Lawrence Pratt
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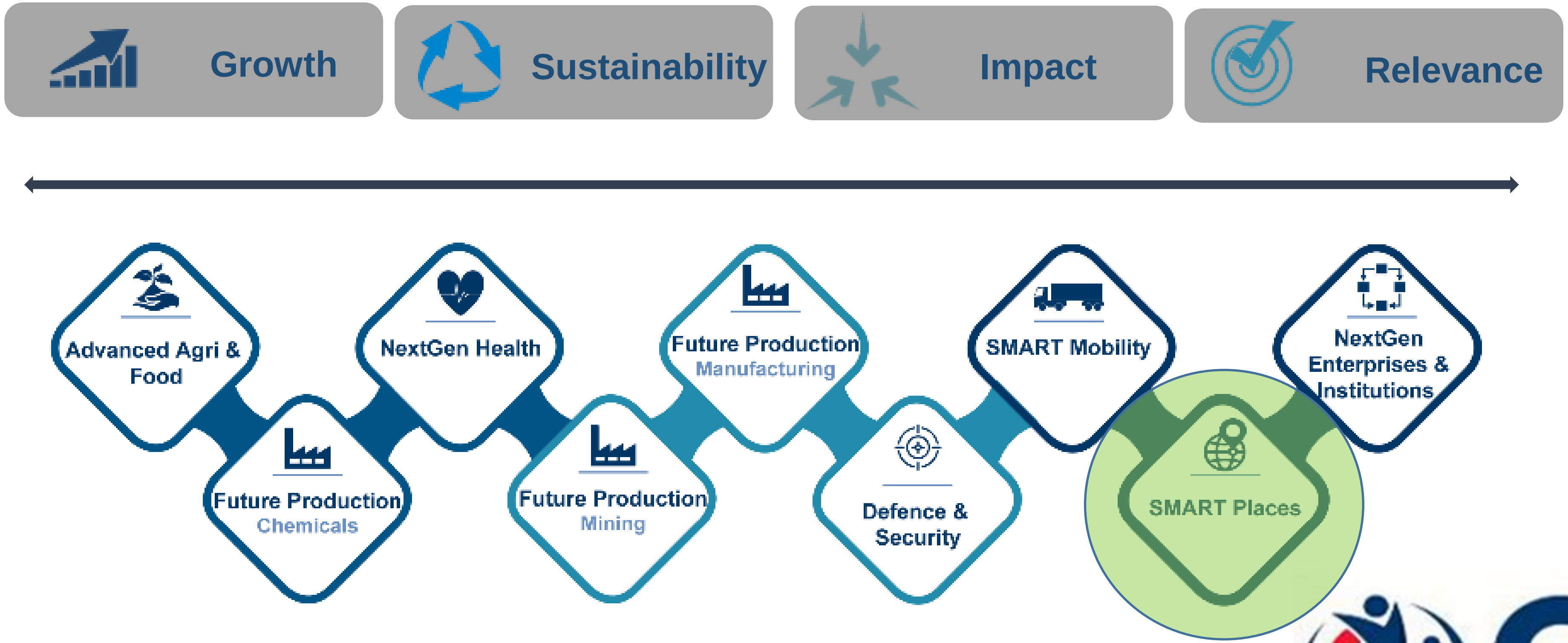
CSIR Energy Research Centre

PV System Performance at the CSIR

Outline

The CSIR strategic intent and RDI pillars



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SMART Places Cluster, Energy Centre

Technology-focussed Research Groups

Energy Supply & Demand

- Energy Efficiency and demand shaping
- Energy Meteorology
- Renewable Energy technology
- Thermal energy
- PV Module Q&R Lab

Electro-Chemical Energy Technologies

- Batteries
- Fuel cells

System-focussed Research Group

Energy Systems

- Energy System Design
- Energy System Operation

End user-focussed Research Groups

Energy Industry

Smart Utilities Programme

Real-world implementation of research programme

Installed solar PV (2015-2022)





Name	**Single axis tracker (SAT)**	**Dual axis tracker (DAT)**	**Building 17 (B17)**	**Phase 1 (P1)**	**Bldg 46E (Dual46E)**
Installed Capacity [kWp]	558	203	250	911	30
CAPEX [m]	10.75	6.9	4.7	12.1	0
CAPEX [R/kW]	19 390	34 207	18 968	13 312	0
LCOE [R/kWh]	0.84	1.00	0.91	0.71	na
Commissioned	2015 August	2016 December	2017 April	2019 April	2021 Mar

