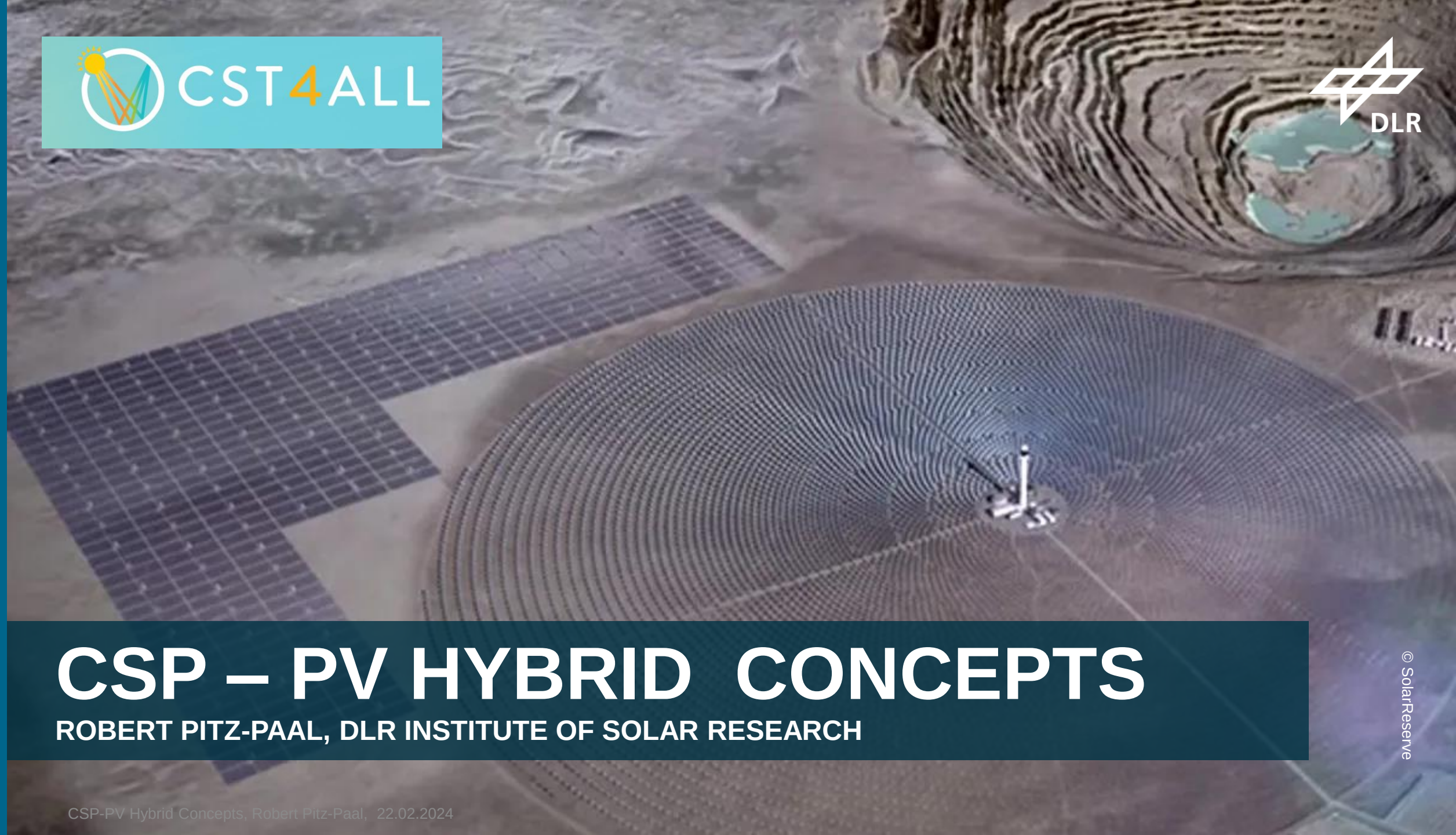


CSP – PV HYBRID CONCEPTS

ROBERT PITZ-PAAL, DLR INSTITUTE OF SOLAR RESEARCH

Why combining two technologies?

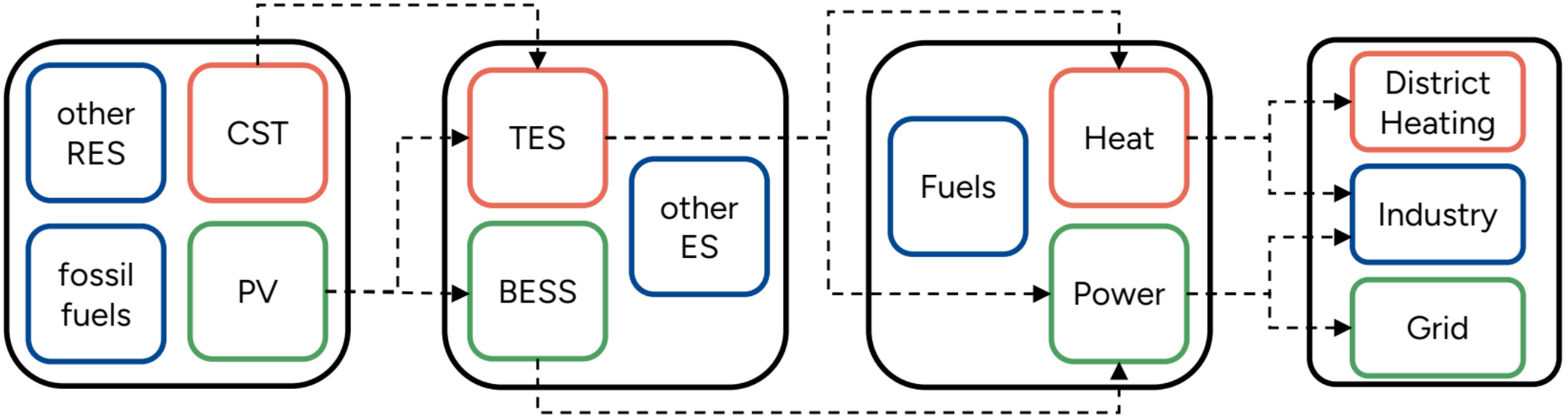
- **photovoltaic power** plants can provide **cheap** electricity from solar when the sun is shining
- **Storage solutions** are required to satisfy demand **after sunset**
- Battery storage systems are expensive, particularly for large power units with several hours of storage capacity
- **Concentrating solar power** plants offer **dispatchable** solar power generation with cheap and proven **thermal storage** units
- **CSP** spinning turbine provides **ancillary services to the grid**
- Combining both solar power generation technologies offers **low cost <u>and</u> dispatchability**

