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T IoT

The sustainability
impact of IoT



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Executive Summary

This report focusses on the potential sustainability and related ESG¹ impacts of a range of IoT solution use cases. Those considered in this report are highly impactful, have proven benefits in carbon emission savings, and are already gaining significant traction amongst end-user adopters.

The report analyses the potential savings in electricity consumption, fuel consumption and also carbon emissions savings that can be achieved by adopting each of the profiled use cases. The use cases considered in this report are most impactful in the context of fuel consumption, followed by electricity and the overall impact of each of the profiled use cases is summarised in Figure 1, below.

We have chosen these use cases due to their relevance to industrial users across multiple verticals. IoT solution use cases considered in this report can aid the sustainability goals of all major industries and sectors. For example, Fleet Management and warehouse management solutions contribute towards a reduction in carbon dioxide (CO₂) emissions in transportation and logistics across several verticals.

Figure 1: Summary Sustainability and ESG impact of selected IoT use cases [Source: Transforma Insights, 2022]

Use Case	Electricity	Hydrocarbon Fuel	CO ₂	Extended ESG
Fleet Management				
Condition Monitoring and Tracking				
Pro-active Asset Monitoring				
Remote Maintenance				
Warehouse Management and Intralogistics				
Smart Building Management				
Smart Street and Outdoor Lighting				
IoT Solution Optimisation				

¹ Environmental, Social, and Governance

Executive Summary

Our major findings are as follows:

- In terms of fuel consumption, the most impactful use cases are **Fleet Management**, **Pro-active Asset Monitoring** and **Remote Maintenance**. Companies adopting Fleet Management solutions can experience a 15 % reduction in fuel consumption on average, mostly due to improved driver behaviour and route optimisation. Pro-active Asset Monitoring and Remote Maintenance solutions can help decrease the fuel consumed in technician visits by 10 – 30 % in many industries.
- For electricity consumption, the most impactful use case is **Smart Building Management**, which can reduce the total electricity consumption of a building by 10 – 20 %, driven by optimised use of building resources such as lighting and heating, ventilation and air conditioning (HVAC).
- The second most impactful use case in terms of electricity consumption is **Smart Street and Outdoor Lighting**. Electricity consumed by street lighting and advertising lighting can be decreased by 20 – 30 % on average as a result of dynamic lighting control (including shutting off when not in use, and task tuning). In some cases, savings can reach 40 % of electricity consumed.
- Overall, **Fleet Management** and **Smart Building Management** use cases have the most impact in terms of reducing carbon emissions (as an indirect benefit of reduced fuel and electricity consumption).
- **Condition Monitoring and Tracking solutions** have limited direct impact on electricity and fuel consumption, but they still have significant impact on reduction in CO₂ and other greenhouse gas (GHG) emissions as they contribute towards a reduction in wasted or spoiled products in supply chains, so avoiding produce going to landfill.

The use cases profiled in this report offer significant other ESG benefits, such as decreasing wastage of raw materials, reducing wastage of food and medicines, wildlife protection, and many others as discussed in detail in this report. The Smart Building Management and Smart Street and Outdoor Lighting use cases in particular are key contributors to these kinds of extended ESG goals. Smart Building Management solutions can improve indoor air quality and occupants' comfort and productivity. Smart Street and Outdoor Lighting solutions can improve public safety and decrease light pollution which is beneficial for nocturnal wildlife as well as humans.

While the main focus of this report is to profile the sustainability benefits associated with the profiled IoT use cases, it also provides insight into wider business impacts. For example, reducing the consumption of fuel and electricity directly reduces that element of the costs of associated operations, and predictive maintenance can reduce the cost of repair and maintenance of monitored devices potentially resulting in quite significant savings. Illustrating this general effect, street lighting electricity costs are generally a significant portion of a municipality's budget and fuel costs are significant in fleet operations. These costs can be substantially reduced through the implementation of Smart Street Lighting and Fleet Management solutions, respectively.

Fleet Management

E	F	CO ₂	+
			

IoT can be used to improve Fleet Management by monitoring driver behaviour and enhancing route efficiency and helping to better manage and maintain a fleet of vehicles. Sustainability benefits in Fleet Management are a result of decreased fuel usage derived from optimised route planning, improved driver behaviour, better fuel management, proactive vehicle maintenance, right sizing of vehicles and efficient loading and accurate location tracking.

The transport sector accounts for 37% of carbon emissions from end-use sectors², and a significant portion (more than 30%³) of these emissions are created from fleet vehicles due to high reliance on fossil fuelsⁱ. Fleet Management solutions can decrease the consumption of fuel in road passenger and road freight vehicles that are operated as part of a fleet by 15%ⁱⁱ. Given that fuel accounts for approximately 30 – 40 % of fleet operating costs this can make a significant contribution to reduction in fleet ownership cost as wellⁱⁱⁱ.

The reduction in fuel usage is a result of route optimisation, improved driver behaviour and effective management of abnormal fuel usage patterns. Route optimisation leads to a reduction of time spent in traffic (and thus less idling) and fewer vehicle miles travelled (by taking shortest routes). Improved driver behaviour leads to reduced cases of vehicle idling, fewer incidents of harsh braking and acceleration, fewer incidents of speeding and other driving patterns that result in fuel inefficiency.

Vehicle idling in particular is considered to be one of the most significant sources of emissions created by vehicles^{iv}. For instance, Natural Resources Canada has estimated that if every vehicle reduces daily idling by three minutes, carbon emissions in Canada can be reduced by 1.4 million tonnes annually. Harsh braking and acceleration and speeding also have a negative impact on fuel consumption and fuel costs. Aggressive driving in general can decrease a vehicle's mileage by 10 – 40 %, depending upon whether the vehicle is running on a highway or in stop and go traffic. Fleet telematics devices can track all of these aspects of driver behaviour enabling more accurate driver feedback, which improves driver efficiency. Lastly, fuel management positively impacts fuel efficiency by helping companies monitor fuel levels and helping to identify leaks or waste and any abnormal fuel trends.

One significant aspect of vehicle maintenance is the remote monitoring of tyre pressure and temperature. The correct maintenance of tyre pressure is often overlooked but it is paramount because it directly impacts fuel economy. The US Department of Energy claims that fuel consumption increases by 0.31% with a 1% decrease in average tyre pressure^{vi}. Additionally, properly inflated tyres are safer and have a longer life, thus the technology contributes to other ESG benefits too including safety and reduced material wastage. Other features of proactive maintenance also contribute to ESG benefits, in particular due to fewer cases of vehicle breakdowns (reducing corresponding material wastage) and including the quick identification of vehicles in need of service to maintain vehicle efficiency and extend vehicle lifetime.

While the major impact of Fleet Management solutions is on hydro-carbon fuel, in the case of fully electric and hybrid vehicles they can also contribute towards savings in electric power. Fleet Management for electric vehicles (EVs) provides real time visibility into energy levels and nearby recharging points, so that they can charge at the optimal time and location. Apart from the potential for benefits similar to fuel powered vehicles, Fleet Management solutions for EVs that have features related to battery pre-conditioning, charging history, battery reaction to weather, and usage can help maximise range, battery performance and improve battery longevity which can help save resources consumed by EVs in the long run.

² i.e. not including emissions from power generation.
³ Fleet vehicles include road freight vehicles (which account for 30 % of total carbon emissions), and some portion of road passenger vehicles.

Case Study: Bardusch: Digital Fleet Management

[Source: Deutsche Telekom]

Bardusch, a medium sized textile service provider, serves around one million customers in Germany using its fleet of 350 vans and 30 trucks. The company collaborated with Deutsche Telekom and DeDeNet (software partner) to deploy an IoT based Fleet Management solution to optimise its route planning process. It installed IoT tracking devices in all 380 vehicles which provided real time insight on driver and vehicle data related to location, mileage and refuelling levels or driving and rest times. By adopting the Fleet Management solution, Bardusch was able to select the cheapest routes, increase vehicle utilisation, decrease empty runs of vehicles, reduce fuel costs and serve its customers more efficiently. The solution also increased customer satisfaction through improved transparency and simple communications.

(Image source: Bardusch)



Definition

Fleet Management includes all aspects of operating, managing, and maintaining a fleet of vehicles, while enhancing driver efficiency. Benefits are mainly derived from reduced consumption of fuel (and electricity in case of EVs) from route optimisation, improved driver behaviour, fuel management, proactive vehicle maintenance, right sizing of vehicles and efficient loading and location tracking. The overall efficiency of electric vehicles additionally benefits from monitoring battery health and degradation patterns.

Sustainability Benefits

- **Electricity:** Fleet Management solutions for EVs reduce the electric power consumed by these vehicles in the same way as hydrocarbon fuels for traditionally powered vehicles, thus resulting in 15 % reduction in electricity consumed.
- **Hydrocarbon Fuel:** Companies adopting Fleet Management solutions can expect a 15 % reduction in fuel consumption on average.
- **Carbon emissions:** An average of 15 % reduction in carbon emissions is expected as a result of decreased fuel and electricity (in the case of EVs) use.

