University of Strathclyde Engineering

# Network Instrumentation and Measurements at PNDC

Glasgow, February 2016

UNIVERSITY of STRATHCLYDE POWER NETWORKS DEMONSTRATION CENTRE

SP ENERGY NETWORKS

Scottish and Southern Electricity Power Distribution

S&C

OMICRON

Locamation smart smart grid solutions

Scottish Enterprise

Scottish Funding Council Promoting further and higher education

# Outlines

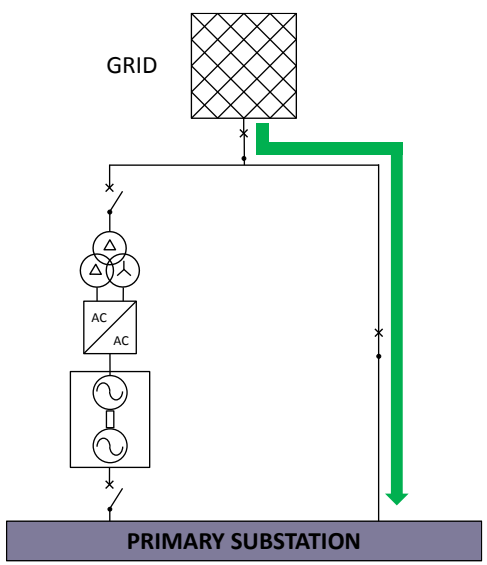
- PNDC Scope
- PNDC Supply Connection Capabilities
- The 11kV/LV Network
- PNDC Measurements Capabilities
- HV/LV Grid Instrumentation For EURAMET Project
- Communication Protocols at PNDC
- SCADA/ Historian System
- Installation of Additional Measurements
- Future Work

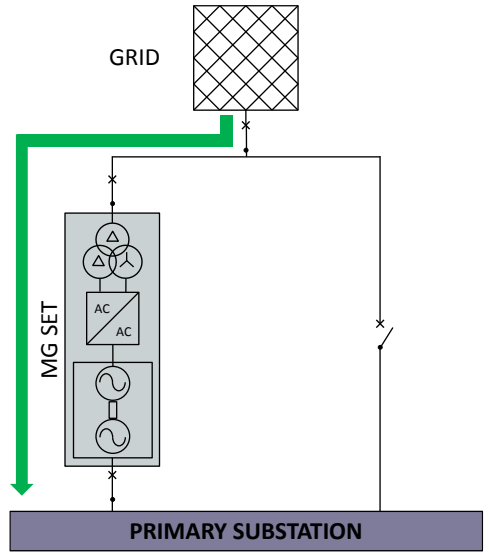
# PNDC Supply Connection Capabilities

Options: Grid connected or islanded system

- Grid connected mode: network is fed directly from an 11kV grid infeed from Scottish Powers distribution network. The network is supplied from the 11kV infeed through an 11/11kV isolation transformer.

- Islanded mode: the network is supplied from a 5MVA motor/synchronous generator set within the PNDC compound. Operating in this mode allows for voltage and frequency a wide range of frequency/ voltage variations to be applied.

