Overview of CSIR and PV Module Rollout

Presented to the
Department of Higher Education and Training
Meeting with Heads of Infrastructure

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science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

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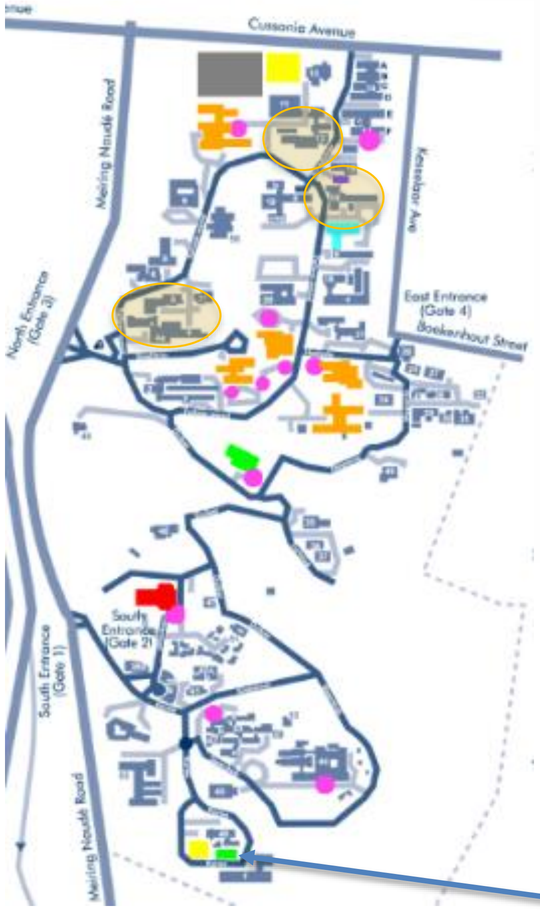
Contents

- CSIR Experience with grid-tied PV generators for self-consumption
- Load-shedding focus and interventions
- CSIR infrastructure and capabilities
- Discussion and next steps

CSIR campus map and renewable energy (RE) demonstrators

~ 2 km



~ 1 km

	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]

Wind and biogas generators were considered but PV was deemed the best short-term option for the Tshwane campus

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Grid-tied PV generators (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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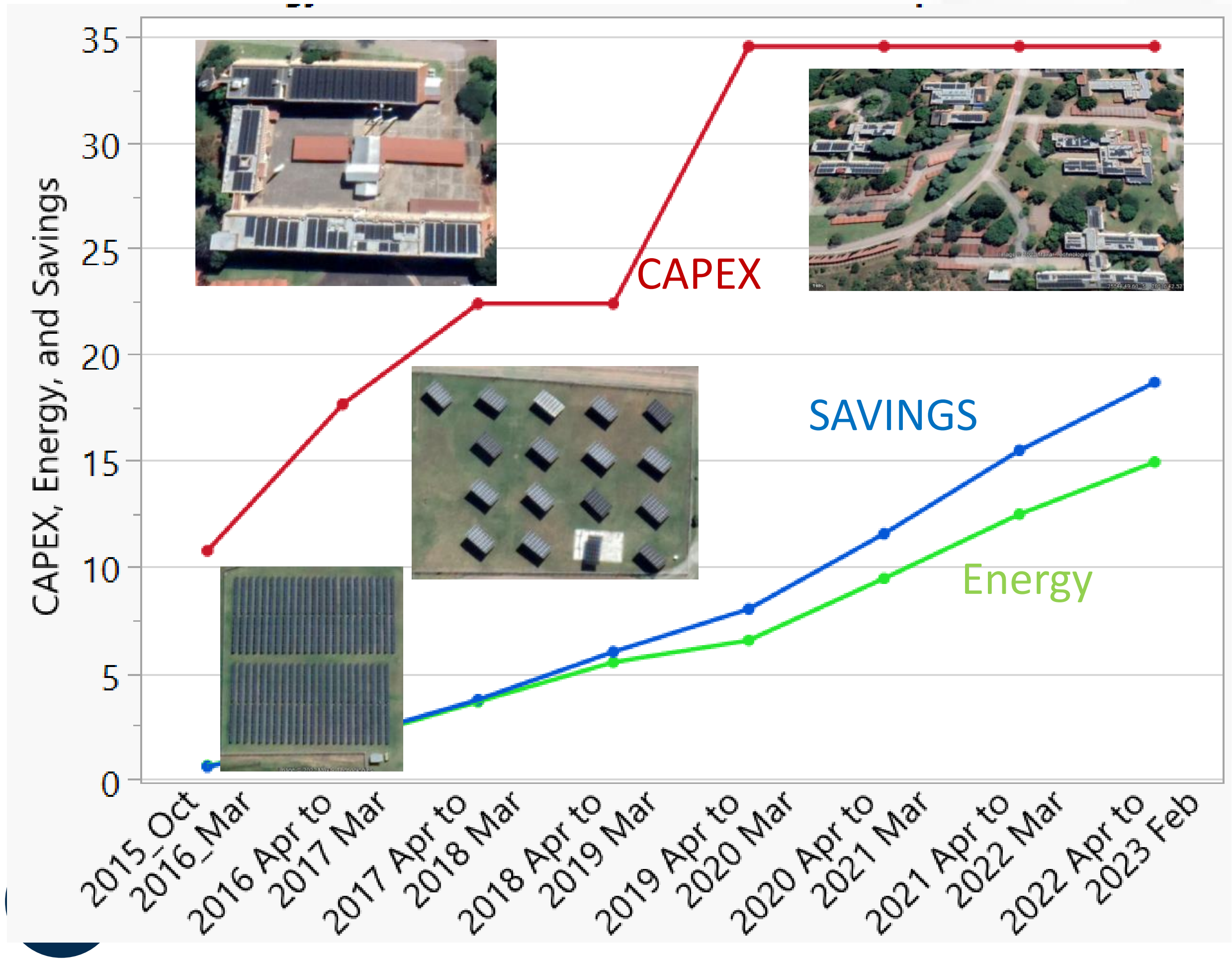
Historical generation and cost savings