Extended ESG Benefits

- **Reduction in road accidents:** Improved driver behaviour reduces instances of harsh braking and acceleration and thus road accidents. The number of road accidents can be decreased by 45–50 %^{vii} on average. In some cases, the reduction in road accidents can be as high as 80 %^{viii}.
- **Improved health and wellbeing:** Enhanced quality of life by reducing stress and time spent in traffic, decreases car pollution, and improves city environments. Additionally, by monitoring the hours of service (HOS) of drivers, Fleet Management solutions can reduce fatigue incidents and ensure compliance with government regulations.
- **Reduction in material wastage:** Reductions in serious breakdowns decreases the extra material wastage associated with them. Additionally, Fleet Management also improves materials wastage by improving the lifecycle of assets such as tyres, batteries and other consumables, and reduces associated pollution including microplastics, brake dust and toxic chemicals. Overall vehicle lifecycles can be extended due to reduced wear.

Enterprise Impact

- **Decreased fuel cost:** The most significant benefit is achieved by reduction in fuel costs: a 15 % decrease in fuel consumption results in same decrease in fuel costs, which typically account for 30–40 % of fleet operation costs. Accordingly, total vehicle operating expenses can be reduced by 5–6 % with Fleet Management.
- **Reduction in vehicle breakdowns:** Preventive maintenance ensures vehicles are well maintained with regular servicing including part replacements and oil changes by analysing the distance travelled by vehicles and residual time for inspection and other parameters. By predicting possible breakdowns in advance and scheduling maintenance, Fleet Management solutions can reduce unexpected breakdowns and repairs by 20 % (on average) and the significant costs associated with such unplanned maintenance^{ix}.
- **Better planning of EV fleet charging cycles:** Real-time visibility into charging levels, charge time and charging locations help to better plan charging cycles and ensure the dispatched fleet has enough battery charge to get the job done.
- **Enhanced customer satisfaction:** Real time location visibility supports the provision of accurate estimated time of arrival to customers, thus enhancing satisfaction levels.
- **Frees up working hours of drivers and overcomes driver shortage:** By finding the most convenient and fastest route, fleet management solutions improve driver productivity and help to overcome the challenge of driver shortages.

Condition Monitoring and Tracking

E	F	CO ₂	+
			

IoT in smart logistics can be used to monitor the location and condition of goods in transit and on arrival at the destination location.

By measuring parameters like temperature, humidity, light intensity, pressure, vibration (or shocks) Condition Monitoring and Tracking can ensure the security and quality of the goods transported. Industries delivering perishable and sensitive items such as food and pharmaceuticals will derive most benefit from implementing Condition Monitoring and Tracking solutions. Roughly one-third of the food produced in the world gets wasted or lost every year^x, with a significant amount of that wastage happening in the supply chain (in transportation, storage, processing units). According to the United Nation's Food and Agriculture Organization (FAO), 14 % of food is lost in the supply chain from post-harvest up to (but not including) retail and consumption level with transport alone accounting for 4 % of loss^{xi}. Food loss in the supply chain can be attributed to lack of adequate infrastructure, loading at incorrect temperatures, driver errors, equipment failures, time delays, uncertainties in demand and supply and changes in weather conditions. It is estimated that 32 % of all cargo is loaded at incorrect temperatures and by using temperature monitoring companies can significantly reduce corresponding wastage by detecting the problem closer to its occurrence^{xii}.

Condition Monitoring and Tracking solutions can reduce food wastage in transport by 30 %^{xiii}, in turn reducing the GHG emissions caused by sending spoiled food to landfill. The technology not only impacts wastage that happens in the supply chain, but ensuring perishable foods arrive at retail stores in better condition increases their shelf life, in turn reducing in-store or retail wastage as well. Additionally, by remotely monitoring shipping conditions these solutions can help to ensure that fruit reaches stores at the right level of ripeness. For example, if a supermarket is short of 'ripe bananas' then it may adjust conditions in the supply chain so that in-transit bananas arrive riper than they might otherwise.

It takes a significant amount of energy (and corresponding GHG emissions) to grow and harvest (or rear), process, store and transport food that ends up getting wasted and thrown away in landfill, where it again produces greenhouse gases such as CO₂ and methane which is an even more potent GHG than CO₂. Different foods have different levels of impact on the environment. For example, the proportion of meat wasted is relatively low compared to cereals or vegetables, but the resources (fertiliser, feed, water, electricity, fuel) used to produce that meat are proportionately much greater, so the wastage of meat also has a significant impact in terms of sustainability.

A typical solution includes sensors deployed in containers carrying food providing real time condition information to determine the condition of produce being transported and enable quick decisions relating to optimal temperature adjustments, rerouting, early offloading, or food repurposing to extend the shelf life of food. Such solutions can allow stakeholders to intervene and take appropriate actions quickly to minimise spoilage. Additionally, the information

provided by sensors can be used to predict (or adjust) ripening durations for fruits and predict the shelf life of vegetables for different customers.

Reductions in food wastage will not have a direct impact on electricity, fuel and water in the production phase, but will indirectly save these resources insofar as they are incurred in the production of food that is ultimately lost: reducing food loss rates in transport reduces the need to produce food by an equivalent amount. In the case of food production, water savings in particular can be quite significant. For example, it typically takes 500 litres of water to produce 1 kg of potatoes^{xiv}. The reduction in production emissions is different for different products as their lifecycles differ, for example one kg of beef and one kg of wheat will have different carbon intensities. It also differs between countries because production methods differ. For example, cereal production is more carbon intensive in Asia than Europe. The impact on CO₂e (CO₂ equivalent) emissions is significant due to saving landfill emissions of CO₂ as well as particularly methane (a far more powerful GHG than CO₂).

The benefits of condition monitoring in the supply chain aren't limited to environmental impacts but also extend to social, economic and enterprise benefits that include stable prices of food, optimised supply chain operations and enhanced customer satisfaction due to precise location visibility, theft reduction, and increased quality. Many companies currently see condition monitoring as a competitive differentiator, since such solutions can help guarantee the condition of delivered goods which ultimately enhances the value proposition. However, some industry participants expect governments to include mandatory condition monitoring alongside existing regulations covering 'track and trace' of goods in supply chains (mainly using barcodes and RFID codes) in the near or mid-term future. Thus, early adoption of condition monitoring may help companies become frontrunners in their market segment.

Similar to the case of the food industry, pharmaceutical and certain other medical-related supply chains also face the challenge of product loss due to failure to maintain the required temperatures in transportation. According to the United Nation's World Health Organization (WHO), every year 50 % of vaccines are wasted globally^{xv}, largely because of lack of temperature control and adequate logistics to support an unbroken cold chain. Sensors deployed in crates, pallets or shipping boxes can be used to monitor the product's temperature and help establish optimal processes for future shipments. IoT solutions can also be used to alert logistics managers in the supply chain to maintain appropriate temperatures allowing for more efficient handling and a reduction in spoilage. Apart from the environmental pollution created from the disposal of spoiled medicines, such actions can also often pose public health risks. By identifying exactly when a shipment was damaged and which items may need to be destroyed, businesses can make targeted recalls more accurately while minimising health risks.

Case Study: Distrilog: Trailer Tracking and Condition Monitoring

[Source: Sensolus]

Distrilog lacked visibility into the location of its trailers which led to logistical challenges such as disputes with drivers and customers. To overcome this, the company partnered with Sensolus to equip its entire fleet of trailers with tracking devices and connect them to the Sensolus IoT platform. Distrilog also equipped its refrigerated trailers with temperature sensors which helped to maintain the condition of goods. For example, when temperatures are either too high or too low, the solution sends a notification to the appropriate team to correct the temperature. With condition monitoring, the company can avoid defrosting problems and food waste by intervening immediately when there is a temperature anomaly.

(Image source: Sensolus)



Definition

Refers to monitoring the condition of goods by measuring parameters like temperature, humidity, pressure, vibration (or shocks) with a goal of delivering the goods (especially perishable and sensitive items) to their destination safely and in good condition. Condition monitoring is particularly relevant in the context of perishable foodstuff and pharmaceutical goods. Condition monitoring makes it possible for manufacturers (or logistic operators) to intervene and act sooner and prevent serious complications if anomaly situations arise. Sustainability benefits are derived indirectly via a reduction in wastage of goods that reach their destination in bad condition and avoiding sustainability costs related to these reduced losses.

Sustainability Benefits

- **Electricity:** No direct impact on electricity in the production phase, but by preventing the wastage of goods and improving yield per unit of electricity it indirectly saves the electricity used to produce and process the goods.
- **Hydrocarbon Fuel:** Reduces the miles travelled by trucks to transport goods that are eventually wasted, and also further transport to disposal locations or landfills. In certain cases, these landfills could be hundreds of miles away from the site of pick-up. Also, indirect benefits due to reduced loss rates.
- **Carbon emissions:** In a condition monitoring context carbon emissions can be reduced not only as a result of reductions in upstream electricity, fuel, and water usage but also reductions in other inputs such as feed (for livestock) or fertiliser (for crops). Condition monitoring also reduces the carbon emissions that are generated by wasted or spoiled products that go into landfill. Temperature monitoring solutions can reduce food wastage in transport by 30 %, in turn reducing associated CO₂ emissions.

Extended ESG Benefits

- **Reduction in other GHGs apart from carbon:** A reduction of 100 kg of food waste sent to landfill corresponds to an average reduction of 8.3 kg of methane emissions^{xvi}, equivalent to 207.5 kg of CO₂ (CO₂e).
- **Safeguarding public health:** Identifying exactly when a shipment has been damaged and which items may need to be destroyed helps businesses to make targeted recalls more accurately while preventing health risks, particularly in a healthcare context.

