Customer-Led Network Revolution

Guide to network technology performance datasets

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1 Introduction

The Customer-Led Network Revolution (CLNR) project consists of five learning outcomes. Within the network flexibility learning outcome, a series of network technology trials have been designed, which examine both individual network technologies and combinations thereof, that can individually and collectively enable the uptake of low carbon technologies and their installation on the electricity distribution network. These low carbon technologies include distributed generation in the form of: solar-PV, wind and combined heat and power systems (CHP) and new load demand from electric vehicles (EV) and air and ground source heat pumps (HP).

The specific learning outcome that is relevant to this report is:

- **Learning Outcome 3 (LO3):** To what extent is the network flexible and what is the cost of this flexibility?

The technologies that can release the flexibility of the distribution network and which have been trialled by the CLNR project are:

- Real Time Thermal Rating (RTTR)
- Electrical Energy Storage (EES)
- Enhanced Automatic Voltage Control (EAVC)
- Demand Side Response (DSR)

Further benefits can be achieved by combining these technologies orchestrated by a complex control platform, named the Grand Unified Scheme (GUS) that has also been designed, procured, installed and commissioned as part of the CLNR project. This control system integrates the devices, hosts the communication protocols and the data flows that are reported by the devices and supplemented by additional network monitoring equipment.

This document is a guide to the CLNR network technology trials datasets which provide data on the performance of the network technologies that have been procured, installed and commissioned as part of this project and the data collected from a series of network trials between the 1st February 2012 and the 30th September 2014. The datasets do not include our analysis of the data although some include charts to enable the reader to quickly understand the data and to illustrate what analysis is possible. Our analysis of the network trials will inform other outputs from the project to be published subsequently.

The datasets satisfy the successful delivery reward criterion to produce *"Selected network data showing performance of selected network technologies in an open and usable format"*

2 Contents of the network performance datasets

Multiple network technologies were integrated onto the distribution network, along with the complex control platform. This included conventional technologies as well as devices new to Northern Powergrid as a network operator. The following components were deployed at 115 different points across the Northern Powergrid distribution system.

- EES1 Electrical Energy Storage System (nominal 2.5MVA/5MWh)
- EES2 Electrical Energy Storage Systems (nominal 100kVA/200kWh)
- EES3 Electrical Energy Storage Systems (nominal 50kVA/100kWh)

- Overhead Line Real-Time Thermal Rating Systems
- Primary Transformer Real-Time Thermal Rating Systems
- Secondary Transformer Real-Time Thermal Rating Systems
- Real Time Thermal Rating of underground cables

- Enhanced Automatic Voltage Control of a primary transformers (EAVC 1)
- HV/LV In-Line regulator Enhanced Automatic Voltage Control (EVAC 2)
- Enhanced Automatic Voltage Control using HV in-line regulators (EAVC 3)
- Enhanced Automatic Voltage Control of a ground mounted HV switched capacitor bank (EAVC 4)
- Enhanced Automatic Voltage Control of LV feeders (EAVC 5)

- Network monitoring of Primary substations
- Monitoring of HV feeders
- HV industrial & commercial customer monitoring equipment
- Network monitoring of secondary substations
- LV Feeder monitoring equipment

- Grand Unified Scheme (GUS)
- CLNR Data Warehouse
- Demand Response

The datasets comprise data from the trials of new technologies and the new or conventional technologies coordinated by the complex control platform. Each dataset is a collection of related trial data composed of a number of separate data elements and which can be manipulated as a unit by a researcher or industry expert. The datasets can be downloaded from the project library.

The measurement data supplied is a mix of raw analogue values and calculated values from the control process. Each data point has a tolerance of accuracy associated with it; further detail on the particular tolerances of each piece of network technology is available from the system technical specifications.

The following table summarises the technologies trialled and the related datasets.

