European Union
European Regional
Development Fund

Investing
in your future

PHOTOVOLTAIC OPTIVERTER®

OPTIVERTER- uudne väike- ja keskmistes energiasüsteemides päikesepaneelidega kasutatav jõupooljuhtmuunduri tehnoloogia

Tanel Jalakas

Ubik Solutions riistvarainsener

TTÜ vanemteadur

TALLINN UNIVERSITY OF TECHNOLOGY

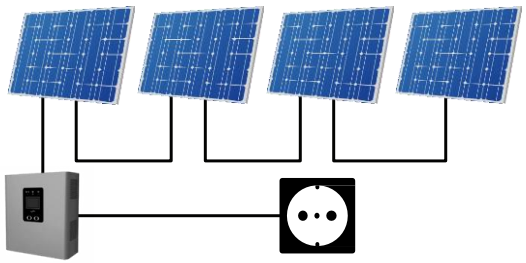
Teadmistepõhise ehituse tippkeskus
Zero Energy Centre of Excellence

POWER GROUP ELECTRONICS

UBIK SOLUTIONS

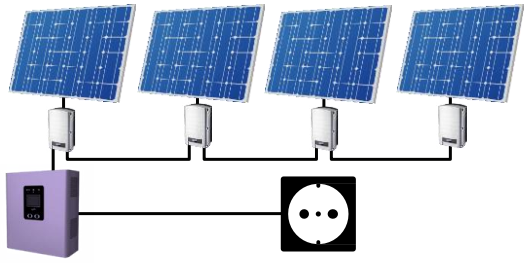
TYPICAL RESIDENTIAL PV INSTALLATIONS

SERIES WITH STRING INVERTER



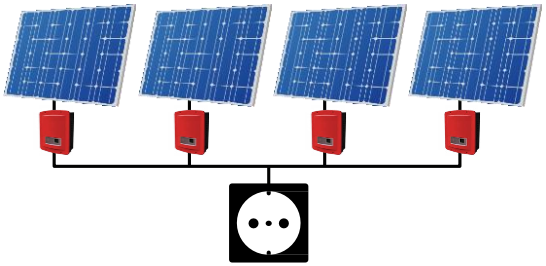
Inverter is located in a climate controlled space

SERIES WITH STRING INVERTER AND POWER OPTIMIZERS



Power optimizer is located behind the PV module and inverter - in a climate controlled space

PARALLEL WITH MICROINVERTERS



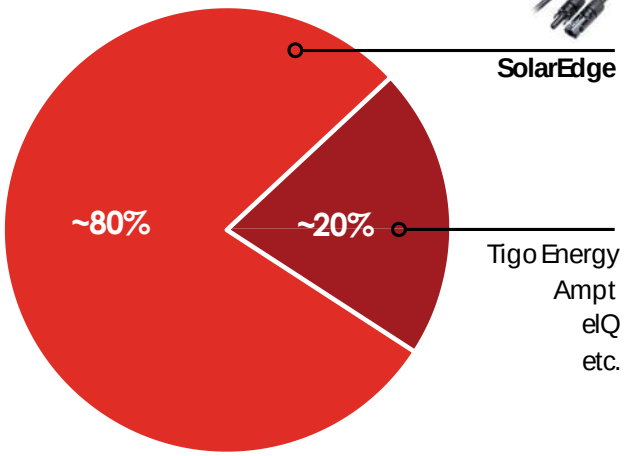
Microinverter is located behind the PV module

MLPE (MODULE LEVEL POWER ELECTRONICS)

The best approach for the residential and small to medium commercial PV installations

COMPARISON OF MLPE TECHNOLOGIES

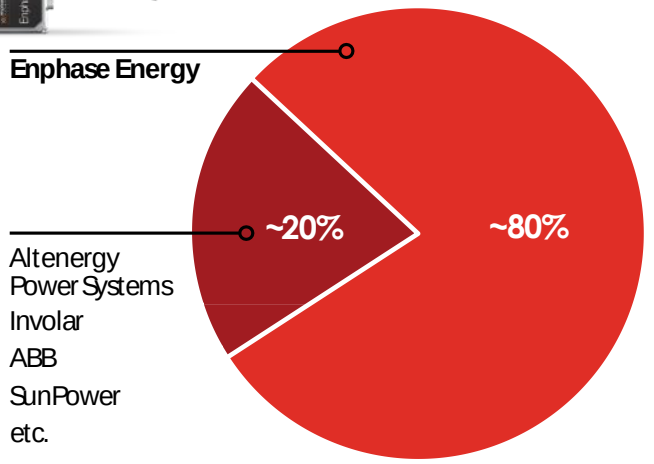
POWER OPTIMIZER



- ☺ Ultrawide MPPT range
- ☺ High efficiency over the wide operation range
- ☺ Great module compatibility and no power clipping
- ☹ High output DC voltage, need for central inverter for AC connectivity
- ☹ Complex DC wiring

VS.

MICROINVERTER



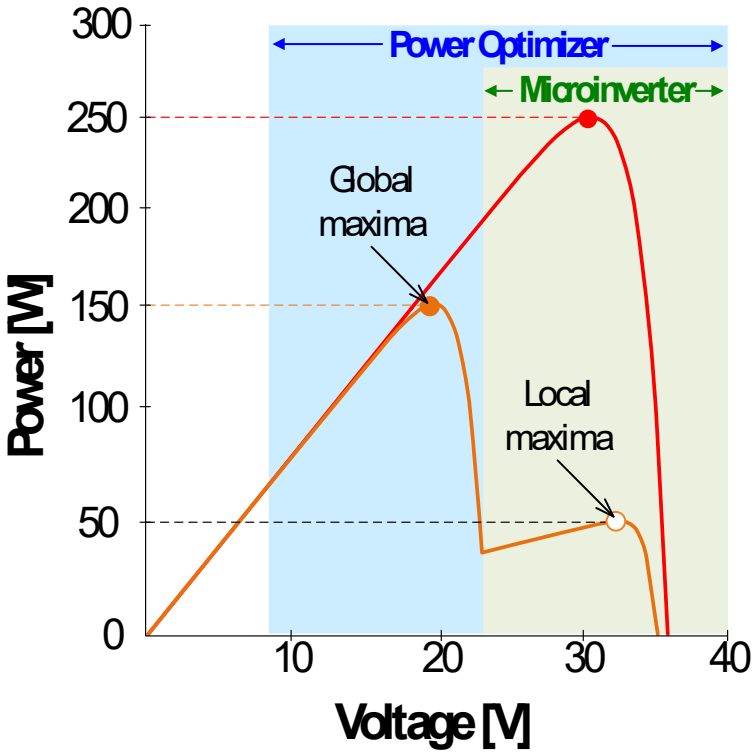
- ☺ Direct AC connectivity
- ☺ Galvanic isolation
- ☺ Excellent flexibility and “easy-to-expand” PV system
- ☺ Module-level monitoring and shut-down
- ☹ High cost-per-watt
- ☹ Limited MPPT range and output power

MPPT RANGE AND SHADE TOLERANCE

PARTIAL SHADING OF PV MODULES

trees, chimneys, roof top structures, neighbouring buildings, clouds, dust, bird droppings, haze, falling leaves, snow, etc.

