THE EVOLUTION OF PREDICTIVE MAINTENANCE

RETHINKING RESPONSE AND REPAIR FOR TOMORROW'S BUILDING PORTFOLIOS

HONEYWELL FORGE

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EXECUTIVE SUMMARY

While modern industry continues to advance, maintenance models for commercial buildings have remained constant for decades and deliver many challenges for maintenance managers.

With break/fix (reactive) maintenance, assets operate until they break down and then corrective action is taken. With preventive (scheduled) maintenance, checks are performed on equipment to lessen the likelihood of failure. These two methods have many disadvantages along with potentially large expenditures. The current industry mindset is moving toward predictive maintenance that evaluates equipment condition by performing periodic on-line and off-line monitoring to predict the future trend of the equipment's performance. The goal is to perform maintenance at the most cost-effective point. This solution provides competitive advantages by improving asset reliability, lower cost of ownership and operational excellence while removing calendar-based service contracts. Breakthroughs in remote connectivity, cloud computing and IoT and AI-based analytics are advancing to make predictive technology a viable opportunity to create business continuity and efficiency – modernizing out-dated and cumbersome maintenance models.

MAINTENANCE CHALLENGES DISRUPT BUSINESS

While modern industry continues to reinvent itself, maintenance models for commercial buildings have stayed the same for decades.

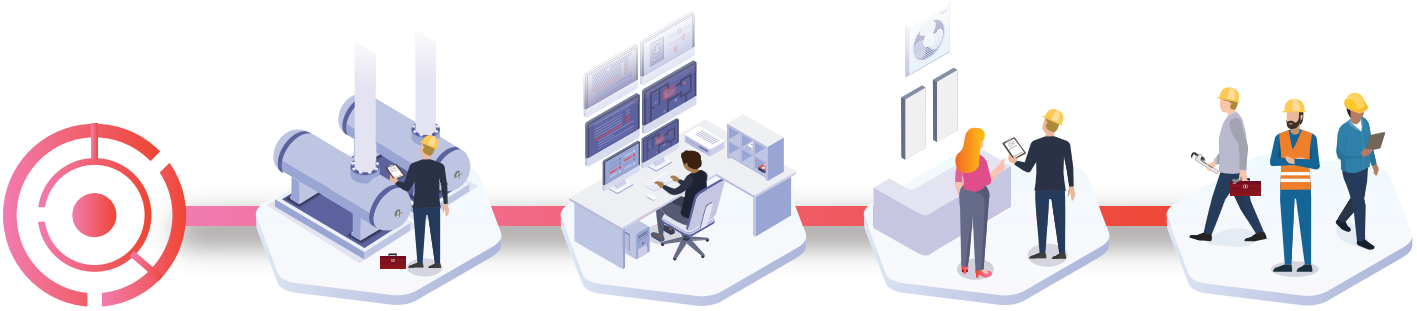
Today, as well as in year's past, there's an uncertain workforce, inefficient processes and a lack of accountability that has building managers, employees and enterprises working harder, not smarter. Oftentimes, maintenance managers are operating with outdated resources, technologies, and workers lacking up-to-date skills.

For example, the inability to forecast equipment failures takes a high toll as unplanned downtime costs an estimated $50 billion a year.[1] When maintenance needs are known in advance, funds can be allocated so the issue can be addressed ahead of failure. Manual inspections are expensive and often an inefficient strategy when trying to diagnose an equipment problem in advance.

Oftentimes when performing maintenance in a commercial building, managers are unable to track previous maintenance as there's little documentation – a paper trail – or a defined record-keeping methodology. This can be problematic for a large building – or series of buildings – that have detailed operations. Capturing and maintaining accurate data when maintenance issues occur is an important strategy for building managers. Determining ROI or assessing performance could be tricky without detailed and accurate records.

And then there's the aging workforce to compound these previous examples. According to the International Facility Management Association (IFMA), the average age of a facility management professional is 49 and within the next decade, half of the existing employees will retire.[2] In addition, building technology is rapidly advancing, providing facilities new ways to increase their efficiency and productivity whilst reducing downtime. These "smart buildings" will require technicians, engineers, and managers who understand and can utilize "smart" technology.

1. Deloitte, "Making Maintenance Smarter: Predictive Maintenance and the Digital Supply Network," May 9, 2017
2. https://foundation.ifma.org/docs/default-source/documents-for-download/gwi-prospectus-singlepage.pdf?sfvrsn=2



Challenges

Manual Diagnostics
Scheduled equipment inspections are an expensive and inefficient strategy for detecting malfunctions in advance

Asset Performance Visability
Without visibility into building performance, business leaders are unable to track or validate optimization strategies

Low Accountability
Time-based, scheduled maintenance contracts provide little transparency into maintenance performance and ROI

Aging Workforce
A diminishing pool of skilled and experienced workers necessitates innovative digitization to ensure business continuity

Maintenance accounts for anywhere from 15% to 40% of total production costs for most businesses.[3] While it may seem like a costly expense upfront, every dollar deferred from maintenance has the potential to quadruple in capital renewal costs later.[4] In fact, running a piece of equipment to the point of failure could cost up to 10 times as much as a regular maintenance program.[5]

"One of the challenges facing the modern maintenance manager is to increase the operational efficiency of the organization and reducing unscheduled downtime by implementing maintenance management programs that appropriately balance preventive, predictive, corrective and replacement options."[6] In order to maximize the productivity of assets, maintenance managers must look at the medium to long-term to ensure the integrity of the maintenance program.

"While maintenance has a primary focus on physical assets and the associated technological/technical elements thereof, maintenance execution is a people-driven process that requires the right balance between process, technology support and leadership."[6] To be successful, maintenance managers must exhibit knowledge of management and communication, along with planning skills. Collaboration is very important in that the manager communicates through various channels (verbal, electronic, print, etc.) with different parts of his/her organization, as well as his/her maintenance staff.

As industry propels into the digital world, our systems must follow suit. The U.S. Department of Energy in their Operations & Maintenance Best Practices Guide: Release 3.0 cites, "Predictive maintenance is highly cost effective, saving roughly 8% to 12% over preventive maintenance, and up to 40% over reactive maintenance."[7] Adopting a predictive maintenance strategy renders scheduled maintenance obsolete by identifying equipment faults before critical failures occur. A true enterprise-wide solution pin-points problems in real-time and diagnoses errors long before a serious breakdown.

