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In Focus:

The Fourth Industrial Revolution in the Kingdom

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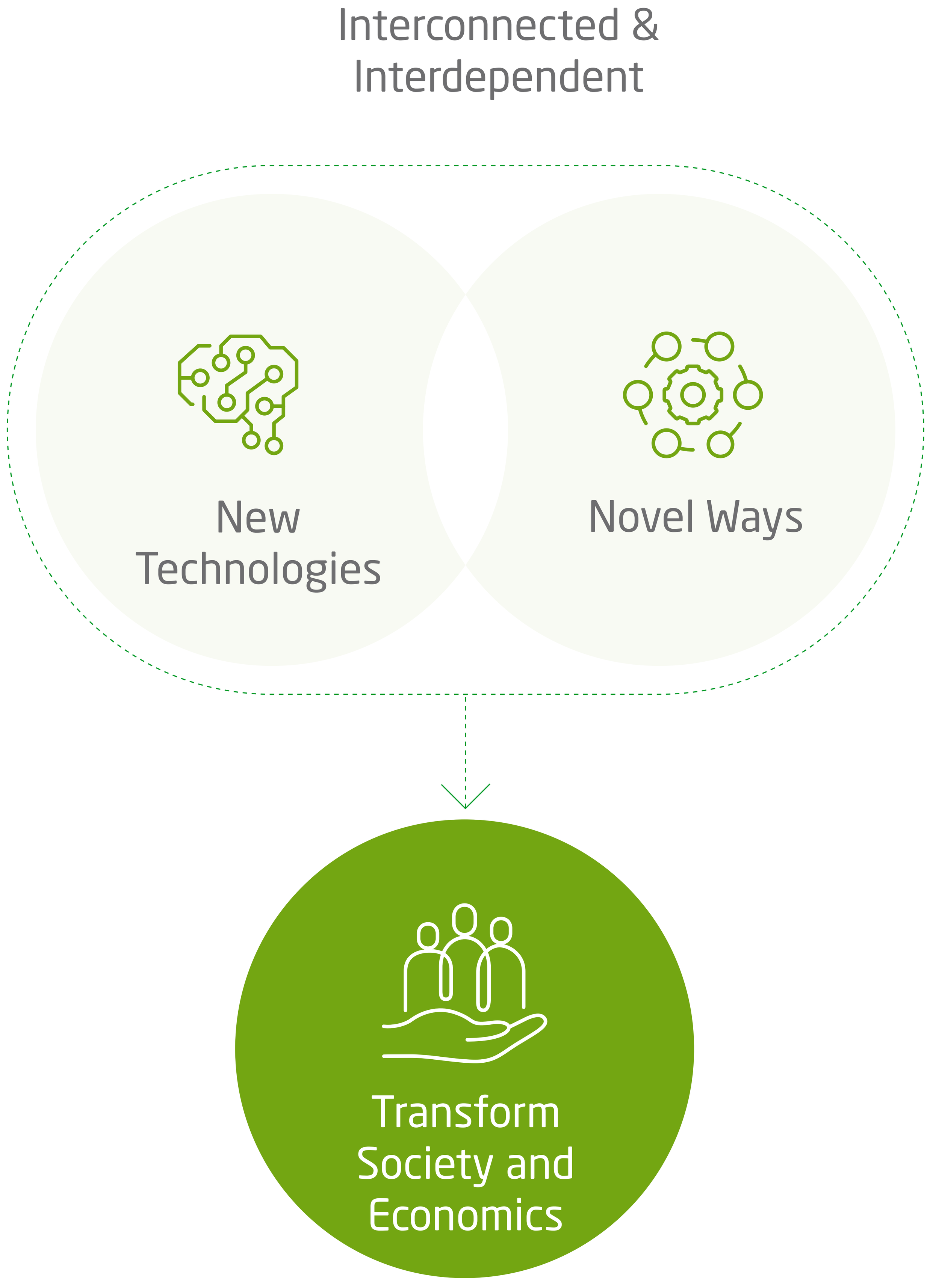
Introduction

The Fourth Industrial Revolution first emerged as a phrase by scientists working on developing a high-tech strategy for the German government. Subsequently in 2015, Klaus Schwab, executive chairman of the World Economic Forum (WEF), introduced the phrase to a wider audience. The term represents the fourth major industrial period since the First Industrial Revolution of the 18th Century. A subset of the Fourth Industrial Revolution is Industry 4.0, often referred to as I4.0, and is a concept of networked connectivity and advanced data analytics, combined with cutting edge technologies, Artificial Intelligence, Additive Manufacturing, Augmented Reality, etc., to create flexible and dynamic automated smart factories.



What is an Industrial Revolution?

One definition is the application of new technologies and novel ways of doing things that are interconnected and interdependent and result in a transformation of both economics and society.

Industry 4.0 is at an early stage, however, governments around the world have recognized the importance of adoption of the new manufacturing concepts in order to capitalize on the potential and have thus established strategic initiative programs, such as:

These strategic initiatives are supported by multi-faceted networks of stakeholders including companies, associations, academia, and policymakers to drive the country's Industry 4.0 mission forward.

