Trends in System Design

October 2021, Sercan Keskinel

Highlights of Enerparc

100 % management-owned

- Strategy of a lean and dynamic organization in the PV industry

2,100 MWp own power plants as IPP

- Leading independent energy producer in photovoltaics in Europe

2,800 MWp under O&M services

- Leading O&M-service provider in Europe with own teams

3,470 MWp connected

- EPC-execution capacity of more than 50 MW per month

Biggest PPA area for Enerparc

- Completion of 90 MWp on an area of 92 ha in Gaarz, Germany

PPA with Deutsche Bahn

- Long-term Power Purchase Agreement of 30 years

Technical Design in large scale PV – „historical“ development

PV as an alternative and expensive energy

- For a long time, interpretation of PV for non-commercial use only, such as off-grid applications etc

Less projects & more resource

- Less variety of PV components compared to today, similar system designs with minor differences

Quality assurance and standards

- Higher importance of some phenomenons such as PID, GCR with the deployment of PV

Technical design in large scale PV – pros & cons

Thinfilm vs. crystalline

- Crystalline technology with a market share of 95%
- Higher efficiency of crystalline modules in general

Fixed vs. tracker

- No moving parts of fixed systems as advantage against tracker systems
- 10-20% more yield for tracker depending on the latitude

Central vs. string

- Easier maintenance and exchange of smaller mini-central inverters up to 250 kW
- Lower CAPEX cost of larger central inverters

Technical design in large scale PV – „new“ constraints

Land prices

- Higher overload ratio and GCR requests for higher land prices
- Using East-West structure and tracker solutions

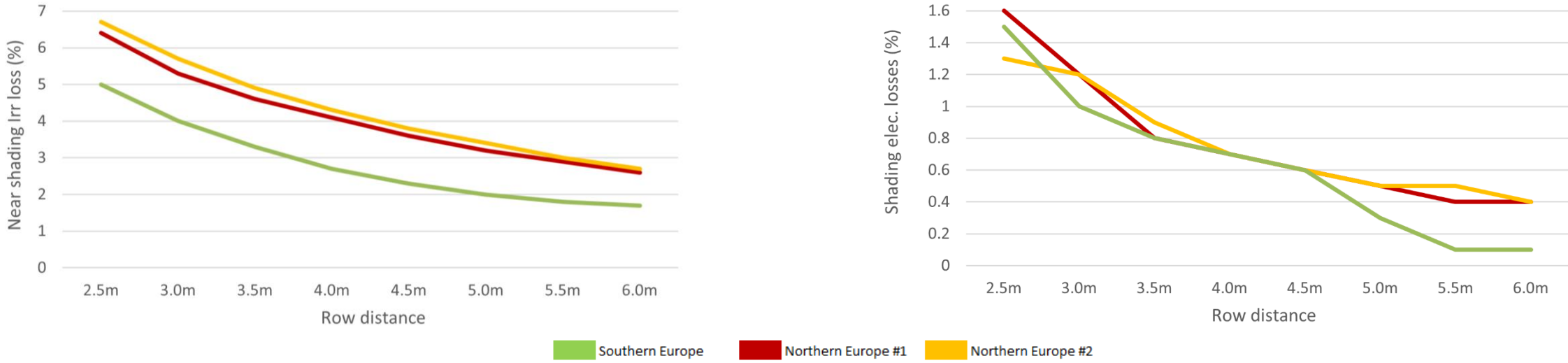
Local regulations

- Country specific regulations and licensing processes affect system designs
- Height limitation for structures and/or buildings

Biodiversity

- Lower biodiversity and soil quality between and underneath of modules for higher GCR
- Advantage of using bifacial modules