Predictive maintenance is cost-effective, streamlines worker duties and enhances an asset's overall lifecycle performance.

3. Dunn, 1987; Lofsten, 2000 https://www.researchgate.net/publication/251887374_A_Comprehensive_Approach_for_Maintenance_Performance_Measurement
4. Rick Biedenweg, President of Pacific Partners Consulting Group https://www.chthealthcare.com/blog/deferred-maintenance
5. https://www.buildings.com/news/industry-news/articleid/21728/title/stop-wasting-money-deferred-maintenance
6. https://www.fracttal.com/en/blog/challenges-faced-by-maintenance-managers
7. https://www1.eere.energy.gov/femp/pdfs/OM_5.pdf

THREE TYPES OF MAINTENANCE PROGRAMS

Streamlining an enterprises' maintenance strategy can extend asset lifespans, reduce energy consumption by maintaining equipment efficiency and improve environmental impact in a meaningful way. With the advent of the IoT and big data innovations, buildings around the world are getting smarter and organizations now have the opportunity to make their data work for them.

So why then are so many commercial organizations still running their facilities with antiquated methods? Let's explore the various maintenance strategies today's companies have to choose from to find out.

BREAK-FIX (REACTIVE) MAINTENANCE

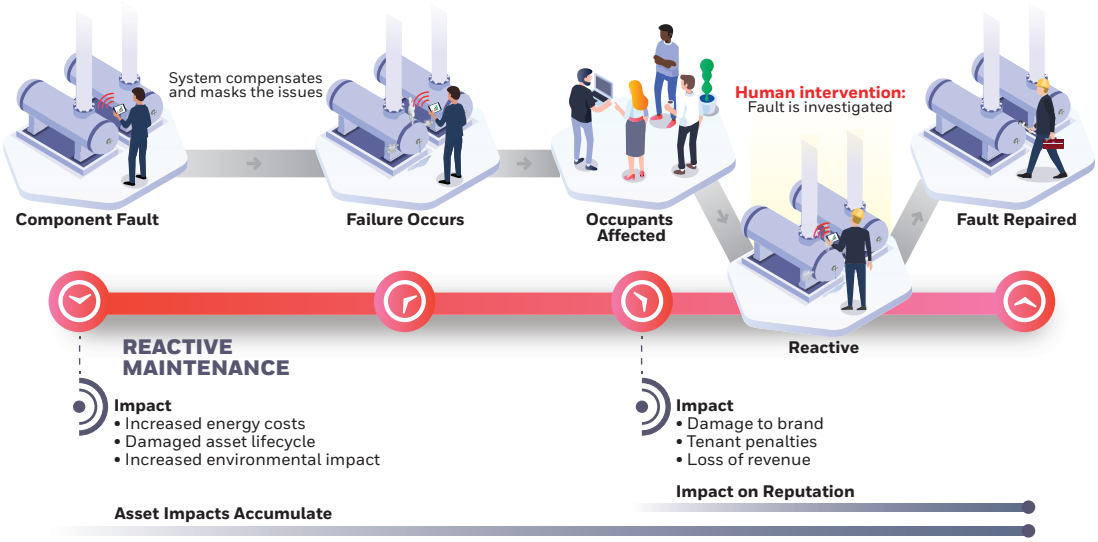
Also known as run-to-fail, the break-fix method is the simplest maintenance strategy. In this scenario, assets are deliberately allowed to operate until they break down, at which point reactive maintenance is performed to correct the malfunction.

Consider a refrigerant leakage. The occupants in the building notice that the building is becoming warmer and not blowing any cool air at all, and someone calls maintenance to look at what is causing the problem. The maintenance technician determines that a refrigerant leak has formed ice around the coil which stops the air conditioning from flowing and must replace it. Until the leak is detained and the coil replaced and working, the building occupants remain uncomfortable and the cooling system wastes energy.

In this scenario, it would be too costly to repeatedly dismantle and inspect the coils, so degradation is only detected when it is so significant that it cannot be ignored. No maintenance – preventative or predictive – is performed on the asset up until this failure.

This strategy is typically implemented on assets that pose no safety risks and have minimal effect on production when they break down. However, the problem with this model is the impact on asset lifecycles and significant effect on a company's reputation.

Besides increased energy costs, damage to and reduction of an asset's longevity and an impact on environmental sustainability, some breakdowns also result in revenue loss and tenant penalties.



Even considering these negative outcomes, some operators shy away from adopting a more proactive maintenance model either because of the upfront costs or the complexity of managing too many disorganized buildings and equipment assets. But the alternative can improve asset lifecycles and business continuity which many operators feel is worth the price tag.

Typically, reactive maintenance is implemented because it is the most affordable practice in the short-term and enables maximum utilization and production output of the asset in its lifetime. This strategy is only beneficial until the asset fails and then must be repaired or replaced. When organizations employ a reactive maintenance model, their maintenance activity is all too often a treatment of the symptom, rather than addressing the root of the problem.

PREVENTIVE MAINTENANCE

Preventive maintenance, also known as scheduled or calendar-based maintenance, is a model where maintenance checks are regularly performed on equipment to lessen the likelihood of it failing. Maintenance is performed while the equipment is still working so that it has less likelihood of breaking down unexpectedly. In terms of the complexity, this maintenance strategy falls between reactive and more advanced, data-driven strategies – and is often carried out using pen and paper. Preventive maintenance is generally classified into two broad categories.

1. **Time-based**

   A time-based, preventive maintenance trigger is a regularly scheduled inspection on a critical piece of equipment that would severely impact production in the event of a breakdown. Typically, the regularity estimations are based on usage patterns, how critical the equipment is to operations and historical evidence of what is best based on the risk profile.

   An example of this type of maintenance is to clean, monitor the temperature and test a on a routine basis. These activities help to prevent problems with such a critical, and expensive, asset and improve energy efficiency by ensuring the chiller is running properly at regular intervals.

   - According to the U.S. Energy Information Administration, a chiller is often the number one energy consumer in a commercial building. When properly maintained, it can last up to 20-23 years in a water-cooled chiller and 15-18 years in an air-cooled chiller.
   - Age is a common cause for chiller failure, but good maintenance can extend lifecycles.