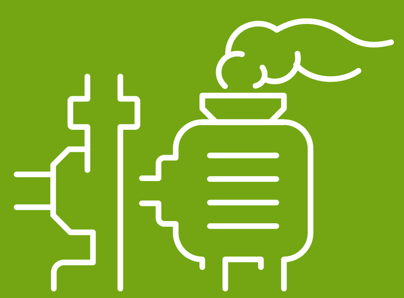
The Global market for industry 4.0 was valued at SR 430 Billion (USD 114.55 Billion) in 2021 and is projected to reach SR 1,414.87 Billion (USD 337.30 Billion) by 2029, at a CAGR of 19.4%.*

430 **SR Billion**
Global Market Value of the Industry 4.0 in 2021

1,415 **SR Billion**
Global market value forecast for the Industry 4.0 in 2029

* Source: https://www.fortunebusinessinsights.com/industry-4-0-market-102375

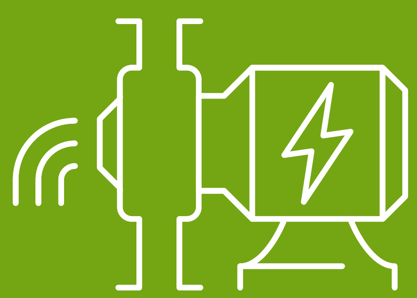
The Evolution of Industrial Revolutions



1760-1830

1st Industrial Revolution

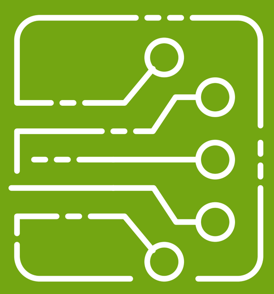
The development and evolution of mechanical production facilities initially powered by water and later using steam, which brought about a major change in productivity and a transition from an agricultural to an industrial society. Whilst machines performed work tasks, processes were labor-intensive.



1870-1914

2nd Industrial Revolution

Electricity and the Electric Motor replaced water and steam as the primary source of power. The new energy source provided decentralized motive power for individual machines, which enabled focus on the sequential order of production machines and led to the creation of the moving assembly line and the concept of mass production, laying in many ways the foundations for the future development of Lean manufacturing methodologies. The revolution resulted in a reduction in labor intensity, accelerated production, and cost reduction.



1969-2015

3rd Industrial Revolution

The invention of electronic components, transistors, integrated circuits and the microprocessor paved the way for the concept of the Programmable Logic Controller (PLC) in 1968. The PLC changed the automation industry forever, enabling evermore complex tasks to be performed repetitively by machines. The miniaturization of electronics, development of sensors, Human Interaction devices, robotics and vision systems complemented the PLC and provided increasingly autonomous machines to supplement or replace operators. In parallel to shop floor automation, computers and software systems evolved to manage business processes. They initially focused on Material Requirements Planning (MRP) and further developed into Enterprise Resource Planning (ERP), to assist humans to plan, schedule, and track product flow through factories.

2022

4th Industrial Revolution Today

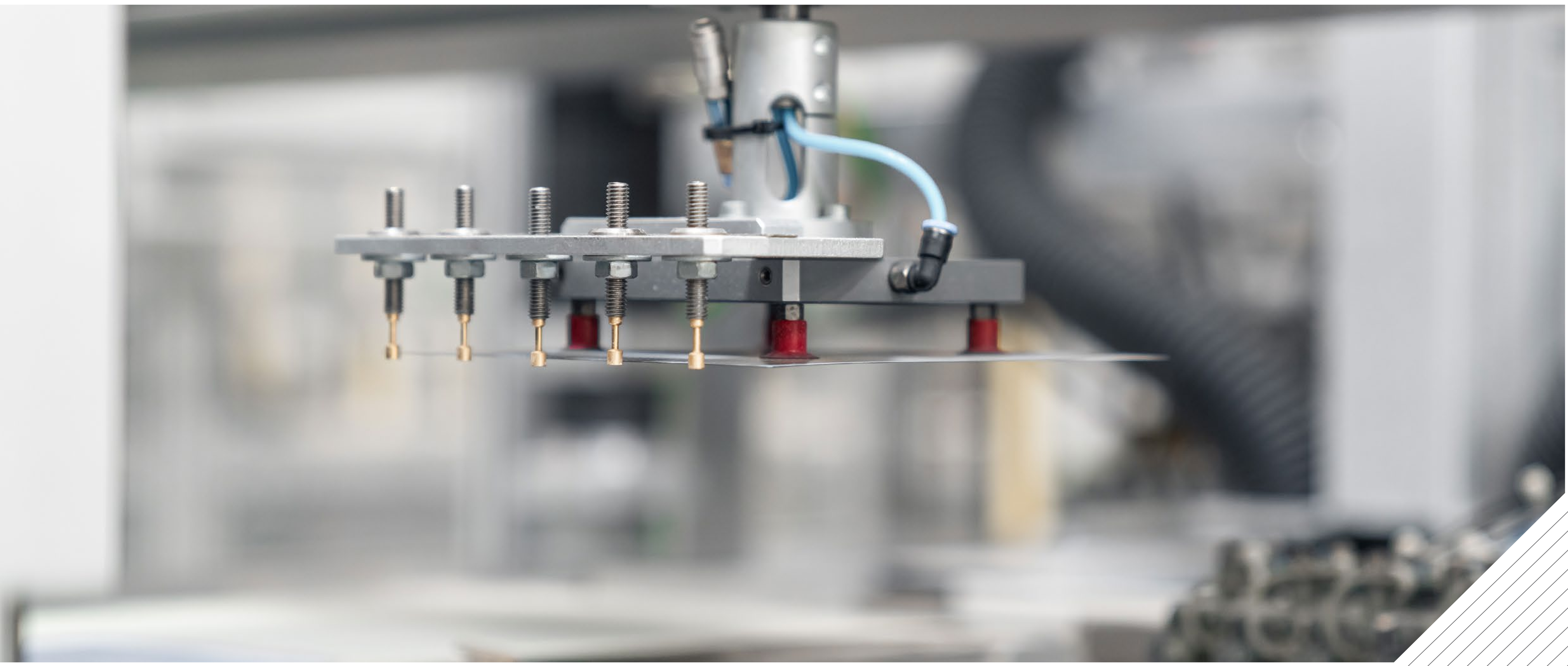
This revolution encompasses an array of emerging technologies such as artificial intelligence, nanotechnology, quantum computing, biotechnology, materials science, energy storage, the Internet of Things (IoT), decentralized decision-making, fifth-generation wireless technologies (5G), additive manufacturing, 3D printing, advanced robotics, virtual reality, augmented reality, and autonomous vehicles.