P-V CURVES OF PV MODULE

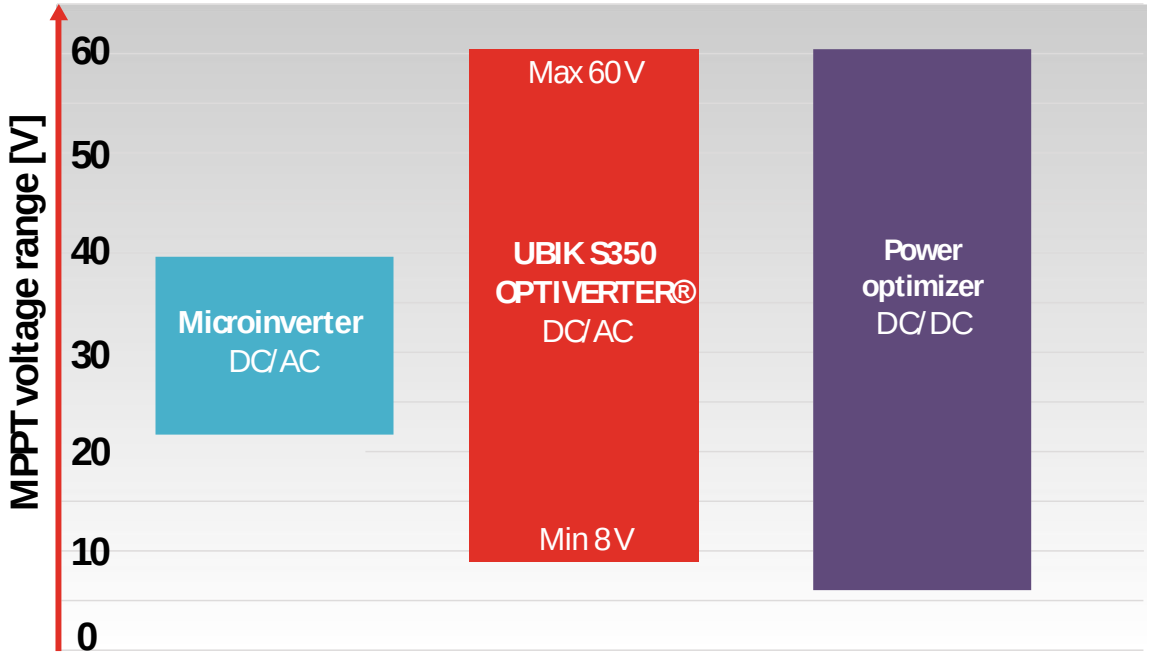


! Partial shading losses are estimated to result approx. 5-25% of annual energy loss !

! Capability to perform MPPT down to very low voltages results in a better energy yield in partial shading conditions !

PHOTOVOLTAIC OPTIVERTER®

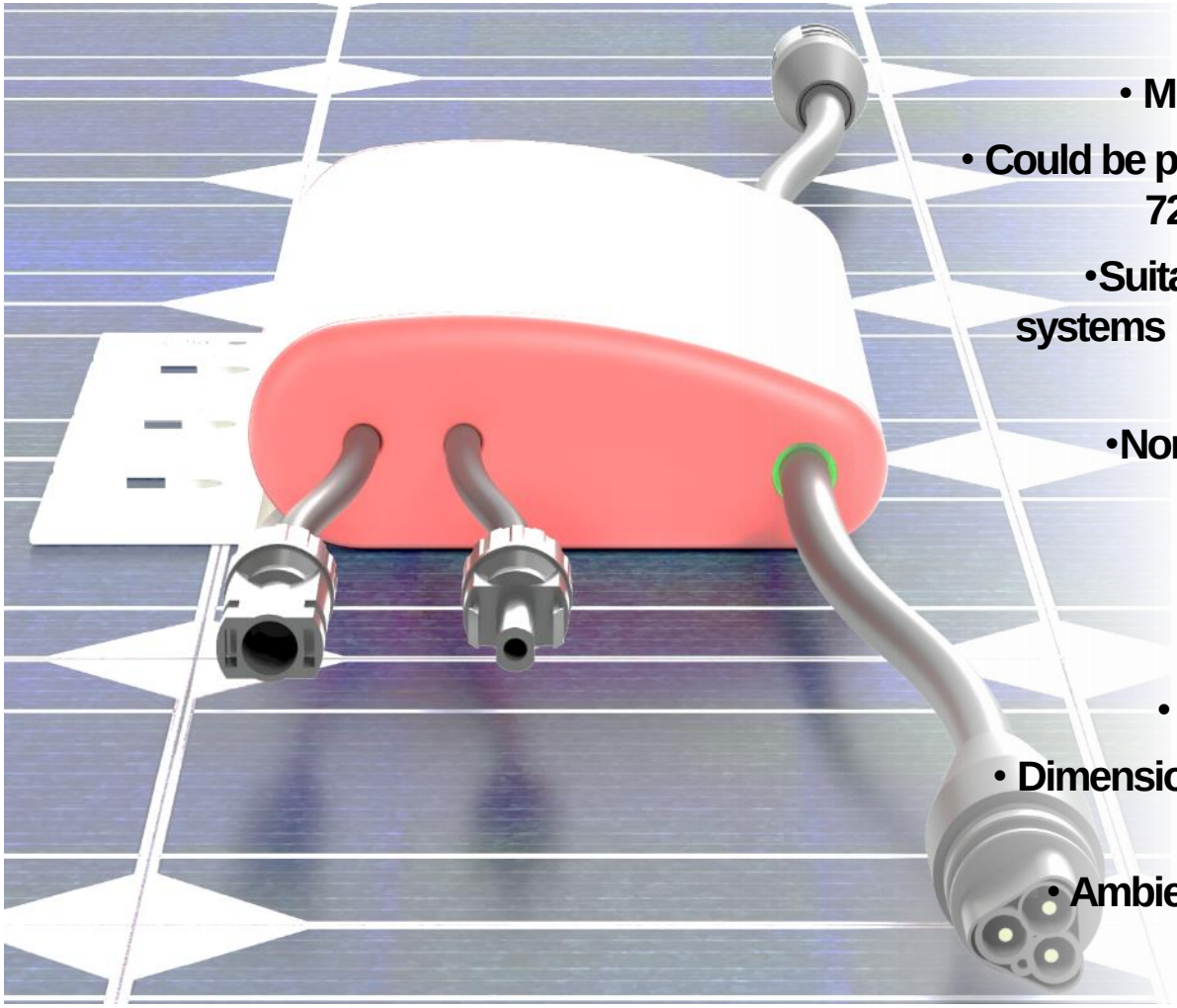
THE FIRST HYBRID OF PV POWER OPTIMIZER AND PV MICROINVERTER



NOVEL MLPE APPROACH, WHICH COMBINES THE KEY ADVANTAGES OF PHOTOVOLTAIC POWER OPTIMIZERS AND MICROINVERTERS

AS POWER OPTIMIZER - Best shade tolerance & energy yield, no power clipping
AS MICROINVERTER - PV system design flexibility, safety and direct AC-connectivity

