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D01	2024.10.11.	Oliver Schiffer	-	Assigning the modules to the partners
D02	2024.12.02.	Oliver Schiffer	-	Following up with partners about delivering the module contents
D03	2025.04.11.	Lili Schweitzer	-	Final discussion about the modules and slight changes /finalization before the EAB meeting
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Contents

A. Summary of Activity 2.5

As part of the broader GREENE project focused on supporting green and digital transitions among SMEs, MGFÜ is responsible for the **Open Knowledge Training Programs** activity within work package 2. This initiative, aligned with Activity A.2.2, is aimed at designing and delivering flexible, impactful training for small and medium-sized enterprises seeking to modernize their operations and embrace sustainable innovation.

The training concept is built around a **modular structure**, which allows companies to engage with distinct learning paths based on their readiness levels and strategic interests. The five core modules address essential themes such as **sustainability fundamentals**, **smart manufacturing**, **digital business modeling**, **green innovation**, and **funding readiness**. This structure ensures a gradual, step-by-step acquisition of knowledge, which is particularly effective for SMEs that often lack the internal capacity or resources to engage with complex transformation programs all at once.

The modules are delivered via a **Massive Open Online Course (MOOC)** format, hosted on a dedicated **Moodle-based e-learning platform** developed and maintained by Krakow Technology Park (PP8). This digital delivery model enhances accessibility and supports a self-paced learning experience, essential for busy SME participants. The goal is to reach a total of **120 companies**, with each project partner engaging approximately 13 firms—MGFÜ and Krakow Technology Park each taking the lead on 16 companies. Participation requires companies to complete at least one module, although additional modules are open for exploration based on interest and relevance. To complement the online learning experience, **physical workshops** will be held prior to summer 2025, providing participants with hands-on opportunities to test and apply the module content in practical settings.

A critical component of the training initiative is the **Training Impact Assessment**, led by the **University of Ljubljana (PP4)**. This evaluation process involves the collection and analysis of data through surveys administered to participating companies. The goal is to assess the effectiveness, usability, and perceived value of the training modules. Findings from the impact assessment will be used to refine and improve the training content and ensure it remains aligned with the real needs and operational challenges of SMEs.

Ultimately, the Open Knowledge Training Programs represent a strategic investment in **capacity building**, **digital competence development**, and **green innovation support** for SMEs. By offering an open, adaptable, and practically oriented learning platform, the initiative empowers companies to take confident steps toward future-ready, sustainable business models.

B. Modules

Module 1: Beginners Program

Introduction to Sustainability

Sustainability is a broad and evolving concept that focuses on the long-term preservation and responsible management of environmental, social, and economic resources. At its core, sustainability seeks to meet the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). The idea has gained prominence in recent decades due to the increasing pressures of climate change, resource depletion, and socio-economic inequality, prompting governments, businesses, and individuals to adopt more sustainable practices.

Environmental Sustainability

Environmental sustainability refers to practices and policies that aim to reduce the negative impact of human activity on the natural environment. This includes actions such as reducing greenhouse gas emissions, conserving biodiversity, and promoting the use of renewable resources. Climate change, driven primarily by carbon emissions from fossil fuels, is one of the most significant global challenges, and addressing it requires an international effort to transition to renewable energy sources like solar, wind, and hydropower (Intergovernmental Panel on Climate Change, 2021).

Conservation efforts also play a critical role in sustainability. Protecting ecosystems, preventing deforestation, and conserving water are all vital components of maintaining environmental balance. According to the United Nations Environment Programme (UNEP), over 1 million plant and animal species are at risk of extinction, which can disrupt food chains and ecosystems (UNEP, 2019).

Social Sustainability

Social sustainability focuses on ensuring that societies can continue to function equitably and cohesively in the long term. This aspect emphasizes human well-being, social equity, and justice, ensuring that all individuals have access to basic needs such as education, healthcare, and economic opportunities. A key challenge to social sustainability is addressing poverty and inequality. The United Nations Sustainable Development Goals (SDGs), particularly Goal 10, aim to reduce inequalities within and among countries (United Nations, 2015).

Furthermore, social sustainability entails creating inclusive communities where all people have opportunities to participate and contribute to decision-making. This aspect highlights the importance of access to clean water, adequate housing, and fair wages. The role of education, empowerment, and community involvement is central to achieving social sustainability (International Institute for Environment and Development, 2020).

Economic Sustainability

Economic sustainability is the ability of an economy to support a defined level of economic production indefinitely. It involves balancing the needs of economic growth with the responsible use of resources. This can be achieved through innovations in green technologies, sustainable business practices, and sustainable consumption. A sustainable economy is one where businesses operate in ways that do not deplete resources or harm the environment, while also ensuring that workers are paid fairly and businesses are profitable in the long term.

The concept of the circular economy is central to achieving economic sustainability. This approach encourages the recycling and reuse of materials, reducing waste and encouraging companies to design products that have a longer lifespan (Ellen MacArthur Foundation, 2019). Rather than following a "take-make-dispose" model, the circular economy aims for a "closed-loop" system where resources are continually reused.

Challenges and Solutions

Despite the growing awareness of sustainability, several challenges hinder global progress. These include political resistance, insufficient funding, and lack of public awareness. However, various solutions are being implemented to overcome these barriers. Policy changes, such as the Paris Agreement on climate change (UNFCCC, 2015), are crucial to creating a global framework for

sustainable development. Additionally, technological innovations, like carbon capture and storage, and the shift towards renewable energy, offer promising solutions to environmental degradation.

Furthermore, individuals and businesses are increasingly adopting sustainable practices. For instance, companies are embracing corporate social responsibility (CSR) programs that include reducing waste, adopting green technologies, and supporting local communities. At the consumer level, a growing demand for sustainable products, such as organic foods and eco-friendly products, is influencing market trends.

Conclusion

Sustainability is a multifaceted and interconnected concept that requires coordinated efforts from all sectors of society. Achieving sustainability is not only about protecting the environment but also about ensuring social equity and economic resilience. As global challenges like climate change, inequality, and resource depletion continue to escalate, adopting sustainable practices at individual, corporate, and governmental levels will be crucial in shaping a future that is both equitable and sustainable for all.

Digital transformation

Module title: **Navigating digital transformation in SMEs**

Module Introduction**:** Welcome to 'Navigating Digital Transformation in SMEs,' your quick-start guide designed to equip small and medium enterprise leaders and employees with the essential knowledge and tools to understand and implement digital transformation effectively. This 20-minute module explores key concepts through informative videos, a detailed case study, and insights into the future of digital transformation, providing a foundational understanding of how digital technology can revolutionize your business operations, enhance customer experiences, and drive growth.

Section 1: Navigating Digital Transformation in SMEs

"Digital transformation reshapes every aspect of a business. It involves not just the integration of digital technology into various areas but also a fundamental transformation of how your business operates and delivers value to customers. This change goes beyond mere technical upgrades—it's about adopting a new culture that challenges the status quo and embraces continual improvement. To start, let's dive into an insightful video that covers the essentials of digital transformation, outlining its significance and the initial steps SMEs can take to embark on this transformative journey."

- Watch the video: **Understanding Digital Transformation**

Duration: 5 minutes

Short break

Section 1 Quiz: Introduction to Digital Transformation

1. What does digital transformation primarily involve?
a) Buying new computers
b) Integrating digital technology and changing how a business operates
c) Hiring more IT staff
d) Updating the company logo

Correct answer: b

2. True or False: Digital transformation is mainly about installing new software.
a) True
b) False

Correct answer: b

Section 2: Key technologies and their impact

"Embarking on a journey of digital transformation requires more than just adopting new technologies. It demands a holistic framework that encompasses every facet of your organization. This video offers a concise blueprint that guides you through the complexities of digital transformation. Whether you're a business leader or a change agent within your organization, understanding the full scope of what's involved—from strategic planning to technology adoption and beyond—is crucial. Dive into this insightful guide that simplifies the multifaceted process of turning your business into a digital powerhouse, ensuring you're well-equipped to navigate the changes effectively."

- Watch the Video: **Technologies Driving Change**

Duration: 5 minutes

- Infographic: An infographic that illustrates the benefits such as increased efficiency, enhanced customer experience, and improved data management.

Short break

Section 2 Quiz: Key Technologies and Their Impact

1. Which of the following is a benefit of digital transformation?
a) Increased paperwork
b) Improved efficiency and customer experience
c) Longer work hours
d) Reduced automation

Correct answer: b

2. True or False: Understanding the bigger picture of digital transformation is only necessary for IT staff.
a) True
b) False

Correct answer: b

Section 3: Real-world application - case study of Volkswagen, IKEA, and LEGO

“In a world driven by digital advancements, staying ahead requires transformative strategies that resonate with today's tech-savvy consumers. This video explores the digital transformation journeys of industry giants like Volkswagen, IKEA, and LEGO—brands known not only for their market dominance but also for their innovative approaches to digital integration. From Volkswagen's ambitious investment to become a mobility service provider to IKEA's efforts in enhancing customer experience and LEGO's community-focused digital initiatives, these stories illustrate the profound impact of digital transformation on maintaining competitive advantage. Join us as we delve into how these companies have redefined engagement and operational efficiency in the digital age."

- Watch the video: Digital Transformation Case Study

Duration: 5 minutes

Short break

Section 3 Quiz: Real-World Application – Case Study

1. What was a key focus of IKEA's digital transformation?
a) Reducing product lines
b) Enhancing customer experience through digital tools
c) Switching to only online sales
d) Eliminating physical stores

Correct answer: b

2. Which company focused on becoming a mobility service provider?
a) LEGO
b) IKEA
c) Volkswagen
d) None of the above

Correct answer: c

3. What role did LEGO play in their digital transformation journey?
a) Closed all physical stores
b) Shifted to self-driving cars
c) Used digital platforms to connect with their customer community
d) Replaced toys with software-only games

Correct Answer: c

Section 4: Preparing for the future

"In the rapidly evolving business landscape, understanding digital transformation is crucial for SMEs aiming to stay competitive. The Coursera course, BCG & UVA Darden Digital Transformation, offers a deep dive into this subject, tailored by experts from Boston Consulting Group and the University of Virginia Darden School of Business. This course, led by Michael Lenox, a seasoned professor and senior associate dean, provides valuable insights into the strategic and technological shifts that are shaping the future of industries. SMEs can gain practical knowledge on how to apply these technologies effectively within their operations to drive innovation and growth."

- BCG & UVA Darden Digital Transformation

"For SMEs keen on navigating the complexities of digital transformation, the MASIT Digital Transformation Guide is an indispensable resource. This comprehensive guide lays out a structured framework that covers strategies, frameworks, and best practices for digital transformation. It is designed to help small and medium-sized enterprises understand and implement the necessary steps to capitalize on digital technologies and thrive in a digital economy. The guide addresses various aspects of transformation, from technological adoption to cultural change, providing SMEs with the tools they need to execute a successful digital strategy."

- Digital Transformation Guide

Duration: 5 minutes

Short break

Section 4 Quiz: Preparing for the Future

1. The BCG & UVA Darden course helps SMEs understand:
a) How to create ads
b) Strategic and tech shifts in industries
c) Building mobile apps
d) Traditional management practices

Correct answer: b

2. The MASIT Digital Transformation Guide is designed for:
a) Only large enterprises
b) Government agencies
c) SMEs
d) Non-profits only

Correct answer: c

Basics of Green Technology

Module Introduction

The text presents a comprehensive view of green technologies, from their historical roots to current applications. Its main objective is to show that green technologies are a key tool for solving environmental problems and achieving a sustainable future. Readers will learn how green technologies have evolved, their benefits, and how they can improve the quality of life for future generations.

Learning Objectives / Scope of Knowledge Obtained

1. Understand the history, development, and current understanding of green technologies.
2. Identify the environmental impacts of human activity.
3. Apply green technologies in specific areas.

Module Structure

Estimated Time for Completion: 20 minutes

Overview of Sections:

- o. Green technologies of yesterday, today, and tomorrow on Humans and the environmental impacts of their activities
- o. Application of green technologies in practice

Content

Section 1: Green technologies yesterday, today, and tomorrow

Green technologies are not new to the 21st century in terms of history. Humanity has been using sustainability principles for millennia, even if it did not realise it then. Among the earliest evidence of human activity in the field of particle technology is the famous galloping horse painted with inorganic pigments in Lascaux Cave (France) from the 15th millennium BC (Peukert, W., & Bück, A. (2024).

1.1 Prehistory and Ancient Times

In prehistory and antiquity, we can see biomass, where people have been using wood as fuel for fires and later for the production of various objects since ancient times. Wood was an essential energy source for cooking, heating, and manufacturing tools and weapons. Water mills, simple machines that use the power of flowing water to grind grain, were used thousands of years ago. These mills allowed grain to be processed more efficiently and contributed to the development of agriculture and trade. The ancient Romans used solar energy to heat their houses by using specially oriented walls to capture the sun's heat. These walls were designed to maximise the absorption of solar radiation during the day and retain heat at night, improving comfort and reducing the need for additional energy sources (Biswas, 2023).

These historical uses of natural resources show how humans have been searching for ways to efficiently use available energy and materials to meet their needs since ancient times. Today, we are returning to these traditional methods to find inspiration for modern green technologies that will help us achieve sustainable development and environmental protection.

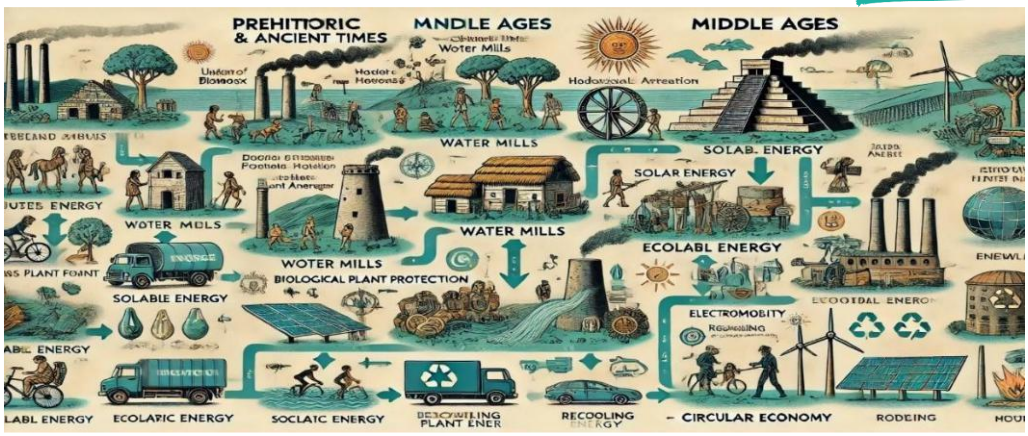
1.2 Medieval Times

The Incas in South America developed sophisticated systems of terraced fields that made efficient use of sloping terrain and water retention. This multi-level farming method was key to their ability to grow crops in harsh conditions. Terraced fields not only increased productivity but also helped prevent soil erosion and improved water retention, which was essential for farming in mountainous areas. Medieval farmers used various plant exudates and natural remedies to protect crops from pests, such as biological plant protection. These methods were precursors to modern organic approaches to agriculture and show how people in the past used natural resources to maintain productivity and protect their crops. The use of natural means not only protects crops but also minimises negative impacts on the environment and human health. (Biswas, 2023).

