CRA was engaged by CTC Global to evaluate the potential benefits for electric utilities of CTC's new GridVista™ System

CTC's GridVista™ System embeds optical sensors with ACCC® Core to directly measure real-time conductor conditions continuously along transmission lines

Data collected by GridVista

- ► Temperature
- ► Strain
- ► Sag
- ► Ice loading
- ► Point loading
- ► Hot spots
- ► Corona discharge
- ► Lightning strikes
- ► Capacity
- ► Galloping
- ► Aeolian vibration

Based on expected performance outputs stated by CTC Global, CRA evaluated the potential benefits of GridVista across the following four applications:

- ✓ **Anomaly Detection:** Continuous line ratings and real-time environmental sensing could enable proactive anomaly detection
- ✓ **Operations:** In operational functions, granular capacity measurements and alerts on actual line conditions could improve situational awareness
- ✓ **Asset Maintenance:** Maintenance teams could benefit from live asset health data, and high-resolution spatial analysis could enable condition-based maintenance
- ✓ **System Planning:** System planners could leverage real-time constraints to optimize dispatch and risk assessments, ensuring dynamic and accurate planning for future growth

CRA identified the following primary categories of benefits associated with GridVista

Capacity Enhancement	Outage Reduction	Operations Streamlining
GridVista's sensing could provide continuous real-time temperature, sag, and tension data, which could enable utilities to replace static seasonal ratings with dynamic, condition-based line ratings	*Embedded optical sensors that capture conductor strain, vibration, and thermal excursions could enable the detection of mechanical fatigue or hotspot precursors before major events*	*Granular real-time or near real-time data could support condition-based inspection and maintenance cycles, and potentially replace calendar-based O&M with risk-based prioritization*
Key derived assumptions about GridVista used to quantify benefits		
Could enable higher real-time line ratings with a higher level of certainty, enabling operators and planners to run lines above their static rating	Could enhance system reliability by catching anomalies early on and enabling utilities to respond, potentially reducing mechanical failures and limiting outage duration	Could enable utilities to safely reduce inspection frequency and reduce field exposure for crews, potentially resulting in lower costs and improved safety

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Assessment of how GridVista could improve capacity enhancement

Potential to reduce new build while increasing capacity

Real time monitoring could increase usable ampacity and raise flows on constrained lines, which may reduce the need for new build; right-sizing projects could **reduce construction costs by up to 75%**

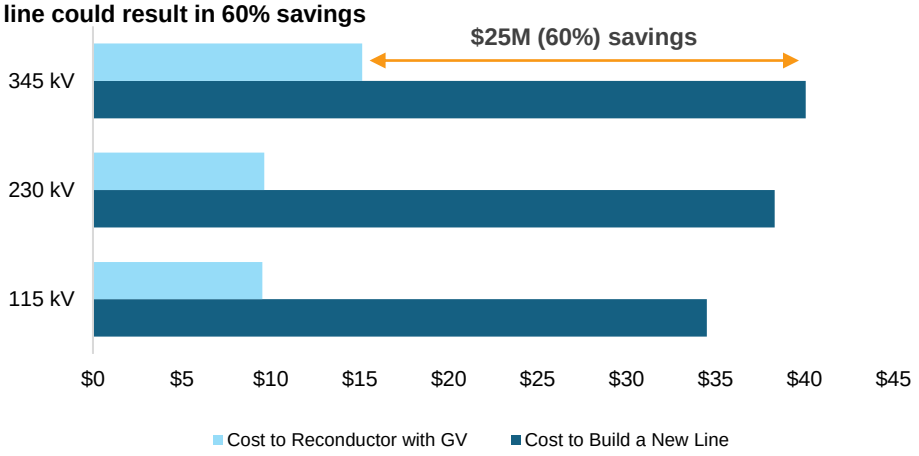
GridVista benefit

By monitoring conductor temperatures and line conditions in real time, operators may potentially boost transmission line capacity by up to 50%. Opting to reconductor with GridVista may enable the necessary increased ampacity to respond to capacity shortfalls without building new lines.

Case study

When faced with overloaded transmission lines, utilities can opt to either reconductor the existing line with GridVista technology or keep the current line in service and construct a new line to manage the shortfall. In our modeling, reconductoring 20 miles of overloaded lines with GridVista could avoid over $20 million in new construction costs.