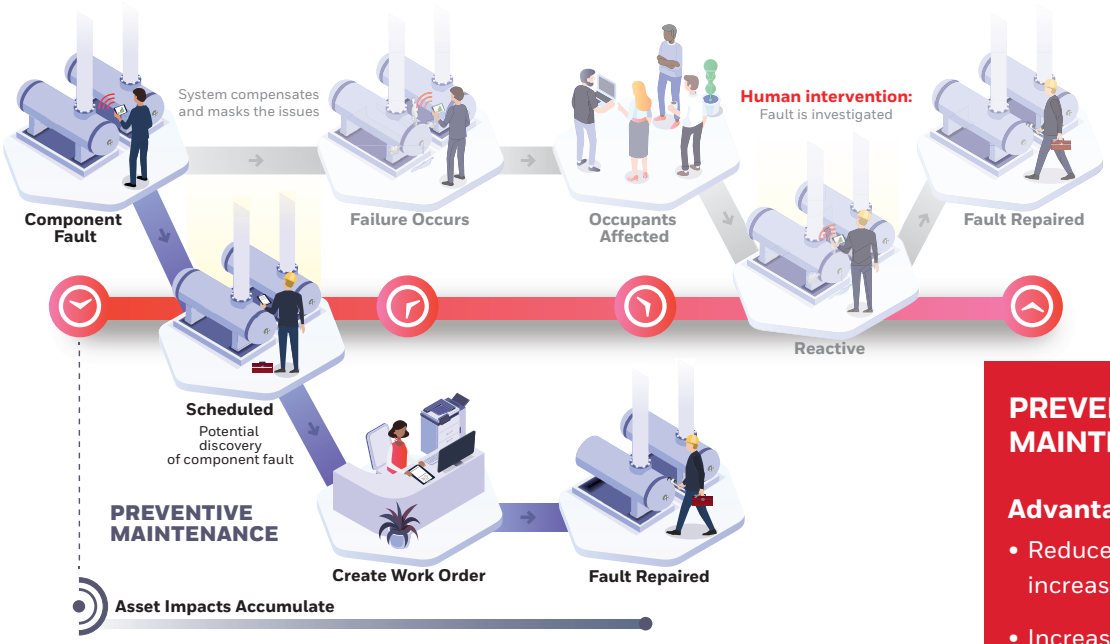
REACTIVE MAINTENANCE

Advantages

- Lower regular operating costs
- Requires less staff

Disadvantages

- Increased energy costs
- Damaged asset lifecycle
- Increased environmental impact
- Damage to company brand
- Tenant penalties
- Loss of revenue due to unplanned downtime
- Occupants affected
- Increased labor time



- The most common causes for chiller failure are compressor, electrical and condenser fan motor problems. It is important to select quality equipment, apply correctly and perform regular maintenance specific to the individual needs of each unit to ensure a long and effective lifecycle.
- Poor maintenance can result in expensive repairs, degraded efficiency and unnecessarily short lifecycles.
- Blanket scheduled maintenance does not consider the unique application and environment of each system, resulting in an inaccurate way to maintain such a critical asset.

2. Usage-based

Usage-based preventive maintenance services trigger after a certain number of hours of runtime, distance or production cycles.

An example of usage-based preventive maintenance is performing oil changes on an automobile every 5,000 miles. In the same way, critical building assets are monitored for run time with maintenance services scheduled at predetermined stages.

Preventive maintenance practices are an industry standard. They are more structured and protective to business continuity and a company's CAPEX (unexpectedly replacing assets) than a reactive strategy. Because maintenance costs are often seen as a cost of doing business, most organizations tend to play it safe and maintain service contracts for their building equipment.

This maintenance model is based on the probability rate of failure rather than concrete equipment performance. Its goal is to extend asset lifecycles, increase efficiency and be more cost-effective in the long-term. However, for some building operators it can be difficult to gauge ROI and justify disrupting business continuity to check a machine with no notable faults. At the same time, little visibility into the accuracy and efficiency of the maintenance work makes it challenging to hold vendors accountable and validate their labor.

While it may be more cost-effective than replacing a machine every time it breaks, maintenance contracts under a preventive model can strain a company's profit and loss (P&L) and are inherently inefficient considering that maintenance is often carried out (and paid for) on equipment that doesn't need to be serviced. This is especially

PREVENTIVE MAINTENANCE

Advantages

- Reduced unplanned downtime / increased occupant productivity
- Increased energy efficiency and savings
- Reduced equipment failures
- Prolonged component lifecycle

Disadvantages

- Component faults may only be discovered at dispersed intervals, allowing inefficiencies to last even longer
- Expensive and labor intensive
- Relies on human accuracy
- Blanket maintenance procedures are inefficient by not providing accurate maintenance to suit each asset's needs
- Equipment components are needlessly cleaned or replaced

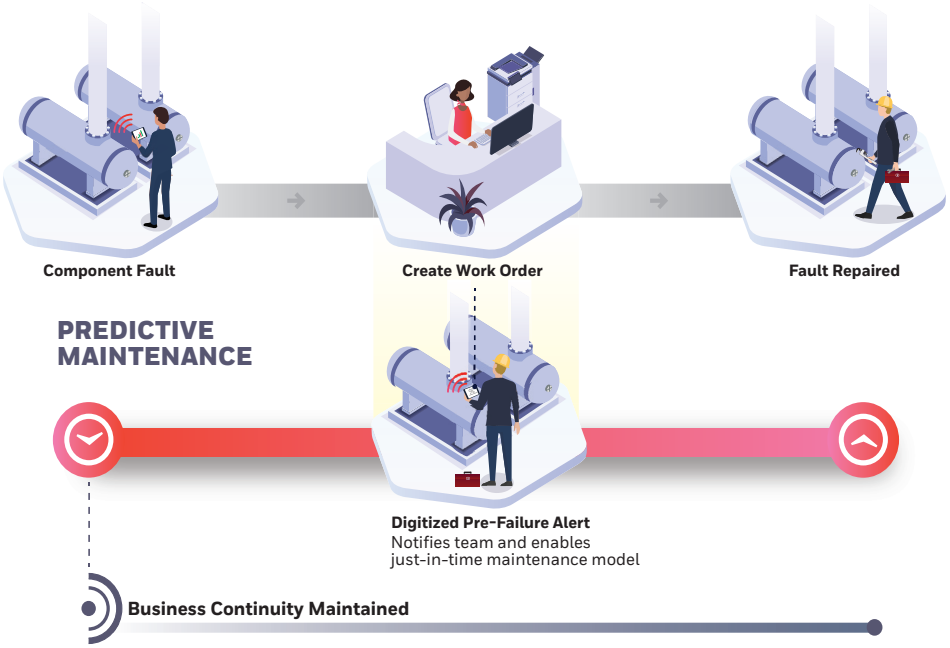
true when considered in the context of a large-scale, multi-faceted operation with dozens or hundreds of buildings and piles of vendor contracts to manage. The complexity leads to costly overpayment of man hours and small parts that could be avoided with a more intelligence-based approach.