1.3 Modern times

With the advent of the Industrial Revolution, fossil fuels became heavily used, leading to significant pollution and depletion of natural resources. In the 1960s and 1970s, the first warning signs about the state of the environment began to emerge, sparking the emergence of the environmental movement and increased interest in the development of green technologies. In recent decades, significant progress has been made in the development of technologies for the use of renewable energy sources such as solar panels, wind farms, and hydroelectric power plants. Electric cars are experiencing a renaissance thanks to advances in battery technology and the growing interest in clean mobility. There is a growing emphasis on recycling materials and a shift towards a circular economy that minimises waste and uses resources as efficiently as possible (Biswas, 2023).

Figure 1 Illustration of the evolution of the use of green technologies

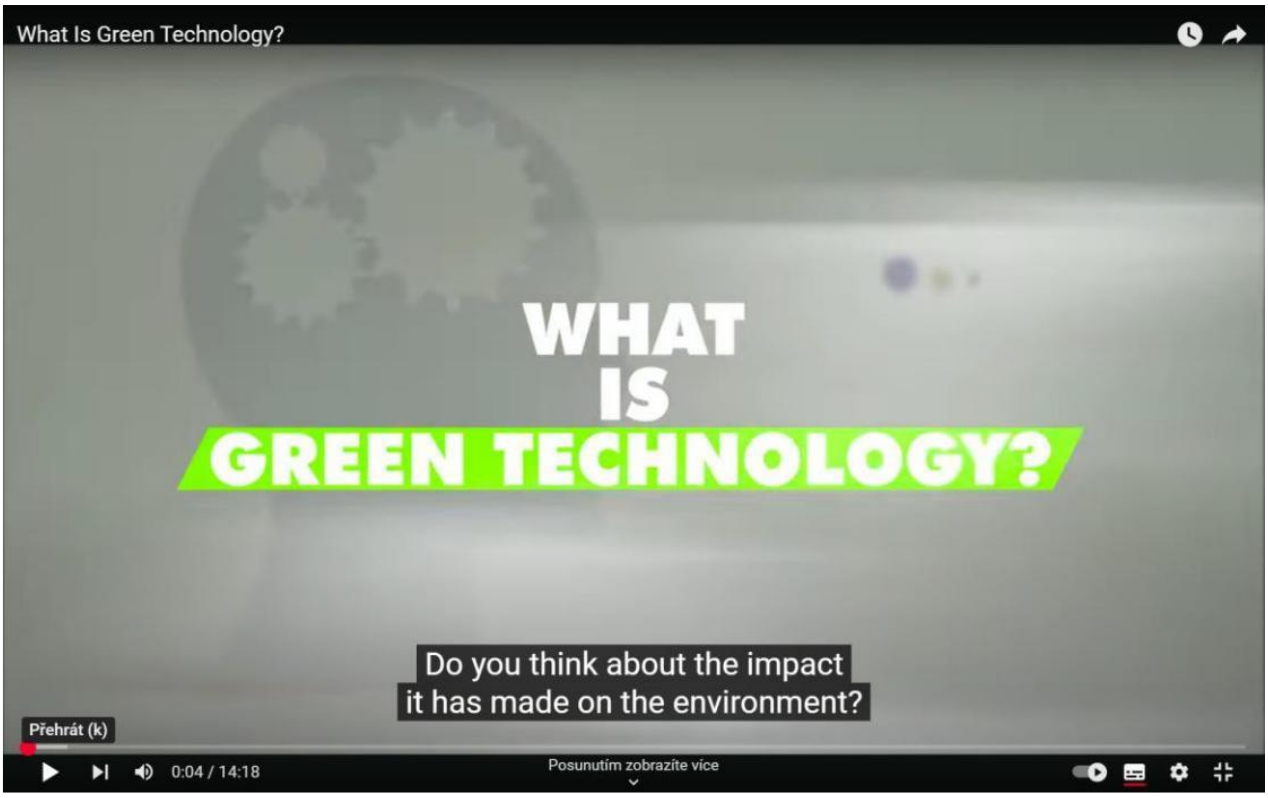


1.4 Present and future

Green technologies are becoming an integral part of our lives and play a key role in addressing the challenges of climate change and environmental protection. The future belongs to innovative solutions that allow us to live harmoniously with nature.

Video: What Is Green Technology?

Time about 14 minutes: https://www.youtube.com/watch?v=TCtIRAFyTIY



Section 2: Man and the impact of his activities on the environment

The impacts of human activity on the environment are extensive and complex, both locally and globally. Here are some of the main areas affected:

2.1 Pollution

Environmental pollution is one of greatest challenges of our time. Human activities have a significant impact on the quality of air, water, and soil.

Air is mainly contaminated by greenhouse gas emissions, which cause climate change. Other major pollutants include fine dust particles and pollutants from industrial production and transport. These pollutants hurt human health and cause several respiratory diseases. Research on the impact of green technologies on air quality has been carried out, for , by Zhang et al. (2023).

Water is polluted in various ways. Industrial waste, oil, pesticides, and fertilisers enter rivers, lakes, and oceans, threatening aquatic ecosystems and degrading drinking water quality.
Soil is contaminated with heavy metals, petroleum products, and industrial waste. Inappropriate land management, such as intensive farming, also contributes to land degradation. Contaminated soil can affect groundwater quality and pose a risk to human and animal health.
The consequences of environmental pollution are complex and far-reaching. They include climate change, loss of biodiversity, deterioration of human health, and economic losses. Tackling this problem requires a comprehensive approach involving technological innovation, changes in consumer behaviour, and international cooperation. Pollution reduction and green technologies are key factors that help achieve green innovation (Nassani et al., 2023).

Figure 2 Areas of environmental pollution

2.2 The loss of biodiversity

One of the most serious environmental crises of our time is the loss of biodiversity. This loss is caused by several factors related to human activity. The main threats include:
Destruction of natural habitats: Human activities such as deforestation, drainage of wetlands, and urbanisation lead to fragmentation and reduction of natural habitats. Many species are unable to adapt to these changes and their populations are declining or becoming extinct.
Pollution: Water, soil, and air pollution have a negative impact on all components of ecosystems. Toxic substances kill organisms directly or disrupt their physiological functions. Pollution also reduces water and soil quality, resulting in the loss of plants and animals.
Introduction of invasive species: The introduction of invasive species into new areas often leads to the disruption of native ecosystems. Invasive species can compete with native species for food and space, transmit diseases, or change the physical characteristics of the environment.
These three factors often interact and amplify each other's impacts. Deforestation can lead to soil erosion and waterway pollution. Pollution, in turn, weakens ecosystems and makes them more susceptible to invasion by alien species.
The loss of biodiversity has serious consequences for the functioning of ecosystems and for people. Ecosystems provide a range of services such as cleaning water and air and pollinating.
Loss of biodiversity undermines these services and threatens our quality of life.
Protecting biodiversity requires a comprehensive approach that includes protecting natural habitats, reducing pollution, and preventing the introduction of invasive species. It is important to recognise that nature conservation is essential for future generations.

2.3 Climate change

Climate change is one of the most pressing issues of our time. It is causing many negative impacts on the environment and human society. Among the most important consequences are:

Temperature rise: Global temperatures are rising steadily, melting glaciers and rising sea levels. This threatens coastal areas and small island states. In addition, the frequency and intensity of extreme weather events such as heat waves, droughts, floods, and severe storms are increasing.

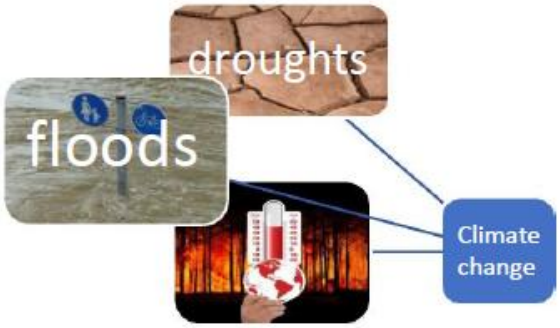
Ocean acidification: Increased amounts of carbon dioxide in the atmosphere are absorbed into the oceans, leading to an increase in ocean acidity. Ocean acidification has a negative impact on marine organisms, especially corals and shellfish, disrupting the entire marine food chain.

Changes in precipitation patterns: Climate change is causing significant changes in the amount and distribution of precipitation. Some areas suffer more frequent and intense droughts, while others are affected by more frequent and more damaging floods. These changes have profound implications for agriculture, drinking water availability, and ecosystems.

The consequences of climate change are complex and interactive. For example, rising sea levels increase the risk of flooding during floods, while droughts can lead to forest fires, in turn, increase greenhouse gas emissions and accelerate climate change.

Adapting to climate change and mitigating its impacts are becoming key challenges for humanity. It is necessary to reduce greenhouse gas emissions, invest in renewable energy sources, and take measures to increase the resilience of ecosystems and human societies to extreme climate events.

Figure 3 Impacts of climate change



2.4 The Waste

Landfilling of waste poses a significant threat to the environment. The decomposition of waste in landfills releases harmful substances that pollute soil and groundwater. It also produces greenhouse gases such as methane, which contribute to climate change.

Microplastics - tiny particles of plastic - enter the oceans and waterways and pose a serious threat to marine ecosystems. Marine animals often mistake them for food, leading to their death. Microplastics can also enter the food chain and threaten human health.
Electronic waste contains several heavy metals and other harmful substances that are released into the environment when improperly disposed of. If not appropriately recycled, e-waste can contaminate soil and water and cause serious health problems.
In conclusion, all these forms of pollution have a negative impact on the environment and human health. It is therefore essential to find sustainable solutions for waste management to minimise their negative impacts.

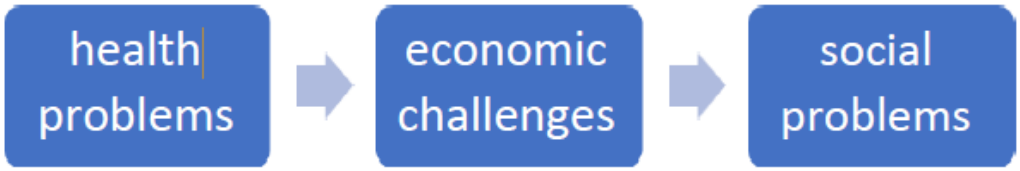
Figure 4 Increasing waste that destroys the environment

2.5 Other impacts
The depletion of natural resources represents one of the most significant challenges of our time. Mineral extraction is devastating landscapes, overfishing is decimating fish stocks, and deforestation is destroying valuable ecosystems. These activities result in a loss of biodiversity and disrupt global cycles of matter.
Land loss is another serious problem. Erosion, soil compaction, and salinity reduce soil fertility and cause soil degradation. Soil loss has negative impacts on agriculture, water management, and biodiversity.
Noise and light pollution are often overlooked but significant problems in the modern world. Noise interferes with natural processes such as animal communication and can have negative impacts on human health. Light pollution disrupts the nocturnal rhythms of organisms and can lead to disorientation and mortality of many species.
The above problems are closely linked and have serious consequences for the environment and human society. It is essential to take measures to limit the depletion of natural resources, protect the soil, and reduce noise and light pollution.

2.6 Implications for humans:
Environmental pollution has far-reaching consequences, not only for the ecology but also for human health, the economy, and society.
The health problems associated with pollution are severe. Polluted air causes respiratory diseases and allergies and increases the risk of cancer. Long-term exposure to pollutants can also damage the immune system. The impact of environmental pollution on the health of not only humans but animals in general is discussed, for example, by Das et al. (2023). These authors point out that there is a rapid increase in environmental pollution due to expanding urbanisation and industrialisation. They see heavy metal contamination as a serious threat to living organisms in aquatic and soil ecosystems.
The economic losses caused by pollution are significant. **The damage to agriculture** is reflected in reduced soil fertility and the quality of agricultural products. The **forestry sector** suffers from air pollution and acid rain. Fishing is threatened by pollution of water sources and declining **fish stocks**. **Tourism** is adversely affected by pollution and environmental degradation.

The **social problems** associated with pollution are complex. **The migration of people** from areas affected by pollution or resource scarcity creates additional problems. Pollution can also cause **conflicts over resources**, especially in areas where access to clean water and fertile land is limited.
The above shows that pollution is a complex problem with far-reaching consequences for human health, the economy, and society. Tackling it requires international cooperation and a comprehensive approach that includes technological innovation, changes in consumer behaviour, and the promotion of sustainable development.

Figure 5 Human consequences of environmental pollution



Video: Human Impact on Earth - Educational Video
Time about 10 minutes: Human Impact on Earth - Educational Video

Section 3 Application of green technologies in practice
Green technologies are key to protecting the environment and ensuring the sustainable development of future generations by reducing greenhouse gas emissions, using renewable energy sources efficiently and minimising waste production.

3.1 Green technology application areas
The practice of green technologies is widespread and covers many areas. Figure 6 gives some examples:

Figure 6 Examples of possible applications of green technologies in practice

Given the high importance of economic criteria, some researchers are exploring the links between green energy and green investments. Kwilinski (2024) offers an in-depth analysis of these variables, which he breaks down into several clusters: the first focuses on renewable energy and sustainable development, the second on government and green energy, and the third on green investment as a catalyst for green energy. Based on an extensive meta-analysis, it also identifies the most active countries and authors working on the issue.

3.2 Practical demonstration - Smart Moss Wall

Locational solutions for improving environmental quality are also interesting for the Smart Moss Wall in London, a natural air purifier. The German start-up Green City Solutions is behind the interesting CityTree solution. This wall claims to purify the air with approximately 275 trees. This admirable feat is made possible by the moss from which this "living wall" is made. The moss has a high ability to absorb pollution, naturally removing harmful particulate matter and nitrogen dioxide from the air. According to the authors' calculations, this moss wall reduces the amount of pollutants in the air by up to 30%.

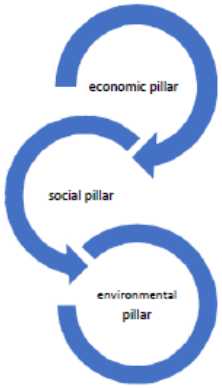
Video: Moss-filled smart wall cleans London's air

Time about 6 minutes: https://www.youtube.com/watch?v=a1aXGYE0iis

3.3. Sustainable development

Three interlinked pillars form the basis for achieving sustainable development.

Figure 7 Three pillars for achieving sustainable development



1. **Economic Pillar:** This pillar aims to promote long-term sustainable economic growth and development that does not deplete natural resources. It includes resource efficiency, innovation, and investment in technologies that promote sustainability. Recent studies confirm that green technology innovations are critical to sustainable development (Zhang et al., 2024).

1. **Social pillar:** This pillar focuses on ensuring social justice, equity, and access to essential services such as education, healthcare, and housing for all members of society. The aim is to improve quality of life and promote social cohesion.

1. **Environmental pillar:** This pillar aims to protect and preserve natural resources and ecosystems, reduce pollution, and promote renewable energy sources. Its aim is to minimise human activity's negative impacts on the environment and ensure its sustainability for future generations.