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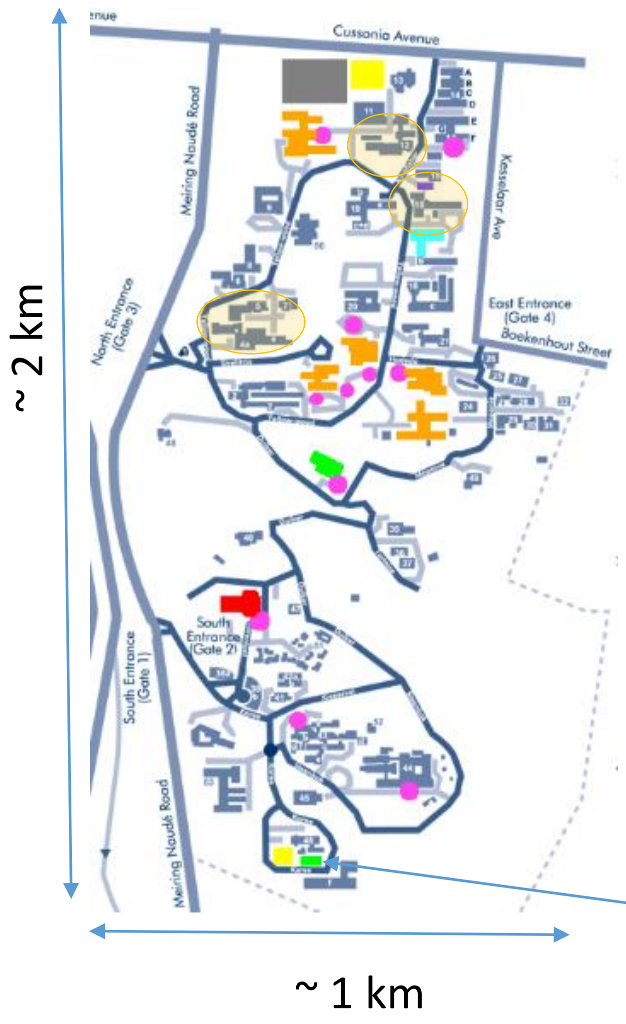
SUP platform for energy project demonstrators



	Single axis tracker ground mounted PV
	Dual axis tracker ground mounted PV
	Building 17 rooftop PV
	Blacklite carport PV
	Phase I rooftop PV
	Building 34 outdoor testing facility
	Building 46 indoor PV testing facility
	EV charging stations
	Thermal storage for ICC A/C
	Proposed buildings for Phase II

PV Module Q&R Lab

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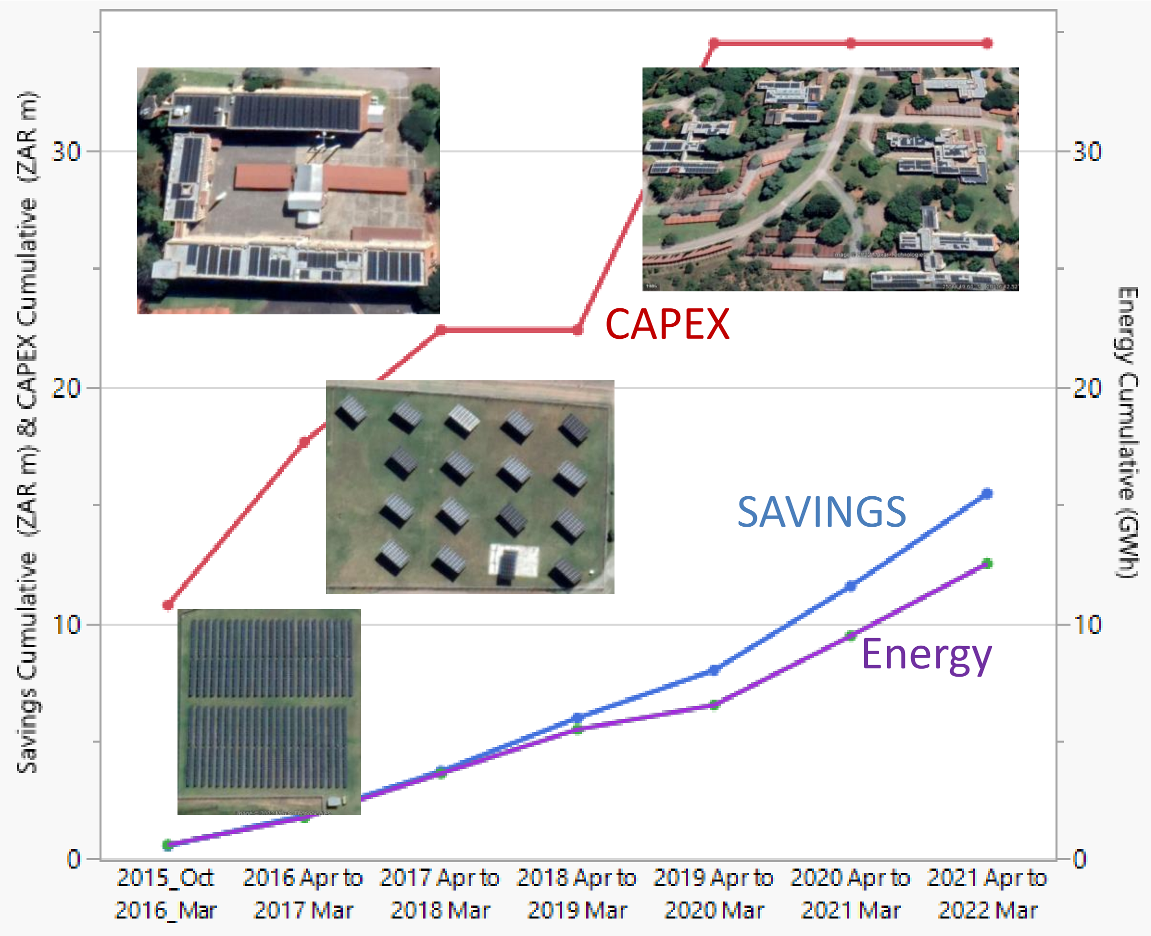
Historical generation and savings