Technology trialled	Dataset title	Dataset description
Eight Real Time Thermal Rating systems:		
Three underground cable rating systems at three voltage levels EHV, HV and LV	Real Time Thermal Rating for Extra High Voltage Underground Cables	Network trials dataset showing how the Real Time Thermal Rating of an EHV underground cable is influenced by Temperature and Load
	Real Time Thermal Rating for High Voltage Underground Cables	Network trials dataset showing how the Real Time Thermal Rating of a HV underground cable is influenced by Temperature and Load
	Real Time Thermal Rating for Low Voltage Underground Cables	Network trials dataset showing how the Real Time Thermals Rating of an LV underground cable is influences by Temperature and Load
Two overhead line rating systems at two voltage levels EHV and HV	Real Time Thermal Rating for Extra High Voltage Overhead Tower Lines	Network trials data showing extracts of Real Time Thermal Rating (RTTR) Overhead line at Extra High Voltage (66kv) – used purely for analysis of cyclic data
	Real Time Thermal Rating for High Voltage Overhead Lines	Network data showing performance of Real Time Thermal Rating (RTTR) – used purely for analysis of cyclic thermal data
Three transformer rating systems at Primary sites, indoor and outdoor distribution sites	Primary Substation Transformer Thermal Dataset	Network trials dataset showing how the Real Time Thermal Rating of the transformer is influenced by the Temperature and Load
	Urban Distribution Substation Transformer Thermal Dataset	Network trials dataset showing how the Real Time Thermal Rating of the transformer is influenced by the Temperature and Load
	Rural Distribution Substation Transformer Thermal Dataset	Network data showing performance of Real Time Thermal Rating Secondary Transformer in an outdoor environment

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Three Electrical Energy Storage systems:		
5MWh energy storage power flow trial data	Primary Substation Electrical Energy Storage – 2.5MVA 5MWh – Autonomous Powerflow management trial	Network trials dataset showing performance of Electrical Energy Storage (EES1) – 2.5MVA / 5MWh being used for powerflow management
200kWh energy storage power flow trial data	Distribution Substation Electrical Energy Storage – 100kVA/200kWh – Autonomous Powerflow management trial	Network data trials showing performance of Electrical Energy Storage (EES2) - 100kVA/200kWh being used for powerflow management
100kWh energy storage voltage control trial data	PV Test Cell Distribution Substation Electrical Energy Storage – 50kVA / 100kWh – Autonomous Voltage Trial	Network trials data showing performance of Electrical Energy Storage (EES3) – 50kVA/100kWh being used for voltage trial
Two Enhanced Automatic Voltage Control systems:		
Distribution transformers equipped with tap changing capability voltage control trial data	Distribution Substation Tapchanging Transformer	Network data trials showing performance of the Distribution Transformer equipped with On Load Tapchanging capabilities (EAVC2) – for analysis of collaborative voltage control and power flow management for HV and LV networks
Low Voltage mains switchable regulator voltage control trial data	Enhanced Automatic Voltage Control for Low Voltage Network Regulator	Network trials data showing performance of the LV regulator (EAVC5) being used for voltage control in coordination with wide area network control from the GUS platform
The Grand Unified Scheme control system:		
Combined voltage control trial data of transformers with tap changers and energy storage	GUS Voltage Control of Tapchangers and Energy Storage	Network data trials showing combined performance of EAVC2 and EES3 under GUS voltage control – providing data of the OLTC equipped distribution transformer and the data of EES3 in both autonomous and GUS voltage control

Appendix: Glossary of terms

Phrase or Abbreviation	Description
CLNR	Customer-Led Network Revolution
RTTR	Real Time Thermal Rating
EES	Electrical Energy Storage
EAVC	Enhanced Automatic Voltage Control
DSR	Demand-Side Response
LV	Low Voltage (230 volts single phase, 400 volts 3 phase)
HV	High Voltage (>1,000 volts <33,000 volts)
EHV	Extra High Voltage (>33,000 volts)
LCT	Low-Carbon Technology
LO	Learning Outcome
PV	Photovoltaic (solar panels)
GUS	Grand Unified Scheme
UGC	Underground cable
OHL	Overhead line
TX	Transformer
DNO	Distribution Network Operator (Electricity)