WESTERN POWER DISTRIBUTION

INNOVATION

NEXT GENERATION NETWORKS

Improved Statistical Ratings for Overhead Lines

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Project Summary

- Aim: to provide DNO's with up-to-date, reliable, and flexible overhead line ratings
- Duration: 3 years – July 2015 to June 2018
  - Including 2 years' data acquisition
- Main deliverables:
  - Update ENA ER P27 (nationally applicable ratings)
  - Software tool to provide DNO flexibility in derivation and application of ratings

OHL Ratings Today

- UK overhead line ratings are probabilistic, and given in ENA ER P27
- They are expressed as having a certain “exceedence” - the risk of a conductor exceeding its design temperature
- The “3%” rating, for example, carries a 3% chance of a conductor’s temperature rising above its design temperature when full rated current is applied

Calculation of Ratings

- Probabilistic ratings are calculated by applying a scaling factor to a reference rating – a rating calculated from a reference set of weather conditions by applying standard heat balance equations
- A function linking the scaling factor to the desired risk level was derived by experiment by the CEGB, Leatherhead, in the late 1970s / early 1980s

Improved Statistical Ratings for Overhead Lines

CERL
C_T vs T_e

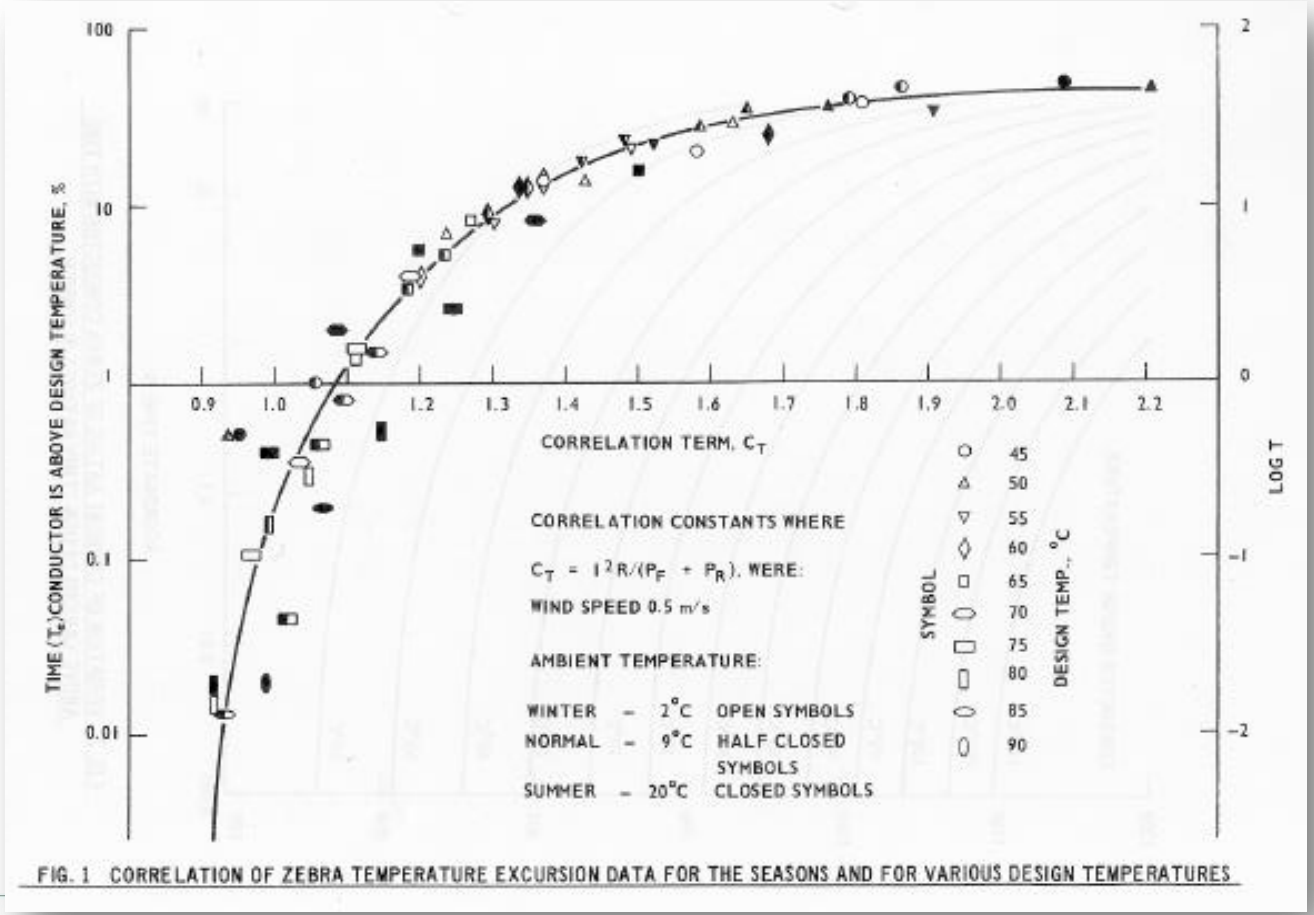


FIG. 1 CORRELATION OF ZEBRA TEMPERATURE EXCURSION DATA FOR THE SEASONS AND FOR VARIOUS DESIGN TEMPERATURES

Problem (1)

- Recent work carried out as part of the Strategic Technology Programme concluded that assumptions used in the CEGB work were erroneous
- A changing climate over the last 35+ years has further invalidated that original work
- ENA ER P27 is no longer considered reliable

Project Aim (1)

- To redefine the function linking reference rating to probabilistic rating
  - Same basic methodology as used by CEGB
  - Designing the experiment to minimise the need for problematic assumptions
  - Outcome to allow more reliable UK overhead line ratings to be calculated
