Project Development- Renewables (Solar)

A Presentation at the GH2 Masterclass, 2023

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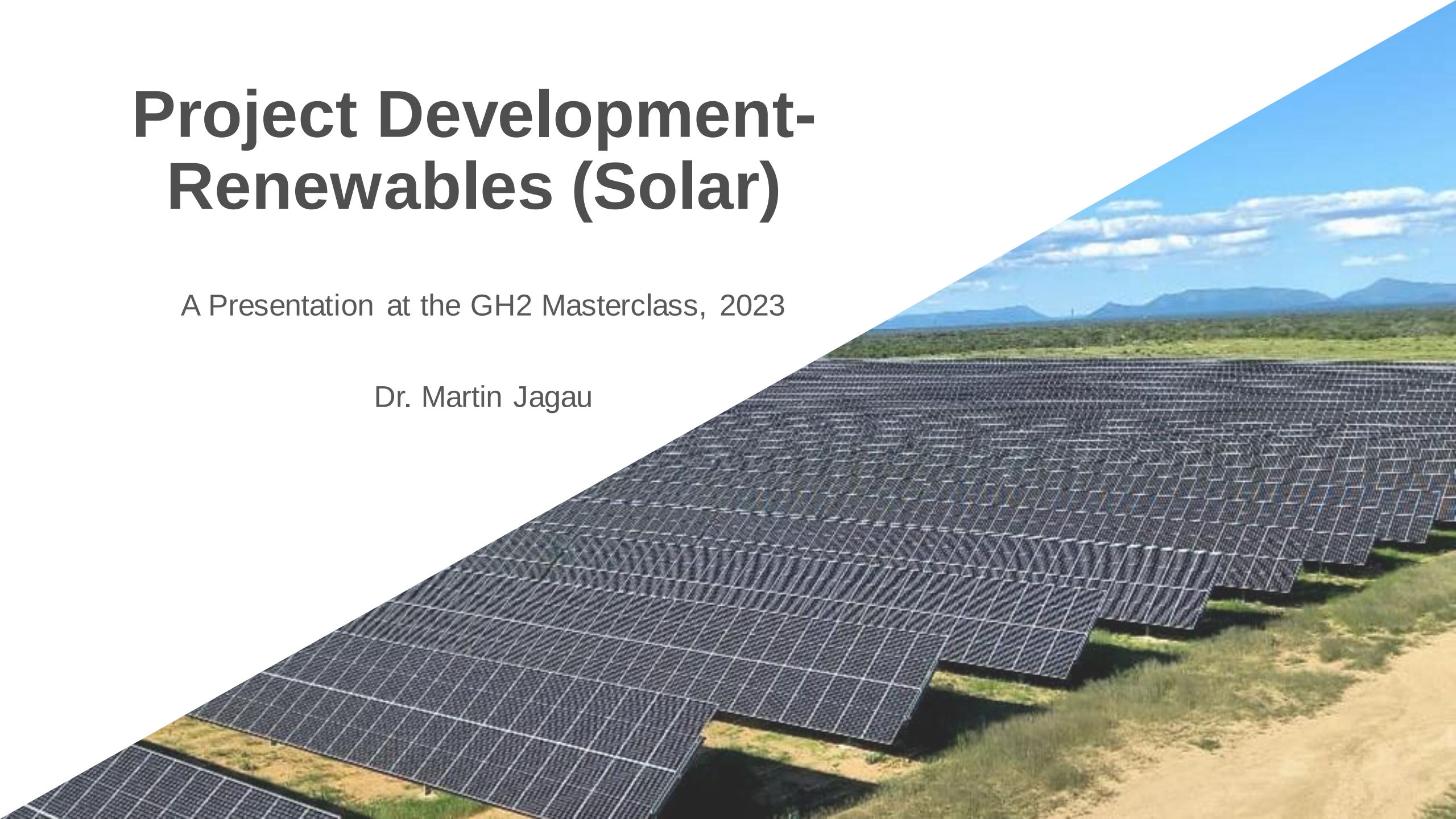