Industry standard practices are not always the most innovative practices. Inherent flaws in reactive and preventive models leave organizations at risk of negative impact to assets, productivity, brand reputation and the environment. Deloitte notes that unexpected downtime due to equipment failure results in an estimated loss of $50 billion each year. In addition, reactive and preventive maintenance strategies can reduce a plant's productivity up to 20%.[8] The future of building maintenance involves a next-step change in accuracy and effectiveness that will require a transformation in the way large companies manage maintenance at scale.

PREDICTIVE MAINTENANCE

Predictive maintenance evaluates the condition of equipment by performing periodic (off-line) or continuous (on-line) equipment condition monitoring to predict the future trend of the equipment's performance. The goal is to perform maintenance at the very point when the maintenance service would be most cost-effective – before performance drops below a pre-determined threshold. This approach applies principles of statistical, machine and deep-learning algorithms to determine the point in which the future maintenance activities will be ideal.

Predictive maintenance solutions seek to provide a competitive advantage by improving asset reliability, lower cost of ownership and operational excellence, while removing the need for expensive calendar-based service contracts. In the example of the refrigerant leakage, machine learning techniques can pick up the warning signs of degradation far earlier than they would be found in a normal maintenance environment. Identifying this issue early helps avoid wasted energy consumption and wear on other components as the equipment compensates for the component fault and continues to run inefficiently.



Achieving true predictive maintenance can involve analysis of vibration and acoustic signals, oil analysis, refrigerant analysis and motor condition testing. Some of the newest and most innovative predictive maintenance solutions can minimize the investment required using sophisticated AI and machine-learning (ML) models to interpret data from existing sensors to pick out warning signs of upcoming failures.

8. https://www2.deloitte.com/us/en/insights/focus/industry-4-0/using-predictive-technologies-for-asset-maintenance.html

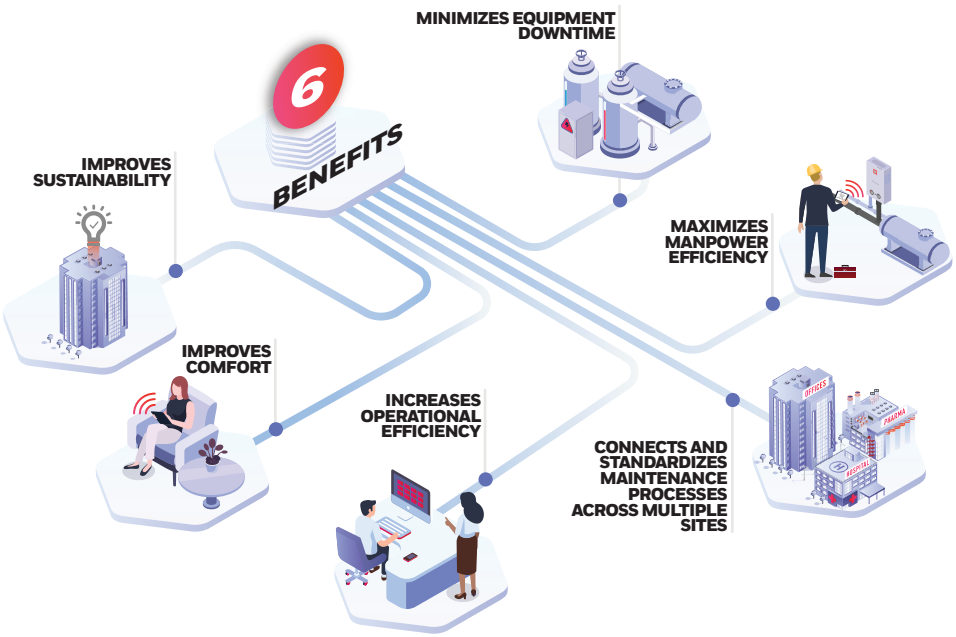
According to the U.S. Department of Energy, predictive maintenance saves 8% to 12% more energy than preventive maintenance and upward of 40% over reactive maintenance. A study by McKinsey & Co. found that predictive maintenance could reduce machine downtime by 30% to 50% and increase the life of machines by 20% to 40%.[9]

Being able to easily interpret data from predictive maintenance solutions, such as the industrial-grade predictive maintenance solution for healthy buildings that Honeywell is prototyping, enables enterprises with an increased probability of detecting equipment problems while also reducing false alarms. This is the kind of dynamic statistical strategy that commercial buildings are looking to adopt.

9. https://www.hartenergy.com/exclusives/benefits-predictive-maintenance-oil-companies-187340

BENEFITS OF PREDICTIVE MAINTENANCE

> Equipment can and will break down – it's part of business. But unplanned downtime is expensive.



MINIMIZES EQUIPMENT DOWNTIME

In a study produced from Aberdeen Research, 82% of companies have experienced unplanned downtime over the past three years and that unplanned downtime can cost a company as much as $260,000 an hour.[10]

Unplanned downtime can also damage an enterprise's reputation. For example, if retailers experience poor performance of boilers or even unplanned boiler downtimes, this could lead to stores being too cold, especially in the winter months when holiday shopping is prevalent. Consequently, shoppers are negatively affected and leave early, instead of extending their time shopping. This type of equipment downtime can have a negative impact on sales in a prime period. With predictive maintenance, it can be anticipated when equipment may need attention and issues addressed proactively rather than wait for the problems to arise. As a result, equipment downtime and disruptions to business are minimized.

MAXIMIZES MANPOWER EFFICIENCY

By predicting when equipment will need maintenance, a building operator knows exactly when to dispatch the appropriate technician, and the technician can be prepared with the right tools to do the job. There won't be any guessing about who can do the work and if the person has the necessary tools to do so.

