Sembcorp Solar Presentation Slides

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DCPE/FT/3B/22

Introduction

My Aims:
What do I want out of the internship?

My aims for the internship are to:

- Learn about the general workplace culture, with a focus on Sembcorp Solar as a government-linked company
- Work with different people to improve my communication skills and build confidence
- Gain and improve my technical and practical skills and tools to add to my toolbox
- Test and apply what I've learned at school in a real-world setting
- Work on projects that have, or could have, a significant impact
- Explore and determine the type of career I want to pursue by experiencing the work life at a company like Sembcorp Solar

The Company, and Industry it is in

What does the company do?

Business Model

- **Renewable Energy Solutions:** Designs, installs, and manages solar PV systems
- **Power Purchase Agreements (PPA):** Provides fixed-rate electricity to customers, often without upfront costs
- **Project Development**: Offers end-to-end services from design to maintenance, including financing options

Culture

- **Innovation and Sustainability**: Focus on creative solutions for environmental responsibility
- **Collaboration:** Emphasises teamwork and cooperation between departments
- **Work-Life Balance:** Supports a flexible, relaxed, balanced work environment
- **Continuous Learning:** Professional development and growth opportunities

Competencies

- **Technical Expertise:** Proficient in solar energy systems
- **Customer-Centric Approach:** Tailored solutions and flexible financing for clients
- **Operational Excellence:** High standards in system operation and maintenance
- **Sustainability Focus:** Commitment to renewable energy practices and support of a low-carbon economy

What are typical career paths for employees?

Technical Roles:

- **Solar Engineer:** Designs and optimizes solar PV systems
- **Project Manager:** Manages solar projects from start to finish

Operations and Maintenance:

- **Operations Engineer:** Oversees solar system operations.
- **Maintenance Technician:** Maintains and repairs solar equipment

Finance and Administration:

- **Finance Analyst:** Manages budgeting and financial planning
- **Administrative Support:** Handles project documentation and coordination

Sustainability and Innovation:

- **Sustainability Specialist:** Enhances sustainability efforts
- **R&D Engineer:** Develops new solar technologies and innovations

Business Development and Sales:

- **Business Development Manager**: Finds and develops new business opportunities
- **Sales Engineer**: Provides technical solutions and closes sales

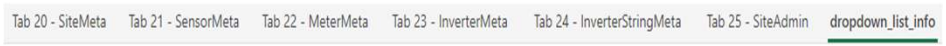
Tasks

As an intern within the OPM *(Operational Performance Maintenance)* department, I and my fellow interns oversaw these tasks...

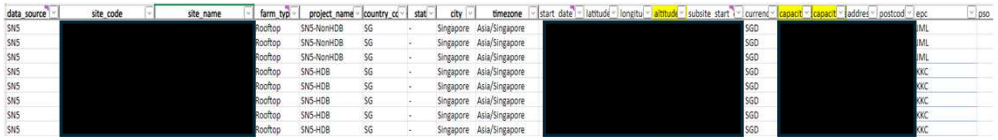
1. Manage data onboarding of solar sites
2. Assist in commissioning and maintaining sites
3. Pre-configure monitoring devices
4. Ensure proper organisation of routine data extraction
5. Daily tracking of offline comms for SN and/or C&I sites

1. Manage Data Onboarding of Solar Sites

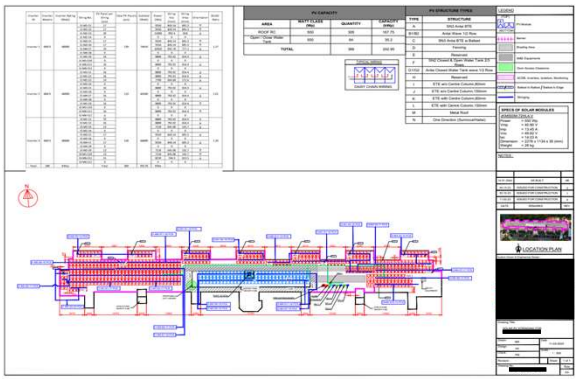
All the tabs in a pre-onboarding Excel template



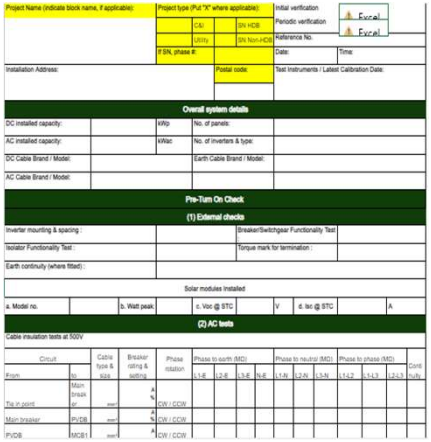
Example pre-onboarding Excel template with filled data columns (Tab 20)



This is done by filling out an Excel template with key solar site data *(e.g. site meta, sensor meta, meter data, and inverter and inverter string meta)*.



AB (As-Built)
>> Shows the exact, completed and finalised layout of a solar site

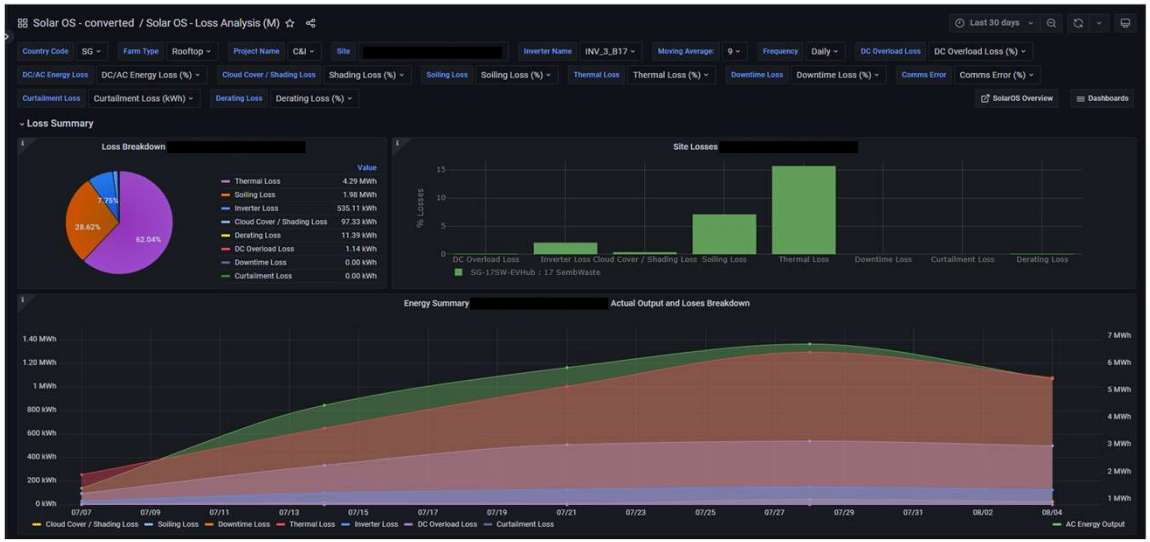


Industry Standard T&C (Testing&Commissioning) Template
>> Verifies all site components are tested and meet standards before system operation)

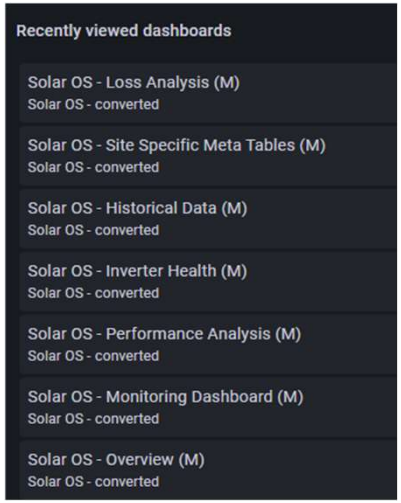
All this data is drawn from T&Cs and As-Built documents provided by EPC *(Engineering, Procurement, and Construction)* companies that commission said solar sites.

The data will be uploaded to SolarOS, an in-house data analytics dashboard, which simplifies accessing and analysing information for any solar site operated by Sembcorp.

Loss Analysis Dashboard

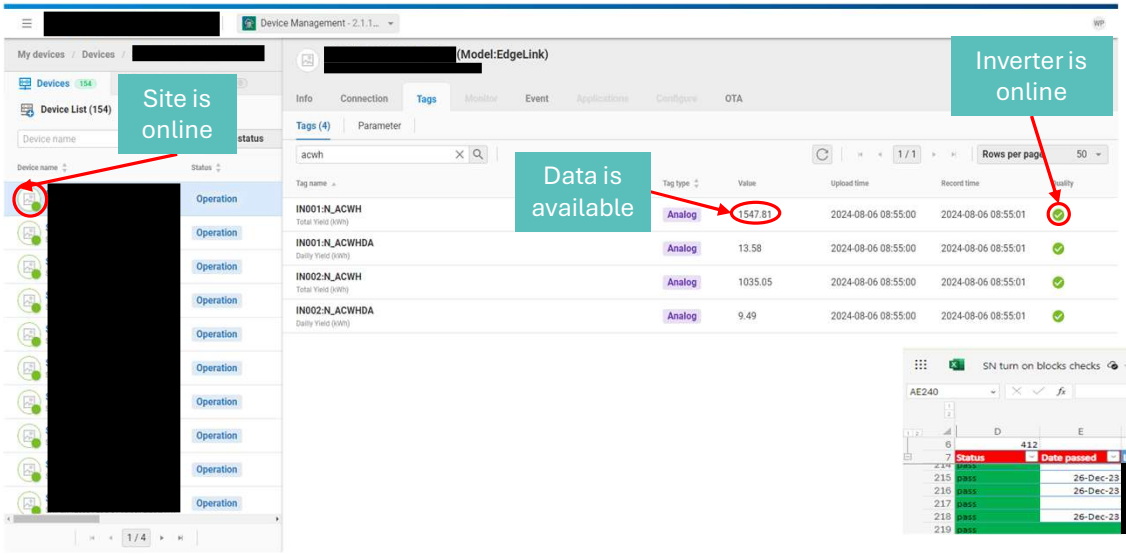


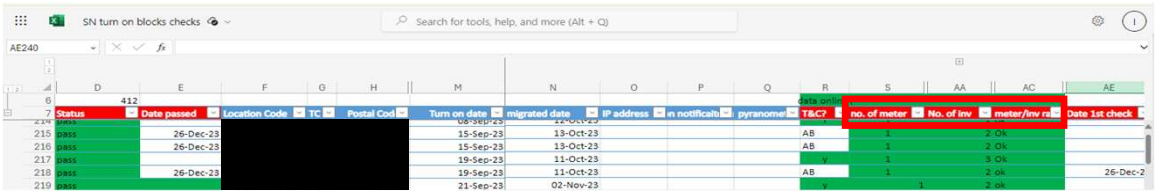
Example dashboards



Once onboarded, employees can easily view various dashboards in SolarOS for data analysis purposes. Some of which include loss analysis, site-specific metadata, and more.

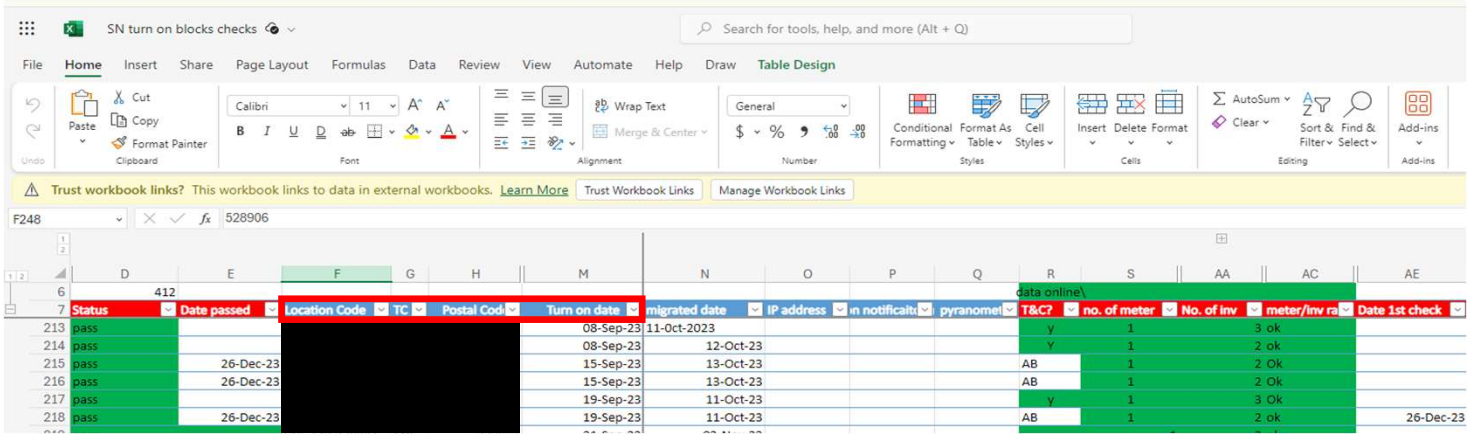
2. Assist in Commissioning and Maintaining Sites

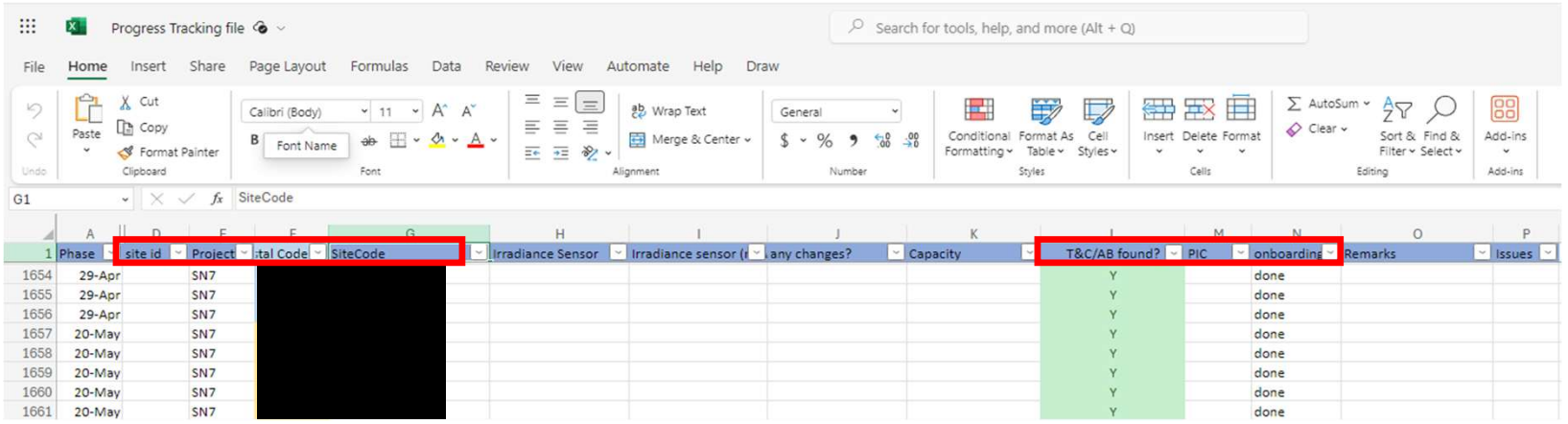




Verify site turn-on checks *(i.e. confirm that solar sites, inverters, and meters are online, and that their respective data is available)*.