1. R 34 million nominal spent on CAPEX
2. 14.9 GWh of electric energy generated
3. R 18.7 m in savings from reduced electricity bills through February 2023
4. 3.1 GWh of electric energy produced in the fiscal year 2021/22 (~15% of total)
5. Electric energy production will start to decline unless new capacity is added
6. OPEX costs ranged from 180 to 825 R / kW / year for the first three years of operation, approximately R 700k for the full fleet per year
7. No fuel costs

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Present focus on load-shedding resiliency at the CSIR

- Critical load assessments underway across the campus
- Convention diesel generator capacity assessment
- Proposals for PV + storage at the data center are in progress
- Considering options to add or re-purpose the existing PV generators for hybrid operation
- Modelling of load-shedding scenarios and solutions for external clients

Grid-tied PV generators are not operational during load-shedding

Load-shedding

Load shedding is a frequent problem in South Africa, causing disruptions to daily life, including academic institutions.

Universities are especially vulnerable to power outages as they require a stable and reliable source of energy for their academic and research activities.

Fortunately, alternative energy sources can be utilised to safeguard South African universities against load shedding.

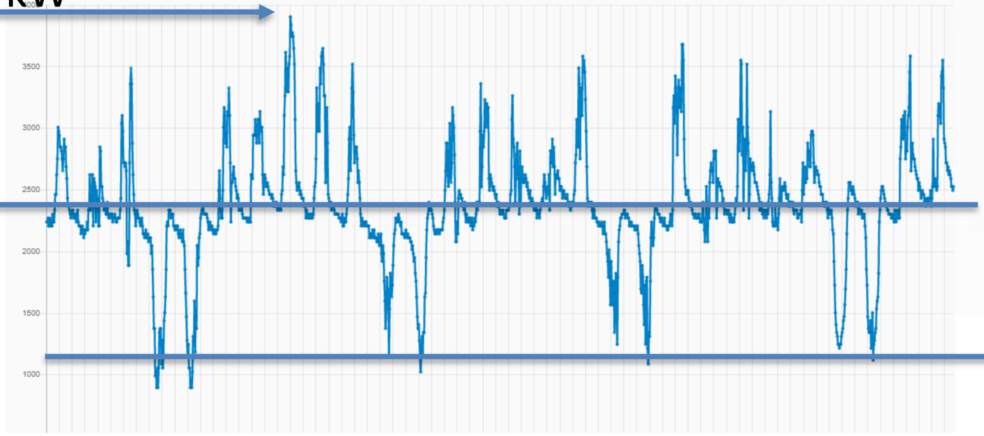
Short-term interventions and preparations to mitigate load-shedding (0-1 year)

- Energy audit to quantify baseline consumption and critical loads
- Implement a data monitoring system for energy consumption
- Conduct structural, electrical, geological, and environmental surveys to prepare for PV + storage solutions
- Procure multiple ‘plug and play’ battery/inverter trolleys to handle small but critical loads like lights and communications where applicable

