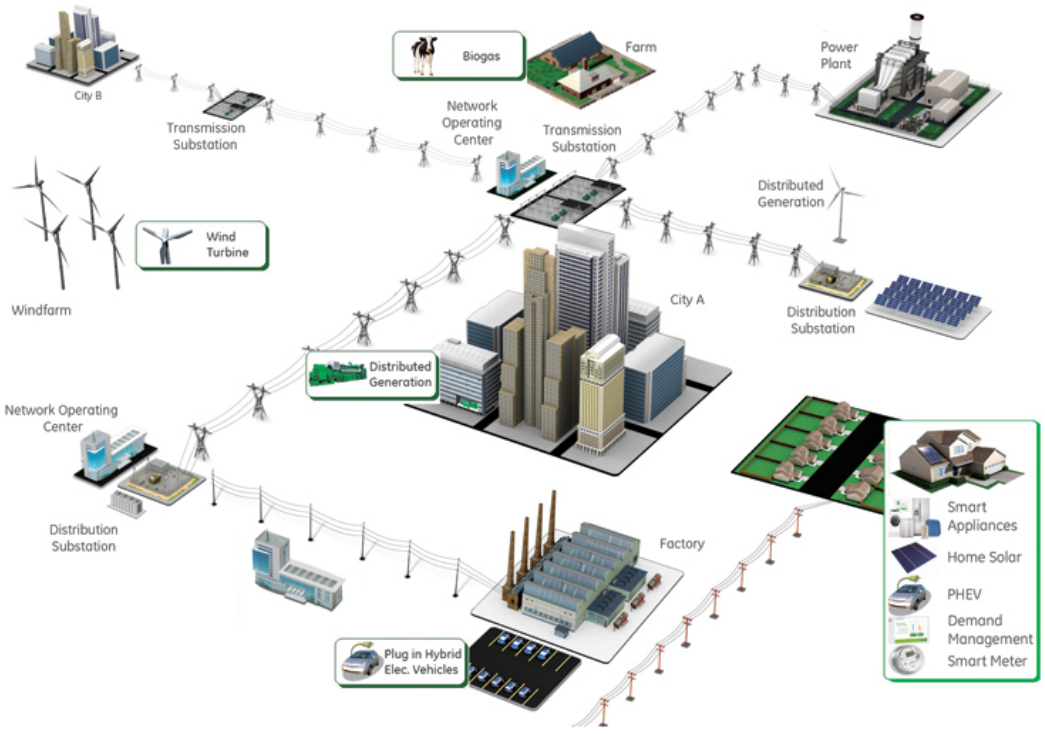
EnergyVille

BIPV : towards the DC nanogrid

Johan Driesen

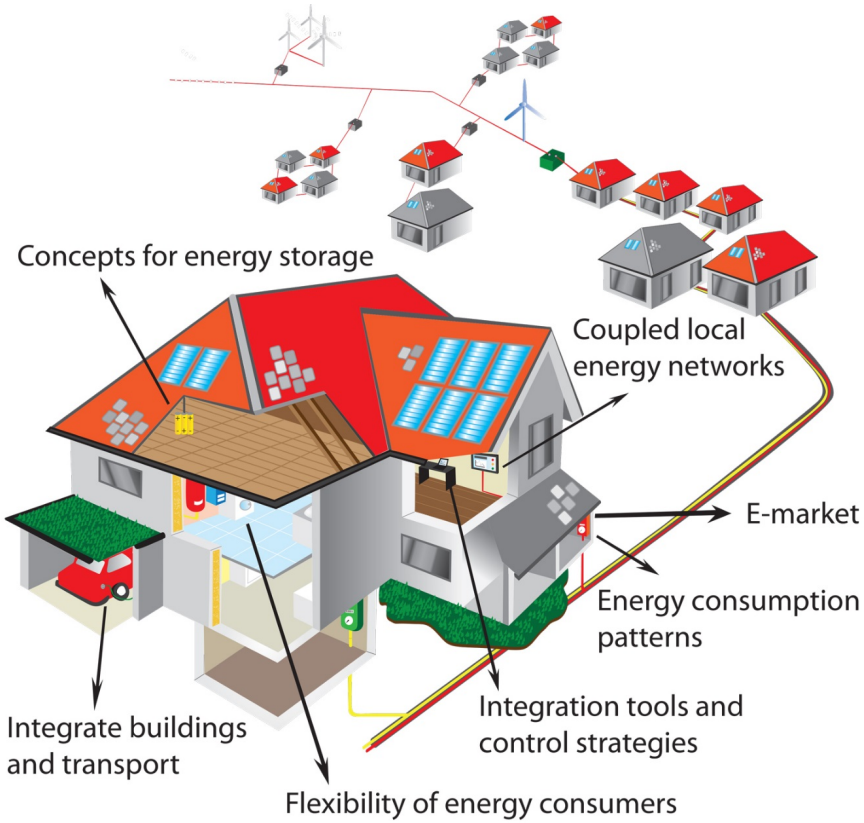
Rethinking the electricity system

Smart Grids



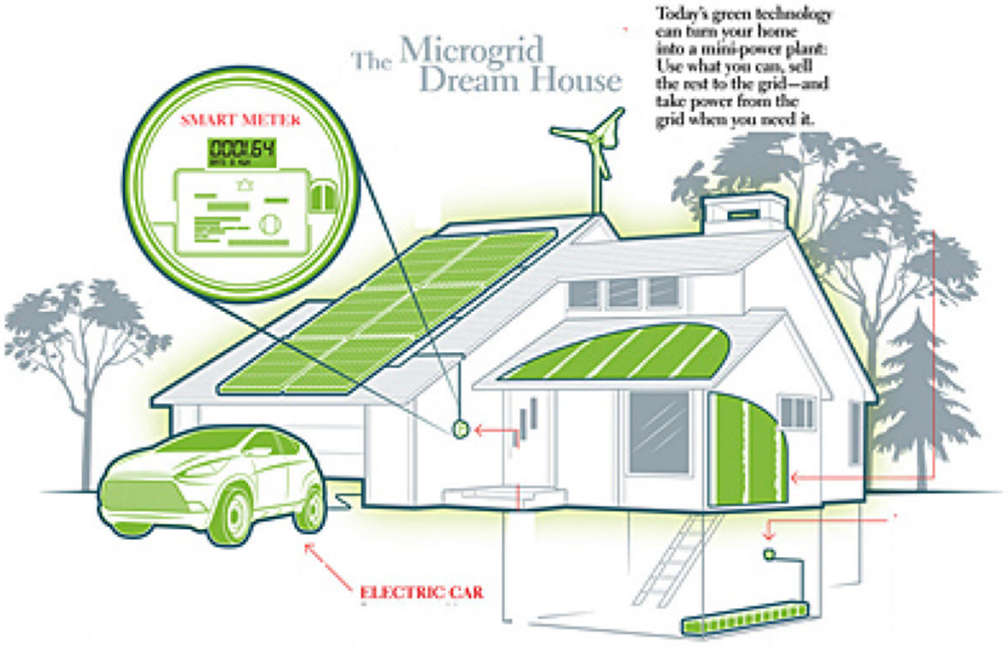
Rethinking the electricity system

- Smart Energy Systems in Smart Cities



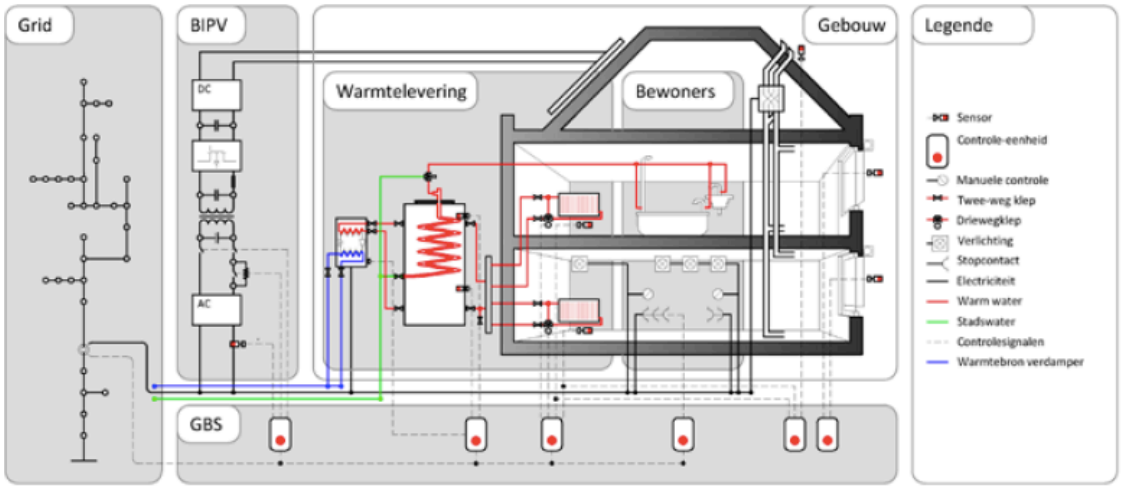
Rethinking the electricity system

Residential (DC) microgrids



Rethinking the electricity system

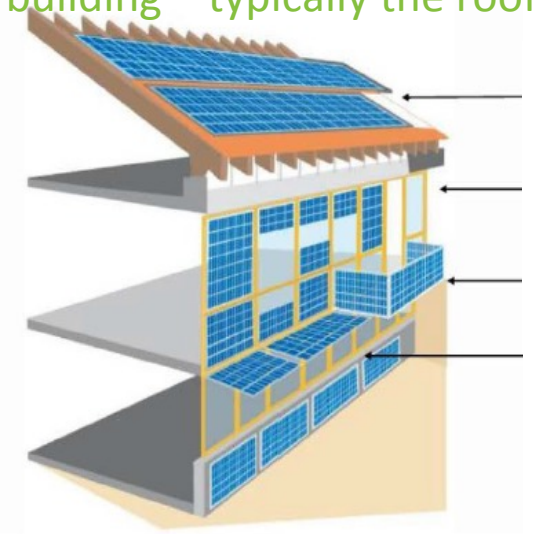
