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RUN-TO-RETIRE ASSET MANAGEMENT FOR STEAM PLANT OPERATIONS

FREQUENTLY ASKED QUESTIONS

Run-to-Retire (RTR) Strategy

Risk-based Life Assessment (RBL)

Understanding Your Operating Risks

Run-to-Retire Outage (RTR)

Planning for What's Next

RTR Strategies Examples

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RUN-TO-RETIRE (RTR) STRATEGY

What operating timeline is a run-to-retire strategy applicable for?
A run-to-retire (RTR) strategy can be applied to coal plants with varying planned operating timelines, ranging from several years to a decade or more. Operating with a targeted end-of-life or conversion date, as well as with aging assets approaching the end of their design life, makes a run-to-retire strategy relevant for any site within this range of time.

What is the best way to start with developing an RTR strategy?
Developing an RTR strategy should start with performing a risk-based life assessment of your primary power equipment. The results and recommendations from this assessment provide the information you need to understand:

- The current condition of your assets
- The estimated remaining life of those assets
- What service work is necessary to operate safely
- and efficiently through your remaining planned life cycle

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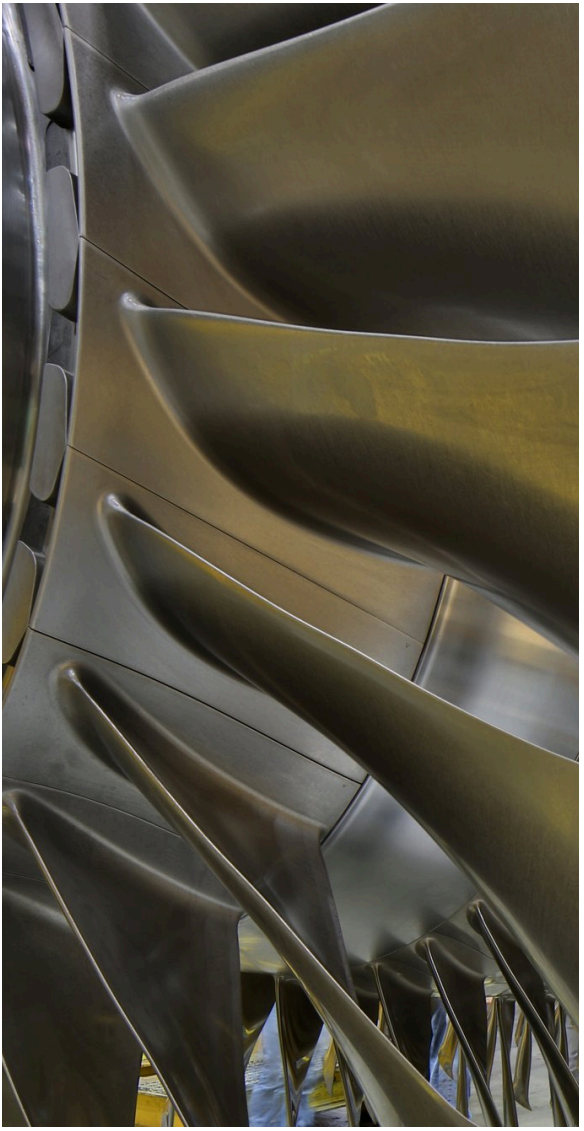
RISK-BASED LIFE ASSESSMENT (RBL)



What is the scope of a risk-based life assessment?

An RBL assessment involves the analysis of a coal plant's primary power equipment including the steam turbine and generator components (related auxiliary components can be assessed as well on request).

This process features the collection of existing inspection, operating and service history data which are then compared to our statistical fleet experience data. From this analysis, our team delivers a report summarizing the current condition of your equipment, an estimation of their remaining life cycle, and service work necessary to continue operating safely and efficiently through your planned remaining life cycle.

Does an RBL assessment require a shutdown?