Enterprise Impact

- **Improvement in income and profits of supply chain participants:** Supply chain participants receive a better return on investment by reduced product spoilage and more efficient transportation.
- **Enhanced customer experience:** Real-time status monitoring, and information relating to the location of goods and better quality of delivered products enhances customer experience.
- **Improved operational efficiency:** Visibility into location and condition provides information on whether products are loaded in the correct vehicles, and if they are secure or if they are stuck anywhere (for example in a custom clearance queue).

Proactive asset monitoring

E	F	CO ₂	+
			

Proactive asset monitoring solutions can provide real-time visibility into the condition and performance of assets across an entire estate. The technology supports the analysis of a range of parameters (such as temperature, vibration and audio footprint) and allows operators to schedule maintenance events and resources (such as technicians) in the most effective manner.

As a result, on-site visits can be scheduled only when needed and schedules can be optimised to visit multiple sites for required maintenance rather than simply visiting for scheduled maintenance or emergency trips when something breaks. This directly results in a reduction in fuel consumption, as it reduces unnecessary field trips (and truck rolls) technicians might take to facilities. For example, Varian Medical, a medical device manufacturer, reduced technician visits (and associated truck rolls) by 42 % by deploying IoT based monitoring for its systems^{xvii}. Though the reduction in number of visits depends upon the factors mentioned above, in most industries, the technology can help decrease technician visits by 10 – 20 %^{xviii}.

Additionally, due to a better understanding of asset conditions, technicians visiting facilities to undertake maintenance can be much better prepared which results in a significant reduction in additional trips required to fetch spare parts in case repairs are needed. It also increases the probability that the issue will be remedied on a single visit, reducing repeated trips by understanding the root cause of the problem in advance before coming to the site. For example, McKinley Elevators, by having increased visibility into its installed base of equipment, achieved a first-time fix rate of around 88 percent, higher than the average rate of service industry at 60 percent^{xix}.

Additionally, predictive maintenance also reduces the raw materials and parts that would have been consumed if a serious breakdown had occurred.

Proactive asset monitoring also helps in identifying energy (particularly electricity) loss caused by suboptimal performance of devices because of incorrect electrical supply, unidentified faults or worn-out equipment. It allows users to do frequent energy audits, ensure motors are drawing the correct amount of power and identify any machines that require maintenance for efficient working, which in turn results in energy savings. For example, an automotive manufacturer in India decreased the energy consumed by its machines by 17 – 19 % by identifying degradation in machines caused by current phase imbalances. Furthermore, by identifying machines that required maintenance, it decreased the energy consumed by these machines by 15 %^{xx}. The data captured by monitoring systems allows operators to benchmark the energy consumption of a machine against machines with similar capacity helping them identify inefficient machines that may require servicing. In addition to analysing a machine's performance and efficiency, monitoring systems can help identify machines (or motors) that are running unnecessarily or running after the tasks have been completed which can bring additional energy savings.

Raw material or goods consumption is a key consideration for companies in order to minimise carbon footprints and save on raw material costs. Remote monitoring can provide visibility on material consumed by assets and the amount of material left, helping companies optimise the consumption and minimise wastage. For example, Bauer Compressors by integrating a remote monitoring capability in its compressors optimised the consumption of gas used by the compressors, which apart from bringing material savings (and in this case energy savings as well) also resulted in financial savings due to reduced consumption of gas^{xxi}.

Reduction in material consumption is further complemented by IoT solutions designed specifically for fill level monitoring of tanks or storage bins. These solutions help in avoiding overflow of things like industrial lubricants (in manufacturing plants), chemicals (in wastewater plants), and gases, in turn reducing material wastage and helping to decrease water and land pollution generated from manufacturing plants. Conversely, remote fill-level monitoring can allow for significantly more efficient supply and distribution networks for companies that need to maintain stock levels at client locations.

In terms of business benefits, proactive asset monitoring has a direct impact by reducing the operating and maintenance costs of a company, most notably in reducing labour and the cost of maintenance parts (including repair costs). Repairs after a failure can result in a huge cost burden and extended outages, but proactive asset monitoring solutions can enable preventive maintenance to be planned and executed at the optimal time, reducing the costs and increasing the uptime of the assets. For example, German public utility company Stadtwerke Rotenburg was able to reduce the repair costs by 30 % by implementing a remote condition monitoring solution for monitoring pumps and machines in its wastewater treatment plants^{xxii}. In a manufacturing facility, increased availability and efficiency of equipment directly enhances the Overall Equipment Effectiveness (OEE)⁴ and productivity of the plant, ultimately increasing the profits of the company by increasing throughput. For example, Tetro, a consumer products manufacturer, by adopting a remote monitoring solution, improved its OEE by 30 %, while saving on energy & material waste, and reducing time to market by 25 %^{xxiii}.

⁴ OEE is a metric used to measure how effectively a manufacturing operation is running, it is calculated with the formula (Availability) x (Performance) x (Quality)

Case Study: Distrilog: Petko: IoT solution for remote servicing and predictive maintenance

[Source: Deutsche Telekom]

Petko, a German manufacturer of compressed air systems, uses Deutsche Telekom's Cloud of Things and PSsystec's Smartbox to monitor its compressed air systems installed at various customer sites remotely. The solution provides real time visibility into machine parameters such as pressure, power supply and temperature to technicians. Before deployment of the solution, the service technicians used to waste time and effort investigating machine malfunctions on-site. Remote monitoring has helped technicians by providing a precise picture of the situation on site beforehand, which better informs the technicians so that they can be prepared with required spare parts. The data collected helps the company assess efficiency (including energy efficiency) of machines, predict failures, and identify the best time to invest in a new system. The solution automatically notifies when repairs are needed and provides a timely reminder of upcoming maintenance. All of this speeds up service assignments and saves time and money. Petko customers also benefit from the solution with increased availability of the compressors and compressed air preparation systems, and faster troubleshooting time. (Image source: Deutsche Telekom)



Definition

Monitoring the condition and performance of assets (such as machines, medical devices and other assets) to make them more efficient and identify faults in advance before a serious breakdown occurs. The category also includes monitoring of fill level of tanks and storage bins to ensure they don't overflow or run out.

Sustainability Benefits

- **Electricity:** Continuous monitoring of assets (especially machines) ensures correct current phase balance, improves efficiency, optimises running time and identifies assets that require maintenance, in turn resulting in energy savings. On average, a 10 % reduction of electricity consumed by sub optimally running assets can be expected, and potentially up to 15 % in some cases.
- **Hydrocarbon Fuel:** Reductions in fuel consumption by optimising maintenance schedules and avoiding unnecessary field trips taken for inspection and repairs. The reduction in technician visits (and fuel) varies by type of asset being monitored, mode of transport and maintenance frequency. In most industries, the technology can help decrease technician visits by 10 – 20 %. In some scenarios the savings can be significantly higher.
- **Carbon emissions:** Reduces the electricity consumed by assets and decreases the need for frequent inspections (and truck rolls). These factors, along with avoidance of material wastage, led to considerable carbon emissions savings.

Extended ESG Benefits

- **Reduction in material consumption:** Predictive maintenance reduces serious breakdowns and associated raw material waste.
- **Reduction in water and air pollution:** Fill level monitoring of tanks or storage bins can lead to a significant decrease in overflow of things like industrial lubricants, chemicals, or gases, in turn reducing water and land pollution.

Enterprise Impact

- **Increased productivity of technicians:** Saves time and effort spent in identifying malfunctions, since technicians get clear visibility into anomalies before visiting an asset and thus can resolve issues more quickly.
- **Parts stock optimisation:** Leads to significant reduction in time taken to initiate the spare part ordering process through remote problem diagnosis and so allows for reductions in stock levels.
- **Reduction in machine downtime (and associated losses):** Quick resolution of issues leads to much shorter period of machine downtime. On average, machine downtime can be decreased by 20 %^{xxiv}.
- **Increased Overall Equipment Effectiveness (OEE) and throughput:** Increases OEE, which ultimately increases the line throughput and profitability of the company. On average, OEE can be increased by 15 – 20 %^{xxv}.
- **Reduction in maintenance costs and downtime:** Proactive repair and maintenance and avoidance of costly downtime due to breakdowns.
- **Reduction in production timeframes:** A decrease in machine downtime enhances operational efficiency and production processes, in turn reducing production timeframes.
- **Decrease in electricity bills:** In some cases, remote monitoring can prevent situations where excessive electricity costs are caused by higher current flow for a given load.

Remote maintenance

E	F	CO ₂	+
			

Remote maintenance extends the predictive maintenance use case and allows companies to perform technical maintenance activities, support and assistance (in case of event or fault), software updates, patches, or reconfiguration of software parameters, completely remotely.

The main sustainability impact of remote maintenance is a reduction in fuel consumption (and associated CO₂ emissions). By allowing support requests to be undertaken completely remotely, remote maintenance can eliminate vehicle trips that might have been taken by staff to perform these activities on-site. For example, Selecta Group, a food tech company based in Europe, was able to reduce technician visits by 30 % for repair and maintenance of vending machines with remote maintenance^{xxvi}. Though the reduction in number of visits depends upon a lot of factors, in most contexts an average reduction of 20 – 30 % in technician trips can be achieved by adopting remote maintenance solutions^{xxvii}. However, the impact on reduction in number of visits varies widely across the type of system being maintained along with maintenance frequency, travel distance and mode of transport. In some cases, where highly specialised skilled resources are required, technicians can be required to travel from across the globe and in such cases the impact could be even higher due to avoidance of airplane journeys.

