PRODUCT MANAGEMENT, REV. FEBRUARY 12- 2020

Mono vs. multi – How many MPPT channels are good for my project?

PV Magazine webinar

Andrea Genovesi, Marco Trova

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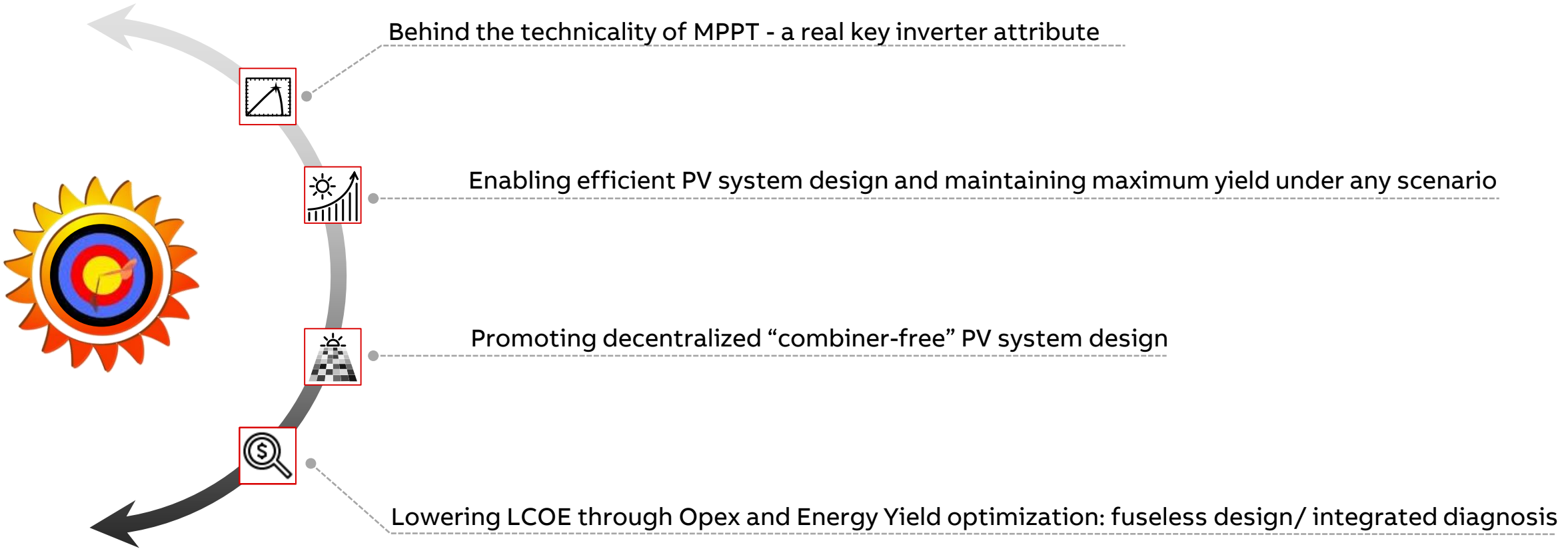
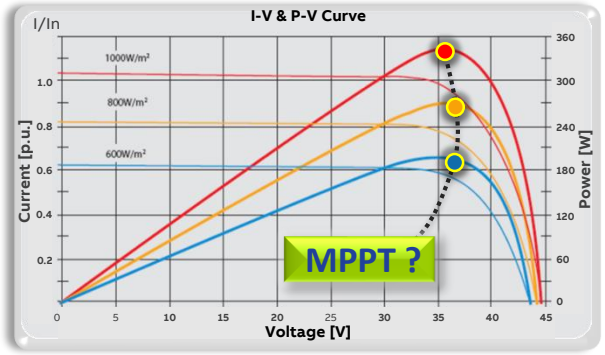
Multi – MPPT: does it really matter?

What are the tangible advantages of multi-MPPT in the design and over the lifecycle of a PV system?

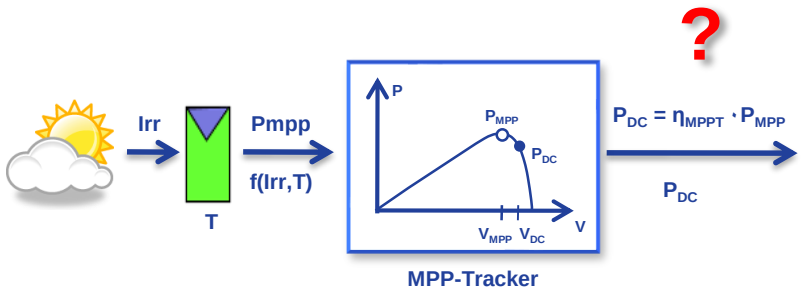


MPPT – a real key inverter attribute

MPPT = Maximum Power Point Tracking

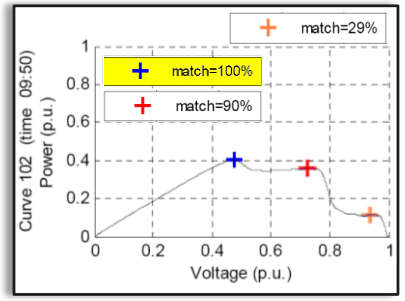


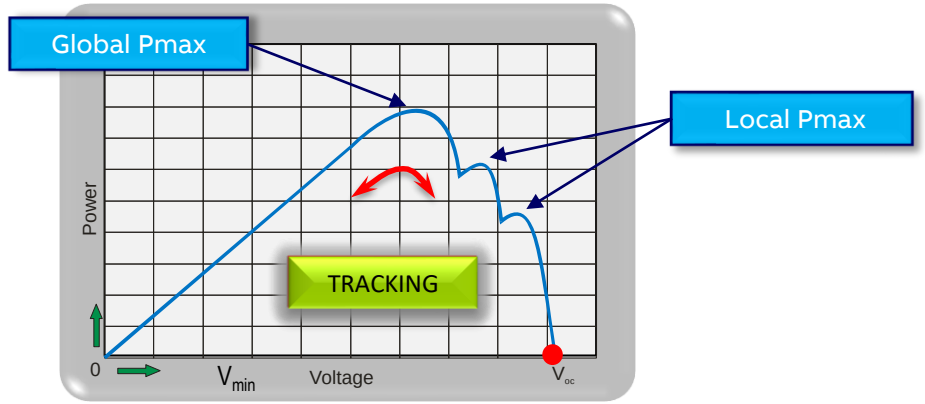
HOW GOOD ARE YOUR REAL TIME MPP TRACKING PERFORMANCE UNDER IDEAL PV ARRAY CONDITIONS ?



η_{MPPT}	Ranking
< 99.0	Poor
> 99.5	OK
> 99.8	Excellent

HOW GOOD IS YOUR MPP TRACKING IN MINIMIZING SHADING LOSSES?

