

# Environment

Environmental sustainability  
is smarter for all

We apply innovative technology and deep  
expertise to minimize the environmental  
impact of our business and develop smarter  
solutions for a more sustainable world.



Plastic Bank's recycling work uses IBM technology.

At IBM, we have seen first-hand what can be achieved with a sustained focus on the environment.

## Commitment to environmental leadership

A decades-old commitment to environmental leadership is an impressive legacy. And, at IBM, we are very proud of our past accomplishments. But we also take pride in sustaining this legacy, and we are always looking to enhance what IBM began half a century ago with the issuance of our first corporate directive regarding pollution control. Thomas J. Watson, Jr. was the CEO at the time, and his vision for the future of the business and its relationship to the environment remains our guidepost.

Today, we have a new Watson — a set of cognitive applications helping clients achieve remarkable outcomes and accelerating discovery using innovative, unique data connections. We have come a long way in this journey and we embrace the future with great anticipation for creating solutions and technologies to improve the environment and our quality of life.

In our own operations, we have seen first-hand what can be achieved with a sustained focus on the environment. That focus has driven impressive and quantifiable results across all our business intersections with the environment. Our complete 2017 IBM and the Environment Report is published separately and available online at [IBM and the](#)

[Environment](#). This section previews the full report with selected highlights from our environmental programs and 2017 performance.

## Environmental management system

IBM implements its environmental, energy and chemical management programs through a global environmental management system (EMS) that drives the implementation of corporate directives which govern IBM's conduct and operations worldwide. Our [corporate environmental policy](#) provides the strategic framework for our EMS and calls for environmental leadership in all of the company's business activities.

In 1997, IBM became the first major multinational company to earn a single global registration of its EMS to the International Organization for Standardization (ISO) 14001 standard. We achieved this credential within just one year of the original standard being published in 1996.

IBM's single global [ISO 14001 EMS accreditation](#) includes its manufacturing and chemical-using research locations as well as several IBM organizations at the individual country level. In addition, several business functions such as product design and development, procurement and supply chain, and Global Asset Recovery Services have also been

certified to ISO 14001. We have sustained this ISO 14001 certification for 20 years, and in 2017, we completed an update to our global EMS to successfully transition our certification to the 2015 edition of the standard.

IBM's global EMS also conforms to the ISO 50001 standard on energy management systems. We achieved a corporate-level registration to the ISO 50001 standard in 2012, within one year of the issuance of the standard. IBM currently has 16 entities worldwide certified to the ISO 50001 standard under its corporate registration.

### Audits and compliance

IBM reviews its environmental performance against both external and internal requirements, and takes prompt action if issues are identified. In 2017, IBM received 73 governmental agency inspections at facilities worldwide with no resulting fines or penalties. IBM locations reported eight accidental releases of substances to the environment related to IBM operations through our Environmental Incident Reporting System — five releases to air, two releases to land and one release to water. The root causes were investigated for all releases and corrective actions were taken as appropriate. None of the releases were of a duration or concentration sufficient to cause long-term environmental impact.

## Energy conservation and climate protection

In 1973, IBM began its formal energy conservation program and in 2000 set its first carbon dioxide (CO<sub>2</sub>) emissions reduction goal, when we helped the World Wildlife Fund create its Climate Savers program. In 2007, IBM published its position on climate change: IBM recognizes that climate change is a serious concern that warrants meaningful action on a global basis to stabilize the atmospheric concentration of greenhouse gases (GHGs). We believe that all sectors of society and the economy, as well as governments worldwide, must participate in solutions to climate change. IBM continues to be a leader in addressing climate change through our energy conservation and climate protection programs.

### Conserving energy

IBM's energy consumption is the predominant source of CO<sub>2</sub> emissions attributed to its operations. In 2017, IBM's energy conservation projects across the company delivered annual savings equal to 4.2 percent of our total energy use at IBM-managed locations, surpassing the corporate goal of 3.5 percent. IBM-managed locations are places where IBM is responsible for procuring energy and managing facilities infrastructure and operations.