Source: Powerway Renewable Energy Co., Ltd

Source: Solar Millennium AG

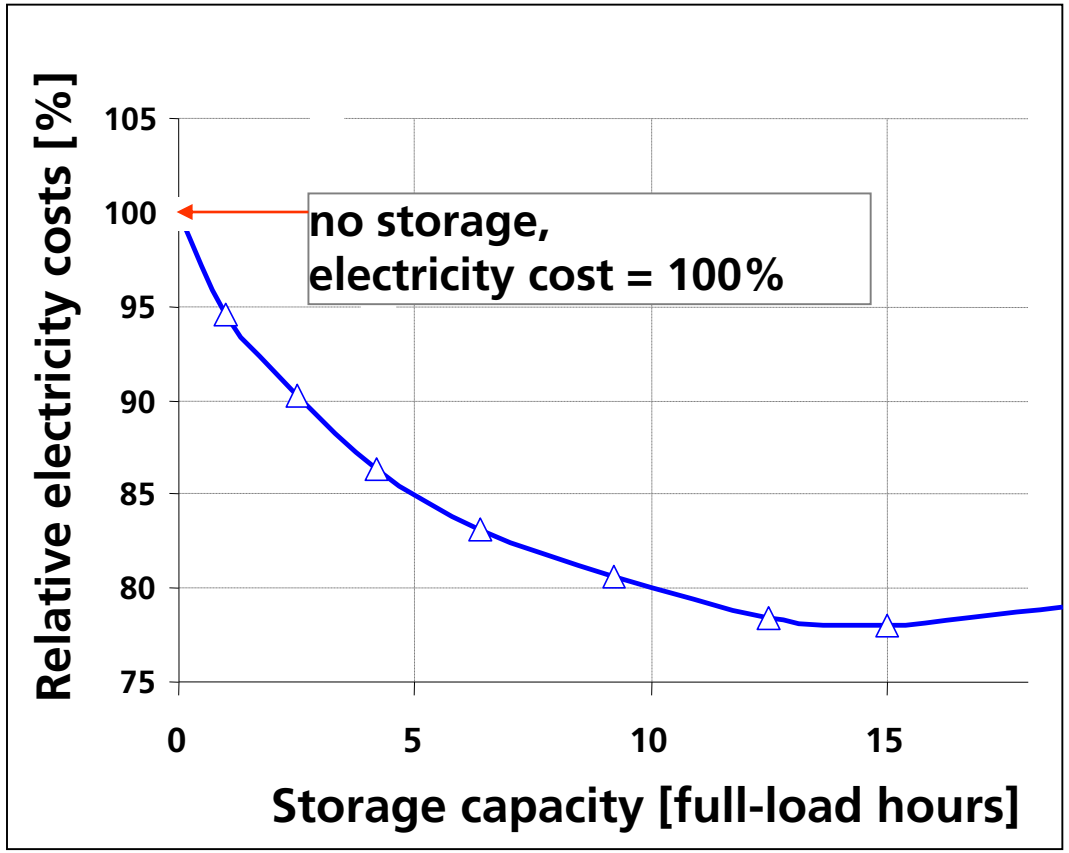
General Concept

Hybridization:
Optimizing tech integration towards more competitive systems



CSP w/ storage cheaper than CSP w/o storage

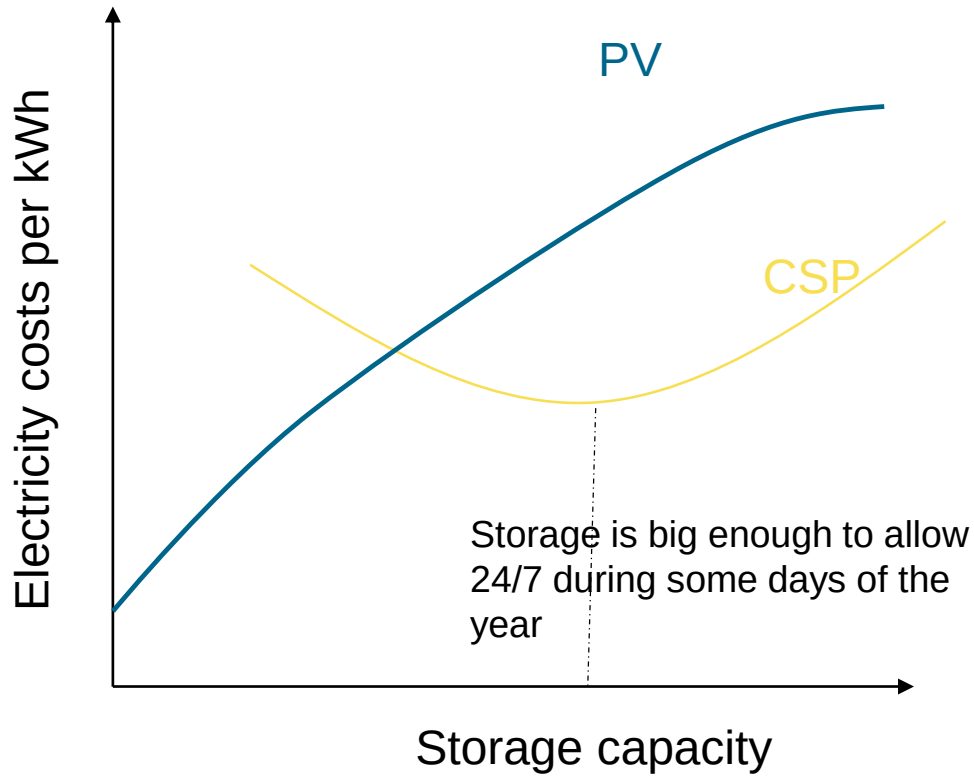
Thermal Storage = more operating hours = higher capacity factor = cost reduction



* assuming specific investment costs for the storage of 10 Euro/kWh

