LOW VOLTAGE POWER QUALITY SSEN - DISTRIBUTION

Understanding the Impact of Low Carbon Technologies on the Low Voltage Network

Scottish & Southern Electricity Networks

INTRODUCTION

- Who we are
- LVPQ – At a Glace
- PNDC Heat Pump Testing
- Domestic Property – How are LCT being Utilised
- PNDC Mitigation Testing

SSEN DISTRIBUTION

WHO WE ARE

We're Scottish and Southern Electricity Networks Distribution. We look after the electricity cables that bring the power to your property and 3.9 million other homes and businesses across central southern England and the north of Scotland.

OUR DISTRIBUTION NETWORK AT A GLANCE

Over **3.9 million** homes and businesses across the north of Scotland and central southern England

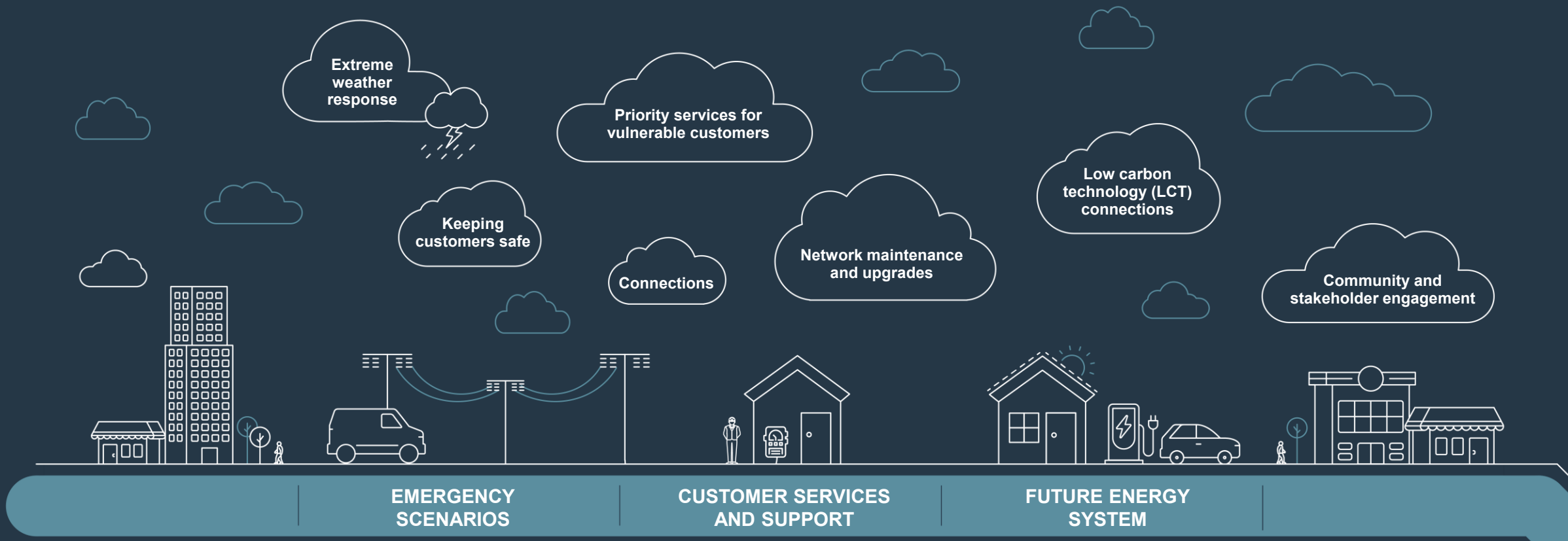
More than **937,300** customers on our Priority Services Register

Over **128,000km** of overhead lines and underground cables

460km subsea cables powering island communities

Over **4,100** employees across the country

POWERING CUSTOMERS AND COMMUNITIES



LOW VOLTAGE POWER QUALITY
NETWORK INTEGRITY MANAGEMENT

LVPQ CHALLENGE

- Transition to Net Zero requires significant deployment of Low Carbon Technologies (LCTs) onto the Low Voltage network.

- Roll-out of LCTs onto existing LV networks has the potential to negatively impact Power Quality (PQ) on those networks
  - Harmonic distortion
  - Phase imbalance (load/voltage)
  - Flicker
  - Voltage drop/rise
  - Statutory limits

- Key project goals are to investigate the PQ emissions of LCTs

- Conventional network reinforcement takes time and may not always be the most efficient solution.

LOW VOLTAGE POWER QUALITY
NETWORK INTEGRITY MANAGEMENT

Install PQ Analysers in consumer homes to better understand real-world LCT operation

Model the PQ impact with Distribution Future Energy Scenarios (DFES) forecasts to proactively identify network locations at risk

Field trials of PQ improvement devices to evaluate installation & operation under normal network conditions

LVPQ PROJECT – Funded by the Network Innovation Allowance

Carry out testing & network simulation at the Power Networks Demonstration Centre (PNDC) to understand how different types & quantities of LCTs may impact the network

Trial & assess performance of PQ improvement devices at PNDC in mitigating or resolving PQ issues

Develop processes & tools to aid Customer Operations in the event of PQ and Load related complaints or faults.

