UNITED ARAB EMIRATES
MINISTRY OF INDUSTRY
& ADVANCED TECHNOLOGY

# INDUSTRIAL TECHNOLOGY TRANSFORMATION INDEX
## USE CASE GUIDE

مؤشر
التحول
التكنولوجي
الصناعي

INDUSTRIAL
TECHNOLOGY
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# FOREWORD

**Dr. Sultan bin Ahmed Al Jaber**

***UAE Minister of Industry and Advanced Technology***

> **"Under the National Strategy for Industry and Advanced Technology, the country is ultimately helping to shape a more competitive, greener economy built on industries – and technologies – of the future."**

The world today is venturing into the Fourth Industrial Revolution (4IR) and as technologies continue to evolve, the outlook for a more productive, sustainable industrial sector is positive. That was the sentiment at COP28, where it was made clear that the global community has committed to a new path towards unlocking the economic and social potential of sustainable industrial development.

As an innovation and manufacturing hub, the United Arab Emirates (UAE) is at the forefront of this shift, driving trends in Industry 4.0 solutions such as artificial intelligence (AI). Under the National Strategy for Industry and Advanced Technology, the country is ultimately helping to shape a more competitive, greener economy built on industries – and technologies – of the future.

The Ministry of Industry and Advanced Technology (MoIAT) has, alongside its strategic partners, introduced initiatives, programs, incentives and enablers to empower industry leaders to integrate and scale 4IR into their businesses. Many of these have been implemented under the Technology Transformation Program (TTP), including the flagship Industrial Technology Transformation Index (ITTI), to which this guide is linked.

The tool aims to empower UAE manufacturers, providing fresh insights and new avenues for partnerships between SMEs, national enterprises and multinationals. In addition to driving positive change, the guide reaffirms the ministry's commitment to strengthening the UAE's position as a sustainable and interconnected advanced manufacturing hub.

Under this approach, the country will continue building on the momentum created by the National Strategy for Industry and Advanced Technology; more manufacturers will join the Fourth Industrial Age and the UAE will strengthen its position as a global hub for innovation and industry.

# FOREWORD

**Sarah Al Amiri**

***UAE Minister of State for Public Education and Advanced Technology***

> **"The Industrial Technology Transformation Index, launched in 2023 under the Technology Transformation Program, was a significant leap forward for the entire industrial community."**

Over the past four years, since the establishment of the Ministry of Industry and Advanced Technology (MoIAT), the United Arab Emirates has worked to accelerate the transformation of industry into a key engine of sustainable national economic growth.

The Industrial Technology Transformation Index, launched in 2023 under the Technology Transformation Program, was a significant leap forward for the entire industrial community. It represented a comprehensive tool for helping factories to start their digital journeys and supporting others to accelerate theirs. Combined with existing technology financing schemes, ICV and I4.0 awareness programs, the ITTI has become a key driver of the UAE's industrial transformation.

Now, with the ITTI Use-Case Guide, MoIAT is further empowering companies to join the Fourth Industrial Revolution by enabling leaders to make informed, strategic decisions. Already, around a third of ITTI-assessed manufacturers have implemented advanced technologies; and we hope this Guide will inspire many more to do the same.

The impact of increased adoption rates will extend far beyond the factory walls; not only strengthening bottom lines but reducing waste and energy to create a more competitive, efficient and sustainable industrial sector in line with the national economic vision and net zero strategic initiative.

# EXECUTIVE SUMMARY

The ITTI Use Case Guide represents a culmination of information and insights related to the digital transformation of the manufacturing industry in the UAE. The backbone of this guide is the Industrial Technology Transformation Index (ITTI) framework, which represents a digital maturity assessment tool developed by the Ministry of Industry and Advanced Technology (MoIAT).

The ITTI framework is baselined against the manufacturing value chain, and within the broad elements of the value chain are defined a total of 20 dimensions – Product Lifecycle Management, Supply Chain Planning, Production Execution, Sales and Marketing, Enterprise Administration, and Sustainability to name a few.

The tool aims to evaluate the current state maturity of manufacturers, and subsequently provide recommendations targeted at digitally transforming manufacturing and enterprise operations. The insights presented in this guide have been derived through the analysis of these ITTI assessments combined with global views and recommendations, which are intended to empower the manufacturing ecosystem as a whole.

The guide intends to empower not only Manufacturers but also Policymakers, Technology Providers and Academia, as the advancement of the manufacturing industry is dependent on the synergies between all.

**1) Manufacturers** are guided through the insights and recommendations distilled in the form of sector-specific deep dives and detailed use case charters.

Sector-specific deep dives aim to provide the readers with insights into Industry 4.0 Use Case adoptions and sustainability initiatives as seen alongside their manufacturing peers in the UAE.

The purpose of the use case charters is to provide an accelerated starting point for manufacturers who are considering the implementation of an Industry 4.0 Use Case.

**2) Technology Providers** are presented with an opportunity to focus their efforts on technology domains of interest, which have been highlighted through the identification and prioritization of Industry 4.0 Use Cases. Additionally, the guide derives a potential market opportunity of 1.5 Bn AED, bifurcated across sectors, and built up through these recommendations.

**1.5 Bn AED**

Potential market opportunity
for prioritized use cases

**3) Academia** has a further role to play in augmenting future curriculums and promoting a healthy balance in the learning and development of foundational and advanced technology concepts. This further ensures that existing and future talent is adequately equipped from a skills-enabled perspective.

**4) Policymakers** can support the ecosystem by developing targeted policies that align with the emerging trends resulting from currently implemented and recommended use cases and technologies.

**32%**

Manufacturers with I4.0 Use
Cases currently implemented

**9 Priority Sectors**

Covering recommended Industry 4.0
Use Cases and Sustainability Initiatives

From the analysis of the Industrial Technology Transformation Index (ITTI) assessment reports, which have captured over 1,530 instances of Industry 4.0 Use Cases and sustainability initiatives, we notice an encouraging trend: as companies mature and expand, their implementation of Industry 4.0 solutions become more prevalent. Remarkably, even small-scale enterprises, which may still operate within the Industry 2.0 model, have begun integrating Industry 4.0 practices into their operations. This suggests a substantial untapped potential for Industry 4.0 adoption among businesses with lower digital maturity.

Considering the globally trending concept of 'hyperconnectivity', Industry 2.0 and 3.0 companies have an opportunity to break the traditional norms and pre-requisites associated with a stage-wise approach towards adopting Industry 4.0 technologies. With the introduction of powerful computing at the edge, hyperconnectivity enables less mature manufacturers to immediately participate in Industry 4.0 opportunities where they too can realize benefits.

In dissecting the ITTI assessment data across the manufacturing value chain, a clear pattern emerges: A dominant 93% of Industry 4.0 Use Cases concentrate on optimizing Manufacturing/Production, Supply Chain Management, and Enterprise Administration – with a rapid adoption of verticalized Industry 4.0 solutions being the most prominent in Manufacturing/Production (62%), followed by Supply Chain Management (17%) and Enterprise Administration (14%). Industry 4.0 Use Cases in these domains are crucial for manufacturers to consider, as they represent the most significant opportunities for operational improvements.

## Primary Industry 4.0 Focal Areas for Manufacturers

**93%**
of I4.0 Use Cases are dominant in the following value chain dimensions:

**62%**
Manufacturing/ Production

**17%**
Supply Chain Management

**14%**
Enterprise Administration

**Rapid adoption of verticalized I4.0 solutions**

**Emerging focal areas for horizontally integrated I4.0 solutions**

Research and Development (R&D) represents a strategic dimension of the value chain that requires additional focus and consideration in order to propel the UAE as a frontrunner in innovation. Manufacturers should pay close attention on R&D to improve regional competitiveness from a global perspective. Additionally, customer centricity within the manufacturing context is maturing across Marketing and Sales, and Customer Care and Services, where Industry 4.0 technologies are bridging the gap between understanding, fulfilling, and servicing customer requirements.

The fourth industrial revolution is advancing the industrial sector with use cases that enhance operational efficiency and innovation. Top use cases based on prioritization cover Robotic Process Automation (RPA), supplier integration in procure-to-pay workflows, the merger of information technology and operational technology, autonomous transport robots, and advanced automated production planning and scheduling systems.

Sustainability efforts are also a core focus for UAE manufacturers, with 92% of assessed companies having already implemented various initiatives. These initiatives are diverse, ranging from waste reduction to wastewater recycling and emissions management, and are driven by regulatory requirements and inherent sustainability principles within the industry. Manufacturers should continue to enhance the country's unified drive towards sustainability, adopting Industry 4.0 technologies to augment the positive impact of sustainable manufacturing operations.

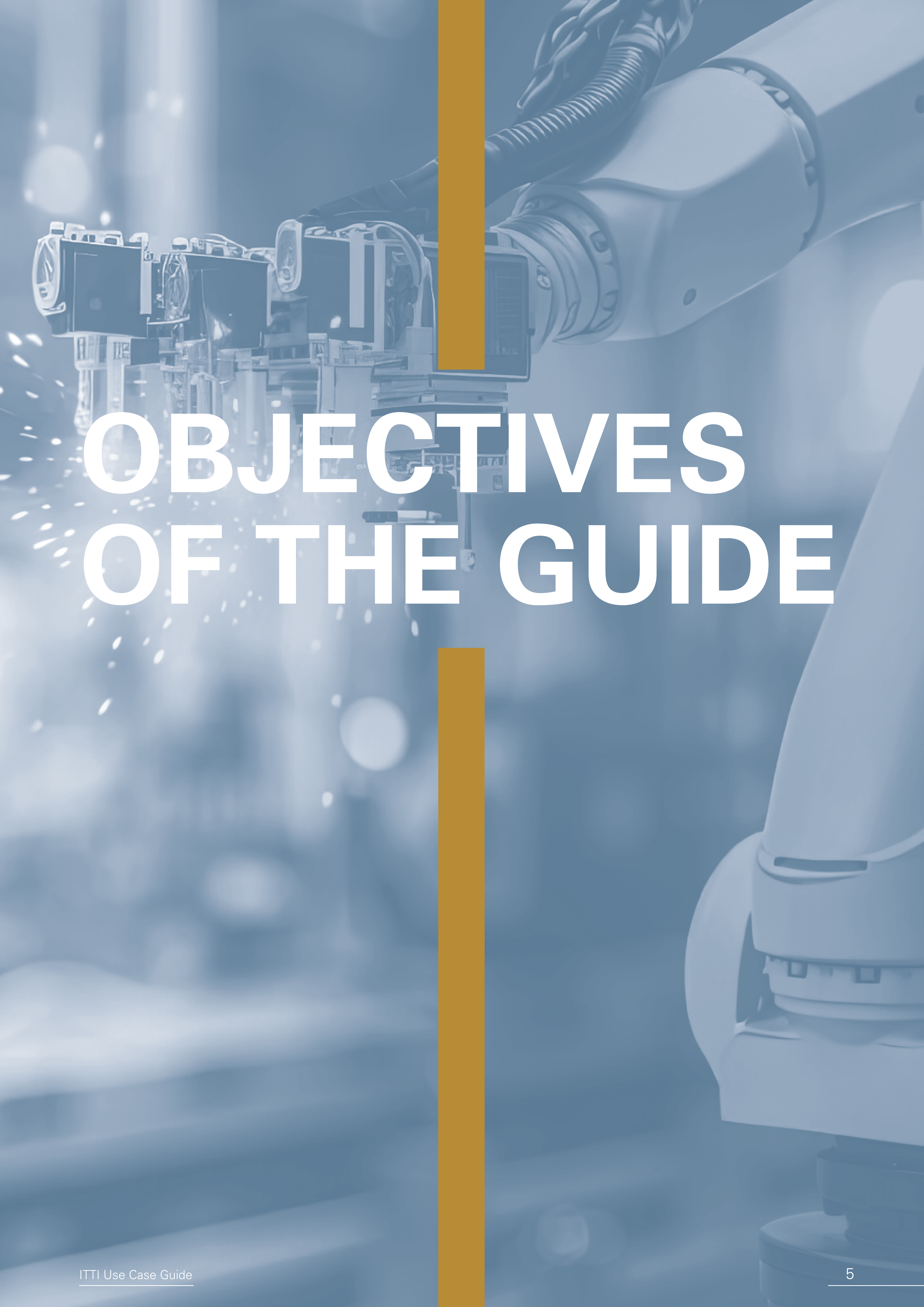
**90+**
Unique Industry 4.0 and Sustainability Use Cases

**~5 Initiatives**
92% of assessed companies have already implemented several sustainability initiatives

**20 Use Case Charters**
Overview of challenges, benefits, advantages, and implementation timelines

Use Case Charters have been developed with a focus on prioritized and recommended use cases as seen across sectors. A total of 20 charters cover each use case in detail, highlighting crucial pre-requisites, supporting technologies, core skills required, ease of implementation and proposed timelines. Furthermore, each use case is linked to the respective ITTI dimension, and potential benefits and impacts are presented.

The directive of this guide is to embrace the insights provided through analysis of ITTI assessments, with a focus on strategies aimed at the adoption of advanced and intelligent solutions. As we look towards the future, leveraging these insights will be pivotal in driving the adoption of innovative and sustainable technologies that align with the global trajectory of Industry 4.0.



# OBJECTIVES OF THE GUIDE

# Through Key Objectives, the ITTI Use Case Guide Builds the Readers' Understanding and Value Extraction

This Guide's objective is to provide the manufacturing ecosystem with a unified resource that offers actionable insights and strategic guidance for adopting Industry 4.0 technologies and integrating sustainability initiatives, drawn from ITTI assessment reports and exemplified through a Use Case Guide.

## Objectives of the ITTI Use Case Guide

1. Showcase globally trending themes driving the adoption of Industry 4.0 technologies and solutions
2. Present regional adoption of Industry 4.0 technologies and sustainability initiatives based on ITTI assessment reports
3. Recommend high-impact Industry 4.0 Use Cases and sustainability initiatives for sector-specific business imperatives
4. Catalogue prioritized sector-agnostic Industry 4.0 Use Cases into charters for further consideration by manufacturers

# MoIAT Aims to Galvanize the Manufacturing Industry in the UAE through the Dissemination of Data-Driven Insights

## Relevance of the ITTI Use Case Guide

The intended audience for ITTI Use Case Guide encompasses a diverse spectrum of stakeholders integral to the advancement of Industry 4.0. Manufacturers, positioned at the core, aim to revolutionize their processes and output through digital transformation. Policymakers represent a key demographic responsible for shaping the regulatory environment. Technology Providers contribute by offering innovative tools that drive manufacturing intelligence. Finally, Academia, representing the scholarly and research perspective, seeks valuable insights to the upcoming Industry 4.0 requirements. Each segment plays a vital role in the ecosystem of modern manufacturing, driving progress and thought leadership in the era of smart industry. Through the ITTI Use Case Guide, the Ministry aims to enable the ecosystem through data-driven insights, thus unlocking opportunities for accelerated adoption of Industry 4.0 and sustainability practices.

## Intended Audience

- **Manufacturers**
- **Policymakers**
- **Technology Providers**
- **Academia**

# The ITTI Use Case Guide Represents a Collaborative and Informative Source of Information for Stakeholders across the Manufacturing Sector

## Manufacturers

- It creates I4.0 and advanced technology awareness through global trends
- The guide prioritizes I4.0 and sustainability use cases for priority sectors
- It catalogs a directory of Use Case Charters covering key outcomes, technologies, required skills and timelines

## Policymakers

- It guides Policymakers in developing ecosystem-relevant support structures and incentive schemes based on emerging trends

## Technology Providers

- Further, the guide identifies and highlights domain-specific needs for technology solutions
- It promotes technology investment in capabilities and products that support prioritized use cases

## Academia

- The guide provides insight into upcoming Industry 4.0-ready skillsets and talent requirements based on globally trending I4.0 technologies, prioritized use cases and recommended technologies

# The Guide Intends to Empower the Manufacturing Ecosystem

| | |
|---|---|
| **Provides a glimpse into global I4.0 trends** | To educate and inform UAE manufacturers about the current global trends in I4.0 technologies, including automation, data analytics and AI, as well as Industrial Internet of Things (IIoT) applications. Understanding these trends is crucial for manufacturers to stay competitive on a global scale |
| **Showcases regional adoption of I4.0 Use Cases** | To provide a detailed analysis of how I4.0 Use Cases are being adopted within the UAE, giving a clear view of the local landscape, including sustainability-related initiatives. This will help manufacturers benchmark their current practices against broader regional activities and identify gaps or opportunities |
| **Deep dives into sector-specific strategies** | To recommend targeted I4.0 applications and sustainability strategies that align with the specific business imperatives of different sectors within the UAE's manufacturing industry. This tailored approach ensures that the recommendations are relevant, actionable, and have the potential for high impact |
| **Provides foundation and directional next steps** | To distill these recommendations into prioritized I4.0 Use Cases, presented in the form of Charters. These Charters will offer manufacturers a clearer framework for evaluating, planning, and executing I4.0 Use Cases and serve as a starting point for manufacturers to develop customized roadmaps for adopting I4.0 technologies in their operations |

While the above focuses on Manufacturers, ecosystem stakeholders, such as Policymakers, Technology Providers and Academia, can draw insights and opportunities relevant to their domains.

# INDUSTRY 4.0 LANDSCAPE

## From Steam to Cyber: The Evolutionary March of Industry from Mechanization to Digitalization

### Industry 1.0

Introduction of mechanical production powered by water and steam

### Industry 2.0

Mass production and assembly line achieved with the help of electric power

### Industry 3.0

Automation of manufacturing production using electronics and information technology (PLCs and SCADAs)

### Industry 4.0

Smart and autonomous systems fueled by data and machine learning (Cyber-physical systems) which are interoperable, and can communicate and collaborate with one another

## Industry 4.0 | A Standard Definition by the Joint Working Group 21 (JWG21) (ISO+IEC)

**Definition By JWG21***

Manufacturing that enhances its performance by employing integrated and intelligent processes and resources across cyber, physical, and human spheres. The goal is to create and deliver products and services while fostering collaboration with other domains within enterprises' value chains

### Components for an Industry 4.0 Use Case

**Industry 4.0 Use Case** = Connected Process/Asset /Worker in a Plant + Integration and Intelligence to Drive Actions + Other Enterprise Domain (Optional)

**Outcome of Performance Improvements**

*Many countries, consortiums and other organizations presented diverse frameworks for Industry 4.0, originating from Germany's 'Industrie 4.0' initiative, until the ISO and IEC established a global standard in 2021

# Enhancing Performance through Advanced Technology is Core to Industry 4.0

## Sample I4.0 Technologies

- Artificial Intelligence
- Industrial Internet of Things
- Cloud Technologies
- Autonomous Systems
- Industrial 5G
- Augmented and Virtual Reality
- Blockchain Technology

## I4.0 Benefits

- Flexibility
- Traceability
- Quality
- Speed
- Productivity
- Sustainability

# Industry 4.0: Bridging Necessity and Innovation for Future-Ready Manufacturing

## Industry 4.0 as a Necessity for Manufacturers

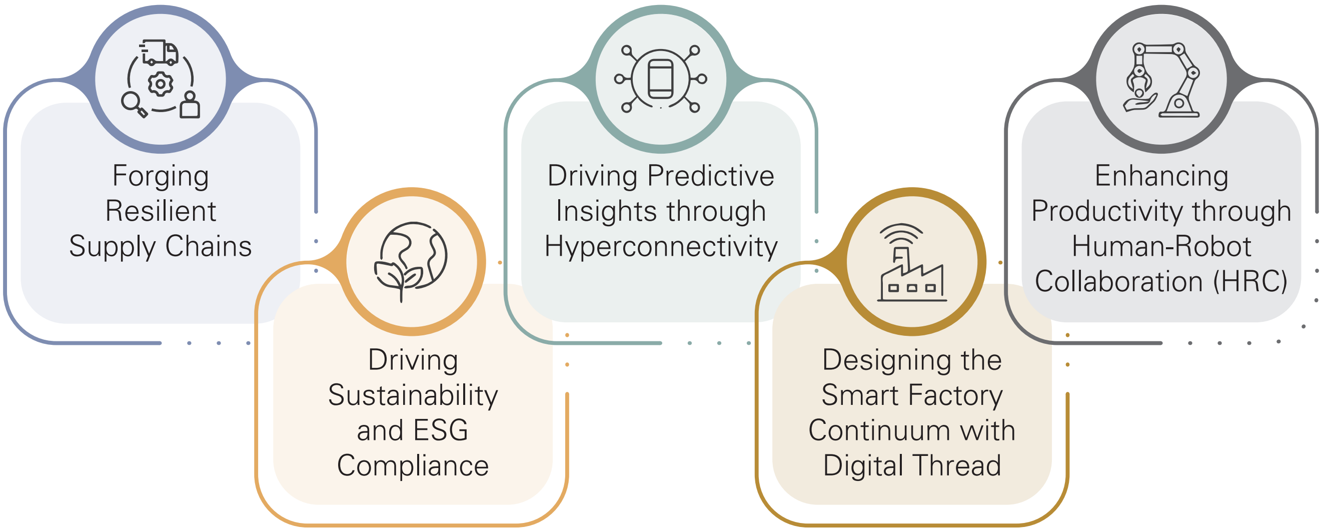
As the industrial landscape continuously evolves, the urgency for manufacturers to embrace Industry 4.0 cannot be overstated. It is a transformation that goes beyond mere technological adoption; it entails a comprehensive reimagining of manufacturing operations. Industry 4.0 promises unparalleled efficiency, agility, and customer-centricity. However, the window for gaining a competitive advantage is closing as more manufacturers shift towards smarter factory operations. Manufacturers who hesitate to embrace this digital revolution risk falling behind, losing market share to more agile, innovative, and technologically advanced competitors.

## Digital Maturity as a Critical Metric

The transition towards Industry 4.0 should be regarded as an imperative. Digital maturity is now a critical metric of organizational health and future viability. In the pursuit of Industry 4.0, data becomes a valuable currency, and connectivity serves as a foundational element of manufacturing strategy. By harnessing the power of the Industrial Internet of Things (IIoT), Artificial Intelligence (AI), and Machine Learning, manufacturers can predict trends, optimize operations, and personalize customer experiences in real-time. Manufacturers who invest in these technologies today will define the industrial standards of tomorrow, securing their place at the forefront of their sector.

# Globally Trending Themes Driving Advanced Technology Adoption

**Industry 4.0 initiatives transforming challenges into opportunities for manufacturing excellence**




**Increased adoption of I4.0 technologies to remain competitive, resilient and meet ESG goals**

## Forging Resilient Supply Chains

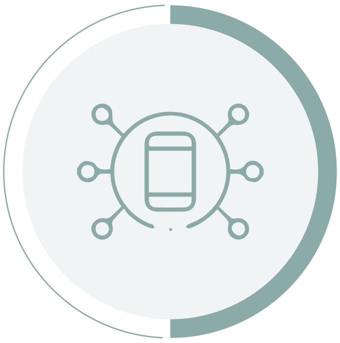
In response to supply chain vulnerabilities, companies are focusing on resilience and risk mitigation. A core component of this shift is reshoring their manufacturing and heightened adoption of Industry 4.0 technologies. As businesses bring production closer to home, automation ensures they remain competitive and resilient in a fast-evolving industrial landscape.

## Driving Sustainability and ESG Compliance

A more prominent global and active interest in the area of sustainability has manufacturers, leaders and investors looking towards innovative solutions for addressing and embedding ethical and sustainable practices in operations. Leveraging advanced Industry 4.0 technologies has enabled manufacturers to attain and, in some cases, exceed sustainability-related targets aligned with ESG (Environmental, Social, and Governance) goals.

# Globally Trending Themes Driving Advanced Technology Adoption

**Hyperconnected systems using AI enhance real-time process optimization through predictive insights**



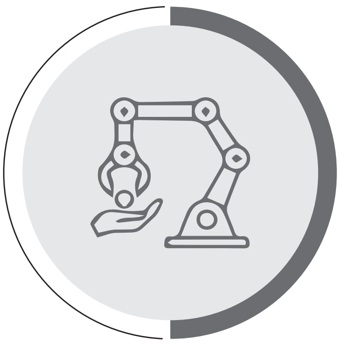
## Driving Predictive Insights through Hyperconnectivity

The time-driven, tightly coupled ISA 95 pyramid is now being disrupted with the introduction of powerful computing at the edge, leading to hyperconnected networks and making data seamlessly available. Through AI, data from hyperconnected systems is utilized in real-time, thus optimization processes, predicting maintenance needs, and enhancing product quality.

## Designing the Smart Factory Continuum with Digital Thread

The digital thread is driven by vertical integration of systems, encompassing the entire process from product design to the relevant planning in the ERP and subsequent execution of production orders led by interconnected systems. Furthermore, horizontal integration with suppliers and customers establishes end-to-end visibility across the value chain, creating truly connected operations.

**Robots co-working with humans in a shared workspace accelerate efficiency and productivity**

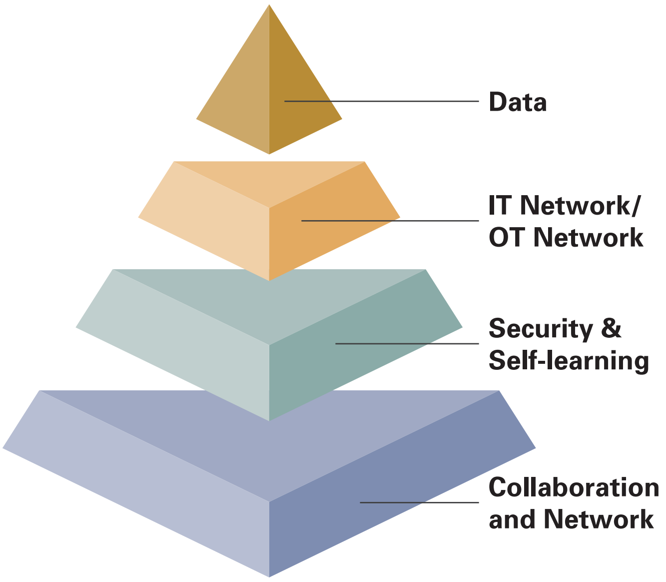


## Enhancing Productivity through Human-Robot Collaboration (HRC)

HRC is all about human and robot teamwork. Robots work alongside humans in lifting heavy weights or delivering feeder material, sharing information and aiding decision-making. They increasingly complement humans in a shared workspace, accelerating productivity, safety and efficiency.

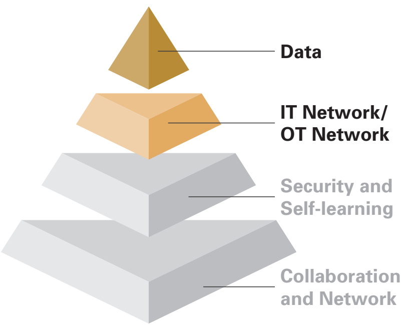
# Technology Adoption Framework

The framework showcases the natural progression towards unlocking true value from technology, starting with the foundational blocks and moving towards more advanced technologies (and the combination thereof).



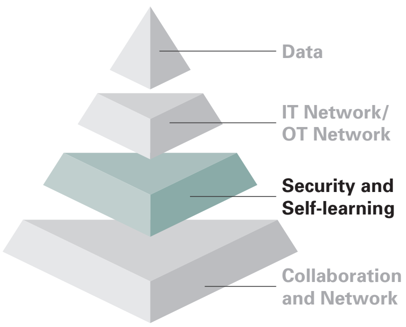

Technology adoption typically follows a chronological approach*. Initially, foundational technologies are required, which subsequently enable the use of further and more advanced technologies.

- The potential for unlocking true value from Industry 4.0 arises where there is a higher maturity of baseline data across shopfloor operations and enterprise applications
- Secure access, interoperability and the flow of this data are imperative for adjacent and offsite systems to analyze and interpret, allowing an intelligence layer to be applied
- At the same time, some advanced technologies can be directly leveraged to augment and enhance operations in various elements of operations (i.e., robotics)



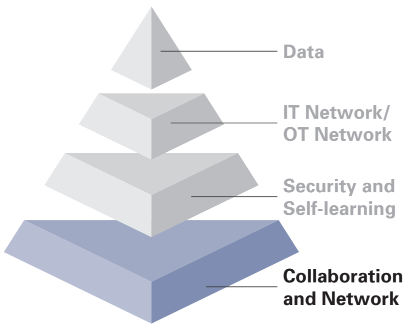

### Data and Network at the Core

- Ensures automated, authentic, high-quality data collection through IIoT or virtualized hardware controls at the source
- Provides low-latency computation capability at the edge as well as highly scalable, reliance, and remote access to the cloud




### Secure and Self Learning

- Enables advanced analytics and persona-based insights through data-driven models once the data has been formalized
- Paves the way for adaptive systems enabled by simulations and autonomous learning through the power of predictions, while ensuring secure operations through best-in-class cybersecurity measures



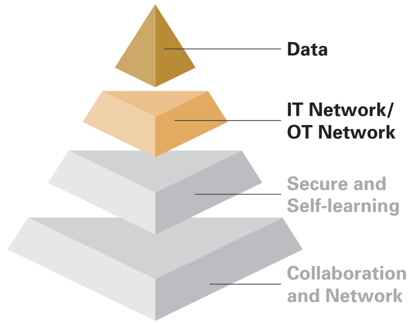

### Collaboration and Network

- Bridges the divide between human and technology, enabling collaboration through digital assistants, augmented or virtual reality, as well as through robots and co-bots, aiding operations-intensive industries
- Ties the horizontal integration of suppliers, customers and real-world scenarios into an operational excellence-oriented agile network

*Not all technologies require foundational technologies to be in place, especially with the advent of advanced technologies such as additive manufacturing

# Technologies Driving Digital Transformation

**Automated data collection, analyzed and transformed at the edge with cloud driving low-latent, remote and high-compute outcomes**




## Hardware Virtualization

The trend towards virtual PLCs, SCADA, and HMI enables high flexibility by ensuring that the software works on any third-party standard hardware.

This reduction in dependency has the potential to substantially increase the adoption of automation, setting the stage for remote and data-driven operations.

**Impact**

- Optimizes control systems
- Optimizes CapEx
- Reduces compute
- Easier upgrades and maintenance

**CAGR*:** ~42.2 – 53.3 Bn (in AED, 2022–28) **4.2%**

## Edge Computing

It represents a distributed IT architecture, enabling data processing and analysis 'at the source' instead of at a nearby or offsite data center.

It supports increased security, low latency and efficient data control while creating opportunities for closed-loop control and AI/ML applications.

**Impact**

- Faster processing
- Better network efficiency
- Greater efficient data transmission
- Lower storage cost

**CAGR:** ~194.6 – 407.6 Bn (in AED, 2023–28) **15.7%**

## 5G Connectivity

5G networks expand broadband wireless services beyond mobile internet to IoT and critical communication through MIMO (massive input, massive output).

It aids in the utilization of technologies requiring low latency, precision, and high-speed operations, such as AGVs/AMRs and assembly line robotics automation.

**Impact**

- Increased speed
- Reduced latency in millisecond
- Aids edge processing, AR/VR and streaming services

**CAGR:** ~45.5 – 517.1 Bn (in AED, 2020–30) **27.5%**

## Industrial Cloud Computing

Cloud computing enables demand-based planning of services, such as storage servers, databases, networking, and software, over the internet.

It allows remote work and collaboration, thus helping to avoid upfront investments as well as maintenance challenges.

**Impact**

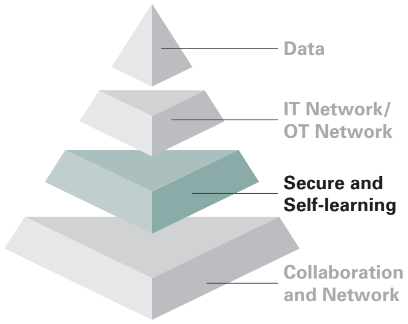
- Supports CapEx model
- Facilitates scalability and elasticity
- Provides auto updates
- Enables remote access

**CAGR:** Up to 762.4 Bn (in AED, 2023–32) **16.1%**

*CAGR refers to the compound annual growth rate

# Technologies Driving Digital Transformation

**Self-learning systems driven by artificial intelligence form the basis of predictive and autonomous operations, coupled with cyber-secure measures to ensure resilient networks**




## AI in Manufacturing

AI revolutionizes manufacturing with tailored applications across production function by ensuring the golden batch is tracked and quality issues are anticipated. It also forecasts unplanned downtime.

For sustainability, AI optimizes the use of resources, such as energy and utilities.

**Impact**

- Predictive analysis
- Process optimization
- Downtime reduction
- Scrap reduction

**CAGR:** ~ 70.4 – 457.6 Bn (in AED, 2023–28) **21.6%**

## Digital Twin

Digital twin leverages a host of sub-technologies to create a digital replica of a physical object or system, allowing for real-time monitoring and analysis through 3D visualization.

It can enable predictive maintenance and performance optimization, where tests in the virtual world reflect in the real world and vice versa.

**Impact**

- Operational efficiency
- Informed decision-making
- Predictive analysis
- Simulation and scenario testing

**CAGR:** ~23.9 – 459.1 Bn (in AED, 2021–30) **36.8%**

## Cybersecurity

Amid expanding vertical and horizontal integrations and the update paradox, prioritizing cybersecurity is crucial to safeguard operations and prevent intellectual property breaches.

Implementing secure network segmentation models, establishing defined firewalls and DMZs, and setting up monitoring and response systems are the keys to effective threat detection and resolution.

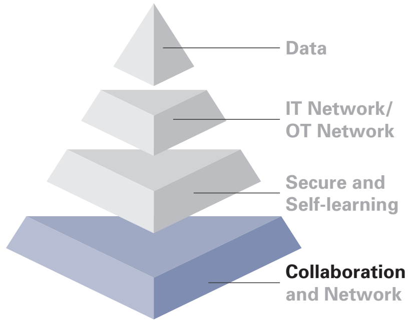
**Impact**

- Data protection
- Business continuity
- Financial losses prevention
- Reputational risk mitigation

**CAGR:** ~3,806 – 5,852 Bn (in AED, 2022 – 27) **8.9%**

# Technologies Driving Digital Transformation

**Creating immersive and collaborative workspaces that seamlessly blend physical and digital realms, fostering inclusivity in touch-free environments**




## Flexible and Modular Lines

Flexible and Modular Lines utilize robots and automated systems to perform tasks traditionally done by humans, often more efficiently and with fewer errors.

