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The Costs of Inaction: Leaving Nuclear Power Plant Profits on the Table

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The average age of a US nuclear power plant stands at almost 40 years, the operational time limit for which plants were originally licensed by the US Nuclear Regulatory Commission (NRC). More than 90% of these plants have already received 20-year extensions that permit operation for 60 years, and approximately 30% have already announced or are in pursuit of a second 20-year extension that will allow operation for 80 years.[1]

As electrification of industrial processes, transport, and heating drives electricity demand growth, the low levelized cost of nuclear power plant energy is becoming a considerable competitive advantage over other forms of power generation.[2] However, plants face challenges in funding large capital outlays and working within increasingly slim operating margins, particularly in deregulated markets, and budget constraints caused by compressed margins can lead to short-sighted investments. Plant decision makers who do not take a long-term view when planning operational upgrades and investments miss opportunities to efficiently and effectively prolong the lifetime of their plants, leaving profits on the table.

With effective long-term planning, opportunities abound for improved profits across a number of areas that include asset management, performance improvement, digitalization, safety, and workforce optimization. Not acting on these opportunities may seem prudent, cautious, and befitting of the nuclear industry culture, but it also means putting future profits and operations at risk.

Eight Opportunities for Profit Improvement

While each nuclear power plant is unique, with specific areas for potential profit improvement and efficiency gains, trends emerge across many operating units in the areas of asset management, operational efficiency, system upgrades, optimization, and new business model structures. Although each profit improvement scenario must factor in plant-specific operating conditions and cost structures, maximizing plant returns requires holistic long-term strategies across all plant systems.

Converting to Digital Asset Management

Plant operations have historically been structured on a time- and labor-based maintenance regime, driven by a conservative approach to preventative and corrective maintenance estimates. Advances in automated diagnostics and prediction/response models, however, enable more dynamic, collaborative, and data-driven asset monitoring. In turn, the improved maintenance planning that results from adopting digital solutions allows utilities to monitor the condition of their assets, address degrading asset health, and predict the remaining useful life of assets with increased accuracy. These advances allow time-based maintenance to be right-sized and ultimately transitioned to a condition-based maintenance strategy.

Predictive digital maintenance capabilities translate into hard profits. Digital asset management can yield as much as a 70% reduction in unplanned breakdowns whereas digital maintenance can deliver a 90% reduction in instrument calibration via sensor drift monitoring.

Maintenance and Inventory Optimization

Converting to a maintenance and inventory optimization system is one of the most effective ways that plants can optimize operations. Such systems enable plants to efficiently undertake only necessary maintenance (based on industry data and utility-specific needs), reduce the scope and cost of outages, and carry minimal required inventory, with no obsolescence risks or excesses.

Outsized benefits include reductions in the time required for on-line maintenance, outage maintenance, and parts readiness. For instance, over a 2-year period one North American 2-station utility with 8 units saved close to $120 million after implementing such programs. These savings were driven by nearly $80 million in increased cash flow from inventory reduction costs and close to $40 million in strategic sourcing gains, as well as reduced operations and maintenance (O&M) inventory carrying costs and maintenance costs. A 3-unit utility was able to see savings of $26 million in 2 years.

A key element to fully capitalizing on all potential savings is working with a partner who is able to leverage industry data to identify all potential savings and drive out costs.

Workforce Optimization

Nuclear power plants increasingly face challenges in workforce attrition, skill retention, and overall labor costs. Approaching workforce management with a modern, centralized service team structure can deliver massive synergies across utilities.

For example, plants often employ a separate team to address each station. For a utility with 3 stations, this has historically meant 3 separate teams to address each station, with a centralized management team for oversite. The result is 3 teams often working on similar (if not the same) issues, managing the same risks, and talking to the same vendors – largely duplicating many tasks.

