

New Power Electronics Concepts for future PV + X Hybrid plants

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www.ise.fraunhofer.de**

Resource requirements in PV power plants

Estimated german demand until 2045 based on multiple sources

430 GW
Photovoltaik
until 2045⁴



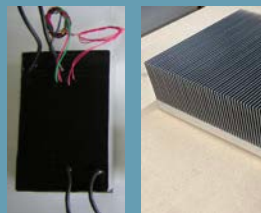
Cable requirements (x MW power plant)

~2.1 kg/kWp Al cable¹
~0.9 kg/kWp Cu stringcable¹



Modules & substructure (x MW power plant)

~ 8 kg/kWp Al for modules & substructure²
~ 40 kg/kWp iron for substructure FF²
~15 kg / kWp Al for rooftop²



Inverter (50 kW stringinverter)

~0.12 kg/kWp Al for the heatsink³
~0.15 kg/kWp copper for magnetics³
~0.3 kg/kWp ferrite in magnetics³

PV-induced requirements
in germany until 2045 for
60% rooftop plants⁴:

- Aluminium: 7,800,000 t
- Iron: 7,000,000 t
- Copper: 1,000,000 t
- Ferrite: 130,000 t

(without AC-transformers,
switchgears)

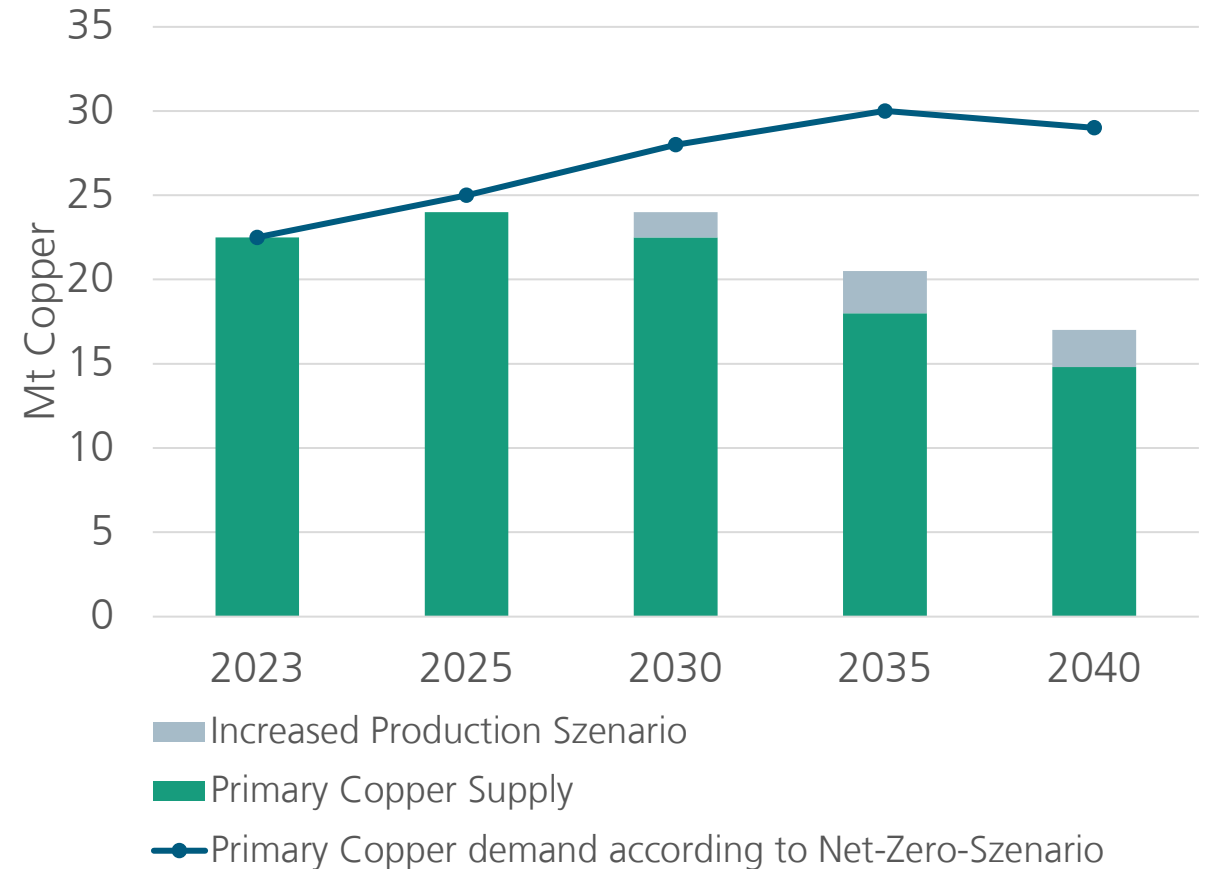
Motivation

- Decreasing copper production at increasing demand
- Shortage projected already next year
- Research identifies several other critical raw materials for energy transition