- Smart Houses with fully integrated energy systems



IDEAS, KULeuven

Building-Integrated-PV potential

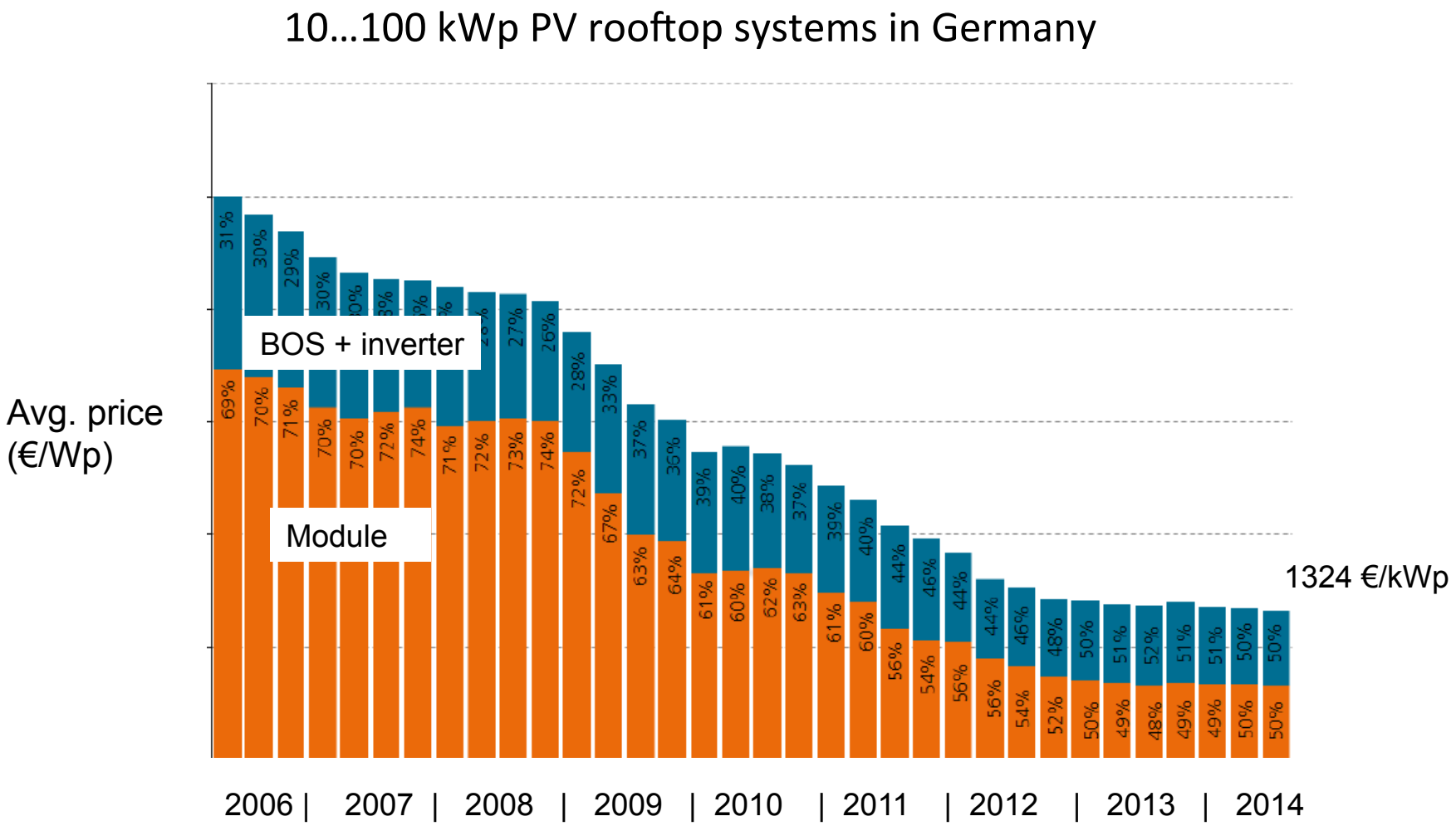
- Today: PV modules “added” to the building – typically the roof



- BIPV = multi-functional use
  - As building component
  - To generate electricity

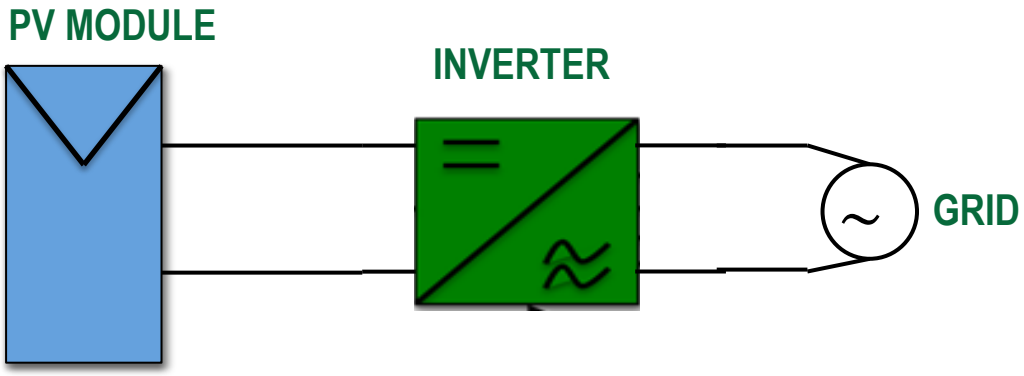
- What will drive BIPV ?
  - Façade-integration of PV for tall NZEB-compliant bu
    potential market > 100 GW/yr
  - PV-roofs with improved esthetics
  - Lower overall cost (building + PV)

