In Collaboration with
McKinsey & Company

WORLD ECONOMIC FORUM

Global Lighthouse Network: Unlocking Sustainability through Fourth Industrial Revolution Technologies

IMPACT PAPER

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Contents

Executive summary

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Fourth Industrial Revolution technologies make environmental sustainability easier.

Lighthouses have established themselves as beacons of the Fourth Industrial Revolution (4IR), adapting to four durable shifts – agility and customer centricity; supply chain resilience; speed and productivity; and eco-efficiency. Among these shifts, eco-efficiency has emerged at the vanguard, its prominence fuelled by increased global concerns about the environmental impact of human activities. United Nations Secretary-General Antonio Guterres called the August 2021 report by the Intergovernmental Panel on Climate Change (IPCC) a "code red for humanity".

This paper challenges the notion that environmental responsibility is inherently at odds with productivity and, by extension, profitability. Revolutionary sustainability impact lies with green technology and breakthroughs, but 4IR transformations that leverage digital and analytics tools can augment not only green technology but also current production methods by bolstering efficiency. By embracing 4IR-driven transformation, a viable kind of efficiency is possible: i.e., eco-efficiency, wherein sustainability and competitive excellence are not only compatible, but, in fact, interwoven.

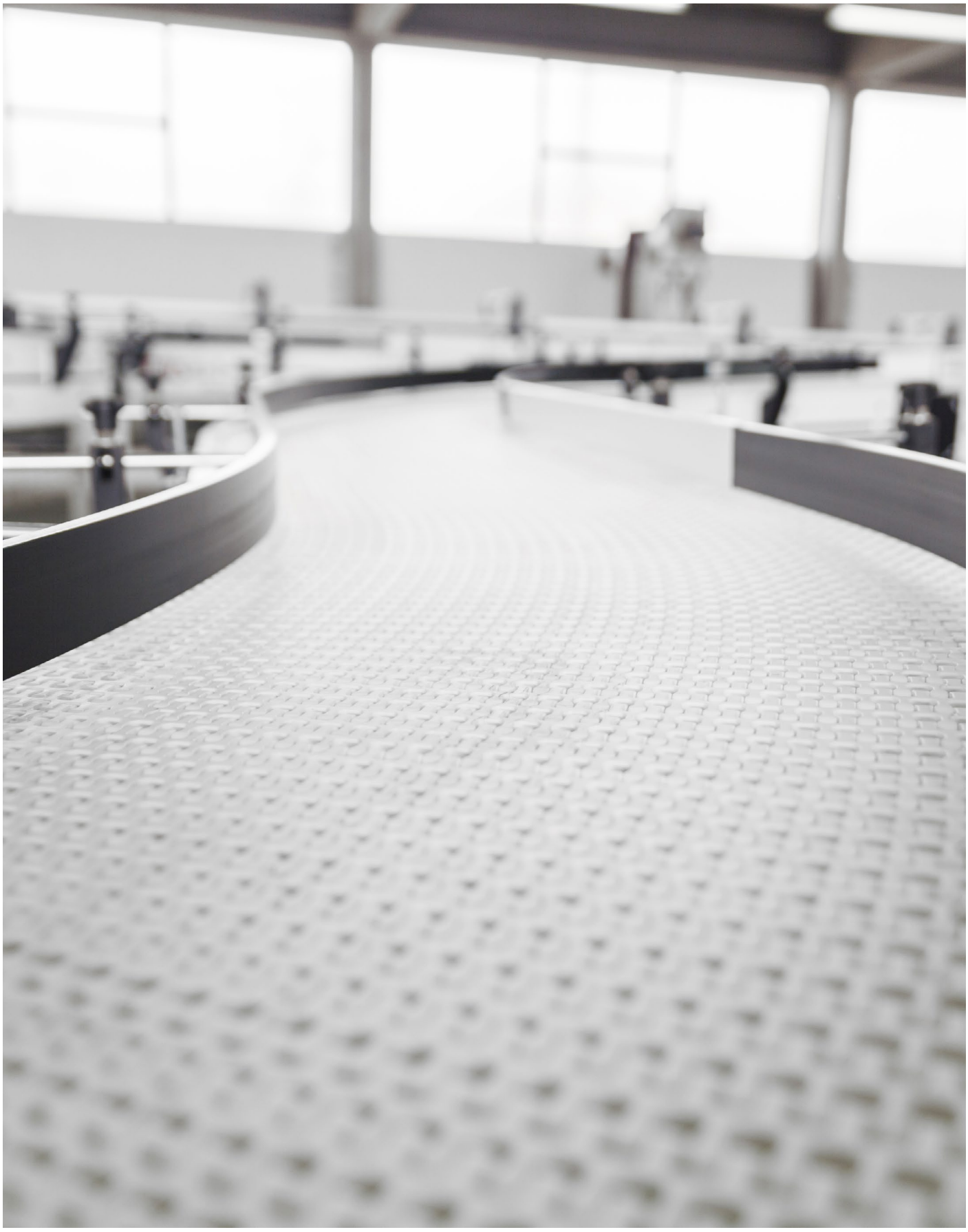
Eco-efficiency is the outcome of 4IR technologies which, when directed to solve business problems, simultaneously boost productivity and sustainability. This concept of efficiency has three dimensions. First, it involves digital technology enabling data-informed actions across production and across the end-to-end value chain. Second, it demonstrates measurable improvements across performance indicators such as cost, agility, convenience and quality. Finally, it drives sustainability gains by reducing consumption, resource waste and emissions.

Organizations need first to understand the impact potential that lies with eco-efficiency in order to realize it. If companies are not looking for it – let alone measuring it – they might not fully realize the unclaimed sustainability opportunities hidden in the midst of their 4IR transformations. Opportunities are there. Data collected since the beginning of this project show half of Lighthouses (64%) report sustainability impact as part of their achievements enabled by 4IR transformation.

To address "code red for humanity", companies must make sustainability part of their business agenda. Lighthouses prove there is room for synergy among technology, productivity and sustainability efforts in different industries; meanwhile, they show others how to accelerate their digitization efforts.

Companies that make a true commitment to environmental stewardship through pledges and corresponding action are setting the bar for sustainability. Those who couple that commitment with the full power of 4IR transformation, thus achieving step-change levels of impact, are leading by example and earning the new designation of Sustainability Lighthouses.

1 Today's trends are tomorrow's standards



1.1 The Global Lighthouse Network recognizes industrial leaders

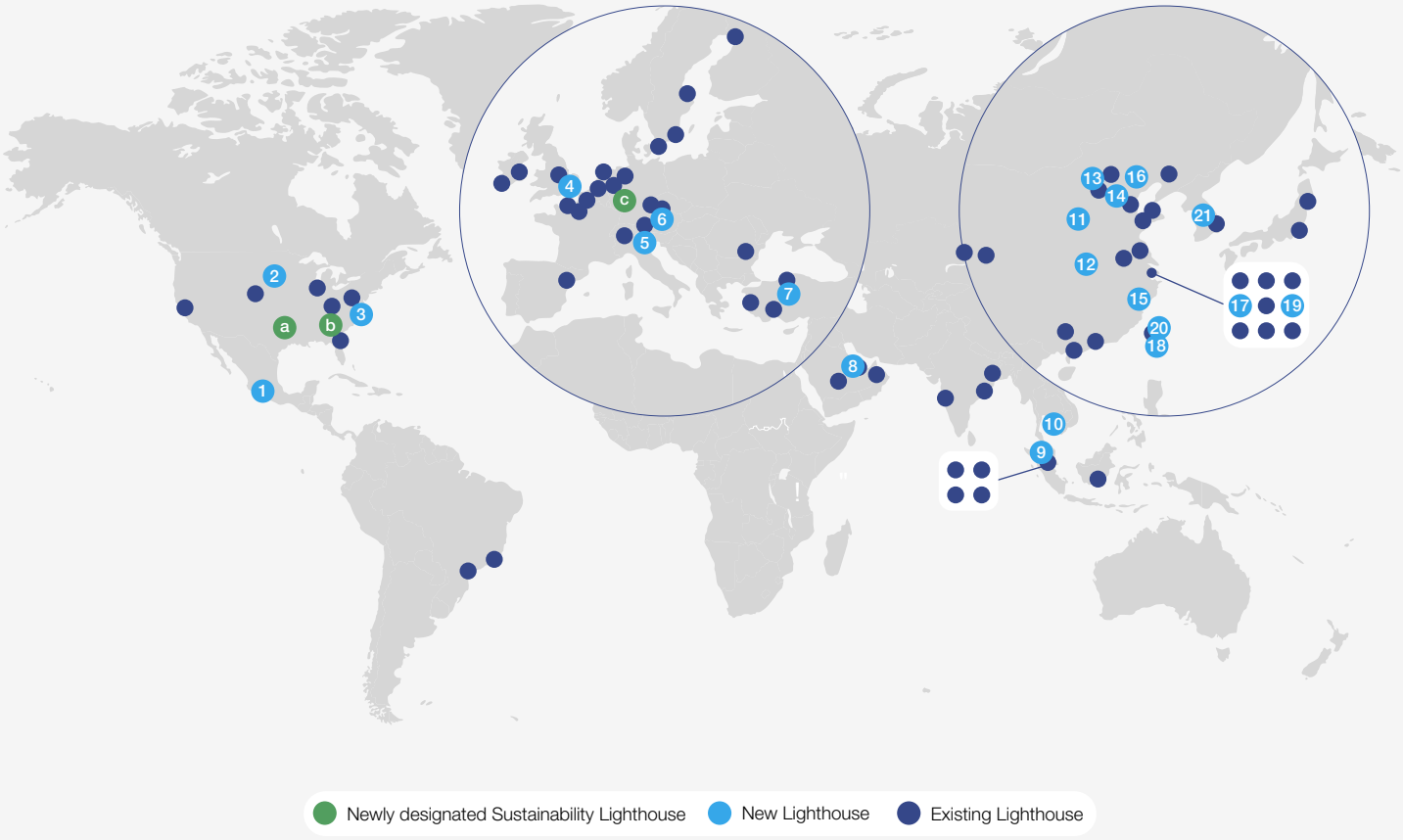
The World Economic Forum, in collaboration with McKinsey & Company, launched the Global Lighthouse Network in 2018. The frontrunner companies that comprise this network continue to demonstrate the true potential of Fourth Industrial Revolution (4IR) technologies to transform the very nature of manufacturing. The 90th Lighthouse has recently been recognized, marking more than a fivefold increase since the launch of the network.

The network's power has grown through thousands of hours of site visits, both virtual and in person. The site visits unlock the mystery behind each of the 450 advanced use cases in action shared to date. In-depth demonstrations of enablers and commentary from the shopfloor have offered an end-to-end view of these digital transformations. At the site level and across value chains, Lighthouses show what is possible when companies combine bold vision, imaginative leadership and agile working modes to maximize the power of emerging digital technologies.