A good example of this is assembly line automation with industrial robots or collaborative robots (co-bots).

**Impact**

- Optimizes production efficiency and accuracy
- Provides quality assurance
- Prioritizes worker safety
- Ensures flexible and agile manufacturing processes

**CAGR:** ~178.1 – 524.4 Bn (in AED, 2023–32) **11.4%**

## Warehouse Intralogistics

Autonomous Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs) are both material handling systems that travel autonomously to service feeder materials or inventory through warehouses and shopfloors.

They are augmented by robotics to create seamless pick-and-place ecosystems.

**Impact**

- Ensures cost effectiveness
- Enhances productivity
- Eliminates the risk of human fatigue
- Establishes traceability and inventory status

**CAGR:** ~17.3 – 54.4 Bn (in AED, 2022–31) **12.2%**

## Augmented Reality (AR)

AR integrates digital information with the physical world, overlaying content with the user's physical surroundings.

It can be used for training and skill development through immersive experiences, guided worker instructions, and remote maintenance assistance.

**Impact**

- Enhances training efficiency
- Facilitates remote collaboration and assistance
- Improves safety measures
- Enables product visualization (virtual testing)

**CAGR:** ~50.7 – 186.9 Bn (in AED, 2022–32) **32.3%**

## Industrial Metaverse

Industrial metaverse is a collective virtual shared space formed through the convergence of physical reality and digital environments, effectively bridging the gap between individuals and transforming the way interactions and operations take place.

Moreover, it facilitates remote avatars/operators to operate machines and visualize insights without the need for physical contact.

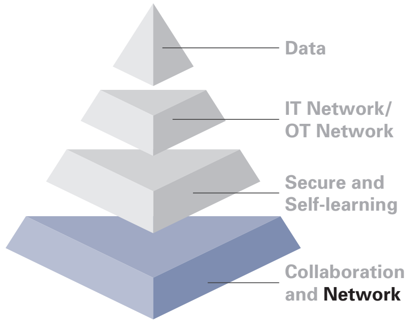
**Impact**

- Facilitates immersive collaboration and experiences
- Enables global interactions
- Empowers inclusive talent - primarily differently-abled individuals

**CAGR:** ~61.3 – 274.3 Bn (in AED, 2023–31) **17.5%**

# Technologies Driving Digital Transformation

**Extending beyond factory walls to suppliers and customer networks to drive collaborative value and expandable operational capacities**




## Additive Manufacturing

Additive manufacturing, or 3D printing, is the process of creating objects layer by layer from digital models, typically using plastic, metal, or composite materials.

It enhances vertical integration through intricate designs, waste reduction, flexibility in production, and shortening of supply chains.

**Impact**

- Rapid prototyping
- Waste minimization
- Mass customization
- Manufacturing decentralization

**CAGR:** ~61.3 – 274.3 Bn (in AED, 2023–30) **20.6%**

## IT - OT Integration

A combination of technologies, such as Robotics Process Automation, edge devices, gateways, Cloud API and Distributed IIoT applications enable IT-OT integration.

Integrating vertically from OT systems, such as PLC and SCADA, to IT systems, such as MES and ERP*, can enable real-time seamless shopfloor operations.

**Impact**

- Increases productivity
- Eliminates errors (or achieves zero errors)
- Delivers high-quality customer service
- Enhances security and compliance

**CAGR:** ~8,712 – 32,824 Bn (in AED, 2022–32) **18.0%**

## Blockchain and DLT

A blockchain is a decentralized and distributed digital ledger used to record transactions across many computers in a way that ensures trust through immutability of the data.

It is fundamentally built on principles of transparency, security, and decentralization, horizontally integrating supply chains.

**Impact**

- Enhances traceability and transparency
- Streamlines processes
- Establishes immutable value chain data trail

**CAGR:** ~30.1 – 909.7 Bn (in AED, 2022–32) **40.3%**

*ERP refers to Enterprise Resource Planning

# USE CASE CATALOGUE

Industry 4.0 Overview

Potential Market Opportunity

Sustainability Perspective

# I4.0 Use Case Features: An Amalgamation of Underlying Technology, Business Impact and ITTI Value Chain Dimension

| Advanced Technology | Business Impact | Value Chain Dimension |
|---|---|---|
| An Industry 4.0 Use Case leverages advanced technology, integration between planes (OT-IT) or intelligence applied to data and/or workflows within an organization.<br>▪ i.e., Artificial intelligence | An Industry 4.0 Use Case solves a real-world operational or enterprise-related problem, and has a tangible and measurable business impact once implemented.<br>▪ i.e., 30% reduction in operating cost | An Industry 4.0 Use Case is tagged with a specific value chain dimension (based on the ITTI Framework) to which it is typically applied.<br>▪ i.e., Production execution |

# The Digital Maturity of a Factory does not Inhibit the Implementation of Industry 4.0 Use Cases; In Fact, I4.0 Encourages Adoption Regardless

UAE Manufacturers across Sectors

| | I3.0 Use Cases in a Plant | I4.0 Use Cases in a Plant |
|---|---|---|
| **Industry 2.0 Maturity** | Integrate WMS Module<br>Condition-based Monitoring | Predictive Maintenance |
| **Industry 3.0 Maturity** | Energy Visualization Systems<br>Digital Performance Dashboard | Robotics Process Automation<br>Water Monitoring and Optimization |
| **Industry 4.0 Maturity** | Digital Work/Maintenance Instruction<br>Scada or PLC System | AR/VR Remote Maintenance Assistance<br>Automated Material Handling<br>Robotics for Assembly<br>AS/RS for Warehouse Management |

The illustration on the left depicts the variation in maturity of use cases adopted by a manufacturer, which could be categorized as either I3.0 or I4.0.

As this guide focuses on advanced technology adoption in the industry, only I4.0 Use Cases have been extracted.

Further, manufacturers belonging to any size or maturity can adopt I4.0 Use Cases.

I3.0 Use Case   I4.0 Use Case   Extracted Use Cases

# INDUSTRY 4.0 OVERVIEW

In the upcoming section, the objective is to showcase regional insights regarding the overall maturity of the manufacturing industry. This bird's-eye view represents the starting point, following which graphical representations are showcased, which subsequently drill down one level deeper, ultimately progressing from a very high level towards specific Industry 4.0 Use Cases.

The ITTI Framework has been leveraged as a baseline throughout the Guide. The Framework provides a standardized approach to highlighting key observations and insights. The Framework, as developed by the Ministry of Industry and Advanced Technology, ensures a clear understanding for manufacturing companies.

Insights pertaining to the manufacturing value chain are presented, highlighting dominant value chain elements and providing a more detailed view of the landscape. The graphic is segmented into company sizes, providing an additional view while showcasing dominant value chain areas.

Continuing with the approach, focal areas at a dimension level are highlighted, providing a more detailed understanding and direction. Additionally, focal dimensions as they appear across priority sectors are visible through a heat map, providing a cross-sector view of trends related to the focus areas.

Individual use cases that are prominent across dimensions are called out and ranked according to priority. This brings the reader's understanding down to a grass-roots level, creating a tangible link in terms of connecting focal areas and on-ground applications.

Finally, through a prioritization of use cases, we have identified the top Industry 4.0 Use Cases as seen across UAE manufacturers. The use cases have been prioritized based on several criteria, namely the frequency, impact, and average implementation time of each use case.

**The ITTI Framework has been leveraged as a baseline throughout the Use Case Guide. The Guide presents insights related to the manufacturing value chain, calls out prominent individual Use Cases and provides a cross-sector view of focus areas.**

# The ITTI Framework Encompasses all Business Functions across the Manufacturing Value Chain and is Used as the Baseline Moving Forward

**R&D and Engineering**
- Product Lifecycle Management

**Marketing and Sales**
- Marketing and Sales

**Supply Chain Management (Inbound)***
- Supply Chain Planning
- Sourcing and Procurement
- Warehouse Management
- Logistics Management

**Manufacturing/Production**
- Production Planning and Scheduling
- Production Execution
- Utilities Management
- Quality Management
- Maintenance

**Customer Service**
- Customer Care and Service

**Supply Chain Management (Outbound)***
- Supply Chain Planning
- Warehouse Management
- Logistics Management

**Enterprise Administration**
- Business Process and Intelligence
- Technology Management

**Strategy and Organization**
- I4.0 Strategy and Governance
- Digitally Fit Organization

**Sustainability**
- Sustainability Strategy and Governance
- Material Circularity
- Water and Wastewater Management
- Emissions Management

Value Chain Element | ITTI Dimension

*Supply Chain Management Inbound and Outbound have been combined for reporting purposes

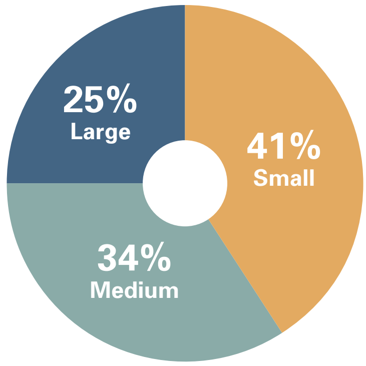
# UAE Manufacturing Sector | An Overview by Numbers

**280**
Total number of reports reviewed*

**~32%**
Manufacturers with I4.0 Use Cases currently implemented

**1,530+**
Number of Use Cases extracted

## Manufacturer Size




## Manufacturing Types Assessed

**70%** Process Manufacturing

**30%** Discrete Manufacturing

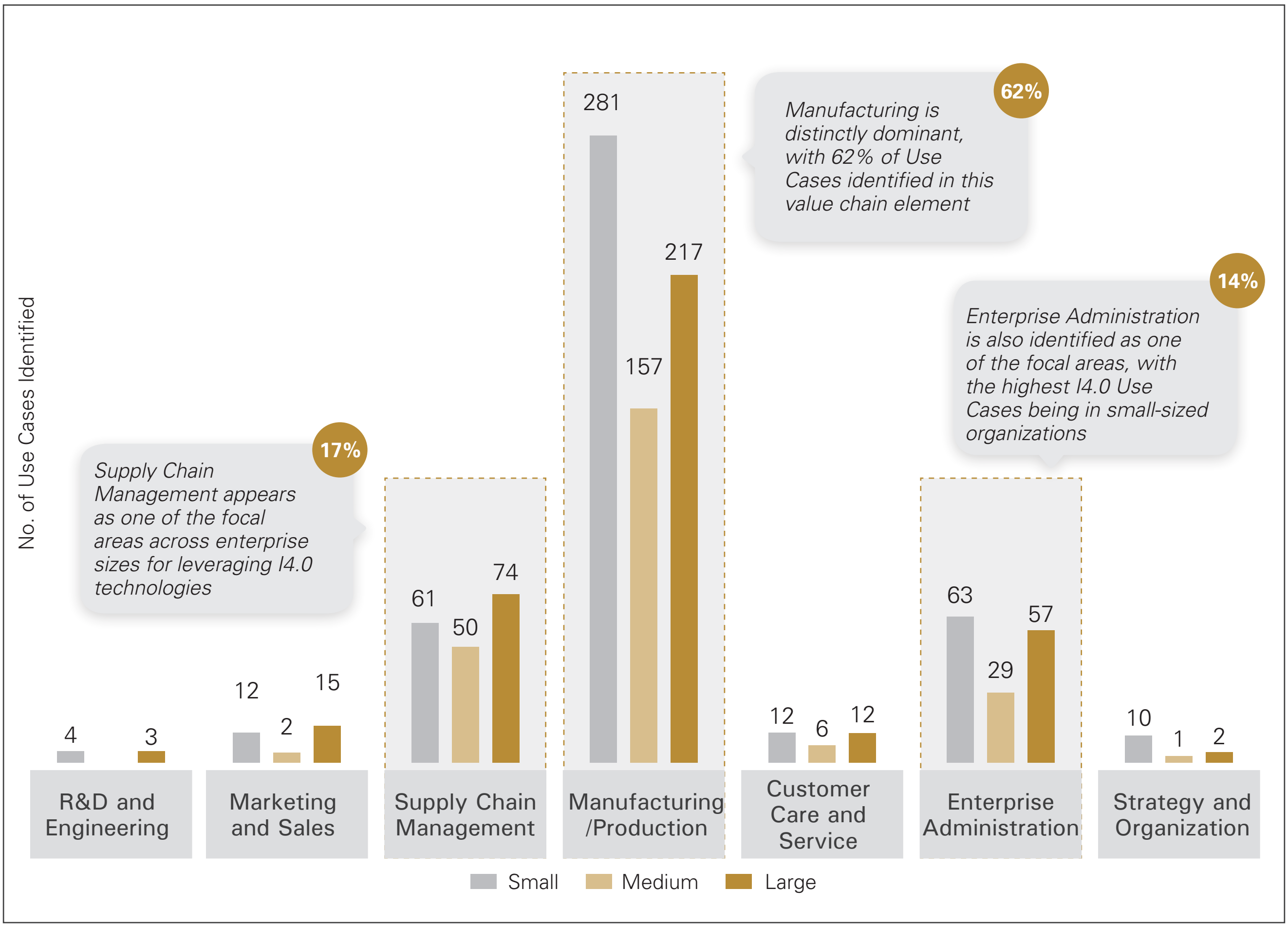
## Reports Assessed by Sector (%)

| | |
|---|---|
| Food and Beverage | 18 |
| Heavy Industries | 20 |
| Pharmaceuticals | 6 |
| Electrical Equipment and Electronics | 5 |
| Petrochem and Chemical Products | 13 |
| Rubber and Plastics | 7 |
| Machinery and Equipment | 11 |
| Others** | 20 |

*Refer to appendix for details on ITTI and the detailed framework

** Others comprise Building Materials and Paper

# ~93% of Use Cases Appear within Production, Supply Chain Management and Enterprise Administration Dimensions




## Key Insights

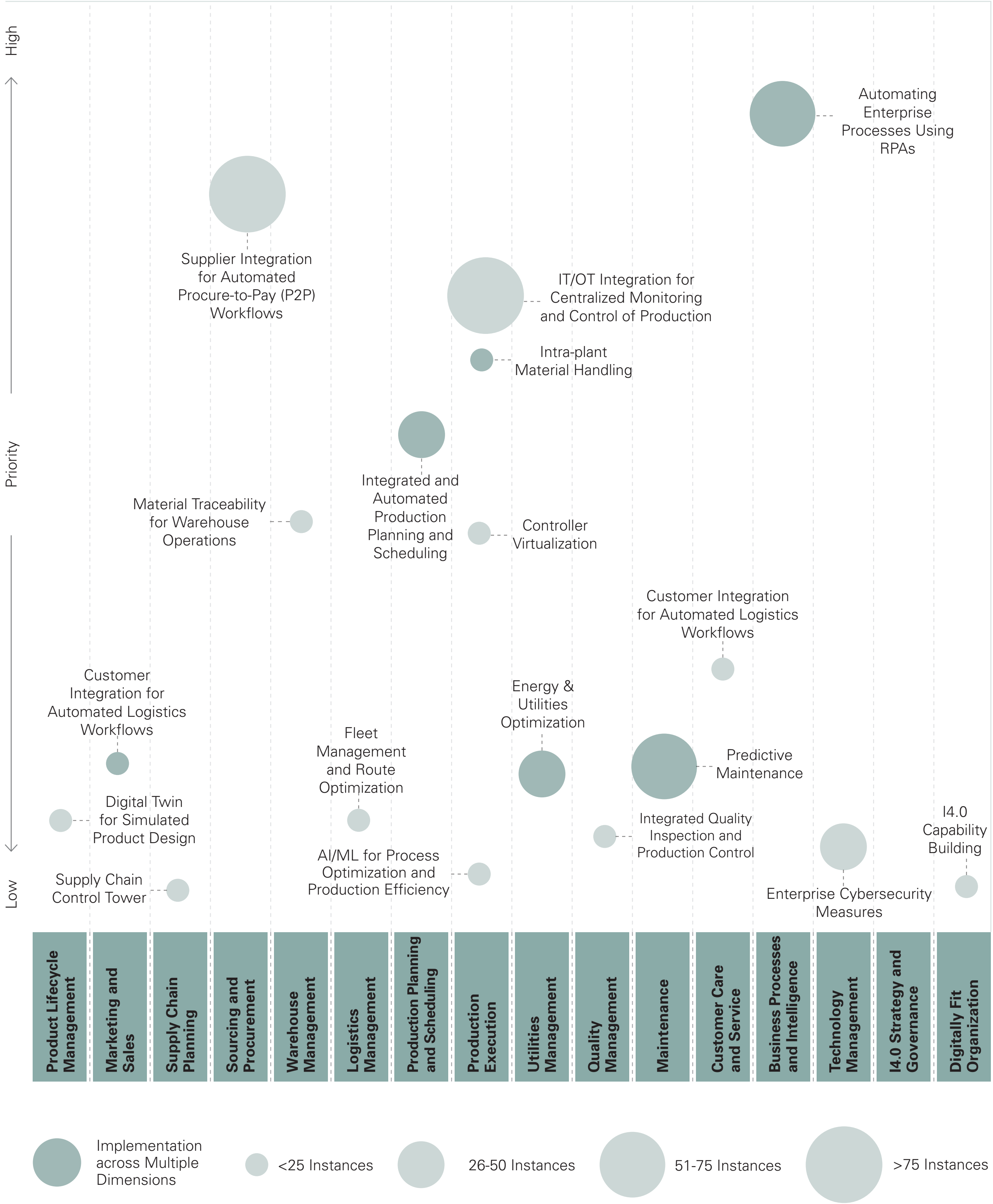
| | |
|---|---|
| **Manufacturing/ Production** | ▪ The area of manufacturing/production appears as the dominant domain, reflective of the intrinsic connection between Industry 4.0 technologies within this element of the value chain<br>▪ This is also indicative of the focus of manufacturing organizations from a transformation perspective |
| **Supply Chain Management** | ▪ Close to 17% of use cases are focused towards SCM, indicating the importance and benefit of optimizing supply chains, especially for more expansive operations across both medium and large organizations |
| **Enterprise Administration** | ▪ The advent of Industry 4.0 Use Cases across EA is evident as organizations focus on optimizing administrative tasks. They are potentially realizing long-term benefits through the use of AI-driven analytics, and horizontally interconnected and interoperable systems<br>▪ From a small enterprise perspective, these companies may also benefit from quick-win opportunities, such as RPA, where the requisites are not as challenging |
| **Other Domains** | ▪ The low count of identified use cases suggests a lack of focus in these areas across enterprise sizes<br>▪ While the I4.0 Use Cases still exist, from a manufacturing perspective in the UAE, they are of a lower priority in other domains |

# The Dominant Dimensions as seen above are Consistent across Sectors, while Sector-Specific Emphasis can be Identified as well

| ITTI Value Chain Dimension | | Instances | Food and Beverage | Heavy Industries | Pharmaceuticals | Electrical Equipment and Electronics | Petrochem and Chemical Products | Rubber and Plastics | Machinery and Equipment | Building Materials | Paper |
|---|---|---|---|---|---|---|---|---|---|---|---|
| R&D | Product Lifecycle Management | 1% | Not Present | Not Present | Not Present | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present |
| Marketing and Sales | Marketing and Sales | 3% | Not Present | Not Present | Not Present | Not Present | Not Present | Several Instances | Not Present | Not Present | Not Present |
| Supply Chain Planning | Supply Chain Planning | 2% | Not Present | Few Instances | Not Present | Not Present | Few Instances | Few Instances | Not Present | Not Present | Not Present |
| | Sourcing and Procurement | 10% | Several Instances | Several Instances | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances |
| | Warehouse Management | 4% | Several Instances | Few Instances | Not Present | Not Present | Few Instances | Few Instances | Not Present | Not Present | Not Present |
| | Logistics Management | 2% | Several Instances | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present | Several Instances | Not Present |
| Manufacturing /Production | Production Planning and Scheduling | 5% | Few Instances | Several Instances | Not Present | Not Present | Few Instances | Few Instances | Few Instances | Not Present | Not Present |
| | Production Execution | 41% | Many Instances | Many Instances | Several Instances | Several Instances | Many Instances | Several Instances | Several Instances | Several Instances | Several Instances |
| | Utilities Management | 5% | Few Instances | Few Instances | Few Instances | Not Present | Several Instances | Few Instances | Few Instances | Few Instances | Not Present |
| | Quality Management | 3% | Few Instances | Not Present | Not Present | Not Present | Few Instances | Few Instances | Not Present | Few Instances | Few Instances |
| | Maintenance | 8% | Several Instances | Several Instances | Few Instances | Not Present | Several Instances | Few Instances | Few Instances | Not Present | Few Instances |
| Customer Care | Customer Care and Service | 3% | Few Instances | Not Present | Not Present | Not Present | Several Instances | Not Present | Not Present | Few Instances | Not Present |
| Enterprise Administration | Business Processes and Intelligence | 8% | Few Instances | Several Instances | Not Present | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances |
| | Technology Management | 6% | Several Instances | Several Instances | Not Present | Few Instances | Several Instances | Few Instances | Few Instances | Not Present | Not Present |
| Strategy and Organization | Digitally Fit Organization | 1% | Few Instances | Not Present | Not Present | Not Present | Few Instances | Few Instances | Not Present | Not Present | Not Present |

Not Present Few Instances (>2) Several Instances (>10) Many Instances (>50)

# The Figure below Showcases a Prioritized List of Use Cases Identified across the ITTI dimensions



# Top Industry 4.0 Use Cases have been Prioritized Based on Frequency of Implementation, Time to Deploy, Potential Benefits, and Resulting Impacts

## List of Prioritized Use Cases

- **Automating Enterprise Processes Using RPAs** ◇
- **Supplier Integration for Automated Procure-to-Pay (P2P) Workflows** ◇
- **IT/OT Integration for Centralized Monitoring and Control of Production** ◇
- **Intra-Plant Material Handling**
- **Integrated and Automated Production Planning and Scheduling** ◇
- **Material Traceability for Warehouse Operations**
- **Controller Virtualization**
- **Customer Integration for Automated Logistics Workflows**
- **AI/ML for Process Optimization and Production Efficiency**
- **Predictive Maintenance** ◇

◇ Prioritized Use Case as seen across sectors

## Key Insights

### Automating Enterprise Processes Using RPAs

- RPA is the dominant use case which is widely identified across dimensions of sourcing and procurement as well as Business Process and Intelligence (BP&I)
- From a technological perspective, RPA is often recommended due to its relatively low barriers for adoption, its ability to handle repetitive tasks more efficiently than humans, and its potential for cost savings and faster task completion

### Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

- Traditionally, manufacturing companies have focused on vertically integrating their operational systems to optimize processes
- However, horizontal integration creates digitized end-to-end and real-time visibility across the entire network, including suppliers, manufacturers, and business partners

### IT/OT Integration for Centralized Monitoring and Control of Production

- Connecting shopfloor machinery to enterprise systems and enabling the seamless transfer and interoperability of data between systems creates an immense opportunity to enhance and improve multiple facets of the manufacturing value chain

### Intra-Plant Material Handling

- Implementing autonomous transport robots for intra-plant material handling can greatly increase operational efficiency by ensuring consistent and timely movement of materials, reducing the reliance on manual labor, and minimizing the risk of human error, thus leading to a smoother and more reliable workflow

### Integrated and Automated Production Planning and Scheduling

- The high-variant nature of production can lead to frequent changes, making manual scheduling inflexible and prone to errors. An integrated and automated production planning and scheduling system swiftly adapts to changes, ensuring optimal equipment and resource allocation for each variant

# POTENTIAL MARKET OPPORTUNITY

## Overall Potential Market Opportunity for Investment in Technology (in AED)

**~170 Mn** — On-ground market opportunity for investment in technology*

**~1.5 Bn** — Forecasted market opportunity for investment in technology

## Potential Market Opportunity by Top Use Cases (in AED)

**270 Mn** — Automating Enterprise Processes Using RPAs

**155 Mn** — IT/OT Integration for Centralized Monitoring and Control

**530 Mn** — Predictive Maintenance for Shopfloor Machinery

**160 Mn** — Digital Twin

Top opportunities potentially across predictive maintenance and RPAs


*Based on assessed companies

# Identified Industry 4.0 Use Cases Suggest a Potential Market Opportunity of Around 1.5 Bn AED across Sectors for Advanced Technology Implementation

**Implementation of predictive maintenance for shopfloor machinery has a huge potential opportunity across all sectors, based on on-ground implementation**

| Top Use Cases | Food and Beverage | Heavy Industries | Pharmaceuticals | Electrical Equipment and Electronics | Petrochem and Chemical Products | Rubber and Plastics | Machinery and Equipment | Building Materials | Paper |
|---|---|---|---|---|---|---|---|---|---|
| Automating Enterprise Processes Using RPAs | >20 Mn AED | >20 Mn AED | 0 Mn AED | 5-20 Mn AED | >20 Mn AED | >20 Mn AED | >20 Mn AED | 5-20 Mn AED | 5-20 Mn AED |
| Supplier/Customer Integration for Automated Workflows | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED |
| IT/OT Integration for Centralized Monitoring and Control | >20 Mn AED | >20 Mn AED | 5-20 Mn AED | 5-20 Mn AED | >20 Mn AED | 5-20 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED |
| Intra-Plant Material Handling | 5-20 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED |
| Integrated and Automated Production Planning and Scheduling | 5-20 Mn AED | >20 Mn AED | <5 Mn AED | <5 Mn AED | 5-20 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED |
| Material Traceability for Warehouse Operations | <5 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED | 0 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED |
| Controller Virtualization | 0 Mn AED | <5 Mn AED | 0 Mn AED | <5 Mn AED | <5 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED |
| Customer Integration for Automated Logistics Workflow | 5-20 Mn AED | 0 Mn AED | 5-20 Mn AED | 0 Mn AED | 0 Mn AED | 5-20 Mn AED | <5 Mn AED | 5-20 Mn AED | <5 Mn AED |
| AI/ML for Process Optimization and Production Efficiency | <5 Mn AED | >20 Mn AED | 0 Mn AED | 0 Mn AED | 0 Mn AED | 5-20 Mn AED | 0 Mn AED | 0 Mn AED | 5-20 Mn AED |
| Predictive Maintenance for Shopfloor Machinery | >20 Mn AED | >20 Mn AED | >20 Mn AED | <5 Mn AED | >20 Mn AED | >20 Mn AED | >20 Mn AED | >20 Mn AED | >20 Mn AED |
| Integrated Quality Inspection and Production Control | <5 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED | 0 Mn AED | 0 Mn AED | <5 Mn AED |
| Digital Twin | >20 Mn AED | >20 Mn AED | 0 Mn AED | 0 Mn AED | >20 Mn AED | 5-20 Mn AED | 0 Mn AED | 5-20 Mn AED | <5 Mn AED |

0 Mn AED   <5 Mn AED   5-20 Mn AED   >20 Mn AED

# SUSTAINABILITY PERSPECTIVE

## Reading Guide

Sustainability-focused initiatives have been analyzed separately. The ITTI Use Case Guide has a focus on both Industry 4.0 adoption as well as sustainability best practices. However, the criteria for evaluating a use case against Industry 4.0 principles would eliminate Sustainability-focused initiatives that are still prevalent in manufacturing operations across sectors.

Sustainability initiatives, such as sustainable sourcing of raw materials, have been considered, even though they do not encompass the required elements typical of an Industry 4.0 Use Case.

The presence of Industry 4.0 technology, coupled with a sustainability initiative, presents a powerful opportunity to create a compounding effect on the impact related to sustainability.

Furthermore, sustainability has been assessed according to three overarching domains (as recognized in the ITTI Assessment Framework). The domains are as follows:

### Water and Wastewater Management

Water and wastewater management pertains to optimizing water utilization in production processes, treating industrial wastewater, and ensuring sustainable water reuse within the facility.

### Material Circularity

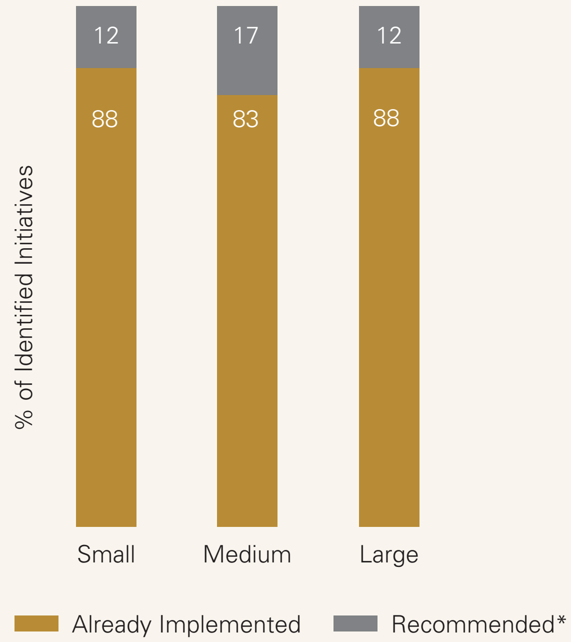
Material circularity in manufacturing refers to the continuous reusing and recycling of materials, minimizing waste, and maximizing resource efficiency.

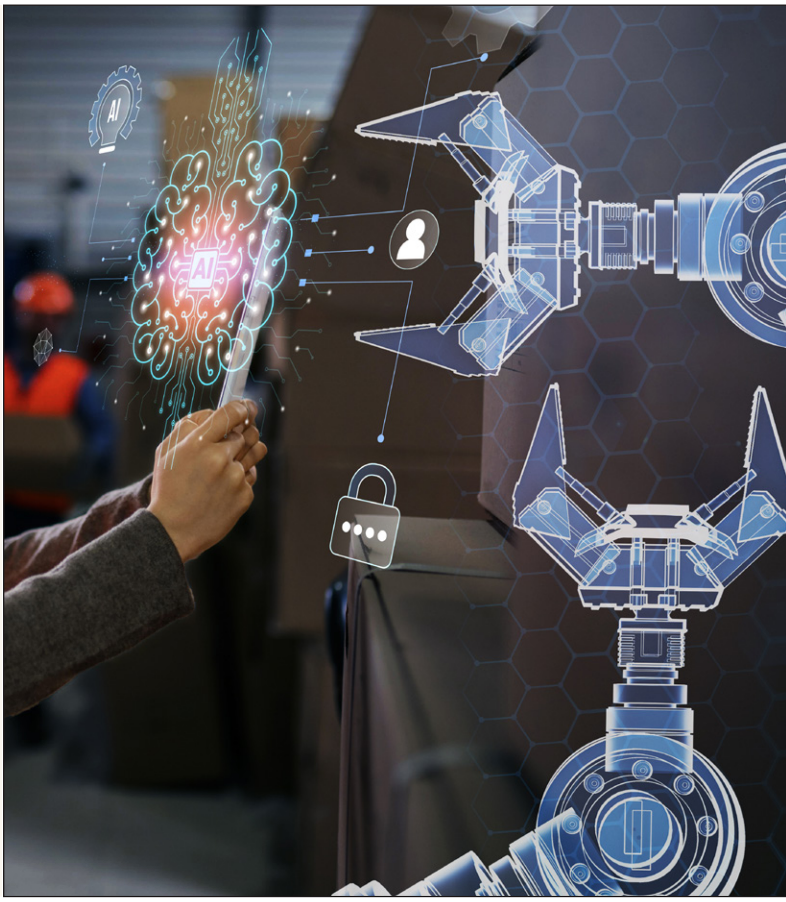
### Emissions Management

Emissions management in manufacturing entails monitoring, controlling, and reducing the release of pollutants to minimize environmental impact.