Price of inverter and balance-of-system (BOS): also decreasing but not so fast as modules



Source: Fraunhofer ISE

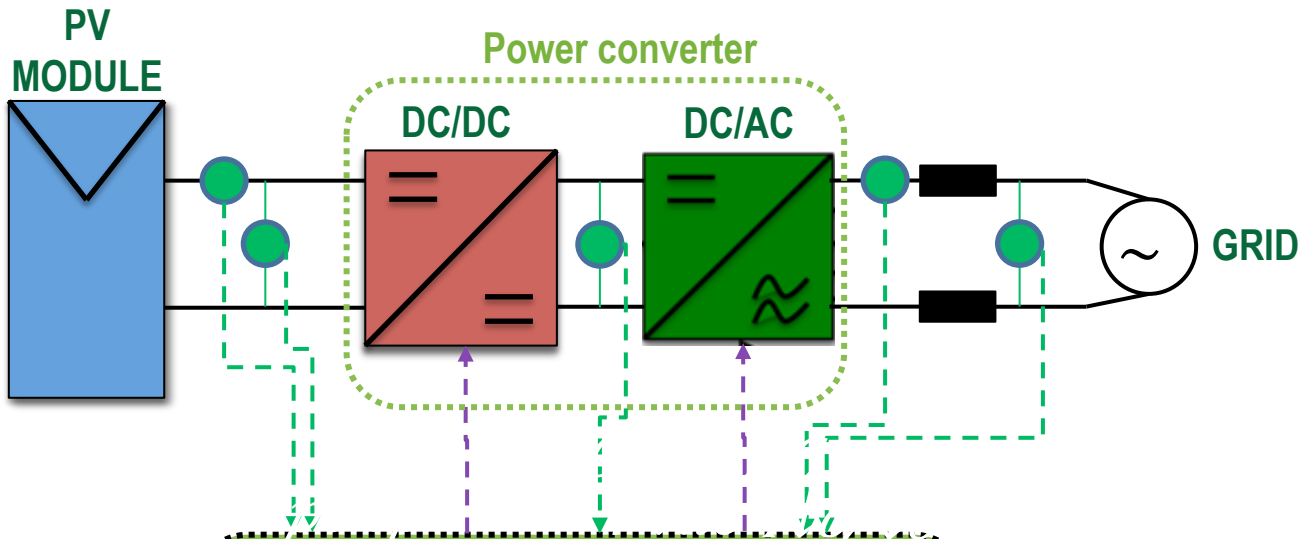
Energy losses ? Also at system level !



Wiring	Any cables have some resistance and therefore more losses.
MPP	Ability of the MPP tracker to consistently find the maximum power point.
Inverter	Inverter efficiency
Mis-sized inverter	If the inverter is undersized, power is clipped for high intensity light. If it is oversized, the inverter's efficiency will be too low for low intensity light.
Transformer	Transformer losses in case electricity has to be connected to a high-voltage grid.

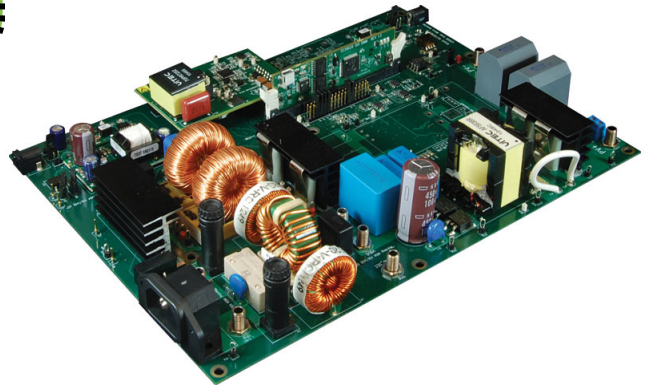
Usually economical compromises are made

From DC module to AC grid



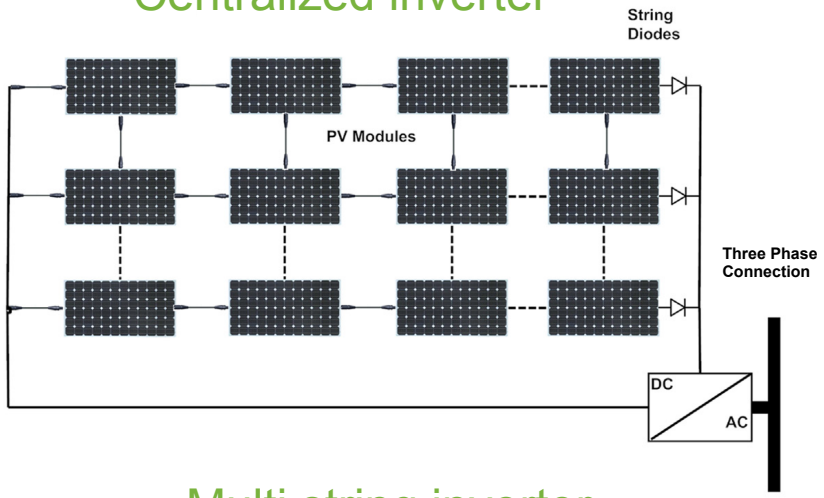
- MPPT algorithm
- Voltage/current controllers
- Synchronization with grid (PLL)
- PWM
- Fault detection

Power controller

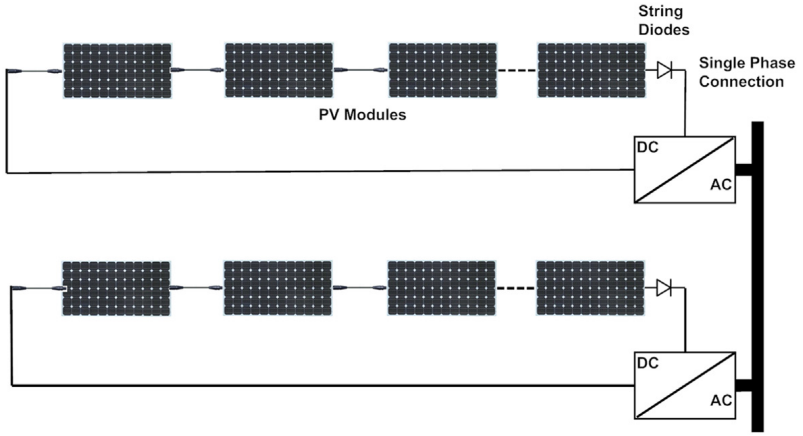


PV Inverter configurations

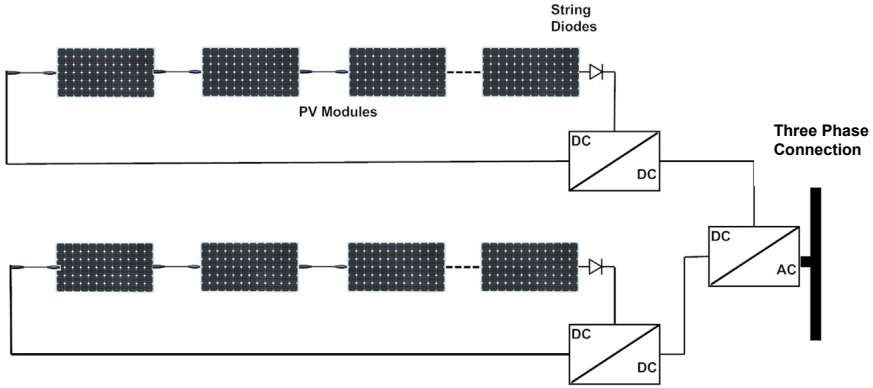
Centralized inverter



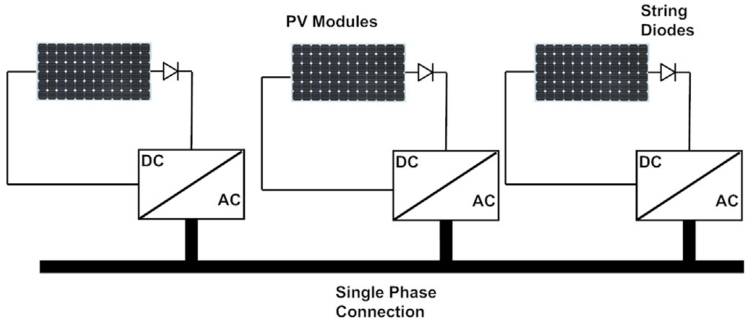
String inverter



Multi string inverter



Micro-inverter



Micro-Inverters

Application/features:

- Module level power conversion
- Easy to install
- Better performance under shading conditions, different inclination/orientation
- Solution for BIPV market
- Data for every PV module

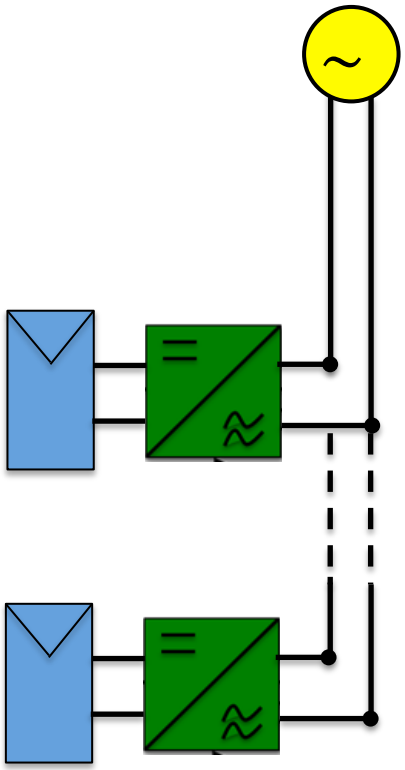
Challenges:

- Price
- Efficiency
- Cable losses
- Lifetime
- Temperature issues

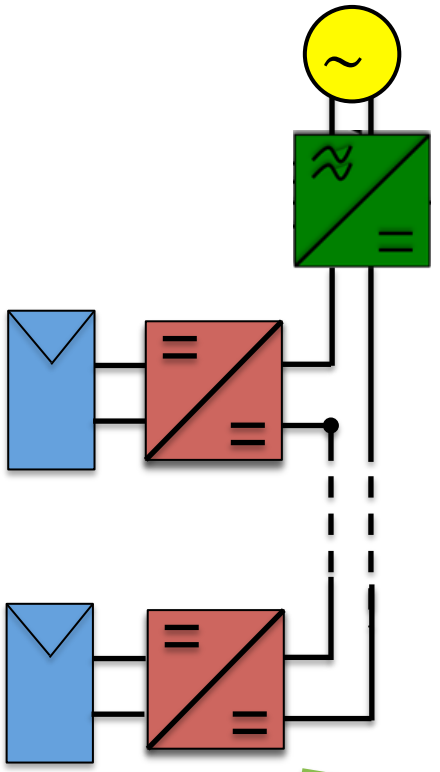
From Micro-Inverters to Power optimizers

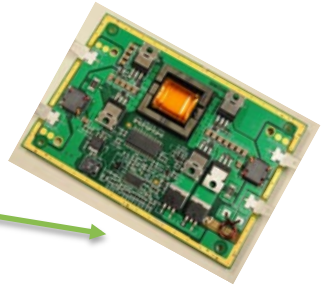
- A power optimizer is a DC/DC converter connected to each PV module
- Replaces the traditional solar junction box

Micro-inverters

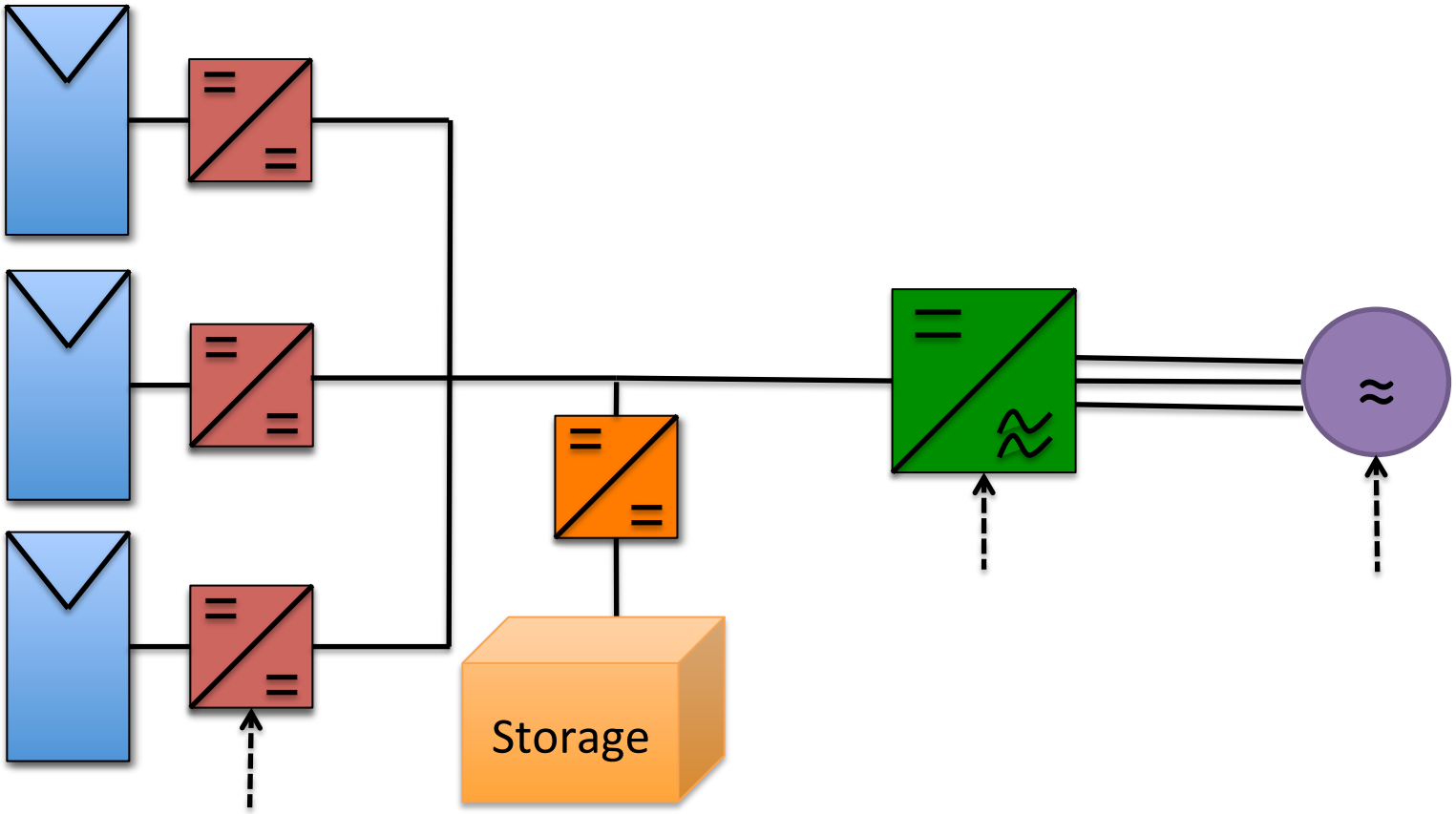


Power optimizers





Or … parallel alternative?