Capital cost to relieve overload on a 20 circuit-mile ACCC line: reconductoring with GridVIsta vs building an additional lower-voltage line could result in 60% savings



Key assumptions:

- Compares the overload on a standard ACCC line to an ACCC line with GridVista to isolate the benefit of GridVista
- Baseline cost comparison against building a new line to meet the capacity shortfall
- Assumes "base" case (40% average annual uplift from real-time ratings); further assumes that this uplift would occur 85% of the time, which is aligned with conservative DLR assumptions
- Cost data based on exploratory cost estimate to rebuild or reconductor an AC transmission from MISO Transmission Expansion Plan Cost Workbook. Exploratory costs are not specific to ACCC or ACSR

Potential to relieve congestion by increasing line rating precision

A GridVista installation on the 10 most congested lines in SPP potentially avoids **up to 30% in annual congestion charges**; based on system-level day-ahead market prices in SPP, this could translate to **$110M in annual congestion savings which would ultimately benefit ratepayers**

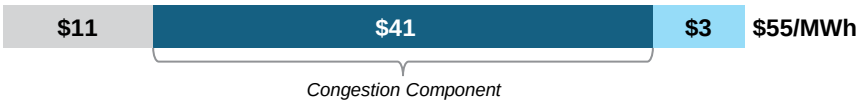
GridVista benefit

Continuous monitoring of conductor temperatures and line conditions could enable operators to increase real-time transmission capacity beyond static ratings by providing insights and actionable data on line loading and thermal margins to optimize flows. This could translate to a 50% uplift in line ratings over static line ratings.

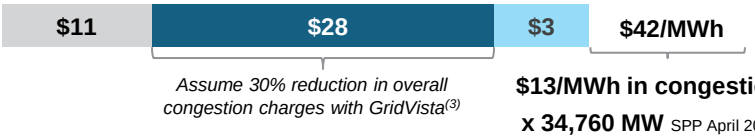
Case study

In 2024, transmission congestion in SPP increased, primarily due to increased demand from large loads, with 43% of all congestion charges stemming from just 10 flow gates. Applying GridVista technology to these lines could potentially reduce congestion charges by up to 30%, resulting in estimated annual savings of $110 million based on day-ahead market prices.

Average Annual Day-Ahead Market Prices – *without GridVista*[2]



Average Annual Day-Ahead Market Prices – *with GridVista*



Energy component

Price variation portion from congestion charges

Price variation portion from marginal energy losses

$13/MWh in congestion savings

x 34,760 MW SPP April 2024 Peak Load[4]

x 11% Portion of total hours with there is congestion with GridVista[2]

x 43% Portion of total system congestion across the 10-most congested lines[2]

=

~$110M in total annual congestion savings

Key assumptions:

- 50% uplift over static line ratings 85% of the time. Assumes average time of 22% where congestion was experienced across the 10-most congested flowgates in SPP. Assume that GridVista could reduce frequency of congestion by up to 50%
- As a result, total annual congestion savings from GridVista deployment across the 10-most congested flowgates in SPP equate to 5-30% annual savings, assuming a constant average annual shadow price with and without GridVista
- The upper bound of 30% annual savings was applied to the congestion portion of the average annual day-ahead market prices reported by SPP in 2024, resulting in a range of market prices of $11/MWh to $32/MWh

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Potential to create headroom for renewables

Taking the assumption that GridVista could enable a 50% increase in line rating relative to static limits,[1] local constraints could be reduced by nearly 40%, allowing more renewable energy to flow and unlocking up to **~$23M in potential recaptured revenue for renewable generators** within CAISO