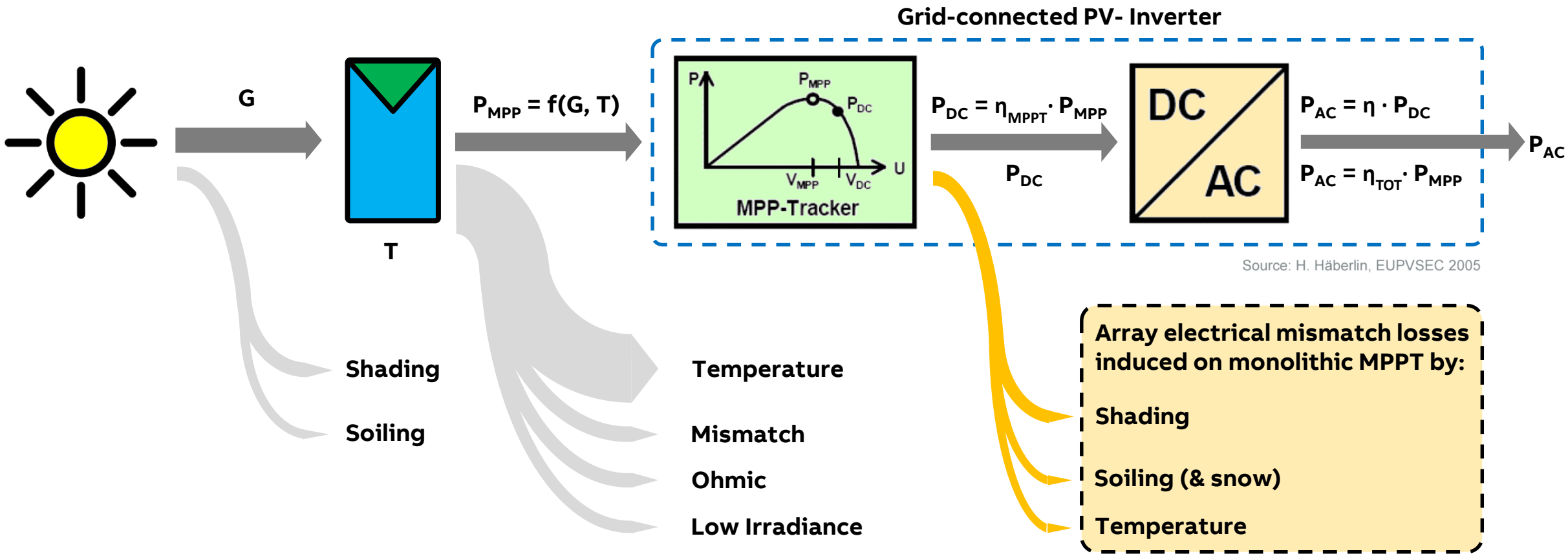




EFFECTIVE MPP SCAN REQUIRES WIDE MPP VOLTAGE RANGE!

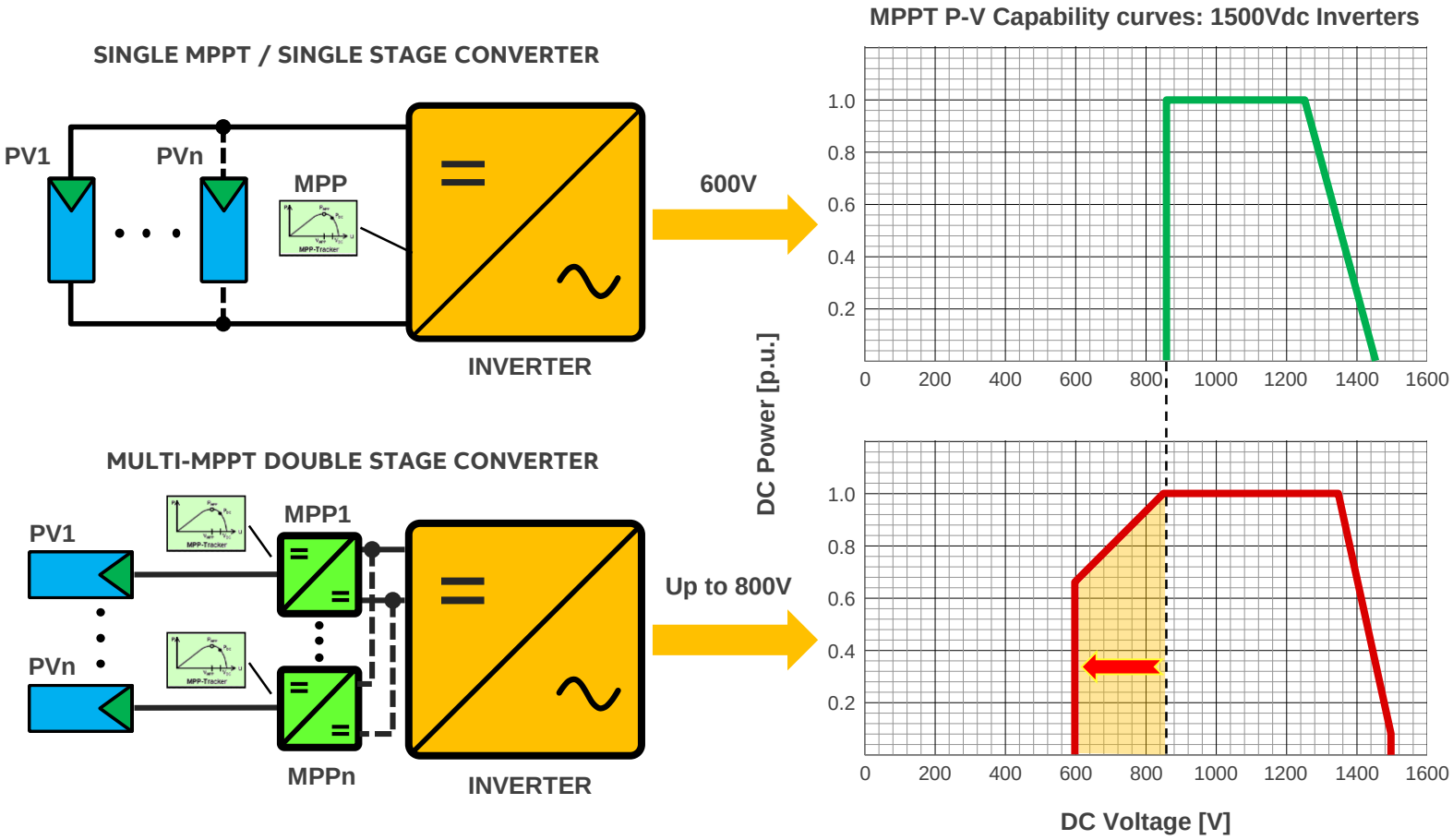
MPPT – a real key inverter attribute

MPPT tracking in single-MPPT monolithic inverter design: **additional mismatch losses**



MPPT – a real key inverter attribute

Comparing multi-MPPT vs single MPPT (single stage) inverter design: **key benefits**



Multi-MPPT DOUBLE STAGE INVERTER

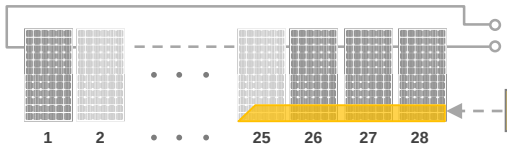
KEY BENEFITS

- Wide input voltage range, extended towards lower MPP voltage values
- Ability to always track the MPP point, also in case of shaded strings
- Support complex PV field configurations minimizing yield losses
- Practically immune to electrical mismatch losses induced by shading, snow, soiling
- MPP voltage range not depending on AC voltage (decoupling of DC & AC voltage levels)

MPPT – a real key inverter attribute

Multi-MPPT vs single MPPT (single stage) inverter design: **behavior with partially shaded arrays**

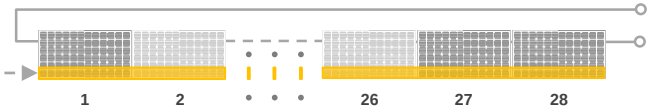
Portrait



30% of the modules are partially shaded
(9 out of 28 in series)

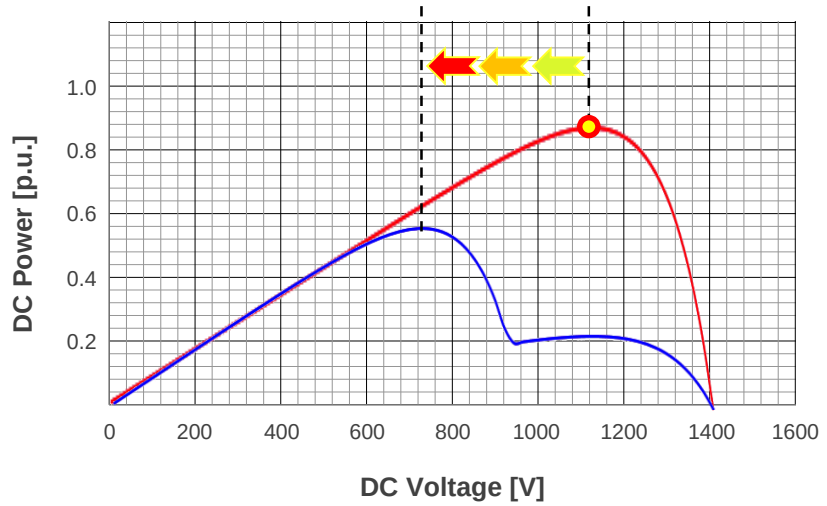
Landscape

Shaded Area



100% of the modules are partially shaded
(less than 30% of the surface)