Later, note down in Excel tracker whether the site, inverter(s), meter(s) have passed the check.

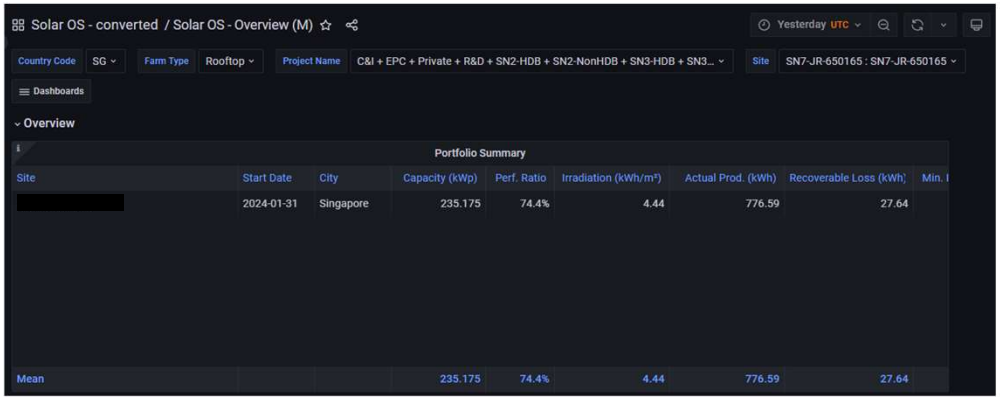




Update Excel trackers for newly turn-on sites and onboarding progress respectively.

SN	Scenario	What to check	Pass or Fail, Remarks
1	**Overview Page**	Go to overview page: • Check if all the sites are available in the 'Portfolio Summary' • Conduct sanity check on the parameters available: o Start Date o Capacity o PR o Irradiation o Actual Production	[redacted]: PR: 77.8% [incorrect data] vs 73.5% [correct] Actual Prod: 378.58 kWh [incorrect data] vs 357.6 kWh Irradiation: 6.04 kWh/m2 [incorrect data] vs 5.93 kWh/m2 

Example of a UAT



Example of a SolarOS Dashboard to check for UAT

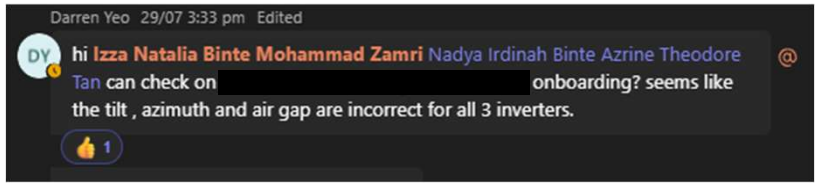
Loss Analysis – Loss Summary	Site checked: Go to Loss Analysis – Loss Summary Page: • Confirm that the data visualization format is correct.

Performance Analysis – Performance Ratio & Specific Yield	Site checked: Go to Performance Analysis – Performance Ratio & Specific Yield: • Confirm that the data visualization format is correct.

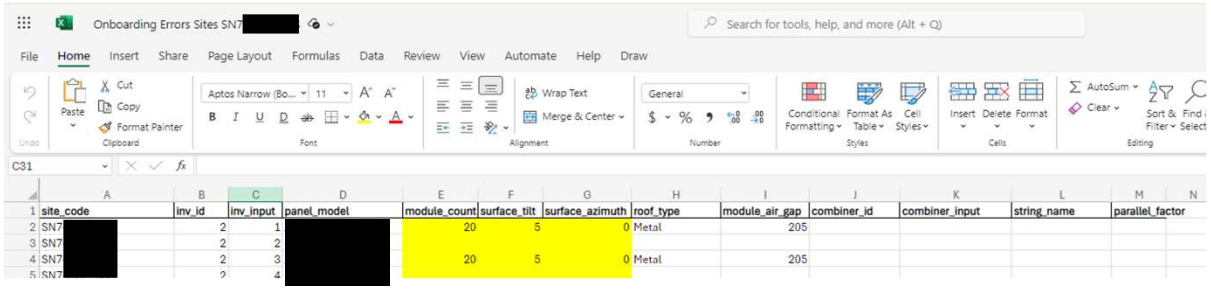
Examples of Different Dashboards to Check

Conduct User Acceptance Testing *(UAT)* to confirm the accuracy of data onboarded onto SolarOS via checking certain dashboards.

Error found in SolarOS

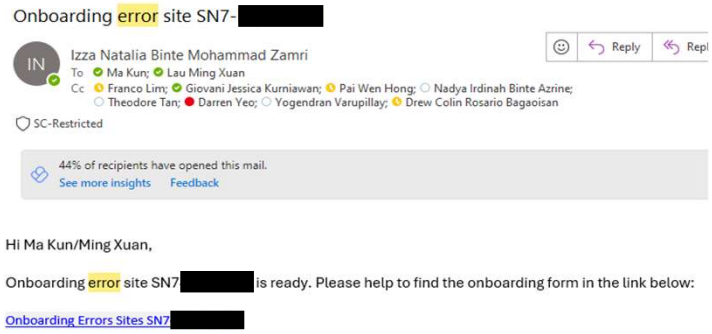


Excel sheet created to fix the onboarding error (Fixing the inverter and/or inverter strings of a site)



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	site_code	inv_id	inv_input	panel_model	module_count	surface_tilt	surface_azimuth	roof_type	module_air_gap	combiner_id	combiner_input	string_name	parallel_factor	
2	SN7[redacted]	2	1	[redacted]	20	5	0	Metal	205					
3	SN7[redacted]	2	2											
4	SN7[redacted]	2	3		20	5	0	Metal	205					
5	SN7[redacted]	2	4											

Email sent to PIC of onboarding the data to SolarOS



Create Onboarding Error Sites Excel to fix any errors with onboarding when checking SolarOS.

3. Pre-configure Monitoring Devices

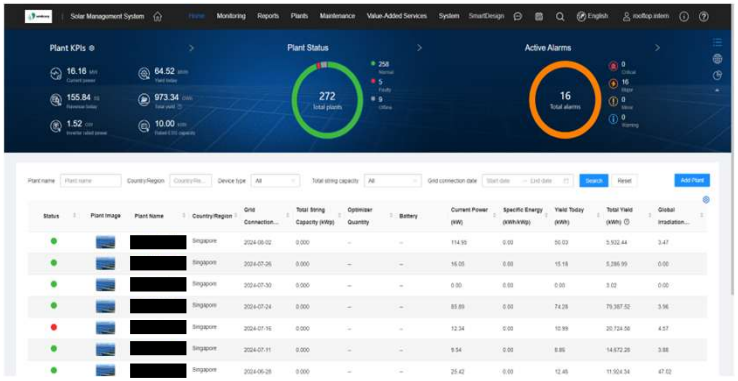
Pyranometer (Irradiance Sensor)

Smartlogger

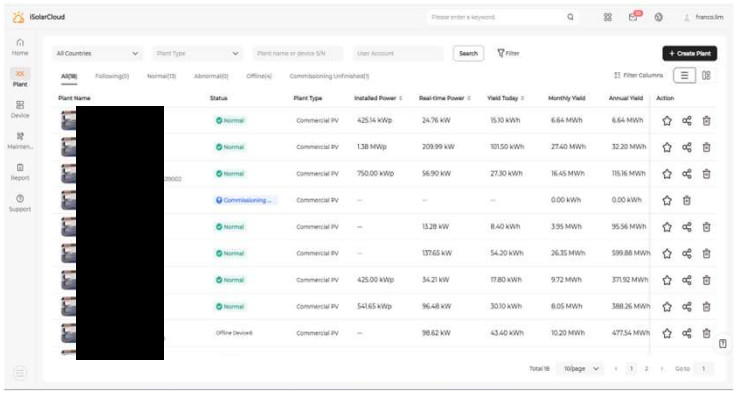
(Monitors and manages performance of solar PV systems)

Temperature Sensors (Module and Ambient)

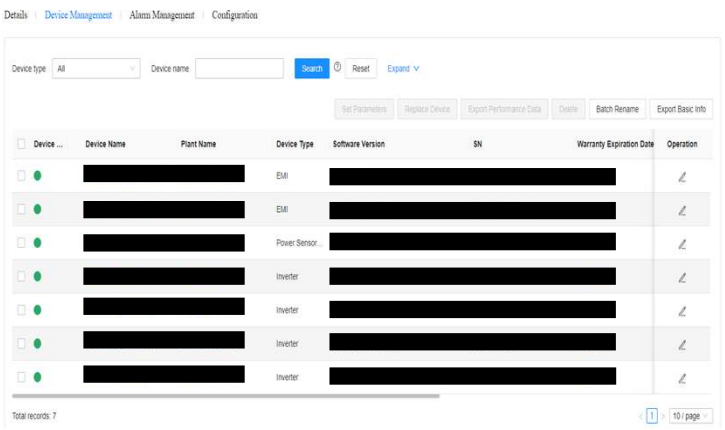
FusionSolar (Developed by Huawei) – All Plant Sites



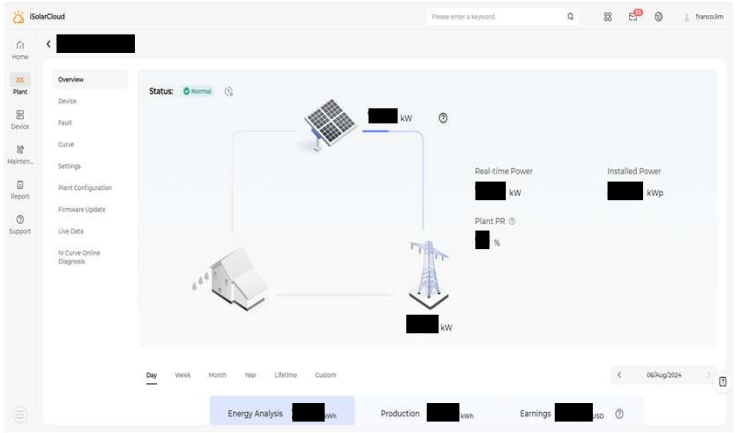
iSolarCloud (Developed by Sungrow) – All Plant Sites



One Site's Devices (e.g. Inverters, Meters etc.)



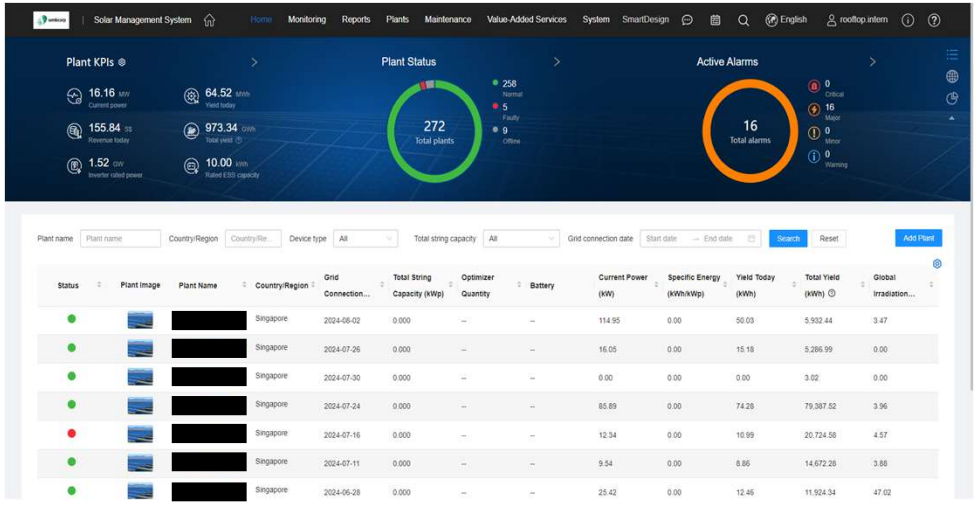
One Site's Overview



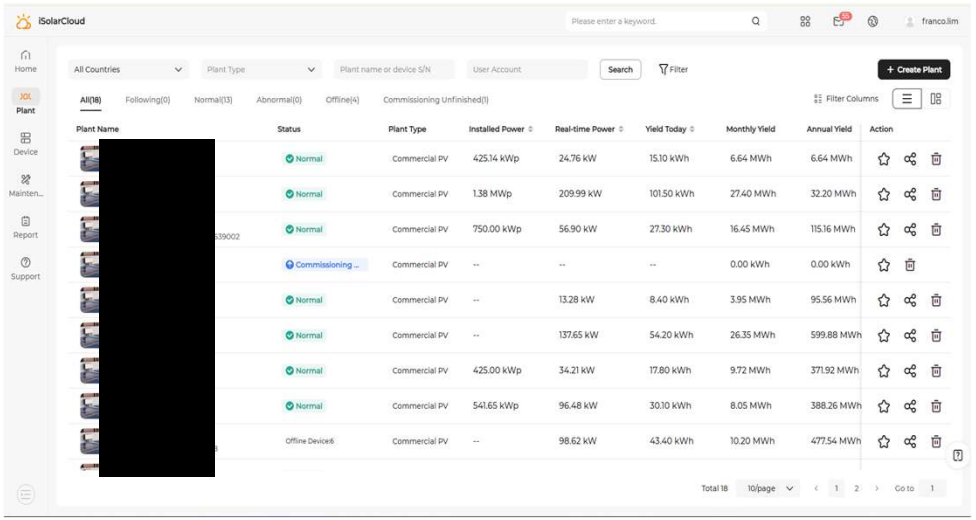
I connect these devices to Original Equipment Manufacturer *(OEM)* platforms such as FusionSolar and iSolarCloud for site asset monitoring.