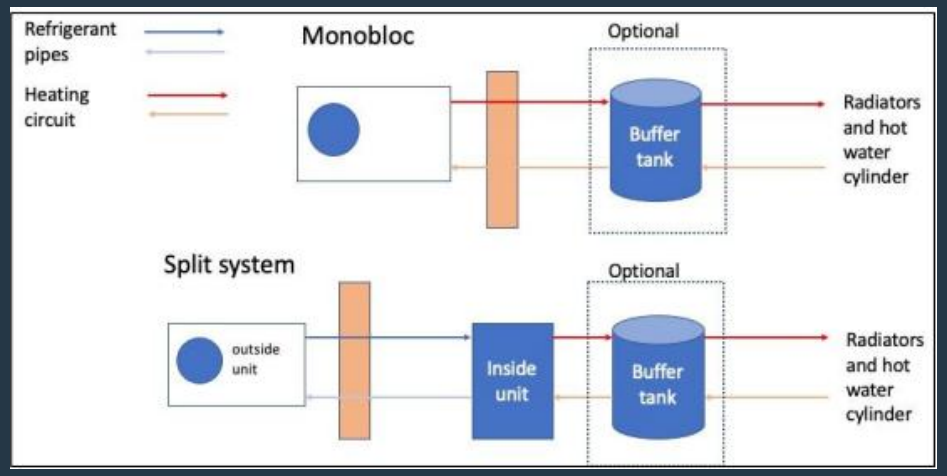
LOW VOLTAGE POWER QUALITY
NETWORK INTEGRITY MANAGEMENT

LVPQ Project Aims

- Better understand PQ impact of LCT deployments on the LV network.
- Model LCT PQ impact to combine with Distribution Future Energy Scenarios (DFES) to estimate where PQ issues may arise in future to enable proactive action.
- Test effectiveness of a range of PQ improvement devices in lab & field.
- Assess lifecycle suitability of devices against conventional reinforcement methods.
- Provide a set of technology-based solutions to diagnose & address PQ issues.
- Develop processes for assessment, selection and installation of most appropriate solutions for both reactive & proactive approaches.

HEAT PUMP TRIALS

- PNDC testing:
  - four domestic heat pumps
  - six electric vehicles using three different charging stations
  - three PV inverters.
- Heat pumps installed within conditions emulating a standard 3 or 4 bedroom semi or detached.
- Installation Criteria – Buffer tanks



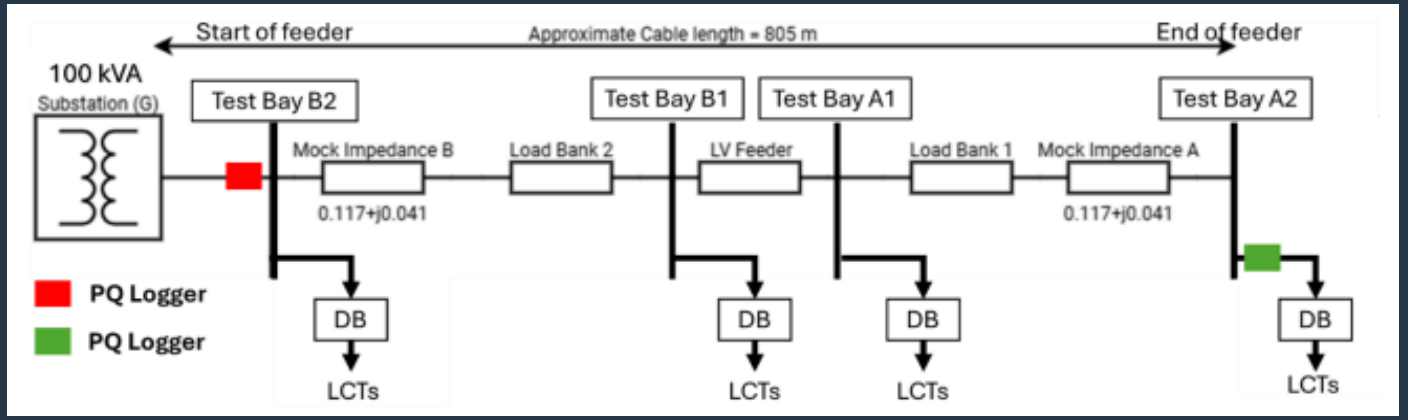
HP #	Format	Rating (kW)	Min/Max Set point (°C)	House type, no. of bedrooms and built year
HP-1	Monobloc	5 (single phase)	35/65	Detached, 4, 2001
HP-2	Monobloc hydro split	4 (single phase)	20/65	Semi-detached, 3, 2001
HP-3	Monobloc	8	25/65	Semi-detached, 3, 1981
HP-4	Monobloc	12	20/65	Detached, 4, 1981