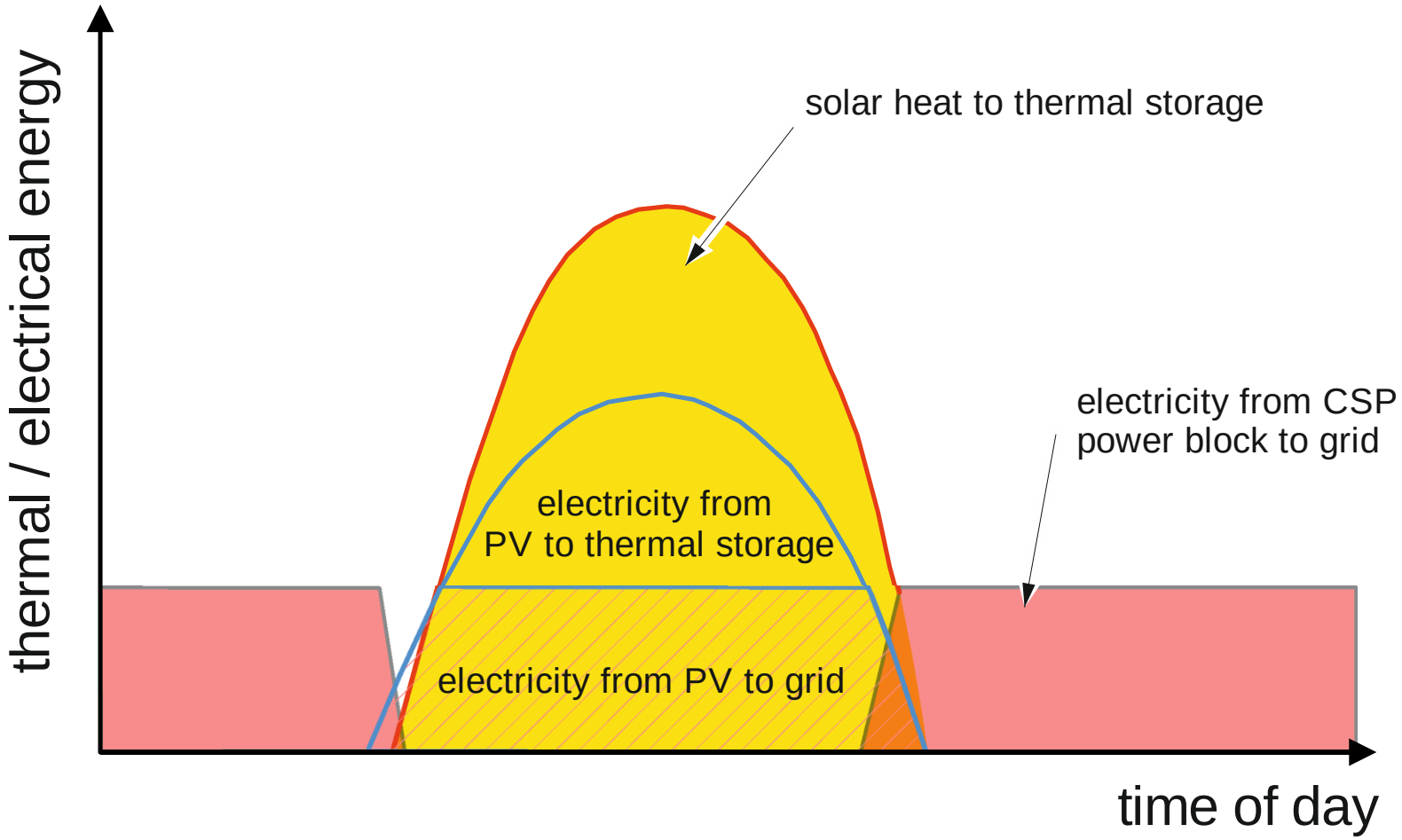
Design of hybrid plants

- For CSP plants the least cost design version often includes thermal storage
- For PV plants a system without storage has always the lowest electricity cost
- Hybrid plants are beneficial if one of the following conditions apply
  - A certain fraction of power demand during night time
  - A limit for the power fed to the grid at any time
  - Time-of-delivery tariffs to favor night time production over direct feed-in



