Predictive Maintenance Strategy for Building Operations: A Better Approach

by Robert Hemmerdinger

Executive summary

Maintenance costs account for almost as large a percentage of a facility's operating budget as energy expenses. But usually this money is spent inefficiently with a reactive "wait till it breaks" approach. This paper shows how a proactive, predictive maintenance approach coupled with analytics can reduce a building's maintenance and energy costs by up to 20%. The pros and cons of different approaches to maintenance are discussed, as well as practical guidance on deciding whether to develop a smart services plan in-house or outsource it.

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Introduction

Building owners invest significant resources in environmental and building control systems. These systems can be costly to operate, yet essential for occupant comfort, productivity, and safety. Keeping systems operating at peak performance also reduces energy use and lowers utility costs, a growing concern for building owners worldwide.

Maintenance constitutes a significant percentage of expenses in most facilities, and is therefore worth optimizing. As shown in **Figure 1,** maintenance costs consume nearly as much of a typical facility's operating budget as utility costs and amount to more than one-third of the total operating expenses.

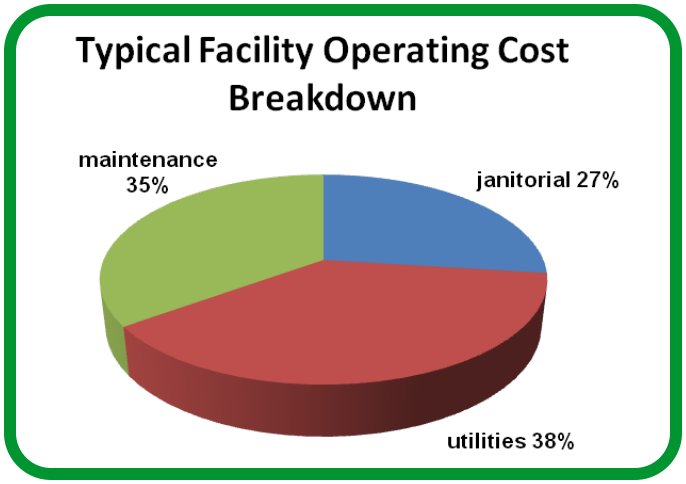


Figure 1
Maintenance expenses are almost as big a part of a building's budget as energy costs.

Source: IFMA, October 2009

The question is, where and why is this money spent — and can the amount be reduced while maintaining or improving building performance? To answer this question, first one needs to understand the different approaches used to manage facility maintenance.

