Modernizing Nuclear Power Plants for Higher Performance

A practical, risk-managed approach to extending plant life, improving reliability and maximizing power generation

Nuclear plant modernization is no longer a narrow equipment-replacement exercise. For many operators, it has become an opportunity to drive long-term higher operating performance, including achieving additional power generation from existing assets. This whitepaper reviews the imperatives and challenges of plant modernizations, as well as sets out Curtiss-Wright's approach to supporting customers throughout their modernization journey.

Nuclear Plant Modernization

Executive summary

Across operating fleets, some investments are simply made because aging or unsupported equipment must be replaced to preserve plant reliability and licensing confidence. Increasingly though, a further driver is the opportunity to improve operational or commercial performance, for example through power uprates, thermal performance improvements, improved equipment monitoring, reduced maintenance burden or more efficient plant processes.

Curtiss-Wright's approach to modernization is to help customers move through their modernization challenges in a practical, risk-managed way. The value we create lies not simply in supplying replacement equipment, but in understanding plant constraints, minimizing change where change creates unnecessary risk, and identifying where new digital capability can deliver better plant insight, automation, standardization and lifecycle support.

This whitepaper sets out the modernization imperative, the practical barriers customers face, the commonly affected systems and the role Curtiss-Wright can play as a flexible, experienced partner with a broad nuclear portfolio and the ability to support integrated, plant-specific solutions.

Modernization imperative

Existing nuclear plants remain among the most valuable generating assets in the global energy system. As operators pursue extended operations, many plants are moving from original 40-year design assumptions toward 60-year, 80-year and in some cases even longer operating horizons. That shift changes the modernization equation. Systems that were acceptable for an earlier phase of plant life must now be assessed against decades of future operation.

At the same time, demand for reliable electricity is increasing. Utilities are under pressure to maintain high availability while also exploring ways to add incremental megawatts through plant uprates, measurement uncertainty recapture, thermal performance improvements, feedwater and balance-of-plant upgrades, and other targeted modifications.

Modernization agendas are shaped by three imperatives:

1.Sustain the asset: address aging systems, obsolete components, unsupported OEM equipment, and long-term lifecycle risk

2.Improve performance: recover additional output, improve plant thermal performance, reduce maintenance burden, and support more efficient operations

3.Enable the future operating model: use digital platforms, data, automation, and standardization to support a changing workforce and a more integrated plant environment

For operators, the challenge is that modernization cannot be treated like a conventional industrial upgrade. Every change must be considered in the context of plant safety, licensing, cybersecurity, human factors, outage execution, configuration control and long-term maintainability.

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Modernization is risk mitigation and value creation

Modernization is often driven by both risk and reward. Safety-related systems may not directly generate additional revenue, but they must remain reliable, supportable, and compliant. In these cases, modernization is frequently driven by obsolescence, end-of-life components, lack of OEM support or the need to preserve the licensing basis for long-term operation.

Non-safety and balance-of-plant systems are often evaluated through a broader commercial lens. If an upgrade can reduce maintenance, enable automated testing, improve data visibility, support thermal performance analysis or contribute to additional megawatts, the investment case may be easier to make.

This is why a like-for-like replacement is not always the right answer but nor is wholesale transformation. In a nuclear plant, the best modernization strategy is often selective. Retain what is still safe, reliable, and supportable. Replace what creates unacceptable lifecycle risk. Introduce digital capability where it improves performance, maintainability, or decision-making.

Why modernization is difficult

The main barriers to modernization are straightforward but formidable: time, money, and risk. Even a relatively targeted system replacement can trigger a wide chain of associated work including drawings, procedures, physical removal and installation, interface verification, simulator updates, operator training, testing, qualification, cybersecurity review and licensing support.

Engineering effort is frequently the dominant cost driver. Total project costs can significantly exceed equipment procurement costs, particularly where safety-related systems, control room changes, or new cabling are involved. Routing new cables, especially in difficult plant areas such as containment, can become disproportionately expensive. As a result, customers often prefer replacement strategies that minimize changes to existing wiring, interfaces, and terminal blocks.