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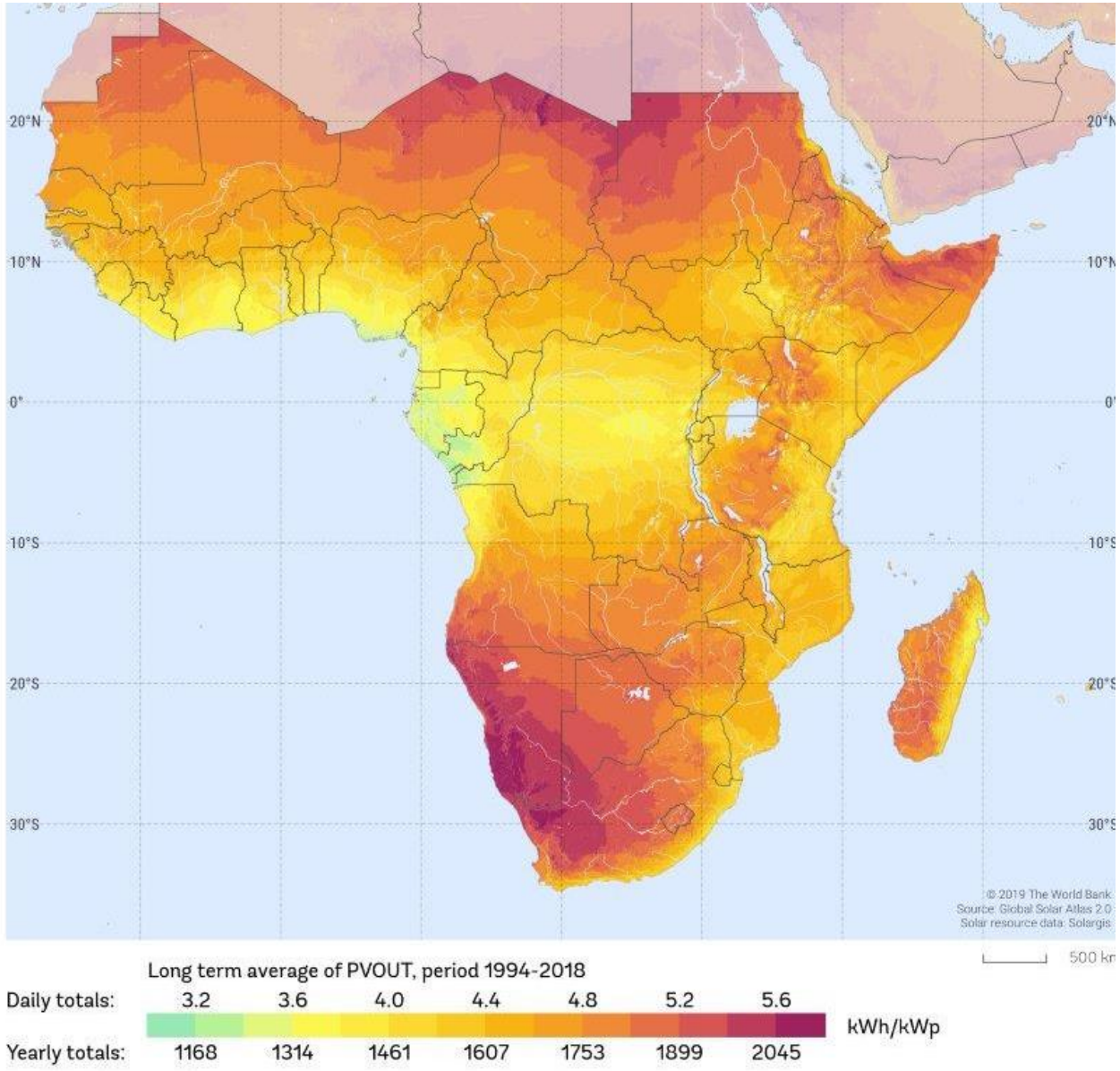
Challenges

- Cost of Energy is one of the main drivers of the total cost of Green Hydrogen
- Renewable energy sources are intermittent

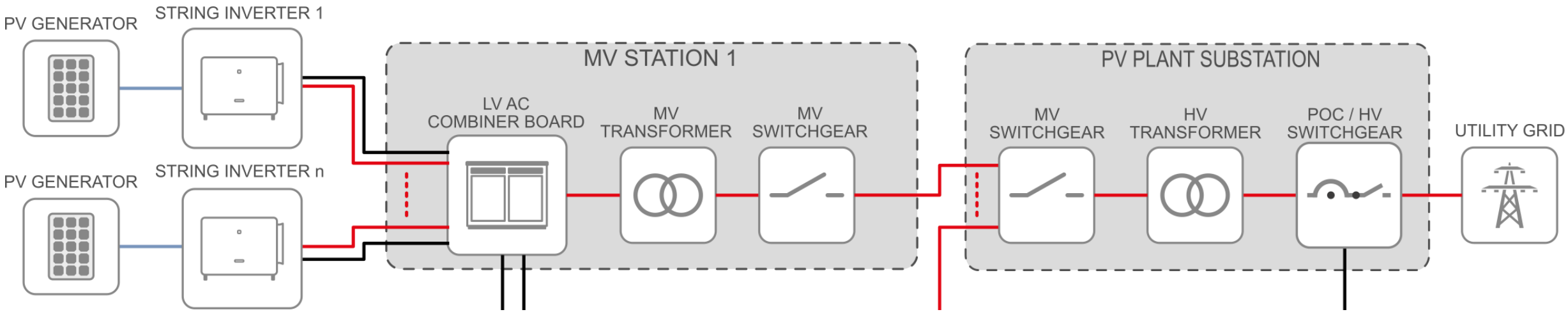
- Namibia has one of the best solar resources worldwide and thus can produce competitive energy
- Solar can be accurately predicted, especially in the southern and western regions of Namibia

- **Solar energy is a reliable and the most competitive energy source**



PV PLANT CONCEPT – String Inverter or Central Inverter?

