Reaching Peak O&M Performance in Power Generation

Eight “building blocks” to improve operations and maintenance in rapidly changing energy markets
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New regulations, alternative energy sources, new technologies, changing customer demands, and new supply-and-demand dynamics for oil and gas are bringing major change to Europe’s power generation market. The focus now is on operational performance—improving the availability, flexibility, and commercial and technical efficiency of conventional power plants.

The power generation market in Europe is evolving rapidly. CO₂-trading regulations have ramped up pressure on generators’ cost and cash positions, and a massive expansion of renewable energy sources—mainly wind and photovoltaic solar—has increased the need for flexibility. New technologies and a change in customer behavior will push carbon-neutral technologies and foster decentralized power generation. The supply-demand dynamics of oil and gas will contribute to a price decoupling between both and lead to more volatility in power prices. Indeed, a shift from energy pricing to capacity-based pricing seems likely. With these in mind, power generators are beginning to focus on operational excellence—to improve the availability, flexibility, and efficiency of their plants.

A.T. Kearney has a framework to help improve operational performance in the power industry (see figure 1 on page 2). Built on eight modules, we address all possible moves to improve operations and maintenance (O&M). By following a pre-defined roadmap and taking all relevant steps, we have helped our clients achieve immediate O&M cost improvements of 15 to 25 percent, plus 5 percent in savings when considering a slightly increased risk level regarding plant availability.

The following offers a detailed discussion of all eight modules—each representing different stages in the quest to reach peak O&M performance in power generation.

Module 1: O&M Strategy

The question is no longer if power generators have to adapt their O&M strategies to the changes in the market, but when. This first module offers a four-pronged approach to crafting an O&M strategy:

Set the O&M direction. All successful strategies begin with a foundation that has room for further development. Key decisions are made at this point, including determining the degree of in-house capabilities that will be necessary (compared to other possible options to deliver these capabilities), and gauging the impact O&M has on company performance to reach availability targets. These and other decisions will help manage costs and become the basis for other strategies such as maintenance, outsourcing, and the O&M information technology (IT) setup.

Gain a maintenance-specific view. Best-in-class maintenance strategies are always consistent across both the system and subsystem levels. Within this module, it is important to have a clear view of how strong O&M currently is and how
best to develop it further to improve costs and ensure longer-term availability.

**Develop an outsourcing and make-or-buy strategy.** This step is the first examination of the strategic relevance of O&M processes and the feasibility of outsourcing, defining the optimal split between in-house and external services and capabilities. This fundamental decision is required for any procurement activity. Plus, any decision in favor of in-house services must be assessed at the component level, evaluating the capabilities and economies of scale to determine your true in-house competitiveness (see figure 2).

**Build an organizational framework.** Often we see the big O&M teams at individual plants with little to no exchange of institutional information or resources, and very little interaction among plants. Defining the organizational framework requires allocating functions (centralized versus decentralized) and other organizational approaches to share information, promote collaboration, and avoid inefficiencies, to name just a few.

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**Figure 2**
A.T. Kearney House of Operational Excellence

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**Figure 1**
A.T. Kearney House of Operational Excellence

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**Module 2: O&M Organization**

Every lean plant-level organization must be supported by highly specialized external services. Yet this, by its very nature, leads to deteriorating internal know-how. And it is often difficult to control the quality and price of specialized external resources, who, if not accessible around the clock, put the availability of the entire plant at risk.

Therefore, pooling valuable and highly specialized internal O&M resources into a central organization is vital for utilities with a generation fleet—not only for sharing resources, but also for transferring knowledge and experience across all plants. In this way, different plants using the same or similar technology can set and follow standards more easily and take advantage of process synergies. From our project experience, we know the savings can range from 5 to 10 percent of O&M costs, depending on a company’s current position and technology. Indeed, in North America, “outage groups,” central teams ready to offer support during outages and bring plants back online as
soon as possible, are common. In Europe, such teams are still rare.

Some large-scale utilities have managed to reduce working capital and operational costs substantially after introducing a shared warehouse for several plants. A dedicated warehouse strategy can help define which spare parts should be managed and stored locally or centrally. Of course, the value of sharing warehouses depends on the geographic distribution of the fleet and how diverse and focused its technology is. Indeed, several other factors are in play in the decision, including which components are covered by service agreements, lead time, component value, logistics costs, and local import and export issues.

Our framework allows for defining a tailor-made O&M organization that works across all levels. It considers several aspects: the generation fleet, technologies, geographic footprint, strategic targets for portfolio development, and make-or-buy decisions.