4. Ensure Proper Organisation of Routine Data Extraction

FusionSolar (Developed by Huawei) – All Plant Sites



iSolarCloud (Developed by Sungrow) – All Plant Sites



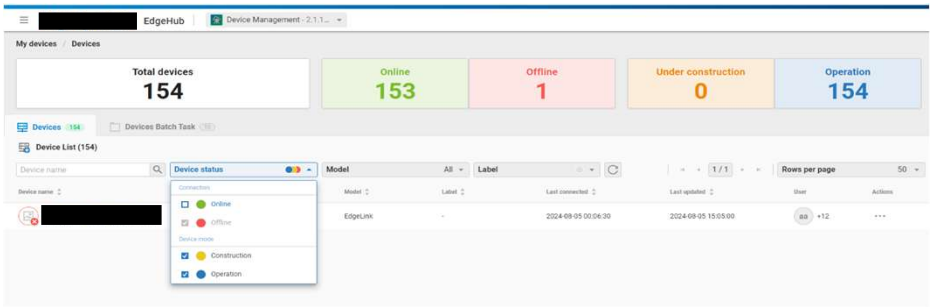
Extract/Query data from different OEM platforms or databases for monitoring, reporting and analysis.

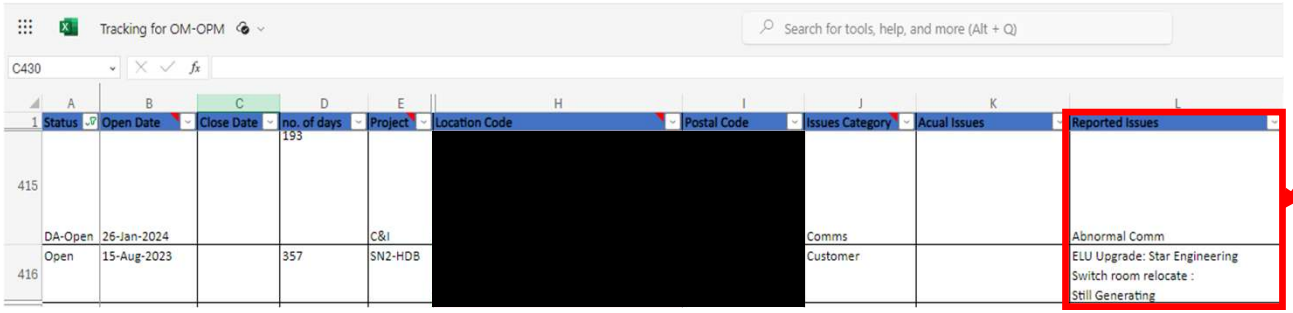
5. Daily Tracking of Offline Communication for SN and C&I Sites

Yesterday's CAR (Corrective Action Recommendations) site cases, categorised by site comms down

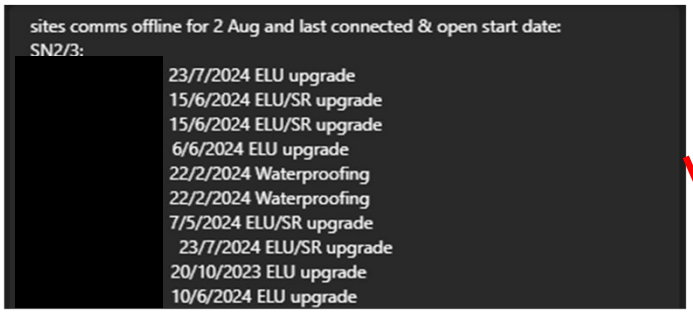
Loggin	Site	Case N	Categc	Type	Site & Scope	Inv Name	Trigger	Open Start Date
5/8/2024	[redacted]	S2150D20	Reliabilit	Site Communication D	Entire Site		All devices got missing data	23/7/2024
5/8/2024		S2151D20	Reliabilit	Site Communication D	Entire Site		All devices got missing data	15/6/2024

These are the sources where I find out the sites that have offline comms.





Reference any previously reported issues in the 'OM-OPM Tracking' Excel sheet that might explain offline communication problems.



Submit a daily list of these sites, their recently connected/open start date and the reasons that might explain their offline comms to the "Tracking Offline Comms" group chat.

This is so that other employees can directly address these issues with these sites with Mirai and other relevant systems.

My CDIO Project

Inverter Loss Analysis

SYNOPSIS

This project analyzes inverter losses at solar sites to identify root causes, providing evidence and informing strategies to reduce these losses across sites.

CONCEIVE

To provide the company with analysis to identify root causes of inverter loss and offer insights for developing solutions to reduce these issues.

DESIGN

Software: Azure Data Explorer (ADX), Microsoft Excel and Powerpoint, Jupyter Notebook, SolarOS

IMPLEMENT

Research and Data Collection

Data Organization/Cleaning/Prepping etc. and Analysis

OPERATE

Analysis pending further actions taken

Name of Student: Izza Natalia

Course and Class: DCPE/FT/3B/02

SP Liaison Officer's Name: Mr Benjamin Lee

Company Liaison Officer Name: Ms Pai Wen Hong

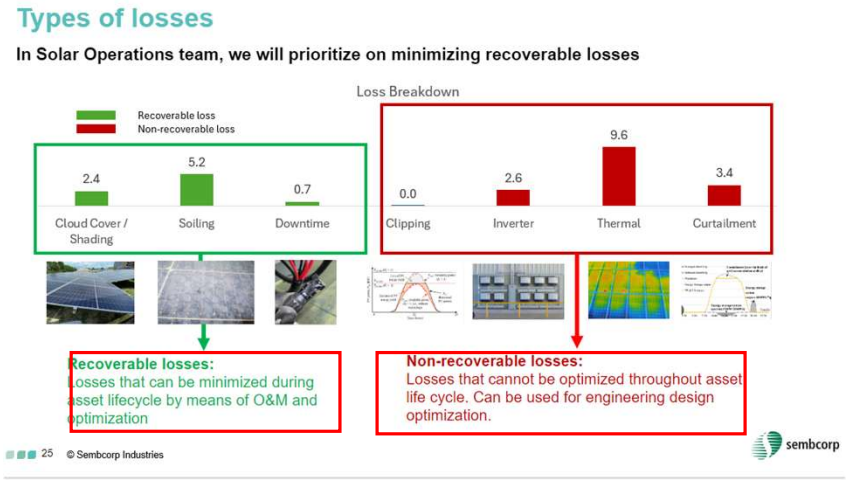
Conceive!

What are the users' needs?

- Provide insightful analysis to understand inverter loss root causes
- Offer information on root causes to develop effective solutions/strategies to reduce inverter loss issues

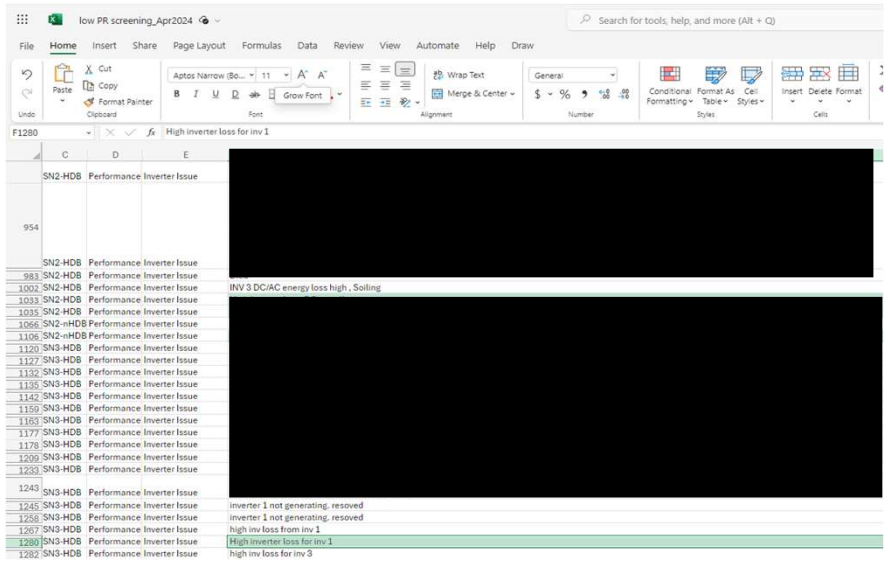
What features will help meet these needs to achieve the functional goals of the project?

- Data analysis tools to detect patterns and root causes of inverter loss
- Interactive visualisations *(graphs, charts, dashboards)* for data interpretation
- Correlation of inverter loss patterns to assess their impact
- Trend analysis to identify anomalies in inverter performance
- Later sharing data, code, and raw materials used on Sembcorp's SharePoint for other employees' use

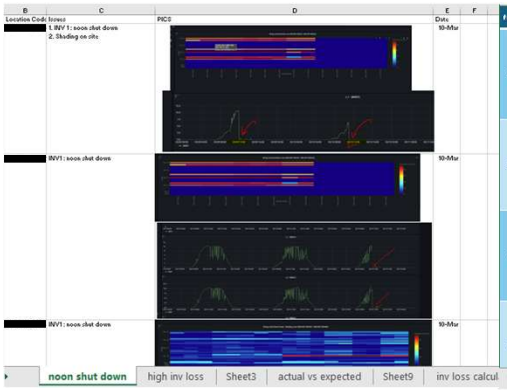


Found in SolarOS training powerpoint by Sembcorp

We began by analyzing various types of non-recoverable losses across our sites.



Each month, we reviewed the 'low PR screening,' identifying inverter loss as a key non-recoverable factor contributing to low Performance Ratio (PR) at the sites.



Sites that experience inv shutdown during noon

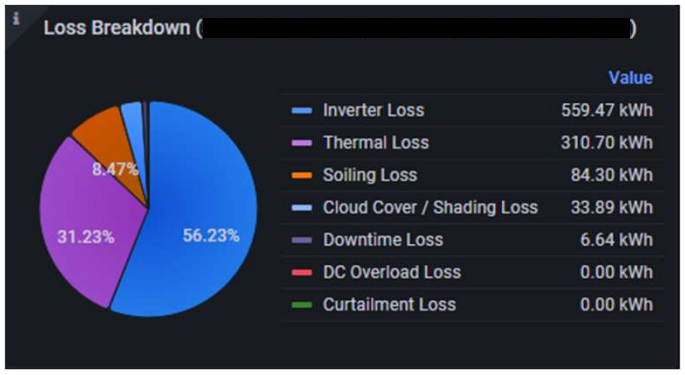
High inverter loss of certain sites (via SolarOS)

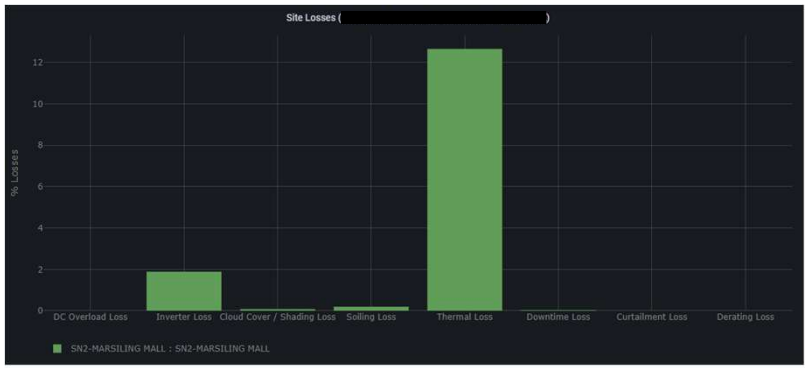
Excel created by RO that lists out project's layout

Project 3 :	Non-recoverable inverter loss improvement			find out the reason for high non-recoverable inverter losses	
Objective :	find out reason for non-high recoverable inverter losses and find measures to reduce recoverable inverter losses				
	- nature of inverters - SolarOS >> Losses				
Scope :	- solar sites				
Internship p	11Mar-8Aug				

Tasks/ Description	Start Date	End Date	Duration	Remarks	Actions
1. Setting Objective : 2. Scope 3. Timeline 4. R & R / Stakeholders	18-Mar	05-Apr	3 weeks	1. Objectives: find out reason for non-high recoverable inverter losses and find measures to reduce recoverable inverter losses 2. Scope: C&I, SN, Rooftype (Metal & RC) , Brand (Huawei, Sungrow) , Model () , Data (ADX) 3. Stakeholders (GD, Procure, Supplier & OM)	1. Model for different asset (PIC : Izza) 2.

Recognizing the impact of inverter loss, we decided to focus our efforts on understanding this issue to improve the overall efficiency of our solar sites.





Design!

Choice of hardware and/or software, including standards

- Azure Data Explorer *(ADX)*
- Microsoft Excel
- Microsoft Powerpoint
- Jupyter Notebook
- SolarOS

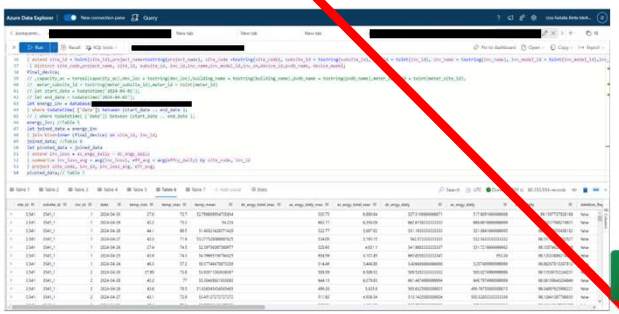
Systems Integration (How does the above work together?)

