

**Next 2 Sun**

3 MWp vertical E-W oriented  
system in Germany

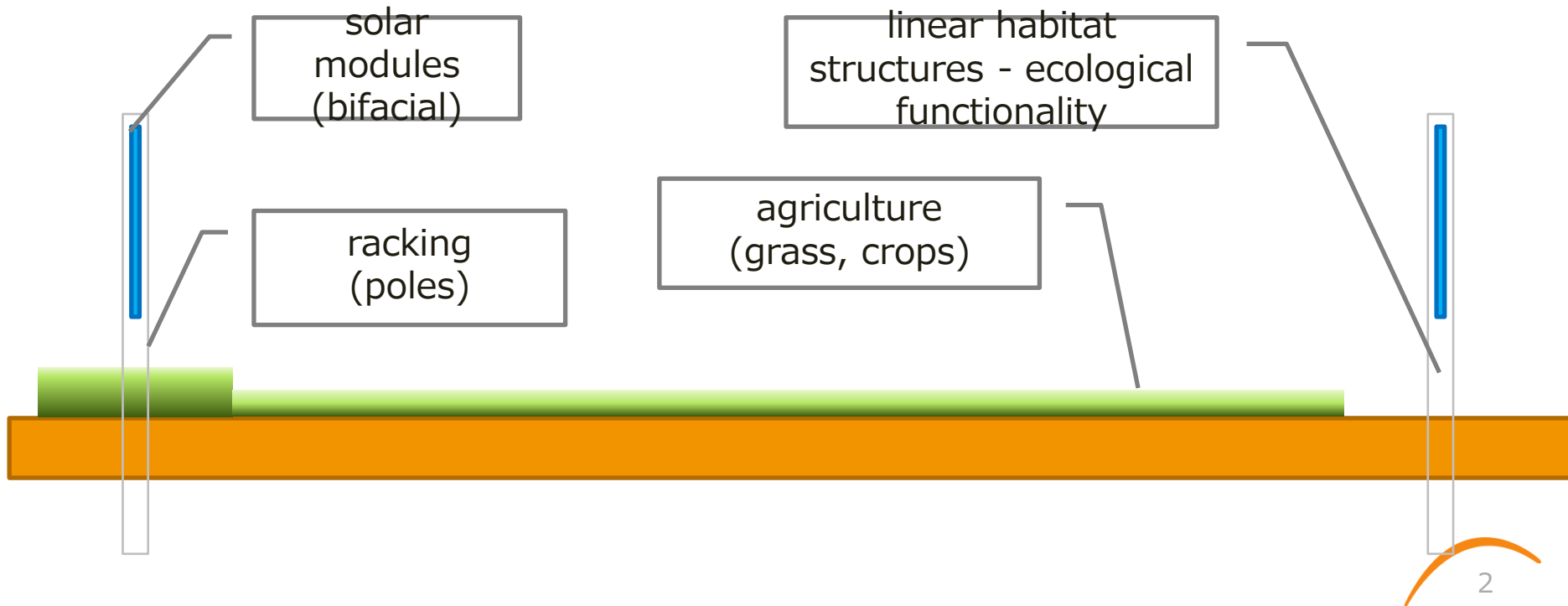
Dipl. Ing. Heiko Hildebrandt



# Advantages of vertical PV

## Three main advantages:

- #1 - gaining yield: 10% typical, 15% possible, both on grassland
- #2 - gaining market value: +7% (nowadays, in Germany)
- #3 - lowering footprint: „no“ ground coverage, agricultural usage of plant area





# #1 yield gain

- The yield of a vertical system depends strongly on bifaciality
- compared to a common (monofacial) system:
  - with BF < 80%: same or lower yield
  - with BF 85-90%: ~10% more yield
  - with BF 95-100%: ~15% more yield
- this is valid for typical conditions in Germany (albedo ~20%)
  - lower gain for lower latitudes (unless with higher albedo!)
  - larger gain for higher latitudes
- in our configuration (10m row spacing / 2m active height), mutual row shading still causes 5-10% loss



## #2 produce & forget ?

- the cost of electricity is one side of the medal – its value is the other one
- nearby any PV installation worldwide has its production peak at (sun-) noontime
- in a system with low share of PV, this is very useful, as it meets demand !
- but in a system with high share of PV, it becomes a disadvantage.

→ what does high share mean ?

**Germany today: approx. 7% PV (annual average)**

→ is this a high share ?