10. https://iiot-world.com/predictive-analytics/predictive-maintenance/the-actual-cost-of-downtime-in-the-manufacturing-industry/

Additionally, with a great deal of the older workforce retiring, more of their time should be allocated to training and mentoring the younger workforce – not being pulled in different directions to fix equipment at any given moment.

Considering the amount of time and energy spent on routine checks and preventative tasks, the case for predictive maintenance insinuates a reduction in inspection and diagnostics, and an increase in repairs and solution-oriented work.

"Predictive maintenance allows portfolio and facility operators to address the right issue with the right person and the right part at the right time," notes Billy Turchin – Chief Product Officer, Honeywell Connected Buildings.

The National Academies of Science, Engineering and Medicine report, "Predictive testing can reduce facilities maintenance costs and improve availability by enabling just-in time maintenance of facilities systems and related equipment."[11] This fiscally strong strategy permits initiation of timely maintenance actions. Out of an average working day, only 24.5% of the average maintenance worker's time is spent performing productive tasks. Doing the math for an average maintenance technician based on average salary, the total time spent on unproductive tasks comes out to about $38,082 in labor costs per personnel per year and those costs are passed directly to the end customer through their existing schedule maintenance contracts. If this has such a deep impact on service within a company, consider the significance it plays in an entire building's capacity to run affordably and efficiently.

"PREDICTIVE MAINTENANCE ALLOWS PORTFOLIO AND FACILITY OPERATORS TO ADDRESS THE RIGHT ISSUE WITH THE RIGHT PERSON AND THE RIGHT PART AT THE RIGHT TIME."

Billy Turchin – Chief Product Officer, Honeywell Connected Buildings

CONNECTS AND STANDARDIZES THE MAINTENANCE PROCESS ACROSS MULTIPLE SITES

For large organizations with multiple and oftentimes isolated locations to manage, predictive maintenance technology can bring sites together so enterprise businesses can draw a holistic view of the activity and performance to make better, more informed decisions. Working within a single system eliminates data (and financial) silos with disparate systems across sites. Unlike what is common today, maintenance managed at different locations using paper or manual processes, which leads to decentralized decision making and a complex vendor management problem.

Consider a healthcare system with numerous sites, each with and a complex infrastructure of multiple buildings. Like many, this industry relies on equipment to function without hiccups and also needs strong data security to protect patients and staff. Predictive analytics can allow facilities managers to remain one step ahead so they can identify potential issues early enough to make informed decisions and avoid critical failures across the portfolio.

This technology can also break down communication barriers in what is often a series of siloed operations, by analyzing historic data across multiple channels to predict future outcomes and identify patterns throughout the entire system. Rather than operate each site, or building as its own entity, an intelligent service strategy enables a broader view of maintenance and equipment performance, draws connections between buildings and teams, and ultimately drives a greater return on investment.

INCREASES OPERATIONAL EFFICIENCY

When equipment goes down unexpectedly, it affects manpower, projects and general business continuity. Predictive maintenance involves a single integrated system, a cohesive approach to asset management. It enables teams to share data and make better decisions, while reducing labor and costly rework. So buildings experience more uptime while reducing costs.

One illustration of how critical equipment efficiency is to an operation is in cold chain transport – a temperature-controlled distribution chain used in highly

11. https://www.nap.edu/read/9226/chapter/7#22

regulated industries such as Pharmaceuticals. The fundamental components for this technology are product, origin and destination and distribution.

Many pharmaceutical products must be maintained at a precise temperature. Variation by even one or two degrees could ruin an entire shipment and cost the manufacturer a great deal in asset loss. Efficient management of a cold chain supply line is essential to maintaining the integrity of the product. Klinge Corporation manufactured a line of cold chain containers designed for this specific purpose. Technology that can spot minute changes at a moment's notice can be incredibly beneficial to operations that depend on stability of the product.[12]

Employing analytical data to improve the efficiency of the machinery means there is no longer a need for unnecessary maintenance and less equipment failures that impact the day-to-day operations. This results in extended lifecycle for the machinery and any issues uncovered by the technology can be scheduled for repair when the machine is offline. If these technologies can be tuned to this level of accuracy in a supply chain, consider the benefit in their application across a fleet of buildings – each with critical systems and too few people to properly manage manually.

IMPROVES COMFORT

Enhanced comfort conditions and energy savings do not have to be mutually exclusive. Building comfort promotes a better employee or occupant experience, increases productivity and protects brand reputation.

Poorly maintained equipment may fail to regularly maintain desired comfort conditions. For example, if one unit fails, others may be able to pick up the slack in moderate climate conditions, but as weather becomes more extreme, and the issue persists without service, the equipment may not have the capacity to keep the building conditions within limits. Identifying problems early through predictive maintenance allows a building operator to perform service before other equipment overworks to compensate for malfunctioning units, and long before a critical failure.

Cornell University has found that worker performance decreases when workers are either too hot or too cold committing 44% more errors and showing less than half their normal productivity in colder temperatures.[13] The more comfortable employees are, the more productive they will be in tandem. Predictive maintenance eliminates system complexities while improving reliability, cost-savings and most importantly, occupants' and employees' well-being.

IMPROVES SUSTAINABILITY

Large buildings, plants and factories are some of the highest consumers of energy. According to the U.S. Department of Energy, maintenance techniques targeting energy efficiency can result in an annual savings of up to 20%.[14]

Buildings account for up to 70% of energy consumption in major cities – and 30% of greenhouse gas emissions globally.[15]

While preventive maintenance may regularly check some components because they are expensive to fix and replace, other smaller, cheaper components can be easily ignored and default to a "run till failure" mentality, even though critical assets can account for the greatest portion of a facility's energy and emissions. SJI Energy Advisors noted, on average, "HVAC systems account for around 30% of commercial facilities' total energy use, and poorly maintained equipment consumes even more energy than necessary." They found that facilities that implement comprehensive maintenance programs see great savings in their energy costs –as much as 15-20%. Keeping an HVAC system running at peak efficiency is vital to reduce wasted electricity and reducing utility bills.[16]

12. https://klingecorp.com/blog/what-is-the-cold-chain-process/
13. http://ergo.human.cornell.edu/Conferences/EECE_IEQ%20and%20Productivity_ABBR.pdf
14. https://energy.gov/sites/prod/files/2013/10/f3/omguide_complete.pdf
15. https://www.forbes.com/sites/insights-inteliot/2018/10/24/smart-buildings-forming-the-foundation-of-smart-cities/?sh=60427810585e
16. https://www.sjienergyadvisors.com/blog/how-preventative-maintenance-saves-you-big-in-energy-costs

A business' maintenance strategy directly influences the sustainability impact and environmental footprint. Assets must be properly maintained in order to meet the sustainability levels expected from their original design.