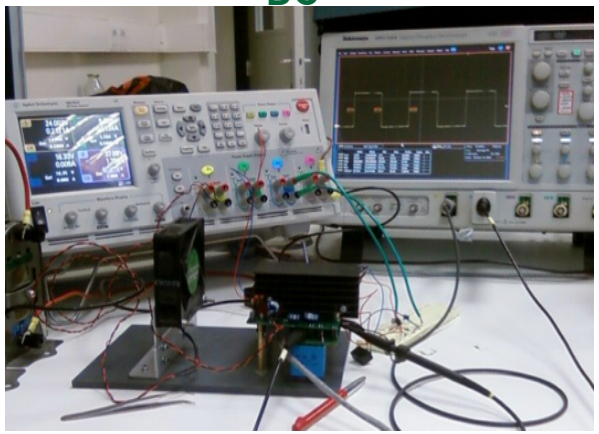


high boost, but more robust + trend towards DC-grids

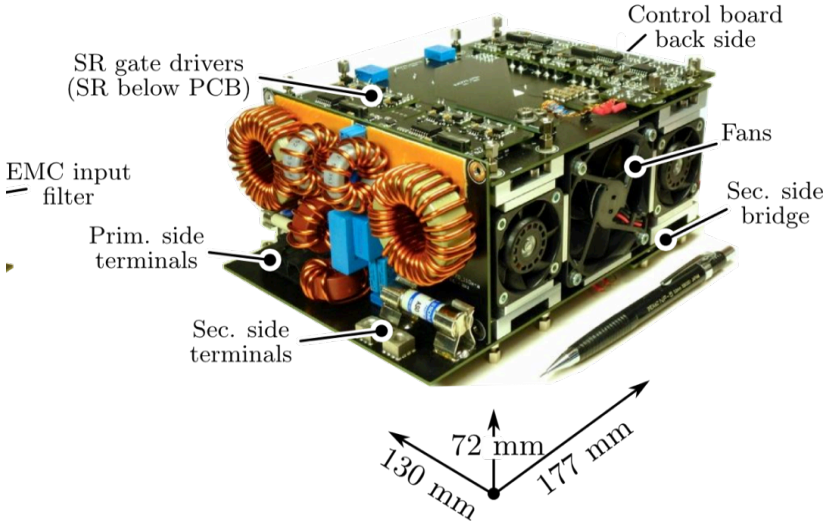
Next challenges for PV power converters

- Power semiconductor technology:
  - ❑ Higher switching frequency
  - ❑ Increased power density
  - ❑ Higher working temperatures
  - ✓ New materials (SiC, GaN)
  - X But some issues (driving, EMC, passives,...)
- Smart features
  - ❑ Multiple MPPT trackers
  - ❑ PFC capability
  - ❑ Enhance monitoring
  - ❑ Integration of storage
  - ➢ Full digital control (uC, DSP, FPGA,...)
- Longer lifetime
- Reliability

