Ricardo
Energy & Environment

Celsius potential contribution for ER P15 and P17

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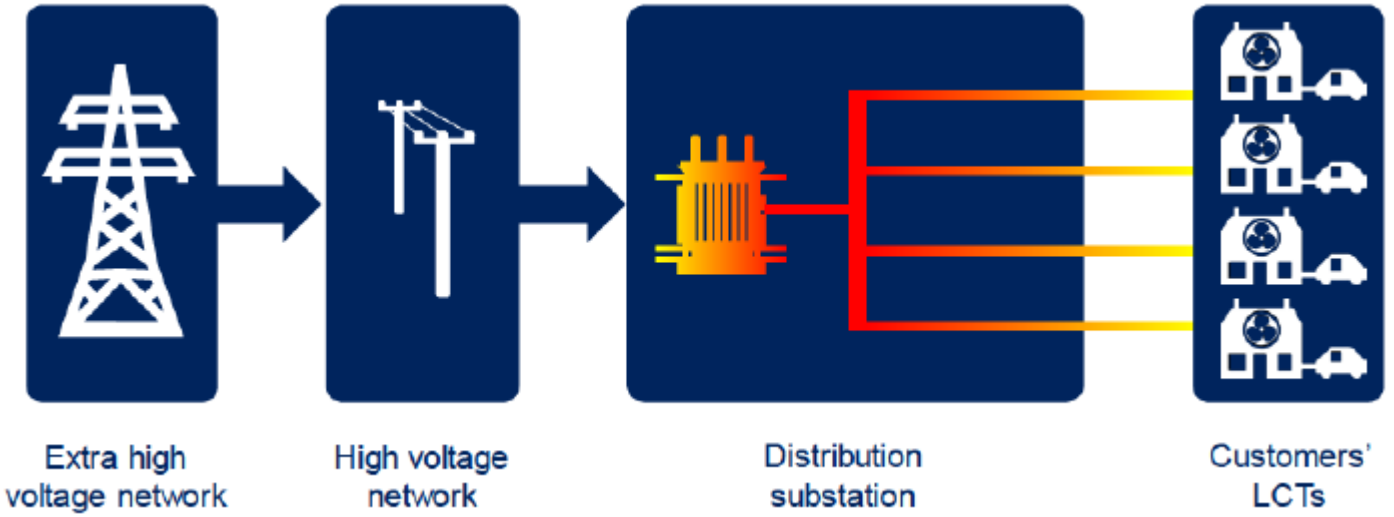
Contents

Introduction

Celsius project will aim:

- Maximise the use of existing assets on LV network
- Increase understanding of the thermal behaviour of distribution substations
- Help Network operators to increase connection numbers for Low Carbon Technologies faster and cheaper.

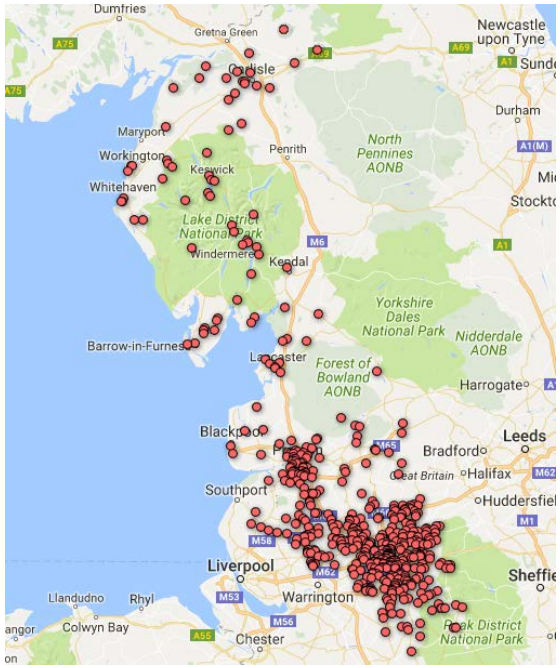


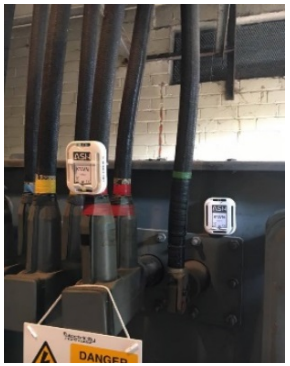
The Celsius methodology is based on a **two-step intervention** approach.