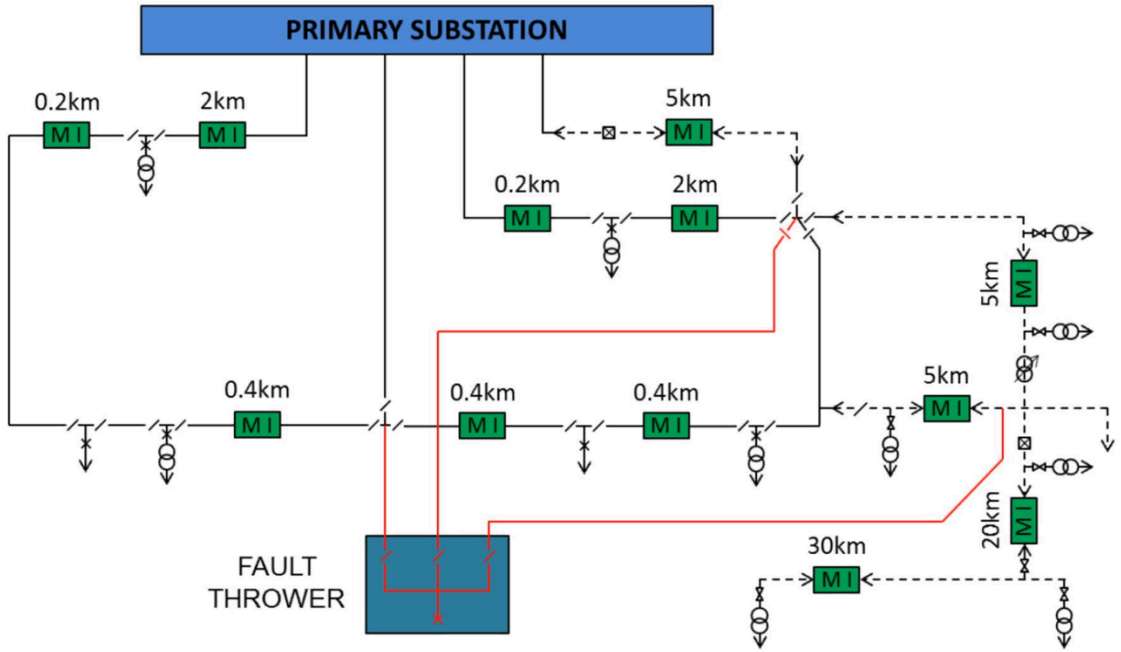


# The 11kV Network

The PNDC has an 11kV network composed of overhead lines and underground cables with mock impedances used to provide a representation of typical overhead lines and cable lengths which cannot be achieved within the network compound.

The overhead line can be configured as a radial feeder with an equivalent length of 60km which permits to demonstrate a number of voltage issue, e.g. due to unbalance load and distributed generation, and to test and demonstrate solutions.




## Technical details

- Three underground feeders for a total equivalent length of 6km.
- One overhead feeder for a total equivalent length of 60km.
- A range of 11kV/400V transformers from 500kVA to 25kVA.
- Pole mounted auto reclosers.
- Series voltage regulator.
- Capability to apply resistive line and earth faults.

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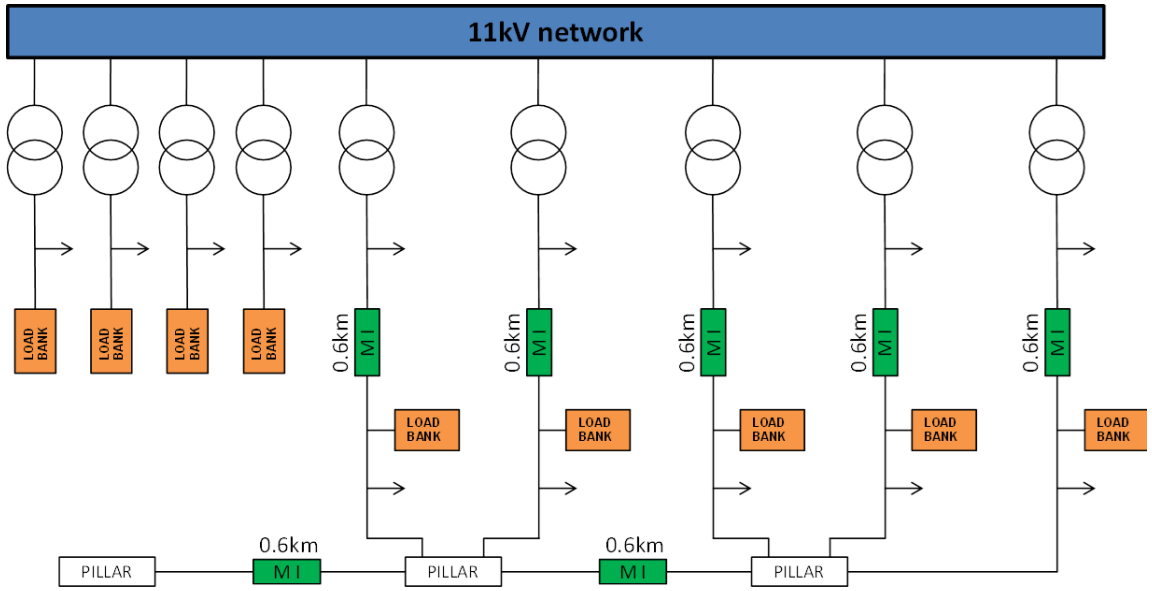
# The LV Network