Alternately, a centralized service team with a mix of local and virtual staff supported by industry-wide data and analytical insights, subject matter experts, and digital tools can markedly reduce complexity for utilities. Reduced complexity allows utilities to focus on core competencies and eliminate wasted cost, time, and effort. For instance, at a fleet with 1,500 staff, 300 were involved in common functionalities that could be delivered from a centralized team. Centralization of teams with overlapping functions could immediately deliver staffing efficiencies of 20% through organizational synergies. Additionally, the continual streamlining of abilities was achieved over time via ongoing improvements and process automation. In this example, the fleet had the ability to unlock $40 million in labor costs in 3 years, with potential savings of more than $100 million in 10 years.[3]

Steam Generator Asset Management

Steam generator asset management programs apply an integrated approach to efficiently maintain a steam generator throughout the life of the plant. These programs benefit plants on multiple fronts.

First and foremost, steam generator asset management programs mitigate the need for a cost-prohibitive steam generator replacement, a cost that is not likely to be recovered within the remaining life of the plant. Additionally, these programs save plants costs by reducing critical path time during inspections. By implementing steam generator asset management programs, some utilities are projected to see savings of more than $250 million in outage inspection costs across their fleets via deferred inspections as well as avoidance of $500 million in steam generator replacement costs throughout the plant's life.[4] Additional benefits include decreased risk of unplanned outages due to leakage or other degradation issues, improved outage scope and budget stability, enhanced response to emerging plant concerns, reduced regulatory risks, and an enhanced operating experience.

Power Uprates

While the opportunities for improvement previously noted enable utilities to reduce overhead, opportunities to increase power and revenue from existing assets can often go unaddressed. Plants can see power uprate magnitudes increase between 2% and 16% by taking advantage of various efficiency improvements, less uncertainty, and capital investments. For example, minor uprates can be gained as a result of reducing feedwater flow measurement inaccuracy while significant modifications to balance of plant (BOP) equipment can achieve a gain of more than 7% in power output.[5]

A utility with 4 units could see close to $20 million in increased revenue over the course of a year by investing in measurement uncertainty recapture (MUR) power uprates at each unit, which would produce an additional 80MWe.[6] At an estimated cost of $20 million per unit, the uprate improvement would be covered in 4 years, and the utility would benefit from an additional $80 million in revenue during that time. This revenue increase would not only fund the uprate but also additional upgrades, or simply benefit the bottom line. Components of the uprate vary based on the power uprate performed.

Refuel Bridge Replacement

Replacement of the refueling equipment improves outage performance, eliminates obsolescence issues, and mitigates equipment reliability risk.