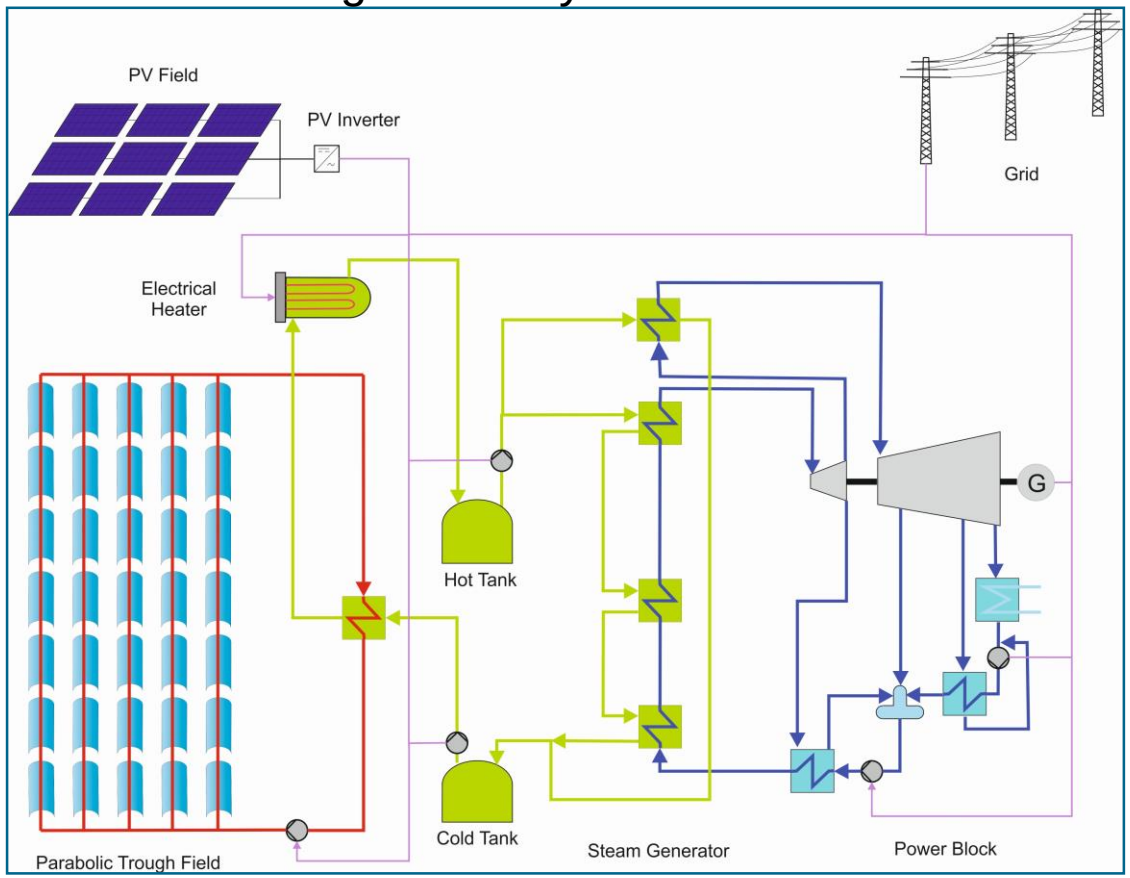
Typical daily production

- During sunshine hours the PV plants delivers electricity to the grid
- Additionally, it delivers electricity to the thermal storage (via electric resistance heaters)
- The CSP power block is not operating during daytime, only the storage is charged
- The hybrid plant will be capable to deliver „round the clock“ solar electricity, for lower cost than two standalone plants

