



# Carnarvon Distributed Energy Resource Trials

September 2020 – AEMO - ESIG Conference

David Edwards – Digital Strategy & Innovation Manager

HORIZON

# Today's Agenda



- Introduction
- Centralised to Decentralised
- Visibility & Control of DER
- Data Acquisition in Carnarvon
- Behind the Meter Control of DER
- Voltage Studies
- Power Factor Control
- Phase Identification
- Battery Optimisation
- Project Update



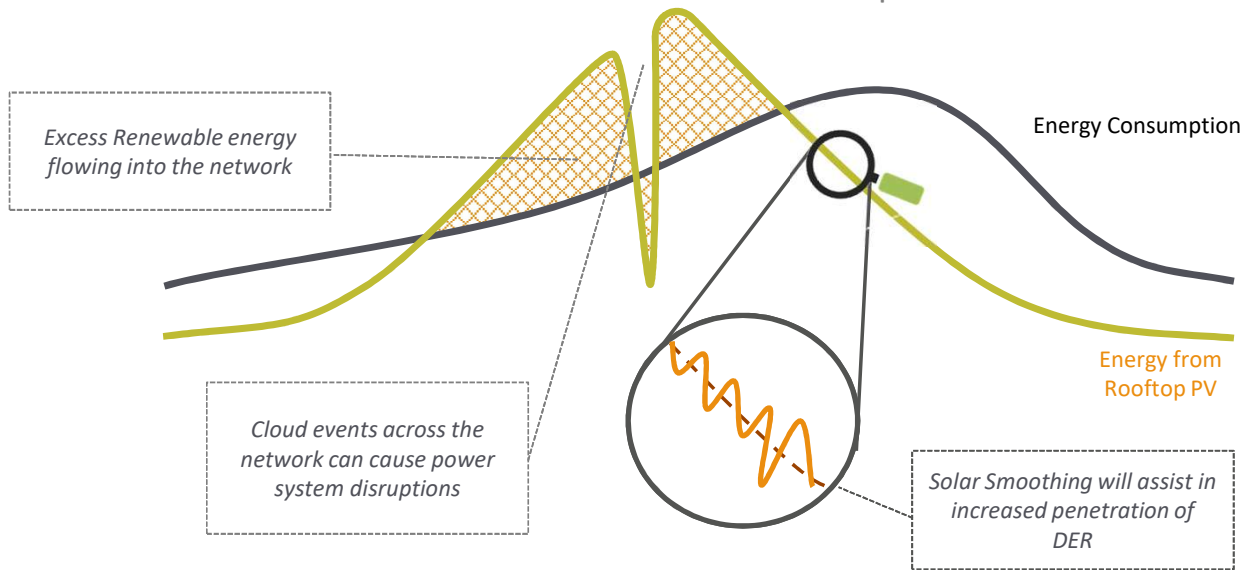
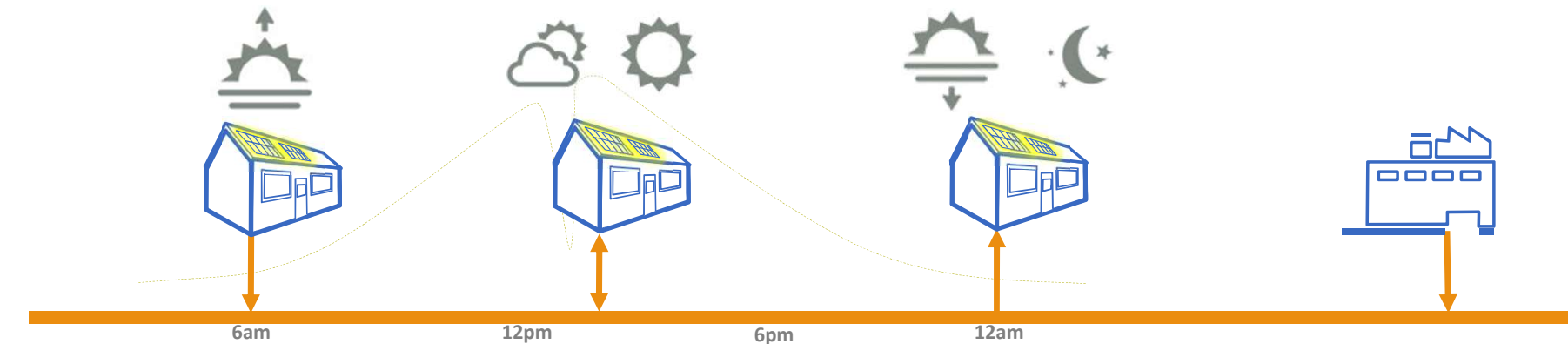
**Q&A** Join at [slido.com](https://www.slido.com) #ESIG-2B [David]

# The Rise of DER



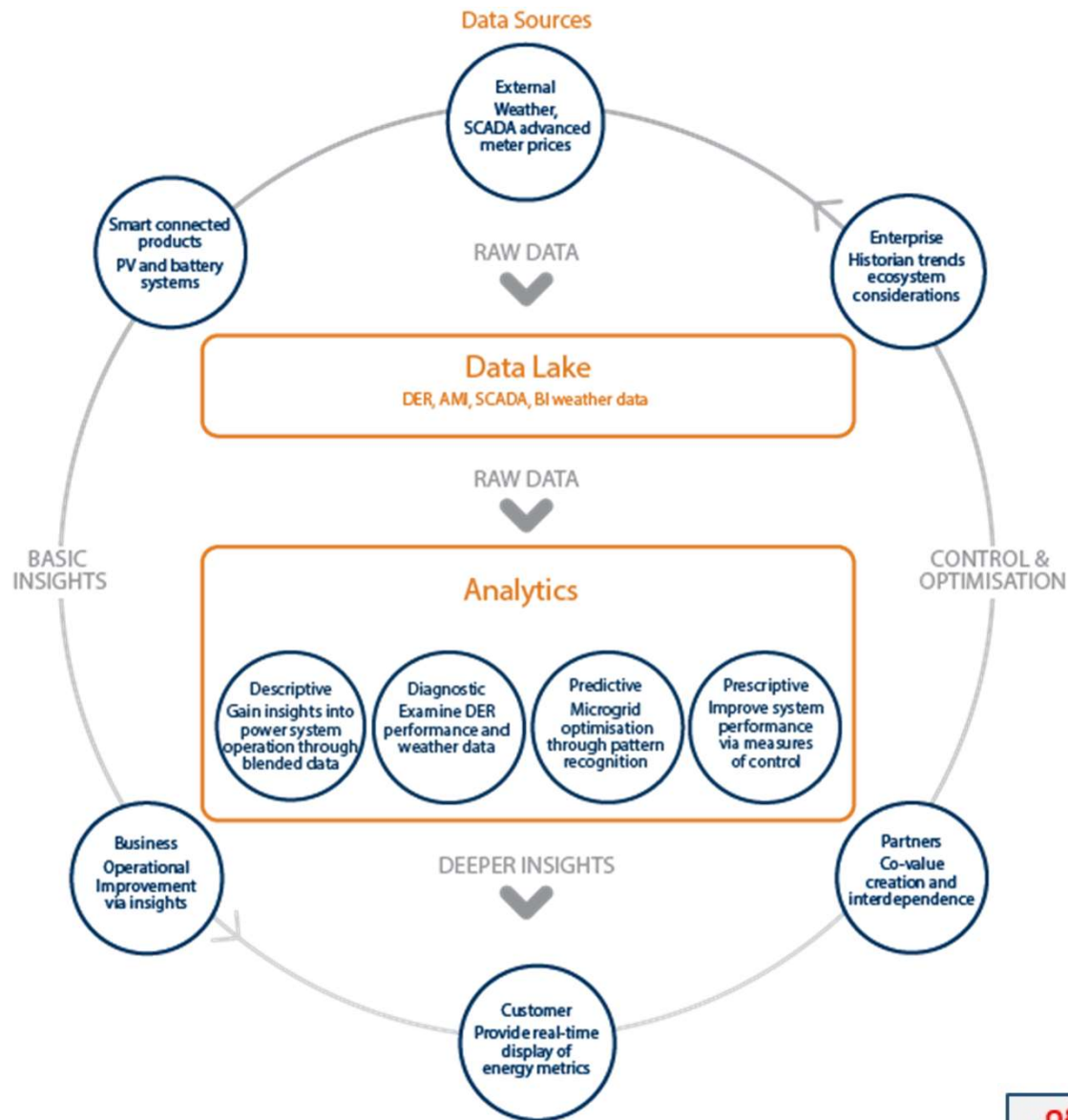
- We have seen distributed generation growing to become the largest generation source on some of our networks, completely changing network load profiles as we have known them for the last few decades.
- Distributed energy storage will grow and completely change network load profiles as we know them today.
- The bulk of energy dispatch on the network will come from non-industrial standard consumer grade electronics
- This dispatch will not be secured by a 10 year power purchase agreement with all the certainties we favour
  - No dispatch profile guarantee
  - No spinning reserve limits
  - No SCADA visibility or control
  - No liquidated damages
  - No step in rights
- How do we address these challenges?
- How do we embrace the uncertainty and still preserve system stability, power quality and reliability?
- What methods can we use to de-risk this future state?
- **We will not find the answer to these questions in the way we have done business over the fifty years**

# Visibility & Control of DER



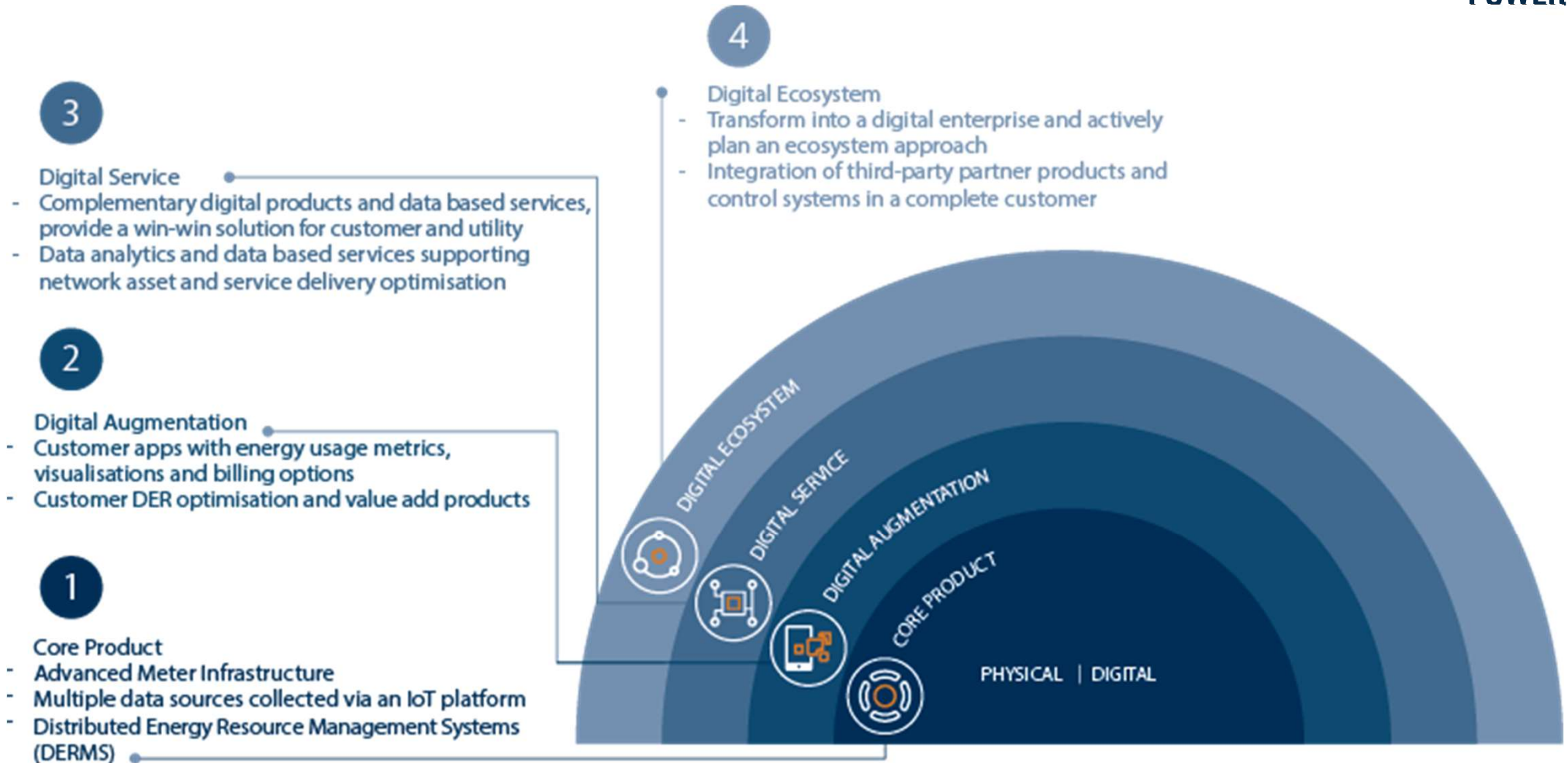
*Hosting capacity Targets are only a short term solution, we need to solve the technical problems that will allow high penetration connection of DER to the network.*