As the network continues to grow, it becomes increasingly clear that 4IR transformation is possible across geographies and industries. Moreover, the evidence accumulates, bolstering the understanding that four durable shifts in agility and customer centricity, supply chain resilience, speed and productivity, and eco-efficiency are playing out across a diverse set of contexts.[1] These are today's trends – companies from vastly different industries that do very different work are adapting to the same shifts. As they do so, leading companies are showing what lies at the heart of success.

FIGURE 1 | **The Global Lighthouse Network includes 90 Lighthouses, of which 3 are designated Sustainability Lighthouses as of September 27, 2021**

Since publication of the "Reimagining Operations for Growth" white paper, the network has grown with **21 new Lighthouses and 3 designated Sustainability Lighthouses**. Determined by an expert panel, the network totals **90 Lighthouses** identified across different industry sectors and includes the newest designation of Sustainability Lighthouse.



a **Ericsson**
Lewisville, Texas, USA

b **Schneider Electric**
Lexington, Kentucky, USA

c **Henkel**
Düsseldorf, Germany

1 **Henkel**
Toluca, Mexico

2 **Protolabs**
Plymouth, USA

3 **Johnson & Johnson DePuy Synthes**
Bridgewater, USA

4 **Johnson & Johnson Vision Care**
London, United Kingdom

5 **De' Longhi**
Treviso, Italy

6 **Flex**
Althofen, Austria

7 **Arçelik**
Eskişehir, Turkey

8 **Saudi Aramco**
Abqaiq, Saudi Arabia

9 **Western Digital**
Penang, Malaysia

10 **Western Digital**
Prachinburi, Thailand

11 **Foxconn**
Zhengzhou, China

12 **Foxconn**
Wuhan, China

13 **Sany**
Beijing, China

14 **Haier**
Tianjin, China

15 **CATL**
Ningde, China

16 **CITIC Dicastal**
Qinhuangdao, China

17 **Unilever**
Taicang, China

18 **Innolux**
Kaohsiung, Taiwan, China

19 **Schneider Electric**
Wuxi, China

20 **AUO**
Taichung, Taiwan, China

21 **LS ELECTRIC**
Cheongju, Korea

Note: Details on previously selected Lighthouses are available in World Economic Forum, "Reimagining Operations for Growth", White Paper, 2021.

FIGURE 2 | **The Global Lighthouse Network is growing in size and diversity across all industry sectors**

Consumer packaged goods

Alibaba
Apparel, China

Henkel
Consumer goods, Germany

Henkel
Consumer goods, Spain

Henkel
Consumer goods, Mexico

Procter & Gamble
Consumer goods, China

Procter & Gamble
Consumer goods, Czech Republic

Procter & Gamble
Consumer goods, France

Procter & Gamble
Consumer goods, USA

Tsingtao Brewery
Consumer goods, China

Unilever
Consumer goods, China

Unilever
Consumer goods, China

Unilever
Consumer goods, United Arab Emirates

Process industries

Baoshan Iron & Steel
Steel products, China

DCP Midstream
Oil and gas, USA

MODEC
Oil and gas, Brazil

Petkim
Chemicals, Turkey

Petrosea
Mining, Indonesia

POSCO
Steel products, Korea

Renew Power
Renewable energy, India

Saudi Aramco
Oil and gas, Saudi Arabia

Saudi Aramco
Oil and gas, Saudi Arabia

Saudi Aramco
Oil and gas, Saudi Arabia

STAR Refinery
Oil and gas, Turkey

Tata Steel
Steel products, India

Tata Steel
Steel products, India

Tata Steel
Steel products, Netherlands

Advanced industries

AGCO
Agricultural equipment, Germany

Arçelik
Home appliances, Turkey

Arçelik
Home appliances, Romania

AUO
Optoelectronics, Taiwan, China

BMW Group
Automotive, Germany

Bosch
Automotive, China

Bosch
Automotive, China

CITIC Dicastal
Automotive, China

Contemporary Amperex Technology
Electronics, China

Danfoss
Industrial equipment, China

De'Longhi
Home appliances, Italy

Ericsson
Electronics, USA

Fast Radius with UPS
Additive manufacturing, USA

Flex
Electronics, Austria

Ford Otosan
Automotive, Turkey

FOTON Cummins
Automotive, China

Foxconn
Electronics, China

Foxconn
Electronics, China

Foxconn
Electronics, China

Foxconn Industrial Internet
Electronics, China

Groupe Renault
Automotive, Brazil

Groupe Renault
Automotive, France

Groupe Renault
Automotive, France

Haier
Appliances, China

Haier
Home appliances, China

Haier
Home appliances, China

Hitachi
Industrial equipment, Japan

HP Inc.
Electronics, Singapore

Infineon
Semiconductors, Singapore

Innolux
Optoelectronics, Taiwan, China

LS ELECTRIC
Electrical components, Korea

Micron
Semiconductors, Taiwan, China

Micron
Semiconductors, Singapore

Midea
Home appliances, China

Midea
Home appliances, China

Nokia
Electronics, Finland

Phoenix Contact
Industrial automation, Germany

Protolabs
Additive manufacturing, USA

Rold
Electrical components, Italy

SAIC Maxus
Automotive, China

Sandvik Coromant
Industrial tools, Sweden

Sany
Industrial equipment, China

Schneider Electric
Electrical components, China

Schneider Electric
Electrical components, France

Schneider Electric
Electrical components, Indonesia

Schneider Electric
Electrical components, USA

Siemens
Industrial automation products, China

Siemens
Industrial automation products, Germany

Weichai
Industrial machinery, China

Western Digital
Electronics, Malaysia

Western Digital
Electronics, Thailand

Wistron
Electronics, China

Pharmaceuticals and medical products

Bayer
Division pharmaceuticals, Italy

GE Healthcare
Medical devices, Japan

GSK
Pharmaceuticals, United Kingdom

Johnson & Johnson Consumer Health
Self-care products, Sweden

Johnson & Johnson DePuy Synthes
Medical devices, China

Johnson & Johnson DePuy Synthes
Medical devices, Ireland

Johnson & Johnson DePuy Synthes
Medical devices, USA

Johnson & Johnson Janssen
Pharmaceuticals, Ireland

Johnson & Johnson Vision Care
Medical devices, United Kingdom

Johnson & Johnson Vision Care
Medical devices, USA

Novo Nordisk
Pharmaceuticals, Denmark

Zymergen
Biotechnology, USA

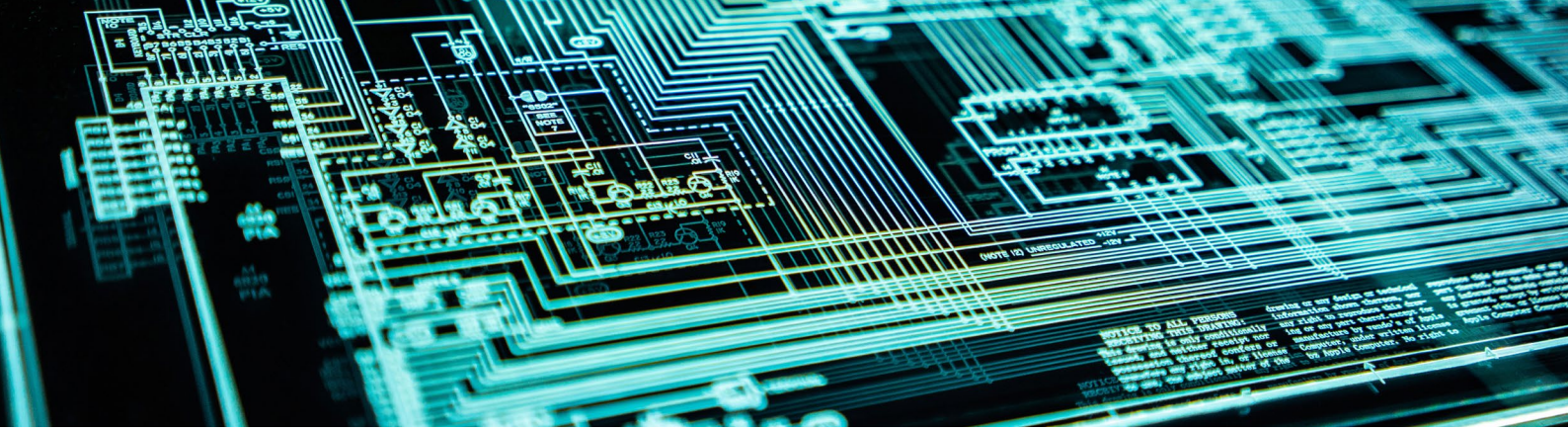


FIGURE 3 | **Lighthouses are deploying 124 use cases across manufacturing sites and connecting the value chain end-to-end (1/2)**

Lighthouse use cases: Within manufacturing sites

Digital assembly and machines

- Additive manufacturing (3D printing)
- Advanced IIoT applied to process optimization
- AI-guided machine performance optimization
- AI-powered material handling system
- AI-powered process control
- Automated material handling
- Automated tool design
- Collaborative robotics and automation
- Cycle-time optimization through big data analytics on lines PLCs
- Digital engineering
- Digital lean tools (e.g., eKanban, eAndon, eSpaghetti)
- Digital twin for flexible production
- Digitally enabled flexible manufacturing
- Digitally enabled modular production configuration
- Digitally enabled variable takt time
- Light-guided assembly sequence
- Mixed reality to enable digital standard work/trainings
- Real-time locating system (RTLS) for key manufacturing components
- Repair process automation

Digital maintenance

- Analytics platform for deviation root-cause identification
- Cost optimization of heavy operations through sensor analysis
- Digitally enabled pipeline leak prevention and detection
- Machine alarm aggregation, prioritization and analytics-enabled problem solving
- Predictive maintenance aggregating data based on historical and sensor data
- Real-time pipeline cost optimization based on edge sensors
- Remote assistance using augmented reality
- Unmanned vehicles for inspection

Digital performance management

- Analytics platform for remote production optimization
- Analytics platform for yield management and root-cause analysis
- Digital dashboards to monitor OEE performance
- Digital recruitment platform tailored to shop floor
- Digital tools to enhance a connected workforce
- Digital twin for remote production optimization
- Digitally enabled man-machine matching
- Enterprise Manufacturing Intelligence system to upgrade operations management
- Integration platform to connect machine-level data with enterprise software
- Real-time asset performance monitoring and visualization
- Sensor-based manufacture KPI reporting

Digital quality management

- AI-enabled safety management
- AI-powered optical inspection
- AI-powered automated testing and repair
- Automated in-line optical inspection to replace end-product manual inspections
- Automated inspection enabled by digital thread
- Digital quality audit
- Digital work instructions and quality functions
- Digitally enabled batch release
- Digitally enabled quality failure diagnosis
- Digitized standard procedures for line operations with integrated workflow
- Field quality failures aggregation, prioritization and advanced analytics-enabled problem-solving
- IoT-enabled manufacturing quality management
- Mixed reality glasses to guide operators in the end-of-line inspection
- Quality improvement by predictive analytics
- Scanning to replace and improve performance for high-cost coordinated measuring machines (CMM)