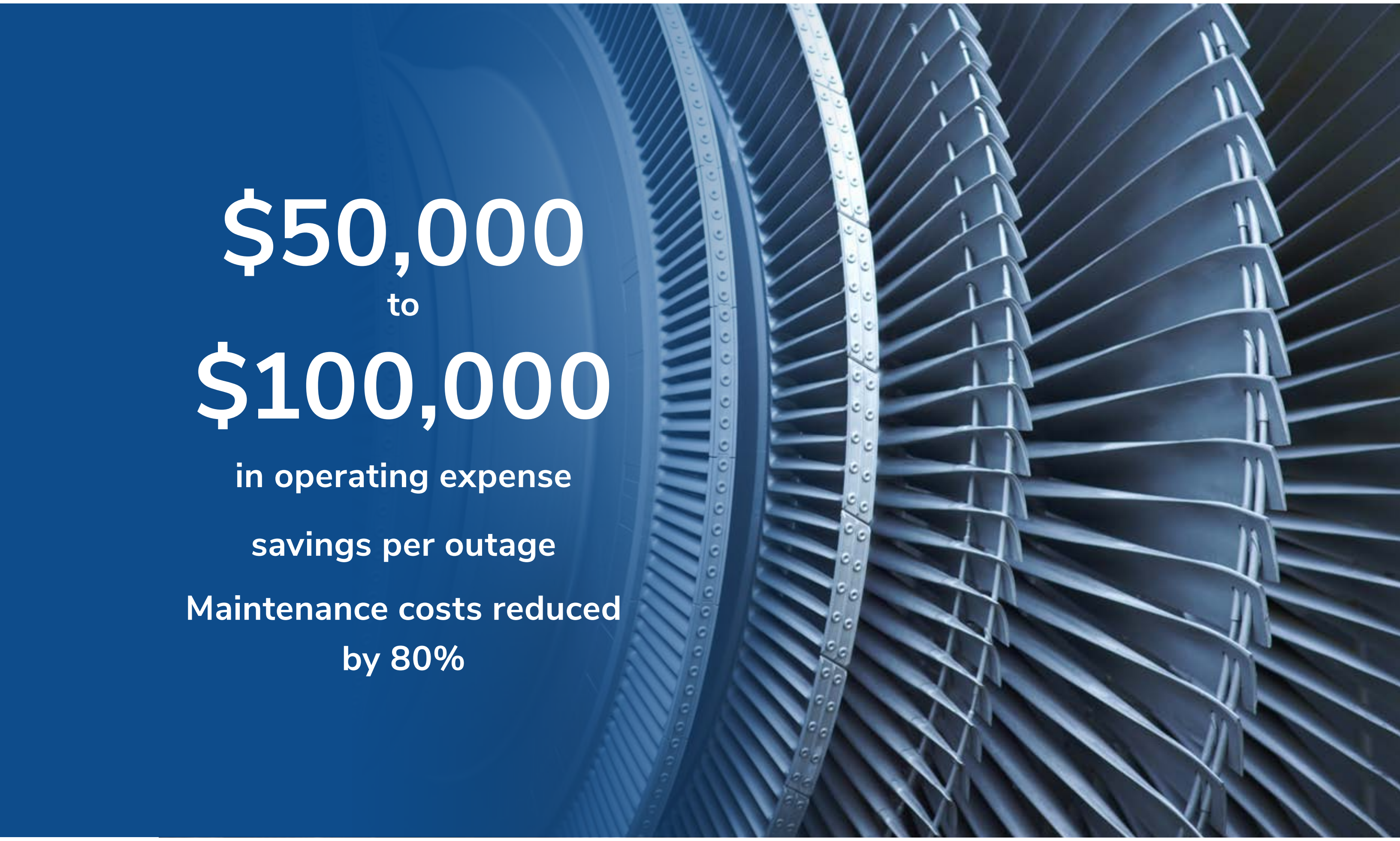
Investing in fuel handling equipment upgrades can increase the average fixed fuel movement rates through enhanced reliability, whereas automatic operations enhance performance via speed and efficiency increases. Additionally, replacement brings increased speeds of assembly-per-hour move rates. Some plants can expect improvements in critical path time of about 80 hours, resulting in savings of more than $2.5 million in vendor and lost generation costs per outage.

Replacement of the refueling equipment removes obsolescence risks as well as risks of future downtime. Downtime or refueling equipment failure comes at a significant cost, with downtimes sometimes lasting several weeks and requiring obsolete replacement parts that can be extremely difficult to obtain.

Turbine Control and Protection Systems

The Institute of Nuclear Power Operations (INPO) routinely reports that the largest single cause of unplanned SCRAMS[7] by system are due to turbine/generator systems. In fact, during a 5-year average (2016–2020), turbine/generator systems caused 36% of SCRAMS at a cost of more than $1 million per day per event. Furthermore, INPO reports that 68% of SCRAMS involve a single point vulnerability (SPV) component.[8]

Upgrading to digital turbine control and protection systems eliminates SPVs with high reliability, which protects plants from contributing to the INPO statistic. In addition, operating expense savings are typically $50,000 to $100,000 per outage. These operational improvements are enabled by reduced maintenance costs of at least 80%. Reduced maintenance costs are derived via a number of sources, including advanced system diagnostics that pinpoint faults, elimination of I/O calibrations required from existing analog systems, automated and rapid valve testing that does not require reducing plant power, mean time to repair of less than half an hour due to advanced diagnostics, automatic linear variable differential transformer (LVDT) calibration in minutes versus hours, an average critical path time of 2 hours, and reduced manpower. Additionally, upgrades allow for monthly speed trip testing not possible with existing systems as well as on-line valve testing at increased power levels in less time.



Digital I&C Safety System Upgrade

Upgrading existing instrumentation and control (I&C) safety systems reduces plant operating risk. As plants age, the risk grows significantly that an unplanned outage or plant trip will occur due to an I&C system issue. These unforeseen outages can come at a cost of more than $1 million a day,[9] but an upgraded I&C system mitigates this risk by reducing or eliminating unforeseen obsolescence that can result in extended offline periods.