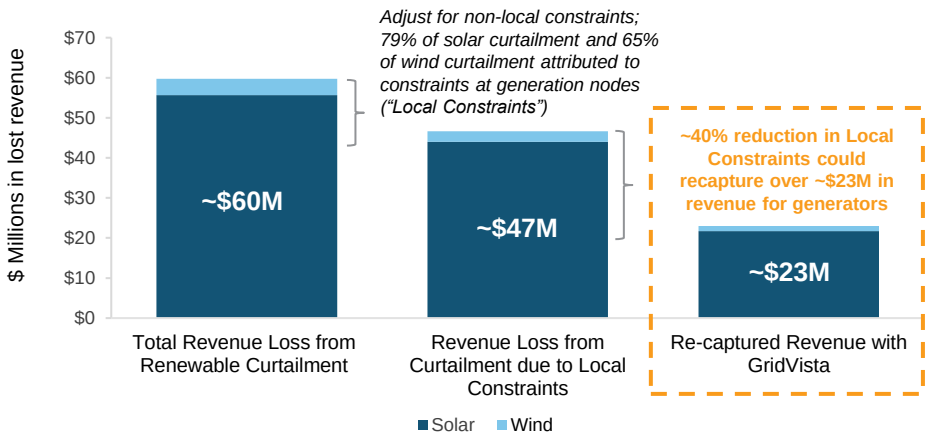
GridVista benefit measured

GridVista could enable transmission lines to safely operate above static ratings during favorable conditions, providing headroom precisely when wind/ solar generation reach their output peaks. This may capture otherwise lost sales and revenue for renewable generators.

Case study

In 2023, renewables in CAISO experienced curtailment 4.3% of the time, which equated to nearly $60 million in lost annual revenue based on average energy prices. Considering only curtailment attributed to constraints at generation nodes, an increase in line ratings relative to static ratings could potentially avoid over $23 million in lost revenue for renewable producers (assuming no PTC).

Average annual revenue loss for renewable generators in CAISO due to total curtailment and local curtailment[6]



Key assumptions:

- The 79% Solar curtailment and 65% wind curtailments are values system-wide curtailment levels caused by local congestion constraints as reported by CAISO for 2023 for renewable generators
- ~40% reduction in local constraints assumes a 50%-line rating uplift over static line rating from GridVista Implementation. This uplift essentially reduces the congestion levels by a factor of (1- %uplift)
- The reported average system-wide energy prices for solar and wind were $26.93/MWh and $48.27/MWh respectively in 2023

Assessment of how GridVista could reduce the impact of outages

Potential to decrease the impacts of outages

Line rating uplifts and continuous monitoring capabilities of GridVista could lead to fewer line trips and faster recovery, potentially **lowering outage impacts by up to 80% based on Value of Lost Load (VoLL)**

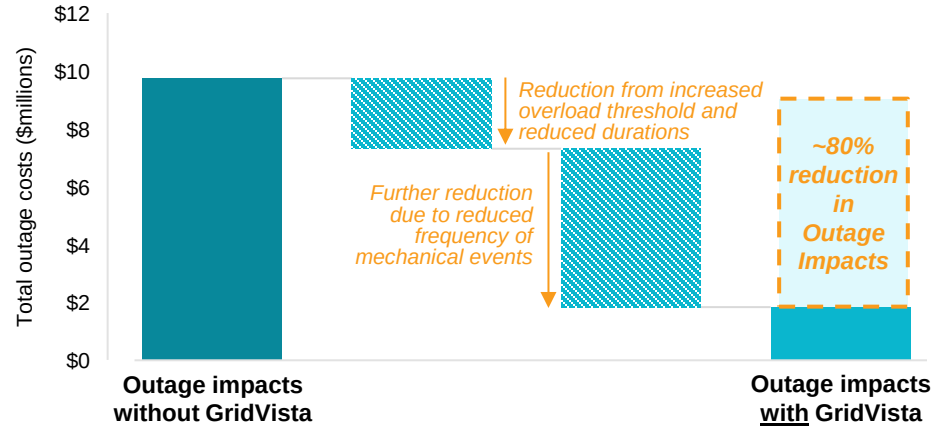
GridVista benefit

GridVista could reduce outage impacts (measured by VoLL) by dynamically increasing real-time line ampacity, monitoring thermal operating limits, and ensuring safe current flow within allowable conductor temperatures, enabling fewer line trips, faster recovery, and lower impacts across customer classes.