HEAT PUMP TRIALS

- Primary Objective: Capture range of power quality signatures
- Secondary Objective: Investigate the interactions and combined effects of multiple LCTs

The key conditions investigated in this phase were:

- Operational conditions: Variations in harmonic loading
- Network location: Changes in the position of harmonic loads in the feeder



Start	End	Approx Cable Length (m)
Substation G	Test Bay B2	150
Test Bay B2	Mock Impedance # B	110
Mock Impedance # B	LB2	35
LB2	Test Bay B1	50
Test Bay B1	LV Feeder Pillar 1	70
LV Feeder Pillar 1	Test Bay A1	140
Test Bay A1	LB 1	110
LB 1	Mock Impedance # A	35
Mock Impedance # A	Test Bay A2	105
Total length		**805**

HEAT PUMP TRIALS

34 different test cases run within 3 main classes:

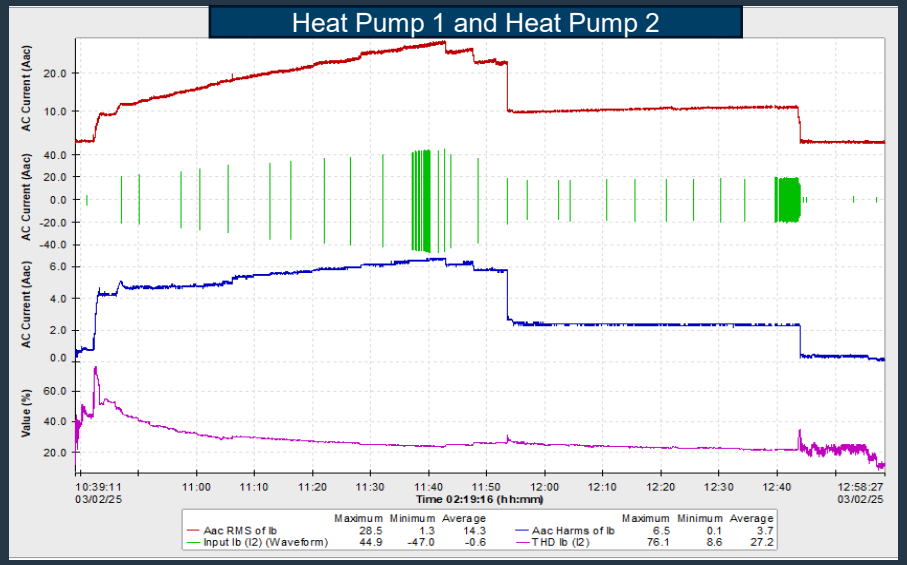
- 14 test cases created a baseline for the HP, EVs, and PVs
- 7 test cases reviewed how a varying number of HPs would interact on the network when run concurrently
- 14 test cases reviewed how the devices might work concurrently with other LCTs at varying distances on the network

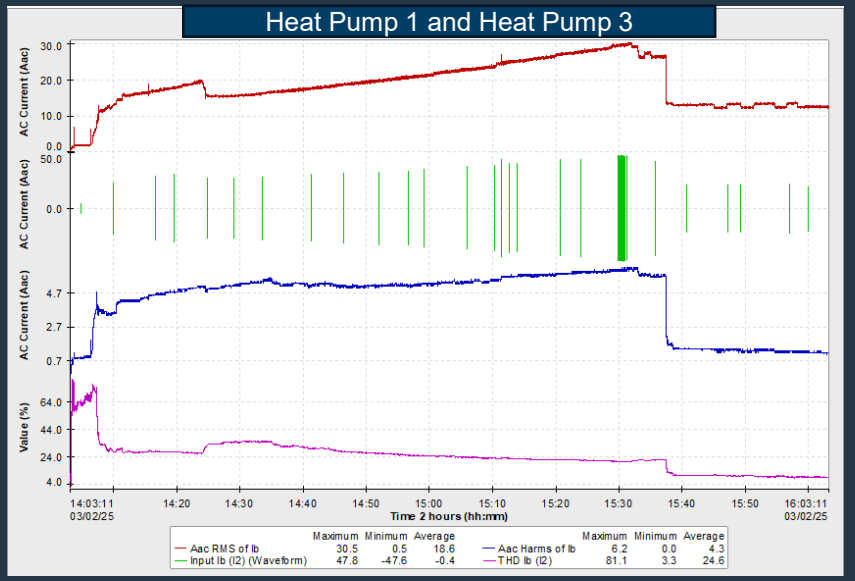
This data has informed the future models.