1. R 34 million nominal spent on CAPEX
2. R 15.5 m in savings from reduced electricity bills
3. 12.5 GWh of electric energy generated
4. 3.1 GWh of electric energy produced in fiscal year 2021/22
5. Electric energy production will start to decline unless new capacity is added

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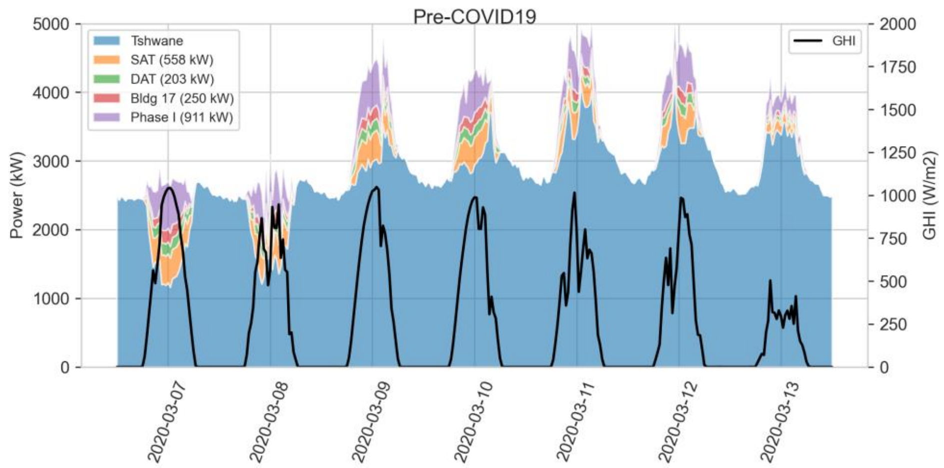
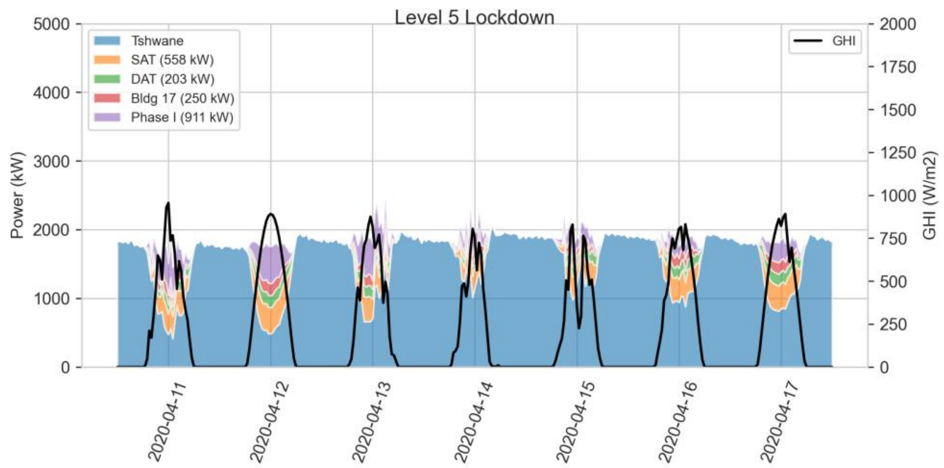
Pre and post COVID19 profiles for selected weeks





	Electric Energy Produced by PV (MWh)	Savings from kWh (ZAR)	Peak demand from utility [kVA]
Mar-2020	262	253 166	4201
Apr-2020 *	186	175 795	2078
Reduction	29%	30%	50%

* Partial shutdown of Phase 1 due to cable theft

1. The base load decreased under the Level 5 lockdown prompted by COVID19
2. 50% reduction in peak demand
3. 1 KVA peak demand savings in April

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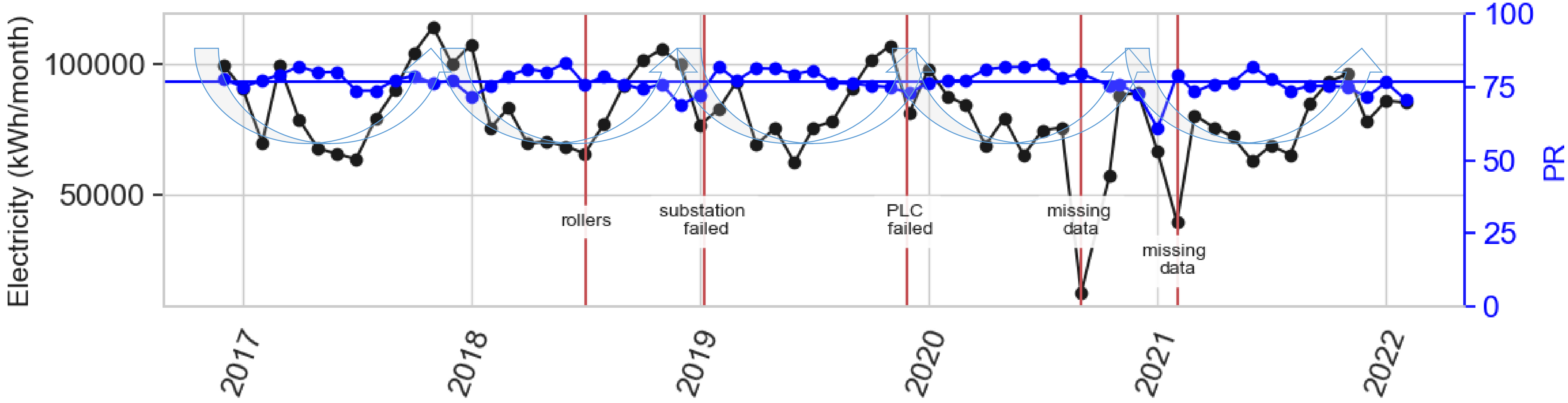
Single-axis tracked system (558 kWp, 8 inverters)