These three pillars are interlinked and form the basis for achieving sustainable development.

Questions - quiz

1. Are green technology issues contemporary, or have they been with humanity since the beginning? Can you give examples?
2. What are the main impacts of human activity on the environment? Which ones have you observed yourself?
3. In which areas can we subsequently see negative impacts on humans?
4. Which three pillars form the basis for sustainable development?

Glossary of Key Terms

SALINITY: Salinity refers to the total amount of solids dissolved in 1 litre of water, including gases, because even these are converted to solids at low temperatures.

INVASIVE SPICES: Invasive species are organisms introduced by humans, intentionally or unintentionally, outside their native range. They spread rapidly, and some pose a major risk to natural systems. However, they also threaten humans, livestock and agriculture.

HABITAT: the habitat of a particular organism, a biotope.

Human-centered transformation

Module Introduction

In today's rapidly evolving world, businesses are undergoing digital and sustainability transformations to stay competitive and responsible. However, technology and policies alone don't drive success – people do.

This module will introduce you to the concept of human-centered transformation, where employees, leadership, and workplace culture play a key role in making digital and green transitions more effective and sustainable.

Learning Objectives / Scope of Knowledge Obtained

1. Understand the principles of human-centered transformation in the context of digital and green transitions.
2. Recognize the key principles of a human-centered approach (empathy, skills development, inclusive decision-making, and responsible technology use).
3. Apply best practices for engaging employees in digital and sustainability efforts.
4. Commit to small, actionable steps to support transformations in their workplace.

Module Structure

- **Estimated Time for Completion:** 20 Minutes
- **Overview of Sections:**
  - Introduction
  - Human-Centered Approach
  - Self-Reflection and Action Plan

Content

Section 1: Introduction

Especially with the rapid development of new technologies, involving many people in a transformation process has become easier. The term „human-centered transformation" highlights that people – their values, thoughts, and experiences – are at the core of successful change. Transformation is not just about implementing new systems or policies; it is about changing long-standing behaviors and underlying beliefs to achieve a desired outcome. To make transformation truly impactful and sustainable, it should not be a top-down initiative dictated solely by upper management. Instead, human-centered transformation actively involves people as key participants, encouraging them to contribute their perspectives, share their insights, and have their voices heard (Duval, 2023).

At the same time, transformation efforts are often brand-driven, meaning they align with an organization's core identity, mission and values. When companies integrate their brand strategy with a human-centered approach, the transformation resonates more deeply with employees and stakeholders. This synergy ensures that change is not just strategic but also personally meaningful, leading to higher engagement, innovation, and long-term success (Hohlfeld, 2024).

By combining these perspectives, organizations can create effective, ethical, and sustainable transformations that empower their people while staying true to their brand purpose. This module will explore how companies can apply human-centered principles to digital and green transformation, ensuring a more inclusive, impactful, and future-proof change process.

- Embedded Video: A Human-Centered Approach to Digital Transformation
- Visualization Methods: [Human-Centered Transformation Model. Adapted from (Hohlfeld, 2024).]

Section 2: The Human-Centered Approach

In the journey toward digitalization and sustainability companies often focus on adopting new technologies and optimizing operations. However, true transformation goes beyond technology – it is about how people interact with and adapt to change. This case study explores how four Norwegian manufacturing companies

successfully combined digital transformation and sustainability initiatives by applying a human-centered approach.

The study highlights the critical role of employees, leadership, and workplace culture in making transformation efforts successful. It provides real-world insights into how companies can navigate challenges by actively engaging their workforce, fostering a culture innovation, and ensuring leadership plays a supportive role.

For a deeper understanding of the human-centered approach in digital and green transformation, focus on these sections:

- Case Description (Pages 31 – 35)
- Human-Centric Approach for Transformation (Pages 36 – 67)
- Organizational Learning and Performance Factors (Pages 67 – 70)
- Final Framework (Page 74)

As you go through the case study, focus not only on the technological advancements these companies implemented but also on the human factors that contributed to success. Consider the following:

- Employee Engagement – How were employees involved in the transformation process? What role did training, communication, and motivation play?
- Cultural Shift – How did companies foster a culture that embraced change rather than resisted it?
- Leadership Influence – What role did leaders, super-users, and innovation champions play in guiding transformation?

Try to connect these insights to your own organization. What lessons can you take away? How could a human-centered approach improve digital and green transformation efforts in your workplace?

The visual final framework provides a structured overview of how digital transformation, sustainability, and firm performance are interconnected, with the human-centered approach acting as a key enabler. Here's how to interpret it:

1. Digital transformation and sustainability are linked, but technology alone isn't enough – people drive change.
2. A human-centered approach strengthens transformation efforts by focusing on:
   - Skills development – ensuring employees are equipped with the right knowledge and tools.
   - Cultural support – creating an environment that encourages collaboration, experimentation, and adaptability.
   - Leadership engagement – empowering employees through supportive leadership, super-users, and innovation champions.
3. External factors like regulations, competition, and customer expectations also shape transformation outcomes, influencing how companies invest in digital and sustainability initiatives.

By understanding how these companies integrated human-centered principles, you will gain practical insights into what makes transformation more inclusive, effective, and sustainable. As you reflect on the case study, consider:

- How does your organization currently approach digital and green transformation?
- Are employees actively involved in shaping the process, or is change being driven top-down?
- What steps can be taken to enhance a human-centered approach in your workplace?

This case study serves as a guide to understanding transformation beyond technology – by putting people at the center, companies can ensure long-term success, innovation, and sustainability.

- Case Study: [Achieving Sustainability through Digital Transformation Using a Human-Centric Approach (Erntsen et al., 2024). Retrieved from https://ntnuopen.ntnu.no/ntnu-xmlui/handle/11250/3156155.] à Interesting Insights on 4 Industries (Materials, Pharmacy, Chemical, Food).
- Visualization Methods: [Final Framework Case Study. Retrieved from Erntsen et al., 2024. Achieving Sustainability through Digital Transformation Using a Human-Centric Approach, p. 74.]

Section 3: Self-Reflection and Action Plan

Now that you have explored the key principles of human-centered transformation, it's time to pause and reflect on how these insights relate to your own experiences. Try to assess your workplace's approach to digital and sustainability transformation. Reflect on how a human-centered approach could improve engagement and success. Commit to one small, actionable step you can take to support transformation in your role.

Transformation is most effective when individuals take ownership and contribute actively. Use this section to think critically about your role and identify concrete ways to apply what you've learned.

Self-Assessment:

- How involved are employees in digital and sustainability initiatives at your workplace?
  Not at all; Somewhat; Actively engaged
- What is the biggest challenge in human-centered transformation?
  Lack of training, Resistance to change; Leadership support
- Which factor do you think is most important for successful transformation?
  Upskilling; Culture; Leadership

Personal Reflection:

- Think of a recent change at your company (digital or sustainability-related).
  How did employees react?
  What worked well, and what could have been improved?
  How could a human-centered approach have made the process smoother?

Now that you have reflected on human-centered transformation in your workplace, it is time to create a personal action plan. This plan will help you apply what you have learned by committing to small, meaningful steps that contribute to successful transformation in your organization.

[Human Centered Transformation Action Plan.xlsx]

Quiz:

- Human-centered transformation focuses on aligning organizational change with the values, experiences and input of the people involved. (**True**/False)
- What is a key benefit of integrating brand strategy with a human-centered transformation approach?
- Reduces the cost of digital tools
- Ensures more efficient automation
- **Increases employee engagement and personal relevance**
- Improves social media visbility
- According to the case study, which of the following factors most influenced successful transformation in Norwegian companies?
- Rapid software upgrades
- Government subsidies
- **Employee engagement and leadership support**
- Cost-cutting strategies

Module 2: Smart (Digital) Manufacturing Toolkit

Module Introduction

Ever wondered why certain SMEs can successfully implement more sophisticated toolkit mastering without significant investments? Do you sometimes still wonder if digitization is just a buzzword for policy makers, rather than an achievable goal for most smaller companies? You've came to the right place!

After all, many people in various institutions and organizations, particularly SMEs, struggle to access clear and useful information on how can they actually 'smarten' or even digitize their production. A widely recognized barrier to faster and smarter digitization has been the software and hardware industry with strong and exclusive proprietary licenses on the one hand and being the source of new security risks on the other. As a result, the need for open innovation grows stronger by the day. For many smaller companies facing financial and time constraints, the key lies in integrating open innovation toolkit mastering into their digital manufacturing roadmap from the very beginning. Even if you are already familiar with or fluent in digitizing your production lines, the latest trends in open innovation approaches might help your company overcome product design challenges or improve aspects of business operations through collaboration with relevant external stakeholders.

This module aims to provide foundational knowledge on the Manufacturing Operations Management, Manufacturing Execution Systems, the foundational role of data, digital twins and similar technologies, while also highlighting common pitfalls and challenges associated with their implementation. At the same time, the detailed descriptions of real case studies included in this learning course go beyond the introductory level and may be particularly valuable for employees or business professionals with more experience in digitization.

The same applies to open innovation concepts such as outside-in open innovation, inside-out open innovation, and coupled open innovation. This learning program will provide a decent foundation in these areas, while the sections on the trajectory with smart manufacturing, open innovation measurements and its illustrative examples may extend beyond the beginner's level.

Learning Objectives/Scope of Obtained Knowledge

By completing this module, you will:

1. Get to know the main components of smart manufacturing systems and the main organizing principles of open innovation paradigm.

2. Explore the common pitfalls, sustainability issues and business dilemmas that usually accompany any advanced digitized manufacturing system implementation.

3. Learn from relevant and referential case studies from diverse industry clusters.

4. Identify various knowledge and machinery gaps where open innovation toolkits can be of use.

Originally, the course has been created for Company Owners, Manufacturing Engineers and Operators, Production or Innovation Managers and the like. All materials have been developed with SMEs in mind. However, the education material is also suitable for other types of organizations dealing with the challenges of digitization, students or any other party interested in the topics of digitization and open innovation.

Module Structure

1. Introduction to Smart Manufacturing
2. MOM and Its Associated Systems and Technologies
    a. MES
    b. APS
    c. QMS
    d. Digital Twins
3. The Relevance of Data
4. Pitfalls and Barriers of Smart Manufacturing
5. Referential Case Studies for SMEs
6. Introduction to Open Innovation
7. Open Innovation Models
    a. Outside-in OI model
    b. Inside-out OI model
    c. Coupled OI model
8. Smart manufacturing with Open Innovation

1st Subcategory: Introduction to Smart Manufacturing & Manufacturing Operations Management

Introduction to Smart Manufacturing

Depends on the industry sector you are currently conducting business in, there exists a common consensus about the post-covid era: the manufacturing sector in the European market currently suffers from an extreme shortage of labour, while the global unemployment is rising (Kozamernik, 2024: 3). It is only natural for people – maybe even for your empyees and other business colleagues to be fearful of automation, since it threatens them with the possibility of losing their jobs. However, one needs to bear in mind that ordinary people at everyday basis are the ones that implement and use technology. If someone's going to replace all their workers with robots and cut jobs, this will be our responsibility, not technology's (Kozamernik, 2024: 4).

This seems simple at first glance, although the current ever-fast pace of technological development complicates things significantly. Both common people and business experts agree the technological development is moving faster than most of business habits. Contrary to many governmental policies, digitization is not a goal or a destination, it is a journey. That means one can not simply implement a

new Enterprise Resource Planning (ERP) system and think this covers the company's digitization for the next 10 or 15 years or so, notwithstanding that the full implementation and monitoring of all processes in real time via an ERP system is hard (Kozamernik, 2024: 8). All modern technological solutions usually come with various degrees of complexity one needs to handle. Either way, to make machines autonomous to a greater or a lesser degree, sufficient and adequate workforce's digitization skills are needed.

Smart manufacturing, Industry 4.0 or the industrial internet of things might come off as very aspirational and ambitious, especially when used in numerous self-promotion pitches across traditional and social media content. Here, we would like to clarify these familiar yet somehow vague and abstract terms (Wolf and Lepratti, 2020: 28). All three terms share overlapping agendas and are often used interchangeably.

The term Industry 4.0 emerged from the German industrial and political context, first introduced at the Hannover Messe, a major German trade fair, around 2011. It quickly gained traction and was adopted by the German government as part of its high-tech strategy to promote the computerization of manufacturing. By around 2014, companies and governments outside Germany began to follow a similar trajectory (Chaplin et al., 2021: 10). Comparable national strategies can now be found worldwide—for example, the Industrial Internet Consortium in the USA, Manufacturing Innovation 3.0 in South Korea, the Robotic Revolution in Japan, and Made in China 2025 (Kraft et al., 2021: 50).

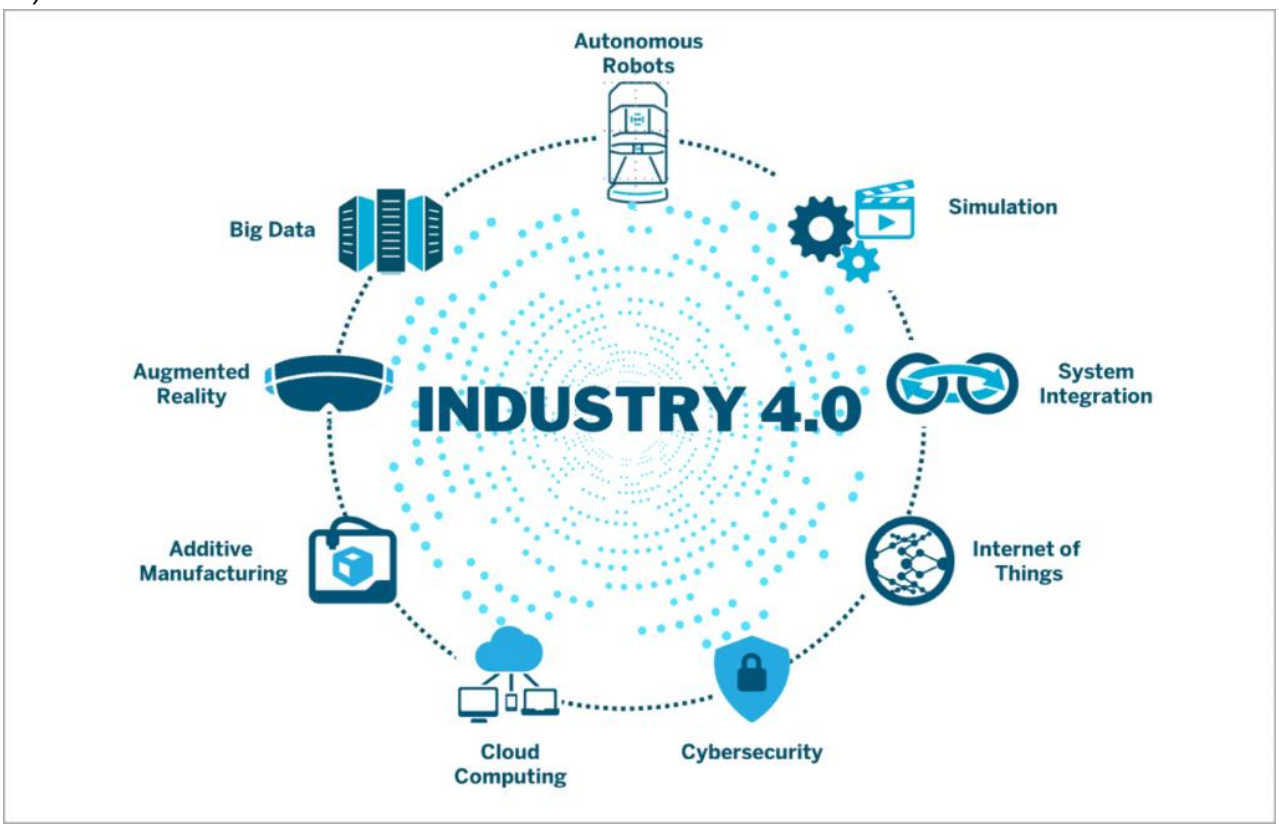


Figure 1: The Definition of the Industry 4.0 (Source: Meloeny, 2022)