- Deliverable: Updated ENA ER P27

Problem (2)

- Climate continues to change with time, and is variable geographically
  - Experimentally derived function highly unlikely to remain valid indefinitely
  - Function could also be adapted to different regions
  - Repeating the experiment is very expensive and time consuming
- The ability to re-run the experiment “virtually” would be very beneficial

Project Aim (2)

- Deliverable: A software tool allowing DNOs the flexibility to produce tailored ratings
  - With weather data and/or current load profiles as inputs, conductor temperature profiles can be calculated
  - Regional or even line specific ratings could be derived, incorporating load profiles if desired
  - Weather data could be logged locally, or produced by specialist provider (hindcast)

Project Progress (1)

- Test rig constructed at WPD's Stoke Depot
  - 4 circuits / 3 conductor sizes continuously loaded at 3 different current levels for 2 years
  - Conductor temperatures, Ambient temperature, Wind Speed, and Wind Direction monitored
- 2-year monitoring period was completed January 2018

Test Rig

- Located at WPD Stoke depot
  - Considered broadly representative of UK 11kV
- 4 Circuits, 30m spans, each energised at constant current
- Weather monitoring
  - Ambient Temperature
  - Wind Speed
  - Wind Direction
  - Solar Radiation
  - Rainfall
- Embedded thermocouples for conductor temperature measurement
  - Arranged in trios, mid-span

Test Rig Circuits

Circuit	Current	Conductor	Summer "P27" Temp	Normal "P27" Temp	Winter "P27" Temp
1	380	2 x 50 Hazel	58.1	46.8	39.6
		150 Ash	55.6	44.6	37.5
2	500	175 Elm	72.1	61.2	54.2
		150 Ash	84.1	73.4	66.4
3	440	2 x 50 Hazel	72.3	61.1	53.8
		150 Ash	68.7	57.8	50.7
4	440	175 Elm	59.6	48.7	41.6
		150 Ash	68.7	57.8	50.7

Project Progress (1) cont.

- Analysis of data has lead to a better picture of seasonal boundaries
  - Using 4 seasons instead of 3 indicated as more appropriate.
  - New curves linking reference rating to probabilistic rating look promising