Digitally enabled sustainability

- Advanced analytics enabled clean water reduction and contaminated water cleaning optimization
- End-to-End CO_2 tracking and reporting across entire value chain
- Advanced analytics enabled sustainability optimization
- Digital twin for sustainability
- IIoT real time sensor based data aggregation for energy, emissions, waste, and water management

FIGURE 4 | **Lighthouses are deploying 124 use cases across manufacturing sites and connecting the value chain end-to-end (2/2)**

Lighthouse use cases: Connecting the value chain end-to-end

Supply network connectivity

- Agile buying through price prediction
- Aggregate demand across end-to-end supplier network
- Analytics-driven procurement supported by spend intelligence and automated spend cube
- Analytics-driven supply risk prediction
- AI to accelerate scaling of digital applications across sites
- AI-powered contract review for decision making
- Digital supplier performance management
- Digitally enabled automatic material call-off system
- Digitally enabled negotiations
- Joint data analytics with equipment OEM for process optimization
- Part traceability from unique digital tag based on surface scanning
- Should-cost modelling to support make-versus-buy decisions
- Supplier and materials quality tracking
- Supplier material delivery by e-Kanban
- Supplier material quality prediction using advanced analytics

E2E product development

- Advanced analytics for performance management across the idea to market
- Automated design for manufacturing analysis
- Big-data/AI-enabled product design and testing
- Crowd-sourcing and competitions to develop digital solutions
- Digital thread implementation through product development lifecycles
- Product development using robotics
- Rapid outsourced prototyping
- Testing automation
- Virtual reality supported prototyping
- 3D printing for rapid design prototyping
- 3D simulations/digital twin for product design and testing

E2E planning

- Advanced analytics to optimize manufacturing and distribution footprint
- Analytics for dynamic warehouse resource planning and scheduling
- Closed loop planning
- Digital integrated business planning
- Dynamic network optimization
- Dynamic production scheduling with digital twin
- Dynamic simulation for warehousing design
- End-to-end real-time supply chain visibility platform
- No-touch master planning (allocation to the plants)
- Predictive demand forecasting
- Predictive inventory replenishment
- Production planning optimized by advanced analytics
- Real-time inventory management (internal/ extremal)
- Real-time sales and operations planning (S&OP)

E2E delivery

- Asset use and yard management for logistics
- ATP based on real-time constraints
- Digital-enabled picking and transport
- Digital logistics control tower
- Digital track and trace
- Dynamic delivery optimization
- No-touch order management
- Predictive maintenance in fleet assets
- Robotics-enabled logistics execution
- "Uberization" of transport
- 3D printing

Customer connectivity

- AI-enabled customer support
- Connected devices to track and measure consumer behaviours
- Connected devices to track and measure product performance
- Customer analytics enabled by RFID
- Customer end-user interface to configure and order a product, and track delivery
- Delivering to customers wherever they are through new delivery solutions
- Digital Twin of Customer System
- Digitally enabled customer performance monitoring
- Digitally enabled final-mile personalization
- Digitally enabled real-time connectivity with customer system
- GPS-based map and customer location
- Market insights generated by Advanced Analytics
- Mass customization and B2C online ordering
- Online communities for customer insights
- Smart/intelligent packaging

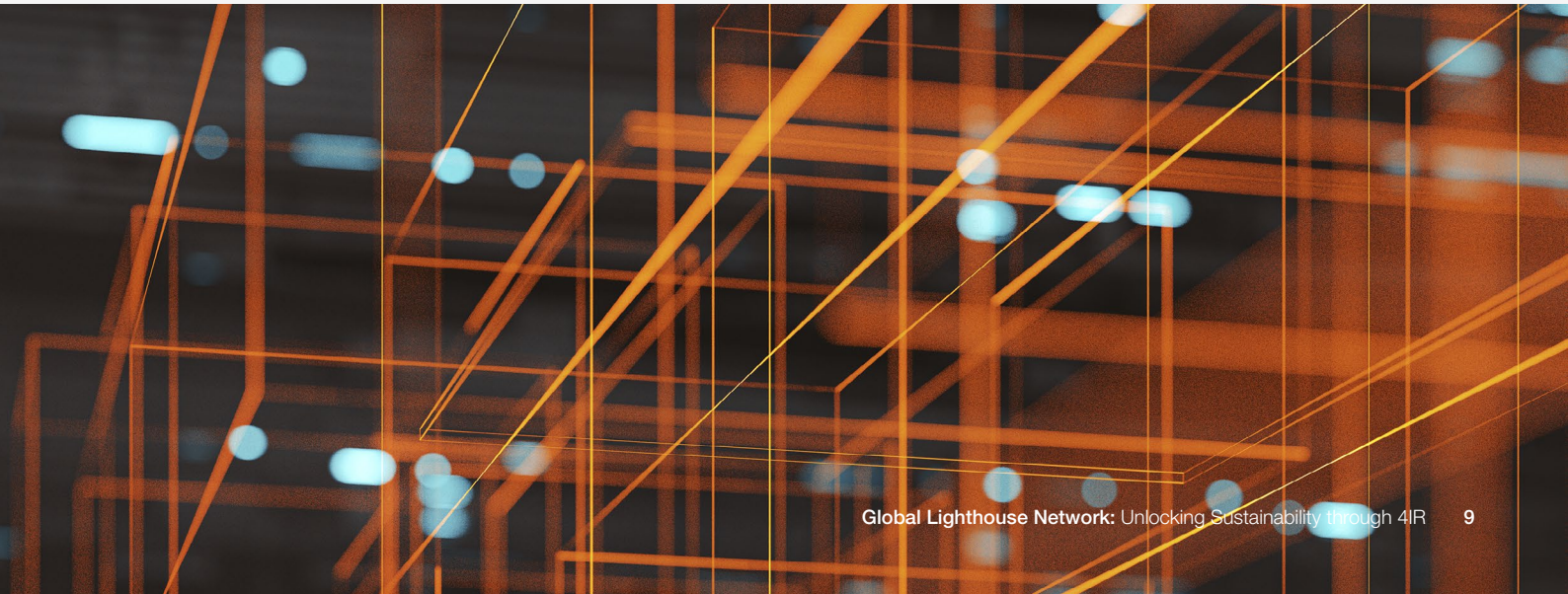


FIGURE 5 | New Lighthouses show a variety of use cases

Asia

Site	Change story	Use case		Impact
AUO Taichung	Facing challenges such as labour shortage, highly customized products requirements and extreme climate conditions in the very competitive industry of display panels, AUO Taichung Fab 3 invested in customized automation and developed a digital analytics and AI development platform to improve productivity by 32% and yield of advanced product by 60%, while reducing water consumption by 23% and carbon emissions by 20%	Automated material handling	▲ 12%	Productivity
		AI-powered automated testing and repair	▼ 3%	Scrap cost
		Advanced IIoT applied to process optimization	▲ 8.5%	Sputter OEE
		Predictive maintenance aggregating data based on historical and sensor data	▼ 32%	Maintenance cost
		Advanced analytics enabled sustainability optimization	▼ 20%	Carbon emission
CITIC Dicastal Qinhuangdao	Faced with rising expectations from automotive OEMs for smaller batch size and higher quality, CITIC Dicastal deployed flexible automation, AI and 5G to build a digital manufacturing system to improve flexibility with a batch size of one and reduce manufacturing cost by 33%	AI-powered optical inspection	▼ 81%	Manpower for inspection
		Digital-enabled flexible manufacturing	▼ 99.7%	Minimal batch size
		AI-enabled CNC quality expert system	▲ 23%	OEE CNC
		3D simulations/digital twin for product design and testing	▼ 38%	Cycle time
		Real-time asset performance monitoring and visualization	▲ 38%	Labor productivity
Contemporary Amperex Technology Co. Ltd. Ningde	Confronted with increasing manufacturing process complexity and demand for high product quality, CATL leveraged AI, advanced analytics and edge/cloud computing to achieve, in 3 years, a defect rate per billion count at the speed of 1.7s per cell, while improving labour productivity by 75% and reducing energy consumption by 10% a year	AI-powered process control	▲ 75%	Labor productivity
		AI-powered optical inspection	▼ 80%	Defect parts per billion
		Big data/AI-enabled product design and testing	▼ 50%	Research & development cycle
		Digital track and trace	▼ 80%	Manpower for screening tests
		IIoT real time sensor-based data aggregation for energy, emissions, waste and water management	▼ 10%	Energy consumption per year
Foxconn Wuhan	To meet customer requirements for greater customization and shorter product order lead time, Foxconn Wuhan leveraged advanced analytics and flexible automation at scale to redesign its manufacturing system leading to an 86% increase in direct labour productivity, and reducing quality loss by 38% and order lead time by 29%, down to 48 hours	AI-powered optical inspection	▼ 50%	SMT misaligment
		Digitally enabled man-machine matching	▲ 23%	Labor productivity
		Lights-out injection moulding workshop	▼ 38%	Manufacturing lead time
		Intelligent kitting and replenishment	▲ 40%	Kitting efficiency
		Advanced analytics enabled sustainability optimization	▼ 37%	Energy consumption per unit
Foxconn Zhengzhou	Confronted with the lack of skilful workers, unstable quality performance and demand uncertainty, Foxconn Zhengzhou adopted flexible automation to improve labour productivity by 102%, and utilized digital and AI technologies to reduce quality defects by 38% and improve OEE by 27%	Repair process automation	▲ 60%	Testing labour efficiency
		Automated material handling	▼ 75%	Labour for material delivery and feeding
		Quality improvement by predictive analytics	▼ 15%	Quality defect rate
		IIoT real time sensor-based data aggregation for energy, emissions, waste and water management	▲ 30%	Energy efficiency for Factory Management Control System
		IoT-enabled manufacturing quality management	▲ 27%	OEE
Haier Tianjin	To meet increased customers' expectations for diversified products, faster delivery and higher quality of service, Haier's greenfield washing machine factory in Tianjin integrated 5G, IIoT, automation and advanced analytics to accelerate product design by 50%, reduce defects by 26% and save energy consumption per unit by 18%	3D simulations/digital twin for product design and testing	▼ 50%	Research & development lead time
		Flexible manufacturing: Hybrid assembly line to meet customer orders	▼ 50%	Order fulfilment lead time
		Automated material handling	▼ 67%	Line inventory
		Advanced analytics enabled sustainability optimization	▼ 18%	Energy consumption per unit
		Big data/AI-enabled product design and testing	▲ 35%	Monthly sales
Innolux Kaohsiung	In the context of fierce competition in the panel industry, and faced with increasing quality requirement from customers and severe decline in gross profit, Innolux fab 8 invested in advanced automation, IoT technology and advanced analytics to improve process capability by 40%, reduce yield loss by 33% and in return unlock niche products production	AI-powered process control	▲ 40%	Process capability
		AI-powered automated testing and repair	▼ 95%	Yield loss rate
		Supplier material quality prediction using advanced analytics	▼ 40%	Quality events
		Digitally-enabled quality failure diagnosis	▼ 91%	Quality alert time
		Predictive maintenance aggregating data based on historical and sensor data	▲ 2.3%	OEE of bottleneck machine

