GSMA Intelligence

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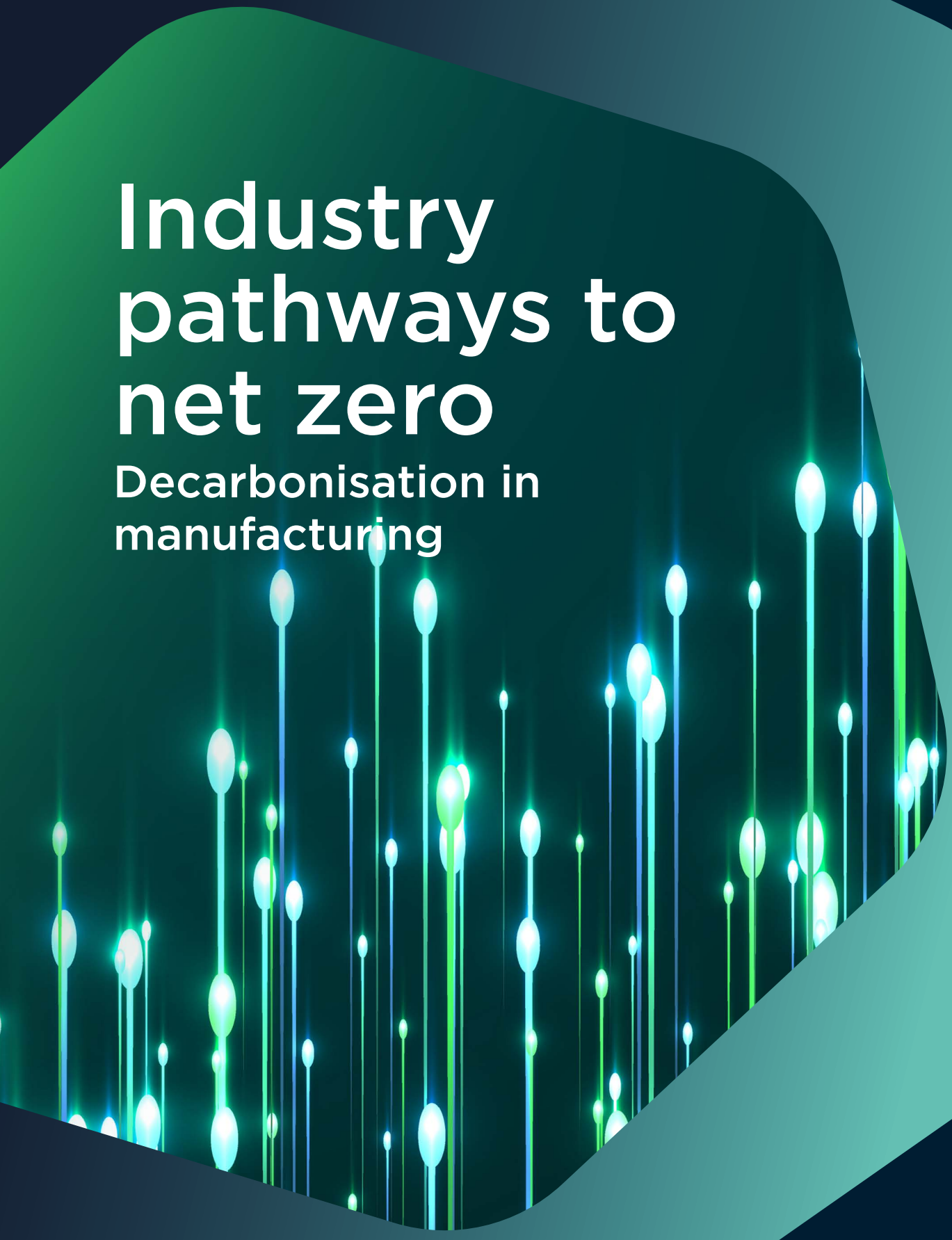
Industry pathways to net zero

Decarbonisation in manufacturing



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GSMA Intelligence

GSMA Intelligence is the definitive source of global mobile operator data, analysis and forecasts, and publisher of authoritative industry reports and research.

Our data covers every operator group, network and MVNO in every country worldwide – from Afghanistan to Zimbabwe. It is the most accurate and complete set of industry metrics available, comprising tens of millions of individual data points, updated daily.

