TECHNOLOGY TRANSFER AWARDS GENERATION SUCCESS STORIES

2021

SUCCESS STORY

WIND TURBINE HEALTH MONITORING TOOLS HELP PGE, WEC, AND XCEL IMPROVE PRODUCTION AND REDUCE COSTS

Portland General Electric (PGE), WEC Energy Group (WEC), Xcel Energy (Xcel), and EPRI collaborated to develop wind turbine health monitoring tools to improve production revenue and reduce operations and maintenance (O&M) costs.

Successful automation and implementation of these innovative monitoring tools assisted operators with asset digitalization and improved overall wind farm annual energy production. Application of these generalized health monitoring methods on other generation assets with gearboxes and generators also results in a public benefit through more efficient power plant operations.

NEED FOR HEALTH MONITORING TOOLS

Wind turbine drivetrain (gearbox and generator) failures are one of the primary reasons for increase in O&M costs. A full gearbox and generator failure may result in unplanned repair costs of $350,000 and $125,000 respectively. These failure events can also lead to prolonged downtime and significant loss of production.

Current wind turbine health monitoring techniques can be expensive, need additional instrumentation, and/or are not as accurate needed. Hence, operators are constantly looking for a low-cost monitoring technique with high accuracy to reduce turbine unexpected failures and the high costs associated with them.

ANALYSIS OF TURBINE OPERATIONAL DATA AND DEVELOPMENT OF MODELS

EPRI conducted a comprehensive wind turbine generator and gearbox reliability analysis and failure assessment based on data provided by utilities and operators. This research includes identification of critical components, development of physics-based machine learning (ML) models for early damage detection, and recommendations for life extension. The research was documented in two reports (3002016434) and (3002019010).

WEC Energy Group Glacier Hills Wind Farm

> *"Participating in EPRI projects has allowed WEC Energy Group to adopt wind turbine performance and health monitoring practices in-house, which has led to substantial avoided capital costs. Our proactive approach to obtain notifications across our wind fleet is more cost efficient than running the equipment to failure, which is substantially more expensive to replace."*
>
> ~ **CODY CRAIG**
> *Asset Manager for Renewables*
> WEC Energy Group

RELATED EPRI PRODUCTS

Title	Product ID
Wind Turbine Gearbox Reliability, Damage Prediction, and Recommendations for Life Improvement: Digitization of Wind Assets to Reduce O&M Costs	3002016434
Wind Turbine Generator Reliability and Damage Prediction: Generator Technologies, Failure Modes, and Life Impact Factors	3002019010

PGE, WEC, and Xcel participated in this research in several ways. The utilities shared with EPRI three years of operational data and reliability records from their wind farms. The wind farms included PGE's Biglow II wind farm (total seventy-one 2.3-MW turbines), WEC's Glacier Hills wind farm (total ninety 1.8-MW turbines), and Xcel's Nobles wind farm (total one hundred and thirty-four 1.5-MW turbines). The three participants also supported EPRI in developing and validating turbine health monitoring tools using ML models.

These wind turbine health monitoring models assisted PGE, WEC, and Xcel in finding issues with main bearings, gearboxes, and generators. The operators are now utilizing EPRI's techniques in-house for efficient monitoring of their wind fleets (total 2.0 GW+).

BENEFITS

Participating in the EPRI projects has allowed the three operators to adopt wind turbine health monitoring practices in-house, which has led to substantial avoided O&M costs. Operators now proactively obtain notifications across their wind fleets. These notifications can lead to low-cost repairs rather than running the equipment to catastrophic failure, which is substantially more expensive to replace.

To date, with early identification of damage, WEC has avoided full generator replacement on 12 turbines and was able to avoid main bearing catastrophic failure on four turbines. These avoided failures resulted in over $2M savings to date.

Xcel identified a gearbox damage in its early stages, and PGE used EPRI's generator reliability projections for its 2021 O&M replacement strategy. These results enabled Xcel and PGE to prioritize and optimize turbine maintenance efforts, and better estimate future maintenance costs.

The top cost benefits of implemented actions include the following. In the area of main bearing, generator, and gearbox health degradation, implementation of EPRI's turbine monitoring techniques and identification of component damage in its early stages avoided full system replacement cost. These savings included $100,000 for the main bearing, $160,000 for the generator, and $350,000 for the gearbox.

In the area of unexpected O&M costs, more preventive O&M actions and fewer corrective maintenance events resulted in crane mobilization and savings by bundling the component replacements during a low wind period ($100,000/wind farm/year).

In the area of turbine unavailability, reduced turbine downtime through efficient inventory management meant an increase in annual energy production, or approximately $100,000 increase in revenue.

For the future, EPRI's wind turbine health monitoring methods will continue to support PGE, WEC, and Xcel O&M activities on their growing wind fleets (3.7 GW+) for decades. This work has successfully demonstrated the value of collaborative efforts and encouraged more utilities/operators to participate in EPRI's P206 wind program, paving the path to more successful projects.

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EPRI

SUCCESS STORY

EPRI ALGORITHM ENABLES SOUTHERN AND HAWAIIAN ELECTRIC TO OPTIMIZE ENERGY STORAGE FOR PV PLANTS

To meet the needs of Southern Company and Hawaiian Electric Company, EPRI conducted research on the potential benefits of coupling energy storage with large-scale solar photovoltaic (PV) plants. In the research EPRI developed a first-of-its-kind algorithm to optimize the size and duration of energy storage to improve the production and dispatchability over standalone large-scale PV plants.

IMPROVING SOLAR DISPATCHABILITY AND PRODUCTION

The capacity of solar PV plants is anticipated to triple in the next decade. As more standalone PV plants are deployed, a sharp decline in the value of solar is anticipated. One way to reverse this trend and increase the value of solar is to couple it with storage. However, current modeling tools lack the capability to optimize the size and duration of storage for an intended purpose.

One potential benefit of coupling PV with storage is a reduction of ramp rates from a plant. The production from a standalone PV plant is dependent on the amount of sunlight reaching the PV modules. During partly cloudy days, production can quickly fluctuate between near zero to full power as clouds pass overhead. The rapid influx of power from this quick ramp-up can be problematic for grid reliability. In some locations, a ramp rate limit has been imposed by the grid operator to throttle how quickly power can return. An appropriately sized battery can reduce the number of violations of ramp rate limits.

SCOPE OF RESEARCH

To address the issues of improving PV plant production and dispatchability, Southern Company and Hawaiian Electric asked EPRI to analyze if and how coupling storage to PV plants could minimize ramp rate violations (i.e., improve grid reliability) and improve plant production (i.e., smooth the power output and avoid being curtailed due to the ramp rate limit).

Southern Company asked EPRI to study a range of hypothetical battery capacities and durations to quantify the impact on ramp rate violations at PV plants. The utility used the data for cost-benefit analysis to inform plans for future PV + storage plants in its service territory.