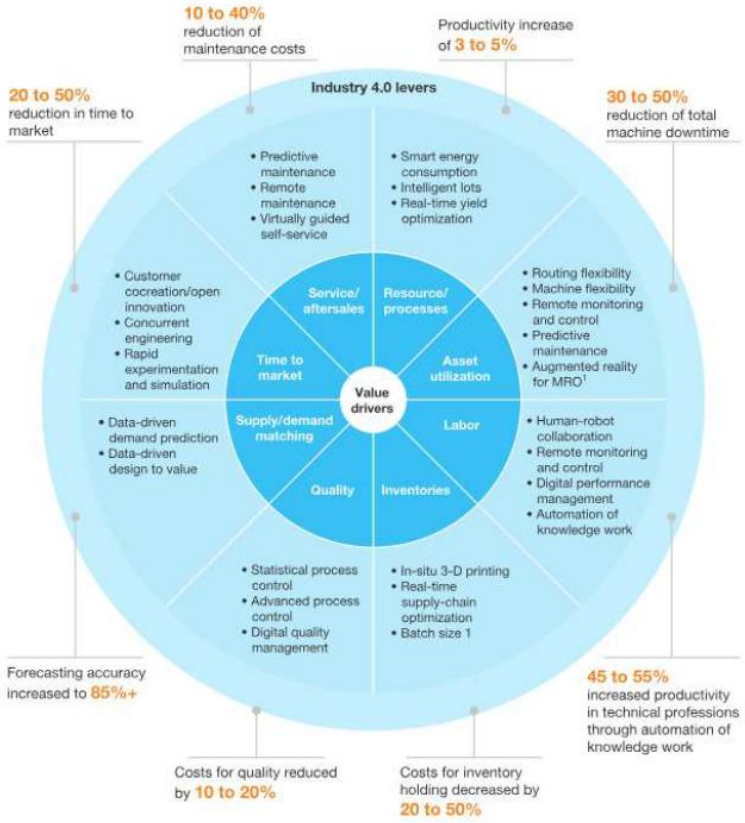
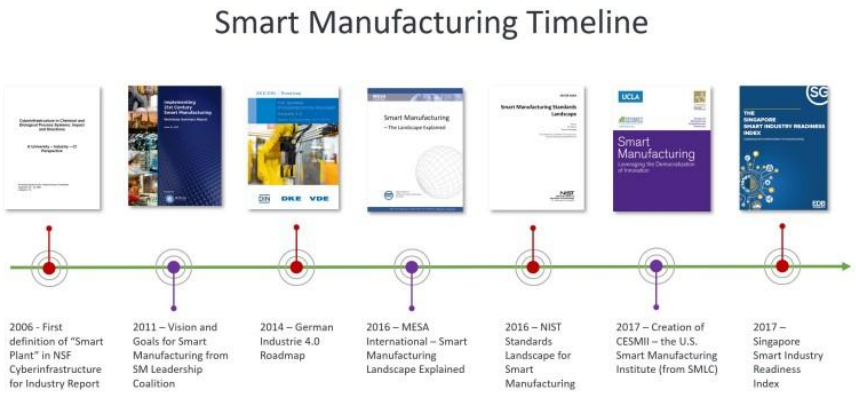


Figure 2: Performance benefits of digitization in Industry 4.0 (Source: Dilmé and de Huete, **2021)**

Smart manufacturing can today be understood as a subset of Industry 4.0, as it has a more limited scope, focusing exclusively on the manufacturing process itself. Interestingly, the term smart manufacturing actually predates Industry 4.0: it was first coined in 2006 during a National Science Foundation workshop on cyberinfrastructure. The buzzword is most commonly used in the American corporate context, where it is supported by a dynamic and diverse network of stakeholders and institutions—such as the Manufacturing Enterprise Systems Association, the (aforementioned) Industrial Internet Consortium, the Smart Manufacturing Leadership Coalition, and, notably, the U.S. Smart Manufacturing Institute(CESMII).



Video Materials:

Industry 4.0 and Smart Manufacturing Explained (by Star Rapid)

A synonymous and widely used expression for Industry 4.0 or smart manufacturing that you may have come across is the Industrial Internet of Things (IIoT). This term typically refers to a bundle of various technologies, including cyber-physical systems, cloud computing, mobile technologies, machine-to-machine communication, advanced robotics, the Internet of Things, radio frequency identification (RFID), cognitive computing, machine learning, big data technologies, and more (Pruncu and Zbitou, 2023: 3).

However, since this educational module is intended for Central European manufacturing SMEs, there is little value in overhyping technological advancements. Rather than emphasizing cutting-edge technologies, we focus on explaining the practical potentials of these versatile tools. The goal of any responsible educational program should not be to promote the idea that “the more digitized and smarter the company, the better,” nor to encourage digitizing every business operation indiscriminately.

Instead, our aim is to empower SMEs with the knowledge necessary for a more gradual, relevant, and strategic digital transformation—beginning with the most impactful areas. This includes understanding the first steps in digitization and learning how to implement a sequence of cost-reducing measures. Rather than fixating on the latest trends such as AI or machine learning, it is more beneficial to explore how smart manufacturing technologies can be combined with existing equipment and machinery to support already defined or future objectives.

Unlike the American corporate ethos epitomized by Silicon Valley's "move fast and break things," this mindset is not only ill-suited but potentially harmful to the business realities of countless European SMEs.

USEFUL TIP: Terms Industry 4.0 and Smart Manufacturing can mean two things at the same time:

1.) A set of technologies (e.g., cloud computing, autonomous robotics, big data etc.)

2.) A governmental strategy and a wider environment of different private and public stakeholders.

In terms of technologies, smart manufacturing is considered a subset of Industry 4.0. However, when referring to strategies or innovation environments, the two terms are often used interchangeably to some extent.

If you're aiming to impress an American business partner, the term smart manufacturing is generally more familiar and widely used. In contrast, within most European contexts, Industry 4.0 tends to be the more commonly recognized term.

That said, all three expressions—Industry 4.0, Smart Manufacturing, and Industrial Internet of Things—share substantial overlap in terms of the technologies they encompass and the developmental agendas they support.

So, what types of Industry 4.0 business applications do European SMEs actually implement?

Below, we summarize findings from several sources (Kraft et al., 2021; Wolf and Lepratti, 2021):

1. Focusing on Basics and Efficiency

   One of the first steps SMEs take in adopting Industry 4.0 is the digital tracking of products—often through barcodes or RFID tags on components and goods. This facilitates faster, more cost-efficient procurement, logistics, manufacturing, storage, and delivery. Many SMEs have already implemented these tools as part of practices such as just-in-time delivery.

   Generally, early Industry 4.0 initiatives involve small-scale digital enhancements to existing products and services, serving as accessible entry points into the broader digital transformation journey.

2. Focusing on Interconnectedness, Integration and Cost Reduction

   The most widespread Industry 4.0 application among SMEs involves transitioning from traditional factories to digitally interconnected "Smart Factories." This goes beyond barcoding—it means integrating machines, products, and employees through a unified digital infrastructure. In such settings, production, quality control, logistics, and maintenance systems are all interlinked, enabling predictive capabilities and real-time responses.

   Research indicates significant cost-saving potential: real-time safety monitoring, for instance, can reduce related costs by up to 40%, while streamlined communication between departments can reduce waste and decision-making time, with overall cost savings reaching up to 70%.

This category includes Manufacturing Operations Management (MOM) technologies and its subtypes:

- Manufacturing Execution Systems (MES)
- Advanced Planning and Scheduling (APS)
- Quality Management Systems (QMS)

The key advantage here lies in the gradual nature of implementation—companies can introduce MOM technologies step-by-step, avoiding the high-risk and disruption of full-scale digital overhauls that may overwhelm employees.

3. Focusing on New Business Models and New Value Creation

While many SMEs use Industry 4.0 to improve existing operations, some go further by creating entirely new business models. These pioneers leverage smart, connected products to deliver added value to customers and explore innovative revenue streams.

Such transformations often require significant internal change and external collaboration. For example, products equipped with sensors may transmit real-time data that enables predictive maintenance, autonomous updates, or adaptive functionality. This, in turn, can support the development of new services, enhance safety in hazardous roles, or offer personalized customer experiences.

In these cases, companies essentially transition from Industry 4.0 solution users to Industry 4.0 solution providers, capitalizing on their technological expertise to offer competitive innovations. However, this form of value creation remains far less common among SMEs compared to the previous two focus areas.

MOM and Its Associated Systems and Technologies

For the purposes of this module, we will explain ‘smart manufacturing’ buzzword as the implementation of different components and entities, namely manufacturing operations management (MOM) and the types of manufacturing systems associated with it (i.e., manufacturing execution system or MES, advanced planning and scheduling or APS, quality management systems or QMS and manufacturing intelligence. As an additional extension of Manufacturing Operations Management, we have decided to include and describe the potential of implementing a specific subtype of intelligent manufacturing: the digital twin. One of the most promising recent developments in this area relates to the application of digital twins in remanufacturing and refurbishment processes for large-scale industrial equipment (Zhang et al., 2021: 1). We will present all the associated systems in greater detail a bit later.

The types of manufacturing systems associated with MOM

Manufacturing execution system (MES): A software solution that ensures that quality, and efficiency are built into the manufacturing process and are proactively and systematically enforced. An MES may connect multiple plants, sites, and vendors' live production information, and should integrate easily with equipment, controllers, and enterprise business applications. The result is complete visibility, control, and manufacturing optimization of production and processes across the enterprise.

Advanced planning and scheduling (APS): A digital solution that helps manufacturers to manage production planning and shop floor scheduling. Using advanced algorithms to balance demand and capacity and generate achievable production schedules, APS software results in shorter lead times to meet customer demands and easier, more rapid responses to unexpected production changes.

Quality management system (QMS): Software that enables manufacturers to electronically monitor, manage, and document their quality processes to help ensure that products are manufactured with in tolerance, comply with all applicable standards, and do not contain defects. QMS software provides the procedures, processes, structure, and resources needed to streamline manufacturing and ERP operations while cost-effectively managing quality issues.

Manufacturing intelligence: Software that integrates, connects, and unifies data sources from other MOM systems, as well as enterprise software, into one accessible analytical data model. Manufacturing intelligence provides capabilities to explore and drill down into contextualized data. It is used at the plant level to improve collaboration and data exchange between the shop floor and enterprise systems, and/or at the enterprise level to benchmark and compare production runs or predict various plant operations.

Figure 3: Table of MOM-associated systems (Source: Wolf and Lepratti, 2020: 33)

The main system, i.e. MOM, should be treated as the digital brain of every smart manufacturing. In the digital realm, MOM helps you bridge the virtual world of products ideas or computer-aided design (CAD) and the real-world production. If you already have a functioning ERP, MOM can connect or link ERP and product lifecycle management (PLM) solutions, which integrate data, processes, and business systems, to the manufacturing floor's production machinery and automation. You will soon realize, that the functionality of manufacturing operations is not something new – as it existed since the second industrial revolution, when trains were built. The MOM functionalities will probably sound familiar to you as you may as well heard of them before. What changes, however, is the mechanism or system that performs those functions, and the delivery mechanism for those very same functions. (Wolf and Lepratti, 2020)

You can have two totally different approaches for producing your series of products, while one uses smart manufacturing and the other doesn't – its code of conduct for manufacturing operations management generally does not change. Everything else does: the how, where, by whom, when, and even the why continually change with implementing MOM systems. So we will be focusing on the technologies that are being used to perform MOM functions.

Companies, especially European SMEs, are usually less enthusiastic about taking risks and do not engage in experimenting with newer things, since they need to be cautious with their resources. This clashes with the complex and resource-intensive nature of any smart manufacturing or Industry 4.0 digital transformation (Ghobakhloo and Iranmanesh, 2021). However, some experts (see Kozamernik, 2024: 76) observe a certain behavior pattern of 'playing safe', as they often encounter companies investing their resources in new machinery and lines than in digitalization – on a yearly level, it is not so uncommon the investments in new machinery being 10 times bigger than the resources allocated for digitalization. If a company decides to buy new machine, a new CNC machine per example, this investment usually influences a minor part of the workflow or impacts fewer employees

If you are already interested in investing in new MOM technology, your purchase should beforehand pay attention to the type of manufacturing you perform, the size of your company and the kind of materials you deal with (Wolf and Lepratti, 2020: 69).

2.1.Manufacturing Execution System

A Manufacturing Execution System (MES) is software that helps track and control production processes on the factory floor. It works in real time to collect data from machines, operators, and sensors to monitor productivity, identify delays, and improve efficiency. MES can help SMEs gain better visibility into their production flow, reduce errors, and support lean manufacturing. Instead of relying on paper or manual reporting, an MES ensures that the right information is available at the right time to make informed decisions.

2.2.Advanced Planning and Scheduling

Advanced Planning and Scheduling (APS) tools help optimize how and when production tasks should happen. These systems go beyond basic planning by considering constraints like machine availability, material supply, delivery deadlines, and workforce capacity. APS can help SMEs better manage production complexity, reduce lead times, and improve delivery reliability. By using real-time data, APS supports faster responses to changes and unexpected disruptions in the production process.

2.3.Quality Management System

A Quality Management System (QMS) ensures that products meet specific quality standards and regulatory requirements. It includes tools and processes for monitoring, documenting, and improving product quality throughout the manufacturing cycle. For SMEs, a QMS is essential to avoid costly mistakes, reduce rework, and build customer trust. Digitized QMS tools allow companies to detect quality issues early, perform root-cause analysis, and ensure continuous improvement in line with certifications like ISO 9001.

2.4.Digital Twins

A Digital Twin in its most basic and simplest terms means ‘a simulated replica of a complex system’ (Chaplin et al., 2021: 159-160). It uses real-time data to simulate and predict how the real-world counterpart performs. In manufacturing, digital twins can help visualize machine behavior, test changes without risks, and predict maintenance needs. SMEs can benefit from digital twins by improving equipment uptime, supporting sustainability efforts (e.g., by optimizing energy use), or enhancing refurbishment strategies—especially for high-value machinery.

Pop Quiz: Introduction to Smart Manufacturing

(Some questions have more than one correct answer – choose all that apply.)