GSMA Intelligence is relied on by leading operators, vendors, regulators, financial institutions and third-party industry players, to support strategic decision-making and long-term investment planning. The data is used as an industry reference point and is frequently cited by the media and by the industry itself.

Our team of analysts and experts produce regular thought-leading research reports across a range of industry topics.

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This report was conducted by GSMA Intelligence and supported by Nokia.

NOKIA

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We would like to thank the Carbon Trust as a trusted advisor in the analysis and modelling for this research.

Carbon Trust
Established in 2001, the Carbon Trust works with businesses, governments and institutions around the world, helping them contribute to, and benefit from, a more sustainable future through carbon reduction, resource efficiency strategies, and commercialising low carbon businesses, systems and technologies.

We are grateful to Nokia's manufacturing operation and Lacroix for their contributions and perspectives in interviews, complementing our broader research featured in this report.

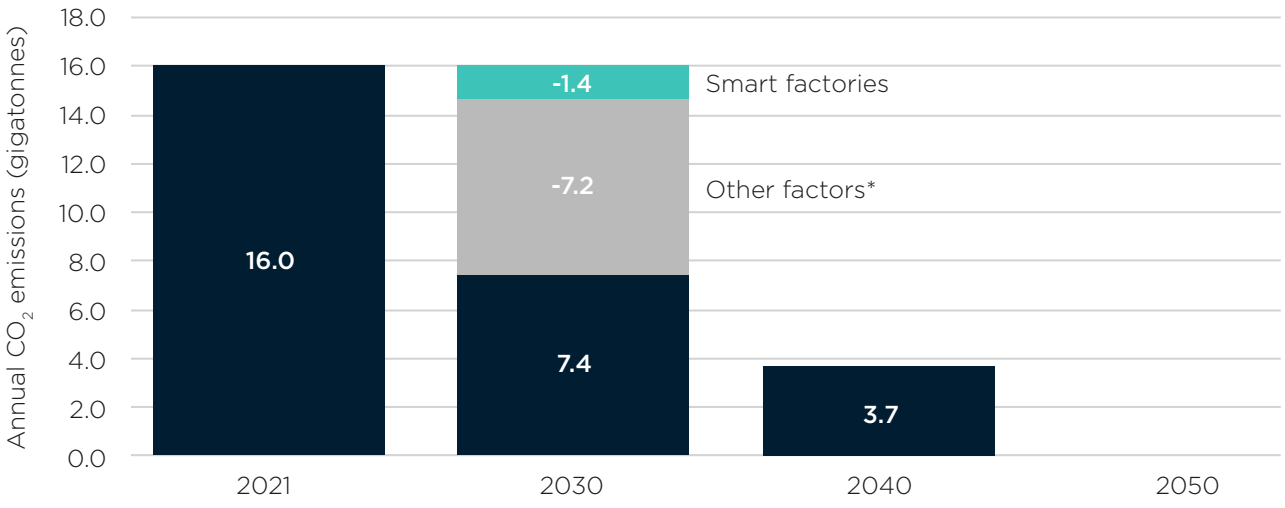
Contents

1. Sector context and overall sustainability strategy

Manufacturing worldwide accounts for around a third of total global CO_2 emissions. This is split across a range of sub-sectors including automotive, consumer electronics, heavy industry and construction materials production. A 50% reduction in emissions between 2020 and 2030 equates to 8.6 gigatonnes of CO_2. However, this is a challenge at a global level as many of the most manufacturing-intensive economies (notably China and India, which combined account for more than 30% of global manufacturing output) remain in high-growth phases, meaning that consumer demand from rising per-capita incomes will continue to drive production needs. Moving to a more sustainable model of manufacturing alongside renewable energy sources is crucial across the board.

Figure 1

The manufacturing sector's path to net zero



*Includes several factors such as use of more sustainable materials, sustainable design, recycling and repurposing, and end-of-life treatment of equipment.
Source: Exponential Roadmap, GSMA Intelligence

A high-level quantification of CO_2 savings from smart factories

Delivering 1.4 gigatonnes of CO_2 savings over the 10-year period to 2030

The equivalent of...

24 million cars in use for a whole year

28 million Return flights from London to Los Angeles in a year

Enough energy to power **165 million** homes for a year (80% of European households)

Decarbonisation drivers: digital

Digital investments are a major part of strategic plans to improve productivity and operational efficiency, consequently reducing energy consumption and emissions. A smart factory refers to a manufacturing setting in which machinery and robotics are fitted with sensors that allow data streams to be analysed on the edge cloud, enabling real-time adjustments in production capacity and equipment maintenance.