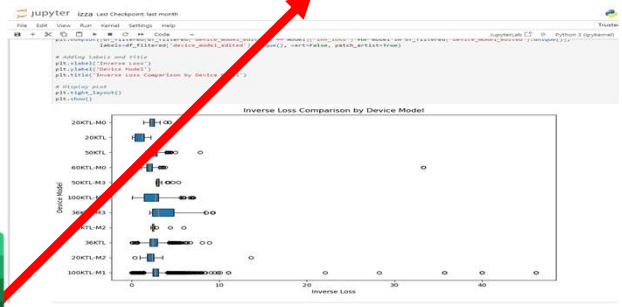
- **Azure Data Explorer:** Retrieves raw data from solar sites, keeping in mind relevant parameters for my project
- **Microsoft Excel:** Cleans, structure, and prepare raw data from Azure Data Explorer
- **SolarOS:** Provides real-time data visualizations from its dashboards when Azure Data Explorer data is unavailable
- **Jupyter Notebook:** Uses Excel's pre-processed data for in-depth analysis, using Python scripts to generate custom visualisations and conduct data analysis on inverter loss
- **Microsoft PowerPoint:** Consolidates all the analysis and graphs into a cohesive report presentation, incorporating data visualizations and insights from Jupyter Notebook and SolarOS

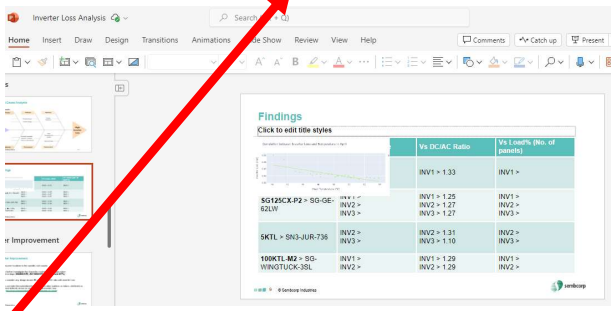
Azure Data Explorer

Jupyter Notebook

Microsoft Powerpoint







Microsoft Excel

SolarOS

Implement!

List of activities carried out in implement stage

1. **Research:**
   - Conducted detailed research on inverter specifications and performance by reviewing datasheets
   - Retrieved raw data from Azure Data Explorer and began data extraction

2. **Data Collection:**
   - Collected solar site data for the entire month of April (1 April to 30 April)
   - Focusing on parameters such as AC energy, DC energy, inverter loss, efficiency, site code, and device model for initial investigation
   - Began data extraction of specified raw data from Azure Data Explorer

3. **Data Preparation:**
   - Organised and cleaned data in Microsoft Excel, including creating new parameters and equations for analysis
   - Generated initial graphs to validate data accuracy and filter out anomalies

4. **Data Filtering and Processing:**
   - Wrote Python scripts to exclude abnormal inverter loss peaks and refine the dataset
   - Set lower and upper boundaries to identify outliers *(i.e., inverters with significantly higher or lower losses compared to their usual/mean)*
   - Identified the top 4 inverter models with the highest percentage of outliers, focusing on models with the most inconsistent and extreme inverter loss values
   - Investigated potential inverter issues based on the outlier data
   - Identified sites where these top 4 inverter models showed the highest percentage of outliers

5. **Data Analysis**
   - Applied research-based analysis techniques and visualization methods to these chosen inverter models and their respective sites

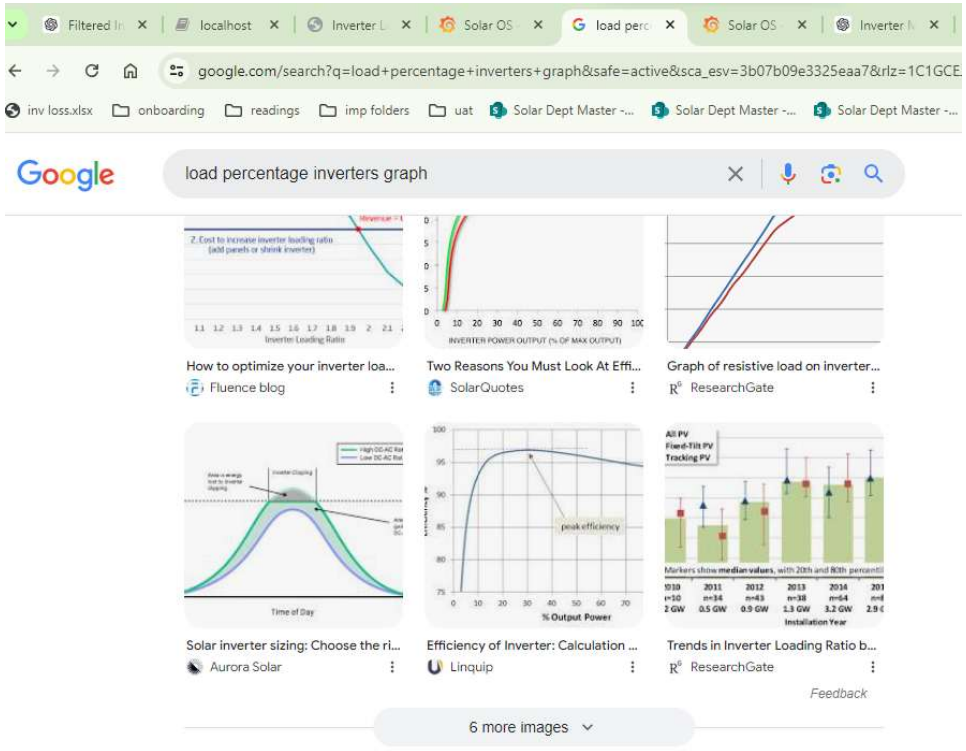
6. **Integration of Additional Data:**
    - Used SolarOS to supplement data with real-time performance insights and granular details not available in Azure Data Explorer

7. **Visualization Creation:**
    - Developed custom visualizations, charts, and graphs in Jupyter Notebook to analyze inverter performance

8. **Reporting and Presentation Preparation:**
    - Created a PowerPoint presentation consolidating analysis findings and visualizations
    - Reviewed and refined the presentation based on feedback from Reporting Officer and OPM employees

8. **Feedback and Iteration:**
    - Incorporated feedback to improve clarity, effectiveness, and detail in both analysis and PowerPoint presentation

Research


Filtered In
localhost
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Solar OS
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google.com/search?q=load+percentage+inverters+graph&safe=active&sca_esv=3b07b09e3325eaa7&rlz=1C1GCE
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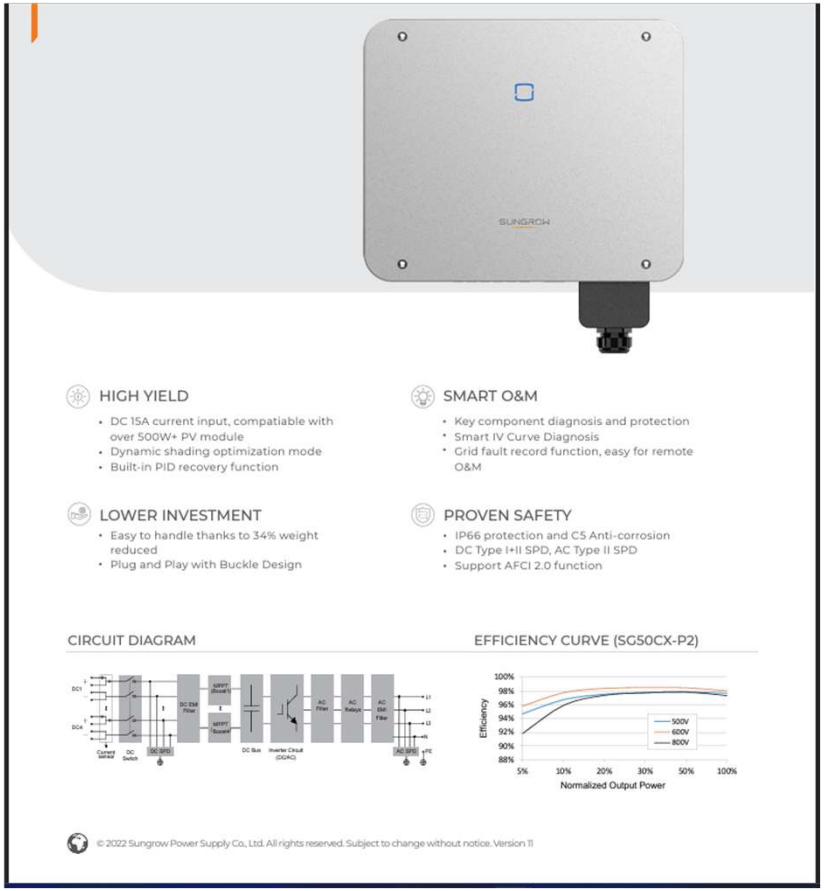
How to optimize your inverter loa...
Fluence blog
Two Reasons You Must Look At Effi...
SolarQuotes
Graph of resistive load on inverter...
ResearchGate
Solar inverter sizing: Choose the ri...
Aurora Solar
Efficiency of Inverter: Calculation ...
Linquip
Trends in Inverter Loading Ratio b...
ResearchGate
Feedback
6 more images


HIGH YIELD
DC 15A current input, compatiable with over 500W+ PV module
Dynamic shading optimization mode
Built-in PID recovery function
SMART O&M
Key component diagnosis and protection
Smart IV Curve Diagnosis
Grid fault record function, easy for remote O&M
LOWER INVESTMENT
Easy to handle thanks to 34% weight reduced
Plug and Play with Buckle Design
PROVEN SAFETY
IP66 protection and C5 Anti-corrosion
DC Type I+II SPD, AC Type II SPD
Support AFCI 2.0 function
CIRCUIT DIAGRAM
EFFICIENCY CURVE (SG50CX-P2)
Normalized Output Power
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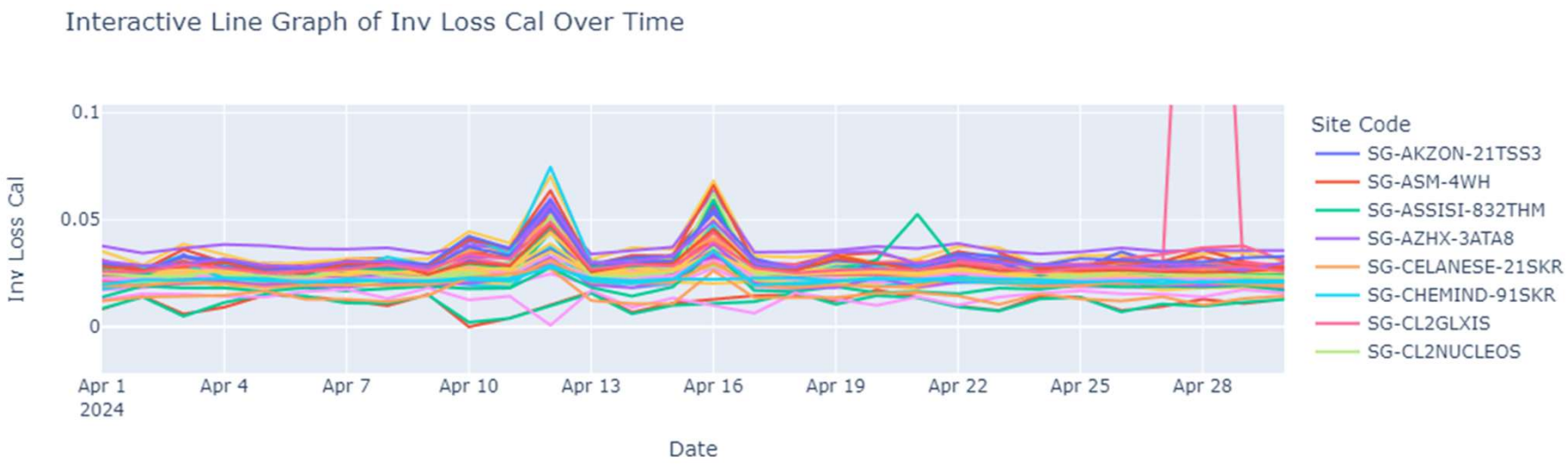
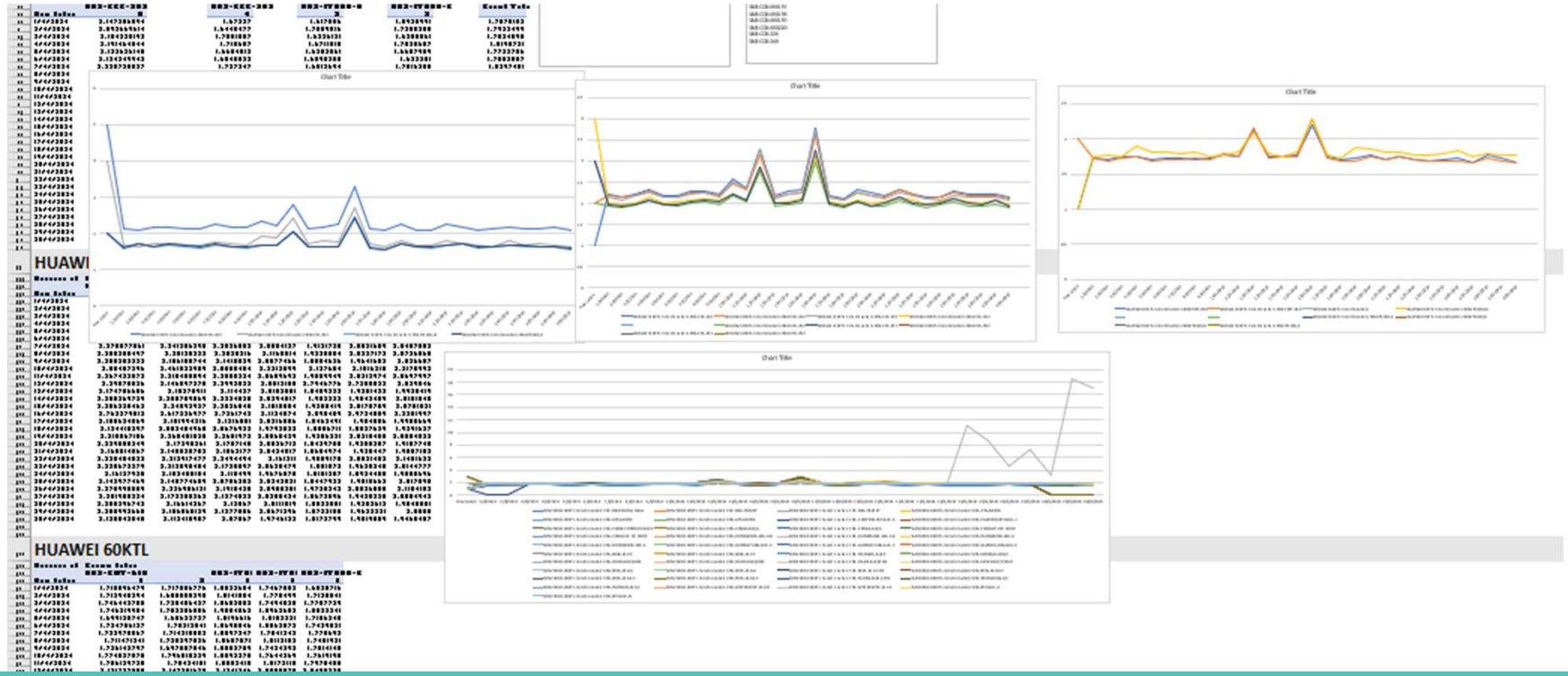
Data Collection

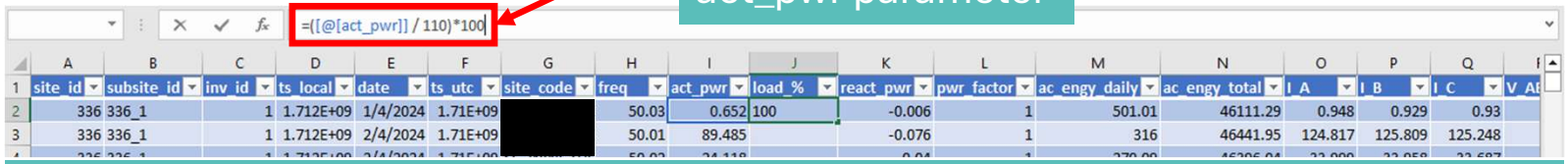


Data Preparation



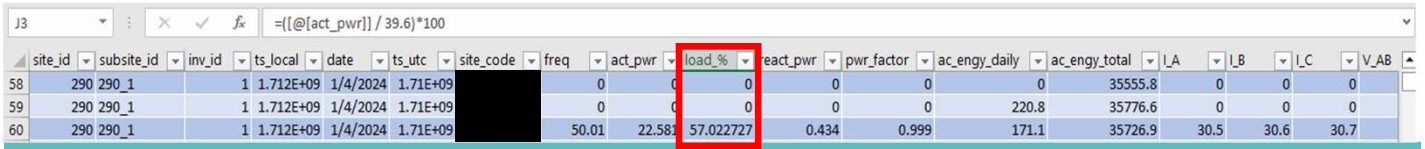
To ensure the accuracy of raw data, I generated initial graphs to test and validate it, checking for any anomalies before moving on to more in-depth analysis in Jupyter Notebook.