GaN high-boost DC/DC

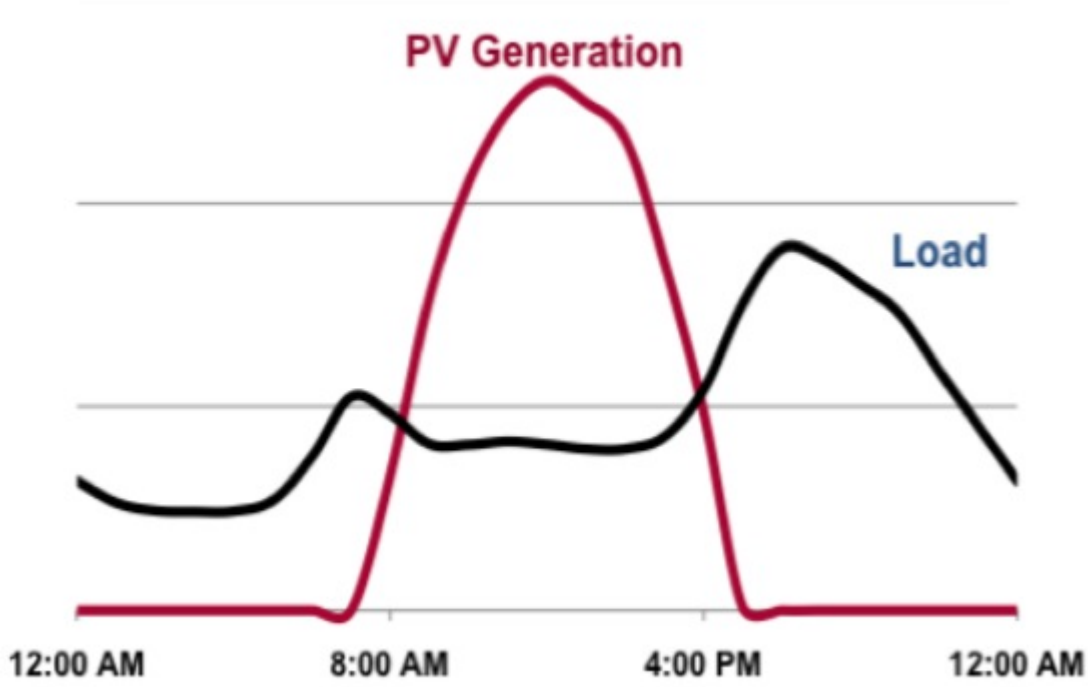


Ultra compact resonant DC/AC interface



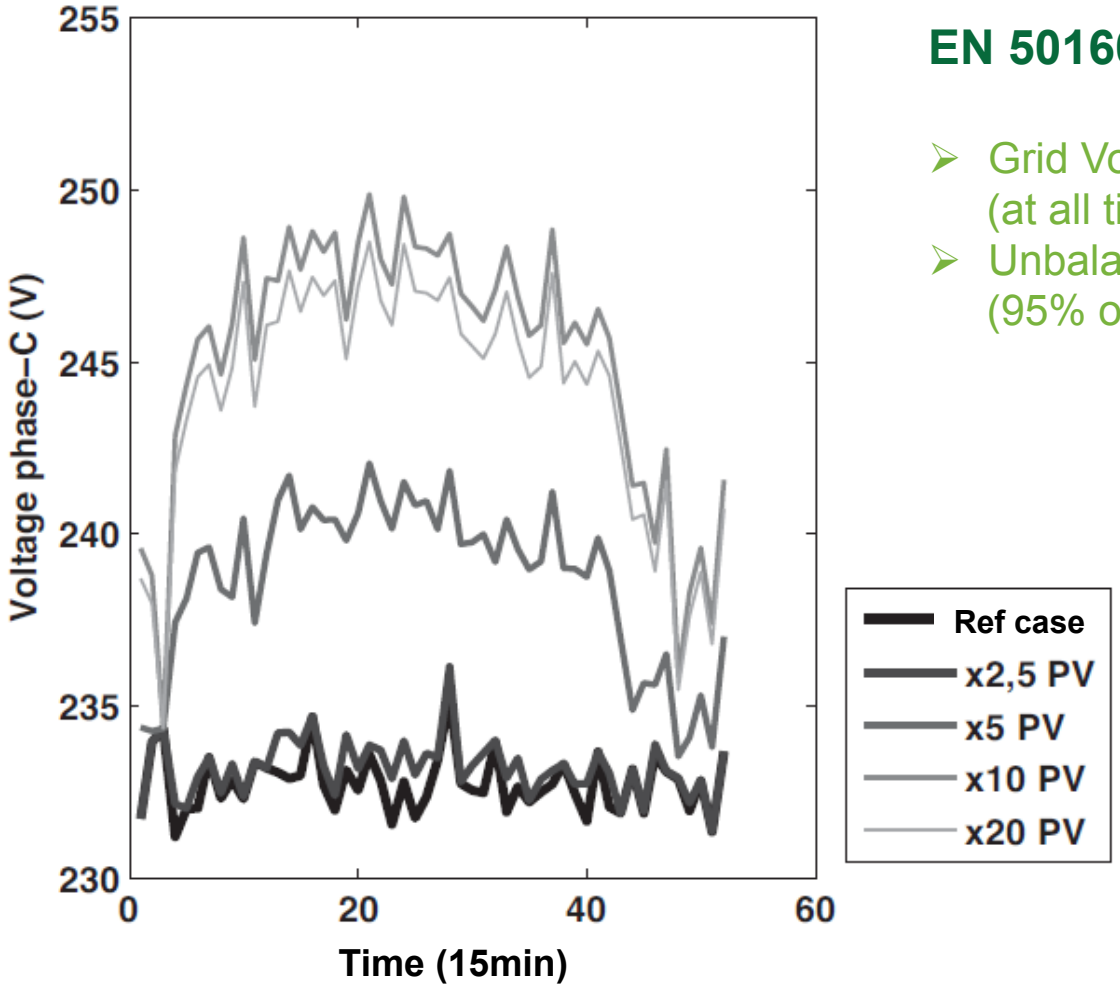
Problem: local injection of PV power

- PV injection does not coincide with the consumption peak



Source: solarpowerworldonline

Excess of PV power can result in overvoltage in your local feeder

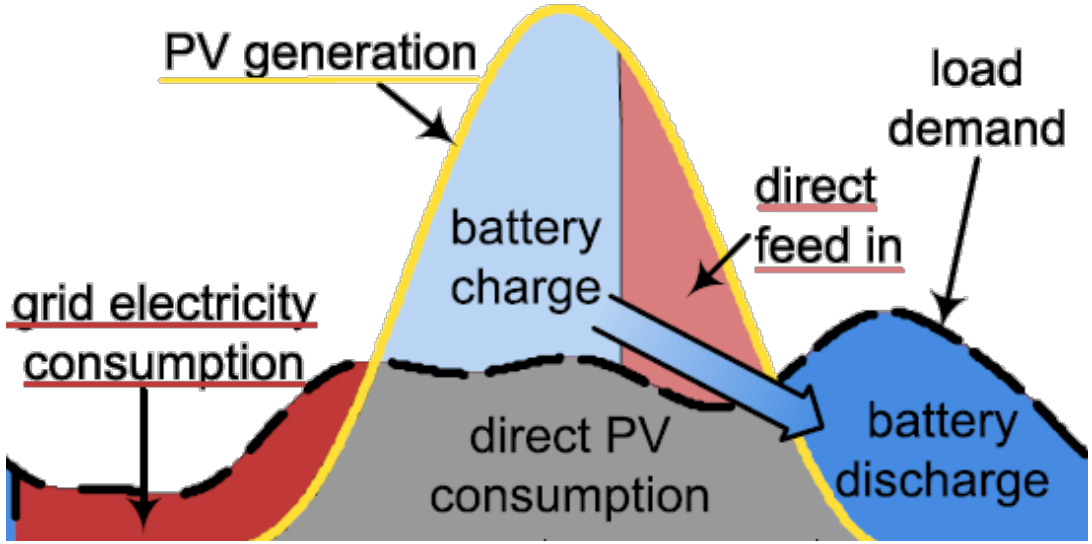


EN 50160 standard:

- Grid Voltage < 230V ±10% (=253V) (at all times)
- Unbalance between phases < ±2% (95% of time)

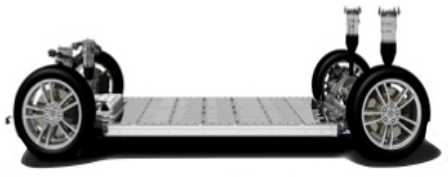
Large PV penetration can violate voltage standard, especially in rural areas

Solution = storage ?



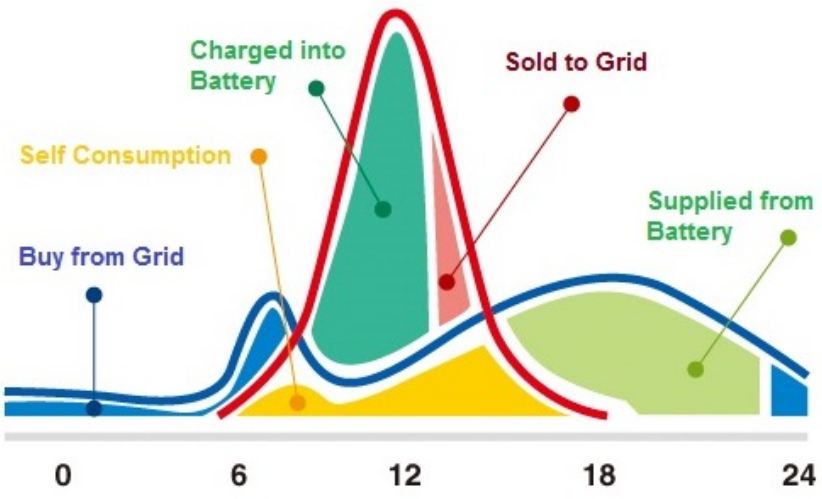
Drivers for storage

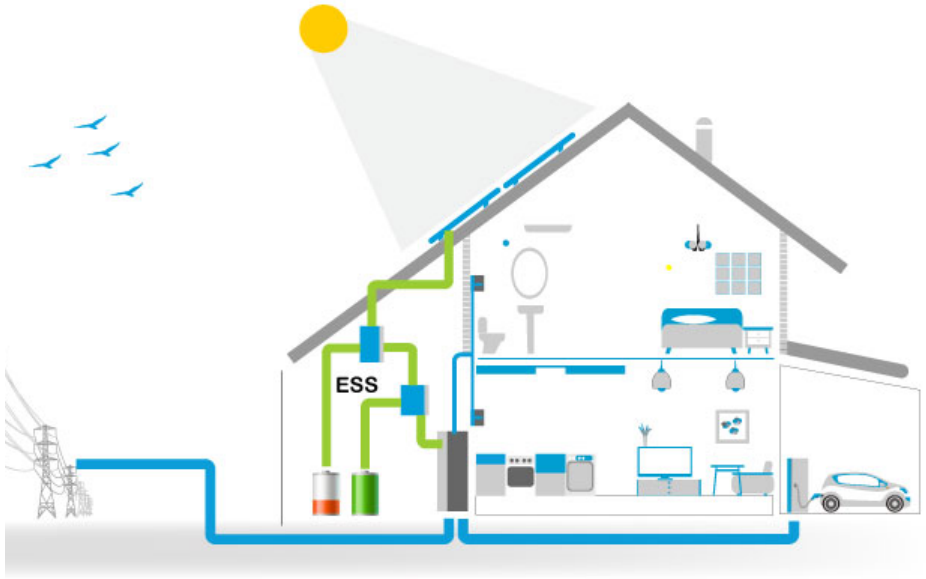
- Peak shaving (grid support)
- Balancing
- Feed-in tariff
- Electricity cost
- Stand-alone operation



