



# International Journal of Innovative Research in Computer and Communication Engineering

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## Significant Role of Big Data Analytics and Internet of Things Aspect in Organizational Development, Governance and Sustainability

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**ABSTRACT:** The internet of things (IoT) is set to play a huge role in the near future, especially in industrial sectors. Sensors, manufacturing equipment, pipelines, and smart meters all have the potential to transform how organizations work. IoT generates a lot of buzz because it expands the functionality of organizations and shores up any weakness in their existing operations. According to Gartner, “internet-connected things will outnumber humans 4-to-1, creating new dynamics for marketing, sales and customer service.” In most ways, Internet of Things (IoT) analytics is like any other analytics. IoT analytics use most of the same algorithms and tools as other kinds of business intelligence (BI) and advanced analytics. Even so, the IoT is creating unparalleled information management and analytics challenges. IoT analytics is the analytics platform that can assess the data collected from IoT devices. This variant of analytics is particularly well-suited to analyze IoT data because the devices typically generate a lot of information, in a relatively short time. Statistics show that IoT devices produce 2.5 quintillion bytes of data on a daily basis.

**KEYWORDS:** IoT, big data analytics, governance, organizational development, sustainability, statistics, information

### I. INTRODUCTION

In simple terms, IoT analytics is the analysis of data gathered from connected devices. Big Data, in turn, helps process and make sense of billions of real-time data points. Big Data systems collect chaotic data (as well as all more or less useful information) from connected devices and structure it into data sets that can help a business improve its work processes. Companies benefit from these data sets to automate processes, empower staff, retain and attract more customers, and optimize operations. Many industries have already benefited from IoT Big Data analysis after hiring IoT developers. These fields include marketing, telematics, IoT-based environmental monitoring, healthcare, smart cities, retail, and many others. For instance, e-commerce businesses can use specialized software to analyze client purchases via an app or website, to create a detailed portfolio of their customer base and predict its behavior. Let's now discuss some ways businesses can benefit from implementing IoT Big Data.<sup>1</sup>

#### 1. IoT Big Data solutions can boost staff productivity

Some companies have implemented smart sensors in offices and manufacturing areas to collect data related to performance ratings, employee engagement, and other activities. Managers can use this data to more effectively manage staff and distribute employees' time and effort more intelligently. For example, a system developed by Humanyze works with devices made in the form of badges with sensors. These badges allow the company to collect employee data on more than 100 indicators to track work productivity in real-time. Devices collect data on how employees communicate with customers, what style and tone of conversation they use, and whether employees listen to customers. In particular, this system may help businesses improve the productivity of call center employees and teach them how to better communicate with customers.<sup>2</sup>



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## 2. IoT Big Data solutions can help businesses automate and optimize operations

Using complex IoT Big Data systems, companies can now automate and analyze routine workflows. This can be especially useful in manufacturing, where each element of the product creation process can be automated and improved. The human factor can also be minimized. In case of any malfunction, the system may notify employees of the delay, which will help them solve the problem more quickly. General Motors, for example, uses sensors to monitor humidity when vehicles are ready for painting. If the humidity level doesn't correspond to the norm, the detailed work is sent to another workshop, which consequently shortens the time of the work process.<sup>3</sup>

## 3. IoT Big Data solutions can help businesses improve security

Using a mix of IoT and Big Data, businesses can make their infrastructure safer in terms of cybersecurity. Read how to hire a cybersecurity developer. Companies that integrate AI and machine learning can respond much more quickly to any security threat because the equipment reacts much faster than a human operator. Also, Big Data security systems learn via examples of previous threats, so they become even more effective with added experience.<sup>4</sup>

