RICARDO

electricity north west

Bringing energy to your door

Celsius

Network Improvements and System Operability

Delroy Ainsworth & Olivia Carpenter-Lomax

LCNI conference

Thursday 31 October 2019

Stay connected...

www.enwl.co.uk

Celsius introduction

Funded by the **2015 Network Innovation Competition**

Project runs from **January 2016 to March 2020**

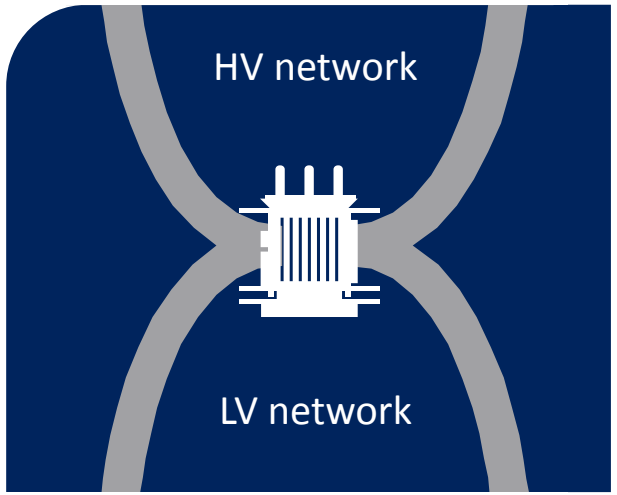
Total project cost: **£5.5m**

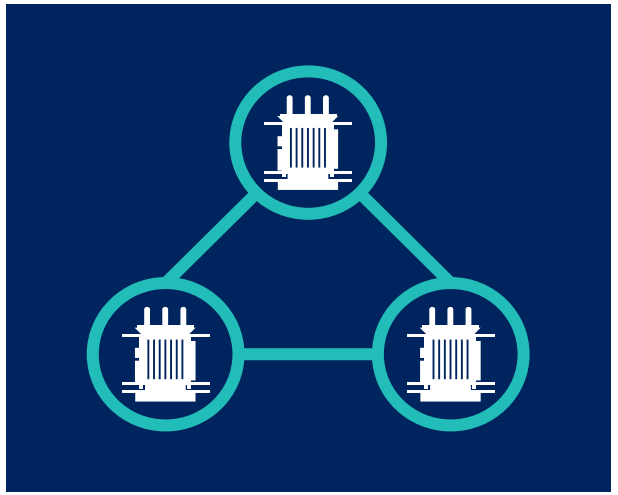
Estimated **benefit of £500m** over Great Britain up to 2050

Project partners

electricity north west – Bringing energy to your door	Lead partner, distribution network operator
RICARDO	Technical partner, focusing on trial design, analysis, deliverable development
ASH – CREATIVE WIRELESS ELECTRONICS	Providing monitoring equipment for trials
Impact Utilities – Pursue, Discover, Act	Customer engagement partner
UK Power Networks	London and South East distribution network operator

Celsius





Celsius aims to increase capacity in distribution substations, enabling connection of low carbon technologies and reducing the need for costly substation reinforcement