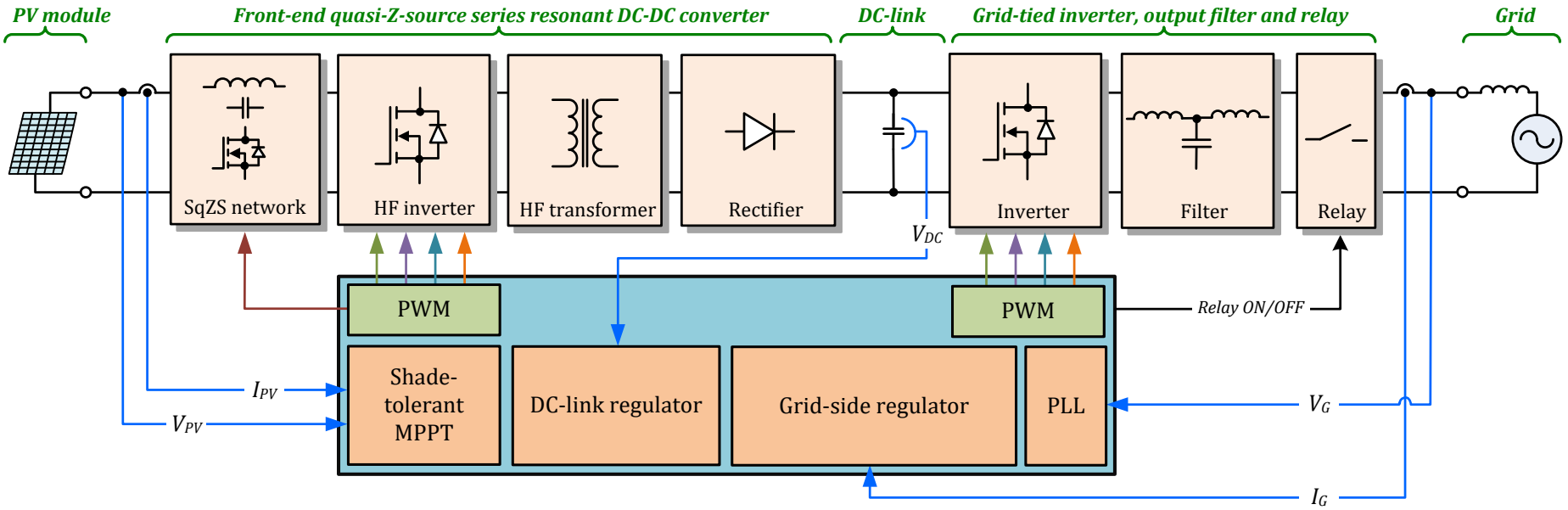
MAIN SPECS OF UBIK S350 OPTIVERTER®



- MPPT voltage range: 8...60 VDC
- Could be paired with all available 60- and 72-cell PV modules up to 350 W
- Suitable for building integrated PV systems (BIPV) incl. solar shingles and solar tiles
- Nominal output voltage: 230 VAC
- Output frequency: 50 Hz
- Enclosure: IP67
- CEC efficiency: 95%
- Static MPPT efficiency: 99.5%
- Dimensions (H x W x D): 215 x 174 x 47 mm
- Ambient temperature: -40°C…+65°C
- Cooling: natural convection

POWER CIRCUIT OF THE OPTIVERTER®

DOUBLE-STAGE POWER CONVERSION WITH POWER DECOUPLING AT HV SIDE



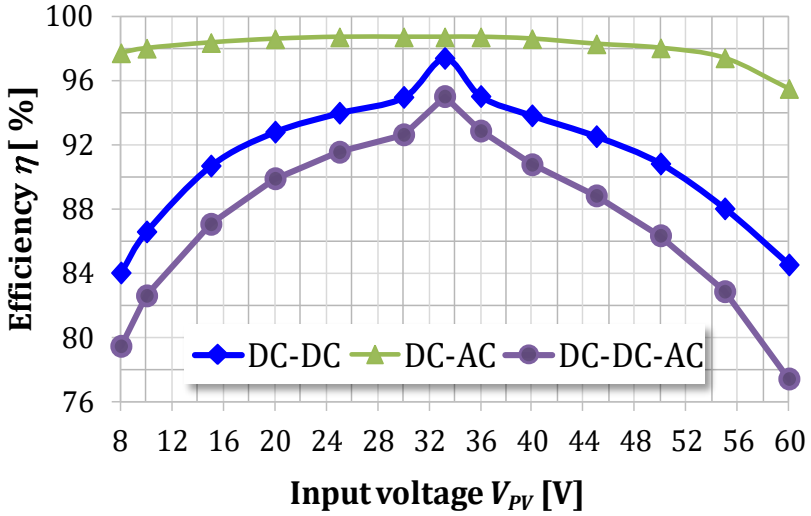
FRONT-END CONVERTER is used for the SHADE-TOLERANT (GLOBAL) MPPT and based on the multi-mode quasi-Z-source series resonant DC-DC converter topology