## #2 produce & forget ?

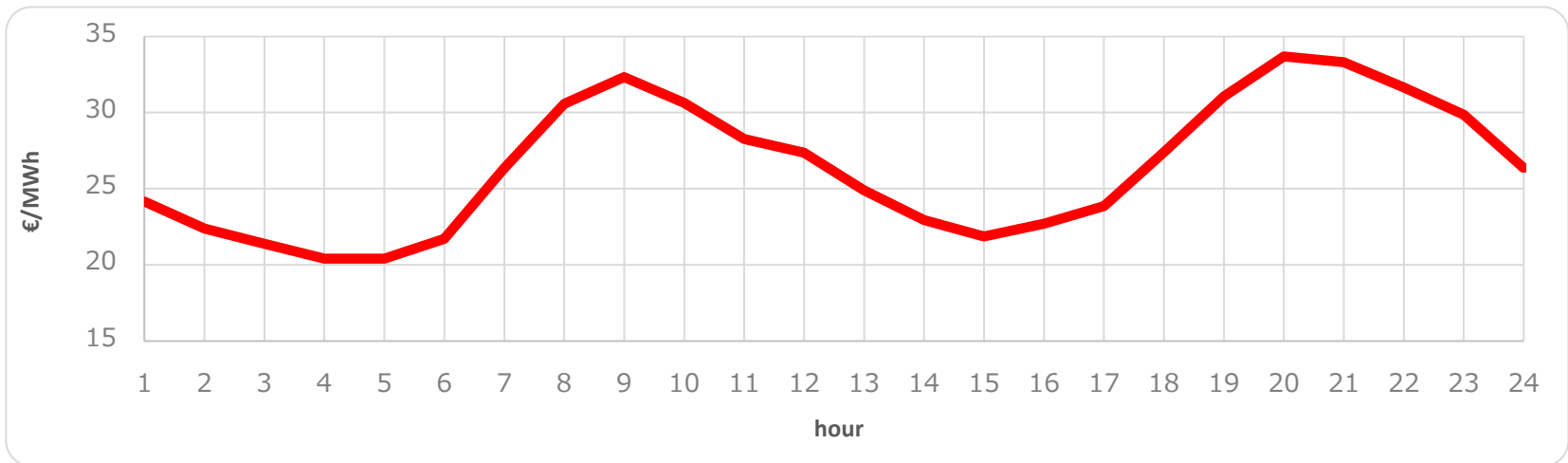
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**→ At least it's enough to drive down the wholesale price at noon as low as it has only been at midnight for many decades !**



# #2 LCOE vs. „LVOE“

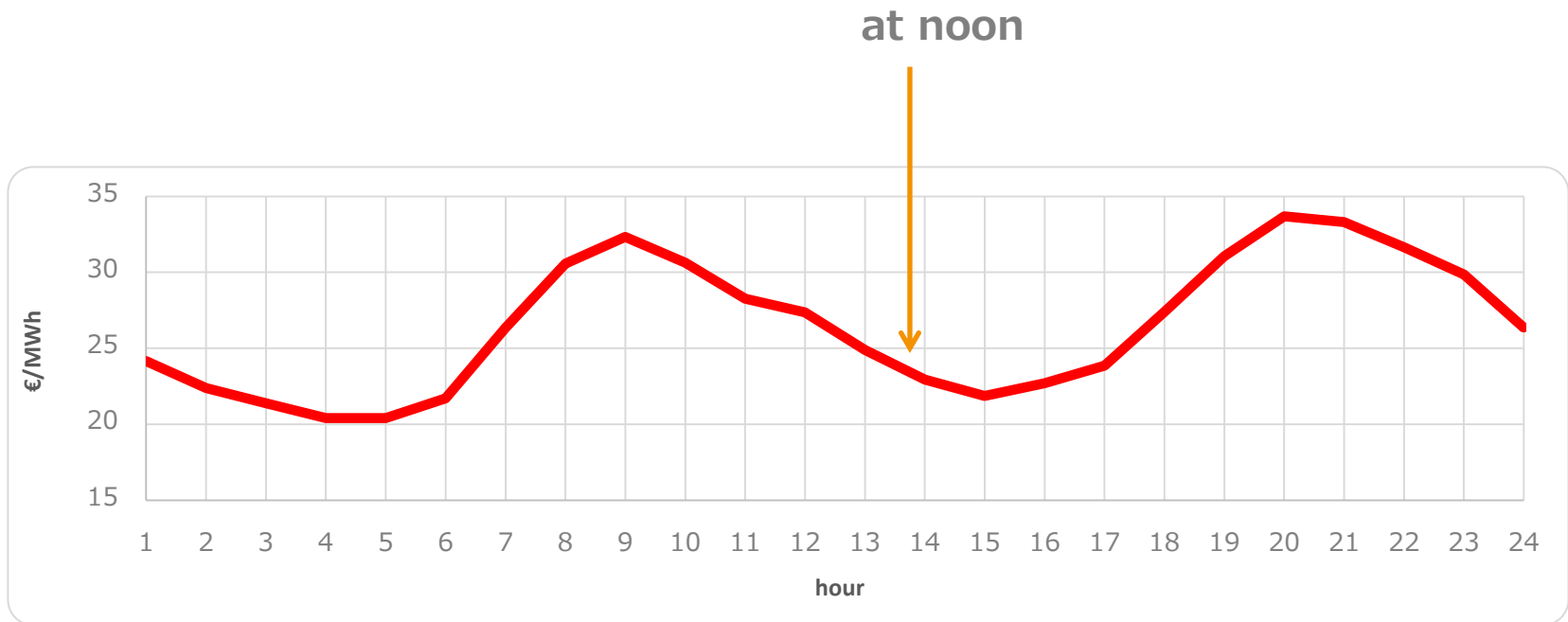
- German electricity wholesale price in Q2+Q3 2016 (average):