CSIR electricity consumption from the grid over several weeks

Peak grid load = 4000 kW

Base load = 2400 kW



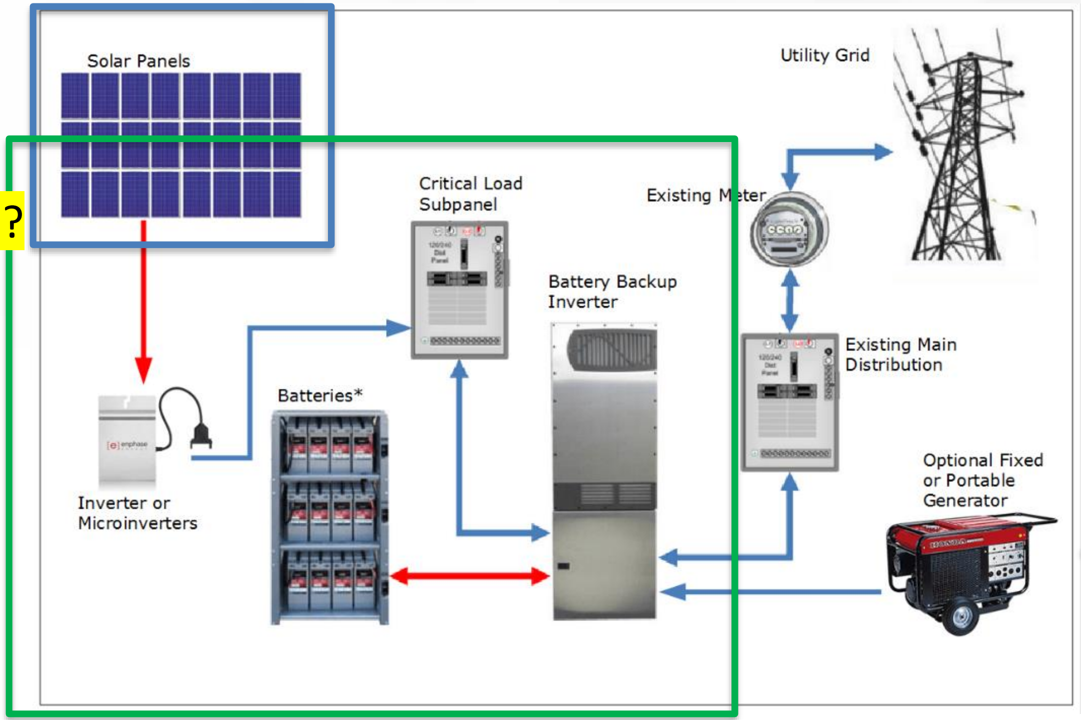
Reduced grid load due to PV generators

Understanding the load profile is essential for load-shedding and off-grid applications

Medium-term interventions to mitigate load-shedding (1-5 years)

1. Phase 1: Install hybrid battery/inverter systems designed with actual meter data and professional surveys as inputs (green square), including inputs for fossil-fuel generators
2. Phase 2: Connect the PV systems based on inputs from professional surveys to extend the load-shedding resiliency and reduce electricity consumption from the utility (blue square)

R 15-20k per kW DC for PV
R 15-20m per MW DC
What are current market prices?



https://floridasolardesigngroup.com/photovoltaic-solar-electric-systems-with-battery-backup/

R 5-8k per kWh DC for batteries
R 5-8m per MWh DC
What are current market prices?

Integrate existing generators for high demand, short-term usage

Hybrid energy systems deliver load-shedding resiliency

Building a hybrid energy system of PV Solar, diesel generators, and storage can be an effective solution to support critical loads during load shedding. By following key considerations and steps, you can design and implement a system that meets your energy needs and helps you achieve greater energy independence and efficiency.

It would cost approximately ZAR 3,520 to run a 1MVA generator at full load for an hour in South Africa, based on the above assumptions and fuel prices as of March 2023.

A solar PV generator + storage is expensive to buy and cheap to operate.

A fossil-fuel generator is cheap to buy and expensive to operate.

Long-term solution: Energy Management Framework

Developing an energy management framework to safeguard South African universities against load shedding would require a comprehensive approach that includes various aspects of energy management, such as energy efficiency, renewable energy, and energy conservation

- Energy Audit
- Energy Efficiency
- Renewable Energy
- Energy Conservation
- Load Shedding Protection
- Education and Awareness
- Monitoring and Evaluation

CSIR infrastructure and capabilities

1. Energy audits
2. Energy planning
3. PV procurement assistance for de-risking investments
4. Pre-feasibility studies for PV and PV + storage solutions
5. Techno-economic models for various scenarios and sensitivities
6. Quality and reliability testing for PV modules and batteries

Energy Audit

Gathering information: The university needs to gather data on energy usage, such as utility bills, equipment and building specifications, and occupancy schedules.

Identifying energy-saving opportunities: After gathering the necessary information, the university can identify areas where energy can be saved. This may involve identifying equipment or systems that are inefficient or wasteful, or areas where energy use could be reduced through behavior changes.

Assessing the costs and benefits of energy-saving measures: The university should evaluate the costs and benefits of each potential energy-saving measure. This includes calculating the initial investment, the expected savings in energy costs, and the payback period.

Developing a plan: Based on the results of the assessment, the university can develop a comprehensive energy management plan that outlines specific actions and timelines for implementing energy-saving measures.

Implementing the plan: The university can then implement the energy-saving measures identified in the plan. This may involve upgrading equipment, retrofitting buildings, or changing behavior and operating procedures.

Monitoring and evaluating the results: Finally, the university should monitor and evaluate the effectiveness of the energy-saving measures implemented. This will help identify any additional opportunities for improvement and ensure that the energy savings are sustained over time.