Furthermore, there is often an untapped opportunity for sharing plant-level resources. From best-practice companies, we know that routine maintenance can be performed by the operations shifts, and that operations teams can also be involved during outages. Doing so builds a mutual understanding of operations and maintenance tasks, fosters communication between the teams, and often speeds up O&M strategy development and planning.

Take, for example, our recent work for a European utility. The leadership team wanted to improve O&M costs and power plant availability for its conventional generation unit—consisting of lignite-fired, hard-coal-fired, gas-fired, and nuclear power plants.

Finding little cooperation or transparency across power plants—and especially across divisions—success, we soon decided, would require a cultural transformation. We began by designing a cross-divisional organization in which processes, responsibilities, and structures were all aligned. Working closely with the company, relevant data was consolidated, budgets and planning were aligned, and an incentive system was launched to encourage collaboration among the plants and divisions. Change management was the tool of choice in getting everyone’s buy-in, especially top management and the engineers; both groups would be crucial to success. We calculated the potential tangible results, established an implementation plan for rollout, and launched two pilots. To date, the company’s overall savings on O&M costs are in the 10 percent range.

Module 3: O&M Processes
One major step toward operational excellence is maximizing the effectiveness of O&M processes. An O&M process map for power generation forms
the basis for many such approaches. Figure 3 highlights a map with eight main processes, in which the sub-processes might include:

1. Administration: finance, HR, IT, among others
2. Asset management: none
3. Health and safety management: health, safety, and environment
4. Contractor management: manage suppliers, develop make-or-buy strategies
5. Procurement and inventory management: procurement, inventory, warehousing
6. Production and operations management: planning, execution, reporting, monitoring, optimization
7. Routine maintenance: none
8. Corrective and preventive maintenance: strategy and planning, execution, reporting, optimization

The process map facilitates building or streamlining the O&M organization. Clustering processes to functions forms the building blocks of the organization and minimizes the number of interfaces needed between organizational entities. A stages-of-excellence model helps quickly assess existing O&M processes. The stages range from “fire-fighter” to best practices, and help identify improvement potential in existing processes.

To capture all prospective synergies, it’s important to standardize processes. The highest level of the O&M process map is applicable to all generation technologies, countries, and sites, which allows all plants to define and roll out the O&M process blueprints. In this way, not only single processes are involved, but cross-plant optimization is possible.

Even when reducing the number of interfaces, O&M processes have several interdependencies that often slow down decisions. For example, load planning (over the long, mid, and short term) might create boundaries for maintenance, such as technical issues (safety, risks), that trigger the need to adjust the short- or mid-term maintenance
plan. Such interdependencies must be prevented whenever possible; if not, they must be reflected in the timelines and O&M steering and reporting cycles to prevent lengthy update cycles.

**Module 4: O&M Steering Model and KPIs**

Operational efficiency and transparency are vital to a consistent steering model, but neither is possible without measuring key performance indicators (KPIs). This is nothing new, of course, but using KPIs in a systematic manner will help avoid using them in a way that rewards the wrong incentives. As Albert Einstein said, “Not everything that can be counted counts, and not everything that counts can be counted.”

With this in mind, our **O&M KPI diamond** allows for a consistent approach for reporting KPIs across all levels. The diamond comprises the six dimensions most relevant for O&M controls, each dimension consisting of several KPIs (see figure 4). When selecting KPIs, four main areas are considered:

- **Relevance.** Why measure hundreds of O&M indicators and then analyze them unless you understand the relevance of each? Logically grouping indicators to overall goals can help focus everyone on the true and relevant data.

- **Transparency.** KPIs must be clearly defined and communicated to staff. Furthermore, they must be measured and reported regularly and, whenever possible, fully automated.

- **Reliability.** Data must be measured precisely, which often requires additional sensors and instrumentation. This should be planned for during the design and construction phase of a plant.

- **Control.** Even transparent and reliably measured data won’t help if the ways to use that data to improve performance are unclear.

In our experience, more than 50 O&M-related KPIs have proven their effectiveness in operational excellence programs in power generation. They range from central-level to plant-level indicators, and from commercial to technical objectives. We use a KPI selection framework to assess and choose KPIs tailored to meet the needs of individual companies.