PV curve
Unshaded & partially shaded string



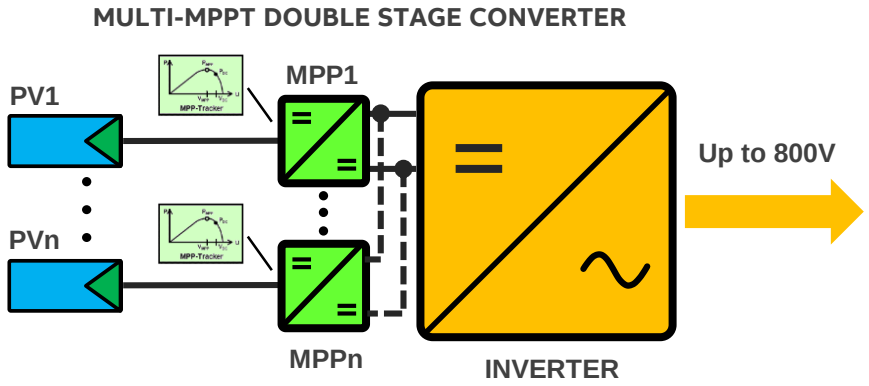
unshaded string

partially shaded string

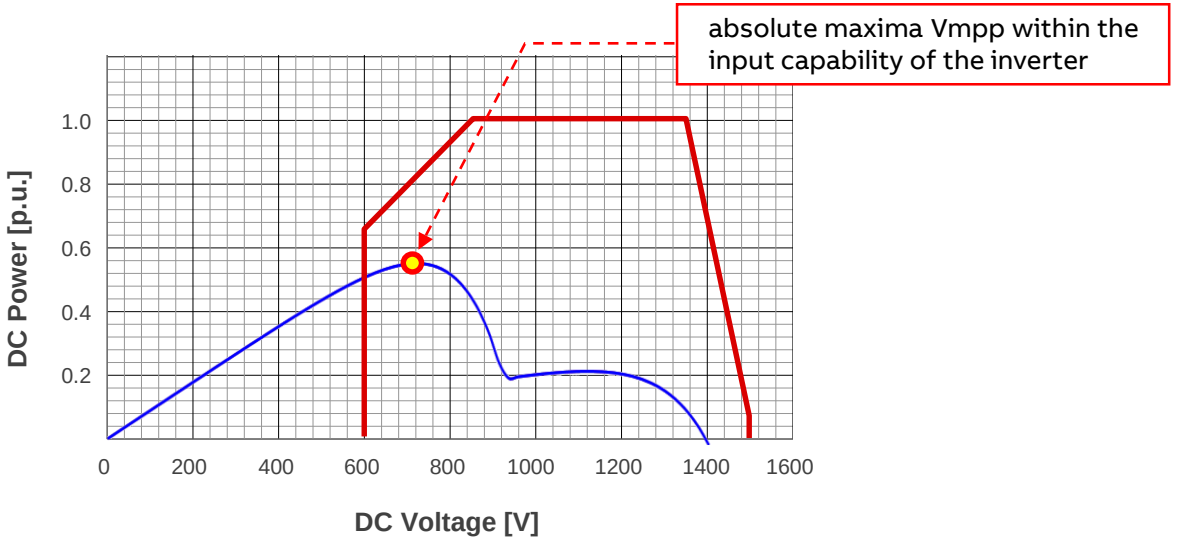
MPPT – a real key inverter attribute

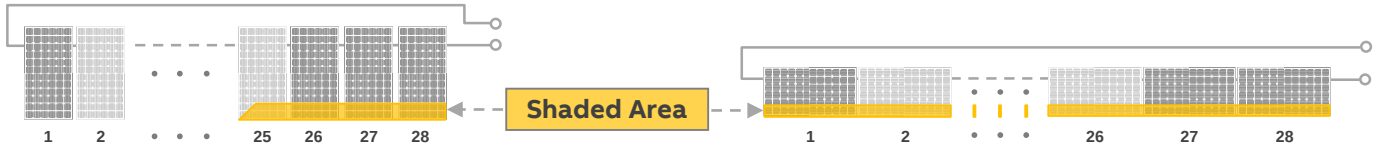
Multi-MPPT vs single MPPT (single stage) inverter design: **behavior with partially shaded arrays**

Always tracking absolute MPP under any condition, including partially shaded arrays



PV curve
partially shaded string





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100% of the modules are shaded
(less than 30% of the surface)

double stage inverter

partially shaded string

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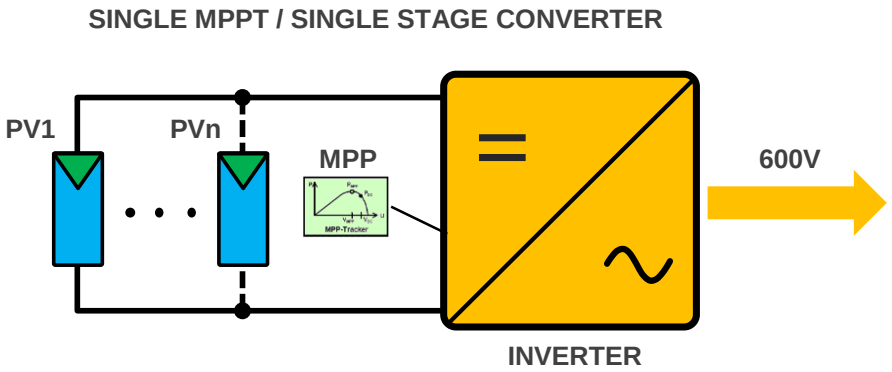
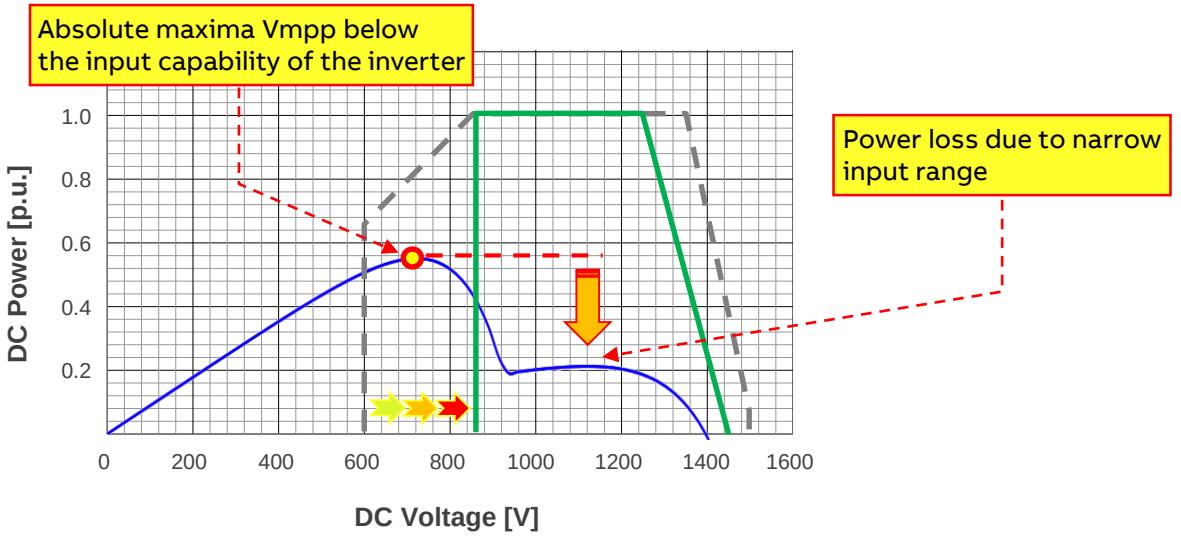
MPPT – a real key inverter attribute

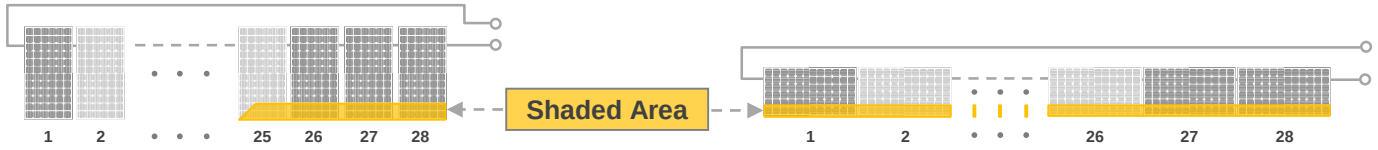
Multi-MPPT vs single MPPT (single stage) inverter design: **behavior with partially shaded arrays**