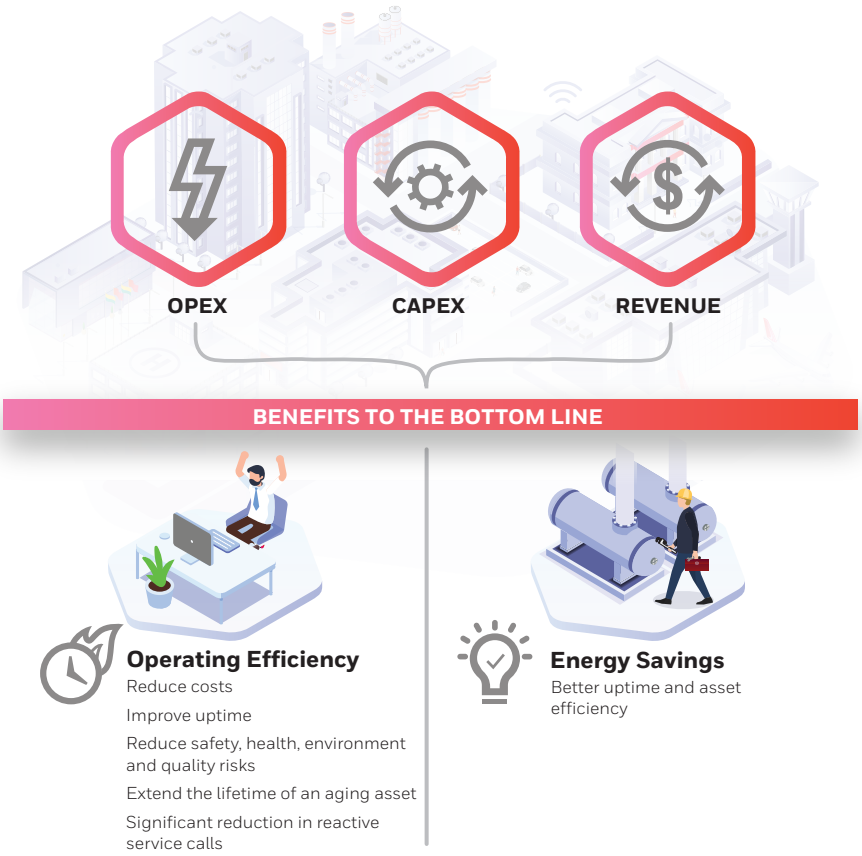
The more efficient a building operates; the less energy and waste is accumulated. Minimizing an operation's negative environmental impact, conserves energy and ensures a safer, more dependable space for employees and their communities.

The tools available for traditional maintenance routes simply do not allow for comprehensive analysis, despite their prevalence and significant energy footprint.

THE RESULT

Maintenance practices impact a range of business operations and cost sectors. From asset lifespan (CAPEX) to maintenance services and utilities savings (OPEX) to occupant experience and brand reputation, investing in modernized maintenance practices can reap new levels of business continuity with end-to-end value across an organization.

Real-time analytics, pre-failure predictions and alerts and visibility into portfolio-level Key Performance Indicators (KPIs) define the sort of strategic transformation operators need to remain competitive. The benefits of this conversion include reduced maintenance and energy costs, increased asset lifecycles and improved occupant experience and productivity. A business that can avoid breakdowns and drive transparency in the outcomes of their service contracts can lean out their operations and their P&L simultaneously.