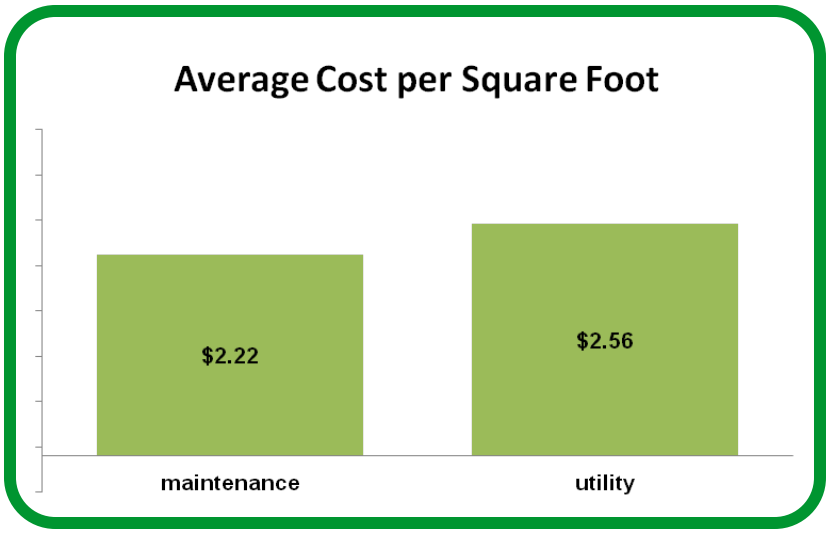
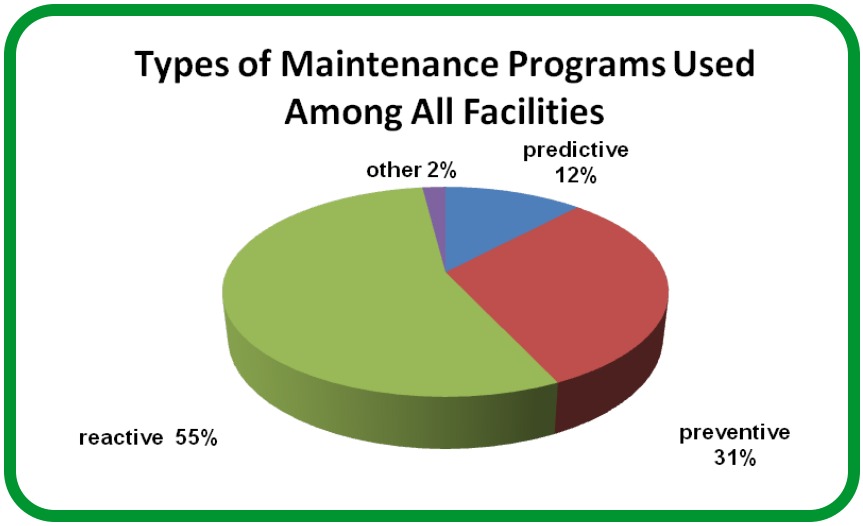


Figure 2
A typical facility's maintenance costs per square foot are almost as expensive as energy costs.

Source: IFMA, October 2009

Despite the importance and expense of maintaining building efficiency, most building owners/operators — some 55% in the United States[1] — rely on **reactive maintenance** programs to care for their equipment. (See **Figure 3.)**[2] This means they wait until equipment falters or fails completely before initiating corrective action. In fact, referring to reactive maintenance as "maintenance" is a misnomer; it should really just be called "repair." By waiting until actual failure, these building operators ensure that repair costs will be at a maximum and that there will be interruptions in service while the repairs are made.

Figure 3
Most facilities take a reactive approach to maintenance — the least cost-effective method.



Source: US Department of Energy, August 2010

"Referring to reactive maintenance as 'maintenance' is a misnomer; it should really just be called 'repair.'"

Slightly less than a third of building operators take a **preventive maintenance** approach, which means performing regular, prescheduled maintenance checks and repairs — whether they are needed or not. This approach yields better results but is still not optimal.

A more efficient way to incur minimal costs and achieve maximum availability is to implement service plans that use proactive and **predictive maintenance** based on the actual condition of equipment rather than a predetermined schedule. With this approach, equipment is maintained at a continuously high level of performance rather than waiting for something to fail. In addition, a predictive approach can be used to prioritize repairs and maintenance so that the most important systems (as judged by the building owner/operator) are repaired first, ensuring the most effective return on investment (ROI).

While reactive maintenance is the most popular approach, and predictive maintenance the least so, among top-performing facilities the opposite is true (see **Figure 4**).[3] The highest-performing facilities overwhelmingly use preventive maintenance and rarely utilize reactive maintenance.

[1] "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy, August 2010
[2] Worldwide percentages are similar.
[3] Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy, August 2010