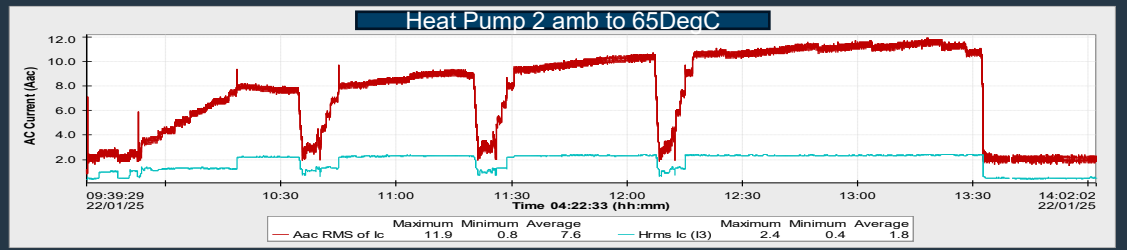
HEAT PUMP TRIALS

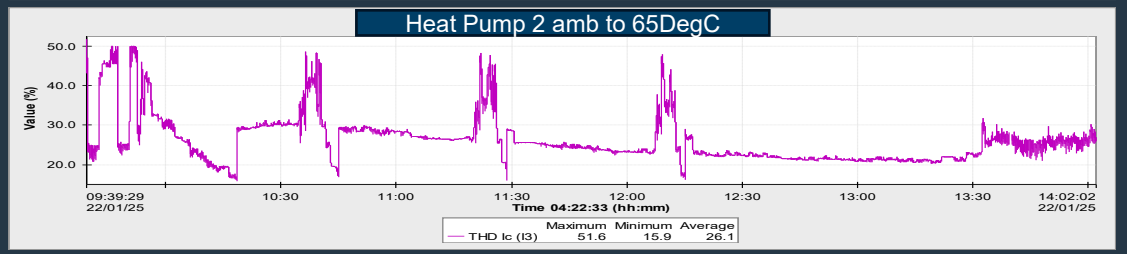
Conclusions:

- Findings
- Informing the model
- Limitations









PROPERTY INFORMATION

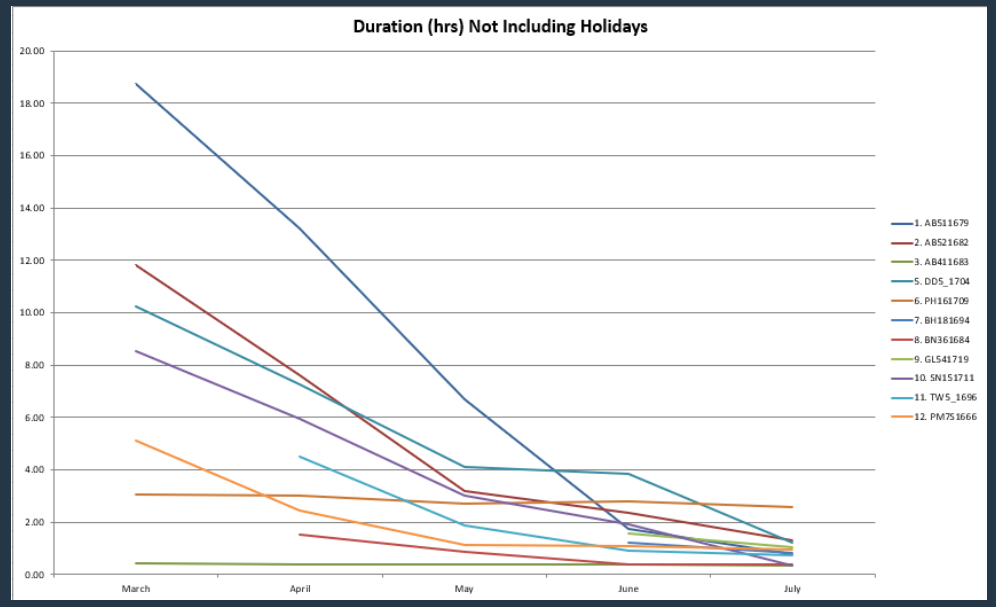
What/Where/Why

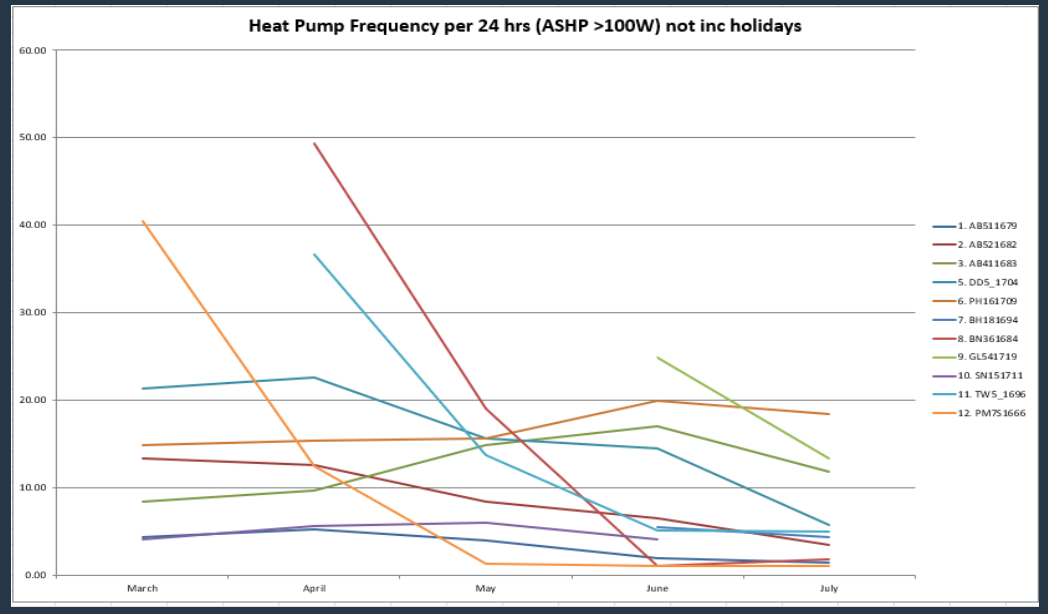
- Installed power quality monitors at 15 properties
- Properties are spread between SHEPD and SEPD
- First installs were in March and completed in June
- All properties had a combination of Low Carbon Technologies – EV, PV, HPs and BESS
  - Only main criteria was the properties needed to have HPs
  - Less concerned which brands were present over what they had total

PROPERTY INFORMATION

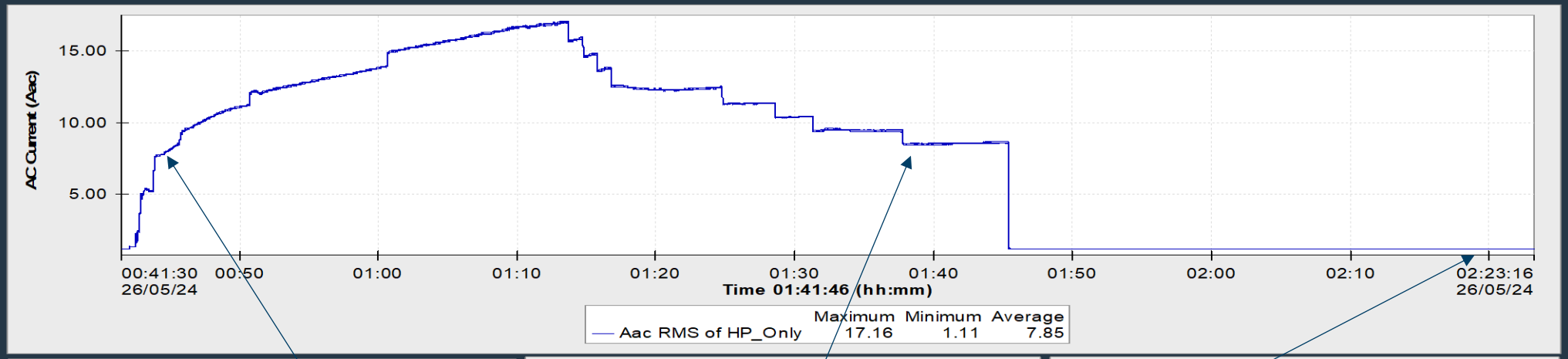
Conclusions

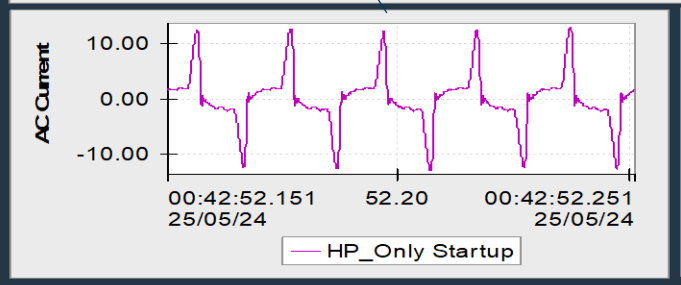
- Every property was different
  - LCTs
  - Reason
  - Use
- Usage time dipped but start ups increased