# Industry 4.0



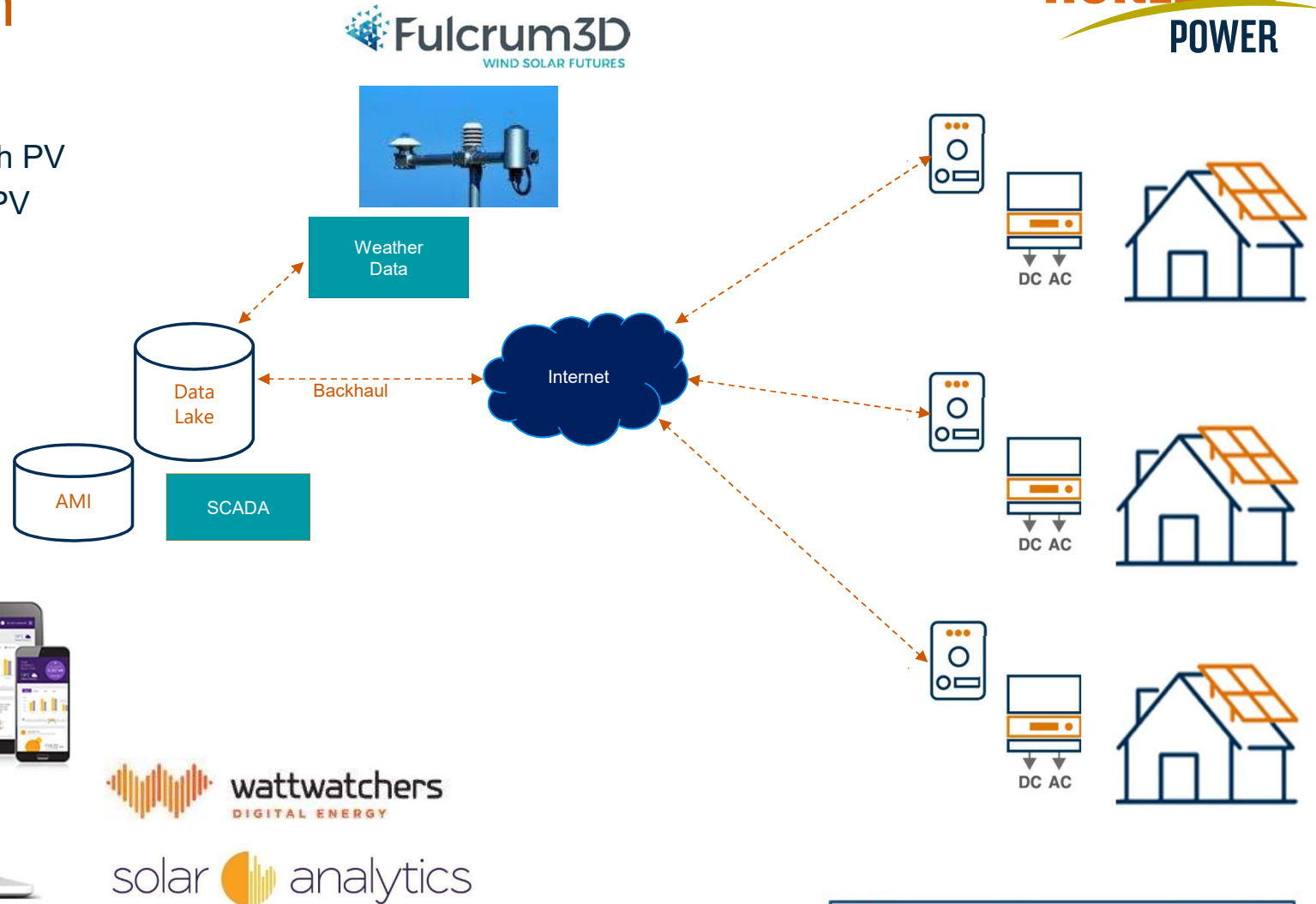
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# Physical Product to Digital Eco System



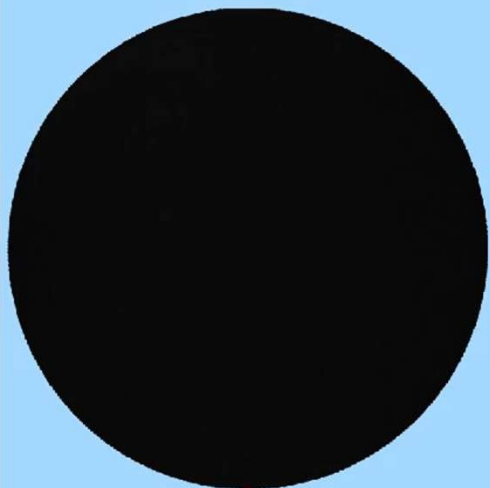
# Data Acquisition

- Recruited 82 Customers with PV
- Separately meter load and PV
- Unmasking true load
- Customer facing App