Yield losses of single MPPT / single stage inverters when operating with partially shaded arrays



PV curve partially shaded string





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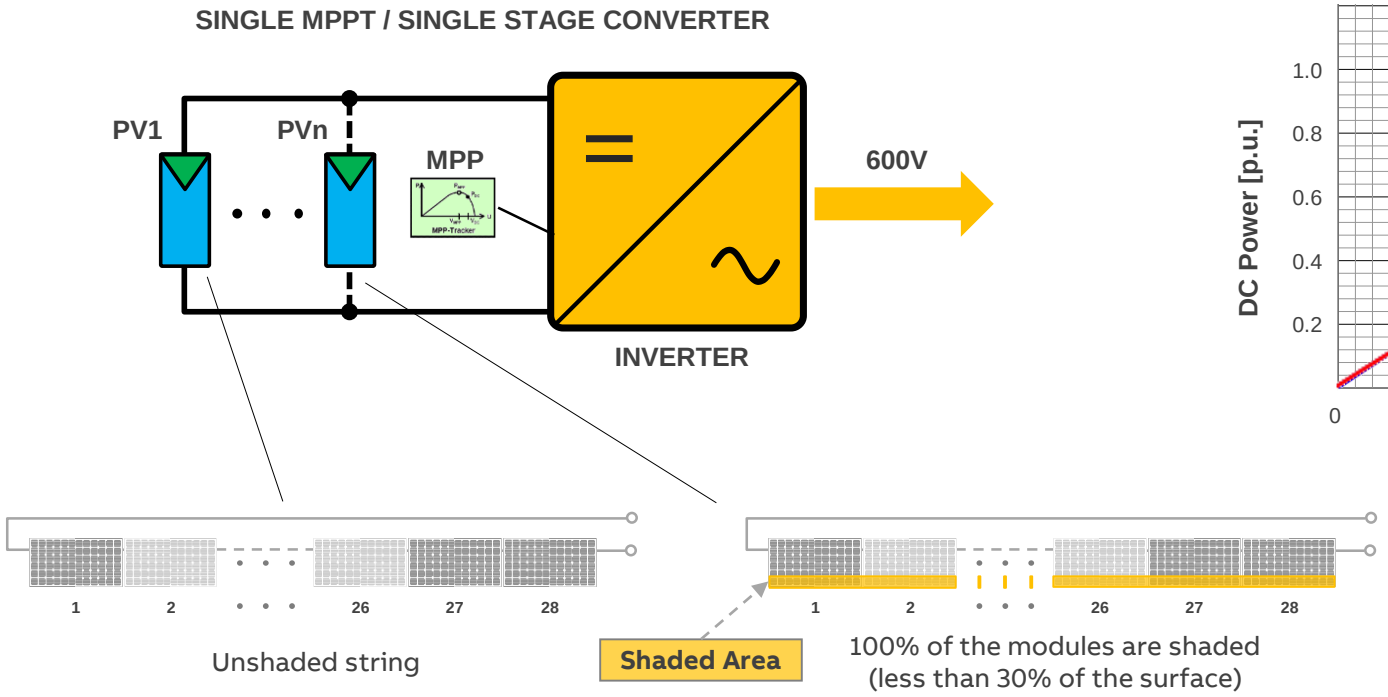
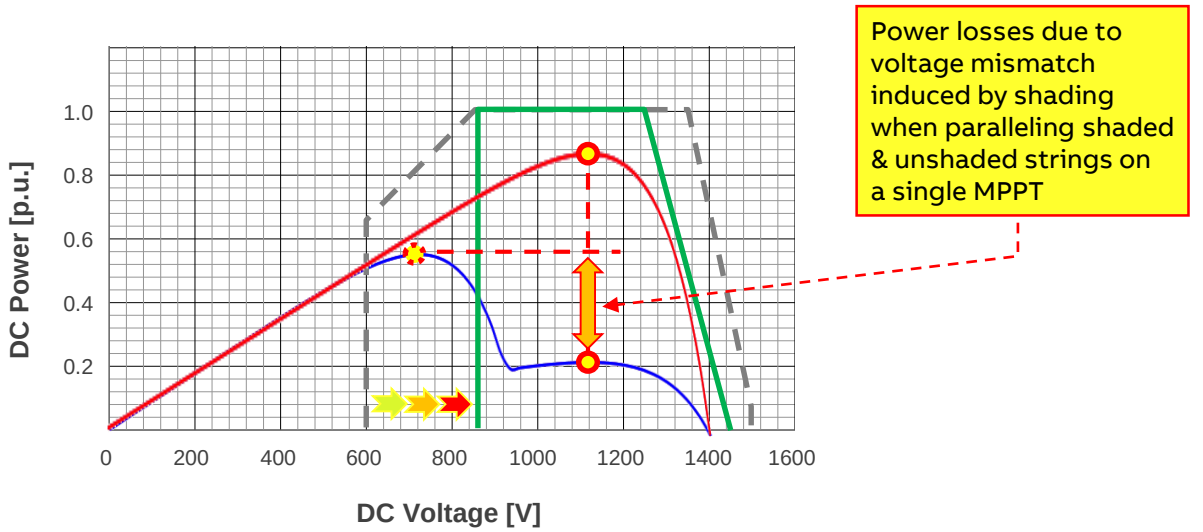


PV curve
Unshaded & partially shaded string

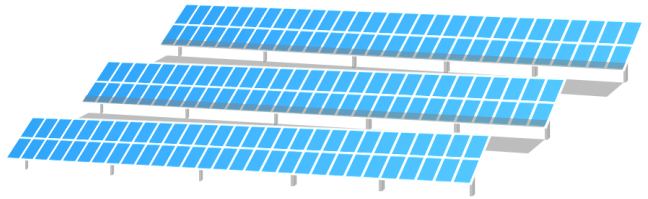


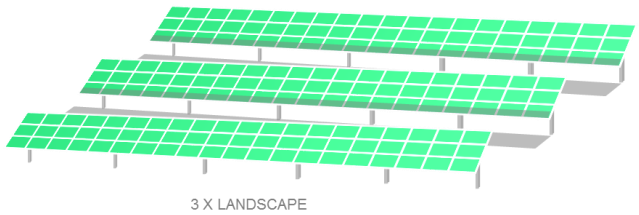
Mono vs. Multi – MPPT

Enabling efficient PV system design and maintaining maximum yield under any scenario

Using commercial software we have simulated several possible scenarios using single or Multi-MPPT inverters to evaluate the impact on the Yield

- Fixed Tilted Ground Mounted or Rooftop system
- Portrait or Landscape architecture
- Several shadow conditions analyzed
- South or East/West oriented systems
- Different Locations (Low Irradiance / High Irradiance)





*The simulations were performed with PV*SOL premium*

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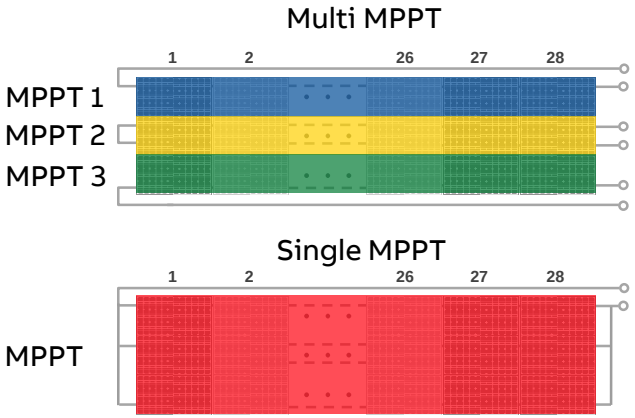
Mono vs. Multi – MPPT