> *“Through this important collaboration, EPRI was able to develop a useful algorithm that optimizes energy production and storage at grid-scale solar facilities. Hawaiian Electric will use this to improve performance for existing and future solar projects.”*
>
> ~ **BOB ISLER**
> *Vice President, Power Supply*
> Hawaiian Electric

Hawaiian Electric asked EPRI to better understand why an existing large-scale PV plant was underperforming production expectations and how adding a battery, among other remediation options, might improve production. The findings were used to inform remediation plans and also to respond to an information request from the Hawaii Public Utilities Commission.

EPRI RESEARCH

To meet the requests of the two utilities, the research team addressed the question of how much fast-responding storage is needed to mitigate high ramp rates of PV plants, and how much benefit is achieved from short-term power forecasting in terms of reducing the storage requirement. In response, the team designed a storage controller algorithm, which can serve as a baseline for system planners and designers to estimate the storage requirement for a given power profile. The controller inputs are the unsmoothed PV system power (averaged over the ramp interval) and the storage state of charge. The storage controller design and optimization were developed, along with the open-source code, such that others can tailor the simulation to their specific plant and weather profile.

APPLICATION OF ALGORITHM

Southern Company and Hawaiian Electric partnered with EPRI to describe the requirements of their respective electricity systems. The utilities also assisted in the development, vetting, and application of the algorithms that EPRI developed to explore the increasingly complex intersection between electricity system reliability, affordability, and plant design options for large-scale solar plants.

The results are being used to inform plans for existing and future PV plants that will either be owned by Southern Company and Hawaiian Electric or connect within their service territories.

BENEFITS

For Southern Company and Hawaiian Electric, the results informed strategic plans for future PV plants to improve production and grid reliability. Cumulatively, the results assist in determining how hundreds of millions of dollars in capital are deployed towards more flexible and dispatchable PV plants. Under low-to-moderate solar penetration scenarios, PV + storage plants increase the value of solar electricity by 5–10%, depending on the electricity market, over non-dispatchable standalone PV plants.

For Hawaiian Electric, opportunities were identified to improve annual solar electricity production by 7– 15% at an existing plant.

More broadly, the algorithm developed by EPRI has been incorporated into the System Advisor Model (SAM) (https://sam.nrel.gov/), a performance modeling software package developed by the National Renewable Energy Laboratory (NREL). SAM is publicly available and its new functionality allows anyone to perform analyses similar to those done by EPRI for Southern Company and Hawaiian Electric.

The use cases developed in the research have been published for others to review—namely, by the Hawaii Public Utility Commission and in a leading solar conference: IEEE's Photovoltaic Specialist Conference (IEEE PVSC).

RELATED EPRI PRODUCTS

D. Fregosi, M. Bolen, and W. Hobbs, "An analysis of storage requirements and benefits of short-term forecasting for PV ramp rate mitigation," 2021 IEEE 48th Photovoltaic Specialists Conference (PVSC), 2021.

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EPRI

SUCCESS STORY

KOEN REDUCES OUTAGE TIME AND FAILURES WITH O&M ASSESSMENT GUIDELINE

To evaluate and improve the operations and maintenance (O&M) performance of its plants, KOEN (Korea South-East Power Co.) has implemented EPRI's *O&M Assessment Guideline and Webtool* throughout its fleet.

Over the past five years, implementation of these tools has reduced failure tendencies by ~37%, reduced forced outage time by 88%, and reduced safety accidents and human errors by 45%—resulting in an estimated $2.7 million in savings.

NEED FOR EVALUATING PERFORMANCE

KOEN operates five power plant sites, generating 10,288 MW of power. Like many other utilities today, KOEN was working to improve its O&M performance, which, in turn, would lead to more reliable, lower cost, and safe electricity with minimal impact on the environment.

However, KOEN recognized that it did not have a means to evaluate O&M performance—that is, what was working well and what areas needed improvements. Without this understanding, KOEN also found it difficult to develop a successful strategy to improve performance.

STANDARDIZING O&M ASSESSMENT

Power plant O&M assessments have always been conducted by experienced personnel who are knowledgeable in the structure and function of O&M departments at the plant level. However, until recently, the industry has lacked a single source of industry standards and best practices for the planning and execution of the assessment process.

EPRI's *Generation Operations and Maintenance Assessment: Guideline and Webtool* seeks to standardize the assessment process by providing guidance on both the subject matter and the execution of an assessment. This guideline provides recommendations on assessment preparation and planning, team makeup, observations, analysis, and reporting. Key elements in the execution of an effective assessment include advance document and procedure reviews, training, team logistics, field observations, personnel interviews, information capture and analysis, and management briefings.

Yeongheung Plant Units 1-4

> *"Through the "O&M Assessment" project with EPRI, KOEN was able to accurately identify the strengths and points of improvement of O&M technology, and the excellence of KOEN's O&M technology. In areas that needed improvement, we developed new technologies and implemented various failure prevention activities, providing an opportunity to continuously improve O&M technology."*
>
> ~ **PARK BU YOON**
> *Vice President, Power Generation Department*
> Korea South-East Power Co.

RELATED EPRI PRODUCTS

Title	Product ID
Generation Operations and Maintenance Assessment: Guideline and Webtool	3002010848
Updated EPRI Alarm Management Program Guideline	3002005535
Power Plant Procedures: Procedure Writing, Management, and Use Guideline	3002008857
What Does Good Clearance and Tagging Process-Execution Look Like? (Video Compilation Package	3002007452
Lockout/Tagout Self-Assessment Guideline: Revision 1	3002012976

The Guideline provides a means whereby the policy, process, and execution of plant O&M departments can be evaluated without relying solely on the assessors' knowledge and experience.

The Webtool is a web-based application for O&M assessments. The Webtool provides a user-friendly electronic format with standardized criteria in which to capture observations and to group like areas for more efficient evaluation.

IMPLEMENTATION ON KOEN'S FLEET

To develop a strategy to improve its O&M performance, KOEN utilized the EPRI Guideline, Webtool, and other resources. Over the past five years, in this endeavor, KOEN has partnered with EPRI to train and develop a KOEN O&M Assessment Team. This team, along with EPRI mentors, has applied this knowledge and training to perform three O&M assessments at two KOEN plant sites.

The KOEN Assessment Team also performed an additional O&M assessment at another plant site. These O&M assessments identified specific strengths and areas for improvement to allow KOEN to focus its efforts for O&M improvement. These assessments also provided feedback to change the company's O&M culture.