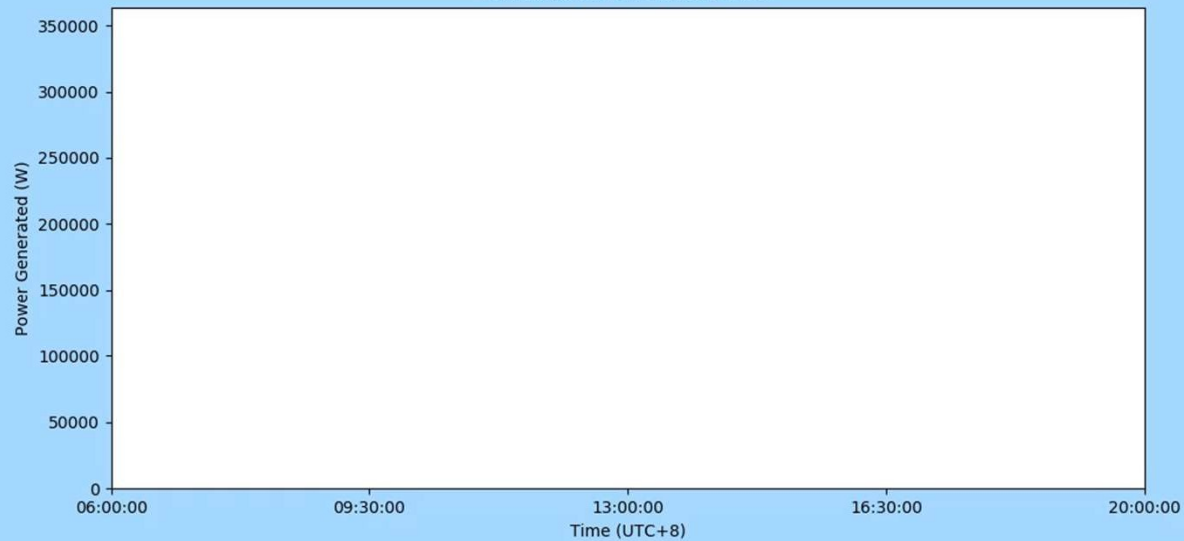


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Sky Camera



Cumulative Generated Power



Satellite



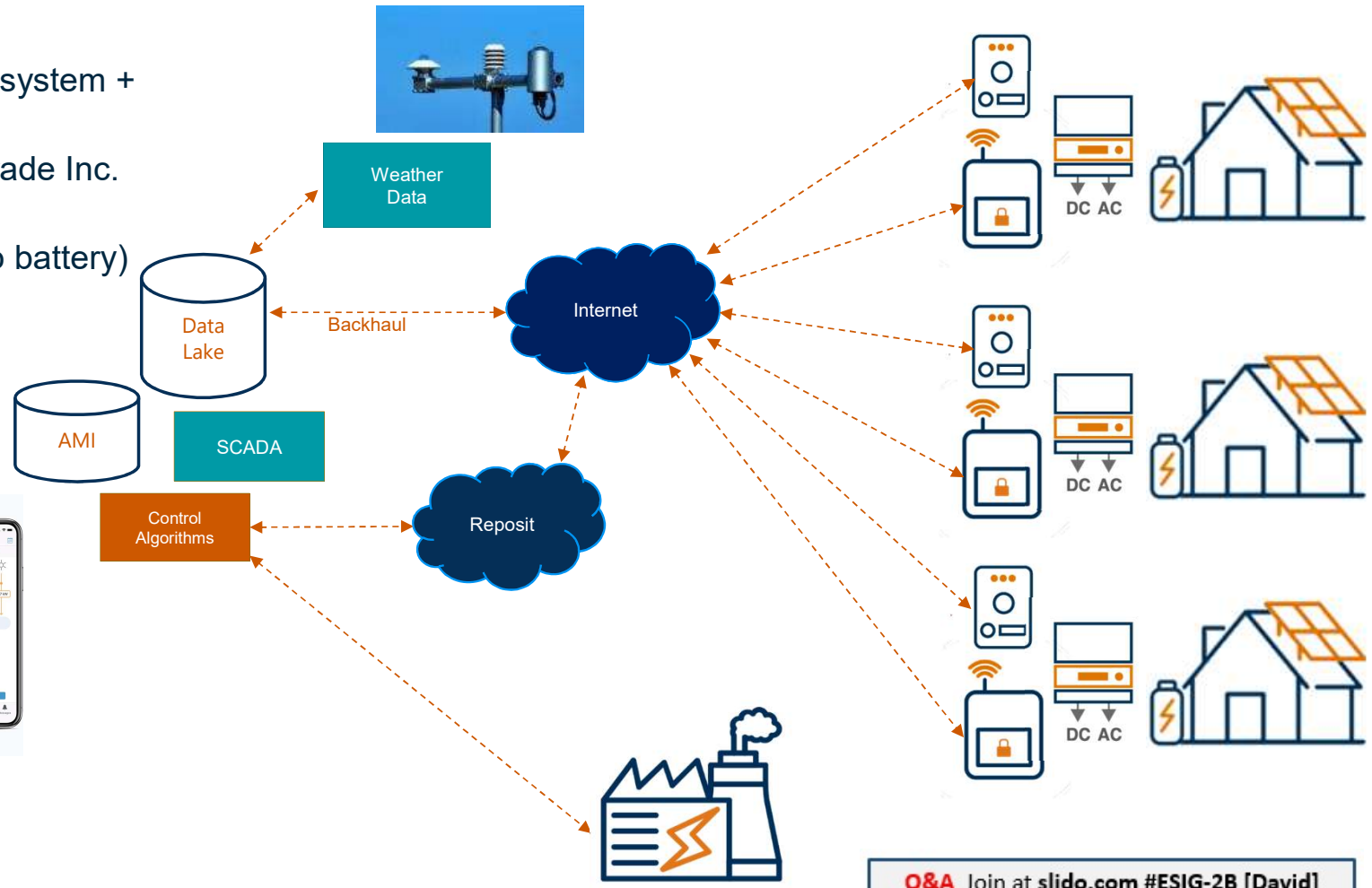
Carnarvon DER  
06:00

**ARENA**  
Australian Government  
Australian Renewable  
Energy Agency

**HORIZON**  
POWER

# Monitor & Control of PV & Energy Storage

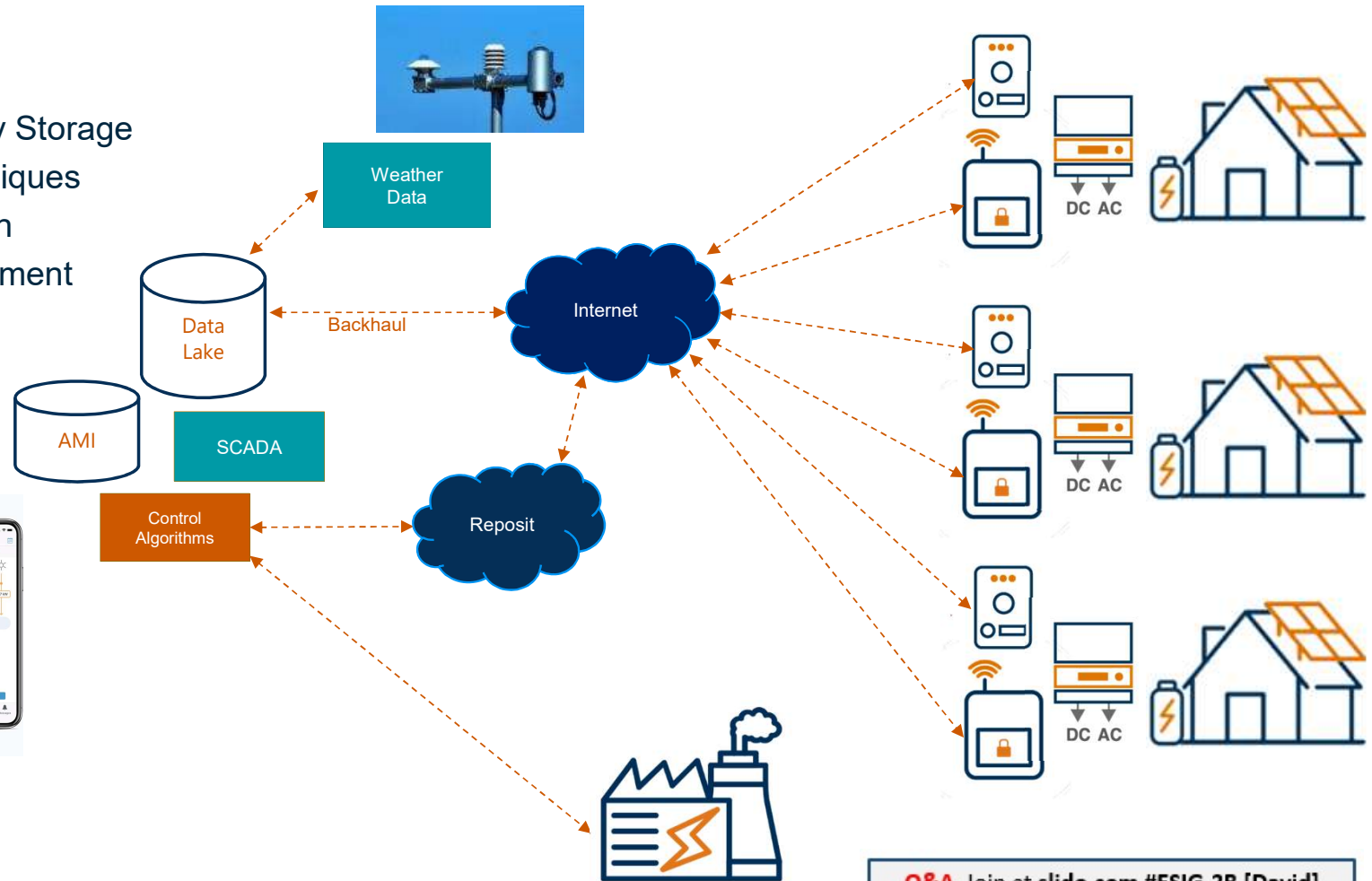
- 10 Customers – PV/Battery system + Reposit Box
- 6 Customers – System upgrade Inc. battery + Reposit Box
- Commercial Solar Farm (no battery)



Q&A Join at [slido.com](https://www.slido.com) #ESIG-2B [David]

# Monitor & Control of PV & Energy Storage

- Visibility & Control of PV
- Visibility & Control of Energy Storage
- Feed-in Management Techniques
- Energy Storage Optimisation
- Virtual Power Plant Management

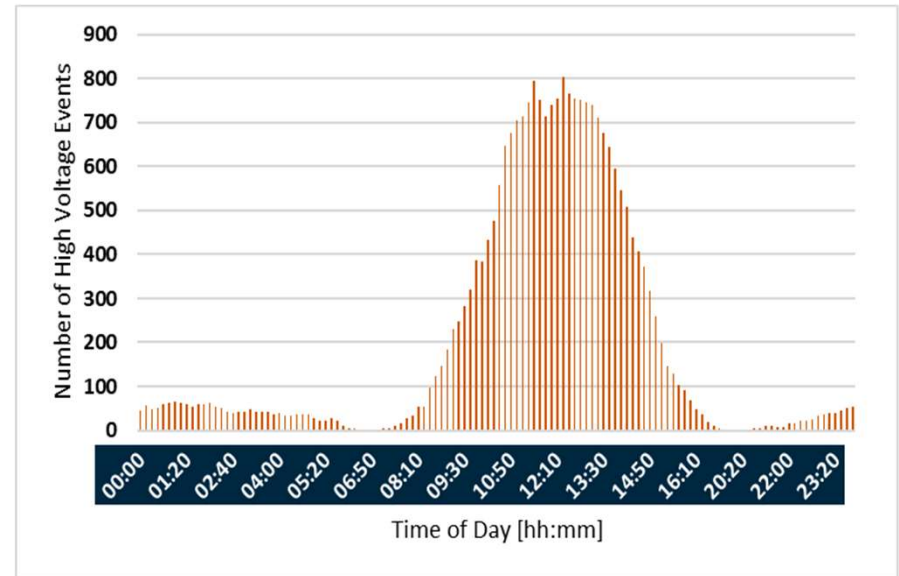


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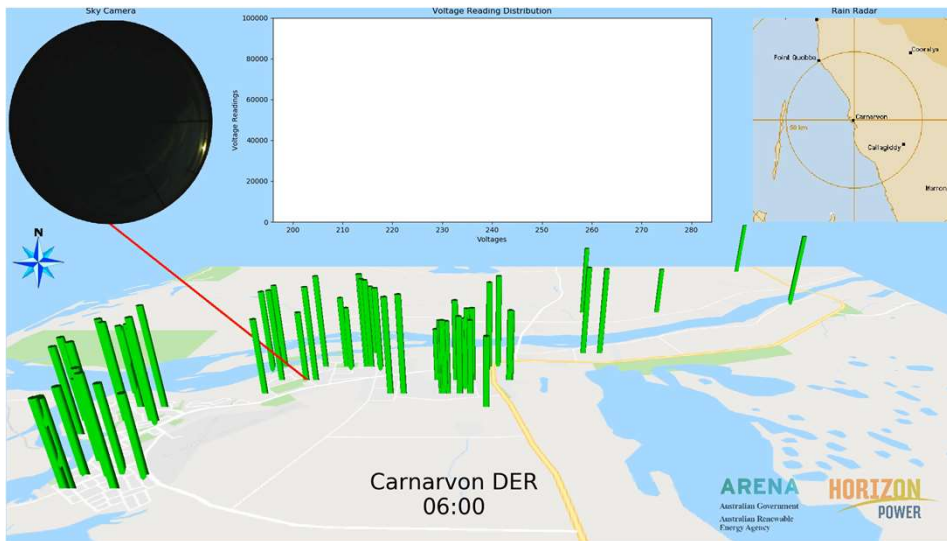
# Voltage Study



- Over voltage events observed at the 82 monitored PV systems spread throughout the town
- 50% of the inverters are not working as well as they could
- Most of the overvoltage activity is during the times of peak solar radiation



Frequency distribution of high voltage events over 24 hours

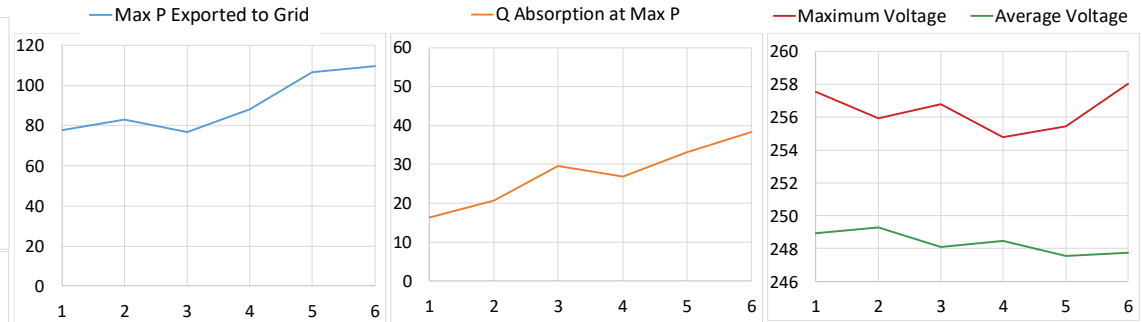
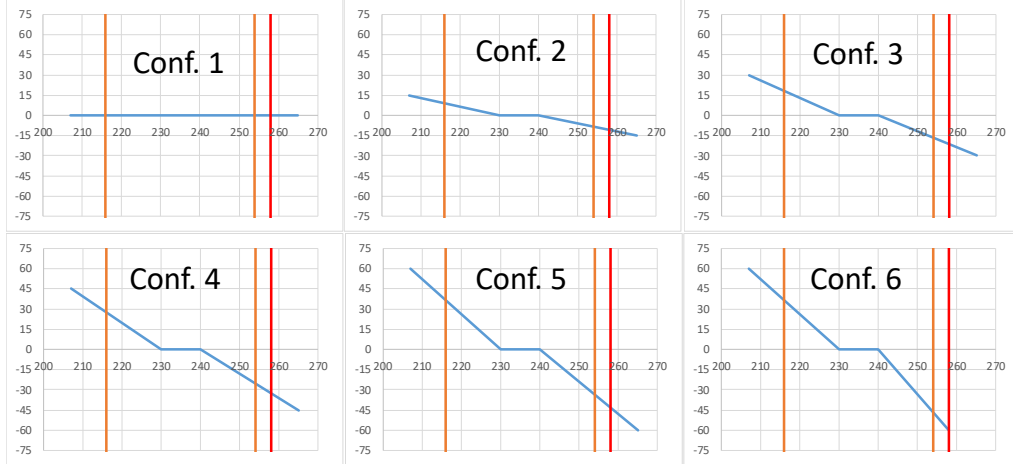