Asia *continued*

Site	Change story	Use case		Impact
LS ELECTRIC Cheongju	To respond to an increase in demand and the need to reduce costs, LS ELECTRIC has transformed one of its plants in Cheongju, South Korea, with an IIoT-based automation, machine learning-powered inspection and advanced process control, enabling mass customization and lowering production cost by 20%	Digital-enabled flexible manufacturing	▼ 87%	Equipment set-up time
		Automated material handling	▼ 39%	Logistics labour
		AI-powered optical inspection	▼ 33%	Defect rate
		Quality improvement by predictive analytics	▲ 80%	Inspection accuracy
		AI-powered process control	▼ 30%	Warranty claims
Sany Beijing	Confronted with growing demand and rising complexity in the multi-category and small-batch heavy machinery market, SANY Beijing deployed advanced human-machine collaboration automation, AI and IoT technologies to boost labour productivity by 85% and reduce production lead time by 77% from 30 to 7 days	Adaptive welding with intelligent robot	▲ 130%	Welding production efficiency
		AI-guided machine performance optimization	▲ 100%	Production capacity
		Collaborative robotics and automation	▼ 83%	Model changes time
		5G-based dual AGV heavy-duty logistics	▼ 50%	Average transferring time
		AI-guided machine performance optimization	▲ 31%	Machine efficiency
Schneider Electric Wuxi	Schneider Electric's 20-year-old electronics parts factory in Wuxi, China, confronted increased demand for product adaptation and order configuration with a flexible production line by deploying 4IR technologies such as modular cobot-stations and AI vision inspection to reduce time-to-market by 25%, and advanced analytics to auto-generate root cause analysis and detect anomalies across the supply chain, which have increased on-time delivery by 30%	End-to-end real-time supply chain visibility platform	▲ 30%	On-time delivery
		Field quality failures aggregation, prioritization and advanced analytics enabled problem-solving	▼ 72%	Warranty cost
		Digital-enabled flexible manufacturing	▼ 25%	Time to market
		Robotics-enabled logistics execution	▼ 43%	Warehouse labour
		Digital twin for sustainability	▼ 32%	HVAC energy consumption
Unilever Taicang	To seize the booming business in e-commerce and big-box channel, Unilever Taicang ice cream factory deployed one-scan, one-view platform to provide E2E supply chain visibility in manufacturing and food handling for customers, and combined the digital voice of consumers with agile R&D digital platform to improve innovation lead time by 75%, from 12 to 3 months	One-click AI sales forecasting	▲ 92%	Forecast efficiency
		Digital-enabled flexible manufacturing	▼ 98%	Change-over time
		AI-powered process control	▼ 95%	Quality defect rate
		Market insights generated by advanced analytics	▼ 75%	Innovation lead time
		Digital track and trace	▲ 28%	Sales growth
Western Digital Penang	With an increase in flash memory demand of more than 2X, stringent quality requirements and the need to optimize costs, Western Digital Penang embarked on lights-out manufacturing journey based on Fourth Industrial Revolution technologies. By automating production and logistics, they were able to deliver 32% factory cost improvement, and transitioned to build-to-order with intelligent planning system, thereby reducing product inventory and order lead time by 50%	Lights-Out Automation with Digitized Warehouse	▲ 360%	Labour productivity in manufacturing and warehouse
		ARV Fleet Optimization with Digital Twin and AI/ML	▲ 15%	OEE
		Production planning optimized by advanced analytics	▼ 55%	Manufacturing lead time
		Quality improvement by predictive analytics	▼ 50%	Annualized failure rate
		Predictive maintenance aggregating data based on historical and sensor data	▼ 60%	Quality excursion reduction in assembly process
Western Digital Prachinburi	With rapidly growing demand, rigorous quality requirements and cost pressure for hard disk drive (HDD), Western Digital Thailand leveraged connectivity and advanced analytics technologies to transform a capacity-saturated manufacturing site into a digital operation system with real-time visibility in suppliers, production, logistics and customers and data-based insights and predictions, ultimately increasing factory output by 123%, avoiding 30% in procurement and production costs, and reducing product return rate by 43%	Analytics driven supply risk prediction	▼ 32%	Procurement material cost avoidance
		Supplier material quality prediction using advanced analytics	▼ 41%	Scrap cost avoidance
		Analytics platform for remote production optimization	▲ 7%	OEE
		Field quality failures aggregation, prioritization and advanced analytics enabled problem-solving	▼ 43%	Annual rate-of-return improvement over two years
		Dynamic delivery optimization	▼ 46%	Logistic cost

Europe

Site	Change story	Use case	Impact		
De' Longhi Treviso	In order to step up competitiveness, De'Longhi's Treviso plant invested in digital and analytics to become more agile (reducing minimum order quantity by 92% and lead time by 82%), more productive (improving labour productivity by 33%), and achieve high standard quality (improving field quality by 33% and obtaining Food and Beverage industry certification)	Digital-enabled flexible manufacturing	▼ 92%	Minimum order quantity
		Digital track and trace	▼ 7%	Warranty repair cost
		Quality improvement by predictive analytics	▲ 30%	Machine lifespan
		Digital dashboards to monitor OEE performance	▲ 7%	Asset utilization
		Digitally enabled man-machine matching	▼ 15%	Scrap
Flex Althofen	Confronted with strong competition from lower-cost regions, Flex's site in Althofen deployed 4IR technologies to improve operational efficiency and agility. By meeting higher regulatory and quality standards, Flex attracted higher margin and longer lifecycle medical business, increasing revenue by 50% within the same physical footprint	End-to-end real-time supply chain visibility platform	▲ 25%	Customer satisfaction
		Digital tools to enhance a connected workforce	▼ 85%	Line clearance time
		Cycle time optimization through big-data analytics on lines PLCs	▲ 24%	SMT placement performance
		IIoT real time sensor based data aggregation for energy, emissions, waste, and water management	▼ 16%	Energy reduction per employee
		Automated material handling	▼ 72%	Work-in-progress
Johnson & Johnson Vision Care London	J&J Vision Care transformed customer experience, through personalized 4IR technologies using Adaptive Process Control, AI and robotics to offset increasing complexity (+ 50% SKUs) which enabled 100% personalized packaging configurations, 8 percentage point increase in customer service level, and reduced the carbon footprint for inbound freight by 53%	Customer end-user interface to configure and order a product and track delivery	▲ 10%	Order automation growth to 93%
		Digital logistics control tower	▼ 100%	Warehouse stock management
		AI enabled customer support	▲ 10%	Research & development cycle
		Digitally enabled final mile personalization	▼ 86%	Manpower for label application
		Robotics-enabled logistics execution	▲ 26%	Lenses shipped

Middle East

Site	Change story	Use case	Impact	
Arçelik Eskişehir	Confronted with rising customer demand and increasing product diversity, Arçelik leveraged their agile studio to deploy in 2 years over 30 advanced use cases across automation, robotics-enabled logistics and data-driven AI systems to enable flexible manufacturing with a return of investment of 1.2 years	Analytics platform for remote production optimization	▲ 18%	Test capacity
		Digital-enabled flexible manufacturing	▼ 81%	Set-up time of pre-assembly line
		Quality improvement by predictive analytics	▼ 40%	Scrap
		AI-powered process control	▲ 4x	Process capability
		Automated material handling	▼ 89%	Assembly line stoppages
Saudi Aramco Abqaiq	Motivated by the need to access new levels of quality and sustainability, the 70-year-old world's largest oil processing and crude stabilization plant has harnessed the power of data, advanced analytics and automation to transform its manufacturing processes, achieving a 21% increase in product quality and 14.5% reduction in energy use	Unmanned vehicles for inspection	▼ 80%	Operator risk exposure
		AI-powered process control	▲ 35%	Customer satisfaction
		AI-powered process control	▼ 11%	Energy intensity
		Predictive maintenance aggregating data based on historical and sensor data	▼ 20%	Unplanned maintenance
		Digital twin for sustainability	▲ 5%	Power generation

Americas

Site	Change story	Use case		Impact
Henkel Toluca	This 1970's factory characterized by low-mix, high-volume production, set out on a 4IR transformation journey centred on people, data transparency and availability to reduce processing costs by 15%, energy consumption by 14% and enhance plant OEE up to 90%	End-to-end real-time supply chain visibility platform	▼ 6%	Inventory
		Digital dashboards to monitor OEE performance	▲ 14%	OEE performance
		AI-powered optical inspection	▼ 55%	Customer complaint
		Digital twin for sustainability	▲ 19%	Energy efficiency
		Digital tools to enhance a connected workforce	▲ 3%	OEE performance
Johnson& Johnson DePuy Synthes Bridgewater	Faced with high complexity, cost pressure and operating room inefficiencies, DePuy Synthes deployed "Advanced Case Management", a 4IR programme leveraging open API architecture, machine-learning algorithms and a suite of digital tools across its joint restoration implant portfolio (hips and knees) value chain in North America to reduce the number of instrument trays in the operating room by 63%, implant inventory by 40% and ultimately lowering the time to set up the operating room by approximately 15% per location	Digitally enabled real time connectivity with customer system	▲ 100%	Real-time data integration to the AI algorithm
		Big data/AI-enabled product design and testing	▼ 40%	Inventory cost
		Digital integrated business planning	▼ 10%	Non-value added time
		Digitally enabled customer performance monitoring	▼ 25%	Response time to customer experience/needs
		AI to accelerate scaling of digital applications across sites	▲ 10x	Speed to scale
Protolabs Plymouth	Protolabs is a digital native manufacturer that embarked on a transformation journey taking it from a prototyping-only provider to a production supplier by leveraging its digital thread to connect customers to its injection molding production services. As a result, it outperforms traditional manufacturing competitors by reducing production lead-times down to as low as 1 day and generating a gross margin 20 points of percentage above industry average	Customer end-user interface to configure and order a product, and track delivery	▲ 95%	Online platform time-to-quote
		Automated design for manufacturing analysis	▼97.5%	Faster lead time than traditional manufacturer
		Automated tool design	▼ 31%	Labour cost
		Real-time asset performance monitoring and visualization	▼ 80%	Scrap
		Automated inspection enabled by digital thread	▼98.8%	Inspection time