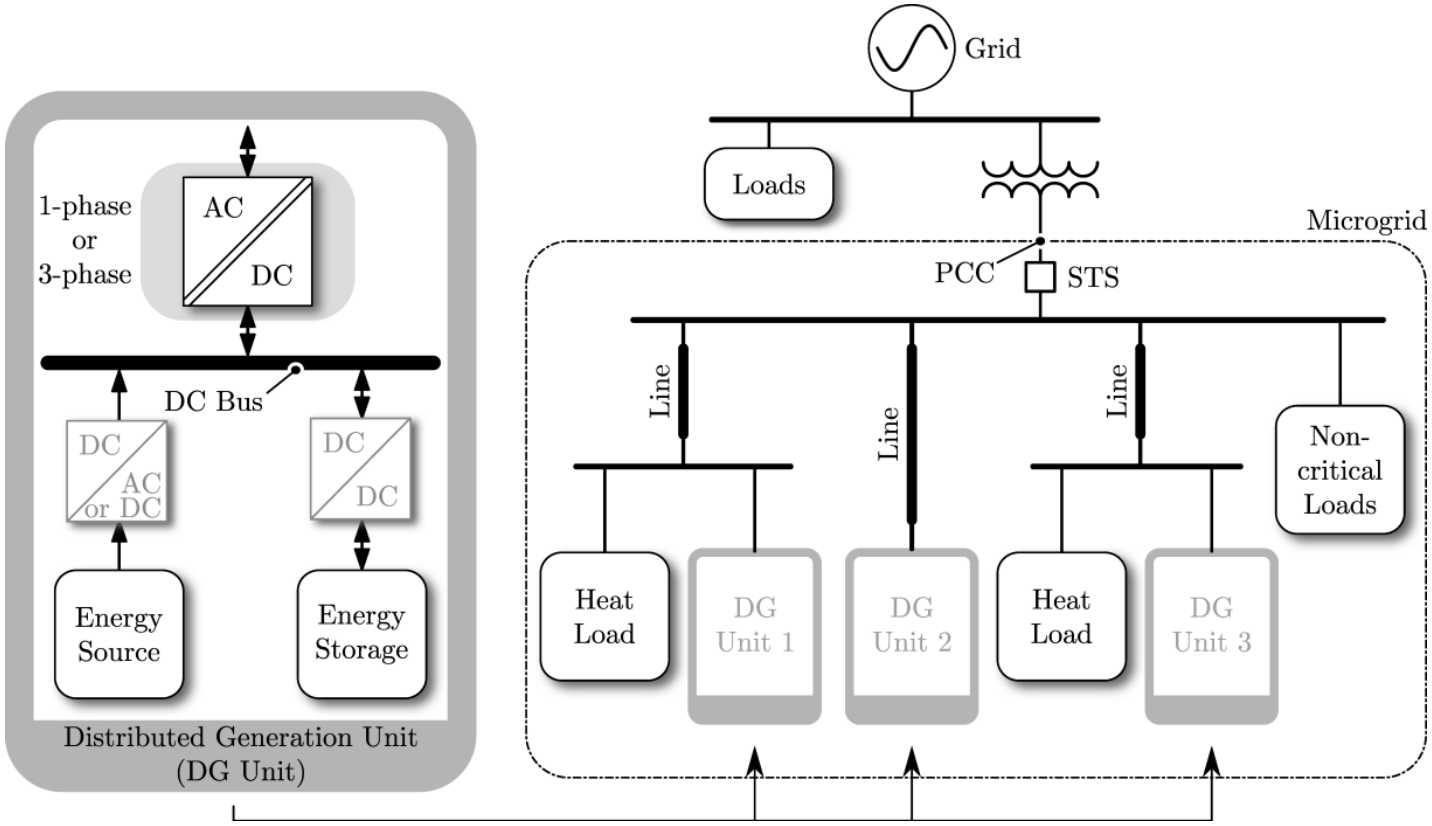
Product Line	Automotive	Residential	Commercial
Power/Energy	310 kW / 85 kWh	5 kW / 10 kWh	200 kW / 400 kWh+