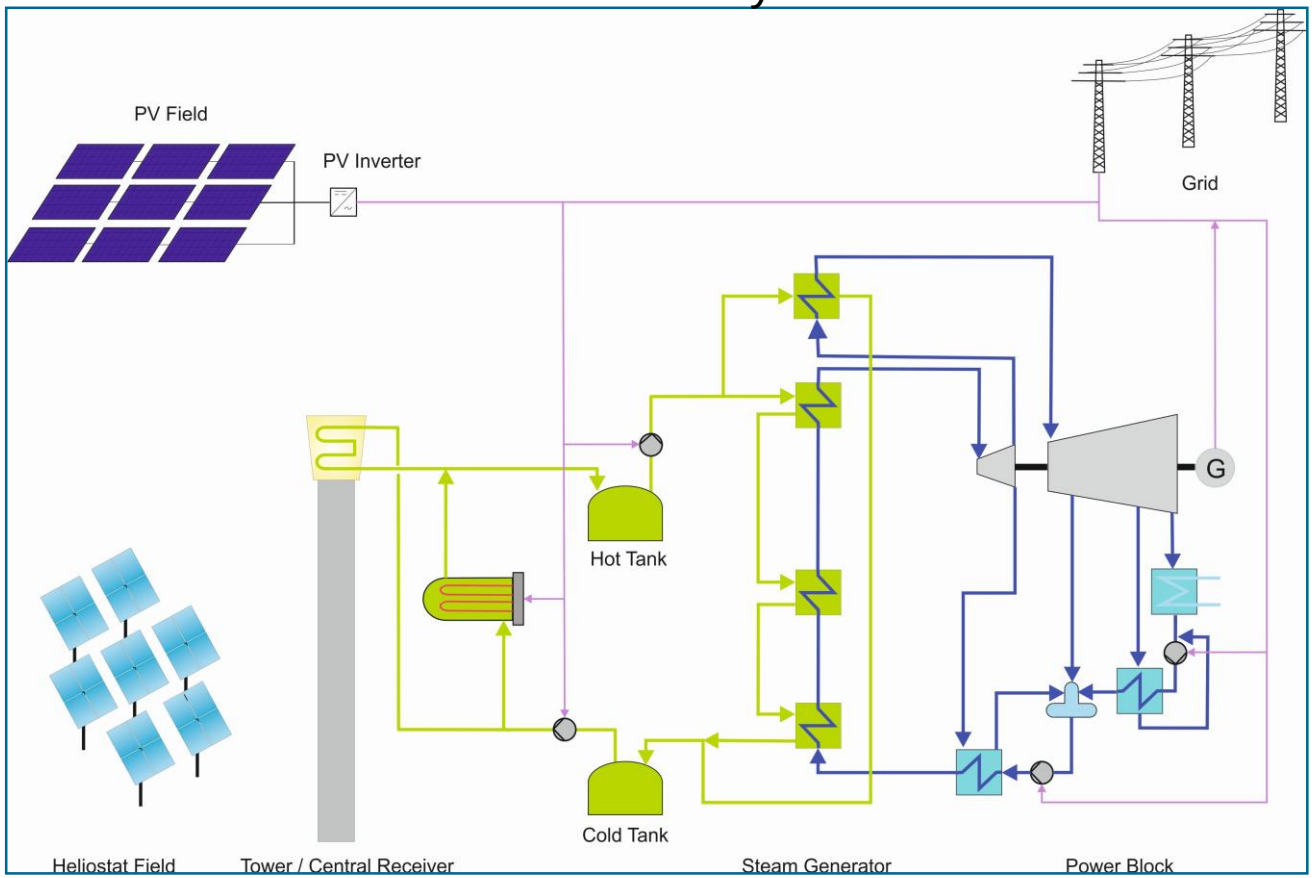


Typical design options

Trough – PV Hybrid

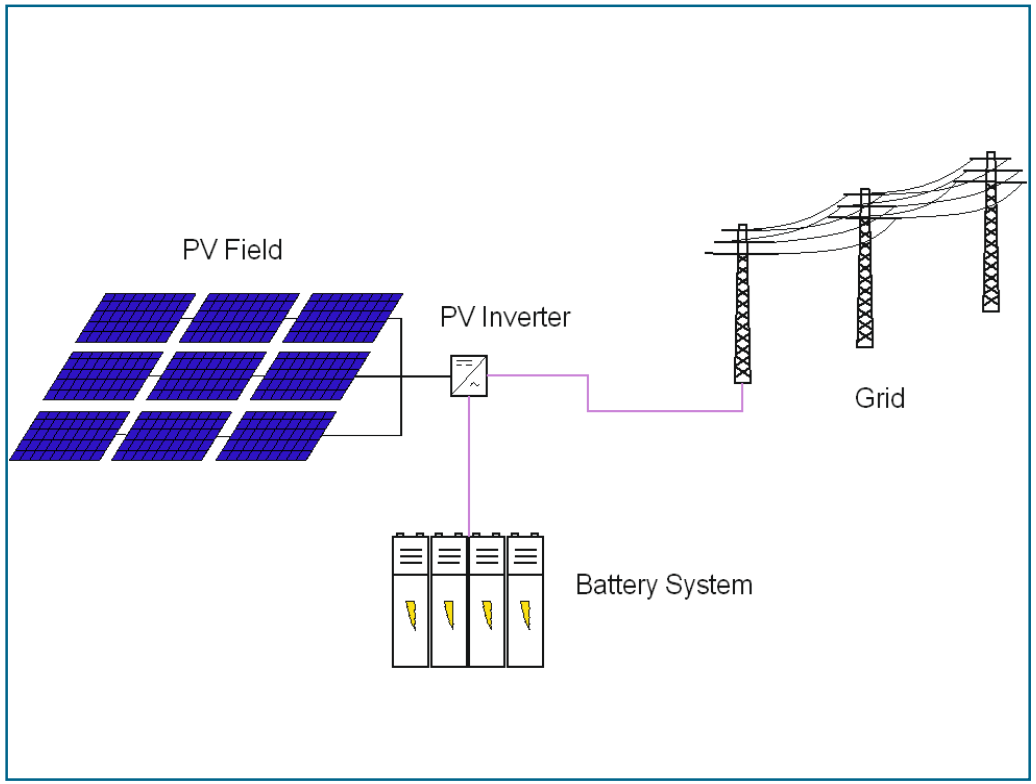


Tower – PV Hybrid

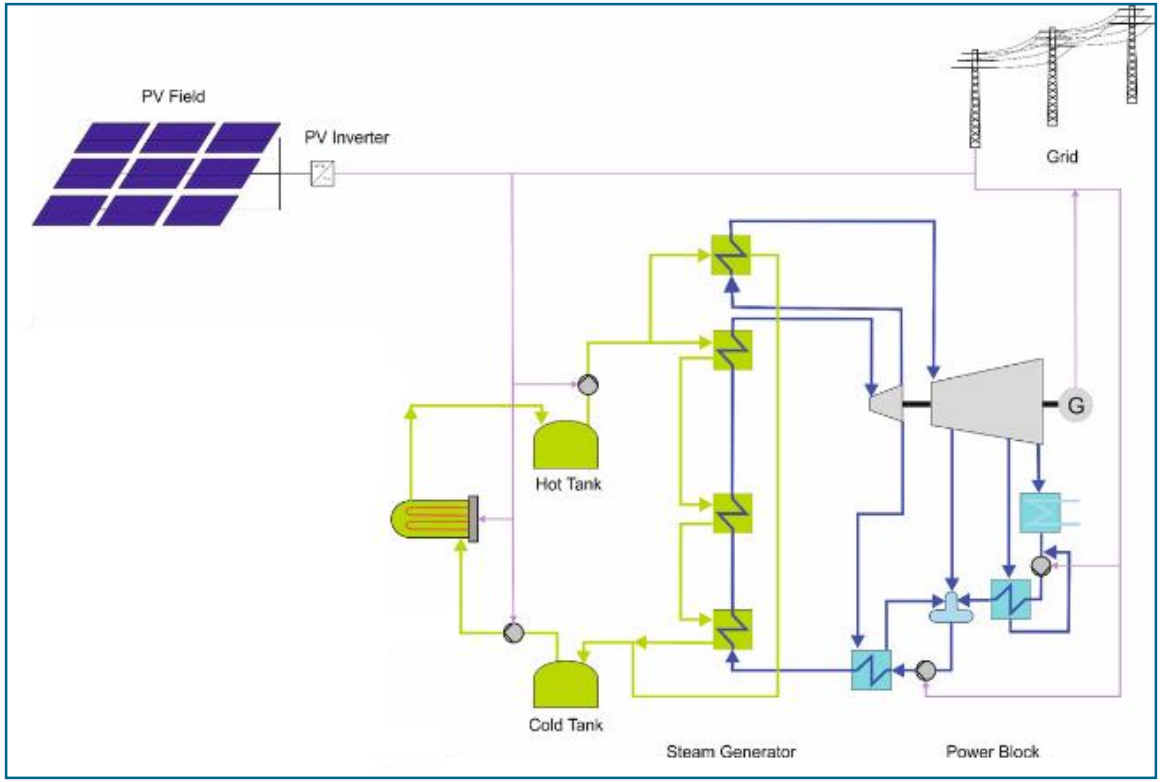