1. PR average = 76.8%
2. Seasonal variation in output due to ‘cosine’ losses on horizontal trackers
3. Challenges: lightning damage to modules, inverter manager, tracker rollers, tracking motors lock, shattered glass from mowing, soiling

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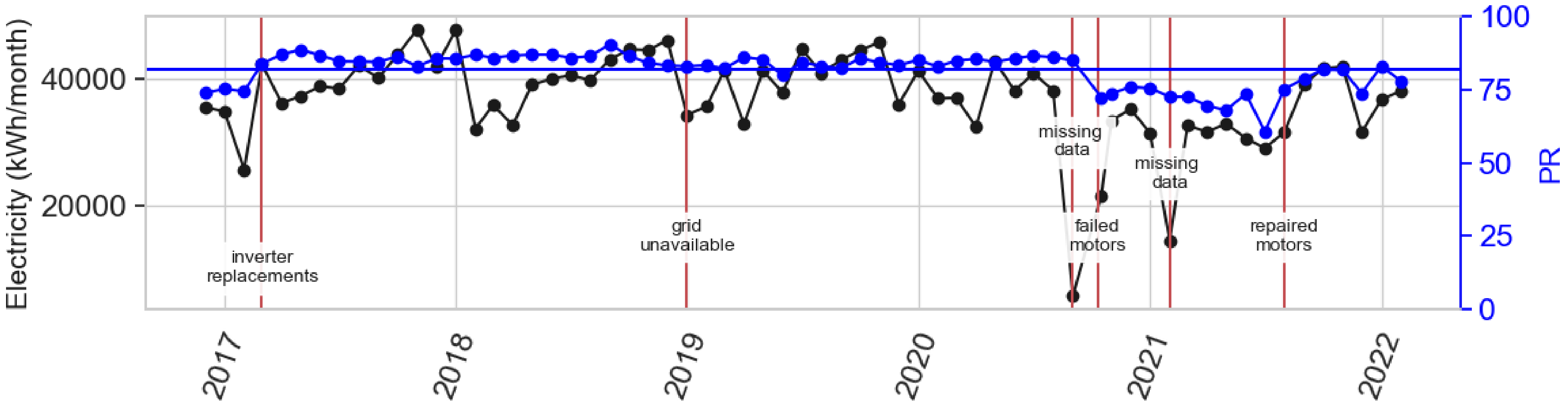
Dual-axis tracked system (203 kWp, 17 inverters)



- PR average = 81.7%
- Seasonality is less pronounced due to absence of the cosine loss
- Challenges: lightning damage on 2x inverters, 10x elevation motors/actuators, tracker/module damage

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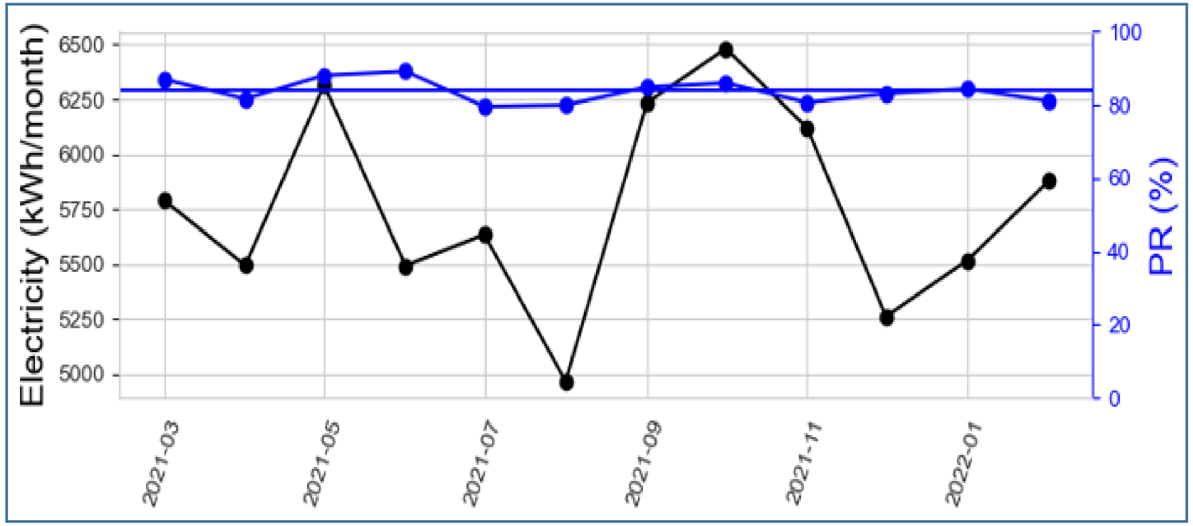
Dual-axis Building 46E (30 kWp, 1 inverter)