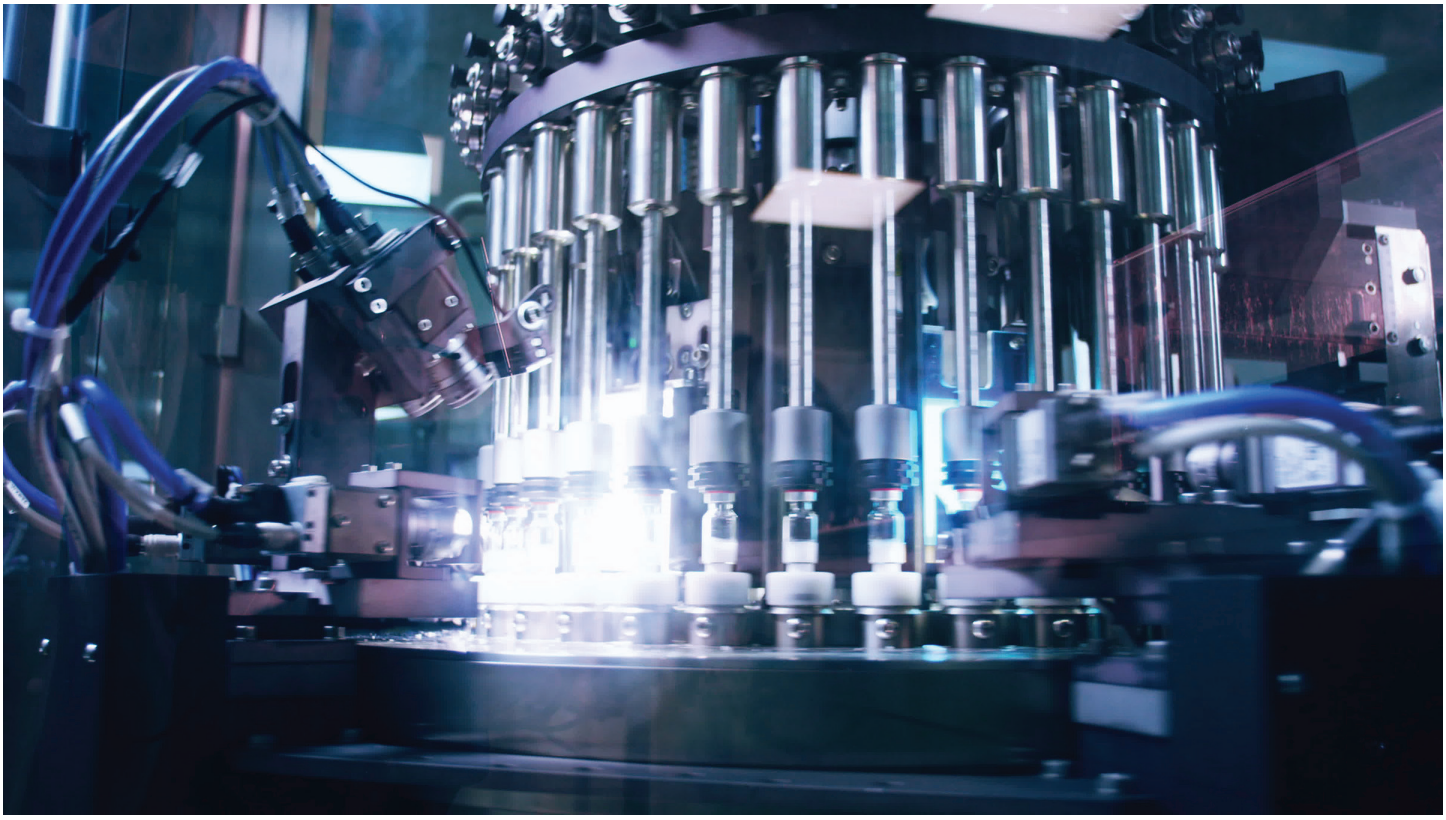
INDUSTRY EXAMPLES

Predictive maintenance technology has applications across industries on a global level. These practices are becoming viable and effective at reducing costs and improving business continuity.

Auto – According to recent reports, Tesla is leaning on new vehicle data to develop cars can self-diagnose internal problems and automatically order replacement parts when an issue is discovered.[17]

Food & Beverage – The food and drink industry plays a huge role in public health. A controlled and stable environment for storage and protection is essential to ensuring safe consumable products. Because broken equipment can result in spoiled food, predictive maintenance practices help maintain operational efficiency, functional performance and compliance with stringent regulatory standards.[18]

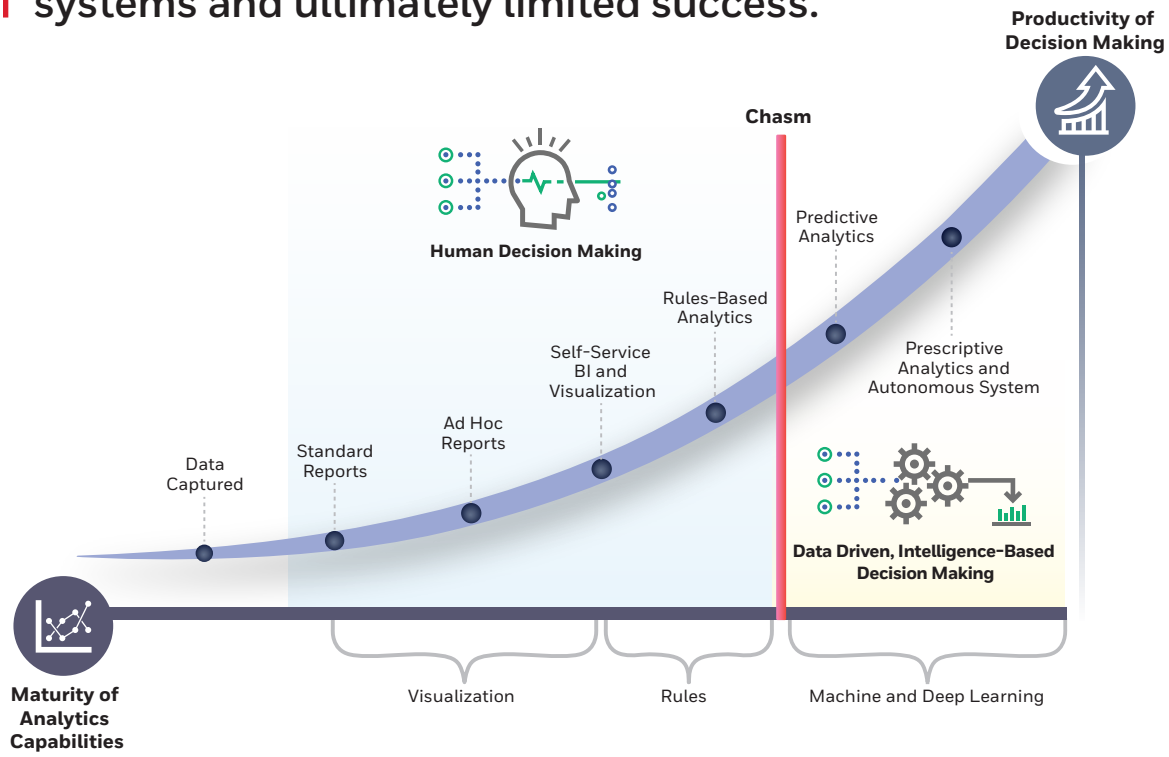
Pharmaceuticals – Pharmaceutical equipment manufacturers, engineers and process plant owners and operators are beginning to leverage emerging predictive technologies that send condition-based data to a centralized server, making fault detection easier, more practical and more direct. By proactively identifying potential issues, companies can more effectively deploy their maintenance services, improve equipment up-time and reduce the cost of maintenance and time-sensitive repairs.[19]



17. https://www.businessinsider.com/tesla-adding-data-driven-offerings-2019-5
18. https://dataconomy.com/2019/08/which-industries-reap-the-biggest-benefits-from-predictive-maintenance-and-why/
19. https://www.pharmamanufacturing.com/articles/2019/the-case-for-predictive-maintenance/

THE FUTURE IS PREDICTIVE MAINTENANCE

The concept of predictive maintenance has been around for more than 50 years. Historically, the challenges of restricted connectivity led to expensive hardware systems and ultimately limited success.



Remote locations were more difficult to access from corporate offices, systems for large scale data storage and analysis were not proven to be scalable and software could be difficult to use, requiring training and expensive customizations.

Breakthroughs in remote connectivity, cloud computing, the IoT and AI-based analytics are now coming together to make predictive technology a viable opportunity in the digital transformation journey for even the world's largest organizations.

Expansion into next generation predictive tools and techniques will yield next-step change value – at scale. And we are beginning to see this trend take hold across a range of industries seeking to cultivate better business continuity and efficiency in the modern era.

For example, a large retailer has been using predictive analytics to improve store checkout experiences. By using predictive analytics, stores can anticipate demand at certain hours and determine how many associates are needed at the counters. By analyzing the data, the larger retailer determined the best forms of checkout for each store: self-checkout and/or facilitated checkout.