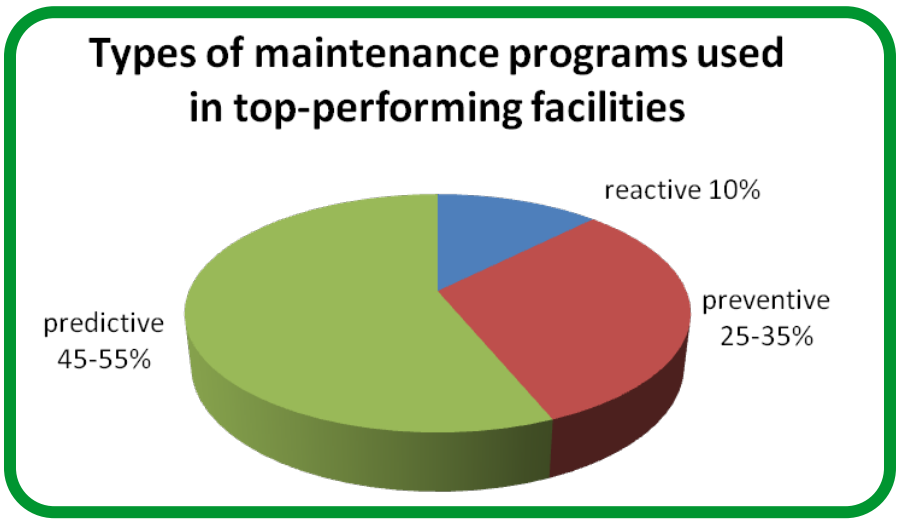


Figure 4
Most top-performing facilities take a predictive approach to maintenance — the most cost-effective method

The most efficient approach is to include advanced **analytics** to leverage the big data generated by today's modern building management systems (BMS). This data provides accurate, timely, and actionable information that can be leveraged to refine service programs even further and achieve optimal building performance and cost-effectiveness. Building owners/operators can make data-driven decisions based on the impact that the recommended maintenance will have on the efficiency of buildings' performance.

"Proactive, predictive maintenance and analytics can save up to 20% per year on maintenance and energy costs."

According to U.S. government figures,[4] such a comprehensive operations and maintenance program for energy and water systems, based on proactive, predictive maintenance and analytics, can save up to 20% per year on maintenance and energy costs, while increasing the projected lifetime of the building by several years. The predictive maintenance approach is gaining ground among facility owners and operators, as experience with this type of approach grows and the cost-justification increasingly becomes understood.

This paper compares the pros and cons of the various approaches to maintenance, with a particular emphasis on using analytics software to leverage BMS data. It then discusses some of the issues that building owners/operators should consider when choosing a vendor to provide the components of a "smart service" plan that the building owners/operators cannot or do not choose to provide themselves.

A note on terminology: The terms used in this paper to describe the three maintenance approaches — *reactive, preventive,* and *predictive* — are generally recognized and accepted by facility professionals. Some professionals use the term *proactive,* but that is not precise enough for the purposes of this paper, since that term can cover both preventive and predictive maintenance.

Reactive maintenance: pros and cons

Reactive maintenance is the practice of fixing equipment when it breaks down or when performance deteriorates to a point that is no longer acceptable. This is the traditional approach to maintenance, because it is the most natural — we tend to fix things when they break. That's also why it is the most commonly used — it's how things have always been done, and offers the path of least resistance.

Advantages The apparent advantages of this approach are twofold. In the short term, it can seem to cost less. For example, in a given week, the cost of maintenance equals only what it takes to repair a broken unit. If nothing breaks, then very little has been spent on maintenance. However, as discussed below, these savings are an illusion. The second

[4] "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy, August 2010

advantage is that it requires minimal staff. Most facilities practicing reactive maintenance employ the minimum staff required to "get by," and equipment is fixed as the staff can manage it.

This approach might work well when all equipment is new, since a high degree of uptime and sound performance are reasonable expectations early in the equipment's lifecycle.

Disadvantages The disadvantages of reactive maintenance are numerous but mostly not visible to management, which is why so many facilities continue to use this approach. Frequently cited disadvantages include:

- Increased cost due to unplanned downtime of equipment
- Increased labor costs, especially if overtime is needed
- Cost involved with repair or replacement of equipment
- Possible secondary equipment or process damage from equipment failure
- Inefficient use of staff resources — who are always in "firefighting mode"

In most cases, these disadvantages are simply the opposite of the advantages. For example, consider the cost of unplanned equipment downtime. Any savings achieved by not doing repairs on the boiler in one week are more than wiped out if the heating breaks down the following week in the middle of winter. Productivity could grind to a halt if it's too cold to open the offices. Business is forced to wait for the maintenance staff to make the needed repairs.