1. **Which of the following statements about the term Industry 4.0 are correct?**

a) It originated in South Korea as a digital innovation policy.

b) It was first introduced at the Hannover Messe trade fair in Germany.

c) It refers to a bundle of advanced digital technologies in manufacturing.

d) It is used only by large multinational companies.

e) It became a part of Germany’s national high-tech strategy.

Correct answers: b, c, e

(Explanation: Industry 4.0 originated in Germany and includes various technologies; it's not limited to big companies.)

2. **Which of the following are commonly associated with Smart Manufacturing?**

a) It's primarily used in the European policy context.

b) It originated before the term Industry 4.0 was coined.

c) It focuses exclusively on logistics.

d) It's more common in American corporate and policy circles.

e) It’s a general term for national innovation policies.

Correct answers: b, d

(Explanation: Smart manufacturing originated in the U.S. and focuses on production-level improvements.)

3. **What technologies are often part of the Industrial Internet of Things (IIoT)?**

a) Cyber-physical systems

b) Mobile phones

c) Blockchain governance

d) Machine learning

e) RFID tags

f) Water turbines

Correct answers: a, b, d, e

(Explanation: IIoT includes technologies that enable real-time data and machine interaction.)

2nd Subcategory: Instructions on Smart Manufacturing Practice (Data, Pitfalls and Barriers, Business Case Studies)

The manufacturing operations management or MOM lies at the heart of any digitized enterprise. However, the underlying condition of any successful 'smartification' of production is the fuel of any digital economy: data. Any form of smart manufacturing necessarily means convergence with modern data science techniques. No need to worry if your company has no need for big data, machine learning or AI technologies, the key is to think about the data that can enhance and optimize your production processes. Sometimes implementing a robust data collection system that does not track large volumes of data is a better choice. However, if you already use an ERP system, improving its efficiency with an AI solution is a viable option.

New manufacturing data is being generated as we speak, becoming useful and beneficial for developing new production insights. This shift towards data is already forcing, and has forced, companies to cooperate with a larger pool of other companies and institutions than before. Some (Kraft et al., 2021: 60) even consider this shift an internal driver of cooperation and openness. More precisely, this demands of manufacturing chiefs and company owners to shift from managing documents, may they be still in papers or digitized, to exploring and incorporating different metrics that are derived across the value chains (Wolf and Lepratti, 2020: 68). Despite these optimistic changes, the increased interconnectivity and data orientation come with risks related to information security and other challenges in responsible data management. SMEs from various countries and continents often cite concerns about these risks and difficulties in ensuring data security as major barriers to adopting digitized and complementary technological solutions (Rauch et al., 2019: 92). This part about smart manufacturing will conclude with some successful real-case examples of relevant European SMEs operating in machinery and equipment industry cluster, (precision) agriculture, and lastly, chemicals – namely lubricants and fluids.

The Relevance of Data

This chapter will guide you through some pointers about the practices of data collection, where to start it and how to set it, how to automate it and use it to your own advantage. Please find no shame in admitting your company still enters a great portion of internal data manually or uses and Excel spreadsheets for the very same purpose. You are not the only one!

A great deal of manufacturing plants still rely heavily on manual data handling. Market research (see Kozamernik, 2024: 60) reveals this state in more detail:

- nearly half (48%) of manufacturing companies continue to use manual methods and spreadsheets for data collection.
- of that 48%, only a mere 12% feel they can make sound decisions based on this manually gathered information.
- This starkly contrasts with the overwhelming majority, 76%, of manufacturing companies who claim to recognize the potential of technology to streamline critical data collection.

Video Materials: Data drives the future of smart manufacturing (by South China Morning Post)

To achieve a successful digital transformation, it is crucial to automate capturing and archiving data. However, just storing the data creates no value for your company. Even though the raw data of a prime minister or a military company may naturally have more value than your own company or your small local supplier, your raw data can add value, although in combination with a right approach. Small local businesses can help themselves with producing and analysing raw data in order to become more stable and develop a predictable business model, which will be resistant to seasonal fluctuations or market changes (Kozamernik, 2024: 63).

The process of data automation starts with the collection of signals, namely with gathering signals from machines, lines, or devices. However, you shouldn't collect signals mindlessly or just convert them into data and store them for later on. You should first ask yourself what is your specific purpose for observing and capturing a particular sound, movement or specific functioning of the machine (Kozamernik, 2024: 63).

Below we list some general recommendations on the types of signals that can be converted into data points:

- The time the machine was turned on.
- The time the machine was turned off.
- The amount of time the machine was in operation.
- The start-up time of the machine.
- The time it took a clear deadlock.

By collecting additional signals, you can produce more detailed data, such as:

- The number of pieces produced
- The number of good and bad components
- Key performance indicators and benchmarks
- Tool change time
- Maintenance time.

(Kozamernik, 2024: 64).

Many SMEs do not collect data, important for process optimization – per example, setup times, changeover times, processing times or downtimes are often not tracked or written down, hence missing. These are usually the moments when staff needs undivided attention elsewhere, follows a protocol or/and is busy with communication, so burdening them with other tasks would prove to be counter productive. In the mentioned cases, smart sensors and the Internet of Things can be beneficial to employ (Chaplin et al., 2021: 95).

USEFUL TIP: Before you start collecting signals from machines, lines, or any other device in your inventory, create a written plan for how the company will use the data. The plan doesn't need to be long: it can just contain some written objectives for analysing the data and states what are the root causes of productivity improvements you would like to achieve. Discuss and communicate the plan with your employees.

- Manual vs. automated data capture
- How to automate data capture
- How to convert a signal into value-added data?
- Recommendations on what to collect for beginners (machine or line cycle time, machine or line downtime, time spent performing activities, active work hours, quantity produced (per minute, hour, day, etc.), manufacturing costs, cost per unit, energy consumption, quality rate (defects, good and bad pieces, tolerance limits, etc.)
- Expected productivity gains that come with the introduction of automated data capture (5-8%)
- Progressing from digital factory to smart factory – this passage underscores the statement 'the future will be data'

Pop-quiz question idea: the learner will need to tick the correct beginnings of data collection amongst an offered mixed pool of true and false answers.

When you decide which KPIs are important, first start with one or two you KPIs which you deem not only important, but you can picture an easy way to collect its necessary data that will be comprehensible to you or to your employees. Alas, "visibility and transparency are key prerequisites for the optimization of manufacturing processes" (Chaplin et al, 2021: 94). What is the point of choosing a KPI which makes a lot of business sense but will be completely unknown to you, hence making you struggle with its interpretation or even with its collection to begin with? "Fancy" machine learning statistics or complex diagrams will not be of any use to you, if you engage yourself in mindless data collection on the ground of its volume, hoping to achieve some ground-breaking analysis. If data is to be useful, it should be:

VISIBLE: Such data should be relatively accessible to you or your employees and backed with a description or a well-defined process on how to access it.

TRANSPARENT: Such data should be given in an easy-to-understand manner, enabling acting upon it. Sometimes this means data should be translated to another format or visualized.

Pitfalls and Barriers of Smart Manufacturing

- how to choose an adequate technology? If it achieves at least one of the following objectives: improving customer experience, faster food processing, faster execution of production processes, automation of workflows, better business intelligence
- the investment dilemma: should one invest in a new machine, line, or digital transformation?

- Commonly identified reasons for unsuccessful implementation of solutions in digital transformation (lack of leadership; absence of people in production operations on the project; poor organization and inadequate process management before implementation; poorly defined production processes; incorrect selection of software and business partners; unrealistic expectations and excessive focus on appearance rather than

functionality; lack of digitally educated staff within the company; partial implementation of the solution; resistance, poor training, and preparations of employees for the new solution)

Pop-quiz question idea: the learner will need to tick the correct conditions under which a technology purchase makes sense, again from the pool of mixed (true and false) answers

Quiz question idea: the learner will need answer the question "Please state at least 5 most common reasons for unsuccessful implementations of solutions in digital transformations?"

Regarding the Industry 4.0: Industrie 4.0 applications and business models can initially lead to increased time-to-market and decreased control (Laudien and Daxböck, 2016). Uncertainty also exists as to whether potential customers are willing to pay the price for such new or enhanced products or services. Other influencing factors include the technical integration of Industrie 4.0 systems as well as organizational and personnel challenges.

The biggest barriers to digital transformation are often established rigid processes, the defense of existing structures, and a lack of willingness to change among employees (Etventure in Kraft et al., 2021: 61).

Caught up in day-to-day business operations, many SMEs and large businesses are struggling to understand current and future technological needs, drive business priorities and define technological implementation plans. In many cases, they do not know how to visualize or translate the smart manufacturing (or the Industry 4.0) paradigm to the specifics of their core business operations. According to a survey conducted by Canon Research, 58% of European SMEs cited lack of internal capabilities, almost 50% stated the smart manufacturing is not a priority right now since it lacks clear ROI. Just under 50% of questioned SMEs feel that following the Industry 4.0 paradigm would demand employee change and management change.

Referential Case-Studies for SMEs

Multilayered Shifts of Cardboard Production: the Case of a German Machinery Manufacturing company BHS Corrugated (Kraft et al., 2021: 62-64)

Although BHS Corrugated can not be classified as 'company like any other', they can nevertheless be qualified as an example of a "German Mittelstand" company. They are one of the global market leaders in the development, production, and installation of production facilities for manufacturing cardboard. Additionally, they produce the machines for cardboard production, using paper rolls (corrugators). During COVID-19 pandemic, they were considering producing digital printers.

Moreover, the company generally offers a variety of innovative service solutions when it comes to corrugating rolls, individual machines, and complete corrugators. (Kraft et al., 2021: 62). They are highly adaptable, since their produced cardboards is then processed and customised according to the needs of their customers. To complicate things: BHS' customers must communicate the preferences of their own customers, in order to make things work. That way, companies can use cardboards in different industries, hence the BHS must handle a great variety in terms of robustness, size, and even colour.

BHS believed they could use digital technology to offer and provide even more sophisticated solutions to their customers in different parts of their value chain. They have also perceived this as an opportunity to include more in-depth interconnectivity within the corrugator, between the machinery within the plant, and between

suppliers and customers as well as within already established cooperation. At the time being, they were also open for new partners.

During the pandemic, the company assumed that E-commerce businesses would enter the industry and started the provide new parts. On the other hand, new technologies (e.g., digital printing, 3D-metal printing etc.) require accurate data from cardboard manufacturing processes. Another assumption the BHS made at the time lied in the expectation of digitally specialised IT companies providing cloud computing and data analytics from outside the cardboard industry.

Product and portfolio changes

Due to different competitive pressures and changes coming from outside and within the marker, BHS decided to develop some Industry 4.0 applications.

The first step was the development of an internal data platform with the highest industry standards to monitor all applications around the corrugators. Maintaining and providing high standards are important in the German business culture. In the second step, BHS equipped all new machinery with more sensors to monitor the cardboard manufacturing process within the corrugator. However, this was done in several phases and not in one shot. Establishing an internal platform was important, since that way BHS stayed independent from big data platform providers entering the market from outside. At the same time, the internal data platform kept costs for BHS and its customers low, which is naturally a significant competitive advantage. This internal platform is called BHS ICorr: it represented a basis for an operations support application and a business automation application, with a direct connection to a fully-integrated e-commerce platform. It also allowed the integration with the BHS internal production planning.

Regarding the machinery aspect, the BHS ICorr was also developed with an ICorr Smart Maintenance Application that came together with interactive smart classes. This platform enabled the BHS to optimise the cardboard manufacturing process, which couldn't happen without data collection from within the corrugator. The very same data that comes from the corrugator enabled BHS to provide predictive maintenance, which improved the company's sales of their machines, as it provided more sophisticated performance offerings.

So, what BHS found out after the successful development and the implementation of its platform? Most importantly, applying big data techniques allowed BHS to generate new knowledge and insights about the process interdependencies. The big data application was installed in the machinery, although in combination with intelligent corrugating rolls that can store the data for longer periods of time. This specific type of data has an interesting feature: it can be transmitted to other machines and used for predictive maintenance. That way, BHS predicted which parts of its machinery needed replacement before they were worn out.

The collected data benefited BHS on another way: in the company's plant, the data served to optimise in-house logistics for paper rolls and cardboard production, which consequentially led to new product development and new product offerings. In this process, it is worth underscoring that the main condition or enabler for new product offerings lied in BHS sharing this data with its industry partners. In the end, BHS provided complementary products and services for the entire cardboard industry and additionally used this data to develop new advanced machinery (with and without partners) to further improve and expand its product portfolio.

The data was a crucial point in another matter: BHS faced the increasing demand for individualised packaging in combination with smaller lot sizes. This business moment led to the development of a digital printer, integrated into the corrugators.

This explanation of BHS' success puts forward technology. However, all the technology could not be implemented without extensive conversations BHS organized with its customers. The discussions and business meetings have become an ordinary part of an on-going process that includes developing and testing pilot installations. There is hardly a way to get around the social aspect of advanced digitized production and maintenance, since data-based products and services must be seen as a benefit to all partners and not a liability. These are sensitive issues and BHS recognized that its customers do not want to face over-dependence in certain business relationships. Lastly, BHS at the time considered the development of new services and pricing models, based on its enriched portfolio.

Organisational changes

Digitization can hardly ever be successful without social aspects and organizational changes. The platform development demanded a formation of a new business unit within the company that specialized for digital products and more importantly, for digital development of interconnectivity of machinery. In order to secure this realization, the company's higher level management needed to first introduce intensive and strictly scheduled meetings between department managers and innovation management, product management, and strategic marketing. Why is that so? Well, the digitization of a company can not really work if it influences only its specialized unit: the company owners and its management need to make sure that the new digital strategy is visible and present at every action.

In this particular case, BHS' top management decided against the establishment of digital services development group outside the company's headquarters, e.g., in a 'digital hotspot' or a 'capital hub', such as Berlin or Munich. BHS wanted better connections to their already existing partners and potential partners. As a result, BHS' top management enhanced the capacities of the department for corporate development. The main role of this department lies in ensuring any joint project, joint ventures or acquisition activities are in line with the digital strategy.

Ground Robot Vehicles for Agriculture: The Case of the Spanish company Mas Llunes

Businesses need to worry about how they affect the environment, especially when it comes to releasing harmful chemicals. Robots can help with this. We usually think of robots in factories, but they're also being used in farming. Using robots in farming can actually be good for the environment. Instead of spraying chemicals everywhere, robots can apply them only where needed. This is called precision agriculture. It stops farmers from using too many chemicals.

For example, Mas Llunes, a small, family-owned vineyard company in Spain with less than 25 employees and a long tradition of winemaking, uses a robot to spray pesticides and fungicides very carefully. This saves a lot of chemicals and keeps the plants from getting too much. The robot can also put special dispensers on the vines to control pests.

The robot has sensors that let it check the health of the vineyard. It can see if the leaves are healthy and if the plants are dry. This helps the owners decide how to take care of their vineyard.

Smart Chemical Factory Jump: The Case of the Italian company Bellini

Bellini, a small company specializing in lubricants and fluids, recognized the need to modernize their production process. The complexities of chemical manufacturing, coupled with the heavy materials involved, demanded a shift towards greater efficiency and automation. Bellini faced a bundle of different problems: at first, they sought to implement software for remote monitoring and integrate automated guided vehicles (AGVs) for material transport. Furthermore, their shop-floor operators relied on standalone programmable logic controllers (PLCs), isolating production data from their enterprise resource planning (ERP) system. The

user interface on their silos and mixers was also limited, hindering effective data sharing. To make matters worse, material handling between production and logistics was entirely manual.