FIGURE 6 **Sustainability Lighthouses show 4IR-enabled sustainability impact**

Site	Sustainability change story		Impact
Ericsson Lewisville, US	Ericsson's greenfield 5G factory is powered 100% by renewable electricity from on-site solar and green-e® certified renewable electricity from the utility grid. The smart factory integrates sustainable technologies such as thermal ice storage tanks with the IIoT stack to proactively monitor energy usage and is designed to utilize 24% less energy and 75% less indoor water usage, avoiding 97% operational carbon emission* than comparable buildings. This year it became Ericsson's first factory globally to achieve LEED Gold® certification	100%	Electricity from renewable sources
		▼ 97%	Reduction in carbon emissions**
		▼ 14%	Factory designed to reduce indoor water consumption
		▼ 24%	Factory designed to reduce electricity usage
Henkel Düsseldorf, Germany	In an effort to improve visibility into factory consumption to drive better decision-making, Henkel deployed utility meters on machines integrated in a digital twin that connects and benchmarks 30 factories and prescribes real-time sustainability actions that has led to 38% less energy (kWh/tonne) used, and has reduced water consumption 28% (m^3/tonne), and waste 20% (kg/tonne) across factory baselines set in 2010	▼ 38%	Less energy utilized
		▼ 28%	Reduced water consumption
		▼ 20%	Reduced waste across factory
Schneider Electric Lexington, US	In order to capture greater energy consumption granularity, when and where it happens in the plant, the Lexington smart factory leveraged IoT connectivity with power meters and predictive analytics to optimize energy cost, and as a result led to 26% energy reduction (GWh), 30% net CO_2 reduction, and 20% water use reduction and Superior Energy Performance 50001™ certification by the US Department of Energy	▼ 26%	Reduced energy consumption
		▼ 30%	Reduction in net CO_2 emission
		▼ 20%	Reduced water consumption

* Emission calculations uses EPA Greenhouse Gas Equivalencies Calculator
** Impact measured in tonnes of CO_2 compared to brownfield factory

1.2 Lighthouses leverage digital technology to generate impact beyond productivity to sustainability

A detailed look at Lighthouse success cases reveals that organizations investing in 4IR technology are realizing improvements in productivity, sustainability, operating costs, customization and speed to market. Companies that drive competitive efficiency through digital transformation can make every kilowatt hour count and every natural resource matter, using every machine and square foot of production space to its fullest, optimized potential.

FIGURE 7 **Lighthouses show 4IR-enabled sustainability impact**

Source: World Economic Forum Global Lighthouse Network

2 4IR enhances sustainability and productivity

2.1 Eco-efficiency: A vital response to the global call for climate action

The Paris Agreement seeks to stave off global temperature rise this century, limiting it to less than 2°C above pre-industrial levels. Moreover, it compels efforts to limit the increase even more ambitiously to less than 1.5°C. By 2020, 83 countries and the European Union (EU) had reported a total of 700 policies related to sustainable consumption and production to achieve these goals.

In contrast, however, only 40 countries had by 2020 reported on sustainable public-procurement policies or plans that would encourage environmentally-efficient products, promote more socially-responsible purchasing practices, and increase the sustainability of supply chains. United Nations Secretary-General Antonio Guterres, called the August 2021 report by the Intergovernmental Panel on Climate Change (IPCC) a "code red for humanity".

It is this call-to-action that puts eco-efficiency at the vanguard of the durable shifts. **Eco-efficiency is the outcome of 4IR technologies which, when directed to solve business problems, simultaneously boost productivity and sustainability**. As companies achieve eco-efficiency, they challenge the notion that environmental responsibility is inherently at odds with increasing operational performance.

FIGURE 8 **Eco-efficiency: A viable kind of efficiency possible through 4IR-driven transformations**

Eco-efficiency is the outcome of 4IR technologies directed to solve business problems that boost productivity and environmental sustainability together.

Environmental sustainability impact

Sustainability gains mean waste is reduced along with water consumption while energy efficiency rises and greenhouse gas emissions drop

4IR technology

IoT to unlock data and digital tools provide analytical insight to enable data-informed actions from across the production line and end-to-end value chain

Increased operational performance

Measurable improvement across performance indicators such as productivity, cost, agility, quality and convenience that are powered by 4IR technologies and enablers

2.2 4IR accelerates sustainability

This bolstered global environmental consciousness has made sustainability a must-have to maintain business viability; moreover, it is necessary to comply with increasingly complex regulations. As they respond to this urgent call to action, industrials can take heart in learning that alongside more immediately recognizable green initiatives such as renewable energy sourcing, the same digital transformation efforts that yield positive return on investment (ROI) also introduce a range of sustainability benefits.

As industrials get better and more efficient at the work they undertake, they can discover a win-win – they can achieve greater operational performance while simultaneously making good on commitments to environmental stewardship.

As pressure from climate change increases year by year, an encouraging lesson has emerged: while the greatest environmental benefits come from core green sustainability initiatives (e.g., commitments to renewable energy), 4IR technologies make being sustainable easier.

Those companies that are able to solve business problems while simultaneously reducing environmental detractors such as waste, consumption and emissions are at the leading edge of sustainability in the Fourth Industrial Revolution. The following sections provide data illustrating the kind of impact Lighthouses are achieving and take a closer look at five case studies involving 4IR technologies and sustainability improvement.

3 Lighthouses show the way: Measurable sustainability impact

3.1 Most lighthouses report that their 4IR transformation improves sustainability

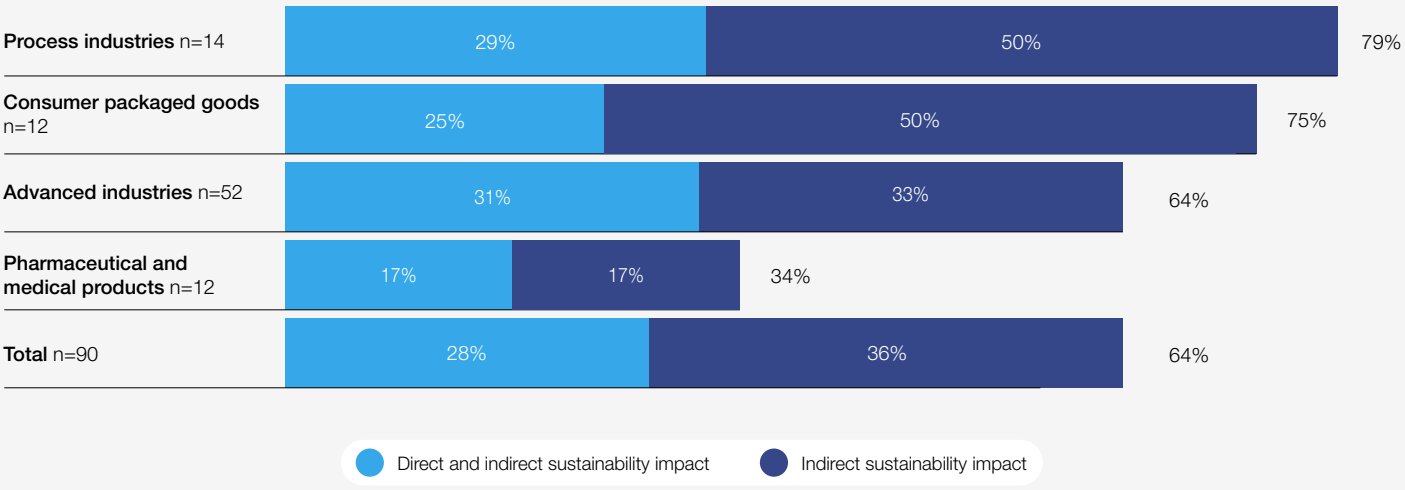
Well over half of Lighthouses (64%) report sustainability impact as part of their 4IR transformation, deriving from both direct and indirect impact use cases. For example, among the 14 Lighthouses in Process Industries, 29% report sustainability gains on KPIs deriving from direct impact sustainability use cases, but 50% of them report indirect impact from other use cases.

Similarly, but even more telling, while 25% of the 12 Consumer Packaged Goods Lighthouses cite direct sustainability use case impact, a full 50% report impact stemming from indirect use cases – 4IR efforts aimed at solving different business problems. Among Advanced Industries and Pharma & Medical Products, the breakdown is more evenly distributed.

The 4IR efforts – both those directly aimed at impacting sustainability and use cases aimed at entirely different purposes – are having positive effects for the environment.

FIGURE 9 **64% of Lighthouses report sustainability improvement as part of their 4IR transformation**

Lighthouses citing sustainability KPIs from use cases



64%
of Lighthouses are driving sustainability through 4IR

All
Lighthouses showing sustainability impact also show productivity impact

3
advanced use cases with direct sustainability impact are most common across Lighthouses

Source: World Economic Forum Global Lighthouse Network

Of course, achieving either sustainability impact alone, or efficiency alone, does not equate to achieving eco-efficiency. To truly address our "code red for humanity", the combination is a must.

To achieve it, companies must make sustainability a driving force of their business agendas. Lighthouses again show this is happening among leaders.

FIGURE 10 | **Lighthouses reporting sustainability improvement also show productivity increase**

* Each dot represents a single Lighthouse that recorded this impact

4 Unlocking sustainability: A closer look

4.1 Selected use cases illustrate how 4IR technologies open the door to sustainability

The three most common direct impact sustainability use cases among Lighthouse sites demonstrate advanced technology being applied intentionally to meet sustainability goals:

- The most direct utilizes IIoT (industrial internet of things) sensors and data visualization to monitor equipment performance and provide early warnings for resource consumption.
- Another advanced use case involves the use of digital twins to create a dynamic energy model that recommends how to optimize high-energy consumption processes.
- The most dynamic use case employs advanced analytics to power real-time energy management systems capable of auto-adjusting settings.

Additionally, a wide range of use cases provide indirect sustainability impact. Two impactful advanced use cases serve as good examples:

- Digital delivery optimization uses advanced analytics to consolidate shipments, which in turn provides emissions benefits.
- Artificial intelligence-enabled process improvement utilizes automation software to improve workflow and traceability alongside flexible real-time resourcing to eliminate human error in the product lifecycle. This reduces rejected material waste while improving energy efficiency along the production line.

Now we'll take a closer look at five eco-efficiency case studies to see how these top advanced use cases achieve sustainability improvements. It is worth noting that these case studies provide insights from across broadly divergent industries in the manufacturing sector, ranging from refineries to advanced electronics. While three of these case study sites employ the most common direct impact use cases described above, two show how indirect impact use cases mentioned above can also have a prominent effect.