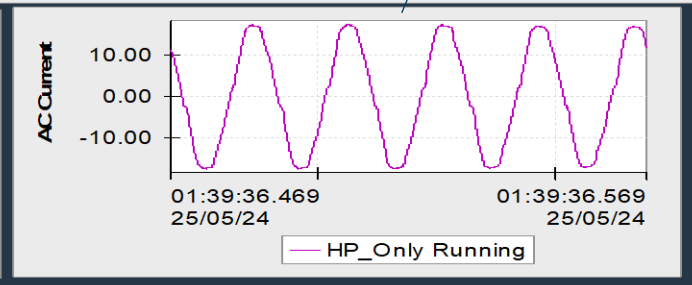


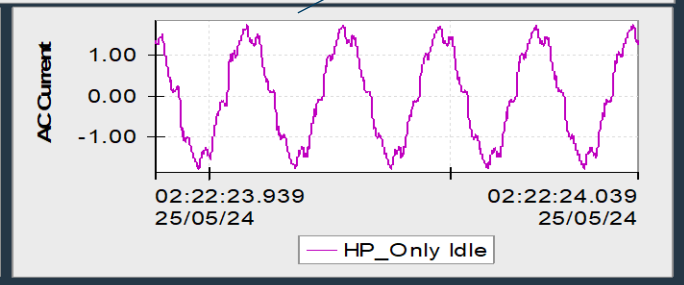


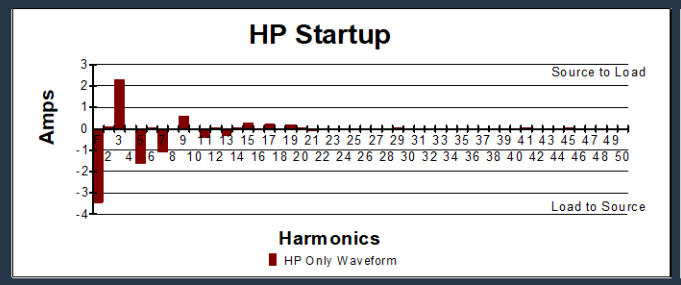
LOW VOLTAGE POWER QUALITY
PROPERTY INFORMATION

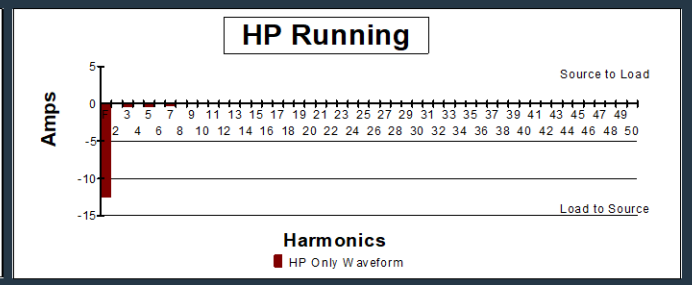


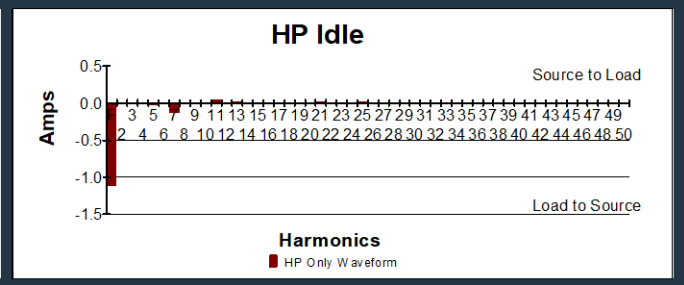