The reporting structure must match the KPI framework. Hierarchical, modular, and IT-based

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**Figure 5**

A focused O&M strategy results in more uptime and significantly fewer losses due to failure

<table>
<thead>
<tr>
<th>Focused O&amp;M strategy</th>
<th>Non-focused O&amp;M strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calendar time (h)</td>
<td>Calendar time (h)</td>
</tr>
<tr>
<td>Planned downtime (h)</td>
<td>Planned downtime (h)</td>
</tr>
<tr>
<td>Losses due to failure (h)</td>
<td>Losses due to failure (h)</td>
</tr>
<tr>
<td>Operating time (h)</td>
<td>Operating time (h)</td>
</tr>
</tbody>
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Note: O&M = operations and maintenance

Old plants with focused maintenance activities reach competitive availability

Old plants with low planned maintenance activities imply poor availability

Source: A.T. Kearney analysis
reporting structures allow for fully automated, customized reports that meet the needs of different positions. So a plant manager does not get the same report as an operations manager, and neither is spammed with unnecessary or irrelevant data. That said, systems often allow for drill-down functionality in case either manager wants more detail.

Similarly, we use more than 40 templates to set up reporting systems that link incentives across all levels to align the entire O&M organization on the same objectives.

Module 5: Maintenance Strategy
Power generators with a focused, system-related maintenance strategy—with planned downtime—will have more up time, less unexpected downtime, and fewer losses from failures (see figure 5 on page 5). Typically, the five maintenance strategies highlighted in figure 6 specify when to replace a piece of equipment:

- **Corrective.** Replacement in case of failure and best applied for low-risk equipment.
- **Time-based.** Replacement after a pre-defined number of cycles or time intervals. This works best for equipment with time-dependent failure probabilities.
- **Condition-based.** Replacement depends on the state of the equipment; the equipment is monitored continually.
- **Reliability-centered.** Maintenance resources are optimized based on equipment reliability.
- **Risk-based.** This overarching framework allows maintenance measures to be prioritized based on importance and reliability.

The first three strategies allow for peak availability, while the last two can reduce maintenance costs. To do so, however, both the reliability-centered and the risk-based strategies will require more sophisticated tracking to establish failure probabilities for defined components or systems.

While every power plant has a maintenance strategy mix in place, we often find that the mix is not systematically developed, documented, or continually improved. In fact, most strategies are dependent on the judgment of a few experts. Our approach, by comparison, is systematic; designed to achieve an optimal strategy mix across the entire plant or fleet. It is based on three levers:

- **Modularity.** Maintenance strategies are often developed at the system level, making them generic in nature. However, giving them a suitable level of detail (at the subsystem, component, and sub-component levels) allows for improving the overall strategy mix, and hence, improving equipment availability at even lower costs.
- **Strategy.** Historically, choosing a maintenance strategy has been a secondary concern because of low cost pressure. This changed considerably in recent years, however, as the focus turned to finding suitable strategies that can improve maintenance costs at the required level of modularity.
Indeed, in our work, we apply a proven strategy decision framework that considers the overall architecture of a plant (that is, the redundancy of components) and other technical and commercial parameters. Importantly, defining a strategy doesn’t stop at the current technical setup of the plant. For instance, upgrades, such as measuring devices that allow for a more sophisticated maintenance strategy, must be part of the approach. The costs for such upgrades are often far outweighed by their positive financial impact on the company, so they are definitely worth considering.

**Coordination.** Defining the ideal strategy mix for all equipment on the modularity level requires harmonization—both in selecting the right strategies, as described above, and applying them in a coordinated fashion. For example, synchronizing time intervals for time-based maintenance improves efficiency.

Deploying these levers systematically, along with the required in-house and third-party capabilities, will ensure a best-in-class maintenance operation—one that increases availability by 4 percent on average, based on our experience.

Our work for a major petrochemical company touches on this concept. Briefly, when the company decided to expand its power generation business with combined cycle gas turbine (CCGT) plants, we supported the maintenance strategy setup, from definition to implementation. The primary target was to excel in cost and availability performance, so a two-phase approach was drawn up. Phase 1: Identify all corrective, time-based, and condition-based maintenance needs. Phase 2: Develop reliability and risk-based maintenance strategies.

Our joint team defined maintenance strategies at the system, subsystem, and component levels, and developed a maintenance service outsourcing process, leading to the selection of local and international providers.

By the time our work was done, the company’s maintenance cost position, when benchmarked against top-quartile plants, indicated roughly a 5 percent cost advantage.

**Module 6: Maintenance Sourcing**

Conventional power plants are complex facilities, with volatile maintenance workloads that often require specialized expertise. As a result, contractors do a large percentage of maintenance activities. Choosing the right contractors and assuring quality are crucial for securing availability and avoiding unexpected failures.