Assets have nominal thermal rating

Ratings $=$ ^{o}C

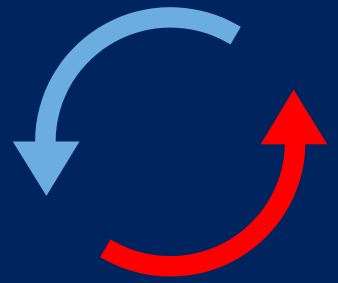
Ratings $\neq$ amps

Diverse range of environments

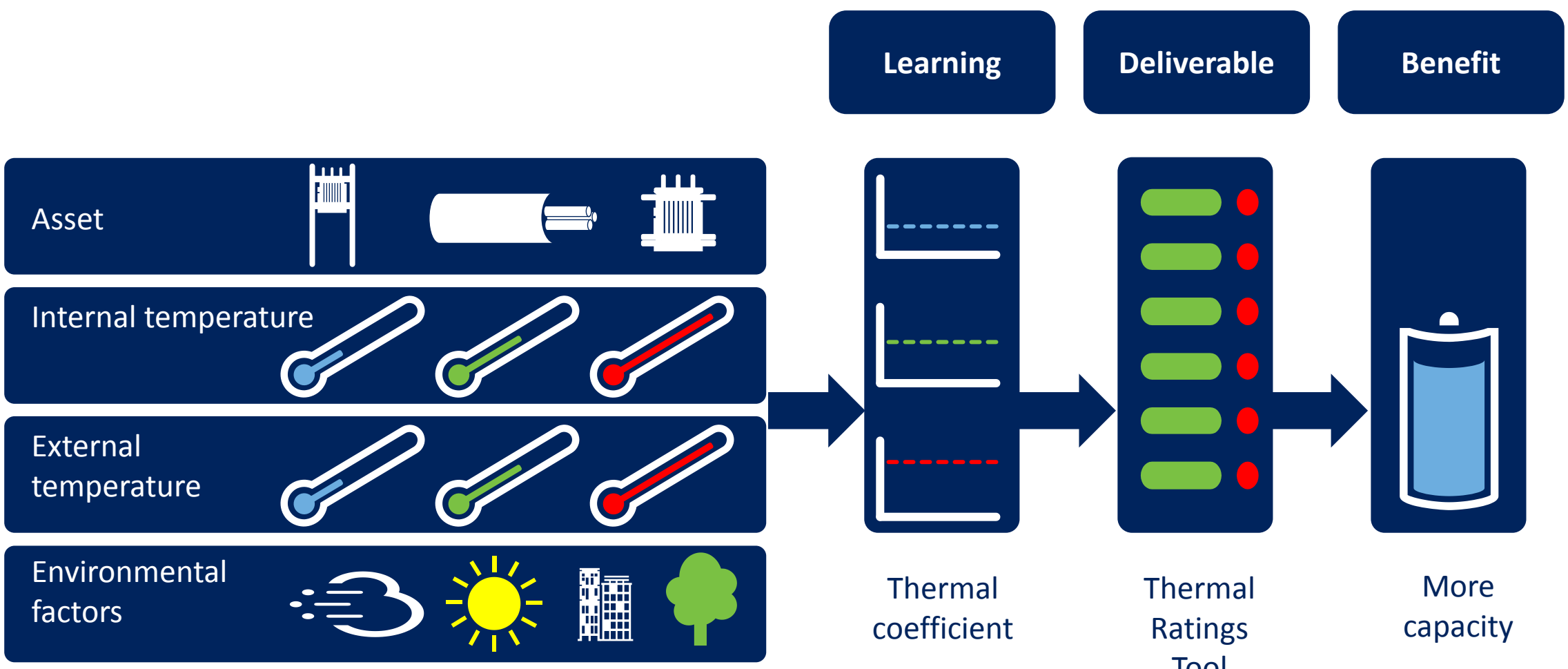
Small changes in environmental factors can result in very different actual ratings

Assumed thermal ratings can lead to capacity being under-utilised or unnecessary risk

