Beyond 'one and done'

Several operators have moved away from a one-off mentality during refuelling outages (RFOs) to take a longer-term view. Their changes have significantly reduced outage costs and improved execution. ***By Andy Patterson***

In general, the US nuclear power industry is one of the world's best-run production sectors. Characterised by close attention to detail, willingness to share best practices, and intense cycles of continuous improvement, the industry has earned a reputation for operational excellence. Recently, the US fleet of 104 plants performed extremely well, turning in strong results as measured by capacity factors, output, and production costs.

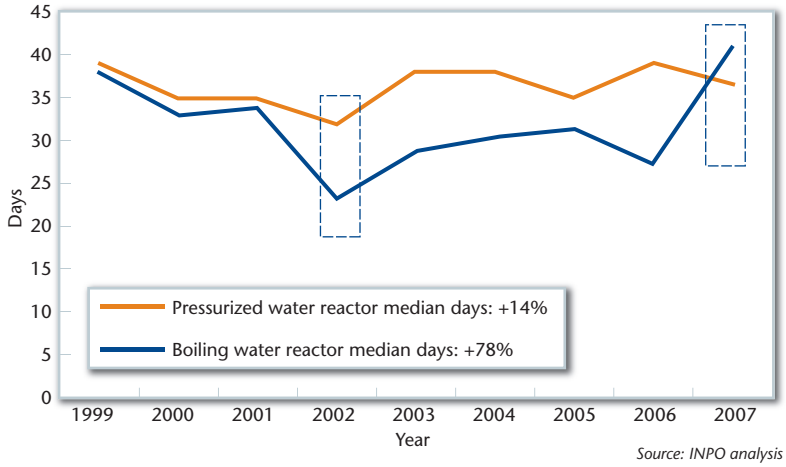
The biggest management challenges come not when the plant is up and running, but rather when the plant is down for some combination of refueling, refurbishment, or major modifications. During outages, plants are exposed to significant operational and financial risks ranging from the caliber of project management to the price of replacement power needed to make up for lost output, to delays caused by supply chain disruption, to the quality of contractor work performed.

Strong RFO performance, in particular, requires operational excellence. The process of taking the unit off-line, loading fuel, disassembling and inspecting major components, upgrading their material condition or capacity, reassembling the components, and re-synching the unit to the grid is a complex undertaking involving thousands of people. The discipline of RFO management tests the plant's leadership, processes, and controls in ways that day-to-day operations cannot. The most important metrics to track results are duration and cost (how long did it take and how much money was spent). Indeed, duration drives costs.

And as shown in Figure 1, RFO duration has increased for both boiling water reactors (BWRs) and pressurised water reactors (PWRs). Note that any firm conclusions from this data would require subjecting the data to a variety of site-specific normalisers, ranging from controllable factors such as the scope of work performed to uncontrollable elements such as changes in regulations governing work rules.

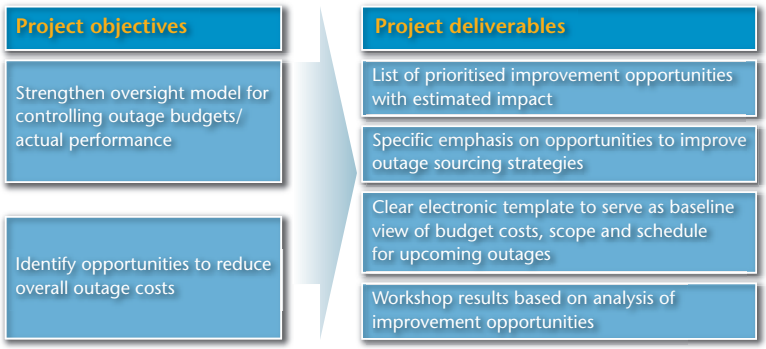
RFO costs can comprise up to 25% of annual O&M budgets, with direct out-of-pocket costs exceeding $800,000 per day (not counting lost margins from off-line units and replacement power costs). Recent experiences of management consultancy Oliver Wyman with plant operators suggests that a variety of factors are undermining outage execution, notably a set of outage planning issues coupled with a lack of supply chain integration.

Fig. 1: Refueling outage durations are creeping up



Source: INPO analysis

Fig. 2: Oliver Wyman's RFO optimisation project objectives and deliverables



OUTAGE PLANNING

Late outage planning processes leave inadequate time to properly resource the project. As individual project teams (e.g., refueling services, turbine services, maintenance) deliberate on work scopes there can be time-consuming delays. Given that much of the labour is outsourced, these late scopes of work require accelerated procurement processes which, in turn, limit negotiation time frames and lead to higher pricing from vendors.

Inadequate scope control during outage planning overextends available resources. An up-front, shared vision among outage planners for the major plant modifications and principal maintenance routines limits scope volatility. In the absence of this shared understanding, a 'wish list' mentality takes hold and extensive lists of possible work come from a wide variety of sources. Having a clear fix on the maximum amount of work to schedule per project type, coupled with a set of

prioritised outage tasks reins in costly scope debates.