Energy planning and implementation

Phase 1: planning and project development

Step 1
Energy master plan

1-1	What mix of technologies to build
1-2	Timeline of deployment
1-3	Financing requirements and project returns
1-4	Projected emissions and impact on energy security

Step 2
Regulatory compliance

2-1	Ensure compliance is achieved with all regulatory requirements
2-2	Environmental impact assessments
2-3	Wheeling agreements if any
2-4	ESCO agreements with tenants

Step 3
Institutional and funding models

3-1	Conduct bankable project specific feasibility studies if necessary
3-2	Finalise business case
3-3	Determine the best model to finance the infrastructure
3-3	Achieve financial close

Phase 2: implementation and operation

Step 4
Procurement support

4-1	Procurement guideline that provides best practice
4-2	Assistance for tender evaluation (if needed)
4-3	Contracting support
4-4	Quality assurance and reliability testing

Step 5:
Operational support

5-1	Data monitoring and visualisation
5-2	Optimal operation and maintenance of the infrastructure
5-3	Model performance validation and refinement
5-4	Maintenance and additional features
5-5	Training and capacity building

Feedback loop

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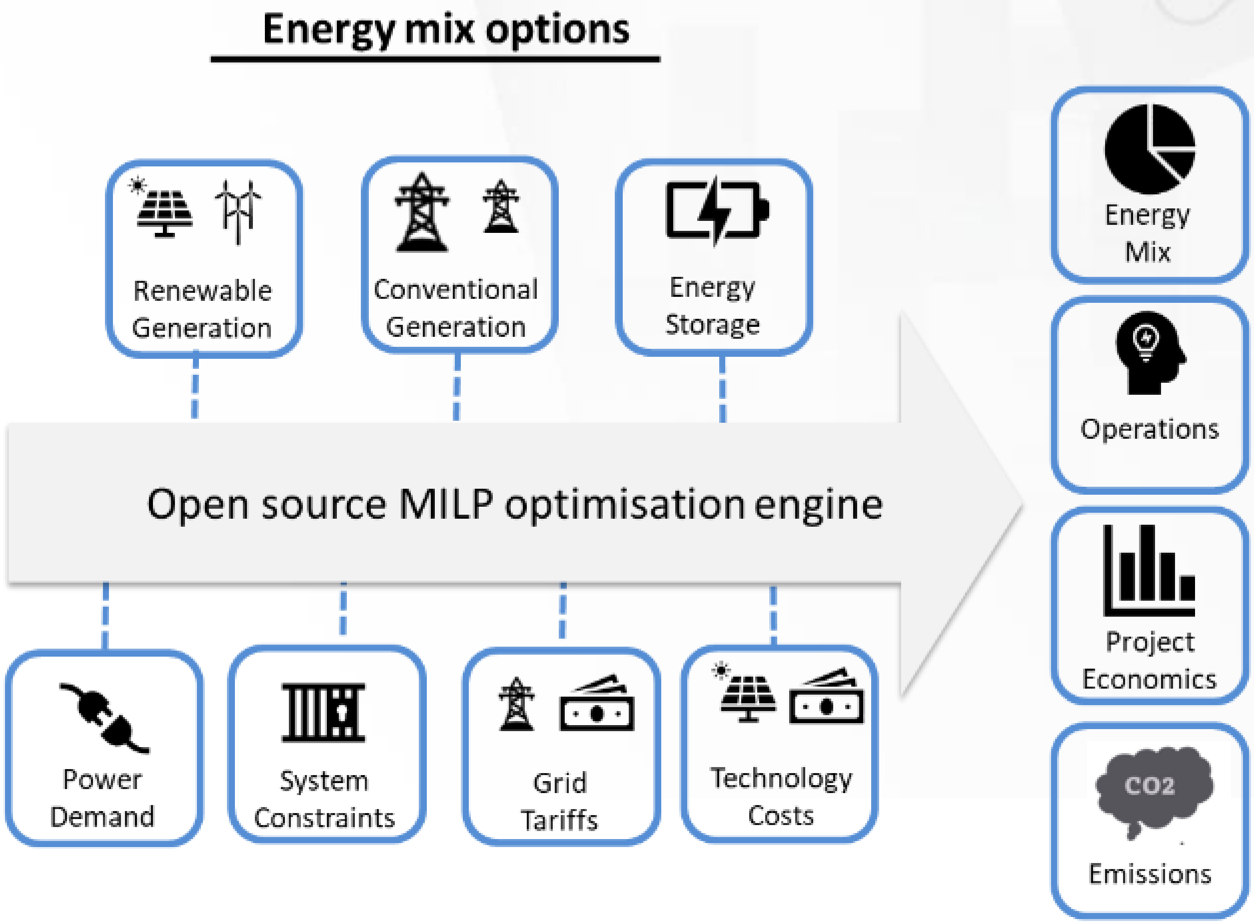
Optimizing the energy mix during Phase 1