## 4. IoT Big Data solutions can help businesses enhance the customer experience

Be it a retail shop or a healthcare company, each B2C organization strives to create a better and more personalized customer experience. Implementing IoT data analytics can help. It allows businesses to analyze and process consumer data to learn more about the behavior of customers and predict their future needs and actions. For example, when customers enter a bookstore, the system can tell them which shelf the book they are interested in is located. The system can also send a personal discount or gift coupon to the client. Among other applications, businesses can use IoT Big Data technology to run effective targeted advertising or promotional campaigns. Healthcare organizations can use IoT Big Data solutions to optimize patient flows, as well as increase the productivity of doctors.<sup>5</sup>

## 5. IoT Big Data solutions can help businesses improve equipment maintenance

Measuring heat, vibration, and other important parameters, IoT sensors, and Big Data analytics solutions may help companies in the manufacturing sector determine which equipment requires maintenance. Equipment with built-in sensors can also notify the staff about wear and delivery schedules, and breakdowns. These solutions not only simplify the work of the staff but also reduce risks and make it possible to predict future breakdowns and issues. Potentially, technology can save companies thousands of dollars by reducing maintenance costs.<sup>6</sup>

If you are thinking about implementing IoT Big Data products, we recommend that you find a professional IoT development company to help you quickly implement the most suitable solution with the highest possible ROI. Today, a combination of IoT and Big Data technologies helps businesses attract more customers, reduce costs, and win the competition. On the other hand, businesses that neglect to implement these technologies risk a huge loss of customers and profits. IoT Big Data solutions can help any company become more successful by:

1. Making employees more productive;
2. Optimizing and automating work processes;
3. Enhancing security;
4. Improving the customer/patient experience;
5. Boosting equipment maintenance.<sup>7</sup>



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## II. DISCUSSION

Technology is touching everything that surrounds us including governance methods. State is not that indifferent in adapting these techniques. IoT basically can be understood as a system of thousands of devices connected to each other via an internet based common system which works on the cloud and allows users to access and create data from everywhere, a lot of such methods are being used in governance of the citizens. Good governance is participatory, consensus-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and follows the rule of law, IoT is just making it efficient and convenient. Governance comprises the functions that take place in a state by the government in order to 'govern' its citizens. This is facilitated by laws, rules and regulation, updating and involving the citizen participation in the government decisions and working. When we speak of governance we are speaking of the administrative, formal and procedural aspects of cause and effects of the decision making and working in the government which will be directly related to the citizens in various aspects. There are various aspects of governance, like decision making, reinforcement of laws, checking on the existing systems, maintaining healthcare, education etc are all the parts of a governance procedure in one way or the other. For various purposes, the governments and the processes hence involved are growing technologically and digitally to make the administration smooth.<sup>9</sup>

IoT can be used for governance in various ways in order to fulfil their duties and regards concerning the citizen. Healthcare, education, safety, banking are all the essential administration components that are using IoT technological systems like web based and cloud based systems, wireless networks, suitable and subjectively curated softwares to provide their services to the citizens in a convenient way. Digital India is one such campaign launched by the Prime Minister of India Narendra Modi on 1 July 2015 in order to make the government's services available to its citizens electronically. Under this program a lot of initiatives are being put forward like the National e-Governance Plan, UMANG (Unified Mobile Application for New-age Governance) to carry out the services digitally. In a way this is the exact representation of how it is being implemented and used to carry out various governance functions. In the form of aforementioned ways, the government is launching the application for various purposes which can simply be accessed by using a smartphone and internet and from where they can educate the citizens about prevailing benefits and schemes, registrations for the same and other essential governmental services.<sup>10</sup>