PV PLANT CONCEPT – String Inverter

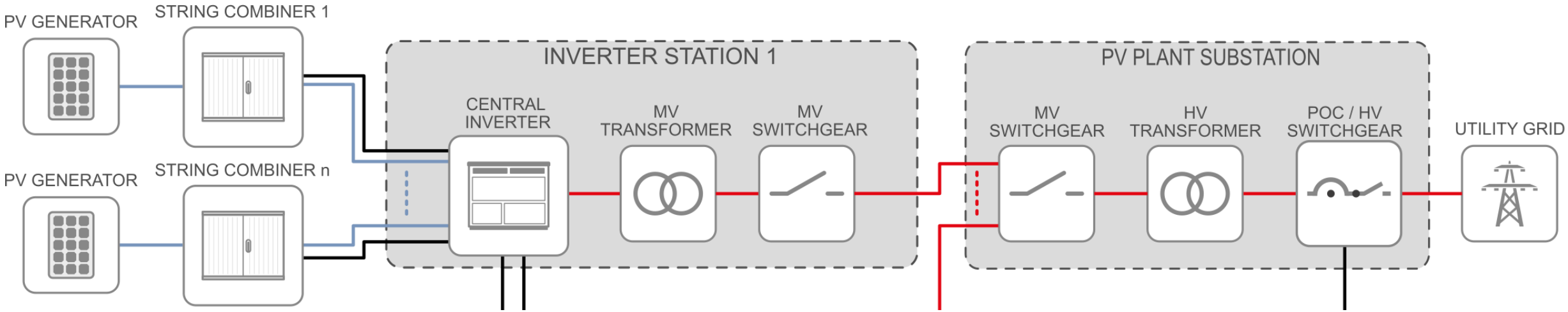


- Inverter size 330 – 350kW
- Multiple MPPT (6 - 12)
- Distributed throughout the PV field
- MV station size up to 9MVA in a 20ft container
- String level monitoring, IV-Curve Scanning
- Communication via Powerline Carrier, no need for communication cables
- Active components present in the field

- ➢ Inverter failure results insignificant downtime, only ~350kW offline
- ➢ No specialized staff required, Plug and Play inverter replacement
- ➢ Maintenance intensive on large plants 100MW ~ 350 inverters

➢ **Best suited for plants < 100MW**

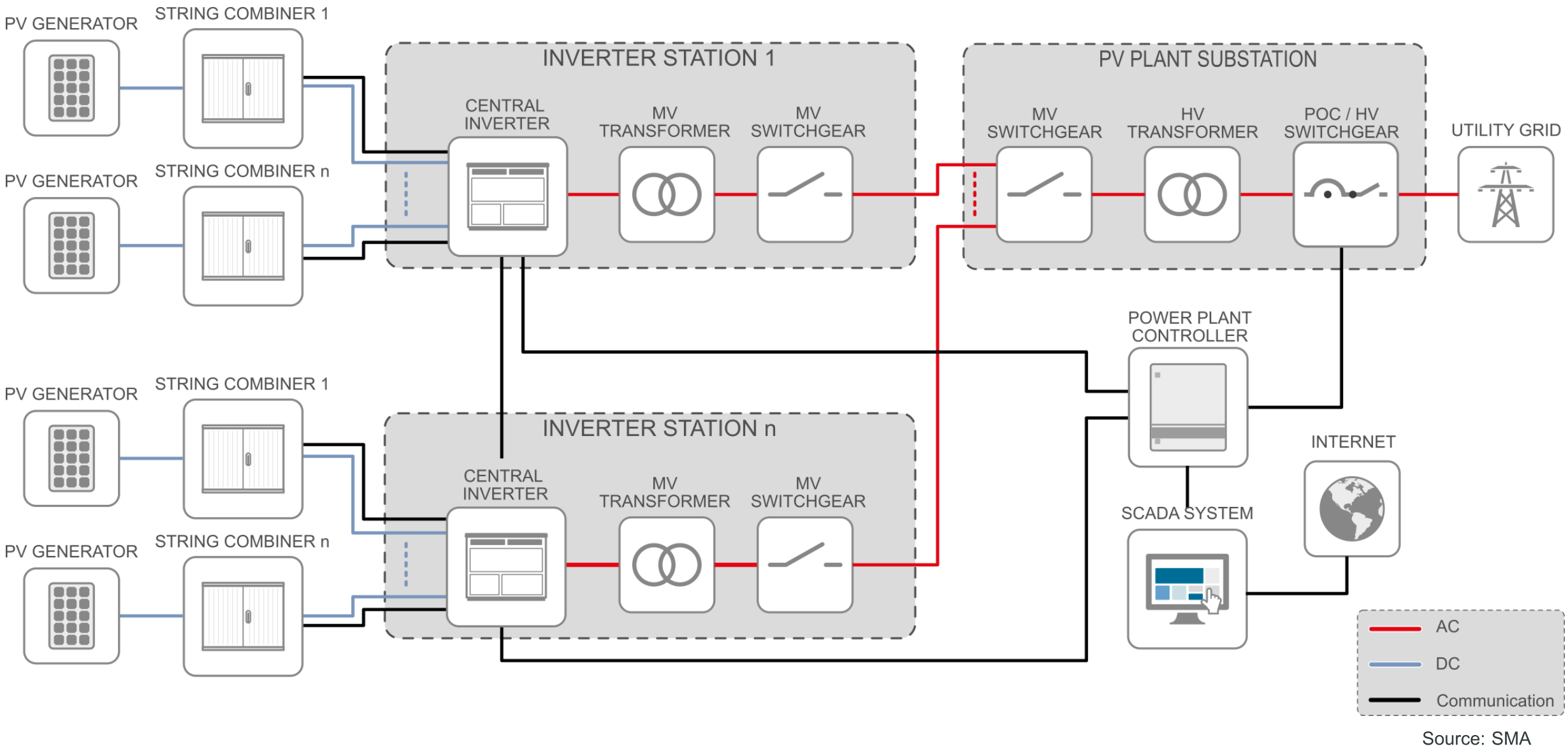
PV PLANT CONCEPT – Central Inverter



- Inverter station up to 4.6MW in a 20ft container
- Low number of MPPTs (1 - 4)
- Connection via String Combiner Boxes (SCBs) ~ 300kW per Box
- String level monitoring via SCBs
- Wireless communication, no need for communication cable
- Only passive components in field – only minor maintenance required