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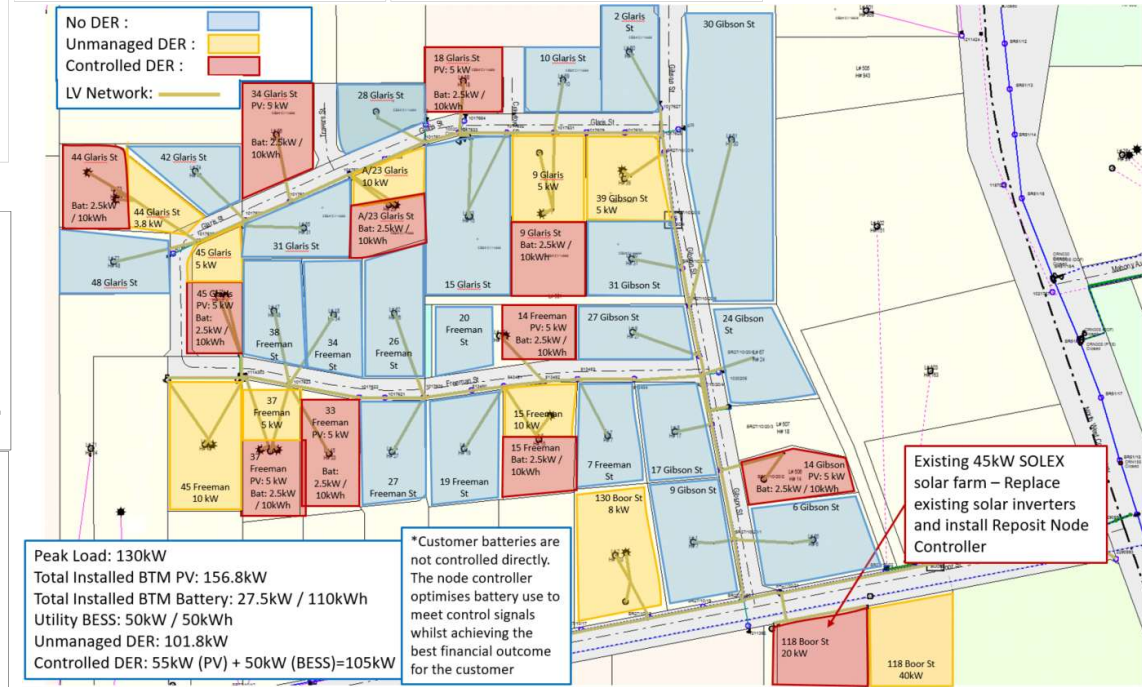
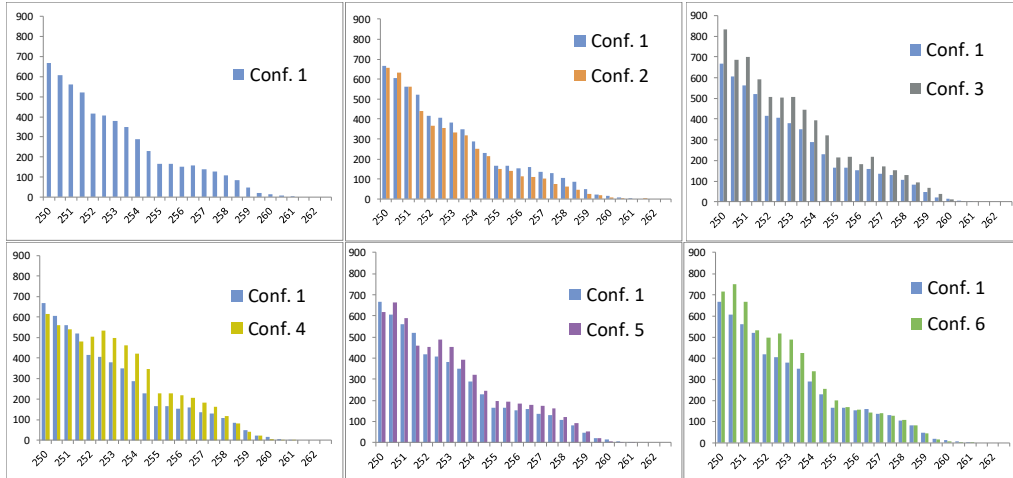
# Droop Curve Configurations



## Reactive Power Droop



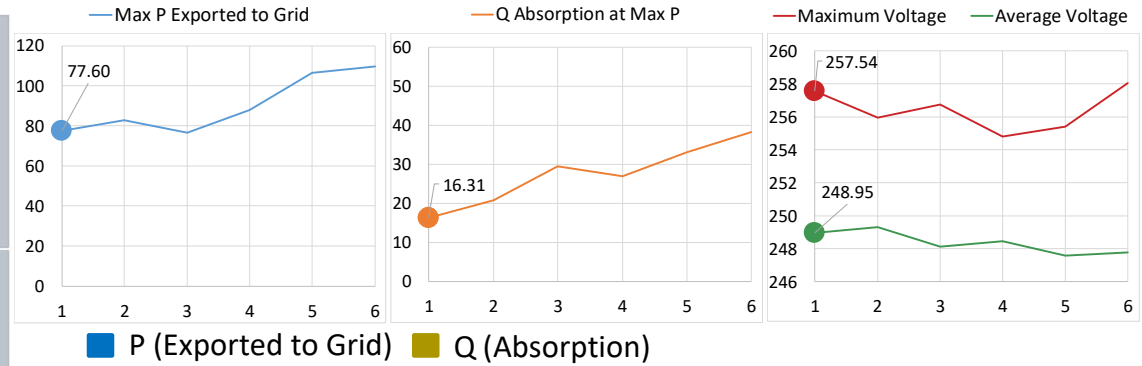
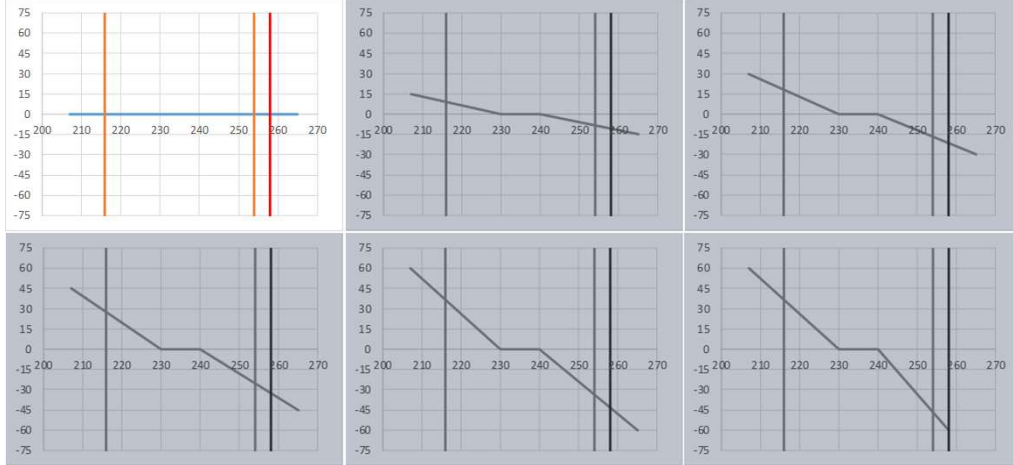
## Histogram – Feeder Voltage



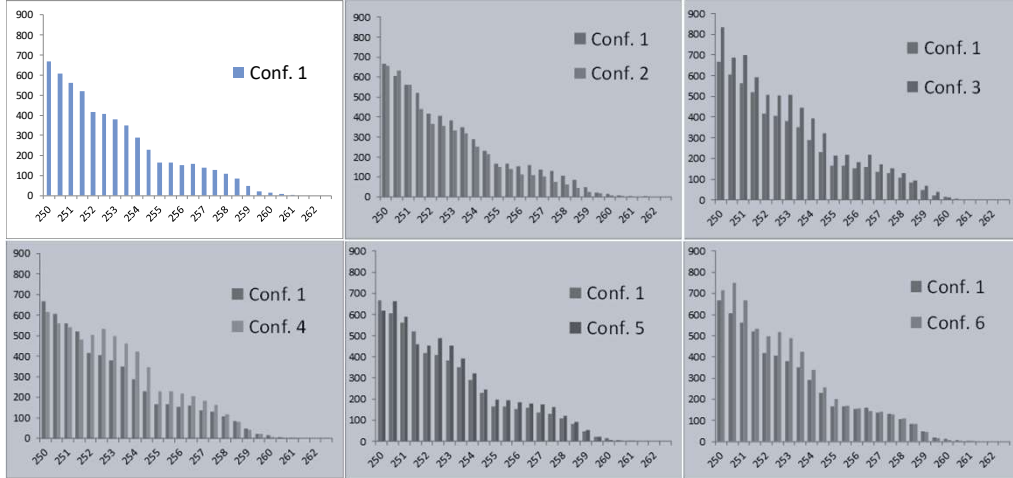
# Configuration 1



## Reactive Power Droop



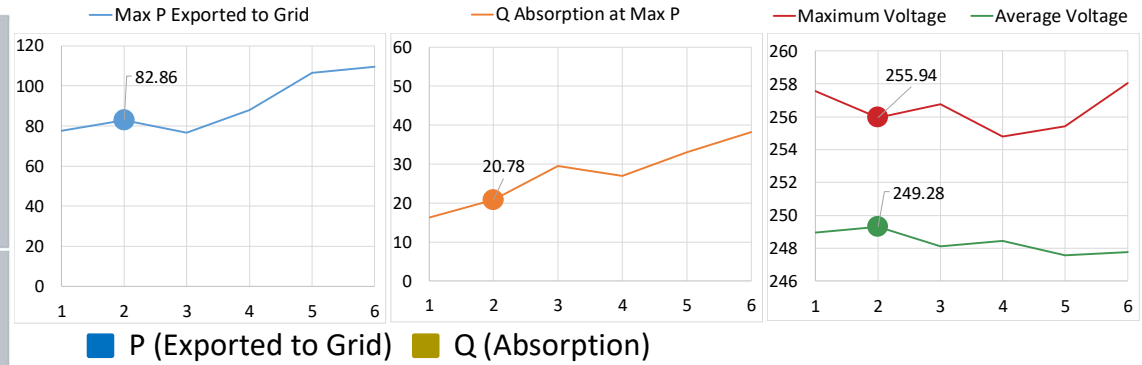
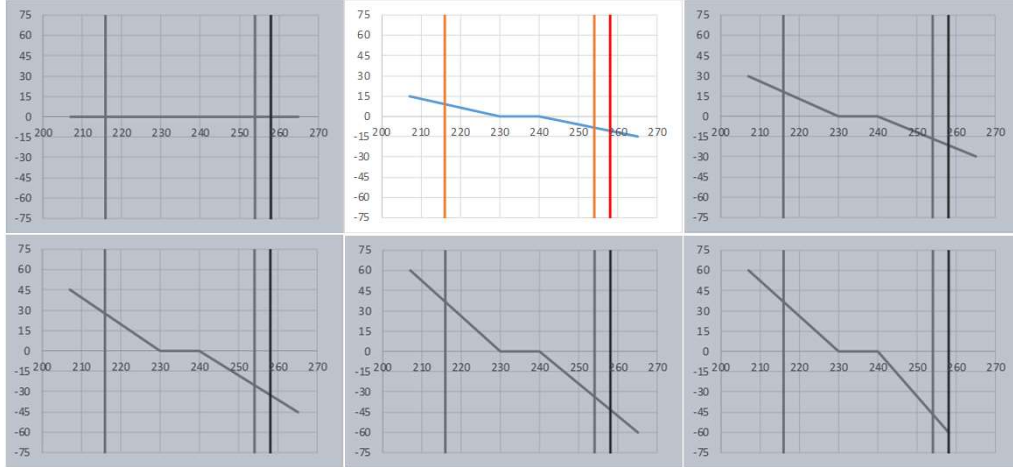
## Histogram – Feeder Voltage