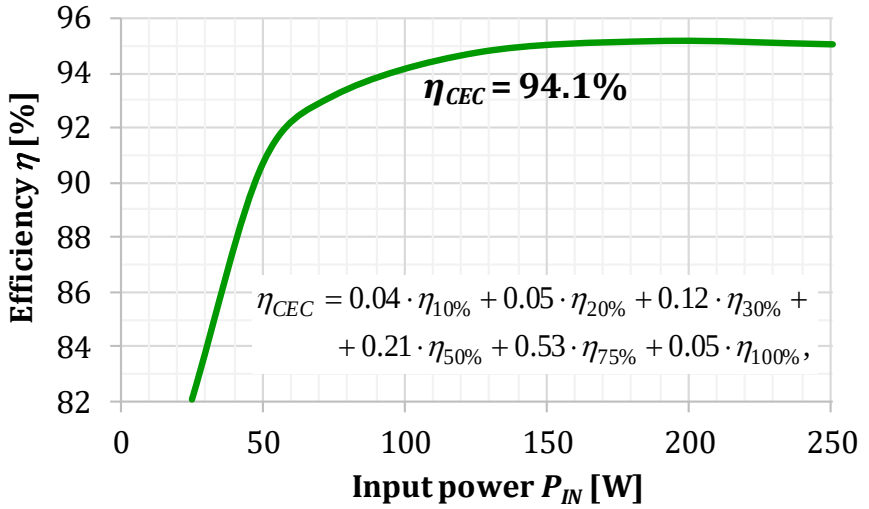
GRID -TIED INVERTER utilizes conventional H-bridge with one leg switched at high frequency and the other – at the grid frequency

HV DC-LINK CAPACITOR filters the output voltage of the front-end converter and buffers the double line frequency voltage ripple caused by a grid-tied inverter

LCL OUTPUT FILTER is used to attenuate the switching noise and create the sinusoidal output waveforms

EFFICIENCY* OF THE OPTIVERTER®





The CEC efficiency can be further increased by the implementation of the cycle skipping modulation technique at power levels below 120 W. Moreover, the part- and light load efficiency could be improved by the implementation of the Asymmetrical Pulse Width Modulation (APWM) instead of PSM for the control of qZSSRC in the buck mode.

**OPTIVERTER® v.1. Efficiency was measured by the precision power analyzer Yokogawa WT1800 and includes all losses in the converter, including auxiliary power and the control system losses*

FROM CONCEPT TO IMPLEMENTATION

TOWARDS THE FIRST INDUSTRIAL SAMPLE OPTIMIZED FOR MASS PRODUCTION

- Considerable **cost reduction** of the Bill of Materials (BoM)
- Nominal output power was increased to **300 W** (peak up to 350 W) for avoiding power clipping issues in the applications with high-power PV modules
- Auxiliary power supply was revised (**+0.2%** efficiency gain)
- Core type of magnetics was changed to **RM14 for unification** and cost reduction
- Protection and EMI damping circuits were revised; **EMC and safety certificates** were obtained

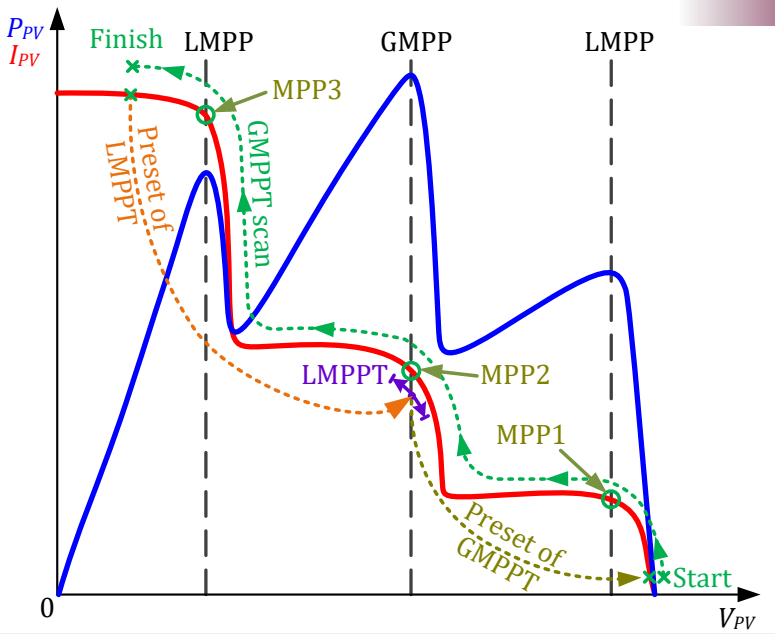
KEY FEATURES OF THE OPTIVERTER®

THE NEXT GENERATION SMART SOLAR EXPERIENCE

- SHADE-TOLERANT (GLOBAL) MAXIMUM POWER POINT TRACKING (MPPT)
- NO POWER CLIPPING
- ALL-IN-ONE APPROACH WITH INTEGRATED GATEWAY
- EASY INITIALIZATION AND DATA MANAGEMENT THROUGH Wi-Fi

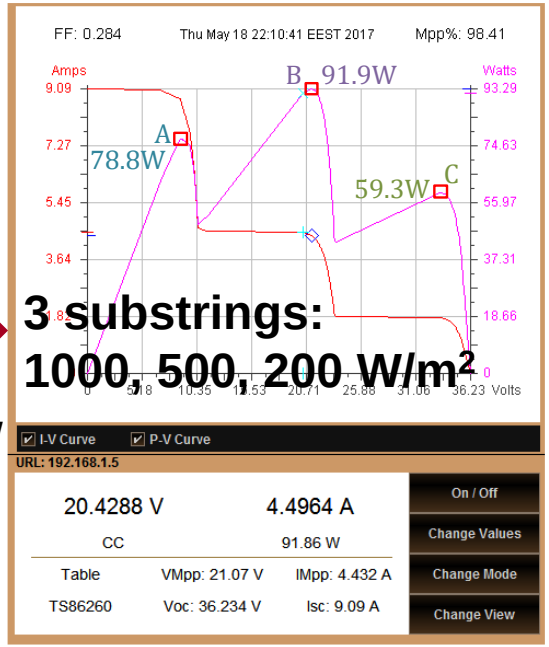
SHADE-TOLERANT (GLOBAL) MPPT

- The DC-DC topology enables GMPPT through **periodic rescanning** of P-V curve
- **Local MPPT** is performed around global maximum after preset of the operation point around the global power maximum
- Rescanning each **30 min**