- Central Inverters require specialized staff
- Inverter failure results in significant downtime - MWs offline
- Lower number of components
- Maintenance intensive components are at centralized locations and easily accessible
- **Best suited for large scale plants >100MW**

LARGE SCALE PV PLANTS –Central Inverter Layout



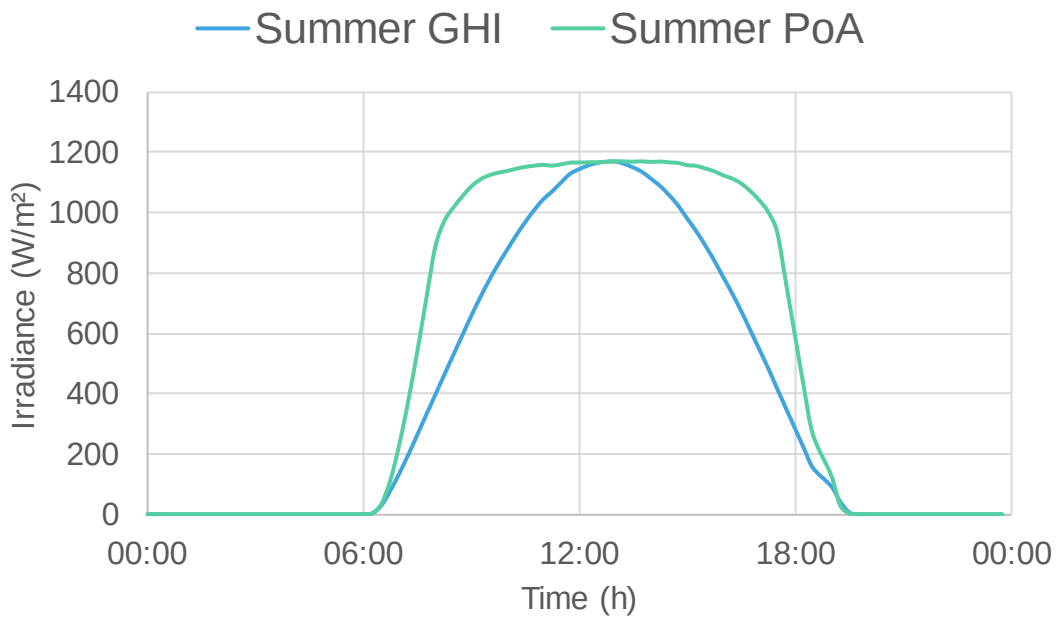
Source: SMA

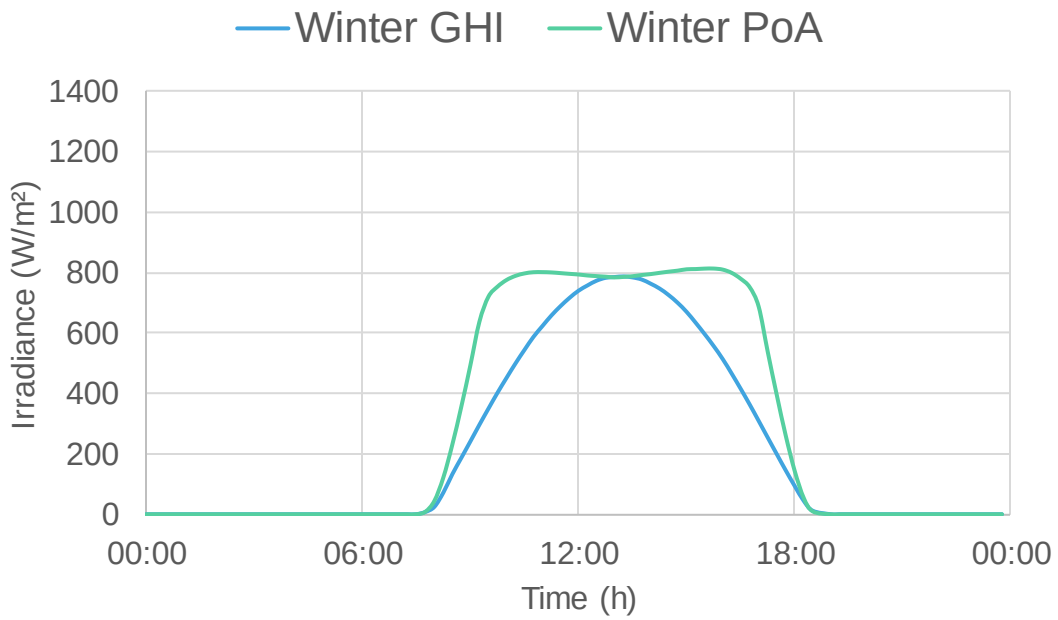
DESIGN CONSIDERATIONS – Mounting Structure

Fixed mount or tracked?