Applications of the technologies of the Fourth Industrial Revolution have relevance across the entire spectrum of the business world including industry, finance, retail, transport & logistics, government, ecosystems - Smart Grid Energy and the Smart City, etc. The impact is widespread and plays a role in multiple aspects of human life.

Industrial technology has continuously evolved from the start of the first revolution, the defining period within each previous revolution being the confluence of inter-related and inter-connected new technologies and novel ways that transformed economics and society.

Some of the major components of each of the previous revolutions have continued to evolve and maintain a presence in the 4th Industrial revolution of today. Main examples being mechanization and steam power from the 1st revolution, electricity and logical production processes (Lean manufacturing foundations) from the 2nd revolution, and computerized manufacturing (PLC's, ERP systems) from the 3rd revolution.

The Role of the World Economic Forum



Since 2016, the World Economic Forum (WEF) has set a consistent theme of promoting the Fourth Industrial Revolution.

Centre for the Fourth Industrial Revolution (C4IR)

The WEF has been instrumental through its Centre for the Fourth Industrial Revolution (C4IR) in the development of a global network of C4IR seeking to maximize the benefits of the revolution though the collaboration of stakeholders at the local and regional level.

In Saudi Arabia, King Abdulaziz City for Science and Technology (KACST) is the local C4IR host institution. It aims to maximize the technological benefits to Society and minimize risks associated with 4IR technologies through facilitation of the design, analysis, and involvement in governance protocols and policy frameworks. The center was launched in April 2020 and focuses on Artificial Intelligence (AI), Internet of things (IoT), Smart Cities, Autonomous Vehicles, Drones, and Blockchain.

Advanced Manufacturing Hubs

The trends regarding the 4th Industrial Revolution (4IR) have a common theme globally but regional variations exist regarding government policies, workforce skills, infrastructure, etc. The WEF provides a platform for a global network of Advanced Manufacturing Hubs (AMHUBs) to aggregate and accelerate regional efforts to adapt to the future of Advanced Manufacturing triggered by 4IR technologies.

SIDF is the host organization for the AMHUB in the Kingdom and is actively engaging with various stakeholders, government entities, Academia, KACST (as the local center for C4IR), industrial sector businesses, and suppliers of I4.0 technology. SIDF aims to drive success in the industrial sector by promoting investment opportunities to strengthen local industry and enhance operational performance.

Lighthouse Networks

In 2018, the World Economic Forum launched an initiative in collaboration with McKinsey & Company to identify manufacturers that have taken 4IR technologies from pilot schemes to full scale integration. The network is a platform for cross-company learning and collaboration to develop, replicate, and scale innovations.

Existing Lighthouse New Lighthouse Newly Designated Sustainability Lighthouse

Geographical Area of Lighthouse Factories*

The lighthouses are being true guiding lights (beacons) for the world and showing the benefits of IR4 and setting new benchmarks in productivity, sustainability, agility, speed to market, and customization. The number of lighthouse factories continues to grow. As of September 2021, there are some 90 recognized lighthouse factories.

In Saudi Arabia, Saudi Aramco has three WEF-recognized lighthouse sites: Abqaiq Oil Processing Facility, Uthmaniyah Gas Plant, and Khurais Oil Complex. Saudi Aramco is pioneering the large-scale use of 4IR technologies, Artificial Intelligence, Industrial Internet of Things, Automation, and Robotics that are setting new benchmarks and achieving significant improvements in cost, efficiency, product quality, energy consumption and environmental performance.

*Data source - World Economic Forum

Smart Industry Readiness Index (SIRI)

Building Blocks	Pillars	Dimension
Process	Operations	Vertical Integration
	Supply Chain	Horizontal Integration
	Product Lifecycle	Integrated Product Lifecycle
Technology	Automation	Shop Floor
		Enterprise
		Facility
	Connectivity	Shop Floor
		Enterprise
		Facility
	Intelligence	Shop Floor
		Enterprise
		Facility
Organization	Talent Readiness	Workforce Learning & Development
		Leadership Competency
	Structure and Management	Inter- and Intra-Company Collaboration
		Strategy & Governance

The WEF supports the International Centre for Industrial Transformation (INCIT), an international organization focused on global thought leadership and innovation in global manufacturing transformation. INCIT is responsible for managing and expanding the Smart Industry Readiness Index (SIRI), a quantitative framework to evaluate and benchmark manufacturing facilities as companies embark on their Industry 4.0 transformation journey. It forms part of the WEF platform for Shaping the Future of Advanced Manufacturing Value Chains. The aim is to build the largest data set in the world in order to provide benchmarks on the state of manufacturing globally.