In these cases, there are insufficient project management training and tools for developing realistic forecasts and keeping them updated. Outage management teams are often placed into roles as major project planners without the benefit of effective training, processes, information systems, and tools. When codified methods are not applied, and planners rely on widely different skill sets for planning, there is an uneven result. This issue is compounded when the planning responsibility shifts from one manager to the next (either between or during outage planning cycles) and documentation on past plans is weak.

These cases typically feature uneven capacity for sustaining management commitment and focus on strong results for an extended period of time. Refueling outages can become a major focus for site management teams. It is not unusual to find a major 'outage workout effort' underway with targeted outage improvements a key performance area. Over time, as gains are realised, an effective change programme is needed to instill new behaviors in employees. In the absence of an effective transformation programme, gains can be short-lived.

SUPPLY CHAIN INTEGRATION

Late or unclear labour strategies force last minute, ad hoc decisions on work performed in-house vs. contractors. Every fleet faces fundamental decisions about who should perform the outage work. There are four primary resource pools – site-based, nuclear fleet, generation fleet and outside labour. These decisions are particularly vital because as the workforce ages, knowledge is lost to retirements, and craft productivity losses occur due to aging and/or lack of experience with new hires. Setting up-front strategies to employ the optimal resource model enables proper training and development of in-house resources on their outage roles as well as effective sourcing of contractors. Too often, late scopes of work coupled with unclear resourcing decisions compromise planning efforts.

Management does not always appreciate the need for disciplined sourcing processes that take time to undertake. Nuclear fleets often have an ineffective relationship with their supply chain teams. The outage planning partnership with procurement is often characterised as 'step and fetch.' That is, late in the process, supply chain teams are told what to buy, whom to use, and when to deliver. An integrated supply chain strategy, enabling outage-planning teams to take full advantage of the supply base strengths, requires intensive, up-front collabouration. Once plans are laid, a disciplined, strategic sourcing process should occur. This issue is particularly vital as third parties perform a large component of outage work.

Companies face increased levels of intra-industry competition for skilled labour and lack access to contractors' 'A team' resources. In the USA, the nuclear supply base is feeling the combined pressures of an aging workforce and a healthy market for services. Over the past five years, suppliers' traditional refueling services market has been augmented by life extension work, power uprate programmes, and the beginnings of the US new-build movement. Competition for resources is growing, and well-run supplier relationship management programmes are needed to gain access to the best talent.

Companies also have a shortage of critical field and technical labour such as welders, carpenters, valve technicians, and health physics technicians. Not only are there limited numbers of skilled craft available, but also multiple industries are expanding their infrastructure so supply shortages are compounded. The nuclear industry competes with fossil plant, refinery, manufacturing, and civil construction projects for labour. The AFL-CIO Building and Construction Trades estimate that 200,000 to 250,000 new craft workers are needed in the USA each year. The Bureau of Labour Statistics suggests 2.5 million new craft workers will be needed by 2015. Craft labour scarcity, for nuclear refueling outages, is compounded by the fact that this labour pool requires higher levels of training and is especially difficult to replace.

There is too much reliance on inexperienced contractor labour and inadequate assumptions about factors such as time to on-board and labour productivity. It's no secret that in well-run programmes, productivity can be much higher with internal resources than with third-party labour. Company employees are trained, badged, oriented to the site, deeply ingrained in the performance culture, and take a so-called owners' pride in their work. Planning assumptions need to fully reflect these issues when it comes to workforce productivity. Our experience suggests that decisions to employ in-house resources need to be constantly revisited in order to ensure an optimum balance with labour markets.

Fig. 3: How to move up the planning cycle

Integrate business plan assumptions, capital planning forecasts and long-range business plans more carefully with outage plans

1. More closely link targets to outage content (based on list cited above)
2. Employ more detailed benchmarks to strengthen estimates and targets
3. Ensure tighter linkages between long-range outage plans and business plans
4. Benchmark best practices with respect to integrating business plans and targets, with outage plans and targets

Clarify labour strategy for in-house site-based staff versus in-house fleet-wide shared resources versus contractor employees

1. Integrate labour-types and sources with scope, duration and costs
2. Benchmark to compare contractor use / costs / productivity versus industry
3. Deconstruct labour costs to understand contractor margins and apply value sourcing techniques
4. Develop best practices with respect to nature of contract (e.g., fixed price, time and materials or open book EPC) and contractor oversight methods

Ensure outage plans leave plenty of time for strategic sourcing to occur

1. Understand supply chain milestones for competing the market
2. Build in time to establish needs, bid and negotiate with contractors

Fig. 4: Codify content by devising standard scopes, costs, schedules

Strengthen outage design by standardising baseline RFO content (pre-outage work, recurring work, O&M and capital projects)