BENEFITS

Using the EPRI resources, KOEN's O&M assessments have reduced failure tendencies in the KOEN fleet by (~ 37%) in the past five years. Fleet forced outage time has reduced from a two-year average of 12.7 hour per unit in 2014-2015 to a five-year average of 2.77 hour per unit in 2016-2020. Also, safety accidents and human errors have been reduced by 45%. The total cost savings for these improvement areas are estimated at $2.7 million, with most savings attributed to the dramatic reduction in equipment failures by human errors. KOEN also improved its Lockout/Tagout program and redeployed the new program across the fleet.

Through conducting O&M assessments with EPRI mentoring and utilizing EPRI's guidelines and webtools, KOEN was able to improve its O&M performance and change its O&M culture. KOEN has implemented assessment recommendations at all sites and is driving continuous improvement in O&M performance through semi-annual assessments at the plants.

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EPRI

SUCCESS STORY

Power plant control room

TRI-STATE IDENTIFIES CONTROLS AND AUTOMATION TO SUPPORT MINIMUM LOAD

Tri-State Generation and Transmission Association (Tri-State) identified process control and automation solutions within the distributed control system (DCS) of one of its coal-fired units in order to support minimum load operations.

Those strategies, which were derived from EPRI research on process control modifications to improve low-load operation, allowed Tri-State to achieve lower, stable minimum loads while improving performance and maintaining emissions compliance at these minimum loads.

OPERATION AT MINIMUM LOAD

In recent years, many large conventional thermal power plants have begun operating over a wider range of loads due to the increasing capacity of non-load-following generation connected to the grid. Frequent shutdown and startups result in significant wear on plant components, and special operational practices are needed to maintain reliable operation following shutdown.

Operation at reduced minimum loads is generally preferred for short durations (e.g., daily load following cycles) in cases where the reduction can be reasonably achieved and sustained without unduly impacting process efficiency. Operation at minimum loads can reduce the environmental impacts of operating a plant in sub-optimal conditions. The targets for these reduced load limits are usually determined based on the design capability of the plant to safely and reliably operate at the revised limits, along with the cost as compared with not operating at the reduced minimum load.

DEVELOPMENT, TESTING, AND DEMONSTRATION

Previous EPRI research in this area provided extensive best practices for improving low-load operations. A unique research project with Tri-State took the next step for increasing operating flexibility for a fossil unit. The project focused on using plant digitization by implementing identified controls and automation within the DCS to support minimum load operations.

A systematic approach for testing and assessment of control requirements was developed. In a demonstration of the approach, opportunities for controls and automation improvement were identified at one coal-fired unit, aiming to improve its low-load operation to achieve specific targets.

> *“It is great to see that Tri-State’s investment in EPRI is paying off with technology that is being applied in the field. EPRI’s collaborative R&D business model is all about advancing technology to the utility end-users.”*
>
> ~ **BARRY INGOLD**
> *Generation SVP*
> Tri-State Generation and Transmission Association

RELATED EPRI PRODUCTS

Title	Product ID
Process Control Strategies for Low-Load Operation: Implementation	3002016325

The first stage of the study followed a specified test method to ascertain the requirements for functional modifications to achieve the low-load targets, as well as the potential impacts on plant and equipment associated with the modifications. Outcomes of this review and assessment were provided to the host site, including the development of proposed controls modifications for implementation.

In the second stage of the study, controls modifications were prepared, implemented, and tested on the unit to help overcome the identified issues and control-related limiting factors. In addition to addressing specific control issues, unit performance at low load was enhanced with the introduction of sliding pressure operation without impacting ramp rates.

BENEFITS

The project at the Tri-State coal plant demonstrated that control enhancements can improve the ability of the unit to achieve lower, stable minimum loads while improving performance at those minimum loads. The case study identified and successfully implemented six process control enhancements within the distributed control system to improve low-load operations at the host site, including:

- Inferred overfire airflow signal development and substitution at low load
- Superheater steam temperature controls tuning
- Superheater outlet temperature controller limiting
- Boiler feed pump balancing
- Sliding pressure control and associated modifications
- Drum level controller adaptive tuning

These enhancements led to four operational improvements, including a 25% reduction in achievable stable minimum-load operations, a greater than 1% improvement in heat rate during low-load operations, improved ramp rate from minimum-load operations as compared to previously achievable minimum-load operations by the unit, and improved selective catalytic reduction inlet temperature to allow nitrogen oxide emissions equipment to remain in compliance during low-load conditions.

Following the successful test and operational results of the changes made on the coal plant unit, many of the controls tuning concepts are being implemented by plant controls staff on the other two units at the site. The results show improved performance, not only at low loads but across the operating range.

FUTURE APPLICATIONS

The project has clearly established a roadmap for the implementation of lower minimum load control strategies on traditional thermal units in the power industry. The steps highlighted in the project can be implemented by any operator in the power industry interested in achieving lower minimum loads in traditional thermal units. An EPRI report (3002016325) includes the process followed for this project as well as common areas to explore.

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SUCCESS STORY

VISTRA SPONSORS GROUNDBREAKING RESEARCH IN ADDITIVE MANUFACTURED TURBINE VANES

PSM 1st stage vane producted with additive manufacturing process

Vistra successfully demonstrated the first industry use of additive manufactured first-stage vanes within the gas turbine hot section. The vanes, which were designed and tested through a partnership between EPRI and Power System Manufacturing (PSM), provide novel cooling to first-stage vanes and effectively improve engine performance by reducing total hot section air consumption.

PSM has recently included the vanes in the market introduction of its latest Gas Turbine Optimized Package (GTOP7) upgrade, making it the first in the industry to use an additively manufactured super-alloy first-stage vane with an advanced, near-wall cooling scheme design. This innovation enables novel heat transfer geometries for the critical first-stage vane of the hot section, which are not possible with existing state-of-the-art investment-casting processes. These geometries allow unique design customization to produce more power output in gas turbines, with no reduction in parts life.

TURBINE VANE COOLING

The first-stage turbine vane is located at the exit of the combustor and thus sees the highest temperatures in the engine hot gas path. To survive the extremely high heat loading, the vane requires a large amount of cooling air. If the cooling air consumption could be made more efficient or reduced, it would open the potential for greater power production.

Additive manufacturing, also known as 3D printing, allows engineers to design even more complex structures than previously allowed by traditional manufacturing methods. Specifically, the technology has allowed gas turbine components to be designed with additional cooling features, such as channels, grooves, and added curvature.

ADDITIVE MANUFACTURED DESIGN

To start the new vane design, the aerodynamic shape was modified to perform better with the latest aerodynamic design of the first-stage blade. The design was also optimized for most efficient 3D printing geometry.

One key element for a successful 3D printed build is to avoid any support structures, allowing the new airfoil to have a specific patented and innovative geometry. The aerodynamic shape itself was optimized using state-of-the-art analysis tools with design modelling, combined with neural network algorithms, to achieve the best overall aerodynamic and cooling design possible. Another design feature was the near-wall cooling hole geometry and its distribution around the airfoil.