- PR average = 83.8%
- Seasonality is less pronounced due to the absence of the cosine loss
- Challenges: none to date
- Note: elevation motors is now on the opposite side and covered

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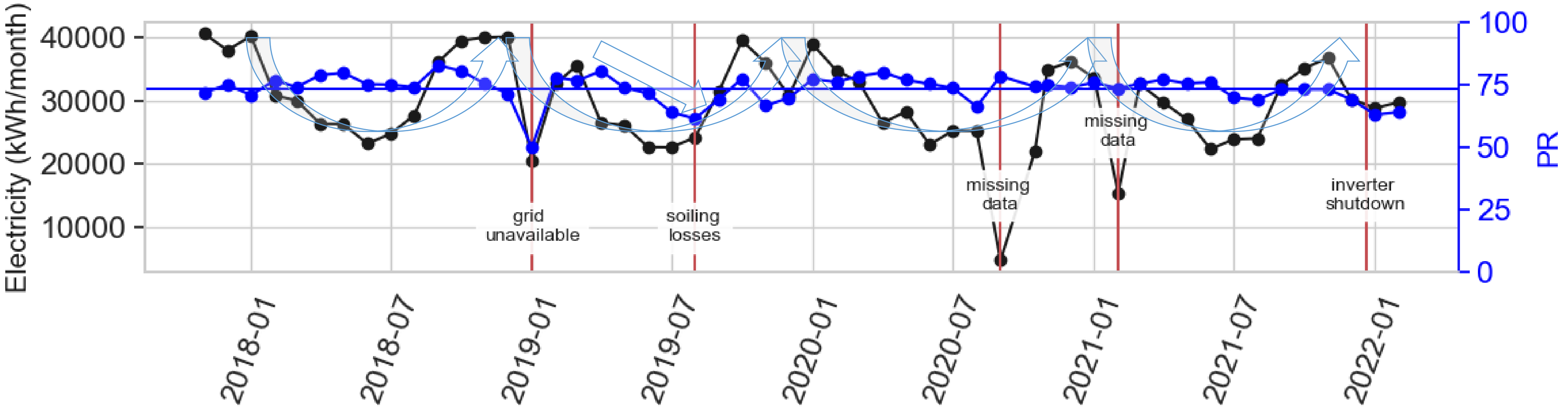
Building 17 east-west rooftop (250 kWp, 11 inverters)



- PR average = 73.3%
- Strong seasonal variation due to ‘cosine’ losses on horizontal mounted systems
- Challenges: soiling losses, 2x inverter failures, working at heights

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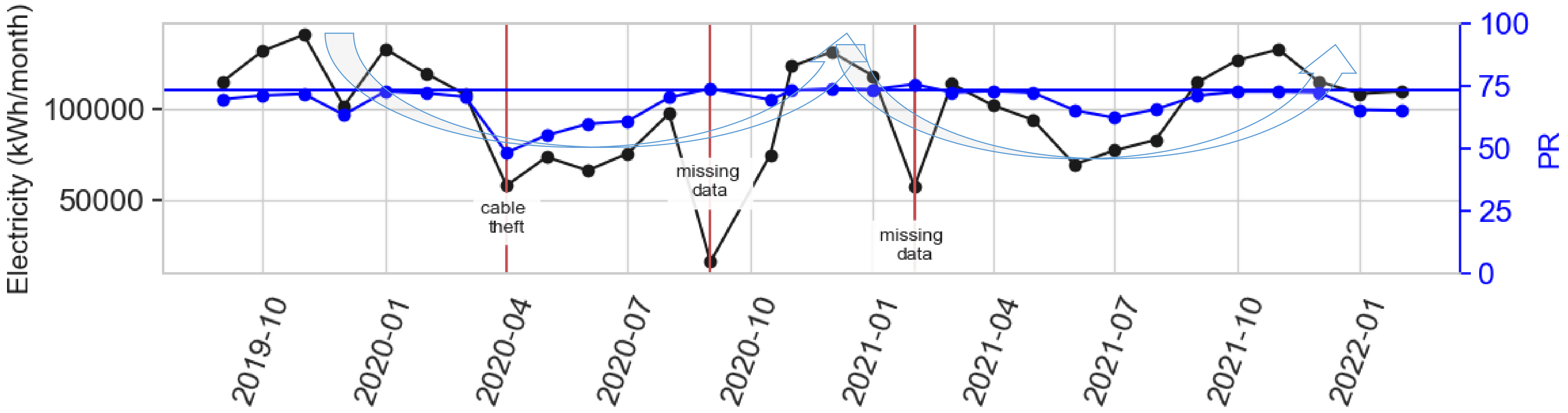
Phase 1 east-west rooftops (911 kWp, 17 inverters)



- PR average = 73.2 %
- Strong seasonal variation due to 'cosine' losses on horizontal mounted systems
- Challenges: 50% wet leakage failure on modules, parapet wall failure, 1x inverter failure, grounding conductor theft