GHI: Global Horizontal Irradiance

PoA: Point of Array Irradiance





- Yield Gain of >30% compared to GHI
- Rectangular output curve
- Increased bifacial gain

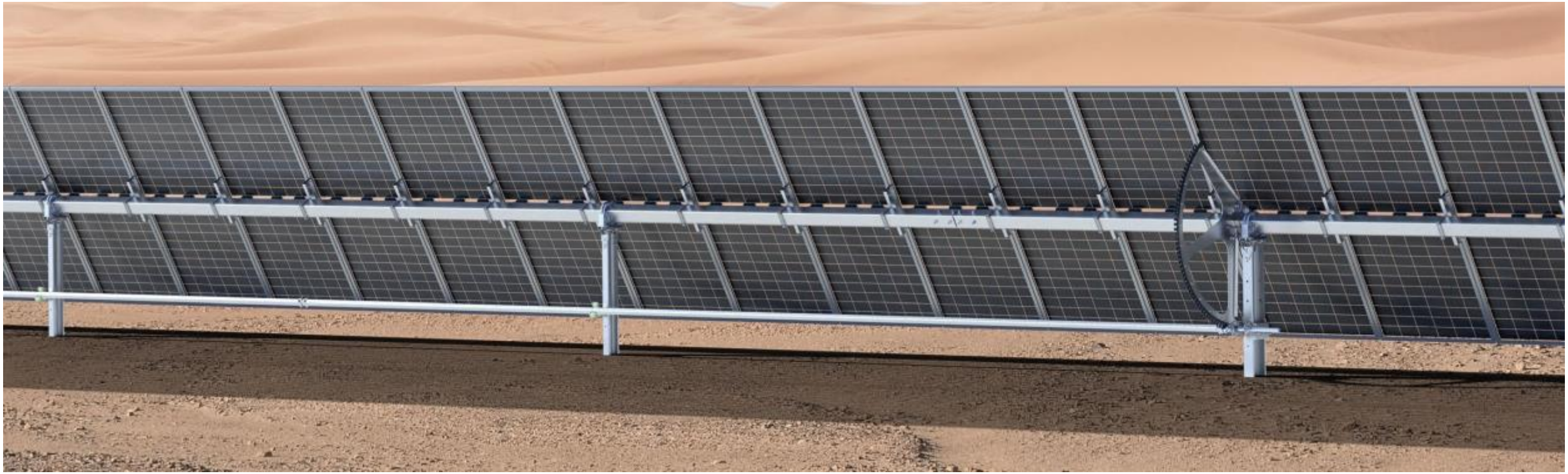
➢ **Overall yield gain of approx. 20% compared to a fixed tilt installation optimally orientated**

➢ Increased maintenance required

➢ Slightly more expensive

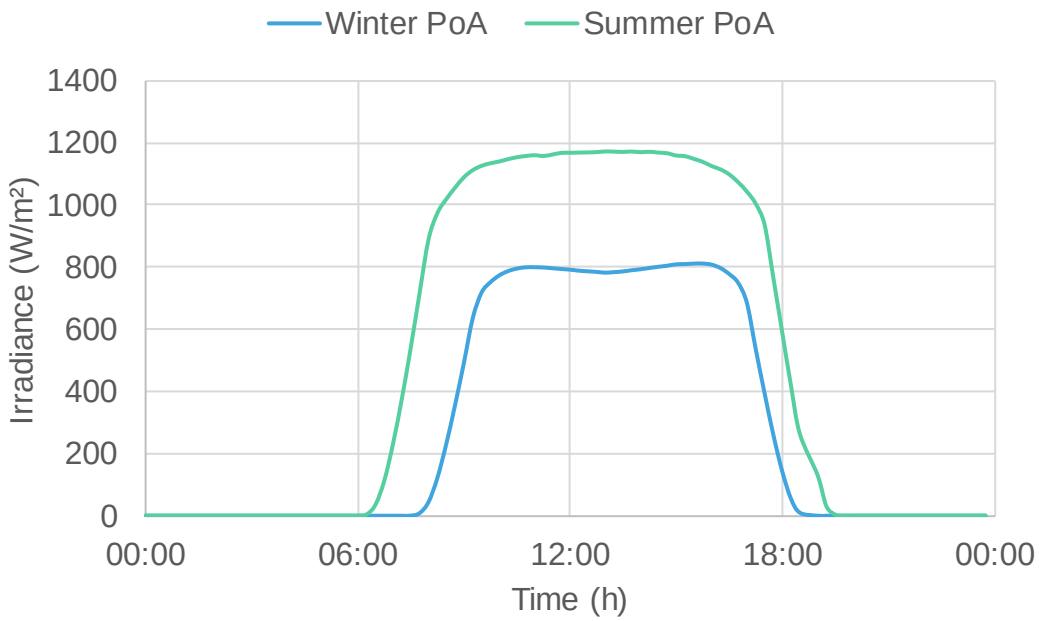
DESIGN CONSIDERATIONS – Tracking System

- Single axis tracking system up to 60° E-W tracking range
- Foundations are a significant cost driver
  - Most sites require pre-drilling and concretion