This can lead to the second point, increased labor costs. Business necessity may require that outside help be called in or that the staff be paid overtime to work extra hours. And if the business chooses not to pay that expense, it must wait until the building is habitable again. Either way, this scenario adds substantially to maintenance costs.

"The apparent cost savings of reactive maintenance are an illusion."

Although reactive maintenance can work with new equipment, there is a caveat. In the same way a new car needs regular oil changes, new equipment needs monitoring and adjusting, and possibly early-intervention maintenance. Failure to provide such maintenance will eventually lead to the same fate as the automobile that did not receive proper care from day one — just as the car's engine will seize up, building systems will fail prematurely and the lifetime cost of equipment will skyrocket.

Simply, it is cheaper to change the oil regularly than to replace the engine. This maxim is the guiding principle behind the next most commonly used maintenance approach, preventive maintenance.

Preventive maintenance: pros and cons

Preventive maintenance refers to the regular maintenance of equipment according to a predetermined schedule that is based on equipment characteristics and capabilities, usually provided by the equipment manufacturer. To continue the car analogy, this approach can be likened to regularly changing the oil every 5,000 miles, along with other regular service milestones such as 30,000- and 50,000-mile checkups.

A preventive maintenance program typically would include regularly scheduled activities such as changing belts and filters, cleaning indoor and outdoor coils, lubricating motors and bearings, cleaning and maintaining cooling towers, testing control functions and calibration, and painting for corrosion control.

Advantages As would be expected, preventive maintenance does a better job of maintaining uptime and good equipment performance than the reactive approach. For this

reason, it also is less expensive over any significant length of time, because there are fewer emergencies and less unplanned downtime.

"With preventive maintenance, facilities personnel are not necessarily working on the most important things first."

Studies indicate that facilities can save from 12% to 18% using preventive maintenance techniques, versus reactive maintenance.[5]

Disadvantages A drawback of preventive maintenance is the lack of prioritization. In other words, all equipment is treated equally and maintenance is performed by "going down the list" of recommended actions. There is no system for ranking maintenance activities according to potential consequences of equipment failure, so facilities personnel are not necessarily working on the most important things first. For example changing a filter on an air handler would carry the same weight as replacing a temperature sensor in a chilled water system. But the former has minimal impact on building performance, whereas failure of the latter can be catastrophic, especially to facilities with data centers.

The "checklist" approach of preventive maintenance is better than "wait till it breaks" reactive maintenance, but is less efficient and effective than the optimal approach, predictive maintenance.

Predictive maintenance: pros and cons

Like preventive maintenance, predictive maintenance is based on the tenet that a proactive approach is better than a reactive one. However, instead of making repairs based on a predetermined calendar schedule, the predictive approach makes repairs based on the actual condition of the equipment.

For example, in a predictive maintenance program, key operating parameters of equipment are checked regularly by staff or monitored automatically by sensors. The readings are then analyzed and used to evaluate the condition of the equipment and predict the future performance or likelihood of failure.

The key to predictive maintenance is that equipment and system condition determines what maintenance is performed, rather than a preset schedule. This means that repairs are performed at the ideal time, resources are not wasted on unnecessary work, and equipment is maintained at a higher level of performance.

"Predictive maintenance makes repairs based on the actual condition of the equipment."