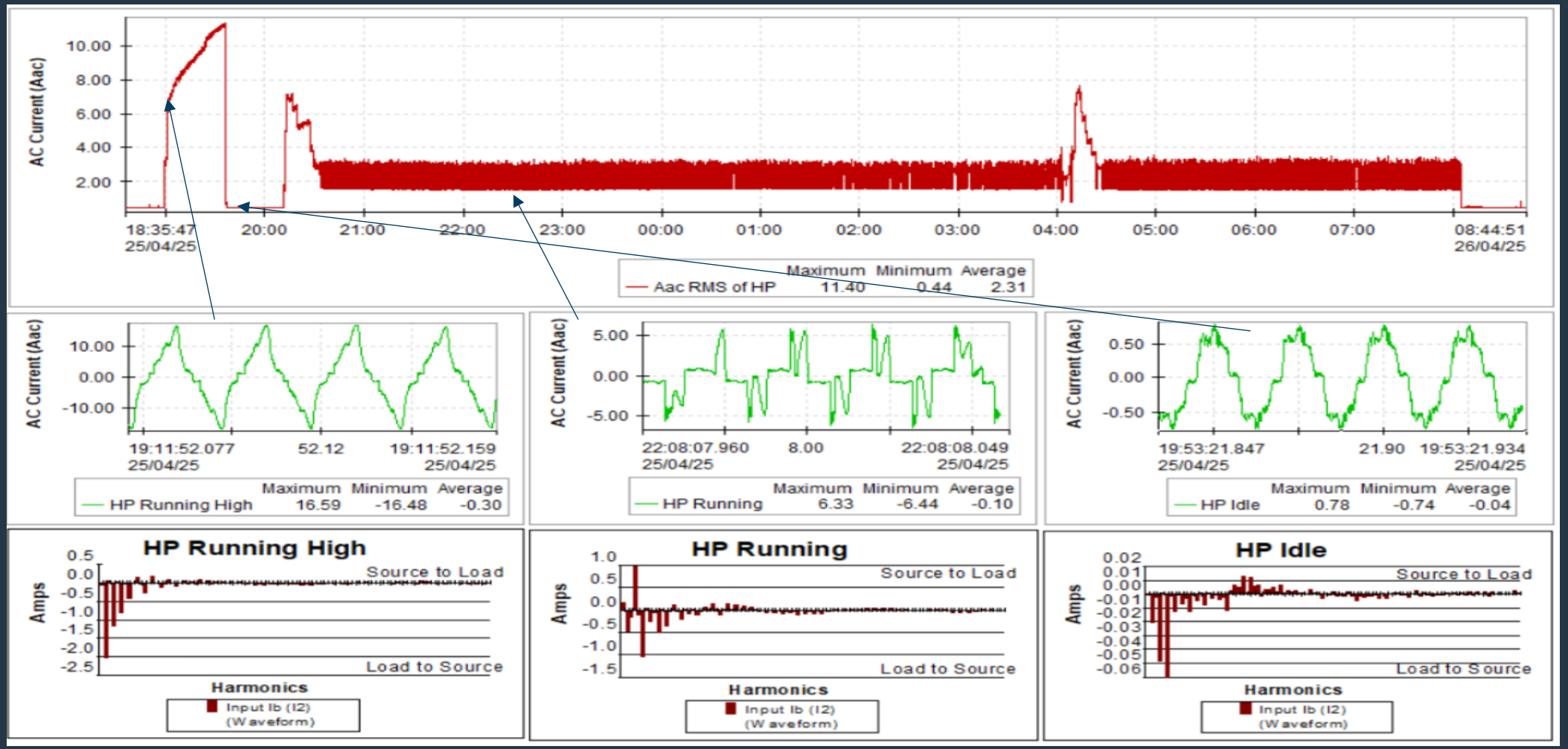








LOW VOLTAGE POWER QUALITY
PROPERTY INFORMATION



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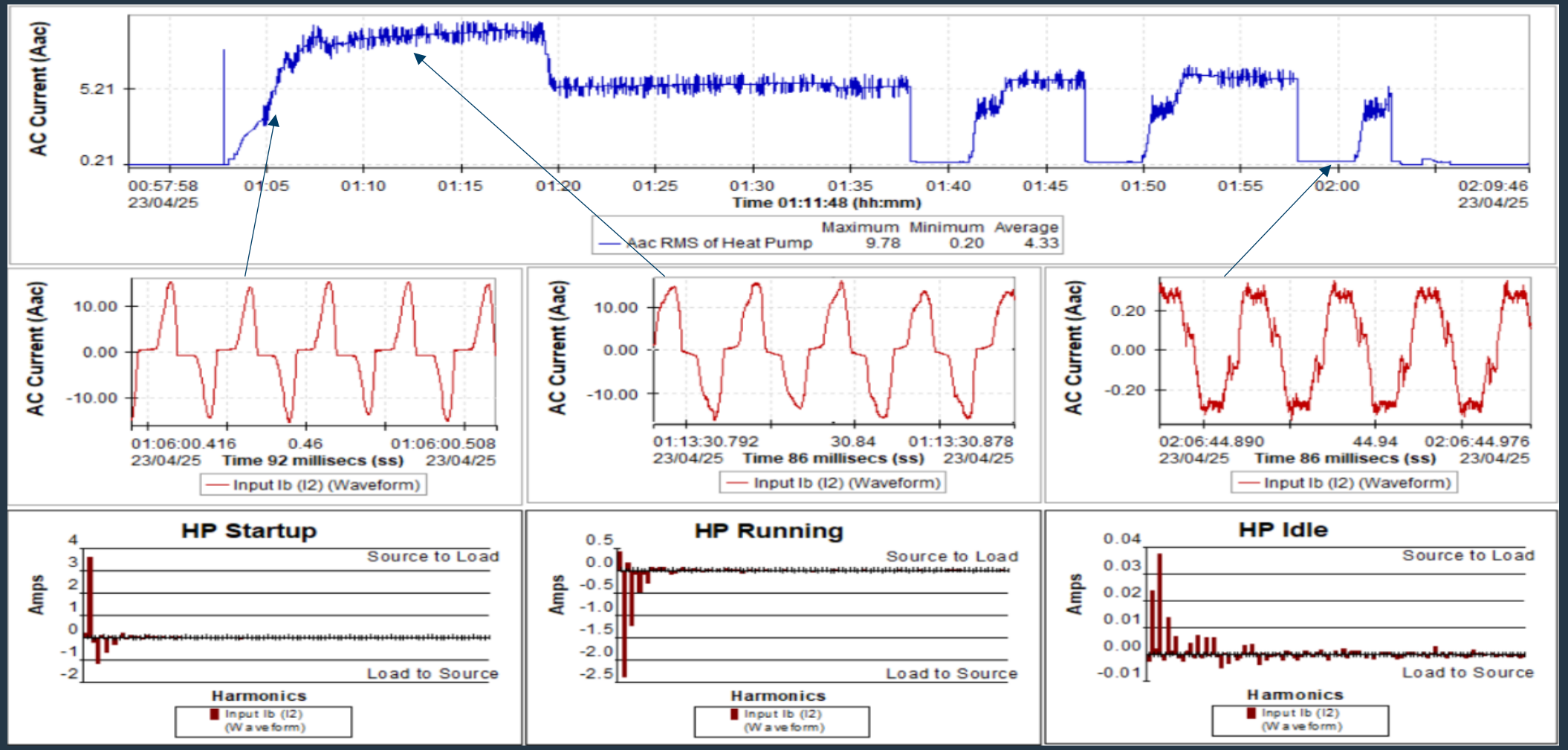
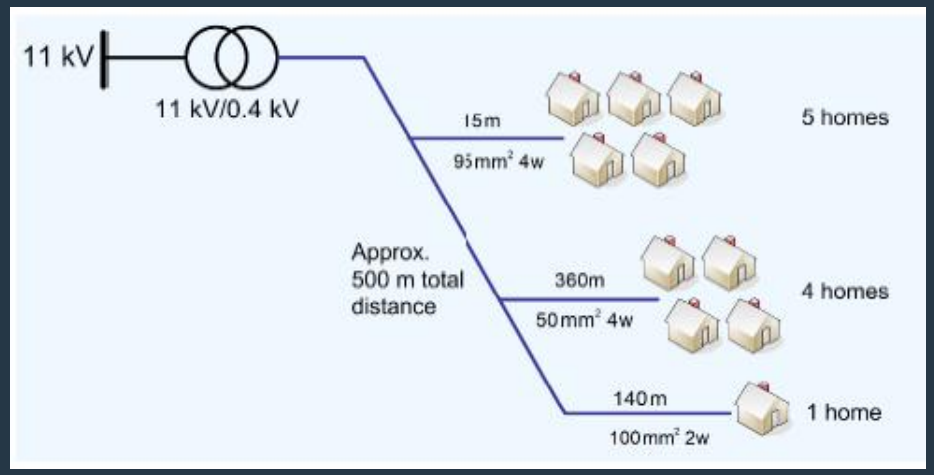