Typical design options

- PV + Electric Battery

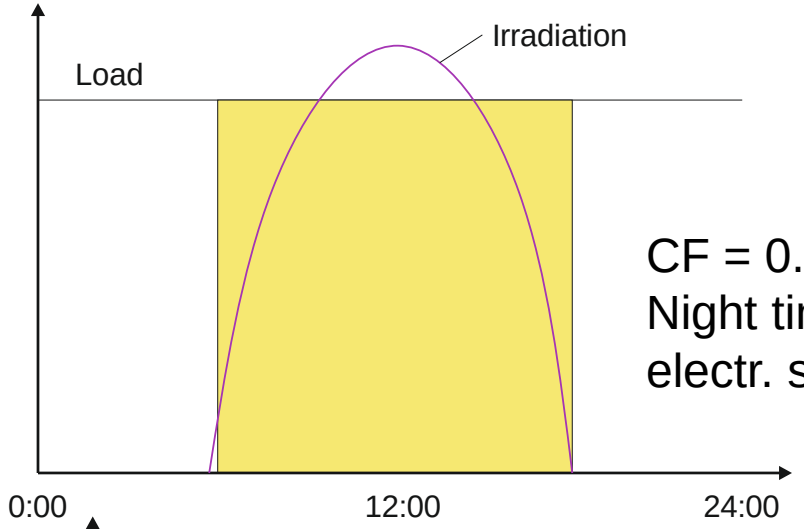


- PV + Carnot Battery

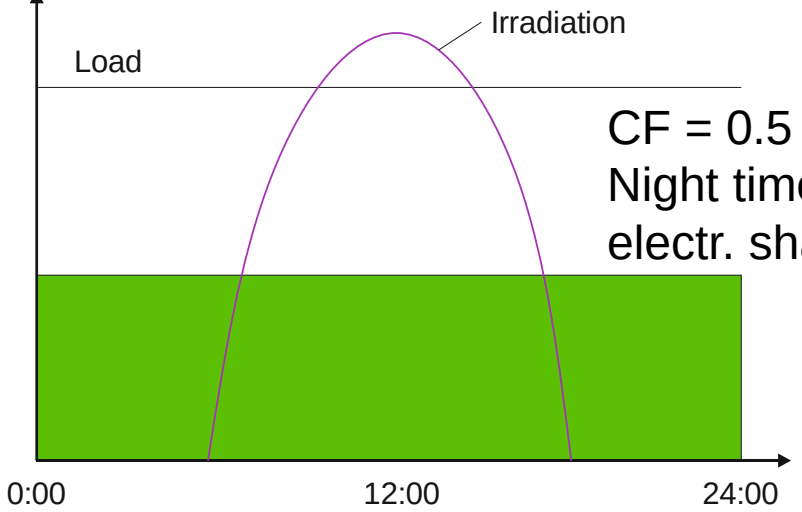


How to compare ?