These features were further optimized, using conjugate heat transfer analysis, to extract heat according to local gas exposure. The final design achieves a beneficial temperature distribution and reduced thermal gradients. In conventional investment-cast parts, steep thermal gradients are responsible for durability limitations.

TESTING AT ONTELAUNEE

Vistra's Ontelaunee Energy Center, a 600-MW, 2x1 combined-cycle gas turbine (CCGT) plant in Reading, Pennsylvania, offered to serve as the host for the final design engine qualification rainbow test. The Ontelaunee plant installed three pairs of new additively manufactured vanes in its high-firing-temperature F-class 501FD2 gas turbines.

The test hardware used novel near-wall internal cooling channel configurations coupled with advanced thermal barrier coatings, including a low-conductivity version developed by EPRI in prior work. To qualify the operating metal temperature, a novel technique was used that contains crystal temperature sensors directly embedded in the test vanes.

After a 6-month run, the hardware was removed and destructively tested by both the PSM and EPRI materials labs. EPRI also carried out extensive characterization and evaluation of high-temperature mechanical testing results in the additively manufactured printed material. Test results and metallography findings showed that required properties were met for full-scale use. The resulting finalized vane design has now been commercialized in the PSM GTOP7 hot section upgrade package.

Subsequently, Vistra installed the final design additively manufactured vanes with the GTOP7 upgrade at the Ontelaunee Energy Center.

BENEFITS

After 4000 hours of operation in the engine of the Ontelaunee plant, the parts still looked pristine. The vanes could have stayed for many more operating hours, since they were designed to operate for 32,000-hr inspection intervals. However, the crystal temperature sensors embedded in the parts needed to be removed for engineering analysis validation. After the engine run, the rainbow parts were "dissected" to fully validate their design. EPRI and PSM collaborated on the material testing to identify possible creep capability improvements though new heat treatments. The creep capability improvements allow the units to be operated at higher MW output levels without shortening the outage interval lengths. Therefore, the units can produce more and last just as long as units using conventional investment-cast parts. The technical data from the Ontelaunee engine run was essential in guiding the final turbine vane design.

At this point, the vanes have performed over 22,000 hours of combined service without issues, thus providing evidence to the effectiveness and longevity of AM turbine vanes.

The Ontelaunee plant is producing 14 MW more power due to the total PSM GTOP7 upgrade. Each gas turbine is contributing 5 MW each to that increase. Essentially, these units have exchanged lower parasitic load (e.g., reduction in cooling air flow) to create more power output and keep the outage intervals the same.

Vistra has since also installed the new upgraded PSM GTOP7 offering on two of its Siemens Westinghouse SW501F units, resulting in the 10-MW increase from these GTs and 14-MW total increase from the 2x1 CCGT for the entire upgrade.

RELATED PRODUCTS

"Metallurgical Evaluation of an Additively Manufactured Nickel-Base Superalloy for Gas Turbine Guide Vanes," by Alex Bridges (EPRI), John Shingledecker (EPRI), Alex Torkaman (North Carolina State University), and Lonnie Houck (Power Systems Mfg.). Proceedings of ASME Turbo Expo 2020, Turbomachinery Technical Conference and Exposition, GT2020, September 21-25, 2020.

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EPRI

SUCCESS STORY

SALT RIVER PROJECT HOSTS EXPERIMENTAL HARDWARE TO VALIDATE SOLUTION FOR DISBONDING OF VALVE HARDFACING

Salt River Project (SRP) took a leadership role in a multi-utility EPRI collaborative project to identify a solution for the disbonding of hardfacing in power plant valves, which represented a damaging and costly industrywide issue. The role involved SRP hosting a demonstration of the solution at one of its plants, whereby valve parts were installed with an understanding that the valves would be removed after five years for destructive metallurgical evaluation.

The hosted demonstration provided a real-world confirmation of EPRI's solution, which to date has completely eliminated disbonding incidents.

DISBONDING OF HARDFACING IN VALVES

In the early 2010s, the power generation industry was confronted with deterioration of the hardfaced surfaces in valve seats. Hardfacing, generally a cobalt-based alloy such as Alloy 6 or 21, is welded to sealing surfaces to provide wear resistance and a low coefficient of friction. Application of the material had been previously considered permanent; however, during plant operation, cobalt-based hardfacing was disbonding in large segments from the body and disc seat faces in numerous valves.

Losing this layer of hardfacing poses three problems: 1) as gaps appear between sealing interfaces, sealing efficiency is lost as steam can leak through, 2) liberated hardfacing can travel downstream, puncturing screens and damaging turbine components, and 3) in the worst-case scenario, hardfacing may stay in the basin of a valve and prevent a full closure of the valve when needed.

The issue occurred in dozens of plants, mostly in the valves of combined-cycle plants, but in other cobalt-based hardfaced components as well. Based on the failure history, valves made by most, if not all, manufacturers were affected.

VALVE DISBONDING IN SRP PLANTS

SRP saw a significant need for EPRI's research and guidelines on applying cobalt-base hardfacing to valves due to an increase in observations of cracking and disbonding in valves, which were causing an increase in inspections, downtime, and replacement hardware costs. Over one outage season, every valve SRP inspected showed evidence of disbonding or cracking, and OEM replacement parts were lasting for shorter periods than the original parts.

RELATED EPRI PRODUCTS

Title	Product ID
Guidelines and Specifications for High-Reliability Fossil Power Plants: Recommendations for the Application of Hardfacing Alloys for Elevated-Temperature Service	3002004990
Experiences in Valve Hardfacing Disbonding	3002004991
Proposed Solutions for Hardfacing Disbonding in High-Temperature Valves	3002004992

EPRI COLLABORATIVE PROJECT

In response, EPRI undertook a collaborative supplemental project, joining ten utilities (including SRP) and three valve manufacturers, to explore the issue, identify a root cause, and offer solutions for repair or replacement.

EPRI's research resulted in recommendations for modification of valve internal parts, specifically highlighting improvements to the welding procedure. As part of the collaborative project, EPRI produced a set of manufacturing guidelines—based on extensive thermodynamic modeling and aged lab-scale welds—outlining the requirements for manufacturing valve seats that are no longer susceptible to disbonding.

HOST DEMONSTRATION AT SANTAN

While several project members began applying these guidelines to their valves, SRP went above and beyond by volunteering to host the installation of validation valve parts; parts which followed EPRI's guidelines and could be evaluated after several years of operation. Santan Generating Station, a 1193-MW combined-cycle plant in Gilbert, Arizona, was the host site for those components. Many of SRP's valves were Trillium designs, and as Trillium was a project member, the company immediately upgraded to its manufacturing processes to be in-line with the EPRI recommendations (including welding procedures) and provided this replacement hardware.