### 1. Healthcare

Healthcare is a crucial responsibility of the government, the healthier and the finer the population will be it will be directly or indirectly proportional to the national growth. In governance the IoT tools are being used by the government to keep a track record of the registered users and not to mention the authorities involved strictly appeals to the citizens to get themselves registered on the platforms. IoT enables efficient governance in such situations by enabling the users have real time updates of the situation via being connected to a central user interface which is used to both communicate, update and collect data from them for the real time update. This can also be used the other way round to update the requirement of the population and generate the data of backward areas with low healthcare facilities so that they can be taken care of.<sup>11</sup> For example: As a tool to prevent the population from the covid pandemic and safely take the corrective measures while enabling them to get the real time and latest updates Aarogya Setu app was launched by the government. This is a contact tracing (bluetooth based mechanism which works by taking the application and health details of any person nearby) and self assessment and also had a feature which updated the details of current cases and decreased cases due to the disease. This updated the details of the covid 19 hotspots nearby which were categorized as zones like red, green and orange. Not just this but the application also provided for nearby available covid testing laboratory for those who needed it.<sup>12</sup> Currently this application is displaying a tab of another web initiative by the government called Cowin which is a vaccine slot booking for various age groups. This enables the population to find the nearest available medical center for the vaccine as well as find the appropriate slot based on date and timing with real time availability and keeps a profile wise record of the dosages of the vaccination. Also the Delhi government's Delhi Fights Corona application is also making the best usage if IoT available to provide with the real time availability of applications, oxygen, ventilators in this time where all the hospitals are flooded with such cases.<sup>13</sup>



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Hence, healthcare is a sector, digitalising which the smooth governance in this respect is being taken care of, the software which works, big data which will be in turn used by the government to say, manage the vaccine supply chain or beds during the pandemic and sending real time updates to the population is all the product of internet of things.<sup>14</sup>

## 2. Education

Education is another factor of successful governance which is being taken care of using the IoT. Smart classrooms, smart boards, online study material, which can be accessed from anywhere and web based teaching methods for distance learners are common things to the people currently. Internet and smart devices are making it possible for the schools and teachers to keep a progress record of the children digitally so that all of it can be tracked at once. Education is a vital component, abiding with such a concept there are several portals open which are successfully operating via a centralised web system making education accessible as per one's convenience.<sup>15</sup> For Example: e-pathshala is one such application with downloadable e-books for the NCERT syllabus for all and accessible throughout the devices. CBSE Saransh is an application used by the parents and the teachers to It to analyse students' performance in order to take remedial measures, this is somehow making the parents who cannot make it to the children's school keep a track record just by using their smartphones. Startup India App enables the users to get the updates on startup from the authorities end so that they can understand the favourable time for their startup and access all the provided benefits and services.<sup>16</sup> National Scholarship Portal is one such portal which aims at making the scholarship process easy, the application, sanctions and details of the beneficiary to understand and clear the verification processes etc. There are several education based applications, smart class combined features and portals working solely using IoT and advanced analytics making the governance efficient.<sup>17</sup>

## 3. Infrastructure and Disaster Management

The government expenditure in the building of roads and bridges, power grids, water supply lines, gas supply, rail lines, airports, etc is huge and inevitable. Any major disruption and damage can not only affect the lives of the civilians but can cause a lot of long term loss.

To cater to these the governance systems can ensure to use sensors and alarm detectors which can alert the systems in the case of some defect. Such an IOT based system with proper software can help in enabling the required alert and monitoring with a track record of previous maintenance and can save a lot of disturbance.<sup>18</sup>

The same system of monitoring and prevention can be used to keep a record of the areas which are disaster prone. IOT can help in providing reliable solutions in disaster management for the governance in accordance with human lives. For example: areas which are prone to forest fires can have temperature based alerting systems, flood prone areas can issue alerts based on the water rise data made available to them via the devices and machines. In the case of man made disasters as well, proper help can be called for if the systems are made handy and quick. IOT has the potential to do all of this.<sup>19</sup> Weather management tools, satellite monitoring are prevalent, there are authorities and governance departments which are web based and are used to provide travel directory, safety guidelines and emergency contacts to work for the safety of the population concerned. The National Disaster Management Authority (NDMA) is a governing body which focuses on building a safer and disaster resilient India.<sup>20</sup>