- LCOE is a standard for comparing different systems
- LCOE for hybrid systems is a mixed calculation
- This single parameter alone is not sufficient
- The capacity factor (CF) is not ideal for comparing the systems
- **Night-time share of electricity production**

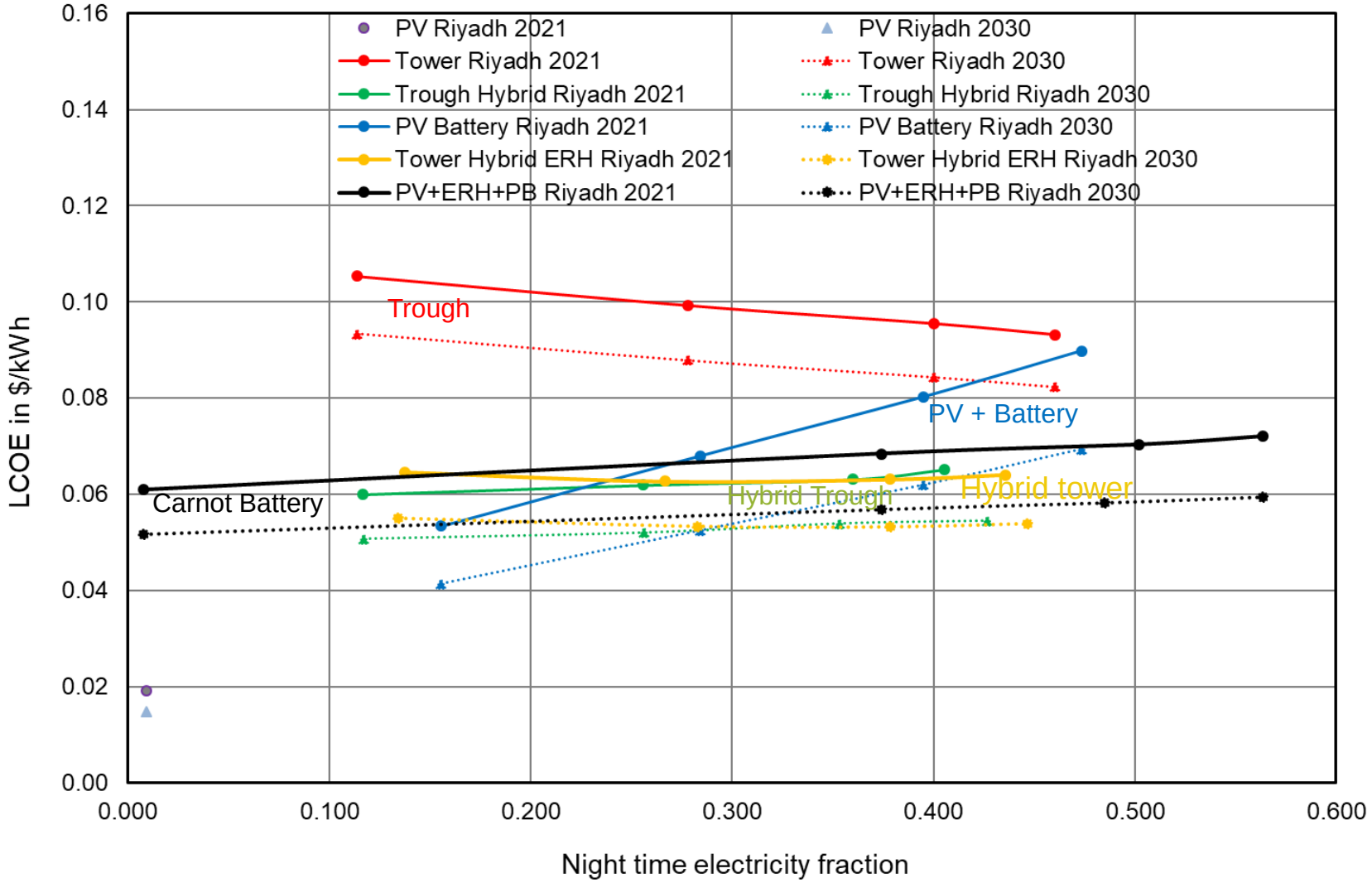


CF = 0.5
Night time
electr. share = 0.0



CF = 0.5
Night time
electr. share = 0.5

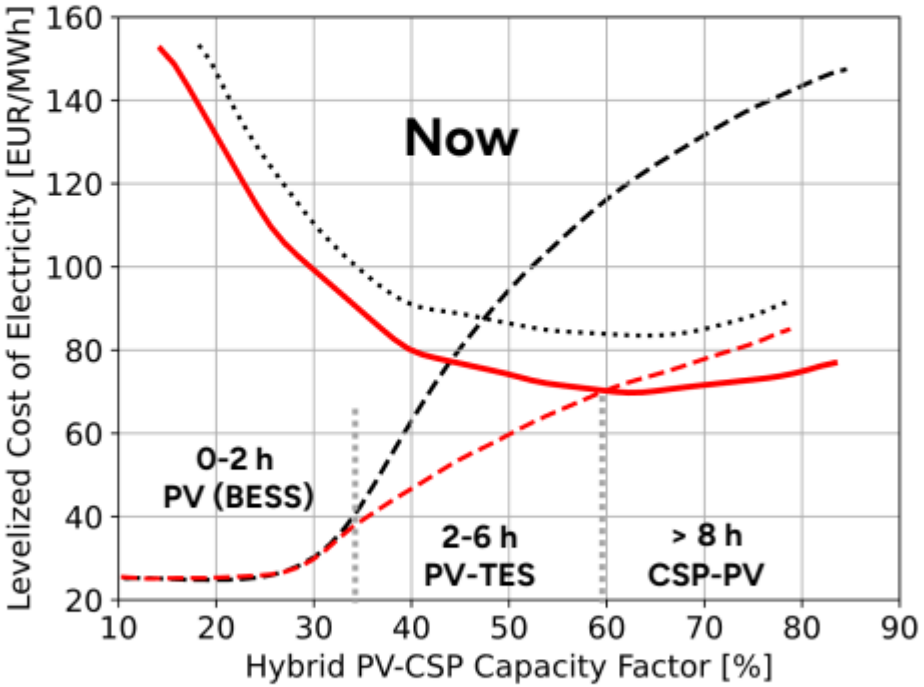
Results of the German IntegSolar Project

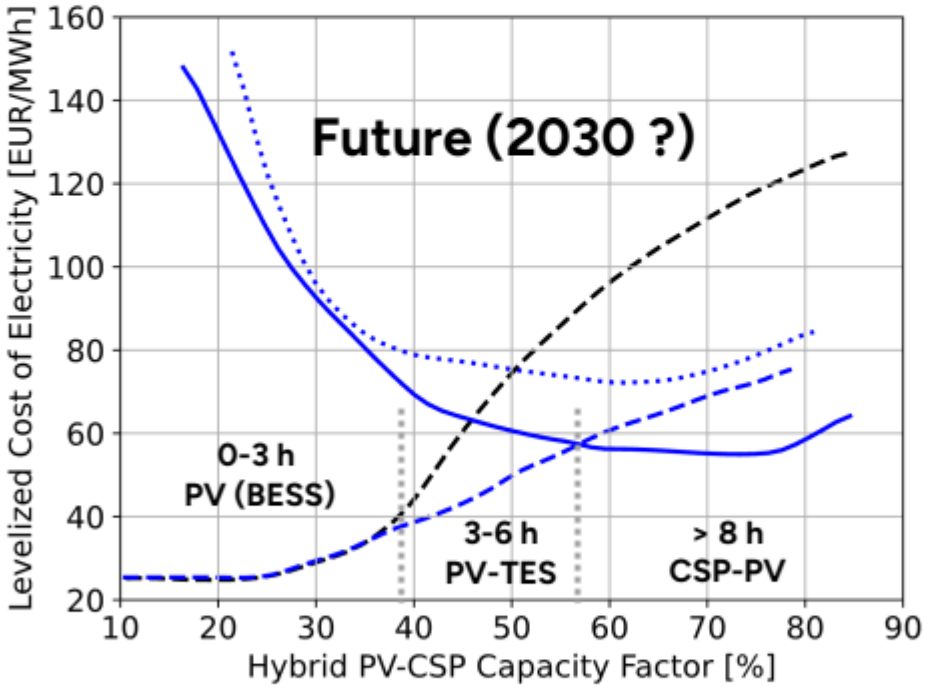


For comparison:

CSP-PV Hybrids for baseload power

In regions* with "good" solar irradiance CSP-hybrids are the most cost-effective technology to supply baseload power today and in future





PV-BESS
MS CSP Steam
MS PV-EH-TES Steam
MS PV-CSP Steam
Par CSP sCO2
Par PV-EH-TES sCO2
Par PV-CSP sCO2

* South EU (DNI ≈ 2000 kWh/m²)
100 MW firm production

Ongoing CSP projects in China

China Solar Thermal Alliance
CSTA

Location	CSP capacity	Project number
Xinjiang	1650MW	16
Qinghai	1300MW	9
Gnasu	610MW	6
Tibet	480MW	8
Inner Mongolia	300MW	1
Jilin	200MW	2
Total	**4540MW**	**42**
Source: China Solar Thermal Alliance		