The validation valve parts were installed in a hot reheat line at Santan from 2016 to 2021, where they accumulated over 24,000 hours of operation (for reference, in the earlier experience, disbonding was observed as early as 12,000 hours). In 2021, the components were sent to EPRI for ex-service evaluation to inspect the effectiveness of the solution. Initial observations indicated no evidence of disbonding or related risk factors.

BENEFITS

Aside from the set of valve parts installed on behalf of the project, SRP, and Santan Generating Station specifically, have also applied the revised manufacturing process to several other sets of replacement valve parts. Over the five years before this research project, Santan had replaced valve parts on their high-temperature valves fourteen times in order to avoid downtime events. In 2012, Santan experienced a forced outage due to hardfacing disbonding, which resulted in over $2 million in parts, labor, and services as well as 53 days of lost generation.

By participating in the project, and requiring EPRI's improved welding recommendations, SRP has been able to return to its nominal five-year inspection interval for these valves with no observed delamination issues from these upgraded valves. Further, disbonding of hardfacing comes with the risk of significant foreign object damage downstream in the steam turbine. The value of reducing or alleviating that risk cannot be overstated, though it is harder to quantify.

The disbonding of hardfacing in high-temperature valves was a broad problem affecting maintenance and unit reliability for many years. While ten utilities participated in the project, others were also impacted and EPRI continues to get questions on this issue to this day. Through the efforts of the three manufacturers who participated in the project and implemented the resulting guidelines, the incidence of disbonding and related maintenance impacts has fallen dramatically over the past five years. The overall industry impact for eliminating this failure mechanism has saved an estimated $10 million in avoided valve maintenance over the past five years.

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SUCCESS STORY

SOUTHERN COMPANY SUPPORTS DEVELOPMENT OF ADVANCED ULTRA-SUPERCRITICAL TECHNOLOGY

Southern Company has supported the development of advanced ultra-supercritical (A-USC) technology, which would make possible the construction of coal-fired boilers operating at much higher efficiencies and lower emissions than the current generation of ultra-supercritical power plants, and which benefits other high-temperature power generation options (e.g., supercritical CO_2 cycles, concentrated solar thermal, and advanced nuclear).

Southern was a principal supporter of Phase II of the A-USC ComTest project, which sought to fabricate commercial-scale nickel-based alloy components, and played a leadership role in the prior 15-year effort to develop and test materials to be operated at steam temperatures up to 760°C (1400°F).

NEED TO QUALIFY NEW MATERIALS OF CONSTRUCTION

The existing state-of-the-art coal-fired power plant technology uses pulverized coal (PC) combustion with an ultra-supercritical (USC) steam generator delivering main and reheat steam at temperatures up to 620°C (1150°F). Operating at higher steam temperatures and pressures can achieve higher steam plant efficiencies—thereby improving the performance of the plant and reducing emissions, including CO_2. However, materials of construction are the limiting factor to achieve higher temperatures.

A-USC COMTEST PROJECT

To address that need, the A-USC materials consortium, primarily funded by the U.S. Department of Energy and the Ohio Development Services Agency, developed and qualified materials suitable for steam-electric power plants at A-USC steam temperatures up to 760°C (1400°F).

Following the successful completion of that consortium, the A-USC ComTest project was launched to conduct a two-phase project to achieve technical readiness to allow the construction of a commercial scale A-USC demonstration power plant. The project sought to validate that components made from the advanced alloys can be designed and fabricated to perform under A-USC conditions reliably, to accelerate the development of a U.S.-based supply chain for key A-USC components, and to decrease the uncertainty for cost estimates of future commercial-scale A-USC power plants, as well as other high-temperature advanced power generation options.

Extruded Pipe Extrusion - Inconel 740H (22″ OD x 3.7″ W x 14′ L)

> *The accomplishments made by EPRI and the A-USC research consortium have enabled advanced generation technologies and will impact the power industry for years to come. Southern Company is proud to support the A-USC research effort.*
>
> ~ **CHARLES BOOHAKER**
> *Principal Research Engineer*
> Southern Company

RELATED EPRI PRODUCTS

Title	Product ID
Progress Report on Advanced Ultra-Supercritical Technology Development	3002001343
Progress Report on A-USC (Advanced Ultra-Supercritical) Technology Development	1023868

PHASE II

Southern Company played a major role in the successful completion of the project's Phase II, which was to complete the manufacturing R&D of A-USC components by fabricating commercial-scale, nickel-based alloy components and sub-assemblies that would be needed in a coal-fired power plant of approximately 800-MWe generation capacity operating at a steam temperature of up to 760°C (1400°F) and steam pressure of at least 238 bar (3500 psia).

Phase II has included successful fabrication of full-scale superheater/reheater components and subassemblies (including tubes and headers), furnace membrane walls, steam turbine forged rotor, steam turbine nozzle carrier casting, and high-temperature steam transfer piping and fittings. Materials of construction include Inconel 740H and Haynes 282 alloys for the high-temperature sections. The project team conducted testing at the National Board qualification lab for nickel-based alloy pressure relief valve designs that can be used in A-USC power plants up to approximately 800-MWe size, allowing these designs to be used under ASME Code. In addition, the team facilitated an ASME Code Case for the use of Haynes 282 alloy materials.

BENEFITS

The work completed under this final phase of the A-USC ComTest project has served to validate the capability of the supply chain to provide these high-temperature materials and components and advance the ASME code to address use of these materials. This high-temperature materials technology supports not only high-efficiency, high-temperature Rankine cycles, but also serves to advance other high-temperature power generation technologies, such as supercritical CO_2 cycles, concentrated solar thermal, and nuclear power generation. These advanced high-temperature power generation cycles have the potential to increase cycle efficiency, lower emissions, and increase the overall robustness and reliability of the power generation grid.

Southern Company has been able to apply the research developed under the A-USC ComTest project to support other advanced generation options, including supercritical CO_2. Additionally, Southern Company has used the research results from this effort to launch detailed investigations into the feasibility and economics of several A-USC technology retrofit scenarios, which could have the potential to increase efficiency and extend the life of existing plant assets.

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SUCCESS STORY

LUMINANT UTILIZES POWER AUGMENTATION RESEARCH TO MAINTAIN CAPACITY MARGINS

Luminant's Midlothian Power Plant

Luminant/Vistra (Luminant) applied EPRI research on power augmentation options for its gas turbine fleet. The results of the research enabled the utility to implement an additional 304 MW in peak firing capacity in order to maintain electricity capacity margins and grid reliability during periods of peak summer demand.

NEED FOR ADDITIONAL GENERATING CAPACITY

Luminant foresaw that additional generating capability would be needed in the Texas ERCOT region during peak summer days due to extremely tight projected capacity and very high marginal pricing during that period.