Advantages Predictive maintenance can save another 8% to 12% overall, versus preventive programs. Surveys show that in some specific areas, the savings can be even greater:[6]

- 10X return on investment
- 25–35% deduction in maintenance costs
- 70–75% fewer breakdowns
- 35–45% reduction in downtime
- 20–25% increase in production

Predictive maintenance activities can be prioritized in-house if staff levels allow. A significant investment in additional personnel and training may be needed. A facility would need a sufficient number of staff that have the technical expertise to continuously monitor and trend all of the data coming out of the BMS and compare that information against optimal performance benchmarks supplied by each manufacturer. Then the maintenance needs to be

[5] "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy, August 2010

[6] "Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy, August 2010

prioritized based on potential cost and comfort impact. It is important to note that most likely additional staff would then be required to actually go out and fix the issues found.

It has been shown that predictive maintenance can extend the lifetime of a building by several years. Other benefits include increased safety from properly maintained equipment, greater comfort and productivity for occupants, and better compliance with efficiency requirements.

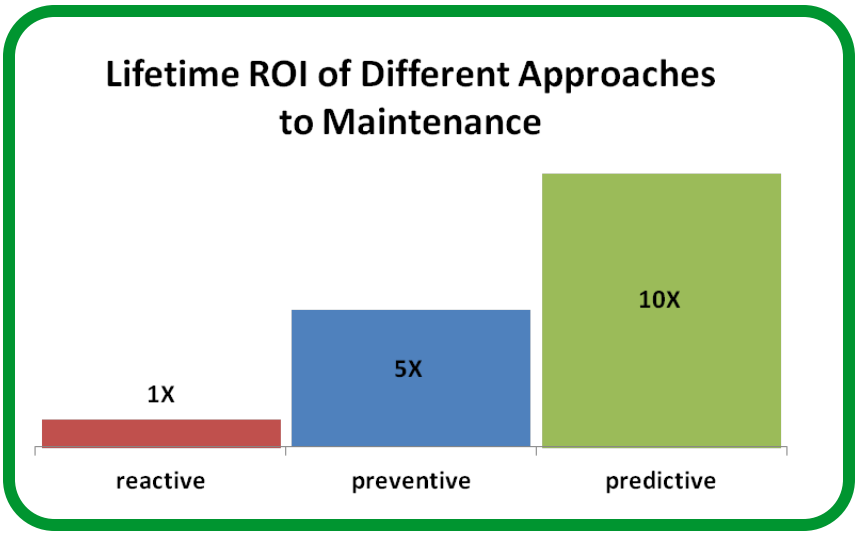


Figure 5
Although carrying a higher start-up cost, predictive maintenance is more cost-effective in the long run.

Source: US Department of Energy, August 2010

"The biggest hurdle will be changing the organizational culture to look at maintenance in a new way."

Disadvantages One perceived disadvantage of predictive maintenance is cost. Organizations may need to earmark funds to implement and support new software platforms capable of capturing data on the actual condition of systems and equipment. Facilities staff may need further training, and perhaps additional staff would need to be hired. These factors obviously require a larger budget than the assumed "no problems" budget of reactive maintenance (i.e., where the planned expense is essentially $0). Whether in-house or outsourced, incorporating analysis and prioritization drives the costs significantly higher. All of these factors will depend heavily on the size and culture of the company that is managing the facility, but the startup cost is not negligible. However, as with the perceived savings in reactive maintenance, this supposed higher expense is an illusion (see **Figure 5**). The return on investment for predictive maintenance is realized several times over. Nevertheless, this higher initial cost presents a challenge for some organizations, since a predictive maintenance program requires buy-in and approval from upper management. The biggest hurdle will be changing the organizational culture to look at maintenance in a new way.

Analytics: pros and cons

As mentioned above, predictive maintenance can utilize automated sensors and expert knowledge to help prioritize maintenance. Taking this concept a step further, it is possible to integrate all of the data coming from the BMS and combine it with advanced analytics capabilities to create a "smart service plan." The plan provides accurate information about facility issues and then ranks them by how they impact the business in different areas such as energy cost, comfort, and maintenance urgency.