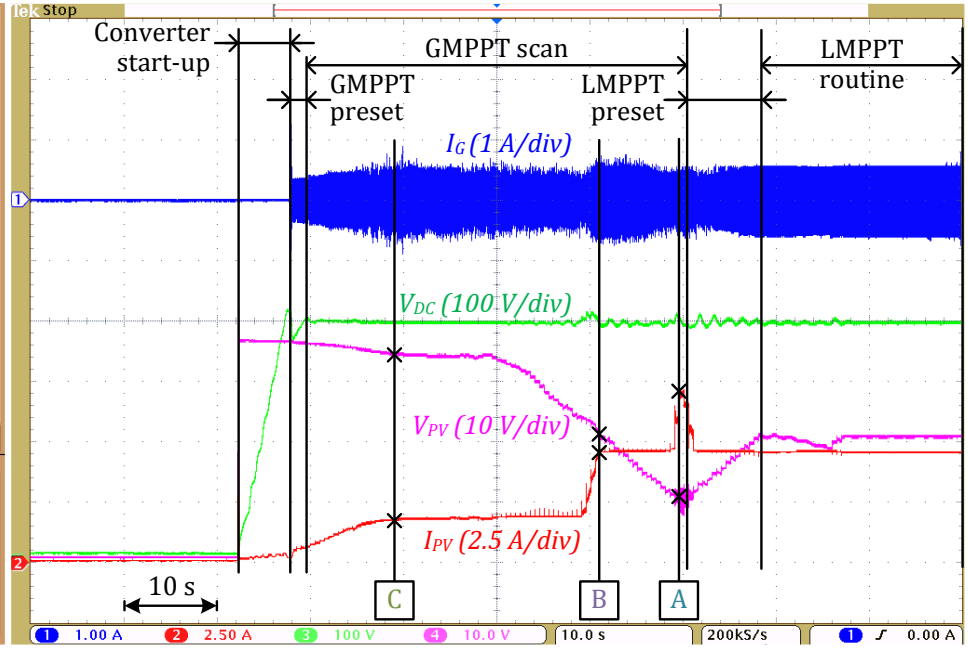


Case study:
+55% power

'C' – conventional MPPT gets 59.3 W
'B' – GMPPT can harvest 91.9 W

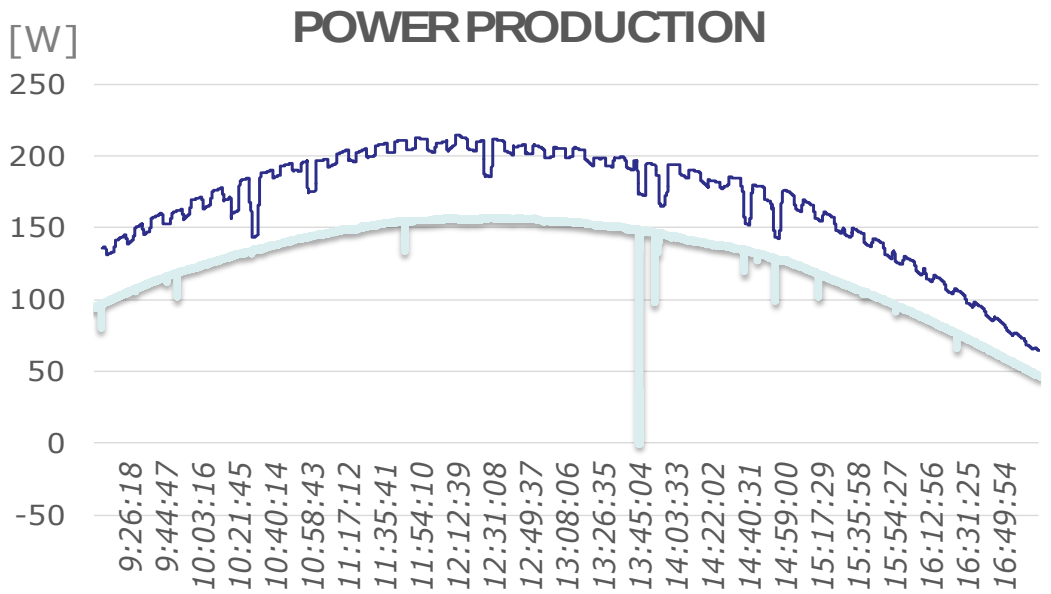


3 substrings:
1000, 500, 200 W/m²



ENERGY YIELD TESTS IN PSC*

OPTIVERTER® Ubik S350 vs MICROINVERTER Enphase M250: Operation with 60-cell PV Module NAPS Saana 250 SP3 MAW at PSC*



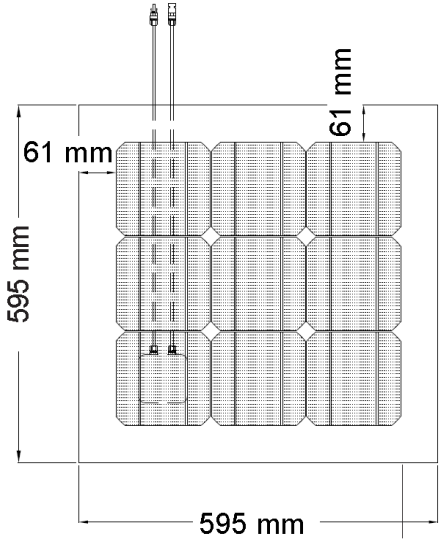
	Cumulative daily energy	Energy harvest
OPTIVERTER Ubik S350	**1317.62 Wh**	**+32.5%**
MICROINVERTER Enphase M250	993.88 Wh	

**The power production under sunny weather and with one shaded substring: Optiverter UBIK S350 reaches +32.5% better daily energy harvest than the Microinverter Enphase M250. Test site location: Pirita, Tallinn (Estonia)*

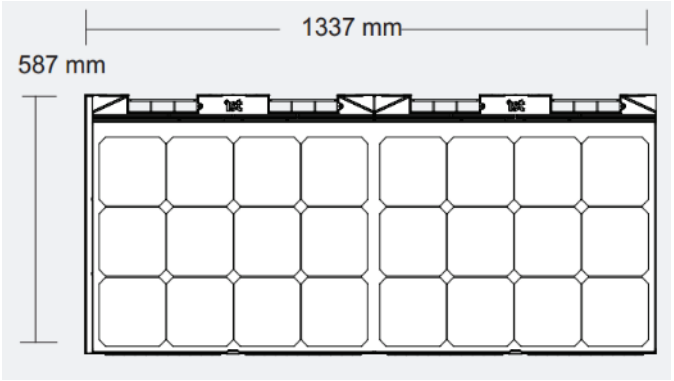
SOLAR ROOF INSTALLATIONS (1)

- **Small** PV **modules** with 9…24 cells
- **Mini-strings** of 3…8 modules could be grid integrated by means of a microinverter
- **Complicated** patterns of **partial shading** are possible and require enhanced MPPT
- **OPTIVERTER® with its shade-tolerant MPPT is a solution!**

Case 1: Mini-string of **eight** Gaia Solar Integra Line SP 595 PV shingles of **9 cells each**