An RBL assessment does not require a shutdown, as it is based on existing data and operator insights. In many cases when service work recommended in an RBL report is performed, a shutdown is needed. In such cases, our team can collaborate with you to plan for executing the work during your planned outage maintenance schedule, or through a one-time run-to-retire outage cycle to minimize your downtime.

Would an RBL assessment identify any issues/risks that standard inspections or maintenance activities don't?

The difference between an RBL assessment and 'standard' service inspections is that while both include the evaluation of current equipment condition, an RBL assessment applies that inspection data to 1) calculate the estimated remaining life of primary power generation assets, 2) identify operating risks based on your planned remaining life cycle and 3) scope the service work necessary to meet your remaining life cycle goals.

How long does an RBL assessment take to complete?

A full scope RBL assessment report can be completed in a range between several months and six months, depending on the resulting scope of the service strategy recommendation.

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UNDERSTANDING YOUR OPERATING RISKS

What are the most common types of risks/failures for coal power equipment reaching or surpassing their design life?
For generators, some common age-related issues include:

- Rotor winding degradation
- Stator winding degradation
- Gas/seal/cooler leakage

These account for ~80% of aging generator component issues.For steam turbines, some common age-related issues include:

- HP/IP rotor crack initiation
- LP rotor cracking
- LP last stage blade cracking
- LP last stage blade airfoil damage
- LP inner casing material loss

Do you have risk models that can provide specific calculations on the risk levels of our coal plant operation?
Based on inputs from inspections, operating data and service history, combined with our OEM fleet data history, we can help pinpoint your highest areas of risk, and provide examples on potential equipment failures. Our fleet history consists of millions of hours of operating data that we use to compare your operating profile- and equipment condition- to sites with similar circumstances that have experienced past failures.

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RUN-TO-RETIRE OUTAGE (RTR)

What is an RTR outage?

An RTR outage is a scope of service work necessary to continue operating your primary power equipment safely, reliably and efficiently through your planned remaining life cycle. It is typically a ‘one-time’ outage event intended to allow you to operate through your remaining planned life cycle without additional outage needs. When recommending an RTR outage scope, our team does not include unnecessary service work that would reduce your return on investment.

Does planning for an RTR outage require different activities/ timelines than a standard maintenance outage?

Planning for an RTR outage takes a highly customized approach that considers all the elements needed for a plant to operate efficiently, reliably and safely through its remaining planned life cycle. This can include:

- Additional assessment on higher-risk areas
- Decision points on repair vs. replace options
- Ordering of new parts if needed, or delivery of spare parts
- Addressing potential parts obsolescence issues

These activities can typically be performed within a similar timeline of a ‘standard’ maintenance outage schedule…typically ~12 months for planning and execution.

What type of work is performed in a RTR outage vs. a standard maintenance project?

The scope of an RTR outage is driven by a plant's life cycle timeline, operating profile, profitability model and assessed condition of its equipment. To help limit costs, our team will research opportunities to perform repairs vs. replace components, locate spare parts, or implement life extension solutions when needed. An RTR outage may consist of:

- Standard maintenance activities such as inspections of the steam path, generator winding, steam valves, bearings and auxiliary systems
- When needed, life extension options such as a generator rewind, blade repairs/replacements, rotor repairs, controls upgrades and repair/replacement of auxiliary components
- Modifications enabling more flexibility to adapt to changing market demands...as example, 'keep warm' or stress control modifications that allow for more cycling capabilities without additional wear and tear on critical components

Is the cycle time for an RTR outage different than a standard major/ minor?

Standard maintenance work that may be needed during an RTR outage can be completed in a similar timeframe as a standard major outage cycle. More complex repairs or life extension work scope may take longer than a standard outage cycle.

As with any outage project, if additional emergent work is discovered once the outage begins, the schedule may be impacted if additional work scope is added. Part of our team's planning process involves analysis of operating profiles, maintenance history and our fleet history to anticipate and plan for emergent work before the outage begins to minimize/eliminate schedule delays.