Region specific designs



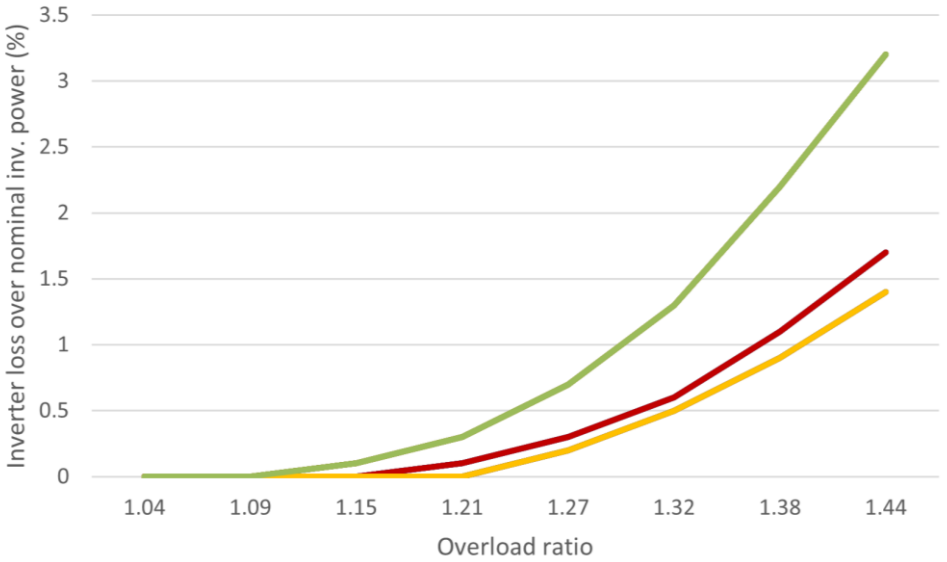
Optimum LCOE

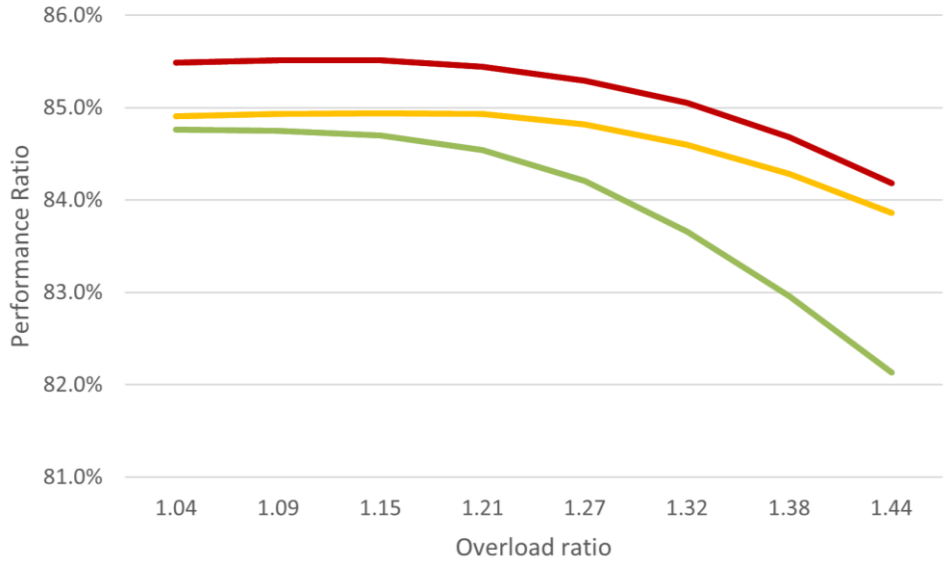
- Finding the balance between the gains and the losses
- More shading irradiance losses in Northern than Southern Europe for the same GCR level

Optimum GCR

- More installed capacity and total yield with higher GCR
- Lower shadowing losses but longer cables and larger project area with lower GCR

Region specific designs





Southern Europe Northern Europe #1 Northern Europe #2

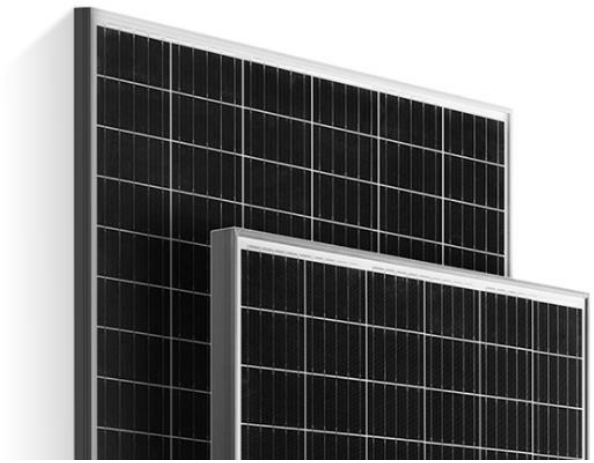
Overload Ratio

- Finding the balance between higher yield and the increased CAPEX
- More inverter clipping losses in Southern than Northern Europe for the same overload ratio

Performance Ratio

- Lower PR with higher overload ratio coming from the inverter clipping losses
- Contractually binding PR guarantees for external parties and financing entities

Future trends



More efficient modules

- Less material, larger and thinner wafers
- Higher efficiency with shingle cells, lower ohmic losses because of half-cut cells, more and more multi-busbars

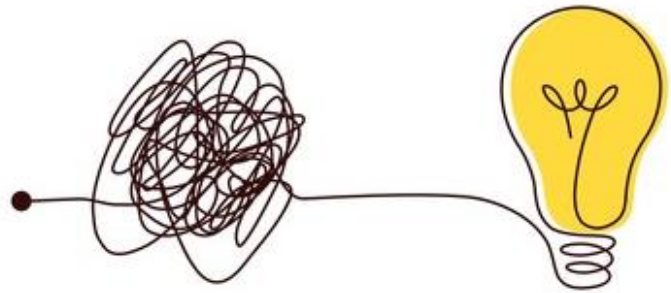
New technologies

- Higher yield with bifacial modules
- Mono-crystalline almost monopoly, new Perovskite tandem cells as a new high efficient promising technology

New applications

- Floating PV to become more worldwide
- Electricity and food production with Agri-PV
- BIPV, carport, solar trees

Summary



Complexity

- Several different parameters such as PPA structures, land prices, ecological requirements as a main driver

Financial engineering

- Finding the optimum balance between a healthy cash-flow, project cycle and technical standards and requirements

Long-term strategy

- Following up new trends in PV market and adapting in earlier stages to system designs, installation and O&M

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Enerparc AG

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