These projects, numbering more than 2,000 and implemented at over 500 global locations, avoided the consumption of 173,000 megawatt-hours

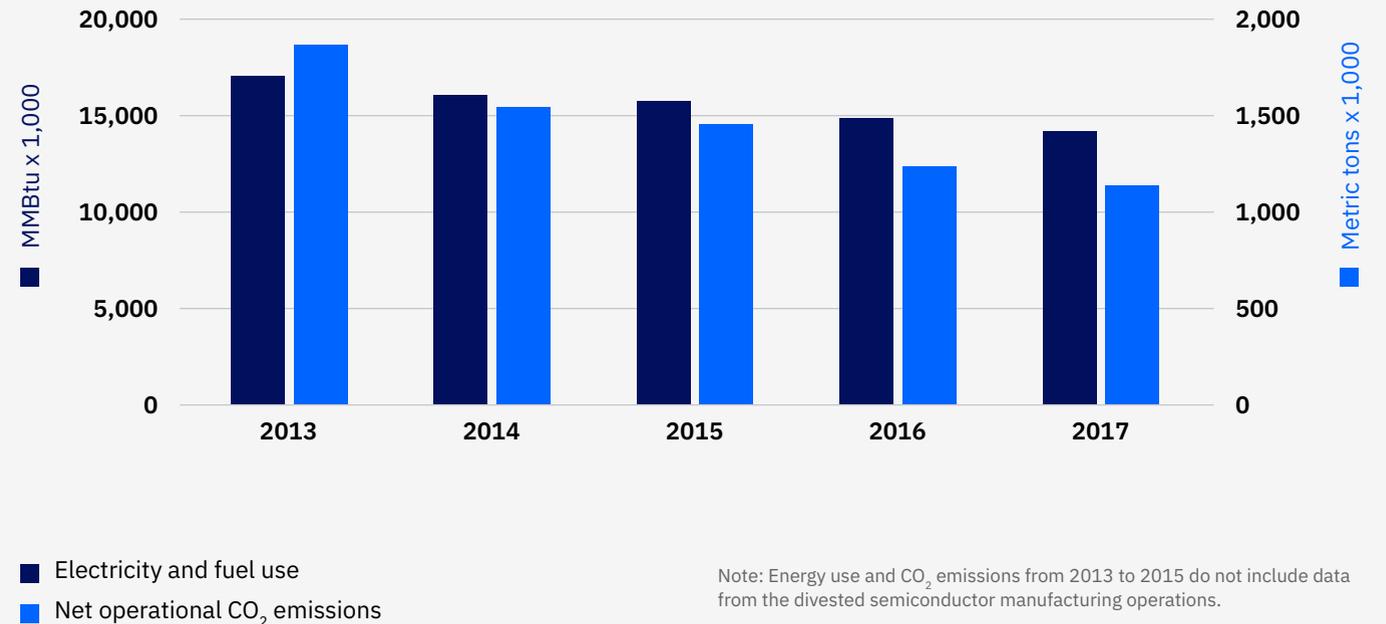
(MWh) of energy, an associated 64,000 metric tons of CO<sub>2</sub> emissions, and saved \$16.1 million in expense. These strong results were due to our continued, across-the-board focus on energy demand reduction; efficiency; and the implementation of standardized, global energy conservation strategies at our facilities.

Conservation and efficiency savings are increasingly enabled by automated, analytics-based systems that optimize data center and building operations. For example, these systems are used to increase utilization of servers and storage equipment, reducing IT hardware requirements. They are also used to improve data center cooling efficiency and to track and correct building system anomalies in near real time to optimize building energy use continuously. Collectively, these analytics-based systems reduced or avoided more than 105,000 MWh of energy consumption and saved \$9 million — 61 percent of IBM's total energy conservation savings during 2017. From 1990 through 2017, IBM conserved 7.4 million MWh of electricity, avoiding 4.4 million metric tons of CO<sub>2</sub> emissions and saving \$616 million.