# On an Average, 92% of Assessed Companies have Implemented ~5 Initiatives across the Three ITTI Dimensions of Sustainability

## Sustainability Initiatives against Company Size



## Key Insights

| | |
|---|---|
| **Sustainability Initiatives in Manufacturing Companies** | ■ Manufacturing companies in the UAE showcase an inherent consciousness towards sustainability, with initiatives spanning domains of material circularity, water and wastewater management, as well as emissions management |
| **Proactive Implementation of Sustainable Operations** | ■ Incorporating sustainability-related initiatives, regardless of company size, is predominantly seen as already being implemented. These initiatives range from simple practices such as waste segmentation and recycling to more advanced measures, such as the installation of onsite effluent treatment plants for wastewater reclamation and reuse |
| **Regulatory Impetus behind Sustainable Initiatives** | ■ Engaging with these initiatives is likely driven by local regulations and industry-mandated requirements, such as complying with local regulations on wastewater treatment or waste recovery and reuse |

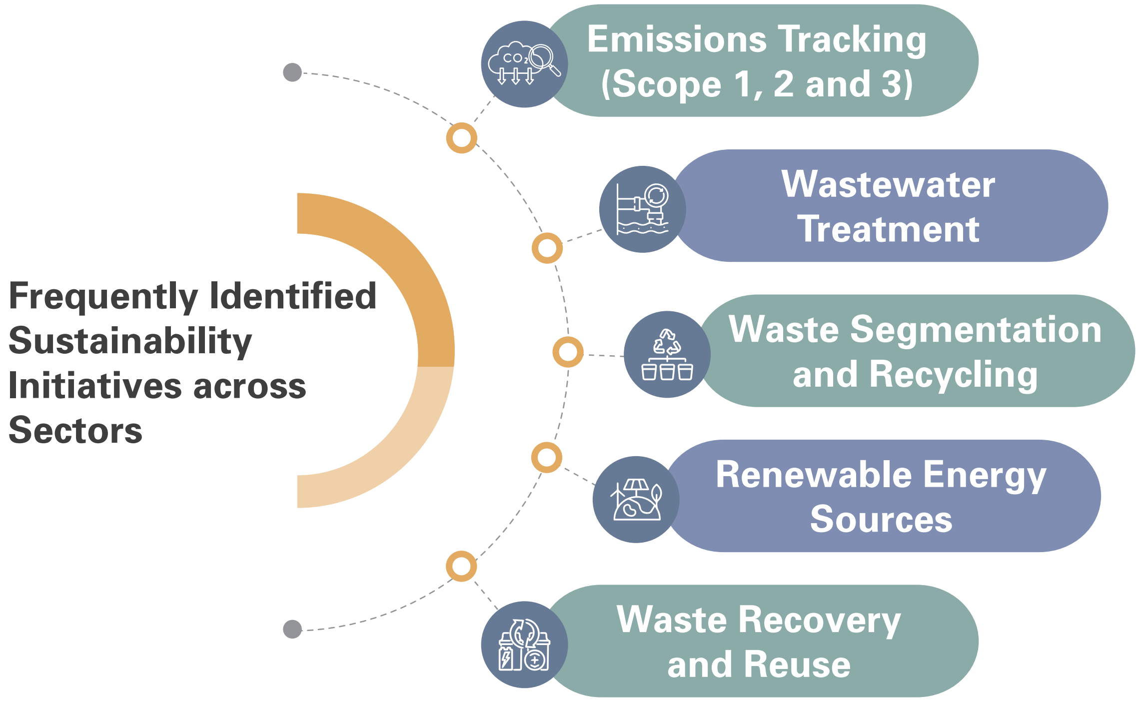
*Recommended here refers to recommendations based on ITTI assessments

# Emissions Tracking is one of the Dominant Focus Areas across Sectors

| | Sustainability Initiatives | Instances (%) | Food and Beverage | Heavy Industries | Pharmaceuticals | Petrochem and Chemical Products | Rubber and Plastics | Machinery and Equipment | Building Materials | Paper |
|---|---|---|---|---|---|---|---|---|---|---|
| Water and Wastewater Management | Wastewater Treatment | 12% | Several Instances | Many Instances | Few Instances | Several Instances | Few Instances | Few Instances | Few Instances | Few Instances |
| | Effluent Treatment Plant | 5% | Few Instances | Few Instances | Few Instances | Few Instances | Few Instances | Not Present | Few Instances | Few Instances |
| | Water Monitoring and Tracking | 3% | Not Present | Few Instances | Few Instances | Few Instances | Few Instances | Not Present | Few Instances | Not Present |
| Material Circularity | Sustainable Product Design | 4% | Few Instances | Several Instances | Few Instances | Few Instances | Few Instances | Not Present | Not Present | Not Present |
| | Sustainable Sourcing of Raw Materials | 6% | Several Instances | Few Instances | Few Instances | Few Instances | Not Present | Few Instances | Few Instances | Few Instances |
| | Waste Recovery and Reuse (ZLD) | 9% | Not Present | Several Instances | Not Present | Few Instances | Few Instances | Few Instances | Not Present | Not Present |
| | Sustainable Production Execution | 1% | Few Instances | Few Instances | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present |
| | Waste Segmentation and Recycling | 12% | Several Instances | Several Instances | Few Instances | Few Instances | Few Instances | Few Instances | Not Present | Few Instances |
| | Waste Management and Reduction | 4% | Few Instances | Several Instances | Not Present | Few Instances | Few Instances | Few Instances | Few Instances | Not Present |
| Emissions Management | Renewable Energy Sources | 10% | Several Instances | Several Instances | Few Instances | Several Instances | Few Instances | Few Instances | Few Instances | Not Present |
| | Waste Heat Recovery System | 3% | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present | Few Instances | Not Present |
| | Emissions Tracking (Scope 1, 2 and 3) | 22% | Many Instances | Several Instances | Several Instances | Many Instances | Not Present | Few Instances | Several Instances | Few Instances |
| | Emissions and Energy Management Platform | 1% | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present | Not Present | Not Present |
| | Emission Recovery Systems | 2% | Not Present | Not Present | Few Instances | Few Instances | Few Instances | Not Present | Not Present | Not Present |
| | Offset through Carbon Credits | 1% | Not Present | Not Present | Not Present | Not Present | Few Instances | Not Present | Not Present | Not Present |
| | Energy-Efficient Operations | 2% | Few Instances | Few Instances | Few Instances | Few Instances | Not Present | Few Instances | Not Present | Not Present |
| | Utilization of Alternative Energy Sources | 2% | Few Instances | Not Present | Not Present | Few Instances | Not Present | Not Present | Few Instances | Not Present |

Not Present   Few Instances (>1)   Several Instances (>5)   Many Instances (>10)

# Furthermore, Top Initiatives are seen to Target Reductions in Energy Usage, Fresh Water Consumption, and Raw Material Management and Recycling




## Key Insights

| | |
|---|---|
| **Emissions Tracking (Scope 1, 2 and 3)** | ■ Establishing a baseline for Scope 1 and 2 emissions is crucial for manufacturers aiming to cut their overall emissions and achieve net-zero targets<br>■ Monitoring these emissions through external audits, often prompted by local regulatory mandates<br>■ Additionally, manufacturers are increasingly requiring their suppliers to disclose environmental impacts, enhancing Scope 3 emissions visibility |
| **Wastewater Treatment** | ■ Prioritizing internal water management, wastewater treatment has become a top priority, with a strong focus on reuse within operations and across ancillary activities, such as cooling, irrigation, and cleaning, among others |
| **Waste Segmentation and Recycling** | ■ Fostering material circularity, this initiative is instrumental in diminishing the environmental footprint of manufacturing operations |
| **Renewable Energy Sources** | ■ Initiating the adoption of renewable energy, especially solar, is recommended to alleviate the power demands of manufacturing plants<br>■ Implementing this transition to renewables supports energy independence and sustainability goals |
| **Waste Recovery and Reuse** | ■ Emphasizing waste recovery and reuse is advised to enhance waste segmentation efforts; by repurposing process waste as raw material for the plant, this initiative promotes a closed-loop system, minimizing waste and maximizing resource efficiency |

# SECTOR DEEP DIVE

- Food and Beverage
- Heavy Industries
- Pharmaceuticals
- Electrical Equipment and Electronics
- Petrochem and Chemical Products
- Rubber and Plastics
- Machinery and Equipment
- Others (Building Materials and Paper)

# Sector Focus | Foreword and Reading Guide

The sector-specific deep dives aim to provide the reader with insights into I4.0 Use Case adoptions and sustainability initiatives as seen alongside their manufacturing peers in the UAE. Through the regional overviews provided earlier, we identified the top use cases that are agnostically beneficial and capable of providing high value for manufacturers.

However, with a sector lens applied, the top use cases identified through the prioritization effort are provided for each sector. Further, an additional list of Industry 4.0 Use Cases has been selected based on the specific nuances (business imperatives) for that particular sector. These Industry 4.0 Use Cases are further detailed for the reader to gain a deeper understanding. Moreover, the additional recommended use cases align with globally identified recommendations for each sector.

To conclude, from an Industry 4.0 perspective, a case study is presented to solidify the benefits associated with manufacturing companies that have successfully implemented and scaled Industry 4.0 Use Cases within their manufacturing and enterprise operations.

Separately, the sustainability initiatives for each sector are subsequently highlighted to show focal areas. These are evaluated across the dimensions of water and wastewater management, material circularity, and emissions management. Any initiatives within these domains have been directly called out to provide a reader with a deeper understanding.

To provide the reader with an additional perspective, a list of recommended sustainability use cases powered by Industry 4.0 technologies and globally recognized from an impact perspective has been outlined. These comprise a mix of sustainability-led and I4.0-powered Use Cases aligned with sector-specific challenges related to a direct impact on one of the three sustainability domains.

**This section provides insights into I4.0 Use Case adoptions and sustainability initiatives, sector-specific top and prioritized Use Cases, and relevant case studies to solidify the associated benefits**

## Overview by Sector

Food and Beverage

Heavy Industries

Pharmaceuticals

Electrical Equipment and Electronics

Petrochem and Chemical Products

Rubber and Plastics

Machinery and Equipment

Others*

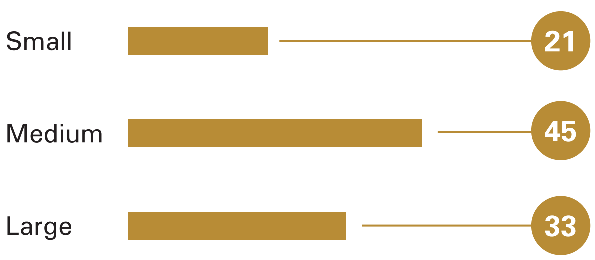
*Others comprise Building Materials and Paper

Sector Focus

# FOOD AND BEVERAGE

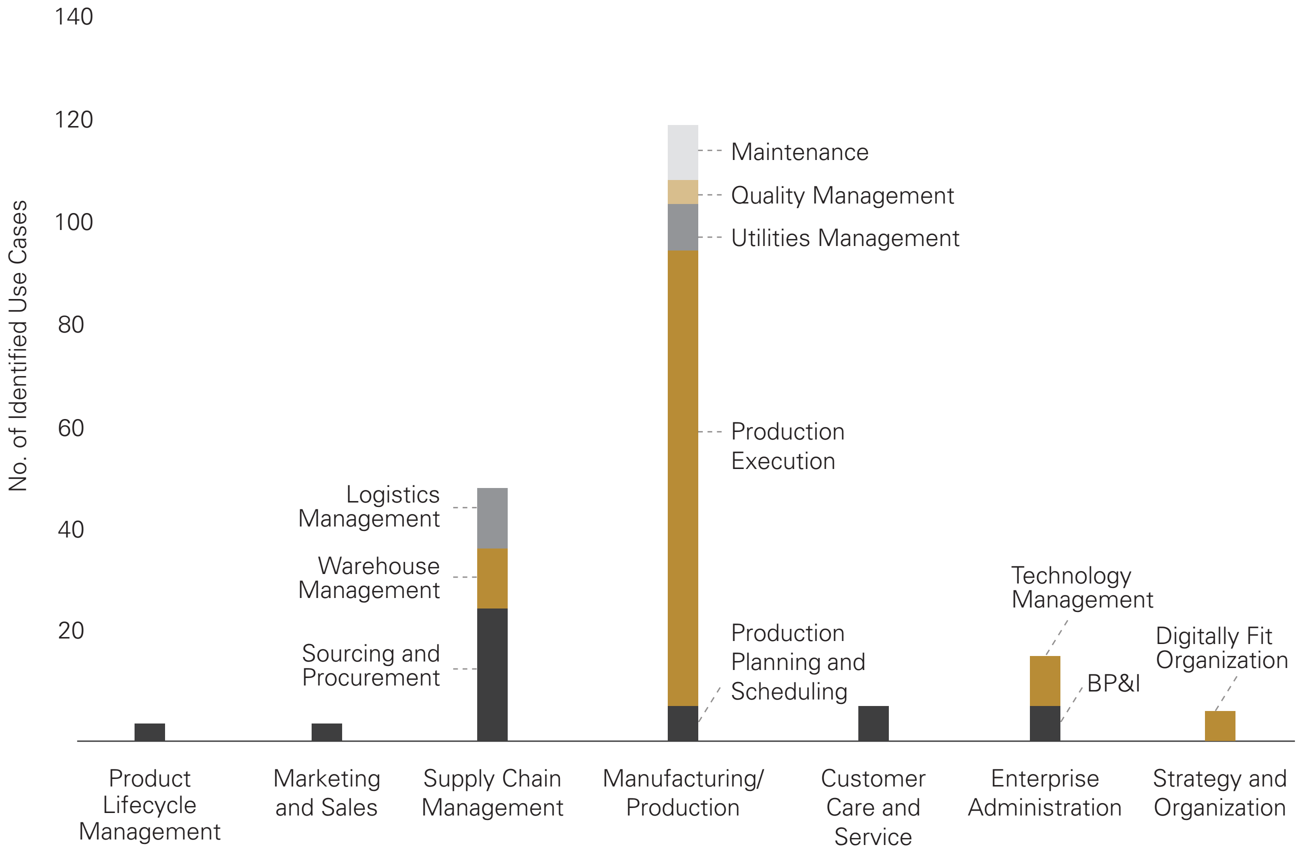
## Overview

### Manufacturer Size Distribution (%)*




F&B sector comprises 36% of manufacturers with I4.0 Use Cases implemented with a potential of 87% implementation in the near future

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the F&B sector mostly comprises small and medium-sized companies
- Use Cases revealed are skewed towards production execution, sourcing and procurement, and logistics and warehouse management

*Figures presented are approximate and rounded to the nearest numbers.

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1. Automating Enterprise Processes Using RPAs
2. IT/OT Integration for Centralized Monitoring and Control of Production
3. Supplier Integration for Automated Procure-to-Pay (P2P) Workflows
4. Intra-Plant Material Handling
5. Predictive Maintenance
6. Integrated and Automated Production Planning and Scheduling
7. Energy and Utility Optimization
8. Customer Integration for Automated Logistics Workflows
9. Automated Material Handling for EoL Activities
10. Fleet Management and Route Optimization

### Top 3 Prioritized Use Cases

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics
- Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

**IT/OT Integration for Centralized Monitoring and Control of Production**

- F&B manufacturing is often characterized by complex processes, diverse equipment, and a pressing need for precision and quality
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- In the F&B industry, it is essential to address the complexities of vast supply chains, ensuring timely procurement and reducing operational inefficiencies
- Allowing the company to swiftly adapt to dynamic market conditions and regulatory demands, safeguarding production continuity and compliance

### Additional Recommended Use Cases

**Predictive Maintenance for Shopfloor Machinery**

- It is imperative to ensure that continuous line operations of critical shopfloor machinery (as well as supporting utilities) are not hindered due to unexpected downtime due to mechanical fault
- Predictive maintenance of such machinery can ensure long term resilience

**Customer Integration for Automated Logistics Workflows**

- By integrating logistics workflows with customer systems, manufacturers can offer real-time order tracking, accurate delivery estimates, and swift responses to changes in order or delivery preferences
- This ultimately results in enhanced customer experiences

# Details on the Prioritized Industry 4.0 Use Cases

## 1 PREDICTIVE MAINTENANCE

**I4.0 Technologies**

Industrial IoT, Predictive Analytics

**Value Chain**

Maintenance

**Impact**

Operating Cost ↓ 18-25%

**Realized Benefits**

- Proactively predicts maintenance needs for assets before reaching complete failure, eliminating the need for manual sensory methods, such as agitators, chillers, and pulverizers
- Reduces unplanned downtime of critical machines, such as Yankee dryers
- Helps identify the optimal repair or replacement through Remaining Useful Life (RUL) prediction

**Pre-requisites for Success**

- Quality data availability is 4-12 months, depending on use case
- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

## 2 IT/OT INTEGRATION FOR CENTRALIZED MONITORING AND CONTROL OF PRODUCTION

**I4.0 Technologies**

IT/OT Integration

**Value Chain**

Production Execution

**Impact**

Factory Output ↑ 10-30%

**Realized Benefits**

- Enhances visibility of shopfloor legacy assets/controllers
- Enables data availability for analytics and other performance monitoring applications, compliance and traceability
- Integrates shopfloor and top-floor systems, enabling strategic business decisions

**Pre-requisites for Success**

- Enhanced network infrastructure
- Standardized protocols for data exchange
- Skilled IT and OT teams for effective collaboration

## 3 CUSTOMER INTEGRATION FOR AUTOMATED LOGISTICS WORKFLOWS

**I4.0 Technologies**

Industrial IoT, AI/ML

**Value Chain**

Warehouse Management

**Impact**

On-Time-in-Full ↑ 20-30%

**Realized Benefits**

- Helps understand customer preferences
- Engages voice of customer during manufacturing
- Aids refill shelves based on buyer choices

**Pre-requisites for Success**

- Seamless integration with customer systems, including EDI/RPA
- Availability of transactional ERP/CRM data, especially customer buying data
- Robust training and support infrastructure for stakeholders and downstream partners

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# PepsiCo – All Things AI

## Project Overview

- Ensuring food quality, compliance and safety
- Maintaining customer-centricity
- Continuing sustainable operations
- Gearing up talent

## Transformation Journey

**Production Execution**

- Sound AI used for ensuring texture of chips
- Vision-based detection of chips weight
- AI for increasing peeling efficiency

**R&D**

- Ada – Augmented intelligence
- Horizontal integration
- Pep Worx – Cloud analytics platform
- Snack BOT – Unmanned vending bot

**Talent Readiness**

- R&D manager for AI driving on field programs

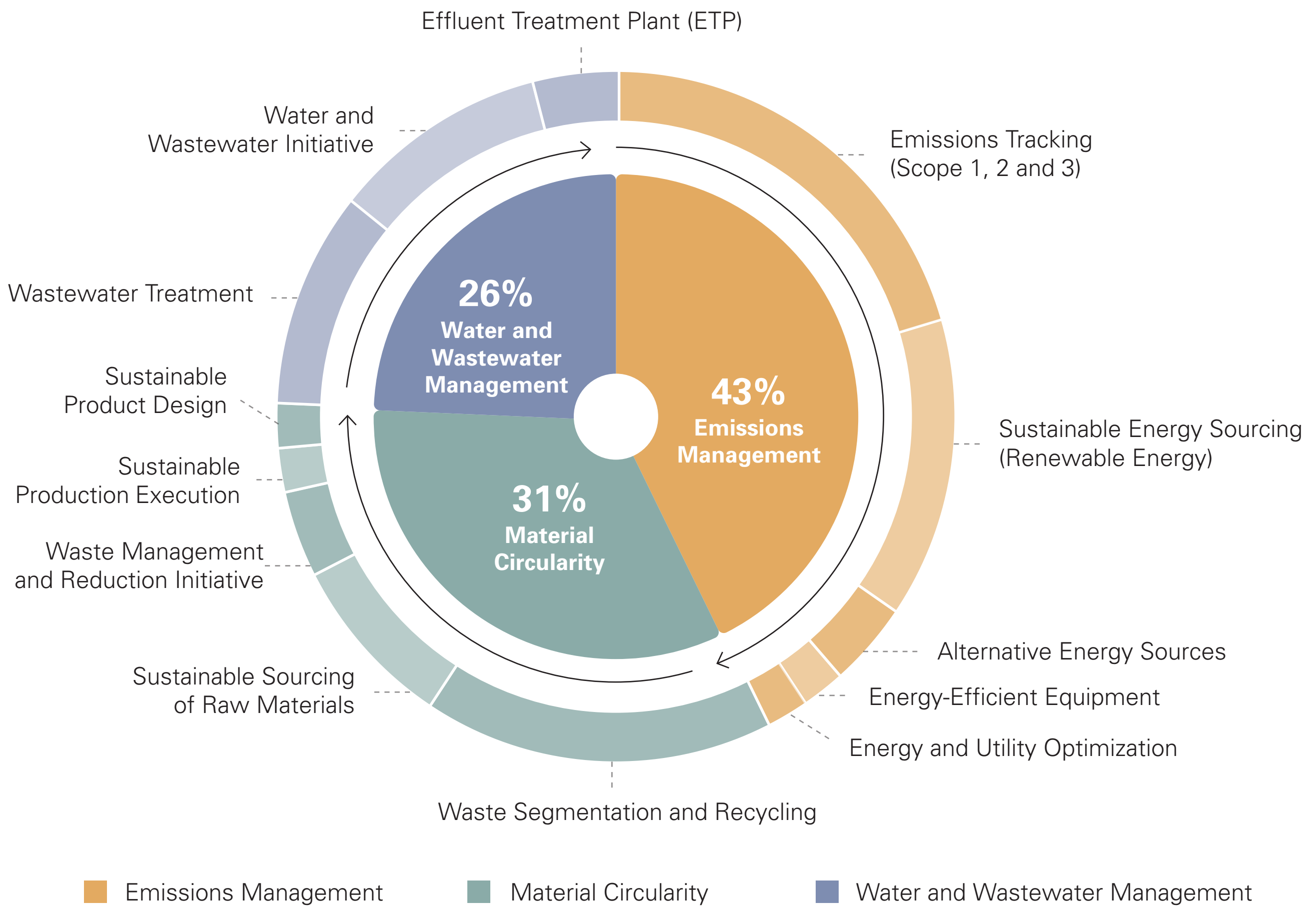
## Project's Benefits

Eliminated **~1,100K AED** worth of weighing scales

Peeling efficiency resulting in **~3.7 Mn AED savings**

- Improved customer-centricity through better design and price improvements
- Targeted the right launch stores with the right material at the right time
- Optimized workforce through bot
- Demonstrated clear sign of strategic foresight and talent readiness

# Sustainability Initiatives across Food and Beverage Sector




## Key Insights

| | |
|---|---|
| **Healthy Focus across Sustainability Dimensions** | ▪ For the F&B sector, sustainability-related initiatives occur across dimensions, with a larger focus (~43%) on emissions management initiatives, followed by material circularity |
| **Emissions Management** | ▪ For emissions management, ~48% of the initiatives are related to tracking their Scope 1 and 2 emissions and, in some cases, seeking disclosure on supplier environmental footprints as part of their Scope 3 awareness<br>▪ Renewable energy sources, particularly solar energy, are incorporated as part of the sourcing mix (33% of the initiatives), typically with a target to reduce Scope 2 emissions |
| **Water and Wastewater Management** | ▪ 42% of the water and wastewater management initiatives pertain to onsite wastewater treatment facilities, where treated and recycled water is reused in production as well as auxiliary activities (irrigation) |
| **Material Circularity** | ▪ While initiatives, such as sustainable sourcing of raw materials and product design have been identified, waste segmentation and recycling initiatives (50%) account for the largest share |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** F&B manufacturers typically consume large quantities of water and energy (electricity) in processing raw materials and as part of their manufacturing operations | **AI/ML-Powered Water Management Systems for Optimized Production** | ▪ Historical data from sensorized plant to trace water consumption needs and optimize for most efficient operating set points<br>▪ Auto-closed edge AI driving alerts and controls for leaks in valves/water circuits<br>▪ AI selection of a water source (well/supply water/ treated rainwater) based on cost and availability | ↓ **Water Consumption** |
| | **Wastewater Treatment Plant for Recycle and Reuse** | ▪ Varying inputs of water can be addressed through sensorized data collection<br>▪ Helps meet stringent regulatory standards for treated water, taste, odor, and color through AI-based real-time decision support for treatment plant operators, for example, BOD control in F&B<br>▪ Water quality control for maintaining ambient conditions in plants for ensuring food texture/ quality | ↓ **Fresh Water Intake** |
| **2** F&B manufacturers operate extensive distribution fleets, posing significant sustainability challenges due to carbon emissions | **Fleet Management and Route Optimization for Distribution** | ▪ Use of AI to identify local or optimized routes to procure materials<br>▪ Use of AI to identify demand and plan fleets through horizontal integration with customers<br>▪ Use of AI to optimize modes of transport based on least carbon footprint, location and optimal delivery time | ↑ **Emissions Management** |
| | **Variable Speed Drives (VSDs) for Optimized Process Equipment** | ▪ Sensorized data from equipment and ambience are pre-requisites<br>▪ AI models are built based on the data collected to drive the VSD<br>▪ The AI algorithms are deployed using edge gateways for automated control based on actual needs over static responses, optimizing energy consumption | ↓ **Energy Consumption** |
| **3** Due to the typical nature and volume of FMCG operations, the F&B sector consumes large quantities of raw materials for packaging purposes, such as plastic, glass, metals, and paper | **Sustainable Sourcing of Raw Materials for Packaging** | ▪ Horizontal integrations can help establish visibility of supplier sources, enabling tracking of supplier processes, quality mandates, and regulatory adherence<br>▪ Use of AI to identify local or optimized routes to procure materials<br>▪ Blockchain-based tracking of supply chain can also be enabled to ensure authenticated and ethical sourcing of raw materials, especially with growing demand for vegan, cruelty-free, organic, locally sourced and local economy-supporting products | ↑ **Improved Circular Economy** |

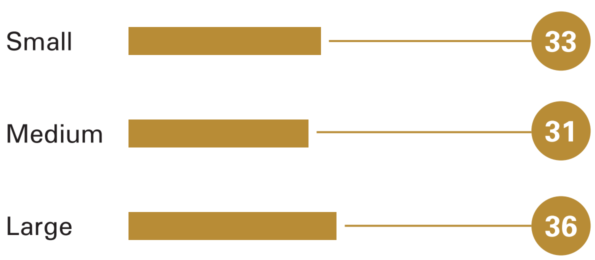
Impact of Sustainability: Material Circularity | Water and Wastewater Management | $CO_2$ Emissions Management

Sector Focus

# HEAVY INDUSTRIES

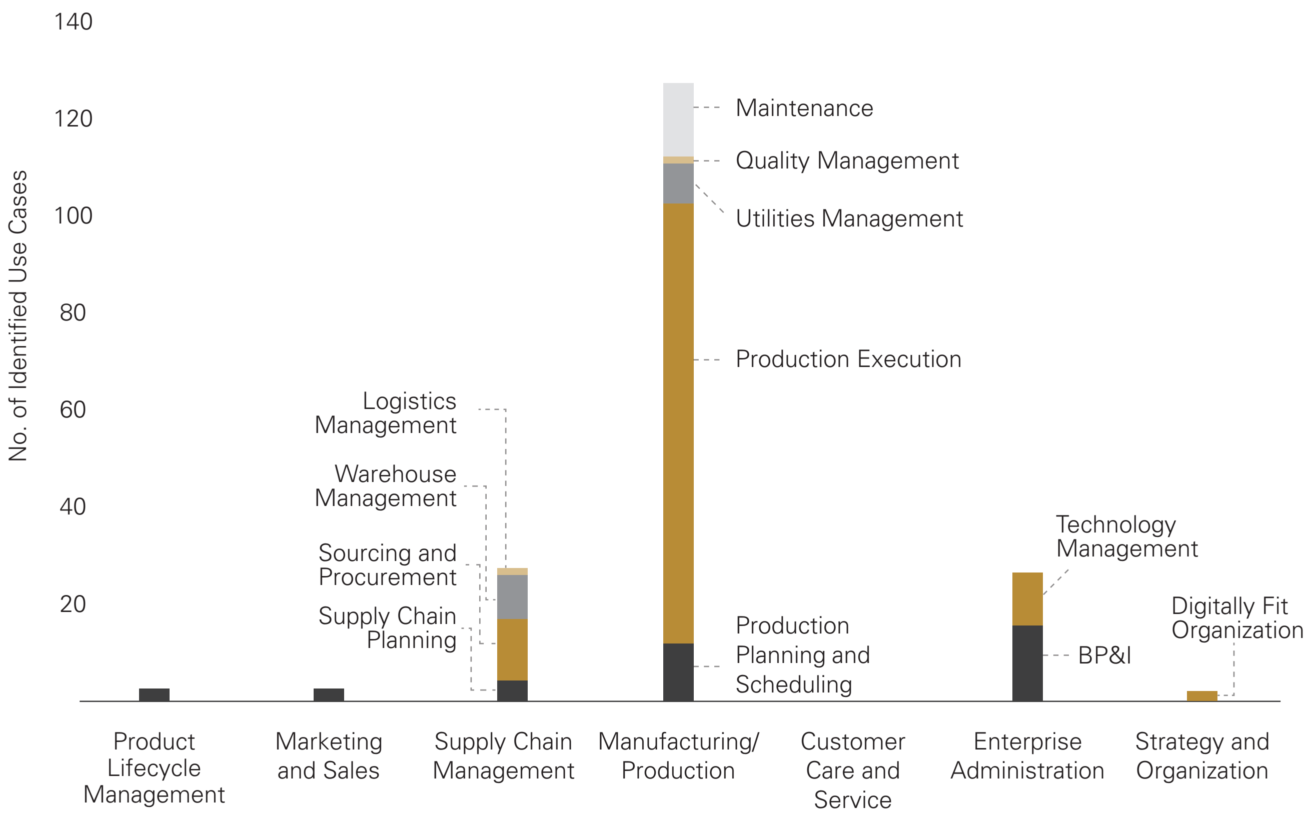
## Overview

### Manufacturer Size Distribution (%)




This sector has 23% of manufacturers with I4.0 Use Cases implemented and the potential to reach 70% implementation in the short- and medium-term

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the heavy industry sector comprises a good mix of all-sized companies
- Use Cases revealed are skewed towards production execution, business process and intelligence, and maintenance

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1. Automating Enterprise Processes Using RPAs
2. IT/OT Integration for Centralized Monitoring and Control of Production
3. Supplier Integration for Automated Procure-to-Pay (P2P) Workflows
4. Integrated and Automated Production Planning and Scheduling
5. AI/ML for Process Optimization and Production Efficiency
6. Predictive Maintenance
7. Energy and Utility Optimization
8. Material Traceability for Warehouse Operations
9. Customer Integration for Automated Logistics Workflows
10. Digital Twin for Production Simulation and Optimization

### Top Prioritized Use Cases

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics
- Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

**IT/OT Integration for Centralized Monitoring and Control of Production**

- Metal manufacturing is often characterized by complex processes, diverse equipment, and a pressing need for precision and quality
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- In the heavy industry, it is essential to address the complexities of vast supply chains, ensuring timely procurement and reducing operational inefficiencies
- Allowing the company to swiftly adapt to dynamic market conditions and regulatory demands, safeguarding production continuity and compliance

### Additional Recommended Use Cases

**Energy Management and Optimization**

- Efficient energy management and optimization are vital to metal processing, which significantly reduces operational costs and enhances profitability amidst high energy demands
- Adapting energy-efficient practices not only ensures compliance with stringent environmental and regulatory standards but also safeguards against disruptions

**Digital Twin for Production Simulation and Optimization**

- The sector faces significant ROI pressures due to high capital outlays. Digital Twin solutions directly counter this by drastically reducing inefficiencies and resource wastage
- With its predictive analytics, the solution preemptively addresses costly machinery downtimes and adapts to market flux, ensuring sustained operational resilience

# Details on the Prioritized Industry 4.0 Use Cases

## 1 SUPPLIER INTEGRATION FOR AUTOMATED PROCURE-TO-PAY (P2P) WORKFLOWS

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Electronic Data Exchange (EDI) | Sourcing and Procurement | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Increases visibility of raw materials and vendor selection
- Optimizes purchasing routes and processes
- Evaluates supply chain scenarios and maintains vendor performance metrics

**Pre-requisites for Success**

- Seamless integration with supplier systems, including EDI
- Availability of transactional ERP data, especially shipping routes, for a minimum of three years
- Robust training and support infrastructure for stakeholders and vendors

## 2 ENERGY MANAGEMENT AND OPTIMIZATION

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Industrial IoT, Predictive Analytics | Production Execution | Energy Savings | ↑ 5-20% |

**Realized Benefits**

- Uncovers and addresses hidden inefficiencies in energy usage
- Pinpoints and targets the most energy-intensive processes and assets
- Uses AI/ML benchmarks to compare and optimize asset performance and production data

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Installation of energy meters at the line or asset level for detailed consumption tracking
- Seamless access to Energy Management Systems (EMS) and Building Management Systems (BMS)

## 3 DIGITAL TWIN FOR PRODUCTION SIMULATION AND OPTIMIZATION

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Industrial IoT, AI/ML | Production Execution | Time-to-Market | ↑ Up to 30% |

**Realized Benefits**

- Consolidates diverse data systems for streamlined insights
- Enhances quality and reduces defects through proactive actions
- Boosts production yield using AI insights and scales best practices across operations

**Pre-requisites for Success**

- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture and TCS

Case Study

# Tata Steel – Diversity, Equity and Inclusion Lighthouse Factory WEF

## Project Overview

- Cost implications of raw materials
- Supply chain resilience
- Quality vs process implications
- Depleting resources and sustainable practices

## Transformation Journey

**I4.0 Vision**

- Target 2018 – data driving savings of ~7.3 Bn AED
- Leverage IT wizards from the Tata Group

**OT Integration**

- Millions of data points and 1,000+ sensors, 5.2 (petabytes) cloud-based iRoC (Integrated Remote Operations Centre)

**Production Execution**

- Digital twin for quality defect management, 200+ AI

**Horizontal Integration**

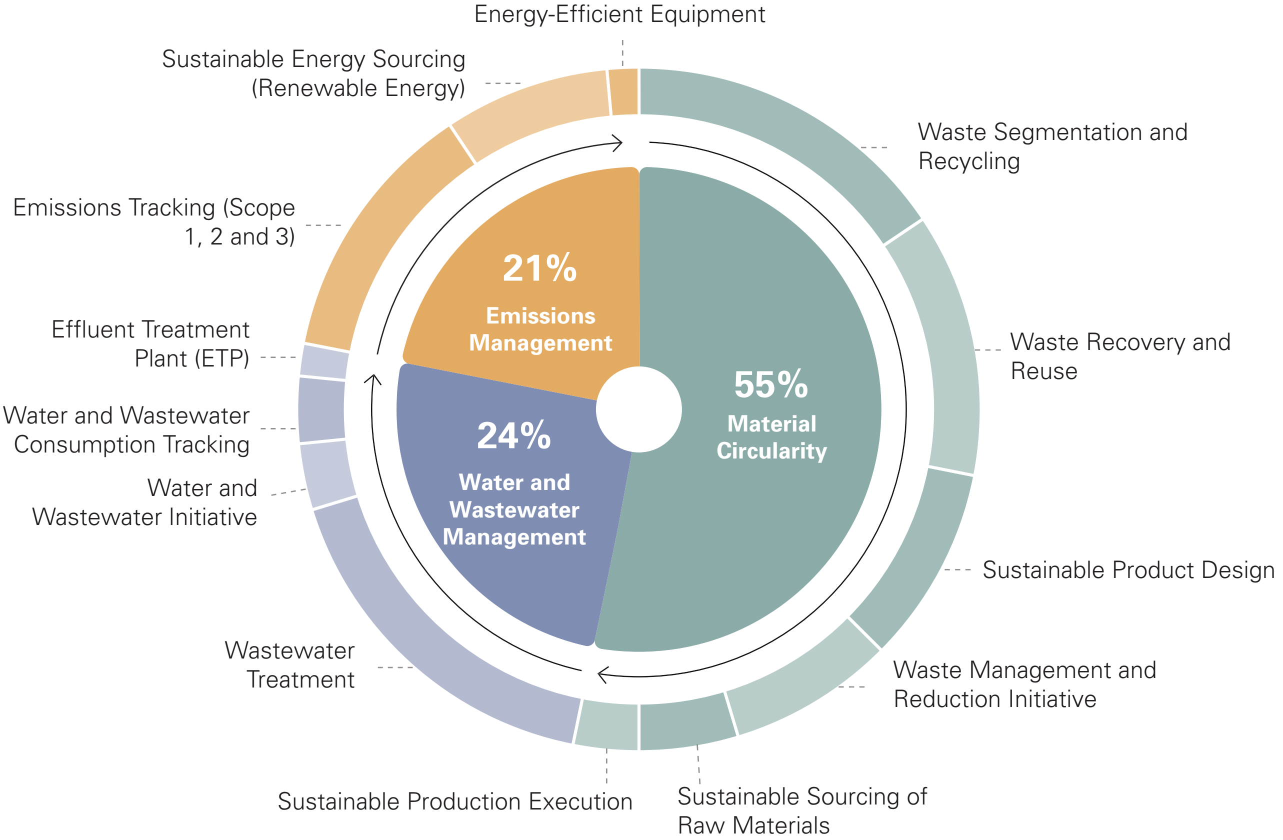
- Supplier integration + logistics optimization