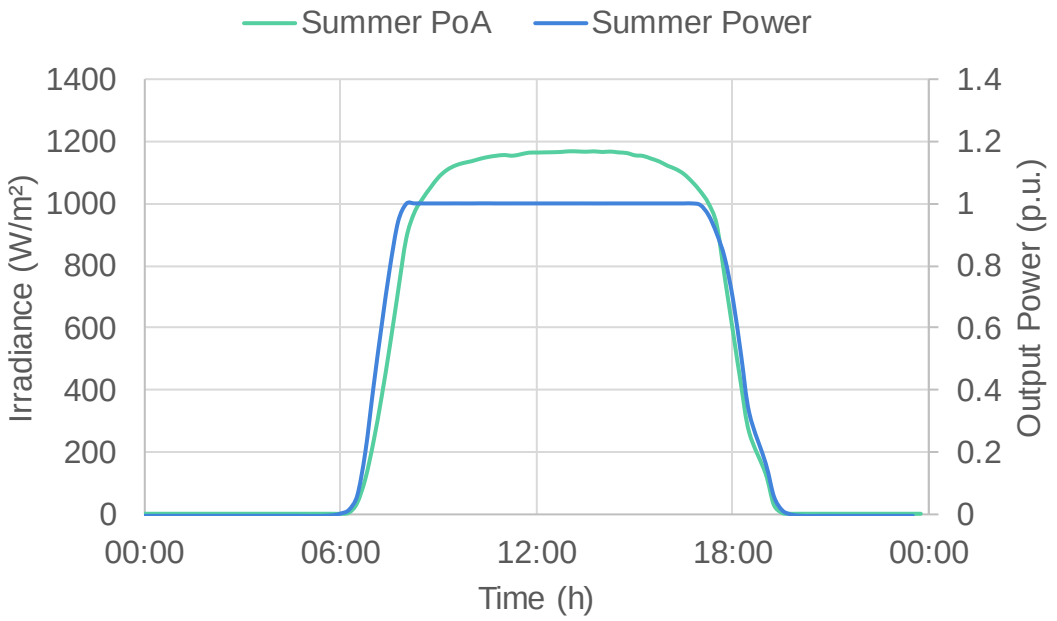
Source: Ideematec

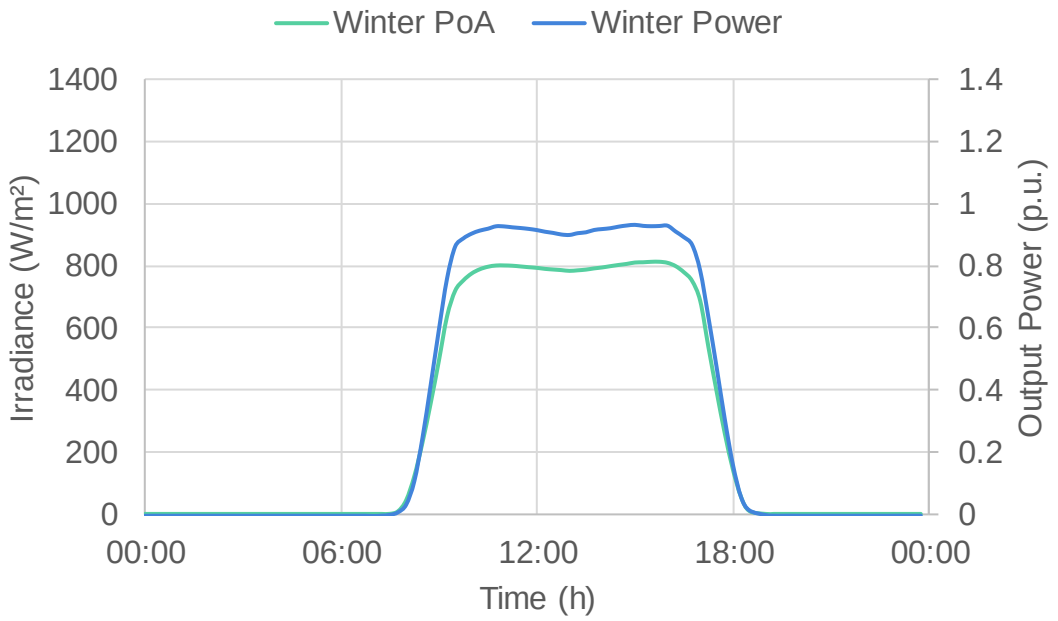
In Plane Irradiance: Summer vs Winter



- Only 60% of yield present in July

DESIGN CONSIDERATIONS – Oversizing of DC





- Oversizing results in curtailment of production and thus deemed energy during summer months
- In winter months the output power is lower than plant power rating