POWER AUGMENTATION RESEARCH

At Luminant's request for an evaluation of power augmentation options, EPRI initiated a supplemental research project focusing on power augmentation for Luminant's General Electric (GE) 7EA and 7FA fleets. A limited timeframe was available to complete the research in time for it to be implemented for the summer season. Power augmentation, or capacity enhancement, of existing gas turbine units includes a number of technologies that can provide an economical means of increasing unit performance, especially during peak demand periods. Gas turbine operators desire to obtain maximum output from existing generating assets, particularly during periods of high electricity demand. The research included performance estimates of the following power augmentation technologies applicable to their 7EA and 7FA units: wet compression (inlet air fogging overspray), combustor water injection, and firing temperature increase. A detailed assessment of the impact of increasing firing temperature was performed to assess the rate of creep damage to turbine blades due to peak firing for limited durations. The work also involved consideration of existing evaporative coolers and review of air-cooled generator limits.

RELATED EPRI PRODUCTS

Title	Product ID
Power Augmentation Performance Advisor, V4.0 (software)	3002020863
Advanced Gas Path Evaluation: GE 7F.04	3002013540
Assessment of Emerging Combustion Turbine Capacity Enhancement Technologies	1005039
F-Class Life Management: General Electric MS7001 Model FA: GE 7FA Hot Section Durability Analysis	1022086
Life Management System for Advanced E Class Gas Turbines: General Electric 7EA 1st Stage Bucket Analysis	1010477

IMPLEMENTATION ON LUMINANT FLEETS

Based on the results, Luminant was able to implement peak firing capability within their control systems of select units with confidence that the benefits would significantly exceed the risks and costs. Peak firing for a limited duration of operation was applied to nineteen gas turbines in the Luminant fleet, including optimization on fifteen 7EA units and super peak firing on four 7FA units. Luminant also applied the wet compression technology to ten Alstom GT24 units.

BENEFITS

The results of the study helped Luminant better understand which power augmentation options would be the most effective in achieving the utility's goals with its gas turbine units. Luminant increased the capacity of its fleet in the ERCOT area by 180 MW on the 7EA and 7FA units. Although EPRI research on wet compression was mainly focused on the 7EA and 7FA units, Luminant also independently applied the technology to ten GT24 units for an additional 124 MW capacity.

Not only did the additional capacity add incremental net revenue to Luminant at a high payback on capital, it helped maintain electricity capacity margins and grid reliability during the most critical periods. For the future, Luminant will have the option of implementing peak firing capability during peak times over the coming years on additional units—and thus realize added benefits.

FUTURE RESEARCH

More broadly, this research highlighted the need in the power industry to provide other power generation companies with an economical means of increasing capacity using existing assets. Subsequently, the Luminant study has led to a broader EPRI research project that seeks to better quantify the performance benefits and costs of various power augmentation technologies, including inlet air cooling technologies and injection of steam, water, and air for capacity enhancement. The research will develop tools to improve and evaluate gas turbine performance over time and will provide training and technology transfer on research that has already been developed. It will assess capacity enhancement technologies and develop improved O&M guidance on their use.

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SUCCESS STORY

FOUR UTILITIES USE EPRI RESEARCH TO DEMONSTRATE VIABILITY OF EXISTING CCP IMPOUNDMENTS

Consumers Energy, DTE Energy Company, Great River Energy, and Salt River Project worked with EPRI to develop research that would show the environmental feasibility of some existing coal combustion product (CCP) impoundments. The research demonstrated that these impoundments could be environmentally protective even if they do not have a liner as defined in the U.S. Environmental Protection Agency's (EPA's) Coal Combustion Residual (CCR) Rule.

Findings of the research saved the utilities millions of dollars by enabling them to avoid closure of existing impoundments and the need to build new facilities.

CCP IMPOUNDMENTS AND THE CCR RULE

Impoundments used for management of CCPs have historically employed a variety of liner designs. While some impoundments did not have liners, others were built using engineered or compacted clay liners or composite liners consisting of a geomembrane barrier overlying compacted clay. Still other impoundments were designed to utilize thick natural clay deposits as liners.

In April 2015, the EPA passed regulations—generally known as the CCR Rule—that govern the disposal of coal ash (coal combustion residuals or CCRs). The CCR Rule established technical requirements for CCR landfills and surface impoundments under Subtitle D of the Resource Conservation and Recovery Act, the central federal regulatory program governing recycling and disposal of solid waste.

The CCR Rule established criteria for liner systems to determine whether a CCP unit was lined or unlined. A lined/unlined classification is important for surface impoundments because unlined impoundments are subject to unique closure requirements. Under the CCR Rule as originally promulgated, a lined CCP unit was required to have one of three types of liner systems.

A 2018 litigation decision called for the EPA to remand portions of the 2015 CCR Rule and amend it to force closure of any CCP impoundment regulated under the rule that did not have a composite liner as specified by the CCR Rule, regardless of whether other triggers for closure, such as a release to groundwater, had occurred.

Project data informed EPA regulation of coal ash impoundments

> *"Protecting the environment and the health and safety of the communities where we live and serve is our top priority. EPRI's research was instrumental in helping EPA develop rules that allowed us to prove that our CCR impoundments are safe, effective, and can remain in place as we wind down coal operations and transition to a clean energy future."*
>
> ~ **ROBERT J. LEE**
> *Manager, Environmental Support*
> DTE Enery

RELATED EPRI PRODUCTS

Title	Product ID
Relative Liner Performance for Coal Combustion Product Management Sites: Conceptual Review and Model Evaluation for Surface Impoundments	3002016498

In meetings with the four utilities (and separately with EPRI), the EPA indicated that it lacked data and information on alternative liner performance that the agency could rely on when formulating this aspect of the amendment to the CCR Rule.

EPRI LINER PERFORMANCE RESEARCH

The EPRI research sought to address this lack of data and information. The research evaluated the performance of alternative liners relative to a base case composite liner as specified under the CCR Rule.

The study postulated that if alternative liners were capable of performing similarly to the base case liner, then that finding would provide evidence that those alternative liners can be protective of human health and the environment (HHE). In turn, the evidence would mean that a performance standard approach to regulating facilities with alternative liners can be protective of HHE. Conversely, if alternative liners did not perform similarly to the base case, then a performance standard was less likely to be protective of HHE.

The results of the research indicated that hydrogeologic scenarios exist where certain alternative liners are capable of protecting HHE similarly to the base case composite liner. These findings and supporting information provide a science-based reference that agencies responsible for regulation of CCP surface impoundments can consider when determining if a performance standard approach to regulating existing CCP impoundments with alternative liners can be protective of HHE.

This EPRI deliverable was provided to EPA for consideration as the agency was developing amendments to the CCR Rule.

