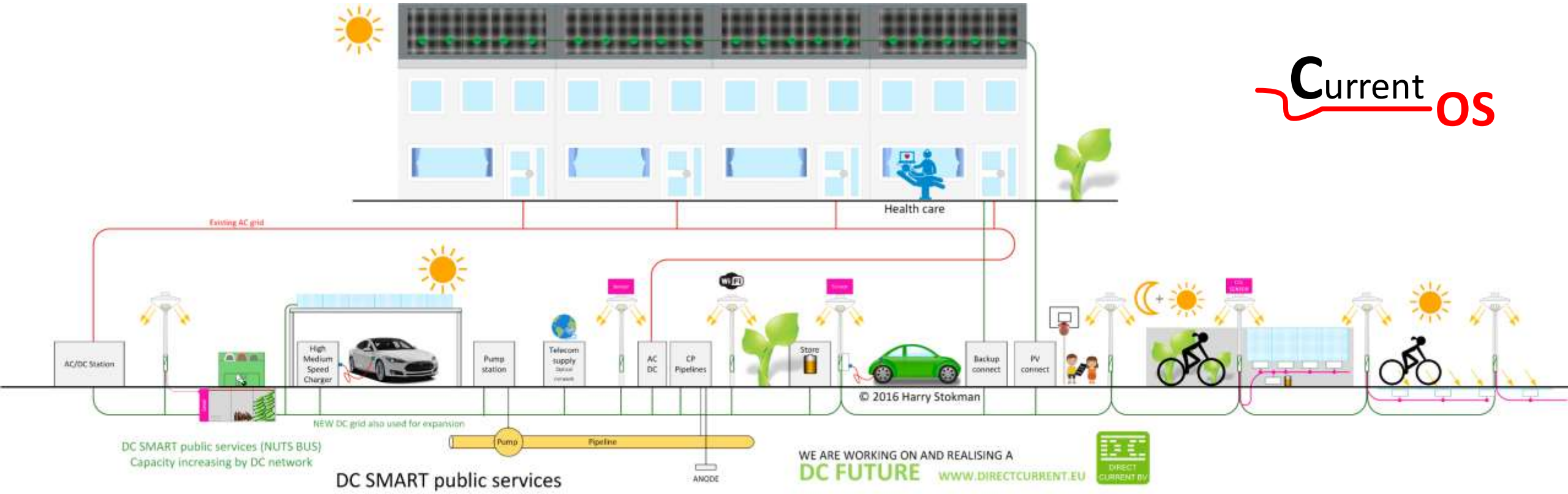

Current OS

DC is NEW

Pit Falls in DC

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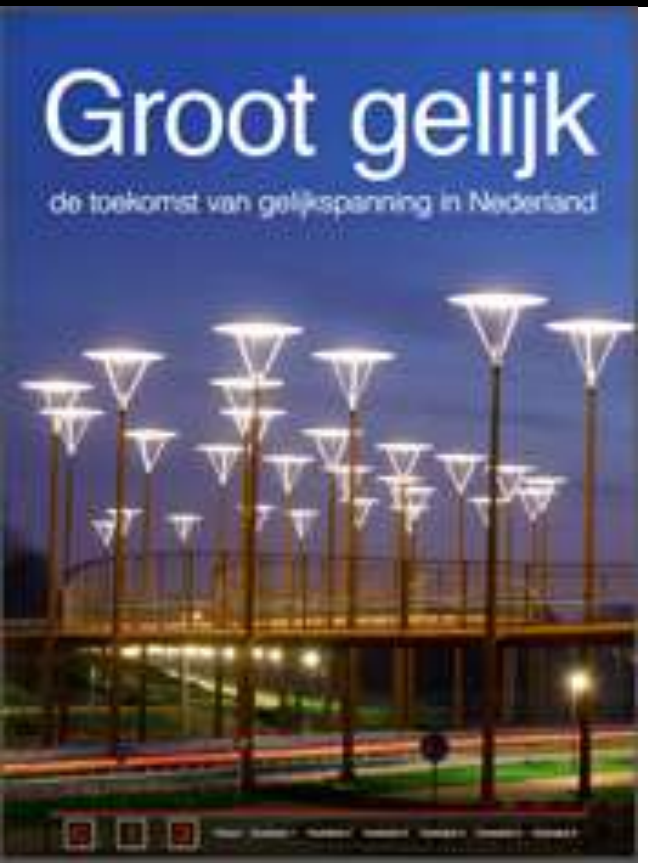
- Low voltage can be dangerous! Hard to protect and fire risk high
- Fuses or circuit breakers not always work
- See an DC installation the same as AC systems but with different sources
- Take care about corrosion a few mA leakage can destroy a building
- Oscillations on the DC BUS
- Surge currents
- Direct connect of batteries, semiconductors must be in between!
- Selectivity hard with standard protection
- Arcing
- Stay below 50A @4A/mm2 for maintenance free connections
- Don’t make the case based on electrical efficiency, SiC & GAN are coming
- Biggest enemy for DC: is lake of knowledge
- USB-C is **HERE** for small devices
- Make systems **future proof**

DC and next steps

The DCify mission is just started



Publication on DC by the DC Foundation
Written in Dutch

Register here to receive a download link for the free PDF version.
Buy the hardcover version (sold out)

- The Business

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www.gelijkstroom.nl

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Links

- https://www.youtube.com/watch?v=snk3C4m44SY
- A isolation transformer is used

- http://www.directcurrent.eu/nl/nieuws/youtube/119-ac-vs-dc-kortsluitingen-op-huidige-net
- Demonstration electronic protection