Remote maintenance can result in business benefits over and above those associated with proactive asset monitoring, since it further reduces the maintenance cost, on-site and travel time of technicians. It also further improves the time taken to resolve queries as troubleshooting can be done from a remote location. For example, ClearLASER was able to resolve 85 % of its queries remotely with TeamViewer remote monitoring and maintenance^{xxviii}. Integration of remote maintenance capabilities in devices can positively impact revenue growth as well, as it can generate an

additional stream of recurring revenue for the company providing assets. This includes an ability to offer services on a pay-per-use, or pay-as-you-go, basis where clients may purchase a certain capacity and the machine shuts down after providing that capacity until the purchase of further credits. This model can benefit the users of the machines in question as a result of potentially simpler licensing models without upfront costs. In 2021, Daikin introduced a subscription service for its air conditioners in Africa, where it charged customers USD 1.40 only on the days customers used the cooling service.

Alongside a decrease in maintenance costs, remote maintenance offers companies an opportunity to update onboard device software more frequently and thus new features and functionalities can be added to the device more frequently. Remote software updating also affords the potential for companies to make new services available to users of their devices, either by updating with new software or by activating a capability that is already built-in but has not been purchased. Altogether, it allows for a much more agile approach to software development, with software that can be synchronised to devices regularly. Additionally, it allows for software updating to happen simultaneously across a device estate rather than devices needing to be updated one-by-one, visit-by-visit. Overall, the technology can support a better proposition for customers, since their device estate can be reconfigured, or have software updated, near instantly so customers don't have to deal with a fragmented device estate.

Case Study: Coca-Cola HBC: Augmented Reality solution for remote support and guided inspection *[Source: TeamViewer]*

Coca-Cola Hellenic Bottling Company (HBC) adopted TeamViewer's xAssist and xInspect solutions for remote support and inspection to avoid downtime in production lines. In the case of a production outage employees using xAssist and smart glasses can connect with experts via video calls and receive remote assistance in restoring operations. For regular maintenance or changeover processes, Coca-Cola HBC has created its own Augmented Reality workflows with the help of TeamViewer xInspect and the Frontline Creator. Workflow information is sent to workers' smart glasses providing step-by-step guidance. The remote support solution has helped Coca-Cola HBC to reduce downtime by 50 % and saved time and travel expenses of experts by helping them perform activities remotely. The use of xInspect enabled 30 percent faster training of employees, saved 20 % of time spent in production changeover processes and improved the quality assurance process. In addition, inspection and management visits can also be carried out via live video call avoiding the travel associated with regular visits. *(Image source: Teamviewer)*



Definition

Performing maintenance and support activities remotely including software upgrades, IT support and assistance. The assets covered by this kind of solution can belong to a wide range of industries including but not limited to manufacturing, medical devices, and renewable energy generation assets. Remote maintenance often leads to a reduction in site visits for regular maintenance and other support activities. Remote Maintenance is an enhancement to Proactive Asset Monitoring. It includes both remotely controlling and monitoring the health of assets and predicting maintenance service, and actually undertaking some aspects of maintenance, support and service activities remotely.

Sustainability Benefits

- **Electricity:** As observed in Proactive Asset Monitoring, continuous monitoring and maintenance of assets (especially machines) can lead to 10 % reduction of electricity consumed by sub optimally running assets, potentially up to 15 % in some cases.
- **Hydrocarbon Fuel:** With Remote Maintenance, service or maintenance related on-site visits can be reduced or even eliminated, resulting in a proportional decrease in fuel to perform these maintenance activities. The impact on reduction in fuel varies widely with the type of system being maintained along with maintenance frequency, travel distance and mode of transport. The reduction in number of visits depends upon a lot of factors, but in most industries remote maintenance can lead to an average reduction of 20 – 30 % in technician trips.
- **Carbon emissions:** Elimination of travel to sites reduces the associated CO₂ emissions by same proportion as fuel.

Enterprise Impact

- **Decreased maintenance cost:** Reduces maintenance costs by maintaining equipment remotely.
- **Increased productivity and satisfaction levels of front-line workers:** As the technology reduces the travel time of technicians it results in more efficient usage of time and freeing up of extra working hours, ultimately improving the satisfaction levels of employees.
- **More frequent upgrade of onboard software:** Software updates, including new features, functionality, and user experience enhancements, can be added more frequently, in turn allowing for a much more agile (and lower risk) approach to software development.
- **Enhanced security:** Bugs and issues in a remotely maintained system can be addressed quickly, enhancing the security of the system.
- **Additional revenue opportunities:** Remote monitoring also provides opportunities for companies to drive recurring revenue by adding digital service capabilities to the machines they supply to customers, particularly when those machines are leased.

Warehouse management and Intralogistics

E	F	CO ₂	+
			

Warehousing is one of the most significant sources of logistics and supply chain emissions. The main sources of emissions in warehouses are heating, cooling, lighting, material handling activities and in-house transportation. 13 % of overall supply chain emissions are caused by material handling activities in logistics buildings (including warehouses and sortation facilities)^{xxix}.

One of the major challenges that warehousing facilities face is to synchronise movement of goods between inspection, sorting and picking, production, and finished good facilities. The significant potential for misdirection and mismanagement not only results in inefficient operations but is also a major cause of unnecessary fuel consumption in warehouses. Trucks travelling between and within these facilities often waste extra fuel looking for empty containers or trolleys, sitting idle waiting for goods to be loaded, or awaiting directions. Sometimes these trucks also make empty runs because of lack of visibility into location of goods. Asset tracking enabled by IoT (including tracking of vehicles, goods and equipment) improves coordination and gives more control over in-house flows of materials. IoT tags can be used to identify the location of trucks within facilities and the load inside each, significantly reducing the amount of time trucks spend idling, waiting for directions and burning unnecessary fuel. It also leads to a reduction in unladen vehicle movements promoting the efficient utilisation of vehicles and, in turn, reducing the consumption of fuel. Improved visibility into the location of goods and equipment also reduces extra miles (and fuel) consumed by fuel-operated (mostly diesel and LPG⁵) material handling equipment such as forklifts.

IoT technology and warehouse management systems enabling coordinated routing, where loads can be shared between different companies or otherwise be synchronised, can help to reduce unnecessary emissions caused by empty trucks and trucks running at less capacity or less than load (LTL). This creates a more efficient logistics capability saving both costs and emissions. In general, inbound freight programs including LTL management, freight consolidation, and efficient synchronisation of logistics, can save around 25 % of associated costs^{xxx}. Furthermore, such an approach can result in around 5 % of savings in carbon emissions for inbound transportation^{xxxi}.

Warehouse management and Intralogistics solutions can also have a positive impact on electricity consumption. IoT trackers used for stock level monitoring and inventory management can help to reduce inventory levels by 15 – 20 % on average^{xxxi}. Proximus, a Belgian telecommunications network operator, reduced its cable inventory by 15 % by tracking inventory in warehouses with the help of sensors placed in cable drums^{xxxi}. This reduction in total amount of inventory held in warehouses allows for potentially smaller spaces to be used, resulting in lower energy use and lower emissions per unit of throughput. Savings include reduced electricity for lighting, reduced heating and cooling, and less fixed material handling equipment (like conveyors) and electric mobile material handling equipment working to support stock movements.

Inventory optimisation solutions are also helpful in reducing fuel consumption. By creating better stock level forecasts, they help optimise the infrastructure required to transport goods (by combining truckloads or combining freight loads) and reducing the incidence of partially loaded or empty vehicles. Additionally, maintaining correct levels of inventory reduces out-of-stock situations further down supply chains, which could avoid extra customer trips and associated fuel consumption.

Inventory and warehouse management can also achieve carbon savings by reducing the wastage of goods due to loss or overstocking. Accurate stock forecasting enabled by inventory monitoring solutions can ensure warehouse operations are running at peak efficiency closely matching demand and minimising wastage of products. For example, in the fashion industry, an industry with relatively long lead times and short product cycles, optimising stock production and allocation across distribution warehouses and retail stores can significantly reduce overproduction and waste.

Supply Chain sustainability has become a key goal for many enterprises due to increasing demand from consumers for transparency and traceability in supply chains, especially where social breakdowns can occur such as with the use of forced labour and child labour for globally traded goods. IoT-enabled solutions can provide visibility into factors such as emissions created in production and warehousing and labour practices followed, which helps brands create a sustainability appeal and build customer loyalty.

Warehouse management and Intralogistics solutions in warehouse facilities also contribute towards wider cost and efficiency business goals of companies including improvements in operational efficiency enabled by synchronised flow of materials, optimised use of resources, elimination of errors, and reduction in time and resources used in searching for goods or supply chain assets (such as pallets and cages). Inventory management specifically helps in improving on-time deliveries, managing supplier lead times, reducing out of stock situations, reducing shipment costs, energy costs and inventory holding costs and increasing floor space utilisation. Out-of-stock situations can be particularly important for retailers since they can result in sales losses. For example, out-of-stock situations in Walmart cost the supplier about 2 % of its total retail sales and 50 % of these are a result of inventory inaccuracies^{xxxiv}. In a study commissioned by Walmart, it found that by deploying RFID based inventory solutions in stores and control centres it can reduce out-of-stock situations by 21 %^{xxxv}.