Creating Load% parameter from act_pwr parameter



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	site_id	subsite_id	inv_id	ts_local	date	ts_utc	site_code	freq	act_pwr	load_%	react_pwr	pwr_factor	ac_engy_daily	ac_engy_total	I_A	I_B	I_C	V_AB
2	336	336_1	1	1.712E+09	1/4/2024	1.71E+09	[redacted]	50.03	0.652	100	-0.006	1	501.01	46111.29	0.948	0.929	0.93	
3	336	336_1	1	1.712E+09	2/4/2024	1.71E+09		50.01	89.485		-0.076	1	316	46441.95	124.817	125.809	125.248	

Creating equations in Excel to calculate new parameters from raw data for data analysis.

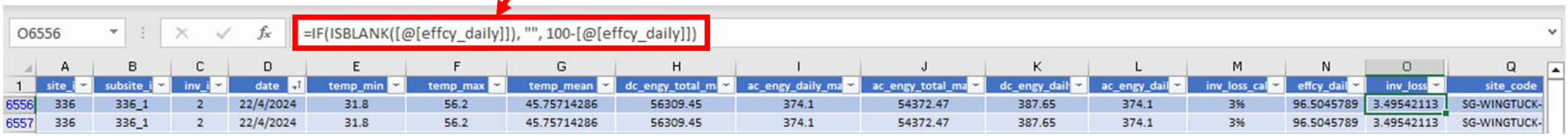


	site_id	subsite_id	inv_id	ts_local	date	ts_utc	site_code	freq	act_pwr	load_%	react_pwr	pwr_factor	ac_engy_daily	ac_engy_total	I_A	I_B	I_C	V_AB
58	290	290_1	1	1.712E+09	1/4/2024	1.71E+09	[redacted]	0	0	0	0	0	0	35555.8	0	0	0	
59	290	290_1	1	1.712E+09	1/4/2024	1.71E+09		0	0	0	0	0	220.8	35776.6	0	0	0	
60	290	290_1	1	1.712E+09	1/4/2024	1.71E+09		50.01	22.581	57.022727	0.434	0.999	171.1	35726.9	30.5	30.6	30.7	

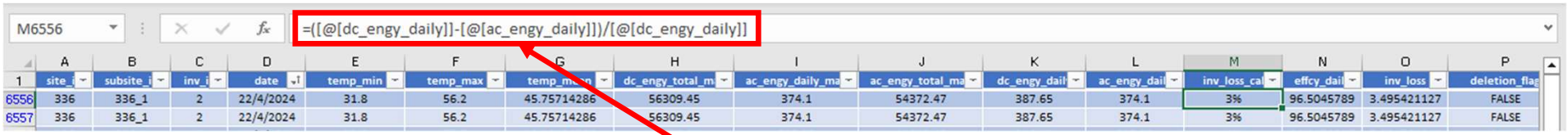
Parameter calculated.

More examples of parameters being created from raw data's original parameters:

Creating inv_loss parameter from effcy_daily parameter



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Q
1	site_i	subsite_i	inv_i	date	temp_min	temp_max	temp_mean	dc_engy_total_m	ac_engy_daily_ma	ac_engy_total_ma	dc_engy_dail	ac_engy_dail	inv_loss_ca	effcy_dail	inv_loss	site_code
6556	336	336_1	2	22/4/2024	31.8	56.2	45.75714286	56309.45	374.1	54372.47	387.65	374.1	3%	96.5045789	3.49542113	SG-WINGTUCK-
6557	336	336_1	2	22/4/2024	31.8	56.2	45.75714286	56309.45	374.1	54372.47	387.65	374.1	3%	96.5045789	3.49542113	SG-WINGTUCK-

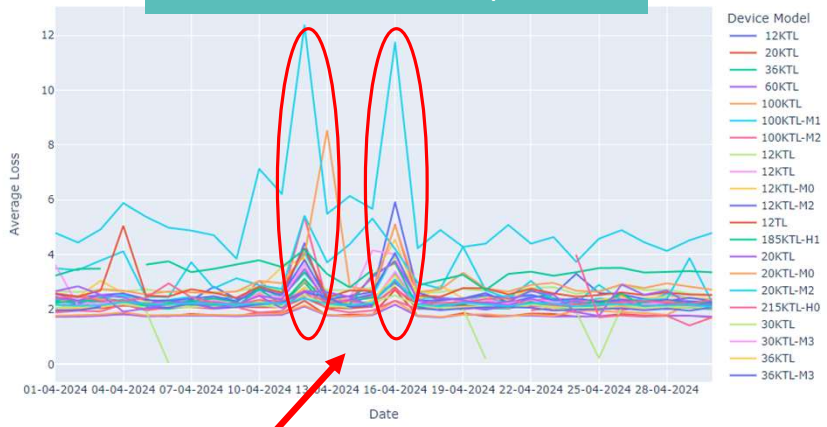


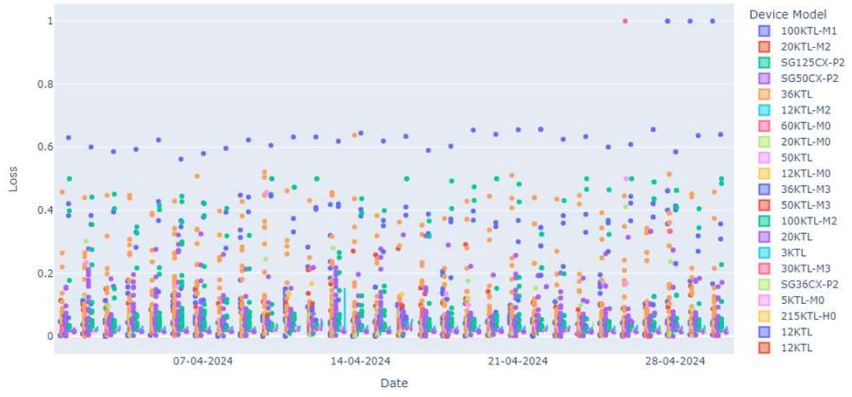
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	site_i	subsite_i	inv_i	date	temp_min	temp_max	temp_mean	dc_engy_total_m	ac_engy_daily_ma	ac_engy_total_ma	dc_engy_dail	ac_engy_dail	inv_loss_ca	effcy_dail	inv_loss	deletion_flag
6556	336	336_1	2	22/4/2024	31.8	56.2	45.75714286	56309.45	374.1	54372.47	387.65	374.1	3%	96.5045789	3.495421127	FALSE
6557	336	336_1	2	22/4/2024	31.8	56.2	45.75714286	56309.45	374.1	54372.47	387.65	374.1	3%	96.5045789	3.495421127	FALSE

Creating inv_loss_cal parameter from dc_engy_daily and ac_engy_daily parameters

Data Filtering and Processing

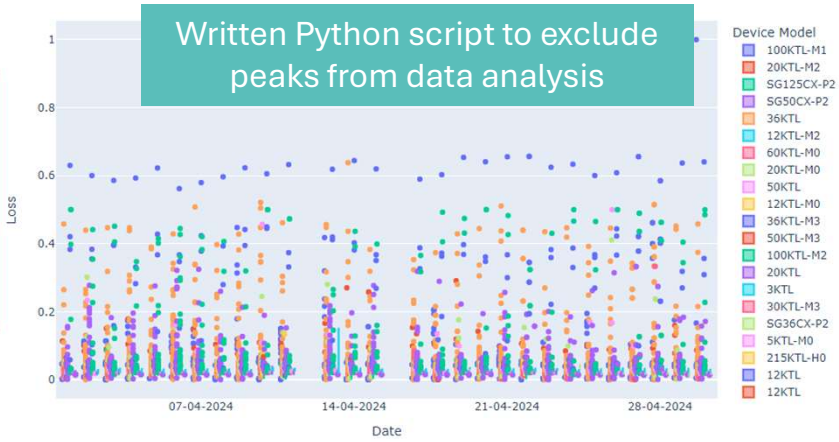
Abnormal inv loss peaks





In this project, I have chosen to ignore inverter losses on April 12th and April 16th, where these abnormal peaks of inverter losses occur.

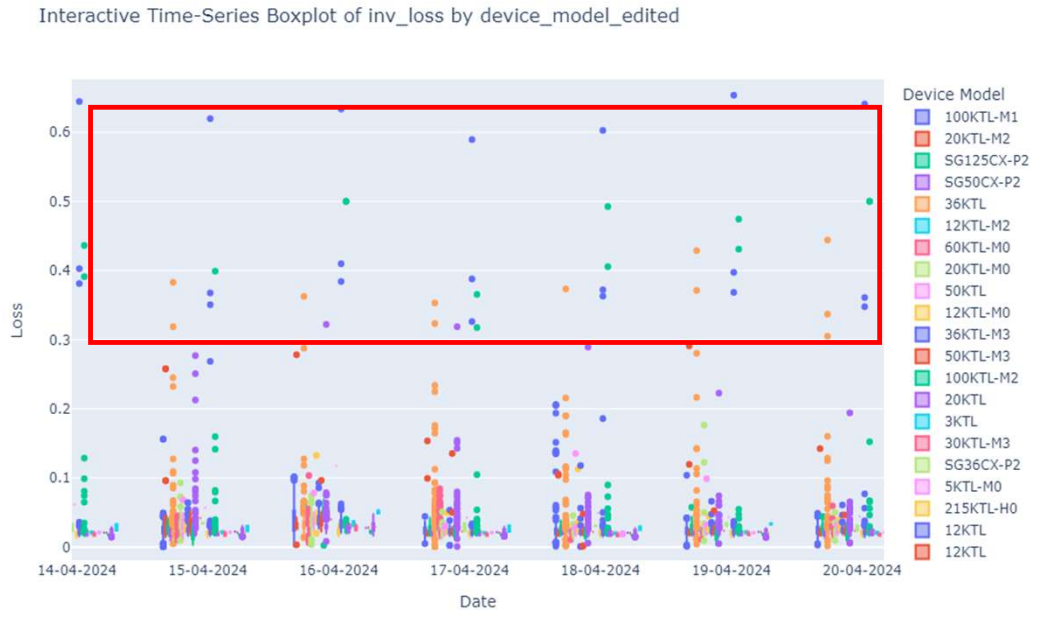
Written Python script to exclude peaks from data analysis



Set lower and upper boundaries to identify outliers:

- ***Upper boundary:*** *Q3 + 1.5 * IQR*
- ***Lower boundary:*** *Q1 - 1.5 * IQR*

- Identified the top 4 inverter models with the highest percentage of outliers, focusing on models with the most inconsistent and extreme inverter loss values
  - ***Outlier percentage*** *= (Outlier count / Total inverter models count) * 100*
  - >> Suspected inverter model issues



Outliers Count Table Apr:

device_model_edited	outlier_count	total_device_count	outlier_percentage
Inv Model A	50	62	80.645161
Inv Model B	38	76	50.000000
Inv Model C	20	62	32.258065
Inv Model D	432	2025	21.333333
[redacted]	166	869	19.102417
[redacted]	32	187	17.112299
[redacted]	2	14	14.285714
[redacted]	47	396	11.868687
[redacted]	57	483	11.801242

I identified sites with the top 4 inverter models that have the highest percentage of outliers.