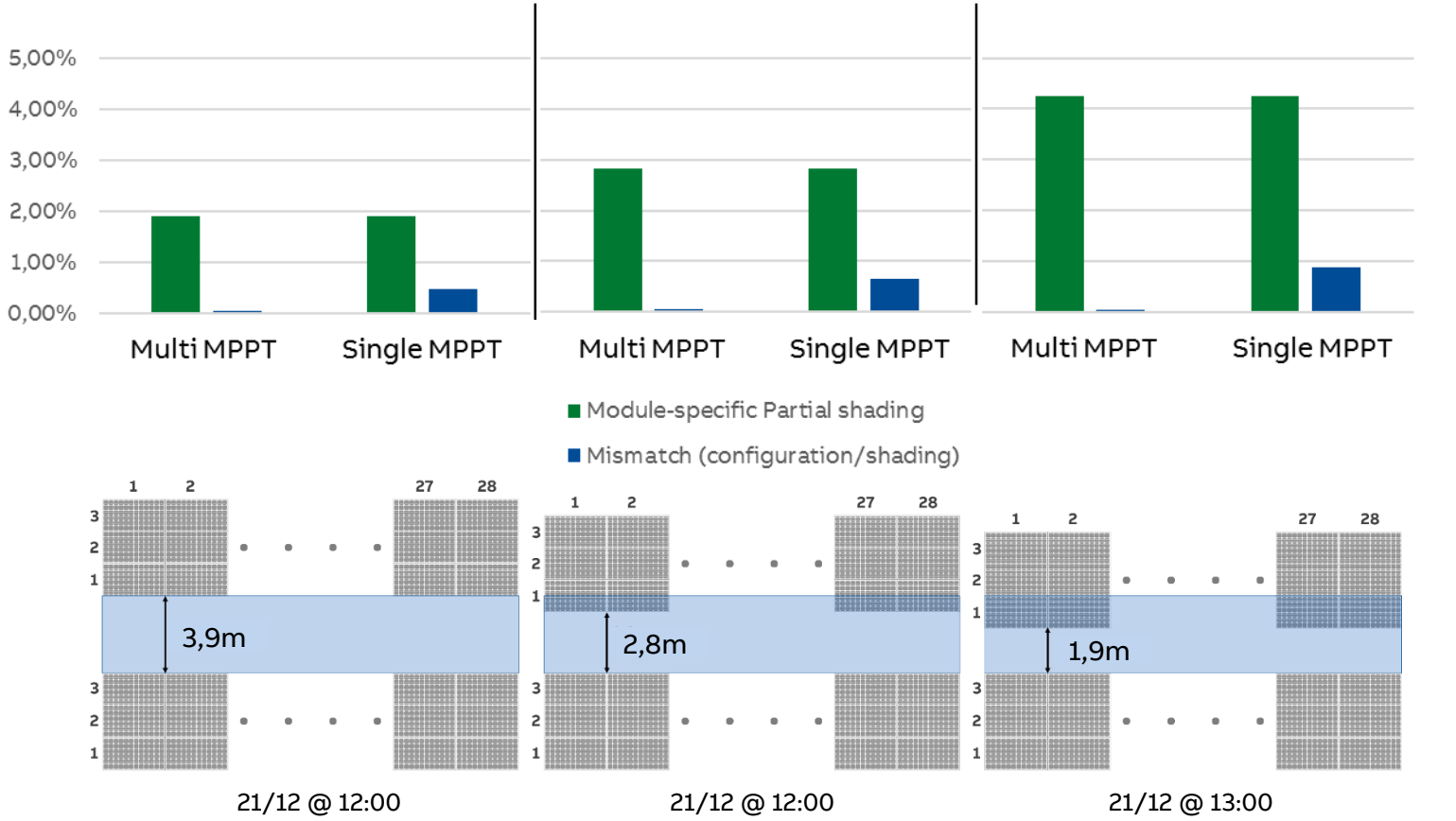
Enabling efficient PV system design and maintaining maximum yield under any scenario

Array configuration: 3-high landscape

Location	North Europe	
Tilt	20°	
DC/AC ratio	1,3	
GHI	[kWh/m²]	**1006.13**

Low Irradiance Scenario





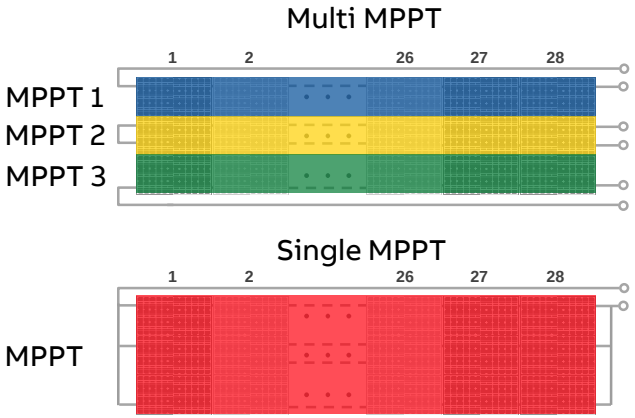
Mono vs. Multi – MPPT

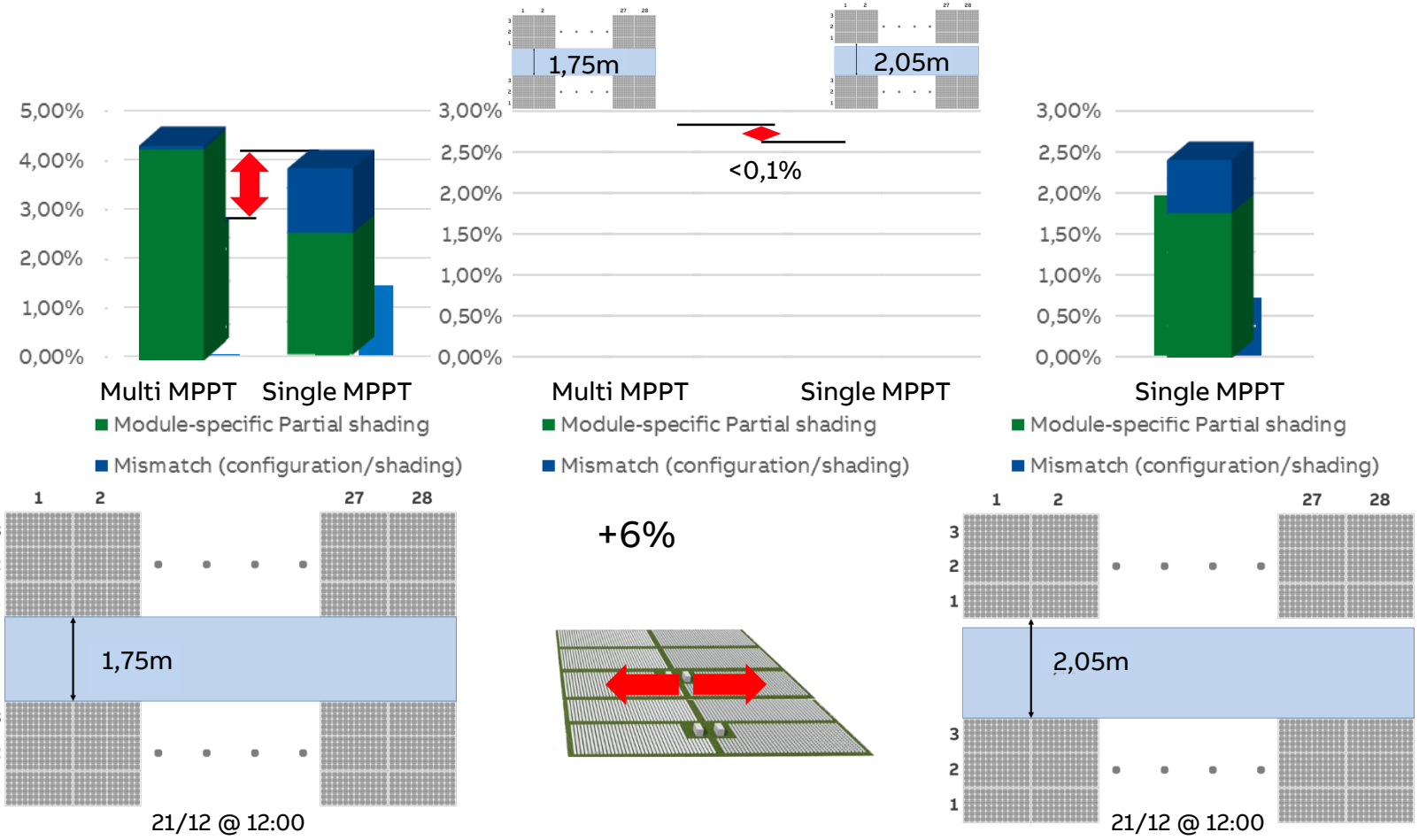
Enabling efficient PV system design and maintaining maximum yield under any scenario