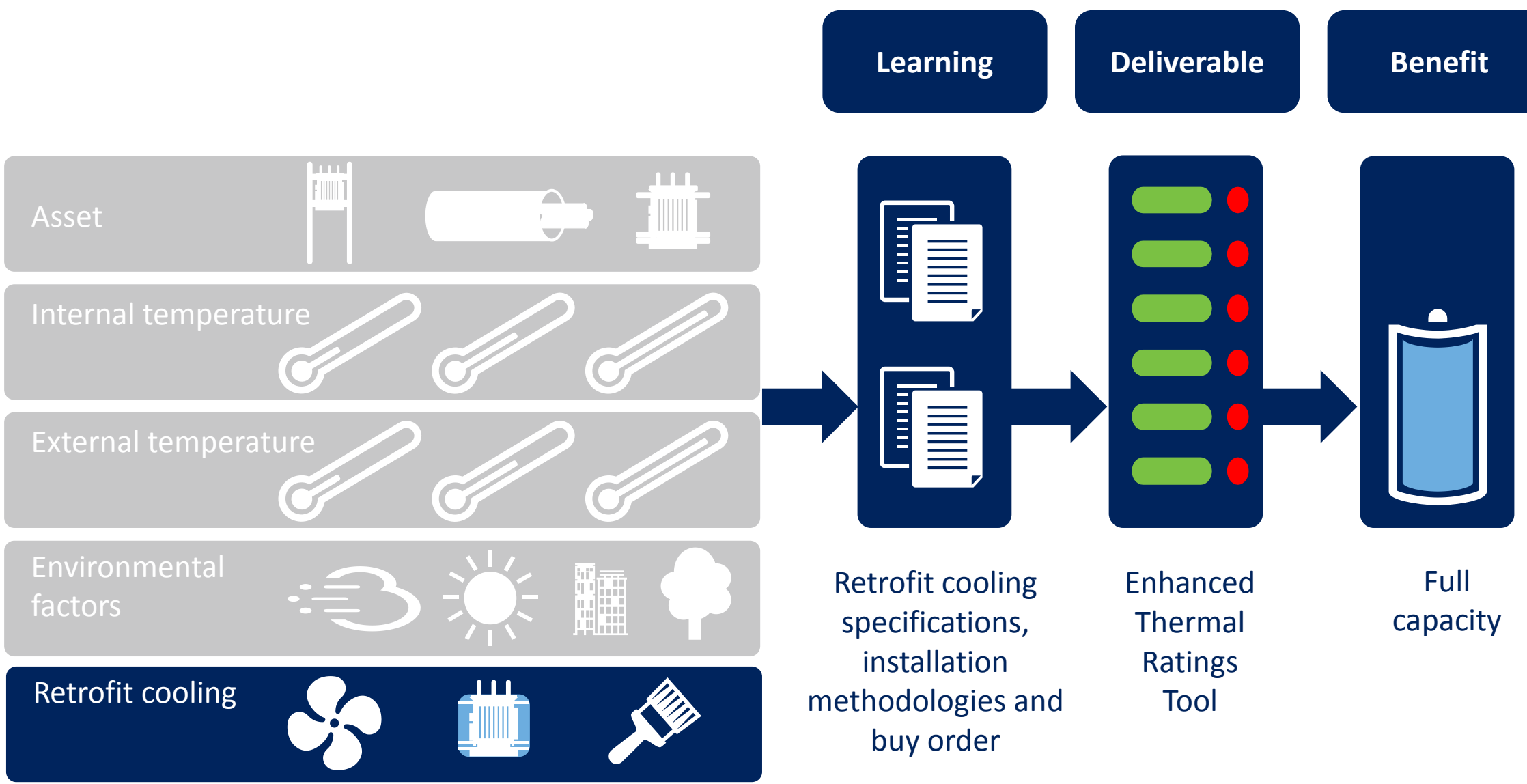
Case studies

Thermal analysis	 q_{core} Internal asset temperature = Thermal coefficient ×  $q_{external}$ External asset temperature
Thermal flow study	 Research into heat and air flows for optimal substation design
Asset health study	 Examines effects of increased load and cooling techniques on assets

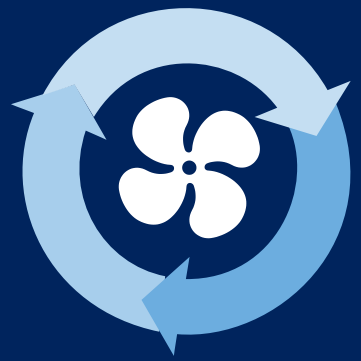
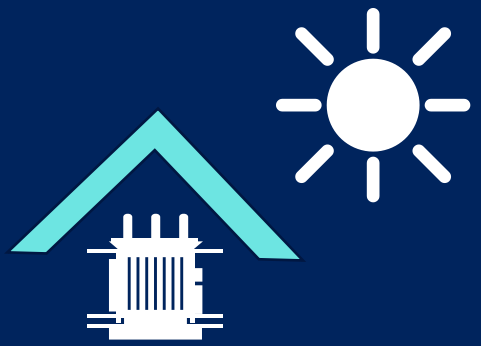
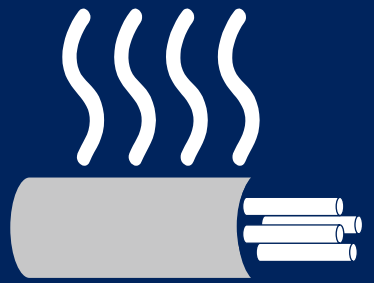
Step 1: Fit thermal monitoring