### Renewable electricity

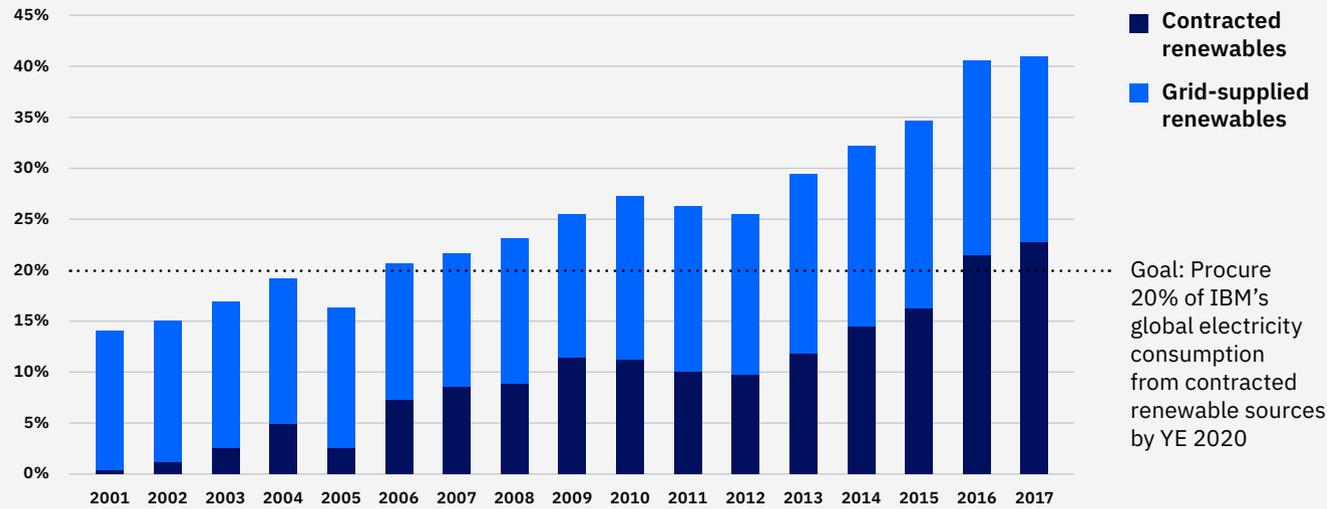
In 2017, IBM contracted with its utility suppliers to purchase approximately 779,000 MWh of renewable electricity, representing 22.9 percent of our global electricity consumption at IBM-managed locations. These purchases exceeded IBM's goal to procure 20 percent of its electricity consumption

Energy use and net operational CO<sub>2</sub> emissions associated with IBM-managed locations

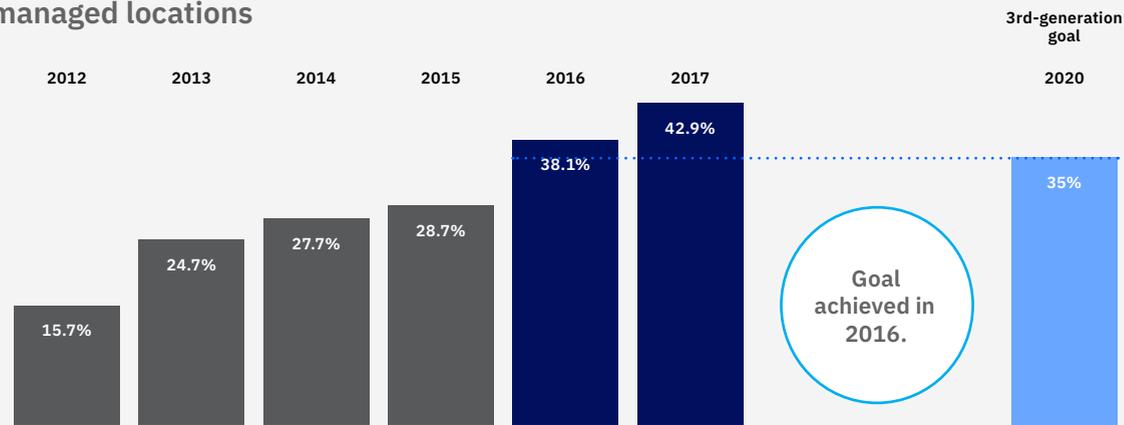


From 1990 through 2017, IBM conserved 7.4 million megawatt-hours of electricity.