To address these issues, Bellini decided to invest in a software solution for remote PLC control, upgrade their sensors, and replace existing LCD panels with intuitive touch screens. This move aimed to provide improved access to information, facilitating data-driven decision-making. They also implemented an automated material handling system using AGVs, connected to positioning sensors, to move materials between departments. This would not only reduce manual labor and errors but also provide a more energy-efficient alternative to their existing forklifts. The primary challenge Bellini faced was identifying the appropriate technological solution, which required four months of design study. Ultimately, they recognized the significant investment required and the importance of developing a solid business case to demonstrate the value of the proposed digital manufacturing technologies.

3rd Subcategory: Open Innovation

Introduction to Open Innovation

Variations of open innovation declare its status simply as a business practice, its pioneers (Chesbrough, 2003: 43) call it a paradigm, while some business consultants (Lindergaard, 2014) prefer to frame it more "as a philosophy or a mindset you should embrace within your organization", whereas a few consulting companies claim it has recently emerged as a new innovation business model. In this respect, opinions may vary heavily since some of the Alliance Management Group partners (see Slowinski and Sagal, 2010) announced open innovation to become a mainstream organizational process. In any case, the consultants are usually always the earliest and the loudest, if you take into the account Charles Leadbeater did a TedTALK in 2007 and proclaimed the 21st century as the era of open innovation, while simultaneously stating open innovation isn't something reserved for business anymore. According to him, all the institutions and organizations should innovate and they should innovate openly! But what does that mean, to innovate openly? What exactly is open innovation and what isn't?

You can grasp the notion and the need for open innovation with a simple thought experiment, which demands of you to answer the following two questions:

- *Do all the capable and intelligent people you know work within your company?*
- *Does your company have all the resources you need for successful business conduct?*

If you answered 'yes' to both questions, you can consider yourself lucky or you may be even called a liar. Still, if you answered 'no' – congratulations, you are ready for open innovation!

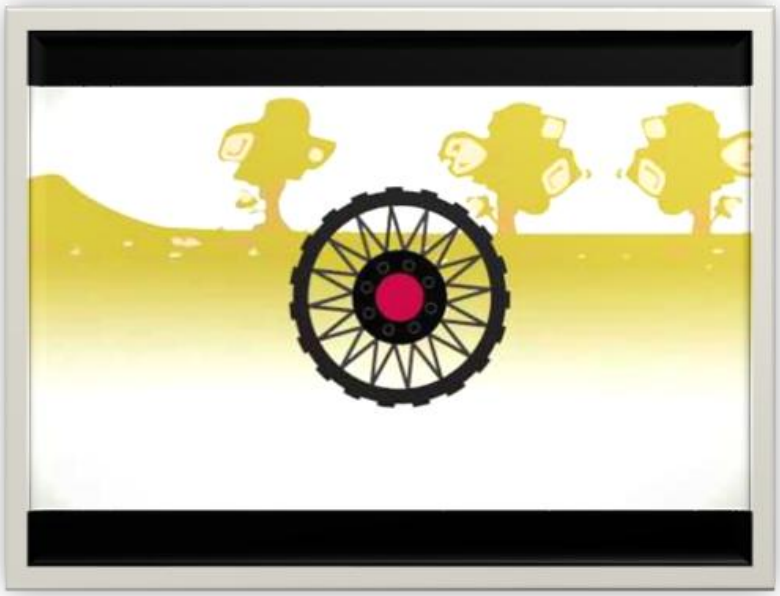
As you may well have guessed, on a most elementary basis open innovation means "that valuable ideas can come from inside or outside of the company and can go to market from inside or outside the company as well" (Chesbrough, 2003: 43).

In comparison with the previous century, today knowledge circulates more freely than before. Numerous public scientific databases, online journals and expert opinions are just a click away due to the advent of the internet and broad-band telecommunications. Remember one needed to register at a library and carry heavy books if one didn't want to purchase expensive literature in a store. Accessing the 'wealth of knowledge' was a far more lengthier and costly thing in the 20th century, which is not so long ago. The R&D institutions of the previous century functioned in a much more closed manner. Similarly, companies were inclined to hoarding the technology for their own use and making profits by creating and using different paths to sell it (Chesbrough, 2003: 51). This is usually named the closed innovation paradigm.

Open Innovation in nature is a collaborative thing, since its main focus lies in creating organizational alliances and partnerships that may catalyze innovation (Slowinski and Sagal, 2010: 38).

Video Materials:

Open Innovation 01 – Wheel (by Klaster LifeScience Kraków)



Open Innovation 02 – What is ‘open innovation’? (by Klaster LifeScience Kraków)

Regardless of the definition you would prefer to your liking, one thing is clear: on the practical level of speaking, open innovation signifies different strategies that help to bridge the internal and external resources of your company. Now that we have learned what the concept of open innovation means, we can progress forward with forming an answer to another pressing question: how helpful or beneficial are open innovation practices to an average SME, since they have more limitations in resources?

Many (Lee and Russell, 2020; Wolf and Lepratti, 2020; etc.) would agree we currently live in an innovation-centric society – after all, who would dare to think otherwise? Rare are those that would openly claim innovation is not something inherently good. Positive and hyped “innovation-speak” (Lee and Russell, 2020) is everywhere and innovation is becoming a priority of different institutions and organizations – from colleges to high schools, governmental office and lastly, in the business sector. Yet the cultural and social obsession with novelty and innovation can mislead and blind many social groups and officials to neglect something even more crucial – maintenance of technological infrastructure. Maintenance is simultaneously needed and sadly, often neglected in our modern societies. To make matters worse, our society overvalues inventors at the cost of failing to appreciate the maintainers, as more often than not they do not get granted with high social status or rewarding salaries.

However, all constructed and developed things, even digital ones, need maintenance (Lee and Russell, 2020: 57). Fortunately, machinery engineers and manufacturing business owners can not be blinded with innovation speak as easily as others, since maintenance usually represents a portion of their operating costs. Consequently, it would be rightfully to ask how can one connect innovation with maintenance? There is certainly a financial reward to greater understanding: with the examples of giant industrial corporations like General Electric or Boeing, maintenance is big business. Larger corporations from industry clusters make heavy investments in tools and procedures for predictive maintenance, since their success depends on the reliability of their products.

Useful resources: Discover great EU-funded Innovations with Innovation Radar Prize

Open Innovation with Open Data: The Case of Zaragoza Taxi Initiative

The taxi company in Zaragoza, Spain shows how using data can help both customers and drivers. They use public data from the city's website, like schedules for concerts and games. They put this information into an app for their drivers. The app tells drivers when and where events end, so they can pick up customers right away. This helps drivers get more fares and avoid driving around without passengers. It also helps customers because they don't have to call or wait for a taxi after an event.

Pop Quiz: Open Innovation

1. **Which of the following statements about open innovation is true?**

   a) Open innovation is solely considered a business practice.

   b) Open innovation is viewed as a mindset to embrace within an organization.

   c) Open innovation is exclusively a new business model.

   d) Open innovation has been proclaimed by Charles Leadbeater as reserved for business only.

Correct Answers:

B) Open innovation is viewed as a mindset to embrace within an organization.
D) Open innovation has been proclaimed by Charles Leadbeater as reserved for business only.

Which of the following best describes the essence of open innovation?

Valuable ideas should only come from inside the company.

Companies should keep their resources and knowledge confidential.

Valuable ideas can come from both inside and outside the company.

Innovation is exclusive to companies with significant resources.

Correct Answer: C) Valuable ideas can come from both inside and outside the company.

Which of the following statements accurately describe closed innovation?

Closed innovation focuses on internal research and development within a company, keeping ideas and innovations strictly within the organization.

Companies using closed innovation seek external partnerships to foster innovation and share ideas.

In a closed innovation model, companies usually restrict access to their research and technology, focusing on proprietary development and profit maximization.

Closed innovation is characterized by a company's reliance on open access to external knowledge and contributions.

Closed innovation practices typically involve keeping all product development and innovation processes private and within the company's own resources.

In a closed innovation system, companies often share their innovations freely with the public and collaborate openly with competitors.

Correct Answers:

A) Closed innovation focuses on internal research and development within a company, keeping ideas and innovations strictly within the organization.

C) In a closed innovation model, companies usually restrict access to their research and technology, focusing on proprietary development and profit maximization.

E) Closed innovation practices typically involve keeping all product development and innovation processes private and within the company's own resources.

Glossary

APS - Advanced Planning and Scheduling

A set of software tools and systems used to optimize production processes by planning and scheduling manufacturing activities. APS helps in making decisions regarding order prioritization, resource allocation, and inventory management, ensuring production runs efficiently and meets customer demands.

MOM - Manufacturing Operations Management

A software suite that manages the entire manufacturing process, providing real-time data and control over various aspects such as production, quality, inventory, and equipment. MOM ensures that manufacturing operations are well-coordinated and aligned with business goals, improving efficiency and flexibility.

MES - Manufacturing Execution System

A system used to track and manage the production process on the shop floor. MES bridges the gap between enterprise resource planning (ERP) systems and the physical production process, providing real-time information about inventory, work orders, labor, and machine performance to optimize manufacturing operations.

Smart Factory

A smart factory is an advanced manufacturing facility that uses digital technologies, automation, data exchange, and the Internet of Things (IoT) to create flexible, efficient, and interconnected production processes. It aims to optimize efficiency, reduce downtime, and improve decision-making through real-time data and intelligent systems.

OI - Open Innovation

A business model or philosophy where companies use external as well as internal ideas, knowledge, and resources to advance technology, products, and services. Open innovation encourages collaboration, partnerships, and knowledge exchange with external entities, such as other companies, research institutions, and consumers, to accelerate innovation and reduce R&D costs.

QMS - Quality Management System

A structured system of processes, procedures, and resources designed to ensure that an organization consistently delivers products or services that meet customer expectations and regulatory requirements. A QMS helps improve quality, reduce defects, and optimize processes within an organization, often following standards like ISO 9001.

Module 3: Digital manufacturing and open business generation and operation

Module 3: Digital manufacturing and open business generation and operation

Module Introduction

This module aims to introduce the reader to the development of green technologies, define terminology, and highlight the importance of digital manufacturing. Understanding the environmental impacts of human activity and the principles of sustainable development within this topic is also important. Last but not least, renewable resources must be mentioned and related issues such as energy efficiency, materials and their life cycle, and wastewater and air treatment must be addressed. Transport and its environmental aspects are also essential parts of the topic.

Learning Objectives / Scope of Knowledge Obtained

1. Understand the history, development and current understanding of green technologies.
2. Identify the impacts of human activity on the environment.
3. Apply green technologies in specific areas.

Estimated Time for Completion: 120 minutes

Module Structure - Sections

Introduction: Terminological definition (3-4 minutes)

1. Implementation of digital production (20 min)

2. Case studies of successful implementations (20 min)
3. Open business generation (20 min)
4. Case studies of open business models (20 min)
5. Digital manufacturing and development of markets (20 min)
6. Strategies for the future (20 min)

Introduction: Terminological definition of digitisation versus digitalisation

Digitisation and digital transformation are related but distinct terms.

Digitisation *refers to converting analogue data—such as documents, photos, or audio recordings—into digital formats. Examples include scanning papers, digitising photographs, and converting library materials into digital files. It's a preliminary step toward benefiting from digital technologies.*

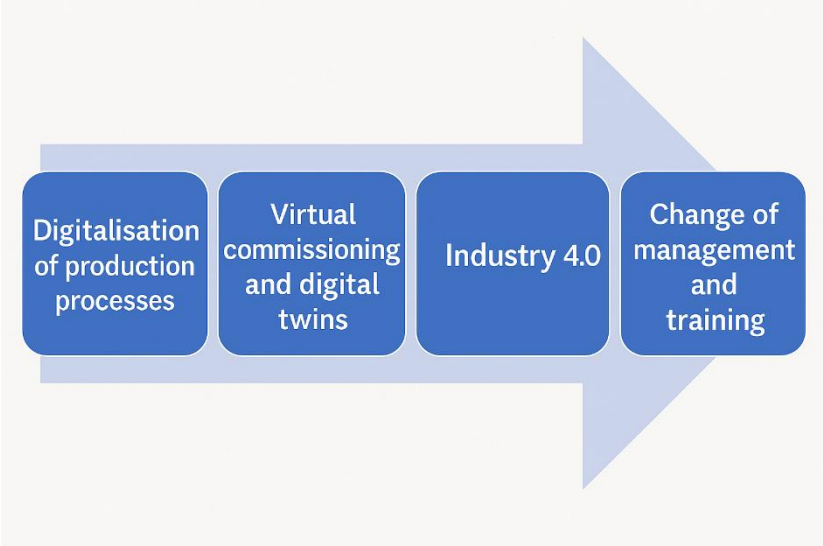
Digital transformation *is more comprehensive, involving fundamental changes to an organisation's operations, culture, and business models through digital technology. Examples include implementing e-commerce, using artificial intelligence for process automation, personalising customer experiences, and moving toward paperless administration.*

Digitisation creates digital copies, while digital transformation reshapes the entire business digitally. Changing the business

Video: What is the difference between Digitisation and Digitalisation?
Time approx. 2 minutes: https://www.youtube.com/watch?v=4X4NjjwN1mY

Section 1: Implementation of digital production

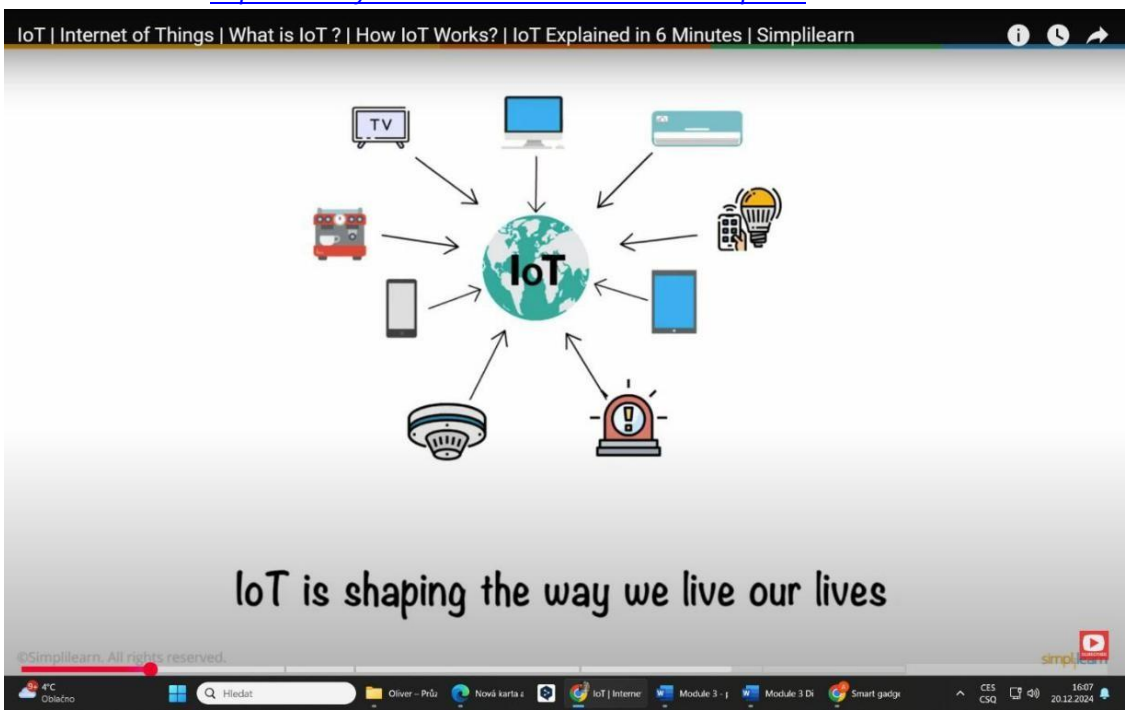
Implementing digital manufacturing involves introducing modern technologies and processes into production systems to increase efficiency, flexibility and sustainability. This process involves several key aspects:



Digitalisation of manufacturing processes: introducing digital technologies such as sensors, IoT (Internet of Things) devices, and automation enables data collection and analysis. This helps to optimise manufacturing processes and improve product quality. IoT can be used in various fields such as science,

technology, engineering and medicine (Kohen-vacs, 2024), but take, for example, the environmental field to monitor pond water quality in real-time and species survival (Kanwal et al., 2024).