Step 2: Retrofit cooling



Passive cooling

Improving ventilation	Painting outdoor transformers	Shading outdoor transformers	Cable backfill
			
Supported by the Thermal Flow Study results, which will provide guidance about the best ventilation arrangements	White paint will be used to reflect solar heating of the asset	To protect from solar radiation	Backfilling cable ducts with a material with beneficial thermal properties, to allow heat to escape from cables more effectively

Improving ventilation

Painting outdoor transformers

Shading outdoor transformers

Positive pressure active cooling – Passcomm

External view

Internal view

Negative pressure active cooling – Ekkosense

Celsius methodology outline

2016 | 2017 | 2018 | 2019 | 2020

Current position

Phase 1: Monitoring trial

520 substations, representative of the whole substation population.
Data used to understand the impact of environmental factors on asset temperature and develop improved thermal ratings.

- Technology development and installation
- Monitoring trial
- Analysis

Phase 2: Cooling technology trial

Installing technologies in 100 sites.
Cost benefit analysis informed by monitoring before and after installation.

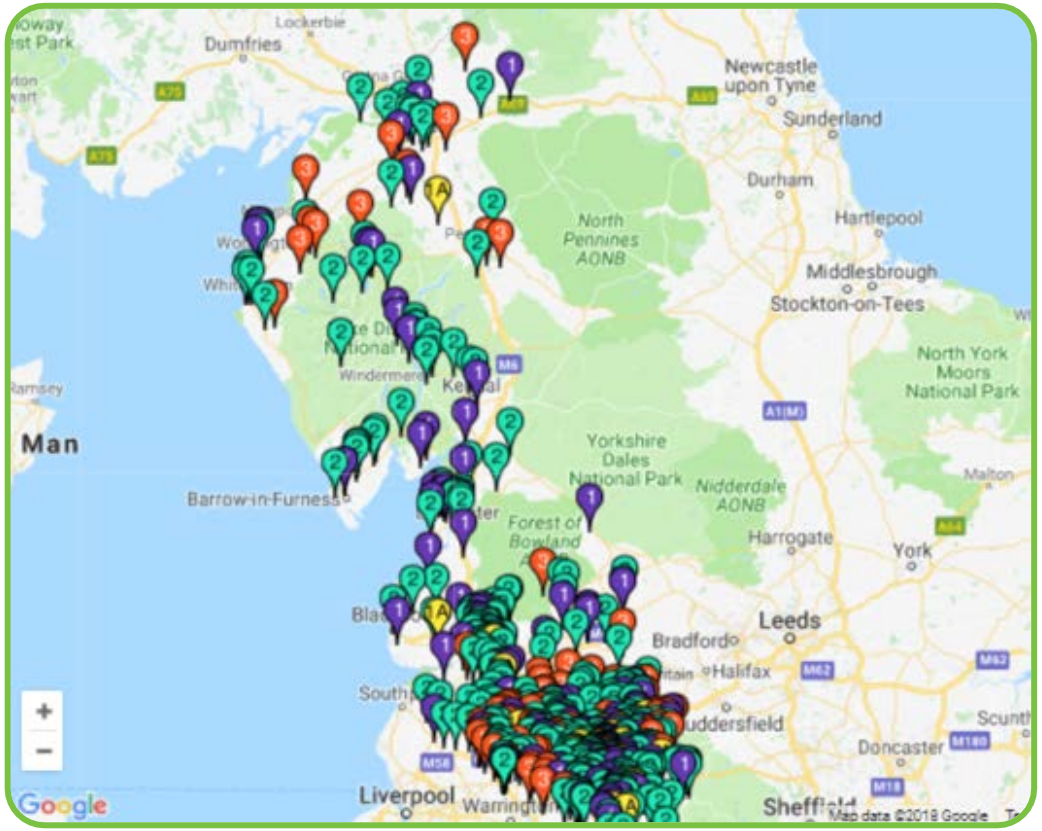
- Technology identification and installation
- Cooling technology trial
- Cost benefit analysis