As factories adjust production to match demand, digital tools such as cloud, IoT, analytics and AI are proving indispensable. GSMA Intelligence IoT forecasts are indicative of the trend, with almost 20% average annual growth in smart manufacturing IoT connections over the 10 years from 2020 to 2030. This is weighted to manufacturing nations such as China, the US, Japan, Germany and South Korea. In the longer term, supply-chain visibility and adaptability, increased automation and resilience will drive manufacturers' investments in a highly competitive and uncertain environment.

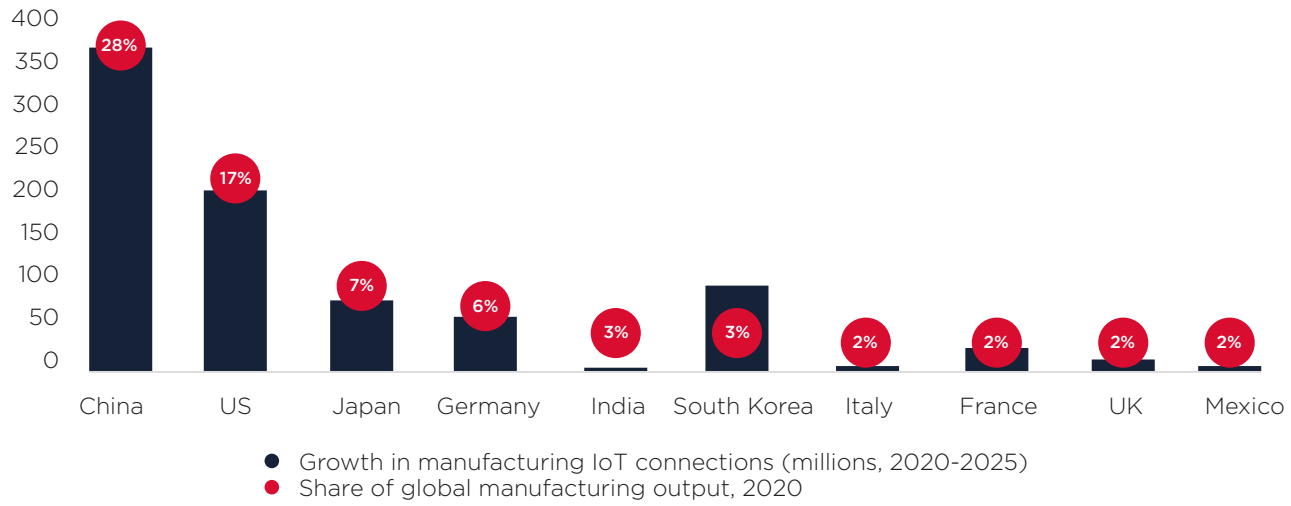
> "A smart factory allows data streams to be analysed on the edge cloud, enabling real-time adjustments in capacity and maintenance"

Decarbonisation drivers: non-digital

The bulk of the sector reduction will come from the use of sustainable materials, refrigerants, and recycling or reuse of components to extend their lifespans rather than sending to waste. This may, for example, involve the use of polymers as base construction materials that can be extracted as natural by-products of other industrial processes, reducing the need for steel, cement and plastics. The reuse concept also applies to end-of-life treatment for materials. Finally, efforts to coordinate with supply-chain partners on production processes and transport are also a key part of lowering emissions.

Figure 2

Expected growth of industrial IoT in largest manufacturing nations*



*Blue bars represent the forecast incremental growth in manufacturing IoT connections over the five-year period to 2025.
Source: World Economic Forum, GSMA Intelligence

2. Digital technology impact

The premise of industrial digitisation is that data analytics, cloud computing and 5G connectivity automate tracking, monitoring and maintenance processes to improve operational efficiency and lower associated energy costs. The flow-through from technology deployments to carbon reductions can happen in a number of ways. Table 1 provides examples, such as optimising lighting systems and monitoring energy usage, and the use of AR-based digital twins to act remotely and avoid manual call-outs. Automation raises efficiency and productivity which, combined with the use of renewable energy, reduces electricity consumption and emissions.