**Use of renewable electricity as a percent of global electricity consumption at IBM-managed locations**



**Operational CO<sub>2</sub> emissions reduction against 2005 baseline at IBM-managed locations**



generated from renewable sources by 2020, over and above the quantity of renewable electricity provided as part of the mix of electricity that we purchase from the grid. IBM avoided 275,000 metric tons of CO<sub>2</sub> emissions through these contracted purchases.

Including the renewable electricity that was part of IBM's purchases of electricity from the grid, 41.4 percent of the electricity consumed in IBM's managed locations was sourced from renewable generation assets in 2017.

In March 2018, IBM finalized a power purchase agreement to procure all of the electricity—roughly 10,000 MWh per year—generated by a 6-megawatt solar array to be constructed at IBM's Boulder, Colorado, facility. The array is expected to go into production by early 2019. IBM continues to work with regulated utilities, energy retailers and service companies, and renewable project developers to craft shorter-term (4–6 year), economically viable contracting approaches for renewables procurement.

**Operational CO<sub>2</sub> emissions management**

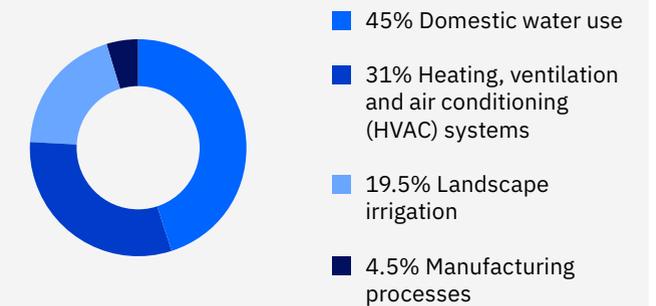
IBM's operational CO<sub>2</sub> emissions reduction goal is applicable to its managed locations. From 2016 to 2017, IBM reduced CO<sub>2</sub> emissions at its managed locations by 96,000 metric tons (7.7 percent) to 1,158,000 metric tons. When measured against the goal's 2005 emissions baseline, we reduced our CO<sub>2</sub> emissions by 42.9 percent, continuing the attainment of our goal to reduce emissions by 35 percent by 2020.

IBM received a Climate Leadership Award from the Center for Climate and Energy Solutions, The Climate Registry and Bloomberg Philanthropies in the category of Excellence in Greenhouse Gas Management Goal Achievement in March 2018, in recognition of achieving our third-generation CO<sub>2</sub> emissions reduction goal in 2016. This award made IBM the first and only company to win a Climate Leadership Award six times in this program's seven-year history.

**Water conservation**

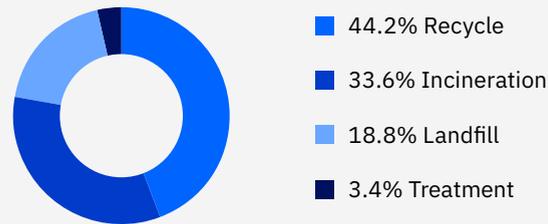
The preservation of water resources and the protection of watersheds are important areas of focus for IBM. In 2016, IBM established a new water conservation goal to achieve year-to-year reductions in water withdrawals at 45 data centers and other large IBM facilities located in water-stressed regions. In 2017, withdrawals at these locations were reduced by 2.9 percent versus 2016.

**2017 water use at IBM locations in water-stressed regions**



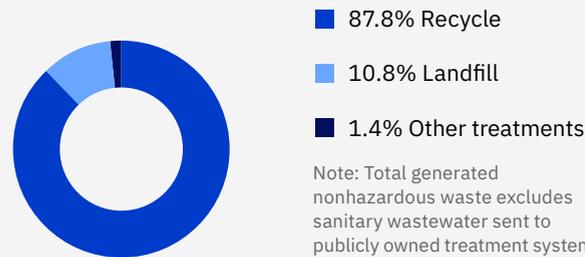
**2017 total generated hazardous waste worldwide by treatment method**

(% by weight of 1,460 metric tons processed)



**2017 total generated nonhazardous waste worldwide by treatment method**

(% by weight of 36,900 metric tons processed)



Note: Total generated nonhazardous waste excludes sanitary wastewater sent to publicly owned treatment systems.