⁵ Liquefied Petroleum Gas

Case Study: BASF Coatings: IoT solution for Intralogistics*[Source: Deutsche Telekom]*

Employees at BASF's Münster site had very limited visibility and control over the in-house flow of materials. Coordinating the process of moving 450 trolleys (carrying raw materials and products) at the site in a targeted manner was a challenge. The lack of synchronisation led to drivers wasting time and fuel looking around for trolleys and sometimes a driver making an empty run because another driver had reached the destination first. With the help of Deutsche Telekom, BASF deployed sixty IoT Service Buttons to digitise the process of collection of the goods to be transported. These buttons are placed near the handover areas where trolley trucks collect the goods. Once a forklift loads containers, barrels and pallets onto the trolleys, the employee in charge presses the button which notifies the driver to collect and transport goods. The solution has helped BASF optimise in-house transportation, reduced empty runs (and associated cost and fuel) and make the process more efficient. *(Image source: Deutsche Telekom)*

**Definition**

Refers to optimised use of resources within a distribution centre or a warehouse leading to increased production capacity, throughput, elimination of errors, and improved visibility and traceability of stock. Includes warehouse equipment like shelf sensors and assets that enable staff to find goods and manage correct inventory levels. Extended benefits include improved synchronisation with a supply chain, such as production planning taking into account the location of goods in a supply chain, and supply chain optimisation given the needs of a production facility.

Sustainability Benefits

- **Electricity:** Inventory monitoring can reduce inventory levels in warehouses by 15–20% resulting in reduced warehouse storage space required for holding stock thereby decreasing electricity usage (such as for HVAC, lighting, and material handling) per unit of throughput.
- **Hydrocarbon Fuel:** Visibility into the location of assets and vehicles enables quick routing of trucks or cargo containers, avoiding engine idling and waiting time and movements of empty vehicles, in turn reducing the consumption of fuel in transportation. It also enables combining of loads between different companies, leading to avoidance of unnecessary fuel used in taking less than load shipments and empty backhauls. In general, freight programs including LTL management, freight consolidation and efficient synchronisation of inbound logistics can save around 5% of associated fuel.
- **Carbon emissions:** Warehouse management and Intralogistics solutions can have a significant impact on carbon emissions by reducing wastage of products enabled by efficient inventory planning and reducing electricity and (heating) fuel consumption enabled by a decrease in warehouse space and by reducing (vehicle) fuel consumption within facilities. A company can save on average around 5% of carbon emissions incurred in fuel usage for inbound deliveries and 15–20% of emissions caused by electricity usage and heating fuel consumption in a facility, with additional savings corresponding to reduced vehicle fuel use within the facility.

Extended ESG Benefits

- **Reduction in waste:** Inventory optimisation and effective demand planning reduces an organisation's product waste, raw material waste and packaging material waste.
- **Increased employee productivity and reduced workload:** IoT-based systems in warehouses provide real-time support to employees, helping them identify correct items and reduce errors, thus reducing the workload while increasing productivity.

Enterprise Impact

- **Increased customer satisfaction levels:** Asset, goods and container tracking solutions can provide customers with visibility into location and expected times of arrival and improve on-time deliveries, resulting in increased customer satisfaction levels.
- **Reduction in inventory holding cost:** Reduction in inventory levels by 15–20% on average, in turn reducing the cost incurred to maintain inventory by 15–20%.
- **Reduction in inventory losses:** Reduction in goods lost or stock that is written-off due to overstocking.
- **Reduction in freight costs:** Freight programs including LTL management, freight consolidation and efficient synchronisation of inbound logistics can save around 25% of associated costs.
- **Reduction in time to trace goods or assets:** Real-time location visibility of assets reduces the time taken to trace them, thereby increasing the operational efficiency in a warehouse.
- **Reduction in out-of-stock situations:** Identification of correct levels of inventory leads to reduction in out-of-stock cases.
- **Reduction in loss of reusable supply chain assets:** Tracking of returnable supply chain assets such as pallets, kegs, containers and boxes can reduce losses significantly.
- **Improved customer loyalty:** Accessibility of information (related to emissions generated in production, manufacturing, warehousing) is helpful in creating sustainability appeal which ultimately builds consumer loyalty for brands.

Smart building management

E	F	CO ₂	+
			

IoT can be used to monitor and control building systems including heating, ventilation and air conditioning (HVAC), lighting, windows, blinds and curtains, and doors. This includes both remote control by a user and automatic reaction by building controllers in response to factors such as occupancy, humidity, airflow and temperature. Monitoring capabilities provide visibility into consumption patterns which helps building managers (in the case of commercial buildings) and residents (in the case of residential) optimise their use of energy.

Buildings account for 27% of energy related carbon emissions^{xxxvi}. The two biggest users of electricity in both home and commercial facilities are HVAC and lighting. On average HVAC accounts for 35 – 40% of a building’s total energy consumption and lighting a further 15 – 20%^{xxxvii}. Even the smallest reduction in electricity and fossil fuels (in the case of heating) consumed by these systems can lead to significant reductions in CO₂ emissions overall. For instance, it is estimated that increasing air-conditioning temperatures in India by one degree Celsius can achieve 6% energy savings^{xxxviii}, so the potential sustainability benefits associated with closely managing temperatures based on occupancy are clear.

Smart HVAC controller systems or central building automation systems can accurately monitor temperature, airflow and other parameters in different areas of a building, in addition to external factors (such as opened windows, weather forecasts, availability of renewably generated electricity, and so on) and adjust the HVAC systems accordingly leading to minimised energy consumption in unoccupied building zones, reduced HVAC usage during peak times of energy demand or when more electricity is generated from non-renewable sources, and optimised supply of conditioned (heated or cooled) air. Overall, smart HVAC technology reduces energy consumption by reducing and optimising heating, ventilation and air conditioning when areas of a building are not in use, and by analysing the air pressure to reduce leakage, often resulting in energy savings of 20 – 30%^{xxxix}. An associated example of optimisation of airflow is a smart ventilation system that senses the levels of CO₂ and other airborne pollutants in occupied areas and modulates the amount of airflow in one area without starving or over-ventilating others. This puts less load on ventilation fan operation and reduces the energy used.

Similar to HVAC, building automation systems can also automate or give better control to building managers to set lighting schedules, enable dimming or switching off of lights based on occupancy, or turn off lights near windows when outside light intensity is high. In combination, these techniques have the potential to save 30 – 40% of electricity consumed through lighting^{xl}. Such systems can also support sophisticated data analysis. By having visibility into energy consumption of different end users, facility managers can identify systems that are working below efficiency and which,

when replaced, can improve overall efficiency. Automated control of windows, blinds, louvres, and curtains can offer additional opportunities for energy savings by effectively managing solar gain, again reducing the load on air conditioning systems and so reducing energy consumption and carbon emissions.

Other IoT solutions that monitor occupancy in office buildings can lead to more efficient usage of office space through room booking or allocation of appropriate workstations. This kind of interaction with the building (often via an app) for tasks such as booking work-places/rooms or submitting a trouble ticket in the case of broken inventory provides an opportunity for building users to become part of the networked community. Alongside the trend for employees to work more from home, this will enable companies to concentrate their office-located workforce into specific areas of buildings and unoccupied areas can have HVAC and lighting systems switched off, and potentially an organisation can reduce its overall requirement for buildings space by better managing occupancy.

Additionally, smart buildings that have been certified (for instance according to SBC⁶ or RESET⁷ specifications) can have higher lease rates and sale value compared to non-smart buildings. These smart building certifications measure the sustainability, health and energy performance of buildings. Energy efficient buildings can achieve significantly higher rental premiums and be sold at higher prices.

⁶ ‘Smart Building Certification’ is a certification process for intelligent buildings.
⁷ ‘Regenerative Ecological, Social, and Economic Targets’ is an international building standard, accompanied by a set of assessment tools, to develop actionable, long-term strategies towards health and sustainability.

Case Study: Accenture: Smart Building Management

[Source: Spacewell]

In 2019, Accenture partnered with Spacewell (represented by Crem Solutions in Germany) to deploy a smart building management solution at its new facility in Brussels. The smart building solution was composed of Space Monitor (with PIR motion sensors) and Comfort Monitor solutions from Spacewell. After the deployment of the solution, Accenture was able to identify opportunities to improve overall space utilisation and was able to enhance employee comfort by tuning the HVAC system by measuring parameters like temperature and humidity. Moving forward Accenture plans to integrate this solution with other building management systems, and the workplace management and trouble ticketing systems of the facility service provider to broaden the scope of available data and further increase efficiency.

(Image source: Spacewell)



Definition

Refers to monitoring and control of building systems including lighting, HVAC, windows, blinds and curtains, and doors, based on occupancy levels of areas within a building and other information such as local weather conditions and the availability of renewably generated electricity.

Demand-oriented management supports turning off lights and heating/cooling when occupancy isn't detected, closing of windows or lowering the blinds when heating/cooling is on, responsible consumption by having visibility into energy use, and optimisation of these resources based on previous trends and ambient conditions. It also includes better usage of office space through room booking or allocation of workstations.

Sustainability Benefits

- **Electricity:** A Monitoring and control of lighting systems can result in a reduction of 30 – 40 % in electricity consumed by lighting systems. Monitoring and control of HVAC systems can lead to a reduction of 20 – 30 % in electricity consumed by HVAC systems. Overall, smart building management can reduce total electricity consumed by a building by 10 – 20 %.
- **Hydrocarbon Fuel:** The impact on hydrocarbon fuel is mainly a result of decreased fossil fuels used in HVAC (specifically heating systems), again by 20 – 30 %.
- **Carbon emissions:** Reduction in carbon emissions as a result of reduced electricity and fossil fuels consumed by lighting and HVAC systems, and also through increasing the share of electricity sourced from renewables. Overall, smart building management can reduce 10 – 20 % of total carbon emissions of a building.