LOW VOLTAGE NETWORK MODELS – RURAL AND URBAN MODEL

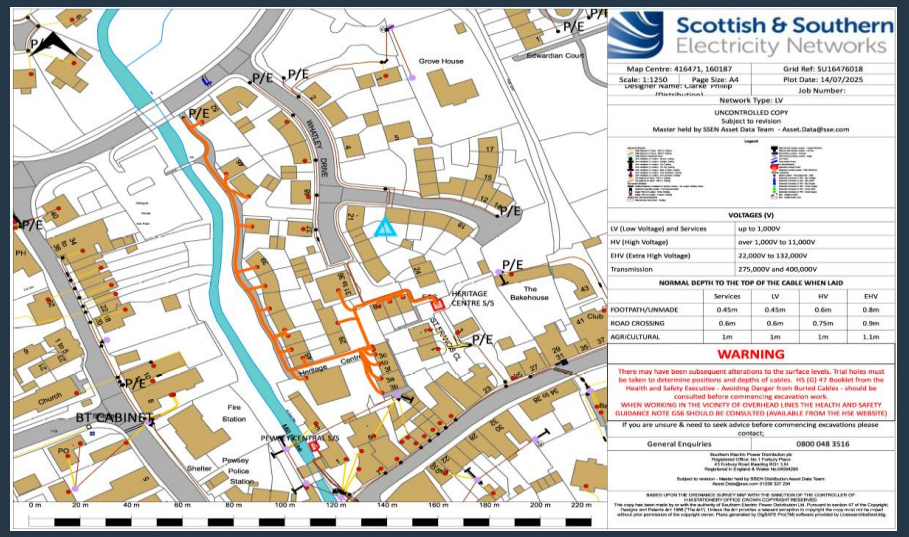


Rural Model:

- Smaller transformer
- Simulating longer route
- 10 house across whole network
- 4 models created for this network
- High phase imbalance

Urban Model:

- A newer network built after 2010
- 27 houses on feeder
- 51 house across whole network
- PQ monitor fitted at a property and at substation
- 3 models created for this network



LOW VOLTAGE NETWORK MODELS – MITIGATION TECHNOLOGIES

Testing beginning September 2025 – March 2026

6 mitigation technologies will be trialled at the PNDC

These will cover:

- Overhead solutions
- Underground solution
- Phase Balancers
- Harmonic filters
- Variety of Capacity levels

Solutions will also be spread amongst some physical ‘core’ based solutions and power electronic solutions

THANK YOU

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