This risk appetite explains why many operators prefer direct replacements or functionally equivalent upgrades that reduce engineering scope. The plant may need modernization, but customers naturally want to avoid unnecessary design, licensing, or outage risk.

- Will the change introduce new licensing or regulatory complexity?
- Can the upgrade be completed within an outage window?
- Will existing plant wiring, cabinets, drawings, and procedures need major rework?
- Can operators be trained effectively before the system goes live?
- Will the new system integrate with the plant process computer, simulator, and wider plant architecture?
- Can the supplier support the equipment for the next phase of plant life?

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What utilities modernize and what they leave alone

Modernization priorities vary by plant, fleet, operating model, and regulatory context. However, there are several broad categories of systems and components that commonly enter the modernization discussion.

Modernization area	Typical drivers	Curtiss-Wright relevance
Instrumentation and control systems	Obsolescence, reliability, reduced manual surveillance, better diagnostics, improved operator information.	Digital system upgrades, replacement strategies, control system integration, testing, lifecycle support.
Plant process computer (PPC) and monitoring platforms	Improved data visibility, centralizing plant information, reducing manual data collection, supporting performance analysis.	PPC modernization, integration of data from plant systems, operational decision support.
Feedwater, thermal performance and balance-of-plant upgrades	Additional megawatts, thermal efficiency, aging equipment, uprates, measurement uncertainty recapture.	Associated valves, flow measurement, instrumentation, modelling, monitoring, and integration.
Radiation monitoring, condenser isolation, pressure transmitters, annunciators, and other plant systems	End-of-life equipment, supportability, regulatory expectations, digital migration, fleet standardization.	System replacement, reverse engineering, component substitution, qualification support.
Mechanical and ancillary equipment	Aging valves, snubbers, feedwater heaters, moisture separator reheaters, flow meters and related components.	Replacement, refurbishment, redesign, remanufacture, and associated instrumentation or monitoring.
Simulator and training systems	Workforce transition, operator readiness, validation of plant changes, reduced dependence on legacy code and hard-to-maintain platforms.	Modern simulation platforms, scenario development, validation support, training alignment.

Just as important is the question of what not to touch. If a system is functioning, supportable, and not creating unacceptable lifecycle or performance risk, customers may reasonably prefer to leave it alone. In modernization, restraint can be as valuable as ambition. The supplier’s role is to help identify where intervention is justified and where unnecessary change would only add cost and risk.

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From equipment replacement to digital foundation

The most significant modernization opportunity lies in the transition from isolated analog systems to digitally enabled plant platforms. Analog systems often require manual walkdowns and operator rounds to collect information about condition, status, or performance. Digital systems can collect, transmit, store, and present that information automatically, reducing the burden on plant personnel and enabling better use of engineering and operations resources.
When data that was previously collected manually can be routed to the plant process computer or other operational platforms, the plant gains more than convenience. It gains a foundation for improved diagnostics, automated testing, performance monitoring, trend analysis, and condition-informed maintenance.

That does not mean every system needs to become part of a fully integrated digital architecture immediately. Rather, each modernization project should be considered as a step toward a more coherent long-term data environment.

Digital modernization outcomes:

- Reduced manual data collection and fewer routine walkdowns
- Improved equipment health visibility and earlier detection of degradation
- Automated or semi-automated testing where technically and regulatorily appropriate
- Better integration between field equipment, control systems, plant computer platforms, and simulators
- Improved workforce alignment as newer engineers and operators increasingly expect modern digital tools
- A stronger basis for future predictive maintenance and AI-assisted analysis, subject to customer data ownership and governance

Curtiss-Wright's practical modernization approach

Curtiss-Wright's modernization approach is pragmatic rather than prescriptive. Customers rarely arrive with a generic modernization problem. They arrive with a plant-specific constraint: an obsolete component, an unsupported system, a performance gap, a licensing challenge, an outage window or a fleet standardization objective.