BENEFITS

The findings and supporting information from this research provided the EPA with a science-based reference to consider when determining if a performance standard approach to regulating existing CCP impoundments with alternative liners can be protective of HHE, rather than prescriptively regulating closure of all ponds with alternative liners.

As of July 2021, nine applications for alternative liners had been submitted to EPA. Salt River Project has estimated a total cost savings of $30 million that can be attributed to this research because the alternative liner portion of the 2020 rule amendment will enable continued use of an existing unlined CCP impoundment that meets the rule's criteria.

Similar order of magnitude savings can be anticipated for the other impoundments that are allowed to continue operation as a result of this research.

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EPRI

SUCCESS STORY

EPRI TOOLS AID NATURGY AND ENEL IN PLANNED OUTAGES OF GAS TURBINES

EPRI collaborated with Naturgy Energy Group S.A.(Naturgy) and Enel S.p.A. (Enel) to develop and demonstrate key tools, methods, and guidance for improving the overall quality control and assurance of planned maintenance outage activities for GE/Alstom GT26 gas turbines.

The guidance and information developed through this project helped Naturgy and Enel to improve the quality of major overhauls at several gas turbine plants, thereby reducing outage times, improving gas turbine performance, and avoiding catastrophic failures of equipment.

To address these issues, from 2016 to 2019, Naturgy and Enel collaborated with EPRI to develop tools and methods for improving the disassembly, inspection, reassembly, and re-commissioning of GT26 gas turbine units during planned outages.

PLANNED MAINTENANCE OUTAGES

Planned maintenance outages account for over 70% of gas turbine unit unavailability. A complete overhaul of a large frame-sized gas turbine can require up to 10-12 weeks. Improper reassembly procedures and wrongly applied maintenance practices can ultimately result in catastrophic failure and loss of human life.

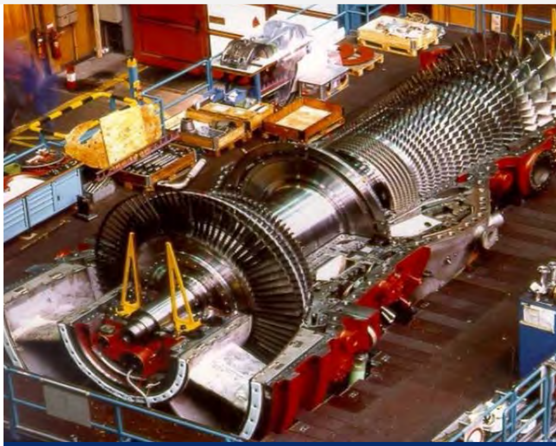
Owner/operator concerns have grown regarding the quality of gas turbine (GT) planned maintenance outages, particularly regarding the tasks of inspection, reassembly, and re-commissioning.

Following a GT26 gas turbine overhaul at Enel's Dock Sud Power Plant in Buenos Aires, Argentina, an improperly installed SEV Burner Balcony became liberated, damaging the downsteam LPT Row 1 turbine blades. The subsequent forced outage event from this avoidable failure lasted six weeks, and repair costs exceeded $1.7 million.

During a 2017 inspection of Naturgy's San Roque Power Plant in Cádiz, Spain, several unexpected issues and situations arose, such as limited access to the objective acceptance criteria, expected dimensions, typical findings, and acceptable field repair methods.

APPLICATION

To address these issues, from 2016 to 2019, Naturgy and Enel collaborated with EPRI to develop tools and methods for improving the disassembly, inspection, reassembly, and re-commissioning of GT26 gas turbine units during planned outages.



GT26 gas turbine rotor in lower casing

> *"The GT26 Overhaul Manual represents an excellent and essential tool for Gas Turbine Users to make their own best decisions based on years of practical experience on planned maintenance outages."*
>
> ~ **TOMÁS ALVAREZ TEJEDOR**
>
> *Head of Gas Maintenance Iberia*
>
> ENEL

RELATED EPRI PRODUCTS

Title	Product ID
GT26 Overhaul Technical Support Manual, Volume 1—Outage Planning: Inspections, Quality Control Process, and Field Service Instructions	3002019992
GT26 Overhaul Technical Support Manual, Volume 2— Part 1: Combustion Component Inspection Forms and Guides	3002019993
GT26 Overhaul Technical Support Manual, Volume 2—Part 2: Rotating Component Inspection Forms and Guides	3002019995
GT26 Overhaul Technical Support Manual, Volume 2—Part 3: Stationary Component Inspection Forms and Guides	3002019996
GT26 Overhaul Technical Support Manual, Volume 2—Part 4: Structural Component Inspection Forms and Guides	3002019997
GT26 Overhaul Technical Support Manual, Volume 3—Commissioning Procedures: Cold and Hot Commissioning for GT26 Units	3002019998
GT26 Overhaul Technical Support Manual Web Application (GT26 App) V1.0	3002012593

The tools and information included:

- Key maintenance activity checklists, which include disassembly and reassembly hold points, verification points, and witness points with acceptance criteria,
- Inspection techniques and quality control Inspection Assessment Data Sheet (IADS) forms for the rotating, stationary, combustion, and structural turbine parts. Each IADS includes a sketch or photo of the part, expected dimensions, typical findings, and field repair methods with GO- or NO-GO acceptance criteria.
- Companion field guidance for each IADS, with recommendations for typical damage locations and findings.
- Reassembly hold points, verification points, and witness points with acceptance criteria (both typical and not-to-exceed criteria).

The developed tools and methods were applied at two subsequent plant outages: Enel's Dock Sud plant in 2018 and Naturgy's Cartagena (Escombreras) Power Station in Cartagena, Spain in 2019.

Following these demonstrations, Naturgy and Enel worked with the EPRI team to publish the *GT26 Overhaul Technical Support Manual.*

BENEFITS

The GT26 Manual aims for optimal execution of outage and maintenance activities, which can reduce unit downtime.

Owners/operators can complete customized inspection forms to identify component-specific locations, conditions, and the severity of the findings. They can curate photographs during inspections to compile site- and equipment-specific photographs, thus building a library of legacy observations and experience for future outages. The result is high-value information to determine component integrity and longevity and therefore extend the life of the gas turbine.

For outage team members, the manual serves as shared language and expectations, thus minimizing uncertainties in decision-making. For discussions with the OEM, owners/operators have credible data to challenge the OEM's standard criteria, such as whether to refurbish or repair rather than replace a component. In addition, owners/operators can implement "real time" corrective actions to mitigate premature component failures due improper reassembly procedures, reduce outage times to correct wrongly applied maintenance practices, eliminate costly replacement of repairable parts, meet emission compliance requirements, avoid unit capacity derating, improve gas turbine performance, and avoid catastrophic failures and loss of human life. Avoided cost from these types of failures are on the order of hundreds of thousands to millions of dollars per event. Most typically, damages range from $1.7 million to $5 million per event, but can easily exceed $10 million for a single event.