## Project's Benefits

**~5.1 Bn AED** EBITDA savings in 2023 after 5 years

- Scale up to 5 plants, 3 plants are lighthouse-certified
- 5x data growth 25PB (petabytes) in 2023 managed by multi-industrial clouds managing 95% data – Amazon, Google, Microsoft, Tata Communications, and IBM
- Adaptive manufacturing processes prevent repetitive errors

# Sustainability Initiatives across Heavy Industries Sector




## Key Insights

| | |
|---|---|
| **Focused Efforts on Material Circularity** | ▪ For the heavy industries sector, sustainability-related initiatives occur across dimensions, with a larger focus (~55%) on material circularity initiatives. This implies that primary raw materials are mined with heavy environmental impacts and high conversion costs requiring minimal material waste and maximum reuse |
| **Material Circularity** | ▪ Multiple initiatives found for this sector are primarily focused on waste segmentation and recycling (~29%), and waste recovery and reuse (~24%) with an increased focus on recycling and reusing scrap metal in steel plants<br>▪ Green steel and eco-friendly product development are being incorporated under sustainable product design and execution initiatives, which account for ~24% initiatives |
| **Wastewater Treatment** | ▪ ~69% of the water and wastewater management initiatives pertain to onsite wastewater treatment facilities, where treated and recycled water is reused in production as well as auxiliary activities (gardening and lavatories) |
| **Emissions Management** | ▪ While initiatives such as sustainable sourcing of raw materials and product design have been identified, emissions tracking for Scope 1, 2 and 3 (~57%) account for the largest share |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** The sector's reliance on vast water quantities makes sustainable water management vital, both to ensure operational continuity and to mitigate environmental impacts. | **AI/ML Water Management Systems for Optimized Production** | ▪ Historical data from sensorized plant to trace water consumption needs and optimize for most efficient operating set points<br>▪ Auto-closed edge AI driving alerts and controls for leaks in valves/water circuits<br>▪ AI selection of a water source (well/supply water/ treated rain water) based on cost and availability | ↓ **Water Consumption** |
| | **Advanced Water Treatment Plant for Water Recovery and Zero Liquid Discharge (ZLD)** | ▪ Varying inputs of water can be addressed through sensorized data collection<br>▪ Helps meet stringent regulatory standards for treated water, taste, odor, and color through AI-based real-time decision support for treatment plant operators, for example, COD control in Heavy metals<br>▪ Water quality control for maintaining ambient conditions in plants for ensuring food texture/ quality | ↓ **Water Waste** |
| **2** Energy is a cornerstone resource in the heavy industry, primarily sourced from fossil fuels, to drive high energy processes, such as smelting and refining. It is imperative for these industries to adopt energy-efficient practices. | **Waste Heat Recovery System (WHRS) for Captured Energy** | ▪ Production data from MES/relevant system and data on energy consumption per batch need to be captured through energy meters<br>▪ AI/ML models can help identify asset level benchmarks for optimal energy consumption<br>▪ Set points or golden batch performance characteristics can be replicated | ↓ **Energy Consumption** |
| | **Renewable Energy Sources to Offset Reliance on Conventional Consumption** | ▪ Post installation of renewable tech like solar, it is possible to optimize yield per panel by AI driven tilt control of panel, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panels based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | ↓ **GHG Emission – Scope 2** |
| **3** Additionally, heavy industry manufacturing can result in substantial amounts of material waste or (such as waste slag) other by-products. | **Recycling and Reusing of Material Waste/Scrap Material** | ▪ Computer vision-based sorting can help in sorting of high and low-quality plastics<br>▪ Use of 3D manufacturing to reuse waste/scrap for new parts or products<br>▪ Quality control of recycled materials shipped to customers using AI | ↑ **Improved Circular Economy** |

Impact of Sustainability: Material Circularity   Water and Wastewater Management   Emissions Management

Sector Focus

# PHARMACEUTICALS

## Overview

### Manufacturer Size Distribution (%)


Pharmaceuticals sector is at 33% current implementation of I4.0 Use Cases, with the potential to reach 80% implementation

### Distribution of Use Cases Identified across Manufacturing Dimensions


- The sample size of the pharmaceuticals sector entirely comprises small and medium-sized companies
- Use Cases revealed are skewed primarily towards the manufacturing/production dimension

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1 IT/OT Integration for Centralized Monitoring and Control of Production

2 Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

3 Energy and Utility Optimization

4 Predictive Maintenance

5 Customer Integration for Automated Logistics Workflows

6 Integrated and Automated Production Planning and Scheduling

7 Paperless Factory Operations for Production Execution

8 Automated Material Handling for EoL Activities

9 Predictive Analytics for Customer Feedback

10 Enterprise Cybersecurity Measures

### Top 3 Prioritized Use Cases

**IT/OT Integration for Centralized Monitoring and Control of Production**

- Pharmaceuticals manufacturing is often characterized by complex processes, diverse equipment, and a pressing need for precision and quality, traceability and compliance
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- In most industries, it is essential to address the complexities of vast supply chains, ensuring timely procurement and reducing operational inefficiencies
- Poor visibility and lack of integrations with supplier systems lead to delayed procurements and affects optimization of production schedules

**Energy and Utility Optimization**

- Pharmaceutical industry requires precision manufacturing of formula which is an energy-intensive process
- The need for stringent ambient conditions, clean room operations, large scale drug manufacturing requires extensive use of HVAC, refrigeration, energy-intensive water purification processes, and sterilization processes

### Additional Recommended Use Cases

**Predictive Maintenance**

- It is imperative to ensure that continuous line operations of critical shopfloor machinery (as well as supporting utilities) are not hindered owing to unexpected downtime due to mechanical fault
- Predictive maintenance of such machinery can ensure long-term resilience through remote monitoring

**Customer Integration for Automated Logistics Workflows**

- By integrating logistics workflows with customer systems, manufacturers can offer real-time order tracking, accurate delivery estimates, and swift responses to changes in order or delivery preferences. This ultimately results in enhanced customer experiences

# Details on the Prioritized Industry 4.0 Use Cases

## 1

### IT/OT INTEGRATION FOR CENTRALIZED MONITORING AND CONTROL OF PRODUCTION

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| IT/OT Integration | Production Execution | Factory Output ↑ 10-30% |

**Realized Benefits**

- Enhances visibility of shopfloor legacy assets/controllers
- Enables data availability for analytics and other performance monitoring applications, compliance, and traceability
- Integrates shopfloor and top-floor systems, enabling strategic business decisions

**Pre-requisites for Success**

- Robust network infrastructure
- Standardized protocols for data exchange
- Skilled IT and OT teams for effective collaboration

## 2

### PREDICTIVE MAINTENANCE

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| Industrial IoT, Predictive Analytics | Maintenance | Operating Cost ↓ 18-25% |

**Realized Benefits**

- Proactively predicts maintenance needs for assets before reaching complete failure, eliminating the need for manual sensory methods, such as agitators, chillers, and pulverizers
- Reduces unplanned downtime of HVAC, affecting ambient conditions of clean rooms
- Helps identify the optimal repair or replace through Remaining Useful Life (RUL) prediction

**Pre-requisites for Success**

- Quality data availability of 4-12 months, depending on use case
- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

## 3

### CUSTOMER INTEGRATION FOR AUTOMATED LOGISTICS WORKFLOWS

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| Industrial IoT, AI/ML | Warehouse Management | On-Time-in-Full ↑ 20-30% |

**Realized Benefits**

- Helps understand customer preferences
- Engages the voice of customer during manufacturing
- Aids refill shelves based on buyer choices

**Pre-requisites for Success**

- Seamless integration with customer systems, including EDI/RPA
- Availability of transactional ERP/CRM data, especially customer buying data
- Robust training and support infrastructure for stakeholders and downstream partners

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# Cipla - 20+ Sites in 2 Years

## Project Overview

- Ensuring scale up to 20+ sites
- Enhancing acquisition of operational data
- Increasing productivity
- Managing Industry 4.0 talent gap

## Transformation Journey

**40+ Digital and Analytics Use Cases**

- Process simulation improving yield
- Dynamic workforce planning
- 18 use cases scaled across all sites, and remaining ones scaled to 5+ sites

**Technology Upgrade**

- Future proof scalable IIoT-Tech architecture
- Edge and SCADA connectivity to push data beyond 90%
- Critical equipment across the network, to a secure enterprise-wide cloud

**Talent Readiness**

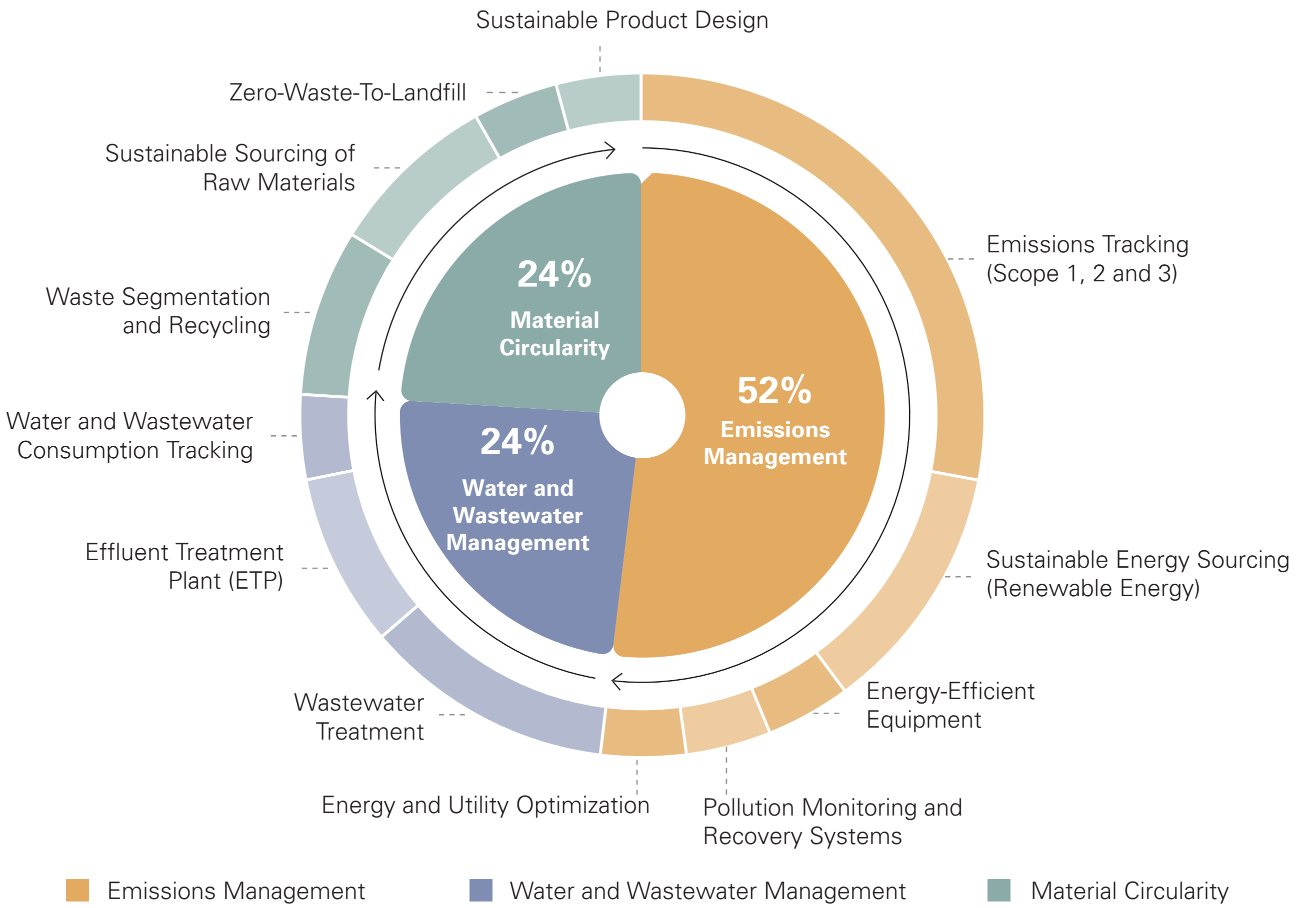
- Dedicated transformation office
- Leadership grooming from I4.0 and workforce engagement initiatives
- Setting up IIoT academy
- Recruiting and reskilling new talent

## Project's Benefits

**20-80% improvement** in operations outcome, such as productivity, machine efficiency, and quality deviations

- Increase in data maturity from 20% visibility to 90%
- 20+ sites scale up in 2+ years
- 1 lighthouse factory

# Sustainability Initiatives across Pharmaceuticals Sector




## Key Insights

| | |
|---|---|
| **Majority Focus on the Direction of Emissions Management** | ▪ For the pharmaceuticals sector, sustainability-related initiatives occur across dimensions, with a larger focus (~52%) on emissions management. This focus stems from being a continuous process industry with stringent ambient conditions, safety compliances and uninterrupted availability of supply chains to meet medical needs |
| **Emissions Management** | ▪ For emissions management, ~54% of the initiatives are related to tracking their Scope 1 and 2 emissions and, in some cases, seeking disclosure on supplier environmental footprints as part of their Scope 3 awareness<br>▪ Using renewable energy sources, specifically solar energy, is the next prioritized initiative |
| **Water and Wastewater Management** | ▪ 50% of the water and wastewater management initiatives pertain to onsite wastewater treatment facilities, where treated and recycled water is reused in production as well as auxiliary activities (cleaning) |
| **Material Circularity** | ▪ Initiatives, such as sustainable sourcing of raw materials, and waste segmentation and recycling initiatives (33% each) account for the largest share |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** The pharmaceutical industry is heavily reliant on water for various processes, from product research and development to manufacturing, leading to consumption and discharge management challenges. | **Advanced Analytics to Predict Optimal Water Usage in Drug Production** | ▪ Proactively predicts maintenance needs for assets before reaching complete failure, eliminating the need for manual sensory methods, such as agitators, chillers, and pulverizers<br>▪ Reduces unplanned downtime of HVAC, affecting ambient conditions of clean rooms<br>▪ Helps identify the optimal repair or replace through Remaining Useful Life (RUL) prediction | ⬇ **Water Consumption** |
| | **Advanced Water Treatment Plant for Water Waste Reduction** | ▪ Optimize yield per panel by AI-driven tilt control of panel, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panels based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | ⬇ **Minimized Water Waste** |
| **2** Energy use in production, especially when synthesizing complex molecules, can result in both, a substantial carbon footprint and operational cost. | **Energy Management Systems for Optimized Energy Usage** | ▪ Ensure elimination of leakages, such as machine idling, with asset level energy management<br>▪ Replicate asset benchmarks and set points for processes to attain optimal energy-efficiency<br>▪ Plan production to increase yield at optimal energy | ⬆ **Emissions Management** |

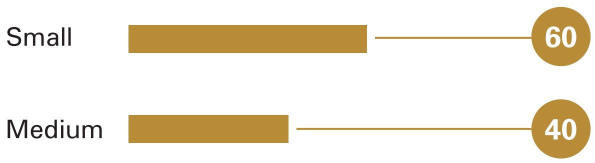
Impact of Sustainability: Material Circularity Water and Wastewater Management Emissions Management

Sector Focus

# ELECTRICAL EQUIPMENT AND ELECTRONICS

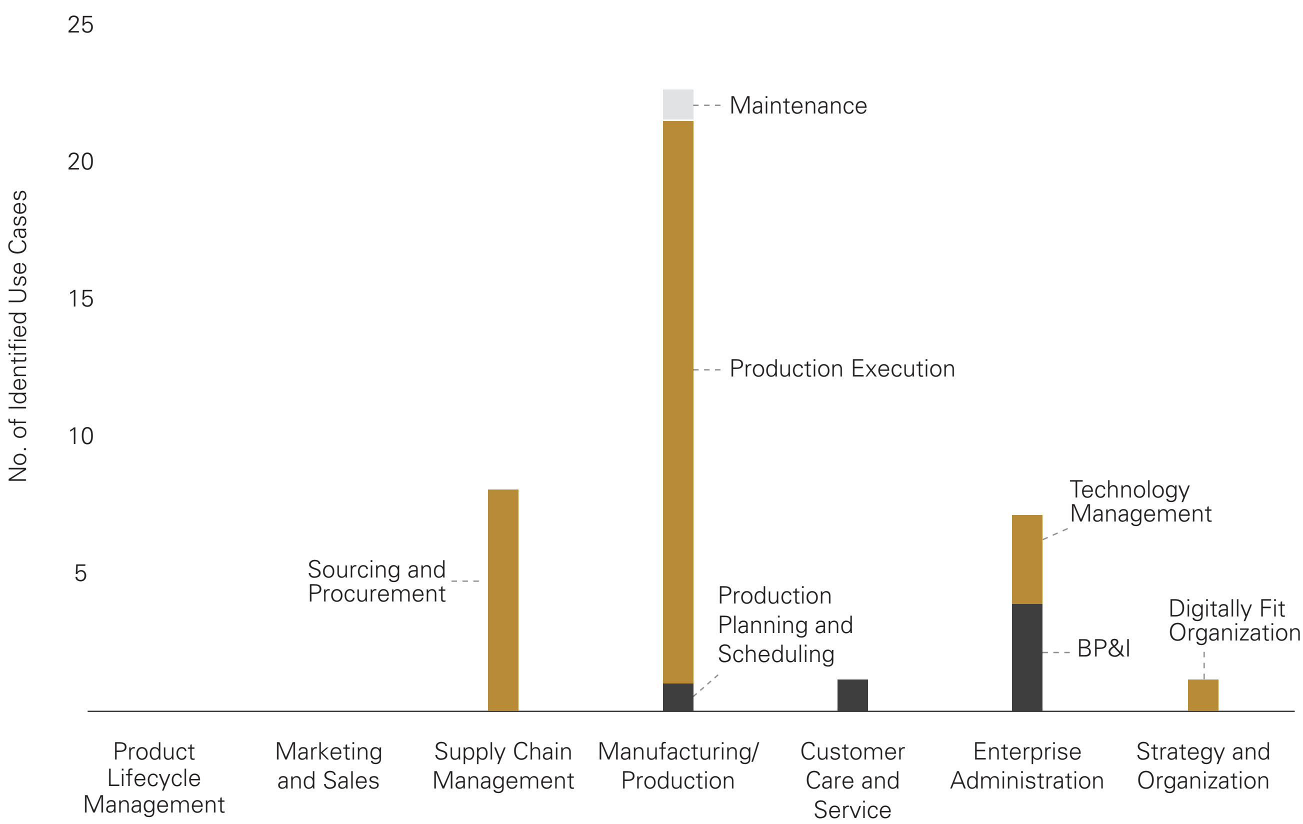
## Overview

### Manufacturer Size Distribution (%)




This sector has 15% current implementation of I4.0 Use Cases and is estimated to reach ~77% in near future

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the electrical equipment sector entirely comprises small and medium-sized companies
- Use Cases revealed are skewed primarily towards production execution, and sourcing and procurement

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1. Automating Enterprise Processes Using RPAs
2. IT/OT Integration for Centralized Monitoring and Control of Production
3. Supplier Integration for Automated Procure-to-Pay (P2P) Workflows
4. Controller Virtualization
5. Integrated and Automated Production Planning and Scheduling
6. Production Monitoring and Operations Optimization
7. Energy and Utility Optimization
8. Predictive Maintenance

### Top 3 Prioritized Use Cases

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics. Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

**IT/OT Integration for Centralized Monitoring and Control of Production**

- Electrical equipment manufacturing is often characterized by complex processes, diverse equipment, and a pressing need for precision and quality
- Managing these demands without a unified system can lead to increased risks, inefficiencies, and inconsistencies

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- It is essential to address the complexities of vast supply chains, ensuring timely procurement and reduced operational inefficiencies
- Allowing the company to swiftly adapt to dynamic market conditions and regulatory demands helps safeguard production continuity and compliance

### Additional Recommended Use Cases

**Integrated and Automated Production Planning and Scheduling**

- The high variant nature of production can lead to frequent changes, making manual scheduling inflexible and prone to errors
- An Integrated and Automated Production Planning and Scheduling system swiftly adapts to changes, ensuring optimal equipment and resource allocation for each variant

**Energy and Utility Optimization**

- The need for injection molding is a highly energy-intensive process in the electrical industry
- Some of the components, such as semiconductors and microchips, require clean room ambience with precise control of temperature and humidity which implies heavy HVAC needs
- Circuit board fabrication, deposition, and high precision machining are significant energy consumption contributors

# Details on the Prioritized Industry 4.0 Use Cases

## 1

**AUTOMATING ENTERPRISE PROCESSES USING RPAS**

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Robotic Process Automation, AI | Business Processes and Intelligence | Productivity | ↑ 15-30% |

**Realized Benefits**

- RPA helps integrate with customers of high-volume transactional base
- Creates audit trails for compliance processes from multiple sources – websites and policy documents, automating submissions
- Improves quality inspection processes of PCB

**Pre-requisites for Success**

- Proper process definitions prior to automation
- RPA trained resources with awareness of workflows

## 2

**SUPPLIER INTEGRATION FOR AUTOMATED PROCURE-TO-PAY (P2P) WORKFLOWS**

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Electronic Data Exchange (EDI) | Sourcing and Procurement | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Increases visibility of raw materials and vendor selection
- Optimizes purchasing routes and processes
- Evaluates supply chain scenarios and maintains vendor performance metrics

**Pre-requisites for Success**

- Seamless integration with supplier systems, including EDI
- Availability of transactional ERP data, especially shipping routes, for a minimum of 3 years
- Robust training and support infrastructure for stakeholders and vendors

## 3

**INTEGRATED AND AUTOMATED PRODUCTION PLANNING AND SCHEDULING**

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Digital Tools and Platforms, AI/ ML | Production Planning and Scheduling | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Easier responses to market fluctuations through optimized realistic production schedules
- Provides scenario risk analysis, for constraints related to human, machine, market fluctuation availability/issues
- Reduces inventory levels and waste, ensuring on-time delivery, based on profitability and urgency

**Pre-requisites for Success**

- Clear understanding of human and material resources
- Integrations with ERP, workforce management systems
- Integrations of machines for availability information

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

## Case Study

# Haier - Largest Mass Customization Platform

## Project Overview

- State-of-the-art production line
- Customer-centricity
- Establishing end-to-end visibility

## Transformation Journey

**15+ Interconnected factories**

- Largest mass customization platform
- Automated and intelligent production line
- Digital information system integration

**COSMOPlat**

- Manufacturing experience of 15 interconnected factories
- 328 manufacturing standards
- 56 handbooks
- Cloudification, Big data and IoT

**End-to-End Visibility**

- Integrates factory process and supply chain
- Connects customers for customization
- Enables transparency in design and production for end-customer

## Project's Benefits

**~44% Revenue Increase**

- 30% new product development time reduced
- 100% on-time delivery
- 79% productivity increase
- 59% product non-conformance rate reduced

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| | Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|---|
| 1 | The production of electronic components and the assembly of electronic devices are energy-intensive, often relying on non-renewable energy sources. | **Renewable Energy Sources to Offset Reliance on Conventional Consumption** | ▪ Optimize yield per panel by AI-driven tilt control of panel, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panels based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | **GHG Emission – Scope 2** |
| | | **Sustainable and Ethical Sourcing of Raw Materials** | ▪ Horizontal integration enhances visibility into supplier sources, processes, and quality mandates, facilitating regulatory adherence<br>▪ Use of AI to identify local or optimized routes to procure materials<br>▪ Blockchain-based tracking of supply chain can also be enabled to ensure authenticated and ethical sourcing of raw materials | **GHG Emission – Scope 3** |
| 2 | The global nature of electronics supply chains, involving the transportation of components and finished products across continents, leads to significant carbon emissions from a sourcing perspective. | **Predictive Analytics and Simulation Models (Digital Twin)** | ▪ Consolidates diverse data systems for streamlined insights<br>▪ Enhances quality and reduces defects through proactive actions<br>▪ Boosts production yield using AI insights and scales the best practices across operations | **Optimized Material Usage** |

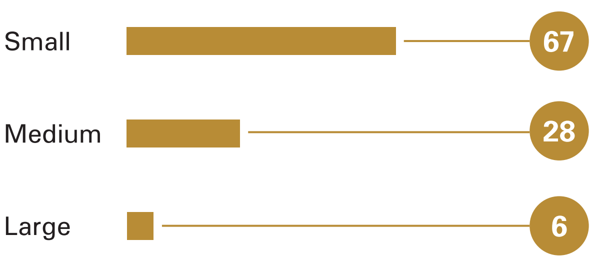
Impact of Sustainability: Material Circularity Water and Wastewater Management Emissions Management

Sector Focus

# PETROCHEM AND CHEMICAL PRODUCTS

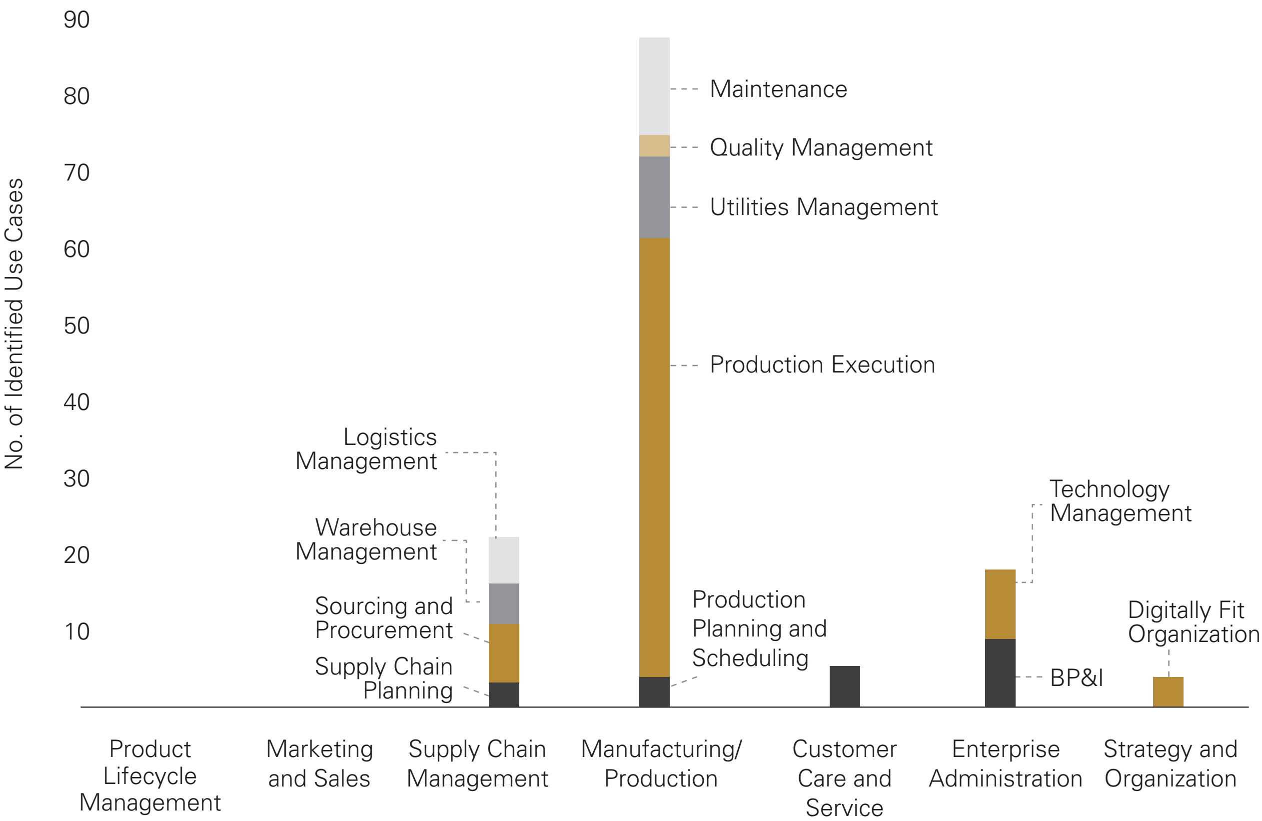
## Overview

### Manufacturer Size Distribution (%)*




Petrochem and Chemical Products sector has 41% deployment of Industry 4.0 Use Cases, which is forecasted to reach double in the short to medium-term

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the petrochem and chemical products sector mostly comprises small-sized companies
- Use Cases revealed are skewed towards production execution, maintenance, and technology management

*Figures presented are approximate and rounded to the nearest numbers.