In addition to increased online operating assurance, plants that upgrade I&C systems also enjoy significant operational cost savings. The most significant of these cost savings is gained when I&C upgrades are applied as a safety system upgrade, thereby eliminating the regular surveillance testing required by existing systems. Legacy surveillance testing can require up to 6 full-time employees for a 2-unit operating site at a cost of $250,000 each, resulting in up to $1.5 million per year in avoidable costs. Plants can achieve further financial benefit through reductions in spare parts inventory, field component requirements, and general maintenance needs. Additional operating benefits can be gained as a result of unlocking I&C digital characteristics (e.g., remote monitoring, soft controls in the MCR). Some plants have quantified these additional savings at up to $1.5 million, bringing the overall annual operational savings of I&C upgrades to almost $3 million.

$3 million in expected annual savings

Conclusion

Multifaceted opportunities to increase profitability exist for nuclear power plants. While budget constraints may lead utilities to default towards inaction, identification of effective long-term planning in partnership with subject matter experts, integration of emerging technologies, and utilization of fresh business model structures applied in innovative combinations will result in profit increases.

Various routes to capitalizing on additional profits and maximizing the long-term value of plants are available to utilities. The first step to pursuing an optimal route is to collaborate with a partner who has demonstrated expertise in long-term planning and license extensions. Operators should work with nuclear service companies to audit existing operations, identify short-term improvements, and engage in long-term planning to expand benefits. Collaborative data and insight sharing will enhance outcomes and optimize the opportunities for improved ROI. Likewise, financial implications will be substantially impacted by the timing and decisions associated with plant life extensions and long-term operations.

> **Each plant faces its own set of challenges and opportunities. Collaborating with a deft and experienced strategic partner enables tailored solutions that optimize the unique conditions of individual plants. Investment in profit-increasing capabilities in conjunction with market growth opportunities points to a bright future for nuclear power plants.**
>
> *– Frost & Sullivan*

Access the **Long-Term Planning Maturity Diagnostic** for a first-level diagnosis of your organization's relative strengths and weaknesses regarding core aspects of long-term nuclear power plant planning maturity at https://westinghousenuclear.com/diagnostic.

Endnotes

1 Estimates based on independent analysis of all US-based plants that have completed, been approved for, submitted, announced, or have otherwise indicated pursuit of 60- and 80-year life extensions.

2 19th CMI Annual Report, The Net-Zero America Project: Finding Pathways to a Carbon Neutral Future, part of the Carbon Mitigation Initiative, Princeton University (2019).

3 Based on a nuclear fleet comprised of three plants.

4 Estimates based on a utility fleet consisting of six nuclear power plants with the range of remaining life across plants spanning 36 to 80 years.

5 The US NRC places power uprates into one of three categories based on the amount of power increase, which therefore corresponds with the associated impact on the plant. A MUR is an uprate which increases power by <2% by reducing the inaccuracy in feedwater flow measurement; hence having a more accurate calculation of power. This uprate only requires the installation of a more accurate feedwater flow device and assessment of the increased power on the unit. A Stretch Power Uprate (SPU) involves an increase in power of greater than 2% but less than 7%. An SPU usually involves changes to instrumentation setpoints but no major plant modifications. An Extended Power Uprate (EPU) involves an increase in power of >7% and typically requires significant modifications to BOP equipment (e.g., high pressure turbine, condensate pumps and motors, main generators and/or transformers).

6 Based on a utility with 4 MUR units; Average spot power price in 2021 expected to be between $33.50 (peak) and $26.90 (non-peak).

7 A SCRAM is “the sudden shutting down of a nuclear reactor, usually by the rapid insertion of control rods, either automatically or manually by the reactor operator.” Definition source: U.S.NRC. https://www.nrc.gov/reading-rm/basic-ref/glossary/scram.html

8 Scram Trends, Institute of Nuclear Power Operations. Industry presentation by John Loyd.

9 SCRAM! When Disaster Strikes, Cascadia Times (2013)

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