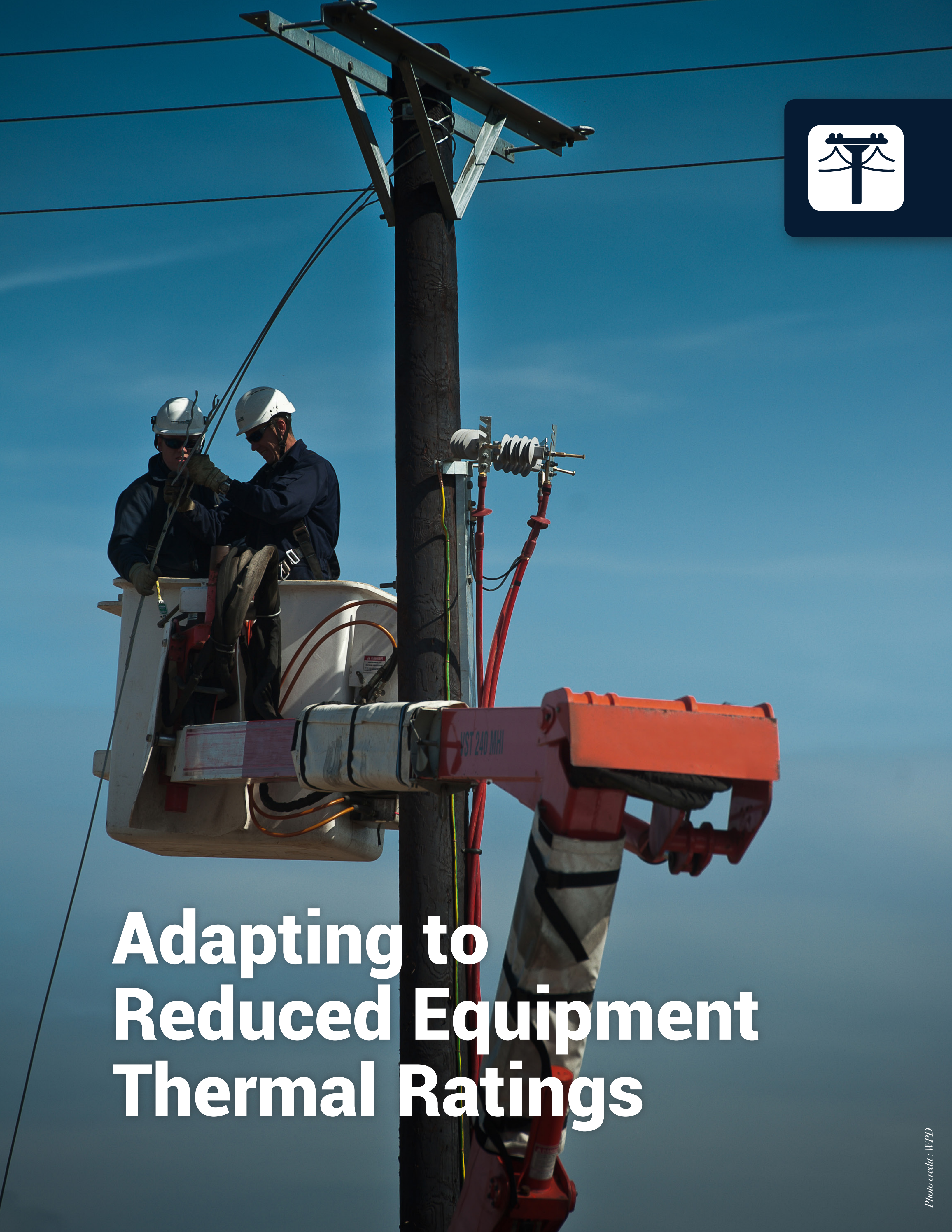

Adapting to Reduced Equipment Thermal Ratings

Photo credit: WPD

SUMMARY

Higher temperatures due to climate change pose a significant challenge for many of the power lines that distribute electricity to homes and businesses. By law, power lines must hang a minimum distance above the ground. Electric utilities operate distribution lines and equipment, and manage minimum clearance requirements on the basis of thermal ratings, which are estimates of the total capacity of an electrical component to carry current at a point in time.

Power lines sag as they heat up, due to two main factors: warmer temperatures and increased amounts of energy transmitted through the lines. As temperatures rise due to climate change, some lines would likely hang below the minimum distance from the ground required by law. This case study describes the approaches taken by several utilities to mitigate this challenge. A cost-effective approach is to adopt improved design standards for new distribution equipment.