The SIRI was created by the Singapore Economic Development Board in partnership with a network of leading technology companies, consultancy firms, and industry and academic experts. SIRI comprises a suite of frameworks and tools to help manufacturers, regardless of their size and sector, to start, scale, and sustain their manufacturing transformation journeys. SIRI covers three core elements of Industry 4.0: Process, Technology, and Organization, and assesses status in 16 Dimensions or Areas.

The aim of the SIRI assessment is to enable companies to:

- Understand the current state of manufacturing plants/facilities
- Identify high impact areas for improvement
- Benchmark against industry peers

The Index has been adopted by both multinational corporations (MNCs) and small and medium enterprises (SMEs). Currently, Official SIRI Assessment (OSA) data has been collated for nearly 600 manufacturing companies across 30 countries. The data provides the following main indicators:

- The Semiconductor, Electronics and Pharmaceutical sectors are leading the way in the digital transformation of manufacturing followed by Energy & Chemicals (Downstream) and Logistics.
- Digitally mature companies are focusing on connectivity and digital process integration.
- Productivity and quality-linked performance indicators are key focus areas for both MNCs and SMEs and that flexibility and speed are fast-emerging priority areas
- There is a high level of diversity across Industry sectors.
- Data confirms SME-dominated sectors are less mature than MNC sectors.
- Average manufacturers are seeking to digitize operational processes.
- MNCs and companies ahead of the maturity curve are more likely to plan for the long term.
- Manufacturers need to place more emphasis on strategy and workforce training.

KSA National Productivity Program

As part of the National Productivity Program in the Kingdom, and in cooperation with SIDF and KACST, MODON embarked on a program of evaluating 100 non-oil industrial factories to improve local output focusing on productivity and efficiency. The program commenced in April 2019 with the aim of developing transformation strategies in operational excellence and Industry 4.0 technologies. The initial 20 assessments were conducted by General Electric and subsequent assessments have been conducted by McKinsey & Company. To date, more than 60 factories have been assessed. The SIRI framework was used in the majority of assessments to benchmark the current state of digitalization for factories.

KSA Development Path to I4.0

Globally, the adoption of Industry 4.0 presents challenges for many companies across the spectrum of Industrial sectors. The challenges to adoption in the Kingdom are no different from those facing companies elsewhere in the world.

SIRI assessments provide a comprehensive view of the current state of a factory digitalization, and results can be interpreted into a more simplified state of maturity of Basic Manufacturing, Operational Excellence, Automation, and Industry 4.0.