PNDC LV network is powered by its HV circuit via 11/0.4 kV step-down transformers. Cables with mock impedances represent an urban distribution network with long feeder lengths. Single and three phase load banks simulate load profiles required during tests. Indoor test bays are available to connect equipment (e.g. EV chargers) while outdoor LV pillars are used to change network topology, isolate parts of the network (e.g. to test generators) or as connection points for equipment placed on (bunded) test bays in the network compound. DAQ points allow remote monitoring and control.




## Technical details

- Transformers ~ 50 to 315 kVA
- Mock impedances ~ 0.6 km
- Load banks ~ 600 kVA (total)

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# PNDC Measurements Capabilities


- PNDC has a continuous network instrumentation process
- PNDC has an extensive field measurements coming to the central control room via SCADA and archived in the PI historian system.
- The measurements incorporate real time digital and  analogue

# HV/LV Grid Instrumentation For EURAMET Project

3X

9X

12X




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# EURAMET`s Project New Instrumentation

- Voltage Transformer

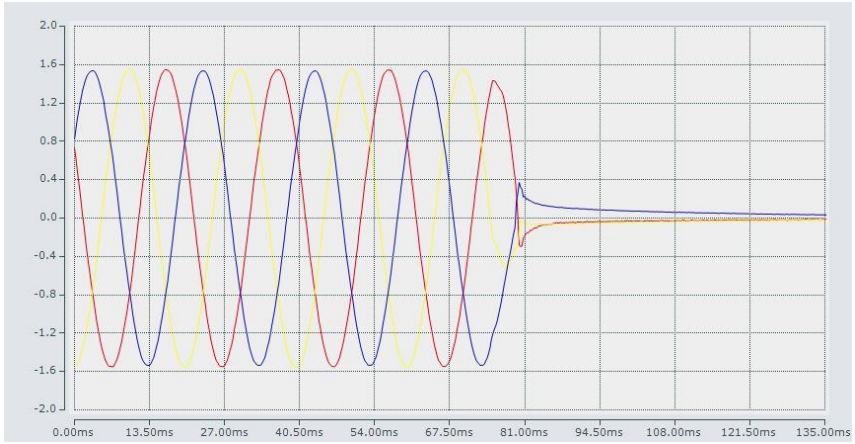
  - **Model:** Single Pole ABB VOG-24
  - **Mount:** Pole Mounted
  - **Ratio:** 11000/110
  - **Class:** 0.2
  - **Burden:** 25VA
  - **Total Installations:** 9
  - **Location:** Overhead Line