## #2 LCOE vs. „LVOE“

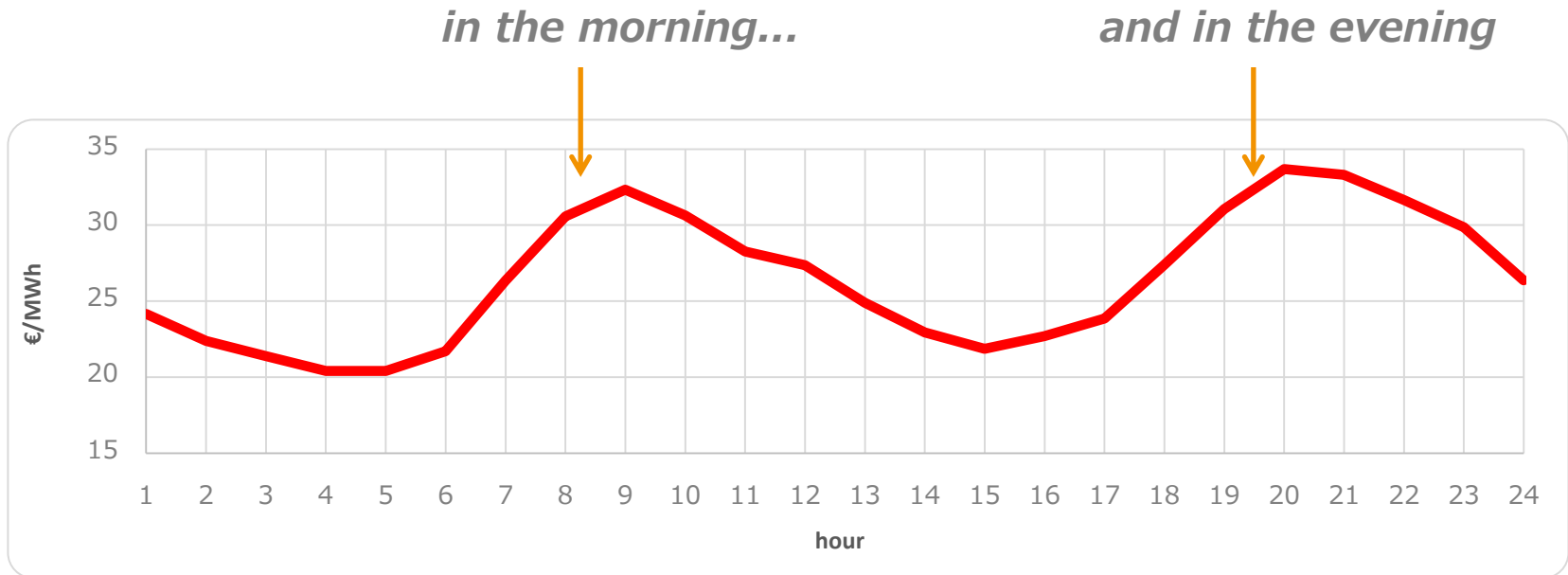
- German electricity wholesale price in Q2+Q3 2016 (average):
- production of a conventional PV plant comes mainly...





## #2 LCOE vs. „LVOE“

- German electricity wholesale price in Q2+Q3 2016 (average):
- production of a vertical bifacial PV plant comes mainly...







# #3 Agriculture

- large distances between rows are needed due to mutual shadowing
- resulting in 10-15m spacing, allowing the usage of common agricultural machines on grassland
- Even several crops could be cultivated – but is it meaningful ?



module row,  
height 3m approx.

grass swathe after mowing  
with common  
agricultural mower (10m)  
→ to be harvested  
commonly

remaining green  
area (~1m)



# Test site

- installed in May 2015
- total capacity **28 kW**
- 96 modules in 3 rows, 12 strings
- customized 66-cell module with n-type bifacial cells, BF = 87%
- three years of gathering data & experience
  
- **annual energy gain +10% (real, not „up to“)**
- **average price gain (based on EEX prices) +7%**