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1 Automating Enterprise Processes Using RPAs

2 IT/OT Integration for Centralized Monitoring and Control of Production

3 Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

4 Energy and Utility Optimization

5 Predictive Maintenance

6 Integrated and Automated Production Planning and Scheduling

7 Controller Virtualization

8 Advanced Analytics and Reporting

9 Fleet Management and Route Optimization

10 Production Monitoring and Operations Optimization

### Top 3 Prioritized Use Cases

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics
- Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of parts specific to each product variant

**IT/OT Integration for Centralized Monitoring and Control of Production**

- The petrochem and chemical products sector inherently involves handling of hazardous materials, high pressures, and high temperatures
- Centralized monitoring allows real-time surveillance of safety parameters, ensuring immediate response to any deviations, thus safeguarding both human assets and infrastructure

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- The petrochem and chemical products sector often involves intricate supply chains with multiple raw materials, intermediates, and end-products
- By integrating with suppliers for automated P2P workflows, companies can streamline procurement processes, ensuring timely delivery of raw materials, reduced lead times and minimized production downtimes

### Additional Recommended Use Cases

**Energy Management and Optimization**

- Efficient energy management and optimization is vital to petrochemical processing, which significantly reduce operational costs and enhance profitability amid high energy demands
- Adapting energy-efficient practices ensures compliance with stringent environmental and regulatory standards as well as safeguarding against disruptions

**Predictive Maintenance**

- Critical equipment requires proactive maintenance measures based on conditions, such as process equipment, mainly pumps, compressors, and reactors, to ensure there is no loss in production yield as pharma industry is characterized by continuous processes
- When applied to valves it ensures safety and prevention of leaks

# Details on the Prioritized Industry 4.0 Use Cases

## 1 IT/OT INTEGRATION FOR CENTRALIZED MONITORING AND CONTROL OF PRODUCTION

| I4.0 Technologies | Value Chain | Impact | |
| --- | --- | --- | --- |
| IT/OT Integration | Production Execution | Factory Output | ↑ 10-30% |

**Realized Benefits**

- Aids visibility of shopfloor legacy assets/ controllers
- Enables process traceability and data availability for analytics and other performance monitoring applications, process's traceability
- Integrates shopfloor and top-floor systems, enabling strategic business decisions

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## 2 SUPPLIER INTEGRATION FOR AUTOMATED PROCURE-TO-PAY (P2P) WORKFLOWS

| I4.0 Technologies | Value Chain | Impact | |
| --- | --- | --- | --- |
| Electronic Data Exchange (EDI) | Sourcing and Procurement | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Increases visibility of raw materials and vendor selection
- Optimizes purchasing routes and processes
- Evaluates supply chain scenarios and maintains vendor performance metrics

**Pre-requisites for Success**

- Seamless integration with supplier systems, including EDI
- Availability of transactional ERP data, especially shipping routes, for a minimum of 3 years
- Robust training and support infrastructure for stakeholders and vendors

## 3 ENERGY MANAGEMENT AND OPTIMIZATION

| I4.0 Technologies | Value Chain | Impact | |
| --- | --- | --- | --- |
| Industrial IoT, Predictive Analytics | Production Execution | Energy Savings | ↑ 5-20% |

**Realized Benefits**

- Uncovers and addresses hidden inefficiencies in energy usage
- Targets the most energy-intensive processes and assets - furnaces, boilers, compressors, and HVAC
- Uses AI/ML benchmarks to compare and optimize asset performance and production, forecasts energy needs in advance, based on hybrid sources

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Installation of energy meters at the line or asset level for detailed consumption tracking
- Seamless access to Energy Management Systems (EMS) and Building Management Systems (BMS)

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# BASF - Chemistry 4.0

## Project Overview

- Sustainability transparency of BSF products
- Power plant efficiency
- Waste management

## Transformation Journey

**SMART - Sustainability Metrics and Reporting Tool**

- Sustainability of products per region and its application
- Sales per product based on sustainability category (emissions, energy and water consumption)

**Power Plant 4.0**

- Optimal generation of captive power using AI/ML
- Predicts energy consumption
- Optimal power purchase recommendation engine

**Waste 4.0**

- Waste volume forecasting using Big Data
- Incineration plant energy diverted to Power Plant 4.0

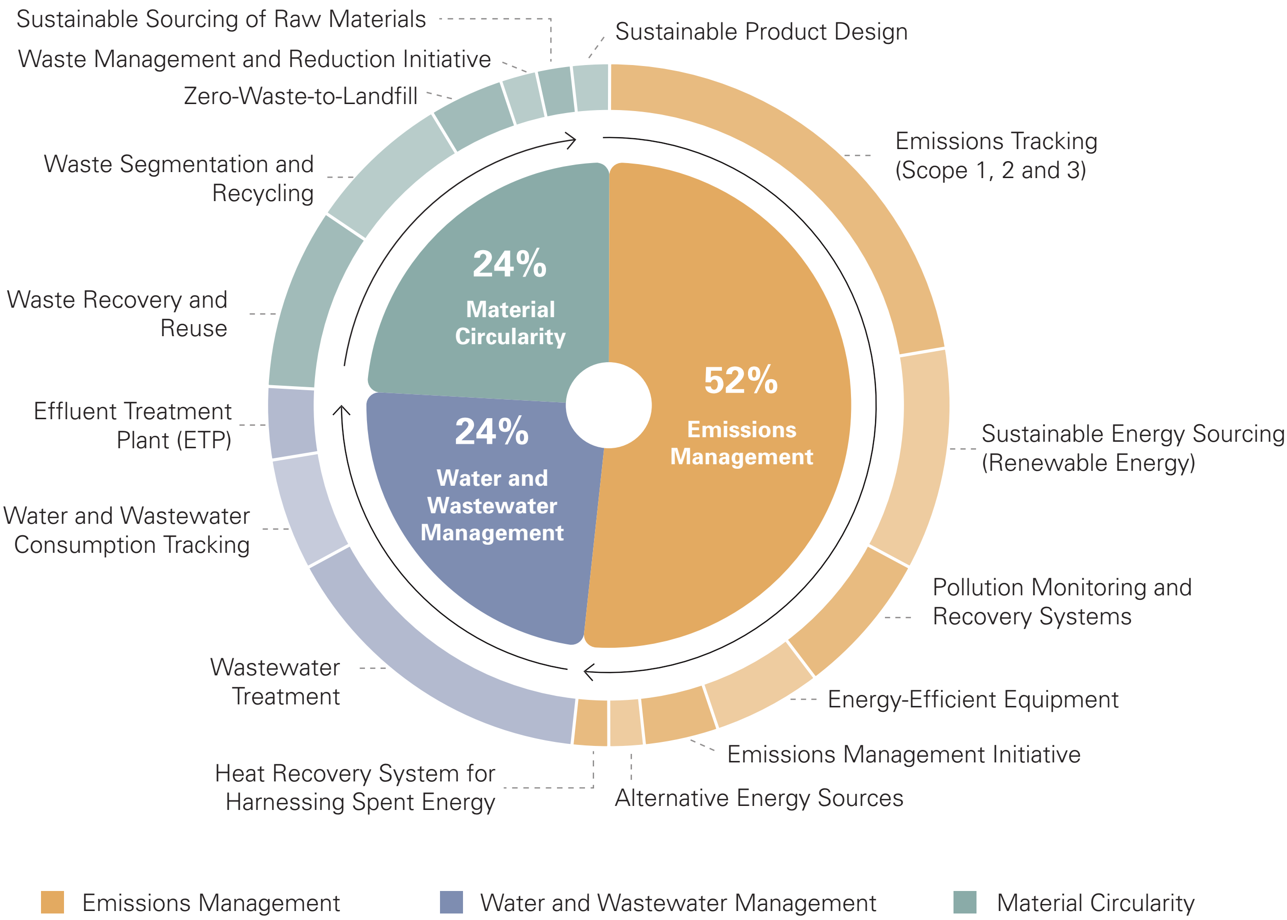
## Project's Benefits

**27% of BASF** products, based on sales, contribute to sustainability

Approximately **~ 3.7 Mn AED** to steam revenues from Waste 4.0 to Power Plant 4.0 initiative

- 95% forecasting accuracy for Power Plant 4.0
- 800 factors of waste streams analyzed to optimize heat packages for optimal energy efficiency

# Sustainability Initiatives across Petrochem and Chemical Products Sector




## Key Insights

| | |
|---|---|
| **Majority Focus in the Direction of Emissions Management** | ▪ For the petrochem and chemical products sector, sustainability-related initiatives occur across dimensions, with a larger focus (~52%) on emissions management. This focus comes with chemical manufacturing processes known to be energy-intensive and emitters of greenhouse gases |
| **Emissions Management** | ▪ For emissions management, ~43% of the initiatives are related to tracking their Scope 1 and Scope 2 emissions and, in some cases, seeking disclosure on supplier environmental footprints as part of their Scope 3 awareness<br>▪ While there is increased focus on initiatives, such as pollution monitoring and recovery systems, using renewable energy sources, specifically solar energy, is the next prioritized initiative |
| **Water and Wastewater Management** | ▪ 64% of the water and wastewater management initiatives pertain to onsite wastewater treatment facilities, where treated and recycled water is reused in production as well as auxiliary activities (cleaning) |
| **Material Circularity** | ▪ While initiatives, such as wastewater segmentation and recycling, have been identified, waste recovery and reuse (~36%) account for the largest share both focusing on reducing and reusing plastic |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** The chemical industry is a substantial consumer of water, used in various processes, including cooling, processing, and cleaning. Inefficient operations can lead to over-extraction of freshwater resources, straining local water supply. | **Advanced Process Control (APC) Leveraging AI/ML for Water Management and Control** | ▪ Historical data from sensorized plant to trace water consumption needs and optimize for most efficient operating set points<br>▪ Auto-closed edge AI driving alerts and controls for leaks in valves/water circuits<br>▪ AI selection of water source (well/supply water/ treated rainwater) based on cost and availability | ↓ **Reduced Water Consumption** |
| | **Predictive Analytics for Optimizing Water Filtration Plants** | ▪ Helps address varying water inputs through sensorized data collection<br>▪ Enables meeting stringent regulatory standards for treated water, taste, odor and color through AI-based real-time decision support for treatment of plant operators (for example CoD control in petrochemicals)<br>▪ Water quality control for maintaining ambient conditions in plants to ensure food texture/quality | ↑ **Water Recovery Rate** |
| **2** The processing of petrochemicals results in a wide range of emissions, including greenhouse gases like $CO_2$ and methane, as well as other pollutants. Unchecked emissions contribute negatively to global warming and climate change. | **Closed-Loop Emissions Monitoring and Optimization** | ▪ Captures production data from MES/relevant system and energy consumption data per batch through energy meters<br>▪ AI/ML models can help asset level benchmark identification for optimal energy consumption<br>▪ Assist replication of set points or golden batch performance characteristics | ↓ **GHG Emission – Scope 1** |
| **3** The sector's heavy reliance on virgin raw materials is inherently unsustainable, leading to increased environmental degradation and missed opportunities for resource optimization. | **Feedstock Recycling (Waste Chemicals as Secondary Raw Materials)** | ▪ Computer vision-based sorting can augment sorting high quality and low quality materials<br>▪ Use of 3D manufacturing to reuse waste/scrap for new parts or products<br>▪ AI helps in quality control of recycled materials being shipped to customers, as quality of recycled input materials varies depending on scrap/waste input generated | ↑ **Effective Reutilization of Material Wastes** |

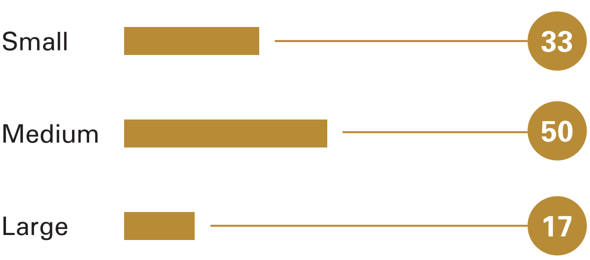
Impact of Sustainability: Material Circularity | Water and Wastewater Management | Emissions Management

Sector Focus

# RUBBER AND PLASTICS

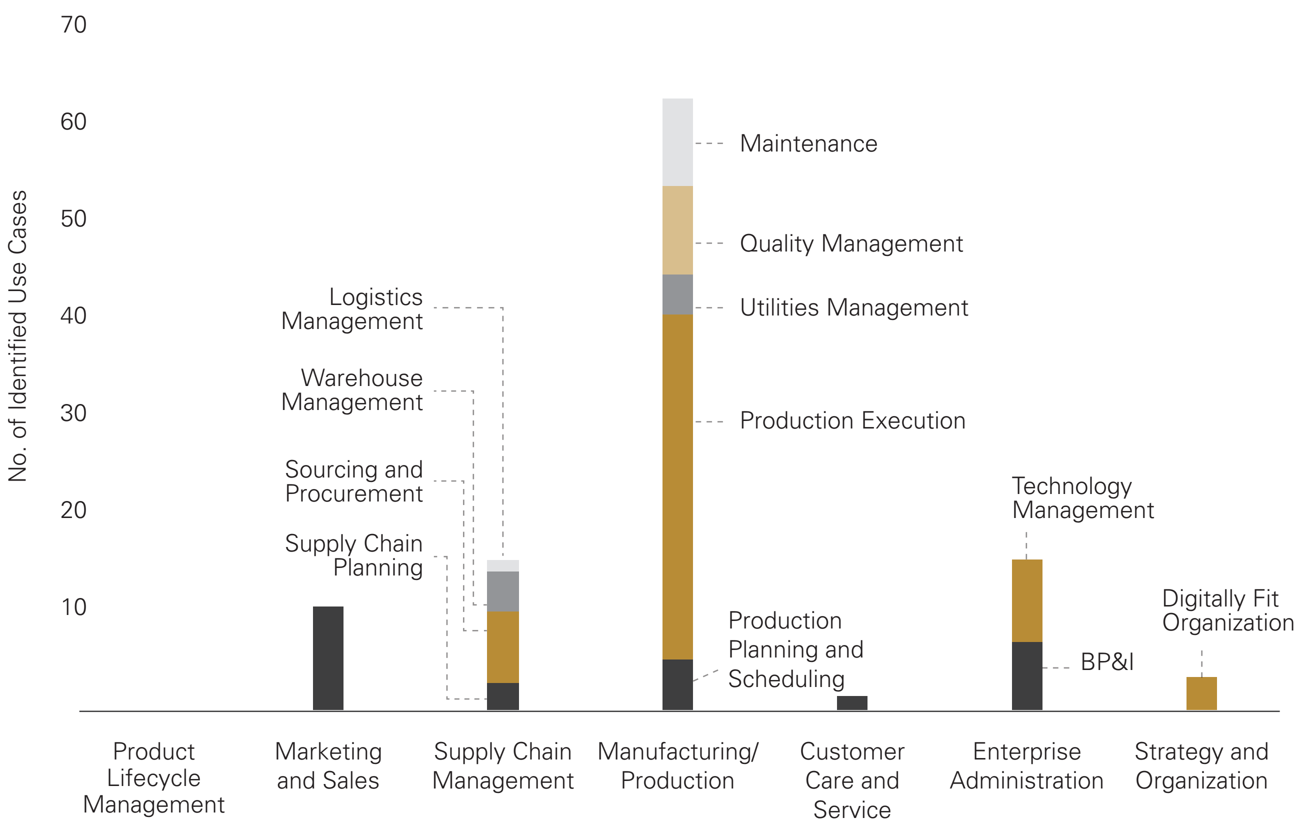
## Overview

### Manufacturer Size Distribution (%)




This sector is currently at 32% implementation of I4.0 Use Cases and is anticipated to reach ~64% implementation

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the rubber and plastics sector mostly comprises medium-sized companies, followed by small-sized companies
- Use Cases revealed are skewed towards production execution, marketing and sales, quality management, and maintenance

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1 **Automating Enterprise Processes Using RPAs**

2 **Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

3 **IT/OT Integration for Centralized Monitoring and Control of Production**

4 **Customer Integration for Automated Logistics Workflows**

5 **Predictive Maintenance**

6 **Integrated and Automated Production Planning and Scheduling**

7 **Integrated Quality Inspection and Production Control**

8 **Intra-Plant Material Handling**

9 **AI/ML for Process Optimization and Production Efficiency**

10 **Automated Material Handling for EoL Activities**

### Top 3 Prioritized Use Cases

#### Automating Enterprise Processes Using RPAs

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics
- Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

#### Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

- In this industry, it is essential to address the complexities of vast supply chains, to ensure on-time procurement and reduced operational inefficiencies
- Further, it allows the company to swiftly adapt to dynamic market conditions and regulatory demands, thus, safeguarding production continuity and compliance

#### IT/OT Integration for Centralized Monitoring and Control of Production

- Rubber and plastics sector is often characterized by complex processes, diverse equipment, and a critical requirement for precision and quality
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

### Additional Recommended Use Cases

#### Integrated Quality Inspection and Production Control

- As plastics production is underway, varying factors, such as temperature, pressure, and material flow rates can influence the final product quality
- AI/ML models can continuously monitor these variables, making real-time adjustments to ensure the end product meets the desired specifications without manual intervention

#### Intra-Plant Material Handling

- The plastics sector involves a plethora of resins, additives, and colorants. Efficient material handling guarantees the prompt delivery of raw materials to the production lines, ensuring continuous operations and reducing waiting times
- Moreover, AMRs/AGVs can operate continuously without fatigue, ensuring uninterrupted material supply

#### AI/ML for Process Optimization and Production Efficiency

- Given the diverse range of products in plastics, AI/ML algorithms can determine the best sequence for production
- This results in reduced setup times and minimized transition wastage, thereby maximizing throughput

# Details on the Prioritized Industry 4.0 Use Cases

## 1 INTEGRATED QUALITY INSPECTION AND PRODUCTION CONTROL

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| IT/OT Integration, Computer Vision, Sensors | Quality Management | Quality Cost ↓ 10-20% |

**Realized Benefits**

- Early warning systems enable proactive quality interventions
- Yield increase in golden batch identification facilitates idea process quality parameters
- Integration with vision-based systems aids in the identification of deformities and defects

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## 2 INTRA-PLANT MATERIAL HANDLING

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| Autonomous Guided Vehicle | Warehouse Management | Productivity ↑ 15-30% |

**Realized Benefits**

- Efficient and cost-effective material movement
- On-time delivery to feeder lines with pallets, and boxes, among other items
- Improved safety and enhanced manual handling

**Pre-requisites for Success**

- Assessment of environmental feasibility includes evaluating flat surfaces for temperature and humidity
- Pre-decided transport volumes
- Ensure marked navigation lanes

## 3 AI/ML FOR PROCESS OPTIMIZATION AND PRODUCTION EFFICIENCY

| I4.0 Technologies | Value Chain | Impact |
|---|---|---|
| Industrial IoT, Predictive Analytics | Production Execution | Factory Output ↑ 10-30% |

**Realized Benefits**

- Enhanced scrap reduction through golden batch identification
- Optimized injection molding process efficiency through AI
- Ensured adherence to compliance specific parameters

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# Specialty Plastics - Reactive to Proactive Maintenance Journey

## Project Overview

Specialty plastics manufacturer for energy supply, oil and water pipeline projects:

- Bring transparency for critical operating processes – LDPE (Low Density Polyethylene)
- Unplanned downtimes due to critical equipment failure - hyper compressor
- Risk of meeting customer order fulfillments
- Impact on profitability decline for an industry with tight margins
- Need for a proactive warning system for condition-based maintenance

## Project's Benefits

**48 days** of advance notice for packing seal failure

**27 days of notice** for central valve problem

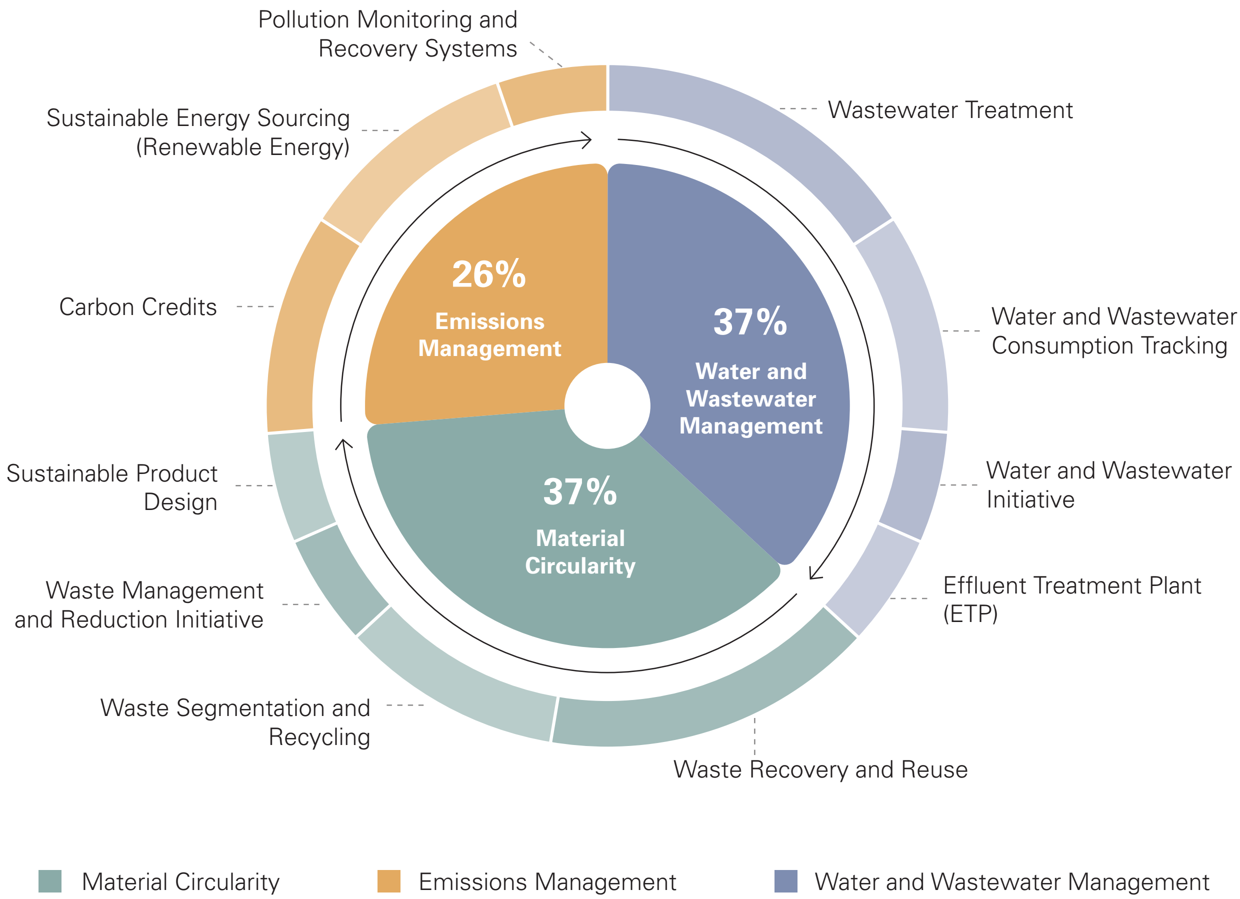
- Better planned maintenance needs
- Reduced maintenance costs

## Transformation Journey

**Maintenance**

- Deployed predictive maintenance solution
- Enabled top two failure modes - packing seal and central valve issues
- Related packing seal hypothesis with startup and shut down
- Shutdown of central valve degradation in milliseconds
- False positive elimination of predicting maintenance needs kept at bay
- Helped staff to be better prepared with early alerts generated
- Rollout to multiple similar assets across plants in pipeline

# Sustainability Initiatives across Rubber and Plastics Sector




## Key Insights

| | |
|---|---|
| **Healthy Focus on All Sustainable Initiatives** | ▪ For the rubber and plastics sector, sustainability-related initiatives occur across dimensions, with a larger focus (~37% each) towards material circularity, and water and wastewater management. Recycling rubber and plastics is highly important as it reflects non-biodegradable waste management, which requires material circularity initiatives along with water and wastewater management |
| **Emissions Management** | ▪ For emissions management, ~40% of the initiatives are related to renewable energy sources, primarily using solar energy and conventional sources to reduce $CO_2$ emissions as a result of the initiative<br>▪ While initiatives, such as pollution monitoring and recovery systems, are being focused, carbon credits (~40%) is seen as an additional prioritized initiative to reduce emissions footprint |
| **Water and Wastewater Management** | ▪ 43% of the water and wastewater management initiatives pertain to on-site wastewater treatment facilities and 100% of the water is recycled in plant |
| **Material Circularity** | ▪ While initiatives, such as waste segmentation and recycling, have been identified, waste recovery and reuse (43%) account for the largest share |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** Both rubber and plastic products often require heating to specific temperatures to be molded into desired shapes, consuming significant amounts of energy | **Thermal Management System Using Predictive Analytics** | ▪ Thermal management systems are utilized to regulate the temperature of molds and machines, enhancing performance and longevity<br>▪ Predictive molds can assist in anticipating the thermal needs of molds and machines, allowing for adjustments in heating and cooling accordingly<br>▪ Real-time anomaly detection can aid in making decisions to ensure quality control | ↓ **Energy Consumption** |
| | **Renewable Energy Sources to Offset Reliance on Conventional Consumption** | ▪ Optimize yield per panel by AI-driven tilt control of panel, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panel based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | ↓ **GHG Emission – Scope 2** |
| **2** During the production process, there are inevitable offcuts, defects, or rejected items that do not meet quality standards, resulting in large quantities of material waste | **Advanced Recycling and Closed-Loop Production** | ▪ Computer vision-based sorting can assist in differentiation of high-quality and low-quality plastics<br>▪ 3D manufacturing allows for the reuse of waste/scrap in the production of new parts or products<br>▪ AI plays a crucial role in the quality control of recycled materials being shipped to customers | ↑ **Effective Reutilization of Material Wastes** |

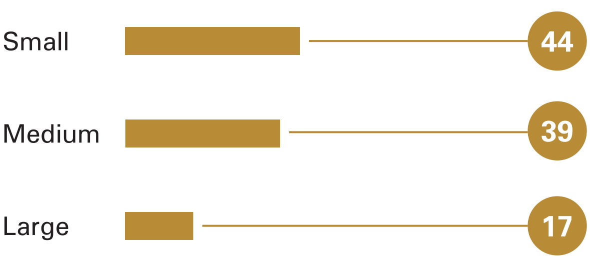
Impact of Sustainability: Material Circularity Water and Wastewater Management Emissions Management

Sector Focus

# MACHINERY AND EQUIPMENT

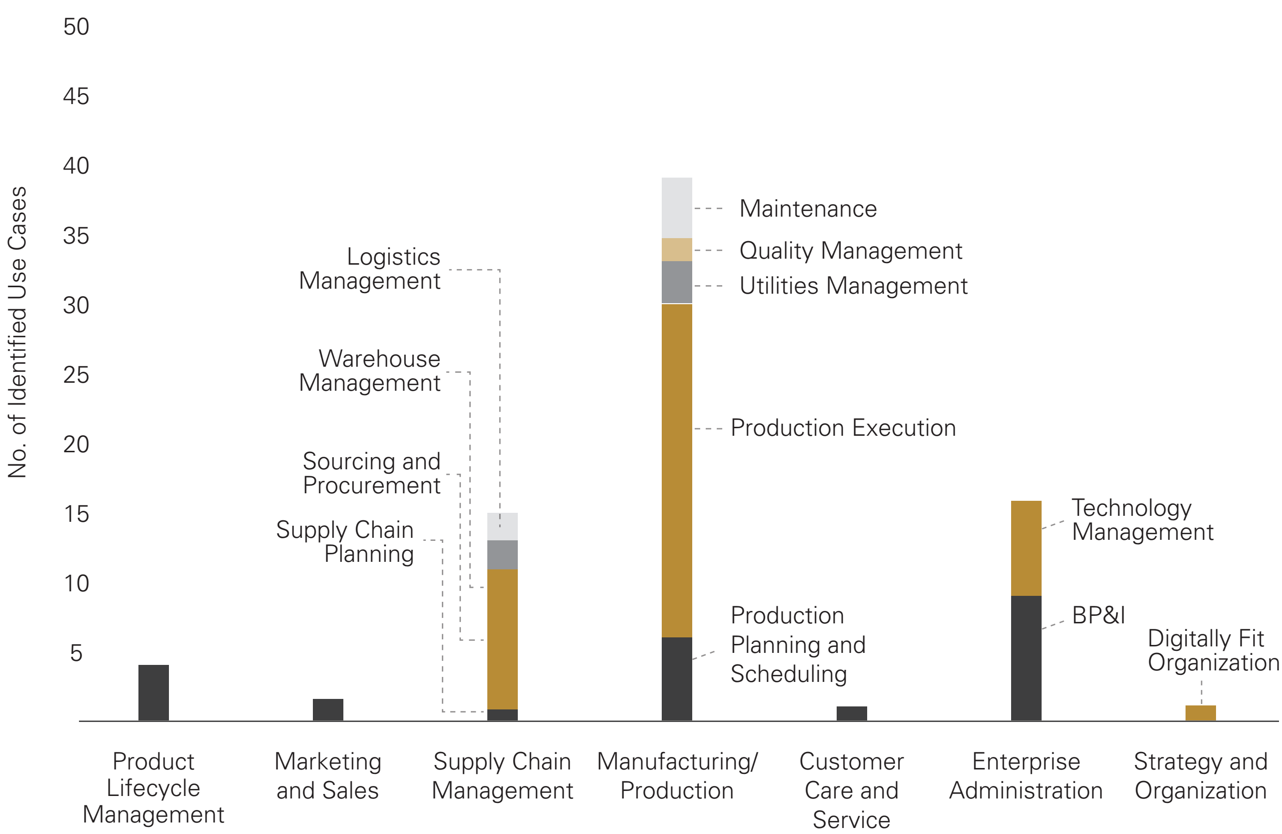
## Overview

### Manufacturer Size Distribution (%)




Machinery and equipment sector has currently implemented 23% of I4.0 Use Cases, with the potential to reach ~65% in the near future

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the machinery and equipment products sector mostly comprises small and medium-sized companies
- Use Cases revealed are skewed towards production execution, business process and intelligence, and sourcing and procurement

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1. Automating Enterprise Processes Using RPAs
2. Supplier Integration for Automated Procure-to-Pay (P2P) Workflows
3. IT/OT Integration for Centralized Monitoring and Control of Production
4. Integrated and Automated Production Planning and Scheduling
5. Predictive Maintenance
6. AI-based Product Pricing Tool
7. Robotics for Automated Assembly Line Activities
8. Advanced Analytics for Optimized Shopfloor Operations
9. Energy and Utility Optimization
10. Digital Twin for Simulated Product Design

### Top 3 Prioritized Use Cases

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics
- Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- It is essential to address the complexities of vast supply chains, ensuring on-time procurement and reduced operational inefficiencies
- Allows the company to swiftly adapt to dynamic market conditions and regulatory demands, safeguarding production continuity and compliance

**IT/OT Integration for Centralized Monitoring and Control of Production**

- Machinery and equipment sector is often characterized by complex processes, diverse equipment, and a critical requirement for precision and quality
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

### Additional Recommended Use Cases

**Integrated and Automated Production Planning and Scheduling**

- The high variant nature of production can lead to frequent changes, making manual scheduling inflexible and prone to errors
- An integrated and automated production planning and scheduling system swiftly adapts to changes, ensuring optimal equipment and resource allocation for each variant

**Robotics for Automated Assembly Line Activities**

- As demand fluctuates, manufacturing plants may need to adjust production volumes, and robots can easily scale operations up or down. Additionally, they can be reprogrammed for different tasks
- Furthermore, machinery components often require meticulous assembly with tight tolerances. Robots can ensure precise and consistent assembly, reducing the likelihood of defects and rework

# Details on the Prioritized Industry 4.0 Use Cases

## 1 SUPPLIER INTEGRATION FOR AUTOMATED PROCURE-TO-PAY (P2P) WORKFLOWS

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Electronic Data Exchange (EDI) | Sourcing and Procurement | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Increases visibility of raw materials and vendor selection
- Optimizes purchasing routes and processes
- Evaluates supply chain scenarios and maintains vendor performance metrics

**Pre-requisites for Success**

- Seamless integration with supplier systems, including EDI
- Availability of transactional ERP data, especially shipping routes, for a minimum of 3 years
- Robust training and support infrastructure for stakeholders and vendors

## 2 INTEGRATED AND AUTOMATED PRODUCTION PLANNING AND SCHEDULING

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Digital Tools and Platforms, AI/ML | Production Planning and Scheduling | On-Time-in-Full | ↑ 20-30% |

**Realized Benefits**

- Simplifies responses to market fluctuations through optimized realistic production schedules
- Provides scenario risk analysis for constraints related to human, machine, market fluctuation availability/issues
- Reduces inventory levels and waste, and ensures on-time delivery, based on profitability and urgency

**Pre-requisites for Success**

- Clear understanding of human and material resources
- Integrations with ERP, workforce management systems
- Incorporation of machines for availability information

## 3 ROBOTICS FOR AUTOMATED ASSEMBLY LINE ACTIVITIES

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Robotics and Automation | Production Execution | Factory Output | ↑ 10-30% |

**Realized Benefits**

- Increased production efficiency and quality
- Customized to be reconfigurable, flexible, and scalable to accommodate changes in demand or manufacturing process
- Redeployed workforce and increased efficiency

**Pre-requisites for Success**

- Prioritize high impact areas for automation, enabling competitive advantage/ROI
- Determine control systems and software
- Ensure compliance with regulations and safety standards

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# Sany's Factory – WEF's First Heavy Machinery Lighthouse

## Project Overview

- Managing multi-variant low volume production
- Upgrading technology
- Ensuring intelligent operations
- Scaling up to 40+ sites

## Transformation Journey

**Production Execution**

- Upgraded 9 manufacturing processes and 32 typical production scenarios
- Enabled track and trace through unique ID

**I 4.0 Tech**

- 1,540 sensors and 20 fully networked robots
- 340 TB of data generated
- AI robots with 3D visualization for cutting and sorting steel plates

**Intelligent Storage System**

- AR glasses-based pick list
- Speech recognition technology, aiding hands-free operation of workers
- 5G-enabled AGV

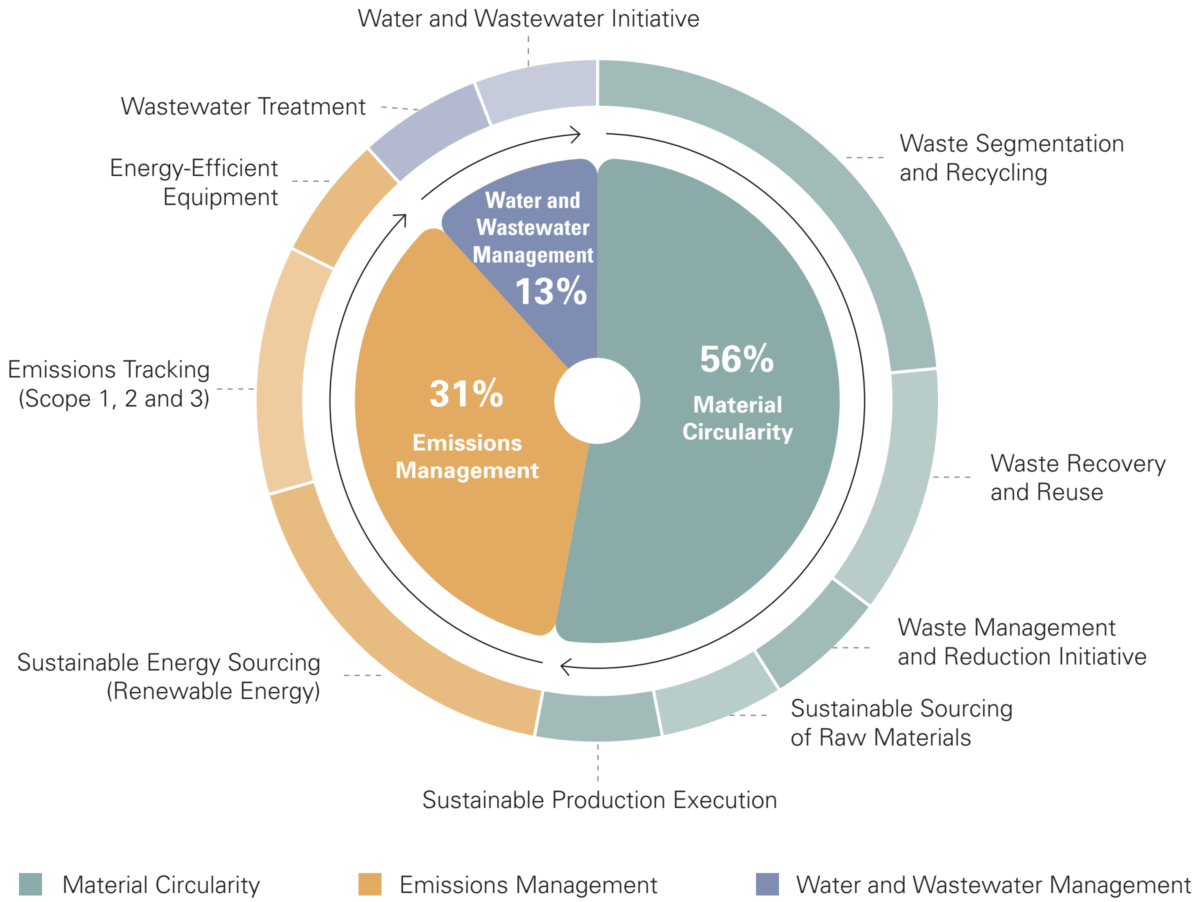
## Project's Benefits

**60% process** time reduced

**73% changeover** time reduced

- 44% rise in production capacity
- 80% increase in output
- 11% growth in delivery rate