1. Set standard scope, duration, and cost for each site (use benchmarking to strengthen critical work scopes), for example:
   a) Shutdown and system turnover (tag-outs);
   b) Refueling services;
   c) Turbine services;
   d) Bulk maintenance work (corrective work orders, elective work orders, performance tests, valve work, etc.);
   e) Radiation protection support;
   f) Recurring inspections;
   g) System and plant start-up;
   h) Explore options and best practices for work groupings (i.e., bundle different work programmes to find synergies);
   i) Explore positive impacts associated with capital spares programmes and component replacements (as opposed to the 'fix during the outage' approach);
2. Standardise pre-outage work – milestones, scope, duration, and cost
3. Standardise post-outage work – milestones, scope, duration and cost
4. Produce a user-friendly electronic template (for above work scopes) to serve as the baseline view

Collectively, the industry has a wealth of opportunities to develop systematic approaches to safely reduce outage costs and schedules.

Most US nuclear operators have enjoyed periods of successful refueling outage performance. Unfortunately, these can be followed by a period of decline. The difference between an extended track record of success, and

periodic 'one and done' victories, lies in the business model. If the model is sustainable, with knowledge tied to the programme not to individuals, the track record can be extended indefinitely. Conversely, if success depends too heavily on individual contributions, when the individuals change roles or depart performance inevitably degrades.

A recent case in which Oliver Wyman collaborated with a large nuclear fleet operator over the systematic reduction of RFO days and duration illustrates the point. Figure 2 shows the case objectives.

The collaborative effort relied on a variety of discovery techniques ranging from site-specific benchmarks by outage project type (refueling, turbine, air operated valves, motor operated valves, scaffolding) to supplier interviews, to deep post mortems of recently completed RFOs.

A consensus emerged that improvements would come through various change levers, including three prominent levers: move up the planning cycle, codify baseline RFO content and strengthen the business model for execution. It became clear that RFO success is closely linked to the calibre of pre-work and the sophistication of the on-site management team during the event.

1. Move up the planning cycle

Synchronising content among long-term financial, operational, and outage plans requires constant attention. Recognising a tendency toward misaligned and compressed planning cycles, the team found that these led to volatile work scopes. Figure 3 shows the specific issues and corrective actions.

2. Codify baseline RFO content

Too often, managers start the definition of outage content – what should be standard maintenance and asset replacement routines – with a blank sheet of paper. Multiple combinations of work packages find their way onto the candidate list (in many cases, despite being previously rejected). The net effect tends to be a high level of scope volatility, expending scarce planning resources on elements that are unlikely to occur, while crowding out efforts needed to prepare for legitimate work scopes. Well-run fleets know what the standard complement of maintenance checks and asset rehabilitation work they should do. We often find an opportunity to codify baseline work (by site and across the fleet) so that only scope exceptions get subjected to extensive planning cycles (as opposed to the entire scope of work). Figure 4 offers examples of how to think about scope management.

3. Strengthen the Business Model for Execution

The reality of an RFO is that thousands of labourers converge on the site at once. Management teams should aim to build a stronger business model that brings high levels of oversight and stronger supplier relationship management practices. Figure 5 offers guidelines for the next-generation RFO business model.

Significant changes result from efforts to institutionalise outage performance, as shown in Figure 6. Here, the implementation prospects are viewed as strongest in the upper right hand corner. These ideas are viewed as both high impact and relatively easily implemented.

Picking up on the themes described earlier, Figure 6 suggests that finishing planning efforts in time to apply more rigorous sourcing processes is the best combination of changes. Given the large amount of outage spend and duration entrusted to supply base partners, this thinking captures a large opportunity space.

The overriding theme is that focusing on and institutionalising good RFO planning and supply chain practices enables nuclear programmes to sustain higher performance levels over longer periods. Individuals may come and go, but the programme should have a set framework and process for excellence in execution.

Chief nuclear officers, fleet chief operating officers, and other members of senior management should be actively engaged in these discussions. Too often, local site decision-making prevents senior leaders from understanding key decisions that underpin outage performance. For nuclear operators with programmes characterised by uneven or sporadic success, that experience turnover in key positions, or that don't devote the same level of attention to the commercial elements of outage programmes as they do to operating and technical issues, it may be time to take a fresh look at how to achieve sustainable improvements.

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Fig. 5: Rethinking the business model for execution

Refine oversight model for managing outage cost and duration during execution, e.g.:

1. Clear methodology, roles, responsibilities and accountability for cost, schedule, risk, scope, and resource-sharing decisions, by project
2. Formal approaches to supplier on-boarding, integrated decision-making, and supplier relationship management (that is, a shared playbook)
3. Real-time, web-enabled information tools for tracking critical path, cost, and risk profiles
4. Controls over when contractors are brought in and exited from the site
5. Close attention to pre-outage work and report-outs
6. Clear protocols linking contingency plans to actions, to eliminate confusion over the need to change the course of the outage

Fig. 6: A schematic diagram of RFO optimisation work, numbered by priority