## 4. Government Services

IoT and advanced analytics can help in making the governance efficient for the population via keeping a track of the services and benefits provided as well as keeping the track of the beneficiaries. There are a lot of essential services and documents needed by the citizens to avail various benefits schemes in which they categorize and register for them. There are web based systems by the government to digitally provide the documents like ration card, domicile certificate, caste certificate, aadhar card, driving licence, pan card etc. These systems just not make it convenient for both the parties involved but as well as these provide an economical and accessible solution from literally anywhere, with no record lost. In some aspects of governance there are document verification processes taking place, online kyc etc. are going digital with the use of IOT systems.<sup>21</sup> In banking, the adaption to online banking has made it easier for



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people to have an integrated record of the transactions across all the platforms with a user id and a password. There are smart cameras on the road connected to a system which can challan for overspeeding and other road defaults by the people, services like online FIR (First Information Report) and cybercrime surveillance are not the aspects which are just paving way for IOT in law enforcing as well but also making it omnipresent.<sup>22</sup> For example Web-based systems like e-district by Delhi Government is a plan to enable door-to-door services for the citizens and solely this operates using the internet and an integrated system. My Gov is another web-based platform that aims to integrate the citizens in governance through a “Discuss”, “Do” and “Disseminate” approach. PDS Portal of India is intended to be one-stop information for the Public Distribution System (PDS) which is a direct concern of the population. There is a considerable role that IOT has to play in governance, all the aspects of governance are seeking to go online and adapt to such techniques pertaining to its efficacy. IOT has widened the scope of governance.<sup>23</sup> Centre of Excellence on Internet of Things has planned for rapid adoption of IoT technology and encourage a new growth strategy understanding the benefits that IOT can bring in governance like transport system, parking, electricity, waste management, water management, and women’s safety to create smart cities, smart health services, and even agriculture and farmers’ education.<sup>24</sup>

### III. RESULTS

Traditionally, advancements in technology and environmental sustainability have seemed mutually exclusive. We often think of technological advancements as having a negative impact on sustainability. Since the first Industrial Revolution in the mid 18th century, technological innovations allowed humans to exert a greater influence over natural resources. This combined with the ever-growing population resulted in a heavier usage of raw materials and an increased amount of production, leading to a significant resource depletion and rise in CO<sub>2</sub> emissions. Until now, the factors that propel digital innovation and sustainability have been disconnected.<sup>25</sup> One is motivated by extensive technological change led by IoT, AI and robotics, all promising to transform industrial and commercial processes. The other is driven by climate and environmental deterioration as well as geopolitical instability, all of which demand a new approach that prioritizes resource conservation and environmental governance — and in particular intensifies efforts to de-carbonize the atmosphere. However, with today’s advancements in IoT sensor technologies and wireless connectivity, the two concepts of digital innovation and sustainability have become mutually reinforcing. Companies must embrace digital transformation and its business-critical insights in order to pivot to more energy-efficient practices, use resources more responsibly and organize processes in ways that reduce waste.<sup>26</sup>

Here are 7 impactful ways companies can use IoT for sustainability:

#### 1. Smart Energy Management

While reduced costs and user comfort has been paramount in the design of HVAC and lighting systems since their inception, customers and communities have placed an increasing emphasis on sustainable technology. Energy consumption accounts for more than 40% of a commercial building’s total energy use. It’s no wonder so many facility managers (FMs) are finding ways to optimize this system’s efficiency.<sup>27</sup> Until recently, HVAC equipment has often been regulated in a uniform, predefined fashion, causing wasteful problems like overheating or under-heating across the property. In this context, real-time, granular IoT sensor data enables on-demand, micro-zoned equipment control to achieve higher energy efficiency. What’s more, leveraging occupancy data can also unveil important trends in HVAC and lighting needs to optimize equipment schedules. For example, if HVAC and lighting systems are set to operate until 8pm, but data reveals tenants don’t stay later than 7pm, facility managers can cut one hour of daily energy use to greatly reduce their carbon footprint.<sup>28</sup> When it comes to usage monitoring, wireless utility submeters help deliver consumption data at discrete building areas or even on individual assets — especially energy-intensive ones. Having these insights at their fingertips, facility operators can swiftly identify and locate bottlenecks for counteractive measures.<sup>29</sup>