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Dual-axis tracked system (203 kWp, 17 inverters)

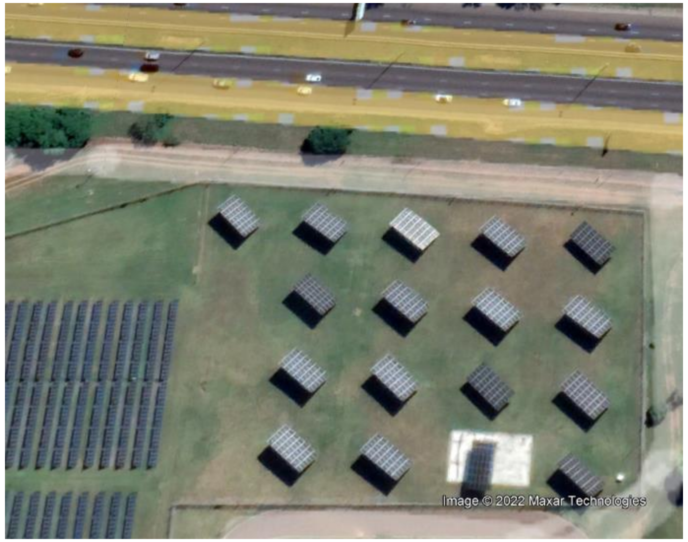
2017 October

T06

T16

2018 September

2022 April



1.15 trackers with mono-facial modules over grass
2.1 tracker with bifacial modules over grass (T06)
3.1 tracker with bifacial modules over brick (T16)

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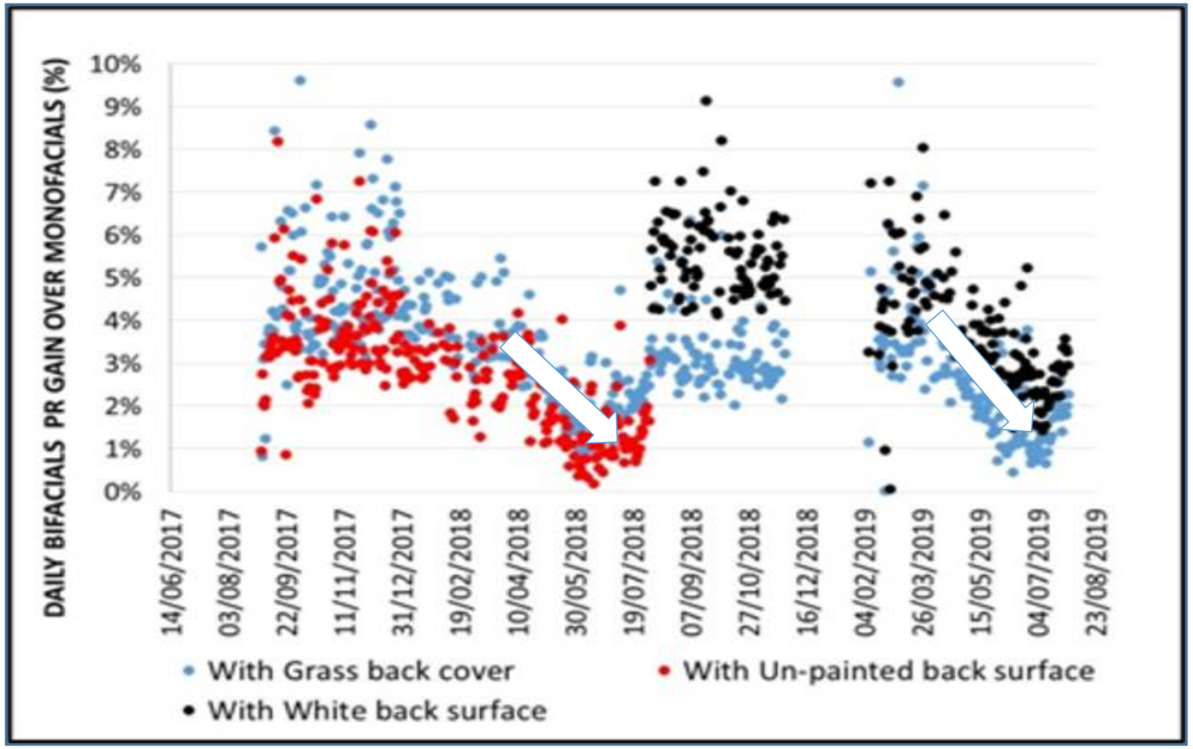
Bifacial module performance on dual-axis trackers



[Source: SASEC 2019 Proceedings]

Bifacial gain is lower during winter months for all installations

a) 2-7% gain in summer months relative to mono-facial modules
b) 0-3% gain in winter months