# Configuration 2

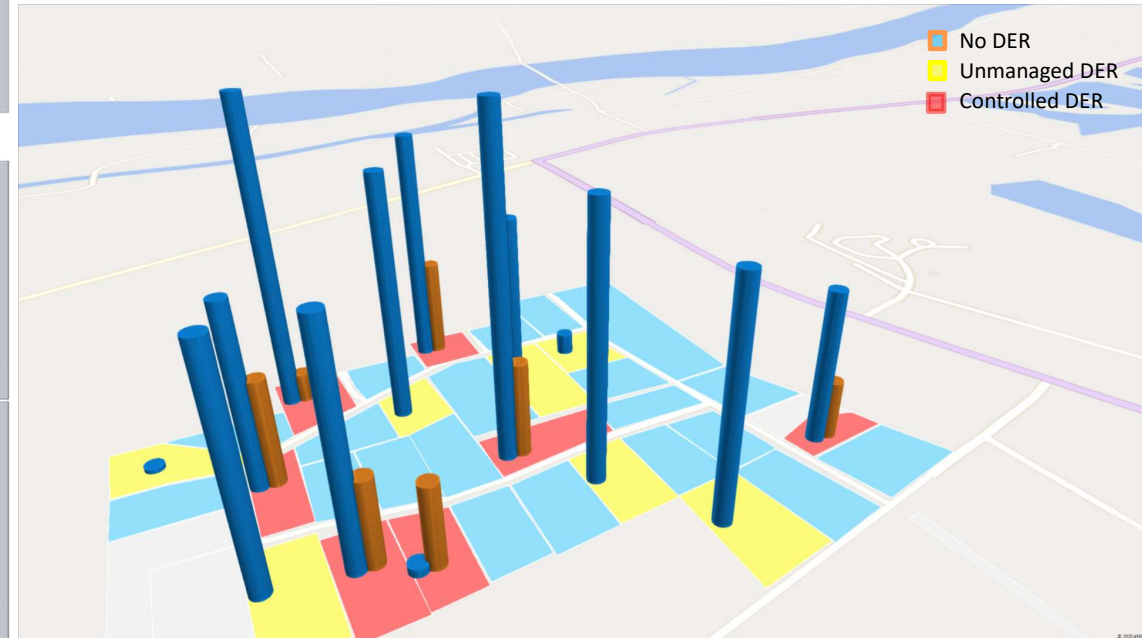
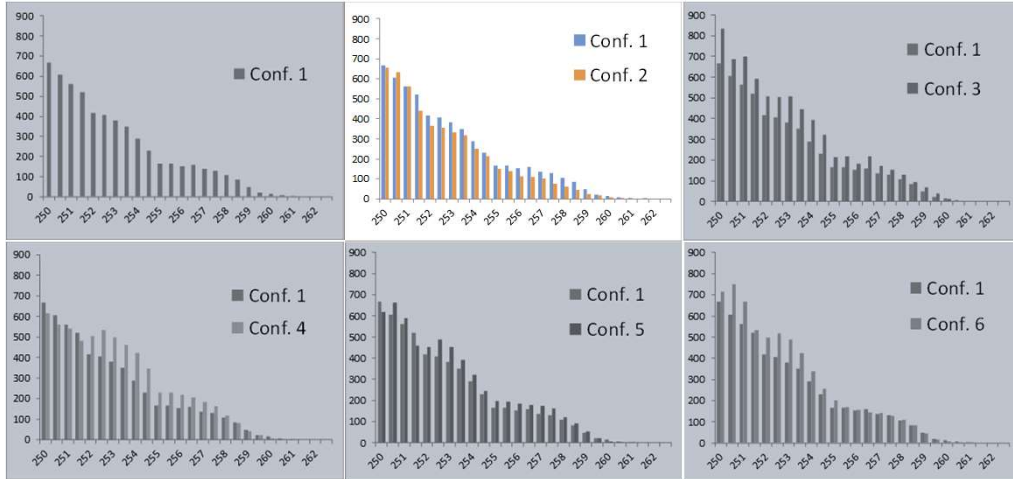


## Reactive Power Droop



■ P (Exported to Grid) ■ Q (Absorption)

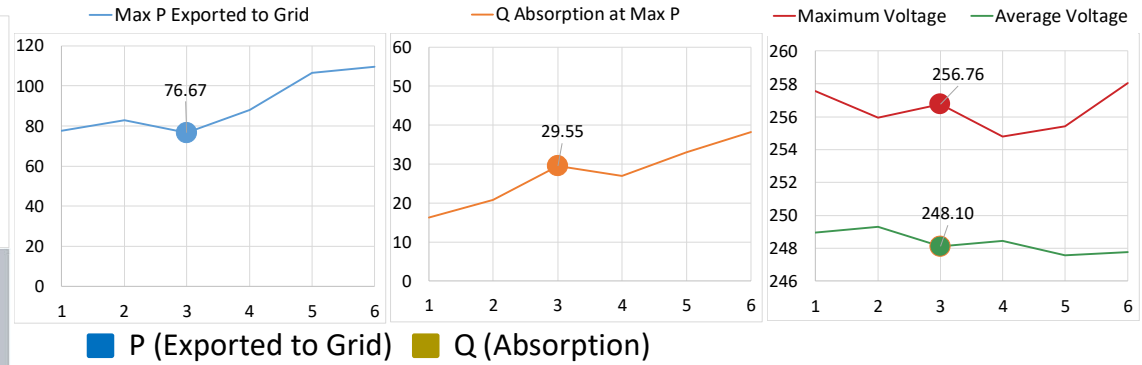
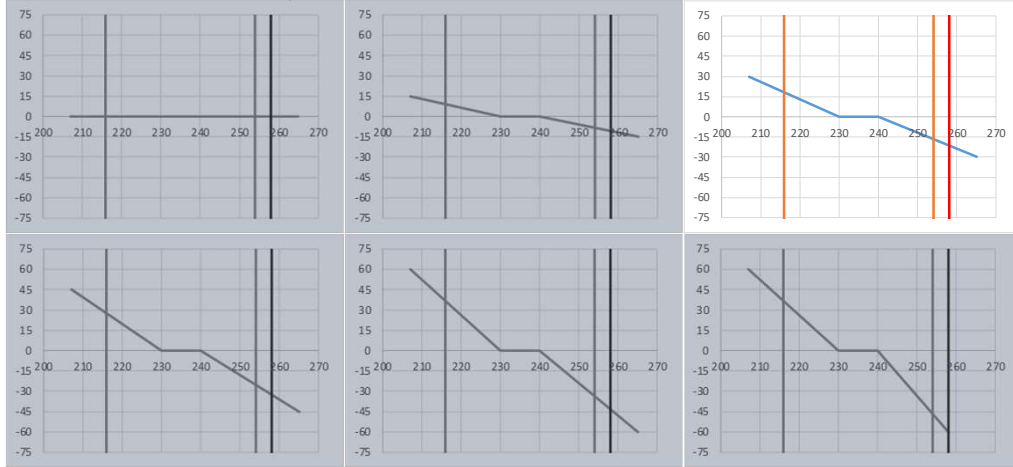
## Histogram – Feeder Voltage



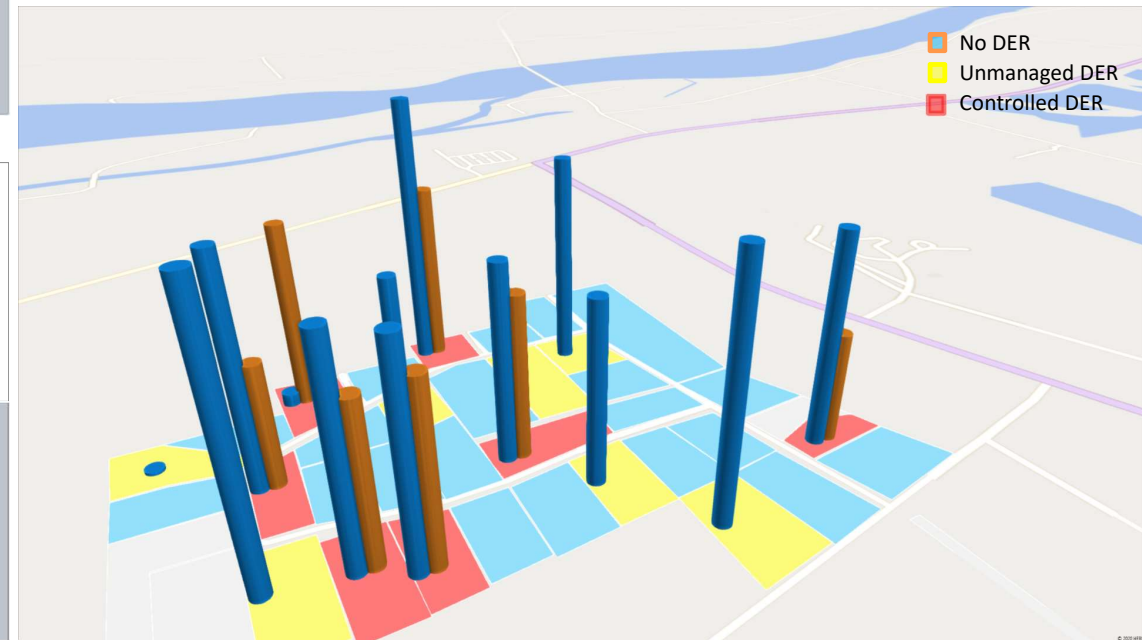
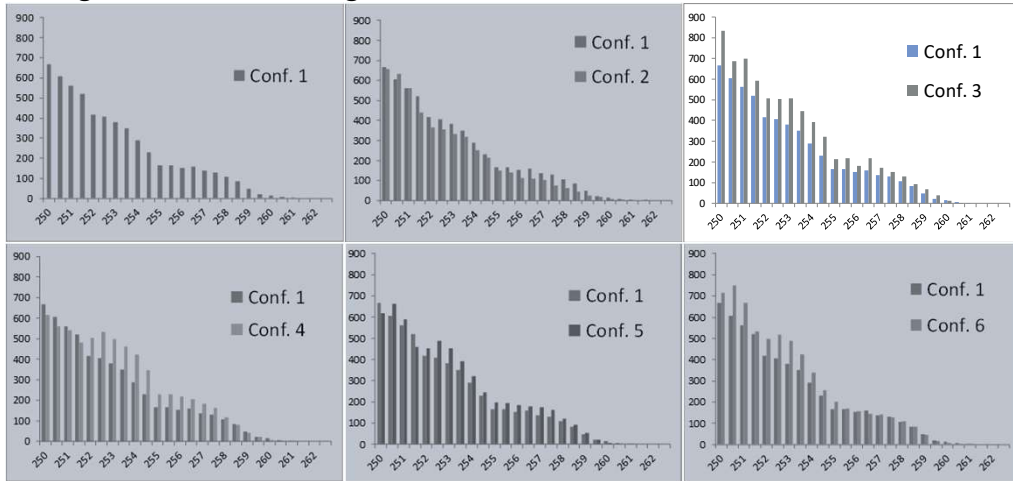
# Configuration 3