# Test site



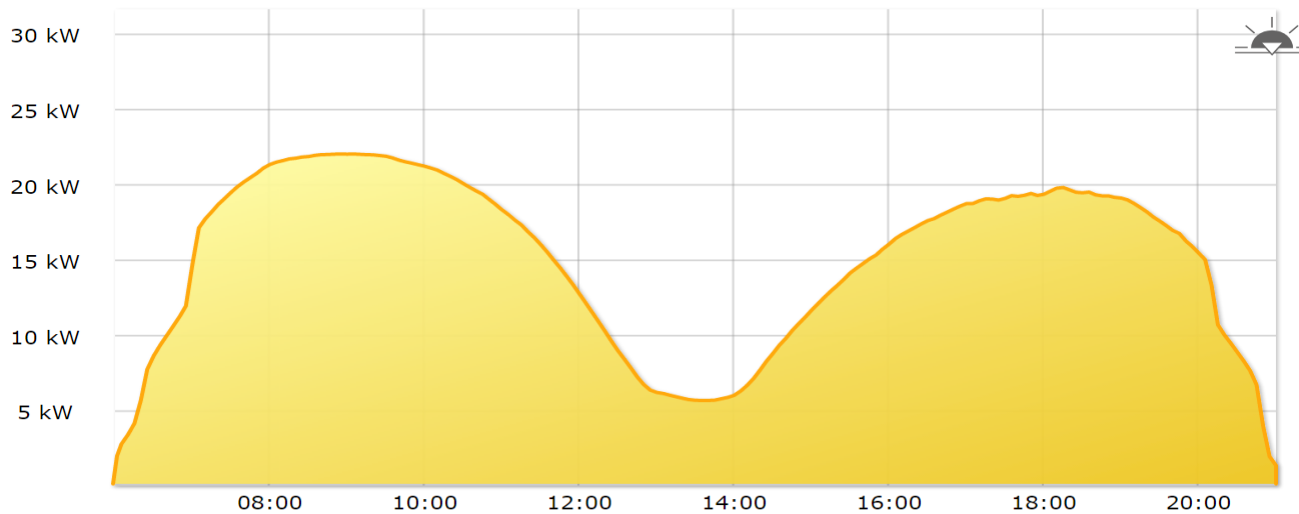
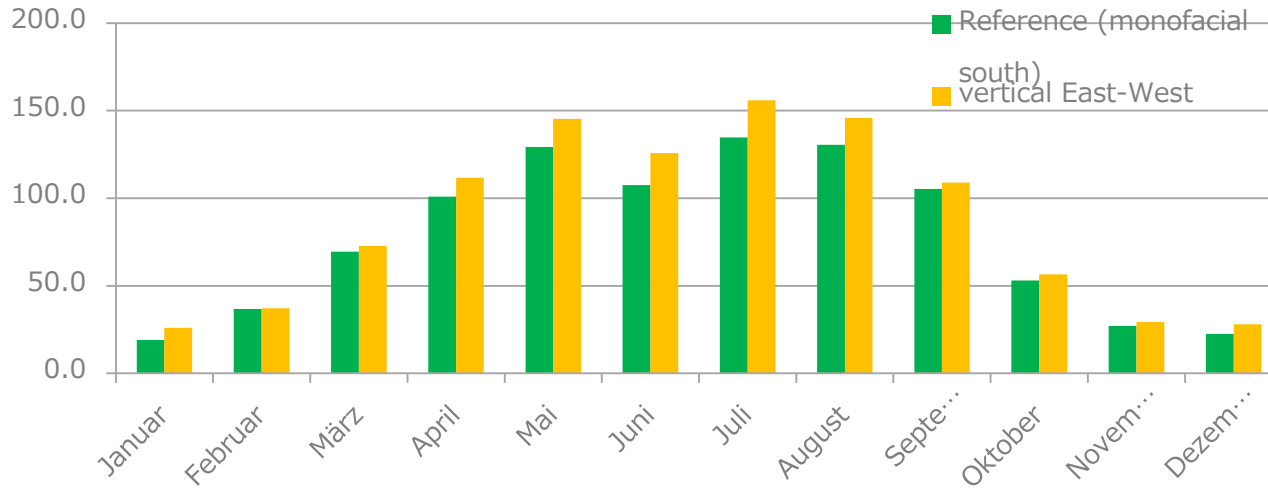


# Test site





# Specific yield





# Next step: Demonstration plant

- Site: Dirmingen, Saarland (south-west Germany)
- Size: 10 hectares (module area)
- Power: **3 MW (full size) / 2 MW (first phase)**
- 300 kW per ha, compared to 800 kW per ha for conventional plants
- Yield estimate: **1.080 kWh/kW**
- compared to 980 kWh/kW on the same site for a conventional plant
- global irradiation: 1.090 kWh/kW
- commissioning in **Q1-2018**