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## 2. Air Pollution Monitoring

Most of the rising global attention to air pollution focuses on the impacts that ozone, particulate matter and other pollutants have on human health. The World Health Organization (WHO) estimates that air pollution inside and outside the home is responsible for about 7 million premature deaths worldwide. The majority of these deaths—4.2 million—are associated with outdoor pollution.<sup>30</sup> It is a leading environmental risk factor affecting urban and rural populations around the world. Outside of the devastating impact on health, air pollution also has significant ramifications on climate, water, weather, renewable energy, food and vegetation. Recent innovation in low-cost pollution sensors has enabled a new generation of air quality monitoring that provides actionable high-resolution data at a fraction of the cost of traditional monitoring systems. Companies now have real-time snapshots of where air pollution is coming from and traveling to, and who and what is most affected. For example, methane, the primary component of natural gas, is a potent greenhouse gas accounting for 20% of global emissions. The largest source of industrial emissions is the oil and gas industry, which loses \$30 billion worth of methane each year from operations. In this context, an air quality monitoring solution enabled by a low-power wide area network (LPWAN), can provide operators real-time insight into previously undetectable leaks in far flung, remote locations, as well as the ability to remotely control valves to prevent further methane leakage.<sup>31</sup>

## 3. Smart Waste Management

As cities grow, so does the amount of garbage we produce. By 2050, the United Nations estimate that 68% of world population will live in urban areas and the World Bank that solid waste will increase by 70%. The inadequacy and inefficiencies of existing trash containers and landfills may lead to the accumulation of garbage on city streets and to illegal dumping, with serious consequences for public health. At the same time, more frequent waste collection means more air and noise pollution, traffic, and higher public costs. Smart waste management has often been discussed in the municipality context, but its benefits and applicability for enterprises are just as far-reaching. It helps to tackle the persistent challenge of emptying schedules that aren't aligned with actual demand. With waste production rates varying from one day to another at industrial and commercial facilities, pickup trucks often arrive just to offload half-full dumpsters.<sup>21</sup> Needless to say, this introduces increased costs and wasted resources, not to mention the amount of carbon emission resulted from redundant truck trips. In other cases, waste containers may already be overfilled before the collection schedule, causing unhygienic conditions and the potential for more hazardous emissions. Wireless IoT sensors can combat these issues by delivering various real-time data on trash receptacles at facility managers' fingertips. Knowing the current fill level of each container, they can better foresee when one needs to be emptied, as well as understand how much and how quickly each type of waste is being disposed on a daily and seasonal basis. On top of that, temperature and humidity data reveal useful insights into undergoing microbial activities inside individual dumpsters.<sup>23</sup> Having all this information at hand, businesses can optimize the pickup schedule of each waste type for higher efficiency, as well as lower transport costs and environmental footprint. At the same time, they can make informed decisions about the container capacity and location to adapt to the actual demand and avoid unwanted overfills.

## 4. Fleet Management

There's an increasing focus on the environmental impact of different fuel types, particularly the affect diesel engines have on air quality. When combined with the ongoing drive to reduce CO2 levels across the board, fleet operators are under more pressure than ever before to make sure their fleet related decisions take environmental factors into consideration. Location, fuel consumption, idle time, driver behaviour and vehicle health all play a role in the total emissions produced by a fleet. IoT sensors powered by low-power wide area networks provide critical insight into these metrics to better optimize routes, improve driving behaviours and ensure timely vehicle maintenance. For example, real-time location data allows for more accurate and responsive route planning. This