Nokia's Oulu factory – used for manufacturing mobile base station and signalling equipment – has indicated that production volumes have doubled over the last five years, with energy consumption reductions of 5–10% per year. **Bosch** has reported productivity improvements of up to 25% at individual manufacturing and assembly sites fitted with smart technology (more details below). For this reason, its management takes the view that connectivity is essential for any manufacturing company that wants to stay competitive.

Table 1

How technology deployment flows through to energy savings

Technology family	Product or service	Mechanism for CO_2 reductions
IoT	Factories and assembly lines equipped with IoT sensors connected to machinery and related equipment	Data processed at the edge and cloud in real time allows for dynamic adjustment of production capacity, higher productivity and reduced manual interventions, which collectively lower energy consumption for a given level of output
	Digital energy management systems	Sensors track energy use in real time at the overall plant and device levels. This allows factory operators to flag and redress areas of inefficient consumption (e.g. lighting, equipment, vehicles), leading to lower power usage
Cellular connectivity (LTE and 5G)	Private networks (and slicing)	Underpins connectivity across the factory, potentially supported by ethernet, enabling use cases to deliver energy-saving benefits
	AR/VR and digital twins for equipment and plant maintenance	Reduces manual labour call-outs and associated travel emissions for equipment diagnostics, repairs and quality control
	Drones and other mobile robots used for moving parts/finished products around a plant	Optimises energy use by reducing the need for petrol or gas-powered forklifts and manual interventions
Cloud and analytics	AI for high-volume parametric data crunching from production lines for machine diagnostics	AI algorithms filter and process data lakes in the cloud to pre-empt and execute tasks on the factory floor, reducing the frequency of manual intervention and optimising energy consumption

Note: use cases are non-exhaustive and designed to illustrate how technology investments can work in parallel with renewable energy supply to lower energy consumption and emissions.

Source: GSMA Intelligence

To help convey practical benefits, we have expanded on some of the interventions in more detail below with examples of real-world deployments.

IoT and sensors

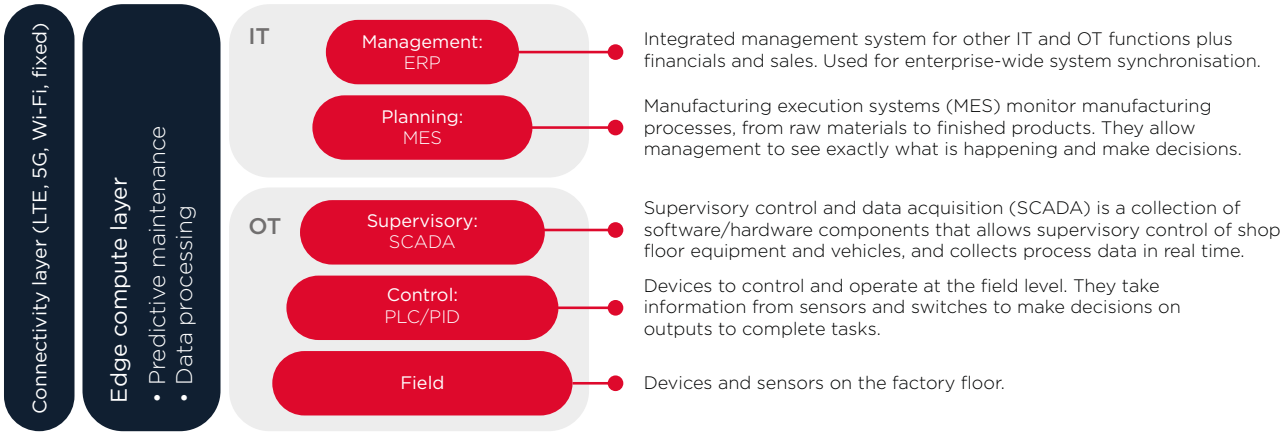
- These are fitted extensively across machines and robots on the shop floor. Data streams from sensors are ultimately passed to a supervisory control layer (a supervisory control and data acquisition – SCADA – system, see Figure 3) that can process and respond in real time.
- The IT layers are then in place for overall analysis of factory production end-to-end, from raw material to finished product at the factory gate. This leads to reduced manual call-outs for equipment repairs and enables dynamic adjustment of production capacity where required, boosting productivity and lowering energy consumption.
- For example, **Ford** has used sensors, in combination with network slicing, at a UK plant to monitor and preemptively remove defective car batteries before they make it into cars.
- **Bosch** has used sensors linked to a 5G network at factories in the UK and Germany for managing robotics and pre-emptive repairs of equipment, reducing call-outs and associated energy consumption.
- **Lacroix**, a supplier of equipment and analytics to factory operators, has designed integrated energy management systems for manufacturing facilities using HVAC[1] technology. Performance of the manufacturing shop floor and building can be monitored in real time, enabling adjustment of power levels accordingly.