## Hazardous and nonhazardous waste management

The best way to prevent pollution is to reduce the generation of waste at its source. This has been a basic philosophy behind IBM’s pollution prevention program since 1971.

IBM’s total hazardous waste generation in 2017 increased by 7 percent (by weight) from 2016, to 1,460 metric tons. This increase was caused by the disposal of hazardous waste generated by a water leak from a fire suppression system at one of our facilities. The water was contaminated with diesel fuel from an emergency generator located within the area where the leak occurred. The contaminated water was contained, avoiding any release to the environment. If hazardous waste generated as a result of this incident had been removed, IBM would have seen a 16 percent reduction in hazardous waste generation in 2017.

Of the total 1,460 metric tons of hazardous waste IBM generated, 44.2 percent (by weight) was recycled, 33.6 percent was sent by IBM directly for incineration, 18.8 percent to regulated landfills, and 3.4 percent for treatment.

In 2017, our worldwide operations generated approximately 36,900 metric tons of nonhazardous waste, a decrease of about 7,600 metric tons from 2016. IBM recovered and sent 87.8 percent

(by weight) of its nonhazardous waste to be recycled — surpassing our goal of 75 percent.

## Product stewardship

IBM established its product stewardship program in 1991 as a proactive and strategic approach to the environmental design and management of our products. The program’s mission is to develop, manufacture and market products that are increasingly energy efficient; that can be upgraded, refurbished, remanufactured and reused to extend product life; that incorporate recycled content and environmentally preferable materials and finishes; and that can be dismantled, recycled and disposed of safely.

IBM’s product energy efficiency goal is to improve the computing power delivered for each kilowatt-hour of electricity used for each new generation of servers. In 2017, IBM released its POWER9-based Power Systems Accelerated Compute (AC922) server for high-performance computing analytics and artificial intelligence. When compared to comparable IBM POWER8® products, IBM POWER9-based servers have Server Efficiency Rating Tool (SERT) weighted geomean active efficiency scores up to three times higher — which represents three times the performance or work delivered without any increase in power use. The SERT was created by the Standard Performance Evaluation Corporation (SPEC).

IBM also introduced its next-generation mainframe, the IBM z14 server, in 2017. On average, the IBM z14 server delivers 23 percent or more work per kilowatt depending on the choice of components and cooling method.

IBM also has a goal to qualify its new server and storage products to the U.S. Environmental Protection Agency’s (EPA) ENERGY STAR program criteria where practical, and where criteria have been developed for the specific server or storage product type. In 2017, IBM certified select configurations of the IBM Storwize V7000 storage product to Version 1 of the ENERGY STAR data center storage requirements. None of the server products IBM released during 2017 were subject to ENERGY STAR criteria.

As of May 2018, IBM had [five Power Systems servers](#) and [seven storage products](#) certified to the ENERGY STAR requirements. The Power Systems servers meet the EPA’s requirements for power-supply efficiency, idle power limits or power management capability, and SPEC SERT metric data reporting. The storage products meet requirements for power-supply efficiency and reporting of the Storage Networking Industry Association Emerald Power Efficiency Measurement Specification results.