RICARDO

Celsius project activity

Phase 1: Monitoring trial

Factor report, focused on transformer temperature, published in September 2018 (updated in October 2019)



Phase 2: Cooling technology

Cooling technology report produced in September 2019 (to be updated with additional data at the end of 2019)

Negative pressure ventilation
Installed at 20 sites

Positive pressure ventilation
Installed at 20 sites

Improving passive ventilation at substations
Installed at 41 sites

Painting outdoor transformers
Installed at 10 sites

Shading outdoor transformers
Installed at 5 sites

Improved cable backfill
Installed at 4 sites

Celsius project key learning

Phase 1: Monitoring trial

A more informed rating can be derived for a transformer by using two temperature measurements and three phase power.

Most transformers have more capacity than their nominal ratings suggest for most of the time – their more informed daily ratings are on average ~30% higher than nominal.

There are factors that impact the operating temperature of a transformer. These include:

Building environment	Season	External weather temperature	Transformer age	Harmonics

Eg A transformer installed outside in winter has ~20% higher calculated daily rating, on average, than a transformer installed in a brick built substation in the middle of summer.

Even taken together, these factors cannot be used to derive the improved rating; the correlation is not strong enough to build a model without using measured data.

Phase 2: Cooling technology

Retrofit cooling technologies can be used to cool the transformer, and therefore release further capacity

Negative pressure ventilation

12% average improvement (conservative view) in transformer ratings, wide variety of impacts from site to site

Positive pressure ventilation

14% average improvement (conservative view) in transformer ratings, site performance is generally consistent

Improving passive ventilation at substations

A very wide range of impacts, with improvement in some sites, and many others with no significant change.

Painting outdoor transformers

4% average improvement in the daily rating. Not all sites saw improvement.

Shading outdoor transformers

Only limited data available due to loading issues. Data suggest an improvement in the daily rating of about 3.6%.

Improved cable backfill

Not assessed

Preliminary results

Celsius BAU process

	Data collecting and reporting	Trigger for intervention	Decision process for intervention	Intervention
Today's process	Nominal rating is used for all secondary transformers Demand from MDIs, spot temperatures, and condition updated manually at inspection	Such as: Load growth (shown by MDI readings) Connection of additional load Network referral Asset risk score	Uses experience to determine if intervention is necessary and selects options based on cost Data is collected to validate load readings from MDIs	Interventions include: Do nothing Network reconfiguration Transformer replacement /additional substation Refurbishment, maintenance, etc
Celsius process	Celsius rating is used for operation and maintenance decisions Demand and temperature data comes from Celsius monitoring data	Celsius notification will inform maintenance teams of temperature/ load issues Connection requests are more informed with accurate data	Determine if the site should be a Celsius site (if not already) If so: Celsius monitoring installed, more informed rating calculated	Intervention selection and design informed by Celsius data Interventions include: Celsius rating Retrofit cooling solution

RICARDO

Celsius next steps

QUESTIONS & ANSWERS

Please contact us if you have any questions or would like to arrange a one-to-one briefing about our innovation projects

innovation@enwl.co.uk

olivia.carpenter-lomax@ricardo.com

www.enwl.co.uk/innovation

0800 195 4141

@ElecNW_News

linkedin.com/company/electricity-north-west

facebook.com/ElectricityNorthWest

youtube.com/ElectricityNorthWest