Introduction

Step 1:

- Gather data across a range of **environmental conditions**, **loading** and **temperature measurements**
- **520 distribution substations**, selected to be representative of **80% of the GB** substation population.





Explore the **relationship** between asset **temperature**, **load** characteristics and the surrounding **environment**.

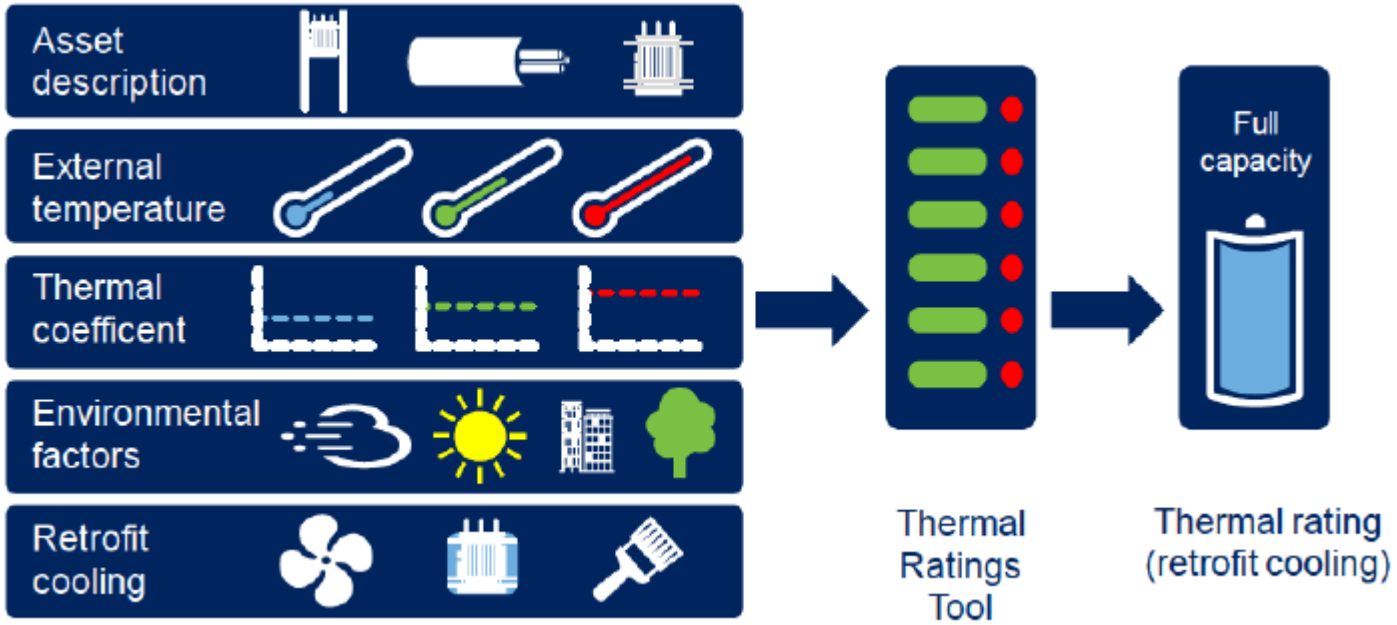
Establish a set of reliable, **thermal coefficients** between the **measured external temperature** and the **internal asset hotspot temperature**.

Reveal **latent capacity** which can be **released quickly** with **no further intervention**.