FIGURE 11 **4IR technologies enable sustainability**

	Use cases	Case studies	4IR technology driving impact
Direct impact sustainability use case: Purpose-built to optimize resource efficiency	**IoT/sensor and visualization for production sustainability**	ERICSSON	IIoT platform connected to sensors installed on machinery tracks energy consumption and feed management tools to support shop-floor decisions
	Digital twin for production sustainability	SOCAR	Digital twin of energy network created to simulate complex, dynamic processes, which allows for simulation of optimum energy utilization scenarios based on data from operations (steam), weather (wind turbines) and electricity grid (cost)
	Advanced analytics for production sustainability	AUO	IIoT platform connected to sensors installed on machinery tracks energy consumption in real-time, and advanced analytics drive changes to balance consumption
Indirect sustainability impact use case: Focuses on operational KPI with sustainability a second order impact	**Data-driven and digitally connected logistics**	Western Digital	A logistics system and IoT sensors were used to feed a transportation reliability model which provides recommendations on optimal shipping consolidation, transit routing and carrier selection
	AI-optimized process	Unilever	AI-powered process optimization software and track-trace technology to improve production planning and product quality, reducing material waste and water consumption

Ericsson enables sustainability with IIoT platform

Ericsson's green efforts at its smart factory in Lewisville, Texas, USA begin with intentional building design that integrates sustainability measures from the ground up, including the heating, ventilation and air-conditioning systems. The factory features a 40,000-gallon tank that collects, treats and reuses rainwater. Additionally, a chiller coupled with ice storage tanks enables efficient site cooling using gathered water. Meanwhile, on-site solar panels generate sufficient electricity to fully power the factory, using surplus energy to freeze the rainwater for future usage.

On top of this green building design, Ericsson has integrated 4IR smart factory tools that augment the sustainability impact even further. A 4G/5G sensor network informs a smart management platform that monitors and visualizes consumption, leaks and temperature throughout the facility. It also automates powering equipment on or off by analysing energy consumption data. Finally, when it detects underperforming equipment, it alerts site staff and provides recommended proactive maintenance solutions.

This advanced site, which has earned LEED Gold® certification, sources 100% of its electricity from renewables, including on-site solar panels. The facility was designed to cut indoor water consumption by 75%, reduce energy consumption by an estimated 24% from that of comparable buildings, and nearly eliminate carbon emissions compared to a brownfield factory. By coupling a green factory design with 4IR sustainability tools, Ericsson has built a site designed to achieve notable direct sustainable impact through the application of a sophisticated advanced digital use case making it a model for companies aspiring to eco-efficiency. This use case is an example of how 4IR technologies can build on green technologies to push their impact further.

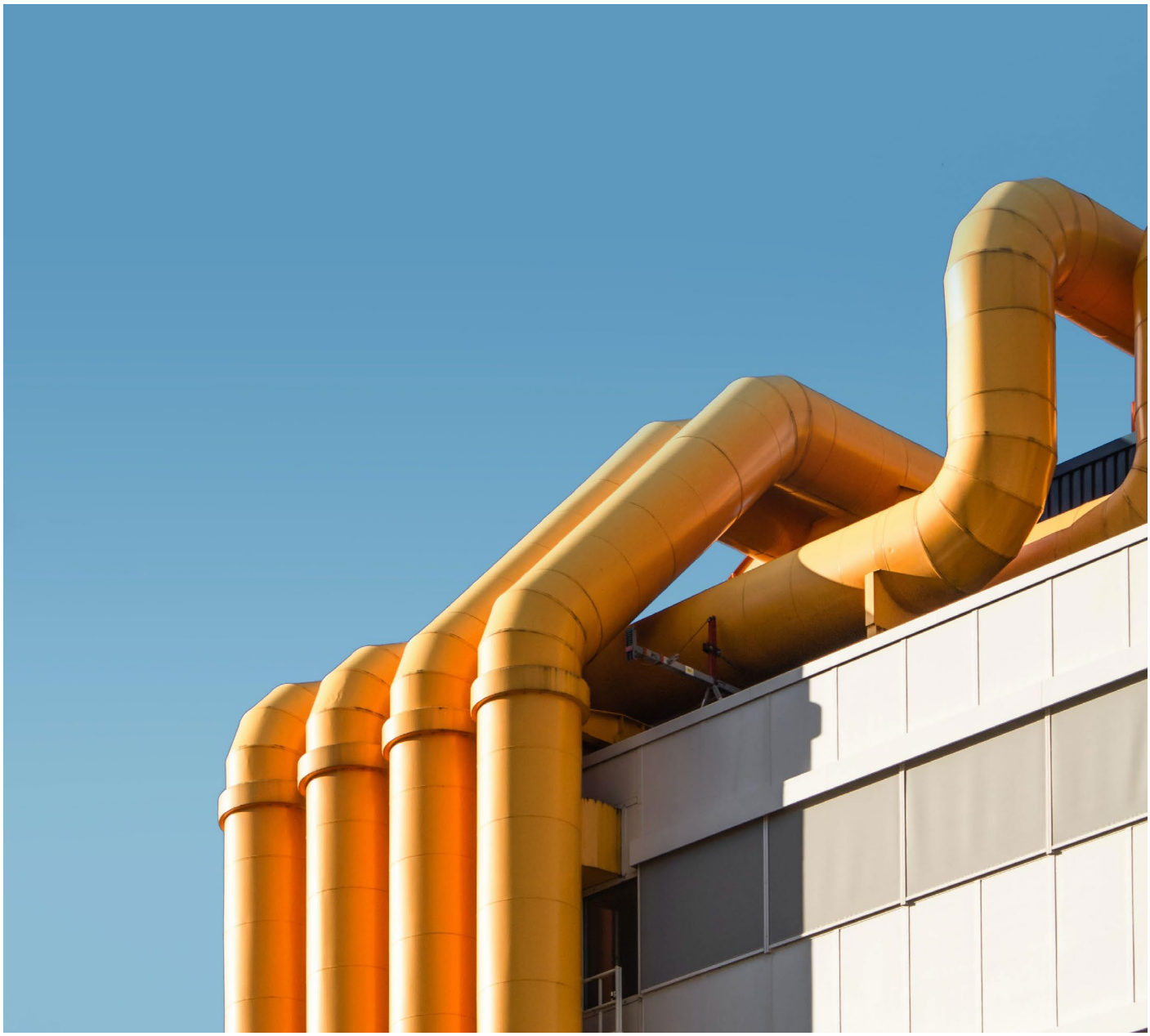


FIGURE 12 | **1: Ericsson's green smart factory equipped with sensors that monitor technology sustainability in real time**

Ericsson's factory is equipped with high-efficiency HVAC, lighting and energy management **systems whose performance is tracked with sensors in real time, enabling digital management** tools to flag abnormal energy and water consumption.

Green building technology integration

Integrating sustainability into building design and operations such as heating, ventilation and air-conditioning systems enabled Ericsson to boost its efficiency and sustainability:

—Installed a 40,000-gallon tank to **collect, treat and reuse rainwater**

—Utilized a high-efficiency magnetic levitation chiller and thermal ice storage tanks to **move cooling demand to off-peak hours**

—Installed on-site solar panels to **produce up to 17% of on-site power requirement**

4IR smart factory sustainability tools

Ericsson built **4G/5G connected sensors** into a smart **management platform** to:

—Monitor and visualize consumption, leaks, temperature in the facility

—Automate powering **equipment on or off** by analysing its energy consumption data

—Generate **alerts of underperforming equipment** and recommended maintenance solutions

Impact

100% electricity from renewable sources

97% reduction in carbon emissions*,**

75% factory designed to reduce indoor water consumption***

24% factory designed to reduce electricity usage***

Third party certified
Ericsson's first global factory to achieve LEED Gold® certification

* Emission calculations uses EPA Greenhouse Gas Equivalencies Calculator
** Impact measured in tonnes of CO_2 compared to brownfield factory
*** Based on design specifications

SOCAR uses digital twins to enable further sustainability impact

Among the most advanced use cases employed by the world's leading manufacturers is the use of digital twins. SOCAR engineered a virtual replica of its energy network based on real-time operational data to create data- driven insights and recommendations to optimize operations. Leveraging these virtual replicas, the energy optimization model across business units created a connected data model between the Petkim petrochemical plant and STAR refinery facility in Izmir, Turkey. Using 4IR technology, process information and external data sources, the system designs optimal energy solutions to meet production plans and has enabled SOCAR to enhance energy utilization efficiency.

Across both the brownfield Petkim petrochemical plant and STAR refinery, SOCAR has deployed over 3,000 4IR sensors to augment available data on equipment. Meanwhile, at the greenfield STAR refinery, these sensors are also feeding statistical machine-learning tools used to optimize the business unit's electricity needs, balancing steam utilization and available wind power. Lab measurements train the data and validate results.

Additionally, machine learning optimizes energy consumption solutions for refinery units.

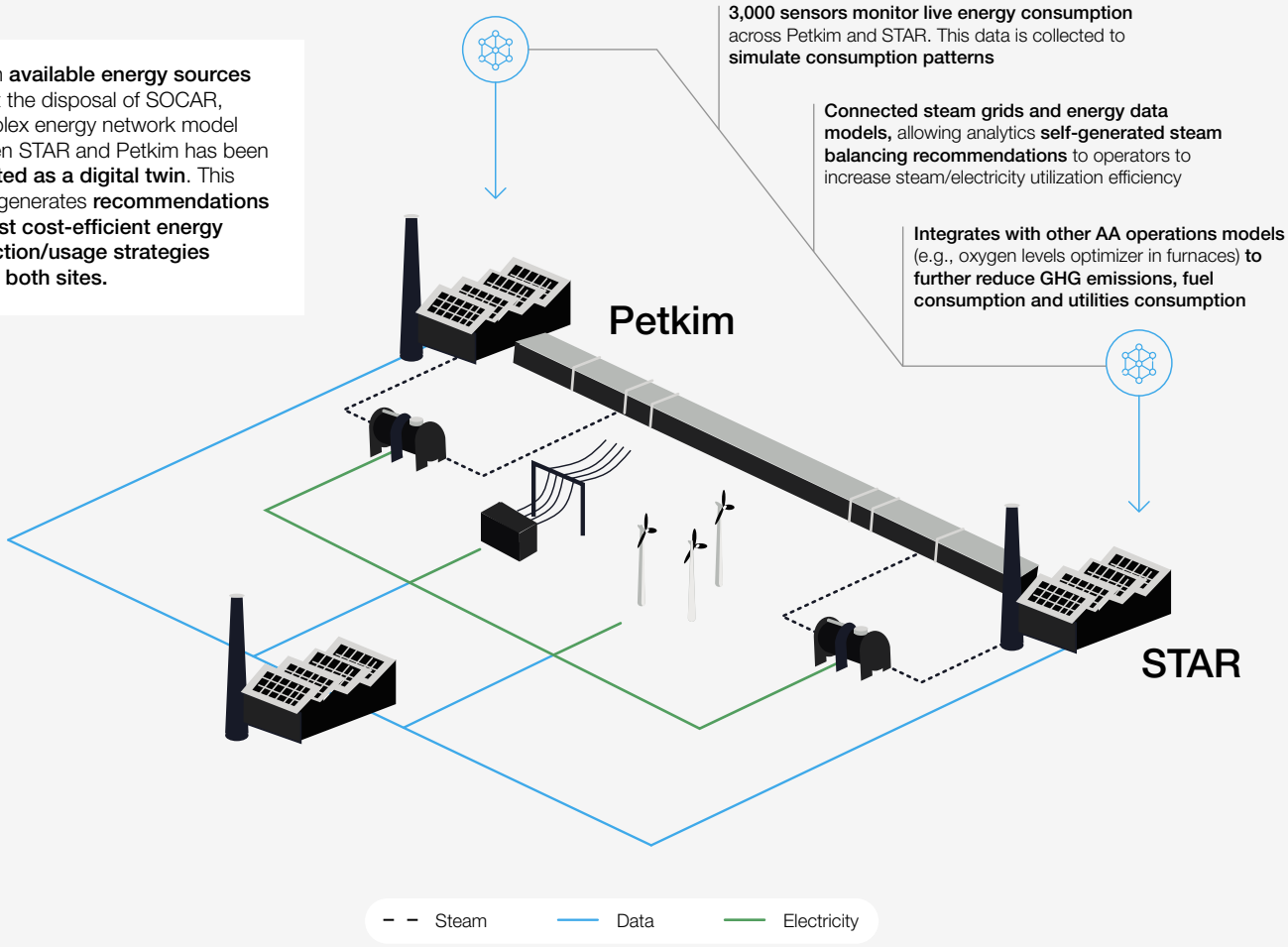
By connecting the STAR and Petkim energy and steam networks, SOCAR is able to power the digital twin energy optimization model that integrates the system as a whole. The connected steam grids and energy data models are able to leverage analytics to provide self-generated steam-balancing recommendations to operators, which increase the overall efficiency of steam and electricity usage.