Since most buildings today are "smart" to some degree — meaning they have some type of BMS capability — implementing a "smart" service plan is a natural next step. Such a plan allows the facility to leverage the data that the BMS collects and put it to use in new ways to reduce energy use and overall costs.

As a report by IDC Energy Insights states, "End users have heightened visibility into how their equipment is operating when analytics and data management solutions become integrated with building systems. These tools allow the building operator to monitor set points and schedules and establish rules for alarms."[7]

"Adoption of analytics for facility maintenance is expected to grow by 20% annually worldwide over the next few years."

Advantages The expected ROI of a smart service plan can be calculated directly from the facility's data, so its implementation can be justified to upper management. Other benefits include:

- Streamlining operations and maintenance
- Facility differentiation — smart, green buildings are a competitive advantage
- Achieving corporate goals

Case Study

Facility: A 5-year-old, 450,000-square-foot research laboratory serving a mix of lab, office, and educational space.

Smart Solution: Building analytics diagnostics and reporting identified several major problems, including leaking and malfunctioning cooling coil valves in three air handlers and leaking heating coil valves in almost 200 VAV boxes.

Results: Based on the recommendations provided, the operations team was able to schedule repairs by prioritizing the most wasteful leaks first. Repairs resulting in $165,000 (€120,000) in annual savings have already been completed with additional repair work ongoing.

For enterprises that operate multiple facilities, a smart service plan promises even greater return on investment since it enables a broader view of maintenance and equipment performance, allows comparisons to be made among facilities and teams, and propagates best practices.

An additional advantage is the tight integration of maintenance with all other facility operations, giving building owners/operators a single view of their operations. By eliminating the silos of information about a facility, and showing how they all interact on a daily basis, facility managers can make better decisions that take into account all the parameters of building performance and all the stakeholders, from owners and operators to tenants and employees.

Because of these advantages, the adoption of analytics for facility maintenance is expected to grow by 20% annually worldwide over the next few years.[8]

Disadvantages The data analysis capabilities to support a smart service plan are not easy to build internally. First, a facility needs a robust BMS solution in place, capable of gathering large amounts of diverse data on all aspects of building and equipment performance. Second, the kind of analysis software required is not standard in BMS solutions, and in fact requires special expertise by professionals who are skilled in its use.

Some enterprises may wish to invest in developing their own staff to implement a smart service plan, while others may choose to engage a third-party service provider.

Do-it-yourself or outsource?

Some very large companies and government facilities might have the resources to completely manage their own service and maintenance plans. In fact, for enterprises with a large staff and maintenance budgets, predictive maintenance and smart service–type plans will be a logical way to leverage their considerable resources.

Most facility staffs, however, will find it challenging to find, hire, and train the necessary people within the constraints of their budget. As noted earlier, a predictive maintenance plan requires an investment in new staff and training. Some facilities may find it more economical and flexible to outsource the implementation of such a plan. For facilities wishing to take the next step to a smart service plan using analytics, it's even more likely that third-party help will be needed.

[7] "Business strategy: Analytics and data management for Smart Buildings," IDC Energy Insights, November 2012

[8] "Business strategy: Analytics and data management for Smart Buildings," IDC Energy Insights, November 2012

Table 1
A summary table comparing the different approaches to maintenance

Maintenance approach	Pros	Cons
Reactive	• minimal staff • lowest initial investment	• least efficient & cost-effective • increased cost of unplanned downtime, labor, repair • inefficient use of staff
Preventive	• more efficient & cost-effective: 12–18% savings over reactive • less equipment failure/ more uptime	• lack of prioritization • unnecessary maintenance
Predictive	• highly efficient & cost-effective: 8–12% savings over preventive • least equipment failure/ most uptime • improved safety, comfort, productivity, efficiency compliance • greater prioritization	• highest initial investment (staff, training, diagnostics) • savings potential not immediately seen by management
Predictive + analytics	• most efficient & cost-effective • greatest prioritization • streamlined operations • quantifiable ROI to show management	• requires robust BMS • special expertise