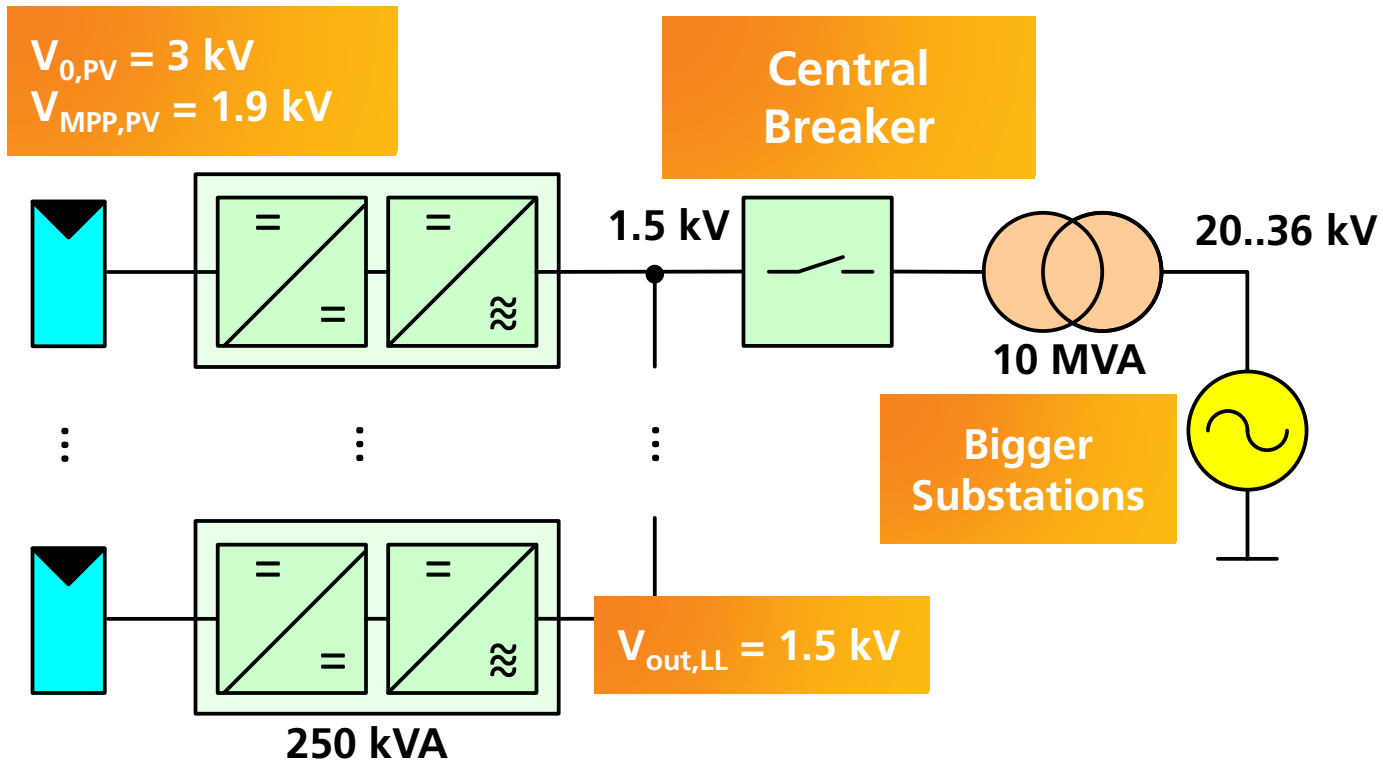
**Today's topic: Innovation approach
at system level for massive material
savings**

Copper development according to IEA*



Concept for medium voltage utility scale PV plant

Decentral string inverters



Higher output voltage

- Doubling of the output voltages
→ Reduction of cable cross section of ~75%

Central breakers

- Disconnection point to the grid provided by MV switchgear
- Central disconnectors for several inverters lead to cost reduction