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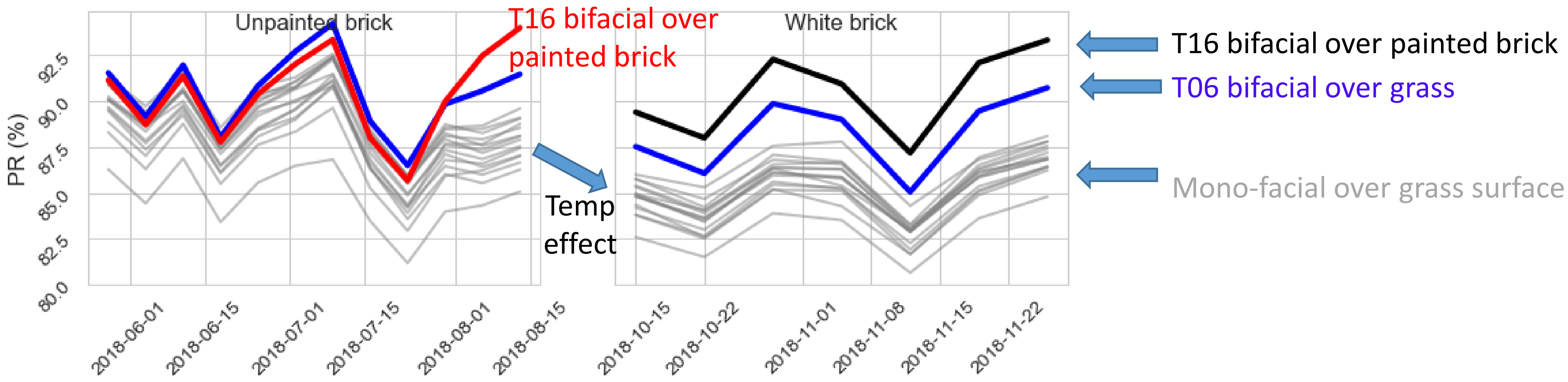
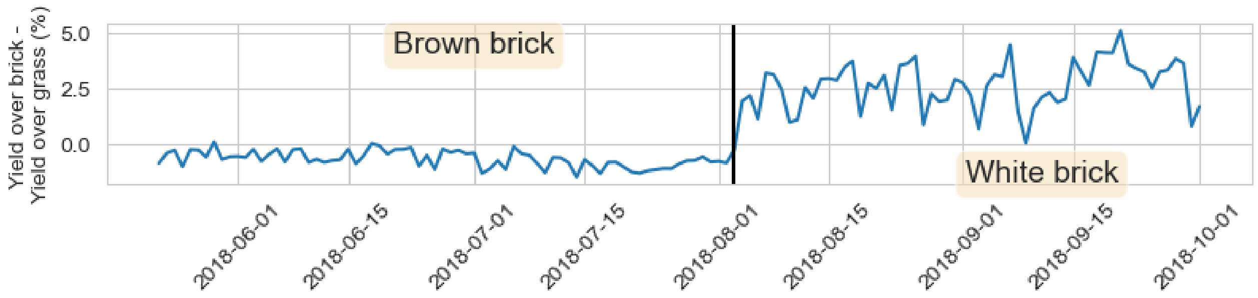
Bifacial module performance on dual-axis trackers





Performance gain increased by 2-3% for bifacial modules over white bricks compared to unpainted bricks

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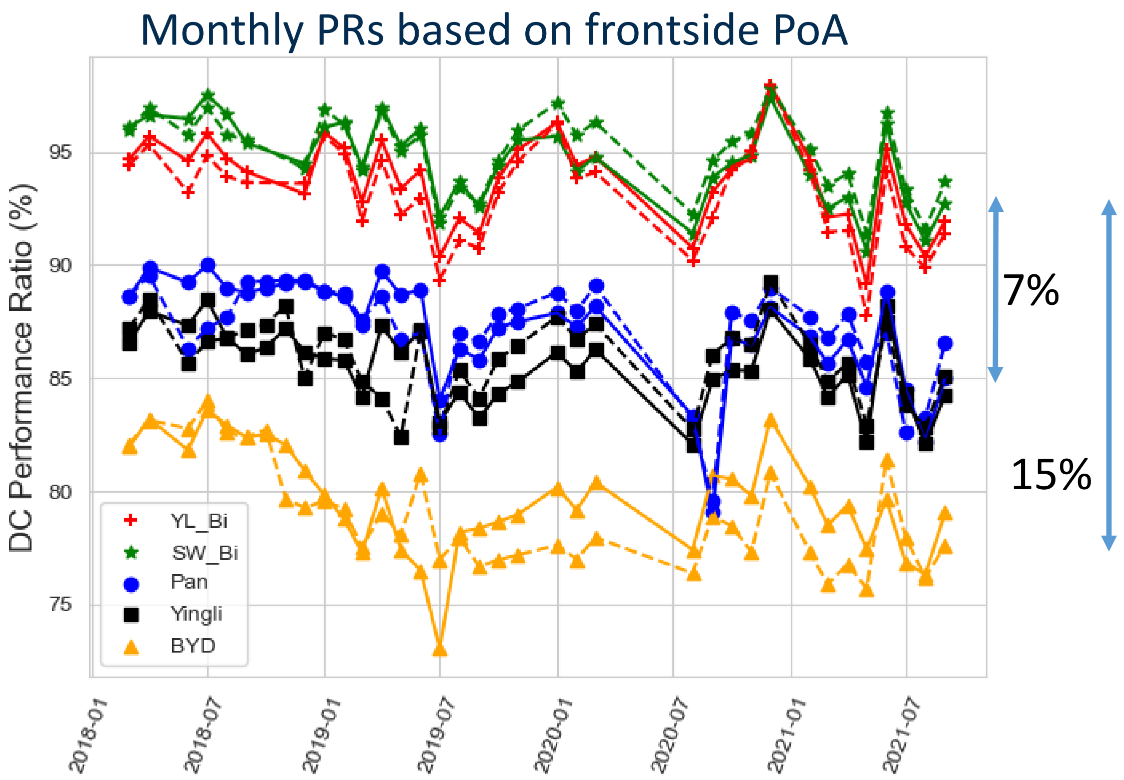
Bifacial module performance on fixed, latitude tilt rooftop