Little has changed on the supplier landscape over the years, which means the entry barrier for new suppliers is quite high. There are a couple of reasons for this. First, established suppliers have acquired a lot of knowledge about plant equipment, so seeking out new relationships often contains too many unknown variables in the eyes of most power plant executives, even if current costs seem high. Second, even when power plant personnel are ready to look for new suppliers, the complexity of the selection process can be daunting. It is far more difficult to source services than equipment.

We solve both issues in four steps:
- Define maintenance activities. Define all maintenance activities for each piece of equipment to increase transparency.
- Map identified tasks with in-house capabilities, select tasks to be performed by third parties. For most equipment, maintenance activities are outsourced, while strategy development, planning, steering, documentation, and others are handled in-house (see figure 7 on page 8).
- Decide contract type. Should we go with full service agreements or frame contracts? In general, the plant’s powertrain (especially for new plants) will be covered by service agreements. But, with more up-time and in-house expertise, frame contracts could be considered.
Execute requests for information or proposal (RFI or RFP). Provide potential suppliers with precise and detailed descriptions of requirements so they can submit accurate and easily comparable quotes.

This broad, four-step process is designed to provide insight into maintenance service requirements and costs, to obtain state-of-the-art maintenance know-how, to improve costs, and to get the best use of in-house and supplier capabilities. In our experience, companies using these tactics can save between 10 and 15 percent on their maintenance costs over the short to medium term in activities covered by frame contracts. Furthermore, longer-term savings within this same range can come from renegotiating service agreements.

Module 7: Life-Cycle Cost Management
Understanding how the market will develop in the future is an essential part of planning and steering...
operations and maintenance. Regulatory and political decisions and expansion of renewable energy sources are already altering the operating characteristics and needs of conventional coal and gas-fired power plants, and will continue to do so for years to come.

The actual and anticipated reduction of operating times, combined with additional cost and margin pressures, require more transparency and an examination of different operating and maintenance scenarios. A comprehensive life-cycle view is a necessary prerequisite for adapting to future operating requirements.

Companies in asset-intensive industries—all quite familiar with market volatility—use life-cycle costing (LCC) models to gain insight into their current O&M costs and to prepare for new requirements and cost pressures. Our LCC approach, a cross-industry tool tested and proven for the utilities industry, occurs in three phases:

**Phase 1:** The LCC model is tailored to each operator’s unique situation. Requirements are built on the stages of excellence shown in figure 8, and consider key dimensions such as the degree of automation, complexity of the system, and the mathematical model. The algorithm and evaluation options include developing different cost and operating scenarios and defining the aggregation possibilities on a block or plant level, or across locations.

**Phase 2:** Armed with the customized LCC model and framework, we now capture maintenance strategies, maintenance measures, and their costs on a component level. Next is to identify corresponding risk levels over the assets’ lifetime (see figure 9). We cover the entire range of applied maintenance strategies—corrective, time- or equivalent-operating-hours-based, condition-based, and risk-based. Each strategy is captured with its relevant parameters; for example, when considering time-based maintenance, frequency is also considered. To simplify the process, we provide a unit list for power plants, which includes more than 50 standardized units and up to 500 maintenance measures.

**Phase 3:** In the final phase, we analyze the long-term development of costs and risks based on different operating scenarios and cost levels to identify the optimal maintenance strategy, as well as the corresponding parameters and measures.

**Figure 9**
The development of life-cycle costs and risk

![Cost-level 1](LCC and risk development)

![Cost-level 2](LCC and risk development)

*Note: LCC = life-cycle cost*

*Source: A.T. Kearney analysis*
We know from our work that the LCC approach can cut costs from 12 to 19 percent, without a direct impact on availability. (The potential cost reduction combines with increased risk, although the risk tradeoffs differ widely, from nearly neutral to a 15 percent increase.) Additionally, comparing maintenance strategies, costs, and risks across blocks and power plants can improve the cross-plant allocation of the maintenance budget—ultimately reducing overall costs and risks of the entire power plant fleet.

What’s more, a life-cycle focus can reveal accumulated maintenance needs from past or present restrictions. Further, it proves valuable to

Figure 10
Scenarios evaluate maintenance measures and LCC costs at the system and sub-system level
understand deferred maintenance measures—otherwise outside the planning period and thus “out of scope”—or to uncover revision cycles and needs not coordinated among plants. It is also ideal for prioritizing maintenance measures based on their costs and opportunities, and for applying different levers—such as maintenance interval length, scope, project management, and spare parts management. Figure 10 highlights the trade-off between maintenance intervals and scope, illustrated in three general scenarios, to maintain a water and steam circuit.