Array configuration: 3-high landscape

Location	Middle East	
Tilt	20°	
DC/AC ratio	1,3	
GHI	[kWh/m²]	**1831.89**

High Irradiance Scenario





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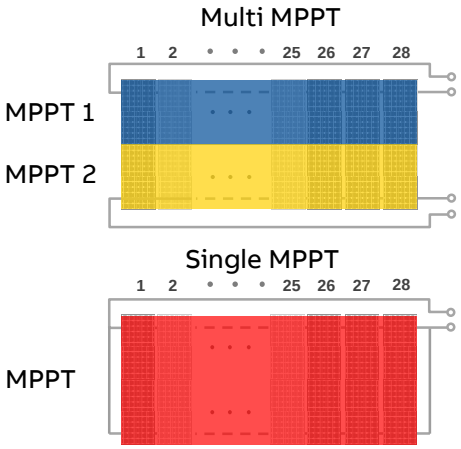
Mono vs. Multi – MPPT

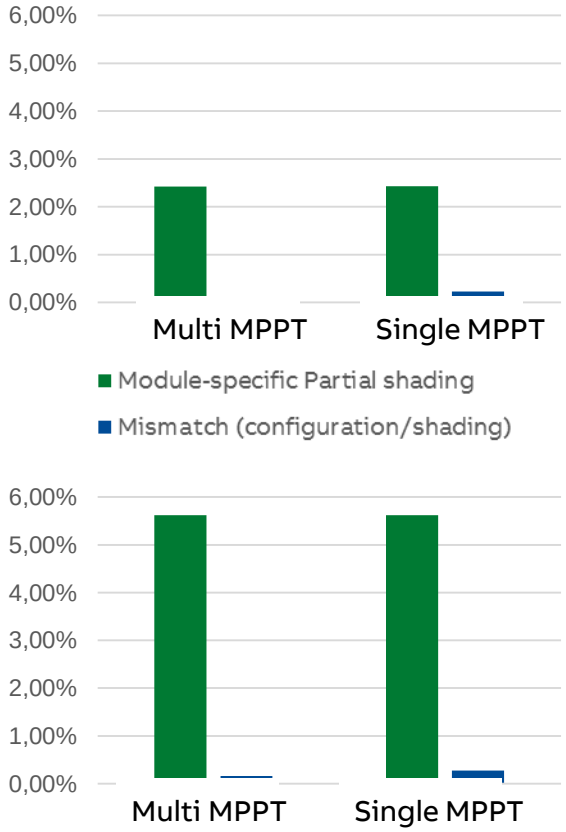
Enabling efficient PV system design and maintaining maximum yield under any scenario

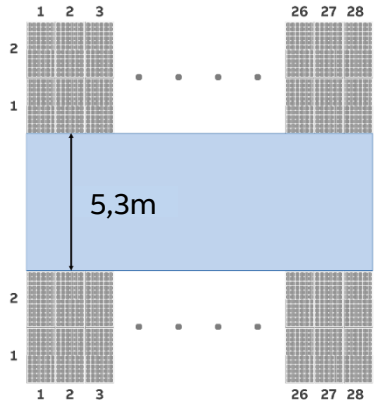
Array configuration: 2-high portrait

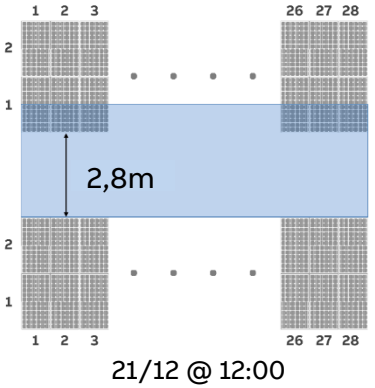
Location	North Europe	
Tilt	20°	
DC/AC ratio	1,3	
GHI	[kWh/m²]	1006.13

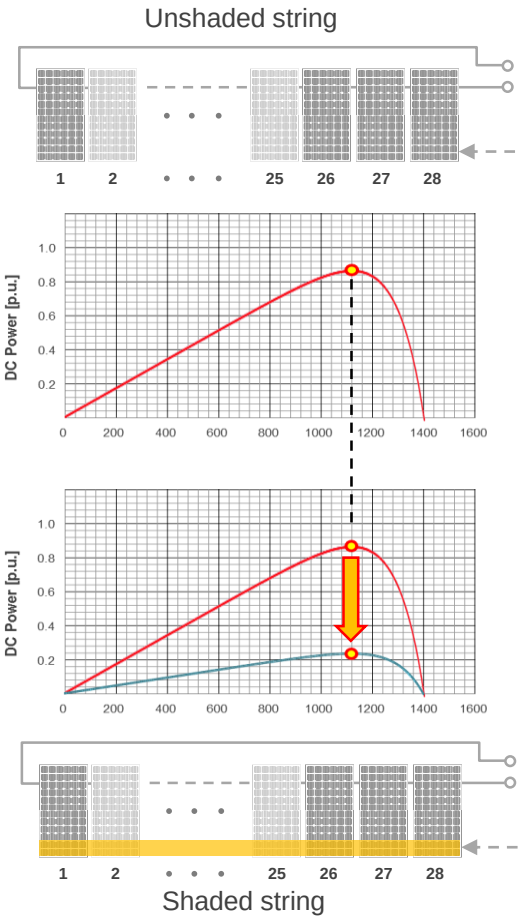
Low Irradiance Scenario





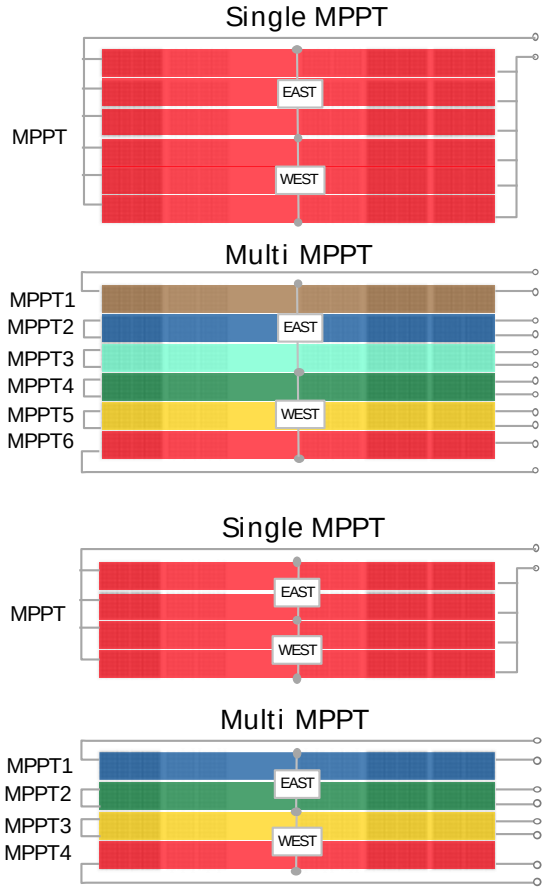






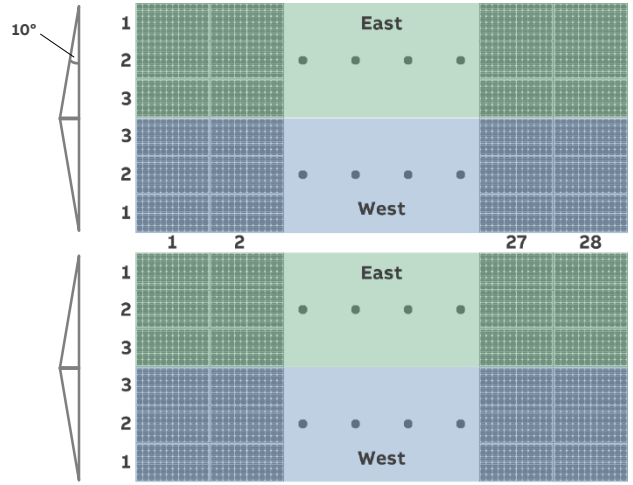
Mono vs. Multi – MPPT

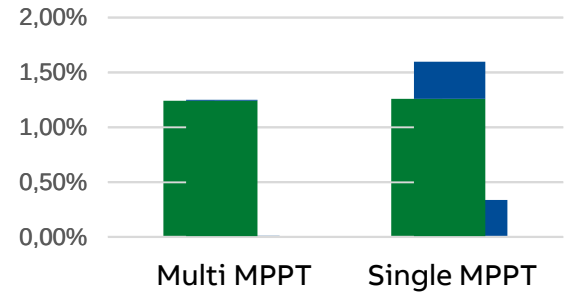
Enabling efficient PV system design and maintaining maximum yield under any scenario