Why storage is needed… in every house



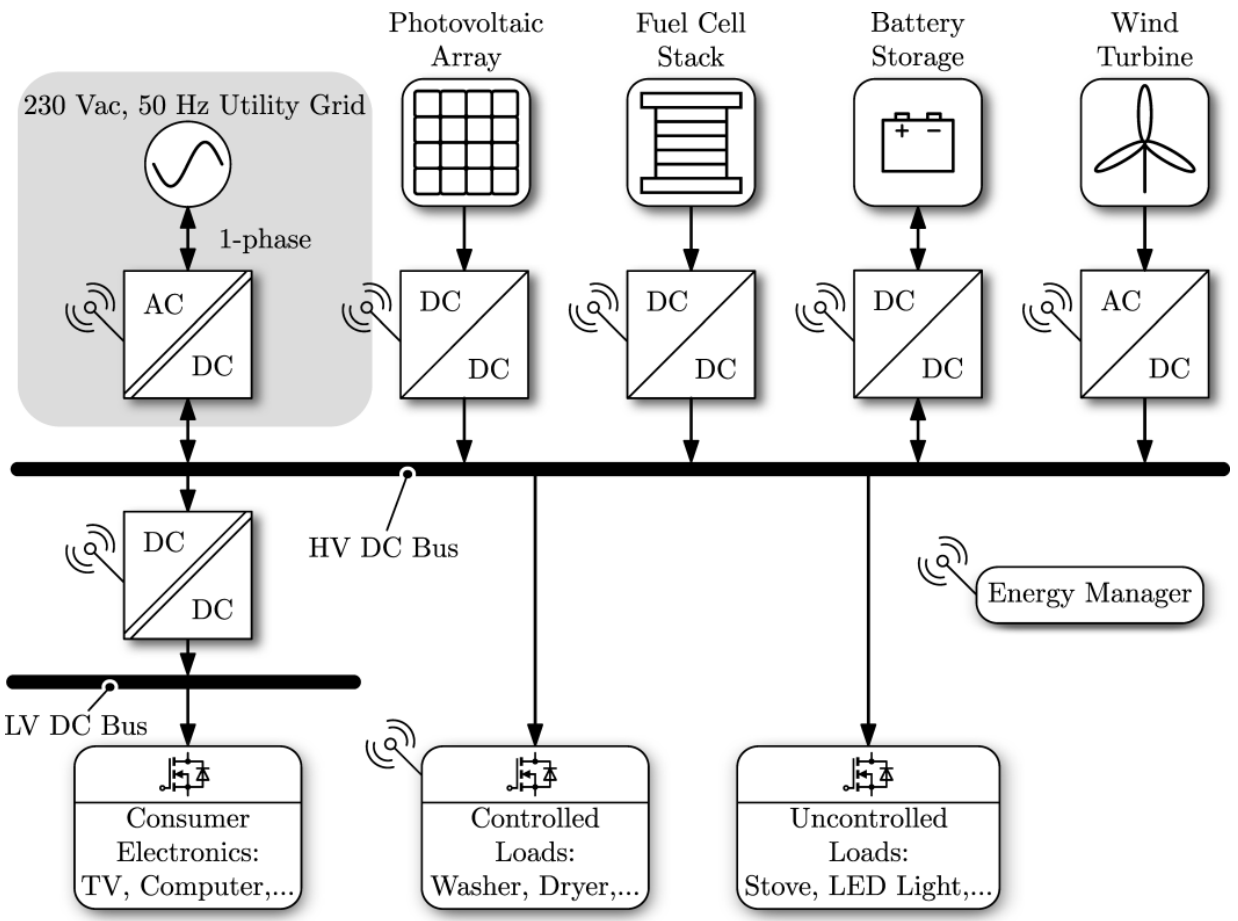


Next step: From Tesla's AC grid…



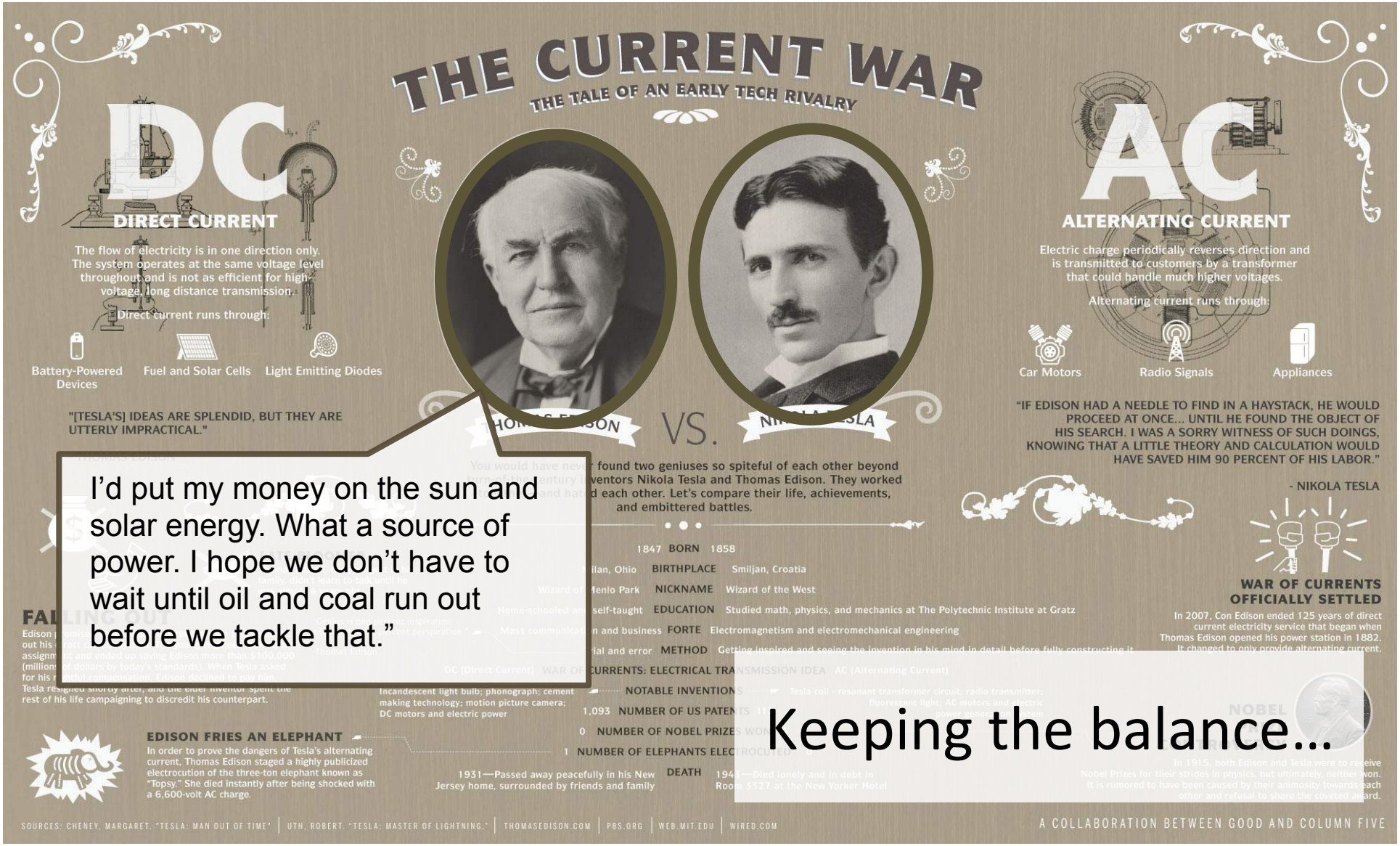
- Many AC/DC – DC/AC conversions
- Many DC loads (e.g. LED lighting, Electric Vehicle charging)

The return of … the DC grid ?



- Especially for (new) buildings, districts …
- Challenges: cabling, connectors, protection, …

What would Edison think of all this?



I'd put my money on the sun and solar energy. What a source of power. I hope we don't have to wait until oil and coal run out before we tackle that."

Keeping the balance…

EnergyVille

vito vision on technology

KU LEUVEN

imec

Expertise in sustainable energy and intelligent energy systems in the built environment

Research – Development – Training – Industrial Innovation

For:

- Industry
- Public Entities

With:

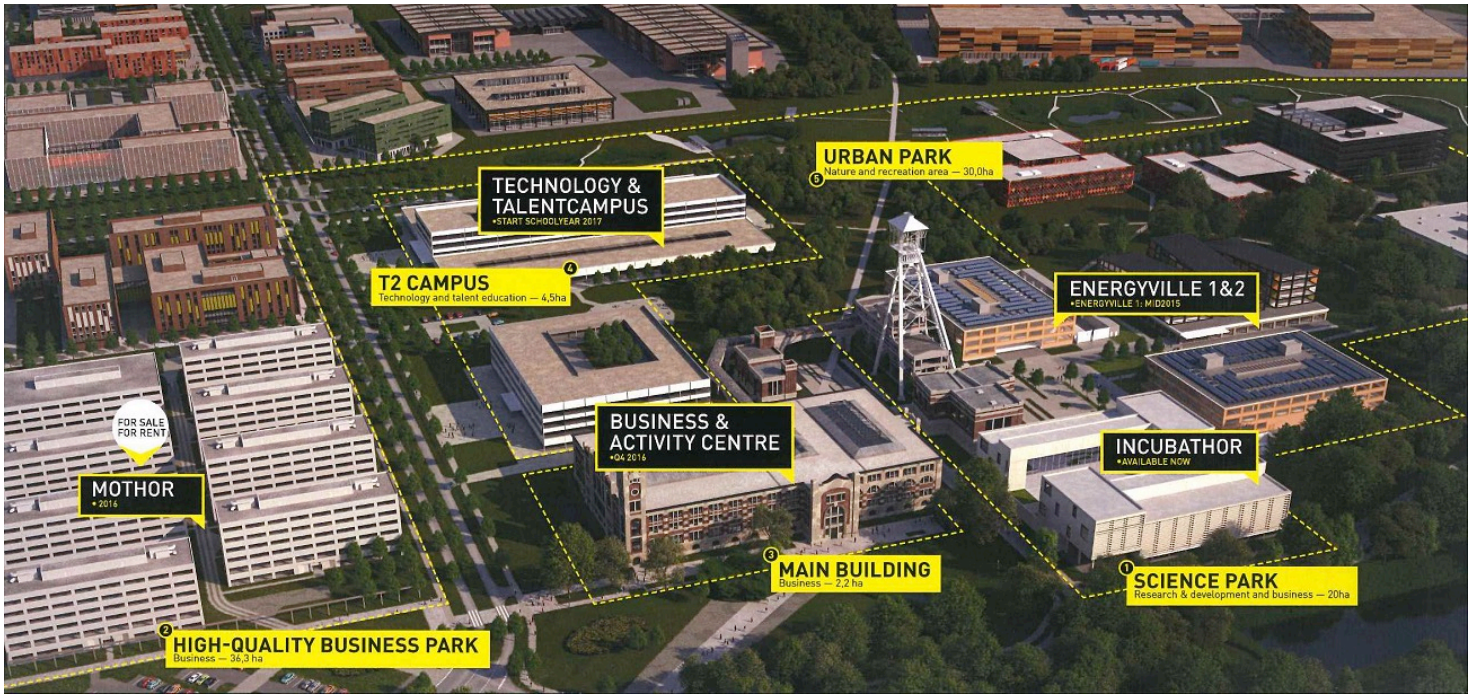
- Local partners
- Regional partners
- International partners

Labs

- Battery Testing Lab
- Home Lab
- Smart Grid Infrastructure Lab
- Thermo Technical Lab
- Medium Voltage Lab
- PV Metrology Lab
- Matrix Lab

Embedded in an eco-system

Campus EnergyVille



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More info?

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