The model's dynamic design minimizes energy costs on the business unit level, guiding operators with optimal energy solutions that take into account electricity market prices, natural gas prices, boiler efficiencies, turbine loads, and let-downs. With a constant stream of data, the digital twin model is able to maintain real-time awareness of conditions affecting efficiency, thereby providing up-to-date optimizing solutions at any moment.

This has yielded a 14% reduction in greenhouse gas (GHG) emissions, a 13% cut in water consumption and a 6% reduction in natural gas consumption.

SOCAR has built and deployed a **digital twin of its energy network to optimize energy efficiency across its business units.** This connected data between its Petkim and STAR facilities is powered by **sensors, process information and external data sources.**

Built on **available energy sources data** at the disposal of SOCAR, a complex energy network model between STAR and Petkim has been **recreated as a digital twin**. This model generates **recommendations for most cost-efficient energy production/usage strategies across both sites.**



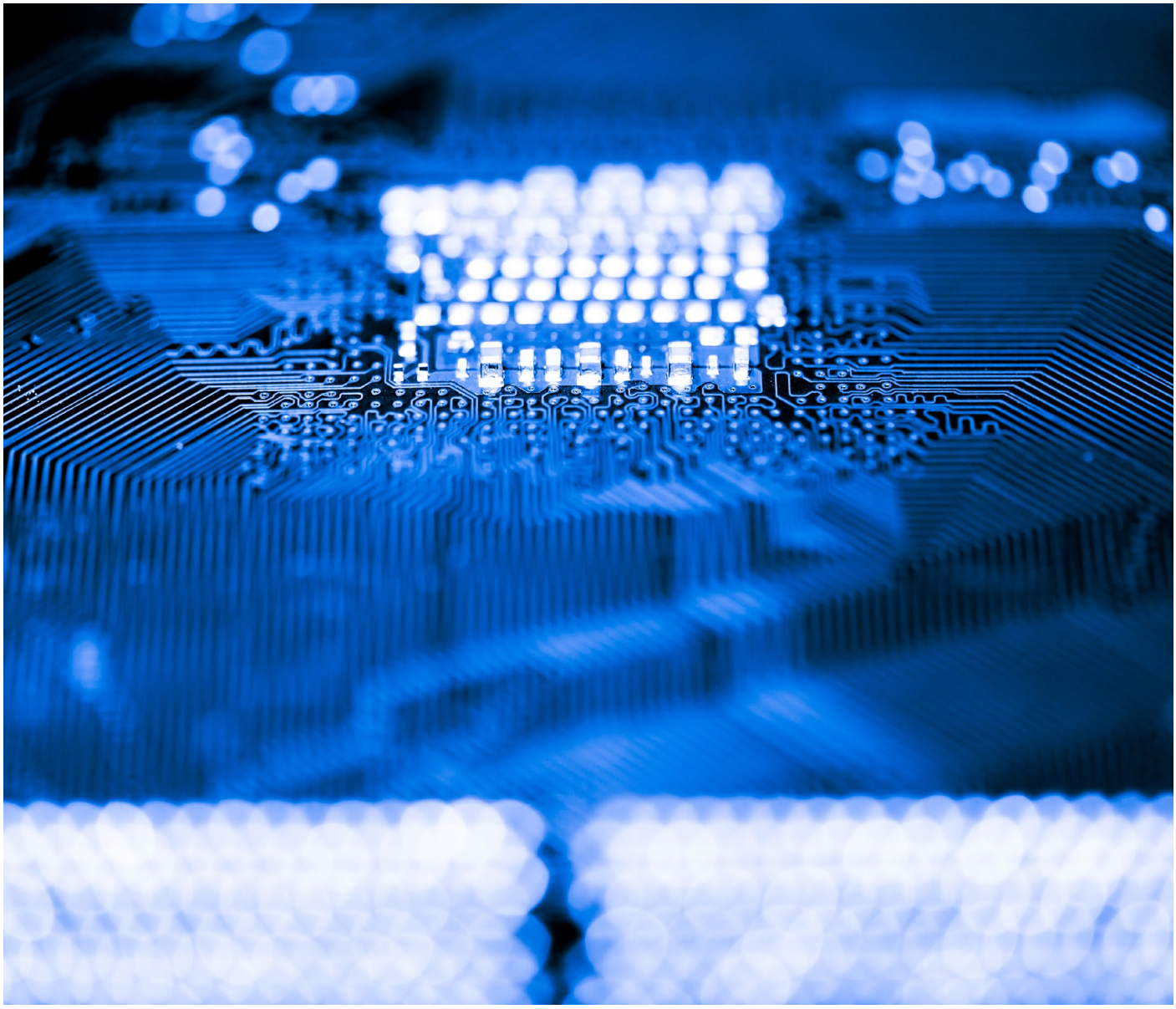
Recommendations are **designed to guide operators to improve business unit level wide** electricity usage based on electricity market prices, natural gas prices and boiler efficiencies, turbines and let-downs loads and available wind energy.

Impact

14% greenhouse gas emissions reduction

13% water consumption reduction

6% natural gas consumption reduction



AUO engages advanced analytics for sustainability impact

Smart technology can optimize systems for ideal performance while also affording sustainability gains. AUO, a producer of advanced display and solar panels with global reach, has developed an in-house, auto-feedback energy system at its Taichung site. The system utilizes IoT sensors and virtual models to drive automatic, real-time adjustments to equipment-operating parameters, boosting eco-efficiency.

The auto-feedback energy system enables smart modification of the product recipe between production runs by balancing equipment parameters such as power consumption and load, while accounting for environmental conditions in the factory such as temperature, humidity, atmospheric pressure and enthalpy (the measure of heat content in a given system). This enables the process to be optimized for each run of glass panel production, while likewise enhancing resource management and making better use of water and raw materials.

The smart system improved the chiller cycle, which comprises 15%-18% of the site's energy consumption. By shifting from manual control to advanced analytics, temperature can be ideally regulated for clean-room operations. The simulation and prediction model determines the best control point based on a statistical model that correlates various parameters, such as outlet temperature, chiller load and clean dry-air flow. This results in the clean room receiving temperature-optimized chilled water based on historical data and the control point algorithm. The system also equips the cooling tower, which exchanges waste heat, with an early warning system to indicate problems.

The impacts of this auto-feedback energy system include a 23% reduction in water consumption, a 20% cut in carbon emissions and a 6% reduction in overall site energy consumption. This case study highlights how Lighthouses have deliberately impacted environmental sustainability by leveraging 4IR technologies.

FIGURE 14 | **3: AUO's auto-feedback energy system optimized utility consumption**

In an effort to **optimize utility consumption for run-to-run production**, AUO developed **in-house an auto-feedback energy system using IoT sensors and virtual models** to automatically adjust in real time equipment-operating parameters.

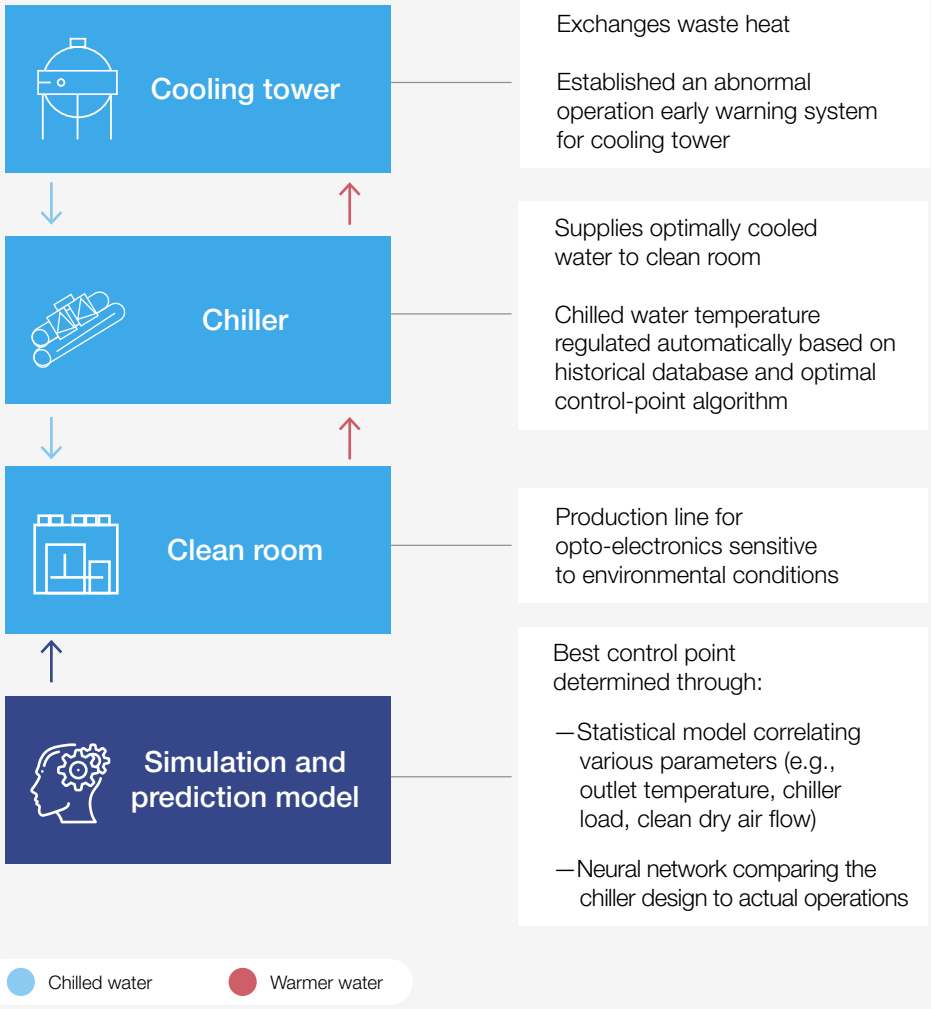
Auto-feedback energy system

Run-to-run control common in semiconductor manufacturing accounts for the multiple stages process, allows modification of a product recipe between "runs", enabling consistent reproducibility.