> ***"What we have done is follow a 'low-regret' approach to take the opportunity of building additional network capacity and resilience as part of planned asset replacement."***
>
> Phil West, former Policy Manager, Western Power Distribution [1]

CONTEXT

Failure to adapt transmission and distribution lines to increased temperatures may be a source of disruptions and revenue loss. In warmer climates, the likelihood increases that lines will exceed established maximum design temperatures and breach minimum ground clearance because of thermal expansion. Where little network redundancy exists to transfer the loads of overloaded circuits, power interruptions could be experienced, along with increased risk of cascading network failures. The risk of overloads can increase when temperatures rise and more people use air conditioners and fans. A warming climate aggravates these network constraints, especially in the parts of Canada that already experience a larger number of hot days coinciding with peak loads.

Thermal rating refers to the maximum electrical current that the conductor of a transmission or distribution line can conduct. When outside temperatures rise above a certain level, the transmission and distribution capacity of an electricity system decreases — a process known as 'de-rating' or 'reduced thermal rating.'

Historically, the capacity of power transmission and distribution networks has been defined through *static* thermal ratings. These are calculated on the basis of heat-balance equations using extreme seasonal climate values (i.e. solar radiation, temperature, rainfall, wind and cloud cover) observed over long periods of time.[i] Another measure, known as *dynamic* thermal rating, relies on real-time data about weather and/or the state of conductors (e.g. conductor tension).

Several adaptation solutions exist to manage projected de-ratings due to climate change. Increasing the height of the poles that support power lines, for example, helps maintain minimum ground clearance and accommodate higher operating temperatures. A more costly option entails installing conductors with hotter operating limits or novel 'low-sag' conductor material. Another option — the use of dynamic thermal ratings — can help utilities improve both carrying capacity and network efficiency by operating their networks closer to their 'real' capacity limits.

U.K. power utilities already recognize that climate change causes thermal de-rating.[2] An assessment of projected increases in average maximum temperatures by 2040-2069 estimated that carrying capacity will decrease by four to nine percent for typical overhead distribution lines, and by up to three percent for typical overhead transmission lines across the country. (see figure CS9.1). Similar 'de-ratings' are expected in southern Canada, though the impacts on operators have yet to be assessed in detail.[3]

EXAMPLES OF ADAPTATION

B.C. Transmission Corporation (now part of B.C. Hydro) supports the research and development of dynamic (real-time) thermal-rating systems. A key benefit is that these systems can help to prevent power

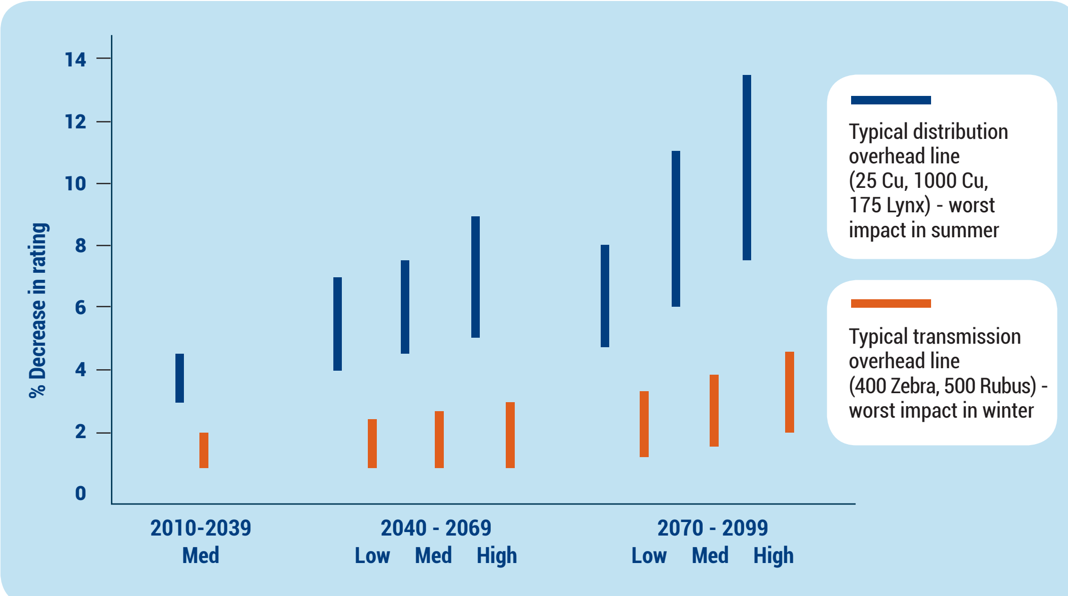

Figure CS9.1 Modeled reductions in overhead line ratings due to increased average daily maximum temperatures projected by UKCP09 under a high greenhouse gas emission scenario (the vertical bars show spread of de-ratings across UK at 25 sq km resolution) (source: Energy Networks Association, 2011)[2]