Basic Manufacturing

- Standalone machines
- Paper-based production systems

Operational Excellence

- Lean Manufacturing
- Quality systems
- KPI measurements

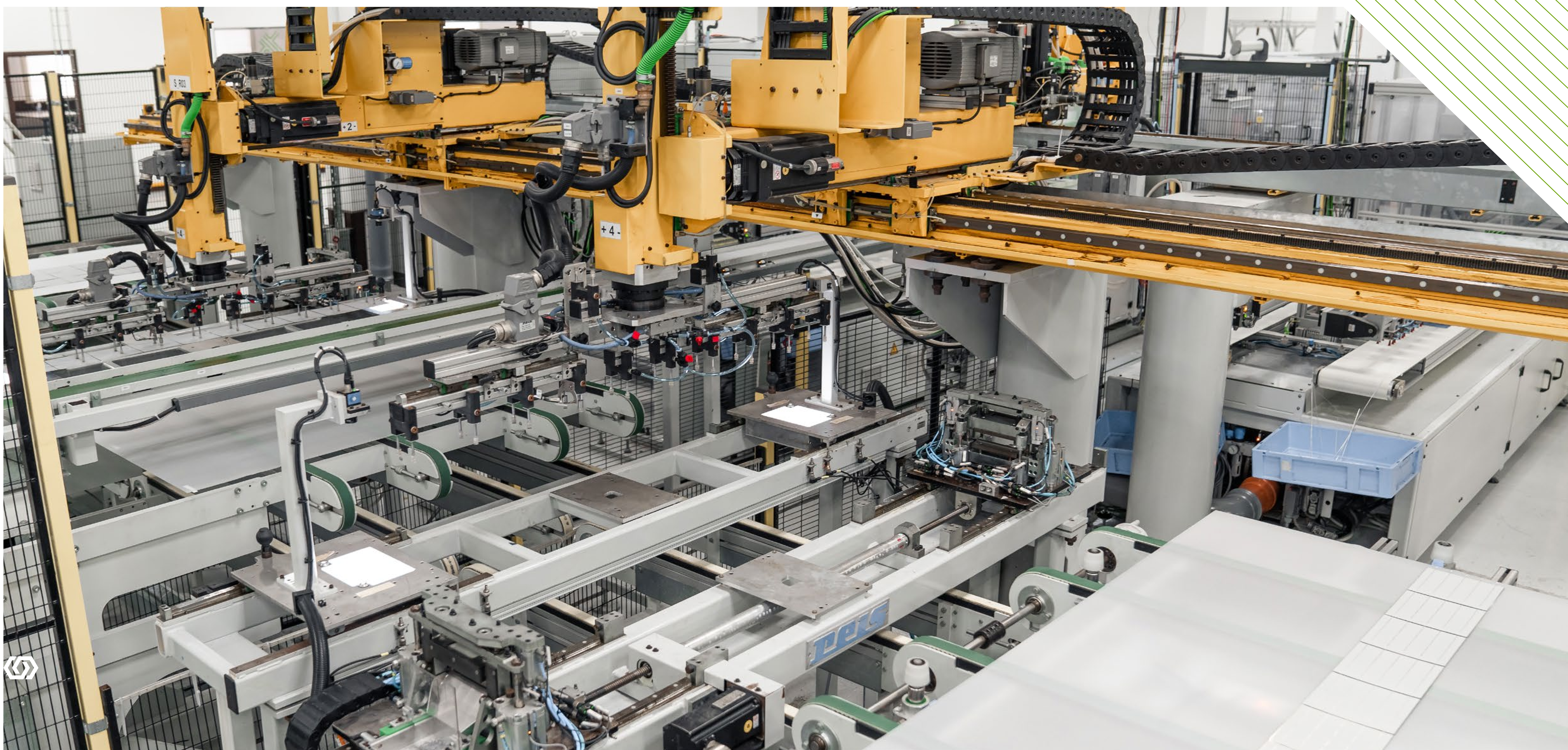
Automated

- Computerized machines
- IT technology (ERP/ MES)
- Integrated processes (Robotics)

Industry 4.0

- Connected assets (IIOT)
- Advanced data analytics
- 3D printing
- Wearable technologies

The adoption of I4.0 technology has a pre-requisite of having good operational practices in order to provide initial data from which I4.0 solutions can learn and further optimize performance. Additionally, the adoption of I4.0 technology is less of a challenge from a suitably mature automated platform with computerized machines, IT business systems, Enterprise Resource Planning (ERP), and Manufacturing Execution Systems.



Implementation Path to I4.0

The implementation of Industry 4.0 for any individual company or factory depends upon the starting point but the methodology of implementation is the same process. Transition to Industry 4.0 requires knowledge of Industry 4.0 technologies and methods, understanding of a company/factory's current digitalization state, development of a strategy, implementation of a plan, and learning from the experience.

Learn

- Principles
- Concepts
- Technologies

Evaluate

- SIRI Assessment
- Understand Current state of facilities and readiness level

Architect

- Develop transformation strategy
- Implementation roadmap
- Infrastructure, systems and processes