Case study

Implementing GridVista in ERCOT could reduce outage-related impacts by increasing real-time line ampacity and shortening outage durations by up to 80%, saving roughly $400,000 per circuit mile and up to $8 million for 20 new miles through increased reliability and faster outage recovery.[8]

GridVista's potential effect on system and avoided outage impacts, measured by VoLL, over a 20-mile 345kV circuit[7]



Key assumptions:

- Texas PUC, VOLL Study Final Report, Project No. 55837. ERCOT assigns a VoLL of~ $35,000/MWh (one-hour outage), representing the estimated economic cost to customers when electricity demand is not served. This number reflects the combined losses households, businesses, and industries experience during outages—including lost productivity, spoiled goods, service disruptions, and safety risks.
- Avoided outages: GridVista helps utilities avoid mechanical outages only, which account for 10-20% of total outages. Assume only 80% of mechanically-cause faults are avoided as a conservative estimate

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Potential to reduce field hours and improve safety

Fewer inspections, avoided outages, and faster restoration could reduce crew field hours and exposure, **potentially lowering the risk of safety incidents**

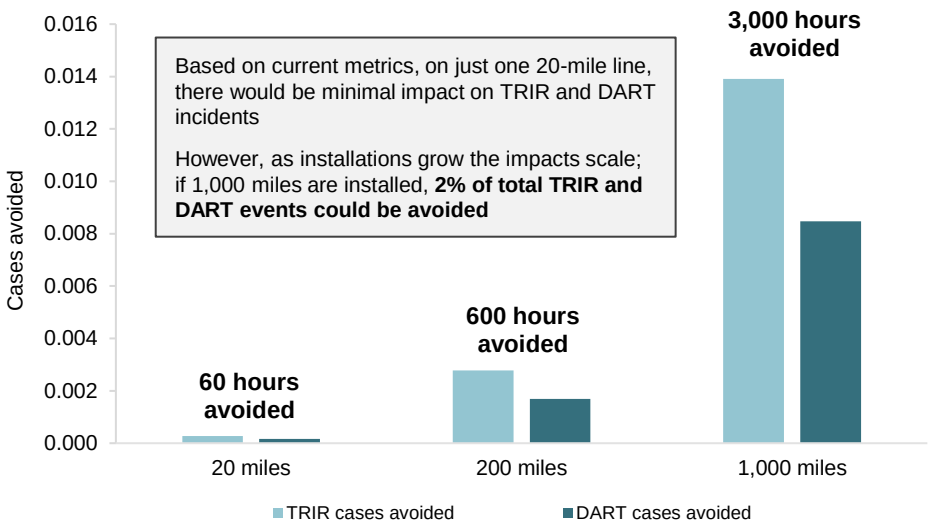
GridVista benefit

Utilities track OSHA safety metrics such as the Total Recordable Incident Rate (TRIR) and the Days Away, Restricted, or Transferred Rate (DART). GridVista could allow utilities to reduce inspection frequency and outage response needs, therefore lowering the total time employees spend on activities that carry safety risks.[9]

Case study

Utilities, on average, report TRIR and DART safety rates of 1.26 and 0.97, respectively.[10] By using GridVista to reduce inspections and speed up outage response on a 20-circuit mile segment, crew exposure could drop by 60 hours annually, improving key safety metrics.

Exposure hours could decrease as GridVista installations scale



Key assumptions:

- Avoided crew hours reflect fewer patrols (annual to every three years), fewer detailed inspections (every three years to every five years), and faster outage response compared with a baseline that lacks fault-detection technology

Assessment of how GridVista could support O&M savings

Potential to decrease outage and emergency response time

Real-time data could enable preventive maintenance that avoids up to 11% of outages, while precise fault-location data may cut response times by as much as 99% compared to a no-fault-detection baseline, resulting in $4,300 annual savings on a 20-circuit mile line