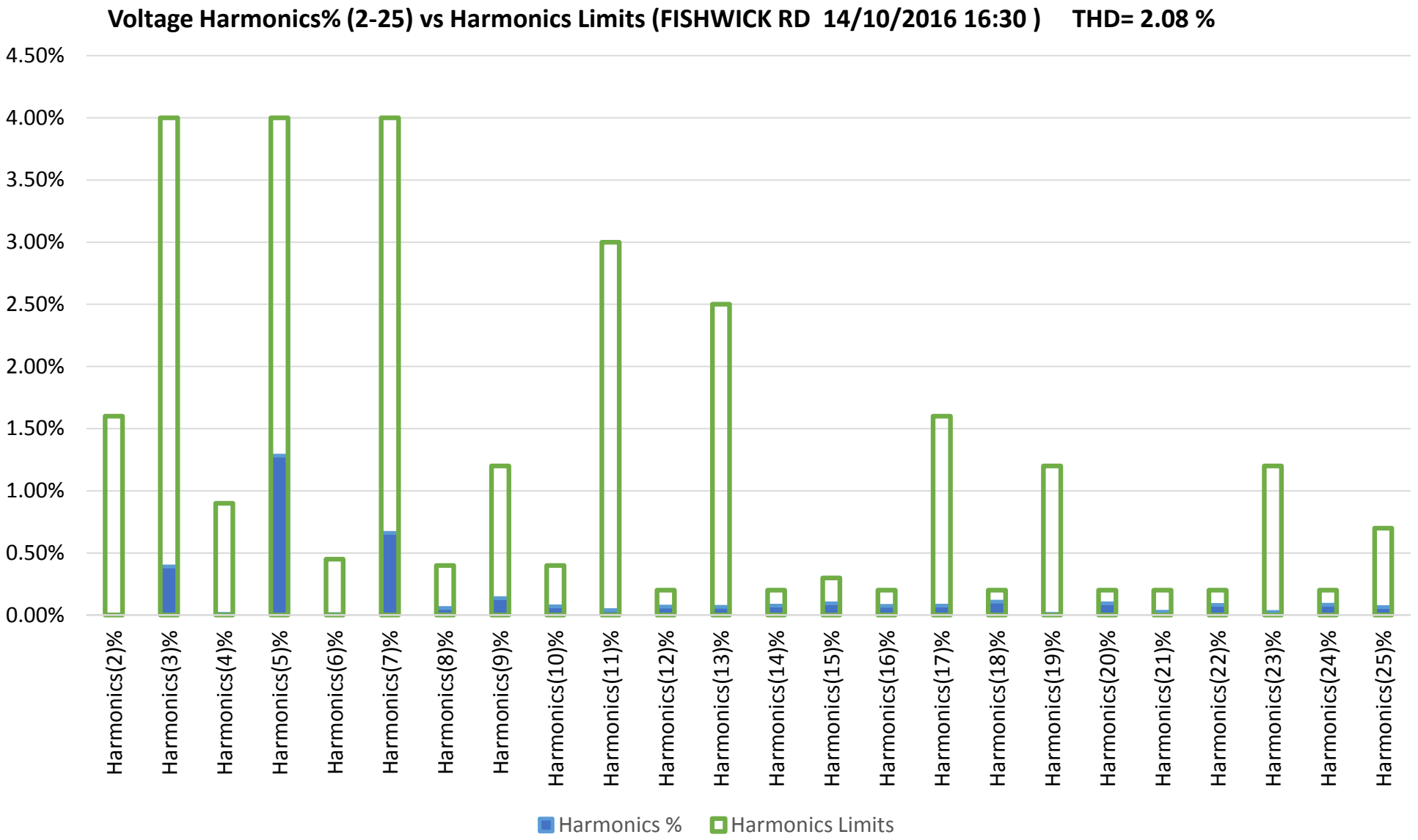
Introduction

Step 2:

- **Release** additional **capacity** through a range of **retrofit cooling techniques**.
- **Explore** a range of **techniques** to **increase capacity** and **demonstrate the benefits** of each.
- **'buy order'** of cooling interventions for network operators to choose from.



Celsius measurement data



ENA Engineering Recommendations P15 and P17

ER P15:Transformers Loading Guide

- A guide to the loading of double-wound transformers having nominal ratings of 120MVA and below, supplying systems at 66kV and below from Supergrid and 132kV system

ER P17: Current Rating Guide for Distribution Cables

- Ratings for 11kV and 33kV having a paper insulation, and ratings for 11kV and 33kV cables having extruded insulation.