Outliers Count Table for Specific Models:

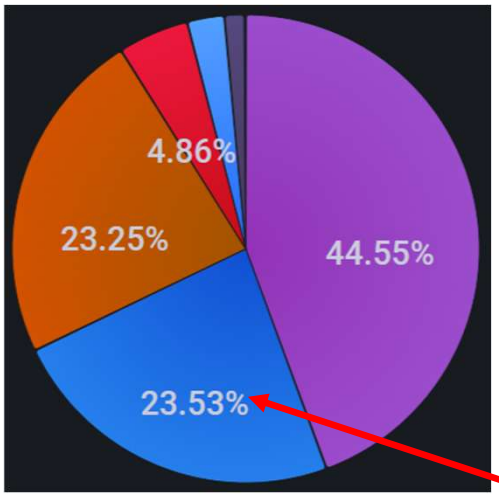
	device_model_edited	site_code	outlier_count	total_device_count	outlier_percentage
2			5	5	100.000000
18	Inv Model A	Site A	27	31	87.096774
17					
8	Inv Model B	Site B	60	93	64.516129
11					
6					
15					
3	Inv Model D	Site D	33	76	43.421053
12					
5	Inv Model C	Site C	20	62	32.258065
0					
1					
16					
7					
4					

Did not choose this inverter model or its respective site because of its unusual outlier percentage

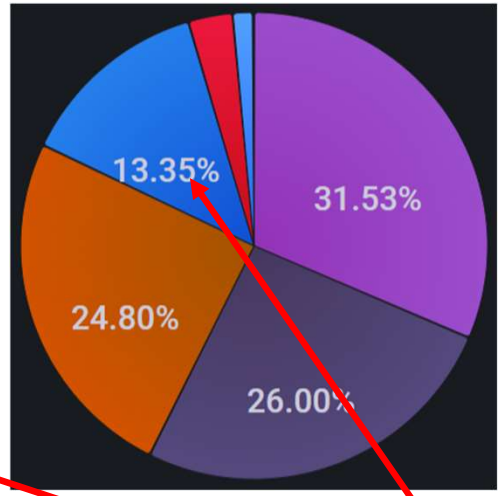
>> Too high, doesn't seem reliable

4 Solar Sites Chosen with Inverter Issues

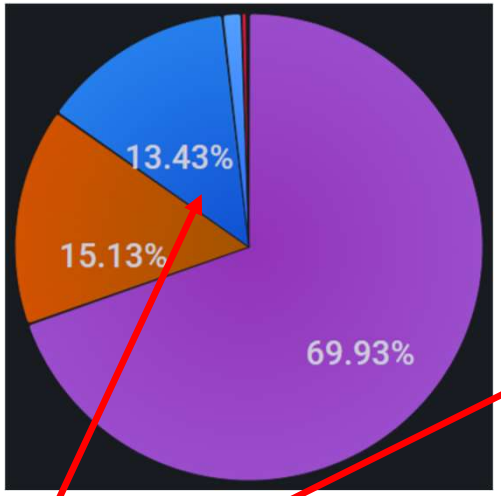
Site A



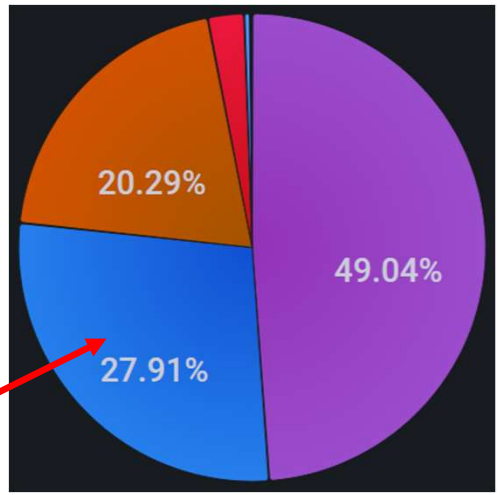
Site B



Site C



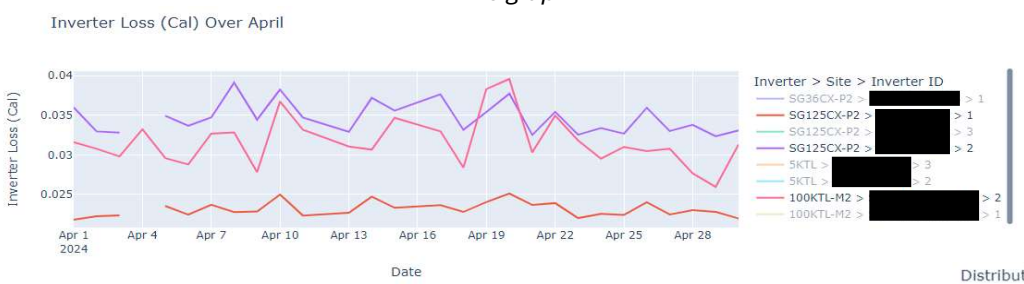
Site D



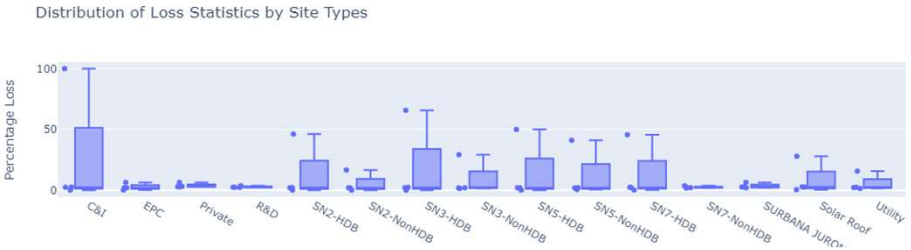
Inverter loss% of out of all the losses of a solar site

Data Analysis

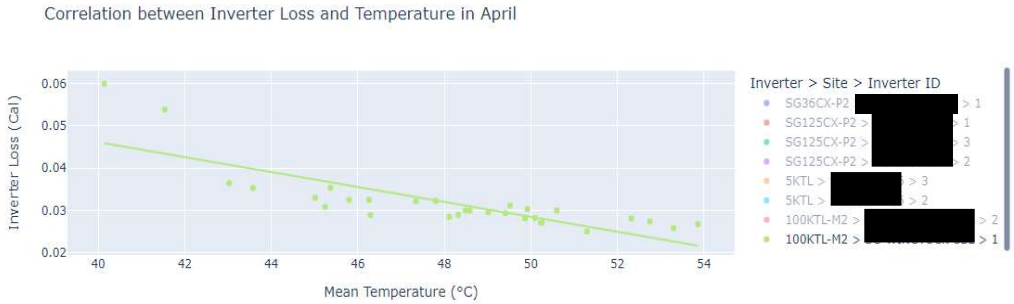
Line graph



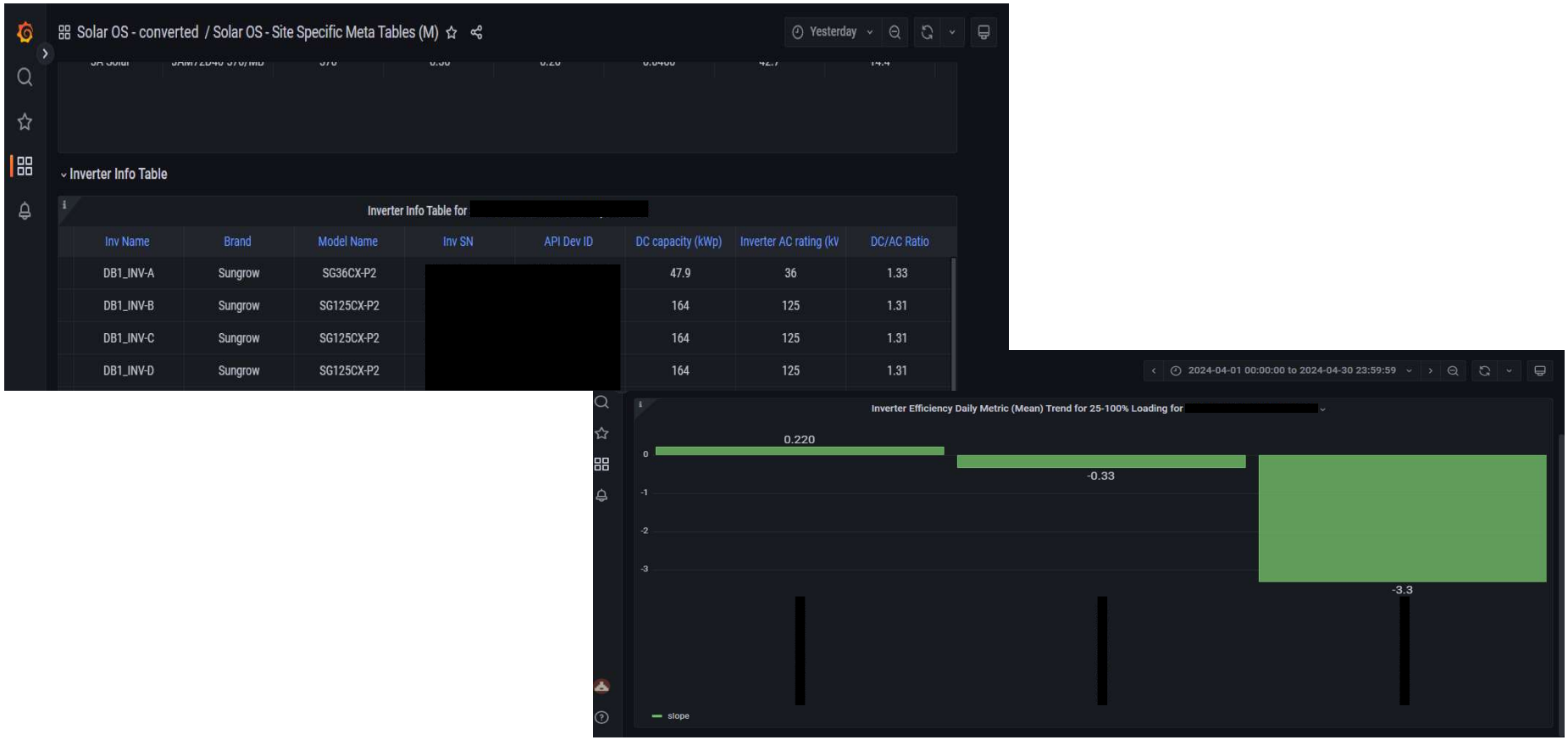
Box and whiskers plot



Scatterplot with correlation line



Integration of Additional Data



Operate and Impact/Benefits!

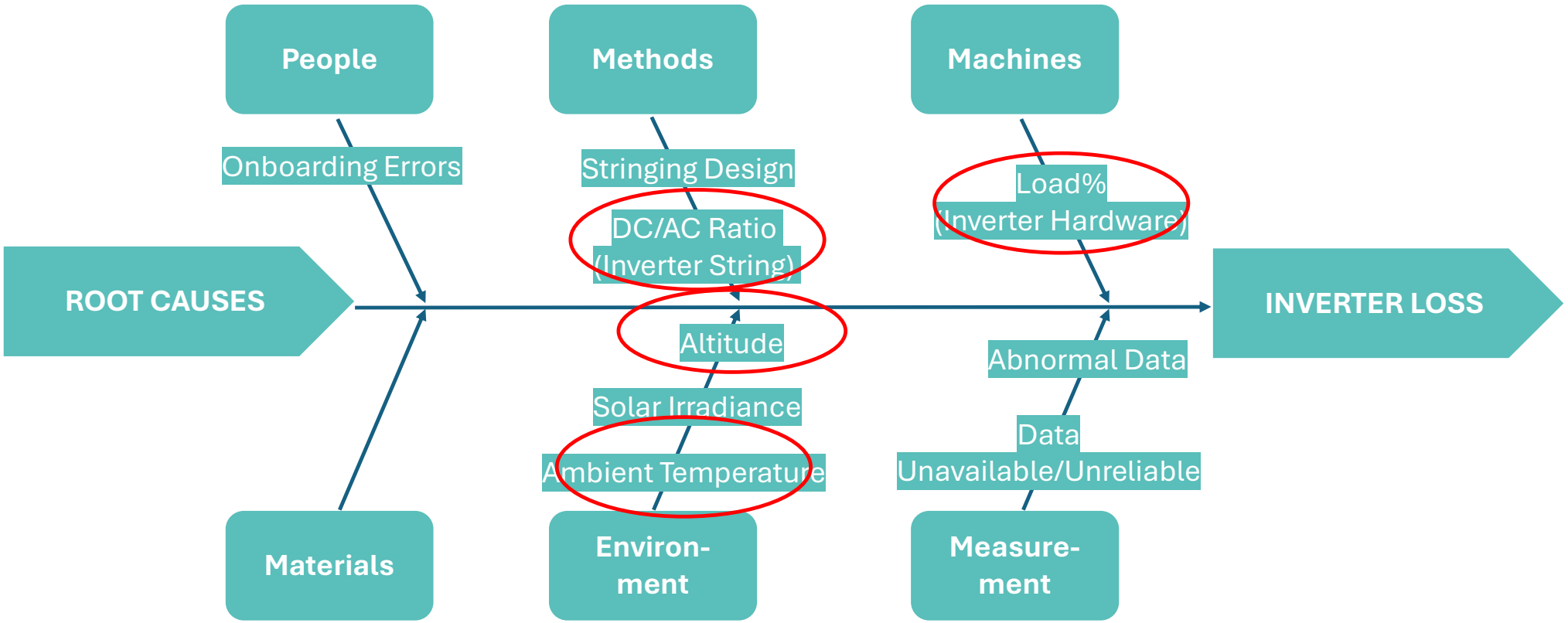
List of activities carried out in operate stage

- Had a final presentation showcasing all my findings, data and solutions to most OPM employees
- Received valuable feedback on both the presentation and analysis
- Identified areas for improvement and future actions, and ensured the project was ready for the Reporting Officer (RO) to continue post-handover

How has the project benefit the users?