Extended ESG Benefits

- **Comfort and productivity of occupants:** Controlling various aspects of the indoor environment (such as ventilation) can have a profound impact on the health, wellbeing, and productivity of occupants.
- **Reduction in material waste:** Continuous monitoring and diagnostics of HVAC systems can extend their life and reduce the resources and material waste consumed in case of system failures.
- **Better indoor air quality:** Ensuring that airflow is sufficient, and that various pollutants are maintained within acceptable limits.
- **Increased utility:** User interaction with the building (often via an app) provides an opportunity to become part of the overall networked community, allowing for further optimised convenience for users.

Enterprise Impact

- **Reduction in energy bills:** Lower consumption of energy reduces the associated expense.
- **Reduction in maintenance costs:** Real-time diagnostics allows for early detection of potential system failures, which helps technicians to undertake preventive maintenance, decreasing system downtime and repair costs.
- **Higher lease rates and valuations:** Certified energy efficient buildings can have significantly higher rental premiums and be sold at higher prices.
- **Reduced operating costs and enhanced system performance:** Particularly in a commercial buildings context, operating costs are reduced as the requirement for manpower to manually maintain and operate building systems reduces, particularly when associated with Artificial Intelligence (AI)-enabled analysis to help identify any anomalies.
- **Additional revenue opportunities with increased employee productivity:** Optimisation of indoor air quality has the potential to generate additional revenue as it can enhance the productivity of employees and decrease employee absence.

Smart street and outdoor lighting

E	F	CO ₂	+
			

Intelligent lighting solutions use IoT to manage outdoor lights (such as street lights and illuminated billboard advertising lights) remotely by providing control functions (switch off, switch on, manage intensity) and monitoring functions (status detection, anomaly detection, light level measurement).

Smart lighting can lower the consumption of electricity as it enables dynamic lighting by switching off or lowering the intensity of light when not required or based on environmental factors such as human presence, type of neighbourhood, type of road, density of pedestrians. In the case of street lights, apart from lowering the intensity of light it can help identify losses (such as due to theft or failing components) in power supply by providing visibility into electricity consumed by each street light.

In most cities, local governments and public authorities are responsible for providing street lighting to ensure the safety of citizens. This obligation, however, accounts for a significant portion of the energy consumption, and thus energy costs, of a city. Street lighting typically accounts for about 1–3 % of the total demand for electricity in a country^{xli}. For example, for the city of Paris 345,000 light sources (including street lights, signage, and park lighting) consume around 140–150 GWh of electricity each year^{xlii}. Street lights with light control systems can reduce the power consumption and related carbon emissions by 20–30 %^{xliii}. Conversion of street lights to LED and integration of smart controls together can reduce the power consumption by 50–60 %^{xliv}. The technology not only contributes towards energy savings but can significantly ease the financial burden of municipalities, since street lighting can account for up to 40 % of the total electricity bill of a municipality^{xlv}.

There are also opportunities for power savings in lighting for illuminated advertising (for instance billboard lighting). In Manchester in the United Kingdom advertising screens use electricity equivalent to three average households in the city^{xlvi}. Advertising installations often illuminate at high intensity to have a positive impact on a company’s image, but auto adjustment of light intensity depending on ambient brightness, along with customised programming schedules, can bring a significant reduction in electricity and so carbon emissions. For example, Porlier Outdoor Advertising Company achieved a reduction of 20 % in electricity consumption per month by adopting a smart lighting control solution^{xlvii}. Like street lighting, smart controls in advertising also can reduce the power consumption of installations and related carbon emissions by 20–30 %^{xlviii}, reducing utility costs by the same proportion. For instance, Rogers media company reduced its utility bills by 30 % after implementing a smart control system in advertising lighting^{xlix}.

Apart from having a positive impact on electricity consumption, smart control integration enables monitoring and control of lights from a control centre which reduces site visits (and associated fuel) required by operators to maintain street lights, and efficient maintenance increases the lifecycle of these assets. Intelligent outdoor lighting systems also contribute towards social and other ESG benefits such as reducing light pollution and improving the safety and security of pedestrians by powering the lights to high intensity when human presence is detected.

Modern street lighting infrastructure can also act as a medium for other IoT applications such as monitoring air pollution and traffic and parking management amongst other use cases. For example, Gijón, a city in northern Spain, is using five Omniflow smart lamp poles to measure air quality, analyse pedestrian flows, and plan vehicle traffic in that area. Light poles can provide an uninterrupted power source for sensors (such as air quality sensors and traffic monitoring sensors) and communications equipment embedded in smart street lighting reduces the need for additional hardware, generators and batteries. This not only reduces the cost of implementing additional IoT systems but can also contribute towards a sustainable environment by decreasing fuel consumed in traffic congestion. This reduces air pollution through enhanced monitoring and decreases the raw material resources for additional equipment. Another service that can be hosted on these poles is parking management where solutions can direct vehicles to vacant spots and decrease fuel usage associated with extra miles travelled looking for a parking space. Additionally, in the near future the Omniflow poles can be augmented with computer vision to activate light and sound alerts when accident risk is detected to warn drivers and people using pedestrian crossings, thus improving pedestrian safety.

Case Study: Berliner Bogen: Smart Illuminated Advertising with IoT [Source: Deutsche Telekom]

Berliner Bogen, a 140 m long building located in Hamburg's Anckelmannsplatz, deployed LichtWART's smart lighting system and Telekom IoT's platform solution to control and monitor lighting arrays at the entrance area of the building. The solution enables an operator to monitor the lighting remotely and enables predictive maintenance, ensuring that maintenance and repairs are carried out in good time. In case of an outage, the repair process is initiated automatically with lower process costs and reduced personnel input, in turn reducing the maintenance and operating costs. The system also informs technicians with details about the fault before they visit the site so they can carry the appropriate spare parts with them. The solution has also helped them reduce energy costs significantly. (Image source: Deutsche Telekom)



Definition

Refers to monitoring and control of outdoor lighting (including street lights and advertising) to adjust the light levels and intensity based on time, events, human presence, and other environmental factors. Includes smart poles that support other smart city IoT use cases such as traffic monitoring, smart parking, and many more. Benefits are derived through a reduction in electricity consumption due to lowered light intensity when humans are not detected and other efficiencies.

Sustainability Benefits

- **Electricity:** Smart outdoor lighting can reduce the electricity consumed by street lights and advertising lighting by 20 – 30 % on average. In some cases, savings can reach 40 %. Conversion of lights to LED and integration of smart controls together can reduce power consumption by more than 50 %.
- **Hydrocarbon Fuel:** Real time monitoring enables operators to take better informed decisions and reduces the need for truck rolls to inspect and maintain street lights. Additionally, smart street lights can potentially support other smart city IoT applications including traffic monitoring and parking management that can also help to reduce fuel consumption.
- **Carbon emissions:** 20 – 30 % savings can be achieved in carbon emissions associated with electricity consumption for lighting. Additional savings can be achieved by reduced fuel consumption due to reduced trips for maintenance and by other smart city IoT applications such as traffic monitoring and parking management.

Extended ESG Benefits

- **Lower light pollution:** Dynamic adjustment of light levels considerably lowers the unwanted light pollution which benefits both city residents and nocturnal wildlife.
- **Increased pedestrian satisfaction:** Smart street lights can illuminate when they detect human presence, which can decrease crime rates and improves overall public safety and satisfaction. Smart street poles can potentially be used to activate light and sound alerts when an accident risk is detected to warn drivers and people using pedestrian crossings.
- **Extended life of lights:** Predictive maintenance improves the lifecycle of lights resulting in reduced levels of material waste and reduced truck rolls.

Enterprise Impact

- **Decreased energy cost:** Electricity costs for a city can be decreased by 20 – 30 %, which, considering electricity can account for up to 40 % of a municipality's energy bill, can result in significant financial savings. Electricity bills of companies incurred in advertising lighting can also be decreased by 20 – 30 %.
- **Lowered repair and maintenance cost:** Remote monitoring enables early diagnosis of faults and malfunctions, enabling operators to take informed actions quickly and thus reducing repair and maintenance costs and extending the lifecycle of assets.
- **Shorter response time to outages:** Predictive maintenance and remote monitoring can spot faults in real-time or in advance, potentially further decreasing the response time to outages.

As described in the previous use cases, IoT solutions offer a massive potential for enabling environmental sustainability and reducing carbon emissions. However, IoT solutions also have a sustainability cost associated with them.

There is often scope to reduce the sustainability cost across all of the lifecycle stages of an IoT device, including design, distribution, live operations and at the end-of-life. IoT Solution Optimisation tools can help companies design and select the most energy efficient solution appropriate for the application use case. Such tools can help to optimise hardware components, solution design and communication protocols based on factors such as data traffic profile, external deployment environment (such as temperature conditions), network coverage, communication, or other deployment characteristics. An optimal interplay of different components, supported with testing in a virtual environment using digital twins, can unlock significant reductions in the energy consumption of IoT solutions. This not only provides visibility on the energy efficiency profile of the IoT solution but can also help companies validate the product sooner, thus reducing the time to market while reducing the development costs such as costs incurred in field test scenarios.