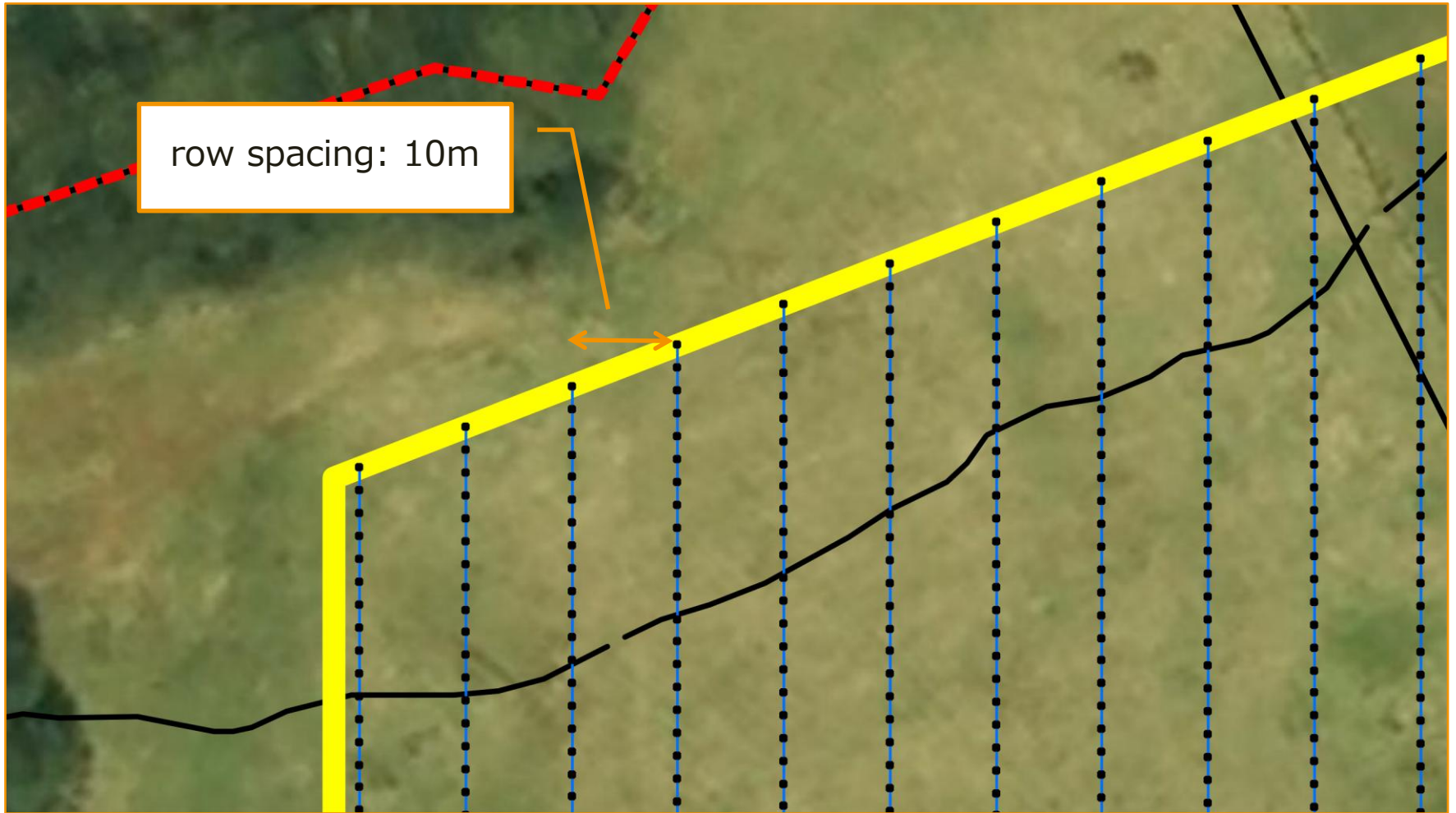


# Site map





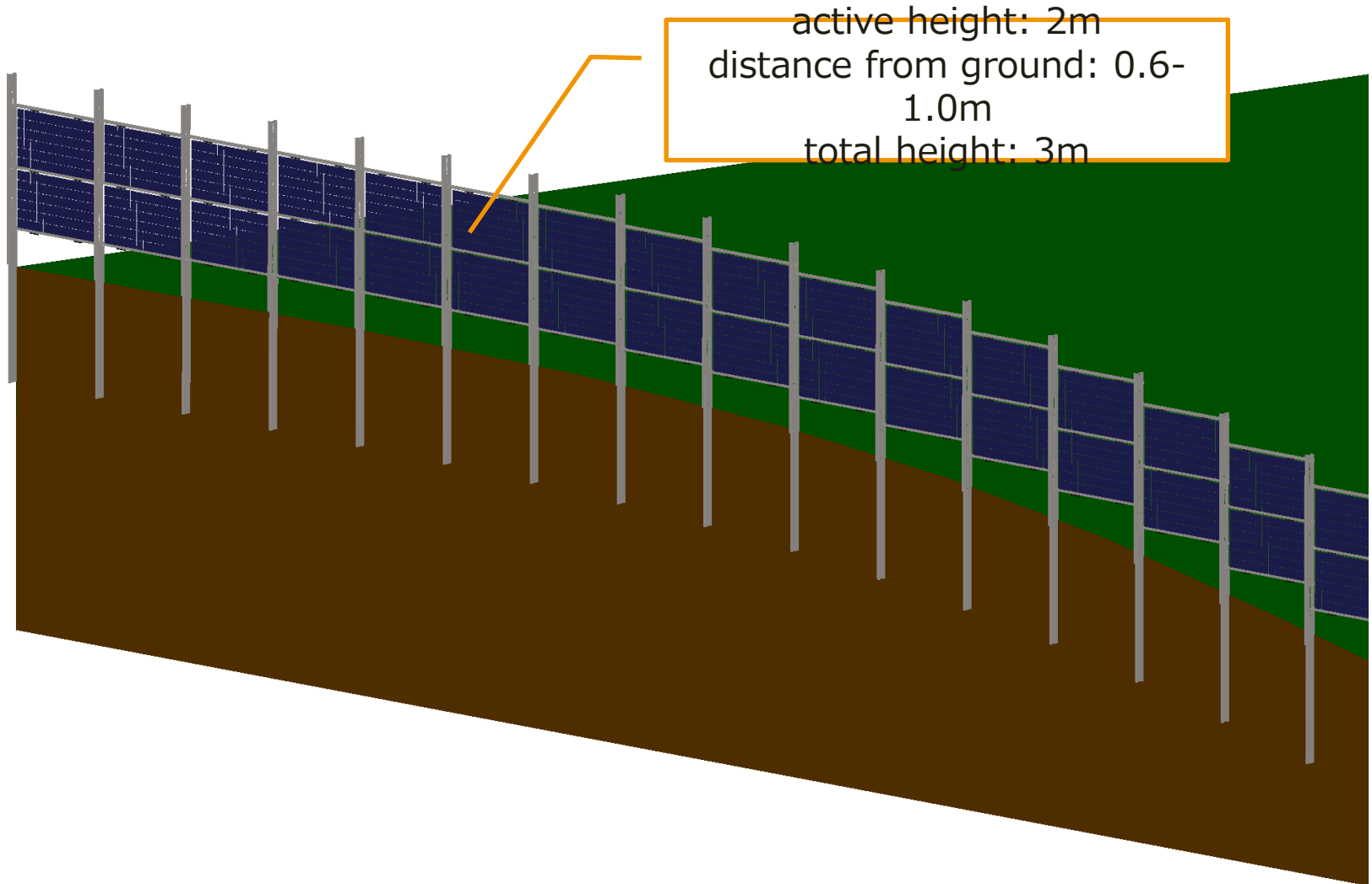
# Installation scheme







# Installation