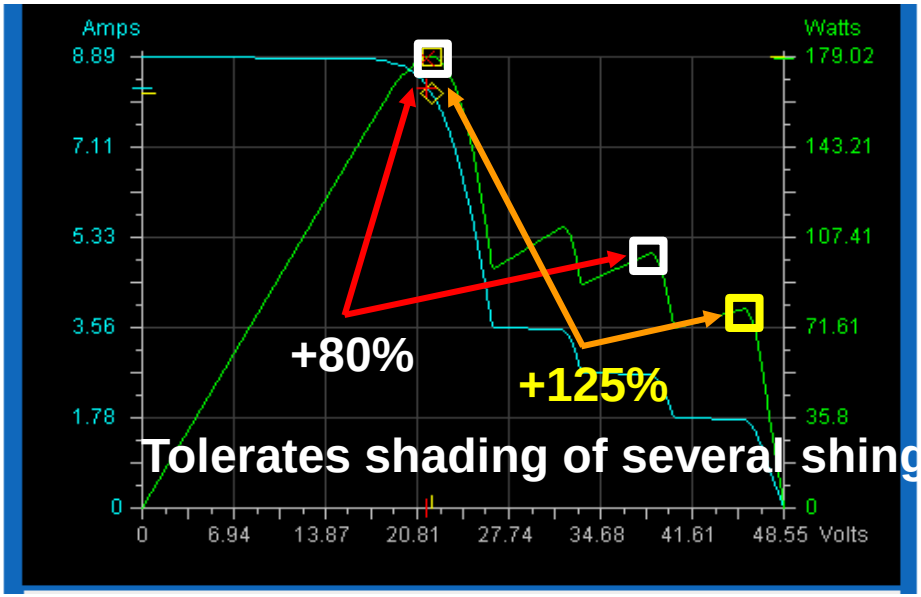


Case 2: Mini-string of **three** SunTegra PV tiles of **24 cells each**



OPTIVERTER S350 Balcony Installation

SOLAR ROOF INSTALLATIONS (2)

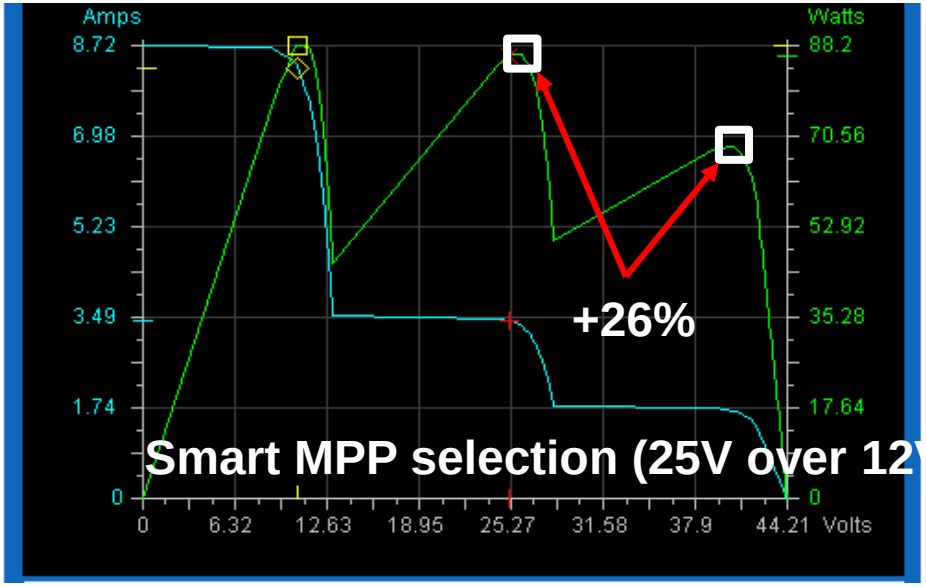


Case 1:

- Complicated shading profile with four power maxima was developed
- Simple microinverter harvests only **~80 W**
- Market leading microinverter harvests **~100 W** due to enhanced variable step MPPT
- **Optiverter® harvests ~180W**

Case 2:

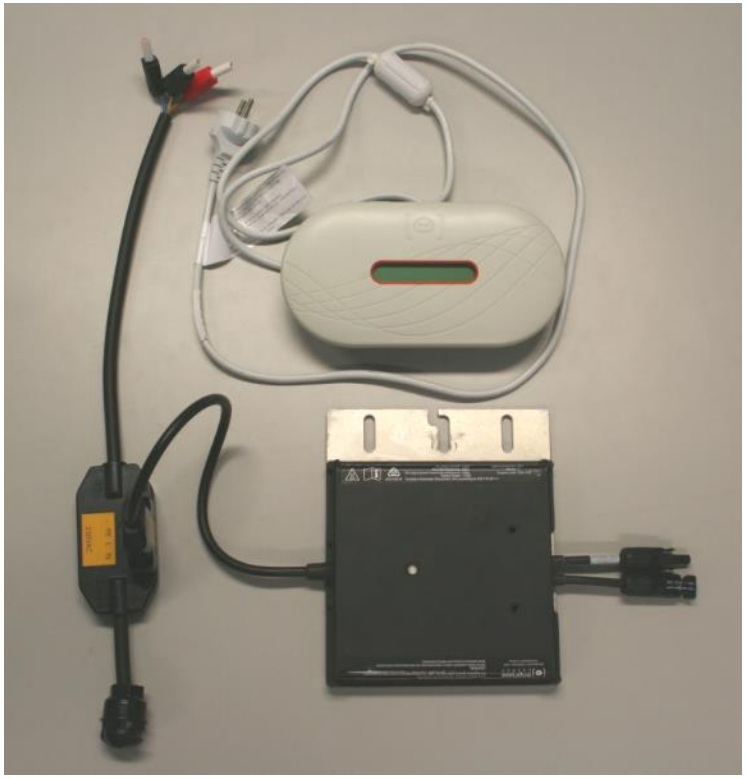
- Shading profile with three power maxima (**two are of the same power**)
- Microinverters harvest **~68W**
- **Optiverter® harvests ~86 W and can select operating point with better efficiency (higher energy yield)**