Some communication protocols may not be suitable for every IoT application and selecting a suboptimal protocol can lead to unnecessary data transmission which in turn consumes more power and reduces battery life. For example, Wi-Fi (802.11) is the most commonly used protocol in connected white goods, but it might not be a suitable option for other home applications such as connected fire alarms because it may significantly increase data transmissions and so reduce battery life. By contrast, the cellular technology NB-IoT is designed to send small amounts of data and allow devices go into a sleep mode and save energy between transmissions, resulting in an extended battery life.

For maximum efficiency, it is also important to design any application associated with an IoT solution carefully and to select the right communication parameters to ensure that devices aren't sending data more frequently than necessary and so consuming extra power. This is particularly important in the case of battery-powered devices that are not easily accessible by the company that operates them, since reductions in battery life result in a need to replace batteries sooner, which would likely involve a visit from an engineer (and an associated truck roll). Thus, more efficient battery-powered solutions have the potential to help save fuel, reduce costs and improve overall operational efficiency.

It is also critical to choose hardware components (such as batteries, chipsets, modules, and antenna) that are most suitable to the deployment environment, because the environmental conditions (such as extreme temperature) to which devices are exposed in turn effects the performance and longevity (or lifecycle) of the device, and particularly any batteries powering the device. Choosing the right set of components can help to maintain efficiency thus avoiding the excess power drain while increasing the lifetime of the solution meaning less e-waste and other material overall. IoT solution design tools can also help to model the power consumption of communications modules in different scenarios and predict the impact to coverage performance and battery life caused by suboptimal placement of antennas.

Case Study: Deutsche Bahn: IoT Solution Optimisation

[Source: Deutsche Telekom]

Deutsche Bahn's (DB's) bike sharing service is using LTE-M connectivity and Deutsche Telekom's IoT Solution Optimizer to optimise product development and its overall offering. IoT Solution Optimizer, a cloud-based Software-as-a-Service (SaaS) solution, enables planning and implementation of IoT projects in the most optimal way. It provides virtual images of a real project, which can be used by DB to trial new developments using a digital twin. With this solution DB has been able to analyse battery life in different hardware configuration and the effect of different reception conditions on energy consumption. The solution helps DB analyse which changes or technology options are promising and most suitable from the perspective of sustainability. For example, if a battery's service life is not expected to meet requirements in certain framework conditions DB is able to rectify matters before launching services and thereby avoid wastage of resources.

(Image source: Deutsche Telekom)



Definition

A solution that helps identify the most suitable and energy efficient solution for an IoT project based on an optimised selection of deployment networks, hardware options and application libraries and interplay between different components for given application requirements.

Sustainability Benefits

- **Electricity:** Decreases power consumed by IoT devices by optimising the selection of network, hardware (battery, module, chipsets, antenna), software, protocols, and payloads. Any such benefits can also be achieved sooner due to accelerated time to market.
- **Hydrocarbon Fuel:** IoT Solution Optimisation tools can avoid trips taken by engineers to conduct trials on-site during the development phase and trips taken by service staff to replace batteries during live operations. Optimising the design of the components used in the IoT solution can help reduce the weight and in turn reduce the fuel consumed by vehicles or fuel operated equipment carrying these devices during live operations. Any such benefits can also be achieved sooner due to accelerated time to market.
- **Carbon emissions:** Carbon emissions are reduced as a result of decrease in truck rolls for site visits, reduced e-waste by improved lifecycle of IoT components, and reduced energy consumption by optimised network technology and improved efficiency of products. Any such benefits can also be achieved sooner due to accelerated time to market.

Extended ESG Benefits

- **Reduces e-waste and material waste:** Choosing the right set of design and components can help maintain or increase the longevity of the components (battery, module, chipsets), resulting in less e-waste and consumption of raw materials overall.

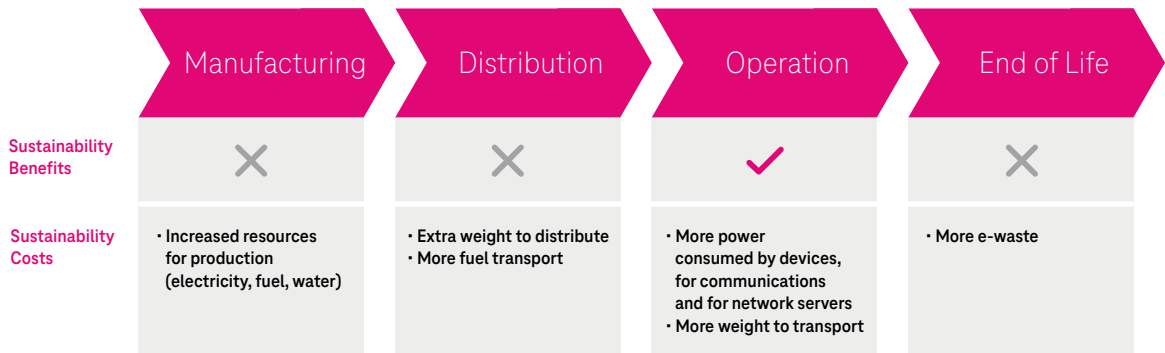
Enterprise Impact

- **Reduced operating costs:** Particularly due to optimised battery performance and a reduced need for field visits to change batteries.
- **Reduced development costs:** IoT Solution Optimisation can help avoid the cost incurred in testing cycles performed to check if the products deliver the desired performance and battery life.
- **Shortens time to market:** IoT Solution Optimisation can help simulate real life conditions in the field based on interplay of different parameters and validate the product quickly leading to improvement in time to market.
- **Access product performance and reliability at early stage:** IoT Solution Optimisation helps access the reliability and performance of the product at an early stage, thus reducing the number of defective products.

IoT Solution Lifecycle

The use cases profiled in this report have clear associated sustainability benefits, however they also have sustainability costs associated with all lifecycle stages: Manufacturing, Distribution, Operation, and End of Life. As illustrated in Figure 2, below, the manufacturing of IoT solutions consumes electricity, fuel, and water and the distribution of those devices consumes fuel. Meanwhile, electricity (and sometimes fuel) is consumed during live operations, and ultimately all IoT solutions contribute to e-waste.

Figure 2: A lifecycle perspective on sustainability [Source: Transforma Insights, 2022]



The key consideration when assessing the lifecycle impact of an IoT solution is the extra ‘weight’ of components that are associated with that solution. IoT solutions differ in that some rely on new dedicated hardware, whereas others are enabled by the addition of new hardware elements to an asset that exists for other reasons. For example, an on-board Fleet Management device is often a completely new device associated with a specific IoT solution, whereas in the case of smart HVAC, IoT capabilities are typically enabled by addition of a few extra components. The extra weight of components required to support an IoT solution directly influences the sustainability footprint of manufacturing and distribution , and clearly eventually becomes incremental e-waste. In the case of vehicle mounted IoT solutions, the transport of incremental weight during live operations also contributes to fuel consumption.

A secondary consideration is the (incremental) power consumed by IoT devices during any live operations phase which is correlated with the (incremental) weight of the IoT device and also the usage

profile (frequency of use and intensity of use). The sustainability impact of such power consumption depends on the source of power, including potentially single-use batteries, rechargeable batteries, or mains power. In the case of rechargeable batteries, the impact further depends on the power source that is used to recharge the batteries, including potentially hydrocarbon fuels in the case of on-board vehicle devices. Meanwhile, in the case of grid power the sustainability impact varies significantly by geography depending on the proportion of renewable energy carried by various national grids. A final consideration is the sustainability impact of the load that IoT devices place on communications networks¹² and computing¹³ infrastructures. This impact is a result of the amount of data transmitted to support an IoT solution, which is again correlated to device usage profile (frequency of use and intensity of use).

Figure 3, below, summarises the use cases analysed in this document from the lifecycle sustainability perspectives discussed above.

Figure 3: Summary of findings [Source: Transforma Insights, 2022]

Use Case	IoT Weight	Power Source	Data Traffic
Smart Building Management	Mix	Mix	Low
Smart Street and Outdoor Lighting	Incremental Components	Mains	Low
Fleet Management	Dedicated Device	Rechargeable Battery	Low
Condition Monitoring and Tracking	Dedicated Device	Rechargeable Battery	Low
Pro-active Asset Monitoring	Incremental Components	Mix	Low
Remote Maintenance	Incremental Components	Mix	Moderate
Warehouse Management and Intralogistics	Dedicated Device	Mix	Low
IoT Solution Optimisation	na	na	na

¹² Around 0.33 kWh per GB for cellular networks in 2020 (GSMA, Transforma Insights analysis)

¹³ Assumed to be immaterial for the use cases discussed in this report.

Conclusions

This report has focussed on a range of IoT use cases that are well-proven in real-world deployments and that are relatively easy to deploy with relatively limited associated risks.

It is clear that IoT-enabled solutions have the potential to help enterprises to significantly reduce hydrocarbon fuel consumption and electricity consumption, so reducing CO₂ emissions, and that many such solutions also have associated benefits in the context of wider ESG goals. These extend from smart building solutions improving employee health and satisfaction through to condition monitoring solutions that can help to reduce wastage of food and medicines.

IoT solutions overall are particularly significant from a sustainability perspective since IoT represents the interface between sophisticated technology-enabled management techniques and the 'real world', and it is in the real world that savings of electricity, hydrocarbon fuel, and raw materials can be made. Moving things around, warming them up, or cooling them down all consume energy and IoT has the potential to make many of these tasks more efficient.

This highlights a further key dynamic: the close relationship between sustainability goals and financial goals. Organisations that reduce the energy (and other resources) consumed to deliver core processes also reduce the amount of money that they spend on these items. Put simply, reducing consumption of input resources reduces costs.