Deliver

- Monitor progress
- Assess impact
- Sustain benefits
- Identify new opportunities

The MODON 100 factories program suggests that many of the companies assessed to date would benefit from developing Operational Excellence, a pre-requisite for progressing to an industry 4.0 manufacturing environment.

Implementation of Industry 4.0 is a continuous journey. The first step for any company is to understand its current state of digitalization in order to develop a strategy and a plan to move forward. A SIRI assessment provides the necessary details to enable the development of a roadmap to implement Industry 4.0.

Major Technology Implementations

Globally, the main technology solutions that are being used in I4.0 and are applicable in KSA are:

01

Advanced Analytics (Big Data)

02

IIOT connectivity and cloud-based solutions

03

Artificial Intelligence - Predictive analysis for sales, stock control, production, and maintenance activities

04

Digital Twins - The simulation and optimization of factory environment, Product Lifecycle Management

05

Wearable technology (Augmented Reality) - Suitable for assembly and maintenance activities

Industry 4.0 Benefit

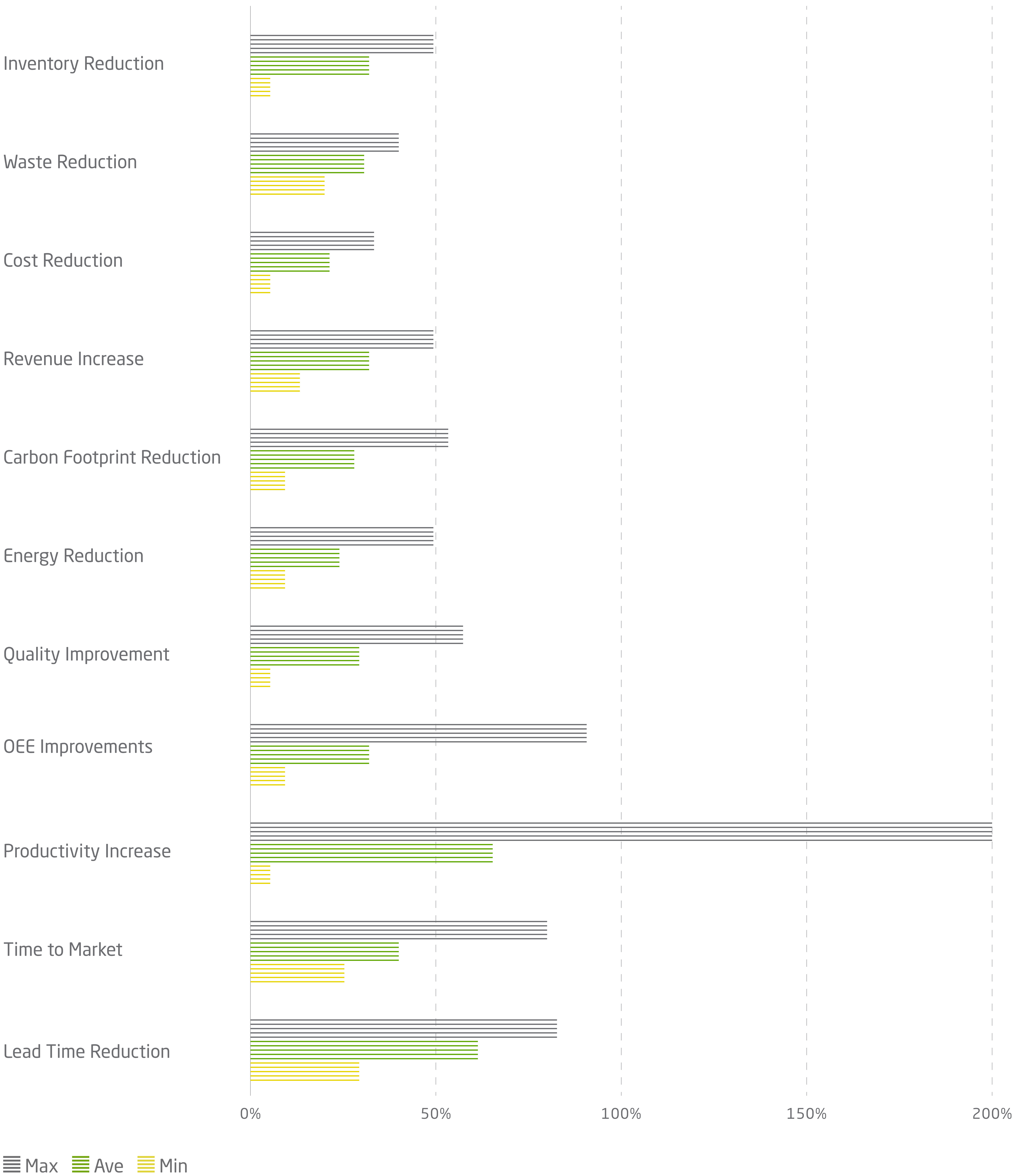
Industry 4.0 provides benefit across all areas of manufacturing. The value and type of benefit achieved is company-dependent and specific to the targeted areas of performance improvement. Lighthouse projects across a range of Industries have achieved a variety of benefits:

Improvements in:

- Productivity
- OEE
- Quality
- Revenue

Reductions in:

- Costs
- Waste
- Inventory
- Carbon footprint
- Time-to-market
- Lead times

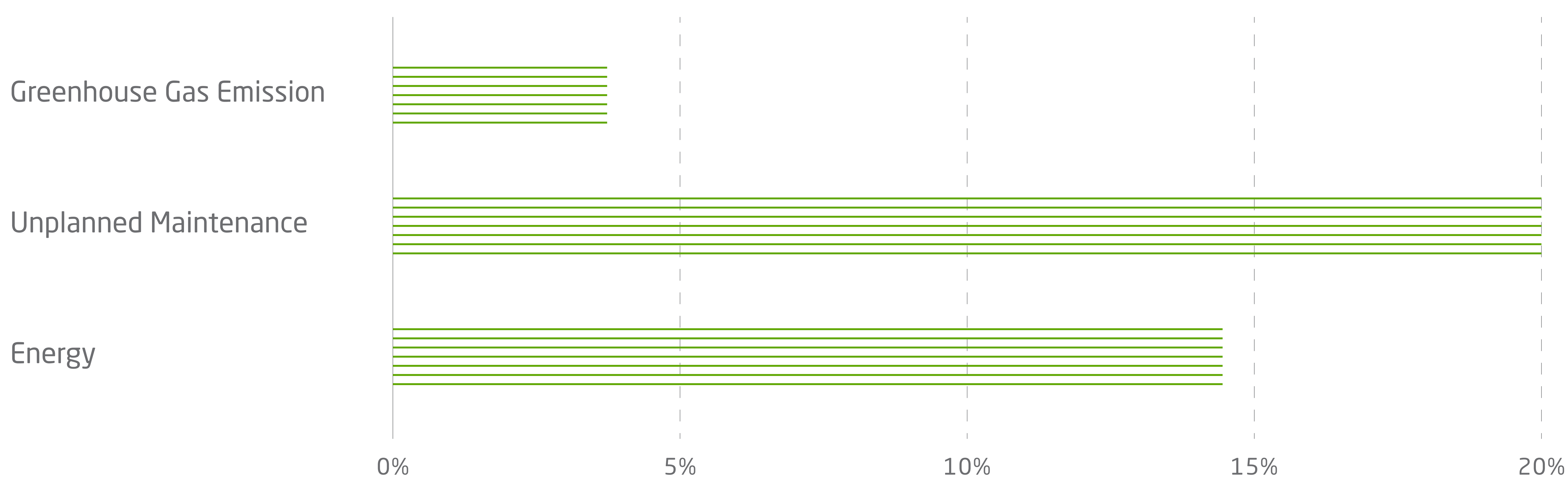


Saudi Aramco – Benefit Examples

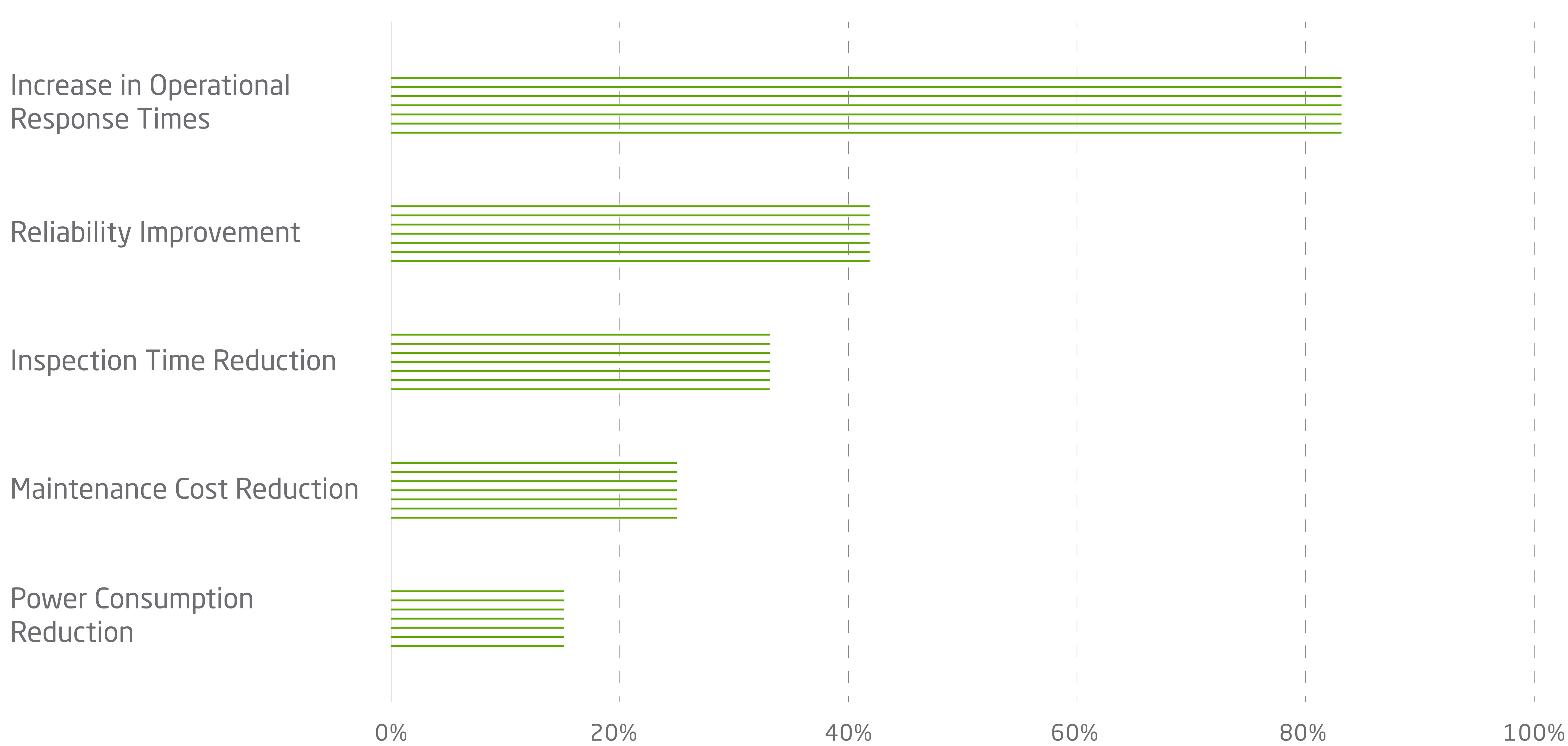
Abqaiq Facility is utilizing I4.0 technologies, such as machine learning, data analytics, AI-powered algorithms, smart unmanned aerial vehicles, and robots in order to improve efficiency and safety.

The Khurais facility utilizes the Industrial Internet of Things (IIoT), digital twin technology, Big Data analytics, machine learning, and smart sensors to reduce overall power consumption by 18%, reduce maintenance costs by 30%, cut inspection times by 40%, improve reliability by 50%, and increase operational response times by 100%.

Reduction %*



Benefit %**



* Source: https://www.aramco.com/en/magazine/elements/2021/welcome-to-the-future-of-industry
** Source: https://www.weforum.org/agenda/2020/09/how-the-4ir-is-driving-a-new-wave-of-energy-innovation

Challenges

The main challenges in transitioning to widespread implementation of I4.0 in the Kingdom are:

Increasing levels of Operational Excellence and Automation.

Developing awareness of I4.0 technologies and their potential benefits.

Understanding the starting position and the current state of digitalization

Creating a talent base of suitably skilled personnel for the implementation and operation of Industry 4.0 solutions.

These challenges are not restricted to the Kingdom but are in fact global challenges faced by all companies.

The Role of SIDF

Finance enabler for I4.0 applications in the industrial sector. SIDF offers enhanced loan terms and conditions for Industrial Digital Transformation (I4.0), Automation, and Energy efficiency projects under the Tanafusiya Program.

Assessment of evaluations and financing of projects completed under the MODON 100 factories program

Actively engaging with stakeholders in the ecosystem as the host of the Advanced Manufacturing Hub in the Kingdom.

