IET Retired Professional Group
(M&WC Branch)

Thursday 13\textsuperscript{th} April 2017
Introducing ENW

- 4.9 million
- 2.4 million
- 25 terawatt hours

£12 billion of network assets

56 000 km of network • 96 bulk supply substations • 363 primary substations • 33 000 transformers
Challenges

- Increasing customer expectations
- Innovation
- Changing energy usage
- Ageing assets
Changing Demand

- Heat pump
- Electric vehicle
- TV
- Fridge
- Lights
- Washing machine
- Dishwasher

Demand (kW) vs. Time of day

2012

2025

Time of day

Demand (kW)
<table>
<thead>
<tr>
<th>Themes</th>
<th>Safety &amp; Environment</th>
<th>Network Resilience</th>
<th>Capacity</th>
<th>Efficiency</th>
<th>Customer Service</th>
<th>Commercial Evolution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Strive to continuously improve safety and reduce impact on the environment</td>
<td>Improve network performance and reduce risk</td>
<td>Maximise the use of existing assets to increase demand and generation capacity</td>
<td>Provide our existing services at lower cost</td>
<td>Improve customer experience, offer new services and more choice</td>
<td>Change our role from network operator to system operator</td>
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**Themes**

- **Safety & Environment**
  - Strive to continuously improve safety and reduce impact on the environment

- **Network Resilience**
  - Improve network performance and reduce risk

- **Capacity**
  - Maximise the use of existing assets to increase demand and generation capacity

- **Efficiency**
  - Provide our existing services at lower cost

- **Customer Service**
  - Improve customer experience, offer new services and more choice

- **Commercial Evolution**
  - Change our role from network operator to system operator
### Smart Street project overview

| **£11.5m, four-year innovation project** | **Started in Jan 2014 and finishes in Apr 2018** | **Quicker connection of LCTs**  
**Lower energy bills**  
**Improved supply reliability** | **Trials period Jan 2016 – Dec 2017** | **Extensive customer engagement programme throughout project** |
|-----------------------------------------|-----------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------------------------|

**Benefits:**
- Quicker connection of LCTs
- Lower energy bills
- Improved supply reliability

**Project Timeline:**
- Started in Jan 2014
- Finishes in Apr 2018
- Trials period Jan 2016 – Dec 2017
Historic networks have no active voltage regulation
Problem - LCTs create network issues

LCTs rapidly surpass voltage and thermal network capacity

Drift range
Smart Street – the first intervention

- Voltage stabilised across the load range
- Power flows optimised
- Low cost
- Quick fit
- Minimal disruption
- Low carbon
- Low loss
- Invisible to customers

Voltage stabilised across the load range • Power flows optimised
6 primary substations
11 HV circuits
38 distribution substations
163 LV circuits
Around 62,000 customers
3 selected primary substations in CLASS
Project Partners

KELVATEK

Tyndall Manchester
Climate Change Research

Siemens

tnei
enterprise with energy

Manchester 1824
The University of Manchester

Queen's University Belfast

Impact Research
Network reliability improvement

Builds on C2C and CLASS

- Storage compatible
- Transferable solutions
The Smart Street System

- On-Load Tap Changing Transformers
- HV Capacitors
- LV Capacitors
- Overhead Line HV Capacitors
- Weezaps
- End Point Monitoring Devices
- Lynx

Spectrum 5 (NMS)
Weezaps

LV vacuum circuit breaker

Advanced measurement and protection capability

Safe LV interconnection, live monitoring and control

Improves supply reliability and restoration through fault management and detection
LV Vacuum switch

Allows active network meshing and un-meshing

Advanced monitoring capabilities

Ability to control the circuit locally or remotely
LV Capacitors

84 LV capacitors
One on each closed ring
Multi staged
HV Capacitors

3 ground mounted HV capacitors
- Secured within GRP housings in urban areas

3 pole mounted HV capacitors
- Installed similar to pole mounted transformers
Distribution OLTC