## Reactive Power Droop



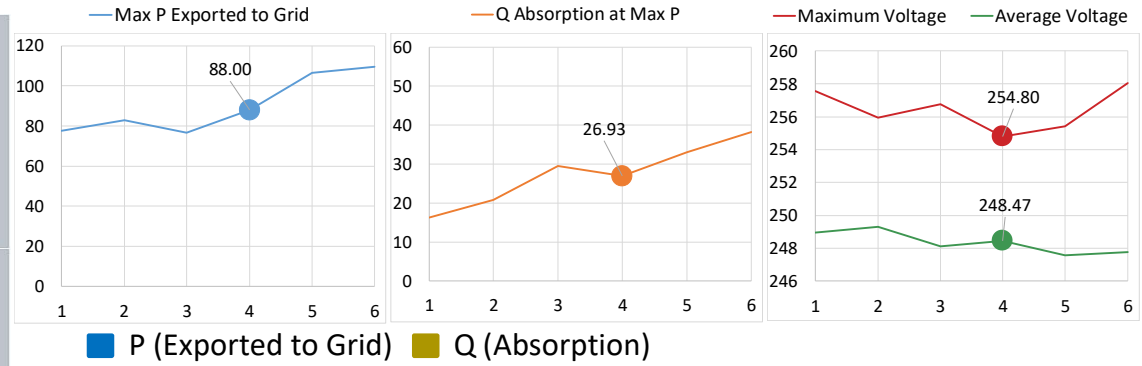
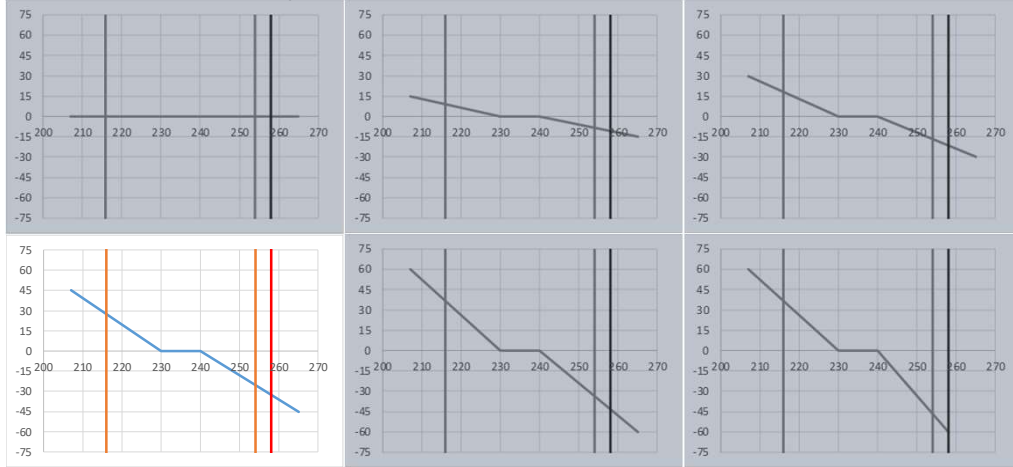
## Histogram – Feeder Voltage



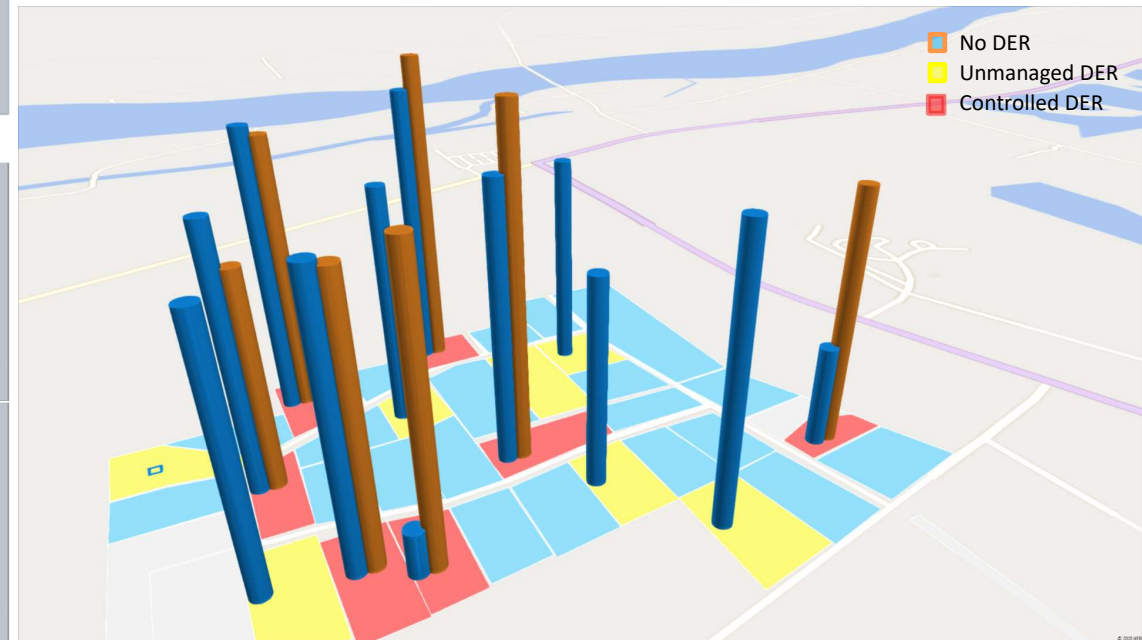
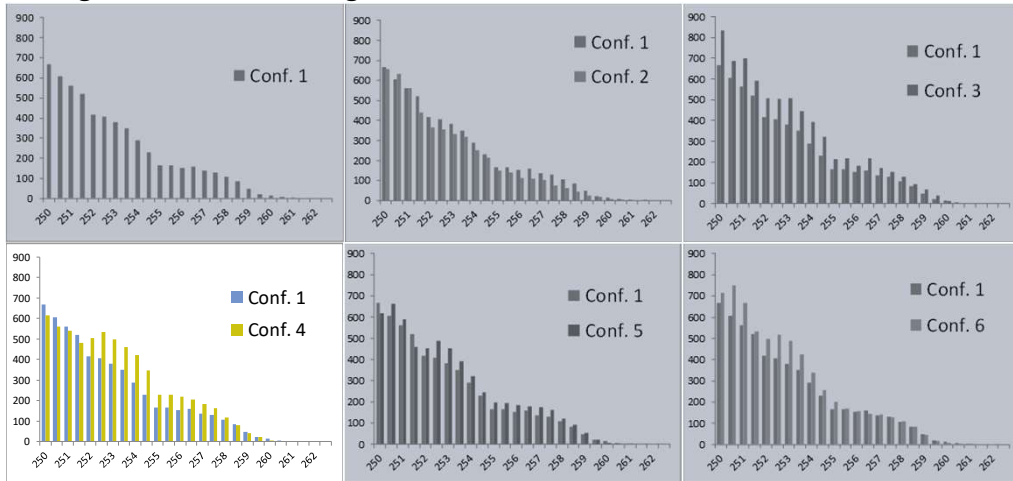
# Configuration 4



## Reactive Power Droop



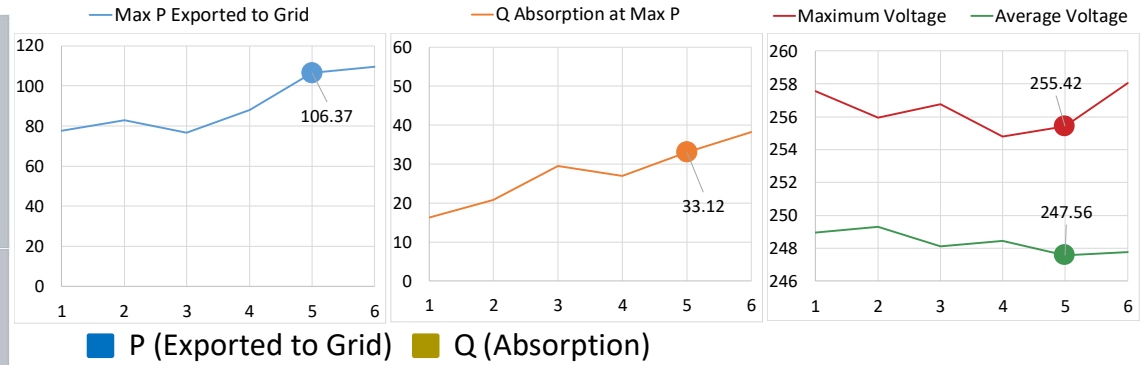
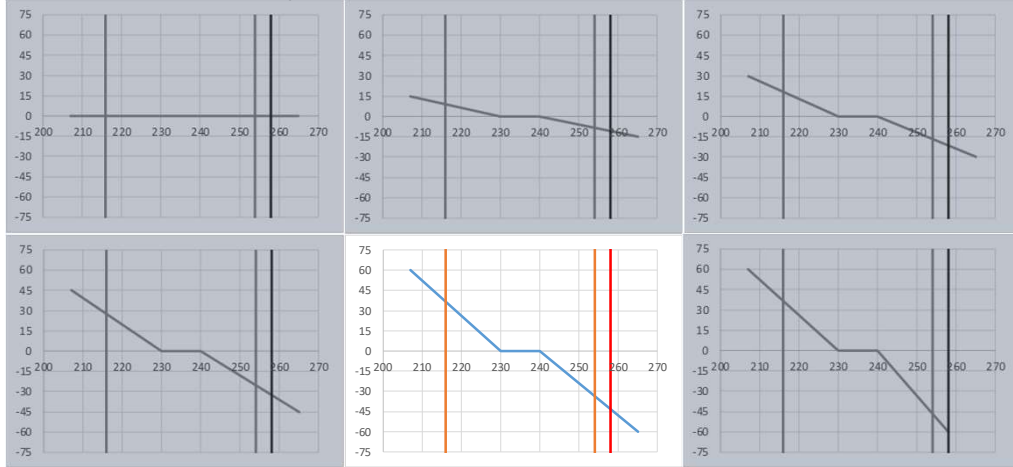
## Histogram – Feeder Voltage