➢ **Grid Connected installations commonly have a DC:AC ratio of 1.3**

➢ **Capacity Factor = 36%**

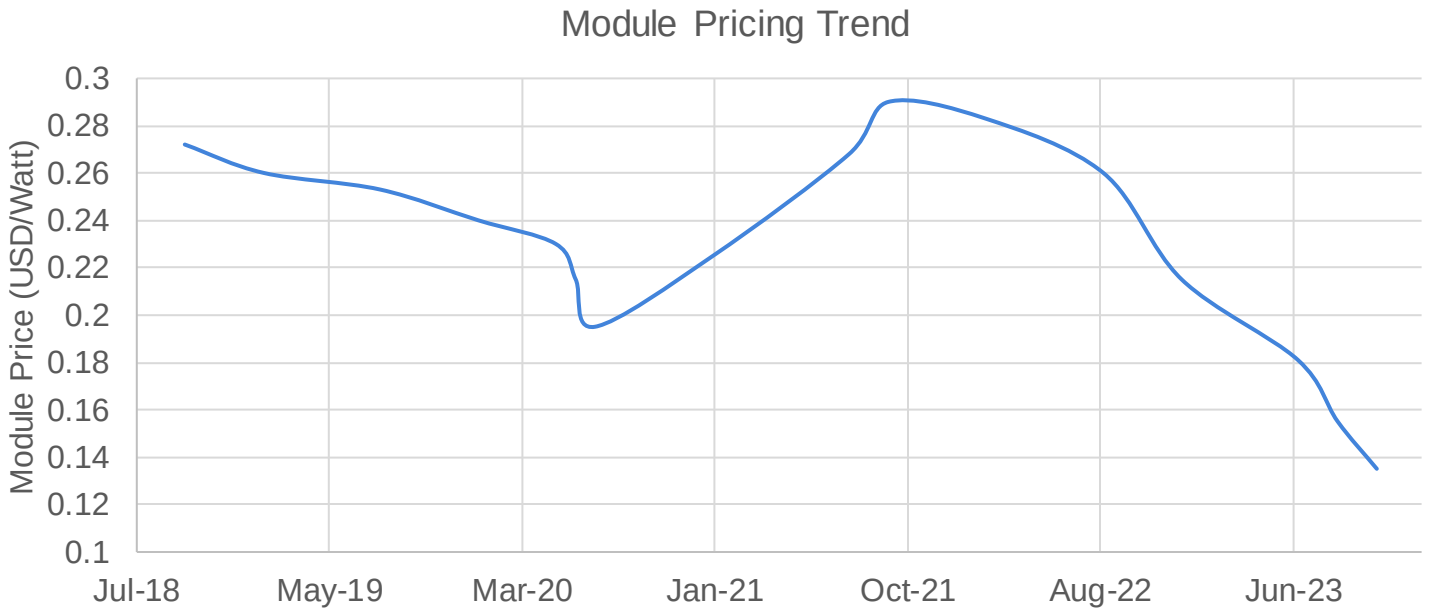
DESIGN CONSIDERATIONS – Module

- Bifacial with dual glass
- Monocrystalline, polycrystalline phased out in 2020
- Since 2022 n-type TOPCon technology
- Module efficiency >22.5%
- Lower degradation
  - First year <1%, Linear annually <0.4%
- Warranty extended to 30 years
- Superior high temperature performance
  - Module temperature coefficient -0.30%/°C (p-type module : -0.35%/°C)
  - Lower operating temperature
- Increased bifacial factor to 85% (p-type module : 70%)

Source: Ideematec

➢ **Overall production gain of ~5% compared to p-type bifacial modules**

PROCUREMENT - Pricing



- Downward trend since 2018
- July 2020 drop to below 0.20$/W during Covid
- Thereafter increase again, also driven by significant increase in transport costs
- Maximum of ~0.29$/W reached in October 2021
- Since then, module price is falling to 0.135$/W in November 2023
- No end in sight?

PROCUREMENT - Pricing

	Today	2020
Solar Modules	30.0%	36.0%
Inverter Stations	14.0%	12.0%
Trackers	26.0%	25.0%
Electrical Balance of Plant	8.0%	9.0%
Civil Works	5.0%	4.0%
Project Management	5.0%	5.0%
PV Plant Substation	12.0%	10.0%

- **Significant decrease in module pricing, downward trend**
- **Increase in Inverter pricing, downward trend**
- **Increase in MV components pricing, slight upward trend**
- **Tracker pricing directly linked to the steel price, stable trend**
- **Specific pricing of ~500-600 US$/kWp**

PROCUREMENT – Lead Times

	EXW (weeks)	Origin	
Modules	8	CN	Not critical
Inverter Stations	12 (54+)	CN (EU)	Not critical
Tracker	14	EU / Turkey / CN	Not critical
Cables	8	EU / SA	Not critical
Monitoring / SCADA system	12	EU	Not critical
Substation / Grid Interconnection	10+ months	SA / CN	critical

- Approx. 6-8 weeks shipping and 2 weeks custom clearance and transport to site

➢ **MV / HV equipment currently on the critical path**

CONSTRUCTION – 2GWp Example

Plant Size = 2GWp

	Total	Per Day
Modules (pcs)	3,418,794	10,928
Tracker (pcs)	126,622	101
Holes (pcs)	633,110	2,024
Trench (m)	800,000	2,557
Cable (m)	26,400,000	84,384
Containers (pcs)	10,600	34

- High level numbers
- Upscaled from construction experience of locally constructed MW PV plants
- Numbers are based on a 585Wp module on a 1P tracker
- Construction period per task = 1 year

Total construction period = 1.5 year

- Total workforce required = 4000
- Total team leaders required = 100
- 3500ha land required
- Machinery required
  - 20 drilling machines
  - 10 pile drivers
  - 15 excavators
  - 30 telehandlers

➢ **Not sufficient suitable machinery currently available in Namibia**

➢ **High workforce must be managed – tradeoff between progress and quality has to be considered!**

OPERATION AND MAINTENANCE

1. Preventative Maintenance
2. Corrective Maintenance
3. Module Cleaning
4. Vegetation Management

- Preventative maintenance: Intervals between 6 months and 1 year
  - Mechanical components – mostly Tracker
  - Electrical components – Inverters, SCBs, Terminations, etc.