Finally, it is no coincidence that the LCC approach aligns with the maintenance strategy and sourcing modules in our O&M Pyramid.

As an example: A leading European utility used our LCC approach in its fossil power plants. The objective was to optimize life-cycle costs to meet a top-down O&M budget allowance, while also improving availability and flexibility. We used LCC to capture maintenance strategies and define measures for each power plant at the system and subsystem levels; and developed scenarios to simulate annual maintenance and opportunity costs, and failure risk.

The company realized a 19 percent cost reduction without a direct impact on availability and only slightly higher risk.

Module 8: O&M IT System Setup

The IT system setup is a major player in O&M—ensuring that activities are carried out in a way that improves power plant availability and reduces costs. IT systems allow for the standardization of O&M processes and structures across power plants, ensure sustainable operational excellence over time, and lead to O&M synergies.

The IT architecture can be divided into five parts—or so-called IT continents:

- **ERP.** The enterprise resource planning (ERP) continent includes all finance, control, and HR-related functionalities required to operate a power plant. The systems are usually predefined with existing ERP systems.

- **Asset management.** This is the strategic power base that provides business-wide asset management functionalities necessary to steer O&M and control the power plant portfolio. Here, best-in-class business intelligence solutions collect required information from various systems and provide analysis, reporting, and dashboard functionalities.

- **HSE management.** The health, safety, and environment (HSE) continent contains all functionalities for defining HSE policies and reporting performance at the group level.

- **Procurement and inventory management.** This continent encompasses the procurement of materials and services, inventory, and warehouse management. These functions, often covered by the ERP system as well, are included in the computerized maintenance management system (CMMS).

- **Operations and maintenance.** This includes all functions for the planning, execution, and monitoring of day-to-day O&M activities. Usually this area is split into three parts from an IT system perspective: (1) field technology, (2) supervisory control and data acquisition (SCADA) for collection, monitoring, analysis, and archiving of real-time operating figures; (3) and the O&M system, which supports the planning and execution of operations and complete maintenance activities (maintenance plans, work-orders, and status reports).

When it comes to setting up a best-in-class O&M system, the challenge is organizing all of the continents into one integrated IT system (see figure 11 on page 12). In our recent survey of executives at leading utilities to understand their IT approaches, we discovered two best practices in turning these separate parts into an integrated one.

First, **align O&M IT systems across all plants.** Leading companies have defined templates, which
are rolled out to all power plants with only minor adaptations to ensure standardized O&M processes and synergies among plants. Second, their ERP systems tend to have a broad scope. The functional coverage includes the classic ERP space (finance, control, and HR), procurement and inventory management, and CMMS. This ensures that financial and material data usually covered in the ERP system are seamlessly integrated in the processes supported by the CMMS.

However, development of a state-of-the-art IT architecture and system selection are only the beginning. True success depends on the follow-through—the seamless and close management of the system integrator to get the O&M system up and running on time and within budget. In a recent engagement for a Central European power generator, we offered support throughout this process—developing a state-of-the art O&M IT architecture and defining (in close cooperation with the client) the business and technical requirements for use in the system and system-integrator selection process. And we were there through the implementation, closely managing the system integrator to avoid costly change requests. In the end, the company not only met its aggressive timeline but also its full implementation budget, and was reaping the rewards of an advanced O&M system.

A Recipe for O&M
There is no one-size-fits-all answer to improving operations and maintenance. Every company is different, so every module discussed in this paper will find unique applications and deliver individual results. We sometimes tell our clients to think of the modules as ingredients in a larger recipe that can be adapted or combined to their advantage. Take a maintenance strategy (module 5), add sourcing (module 6) and life-cycle costing (module 7), and stir.

The greatest impact on O&M performance occurs when all of the modules are applied systematically. First, define the target: Do you want to reduce costs? Increase availability? Lower your risk levels? Then, by following a pre-defined road map that outlines where and when to bring in the modules, it becomes possible to improve O&M costs from 15 to 25 percent, with an additional 5 percent savings for firms that are comfortable with a slightly increased risk level in terms of plant availability.

And, while the immediate cost savings will almost always depend on market conditions and your appetite for risk, the longer-term results—are designed for longevity: to establish a competitive position well into the future.
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