Seasonal Boundaries

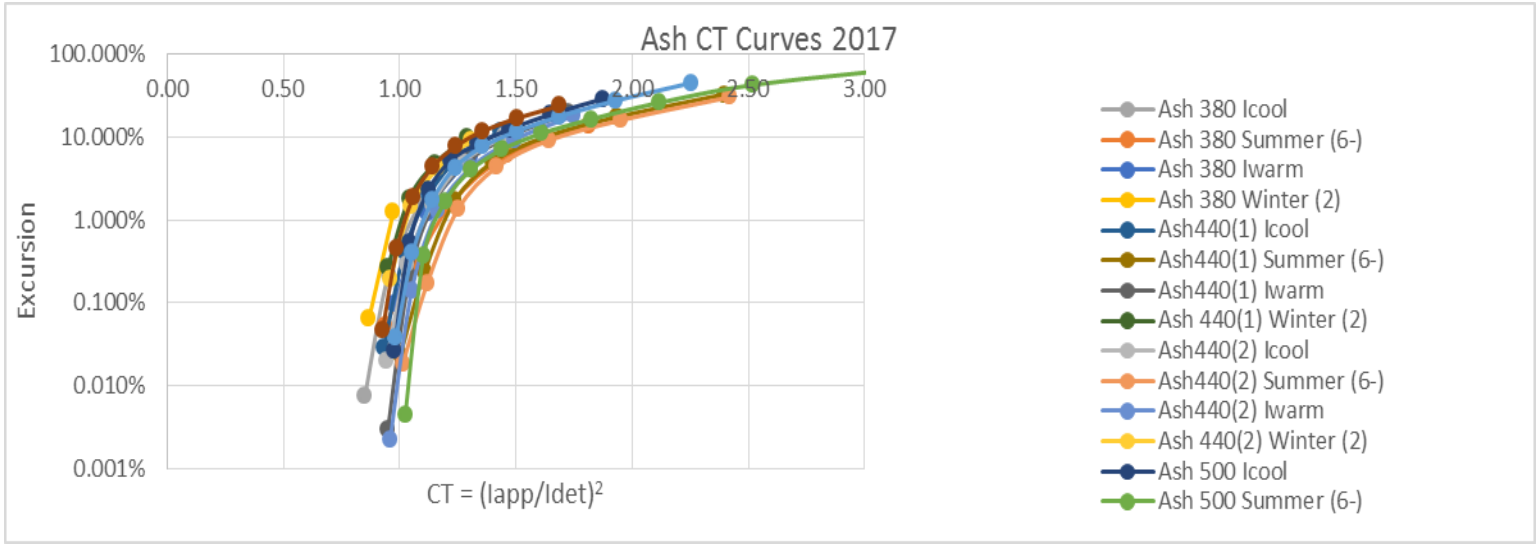
"Old" Seasons

	Winter			Normal*		Summer				Normal*		
P27	2			9		20				9		
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
71 to '00	5.1	4.3	4.5	6.2	7.9	11.0	13.7	16.2	16.0	13.6	10.3	7.0
		4.6			7.1			14.2			10.3	
81 to '10	4.7	4.6	4.6	6.5	8.4	11.4	14.1	16.4	16.2	14.0	10.6	7.3
		4.6			7.5			14.5			10.6	