- Only minor corrective maintenance expected,
  - When high quality components are installed with good workmanship
  - Requires specialized staff

OPERATION AND MAINTENANCE (O&M)

Cleaning of modules – 2GWp Example

- Robotic cleaning required
- 15 brushes with vehicle required to clean complete plant in 30 days
- Wet cleaning requires 88m³ of water per day and 2640m³ for one complete cleaning cycle
- Cleaning ratio Dry / Wet = 3 / 1
- Four cleaning cycles required per year

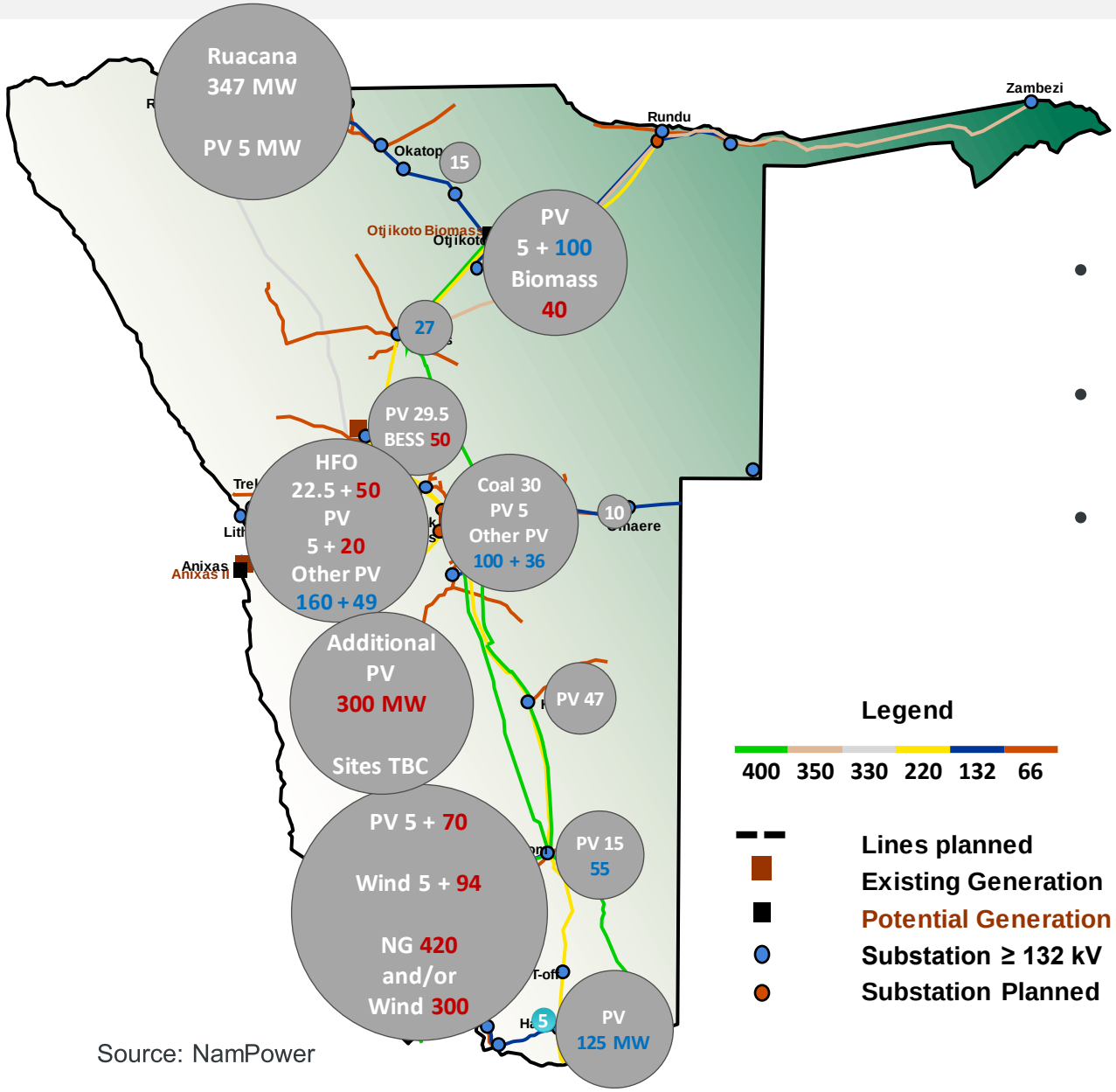
- **~500 permanent O&M staff required**
- **Approximate OPEX cost 1-1.5% of CAPEX**
- **OPEX can increase significantly with substandard equipment and poor workmanship**

NAMIBIAN KEY PLAYERS

1. HopSol Africa
2. NEC
3. Alensy

HOPSOL Smart Energy Solutions	**Size**	**Role**	**COD**
Khan PV Park	25MWp	EPC incl. 66kV Substation	In Construction / 2024
Omburu PV Park	26 MWp	EPC incl. 66kV Substation	March 2022
Hardap PV Park	47 MWp	C / EPC on 66kV Substation	2019
Ohorongo PV Park	6.57 MWp	C	2018
Karibib PV Park	5.28 MWp	EC	2017
Otjozondjupa PV Park	5.84 MWp	EPC	2016
Otjiwarongo PV Park	5.71 MWp	EPC	2015

NAMIBIAS GRID READINES – 2028



Source: NamPower

- NamPower currently the only licensed Transmission operator
- NamPower in the process of overlaying legacy 220kV grid with 400kV
- Main generation potential in the south, but main consumption in the central and northern regions of Namibia

NAMIBIAS GRID READINES

- Issues to be resolved to integrate large-scale variable renewable energy (VRE), including excess energy from GH2 projects
  - Managing intermittencies to ensure grid stability, including optimizing of BESS
  - Providing grid capacities to wheel energy within Namibia and exporting energy into the SAPP region

CONCLUSION

Are we geared for this challenge?

- Engineering
- Financial
- References

Thank you for your attention

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