Many of the use cases analysed in this report also have top-line revenue benefits for reasons ranging from improved customer loyalty (due to better services) through to the enablement of new business models, particularly in the case of Remote Asset Monitoring.

In conclusion, any organisation deploying the solutions profiled in this report will improve their sustainability footprint, unlock wider ESG benefits and help to save the planet. Crucially, all of the solutions profiled also have significant business benefits so that sustainability benefits are also associated with financial benefits.

Methodology

The impact analysis presented in this document covers a wide range of IoT-enabled applications and scenarios. Meanwhile, analysis of the sustainability impact of different IoT applications is early stage and fragmented in nature. Accordingly, the results presented in this document are based on a wide range of sources and comprehensive analysis as described below.

Global consistent sources

In all cases we have referenced high quality and globally consistent sources wherever possible, for instance, UN, FAO, EU, and other publications by internationally respected organisations are preferred. Information gleaned from these kinds of sources typically relates to overall market sizes and emissions of CO₂ (or consumption of fuel, electricity and water), but also can include specific impact assessments (such as, for example, the US Department of Energy claims that fuel consumption increases by 0.31% with 1% decrease in average tyre pressure). Wherever information has been drawn from such sources it has been specifically referenced in the document. Where we have cited two closely related datapoints, we have made efforts to draw these from the same source (rather than combining information from different sources) to help ensure consistency of definitions.

Case study analysis

Sustainability impact information for many of the IoT-enabled applications that are presented in this document is not currently available from any global consistent source. In such cases we have undertaken extensive research to identify relevant case studies that do provide sustainability impact information.

In all, we have drawn from the results of seventy-five (75) individual case studies as part of the research to support the findings of this document. Individual case studies have been assessed for suitability, credibility, and relevance before being included in our analyses. We have also sought to ensure alignment of the published results of case studies with the individual application areas profiled in this report, making adjustments as appropriate.

Where we have based sustainability benefit figures on this kind of case study analysis, we have sourced the relevant figures to 'Transforma Insights analysis'.

In all cases, we have been careful to avoid incorporating vendor claims of sustainability impacts into our analyses, unless these are well-supported by referenced case studies with named end-users.

Illustrative examples

This document also includes a range of specific illustrative examples, or case studies, and these have been specifically referenced as appropriate.

About Transforma Insights

Transforma Insights is a research firm focused on the world of Digital Transformation. Led by seasoned technology industry analysts Transforma Insights provides advice, recommendations and decision support tools for organisations seeking to understand how new technologies will change the markets in which they operate.

To address the implications of the technology-driven change, often referred to as Digital Transformation (DX), we examine the intersection of three inter-related areas: **New Technologies** (which comprises a dozen technology families including concepts such as IoT, AI and distributed ledger), **Transformational Use Cases**, and **Enterprise Change Management**.

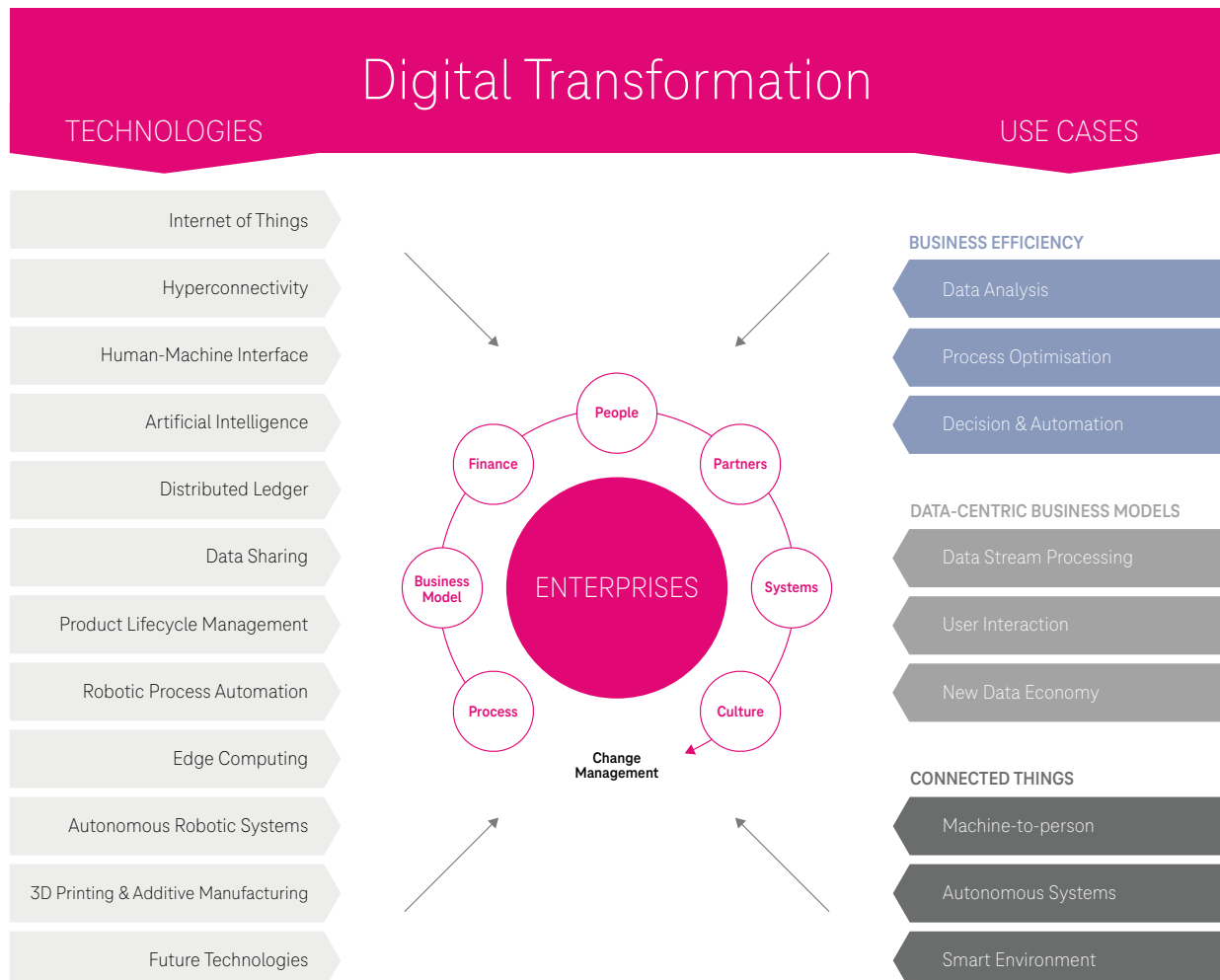
In order to support our clients' as they navigate this intersection of these three areas, we provide a set of research tools. The **Best Practice & Vendor Selection Database** offers unrivalled information on current and historic DX deployments, comprising thousands of Case Studies providing would-be adopters with critical understanding of project prioritisation, best practice, key success factors, and the leading vendors with which they should be working. The Database links seamlessly to our new **Vendor Connect** platform, a mechanism for connecting technology vendors and would-be technology adopters.

Based on our detailed understanding of the strengths and weaknesses of supporting vendors, we provide competitive benchmarks in the form of our **Peer Benchmarking**. These tools help vendors understand how they are positioned relative to their peers in these emerging markets. Our **TAM Forecasts** are quantitative guides to the market opportunity, covering each of twelve technology families, looking at hundreds of use cases across 20 vertical sectors and covering 200 countries. Finally, our **Insight Reports** provide a qualitative guide to the dynamics and impact of the twelve technology families upon which we focus. These are updated annually.

Learn more at

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SOURCES:

- i IEA, 2021
- ii Transforma Insights analysis
- iii Washington Post, 2016
- iv Government of Canada, 2016
- v U.S. Department of Energy
- vi US Department of Transportation, National Highway Traffic Safety Administration
- vii Transforma Insights analysis
- viii MiX Telematics, 2017
- ix Transforma Insights analysis
- x Food and Agriculture Organization of the United States, 2019
- xi TNO
- xii Orbcomm
- xiii Transforma Insights analysis
- xiv World Wide Fund for Nature
- xv UN Environment Programme, 2020
- xvi ExtraFood
- xvii PTC, 2019
- xviii Transforma Insights analysis
- xix Servicemax, 2016
- xx Zenatix
- xxi Netbiter
- xxii Mitsubishi Electric
- xxiii Matics
- xxiv Transforma Insights analysis
- xxv Transforma Insights analysis
- xxvi Ericsson, 2022
- xxvii Transforma Insights analysis
- xxviii TeamViewer, 2020
- xxix City, University of London, 2016
- xxx Transforma Insights analysis
- xxxi Transforma Insights analysis
- xxxii Transforma Insights analysis
- xxxiii SAP, 2019
- xxxiv Packaging Digest, 2014
- xxxv ResearchGate, 2008
- xxxvi IEA, 2021
- xxxvii Transforma Insights analysis
- xxxviii Bureau of Energy Efficiency, India
- xxxix Transforma Insights analysis
- xl Transforma Insights analysis
- xli The Climate Group, 2012
- xlili Energy Cities, 2015
- xlili Transforma Insights analysis
- xliv Transforma Insights analysis
- xliv Copenhagen Centre on Energy Efficiency
- xlvi The Guardian, 2022
- xlvi SmartLink Australia
- xlvi Transforma Insights analysis
- xlvi SmartLink Australia
- l Our World in Data

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