Private cellular networks

- The ability to automate factory functions at scale has become dependent on high-grade connectivity and edge computing capabilities.
- Private networks, typically over LTE or 5G, are an important emerging part of the story as they offer guaranteed quality of service (QoS). The very high speeds (over 1 Gbps) and ultra-low latency are key technology underpinnings for mobile robotics.
- Low-latency connectivity is also beneficial for the use of autonomous mobile robots (AMRs) and intelligent autonomous vehicles (IAVs), which function as roving control centres that can adjust factory production by transferring new electronic workloads. AMRs are fitted with 3D cameras, with data transmitted over high-speed links (including private networks) and analysed in the cloud, so the vehicle can alter direction if it encounters objects in its path.
- **ASE** (a semiconductor manufacturer) in Taiwan has partnered with **Chunghwa Telecom** and **Qualcomm** to deploy a 5G private network over mmWave spectrum. AMRs were able to conduct maintenance and fault repairs on the shop floor, while any human engineering support was carried out remotely using AR renderings of the actual machines.
- Similarly, **Volkswagen** has set up a private 5G network at its plant in Wolfsburg, Germany for monitoring vehicle production and pre-emptive maintenance.
- As with the automation enabled by high data streams from IoT sensors, the benefits of these deployments are reduced manual labour call-outs and the ability to dynamically adjust production capacity – all of which improves productivity and lowers energy consumption over time.

Figure 3

Hierarchy of technology in digitised manufacturing

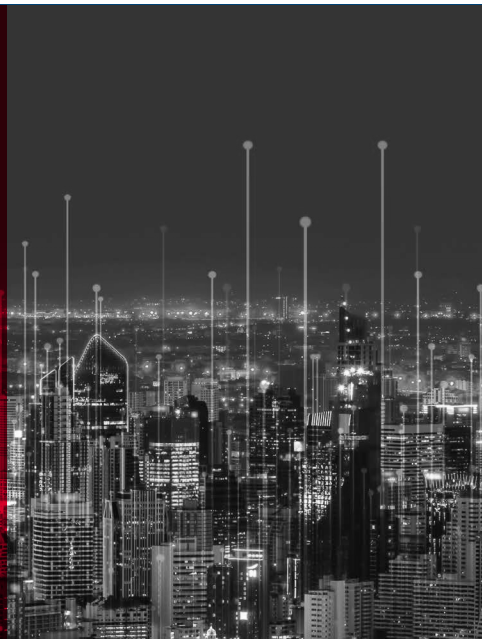


Source: GSMA Intelligence, SmarterChains

We forecast that smart factories will account for around 5% of manufacturing facilities by 2030 (up from 1% now), which feeds through to CO_2 emissions reductions of 1.4 gigatonnes over the 10 years to 2030, equivalent to 16% of the total sector reduction over the period.

[1] Heating, ventilation and air-conditioning

3. Go to market: opportunities and challenges



Manufacturing groups typically look to industrial-grade solutions with simplicity, security, reliability and cost efficiency as key purchasing criteria in assessing industrial connectivity options. Performance can be defined in multiple ways, with speed of transmission, reliability, redundancy, latency, jitter and support of common industrial protocols as key performance indicators (KPIs). The complexity of the OT and IT software value chain alongside the connectivity and cloud layers means that most implementation models for smart factories are partnership approaches.

There are numerous examples of such approaches. The **ASE** pilot in Taiwan is one. **Lufthansa** partnered with **Nokia** and **Vodafone** to deploy a 5G private network at an aircraft hangar in Hamburg[2], enabling safety inspections of fuselage, engines and parts to be carried out remotely using AR. **Volkswagen** at its plant in Wolfsburg, Germany is a further example. Finally, **John Deere** intends to work with a variety of partners to help implement private 5G networks (starting on a non-standalone basis) at various sites in the US, with some running on CBRS spectrum.