scheme





# Components

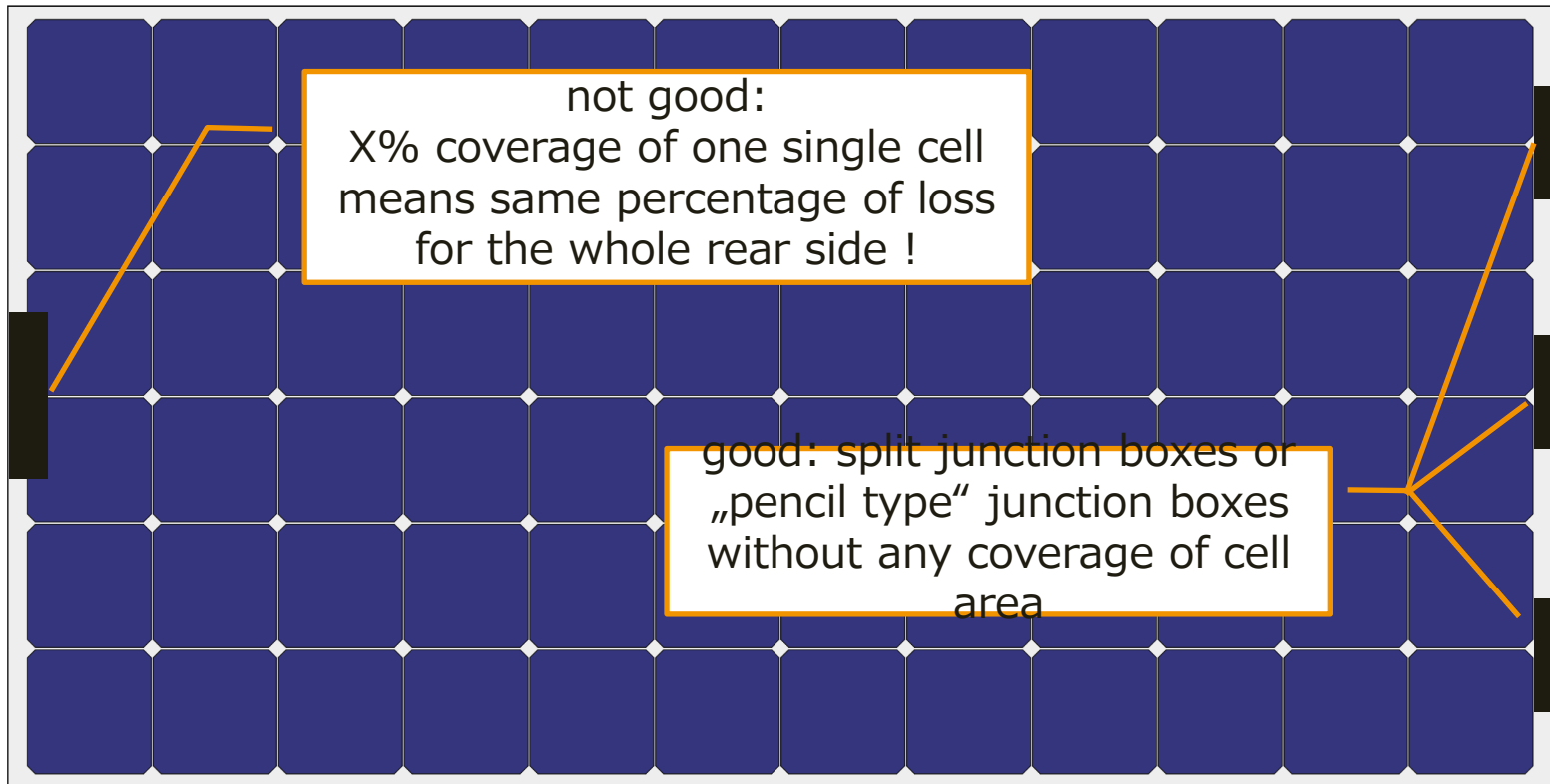
- Modules

finding a suitable module is still challenging, so...