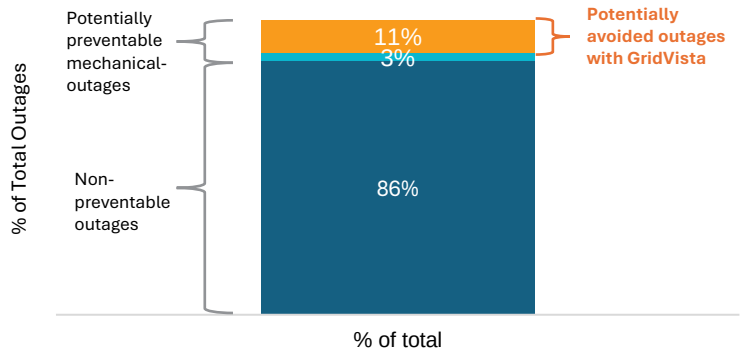
Avoided number of outages

GridVista's line condition insights could help utilities employ predictive maintenance practices to prevent mechanically-driven outages, which make up 14% of transmission failures. By preventing up to 80% of these events—around 11% of total outages—utilities could experience fewer outages, less damage, and lower costs for emergency repairs and materials.

Shorter response time via more targeted investigation

Without fault detection, crews patrol long stretches, delaying restoration and raising labor costs. GridVista could support pinpointing faults, and the dispatch of nearby crews, reducing down-time and expenses. This could improve fault-location accuracy by 65% over impedance-based fault locating (IBFL) technology.

Decrease in number of outages



Key assumptions:

- Avoided outages: GridVista helps utilities avoid mechanical outages only, which account for 10-20% of total outages. Assume only 80% of mechanically-caused faults are avoided as a conservative estimate
- Shorter response time: With no fault-detection technology in place, assume search distance is the full line length. Assume search distance with GridVista is limited to one span (~0.14 miles)
- Utilities can respond to events with vehicle or aerial crews. Values here show the average cost of the two types of responses
- High variability and lack of public data does not allow CRA to quantify repair cost savings

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Potential to optimize inspections on high-fire risk lines

Real-time condition data could enable utilities to opt to decrease the frequency of inspections of high-fire risk lines

GridVista benefit

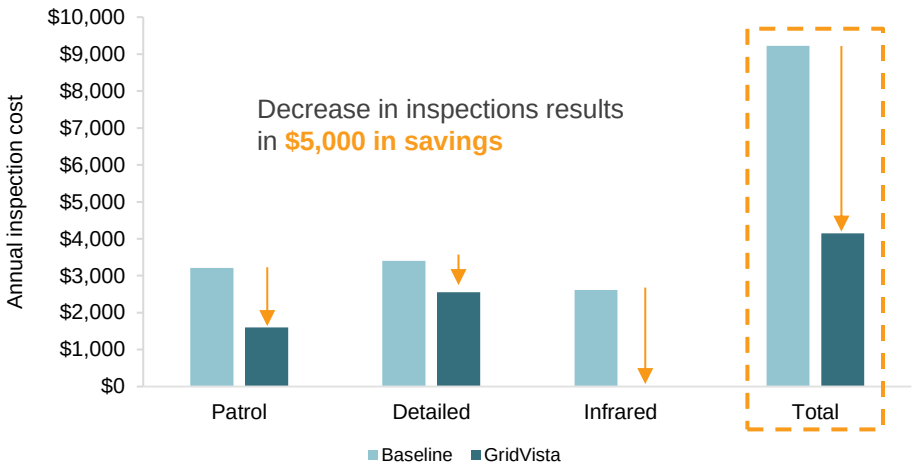
With GridVista's continuous line-condition data, utilities in high wildfire-risk areas can reduce patrol, detailed, and infrared inspections, cutting crew hours, costs, and reliance on helicopters and infrared sensors.

Case study

By leveraging GridVista on a 20-circuit mile transmission line situated in a Tier 2 High-Fire Threat District, utilities could significantly reduce their inspection frequency. If a utility opted to shift inspections from annual to biennial, detailed inspections from every three years to every four, and eliminate infrared inspections, then overall inspection efforts would decrease by 55% which could generate savings of $5,000 annually for the utility.

Potential decreased inspection savings with GridVista

On a 20 circuit-mile, Tier 2 HFTD line



Key assumptions:

- Inspection requirements for distribution under California GO 165 used as basis to decrease inspection frequency with GridVista
- Savings due to reduced inspection frequency decreasing crew costs in terms of wages and vehicle costs (fuel, maintenance costs, etc.)