**VOG-24**

VOG- 24 Outdoor Installation

# EURAMET`s Project New Instrumentation (Continue)

- Rogowski Current Transformer Plus Integrator

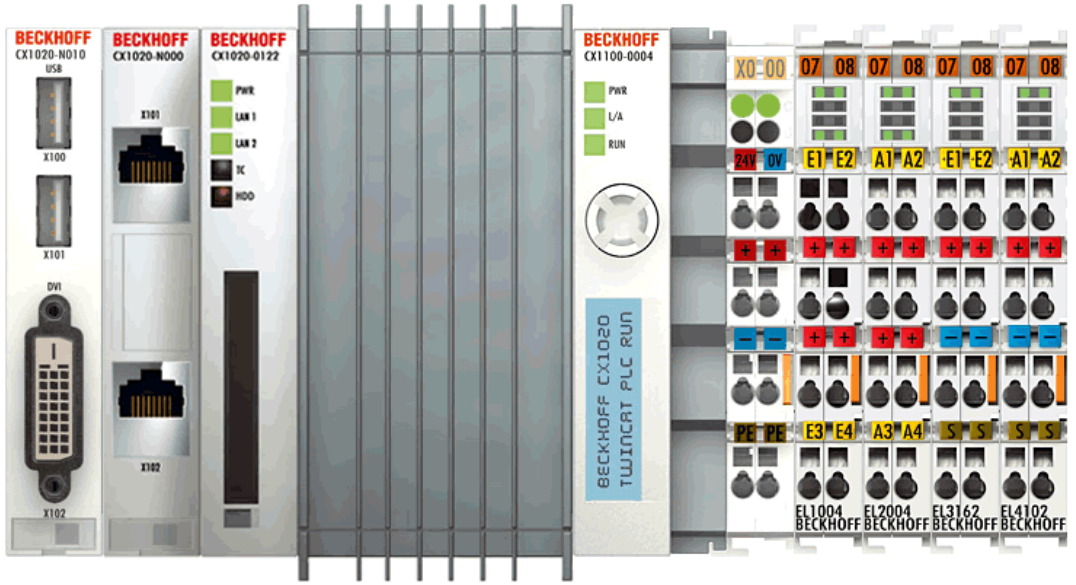


- **Model:** Rigid Coil
- **Output:** Single output ± 10V
- **Class:** 0.2
- **Total Installations:** 3
- **Location:** Cable Box

- **Model:** Tube Coil
- **Output:** Dual output ± 10A/V and ± 60A/V
- **Class:** 0.5
- **Total Installations:** 12
- **Location:** Cable Box

# EURAMET`s Project Instrumentation (Continue)

- The new current/voltage transformer will be connected to FastDAQ computers.
- Local/Central GPS time synchronised




**EL3773 Specifications**

- **Input :** max. ±500 V
- **Sampling Freq.:** 10kHz
- **ADC:** 16 Bit incl. Sign



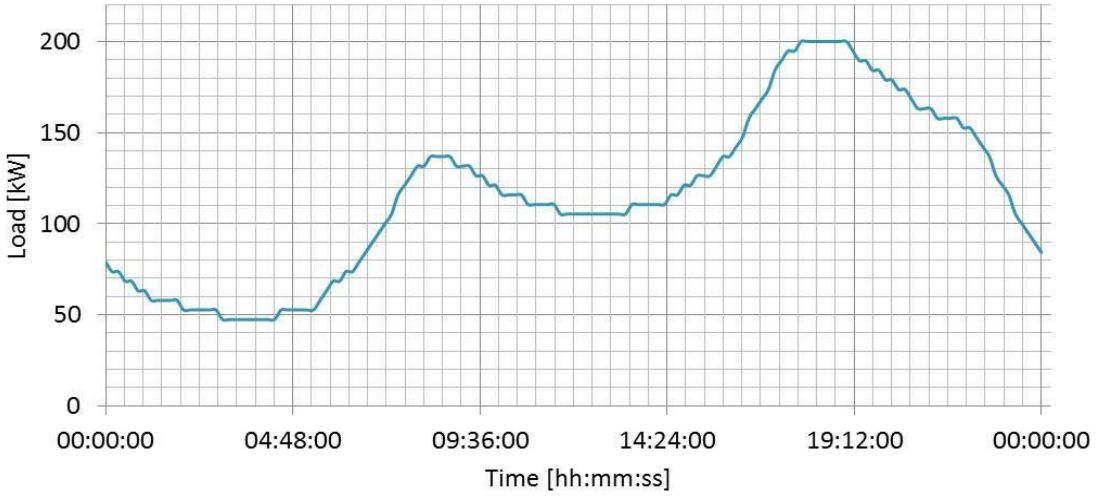
**EL3104 Specifications**

**Input:** max. ±10 V
**Sampling Freq.:** 10kHz
**ADC:** 16 Bit incl. Sign

# EURAMET`s Project existing Instrumentation

- Load Banks
  - 8 programmable Load banks can be connected together to achieve a total of 600kVA
  - Measurements Accuracy is  0.5%
- Portable Power Quality (Fluke 435)
  - Accuracy between 0.5-1.0 %
  - 1 msecond sampling