outages during periods of high loads and ambient conditions close to maximum operating temperatures by leveraging unused capacity within a power system. Other utilities around the world have confirmed the benefits of dynamic thermal-rating technologies. Hydro Tasmania, for instance, relies on observed weather station data, as well as conductor tension data from Transend, Tasmania's transmission asset owner and system operator, to maximize transmission network capacity.

Based on the results of the Met Office study *EP2 Climate Change Impacts on the U.K. Energy Industry Project*, National Grid began to investigate the use of real-time rating, monitoring and management technology to maximize network capacity and realize efficiency gains.[4] The U.K. transmission utility determined that a three percent de-rating of its overhead lines by mid-century is unlikely to considerably affect its operating costs, and therefore does not justify other adaptation investments. The impact of transmission and distribution de-rating of this magnitude pale in comparison with the effects of steady demand growth on transmission and distribution capacity — approximately two percent per decade.

WESTERN POWER DISTRIBUTION'S 'LOW-REGRET' APPROACH

In the U.K., most overhead lines at 132kV and below have been designed to operate at temperatures of up to 50°C. Most distribution equipment, including transformers and switchgear, comply with international standards such as those of the International Electrotechnical Commission (IEC) and the

European Committee for Standardisation (EN). Following several years of collaboration with its industry peers as part of the U.K. Energy Networks Association, Western Power Distribution (WPD) has increased the rated design temperature of newly installed wood pole overhead lines from 50°C to 55°C to accommodate projected increases in sagging.

"This new design standard translates into negligible additional capital expenditures by increasing the required height of wood poles being replaced by 0.5 metres," reports Phil West, former Policy Manager at WPD. "This adaptation solution is a 'low-regret' option as it tags on planned asset replacements, and derives clear and reliable resilience benefits at very low costs. It was an 'easy sell' to corporate executives, and something WPD was able to take on without necessitating increases in user fees."

In its corporate-wide assessment of climate change risks and adaptation, WPD decided against early re-conductoring whole sections of overhead lines because the associated costs far exceed the anticipated benefits. Furthermore, most conductors have long operating lives and early replacement would carry a very high opportunity cost.

Notwithstanding WPD's 'low-regret' adaptation approach, the U.K. power industry, with support from its regulator, decided to make large investments to manage two other climate change risk areas: pluvial-flooding resilience for substations and vegetation-growth management. Between 2011 and 2023, the industry has made financial commitments of CA$330 and CA$300 million, respectively.[5]

Between 2011 and 2023, the industry has made financial commitments of CA$330 and CA$300 million, respectively.

LESSONS LEARNED

WPD, in collaboration with industry peers, began preliminary work on climate change impacts in 2006. The company based its adaptation investment decisions on the 2008 findings of the *EP2 Climate Change Impacts on the U.K. Energy Industry Project* study. The sector-wide study benefited from an innovation-funding incentive by the U.K. energy regulator Ofgem. Technical support from the U.K. Met Office, a highly experienced and credible scientific organization, contributed to the quality of the study. The work was co-ordinated through the UK T&D trade body The Energy Network Association, whose Climate Change Adaptation Task Group is comprised of representatives of each member electricity-network operator, along with government and regulating agencies. The subsequent introduction of a regulatory obligation to report on climate change adaptation helped spur WPD and other utilities to operationalize the EP2 study's findings by implementing adaptation plans.

According to WPD's Phil West, "having a clear and common view across the industry on the mechanisms of assessing risks and solutions" is an important prerequisite for successful collaboration between industry and government on climate adaptation. Many of the risks and solutions to climate change are common across the whole power industry, and in most cases utilities do not consider climate adaptation as a source of competition. As such, adaptation is by nature an issue that is fit for industry collaboration.