Bigger and less Substations

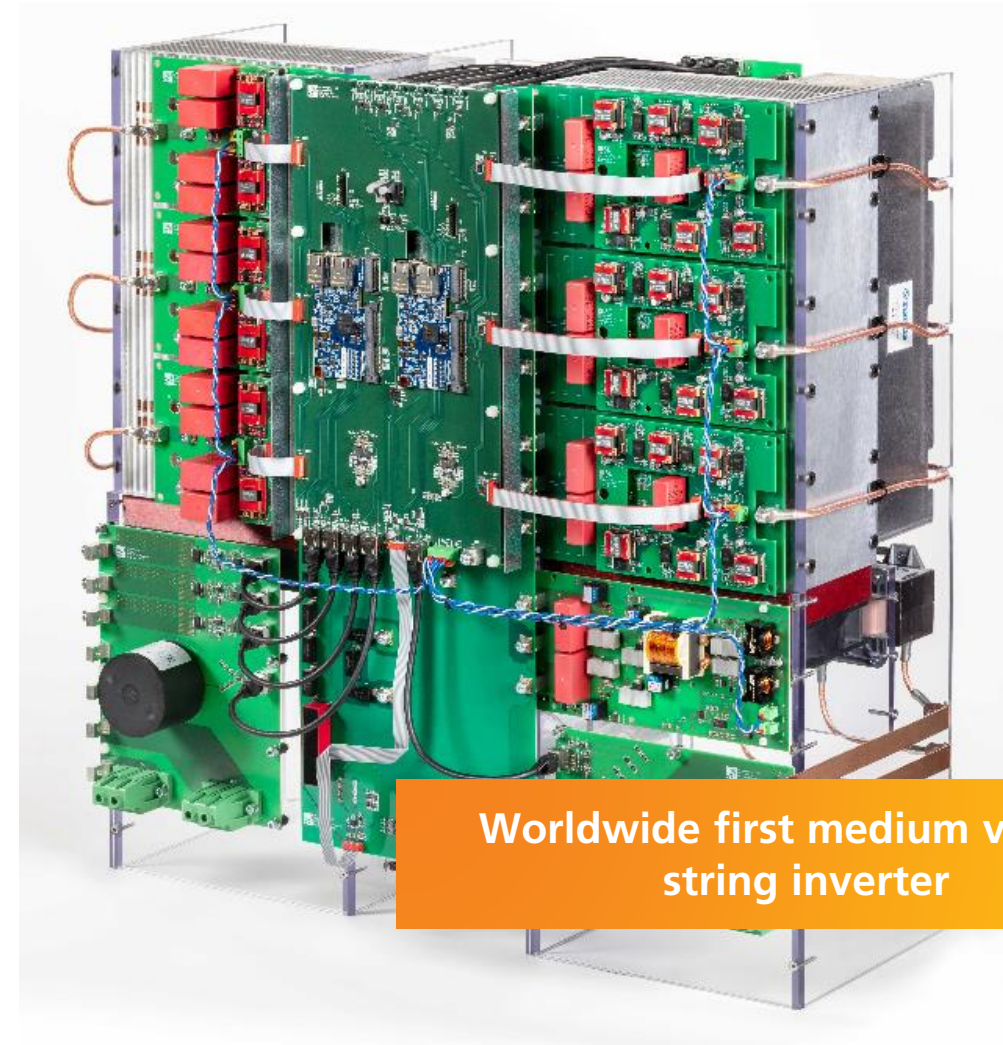
- Higher transformer outputs possible due to lower currents
- Less construction measures and lower installation costs (foundations, enclosures, etc.)

Research project MS-LeiKra

Power electronics for the next generation of medium-voltage PV power plants

- 3-phase ANPC
- hybride module with 1.7 kV semiconductors (2x SiC MOSFET, 4x Si IGBT)
- 96 A output current
- power: 250 kVA
- output voltage: $1.5 \text{ kV}_{LL,rms}$
- third harmonic injection
- switching frequency: 48 kHz

- Pilot phase planned in 2025/ 2026



Actual Developments

World-wide development activities towards medium-voltage

TÜV Rheinland tests 2 kV

New test specification: PV products for 2000 V



As the performance of PV modules with covers the requirements of 1500 V. TÜV Rheinland (PFGs).

Since March 2023, VDE 0105-100 (2 PFG 2928) in addition to the components. The in-

(PV connectors) and IEC 62790 (PV junction boxes) and contain additional requirements. The installation of these components is only permitted in areas that contain Class II components) or the requirements for restricted access areas (

Prospect: An internal test specification for PV cables for use in 2000 V

<https://www.tuv.com/landingpage/en/pv-solar-energy>

2 kV PV plant in China

DAS Solar receives “2023 Clean Energy Outstanding Innovation Case” award

2023-08-01

DAS Solar, a leader in N-type technology, has announced that it has received the “2023 Clean Energy Outstanding Innovation Case” award at the 2023 Clean Energy Capital Forum for the world's first 2,000V - Mengjiawan PV project supplied by DAS Solar. The forum aims to strengthen investments in the capital market, showcase outstanding innovations in clean energy, promote the integrated development of clean energy, and establish a model of innovation in the capital market.