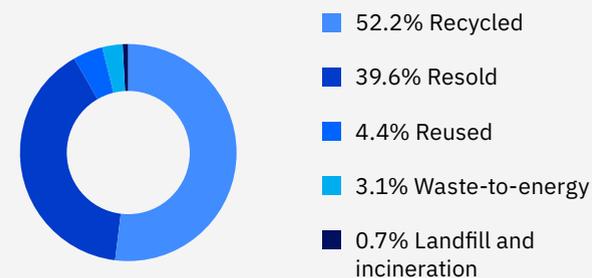
### Product end-of-life management

As part of our product end-of-life management (PELM) activities, IBM began offering product takeback programs in Europe in 1989, and has

extended and enhanced them over the years. In many countries and U.S. states, we offer solutions to household consumers for the end-of-life management of computer equipment, either through voluntary IBM initiatives or programs in which we participate. IBM's global PELM operations processed 26,500 metric tons of end-of-life products and product waste in 2017. Of this total, we sent 0.7 percent directly to landfill or incineration as a disposal treatment, better than our goal of not-to-exceed 3 percent (by weight), while 52.2 percent was sent for recycling as materials, 39.6 percent was resold as products, 4.4 percent was product reused by IBM, and 3.1 percent was incinerated for energy recovery.

### 2017 product end-of-life management operations

(% by weight of 26,500 metric tons processed)



## Solutions for environmental sustainability

At IBM, we thrive on challenges. And, striving to solve environmental challenges is a job we take very seriously. We apply our vast technology, expertise and insight across industries, addressing the necessities of life itself—from the air we breathe, to the water we drink and the food we eat. The challenges we face today have never been more complex, demanding or seemingly impossible to solve. However, IBMers are working to develop and implement solutions once only dreamed of—creating innovation that truly matters for our company and the world. Following are examples of some innovative solutions we are developing and implementing that contribute toward environmental sustainability.

### Protecting and managing our water resources

Water affects every aspect of human life. It plays a role in everything from health and nourishment, to business and commerce, to energy and transportation. IBM solutions provide the technical foundation to facilitate the flow of information across organizations and establish a shared, comprehensive view of our water resources. Our solutions also help the farming industry to improve crop yield while using less water.

### Tackling ocean plastic with IBM

A 2015 research paper published in *Science* magazine estimated that between 5.5 and 14.6 million metric tons of plastic made their way into our oceans that year, and that the yearly amount could double by 2025.

Working with IBM and IBM Business Partner® Cognition Foundry, Plastic Bank is mobilizing entrepreneurs from the world's poorest communities to recycle plastic waste in return for life-changing goods. The team developed a blockchain-powered token reward to underpin the recycling of plastic waste. The tokens can be exchanged for valuable commodities. IBM's blockchain technology tracks the plastic recycling process, from waste collection, credit and compensation through delivery to companies for reuse.

Plastic Bank's token rewards and exchange platform incentivizes the collection of plastic, preventing it from entering the oceans. To date, Plastic Bank has collected over 8 million pounds of plastic waste—the equivalent of 144 million plastic bottles—from its first recycling centers in Haiti. This was accomplished by more than 1,850 full-time collectors working across 40 collection locations. ([Watch a video](#) about this project.)



IBM researcher Harry Kolar deploys a Dublin City University Water Institute sensor at Lake George in New York.

### Using sensors with IBM's cognitive IoT technologies to improve water management

In 2017, IBM teamed with Dublin City University (DCU) Water Institute to launch a pilot program that uses the Internet of Things (IoT) combined with advanced analytics to monitor and manage ecological systems. The deployment of DCU sensors with IBM's machine learning and cognitive IoT technologies will help protect and conserve natural resources and address environmental management issues such as water quality for both freshwater and marine environments.

In the past, water systems have been monitored by technicians manually gathering water samples and sending them to labs for analysis. Yet with sensors becoming cheaper and more durable, it is now possible to place them directly into water systems and continually gather data. That, combined with geospatial coverage, creates full models of ecosystems that scientists can use to identify problems and intervene before they become major environmental issues. The sensors can measure physical, chemical and biological parameters to better understand changes in the environment. Additional applications may include improved management of pollution from sources such as agricultural or stormwater runoff that can affect lakes, rivers, estuaries and marine ecosystems.

IBM and DCU Water Institute are piloting these technologies in Ireland and the United States. In the United States, the first DCU sensors are being used

in Lake George, New York, in conjunction with the ongoing Jefferson Project at Lake George. This project, begun in 2013 with partners Rensselaer Polytechnic Institute and The Fund for Lake George, is an ambitious effort in lake modeling in order to get a holistic view of everything happening in and around one of the United States' most pristine lakes. The project not only helps to manage and protect this particular natural resource, but also provides a blueprint to preserve important lakes, rivers and other bodies of freshwater around the globe. ([Watch a video](#) about this project.)