3-high landscape / Tilt 10°

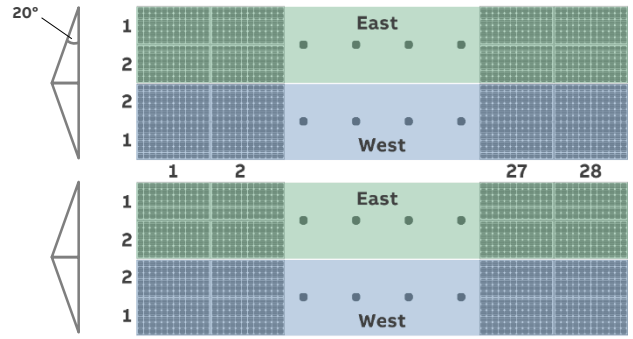
Location	North Europe	
Tilt	10°	
DC/AC ratio	1,3	
GHI	[kWh/m²]	1006.13

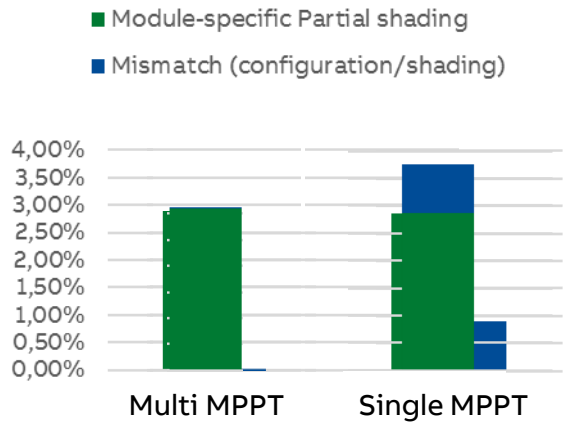




2-high landscape /Tilt 20°

Location	North Europe	
Tilt	20°	
DC/AC ratio	1,3	
GHI	[kWh/m²]	1006.13





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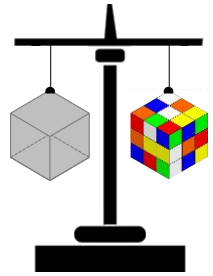
Mono or Multi – MPPT ?



How many MPPT channels are good for my project?

MONO

- String length is not an issue and can be optimized to match the narrow MPP voltage window (OK for climates with limited temperature excursions)
- Land is flat or with very limited ripple
- Modules are mounted in portrait
- Land coverage ratio is not critical (unconstrained space / low cost of land lease)

IDEAL CONDITIONS!

?

MULTI

- Best choice with landscape PV module mounting layout
- Best choice when maximum land coverage ratio shall be achieved
- Best choice when land planarity is not guaranteed
- Minimize the yield losses caused by electrical mismatch between different strings (shading or different orientation)

BUT WHAT OTHER FACTORS SHALL BE CONSIDERED UNDER REAL WORLD CONDITIONS?

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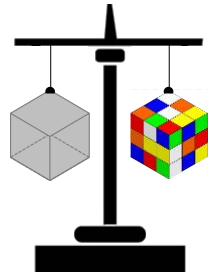
Mono or Multi – MPPT ?

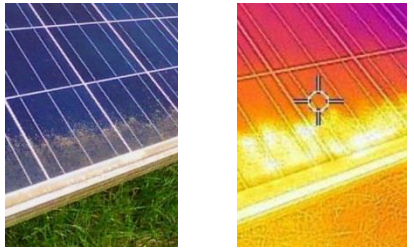


How many MPPT channels are good for my project?

WHAT OTHER FACTORS SHALL BE CONSIDERED UNDER REAL WORLD CONDITIONS?

Soiling effects on performance

Especially at low tilt angles, soiling is building up mostly on the lower frame rail of the modules.
This layer of dirt is shadowing the underlying cells, resulting in hot-spots and significant yield losses that are more pronounced with single-MPPT configurations.

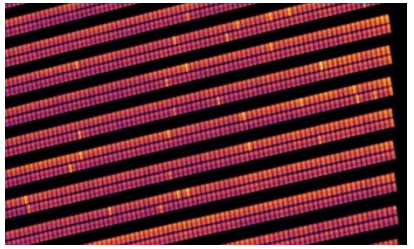


Soliling doesn't just cause shading but also hot spots

Defects or degradation over time of the PV modules…inducing additional electrical mismatch losses

Any defect that produce electrical alteration of the PV curve, is adding more losses when paralleling multiple strings. This includes, for example:

- Damaged or broken up cells
- Faulty bypass diodes
- PID effect



IR image of a ground-mount PV array with numerous modules having bypass diodes failed in short-circuit. Heliolytics

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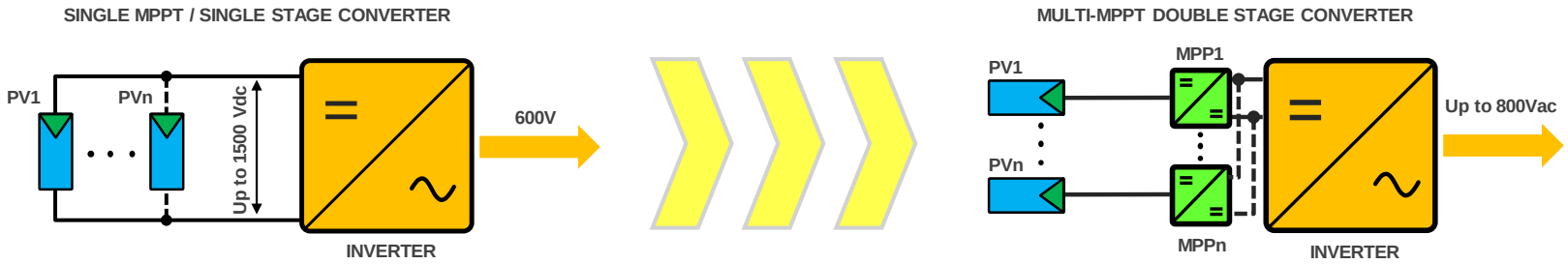
Multi-MPPT: other advantages

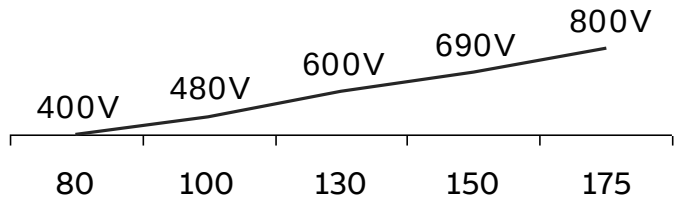
Enabling cost savings with decentralized «combiner-free» PV system design



800VAC to reduce **Balance of System cost (i.e. AC side cabling)** and **enabling higher power units with same current (less units per power block)**

More power from the same enclosure

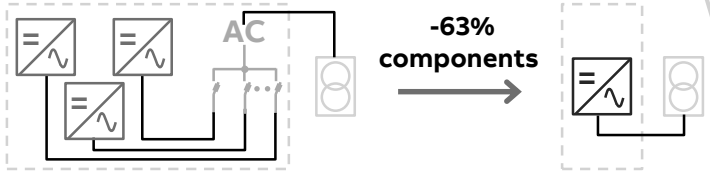
AC power vs AC voltage



600Vac → **+31%** → 800Vac

(140kVA/130kVA) (185kVA/175kVA)

Less units and resources are needed



-63% components

AC-BOS cost savings (LV distribution)