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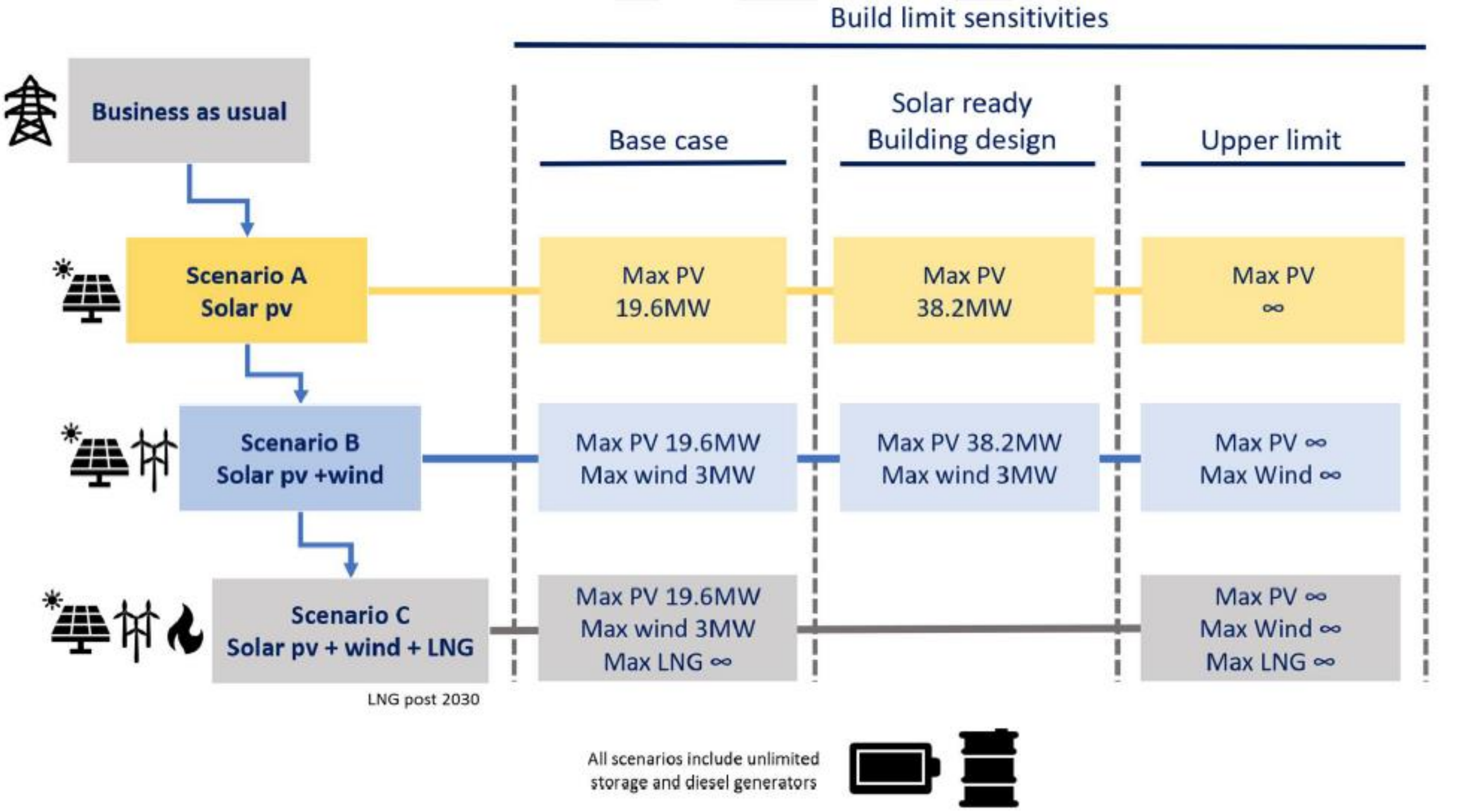
