Celsius

Awarded: 9th December 2015

- Go live
- Monitoring installation Mar 2017
- Monitoring trial Mar 2018
- Thermal ratings tool stage 1 Oct 2018
- Retrofit cooling installation Jun 2018
- Cooling trial Jun 2019
- Thermal ratings tool stage 2 Jan 2020
- Closedown Mar 2020

£5.5 million

Up to £583m across GB by 2050

Financial benefits

RICARDO – AEA
ASH
Impact Research
UK Power Networks
Delivering your electricity
The problem

Distribution substation

Customers’ LCTs
Step 1: Fit thermal monitoring

- Asset
- Internal temperature
- External temperature
- Environmental factors

Learning

Thermal coefficient

Deliverable

Thermal Ratings Tool

Benefit

More capacity
Step 2: Retrofit cooling

### Asset
- Internal temperature
- External temperature
- Environmental factors
- Retrofit cooling

### Learning
- Retrofit cooling specifications, installation methodologies and buy order

### Deliverable
- Enhanced Thermal Ratings Tool

### Benefit
- Full capacity
Celsius as part of the smart future

Smart meter data

Thermal Ratings Tool

- Celsius monitoring
- Retrofit cooling
- Reinforce

Extra capacity

Lower bills for customers
Celsius studies

Thermal analysis (step 1)

- $q_{\text{core}}$
  - Internal asset temperature
  - Thermal coefficient
  - $q_{\text{external}}$
  - External asset temperature

Thermal flow study (steps 1 & 2)

- Research into heat and air flows for optimal substation design

Asset health study (steps 1 & 2)

- Examines effects of increased load and cooling techniques on assets
Thermal flow study

Step 1 report published on Celsius Website  
www.enwl.co.uk/celsius

Six trial substations modelled

Validated with monitoring data
Changes to ENW Substation Policy implemented

Step 2 Application of cooling to models underway

Step 2 Optimise cooling trial installation
Key deliverables to date

- ENA P15 & P17 Review
  Feb 2017

- Cooling workshops &
  selection May/July 2017

- Customer focus groups
  July 2017

- Raw data published
  July 2017

- Monitoring equipment
  specifications and
  installation report Sep 17

- Thermal flow study Step
  1 Nov 2017

All publications and learning can be found in the library section of the Celsius website: www.enwl.co.uk/celsius
Progress and next steps

- **January – June 2017**
  - Data capture
  - Thermal flow study
  - ENA cooling workshop
  - Customer focus groups

- **July – December 2017**
  - Monitoring installation report
  - Cooling installation plan
  - Thermal flow study report

- **January – June 2018**
  - Baseline customer survey
  - Thermal flow study part 2
  - Cooling technology installation

- **July – December 2018**
  - Asset temperature behaviour report
  - Asset health study report
  - Thermal Ratings Tool step 1

Knowledge sharing and dissemination
Celsius – Data Analysis
Olivia Carpenter
Senior Consultant - Technical
System health dashboards – allows tracking of installation and data quality across all sites, including overview, site summaries, and issue tracking.
System health dashboards – allows tracking of installation progress and data quality across all sites, including overview, site summaries, and issue tracking.

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<th>Site</th>
<th>Code</th>
<th>Type</th>
<th>Status</th>
<th>Hubs</th>
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</table>
Celsius: Dashboards

Data Dashboards – allows visualisation and download of retrofit monitoring data across any site, sensor position and timescale

Nearly 130 million measurements taken

Over 750,000 inbound requests handled

Celsius data management system consists of over 86,000 lines of code
Transformer hotspot: buried in the coils of the transformer, and difficult to measure directly.

Cable conductor temperature: difficult to measure directly.

Therefore we need to understand maximum internal operating temperature from easily accessible measurements.

Understanding operating temperature: The first step to developing improved thermal ratings.
Data available includes:

- **Over 500 transformers with surface and ambient measurements:** measuring a selection of transformers representative of the range across GB.

- **About 20 transformers with oil measurements** in a range of transformer sizes, specifications, and ages.

- **5 ‘Smart’ Transformers:** manufactured with sensors integrated (these transformers have oil, surface and ambient measurements as well).

As well transformer leading, and size, specification, and age information.

- **Ambient:** high and low ambient levels, and ventilation
- **Surface:** including top and bottom oil level
- **Oil:** inside transformer tank, top and bottom oil level
- **Hotspot:** at 50mm from top on coils B and C, HV and LV
Celsius: Transformer hotspot study

Goal: To know the hotspot temperature from one external sensor

Approach Steps:

1. **Use ‘Smart’ Transformer data** to understand link between hotspot and internal oil
2. **Use oil measurements** to link between internal oil and surface measurements
3. **Develop a method to use surface measurements to estimate hotspot**

Taking into account the ambient conditions and characteristics of the transformer.

**Ambient:** high and low ambient levels, and ventilation

**Oil:** inside transformer tank, top and bottom oil level

**Surface:** including top and bottom oil level

**Hotspot:** at 50mm from top on coils B and C, HV and LV
Early analysis supports the case for single sensor hotspot calculation that could be rapidly deployed to BAU and at low-cost.
For more information

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