Digital investments to drive productivity gains and decarbonisation must be viewed holistically over the long term (10+ years) across a company's operational footprint rather than per factory or per year. The main challenges are around the cost and complexity of retrofitting, or swapping out, legacy equipment when the return-on-investment timelines can extend to 5–10 years.

Proof points from commercial deployments will help. **Lacroix** asserts that while most equipment is still physically connected, it plans to shift more of its infrastructure to transmit data over wireless as traffic rises, including 5G and Wi-Fi 6 in tandem.

The big picture opportunity from digitisation and the use cases it enables is to structurally rework the operations and control mechanisms of factories to increase productivity. Combined with materials reuse, intelligent design, repurposing and the use of renewables (all of which drive new business models), the overall effect is to reduce energy consumption and carbon emissions. This rationale is the driver for enterprise investments in digital capabilities. Our projection that smart factories can account for 16% of manufacturing sector CO_2 reductions over the 10 year period to 2030 is, of course, only for the first decade in a 30-year pathway to net zero. We would expect this contribution to rise over time as more factory operators design facilities to be smart.

The implications from a competitive standpoint are that companies offering connectivity, cloud and analytics solutions will increasingly work in partnership (rather than head-on) to facilitate a joined-up approach, putting the manufacturing sector on a clear path to net zero.

> "The big picture opportunity from digitisation is to structurally rework the operations and control mechanisms to increase productivity"

[2] https://www.mobileworldlive.com/featured-content/top-three/nokia-lufthansa-private-5g

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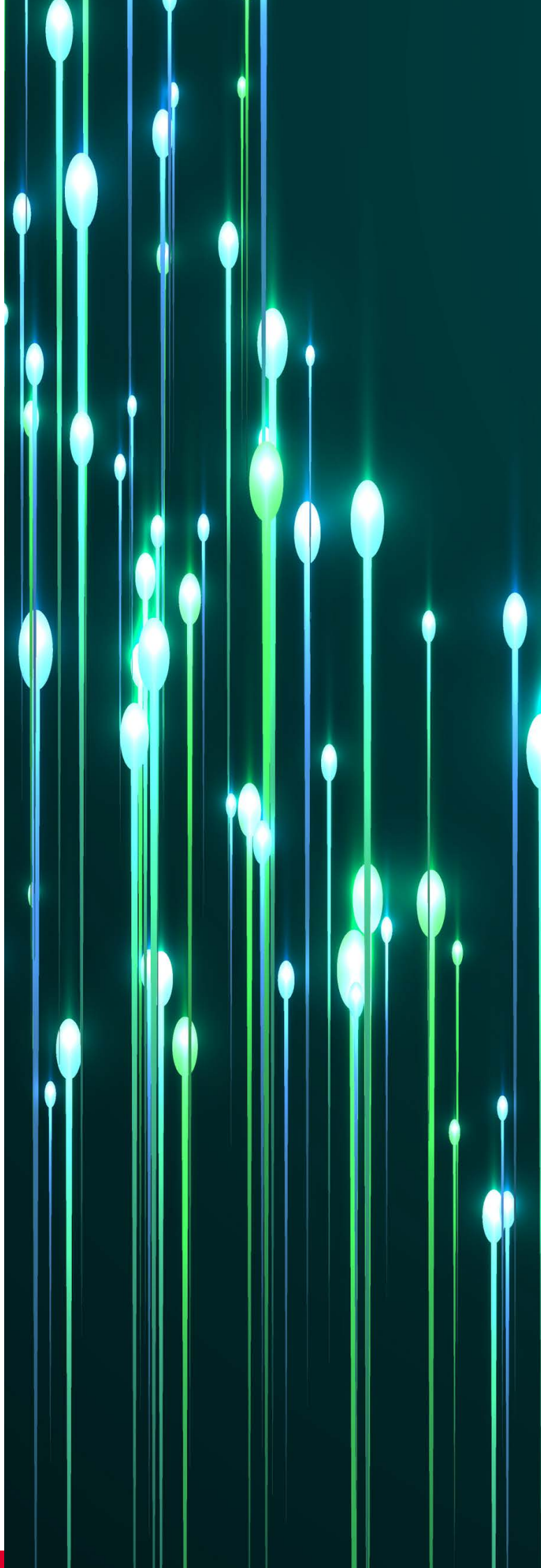

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