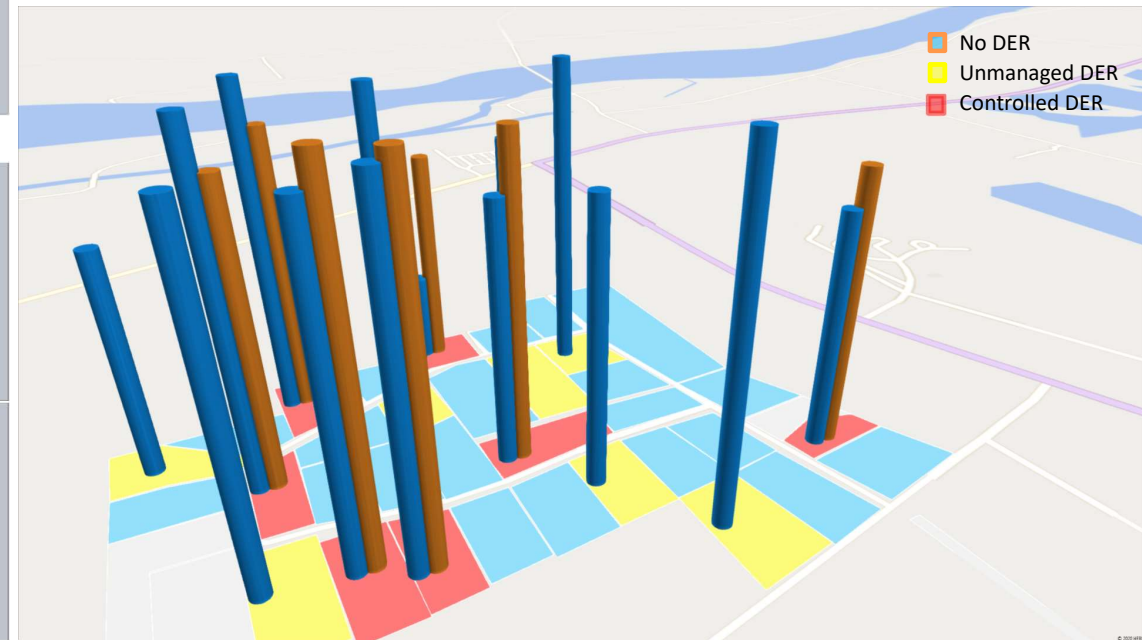
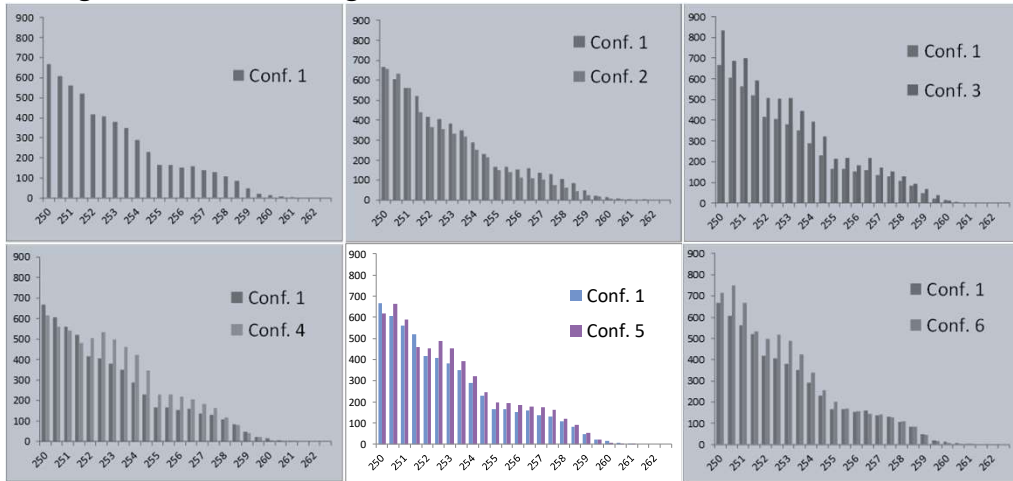
# Configuration 5



## Reactive Power Droop



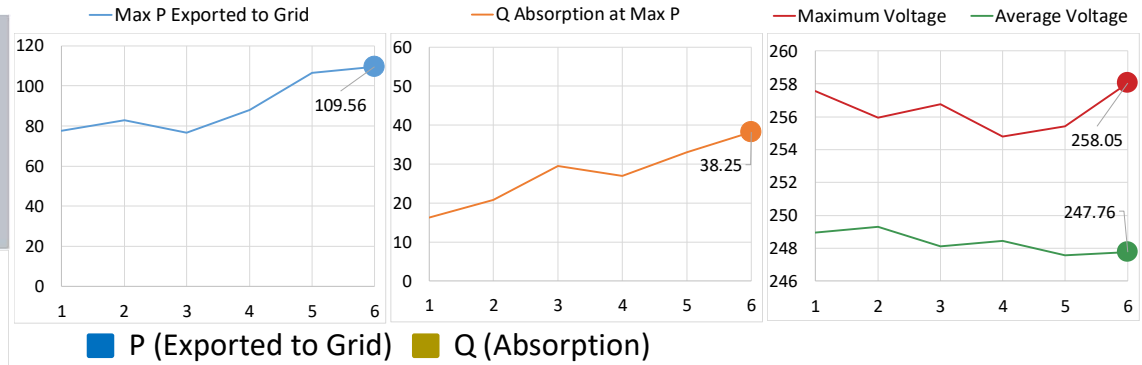
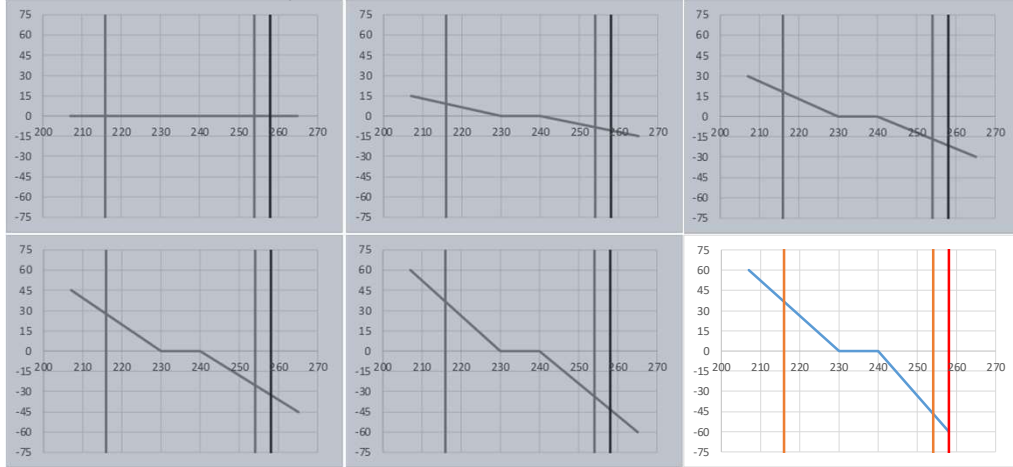
## Histogram – Feeder Voltage



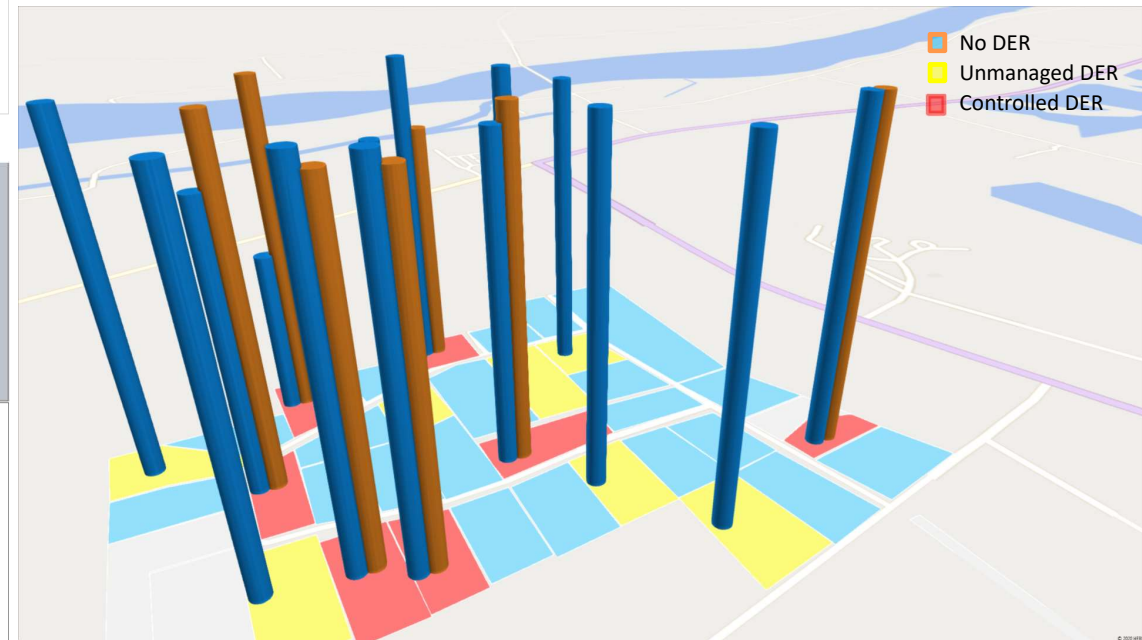
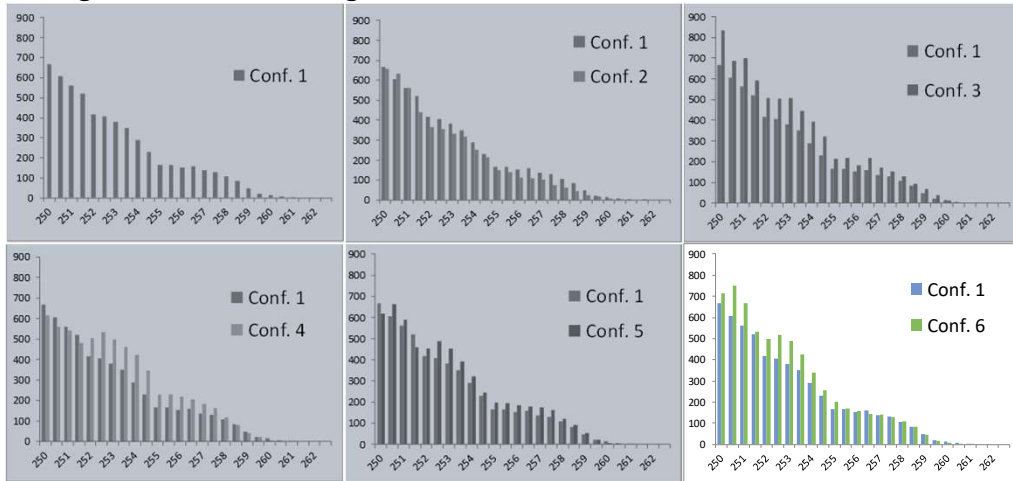
# Configuration 6