- Pinpointed the root causes of inverter loss and their correlations
- Proposed simple solutions to reduce inverter losses and enhance solar site performance
- The data contributed significantly to the study and analysis of inverter loss across solar sites
- Guided further, more specific, actions to be taken on my project such as...
  - Further analysis on how solar irradiance affects inverter temperatures
  - Investigating Load% issues at specific sites
  - Proposed an optimal DC/AC ratio to minimize inverter loss
  - Reviewing SolarOS methodology on Load%
  - Identifying the necessity for more detailed temperature data (specific 5-minute intervals vs general daily) for improved analysis

Root Cause Analysis



Conclusion - Findings

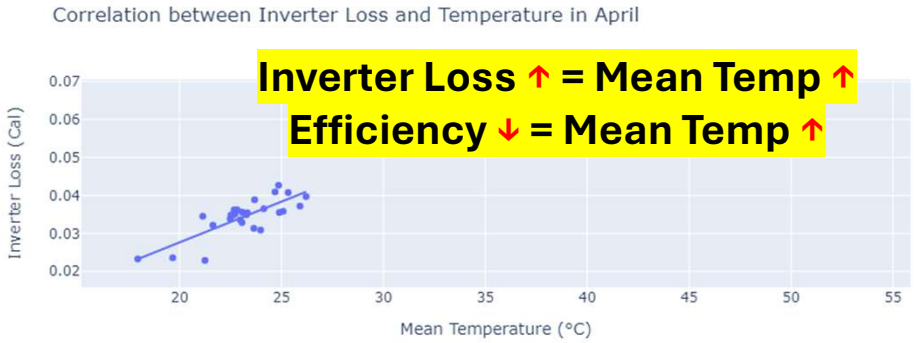
<table>
<tr><th rowspan="2">Model (Site)</th><th colspan="3">Correlation between Inv Loss</th></tr>
<tr><th>Vs Temperature/Altitude</th><th>Vs DC/AC Ratio</th><th>Vs Load%</th></tr>
<tr><td>Inverter Model A
(Site A)</td><td>• Temperature range is very low
• Inverter loss is within the expected range according to the datasheet
• Inverter loss increases as temperature increases</td><td rowspan="4">• As DC/AC ratio increases, inverter loss increases
• This happens when…
○ DC input power increases while AC output power remains constant,
○ or DC input power remains constant while AC output power decreases</td><td>• As Load% increases, efficiency improves, and inverter loss remains within the expected range
• At a certain point, as Load% continues to increase, efficiency becomes stagnant</td></tr>
<tr><td>Inverter Model B
(Site B)</td><td rowspan="3">• Inverter Model B: Temperature range is very low
• Inverter Model C: Temperature range varies from very low to very high
• Inverter Model D: Temperature range is very high
• Abnormal Findings:
• Inverter loss decreases as temperature increases
• Efficiency improves as the inverter heats up</td><td rowspan="2">• The lowest efficiency% is below datasheet expectations, but the highest efficiency% aligns with the datasheet</td></tr>
<tr><td>Inverter Model C
(Site C)</td></tr>
<tr><td>Inverter Model D
(Site D)</td><td>• Same conclusion as for Inverter Model A and Inverter Model B</td></tr>
</table>

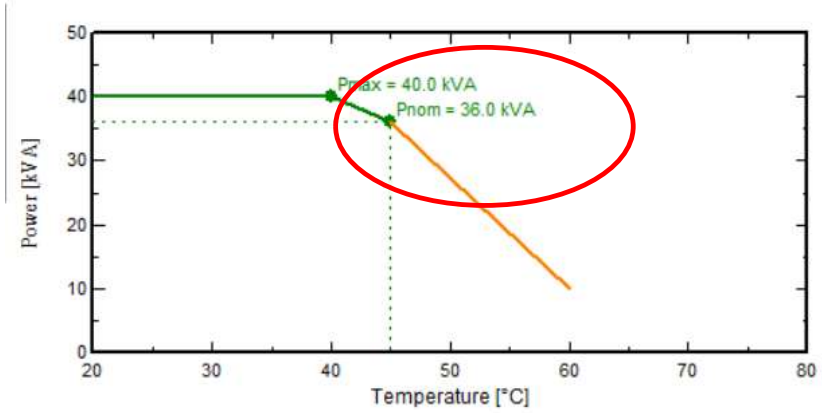
Conclusion - Solutions

Model (Site)	Correlation between Inv Loss			
	Vs Temperature	**Vs Altitude**	**Vs DC/AC Ratio**	**Vs Load%**
Inverter Model A (Site A)	• Since temperatures are low and inverter loss is normal, keep monitoring • If inverter loss increases with temperature, make sure inverter has good ventilation and cooling	• Make sure the inverter is well-ventilated and maintained	• To propose an optimal DC/AC ratio (? Ratio) • Ensure the DC input and AC output are balanced to minimize loss	• Optimize the system load to stay within efficient operating ranges (? Load%) • Avoid extreme loads where efficiency might stagnate
Inverter Model B (Site B)				
Inverter Model C (Site C)	• Improve cooling or ventilation to manage the wide temperature range • Regular maintenance can help keep performance stable across different temperatures			• Investigate factors causing lower efficiency at higher loads (More than 25% Load)
Inverter Model D (Site D)	• Enhance cooling systems to handle high temperatures • Ensure the inverter is in a well-ventilated area to maintain optimal performance			• Same conclusion as Inverter Model A and Inverter Model B

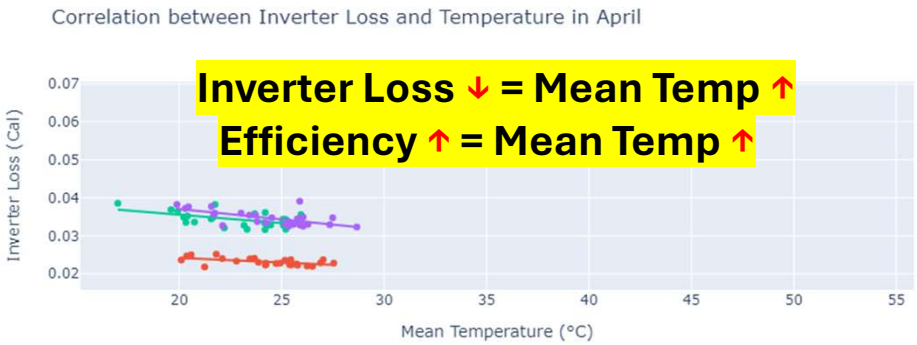
Inv Loss vs Temperature

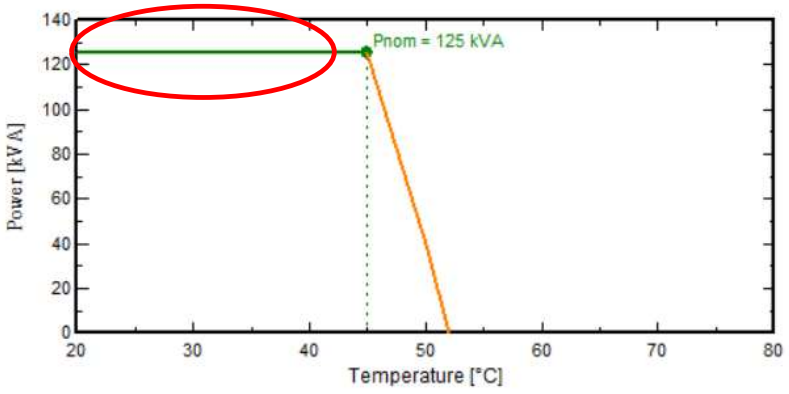
Inv Model A





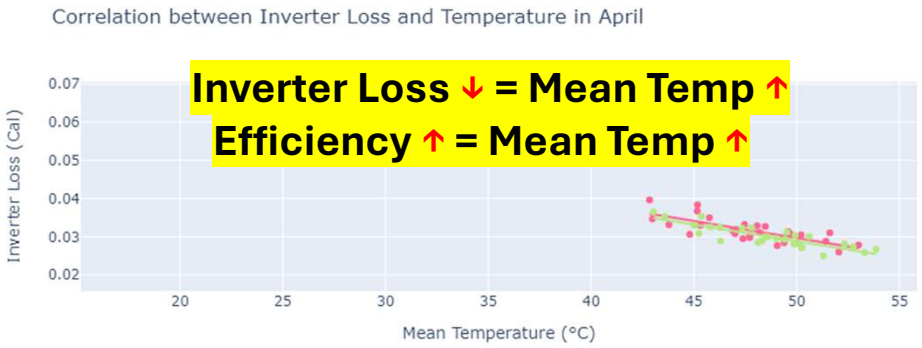
Inv Model B

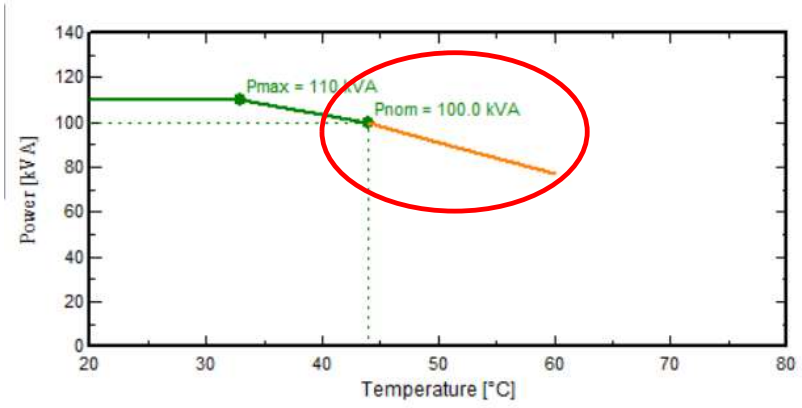




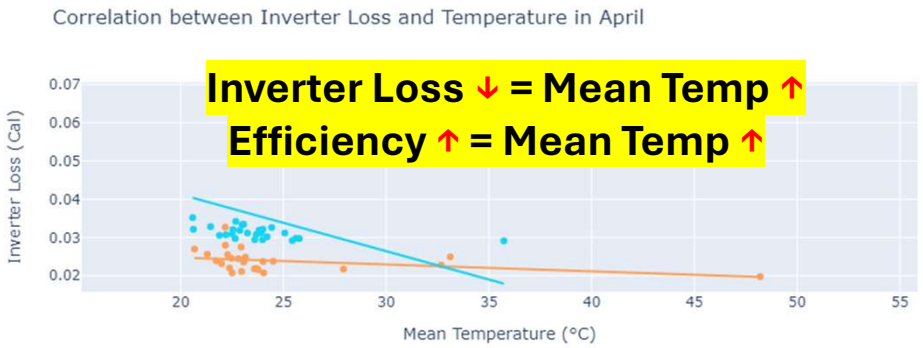
Inv Loss vs Temperature

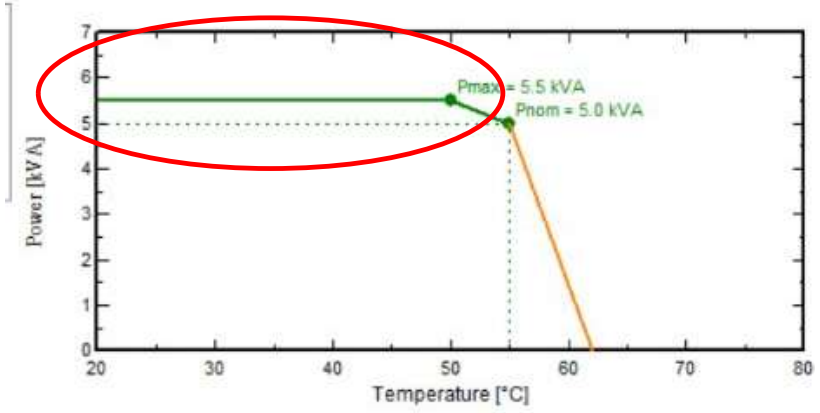
Inv Model D



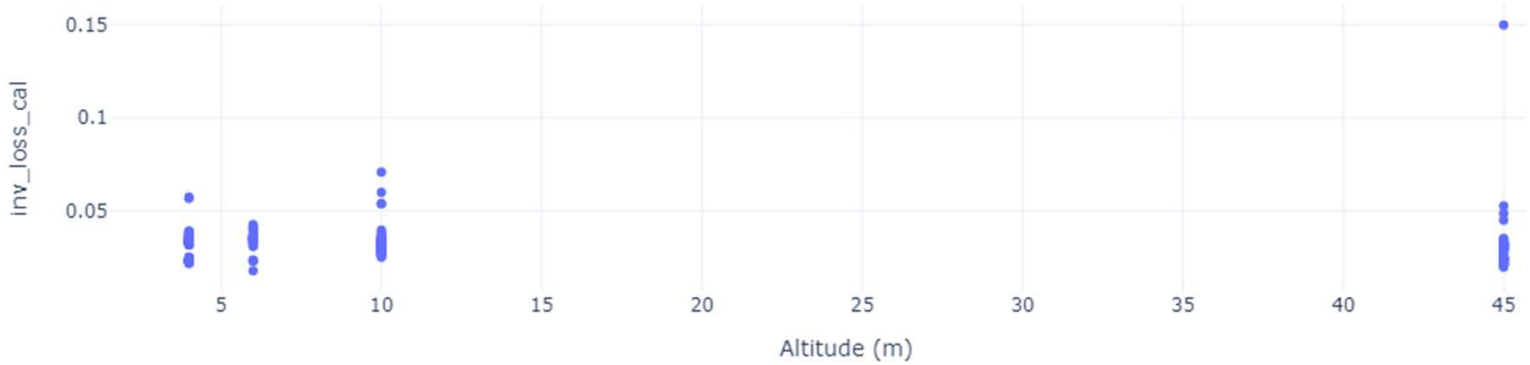


Inv Model C





Inv Loss vs Altitude

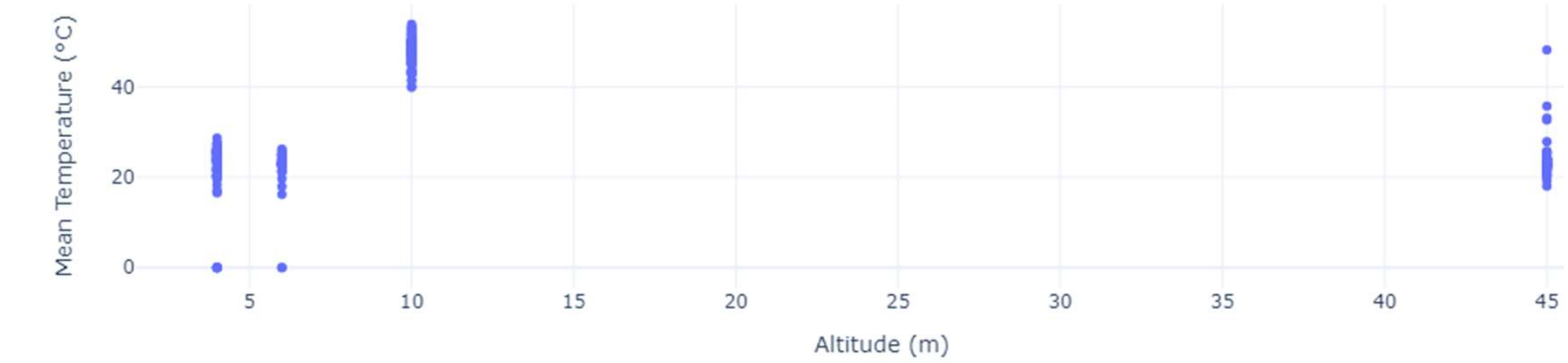


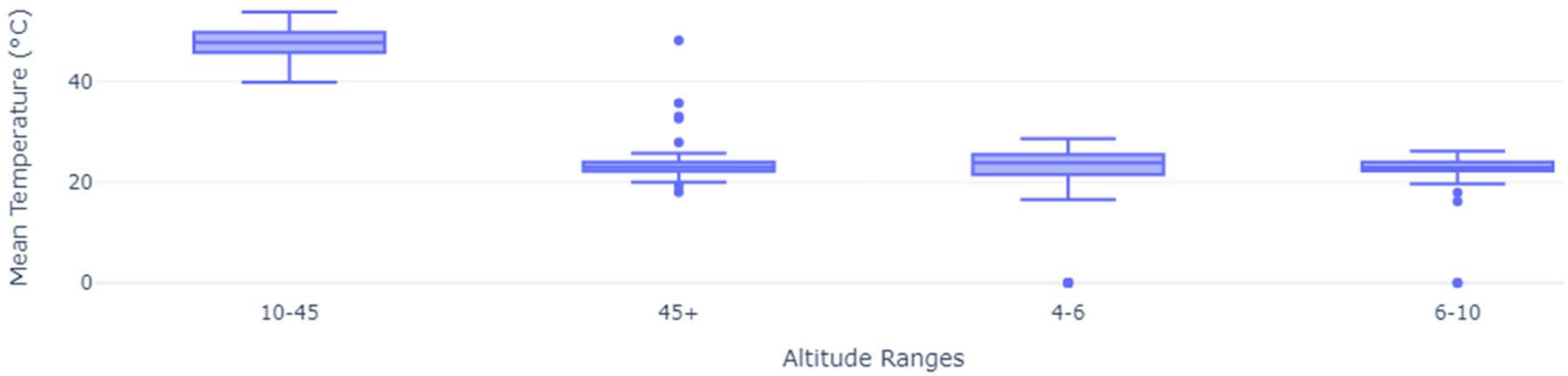
Correlation between altitude and inverter loss: -0.05