400VAC → **75% less Cu/Al** → 800VAC

Bigger PV clusters may be designed

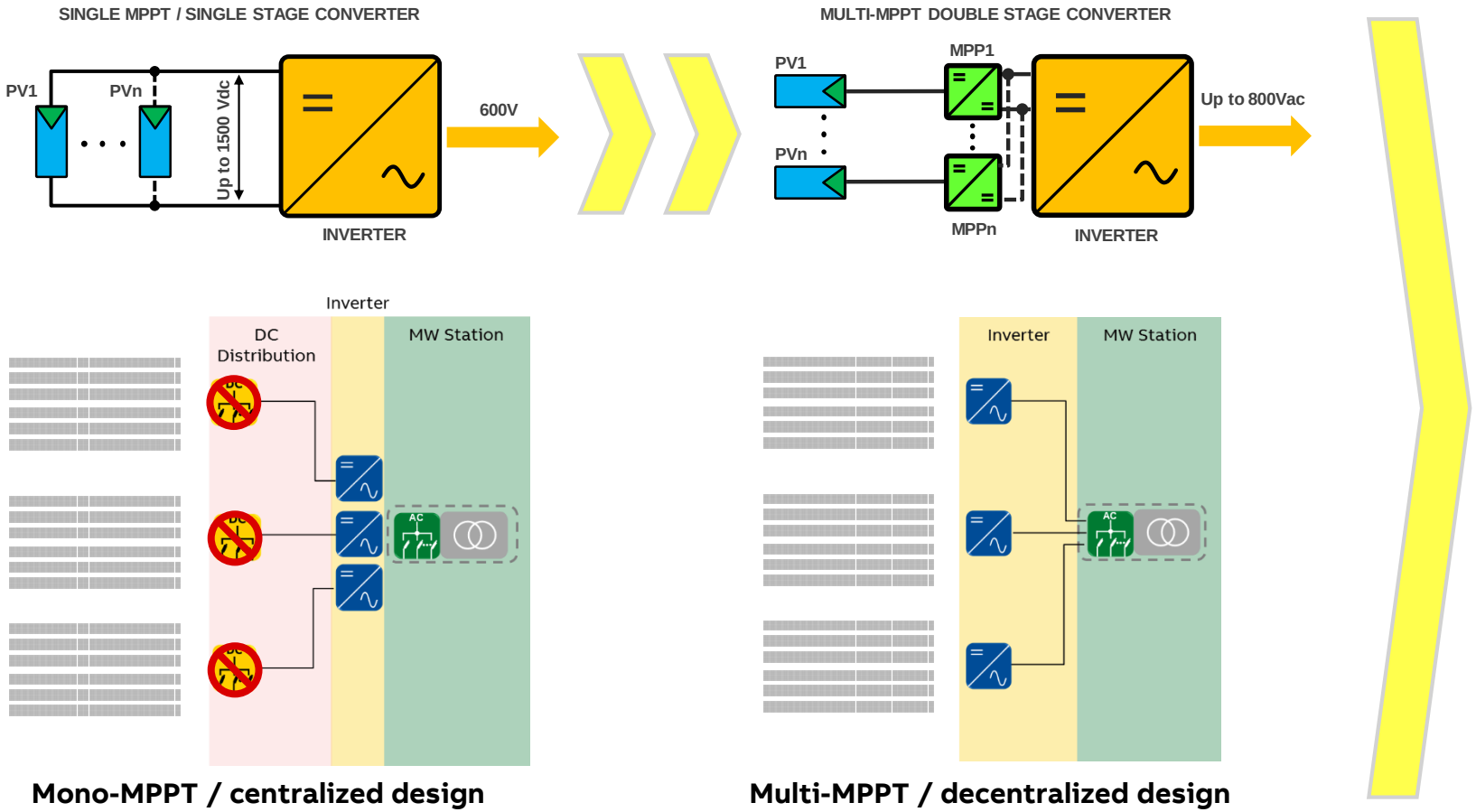
3,7MVA

+35% Cluster size

5MVA

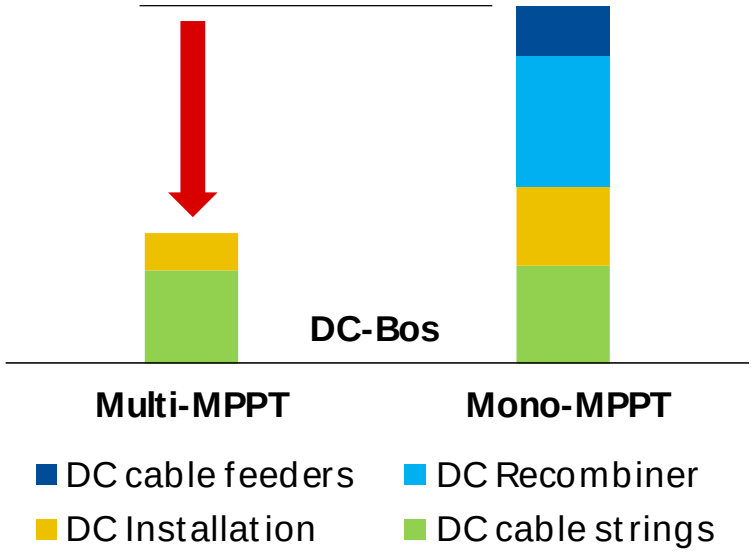
Multi-MPPT: other advantages

Enabling cost savings with decentralized «combiner-free» PV system design



100MWac system / 23 clusters x 4.4MW
DC/AC Ratio = 1.15

-1,4€c/ Wac
cost saving > 63%



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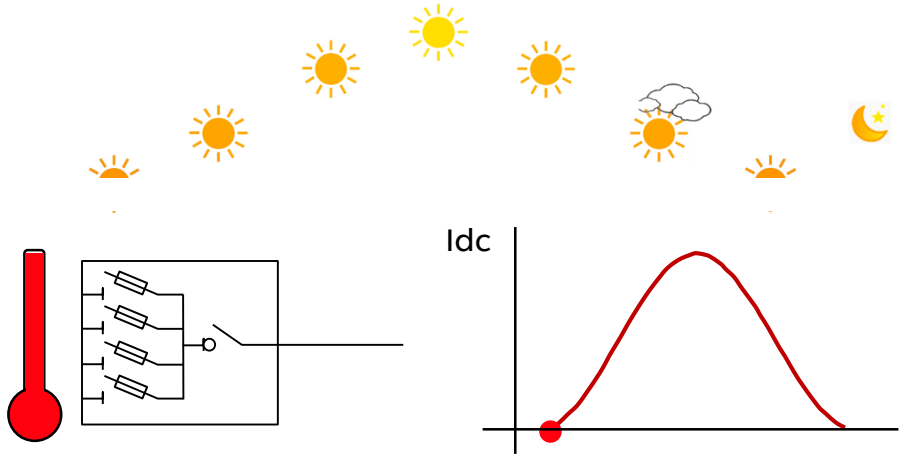
Lowering LCOE through Opex and Energy Yield optimization

Fuseless design/ integrated diagnosis

Fuses are prone to nuisance tripping over the years. Main reasons are:

- Normal aging of the components
- Acceleration factors typical of PV duty: temperature & current daily cycling
- PV module current ratings are rapidly increasing
- Bifacial technology will likely exacerbate these issues

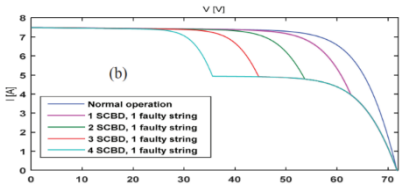


This increase:

- **O&M cost** → Site inspections are needed to check and replace fuses
- **Energy yield losses**

Multi MPPT inherently enables low cost online monitoring and fault detection of the PV array

- String-level data monitoring can be embedded in the inverter for diagnostic purposes
- String-level Arc fault detection can embedded in the inverter to enhance system safety
- Anti PID Board



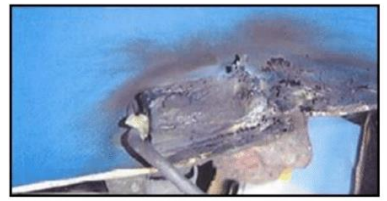
I-V curve with shorted bypass diodes

This reduce:

- **O&M cost** → Remote diagnosis is possible avoiding Site inspections to promptly identify the fault
- **Installation Cost** → feature already available on the inverter. No need to install external devices
- **Energy yield losses**

This increase:

- **System availability** → fast fault detection and fast on site solution
- **Safety**



Junction box after an Arc Fault

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