**Christmas is coming close – here's our wishlist for module manufacturers supplying Santa Claus:**

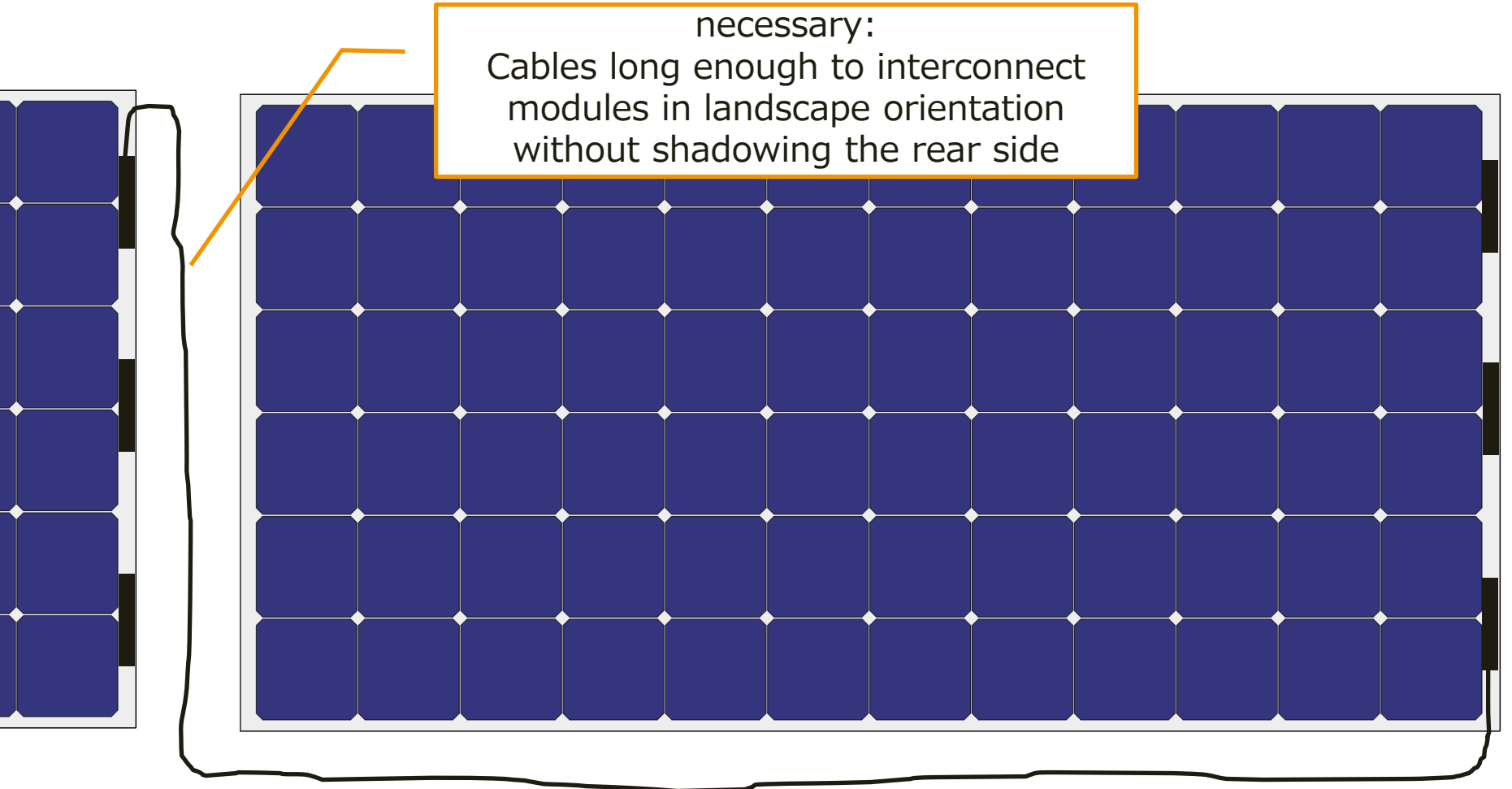


# module requirements: junction boxes





# module requirements: cables





# module requirements: cell/electrical design

preferred:  
standard 3-substring design  
(mutual row shadowing)