GETTING STARTED

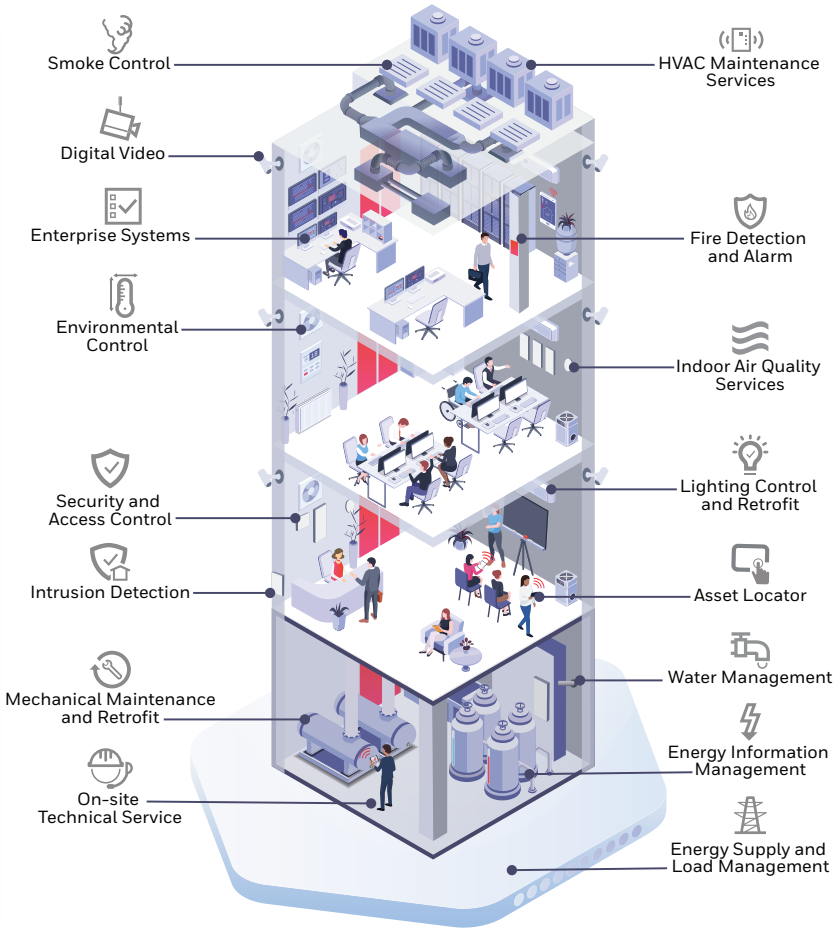
THE BUILDING OF THE FUTURE

Run Your Buildings From a Coffee Shop
Buildings will be cloud connected, remote controlled and managed by a lean central organization.

Better Tomorrow Than When You Built It
Buildings will constantly learn how they behave under changing conditions and automatically adjust to ensure optimal performance.

Enhanced Experience of the Occupants
The people inside the building give the space purpose, and they need to feel safe and comfortable with a frictionless experience with their enviroment.

Accommodate Change and Future Needs
Buildings are living environments that constantly evolve. Honeywell Forge is built to accommodate that change.



BASIC STEPS TO CONSIDER:

1. Moving to predictive maintenance solution is not just a technology choice, it opens the possibility of transforming your entire maintenance operation.
2. Set objectives and KPIs that drive the right behaviors. For example, what do you want for maintenance that is aligned at various levels of your organization?
    a. What KPIs should you have for comfort, energy, uptime and responsiveness to reactive problems?
    b. Do these indicators encourage the behavior you want from your facilities team (including your subcontractors)?
    c. Are individual members of the facilities team empowered to make decisions to meet their KPIs?
    d. Are there incentives aligned to meeting your maintenance KPIs or any incentives that act against your maintenance goals?
3. Take steps to ensure you are working with the right data.
4. Over time, many changes that are supposed to be temporary fixes accumulate in building systems so be sure to review comfort set points to ensure they are aligned with comfort standards.

5. Energy data can be a clue to maintenance issues and energy efficiency can be an important driver for transforming maintenance. It is important to review your energy data to ensure that you are covering the key equipment and the quality is being managed.

6. Good quality maintenance tracking can give you important clues on where to focus your transformation efforts. And, getting good quality data before you start your transformation will give you a baseline that will help measure the results of your program, highlighting the benefits of the approach and potentially giving you feedback on elements to adjust as you mature your program.

7. Review the data you are capturing.

    a. Are you tracking root causes of problems and the major resolution categories? (The more structured, the better).

    b. Is work being tracked against the assets that are failing?

    c. Are you tracking corrective maintenance that happens during preventative maintenance checks or is it hidden?

8. Consider capturing the history of key operating parameters for your equipment (physical values such as temperatures, pressures, fan speeds, damper positions etc. and key control parameters). A history of this data can accelerate the application of machine learning models to your buildings.

9. Start mining the data/creating reports that align with your KPIs. Even some simple reports can point you towards some assets that need attention and help you make your maintenance more data driven.

10. Consider your ideal operating model:

    a. How do you want information to flow between your extended team members?

    b. When you are operating in a fully data driven mode, this would be the approach for most of your maintenance work, but you can start out by implementing your target approach for reactive maintenance.

    c. How do you want faults (reactive or predictively discovered) to be prioritized?

    d. Do you want a centralized model with triage carried out by a small team or a more devolved model?

    e. What processes will you have to ensure there is regular communication in between your controls and mechanical contractors?

11. Consider implementing a near predictive approach as a first step.

Major capital expenses are no longer a necessity to 'get started.' While end-to-end solutions are good on paper, they imply a system that is not agnostic to different manufactures. Open up the possibility of transforming your entire maintenance operation. Get started with a solution that works for you and evolves to fit your specific needs and expectations.

CONCLUSION

There are a number of solutions that can help you move towards a data driven maintenance approach and free up "problem discovery" labor and refocus it on improving the business outcomes (fixing issues!).

A "walk before you run" approach can help with change management. Think about a single supplier who can provide an end-to-end solution. There are a range of solutions available to advance your organization into better maintenance technology. Operators can work with what they already have in place, connect new solutions into old systems and, when they are ready, upgrade to entire operations to the next generation.

For more information
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