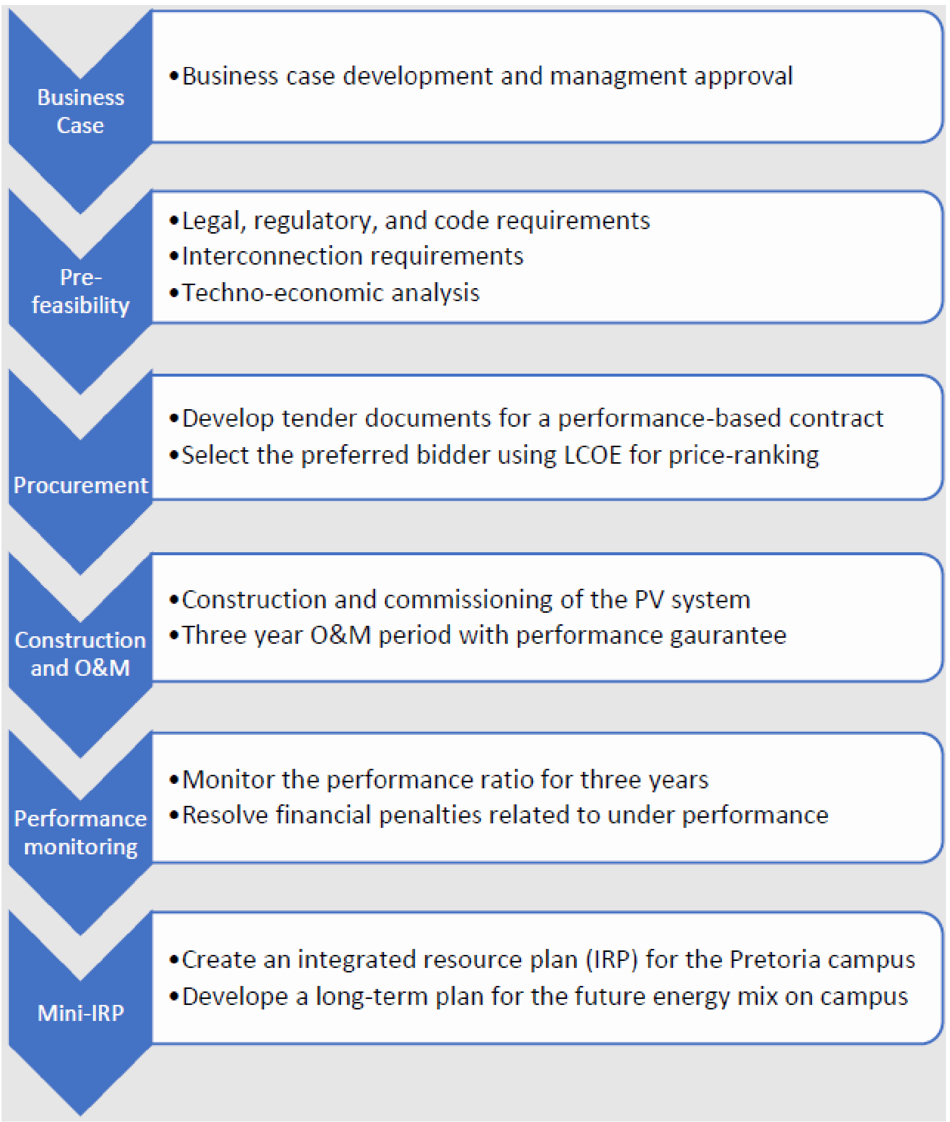
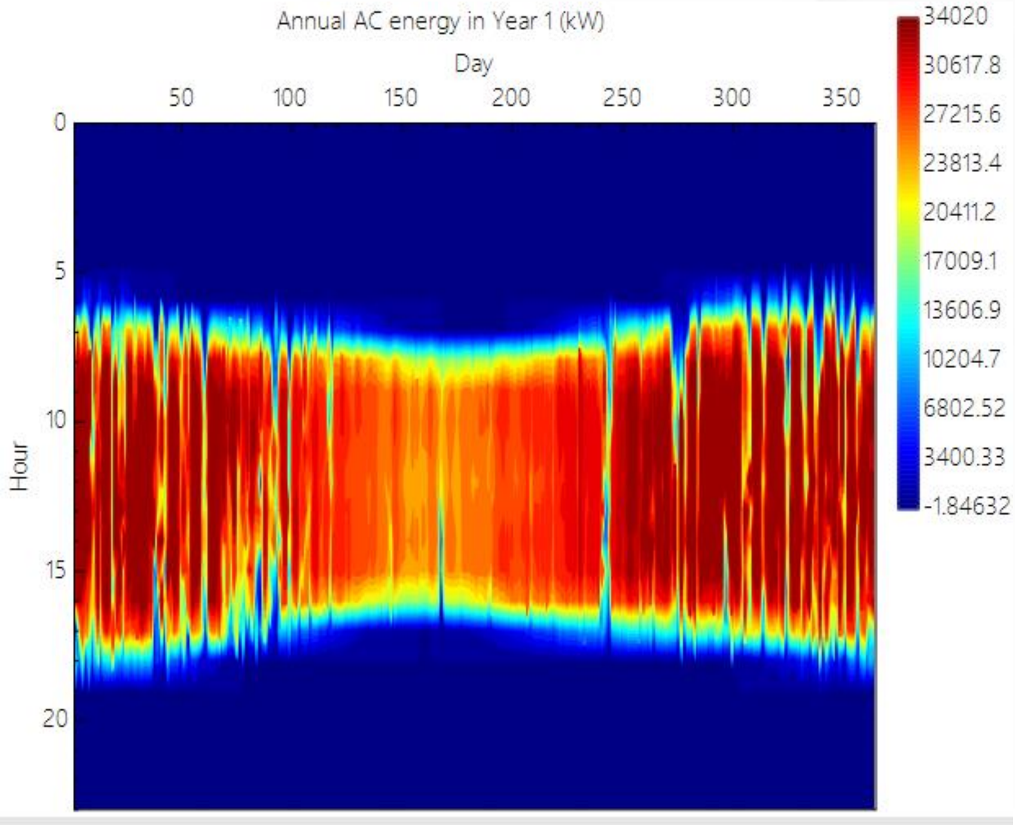
Scenarios and sensitivity planning during Phase 1