For instance, government approvals for adaptation-related rate hikes and capital expenditures have been made possible by the plentiful evidence of costs and benefits shared by all regulated transmission and distribution utilities. Undoubtedly, the already high levels of collaborative research and engagement between utilities and regulators in the U.K. have also played a favorable role. Conversely, WPD's Phil West recalls an instance in Australia where power distribution companies were unable to agree with regulators on the likelihood and consequences of climate change impacts, which led to the rejection of a request to increase rates to fund adaptation projects.[1]

Phil West warns that "using too many climate change scenarios can sometimes prevent progress." In the case of the EP2 study, utilities decided to base their adaptation assessment on a single scenario and probability level to simplify the assessment and avoid diverging views on risk levels. While this approach may not be adequate for other climate change risk areas with highly uncertain projections and/or impacts that are highly sensitive to climate uncertainty, it illustrates that adaptation decisions do not always require multiple complex climate scenarios.

Finally, WPD's work on thermal ratings illustrates another important reality: the return on investment of adaptation projects is always pitted against other capital plans, and in many cases time discounting weakens the business case for adaptation. For example, while the projected distribution de-ratings are significant, they are much smaller than the anticipated impacts of demand growth and increased renewables on the grid. It is only by incorporating an 'adaptation allowance' into its design standard for new overhead distribution lines that WPD managed to reduce its vulnerability to thermal de-ratings. WPD expects that this investment will improve its network resilience at a minimum cost.[1]

Author : Jean-Christophe Amado, Deloitte | **Collaborators :** Élyse Fournier, Ouranos, Marco Braun, Ouranos, Philip J. West, Western Power Distribution
Copy Editing : Peter McKinnon | **Translation to French :** Lise Malo, La Plume Déliée | **Layout Design :** André Hughes, Pro-Actif
Suggested citation : Ouranos 2016. Adapting to Reduced Equipment Thermal Ratings. Case Study presented to Climate Change Impacts and Adaptation Division, Natural Resources Canada, 7 p.

[i] Three basic heat-balance equations are used to calculate static thermal ratings across the world: the Institute of Electrical and Electronics Engineers IEEE 738 Standard, the International Council on Large Electric Systems CIGRE Technical Brochure 207 Standard, (now TB 601, December 2014) and the Electric Power Research Institute EPRI Dynamp Standard.

1 West, P. Personal Communication. (2015)
2 Energy Networks Association. Electricity networks Climate Change Adaptation Report - Engineering Report 1. (2011).
3 Mirza, M. Q.. Climate Change and the Canadian Energy Sector - Report on Vulnerability Impact and Adaptation. (Environment Canada, 2004)
4 National Grid Electricity Transmission plc. Climate Change Adaptation Report. (National Grid, 2010).
5 Adaptation Sub-Committee. Managing Climate Risks to Well-being and the Economy – Adaptation Sub-Committee Progress Report 2014. (UK Committee on Climate Change, 2014). at <https://www.theccc.org.uk/wp-content/uploads/2014/07/Final_ASC-2014_web-version.pdf>

AT A GLANCE

KEY TAKEAWAYS

1. For costly adaptation options, with payback exceeding typical planning horizons, collaboration on financing between industry, regulators and government is essential

2. Low-regret' adaptation options, e.g. low-cost upgrades during normal asset replacement, trigger benefits in most future scenarios, and are easy to finance and implement

3. Collaboration between companies, regulators and governments is essential to design and implement adaptation policies in the power sector

ORGANIZATION(S)
B.C. Hydro (Canada); Hydro Tasmania (Australia); National Grid (U.K.); Western Power Distribution (U.K.)

POWER SUB-SECTOR(S)
Transmission and distribution

ADAPTATION TYPE(S)
- Physical – Equipment protection, upgrades and alternative materials

CLIMATE CHANGE IMPACT(S)
- Rising temperatures and number of hot days
- Changes in natural cooling (rainfall, wind and cloud cover)

ADAPTATION COSTS
- The marginal cost of increasing the height of wood pole overhead line support structures during normal asset replacement is low.
- The cost of re-conductoring whole sections of a network is medium to high
- The cost of 'real-time' thermal rating technology is medium to high

ADAPTATION BENEFIT(S)
- Increased network resilience
- Greater transmission and distribution capacity and efficiency

CONTACT DETAILS
Philip J. West
pwest@westernpower.co.uk

FULL REPORT
https://ouranos.ca/en/programs/energy-adaptation-case-studies/

OURANOS

Ressources naturelles Canada | Natural Resources Canada
Canada