Video: What is Internet of Things?
*about 5 minutes**:** https://www.youtube.com/watch?v=6mBO2vqLv38*



Virtual commissioning and digital twins: using digital twins to simulate and test production processes before deployment. This enables faster and more efficient engineering processes, employee qualification and saving valuable resources (Christ et al.).

Industry 4.0: Integrating AI, machine learning, robotics, and cyber-physical systems in manufacturing.

Management and training: Digitalisation requires technical training and cultural change to effectively adopt new technologies.

Benefits: Enhanced productivity, reduced costs, improved quality, greater flexibility, and support for sustainable development.

1.1 The benefits of digital manufacturing and open enterprises

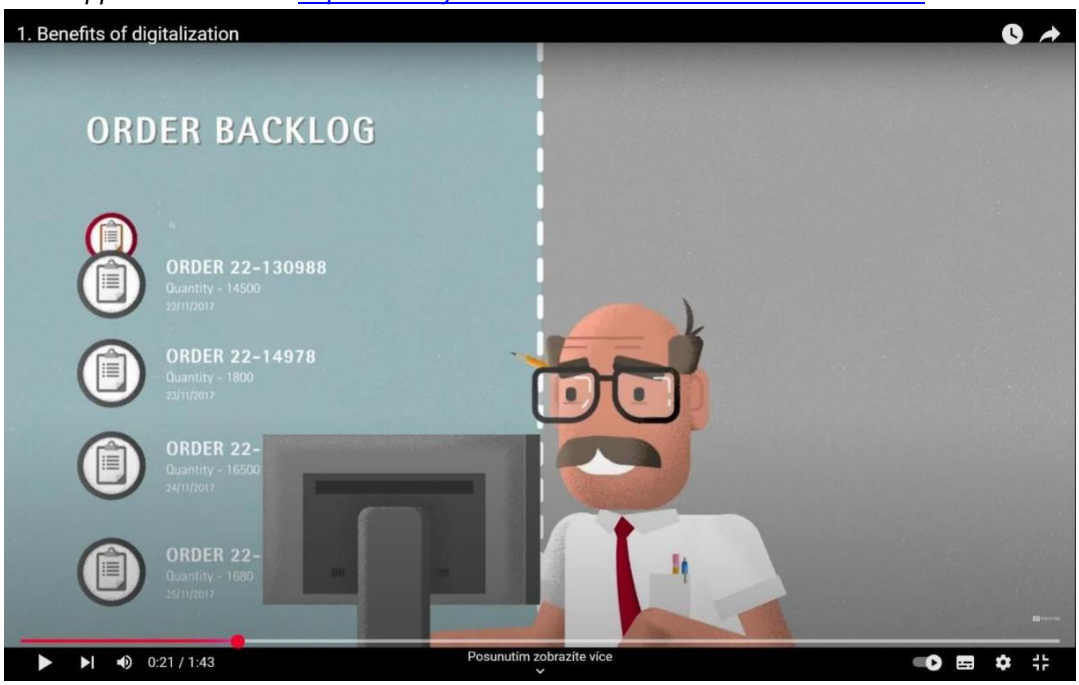
Digital production boosts flexibility, allowing quick adaptation to market changes and customer needs. It reduces costs through process optimisation, waste reduction, and efficient resource use. Product quality improves with better process control and early problem detection. It also fosters innovation through collaboration and new technologies, while supporting sustainability by lowering environmental impact.

Various scientific studies are emerging to determine whether there is a link between the implementation of digital technologies, organisational practices, quality and operational efficiency of manufacturing firms. For example, Manresa et al. (2024) based their work on innovation theory, resource-based view and socio-technical systems theory. They analysed data from a questionnaire survey among 502 Spanish and Dutch organisations. The results show that both digitalisation and organisational practices affect operational efficiency positively. Digitalisation leads to greater efficiency, especially regarding quality aspects (scrappiness, quality complaints).

Figure 1: Benefits of digitalisation in manufacturing

Video: Benefits of digitalisation

Time approx. 2 minutes: https://www.youtube.com/watch?v=UD33UWmwSYE



1.2 Prerequisites for successful digitalisation vs. possible barriers

There are many to digitalisation, whether within production or in the enterprise. However, its implementation is not without obstacles. Among the most common are:

Investing in technology: Introducing new digital technologies requires significant financial resources. From purchasing the hardware and software to implementing and maintaining, these investments can be challenging for many companies.

Culture change: The transition to digital working often requires a fundamental change in company culture. Employees must be willing to embrace new technologies and ways of working, which may require extensive training and a change in their habits.

Cybersecurity: As digitisation increases, so does the risk of cyber attacks. Protecting sensitive data and systems from hackers and other threats requires investment in security solutions and constant monitoring.

Skills shortage: The rapid development of digital technologies is leading to a shortage of professionals with the necessary skills. Finding and retaining skilled IT and digital employees can be challenging for companies.

1.3 Key steps to successful digitalisation

Successful digital transformation is a complex, organisation-wide process—not just the adoption of new technologies. It requires a clear strategy, smart technology selection, employee development, strong partnerships, and effective use of data.

The cornerstone of success is a clear **strategy** that defines the goals of digital transformation. A concrete, time-bound plan should follow, aligned with the overall organisational strategy.

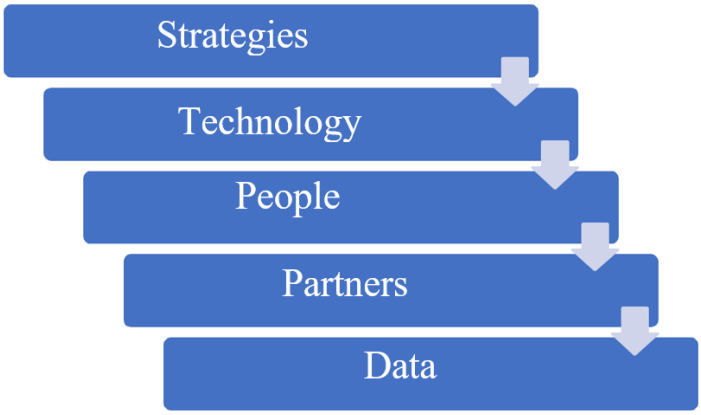
The right **choice of technology** is essential. Technologies must meet business needs, integrate easily, and be flexible and scalable to adapt to future changes.

Employees play a key role and need training to work with new technologies. Supporting innovation and collaboration through cultural change is also crucial.

Strong **external partners** help accelerate digitalisation by providing access to technologies, expertise, and resources, while sharing risks and costs.

Data must be effectively collected (e.g. what, how, and why), analysed, and used for decisions and process improvement. Security and a data-driven culture are essential for success.

Key to success are agility, the ability to adapt to change, continuous progress measurement, and strong leadership with transparent communication to guide the transformation.



The success of digital transformation relies on the integration of strategy, technology, skilled employees, strong partnerships, and data use.

People, especially managers, play a crucial role in this process. An insightful study explores how managers develop in a digitised industry. The first chapter provides a theoretical foundation, focusing on the sociological aspects of digitalisation and the key leadership competencies needed in a digital context. The second presents practical development tools, drawing from the experience of “The Center for Creative Leadership.” The third proposes a methodology tailored to the digital industry, justifying its relevance (Pavlica et al., 2019). This work offers valuable guidance for HR in supporting digital transformation.

Video: The 6 Stages of Successful Digital HR Transformation

Time approx. 4 minutes: https://www.youtube.com/watch?v=T2xwbj7FLd0

Questions

1. What are the benefits of digitalisation in manufacturing?

Choose one:

A) More manual processes and increased labour intensity
B) Greater flexibility, reduced costs, improved quality, innovation, and sustainability
C) Increased bureaucracy and slower innovation cycles
D) Standardised products with limited personalisation

✅ **Correct answer: B**

(Source: Section 1.1 – *Benefits of digital manufacturing and open enterprises*)

2. Why is it important to distinguish between digitisation and digital transformation?

Choose one:

A) Because they are technical synonyms and can be interchanged freely
B) To ensure digital files are named correctly
C) Because they involve different scopes, goals, and implementation strategies
D) Because transformation always follows digitisation in a timeline

✅ **Correct answer: C**

(Source: *Introduction: Terminological definition of digitisation versus digitalisation*)

3. True or False:

A lack of digital skills and resistance to culture change can be barriers in the digitalisation process.

✅ **Correct answer: True**

(Source: Section 1.2 – *Prerequisites for successful digitalisation vs. possible barriers*)

Glossary of Key Terms

- **Digital manufacturing** uses technologies like 3D printing, robotics, AI, and IoT to speed up production, increase flexibility, and enable customisation.
- **Open enterprises** collaborate with partners, customers, and suppliers, using open innovation and knowledge sharing to develop new products and services faster.

Section 2: Case studies of successful implementations

Digital transformation has driven innovation in many sectors. Companies that have successfully adopted digital technologies have experienced significant growth, increased efficiency and gained a competitive advantage. Let's take a look at some inspiring examples.

2.1 Examples of successful companies in digital transformation

Retail AMAZON

Amazon is undoubtedly one of the best examples of successful digital transformation in retail. The company started as an online bookstore and has gradually grown into the world's largest retailer. With innovations such as personalised recommendations, seamless delivery, Amazon Prime and the Alexa voice assistant, Amazon has become a pioneer in e-commerce.

Automotive: Tesla

Tesla, led by Elon Musk, has completely changed the automotive industry. With its electric cars, autonomous technologies and vertically integrated business. Tesla has pushed the boundaries of what is possible in the industry with the model. The company is also innovating in the production and distribution of cars, using the Gigafactory for battery production, for example.

Healthcare: Teledoc Health

Teledoc Health is a leading provider of telemedicine services that allows patients to consult with healthcare professionals online. The COVID-19 pandemic has significantly increased the demand for these services. Teledoc Health offers a wide range of telemedicine services, from physician consultations to psychotherapy.

Financial services: Revolut

Revolut is a British fintech company that offers modern banking services through a mobile app. Revolut allows its customers to make free money transfers, exchange currencies at a favourable rate and use a range of other financial services. The company targets the younger generation who are looking for flexible and digital solutions to manage their finances.

Manufacture by Siemens

Siemens is an industrial giant that has successfully implemented digital transformation in its manufacturing plants. The company uses technologies such as the Internet of Things (IoT), artificial intelligence and big data to optimise production processes, increase efficiency and reduce costs.

Travel: Airbnb

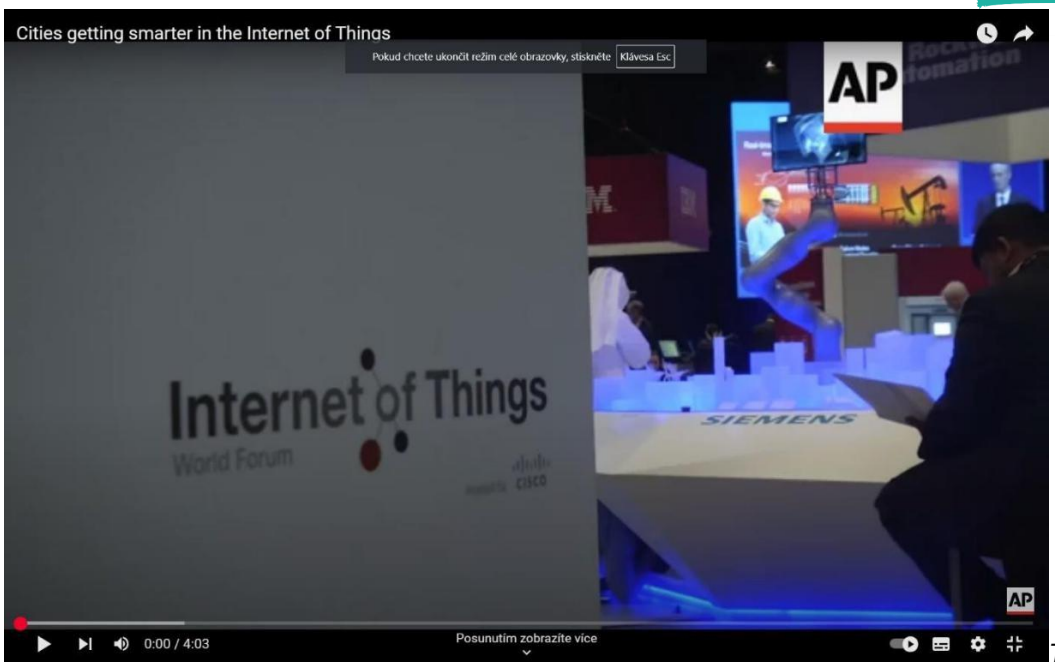
Airbnb has revolutionised the travel industry by allowing people to rent out their properties to tourists. The platform has connected millions of property owners with travellers around the world. Airbnb offers a wide range of accommodation, from apartments and houses to condos and cottages.
What do these cases have in common?

These examples show that digital transformation is not just a fashion trend but a necessity to survive in today's competitive environment across industries. Companies that can adapt quickly and harness the potential of digital technologies will have the best chance of success in the future.

2.2 Cities and homes getting smarter due to the *Internet* of *Things*

Over the past decade, international exhibitions and forums have highlighted the rapid evolution of the Internet of Things (IoT), especially in smart cities and smart homes. The World IoT Forum 2015 in Dubai already emphasised the potential of connected devices to transform urban life, showcasing smart services accessed via mobile apps and stressing the importance of investment in digital infrastructure. At the same time, trade fairs like CES 2015 marked a turning point for smart home technology, presenting connected gadgets that automate lighting, heating, security, and entertainment. Innovations such as voice-controlled assistants (e.g. Amazon Echo, Google Home), smart thermostats, sockets, and cameras demonstrated how homes could become more efficient, secure, and personalised. Trends like expanding ecosystems, improved affordability, and stronger privacy measures have since pushed smart devices further into the mainstream. These events confirmed that the IoT is no longer a futuristic concept but an integral part of daily life, reshaping both homes and cities through ongoing technological advancement.