# Sustainability Initiatives across Machinery and Equipment Sector




## Key Insights

| | |
|---|---|
| **Healthy Mix of Initiatives under Material Circularity** | ▪ For the machinery and equipment sector, sustainability-related initiatives occur across dimensions, with a larger focus (~56%) on material circularity. Managing asset lifespans of machinery and retaining useful parts before scrapping is a key characteristic of this sector |
| **Material Circularity** | ▪ Waste segmentation and recycling, with a 44% share within material circularity, is a prioritized initiative, primarily recycling papers, used oils and excess steel<br>▪ Other initiatives comprise waste recovery and reuse, and sustainable production execution |
| **Emissions Management** | ▪ Other than emissions tracking as a focus, renewable energy sourcing accounts for the largest share (~50%), which typically comprise usage of solar energy |
| **Water and Wastewater Management** | ▪ 64% of the water and wastewater management initiatives pertain to on-site wastewater treatment facilities, where treated and recycled water is reused in production |

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| **1** The manufacturing processes in this sector often require significant energy, especially in processes, such as forging, welding, and machining, as inefficient or outdated machinery can lead to overspent energy. | **Predictive Maintenance for Optimized Machine Runtime and Energy Consumption** | ▪ Predicts maintenance needs proactively for assets before reaching complete failure, eliminating the need for manual sensory methods, such as agitators, chillers, and pulverizers<br>▪ Reduces unplanned downtime of critical machines, enhancing reliability, and ensuring optimal energy consumption<br>▪ Aids in identifying the optimal repair or replacement through Remaining Useful Life (RUL) prediction | ↓ **Reduced Energy Consumption** |
| | **Renewable Energy Sources to Offset Reliance on Conventional Consumption** | ▪ Optimize yield per panel by AI-driven tilt control of panel, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panels based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | ↓ **GHG Emission – Scope 2** |
| **2** The machinery and equipment sector is inherently resource-intensive from a raw materials perspective, relying heavily on various metals, plastics, and other materials. | **Sustainable and Ethical Sourcing of Raw Materials** | ▪ Horizontal integration enhances visibility into supplier sources, processes, and quality mandates, facilitating regulatory adherence<br>▪ Use of AI to identify local or optimized routes to procure materials<br>▪ Blockchain-based tracking of supply chain can also be enabled to ensure authenticated and ethical sourcing of raw materials | ↓ **GHG Emission – Scope 3** |
| **3** Machinery and equipment have finite operational lifespans. After their useful life, these items become waste, leading to disposal challenges. | **Reverse Logistics for Recovery, Reuse and Recycle of End Products** | ▪ AI-based tracking of returns due to complaints involves making decisions on whether to repair, scrap, or reuse items, and taking actions to prevent similar issues in the future<br>▪ AI-based route optimization for collecting returns, ensuring shipping costs are managed without compromising the value of the return<br>▪ Blockchain and smart tagging options can ensure minimizing returns by authenticating counterfeit products or fake complaints | ↑ **Material Circularity** |

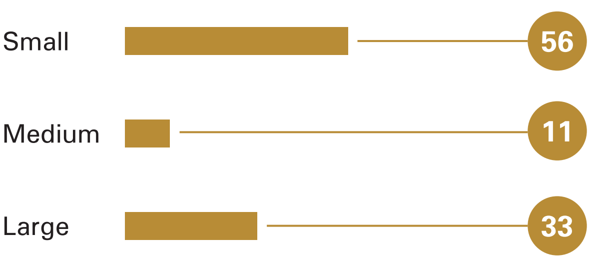
Impact of Sustainability: Material Circularity  Water and Wastewater Management  $CO_2$ Emissions Management

Sector Focus

# BUILDING MATERIALS

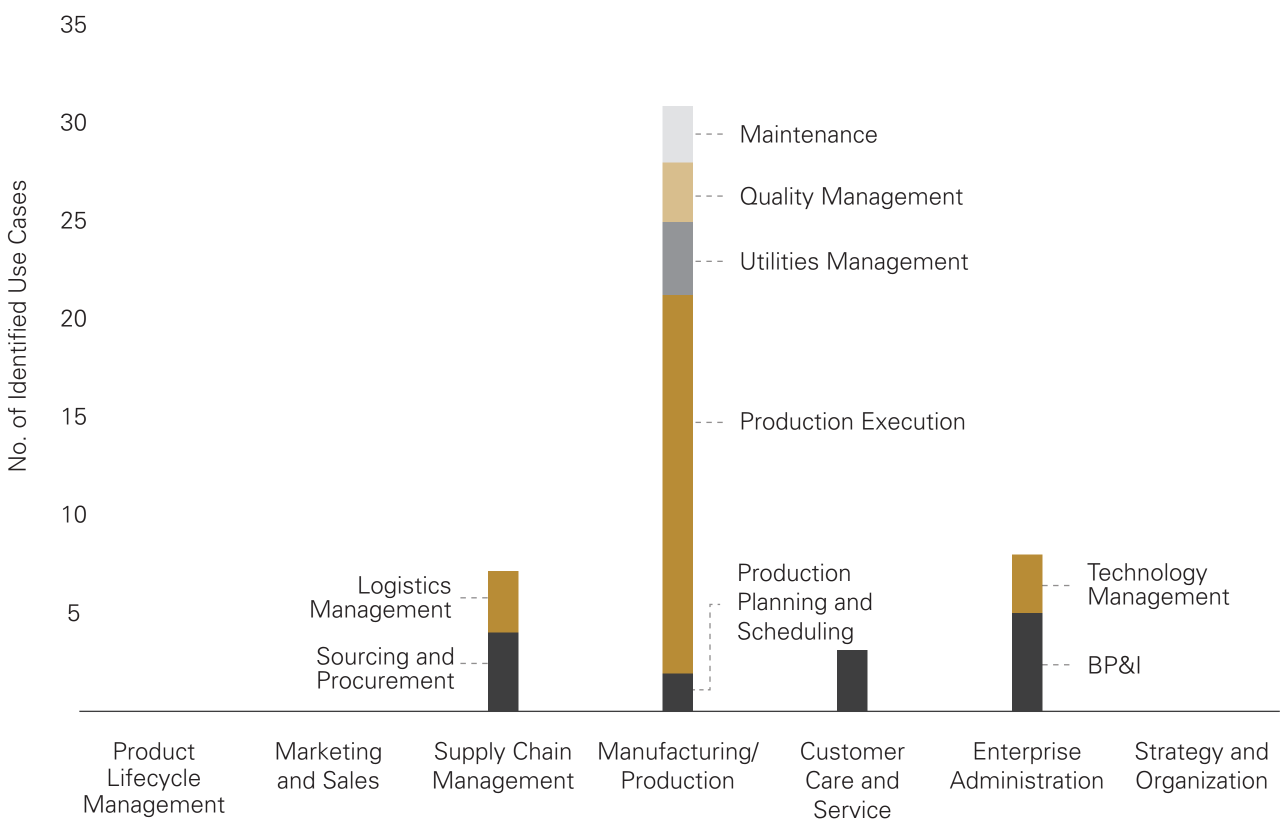
## Overview

### Manufacturer Size Distribution (%)




Building materials sector has currently implemented 25% of I4.0 Use Cases and is estimated to reach ~90%, owing to major deployment across production execution

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the building materials sector mostly comprises small and large-sized companies
- Use Cases revealed are skewed primarily towards production execution

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1 IT/OT Integration for Centralized Monitoring and Control of Production

2 Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

3 Predictive Maintenance

4 Automating Enterprise Processes Using RPAs

5 Energy and Utility Optimization

6 Integrated Quality Inspection and Production Control

7 Customer Integration for Automated Logistics Workflows

8 Fleet Management and Route Optimization

9 Integrated and Automated Production Planning and Scheduling

10 Digital Twin for Production Simulation and Optimization

### Top 3 Prioritized Use Cases

**IT/OT Integration for Centralized Monitoring and Control of Production**

- This manufacturing is often characterized by complex processes, diverse equipment with multiple data formats that could either be legacy or state-of-the-art
- There is a pressing need for precision and quality
- Managing these demands without a unified system can lead to inefficiencies, inconsistencies, and increased risks

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- In this industry, it is essential to address the complexities of vast supply chains, ensuring on-time procurement and reduced operational inefficiencies
- Allowing the company to swiftly adapt to dynamic market conditions and regulatory demands, thus safeguarding production continuity and compliance

**Predictive Maintenance**

- It is imperative to ensure that continuous line operations of critical shopfloor machinery (as well as supporting utilities) are not hindered owing to unexpected downtime due to mechanical fault
- Predictive maintenance of such machinery can ensure long-term resilience

### Additional Recommended Use Cases

**Energy and Utility Optimization**

- The cement industry is one of the major energy consumers and $CO_2$ emitters
- By integrating IT and OT, plants can better manage energy consumption and emissions, ensuring compliance with environmental regulations and optimized energy costs

**Integrated Quality Inspection and Production Control**

- Anomalies in the raw materials or production process can lead to off-spec cement
- By integrating quality inspection with production control, plants can make real-time adjustments to the process, ensuring consistent output and reduced wastage

**Digital Twin for Production Simulation and Optimization**

- Cement production involves multi-faceted processes with interdependent stages
- Digital twin offers real-time, virtual representation of the physical production system, allowing operators to visualize process flows, equipment status, and production bottlenecks

# Details on the Prioritized Industry 4.0 Use Cases

## 1 ENERGY AND UTILITY OPTIMIZATION

| I4.0 Technologies | Value Chain | Impact |
| --- | --- | --- |
| Industrial IoT, Predictive Analytics | Production Execution | Energy Savings ↑ 5-20% |

**Realized Benefits**

- Uncovers and addresses hidden inefficiencies in energy usage
- Targets most energy-intensive processes, such as clinker production/pyroprocessing, furnaces, and grinders
- Uses AI/ML benchmarks to compare and optimize asset performance and production, and forecasts energy needs based on hybrid sources

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Installation of energy meters at the line or asset level for detailed consumption tracking
- Seamless access to energy management systems (EMS) and building management systems (BMS)

## 2 INTEGRATED QUALITY INSPECTION AND PRODUCTION CONTROL

| I4.0 Technologies | Value Chain | Impact |
| --- | --- | --- |
| IT/OT Integration, AI/ML, Computer Vision, Sensors | Quality Management | Quality Cost ↓ 10-20% |

**Realized Benefits**

- Predictive quality models can ensure accurate quality forecasts at points in production processes
- Ensures an increase in yield through the identification of the golden batch/chemical mix, facilitating ideal process quality parameters
- Establishes monitoring of perishables or time-sensitive materials, such as ready-mix

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## 3 DIGITAL TWIN FOR PRODUCTION SIMULATION AND OPTIMIZATION

| I4.0 Technologies | Value Chain | Impact |
| --- | --- | --- |
| Industrial IoT, AI/ML, 3D Visualization, AR/VR | Production Execution | Time-to-Market ↑ Up to 30% |

**Realized Benefits**

- Consolidates diverse data systems for streamlined insights
- Simulates hazardous or widely dispersed assets/scenarios, reducing operator safety risks and minimizing wastages
- Boosts production yield using AI insights and scales best practices across operations

**Pre-requisites for Success**

- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# CEMEX - Industry 4.0 Initiatives


## Project Overview

- Rise in digital innovation in the motion ecosystem
- Increase in customer centricity
- Accelerate decarbonization
- Enhance manufacturing efficiency

## Transformation Journey

**AI-based Planning and Scheduling**

- Dynamic fleet optimization considering traffic conditions, distance to batching, and customer locations
- Predictive demand sensing for ready-mix customers

**Horizontal Integration**

- Cemex GO platform
- Predict order cancellations
- Forecast reschedules based on cancellation
- Optimize delivery and production capacity

**Ball Mill Performance**

- Ball mill performance prediction model
- Controlled operating levers, primarily material feeding speed, separator moving speed, and fan speed
- Energy efficiency improvement

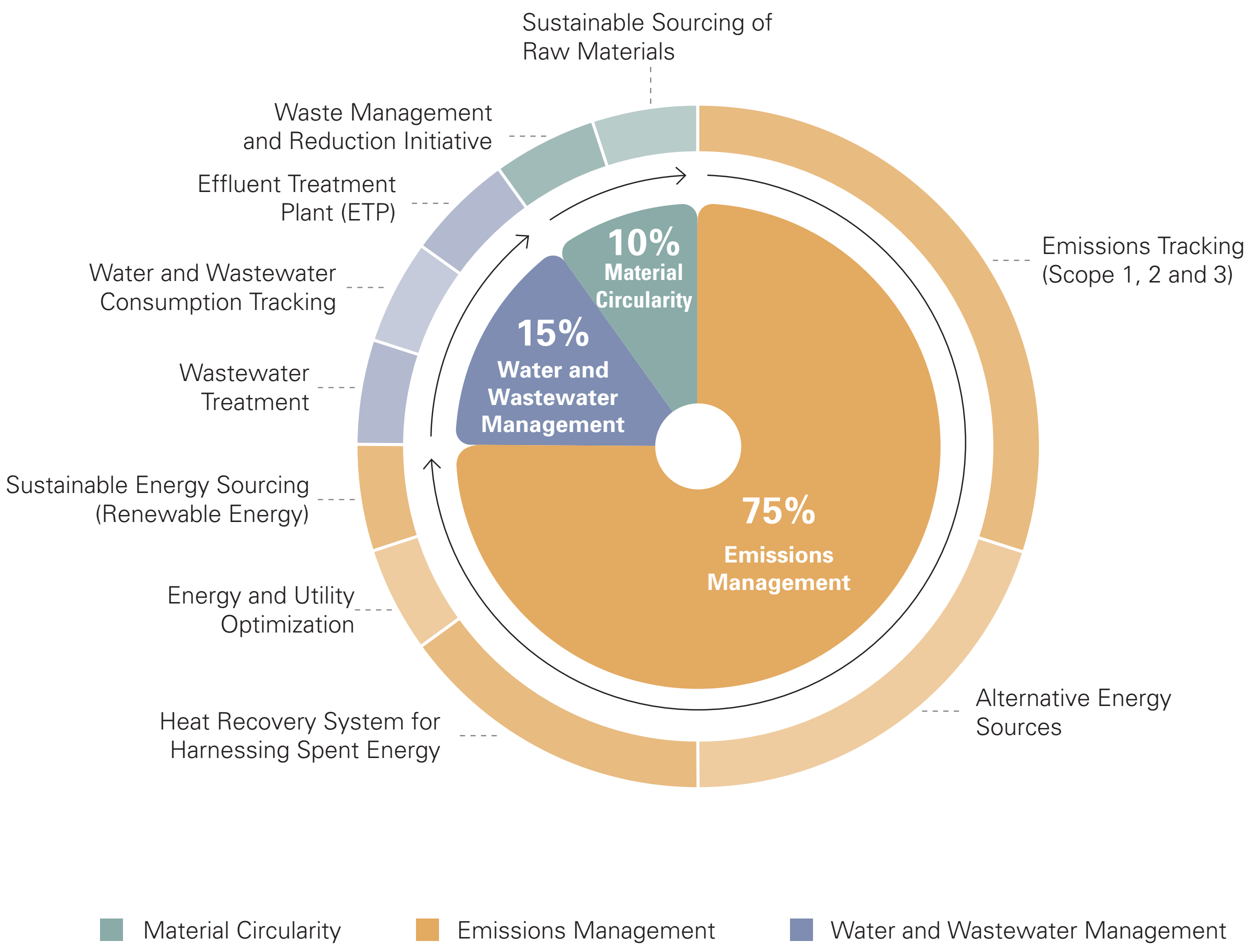
## Project's Benefits

**50,0000+ Customers** on Cemex Go

Estimates **~ 367.2 Mn AED** savings from next generation service contracts and internal delivery transformation

- 50% increase in net promoter score
- Enhancement in cement yield quality

# Sustainability Initiatives across Building Materials Sector




## Key Insights

| | |
|---|---|
| **Majority Focus on the Direction of Emissions Management** | ▪ For the building materials sector, sustainability-related initiatives occur across dimensions, with a larger focus (~75%) on emissions management. The manufacturing of building materials, such as cement, is highly carbon intensive with large particulate matter emissions; this pushes the industry to primarily focus on emissions management |
| **Emissions Management** | ▪ For emissions management, ~40% of the initiatives are related to tracking their Scope 1 and 2 emissions, and in some cases seeking disclosure on supplier environmental footprint as part of their Scope 3 awareness<br>▪ While primary focus is on initiatives, such as heat recovery system, for harnessing spent energy, using alternate energy sources (~27%) is the next prioritized initiative by implementing waste-to-energy program |
| **Water and Wastewater Management** | ▪ Initiatives related to wastewater consumption tracking and onsite treatment of wastewater through ETPs are being prioritized |
| **Material Circularity** | ▪ Sustainable sourcing of raw materials, and waste management and reduction (50% each) account for the top initiatives |

Sector Focus

# PAPER

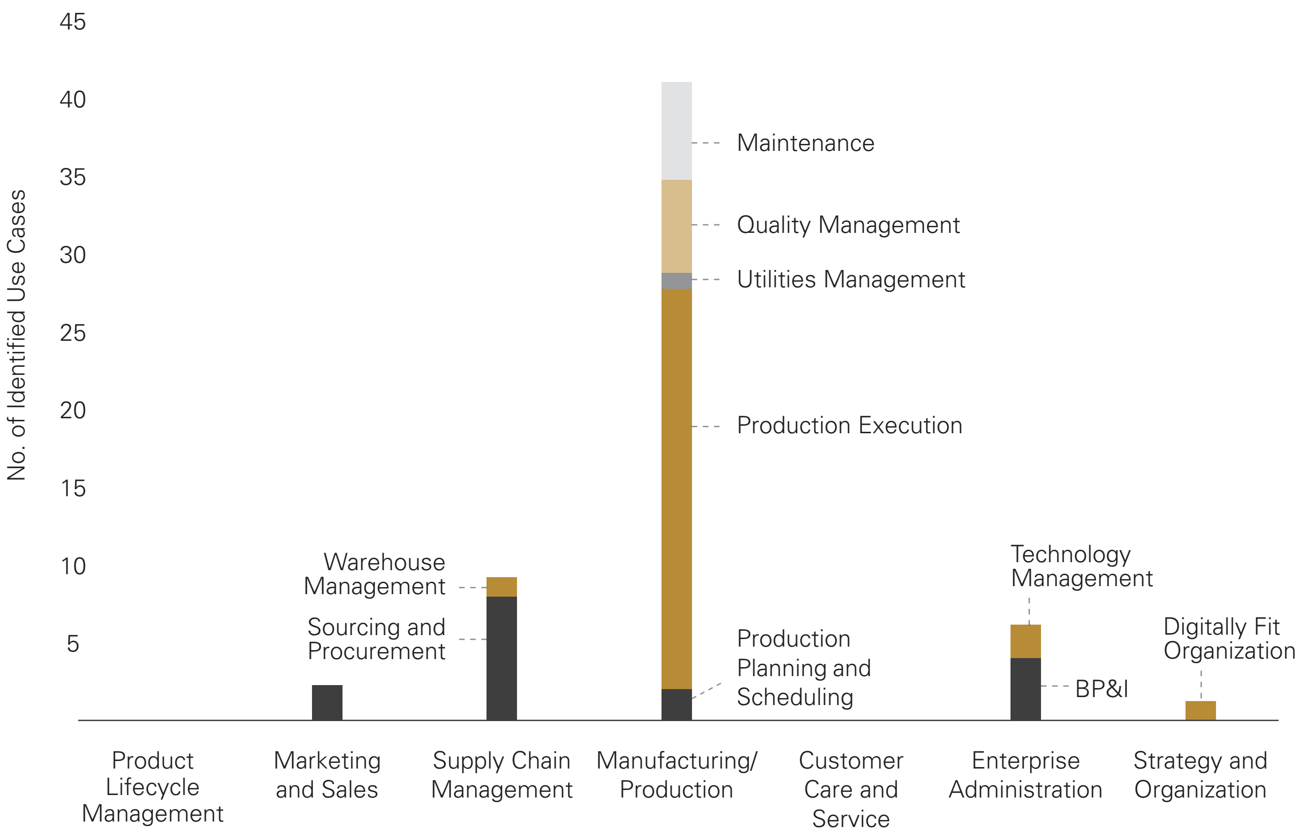
## Overview

### Manufacturer Size Distribution (%)

| | |
|---|---|
| Small | 50 |
| Medium | 25 |
| Large | 25 |

This sector has a lot of scope for deploying I4.0 Use Cases across plants with a potential to reach 70% implementation

### Distribution of Use Cases Identified across Manufacturing Dimensions




- The sample size of the paper sector comprises a good mix of all sized companies
- Use Cases revealed are skewed towards production execution, and sourcing management

# Prioritized Use Cases Targeting Business Critical Imperatives

## List of Prioritized Use Cases

1 Supplier Integration for Automated Procure-to-Pay (P2P) Workflows

2 Automating Enterprise Processes Using RPAs

3 IT/OT Integration for Centralized Monitoring and Control of Production

4 Intra-Plant Material Handling

5 AI/ML for Process Optimization and Production Efficiency

6 Predictive Maintenance

7 Integrated Quality Inspection and Production Control

8 Energy and Utility Optimization

### Top 3 Prioritized Use Cases

**Supplier Integration for Automated Procure-to-Pay (P2P) Workflows**

- It is essential to address the complexities of vast supply chains, ensuring on-time procurement and reduced operational inefficiencies
- Allowing the company to swiftly adapt to dynamic market conditions and regulatory demands, safeguarding production continuity and compliance

**Automating Enterprise Processes Using RPAs**

- At an enterprise level, RPA streamlines operations across departments, enabling a cohesive and agile response to market dynamics. Additionally, with numerous product variants, inventory management becomes complex
- RPA ensures accurate tracking, ordering, and usage of materials specific to each product variant

**IT/OT Integration for Centralized Monitoring and Control of Production**

- Paper manufacturing is a continuous process where minute changes can impact product quality
- Integrating IT and OT allows for instantaneous data gathering from machinery (OT) to be processed and analyzed by IT systems, enabling timely decisions and adjustments

### Additional Recommended Use Cases

**AI/ML for Process Optimization and Production Efficiency**

- Paper production is energy-intensive, especially in processes, such as pulping and drying
- Optimizing energy use not only reduces operational costs but also decreases environmental footprints. Similarly, concerning water, the paper manufacturing process heavily relies on water

**Predictive Maintenance**

- Paper manufacturing operations are continuous and capital-intensive
- By recognizing wear and tear trends or performance anomalies early, predictive maintenance ensures assets are serviced or replaced just in time, maximizing their operational lifespan and ROI (Return on Investment)

# Details on the Prioritized Industry 4.0 Use Cases

## 1 IT/OT INTEGRATION FOR CENTRALIZED MONITORING AND CONTROL OF PRODUCTION

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| IT/OT Integration | Production Execution | Factory Output | ↑ 10-30% |

**Realized Benefits**

- Enhances visibility of shopfloor legacy assets/controllers
- Enables data availability for analytics and other performance monitoring applications
- Integrates shopfloor and top-floor systems, enabling strategic business decisions

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## 2 PREDICTIVE MAINTENANCE

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Industrial IoT, Predictive Analytics | Maintenance | Operating Cost | ↓ 18-25% |

**Realized Benefits**

- Predicts asset maintenance proactively prior to complete failure by employing either manual sensory methods, such as pumps and centrifuges, or automated systems
- Reduces unplanned downtime of critical machines, such as Yankee dryers
- Helps identify the optimal repair or replace through Remaining Useful Life (RUL) prediction

**Pre-requisites for Success**

- Quality data availability of 4-12 months depending on use case
- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

## 3 AI/ML FOR PROCESS OPTIMIZATION AND PRODUCTION EFFICIENCY

| I4.0 Technologies | Value Chain | Impact | |
|---|---|---|---|
| Industrial IoT, Predictive Analytics | Production Execution | Factory Output | ↑ 10-30% |

**Realized Benefits**

- Proactive identification of set points to avoid pulp quality deviations
- Scrap reduction through ideal GSM compliance
- Ensures an increase in yield through the identification of the golden batch/chemical mix, facilitating ideal process quality parameters

**Pre-requisites for Success**

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

*Impact ranges have been leveraged from multiple credible sources, such as WEF, McKinsey and other global tech-providers — PTC, GE, Accenture, and TCS

Case Study

# Essity – Remote Critical Asset Health

## Project Overview

- Multi-site rollout in 14 countries
- Eliminate silo between maintenance and operations
- Enable remote maintenance
- Reduce manufacturing costs
- Increase critical machinery uptime

## Transformation Journey

**Predictive Maintenance**

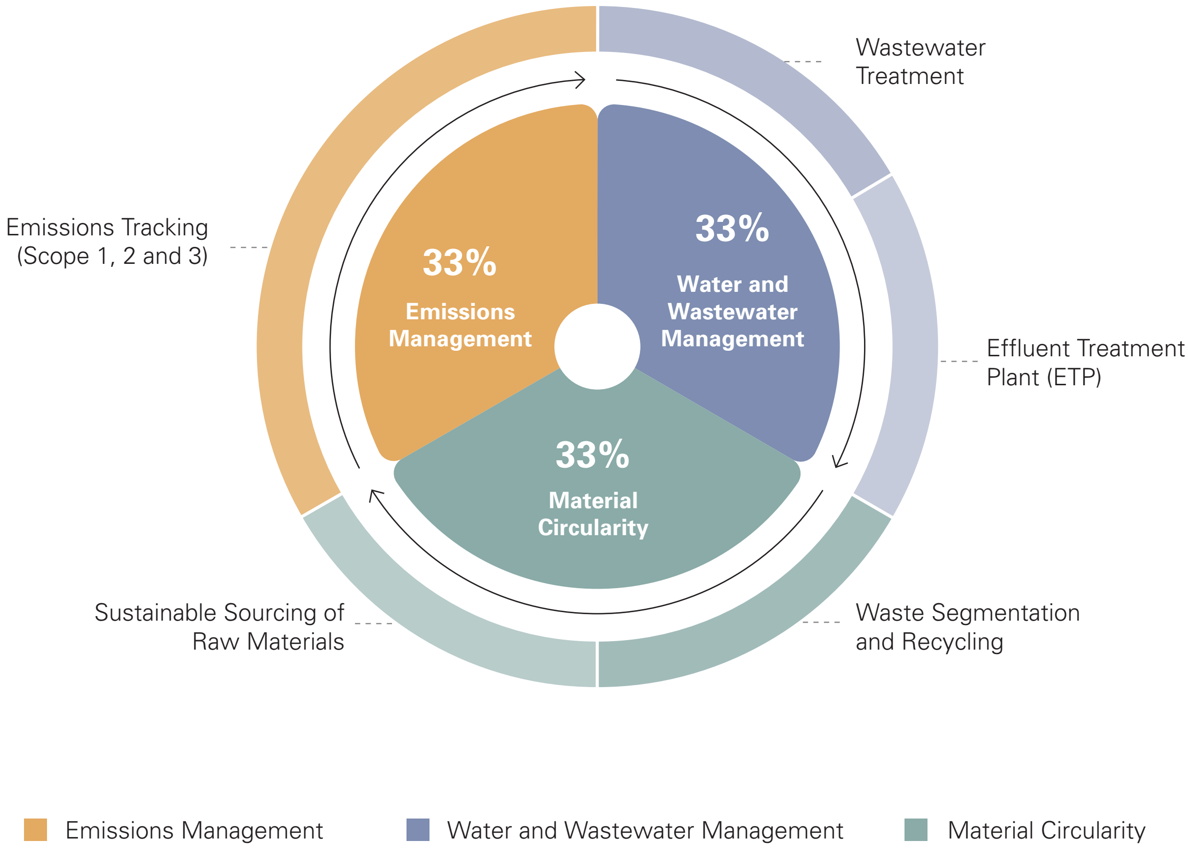
- Remote alerts on Yankee gearbox
- Oil pressure and temperature thresholds breached in four gear boxes predicted by AI
- Lubricant spray bar has been clogged
- Remote team alerted onsite team to fix the issue on-time
- Solution extended to 30+ sites pre-Covid-19 pandemic
- Savings of unplanned downtime and repair costs

## Project's Benefits

**~ 84.5 Mn AED saving**
from downtime reduction

- ROI in 6 months
- 10,000+ actionable insights

# Sustainability Initiatives across Paper Sector




## Key Insights

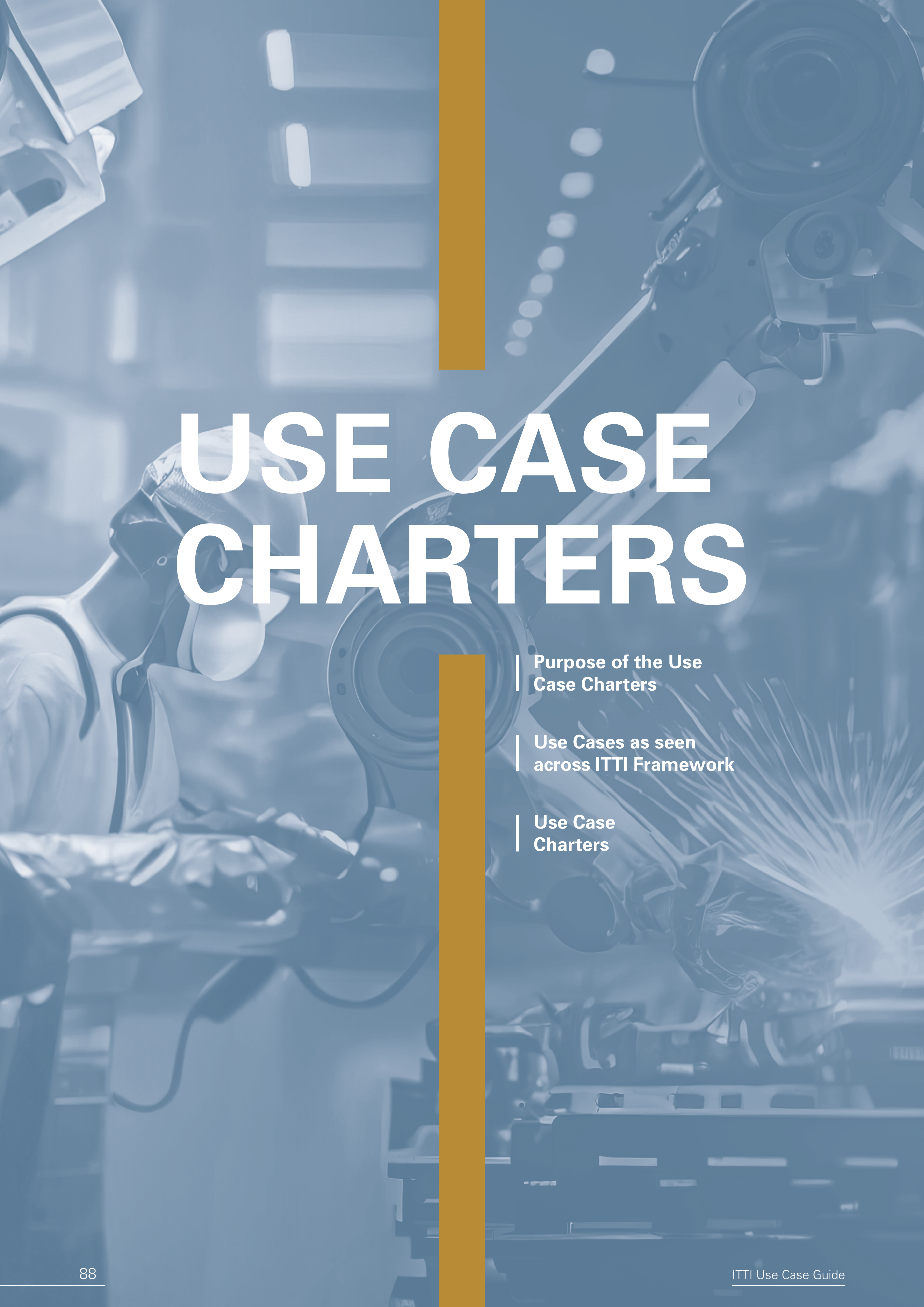
| | |
|---|---|
| **Healthy Focus on All Sustainability Initiatives** | ▪ For the paper sector, sustainability-related initiatives occur across dimensions, with a larger focus (~33%) on emissions management. Paper industry is driven by fast-depleting raw materials dependent on forests, high energy needs, and water intensive processes for its conversion, which necessitates an undivided focus across these three dimensions |
| **Emissions Management** | ▪ For emissions management, tracking and monitoring of Scope 1 and 2 emissions are priority, with the aim to reduce energy consumption in operations |
| **Water and Wastewater Management** | ▪ Top water and wastewater management initiatives pertain to onsite wastewater treatment and ETP facilities, where wastewater is treated, recycled, and reused |
| **Material Circularity** | ▪ Initiatives, such as sustainable sourcing of raw materials, and waste segmentation and recycling are the key focus areas driving this dimension |

*Figures presented are approximate and rounded to the nearest numbers

# Recommended Sustainability Initiatives Driven by Industry 4.0 Technologies

| Sustainability-related Opportunities | Recommended Initiatives | Role of I4.0 Tech | Impact |
|---|---|---|---|
| 1 Beyond the sheer volume of water used, the process can result in wastewater that contains organic pollutants, chlorinated compounds, and other contaminants. | **AI/ML Water Management Systems for Optimized Production** | ▪ Historical data from sensorized plant to trace water consumption needs and optimize most efficient operating set points<br>▪ Auto-closed edge AI driving alerts and controls for leaks in valves/water circuits<br>▪ AI selection of water source (well/supply water/ treated rainwater) based on cost and availability | ↓ **Reduced Water Consumption** |
| | **Wastewater Treatment Optimization Using Artificial Intelligence (AI)** | ▪ Address varying water inputs through sensorized data collection<br>▪ Meet stringent regulatory standards for treated water, taste, odor and color through AI-based real-time decision support for treatment plant operators (for example BOD control in F&B)<br>▪ Adhere to water quality control for maintaining ambient conditions in plant, ensuring food texture/quality | ↑ **Optimized Recovery of Wastewater** |
| 2 The paper manufacturing process, especially the pulping and drying stages, consumes significant amounts of energy, powered mostly from traditional energy sources. | **AI/ML for Process Optimized Production Process Parameters** | ▪ Capture production data from MES/relevant system and energy consumption data per batch through energy meters<br>▪ Support asset level benchmark identification for optimal energy consumption through AI/ ML models<br>▪ Replicate set points or golden batch performance characteristics, ensuring energy-efficient operations | ↓ **Reduced Energy Consumption** |
| | **Renewable Energy Sources to Offset Reliance on Conventional Consumption** | ▪ Optimize yield per panel by AI-driven tilt control of panels, post installation of renewable technologies, such as solar panels<br>▪ AI-based maintenance of solar panels based on panel efficiency<br>▪ Hybrid power sourcing from the grid and solar by predicting solar yield in advance based on trends and weather data | ↓ **GHG Emission – Scope 2** |
| 3 Paper manufacturing traditionally relies on wood (a depleting raw material) as the primary raw material; as such, the sector faces pressure to source wood from sustainably managed forests and to offset this use through reforestation. | **Sustainable and Ethical Sourcing of Raw Materials** | ▪ Horizontal integration enhances visibility into supplier sources, processes, and quality mandates, facilitating regulatory adherence<br>▪ Use of AI to identify local or optimized routes to procure materials<br>▪ Blockchain-based tracking of supply chains can also be enabled to ensure authenticated and ethical sourcing of raw materials | ↑ **Material Circularity** |

Impact of Sustainability: Material Circularity | Water and Wastewater Management | Emissions Management



# USE CASE CHARTERS

Purpose of the Use Case Charters

Use Cases as seen across ITTI Framework

Use Case Charters

# Purpose of the Use Case Charters

## Addressing Key Challenges

At the very heart of the charter lies the problem statement, which succinctly captures the pain points faced by traditional manufacturing processes. By highlighting issues, such as inefficiencies, inconsistencies, and potential human errors, the charter offers a starting point for enterprises to recognize areas of improvement.