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reduces the amount of time vehicles spend idling in traffic, producing harmful emissions. Likewise, IoT sensors can be configured to identify and track sudden acceleration or braking, speeding, high-speed turning, frequent stopping, and slow driving – all of which result in wasted fuel.<sup>25</sup>

## 5. Smart Water Management

According to MIT Researchers, more than 50% of the world's population will be living in water-stressed regions by 2050. It's therefore vital that individuals, companies and municipalities find ways to reduce the amount of water wasted annually. On average 85% of properties waste 35% of their water consumption by means of leaks. At the municipal level, pipe leaks can account for 20-30% of total drinking water. In addition, when factoring in the flood mitigation system, one to two tonnes of material waste per square meter is produced from demolition due to floods. This also makes mitigating water loss essential to reducing the waste that goes into landfill as a result of floods. Advances in IoT sensors and wireless connectivity have dramatically lowered the cost of gathering, storing and analyzing data from specific equipment, like pumps or valves, or entire processes like water treatment or irrigation. Sensors can monitor fill levels, control the quality water and be used to detect leaks. For example, by installing leak detection sensors in high-risk areas throughout a building or plant, facility managers can be alerted upon the very first sign of a leak allowing them to take remedial action. Taken a step further, hooking this data into a building management system enables automated responses like shutting off the supply valve or HVAC equipment.<sup>27</sup>

## 6. Smart Farming

Faced with tough challenges of exploding world population, dwindling arable lands and natural resources, alongside growing extreme climate events, the agriculture sector is under undue pressure. According to the UN's Food and Agriculture Organization (FAO), worldwide food production will need to increase by 50 percent by 2050 to feed an expected population of nearly 10 billion. Optimizing farming efficiencies opens the door to a sustainable food production system that can cater to global demand while reducing resource usage and environmental footprint. Powered by granular wireless sensors, smart farming systems deliver real-time data of soil conditions and various external factors that play into crop growth. An analytics platform then processes this data for demand-based, targeted execution of various farming practices like seeding, irrigation, fertilization and fumigation. Having enough reliable data at hand, predictive models can even be developed to help identify and prevent conditions unfavourable to crop health. With IoT technologies, farmers can also monitor their cattle's well-being and get immediate alerts on the first signs of illness, from anywhere. Besides reducing inefficient and error-prone human intervention, smart agriculture boosts yields while minimizing chemical, water and other resource utilization. This, in turn, translates into higher production rates at a lower environmental footprint.<sup>29</sup>

## 7. Cold Chain Monitoring

Roughly one-third of the food produced globally is wasted, with much of that loss occurring along the global supply chain. Overall, that translates to 1.6 billion tons of food, worth about \$1.2 trillion, down the chute.

Temperature is considered the most important factor affecting the quality of foods. Improper temperature control and settings in the food cold chain can accelerate the deterioration of food quality, which can increase the generation of food losses and food waste. Traditionally, personnel along the supply chain have manually read and recorded the temperature of goods to ensure optimal conditions. While this pencil scribble method is highly prone to errors, there also arises the challenge of goods moving through multiple parties (loader, carrier, shipper, and receiver) all of which have a different record-keeping system. This process significantly increases the risk of spoiled products in the event that a log is recorded incorrectly, not on time or unchecked altogether. Smart cold



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chains provide end-to-end visibility of the supply chain from production and pallets to cargo and retailers. Wireless IoT sensors can track ambient conditions like temperature, humidity, air quality, light intensity and other environmental factors in any location, from anywhere, 24/7. When a threshold is breached, alerts are triggered in real-time to prompt immediate mitigation and avoid any compromise to the product's integrity. While technology has plagued environmental sustainability efforts in the past, it has now become an ally to building a greener planet. The advancements in IoT sensors and wireless connectivity are enabling individuals, companies and government to move to energy-efficient practices, use resources more responsibly and organize processes in ways that reduce or reuse waste.<sup>31</sup>