Our approach is framed in four stages:

1. **Assess** - Establish the current condition, supportability, and operational importance of the system or component. This includes obsolescence exposure, safety classification, existing interfaces, availability of spare parts, OEM support status, cybersecurity considerations, and the consequences of failure or continued deferral.
2. **Define options** - Identify the practical modernization routes: like-for-like replacement, functionally equivalent replacement, refurbishment, remanufacture, reverse engineering, redesign, digital upgrade, or integrated system replacement. The right answer should be driven by risk, cost, schedule, and expected plant value.
3. **Plan and de-risk** - Develop a change strategy that minimizes disruption. This includes interface management, qualification planning, licensing support, testing strategy, simulator and procedure impacts, outage integration, and long-term configuration control.
4. **Implement and sustain** - Deliver the equipment, system, or service and support the customer through installation, testing, commissioning, training, and lifecycle sustainment. Long-term support should include spares, repairs, obsolescence management, documentation, and future upgrade pathways.

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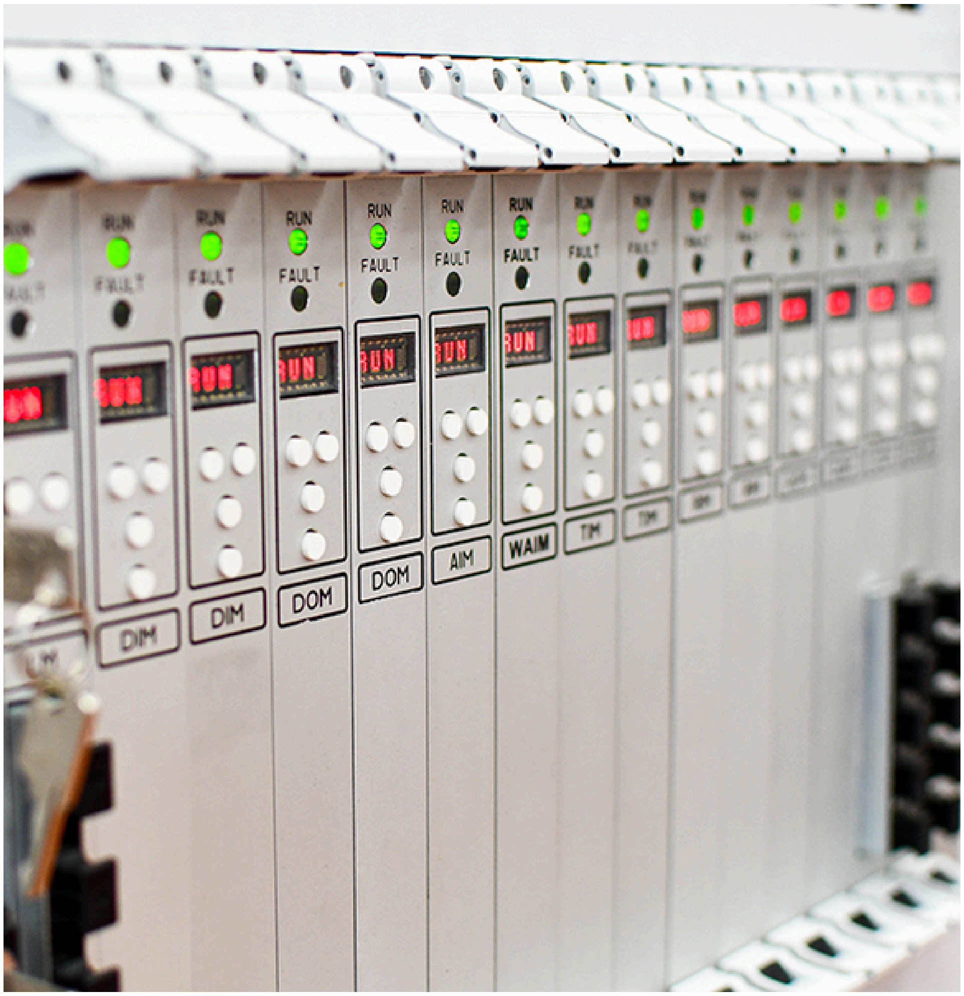

Standardization across fleets

Fleet standardization is becoming an important modernization driver. Operators with multiple units or sites want to reduce variation of equipment, procedures, training, spare parts, engineering support and maintenance practices. A modernization project at one site can become more valuable if it creates a template for the rest of the fleet.