Recommended process for vendor selection

- Develop clear objectives (comfort, efficiency, equipment uptime, etc.)
- Develop and apply a screening process specific to the site and expectations
- Select 2 to 4 potential contractors and obtain initial proposals
- Develop major contract requirements using the contractors' initial proposals
- Obtain final bids from potential contractors based on the owner-developed requirements
- Select the contractor and develop the final contract language and service plan
- Manage and oversee the contracts and documentation
- Periodically review the entire contract; build in a feedback process

Source: U.S. Department of Energy

Depending on the scope of operations, most facilities will find it less costly to hire a third-party vendor who already has the expertise on-board and can leverage best-practice experience from many engagements.

A third-party provider of maintenance services should act as an extension of the company's own staff, working closely with the facilities department to provide the needed personnel and expertise, planning guidance, and so on.

What to look for in selecting a vendor depends on an organization's specific goals, size, budgets, etc. Some considerations to keep in mind:

- **Previous experience** Does the provider have experience with this type of facility? Education campuses, government buildings, life science facilities, industry — all these building types present their own special challenges.
- **BMS and analytics capabilities** Even if a building owner/operator doesn't need these capabilities now and only wants a manually implemented maintenance plan today, it may be worthwhile to choose a vendor who offers a broad range of technology and expertise in case they are wanted in the future.
- **Coverage area** Does the provider cover the territories for all facilities? A company with many facilities will find it more effective and economical to deal with one large maintenance contract provider, rather than many smaller ones. Therefore, a global company will probably want to find a global maintenance partner.
- **Contract flexibility** Every enterprise and facility is different and requires its own maintenance contract. The contract should offer options for length, commitment, responsibilities, etc., and these options should meet budget limitations and business goals.

The process used to select a vendor can be an important factor to a successful relationship. The U.S. federal government has published recommended steps to take when choosing an outside provider for maintenance and operations services (see sidebar, **"Recommended process for vendor selection").**

Conclusion

By instituting a formal “smart service plan” that takes a predictive maintenance approach, using either internal resources or a third-party provider, building owners/operators can substantially improve equipment performance, reduce energy costs, and operate a greener facility. Savings can be increased further by using analytics to leverage the data that is generated from building management systems.

Most facilities should consider retaining an outside vendor to operate their smart service plan. Before contacting vendors, facility owners need to educate themselves about a few things. First they need to take stock of their facility’s technical infrastructure. Understanding the capabilities of their facility and any internal maintenance resources is a critical first step. The next step is to contact reputable service providers who can act as a trusted advisor. It is important to find a service provider that offers a portfolio of service plans to avoid being shoe-horned into a one-size-fits-all plan. Good resources include vendor websites, recommendations from other facility managers/owners, and trade publications. Be sure to look online for relevant information, such as case studies and webinars that talk about predictive and preventive maintenance. Government sites can also be a good source of information. The U.S. Department of Energy has published an excellent reference, “Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency.” A helpful site in Europe is BUILD UP, a portal for energy efficiency in buildings. Other regions have their own relevant websites.

It is important to build a case for upper management. Using the arguments and data presented in this paper, augmented with goals and requirements unique to the facility, maintenance and facility managers can prepare a strong business case for predictive maintenance and, optimally, a smart service plan as well.

By educating themselves, establishing clear goals, and screening vendors carefully, facility owners and operators will be able to find a service plan solution that meets their needs and budget.

About the author

Robert Hemmerdinger is director of Buildings Field Services Offer Management for Schneider Electric. He oversees transition services, helping customers upgrade their building management system (BMS). Previous positions include director of iBMS for the systems line of business of Schneider Electric and member of the strategic sales team focused on life sciences and education solutions.