https://www.das-solar.com/en/site/news_details/1

2 kV in the US

RE+ 2024 SPECIAL PRODUCT ANNOUNCEMENT

GE Vernova proudly Introduces the FLEXINVERTER 2kV

In addition to our widely deployed 1.5kV FLEXINVERTER platform, GE Vernova is proud to introduce the brand new FLEXINVERTER 2kV Solar Power Conversion Station at RE+ 2024 in Anaheim, California

"Visit our **Booth N880011** to learn more about FLEXINVERTER & our existing multi-megawatt 2000Vdc pilot project in North America.

Let's start the next chapter in utility scale solar power!

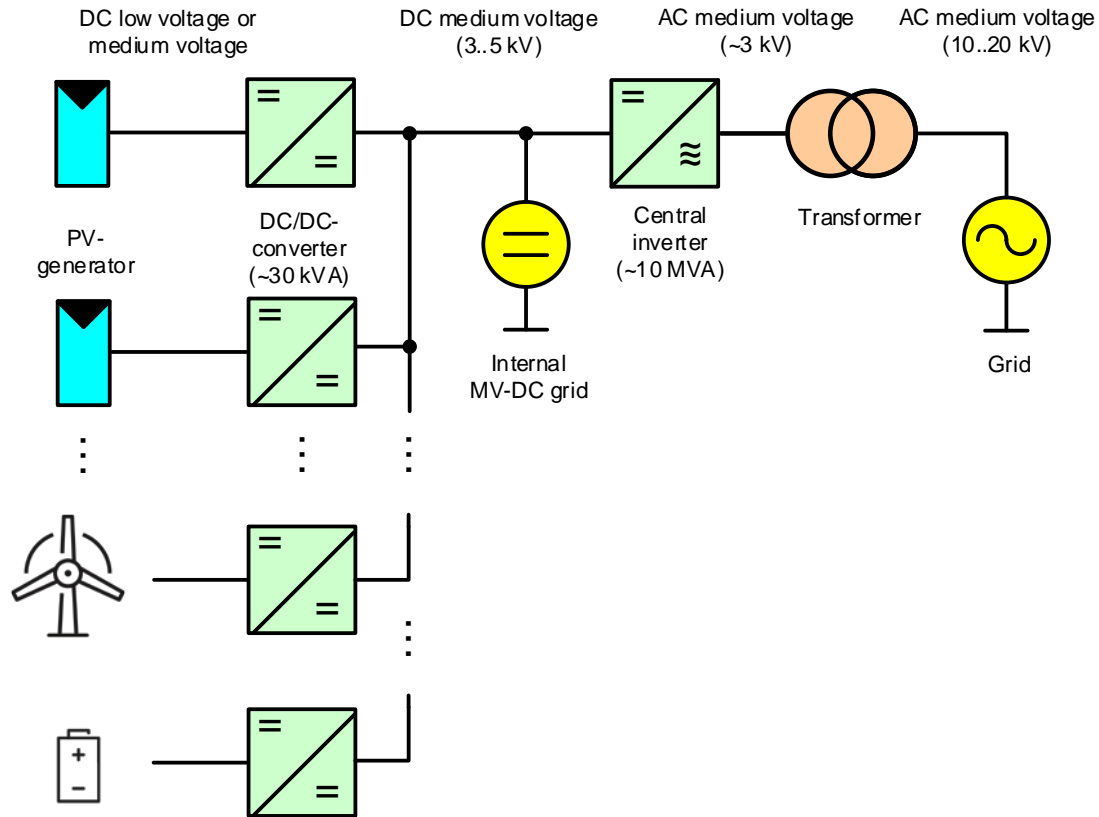
FLEXINVERTER 1.5kV Solar Power Station

FLEXINVERTER 2.0kV Solar Power Station

<https://www.governova.com/solar-storage/flexinverter>

Medium voltage concepts will come for all RE applications

Future MV-DC Distribution in hybrid plants



- Goal: Increase the voltages in the power plant that are currently still at low voltage to medium voltage level
- Direct coupling of batteries and electrolysers in the power plant via DC
- No transformers within the power plant, no no-load losses
- Larger substations in power plants are possible
- Reduction of cable costs in the power plant
- Cross-section reduction of Cu



According to „DIN VDE 0298-4, Tabelle 9.2“ when assuming „cables in ground“

Einspeisung

=J83

Anschlussfeld
3-36 kV

Anschlussfeld 20 kV-Netz
oder MS Widerstand



Thank you!

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Prüfling