With a remaining life cycle window of just a few years, will an RTR outage deliver a worthwhile ROI?

The scope of an RTR outage is designed to deliver a targeted return on investment, enabling the plant to operate competitively through its remaining life cycle timeline. Services, and associated costs that don't contribute to your ROI target will not be included in an outage scope recommendation, except for those needed for you to operate your site safely. While operating needs and market dynamics can change, we can collaborate with you to identify an ROI work scope based on our risk-based assessment results and mutually agreed upon assumptions with you.

Are there ways to monitor specific operating risks on aging equipment before and/or after an RTR outage to avoid a forced shutdown?

Yes. The most effective and cost-efficient way to monitor aging equipment is by tapping into digital technology. Major coal plant assets including your steam turbine and generator can be configured with sensors to provide 24/7 monitoring of operating and asset performance, and help flag potential issues in their early stages.

These digital offerings can give you the ability to directly monitor your equipment on site if you have the resources to do so, or our team can monitor your plant for you and provide remote support in a proactive way.

What happens if an RTR outage is performed on our site, and we then learn that our market wants us to continue operating longer than our targeted timeline?

In this scenario, our team can coordinate with you in a similar way to reassess if any additional service work is needed to reach your extended life cycle target and, if so, deliver a recommendation scope that includes only the necessary work for that timeline.

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PLANNING FOR WHAT'S NEXT

Can Steam Power help us determine if it's financially viable to convert our operation to another fuel source, or keep our site available in cold reserve for peak power demand periods?
Absolutely. We can perform a full risk-based health assessment on your steam turbine and generator equipment, which can be used to calculate the costs of keeping your assets operating in a coal-fired configuration for scenarios such as cold reserve.

Additionally, our Energy Consulting sister business can help you assess financial models for converting your operation to alternate fuel sources such as a gas configuration, or investing in renewable options. These assessments can arm you with a holistic picture of your options to make a data-driven decision on your operating strategy.

Are there steps that can be taken now to prepare for a run-to-conversion strategy that's years down the road?
You can have a full risk-based health assessment performed on your steam turbine and generator equipment at any time to assess their current condition, identify operating risk levels over time and understand costs associated with continuing to operate them in a different fuel configuration.

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RTR STRATEGIES EXAMPLES

Do you have examples of RTR strategies you've recommended/ implemented with coal operators?
If so, can you share some outcomes/results?
We do! Explore the following examples of RTR solutions our team has developed and implemented on coal plant equipment:

Steam turbine

Steam Power recently supported a coal operator in Germany to modify a steam turbine low pressure rotor from a decommissioned site, repurposing it to be installed on their operating unit. Our team adapted the rotor to the new site's dimensions by removing its coupling and shaft end, and welding on a new stub shaft. This project enabled our customer to save a significant amount of investment in a new rotor to continue operating through the latter stage of their planned life cycle Our team in the U.S. identified a solution to remove a row of damaged blades from a steam turbine unit, and return it to service safely without them until new parts could be delivered and installed. This type of solution can be applied to a coal site nearing the end of its operating life or having reduced capacity demand, saving significant costs in unneeded replacement parts, while still being able to operate safely.

Generator

When a coal operator in the U.K. was looking for a low-cost alternative to extending the life of three generators approaching the end of their life cycles, our team delivered a viable solution. Leveraging software and sensor technology from our portfolio, the operator was able to monitor the units 24/7, and detect potential issues early before a forced shutdown occurs. With this capability, the customer postponed the recommended rewind, and purchased just one rewind kit to limit the costs of continuing to operate the generators in their advanced life cycle stages with minimum risk.
 When deformation and reduced clearance were observed on a generator unit in the Middle East due to coil displacement, the operator needed a cost-effective solution for shorter-term operation. To avoid an inter-turn fault, our team executed a repair allowing the site to continue operating safely with only periodic inspections, but eliminated the cost of a rotor rewind life extension.