Feedback system balances:

- —Equipment parameters such as power consumption and load
- —Factory environmental conditions such as temperature, humidity, atmospheric pressure, enthalpy
- —Conditions unique to in-production glass panels being produced run-to-run

Resources managed and optimized: water, raw material management, and chilled water temperature.



Impact

23% water consumption reduction

20% carbon emissions reduction

6% energy consumption reduction

Water efficiency certification

The first global display industry to receive ISO 46001 certification for water efficiency management

Western Digital applies 4IR to optimize delivery logistics

The transport of materials, especially air freight, can be a resource-heavy undertaking. Western Digital in Prachinburi, Thailand, used 4IR technology to reduce GHG emissions while simultaneously cutting logistics costs. With its automated logistics system, the company utilized operational data with IoT and machine-learning tools to develop a shipment consolidation and logistics optimizer. This has optimized air freight shipment usage, thereby reducing costs and eliminating GHG emissions from unnecessary shipments.

The impact hinges on a machine-learning data model that improves transportation reliability. The system processes data from IoT-connected sensors along with operational (transportation management system) data to form a continuously updated dataset. IoT sensors attached to each shipment monitor and report real-time logistics data, including GPS location and conditions such as tilt, temperature shock, humidity and light. Meanwhile, the digital transportation management system streamlines operational data like carrier details, service performance, shipment requirements, pick-up information and customer data.

This combined wealth of data and the analytics power to make sense of it enables the building of an optimization model that generates best-in-class logistics recommendations. By correlating shipment delivery performance data points such as transit times, routing, shock, temperature and customer satisfaction, the reliability model creates carrier performance "score cards" to inform carrier selection. As result of the model, the system delivers scenario recommendations that improve routing, shipping consolidation and transit times while decreasing latency for real-time decision making.

By deploying this 4IR automated system, Western Digital has cut GHG emissions by 12% while enjoying a 46% reduction in logistics costs.

Western Digital in Prachinburi, Thailand, **utilized operational data** with **IoT and machine learning tools** to develop a **shipment consolidation and logistics optimizer.**

The outcome **optimized air freight shipment usage**, reduced costs and eliminated emissions from unneeded shipments.

Transportation reliability model optimizes logistics, eliminating excess air freight miles

Machine learning data model optimizes **shipments consolidation** and **freight utilization** to improve transportation reliability and, as a result, **reduces emissions** attributed to the transportation network.

- Processes **IoT (sensors)** and **operational transportation management system data** into continuous stream of **model optimization dataset** to provide best-in-class logistic solutions recommendation
- **Correlates shipment delivery performance data points** (transit times, routing, shock, temperature, costumer satisfaction) to create carrier performance score cards used for carrier selection
- Delivers **scenario recommendations** to improve routing, shipping consolidation, transit times and decreases latency for real-time decision/action

IoT enabled real-time shipment tracking

IoT **sensors attached to each shipment to monitor and report real-time logistics data** (e.g., GPS coordinates, temperature shock, tilt, humidity, light)

Digital transportation management system

Deployed a **transportation management system** to streamline **operational data** (e.g., pick up information, shipment requirements, customer data, carrier details and service performance)

Impact

46% logistic costs reduction

12% greenhouse gas emissions reduction

Unilever deploys optimizing algorithms to improve quality and throughput

By integrating varied 4IR solutions at its Dubai Personal Care plant, Unilever improved its production line performance while making sustainability gains. The company coupled embedded IoT devices and production line optimization systems to drive improvements in both quality and throughput while cutting waste and water consumption.

At the heart of these achievements lies a sophisticated cloud computing platform, which unlocked 4IR opportunities. The platform enabled consolidation of existing IT architecture, including production plans, bills of material, material management, automation system programmable logic controllers (PLCs) and enterprise resource planning (ERP) systems. Additionally, the computing platform utilizes data from 4IR technologies, such as registry data from Radio Frequency Identification (RFID) sensors or QR codes and that gained from wireless devices embedded in equipment.

This platform uses a sequence-optimizing software to reduce changeovers. Designed in-house, the software generates efficient production plan sequences for multi-product scenarios. By reducing changeovers, production line OEE is boosted while water consumption for line cleaning is reduced. Meanwhile, track-trace technology utilizing IoT-enabled equipment and RFID/QR codes enables smart validation and production control. Validation process checkpoints and automation of critical work steps combine to reduce human error, thus reducing the potential for quality deviations while cutting waste. Finally, an inflight correction system utilizes dosing software to optimize dosing accuracy. Continuous self-optimization logic, informed by historical errors and real-time sensor data, further reduces quality deviation and waste.

These 4IR technologies applied to the production line have afforded Unilever's Dubai site a 42% reduction in material waste, a 15% reduction in water consumption, and cost savings of 26% per tonne.

FIGURE 16 | **5: Unilever integrated 4IR solutions to improve its production line performance and environmental footprint**

Unilever, Dubai Personal Care plant embedded **IoT devices** and developed **AI-powered optimization systems for production lines** to drive improvements in quality and throughput while reducing waste production and water consumption.

Cloud-computing platform unlocked 4IR digital opportunities

Consolidated existing IT architecture (e.g., production plans, bills of material, material management, automation system PLCs and ERP systems)

Data from 4IR technologies (e.g., registry data from RFID/QR codes, wireless devices embedded in equipment such as weighing scales)

Sequence optimizer software to reduce changeovers

In-house designed computational sequencing software powered by AI assists production planners to compute efficient production plan sequences for multi-product production plans

Reduction in number of changeovers, translates in an increase of line OEE and reduction of water consumption used for cleaning the lines

Track-trace technology to improve quality control

QR codes, RFID technology and IoT-enabled (smart) equipment validate and control production steps

Validation checkpoints of process steps and automation of critical work steps (e.g., raw material weighing), reduce the room for human error which lead to quality deviations and waste

Inflight correction system to optimize dosing accuracy

Dosing AI software allows the control system to self-improve its dosing accuracy in a continuous self-optimization logic

Historical errors and real-time production line sensor data analysed by the dosing software prevents under/overfill which can also lead to quality deviations and waste

Impact

42% material waste reduction

26% cost per tonne reduction

15% water consumption reduction

5 The eco-efficiency pacesetters: Sustainability Lighthouses

The Global Lighthouse Network was established to light the way for 4IR transformation across the manufacturing sector, and its 90 frontrunner sites have already set new benchmarks when it comes to successful 4IR transformation at scale. These leading companies are also positioned to lead a next-level drive when it comes to sustainability.

5.1 A global community sets a global goal

At the World Economic Forum Annual Meeting 2020 in Davos, foremost leaders from industrial companies charged the Global Lighthouse Network with the task of uncovering how sites and end-to-end value chains could make themselves more sustainable through technology. Additionally, the network was encouraged to identify member organizations that especially exemplified sustainability impact – and could serve as aspirational models for other companies.

5.2 A meaningful designation among recognized industrial leaders

The new designation of "Sustainability Lighthouse" has been created to recognize these leaders. Sustainability Lighthouses, in addition to achieving the impressive level of 4IR maturity characteristic of other Advanced Lighthouses, have demonstrated exemplary commitment to environmental sustainability through intent, impact and scale of deployed advanced use cases.

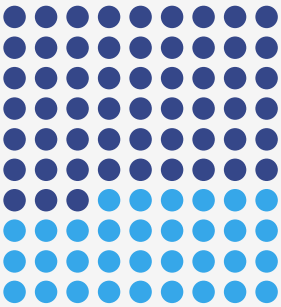
Identifying Sustainability Lighthouses was based on pre-existing information shared as part of the Lighthouses' initial applications. This close examination of available data from the 90 member sites helped determine which among them might best inspire future Lighthouses in this regard. With 64% reporting sustainability impact, further discernment was needed to identify the true frontrunners. Some 16 Lighthouses highlighted dedicated advanced use cases aimed at enabling sustainability impact. Eventually, three emerged from an independent panel of experts for their use of 4IR technology and step-change impact in environmental categories: Ericsson (Lewisville, USA), Henkel (Düsseldorf, Germany)[3] and Schneider Electric (Lexington, USA).[4]

FIGURE 17 **The first cohort of designated Sustainability Lighthouses came from members of the Global Lighthouse Network**

A Sustainability Lighthouse designation created to highlight pacesetters

Sustainability Lighthouse designation reflects the same level of 4IR maturity of other Advanced Lighthouses and highlights a commitment to environmental sustainability through intent, impact and scale of deployed advanced use cases

The first Sustainability Lighthouses were identified from across the Global Lighthouse Network



90 Lighthouses

Within the Global Lighthouse Network, 64% impacting sustainability through their top 5 use cases

3 Lighthouses

Identified as the first cohort of Sustainability Lighthouses against peers

Ericsson: Lewisville, USA

Henkel: Düsseldorf, Germany

Schneider Electric: Lexington, USA

Call-to-action

Global Lighthouse Network invites future Sustainability Lighthouses to join the network

Together, the network learns and shares insights to advance 4IR adoption and generate greater environmental impact.

Sustainability Lighthouses are pursuing ambitious impacts on environmental sustainability and realizing highly notable achievements in return. They have been explicit about incorporating sustainability goals with specific timelines as part of their 4IR journey. The results they have achieved fall into multiple environmental categories and reach the level of step-change improvement.

FIGURE 18 **Sustainability Lighthouses are eco-efficiency pacesetters, leveraging 4IR to minimize environmental impact**

Frontrunner in deploying 4IR technology at scale to set new levels of operational performance

Transforming the entire manufacturing context, break down internal divisions, share data with external stakeholders and build new capabilities

Transforming the ways in which people work together, keeping people at the centre to realize their full potential alongside digital technology

Highest ambitions for environmental sustainability along with step-change achievement

Sustainability goals and timeline included as part of 4IR journey

Multiple environmental categories with step-change improvements

Sustainability impact across multiple 4IR use cases deployed

5.3 Call for applications

The Global Lighthouse Network continues to grow and encourages leading organizations to consider applying to join as site or as an end-to-end value chain. All members of the network – whether newly recognized or existing – are eligible to be considered for designation as Sustainability Lighthouses. Excited forward-thinking companies are invited to learn more by emailing LighthouseNetwork@weforum.org.

Acknowledgements

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Endnotes

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