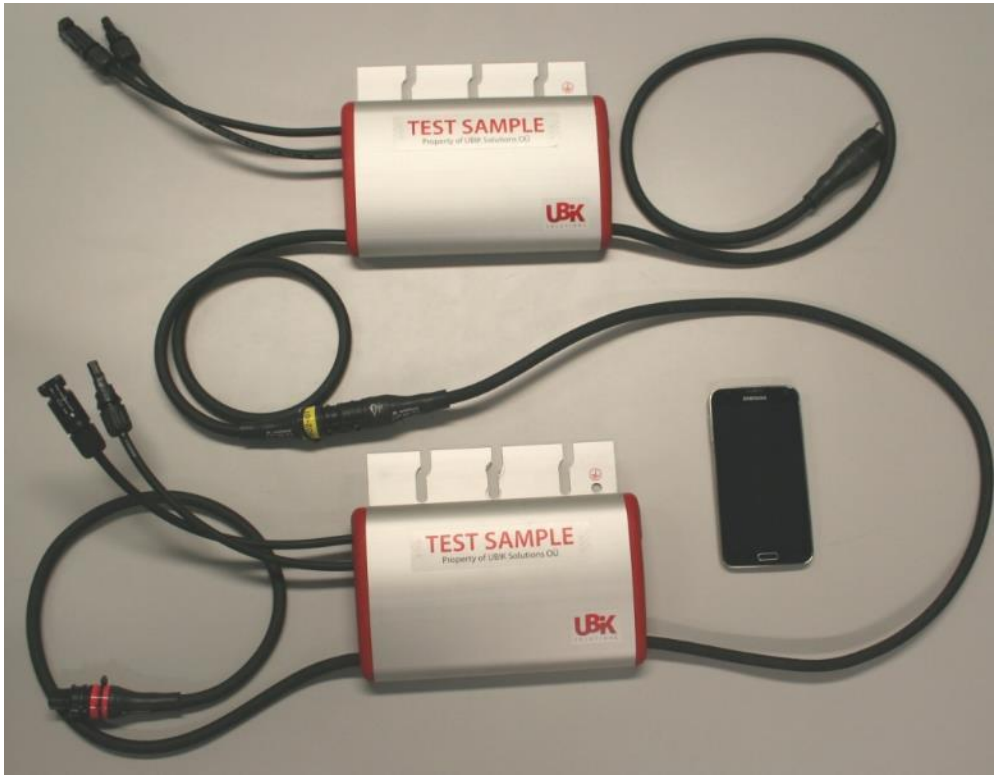
ALL-in-ONE CONCEPT

CONVERTER, GATEWAY AND CONNECTING WIRES ARE INCLUDED IN PRICE

MICROINVERTER ENPHASE M250



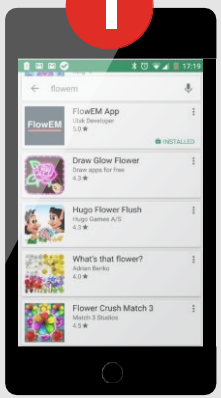
OPTIVERTER ® UBIK S350



INITIALIZATION OF OPTIVERTER

SIMPLE AND EASY-TO-FOLLOW 5-STEP PROCEDURE WITH YOUR SMARTPHONE

1

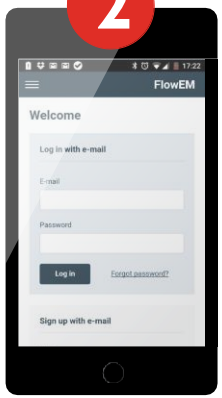


Download and open Android/iOS app

Download on the App Store

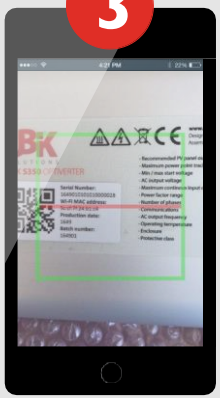
GET IT ON Google Play

2



Register yourself and create new site

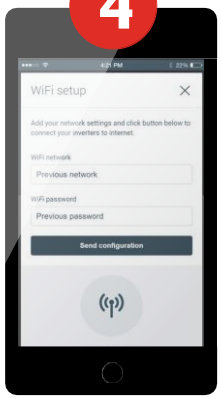
3



Scan Optiverter's QR code you want to add

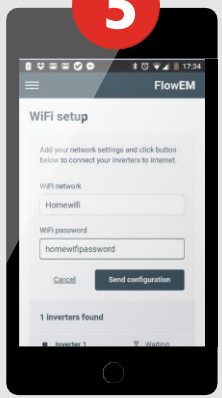
All scanned Optiverters will be added to your profile

4



Enter your home Wi-Fi name and password

5



Select Optiverters you want to connect to your home Wi-Fi

Optiverters will be configured automatically to connect to your home Wi-Fi

6 DONE :)

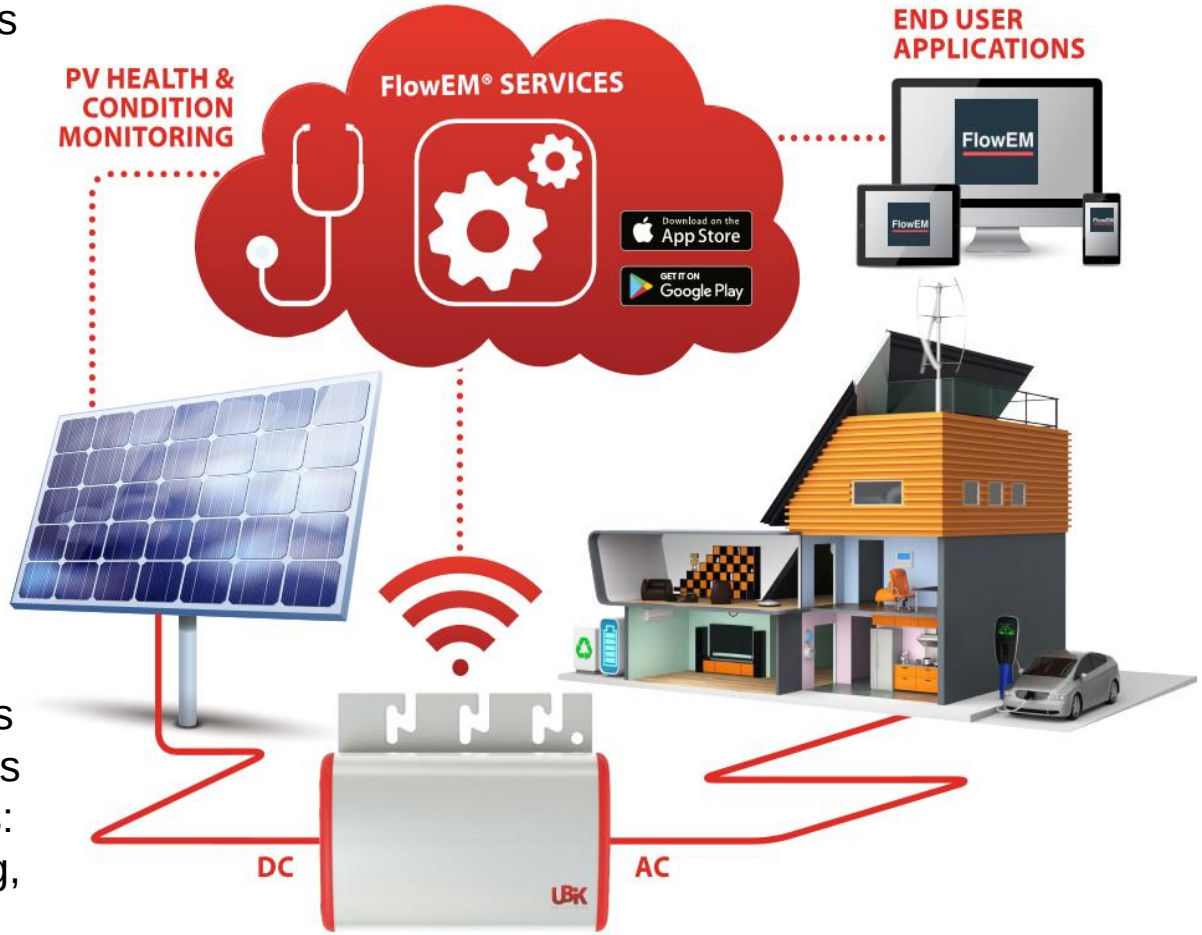
After the Optiverter has been successfully initialized, it will automatically start sending all measured data to the FlowEM® cloud server for data analysis and visualization

OPTIVERTER ENERGY MANAGER – FlowEM®

FlowEM® is an energy manager that monitors, analyzes and manages energy production and consumption over the cloud in order to optimize household processes, improve energy efficiency, decrease the costs and offer enhanced user experience.