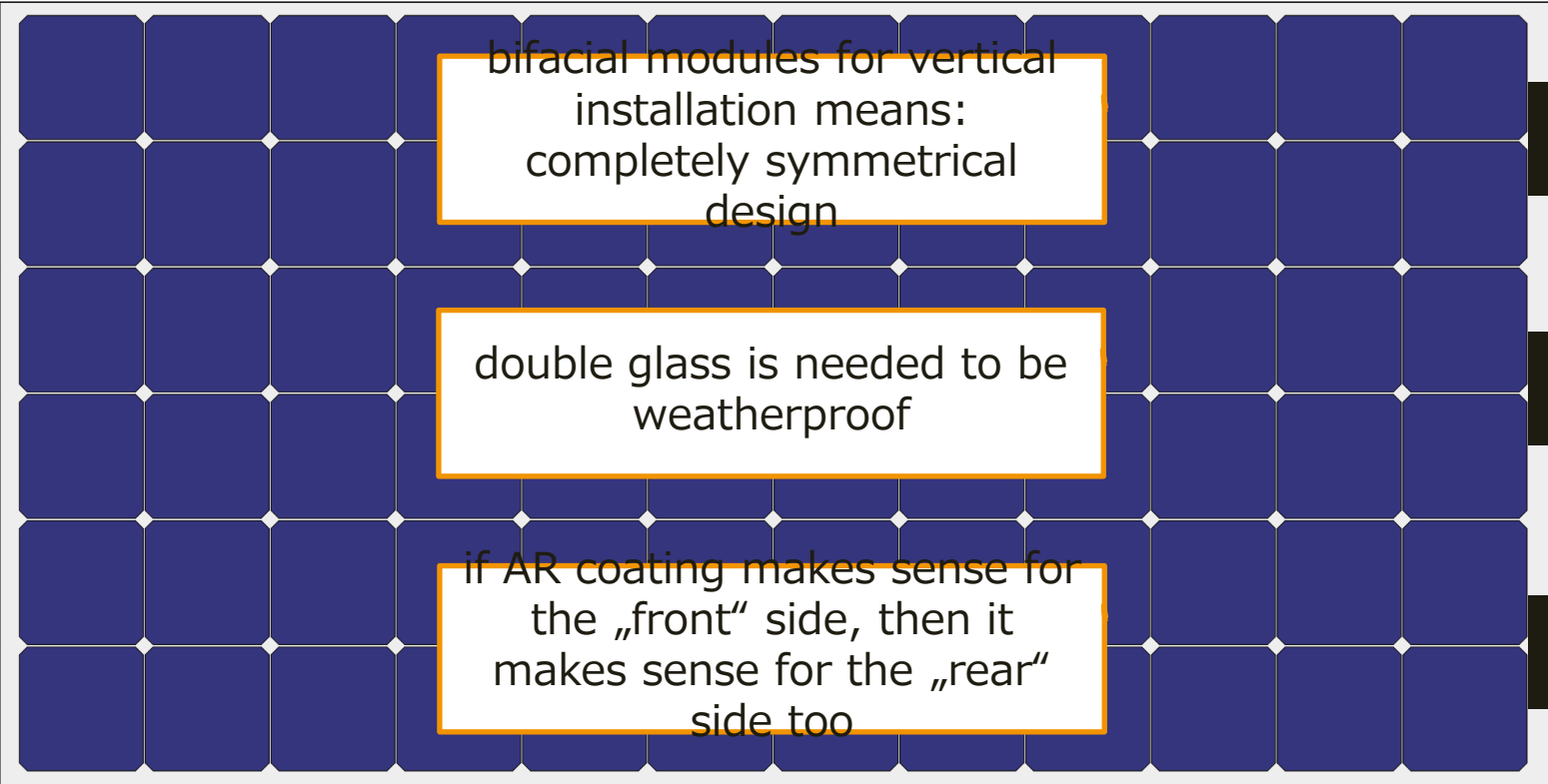
preferred:  
large, full-size cells  
(shadowing from the racking)

less preferred:  
half-cut cells  
(lower shadowing tolerance)

most important:  
high bifaciality !



# module requirements: module design



bifacial modules for vertical  
installation means:  
completely symmetrical  
design

double glass is needed to be  
weatherproof

if AR coating makes sense for  
the „front“ side, then it  
makes sense for the „rear“  
side too



# Components

- **Inverters**

State-of-the-art inverters can be used, with some restrictions:

- mpp-tracking with „global peak“ algorithm (surprisingly for us, this is not a given)
- at least 2 mpp-trackers
- decentral

Sizing is similar to monofacial south oriented plants (here: ~80% of nominal DC power)



# Components

- **Racking**

No state-of-the-art products available → proprietary development

- high wind load on a cantilever system  
→ challenging mechanics
- low shadowing
- quick fastening and mounting solutions
- patent pending

- **Cabling**

less challenging, but some issues to be considered:

- longer distances
- avoiding shading on the rear side
- durable fixation over spacings





# Conclusion

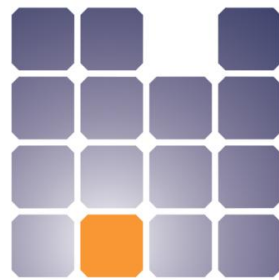
- vertical E-W PV plants are nothing crazy, but a real choice
- in grid systems with high share of PV, the East-West component becomes essential  
→ vertical bifacial can deliver this cheaply
- gain in yield & proceeds is proven
- improvements in module & plant design to be done

**→ only small steps are necessary to make vertical bifacial a real business case in many markets !**

# Thank you for your attention !

## Questions ... ?

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