### Watson IoT enables water conservation through precision irrigation

Having farmed in California for more than 80 years, E. & J. Gallo Winery believes that no resource is more important than water, making water management a top priority of the company for decades. The winery worked with IBM Watson IoT™, which developed technologies to use weather reports and remote sensor data to deliver precise amounts of water to each grapevine, optimizing growth and reducing the amount of water required for irrigation. The secret is located above the clouds, in a satellite looking down on the vineyard.

A 30-by-30-meter grid, aligned with National Aeronautics and Space Administration satellite imagery, is mapped over the vineyard block. Each block of vines in the grid gets its own personal irrigation plan based on weather data and soil moisture levels. This allows the exact amount of

water needed — based on highly targeted irrigation requirements — to be dispensed to each grapevine. As the weather changes, the irrigation rates change to ensure vines only receive water when needed. The result? For E. & J. Gallo Winery, the world's largest family-owned winery, the Watson IoT solution resulted in a 26 percent improvement in yield quantity, a 50 percent improvement in uniformity, and a 25 percent reduction in water use required.

### Improving the air we breathe

According to the World Health Organization (WHO), exposure to outdoor air pollution accounts for approximately 3 million deaths annually. WHO [has concluded](#) that this more than doubles previous estimates, and confirms that air pollution is now the world's largest single environmental health risk. IBM is working with cities around the globe to tackle air pollution challenges and provide solutions to help improve the air we breathe.

### Providing community air quality data

One way to increase public awareness of the impacts of air pollution is by making air quality data more broadly available. In 2017, The Weather Company (an IBM Business) collaborated with air quality sensor manufacturer PurpleAir to expand the availability of local air quality and pollution data for the public. As a result of this collaborative effort, owners of PurpleAir devices can now contribute data from their units to Weather Underground®, a consumer division of The Weather Company. This



Dr. Jin Dong of IBM Research—China leads IBM's Green Horizons initiative.

data is displayed on maps on its website to provide one of the most granular pictures available of air pollution within the United States.

### **Green Horizons initiative and air pollution forecasting**

Green Horizons is a 10-year initiative launched by IBM in 2014 with the city of Beijing. It uses advanced machine learning and IoT technologies to improve the understanding and forecasting of pollution events. The IBM China Research Laboratory is working with the Beijing Environmental Protection Bureau to provide one of the world's most advanced air quality forecasting and decision support systems, able to generate high-resolution pollution forecasts and pollution trend predictions. It models and predicts the effects of weather on the flow of pollutants in the air and the reactions between weather and pollutant particles.

Utilizing IBM's data assimilation and cognitive modeling, the city of Beijing has seen a significant reduction in fine particulate matter concentration (known as PM2.5). During the first seven months of 2017, the PM2.5 concentration was recorded to be **34.7 percent lower** than during the same period in 2013, prior to the launch of Green Horizons. IBM has also entered into research collaborations with governments in Delhi, India, and Johannesburg, South Africa, to leverage Green Horizons technology and address air pollution issues in those cities as well.

For future applications, Green Horizons will move toward personalized pollution exposure measurements and health services. Because environmental pollution, health, and safety are highly connected, IBM is moving swiftly to apply a targeted yet integrated approach to enable governments and individuals in their efforts to battle pollution and associated diseases.

### **Conserving energy and addressing climate change**

Climate change is one of the most critical environmental challenges facing the planet. Since the early 1990s, IBM has been collaborating with clients and others on innovations to help protect the world's climate through energy conservation and the use of renewable energy. Today, we continue that effort and reinforce our long-standing commitment to addressing these environmental challenges.

#### **Developing smart sensors to detect greenhouse gas emissions**

Most pollutants are invisible to the human eye, until their effects make them impossible to ignore. Methane, for example, is the primary component of natural gas. If methane leaks into the air before being used, it can warm the earth's atmosphere. Methane is estimated to be the **second-largest contributor** to global warming after carbon dioxide.