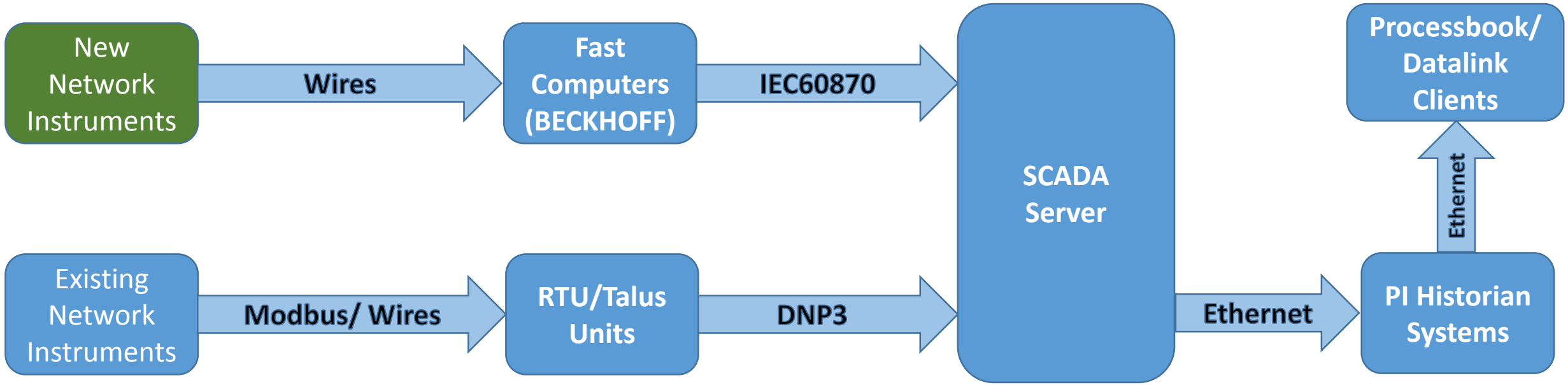
**Load Bank**




Load Profile

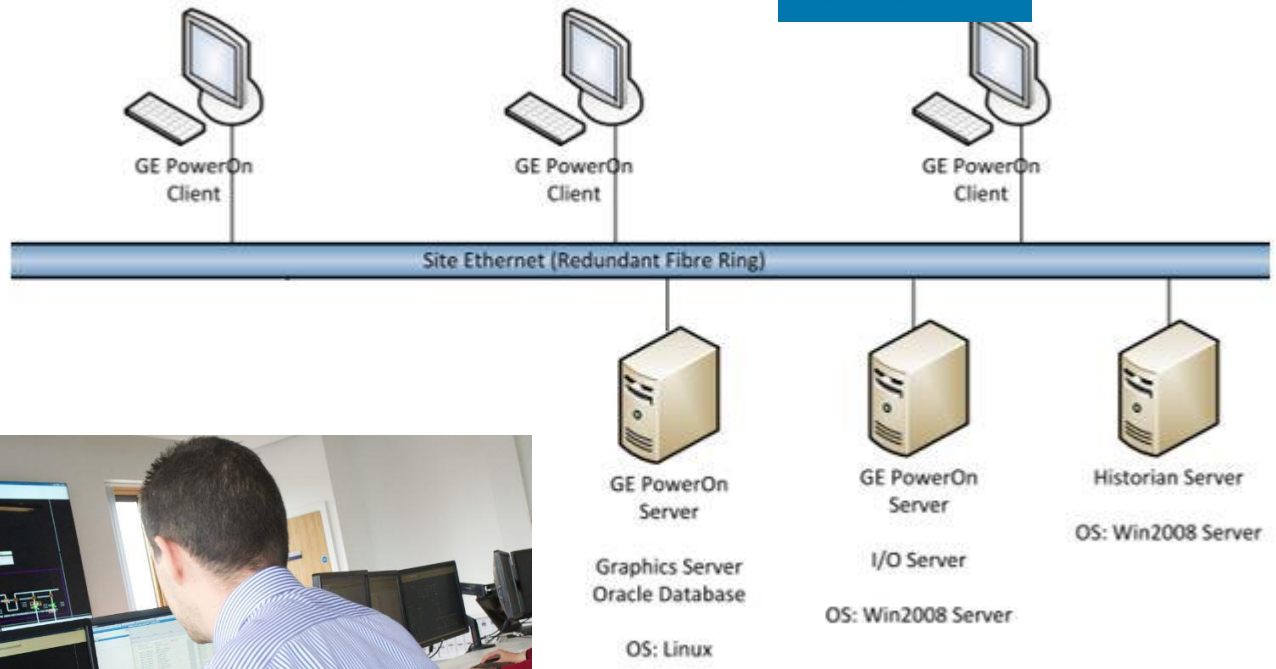
# Communication Protocols at PNDC

- Communication protocols currently used at PNDC are: DNP3, IEC 61850, IEEE C37.188, and IEC 60870

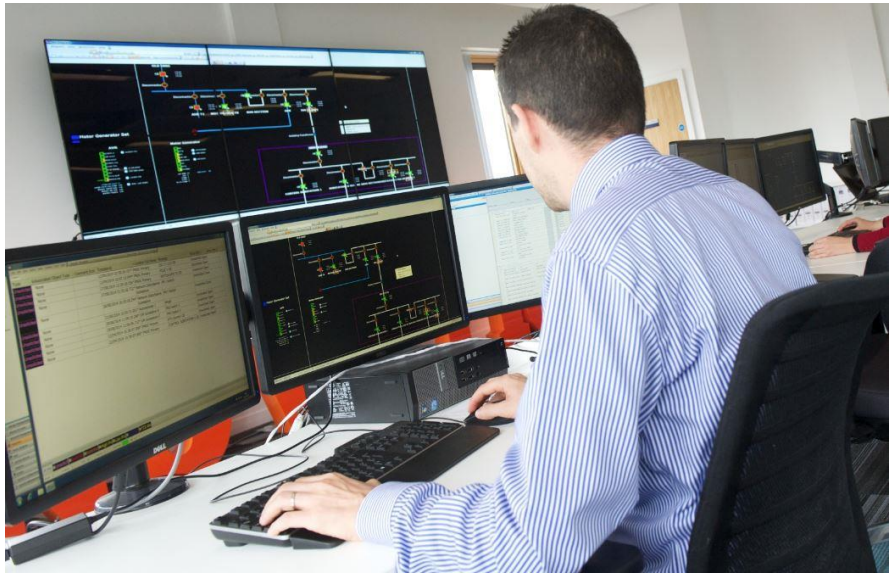


# SCADA/ Historian System

- SCADA system at PNDC provides continues real time monitoring and control of most of the equipment form the central control room




- The PI Historian system archives the data received from the SCADA system or directly connected to the PI Historian



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# Installation of Additional Measurements

| Item | Qty. | Ordered | Installation | Commissioned | System Integration | Expected Completion |
|---|---|---|---|---|---|---|
| Rogowski Rigid Coil CTs | 3 | ✓ | ✓ | × | × | 15/2/2016 |
| Rogowski Tube Coil CTs | 12 | ✓ | 3/12 | 3/12 | 3/12 | 1/3/2016 |
| Pole Mounted VTs | 9 | ✓ | ✓ | × | × | 22/2/2016 |
| FastDAQ System | 2 | ✓ | ✓ | ✓ | × | 15/3/2016 |

# Future Work

- Completion of the network installation and integration
- Running two different scenarios and acquire the measurements at all buses
- Support NPL on the development of algorithms to ascertain missing topology as well as for the estimation of line impedances
- Support NPL and PTB on the validation of the algorithms created
- Write and submit at least one paper to a peer-reviewed journal
- Submit and present at least 2 conference papers
- Provide training in the use of the PNDC to JRP partners
- Consider whether any of the algorithms developed are suitable for patenting
- Provide input for JRP project reports

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www.strath.ac.uk/pndc/

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