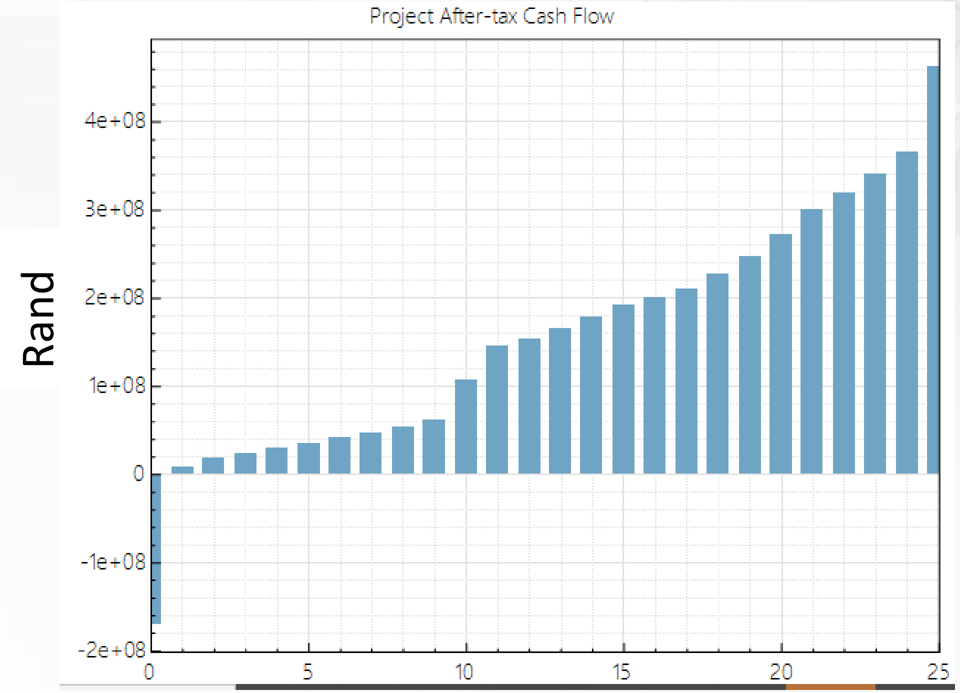


PV Procurement Guideline during Phase 2



Prefeasibility studies for specific projects





NREL NATIONAL RENEWABLE ENERGY LABORATORY System Advisor Model (SAM)

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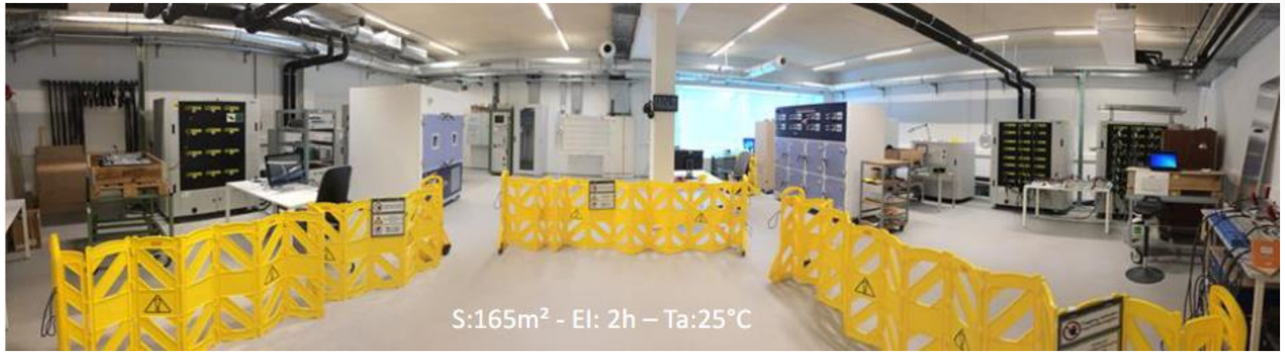
CSIR battery testing lab

Performance Testing, Validation

- Performance and reliability testing
- Battery calendar life
- Storage capacity
- Cycle life
- Depth of discharge
- Verification and validation
- Aged Battery services
- Battery Aftermarket services
- Post-mortem analysis (Part of root cause analysis)