Provision of a number of advisory services:

- Operational Excellence
- Lean Manufacturing
- IDT and Automation projects

Summary

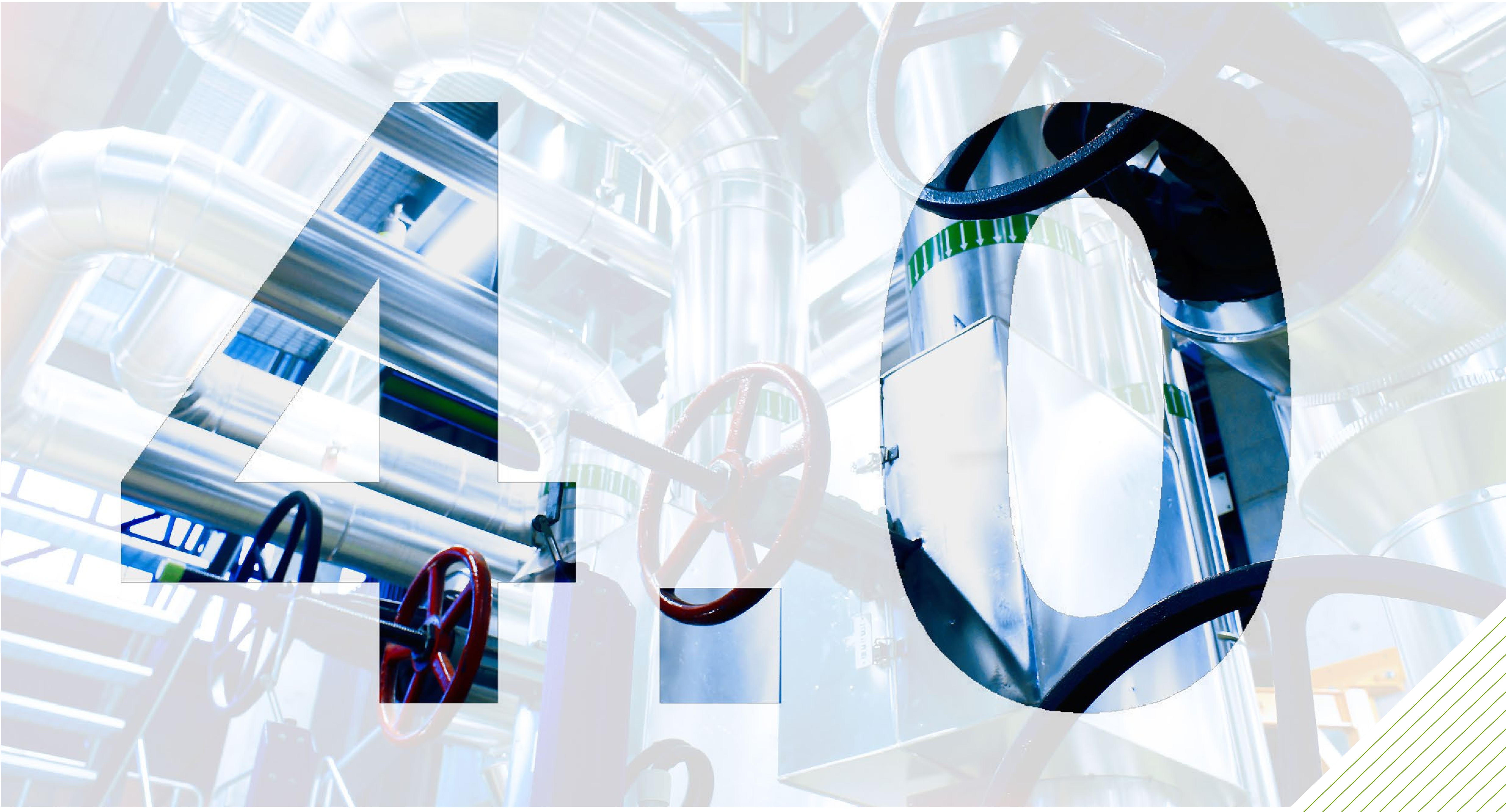
The Fourth Industrial Revolution is just beginning and holds great promise for major changes both economically and socially in the Kingdom, from smart cities such as NEOM and Smart Grid energy solutions to the transformation of the industrial landscape. Within the industrial sector in Saudi Arabia, migration of factories from the current state, whether that is basic manufacturing, Operational Excellence, or Automated, to a smart I4.0 factory is a journey supported by stakeholders at all levels of the Kingdom's ecosystem, using similar facilitation models as other major industrialized economies.

SIDF is not just the finance enabler for companies embarking on the journey to I4.0, it is a driver of the AMHUB to promote excellence in manufacturing and offers advisory services to assist in the improvement of the Industrial Sector. The starting point for all companies is an understanding of their current digitalization state.

The SIRI assessment tool is one method of defining the start point and also of providing indicators for appropriate development. Companies that have already embraced industry 4.0 have demonstrated that the technology provides significant benefits. SIRI assessments conducted to date under the MODON 100 program indicate that the digitalization state of factories in the Kingdom, within the Machinery & Equipment and General Manufacturing sectors, is on average, comparable to the state of factories elsewhere in the world. The challenge in the Kingdom, with the help of the ecosystem, is now to progressively migrate the manufacturing landscape from its current state to an I4.0 advanced manufacturing platform.

Appendix - Supplementary Data

Saudi Aramco I4.0 Technology



	Application	Benefits
Khurais Oil Field	• Application: Smart Oil Field • Advanced Data Analytics (Big Data), Artificial Intelligence (AI) • Digital Twins • Robotics • Automation	• 21% increase in quality • 14.5% reduction in energy use.
Uthmaniyah Gas Plant	• Application: Maintenance Inspections • Advanced Analytics (Big Data), Artificial Intelligence (AI). • Drones for inspections • Wearable technologies - digital helmets to assist inspections by workers.	• 90% reduction in inspection times
Abqaiq Oil Processing	• Application: Energy Management • Advanced Analytics (Big Data) • Artificial Intelligence (AI).	• Unknown