## Reactive Power Droop



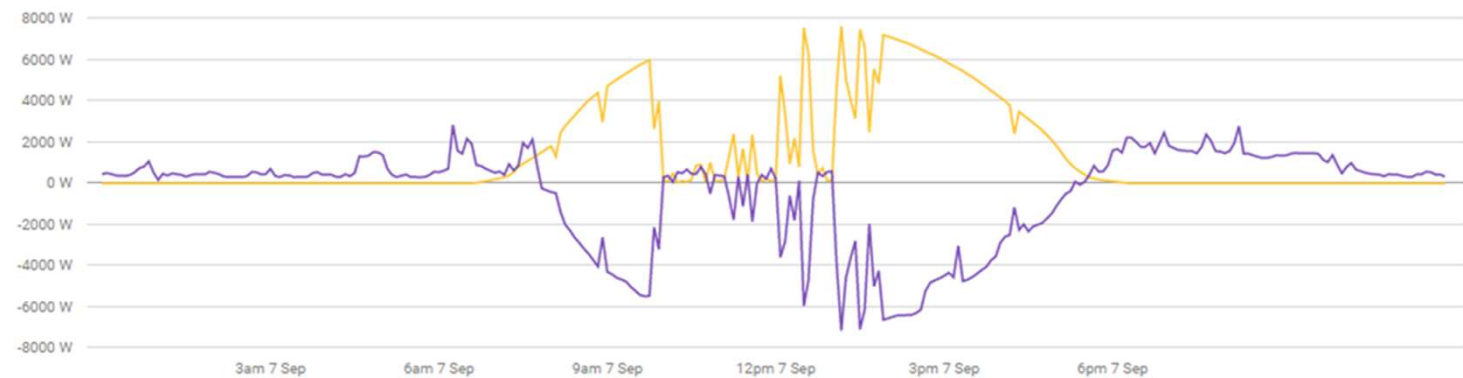
## Histogram – Feeder Voltage



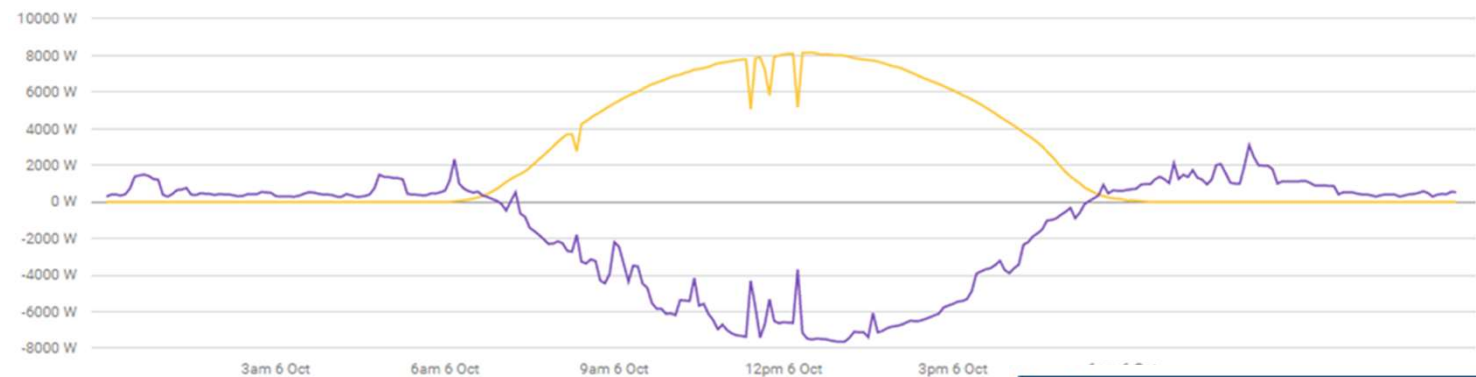
# Power Factor (Q) Control

We are experimenting with ways to use inverter settings to improve inverter performance

- Pre Q control this inverter is tripping regularly because of voltage rise

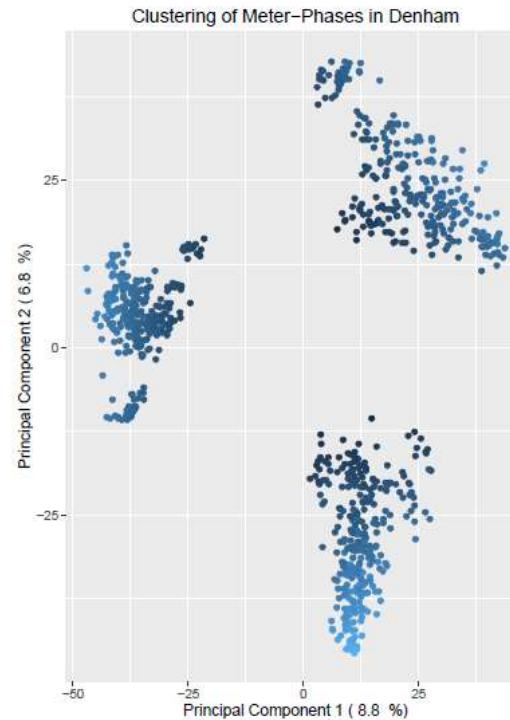


- Post Q control this inverter is able to produce more renewable energy

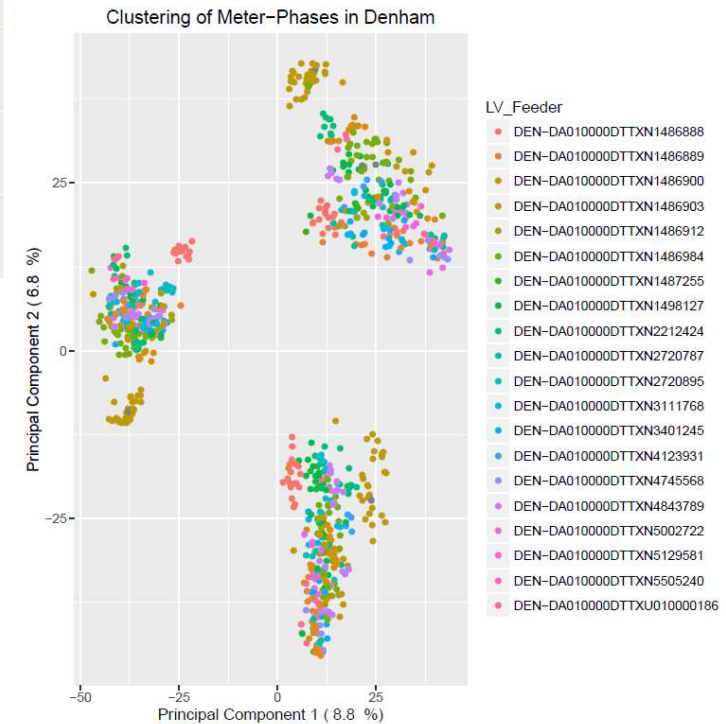


# Phase Identification

- Can we improve PV network hosting capacity by physically rebalancing the network?
- Can we improve network performance by moving some single phase inverters to less congested phases?
- K-means clustering to identify phase allocation of PV systems and calculate their contribution to voltage rise - underway
- Identify opportunities for improvement of network operation
- A Carnarvon wide audit of inverter models and settings is under way



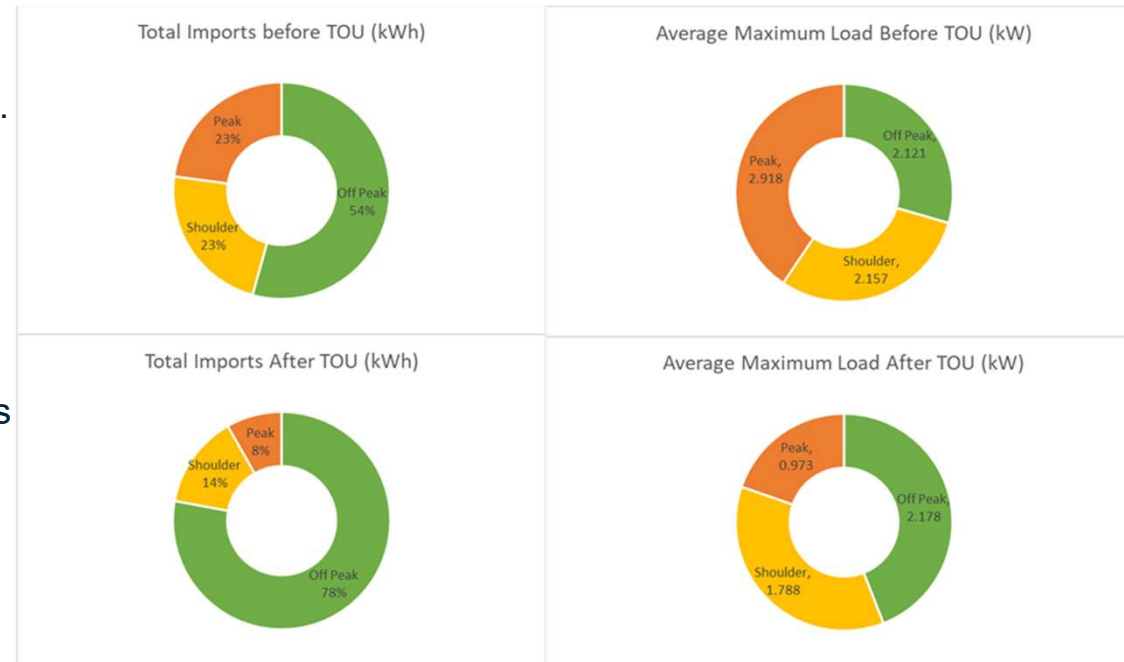
Cluster models for the town of Denham



Q&A Join at [slido.com](https://www.slido.com) #ESIG-2B [David]

# Time of Use tariff with Smart DER

- Synergy’s ToU tariff pricing was applied to the Reposit Box which controlled the battery charge and discharge.
- Pre-charged the battery before 7 am if it estimated the solar will not provide enough energy to charge the battery ready for the peak period usage.
- It does this by using machine learning of the customers daily usage patterns and PV production and the application of a weather forecast signal from Reposit.
- It then discharged the battery to match demand during the peak period



- Reduced peak time network load by **64%**
- Reduced network average peak load by **67%**
- Delivered a customer bill saving of **36%**

Synergy ToU Tariff used for the experiments

Banded/Time of Use Tariff		
Charges	Time	inc GST
Supply Charge		1.015496 \$/day
Off-peak (everyday)	9PM - 7AM	0.148405 \$/kWh
Shoulder (Weekdays)	7AM - 3PM	0.282139 \$/kWh
Peak (Weekdays only)	3PM - 9PM	0.538714 \$/kWh
Shoulder (Weekends)	7AM - 9PM	0.282139 \$/kWh
Feed in Tariff (HP -Carnarvon)		0.1056 \$/kWh

## Deliverables to Date

- We have developed a framework for complex power system analysis using PowerFactory
- Transferable knowledge that is de-risking Onslow Stage 2 DER & Hydrocarbons Off
- Building core competencies in the management of DER via VPPs within a microgrid
- Informing a customer centric approach to DER orchestration
- Experience in building and using very large data sets >150 Billion data points
- We have commenced Knowledge Sharing with the Alice Springs Future Grid Project
- The Murdoch University Inverter test report is being submitted to the public comments process for the next version of AS 4777



The Carnarvon DER Trial Activities received funding from ARENA as part of ARENA's Advancing Renewables Fund.

ARENA Project Portal <https://arena.gov.au/knowledge-bank/horizon-power-carnarvon-der-trials-technical-report/>

[www.horizonpower.com.au](http://www.horizonpower.com.au)



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