Altitude ↑ = Inverter Loss ↓

Altitude ↑ = Efficiency ↑

Temperature vs Altitude



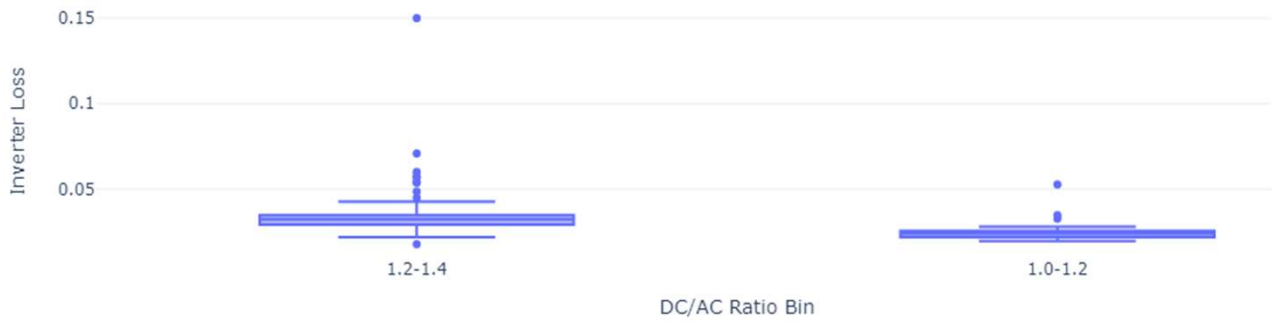


Correlation between altitude and temperature: -0.14

Altitude ↑ = Temperature ↓

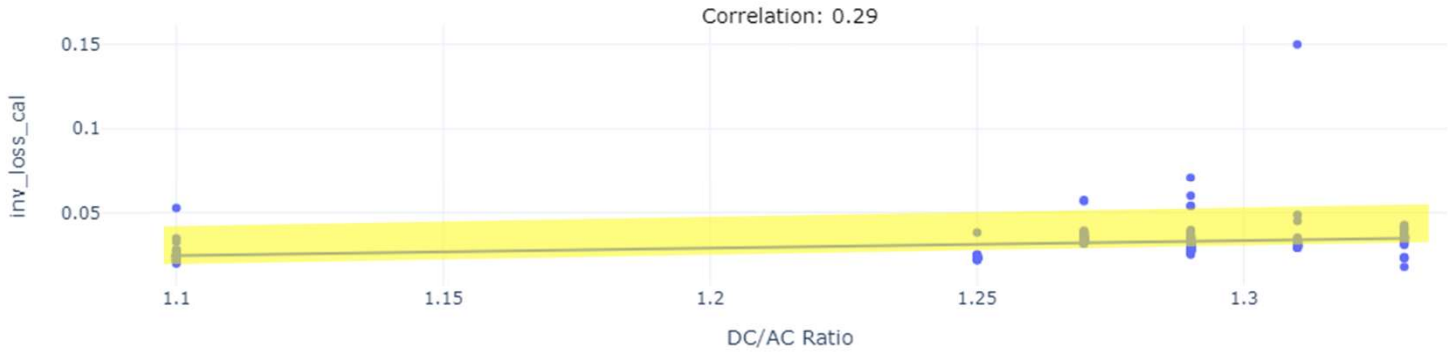
Inv Loss vs DC/AC Ratio

dc/ac ratio bin	count	mean	median	std_dev	min_val	max_val
<=1.0	0	NaN	NaN	NaN	NaN	NaN
1.0-1.2	32	0.03	0.02	0.01	0.02	0.05
1.2-1.4	236	0.03	0.03	0.01	0.02	0.15
1.4-1.6	0	NaN	NaN	NaN	NaN	NaN
1.6-1.8	0	NaN	NaN	NaN	NaN	NaN
>1.8	0	NaN	NaN	NaN	NaN	NaN



DC/AC Ratio ↑ = Inverter Loss ↑

Correlation: +0.29



How to Calculate Total Voltage Range & Load Percentage

Total Voltage (Vmp) = Vmp STC (per panel) × Smallest Number of Panels

Total Voltage (Vmp) = Vmp STC (per panel) × Largest Number of Panels

Module Meta Table for SG-UPS-31ALPS : UPS 31 Alps Avenue

Module Brand	Model Name	Module Power	Pmax Temp Coeff	Voc Temp Coeff	LSC Temp Coeff	VMP STC	IMP STC	Firs
[redacted]		570	-0.30	-0.26	0.0460	42.7	14.4	

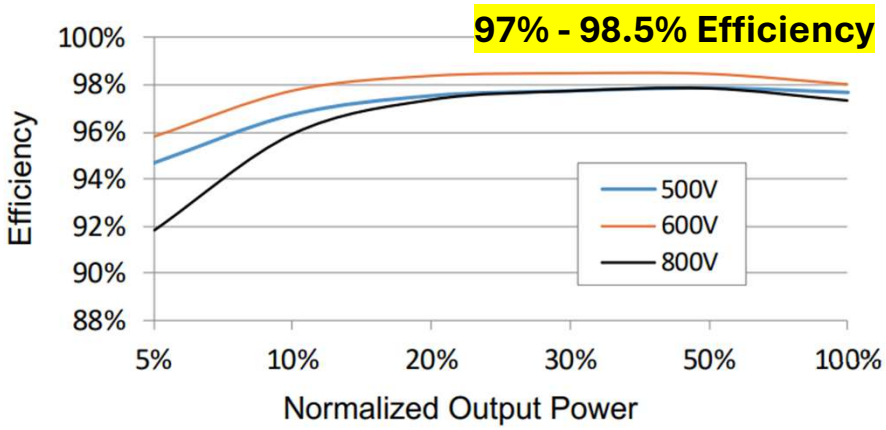
Subsite ID	Inv ID	MPPT Input	Inv Input	Brand	Panel Model Name	Model Power	Module Count	Surface Tilt	Surface Azimuth
290_1	1	1	1	[redacted]		570	20	5	243
290_1	1	2	3			570	16	5	243
290_1	1	2	4			570	16	5	243
290_1	1	3	5			570	16	5	243
290_1	1	4	7			570	16	5	243

LOAD % = ACT_PWR / 110% OF INVERTER'S RATING

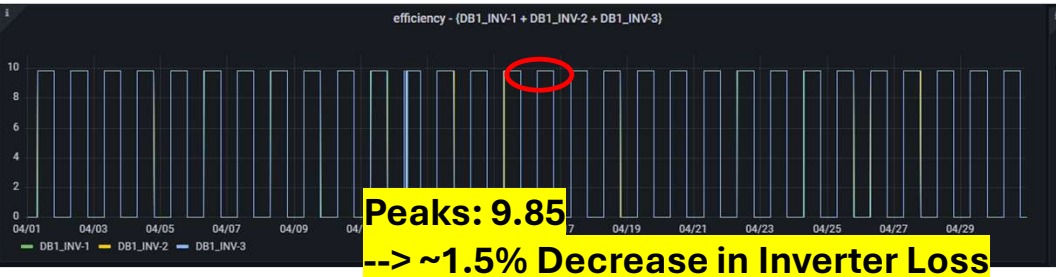
E.G. 100KTL INVERTER -> 100KTL x 110% = 110KW

Inv Loss vs Load Percentage

Inv Model A

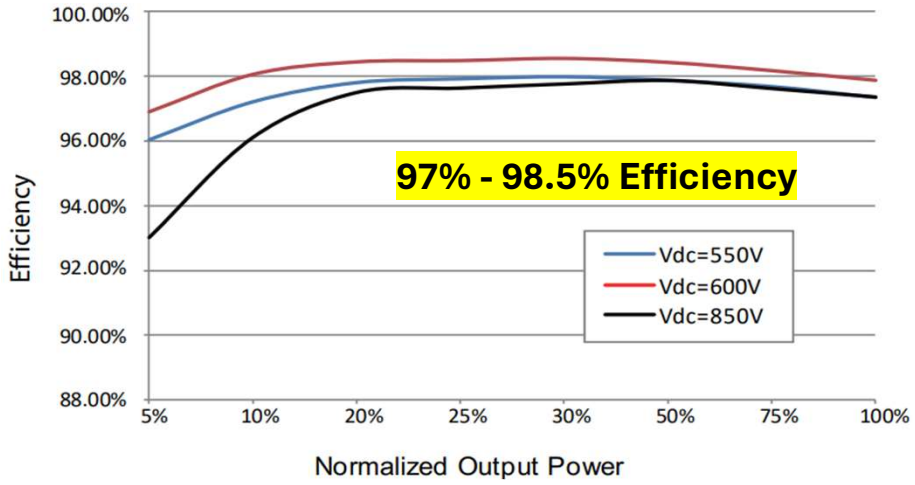


Voltage Range: 683.2 V --- 854 V

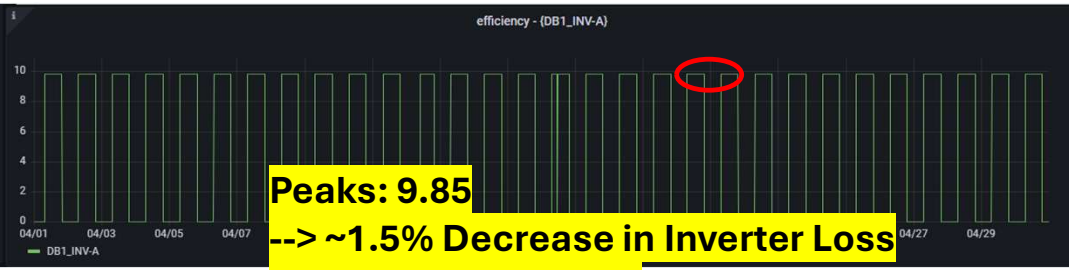


Peaks: 9.85
--> ~1.5% Decrease in Inverter Loss
--> ~98.5% Efficiency

Inv Model B



Voltage Range: 643.5 V --- 815.1 V



Peaks: 9.85
--> ~1.5% Decrease in Inverter Loss
--> ~98.5% Efficiency

Further Actions

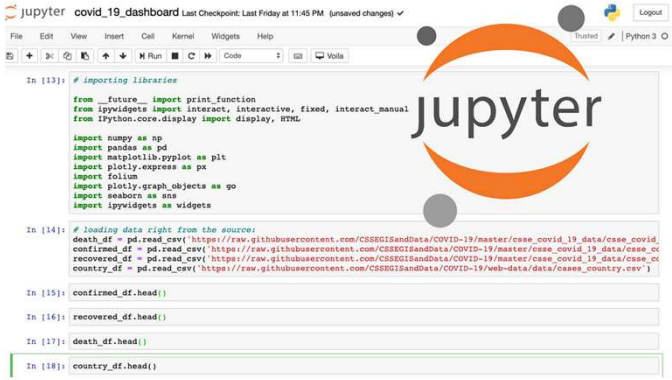
- Propose more in-depth solutions to the specific root causes
- Check the correlation between solar irradiance and temperature for inverters:
  - High irradiance leads to higher temperatures due to increased energy absorption
  - However, high temperatures can negatively impact the performance of both solar panels and inverters, reducing overall efficiency
- Examine the causes of Load% issues for the Inverter Model C at Site C:
  - Review EIOT 5-minute data and inverter logs
  - Issues could be related to SN data problems or hardware issues
- Determine and propose optimal DC/AC ratio range to minimize inverter loss
- Find out the SolarOS methodology on Load%
- Define the project scope clearly at the start
- Temperature range of the sites is based on 25 degrees Celsius *(using data from 25-100% load%)*: This approach may overlook crucial data, as it relies on daily temperature averages rather than more detailed 5-minute interval temperature data

Conclusion:
Skills Learnt or Practiced

- **Data Analytics and Tools:** Improved Excel skills, learned Jupyter Notebook for data analysis skills, as well Azure Data Explorer for data extraction skills

- **Understanding Solar Energy and Engineering**: Gained new knowledge of solar energy systems and engineering concepts

- **Monitoring Device Configuration**: Gained hands-on experience with monitoring device configuration and saw results on Sembcorp Solar's analytic platforms



- **Time and Task Management**: Improved skills in organizing meetings and balancing internship responsibilities

- **Professional Communication**: Improved email and messaging skills for effective communication with colleagues and supervisors etc.

- **Problem-Solving and Adaptability**: Tackled task-related challenges using work instructions and seeking help from colleagues

Conclusion
My Reflection on SDL

- Learned to ask for help and used coworkers' expertise when facing challenges—I wasn't afraid to feel "stupid" to seek assistance

- Used various sources *(work instruction documents/videos, guidance from senior colleagues, and fellow senior temps/interns)* for supplementary learning to improve my understanding and resolve any confusion regarding regular tasks and issues encountered during the internship

- This, as well as the theory and practical aspects of solar energy and solar sites >> This was immensely helpful in understanding and adding value to my internship project

- Able to manage my time between regular tasks and my own internship project by seeking my colleagues' help when under tight deadlines >> enabled me to accomplish more within the available time

Thank you! ☺