FEATURES:

- Initialization of the inverter
- Monitoring & controlling
- Data collection & analysis
- Charting & reporting
- Automatic software updates incl. grid code specifications
- System remote diagnostics: PV panel health monitoring, I-V curve tracing, etc



OPTIVERTER ENERGY MANAGER – FlowEM®

Overall Production

Today's performance

Environment savings

System status

Generated energy

Installation site details

TECHNOLOGY VALIDATION TESTS

CURRENT TEST SITES

ESTONIA 5X

TALLINNA TEHNIKAÜLIKOOL
TALLINN UNIVERSITY OF TECHNOLOGY
Energiapartner
UBIK SOLUTIONS

SPAIN 1X

University of Extremadura (UEX)

PORTUGAL 1X

New University of Lisbon (Uninova)

AUSTRIA 1X

DAS Energy

TECHNOLOGY VALIDATION TESTS

TEST SITES

- ESTONIA
- DENMARK
- GREECE
- FRANCE
- SPAI
- PORTUGAL
- SWEDEN
- NETHERLAND
- GERMANY

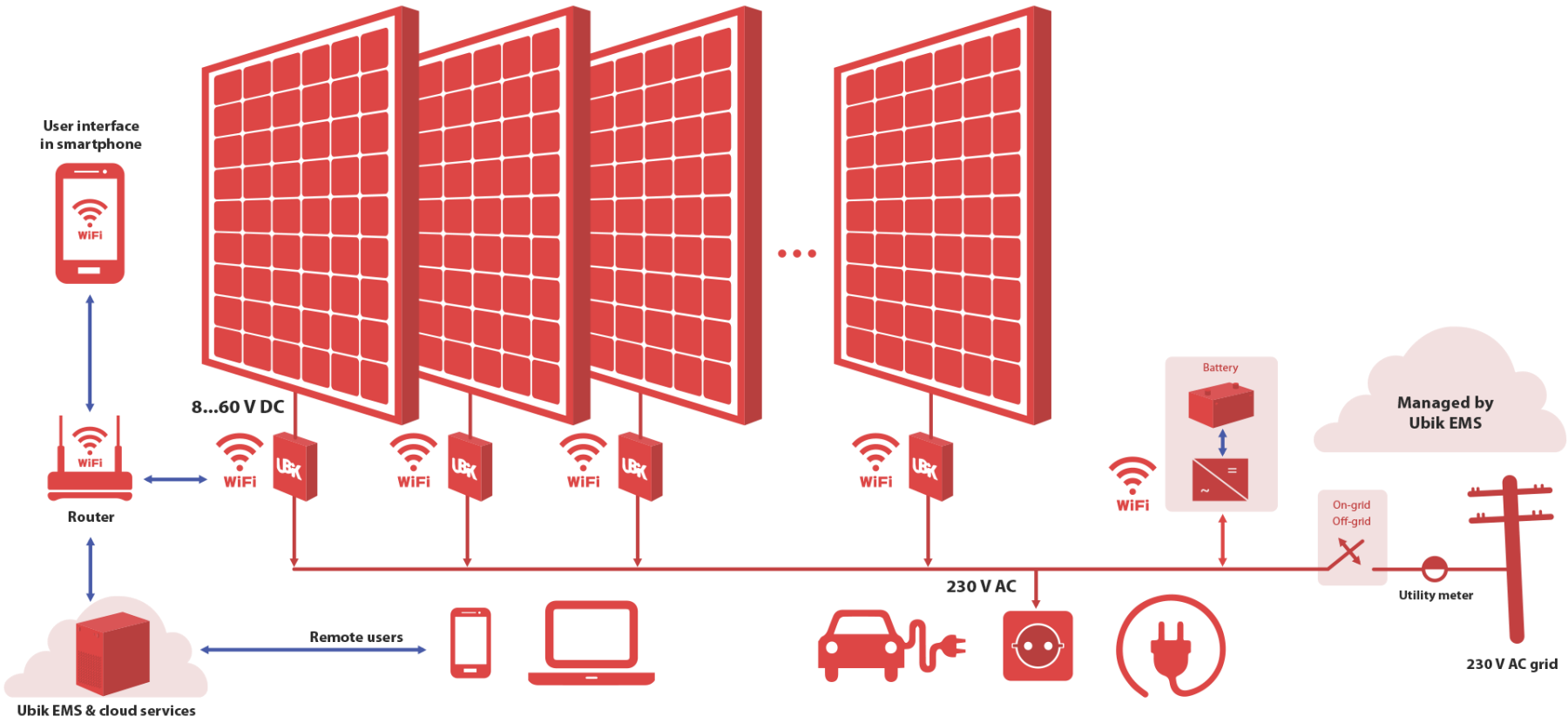
CONCLUSION AND REMARKS

TOWARDS THE OPTIVERTER GEN. 2

- To further enhance the **efficiency** the number of power conversion stages should be minimized – implementation of a single-stage qZS DC-AC isolated topology will be investigated
- To improve the **reliability** the electrolytic caps should be avoided – active power decoupling techniques will be studied
- To improve the **power density** the switching frequency should be further increased – the application of GaN HEMTs will be studied
- To make the Optiverter's concept more attractive the integration into PV module will be realized (**AC module** concept, max height 2 cm)
- To decrease the **production costs** the re-utiliziation of the topology could be considered – implementation of the bidirectional qZS DC-AC converter topology will be studied for the AC-battery applications

AMBITIONS AND ONGOING RESEARCH

SMART POWER SYSTEMS FOR NEARLY ZERO ENERGY BUILDINGS



THANK YOU FOR YOUR TIME!

– POWER ELECTRONICS GROUP –

Your Reliable Partner in Power Electronics

POWER GROUP ELECTRONICS