## Use Case Overview

The Use Case overview serves as a guide, detailing how the Industry 4.0 solutions can be integrated into operations to address prevalent challenges. The overview provides an expansion of the use case, and a succinct summary of what, where and why it would be implemented. Further, each use case is linked to respective ITTI dimension, as seen across Value Chain.

## Highlighting Essential Technologies and Skills

Embracing the promise of Industry 4.0 is contingent on understanding its technological foundation. The Charter elucidates this by outlining key technologies and skills pivotal to I4.0 integration. Whether it's harnessing data analytics, leveraging intelligent sensors, or exploring the realms of machine learning, the Charter ensures manufacturers are equipped with the knowledge to navigate the I4.0 ecosystem effectively.

## Targeting Relevant Stakeholders

The persona section of the Charter identifies the primary beneficiaries of the use case within an organization. By delineating the persona segment, the Charter emphasizes the cross-functional impact of I4.0, signifying its relevance to a broad array of organizational roles.

## Quantifying Benefits and Impact

The Charter goes beyond theoretical discourse by spotlighting the concrete benefits poised to be reaped from I4.0 integration. From operational cost savings and heightened efficiency to augmented customer experiences, the Charter sets clear expectations for manufacturers. Paired with a concise implementation timeline and a projection of anticipated productivity gains, the Charter offers a pragmatic view of the returns on I4.0 investments.

# Industry 4.0 Use Cases as seen across Value Chain within ITTI Framework

### R&D and Engineering

- Digital Twin for Simulated Product Design

### Marketing and Sales

- Customer Integration for Automated Logistics Workflow

### Supply Chain Management (Inbound)

- Supplier Integration for Automated Workflows
- Integrated and Automated Production Planning and Scheduling
- Material Traceability for Warehouse Operations
- Supply Chain Control Tower
- Fleet Management and Route Optimization

### Manufacturing/Production

- Intra-Plant Material Handling
- IT/OT Integration for Centralized Monitoring and Control
- Controller Virtualization
- Integrated and Automated Production Planning and Scheduling
- AI/ML for Process Optimization and Production Efficiency
- Integrated Quality Inspection and Production Control
- Predictive Maintenance for Shopfloor Machinery
- Digital Twin for Production Simulation and Optimization
- Robotics for Automated Assembly Line Activities
- Energy and Utility Optimization

### Customer Service

- Customer Integration for Automated Logistics Workflow

### Supply Chain Management (Outbound)

- Material Traceability for Warehouse Operations
- Integrated and Automated Production Planning and Scheduling
- Supply Chain Control Tower
- Fleet Management and Route Optimization

### Enterprise Administration

- Automating Enterprise Processes Using RPAs
- Enterprise Cybersecurity Measures

### Strategy and Organization

- I4.0 Capability Building (AR/VR)

### Sustainability

- Recycle and Reuse of Material Waste/Scrap Material
- Wastewater Treatment Optimization Using Artificial Intelligence (AI)

*These Use Cases have the potential to be implemented across sectors

# Automating Enterprise Processes Using RPAs

## Problem Statement

In traditional manufacturing and processing environments, manual documentation, data entry and reconciliation are often characterized by repetitive tasks, long hours, and potential human error, leading to inefficiencies and inconsistencies in workflows within the company and its supplier and customer network.

### Objectives

Reduce the reliance on labor for manual, repetitive and strenuous enterprise process activities

## Use Case Overview

Robotics Process Automation (RPA) streamlines processes and delivers the following benefits:

- **Automated Inventory Management:** Monitors inventory level and generates P. O.
- **Maintenance:** Triggers maintenance request based on machine issues
- **HR Functions:** Automates 'Hire to Retire' data entry processes
- **Customer Service:** Handles customer inquiries and complaints
- **Finance:** Manages invoice matching, data entry and approval routing
- **Data Base:** Analyzes and enables business reporting and decisions

## Core Skills

- RPA tool proficiency, for example UI path, Blue Prism
- Programing and scripting for automated workflows in RPA, for example, Python/ Java
- Process expertise/analysis

## Key Technologies

- **Process Mining:** Business process analysis-based prioritization
- **Bot Creation Tools:** To create BOTs and automate specific tasks
- **Plugins for Connecting to IT Systems:** ERP, CRM and databases
- Integrations with machine learning, natural language processing, and computer vision

## Benefits

- Improved staffing costs
- Increased productivity
- Enhanced customer experience
- Reduced human error
- Enhanced capacity for high-value work

## ITTI Dimension

**D13. Business Processes and Intelligence**

## Pre-requisites

- Proper process definitions prior to automation
- RPA trained resources with awareness of workflows

## Persona

- IT heads
- Finance and accounting heads
- Customer service department
- Logistics department

## Timeline

Up to **4** months

## Impact

Productivity: **15-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

RAK CERAMICS

SHARJAH CEMENT FACTORY

Lipton

# Supplier Integration for Automated Workflows

## Problem Statement

Integrations between suppliers carry the risk of redundant manual processes, analog communication tools, and limited visibility into supplier risks. Consequently, this leads to diminished visibility, extended lead times, delays, and inefficiencies in order fulfillment.

### Objectives

Reduce the reliance on manual, repetitive, time-consuming and ad-hoc communications with suppliers

## Use Case Overview

Electronic Data Interchange (EDI) facilitates automated exchange of business documents in a standardized electronic format between manufacturers and their suppliers. Further, EDI also provides the following advantages:

- Reduces manual errors with seamless communication
- Speeds up processes, such as procure-to-pay
- Ensures production continuity

## Core Skills

- EDI standards – ANSI, X12, UN/EDIFACT
- Communication protocols – AS2, FTP, SFTP and HTTP
- Data mapping and transformation

## Key Technologies

- **EDI Software:** Converts business documents to EDI format
- **Integration Middleware:** Integrates ERP system and the EDI system
- **Secure Data Transmission Protocols:** AS2, FTP over SSL, HTTPS
- **Data Mapping Tools:** Converts custom data formats to standardized EDI formats and vice versa

## Benefits

- Increased speed of communication
- Improved on-time-in-full (OTIF)
- Enhanced inventory
- Standardized data exchange ensures compliance

## ITTI Dimension

**D4. Sourcing and Procurement**

## Pre-requisites

- Trading partner agreements
- Business process analysis
- Data standardization
- Security and infra considerations
- EDI software

## Persona

- Logistics provider
- Manufacturer-supply chain head
- Logistics head
- Procurement head

## Timeline

Up to **4-8** months

## Impact

On-time-in-full: **20-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | **No Brainer** | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

UNIVERSAL CARTON INDUSTRIES

ALPLA

# Customer Integration for Automated Logistics Workflow

## Problem Statement

The pinch for visibility on customer needs has always been a test of strength for customer trust. Low visibility into shipments, ad-hoc communications through email or paper, inaccurate demand forecasting and discrepant order fulfillments are inherent challenges of a lack of customer-side integration.

### Objectives

Increase end-to-end horizontal integration to instill customer centricity at the core of business

## Use Case Overview

Customer integration for automated logistics workflow enables customers to integrate with manufacturers through EDI or RPA-enabled portals. It also offers the following benefits:

- Enables involvement of the customer to have a voice during production
- Establishes transparency of order tracking, order modification, delivery preferences, intimations on delays placing orders, analytics to target customer preferences, accurate demand forecasting, and streamlined order fulfillment
- Offers virtual personalized services

## Core Skills

- EDI standards – ANSI, X12, UN/EDIFACT
- Communication protocols – AS2, FTP, SFTP and HTTP
- Data mapping and transformation
- AR/VR software to configure/ customize

## Key Technologies

- **EDI Software:** Converts business documents to EDI format
- **Integration Middleware:** Integrates ERP system and the EDI system
- **Secure Data Transmission Protocols:** AS2, FTP over SSL, HTTPS
- **Data Mapping Tools:** Converts custom data formats to standardized EDI formats and vice versa
- **AR/VR:** Enables virtual shopping or product information assistance

## Benefits

- Higher customer satisfaction
- Efficient communication
- Better on-time-in-full (OTIF)
- Accurate demand forecasting
- Reduced complaints and returns

## ITTI Dimension

**D2. Marketing and Sales**

**D12. Customer Care and Service**

## Pre-requisites

- Trading partner agreements
- Business process analysis
- Data standardization
- Security and infrastructure considerations
- EDI software

## Persona

- Sales and marketing head
- Warehouse head
- Production planner and scheduler

## Timeline

Up to **4-8** months

## Impact

On-time-in-full: **20-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

# Intra-Plant Material Handling

## Problem Statement

Ensuring the right material is available at the right time at the right place is one of the key contributors of material waiting time. Manual errors while fetching parts, and pile up of line inventory are other challenges that come along with manual intra-plant material handling. Manual handling also results in exhaustion, muscular skeletal disorders and safety incidents.

### Objectives

Enhance shopfloor operations through use of AGV instead of repetitive manual material handling

## Use Case Overview

Autonomous guided vehicles are used to manage intra-plant logistics, avoiding the need for manual intervention in areas where repetitive material transport is needed. They further support operations through the following:

- Ferrying materials and goods based on pre-defined paths or routes
- Capabilities to sense objects and adjust according to environmental changes
- Integration of an inbuilt control system, mitigating the risk of accidents and collisions

## Core Skills

- Robotics programing – Proficiency in Python/C++ to customize AGV
- Integration with WMS, ERP
- Navigation algorithm, such as SLAM (Simultaneous Localization and Mapping)

## Key Technologies

- **Navigation Systems:** Lasers, cameras, LIDAR (Light Detection and Ranging), and magnetic tape-based systems
- **Control and Safety Systems:** Processes sensor data and controls the motor for further movement and steering
- **Path Planning Algorithm:** Defines optimal route based on constraints
- **Wireless:** Real-time data exchange through centralized or AGV to AGV communication to coordinate paths
- **Battery and Charging Station:** Rechargeable battery-based AGV

## Benefits

- Increased operational efficiency
- Enhanced safety
- Reduced material waiting time
- Elevated productivity
- Decreased labor charges

## ITTI Dimension

**D8. Production Execution**

## Pre-requisites

- Assessment of environment feasibility – flat surfaces temperature and humidity
- Transport volumes to be pre-decided
- Charging infra readiness

## Persona

- Warehouse lead
- Supply chain manager

## Timeline

Up to **4-8** months

## Impact

Productivity: **15-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | **Quick Wins** | Thankless Tasks |

## Local Highlight

Mai Dubai

Lipton

RAK CERAMICS

# Material Traceability for Warehouse Operations

## Problem Statement

Warehouses, stores, and shop floors often face challenges in efficiently managing stock or inventory. Manually handling tasks, such as rules application (FIFO/LIFO), storage location allocation, item retrieval, shelf or expiry life management, and recall or warranty management are highly prone to discrepancies. Further, traceability using analog tools, such as paper, Excel, mail, or manual entry into IT systems increases the likelihood of errors.

### Objectives

Reduce search times, increase inventory accuracy and ensure quality control

## Use Case Overview

Material traceability is the ability to track, trace and retrieve products from its source to the final destination. Further, it also:

- Enables capability through track and trace technologies, such as RFID, sensorization, Bluetooth, and ultrawide band, among others
- Ensures that all finished products or raw materials are identified using a unique ID
- Uses sensor-based condition monitoring of inventory in transit
- Ensures data immutability based on blockchain-based genealogy

## Core Skills

- RFID tech skills
- WMS software to configure/ customize
- Sensorization expertise
- Blockchain technology

## Key Technologies

- **RFID Tags/Barcode:** Labeling material, enabling unique identifications
- **WMS:** Tracking, managing and optimizing warehouse operations
- **Sensors:** Condition monitoring of materials like temperature, humidity and integrity
- **Blockchain:** Immutable ledger for recording material transactions and provenance data

## Benefits

- Improved inventory accuracy
- Reduced inventory holding cost
- Decreased search time
- Minimized scrapping of expired stock
- Enhanced recalls/warranty/returns

## ITTI Dimension

**D5. Warehouse Management**

## Pre-requisites

- RFID tag and infra selection based on environment of operation
- Integration with ERP/WMS
- Connectivity for in-transit sensorization

## Persona

- Warehouse head
- Logistics head

## Timeline

Up to **4-8** months

## Impact

Inventory management: **10-20%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

hotpack

RAK CERAMICS

# IT/OT Integration for Centralized Monitoring and Control

## Problem Statement

Manufacturing shopfloors are often faced with the challenge of data acquisition when it comes to embarking on an Industry 4.0 journey. Most of these have legacy assets/controllers, multiple data formats and standards to acquire data from. The lack of integration of OT/IT systems often leads to deficient data sets for further analysis and insights.

### Objectives

Increase the visibility of shopfloor assets and integrate them with IT systems for better insights and control

## Use Case Overview

Acquiring data from legacy assets and integrating them with IT systems, such as MES, ERP or other business systems, enables better planning and control. Further, it also unlocks:

- Integration software or edge devices or gateways which can acquire data from controllers, sensors or IT/OT cards
- Extraction, transformation and loading of data
- Value for enabling use cases, such as digital performance management, predictive maintenance, early warning systems, and remote monitoring. It further enables business insights, decisions, resilience and agility in critical manufacturing operations

## Core Skills

- Sensorization, edge gateways programing
- Downstream protocols – OPC UA, Modbus and Profinet
- Upstream protocols – API, ERP, MES and DB

## Key Technologies

- **Edge Devices/Gateways:** Data processing and low latent actions closer to source
- **Wireless Networks/5G:** Enables connectivity, mobility and flexibility at high speeds
- **Cloud API:** Standards for OT/IT to communicate (for example OPC-UA)
- **Distributed IIoT Applications:** Helps with pre-built plug-ins to bridge OT/IT applications via internet

## Benefits

- Integrated real-time insights
- Standardized data from multiple machine types, legacy assets
- Enabled use of AI/ML use cases

## ITTI Dimension

**D8. Production Execution**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## Persona

- Manufacturing heads
- CDO
- CTO

## Timeline

Up to **4-8** months

## Impact

Factory output: **10-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

ALPLA

IPM ITTIHAD PAPER MILL L.L.C.

Lipton

# Controller Virtualization

## Problem Statement

A pressing challenge commonly faced by manufacturers is the variety of PLCs or SCADA controlled by OEM-specific hardware and pre-built software, causing vendor lock-in. Scaling or switching to new controllers involves the purchase of hardware and additional software licenses, increasing capital expenditure and maintenance hassles.

### Objectives

Reduce the need for dependence on capital heavy hardware-based controllers, requiring proprietary software and enforcing vendor lock-in

## Use Case Overview

Controller virtualization is a new trend that enables virtualization of multiple controllers that can be deployed or run on a single or agnostic physical device, reducing the need for multiple devices. Additionally, it also provides the following advantages:

- Utilizes virtualization software to enable the creation of virtual machines (VM)
- Manages VMs independently of each other, with individual user access, avoiding any issues or threats in one of them affecting the whole
- Leverages inherent features of cloud computing

## Core Skills

- Hypervisors and networking
- PLC/SCADA programing
- Industrial communication protocols
- Integrations with HMI and sensors

## Key Technologies

- **Hypervisors:** Enables creation and management of VMs
- **Virtual Machine Monitor:** Manages resource utilization
- **Resource Pooling:** Pools and manages hardware resources, such as CPU, memory, storage and network bandwidth
- **Security Technology:** Isolates virtual controllers and access control

## Benefits

- Reduced CapEx
- Easier management of resources
- Faster scalability
- Green computing with server consolidation

## ITTI Dimension

**D8. Production Execution**

## Pre-requisites

- Hardware compatibility assessment
- Virtualization software selection
- Cybersecurity measures

## Persona

- IT /OT head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Productivity: **15-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

*This is a relatively new use case and is in the initial phase of implementation

# Integrated and Automated Production Planning and Scheduling

## Problem Statement

Production planning and scheduling is a complex functional area that is subject to a high degree of uncertainty. Typical constraints involve large variant mix and shorter lead times, ensuring the right mix of resource allocation and synchronizing processes, orders and changeovers. Planning schedules effectively, considering these constraints is a daunting task for most manufacturers.

### Objectives

Mitigate risk of uncertainties in logistics and shopfloor, thereby increasing demand sensing and optimal production schedules

## Use Case Overview

Integrated and automated planning and scheduling targets a seamless flow of dynamic changes in the environment or logistics to be reflected in the production systems. Moreover:

- Dynamic production scheduling algorithms can assess multiple ‘what-if’ scenarios
- Constraints, including demand, machine and operator availability, and grouping based on variants, can be factored in to predict realistic schedules with minimal changeovers

## Core Skills

- Digital planning and scheduling software skill – to configure/customize
- Integrations with machines, ERP and workforce management systems

## Key Technologies

- **APS Software:** Creates constraint-driven optimal production schedules
- **IIoT:** IoT sensors and devices for status of machines and quality
- **Artificial Intelligence and Machine Learning:** Predicts patterns and optimizes schedules
- **Simulation and Modeling Tools:** Enables ‘what-if’ scenario planning

## Benefits

- Improved on-time delivery
- Real-time decision-making
- Cost reduction
- Better customer service
- Resource optimization

## ITTI Dimension

**D3. Supply Chain Planning**

**D7. Production Planning and Scheduling**

## Pre-requisites

- Understand human, material resources and logistics constraints
- Integrate with ERP, MES, and workforce management systems
- Integrate machines for availability information

## Persona

- Production planners and schedulers
- Plant head

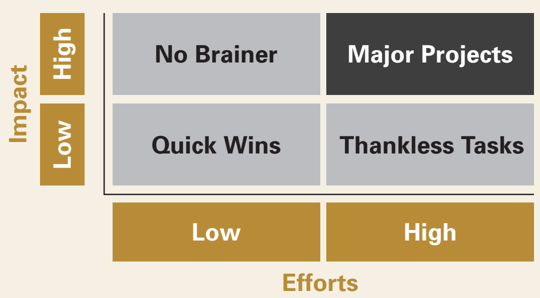
## Timeline

Up to **4** months

## Impact

On-time-in-full: **20-30%**

## Ease of Implementation




## Local Highlight

# AI/ML for Process Optimization and Production Efficiency

## Problem Statement

Manufacturing processes are predominantly run based on the judgement of operators and the intuition of in-house expertise. Data from past productions that have caused quality issues or those that have maximized yield is seldom analyzed due to lack of visibility and analysis.

### Objectives

Improved process efficiency through data-driven insights

## Use Case Overview

As manufacturers increasingly adopt I4.0 technologies, large volumes of production processes parameters and performance characteristics, such as yield, accumulate. Moreover:

- Application of AI/ML models to identify patterns and trends can help uncover golden batch and set point benchmarks
- AI/ML models also prove instrumental in uncovering hidden inefficiencies and bottlenecks
- Establishment of quality control at the edge becomes feasible when specific events signaling failure or discrepancies are revealed through these self-learning models

## Core Skills

- AI/ML skills
- Process knowledge
- Domain understanding

## Key Technologies

- **IIoT:** Collects data from equipment/machinery
- **Predictive Analytics:** Utilizes machine learning algorithms for data analysis, identifying patterns through anomaly detection, regression, and clustering
- **AI:** Employs self-learning mechanisms based on new data fed to models, encompassing technologies such as deep learning, convolution neural networks, and recurrent neural networks

## Benefits

- Increased efficiency
- Improved first pass yield (FPY)
- Reduced scrap
- Minimized human error
- Enhanced safety

## ITTI Dimension

**D8. Production Execution**

**D20. Emissions Management**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## Persona

- Plant head
- Manufacturing head
- Process experts

## Timeline

Up to **4-8** months

## Impact

Yield improvement or factory output: **10-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

ADNOC

IPM ITTIHAD PAPER MILL L.L.C.

# Integrated Quality Inspection and Production Control

## Problem Statement

Quality serves as the backbone for establishing a reputation in the market and reducing customer churn. Although it carries a substantial cost imperative, it also holds a high reputational stake. Reactive quality measures, whether identified at the end-of-line or post-yield loss, or worse, discovered by the hands-on customer, can result in significant costs associated with quality non-compliance with regulations.

### Objectives

Improved process efficiency through data-driven insights

## Use Case Overview

Quality 4.0 enables digital transformation in process and product quality by leveraging data analytics, computer vision, AI and IoT. It emphasizes on real-time monitoring, proactive issue detection, early warning systems, and continuous improvement. Henceforth:

- Interlocking based on computer vision in assembly lines or operators through early detections helps avoid excess value additions
- Process traceability ensures compliance and effective warranty claim management
- Determining optimal set points/golden batch and managing process wandering can contribute to assessing the quality of yield and reducing scrap

## Core Skills

- Vision-based programing
- AI/ML skills
- Process knowledge
- Domain understanding

## Key Technologies

- **IIOT:** Helps identify and control quality issues
- **Artificial Intelligence:** Analyzes large volumes of data to identify potential quality issues in advance
- **Automation:** Avoids human errors and streamlines quality operations
- **Computer Vision:** Applies image-based analytics to identify defects, cracks or flaws based on past patterns

## Benefits

- Increased yield
- Reduced scrap
- Decreased value additions to defective parts
- Enhanced customer satisfaction
- Minimized warranty costs

## ITTI Dimension

**D10. Quality Management**

**D20. Emissions Management**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- OEM warranty and access along with robust cybersecurity measures

## Persona

- Quality leads
- Manufacturing head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Cost of quality: **10-20%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

RAK CERAMICS

HALCON

SHARJAH CEMENT FACTORY

# Predictive Maintenance for Shopfloor Machinery

## Problem Statement

Manufacturers are pressed for ensuring lower costs of manufacturing. One of the significant levers of manufacturing costs stems from downtime, which averages about ~700K AED per hour globally. Unplanned maintenance or time-based schedules often result in unavailability of assets, throughput, failure to meet delivery times and hence attract reputational risks.

### Objectives

Prevent unplanned downtime through proactive maintenance predictions of assets

## Use Case Overview

Predictive maintenance of assets involves proactive maintenance prior asset malfunction, as:

- Prioritizing assets is based on criticality, considering the availability of data points derived from the physics and dynamics of the assets, understanding their failure modes, assessing their interaction and impact on the whole system, and considering the needs of ambient conditions
- It is essential to arrive at the right AI/ ML model based on the above prioritization for proactive maintenance insights

## Core Skills

- AI/ML skills
- Process knowledge
- Domain understanding

## Key Technologies

- **IIoT:** Collects data from equipment/machinery
- **Predictive Analytics:** Utilizes machine learning algorithms for data analysis, identifying patterns through anomaly detection, regression, and clustering
- **AI:** Employs self-learning mechanisms based on new data fed to models, encompassing technologies such as deep learning, convolution neural networks, and recurrent neural networks

## Benefits

- Reduced downtime
- Optimized repair costs
- Ensured optimal spares management
- Increased throughput/yield
- Reduced intuitional dependency

## ITTI Dimension

**D11. Maintenance**

**D20. Emissions Management**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to critical asset selection
- OEM warranty and access along with robust cybersecurity measures

## Persona

- Maintenance, Repairs and Operations (MRO) head
- Facilities head

## Timeline

Up to **4-8** months

## Impact

Operating cost: **18-25%**

## Ease of Implementation

| Impact | | Efforts: Low | Efforts: High |
|---|---|---|---|
| | High | No Brainer | Major Projects |
| | Low | Quick Wins | Thankless Tasks |

## Local Highlight

bin ghalib GROUP OF COMPANIES

RAK CERAMICS

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# Digital Twin for Simulated Product Design

## Problem Statement

Product design is an area where manufacturers constantly try to raise the bar by striking the right balance among the latest customer preferences, compliances and cost fluctuations. Today, green materials and being sustainable by design are new dimensions to be addressed, stemming from the needs of climate goals, sustainability-driven investors and consumers. Rapid prototyping to meet all of these expectations is the need of the hour.

### Objectives

Enhance rapid prototyping to accelerate time-to-market without compromising costs, quality and sustainability

## Use Case Overview

Manufacturers benefit from an accelerated product development approach employing digital twins to predict and finalize the characteristics of their physical twin. This involves:

- Decomposition into the components: the digital twin, the physical twin, and the communication between the two
- Facilitation of virtual real-time monitoring, performance analysis, and iterative testing
- Integration with additive manufacturing for rapid prototyping

## Core Skills

- 3D simulation software
- AI/ML skills
- Industrial communication protocols
- R&D expertise

## Key Technologies

- **IIoT:** Provides real-time equipment/asset information
- **Artificial Intelligence:** Analyzes large volumes of data to optimize performance characteristics
- **Edge Computing:** Allows closed-loop, low-latent controls
- **3D Modeling and Simulation:** Enables visual representation of production environment

## Benefits

- Enhanced productivity
- Increased throughput
- Reduced human error
- Enhanced speed to market

## ITTI Dimension

**D1. Product Lifecycle Management**

## Pre-requisites

- Prioritize high impact areas for automation, enabling competitive advantage/ROI
- Determine control systems, software
- Ensure compliance with regulations and safety standards

## Persona

- Manufacturing head
- Plant head

## Timeline

**8+** months

## Impact

Product development time: **30-40%**

## Ease of Implementation

| Impact | Low Efforts | High Efforts |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

LiN SCAN A PIPECARE COMPANY

الخليج للسحب Gulf Extrusions

# Digital Twin for Production Simulation and Optimization

## Problem Statement

Production process inefficiencies are often left undetected due to a lack of real-time visibility of actual production information. Identifying bottlenecks, the optimal set points, line balancing, ensuring process consistency, identification of root causes and process control are critical to ensuring success.

### Objectives

Optimize processes, reduce downtime and accelerate time-to-market

## Use Case Overview

A digital twin for production simulation and optimization can primarily help simulate the best way to run a process. Further, it also provides the following benefits:

- Helps identify golden batch to establish benchmark
- Reduces process variability by utilizing AI/ML-based controls through closed-loop production controls
- Ensures faster trouble shooting to address process performance issues

## Core Skills

- 3D simulation software
- AI/ML skills
- Industrial communication protocols
- Process knowledge
- Domain understanding

## Key Technologies

- **IIoT:** Provides real-time equipment/asset information
- **Artificial Intelligence:** Analyzes large volumes of data to identify potential quality issues or maintenance issues in advance
- **Edge Computing:** Enables closed-loop, low-latent controls
- **3D Modeling and Simulation:** Facilitates visual representation of production environment

## Benefits

- Improved process efficiency
- Increased process and product quality
- Enhanced time-to-market
- Upgraded collaboration between teams
- Reduced downtime

## ITTI Dimension

**D8. Production Execution**

**D20. Emissions Management**

## Pre-requisites

- Seamless integration with controllers, PLC, SCADA, and DCS data systems
- Appropriate sensorization tailored to specific use cases
- Implementation and verification of robust cybersecurity measures

## Persona

- Manufacturing head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Factory output: **5-20%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

bin ghalib GROUP OF COMPANIES

# Robotics for Automated Assembly Line Activities

## Problem Statement

Liberating humans from repetitive, hazardous tasks and ergonomically challenging activities, such as heavy lifting and fatigue, have always been the driving factors behind introducing automation in manufacturing. Ensuring maximum productivity through continuous operations with high accuracy is also a crucial challenge for most manufacturers.

### Objectives

Replace labor-intensive operations, freeing time for creative and challenging skills

## Use Case Overview

Implementation of robotics in areas that demand labor-intensive, repetitive tasks, high precision and high accuracy delivers the most value, for example, incorporating arm tools, integrating with vision systems, and integrating with existing manufacturing environments like conveyors. Further:

- Robotic design is determined by the end objective
- Robotics simulation software is designed to program its behavior when used as co-bots
- AI/ML-driven robots have the capability to self-improve productivity, enhance utilization, and predict maintenance needs

## Core Skills

- Robotics programing
- Kinematics and dynamics
- Mechanical/electrical engineering
- AI/ML
- Computer vision

## Key Technologies

- **Industrial Robots:** Support precise and repetitive tasks through robotic arms
- **Sensors and Vision Systems:** Integrate for real-time feedback about environment or task, ensuring completion accuracy
- **AI/ML:** Enhance robot capabilities, improve self-learning and provide predictive maintenance
- **5G:** Facilitate high-speed, low-latency communication for real-time control of robotic systems in manufacturing

## Benefits

- Enhanced productivity
- Increased throughput
- Reduced human error
- Increased speed to market

## ITTI Dimension

**D8. Production Execution**

## Pre-requisites

- Prioritize high impact areas for automation, enabling competitive advantage/ROI
- Determine control systems and software
- Ensure compliance with regulations and safety standards

## Persona

- Manufacturing head
- Plant head

## Timeline

**8+** months

## Impact

Factory output: **10-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

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# I4.0 Capability Building (AR/VR)

## Problem Statement

With an aging population and the next generation of talent visiting the shopfloor, manufacturers are dreading the fear of knowledge loss with the retiring workforce. Paper-based documents are often misplaced or poorly updated and the challenge of retrieving the right information is gruesome. With customer delivery times shortening, it is a challenge to quickly onboard new talent and bring them up to speed on-the-job at hand.

### Objectives

Enable faster onboarding of new joiners with a higher retention rate of knowledge required to complete the job

## Use Case Overview

AR/VR or digital work instruction based on-the-job training, provides immersive, easily assimilable hands-on simulation for employees. Further, it also provides:

- Immersive training modules for near real experience of assembling, equipment operation and safety practices in hazardous environments
- AR-based maintenance step-by-step guide
- AR-based remote assistance of expert/worker instruction bots during on-the-job activities for new joiners

## Core Skills

- Game development engines – Unity 3D or Unreal engine
- 3D modeling and animation
- UI/UX design
- Interactivity design and instead of, Interactive design

## Key Technologies

- **Hardware:** AR/VR headsets, VR controllers and input devices
- **Interaction Tech:** Enabled by spatial mapping, spatial audio, gesture recognition and eye-tracking
- **Development Platform:** Content development through Unity 3D or Unreal Engine, AR SDK such as Arkit (iOS) and ARCore (Android)
- **3D Modeling and Animation:** Blender, Autodesk Maya and 3D Max

## Benefits

- Accelerated onboarding
- Enhanced productivity
- Increased knowledge retention
- Enhanced assistance

## ITTI Dimension

**D16. Digitally Fit Organization**

## Pre-requisites

- **Hardware Readiness**: Headsets and controllers, among others
- Content creation tools
- Trainings need pre-identified
- Integration with learning management systems

## Persona

- Learning and development head
- Manufacturing head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Up to **50%** training cost

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | **Quick Wins** | Thankless Tasks |

## Local Highlight

ADCAN Pharma

HALCON

# Enterprise Cybersecurity Measures

## Problem Statement

The convergence of OT/IT systems, along with horizontal integration with suppliers and customers, has multiple benefits. However, there is a significant risk of cyberthreats that needs to be addressed as OT systems are no longer air-gapped. Manufacturers are imposed with the responsibility of establishing strong cybersecurity measures and policies to address these challenges.

### Objectives

Increase the need for cybersecurity measures to establish a robust defense mechanism against threats to ensure reputational risks

## Use Case Overview

Incorporating cybersecurity measures provides the following advantages:

- Safeguards digital assets against unauthorized access, data breaches and cyberthreats
- Ensures confidentiality, integrity, and availability of information through technologies, policies, and practices
- Targets network security, data protection, threat detection and incident response
- Enables shared responsibility models and distributed computing through in-cloud services

## Core Skills

- Security architecture and design
- Cyber threat intelligence
- Network security
- Cryptography
- Endpoint, cloud security

## Key Technologies

- **Firewalls and Intrusion Prevention:** Protection through monitoring and controlling of networks
- **AI/ML:** AI-based threat detection and anomalies
- **Zero Trust Security Model:** Verification overrides trust, irrespective of location or network
- **Antivirus and Antimalware:** Detection and removal of malicious software

## Benefits

- Enhanced data protection
- Reduced risk
- Upscaled operational continuity
- Increased legal compliance

## ITTI Dimension

**D14. Technology Management**

## Pre-requisites

- Compliance and legal awareness
- Risk assessment
- Clear security policies
- Identity and access management systems

## Persona

- IT head
- OT head

## Timeline

**8+** months

## Impact

Ransom cost of
**180k-18 Mn AED**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

# Supply Chain Control Tower

## Problem Statement

Manufacturers are frequently challenged by the necessity for visibility across supply chain networks, directly influencing optimal inventory management and delivery fulfillments. Transport risks arising from factors such as traffic, pandemics, uncertainties, seasonal variations, shifts in consumer preferences, and competitor disruptions contribute to the complexities of efficiently managing supply chains.