In the United States, emissions from oil and gas systems are the largest industrial source of methane gas in the atmosphere. The U.S. Environmental Protection Agency estimates that 9.3 million metric tons of methane leaked from natural gas systems in 2016. Scientists at IBM are working with natural gas producers, such as Southwestern Energy, to develop intelligent methane monitoring systems.

At the heart of IBM's research is silicon nano-photonics that are tuned to detect minuscule amounts of methane. This evolving technology transfers data by light, enabling computing literally at the speed of light. These chips can be embedded in a network of sensors on the ground near natural gas infrastructure, or even fly on autonomous drones—generating insights that, when combined with real-time wind data, satellite data and other historical sources, can be used to build complex environmental models to detect the origin and quantity of pollutants as they occur.

#### **Smarter Buildings**

The IBM Smarter Buildings solution started as an internal pilot initiated by IBM's Real Estate Strategy and Operations, software development, and research organizations. The objective was to apply IBM analytics to existing building system operational data, generating insights to improve energy efficiency. What began as a pilot at one IBM location in 2009 is now deployed at 24 major IBM campuses, encompassing 155 buildings and over

24.5 million square feet of space around the globe. This solution captures 40 percent of IBM's energy usage and 34 percent of our energy spending.

The IBM Smarter Buildings solution combines IBM's real estate management, software and services expertise with analytics to reveal a building's hidden failings and to identify opportunities for improvement in building performance and efficiency. The solution implemented at IBM compiles real-time operating data from approximately 27,000 field data sources (e.g., air conditioning systems, boilers, chilled water systems) every 15 minutes. The Smarter Buildings solution sends out automatic alerts when systems are operating outside of optimal conditions, with a specific focus on energy efficiency, so that personnel can take corrective action and implement operational modifications.

From 2013 to 2017, IBM's global energy management team utilized IBM's Smarter Buildings solution to reduce energy consumption by 35,000 MWh per year, with associated annualized savings of \$1.7 million. The implementation has demonstrated on average a positive return on investment after one to two years, while energy savings have increased in each year of operation. Due to the outstanding results of IBM's internal Smarter Buildings solution implementation, IBM offers the service to its clients as Building Optimization with IoT.

## Protecting wildlife

The protection of wildlife and endangered species from extinction is important to the health of the planet. While it may be viewed as a natural process, extinction is being hastened due to a number of factors — poaching being one of them. IBM technology is being used on the front line to help save African rhinos from the threat of poachers and extinction.

Today, South Africa is home to more than 70 percent of the world's remaining rhino population. Conservationists are battling to protect these iconic animals. Over the past decade, more than 7,000 rhinos were killed across the African continent, and in 2016, 1,054 were reported killed in South Africa alone.

In 2017, IBM joined forces with Wageningen University in the Netherlands, India IT provider Prodapt, and MTN, a leading African telecommunications provider, to protect endangered rhinos at South Africa's Welgevonden Game Reserve. A solution was needed that would help the wildlife managers to understand and predict possible threats of poaching, and act ahead of time to prevent harm to the animals.

According to research conducted on Welgevonden Game Reserve, prey animals in the wild react in different ways, depending on the type of threat they encounter and the perceived danger from predators, such as lions and leopards, or the presence of

people in the vicinity. IBM's IoT technology was selected by MTN as part of their Connected Wildlife Solution.

Protecting the rhinos begins with fitting collars containing custom sensors onto prey animals including zebra, wildebeest, eland and impala. Information is collected on animal location, movement, direction and average speed of travel. Using the data, patterns are developed based on the animals' response to threats. As a result, animals such as zebras will act as sentinels with their response patterns becoming an early warning system to indicate the presence of poachers and protect the rhinos.

The predictive nature of this solution takes away the reliance on game reserve teams to be in the right place at the right time, or to respond to events such as the distant sound of gunfire. The aim is for the technology to be made available for deployment at game reserves across Africa and abroad.