## IV. CONCLUSIONS

Sustainability is an increasing priority for nearly every high-tech company -- and it is no coincidence. Emerging technologies such as 5G, blockchain and AI are unlocking new use cases for smart, connected devices that make up IoT. However, they are also causing a massive surge in energy consumption, water usage and CO<sub>2</sub> as devices become more powerful, Accenture reported. In response, high-tech companies are rolling out sustainability programs and designing products with environmental, social and governance (ESG) goals in mind. These initiatives are plain to see at recent tech events, with many high-tech companies demonstrating their dedication to developing more sustainable products and initiatives. For instance, at CES 2018, LG pledged to use up to 600,000 tons of recycled plastic in its manufacturing process and increase the recovery of electronic waste to up to 8 million tons by 2030. Meanwhile, Samsung announced a new version of its Eco Remote and new smart monitors. While IoT is designed for energy efficiency, the explosive growth of the number of IoT devices is elevating the need for device manufacturers to further improve power efficiency. Universal Electronics Inc. has announced sustainability solutions to minimize power consumption and reduce battery waste, including its UEI Extreme Low Power Connectivity system-on-chips (SOCs.) The company's new connectivity offerings with integrated energy harvesting capabilities can deliver up to 2.5 times more computing power with up to 80% less battery power consumption compared to traditional Bluetooth smart SOCs.<sup>30</sup>

### Ways to implement sustainability into IoT

Companies should consider how to best use IoT technologies to improve product sustainability and support more eco-friendly manufacturing. Accenture has outlined the following three steps that high-tech companies can take to help achieve their ESG goals.

#### 1. Optimize cloud resource use

Green cloud is a term that emerged due to the explosive growth of cloud usage. It is a practice that focuses on cloud energy and resource optimization. Companies should establish a baseline of existing data center energy consumption, computing requirements and sustainability goals. There are tools that can help with this and cloud design products that reduce carbon emissions across all stages of the journey. Such tools use algorithms to quantify the greenness of potential cloud options based on a range of information, such as the cloud service providers' carbon emissions goals, locations, energy sources and readiness to transition.<sup>27</sup>

#### 2. Transition to energy-efficient smart buildings

Smart buildings can reduce energy consumption, cut costs and generate revenue. High-tech companies can develop smart building products and services to sell while they simultaneously test and use them to achieve their own sustainability goals. Automated processes can help control building operations such as climate control, lighting and security. This enables companies to help reduce energy consumption, optimize space use and minimize their buildings'





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environmental impact. Johnson Controls is one company that uses IoT and edge computing to monitor environmental controls and leverages 5G and AI to minimize building pollution and improve supply chain management. Its recent acquisition of FogHorn Systems, a developer of edge AI software for industrial and commercial IoT, brings new opportunities for smart and autonomous buildings.<sup>22</sup>

### 3. Improve semiconductor design and processing

Semiconductor design and manufacturing are at the core of creating nearly any product these days. With the growth of IoT, AI and machine learning, semiconductor manufacturers now have the tools to manage and analyze data to implement predictive maintenance programs. Custom analytics can predict process issues to detect impending deposition process failures and prevent significant yield reductions. Organizations can apply data to a single asset, across multiple machines, to a manufacturing line or even an entire fabrication process. To take these processes a step further, digital twins offer a detailed simulation of real assets that updates in real time through a constant stream of sensor data. They provide a test bed for organizations to try out new processes and analyze issues without unnecessary costs or negative environmental outcomes. Companies should adopt a circular model, where sustainability starts at the design stage instead of after the fact via recycling. High-tech manufacturers that design for refurbishment and longevity can save money, potentially create new revenue streams and reduce their carbon footprints. Sustainability improvements are happening all around us and are incorporated into personal devices, smart electronics in our homes, cars, office buildings and the environment. It's time to act now and use sustainable offerings as a competitive advantage.<sup>31</sup>

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