### Objectives

Drive enhanced visibility, collaboration and efficiency in complex supply chain networks, increasing agility and resilience

## Use Case Overview

Supply chain towers help streamline operations, optimize inventory management and mitigate risks by providing real-time insights and coordination across supply chain. These also provide:

- End-to-end visibility and control through a digital twin of supplier order status, transportation, IoT sensors, weather, POS sales, and inventory levels
- AI-based scenario analysis and self-learning for better future predictions
- Proactive disruption discovery through risk anticipation and mitigation

## Core Skills

- AI/ML programing
- Sensorization, telematics
- EDI integrations
- Integrations with ERP and CRM

## Key Technologies

- **Sensors and IIoT Devices:** Devices that enable real-time monitoring fleets
- **AI/ML:** Models that help identify optimized routes, 'what-if' scenario analysis
- **Integration:** ERP, CRM integrations with supplier and customers through EDI, internet XML, and API, among others

## Benefits

- Increased visibility
- Reduced supplier delays
- Increased on-time-in-full
- Improved risk mitigations
- Increased resilience

## ITTI Dimension

**D3. Supply Chain Planning**

## Pre-requisites

- Digital infrastructure readiness
- Integrated systems with ERP and CRM
- Change management for smooth adoption among partners

## Persona

- Supply chain head

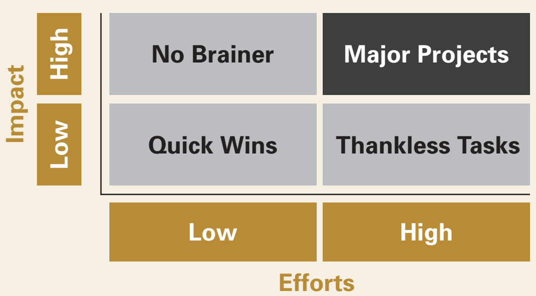
## Timeline

8+ months

## Impact

Inventory reduction: **5-15%**

## Ease of Implementation




## Local Highlight

RAK CERAMICS

# Energy and Utility Optimization

## Problem Statement

With fast-depleting resources and increasing population needs, manufacturers face a dilemma of ensuring production without incurring additional costs while optimally using resources, such as energy, water, industrial gas, and air pollution. Many industries rely on energy-intensive assets, such as HVAC, furnaces, conveyors, and pumps, which contribute to over 30-40% of energy needs. This challenge is exacerbated by the stringent demand for sustainability-related regulations and the climate goal of fostering a minimal carbon footprint.

### Objectives

Optimize energy and utility consumption through AI-driven models and actual needs, eliminating inefficiencies

## Use Case Overview

Energy and utility optimization is enabled by analyzing current consumption levels and identifying areas of optimization through AI-driven models. This involves:

- Identifying idle energy consumption, asset benchmarks, optimal set points, and specific energy or resource consumption through AI/ ML techniques
- Forecasting energy/water needs and making purchases at optimal rates
- Implementing AI/ML driven hybrid power sourcing (for example, solar and grid)
- Generating alerts for fugitive water or gas leaks

## Core Skills

- AI/ML skills
- Energy and utility domain knowledge
- Energy-intensive asset expertise

## Key Technologies

- **Sensors and Smart Meters:** Tracks energy and utility consumption
- **Edge Computing:** Enables closed-loop, low-latent controls
- **AI/ML:** Utilizes AI/ML for identifying asset benchmarks, optimal energy per yield, forecasting energy/resource needs, and condition monitoring

## Benefits

- Reduced energy consumption
- Minimized gas leaks/consumption
- Decreased process water consumption
- Increased quality of process water

## ITTI Dimension

**D9. Utilities Management**

**D20. Emissions Management**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS data systems
- Installation of energy/utility meters at the line or asset level for detailed consumption tracking
- Application of methods facilitates access to energy management systems (EMS) and building management systems (BMS) data

## Persona

- Chief sustainability officer
- Facilities head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Energy efficiency: **10-20%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

Mai Dubai

RAK CERAMICS

Lipton

# Fleet Management and Route Optimization

## Problem Statement

Manufacturers face the dual problem of keeping transport costs low, while also seeking low-emission routes or modes of transport. Today, the focus has shifted from mere costs to sustainability agendas, where manufacturers need to choose the minimal carbon footprint route without overshooting costs and lead times.

### Objectives

Optimize fleets and routes for cost effectiveness and sustainability

## Use Case Overview

AI-based fleet management and route optimization contribute to identifying the most efficient and eco-friendly routes. Additionally:

- Consideration of 'what-if' scenario analysis proves to be valuable
- AI-based route optimization focuses on finding the shortest, fastest, and most sustainable routes
- Sustainable fleet management aims at balancing costs while simultaneously reducing the carbon footprint

## Core Skills

- AI/ML
- Telematics

## Key Technologies

- **AI/ML:** Identify most optimal route considering 'what-if' scenario planning
- **Telematics:** Collect real-time data on vehicle location, speed, fuel consumption and other crucial metrics

## Benefits

- Transport cost reduction
- Better optimized routes
- Lower emissions
- Faster deliveries

## ITTI Dimension

**D6. Logistics Management**

**D20. Emissions Management**

## Pre-requisites

- Comprehensive historical data of routes, vehicle performance, traffic performance
- Equip vehicles with telematics
- Geospatial information systems

## Persona

- Logistics head
- Warehouse head
- Supplier head

## Timeline

Less than **4** months

## Impact

Transport cost up to **15%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | Major Projects |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

Mai Dubai

# Recycle and Reuse of Material Waste/Scrap Material

## Problem Statement

Manufacturers address waste management through multi-faceted phases, encompassing scrap optimization during the production process, the return of defective products, product recalls, and waste generated during its use and disposal at the end of its life. Sustainability initiatives play a crucial role, imposing mandates to ensure material circularity and guarding against false claims of greenwashing and fraudulent practices.

### Objectives

Establishing authentic measurement and verification for recycling and reusing the material waste

## Use Case Overview

The core foundations of Industry 4.0-driven recycling and reusing of material waste or scrap material involve enabling waste segregation, making decisions on repairing or recycling, and tracing recycling across the value chain through immutable transactions. Key components include:

- AI or computer-vision-based sorting
- Utilizing blockchain and smart tagging options to minimize returns by authenticating counterfeit claims or greenwashing
- Implementing 3D manufacturing to reuse waste/scrap for new parts or products

## Core Skills

- Computer vision
- Blockchain technology
- AI/ML
- Robotics programing

## Key Technologies

- **Robotics:** Supports in waste segmentation through IIoT or computer vision
- **Computer Vision:** Enables waste segregation
- **AI/ML:** Provides models for efficient repairing, recycling or returning decisions
- **Blockchain:** Enables immutable ledger for recording material transactions and provenance data

## Benefits

- Enhanced waste segregation
- Increased recycled input as raw material
- Reduced scrap
- Increased asset life

## ITTI Dimension

**D18. Material Circularity**

## Pre-requisites

- Camera infra readiness
- Stakeholder agreement for blockchain-based tracking among manufacturers

## Persona

- Chief sustainability officer
- Facilities head
- Plant head

## Timeline

**8+** months

## Impact

Reduce emission footprints by at least **6%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

## Local Highlight

hotpack

الغربية Al Gharbia

RAK CERAMICS

# Wastewater Treatment Optimization Using Artificial Intelligence (AI)

## Problem Statement

Water scarcity is a pressing challenge as most water sources are stressed by growing population, subsequent urbanization and challenges related to climate change. Manufacturers are constantly looking for antidotes to ensure water-positive operations, addressing water scarce geographies, regulations and ESG-related compliances. The need for treating wastewater comes with challenges of varying quality of wastewater, seasonal changes and emerging contaminants without compromising on the output treated water quality.

### Objectives

Reduce, reuse and replenish water through data-driven insights

## Use Case Overview

Wastewater treatment optimization using artificial intelligence (AI) uses AI techniques for process optimization of wastewater treatment plants or facilities. Additionally, it provides the following benefits:

- Observes real-time flow rates and tracks flow rates, pH levels, turbidity, dissolved oxygen and nutrient concentrations
- Identifies ideal set points for aeration rates and establishes closed-loop controls for chemical dosing through AI models
- Sets alerts to operators on process deviations
- Enhances consistent reliability of treated water using AI

## Core Skills

- AI/ML programing
- Domain expertise of wastewater treatment
- Sensorization

## Key Technologies

- **Sensors and IIoT Devices:** Enables real-time monitoring of water quality, flow rates and equipment status
- **Edge Computing:** Facilitates closed-loop low latent controls
- **AI/ML:** Models that help identify optimized wastewater treatment processes

## Benefits

- Reduced water consumption
- Improved quality of treated water
- Elevated process efficiency
- Improved effluent management

## ITTI Dimension

**D19. Water and Wastewater Management**

## Pre-requisites

- Integration with controllers, PLC, SCADA, and DCS data systems
- Installation of sensors or IIoT devices for water quality monitoring

## Persona

- Chief sustainability officer
- Facilities head
- Plant head

## Timeline

Up to **4-8** months

## Impact

Process cost reduction by **25-30%**

## Ease of Implementation

| Impact | Efforts: Low | Efforts: High |
|---|---|---|
| High | No Brainer | **Major Projects** |
| Low | Quick Wins | Thankless Tasks |

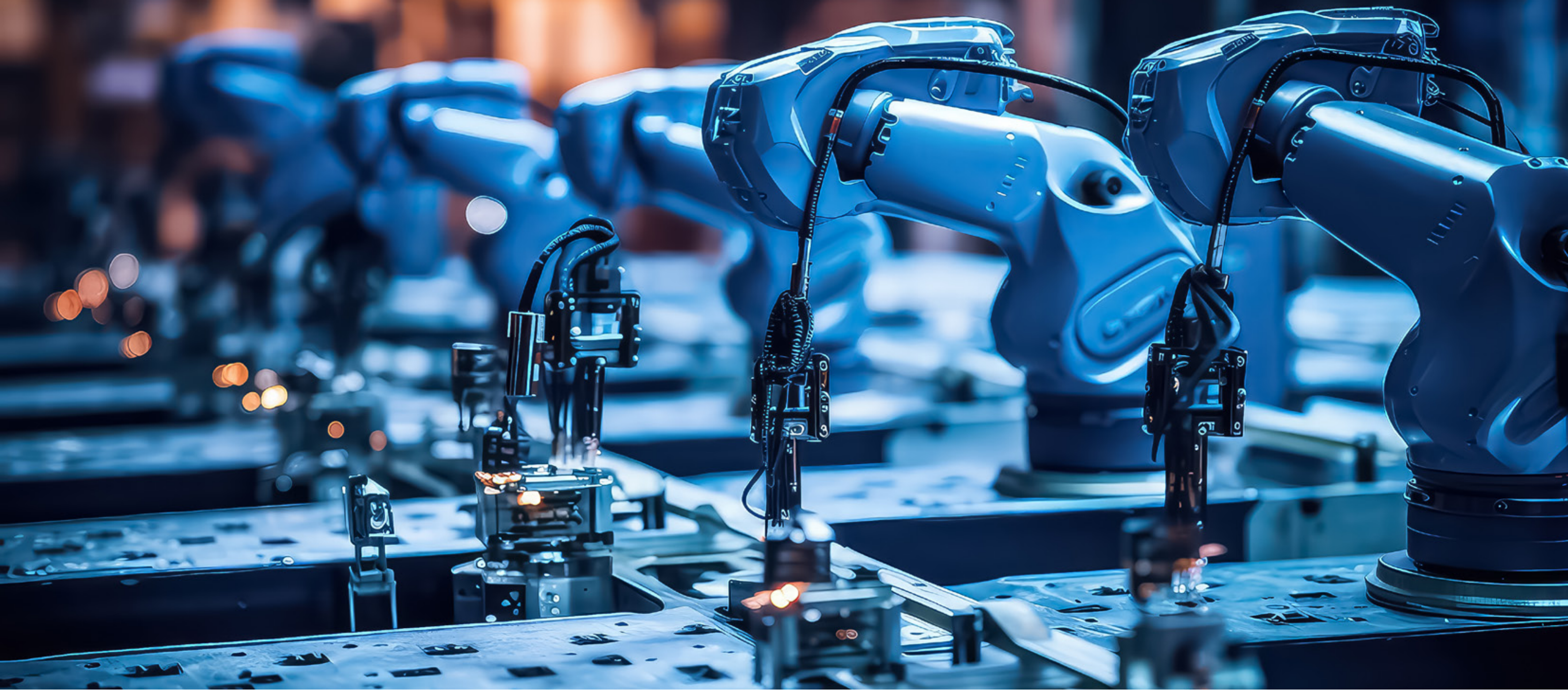
## Local Highlight

SHARJAH CEMENT FACTORY

الغربية Al Gharbia

Mai Dubai

# WAY FORWARD



The advent of Industry 4.0 marks a transformative era for manufacturing. The ITTI Framework as a digital maturity assessment tool provides a systematic method for manufacturers to refine their digital strategies. The insights from this Use Case Guide aim to inspire manufacturers with purpose and prompt introspection, ultimately encouraging them to align with Industry 4.0's principles and practices. The UAE's commitment to climate-friendly measures is commendable, and manufacturers should incorporate sustainability into their strategies while harnessing advanced technology to amplify their impact.

Sector-specific insights enable manufacturers to address their most pertinent industry imperatives. By applying these tailored recommendations, manufacturers can intelligently craft their strategic roadmaps with the confidence that they are at par with their industry peers, who have either incorporated similar strategies or have received recommendations accordingly. Use Case Charters offer crucial metrics and data points, and serve as a launchpad for manufacturers to kick-start their adoption journey with momentum.

We urge manufacturers to get an ITTI assessment done to kickoff and accelerate their digital transformation journey. Further, they can delve into these findings and collaborate with technology providers to explore solutions and chart a way forward. Adopting a methodical approach, manufacturers should foster internal environments that support the development, testing, and deployment of cutting-edge technologies, while partnering strategically. In tandem, manufacturers must invest in digital training and talent acquisition to deepen their grasp of Industry 4.0 and digital transformation, thus ensuring continuity in operations and next steps.

Manufacturers' success is not solitary but hinges on ecosystem support. Technology Providers can draw on insights from this Guide to refine their offerings, thereby actively facilitating manufacturers. The potential for market growth in these solutions is significant, presenting a realistic opportunity for technology firms. Policymakers and Academics should use this Guide as catalyst for an open dialogue on ecosystem enhancement. With Industry 4.0 Use Cases identified for manufacturers, it's now crucial for the local technology sector to offer robust support if these recommendations are to be considered. Moreover, there is a call for a renewed dedication to digital education and training to future-proof the workforce.

**The insights from this Use Case Guide aim to inspire manufacturers with purpose and prompt introspection, ultimately encouraging them to align with Industry 4.0's principles and practices. The practical suggestions and recommendations from ITTI assessments serve as an excellent foundation and stepping stones for embarking on a digital transformation journey.**

The ITTI assessment's recommendations serve as an excellent foundation for manufacturers to act on this knowledge and initiate tangible changes within their organizations. These practical suggestions form the stepping stones for a transformation journey, enabling the identification of opportunities and strategies through Industry 4.0.

# APPENDIX

# GLOSSARY OF TERMS

## Glossary

| | |
|---|---|
| **AI/ML for Process Optimization and Production Efficiency** | Utilizing artificial intelligence and machine learning to enhance manufacturing processes and productivity |
| **Automating Enterprise Processes Using RPAs** | Employing robotic process automation to streamline and automate routine business tasks |
| **Autonomous Guided Vehicle** | Self-directed vehicles used within manufacturing settings for material transportation |
| **Compound Annual Growth Rate (CAGR)** | It is a measure of an investment's annual growth rate over time, with the effect of compounding taken into account |
| **Cemex GO Platform** | A digital solution by Cemex, enabling streamlined management of orders, logistics, and customer relations |
| **Controller Virtualization** | The use of software to simulate hardware controllers for industrial machinery, reducing the need for physical equipment |
| **Customer Integration for Automated Logistics Workflow** | Integrating customer systems with logistics to automate and synchronize the supply chain |
| **Digital Twin** | A virtual model of a physical system or process that is used for analysis and optimization |
| **Effluent Treatment Plant (ETP)** | A facility for treating wastewater to remove or reduce pollutants before discharge or reuse |
| **Electronic Data Interchange (EDI)** | The inter-company communication of business documents in a standardized electronic format |
| **Environmental, Social and Governance (ESG) Goals** | Objectives set by companies to operate sustainably and ethically, considering environmental, social, and governance impacts |
| **Enterprise Resource Planning (ERP)** | Enterprise Resource Planning, a system integrating core business processes to streamline operations and data management |
| **Industrial Internet of Things (IIoT)** | Networked sensors and instruments in industrial settings, enabling data collection and exchange for improved operations |
| **Industry 2.0, 3.0, 4.0 (I2.0, I3.0 and I4.0, respectively)** | Different phases of industrial evolution, from mass production, to automation, to cyber-physical systems |
| **Integrated and Automated Production Planning and Scheduling** | Systems that combine and automate the planning and scheduling of production to optimize workflow |

| | |
|---|---|
| **Integrated Quality Inspection and Production Control** | The combination of quality inspection and production processes to ensure product quality and efficiency |
| **Intra-Plant Material Handling** | Internal logistics process for transporting materials within a manufacturing facility |
| **Integrated Remote Operations Center (iROC)** | A centralized facility that remotely monitors and controls industrial operations |
| **ISA 95 Pyramid** | A model outlining the integration of enterprise and control systems in manufacturing environments |
| **IT/OT Integration for Centralized Monitoring and Control** | Merging information and operational technology to oversee and manage industrial processes from a central point |
| **Joint Working Group (ISO+IEC)** | A collaborative body formed by the International Organization for standardization and the International Electrotechnical Commission for standard development |
| **Material Traceability for Warehouse Operations** | The ability to track the origin, use, and location of materials within warehouse operations |
| **Manufacturing Execution System (MES)** | Manufacturing Execution System, software that manages and monitors work in progress on a factory floor |
| **Offset through Carbon Credits** | Compensating for emissions by purchasing carbon credits that fund equivalent carbon savings elsewhere |
| **Predictive Maintenance for Shopfloor Machinery** | Using data analysis tools to predict when machinery will require maintenance before it fails |
| **SCADA or PLC** | Systems for industrial control (Supervisory Control and Data Acquisition or Programable Logic Controller) that manage machinery and processes |
| **Scope 1, 2, and 3 Emissions** | Different levels of a company's greenhouse gas emissions, from direct to indirect to those in the value chain |
| **Stock Keeping Units (SKUs)** | A unique code assigned to a product in inventory for efficient tracking and management |
| **Sound AI** | Artificial intelligence technologies that analyze sound patterns to detect anomalies or improve user interactions |
| **Supplier/Customer Integration for Automated Workflows** | Connecting supplier and customer systems to streamline business processes |
| **Yankee Gearbox** | A mechanical component in paper manufacturing machinery for drying paper |
| **Zero Liquid Discharge (ZLD)** | Zero Liquid Discharge, a wastewater treatment process that leaves no liquid waste, only solids |

# GLOBAL INDUSTRY 4.0 LANDSCAPE EXTRACTION METHODOLOGY

## Our Approach to Identifying and Documenting Globally Trending Use Cases Relevant to Industry 4.0 Technology and Transformation Principles is Logical for the UAE

**1**
**Define the Baseline**

A standardized baseline supports the development of insights when referenced locally.

The 20 dimensions across the manufacturing value chain as per the ITTI are leveraged as a baseline framework to identify I4.0 trends.

**2**
**Source I4.0 Trends**

To identify trending Use Cases, the following sources were leveraged:

- World Economic Forum
- Strategy Consulting Firms (McKinsey, Deloitte, BCG, and Kearney, among others)
- Independent Surveys by Tech Companies (Siemens, Altair, Zebra)
- Research Houses (Mordor, Markets and Markets, and Gartner, among others)

**3**
**Extract Key Trends**

Industry 4.0 technologies have given rise to untold permutations of use cases. However, key trends are extracted largely considering the frequency of occurrence.

SME input represents a crucial element to contextualize the key use cases to ensure relevance and applicability.

# USE CASE EXTRACTION METHODOLOGY

## A Meticulous Process of Reviewing Reports, Identifying, Extracting and Validating Use Cases has been Defined to Ensure Thoroughness

### USE CASE EXTRACTION APPROACH

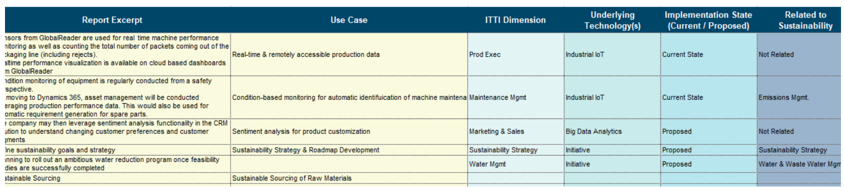
**Extraction and Cataloging**

Principles for extracting Use Cases defined next

Provides a means of validating extracted Use Cases later on

Review ITTI Guide → Identify potential I4.0 Use Case → Pull excerpt from assessor comments/ recommendations → Document the Use Case, tagging the domain, underlying technology, impact and sustainability


Assessor notes or recommendations



| Report Excerpt | Use Case | ITTI Dimension | Underlying Technology(s) | Implementation State (Current / Proposed) | Related to Sustainability |
|---|---|---|---|---|---|
| nsors from GlobalReader are used for real time machine performance nitoring as well as counting the total number of packets coming out of the ckaging line (including rejects). altime performance visualization is available on cloud based dashboards m GlobalReader | Real-time & remotely accessible production data | Prod Exec | Industrial IoT | Current State | Not Related |
| ndition monitoring of equipment is regularly conducted from a safety spective. moving to Dynamics 365, asset management will be conducted eraging production performance data. This would also be used for omatic requirement generation for spare parts. | Condition-based monitoring for automatic identifuication of machine maintena | Maintenance Mgmt | Industrial IoT | Current State | Emissions Mgmt. |
| company may then leverage sentiment analysis functionality in the CRM ution to understand changing customer preferences and customer ments | Sentiment analysis for product customization | Marketing & Sales | Big Data Analytics | Proposed | Not Related |
| ine sustainability goals and strategy | Sustainability Strategy & Roadmap Development | Sustainability Strategy | Initiative | Proposed | Sustainability Strategy |
| nning to roll out an ambitious water reduction program once feasibility dies are successfully completed | | Water Mgmt | Initiative | Proposed | Water & Waste Water Mgm |
| stainable Sourcing | Sustainable Sourcing of Raw Materials | | | | |

**Validation**

Review excerpts and standardize Use Cases where possible → Validate Use Cases (through ITTI assessors) for completeness

# I4.0 Use Case Extraction Sample

## Dimension 2 – Supply Chain Planning

### Upgrade of ERP System

A modern ERP system will help the company in digitalizing multiple processes and workflows which are currently executed on excel sheets (e.g. demand forecasting, inventory requirements). **The company should evaluate the upgrade of their in-house ERP system, and we recommend it to explore adoption best practice workflows of SAP with change management effort requirements.** In some cases, despite high change management efforts the potential for benefit is high and such changes should be actively considered.

**Recommendation NOT Extracted**

The recommendation to upgrade their existing in-house ERP to SAP does not represent an Industry 4.0 Use Case

### Flexible Reporting (Drill Down, Multi-Dimension, Remote Accessibility) Using Business Intelligence (BI) Software

Reporting of KPIs on real-time basis can immensely help businesses by enabling informed decision-making. Many companies in UAE have implemented digital dashboards, which has helped them manage their costs, processes, and customers better. **We recommend the company to use such tools for digital dashboards.** In some companies, specific team members are identified in each team (for example production, quality HR) and trained to build customized dashboards for their own function. Such reporting requires effective master data management, which should be proactively managed by the company.

**Recommendation NOT Extracted**

The recommendation to incorporate flexible reporting using business BI software does not represent an accepted Industry 4.0 Use Case, as no advanced analytics is being leveraged over and above the general dashboarding

# USE CASE PRIORITIZATION METHODOLOGY

## Use Case Prioritization Framework

**1,530+**

**I4.0 Use Case Extraction**
A prioritization methodology has been derived to determine the top Industry 4.0 Use Cases that have been identified through the extraction of assessment reports

**I4.0 Use Case Extraction**
An exhaustive list of Industry 4.0 Use Cases has been extracted based on availability of data in the ITTI assessment reports

**Metadata Tagging**
Each use case has been tagged according to the value chain dimension for which it is typically applied to, and the associated impact is also tagged

**Scoring Criteria and Prioritization**
The prioritization of each use case follows three main criteria for which an overall score is calculated based on a weighted average of the inputs:

- Frequency
- Realized impact
- Implementation timeline

**Additional Recommendation**
Additional sector-specific use cases are provided based on business-specific imperatives and validated by SME inputs

- Use Case 1
- Use Case 2
- Use Case 3

## Further Details on the Scoring Criteria

**50%**

**Frequency**

A pure count of the number of instances for a particular use case. A score of 1-5 is allocated based on relative ranking. i.e., the use case with the highest frequency is provided the highest score, compared to that of the lowest

**25%**

**Impact**

Each impact is marked with typical range as seen in industry. These impacts are captured from multiple reputable sources* and validated by case studies and SME inputs. Similar to the frequency, a score is provided based on the relative ranking

**25%**

**Implementation Timeline**

Implementation timelines are also been considered. Three time frames have been defined, < 4 months, between 4 and 8 months and > 8 months. Use Cases are been allocated accordingly based on research and case studies for typical implementations

**Overall Score**
Finally, a combined score is calculated for each use case, resulting in a ranked list of use cases for both global and sector views

*World Economic Forum and Bosch Implementation Case Studies

# ITTI FRAMEWORKS

## 20 Dimensions Designed to Holistically Assess the Digital Maturity State within a Manufacturing Plant

### R&D and Engineering
- Product Lifecycle Management

### Marketing and Sales
- Marketing and Sales

### Supply Chain Management (Inbound)
- Supply Chain Planning
- Sourcing and Procurement
- Warehouse Management
- Logistics Management

### Manufacturing/Production
- Production Planning and Scheduling
- Production Execution
- Utilities Management
- Quality Management
- Maintenance

### Customer Service
- Customer Care and Service

### Supply Chain Management (Outbound)
- Supply Chain Planning
- Warehouse Management
- Logistics Management

### Enterprise Administration
- Business Process and Intelligence
- Technology Management

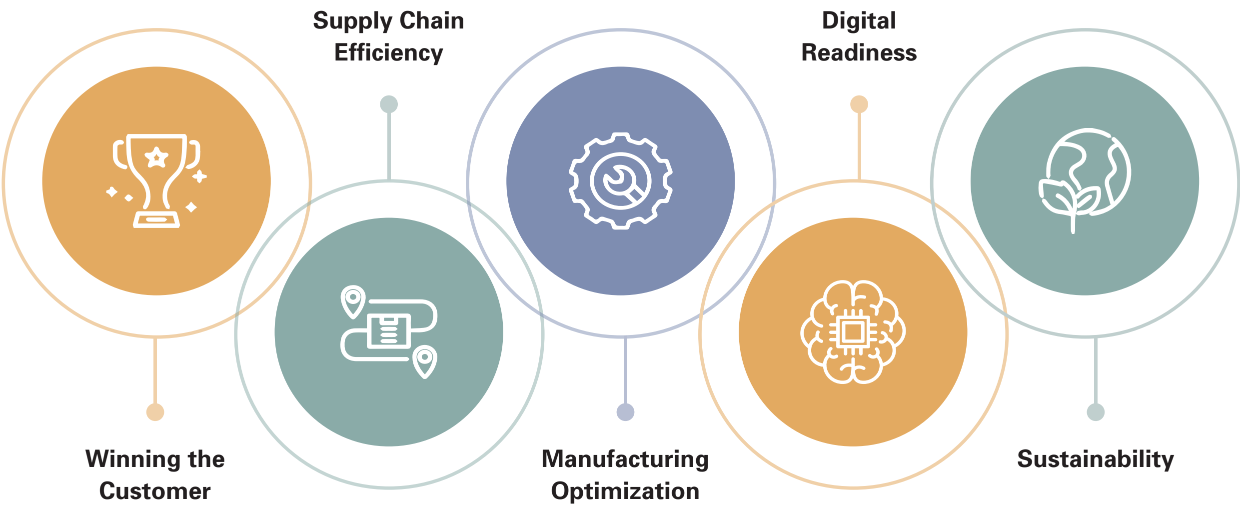
### Strategy and Organization
- Strategy and Governance
- Digitally Fit Organization

### Sustainability
- Sustainability Strategy and Governance
- Material Circularity
- Water and Wastewater Management
- Emissions Management

Value Chain Element

ITTI Dimension

# Business Objectives can be Aligned with the Below Highlighted Focus Areas




## Focus Areas

- Time-to-Market
- Sales Process Efficiency
- Time-to-Delivery
- Customer Satisfaction
- Demand/Supply Planning Accuracy
- Procurement Efficiency
- Inventory Management
- Production Planning and Scheduling Effectiveness
- Production Flexibility
- Manufacturing Process Efficiency
- Utility Optimization
- Quality Improvement
- Maintenance Management
- Enterprise Process Digitalization
- Cybersecurity
- Digital Capabilities
- Sustainability Management


# Five Focus Areas to be Selected by the Company to Support the Prioritization Methodology

### Time-to-Market

Time taken from product design to launch in the market, for example typical KPIs tracked, include development cycle time, and R&D investment, among others.

### Time-to-Delivery

Time taken to deliver finished goods to a customer's location from order receipt. Typical KPIs tracked include on-time-in-full delivery percentage, customer order cycle time, shipping time, and logistics cost per unit of production, among others.

### Sales Process Efficiency

Efficiency in generating leads, converting them to confirmed orders, and providing accurate sales forecasts; typical KPIs tracked include order conversion ration, among others.

### Production Planning and Scheduling Effectiveness

Effectiveness in developing production plans, utilizing capacity, optimizing changeovers, and handling changes. Typical KPIs tracked include planning accuracy, production capacity rate, and capacity utilization, among others.

### Demand/Supply Planning Accuracy

Accuracy in developing the demand and supply forecasts for the organization and S&OP collaboration, typical KPIs tracked, including forecasting accuracy, among others.

### Procurement Efficiency

Ease of handling multiple Stock Keeping Units (SKUs) and changeovers on production line. Typical KPIs tracked include SKUs per line and digital work instructions, among others.

### Procurement Efficiency

Optimization of procurement cycle time, procurement costs and source-to-pay processes. Typical KPIs tracked include purchase order cycle time, emergency purchase ratio, savings realized per period, and supplier performance, among others.

### Manufacturing Process Efficiency

Availability, reliability and performance of production processes - machines, labor and other resources. Typical KPIs tracked include throughput rate, OEE, and TEEP, among others.

### Inventory Management

Efficient inventory management to build transparency and visibility on current stock. Typical KPIs tracked include inventory turnover, average replenishment time, and inventory days of supply, among others.

### Utility Optimization

Optimizing utility duplication of performance to minimize costs while sustaining performance. Typical KPIs tracked include energy consumption per unit of production, and water consumption per unit of production.

### Quality Improvement

Quality check and assurance processes for minimizing cost of quality and improving yield. Typical KPIs tracked include first pass yield, defect rate, scrap ratio, and early detection rate, among others.

### Cybersecurity

Adopting secure practices and protocols to protect assets against cyber threats. Typical KPIs tracked include number of cybersecurity incidents.

### Maintenance Management

Optimizing maintenance processes to ensure maximum uptime and asset lifespan. Typical KPIs tracked include critical equipment downtime, unscheduled downtime in days, and spare availability, among others.

### Digital Capabilities

Enabling I4.0 readiness by empowering employees, and leadership with digital learnings, and strategy among others. Typical KPIs tracked include digital initiatives piloted, and capability building program effectiveness, among others.

### Customer Satisfaction

Retention and continuous engagement with customers to build a customer-centric culture. Typical KPIs tracked include net promoter score, customer complaints per product sold, recurring customers percentage, and after sales performance, among others.

### Sustainability Management

Developing a sustainability roadmap with targets to be publicly committed to and in alignment with international best practices. Typical KPIs tracked include percentage of waste generated recycled, and percentage of emissions tracked, among others.

### Enterprise Process Digitalization

Optimizing productivity by building a modern business process house using end-to-end process design, for example, order-to-cash, procure-to-pay. Typical KPIs tracked include process handling time, and percentage of processes digitalized.

# SOURCES

The information published in this Guide has been leveraged from various public articles, magazines and other credible sources listed below:


- '*Reimagining Industrial Supply Chains*'. McKinsey
- *'Global Lighthouse Network: Shaping the Next Chapter of the Fourth Industrial Revolution'.* WEF
- *'The Data-Driven Journey Towards Manufacturing Excellence'*. WEF
- *'Capturing the True Value of Industry 4.0'.* McKinsey
- *'Industrial Augmented Reality'.* PTC
- *'The State of Ransomware in Manufacturing and Production 2023'.* Sophos
- *'Industry 4.0 can Usher Zero-Waste Manufacturing'.* TCS
- *'Digital Twin Software'.* GE
- *Digitally-Enabled Reliability: Beyond Predictive Maintenance'.* McKinsey
- *'Cybersecurity in a Digital Era'.* McKinsey
- *'Supply Chain Control Tower - from Visibility to Value'.* Accenture
- *'Global Lighthouse Network 2023'.* WEF
- *'Data Excellence: Transforming Manufacturing and Supply Systems'.* WEF
- *'Robotics Process Automation'.* IBM
- *'B2B-Integration-SaaS'.* IBM
- *'Track and Trace (Real Traceability)'.* Microsoft Azure Marketplace
- *'Stop Believing the Myth Remote Monitoring and Alarming are Too Expensive'.* eLynx
- *'Do You Really Need a Vision System?'.* Assemblymag
- *'Digital Twin Solution Development Guide'.* Visartech
- *'Chemistry 4.0 – Sustainable and Digital'.* BASF