The knowledge developed throughout this project assisted Naturgy and Enel, the owners and operators of high-merit GE/Alstom GT26 gas turbines, to plan, manage, and document the quality control and assurance of major overhauls at three combined-cycle power plants: San Roque (Spain), Dock Sud (Argentina), and Cartagena (Spain).

More broadly, in the future, the GT26 Manual can be applied to the more than 100 units throughout the world in 21 countries. Furthermore, the process and resulting manual can serve as an approach for other gas turbine models.

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EPRI

SUCCESS STORY

DUKE AND SOUTHERN TAKE LEADERSHIP IN RISK ASSESSMENT OF US COMBUSTION TURBINES

Duke Energy (Duke) and Southern Company (Southern) provided leadership in the design and execution of EPRI's Human Health and Environmental Risk Assessments for U.S. Combustion Turbines and in communication of the results to key stakeholders.

EPRI conducted these risk assessments in support of the U.S. Environmental Protection Agency's (EPA's) National Emission Standards for Hazardous Air Pollutants (NESHAP): Stationary Combustion Turbines Risk and Technology Review (RTR). Collectively, EPRI's assessments addressed human health and environmental health risk from 846 turbine units in 272 facilities that would be subject to the NESHAP for stationary combustion turbines (40 CFR 63, subpart YYYY), which have been identified by the EPA.

Ultimately, these risk assessments demonstrated that the human health and environmental risks posed by this source category were below all EPA risk thresholds and helped inform comments to EPA and discussions with the agency and other stakeholders.

HUMAN HEALTH AND ENVIRONMENTAL RISK

As part of its RTR process following implementation of the NESHAP, the EPA is evaluating the inhalation human health risks, the multi-pathway human health risks, and the environmental (ecological) effects related to stationary combustion turbine (CT) emissions of hazardous air pollutants (HAPs).

To determine the residual risk from emissions of HAPs from CTs in the United States, an assessment must be conducted of the emissions, stack parameters, and associated inhalation risks of these emissions. In addition, EPRI evaluated multi-pathway human health risks for model adult and child receptors representing gardener (resident), farmer, and fisher populations. Receptors were assumed to be exposed through direct inhalation, as well as consumption of locally grown crops and livestock, incidental ingestion of local soil, and ingestion of mother's milk for children under the age of one. Finally, EPRI also studied the potential risks posed to the environment from HAPs.

Results of this assessment, as conducted by EPRI, can inform the RTR process.

EPRI'S STUDY OF RISK ASSESSMENTS

EPRI's study of these risk assessments began by analyzing a database of CTs that EPA posted on its website in support of the NESHAP for stationary CTs. Duke and Southern helped identify issues with facility locations, stack parameters (e.g., stack heights), and (critically) emissions from those CTs. The utilities also worked together with EPRI to help rectify these

> *"Duke Energy is committed to taking aggressive action to address the impact of climate change while delivering affordable, reliable, and increasingly clean energy. We set ambitious climate goals of at least 50% carbon reduction from 2005 levels by 2030 and net-zero by 2050 from power generation and net zero methane from our natural gas business by 2030," said Regis Repko, Senior Vice President, Generation and Transmission Strategy. Accelerating the development and reducing the costs of emerging low-carbon technologies like hydrogen and other zero carbon fuels will be critical to achieving net zero. That's why Duke Energy is proud to sponsor the Low-Carbon Resources Initiative, which brings together our industry to advance these critical clean energy technologies."*
>
> ~ **REGIS REPKO**
> *Senior Vice President, Generation and Transmission Strategy*
> Duke Energy

RELATED EPRI PRODUCTS

Title	Product ID
Inhalation Human Health Risk Assessment for U.S. Stationary Combustion Turbines: 2014 Base Year Evaluation	3002016528
Multi-Pathway Human Health Risk Assessment for U.S. Stationary Combustion Turbines: 2014 Base Year Evaluation and Refined TRIM Analysis	3002016745
Environmental Risk Screening Assessment for U.S. Combustion Turbines: 2014 Base Year Evaluation	3002017441
Supplemental Human Health and Environmental Risk Assessment for U.S. Combustion Turbines	3002020134

issues by contacting key stakeholders and obtaining improved information, such as the concentrations of metals in fuel oil units that were included in the universe of CTs that must be addressed collectively as part of EPA's RTR. The initial analyses were documented in the reports cited in this success story.

The timely completion of these studies enabled EPRI to communicate the results in formal regulatory comments to EPA (developed independently by EPRI based on the research results), as well as in direct discussions with key stakeholders, including EPA, to discuss the methodologies and results of the studies.

After these initial results were shared with EPA, EPA identified an additional 107 CTs to assess that were not in their original database of units. EPA and EPRI engaged in further communications and data exchange (i.e., tech transfer), which resulted in EPRI assessing and submitting information for these additional CTs in a supplemental risk analysis in 2020. The facilities included in this EPRI supplemental risk assessment study increased the total facilities assessed by EPRI from 251 to 272, and the total number of CTs assessed by EPRI increased from 739 to 846 units.

RESULTS

The assessments found risk values from stationary CTs below EPA risk thresholds for the corresponding human health and environmental endpoints considered in the modeling.

Ultimately, the inhalation modeling for maximum cancer risk resulted in a cancer risk below the threshold of one in a million. The chronic and acute hazard risks from inhalation for the turbines modeled were also well below the risk threshold. Similarly, for the multi-pathway (e.g., ingestion) risk screening assessment, all cancer and non-cancer risks were below EPA thresholds. All facilities fully screened out of the ecological risk screening assessment.

BENEFITS

Overall, the model inputs (stack parameters and emissions) for the turbine risk modeling were refined by EPRI by using data obtained online (permit applications, emission inventories, etc.) and data provided several stakeholders, with the help of Duke and Southern. The two utilities also helped review the risk modeling and reporting thereof.

The rigor and credibility of EPRI research demonstrated low levels of health and ecological risk to inform the RTR and stakeholder communications. Ultimately, EPRI's analysis informed EPA's final evaluation and rulemaking, supporting EPA's conclusions in its RTR that CT risks were acceptable and additional HAPs reductions were unnecessary.

Beyond resulting in no changes to the standard, the EPRI work was critical to informing the EPA's decision to not immediately lift an administrative stay on a formaldehyde limit and compliance for new (post-2004) gas-fired CTs. These results provide the power generation industry with greater confidence and flexibility in CT operations and mitigated the substantial impact of potential new rulemaking on a critical generation source. Specifically, it allowed sources to avoid certain compliance requirements such as stack testing on new (post-2004) units.

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About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

August 2022

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