Source: SASEC 2019 Proceedings

Module	Degradation Rate (%/year)	p-value *	Datasheet
Yingli bifacial	-0.69	0.003	98% year 1 -0.48% / yr
SolarWorld bifacial	-0.84	< 0.0001	-0.35% per year
Panasonic HIT	-1.16	< 0.0001	-1.0% per year
Yingli	-0.60	0.001	98% year 1 -0.67% / yr
BYD	-1.15	< 0.0001	97.5% year 1 -0.73% / yr

* Based on simple linear regression of monthly PRs versus time

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Summary

1. The CSIR Pretoria campus successfully installed 2 MW of PV for self consumption
2. The dual-axis tracker has the highest PR while the rooftop east-west have the lowest
3. Bifacial modules on dual axis trackers show relatively low gains in winter months relative to summer months, while white paint surface improved the gain by 2-3%
4. Bifacial modules on fixed tilt rooftop installation show a 7-15% gain over mono-facials, depending on the mono-facial module type
5. A mix of challenges impact production across the various PV generators
6. Fixed tilt systems do not incur O&M costs related to motors
7. **What is the true cost of O&M and the impact on LCOE?**

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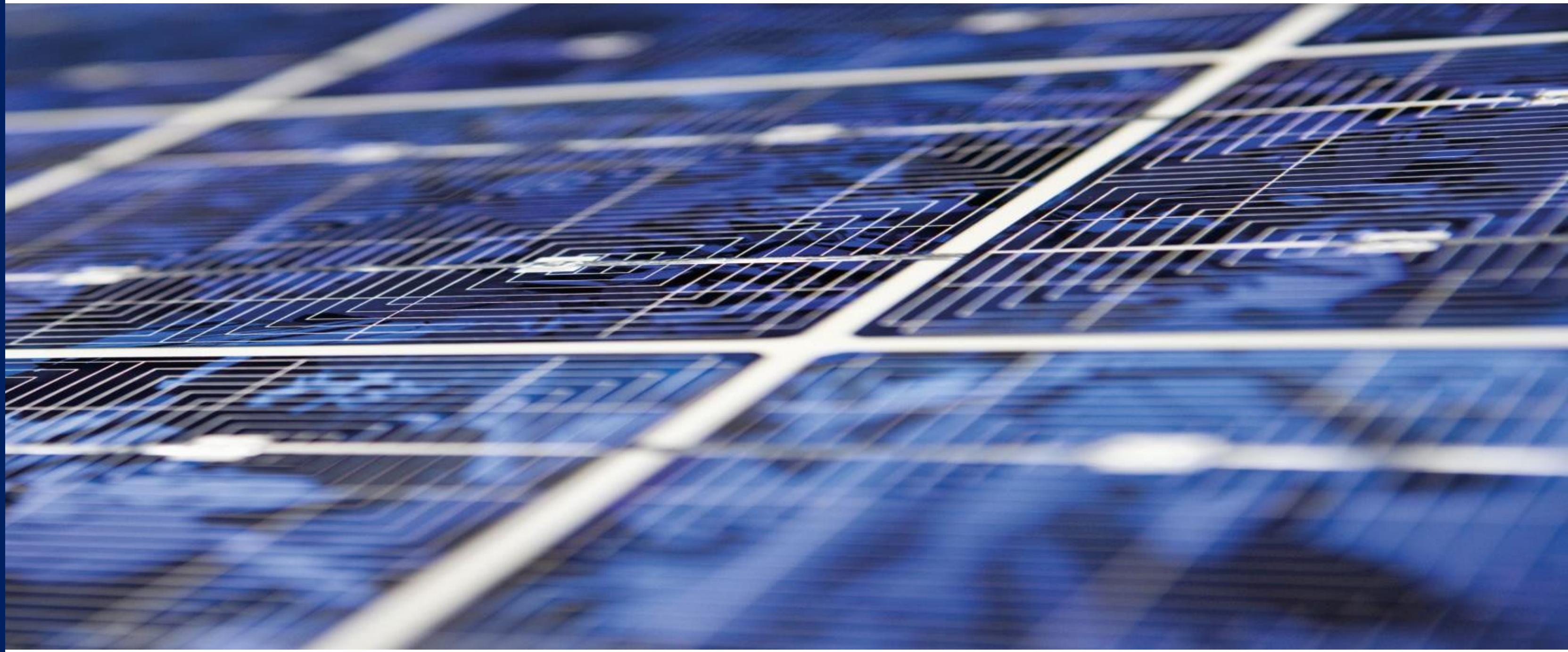

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