- 5 OLTCs
- 9 taps
- Local or remote
Trials – test regimes

<table>
<thead>
<tr>
<th>Smart Street trial</th>
<th>Test regime</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LV voltage control</strong></td>
<td>1. On-load tap changing distribution transformer only</td>
</tr>
<tr>
<td></td>
<td>2. On-load tap changing distribution transformer and capacitor(s) on LV circuits</td>
</tr>
<tr>
<td></td>
<td>3. Capacitors at distribution substation only</td>
</tr>
<tr>
<td></td>
<td>4. Capacitors at distribution substation and on LV circuits</td>
</tr>
<tr>
<td></td>
<td>5. Capacitor(s) on LV circuits only</td>
</tr>
<tr>
<td><strong>LV network management &amp; interconnection</strong></td>
<td>1. LV radial circuits</td>
</tr>
<tr>
<td></td>
<td>2. LV interconnected circuits</td>
</tr>
<tr>
<td><strong>HV voltage control</strong></td>
<td>1. Voltage controllers at primary substation only</td>
</tr>
<tr>
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<td>2. Voltage controllers at primary substation and capacitor(s) on HV circuits</td>
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</tr>
<tr>
<td><strong>Network configuration &amp; voltage optimisation</strong></td>
<td>1. Losses reduction</td>
</tr>
<tr>
<td></td>
<td>2. Energy consumption reduction</td>
</tr>
</tbody>
</table>
**Research Workstreams**

<table>
<thead>
<tr>
<th>WP1</th>
<th>WP2</th>
<th>WP3</th>
<th>TNEI</th>
</tr>
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<tr>
<td>Will look to quantify the voltage optimisation and loss reduction techniques used in Smart Street</td>
<td>Will look to produce the design and operation policies required to convert UK networks into optimal meshed configurations</td>
<td>Will research the cost benefits and carbon impact related to the Smart Street solution</td>
<td>Will provide research support and consultation for the duration of the trials</td>
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- **WP2** will look to produce the design and operation policies required to convert UK networks into optimal meshed configurations.
- **WP3** will research the cost benefits and carbon impact related to the Smart Street solution.
- **TNEI** will provide research support and consultation for the duration of the trials.

**Supporting Institutions:**
- Manchester
- Queen's University Belfast
- Tyndall Manchester
- TNEI
Percentage reductions on LV networks

Energy Reduction
Loss Reduction

Percentage Reduction (%)
UoM simulation

Energy and losses reductions on HV networks

<table>
<thead>
<tr>
<th>Location</th>
<th>Energy Reduction</th>
<th>Energy Loss Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denton East</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egremont</td>
<td></td>
<td></td>
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<tr>
<td>Green Street</td>
<td></td>
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<tr>
<td>Hindley Green</td>
<td></td>
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<tr>
<td>Longsight</td>
<td></td>
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<tr>
<td>Wigton</td>
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</table>

Percentage Reductions (%)

Energy and losses reductions on HV networks
Ring operation

Improvement of overloaded cables

Dependent on customer mix

~20% Reduction in losses
QUB simulation

Energy consumption reduction

11 networks only
5 with OLTC
6 heavily loaded
Trial results

Active and Reactive Power (kW, kvar)

Real Active Power
Real Reactive Power
Simulated Active Power
Simulated Reactive Power

Voltage at the end of line (V)

Real
Simulation
### UoM results

<table>
<thead>
<tr>
<th></th>
<th>Voltage reduction</th>
<th>Energy reduction</th>
<th>Losses reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UoM simulated results</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>HV</td>
<td>5.50%</td>
<td>5.97%</td>
<td>3.98%</td>
</tr>
<tr>
<td>LV</td>
<td>4.88%</td>
<td>5.12%</td>
<td>1.83%</td>
</tr>
<tr>
<td><strong>QUB results</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LV</td>
<td></td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Trial data</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LV</td>
<td></td>
<td>8.7%</td>
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### Outcomes to date

<table>
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<tr>
<th>Category</th>
<th>Details</th>
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<tr>
<td>~25GB of data recorded so far</td>
<td></td>
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<tr>
<td>Trial area networks modelled</td>
<td></td>
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<tr>
<td>Calculated CVR factor of 1.10 for LV and 1.01 for HV networks</td>
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<tr>
<td>Analysis techniques indicate optimisation algorithm is close to optimal</td>
<td></td>
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<tr>
<td>Ring operation modelled and compared to radial</td>
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Still to come

- Effects of voltage reduction on lighting and domestic appliances under investigation
- Carbon impact being studied
- Analysis of trials data ongoing
Smart Street summary

First example of centrally controlled LV network
Range of intervention solutions

Combine into one end-to-end system
Optimisation

Faster LCT adoption
Less embedded carbon
Re-usable technology
Optimise energy and losses

Carbon Footprint

Challenge

Learning

Benefit

£

Lower energy bills
More reliable supply
Reinforcement savings
Any Questions?
For more information

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<thead>
<tr>
<th>Icon</th>
<th>Information</th>
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Please contact us if you have any questions or would like to arrange a one-to-one briefing about our innovation projects.