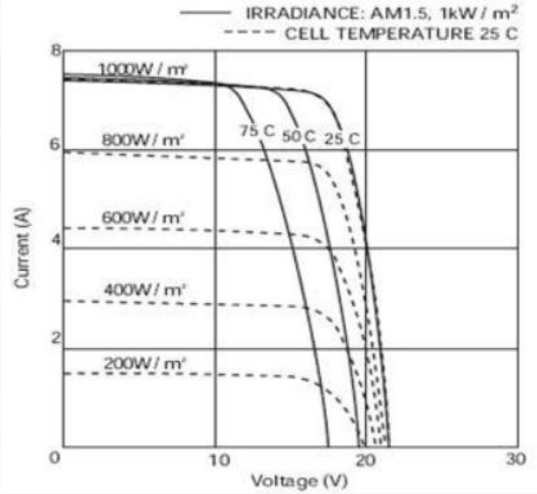


CSIR PV module quality and reliability lab

Thermal Cycling and Humidity Freeze with Power Supply Rack

Sun simulator with temperature chamber

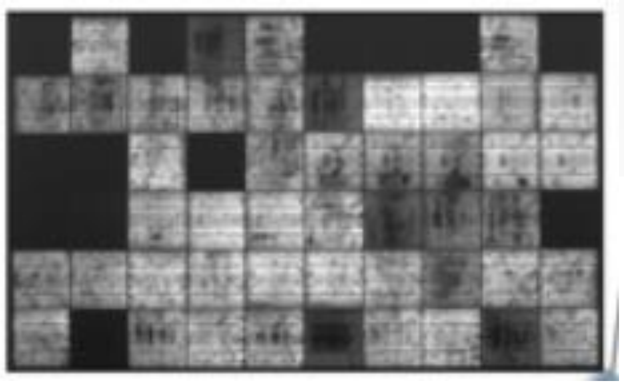
IV Curves



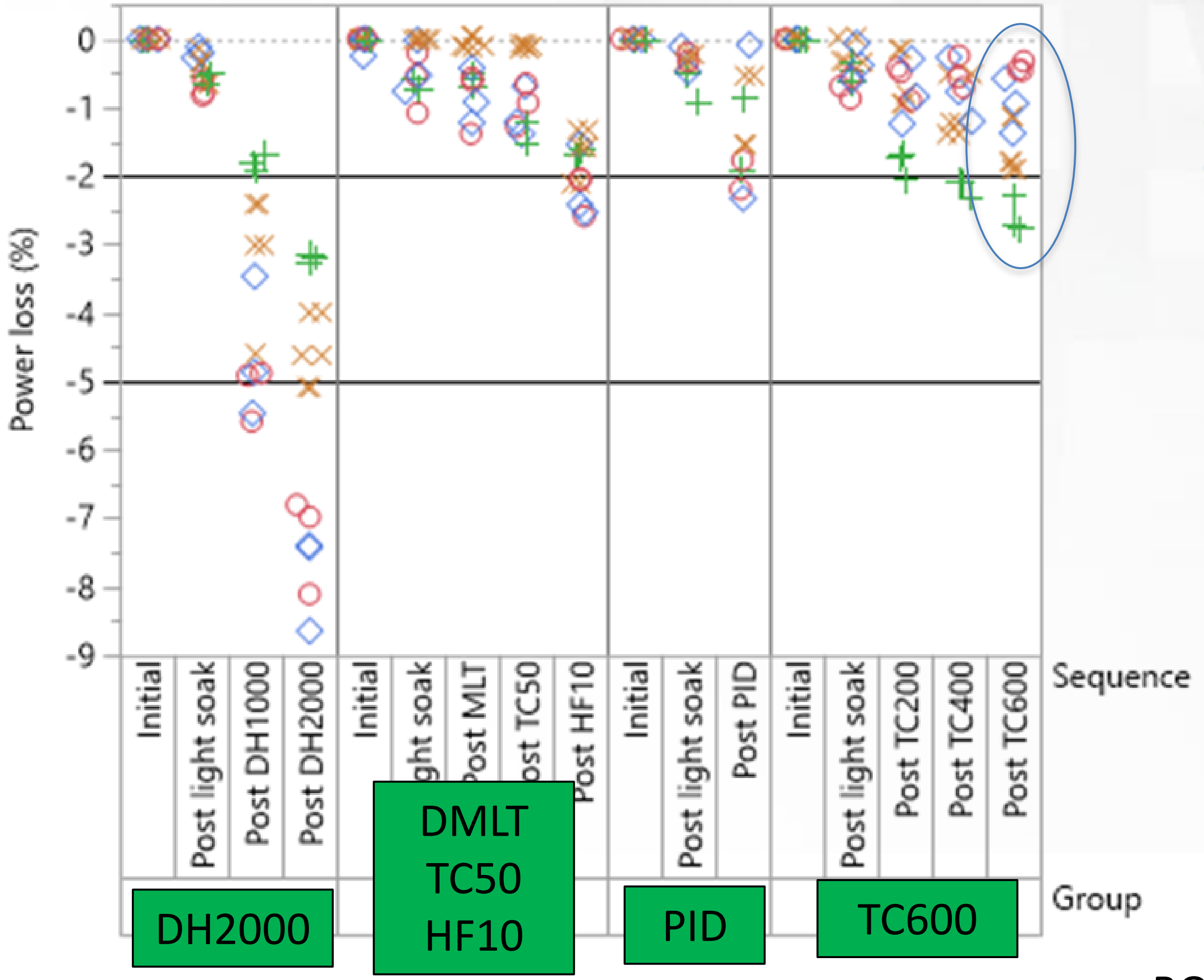
Damp Heat with PID Rack

Mechanical load tester

EL



Accelerated stress testing – results from PV lab
Electrical performance versus environmental stress



1. Four-month long sequence
2. Nearly all 'top performers', per PVEL terminology, for MLT, PID, and TC
3. Two module BOMs degraded by more than 5% after Damp Heat 2000 hours, but show significant recovery after IEC 61215-2 MQT 19.3
4. In less than 3 months, a clear difference emerges in reliability performance following TC600 (-0.5% versus -2.5%)

TC600 ≈ 600 diurnal cycles ≈ 1.6 years

BOM 1 (red) = **-0.3%/yr**

BOM 2 (green) = **-1.5%/yr**

Discussion

Thank you