- **Developer:** stated-owned company leading, including China Three Gorges, CGN New Energy, China Gezhouba, CNNC, SPIC, POWERCHINA (NORTHWEST, Eastwest, Zhongnan Engineering Design Institute), EnergyChina (NORTHWEST, Eastwest Design Institute, Zhejiang Thermal Power), China Green Development
- **CSP hybrid ratio:** 1:6 (Gansu) or 1:9 (Xinjiang) in capacity with PV and wind for economy (design institute calculation). Using the profit margin of PV to compensate the high cost CSP
- **Overall progress:** 10+ CSP projects have finished the EPC contractors or key equipments bidding, 2023-2025 in operation
- **EPC contractors:** EnergyChina Northwest, POWERCHINA NORTHWEST, Cosin Solar, Shouhang, SEPCOIII, China Shipbuilding New Power, DCTC
- **Technology selection:** Tower, LFR, PT (Tibet)

Conclusions

- Several solar hybrid option exist to provide a night- time power supply
  - PV + Battery
  - PV + TES + PB
  - PV + CSP + TES

Recent studies show that the options including a TES are significantly more competitive compared to battery options for high night time fractions

Today CSP –PV hybrid power plants are installed mainly in China to balance high fraction of PV power

High night time fraction are also required to power remote industrial installations (e.g. mines)

CSP Market Size