Potential to enable preventive maintenance

GridVista could help utilities transition from reactive fixes to proactive maintenance, thereby cutting annual maintenance costs **up to 25%**

GridVista benefit

Insights provided by GridVista could allow utilities to shift from scheduled or reactive to performance-based maintenance. Over time, with deeper data, GridVista could enable predictive maintenance practices

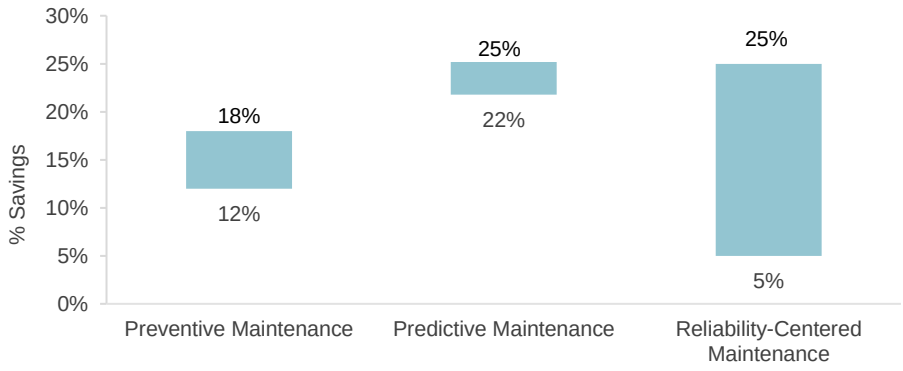
Current types of maintenance strategies

Utilities maintain transmission lines using several strategies: reactive repairs after failures, scheduled preventive tasks due to time or usage, predictive interventions based on monitoring and diagnostics, and risk-based Reliability-Centered Maintenance (RCM) to optimize maintenance policy for failure modes based on risk.

Case study

Utilities spend around $1,900 per mile annually on overhead line maintenance [12] . With RCM enabled by GridVista, utilities could potentially reduce costs by $4,600 to $9,500 a year, or up to 25%, for a 20-mile line.

Reported Savings of maintenance strategies relative to reactive maintenance



Reported savings[11]

- Shifting maintenance from reactive to risk-based programs that use condition data and RCM to target the right work at the right time has demonstrated impact across multiple studies
- Reported cost reductions versus reactive: **preventive 12-18%, predictive 22-25%, RCM 5-25%**
- Reliability improves alongside cost: fewer failures, shorter outages, and better deployment of crews and capital
- **Savings in one O&M category could free up budget to tackle deferred maintenance with higher opportunity cost, allowing utilities to address the riskiest, most value-adding work sooner**

Key assumptions:

- Utility overhead line maintenance costs are inclusive of costs to service non-conductor assets. GridVista would only decrease conductor-related costs

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Assumptions and Footnotes

CRA was tasked with evaluating the potential benefits across the utility ecosystem with the assumption that the GridVista technology would meet the specified and stated performance criteria

CRA did not evaluate the effectiveness or accuracy of the stated capabilities of GridVista; these capabilities were defined by CTC Global

CRA used publicly available data and public test cases to test assumptions and outcomes; any actual benefits accruing to an individual utility or ISO region would necessarily be specific to individual utility or ISO circumstances

CRA makes no guarantees regarding the realization of actual benefits of the product as described in this report

1) Assumes “high” case. Further assumes that this uplift over static-line ratings would occur 85% of the time, which is aligned with conservative DLR assumptions
2) SPP State of the Market 2024
3) CRA internal analysis
4) S&P April 16, 2024. 0.65 Load Factor (Average Load to Peak Load)
5) Due to uplift of line rating over static, total congested hours would be reduced by 50%
6) Assuming no impact of PTC; total curtailed levels of output X average solar energy cost ($/MWh)
7) Baseline line overload based on three studied 345-kV lines in ERCOT (Board of Directors information sheets) to obtain emergency ratings over static ratings. Average overload per circuit mile across those three lines equated to 8.7 MW/circuit mile
8) ERCOT’s 2024 RTP 345-kV plan assumes a total of ~1,500 new circuit miles by 2030, a YoY increase of ~200 new circuit miles per year. Assume 10% is GridVista
9) Exposure hours is defined as total on-duty hours spent at or moving between work locations for inspection, maintenance, or restoration activities
10) Based on average costs and savings reported by various utility studies, not specific to transmission maintenance.