Curtiss-Wright can support this by helping customers identify repeatable modernization patterns: common component replacements, common digital system architecture, common qualification approaches, common training updates and common long-term support arrangements.

The aim is not to force every plant into the same configuration. Nuclear plants have site-specific histories and licensing bases. The aim is to standardize where it reduces cost, risk, and operational complexity, while preserving the plant-specific engineering discipline that nuclear modernization requires.

Licensing, qualification, and regulatory support

Modernization programs often create licensing and qualification questions. The customer remains responsible for licensing decisions and regulatory submissions in many jurisdictions, including the United States, but suppliers can play a critical role in supporting the customer's case.

Curtiss-Wright's role may include technical documentation, qualification evidence, design basis information, engineering support, and direct participation in regulatory discussions where appropriate.

That kind of support is important because modernization risk is not only technical. It is also institutional. Customers need suppliers who understand the documentation, traceability, testing, and review expectations associated with nuclear plant change.

Nuclear Plant Modernization

A phased roadmap for customers

A practical modernization conversation begins with a phased roadmap:

- **Baseline the plant or fleet** - identify obsolete systems, unsupported components, manual data collection burdens, recurring maintenance issues, and potential performance gaps.
- **Prioritize by value and risk** - distinguish between mandatory replacement, reliability-driven upgrades, revenue-generating improvements, and longer-term digital opportunities.
- **Select the least-risk viable path** - determine whether like-for-like replacement, refurbishment, reverse engineering, digital upgrade, or integrated system replacement is most appropriate.
- **Align with outage and licensing strategy** - assess drawings, procedures, simulator impacts, training, qualification, cybersecurity, and regulatory support requirements early.
- **Deliver repeatable value** - use each project to create lessons, documentation, and standardization opportunities that can support the wider fleet.
- **Build the digital foundation** - where appropriate, connect modernized equipment to plant information systems to support diagnostics, automated testing, equipment health monitoring, and future predictive capabilities.

Why Curtiss-Wright?

Curtiss-Wright's has advanced nuclear capabilities and an extensive technologies portfolio. With this, we can support the entire modernization problem facing customers while also reducing supplier complexity. Customers increasingly value the ability to source multiple related capabilities, such as simulation, protection systems, and distributed control systems, from a supplier that understands how those systems interact. Modernization is easier to justify when suppliers can connect equipment, data, support, and lifecycle thinking.

- **Nuclear experience** - Curtiss-Wright understands the constraints of operating nuclear plants, their safety classifications, licensing basis, qualification, cybersecurity, outage planning, configuration control and long-term support requirements
- **Technical flexibility** – We can consider multiple solution paths, from like-for-like replacement to reverse engineering, refurbishment, redesign, digital upgrade, and integrated system support. This flexibility matters when customers are trying to minimize risk without deferring necessary modernization.
- **Breadth of portfolio** - Curtiss-Wright can support a broad set of modernization needs across equipment, instrumentation, controls, plant computing, simulation, training, lifecycle services, and sustainment.
- **Mature nuclear supply-chain options** - Long lead times are a growing concern across the nuclear supply chain. Curtiss-Wright's established nuclear supply-chain relationships and multiple technical options may help customers identify more competitive schedules, subject to project-specific constraints.
- **Digitally enabled** - As plant systems generate more data, the opportunity is to connect equipment condition, plant performance, maintenance information, simulator models, and operational platforms more intelligently. Curtiss-Wright's digital solutions portfolio provides a strong foundation for helping customers move toward a digitally enabled, integrated environment.

Conclusion

Nuclear plant modernization is a disciplined balancing act. Operators must keep plants generating safely and reliably while preparing assets for decades of future operation. They must address obsolescence without introducing unnecessary change. They must pursue digital capability without losing sight of licensing, outage, and configuration realities.

Curtiss-Wright's value is in helping customers navigate that balance. The company can support immediate obsolescence and replacement needs, but it can also help customers think more strategically about how individual projects contribute to a more reliable, more maintainable, more standardized, and more data-enabled plant.

The modernization opportunity is therefore bigger than equipment replacement. It is an opportunity to extend the value of the existing nuclear fleet, reduce lifecycle risk, recover operational performance, and create a foundation for the next generation of nuclear plant operation.

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