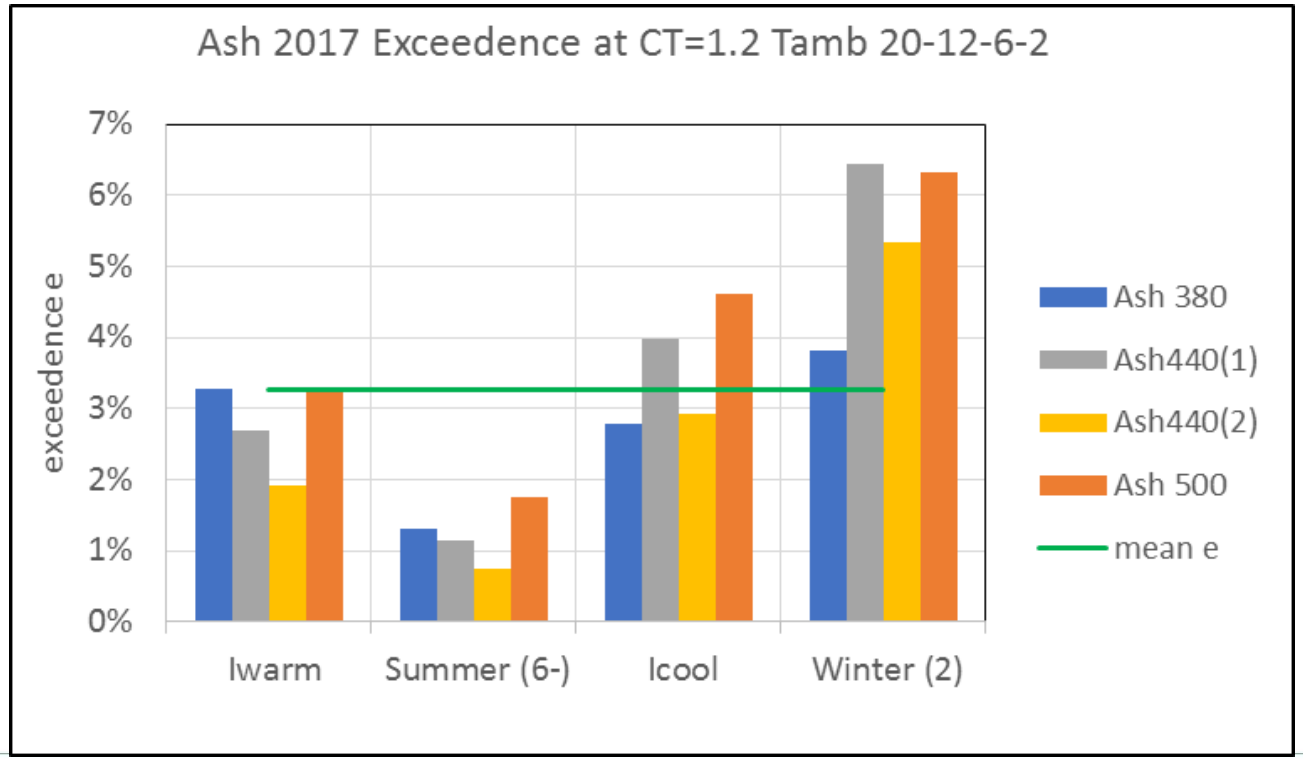
"New" Seasons

	Winter			Intermediate (Cool)			Summer			Intermediate (Warm)		
Stoke Measured	3.6			6.6			14.3			11		
	Dec	Jan	Feb	Mar	Apr	Nov	Jun	Jul	Aug	Sep	Oct	May
71 to '00	5.1	4.3	4.5	6.2	7.9	7.0	13.7	16.2	16.0	13.6	10.3	11.0
		4.6			7.0			15.3			11.6	
81 to '10	4.7	4.6	4.6	6.5	8.4	7.3	14.1	16.4	16.2	14.0	10.6	11.4
		4.6			7.4			15.6			12.0	