Project that have already identify areas that could be updated:

Customer-Led Network Revolution[1] have suggested that use of an offline thermal modelling tool based on localised site specific data :

- **P15 – additional capacity of up to 15%** can be obtained by **using site specific data** for **load curves** and **ambient temperature**. It may be possible to **release capacity by removing the nominal 150% load limitation** advised in P15 if the **capability of ancillary components is not exceeded**;

- **P17 – additional capacity of up to 10%** could be released for **LV cables**;

[1] D. Miller and D. Yellen, "Customer-Led Network Revolution: A Review of Engineering Recommendations P15 , P17 and P27 (Transformers , Cables and Overhead Lines)," CLNR-L263, Mar. 30, 2015.

ENA Engineering Recommendations P15 and P17

Celsius:

- **High Level review** of the existing recommendations with respect to the impact that Celsius could have on them
- **Identify areas** which could help to **update the existing recommendations**

Celsius is monitoring a variety of distribution substations sites:

1. Power measurements (P,Q,I,V as well as harmonics)
2. Temperature measurements (Transformer, ancillary components, ambient)

Findings from Celsius could lead to potential improvements and suggestions to the current Engineering Recommendations

Potential contributions to ER P15

Celsius findings which could help ER P15:

- ER P15 describes the **factors** that determine **transformer temperature** including **load cycle shape**, **ambient temperature** and **individual transformer characteristics**. These factors could be reviewed as part of the Celsius project

- ER P15 works on the basis of **loading to certain cyclic loading levels (150%)** and on the same time **maximum hotspot temperature of 140°C** must **not be exceeded**. These loading levels will be reviewed as part of Celsius

- **Identify new load patterns on the LV network** that could be included on the ER P15 example of **assessment of transformer** under **overloading conditions**

Potential contributions to ER P17

Celsius findings which could help ER P17:

- Celsius project will cover LV cables hence could help to **identify the possibility of including LV cables** as a part of ER P17 which are not covered at the moment.

- Key aspects that will be taken on board during Celsius project for LV cables:
  - Maximum conductor temperature
  - Depth and proximity to other loaded circuits
  - Impact of different environments on the thermal performance of cables

Thank You

Appendix

Appendix 1 Review of ER P15 against Celsius

Location in ER P15	Subject	Comment
Sections 1- 2	Introduction & Scope	This could be updated with our findings related with potential "thermal pinch points" in distribution transformers – noting that the scope for P15 is much wider including system transformers.
Section 3	"The winding hotspot temperature, in turn, is determined by…"	This could be updated with our findings – Celsius will aim to identify key influencers on asset temperature, and so there may be additional factors to add beyond those already listed.
Section 3	Basis of the recommendation	If changes are made, an additional explanation of where this learning has come from might needed.
Section 4	Recommendations	This could be updated specifically, the rule of loading to 150% may be replaced with a dynamic factors depending on the transformer environment and updated standards Note that the temperature of the hotspot will still be maintained below 140°C for equipment conforming to the standards referred in P15, with a recommendation for a margin of safety and consideration of equivalents for transformers built to later international standards
Section 4 and Appendix A	Calculation of hotspot temperature	Through the monitoring of 469 ground mounded transformers located in different structures (Stone/Brick, Fenced Enclosure, Glass Reinforced Plastic, Part of a Larger Building), 51 pole mounted transformers, load curve from each site and weather conditions (air ambient, solar radiation, etc.) could give some vital information which can help to update the current recommended equations of transformers hotspot temperatures based on classified site specific. An additional set of calculations will be developed for the calculation of additional capacity headroom, may also be included. Recommendations for the margin of error will also be included Note that Changes to the rate of use of life from the environmental conditions may also be impacted by Celsius findings, but calculations of the rate of use of life are not directly part of the Celsius scope.
Section 6	Operational Considerations	Some references to the 150% limit as well as transformer hotspot temperature 140°C might need to be revised.
Appendix B	Example of assessment of overload capability	This may have to be updated

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