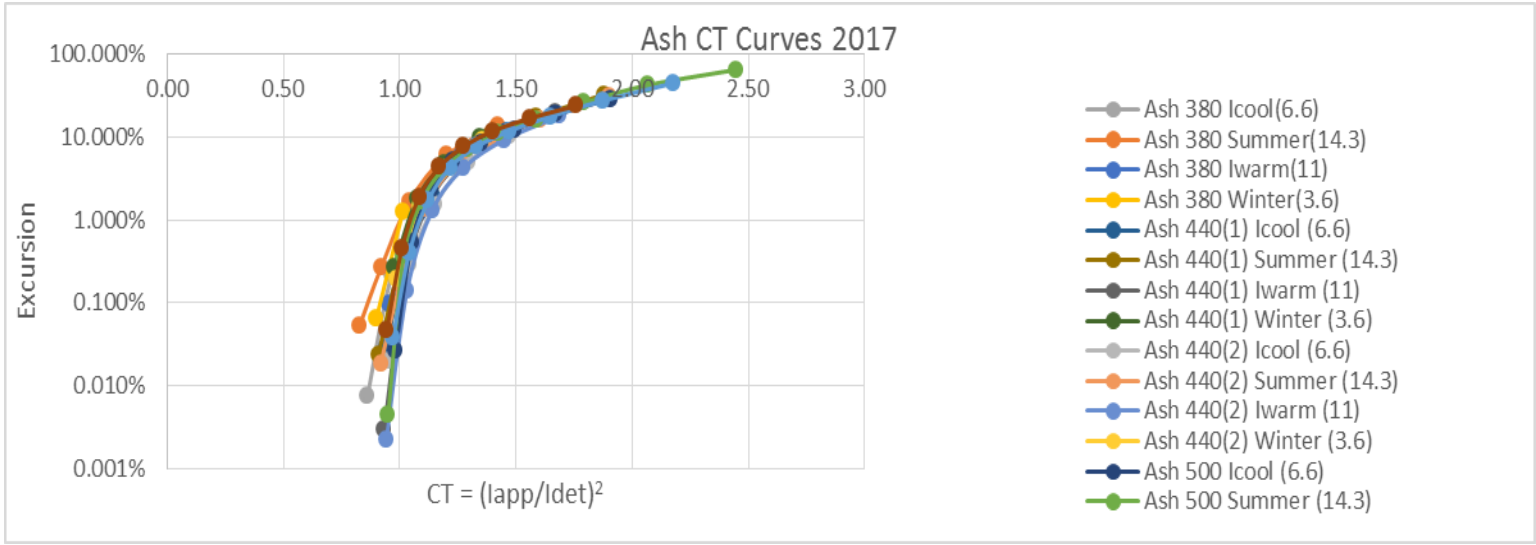
C_T vs T_e Curves – Guessed Ambient



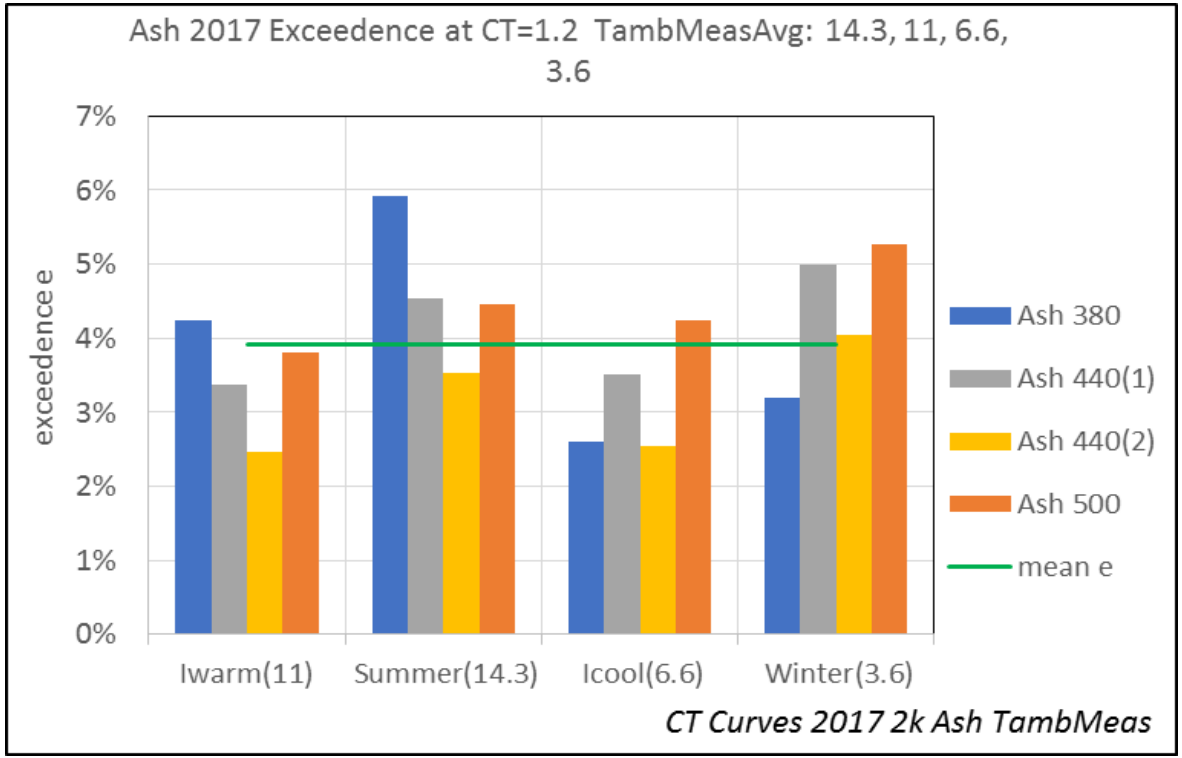
Excursions – Guessed Ambient



C_T vs T_e Curves – Measured Ambient



Excursions – Measured Ambient



Project Progress (2)

- Logged data used to successfully validate heat balance equations & temperature calculation methodology
- Software code completed allowing conductor temperatures and reference ratings to be calculated
  - Code initially to be used for data analysis, subsequently to be incorporated into software tool deliverable

Next Steps

- Further analysis of data
  - Formalise new function linking reference rating to probabilistic rating
  - Produce draft P27 issue 2 for ENA consideration
- Complete development of software tool
  - Determine methodology / specification for utilising hindcast datasets
- Project on track to complete by June 2018

Notes - Flexible Networks

- Originally aimed to have new P27 incorporate a "standard" load duration curve
  - temperature risk = weather risk x load risk
- Alternative connection schemes and renewables now mean that this is no longer considered appropriate
- Software tool will, however, allow DNOs to consider load scenarios themselves

THANKS FOR LISTENING

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Serving the Midlands, South West and Wales

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