Video Cities getting smarter in Internet of Things



Time approx. 4 minutes: https://www.youtube.com/watch?v=cYsTOiiX6Xo

Examples of smart gadgets - Smart thermostats, sockets, camera

Video Smart gadgets for the home on show at the Internet of Things show time

app rox. 4 minutes: https://www.youtube.com/watch?v=cQgIs0By_Hg&t=27s

Video: The International CES gadget show has gotten underway in Las Vegas

Time: about 2 minutes: https://www.youtube.com/watch?v=HCL1p_VPkBI

Questions

1. Which of the following is a common feature of companies that have successfully undergone digital transformation?

A) Limiting product updates to reduce change
B) Emphasis on customer needs and innovation
C) Avoidance of emerging technologies
D) Reducing digital investments to lower risk

✅ Correct answer: B

2. What is one of the key benefits of using IoT in smart homes?

A) Higher energy consumption
B) Reduced device connectivity
C) Automation and personalisation of home functions
D) Increased reliance on manual controls

✅ Correct answer: C

3. True or False:

Smart homes use IoT to automate functions like lighting, heating, and security, improving comfort and efficiency.

✅ Correct answer: True

Glossary of Key Terms

- **The Internet of Things (IoT) refers to a network of connected devices—like appliances, vehicles, or sensors—that communicate and share data. This enables smart functions, such as a fridge ordering food or a thermostat adjusting to your routine.**
- **A gadget is a small, often tech-based device with a specific function, like a smartwatch or speaker. Gadgets are known for being innovative (new), practical (function), and stylish (design).**

Section 3: Open business model generation

3.1 Business model creation

What is a Business Model

A business model is a framework for how an organisation creates, delivers, and captures value. It explains how a company makes money, reaches customers, and manages key resources, processes, and costs. It answers questions like: Who is the customer? What problem do we solve? What do we offer? How do we deliver and sustain it?

Simplicity and Adaptability

Due to rapid market changes, businesses now favour concise, flexible plans over lengthy documents. Inspired by the Lean Startup approach, this shift focuses on quick validation of assumptions through an iterative process: Ideas → Product → Measurement → Learning. Models must be desirable (customer-focused), feasible (technologically possible), and viable (financially sustainable), with growing attention to social and environmental impact. Simpler models save time and resources and are now standard for investors and startups.

Business Model Tools

- Business Model Canvas (BMC): A visual tool with nine blocks (e.g., Customer Segments, Revenue Streams) ideal for mapping and developing business strategies.
- Lean Canvas: Adapted for startups, it emphasises solving customer problems and includes sections like Problems, Solutions, and Key Metrics. It supports fast testing and iteration.

Comparison:

- Audience: BMC suits all businesses; Lean Canvas is tailored to startups.
- Focus: BMC takes a broad strategic view; Lean Canvas zeroes in on problem-solving.
- Format: Both are visual; Lean Canvas is simpler and built for rapid validation.

3.2 Open business model and its creation

Open Business Model Generation (OBMG): Collaboration for innovation

OBMG promotes openness, collaboration, and innovation by involving external partners, customers, and suppliers in business development. Unlike traditional models, it values diverse perspectives to generate better solutions.

Relation to Open Innovation:

Both concepts focus on sharing resources and ideas across ecosystems. While Open Innovation brings in external ideas, OBMG applies openness to partnerships, value creation, and distribution—together enabling more adaptive, sustainable strategies.

Key elements of OBMG:

- Openness – Sharing knowledge and resources
- Collaboration – Working with partners on joint projects
- Innovation – Continual improvement and new ideas
- Customer orientation – Meeting user needs
- Digital technology – Supporting collaboration and innovation

Why it matters:

- Faster innovation
- Greater competitiveness
- New market opportunities

- Higher flexibility in responding to change

3.3 Examples of OBMG tools

Several tools and institutions support open business model generation by fostering collaboration, innovation, and experimentation:

- Hackathons are short events where experts develop solutions to specific challenges, often in competition formats. They generate innovative ideas, prototypes, or proof-of-concepts. Formats vary—physical, online, internal—and often include mentoring. Related formats include Innovation Days and Ideathons. One example is *CEE Hacks*, organising events like *Greenhack* focused on sustainability.
- Incubators and Accelerators help businesses grow. Incubators support early-stage startups with space, mentoring, and training. Accelerators focus on scaling existing companies through intensive, time-limited programs. Both offer access to technologies, pilot projects, and expert networks.
- Open-source projects provide free tools and platforms that businesses can adapt, encouraging experimentation and collaboration while lowering innovation costs.
- University and research partnerships enable technology development through joint projects, consortia, or contract research. Institutions also offer support via tech transfer offices, labs, and incubators.
- Knowledge transfer projects (e.g., Horizon Europe, EIC) offer technologies, best practices, and access to networks that help SMEs overcome innovation barriers and adapt to change.

- Additional support structures include regional innovation centres, digital innovation hubs (DIHs), EDIH, and EIT, all offering valuable resources for open innovation.

Conclusion

The open business model offers companies a modern, flexible approach that fosters innovation and success. By collaborating with external partners, businesses gain access to new knowledge and technologies, enhance creativity, and improve their reputation. This openness also helps attract new customers and partners, enabling faster responses to market changes and the creation of new value.

Questions

1. Which of the following is a key benefit of adopting an Open Business Model (OBMG)?

A) Reduced flexibility in responding to change
B) Access to new knowledge and technologies
C) Isolation from external influences
D) Lower engagement with partners and customers

✅ Correct answer: B

2. What is the main difference between the Business Model Canvas (BMC) and Lean Canvas?

A) BMC is used only by startups
B) Lean Canvas ignores customer problems
C) Both are focused solely on financial reporting
D) Lean Canvas focuses more on problem-solving and rapid validation

✅ Correct answer: D

3. True or False:

Open Business Model Generation (OBMG) encourages collaboration with external stakeholders to drive innovation and adapt to market changes.

✅ Correct answer: True

Glossary of key terms

- Business model: a framework describing how an organisation creates, delivers and captures value.
- Business Model Canvas (BMC): a visual tool for mapping the key elements of a business model on a single page.
- Lean Canvas: a modified version of BMC, focused on startups and rapid validation of problems and solutions.
- Open Business Model (OBM): an approach to business that emphasises collaboration, resource sharing and openness in value creation.
- Open innovation: a process whereby organisations open up innovation to external partners such as universities or start-ups.
- Hackathon: an event where teams of experts search for solutions to specific problems and create prototypes or concepts.
- Incubator: a programme offering early-stage business support in the form of mentoring, infrastructure and training.
- Accelerator: an intensive programme for companies to scale their business, improve business models and attract investment.

Section 4: Case studies

Case study: Digital transformation and collaboration with external partners in the brewing industry
Climate change is threatening traditional hop production in the Czech Republic, essential for brewing. To address this, Asahi Group launched the For Hops project—combining digital technologies with collaboration from partners like Microsoft, TensoAI, Ackee, and the Czech Hop Growers Union. Using AI, data analytics, and IoT, the project developed a system that optimises irrigation based on real-time data from sensors. A mobile app now helps growers determine the exact water needs of their crops, leading to yield increases of up to 40% on pilot farms and supporting long-term sustainability.

Source: https://pxhere.com/cs/photo/476612

A key factor in success was collaboration with external partners, merging technology with field expertise. The project highlights how digital transformation and open business models can reshape traditional industries, offering a new approach that balances innovation with heritage to tackle global challenges.

Case study: Digital transformation of LINET and cooperation with external partners
LINET, a global leader in hospital bed manufacturing, has undergone a major digital transformation that reshaped its business model and deepened collaboration with external partners. The integration of advanced technologies improved efficiency, flexibility, and competitiveness.
By automating production and enabling real-time monitoring through digital tools, LINET shifted from a traditional manufacturer to a provider of healthcare solutions. The company now offers services like remote patient monitoring, predictive maintenance, and bed utilisation optimisation.

Key partnerships supported this transformation. In 2020, LINET acquired CubileHealth, an Austrian startup with non-contact sensing technology for monitoring vital signs, improving patient care. Collaboration with the University of Hradec Králové led to an intelligent hospital bed system that enhances patient safety and won a national innovation award. LINET also partnered with Newton University to launch an MBA programme focused on innovation in medical technology.

As a result, LINET improved operational efficiency, reduced costs, and expanded its service offerings. Its experience shows how digital transformation, driven by external collaboration, can strengthen a company's market position and inspire others.

Case study: Blockchain and Partner Collaboration in the Pharmaceutical Industry
The pharmaceutical industry faces challenges like inefficient supply chains, costly clinical trials, and limited data on rare diseases. Blockchain technology, combined with external partnerships, offers innovative solutions that reshape business models.

StaTwig developed VaccineLedger™, a blockchain-based system that tracks vaccines throughout the supply chain. It ensures temperature control, improves transparency, reduces losses, and cuts logistics costs by assigning each vaccine a unique ID.

FarmaTrust uses Ethereum-based blockchain to secure and anonymise clinical trial data, supporting accurate double-blind testing. Its mobile apps and wearable tech enhance patient monitoring and accelerate drug approval.

Humanscape's Rarenote platform gathers anonymised data from patients with rare diseases, enabling pharmaceutical firms and researchers to develop treatments—if patients consent.

Blockchain and collaboration are transforming pharma by improving transparency, efficiency, and innovation in supply chains, clinical trials, and rare disease research—supporting more sustainable business models.

Metalworking industry - Kheoos
Kheoos applies an open business model to improve industrial maintenance parts management through collaboration, technology, and sustainability. Its core tools—the Mykheoos SaaS platform and B2B Kheoos marketplace—enable manufacturers to share resources, reduce waste, and boost efficiency. The marketplace allows companies to sell idle stock and find rare parts, promoting community-driven innovation. AI supports this by automating data processing and enabling smarter decision-making.

Impact:
Kheoos has helped reduce idle inventory by up to 25% and cut production downtime by 47%. Partners also save up to 50% by adopting circular economy practices. Beyond cost savings, Kheoos advances sustainability by promoting reuse and reducing resource waste—showing how open, tech-driven models can transform industry practices.

Plastics and rubber
Precious Plastic embodies the Open Business Model by promoting global collaboration, open-source sharing, and grassroots innovation to tackle plastic waste. It empowers individuals and communities worldwide to build their own recycling systems using free access to research, designs, and video tutorials under a Creative Commons license.

The initiative provides open-source machine designs (e.g., shredders, moulding machines) and recycling guides for plastics like HDPE and PP. Through its online academy, forums, and the Precious Plastics Bazaar marketplace, users can learn, connect, and exchange tools, products, and ideas—fostering circular economy practices.

Impact:
By decentralising recycling efforts, Precious Plastic reduces waste, lowers entry barriers to sustainability, and builds a global network of local recyclers. Its community-driven model proves that open collaboration can deliver scalable, sustainable solutions to environmental challenges.

Electronics - Arduino

Arduino exemplifies the open business model through collaboration, open access, and innovation across disciplines. This open-source platform empowers students, makers, educators, and professionals to create and solve real-world problems using accessible electronics and digital technologies. All hardware, software, and documentation are freely shared under a Creative Commons license, encouraging global knowledge exchange. Makers use Arduino for DIY solutions, educators benefit from STEAM-focused kits, and businesses leverage IoT tools to boost efficiency. Arduino simplifies prototyping and integrates with platforms like Processing. It supports STEAM education through kits and remote learning tools. Businesses use the Arduino Pro Series for automation and IoT solutions.

Impact:

With a global user base and affordable tools, Arduino supports sustainability and education while enabling innovation in areas like robotics and programming. Its open, community-driven model has transformed how people learn, invent, and operate.

Building materials and furniture - WikiHouse

WikiHouse embraces the open business model by providing open-source tools that empower individuals, communities, and small businesses to design and build sustainable, zero-carbon homes. The project shares files, designs, and software under a Creative Commons license, enabling users to customise and produce components locally using CNC machines. Built on principles like modularity and poka-yoke, WikiHouse offers prefabricated parts that are easy to assemble without formal training. The homes are highly insulated, adaptable, and designed for disassembly and reuse—supporting circular construction and low-carbon impact.

Impact:

With buildings constructed in countries like New Zealand, Scotland, and Brazil, WikiHouse promotes global collaboration and local empowerment. It lowers barriers to sustainable construction by reducing costs and complexity, proving that openness and innovation can make eco-friendly housing accessible to all.

Questions

1. What is a key benefit of the open business model as demonstrated by Arduino?

A) Limits user access to technology for security reasons
B) Encourages global collaboration and innovation through open access
C) Requires licensing fees for educational tools
D) Focuses only on corporate users, excluding educators and makers

✅ Correct answer: B

2. How does Precious Plastic's open business model contribute to sustainability?

A) By mass-producing plastic at low cost
B) By centralising recycling in large factories
C) By promoting single-use plastic innovation
D) By enabling communities to build local recycling systems and reduce waste

✅ Correct answer: D

3. True or False:

Open business models encourage knowledge sharing and collaboration, which can drive innovation and make sustainable solutions more accessible.

✅ Correct answer: True

Glossary of Key Terms

- Creative Commons licence: A system that lets creators share work under set terms, encouraging reuse and collaboration.
- Circular economy: An approach focused on minimising waste through reuse, recycling, and recovery.
- Distributed network: A decentralised setup spreading resources and decisions across locations for flexibility.
- Community-driven innovation: Solutions developed collaboratively by stakeholders to solve shared problems.
- Modularity: Designing components as independent, interchangeable units for easy scaling and flexibility.
- Poka Yoke: A Japanese concept for designing processes to prevent errors.
- SaaS (Software as a Service): Cloud-based software that doesn't require local installation.
- Decentralised production: Localised manufacturing to reduce transport and meet local demands.
- Agile collaboration: Flexible partnerships that adapt quickly to change and drive innovation.
- Data integration: Merging data from various sources (e.g., IoT, apps) to improve decision-making and efficiency.

Section 5: Digital manufacturing and development of markets (20 min)

Introduction

Digital manufacturing is a cornerstone of modern industry. It enables automation, improves efficiency, reduces labour costs, and supports new models like mass customisation. It also enhances sustainability by lowering waste and encouraging the use of eco-friendly materials. Real-time data supports faster problem detection and informed decision-making. In today's dynamic environment, companies investing in digital technologies gain a significant competitive advantage (Mangla et al., 2024).

5.1 Trends in Digital Manufacturing and Open Business

Digital manufacturing continues to drive innovation and competitiveness. The use of artificial intelligence (AI) and machine learning (ML) is transforming production—improving efficiency, product quality, and enabling predictive maintenance. AI enhances open innovation, reduces human error, and supports personalisation strategies that strengthen customer relationships and market position (Holgersson et al., 2024; IFR, 2022).

Video: How Generative AI is Revolutionizing Manufacturing

Time approx. 4 minutes: https://www.youtube.com/watch?v=dFXvlrMliHk

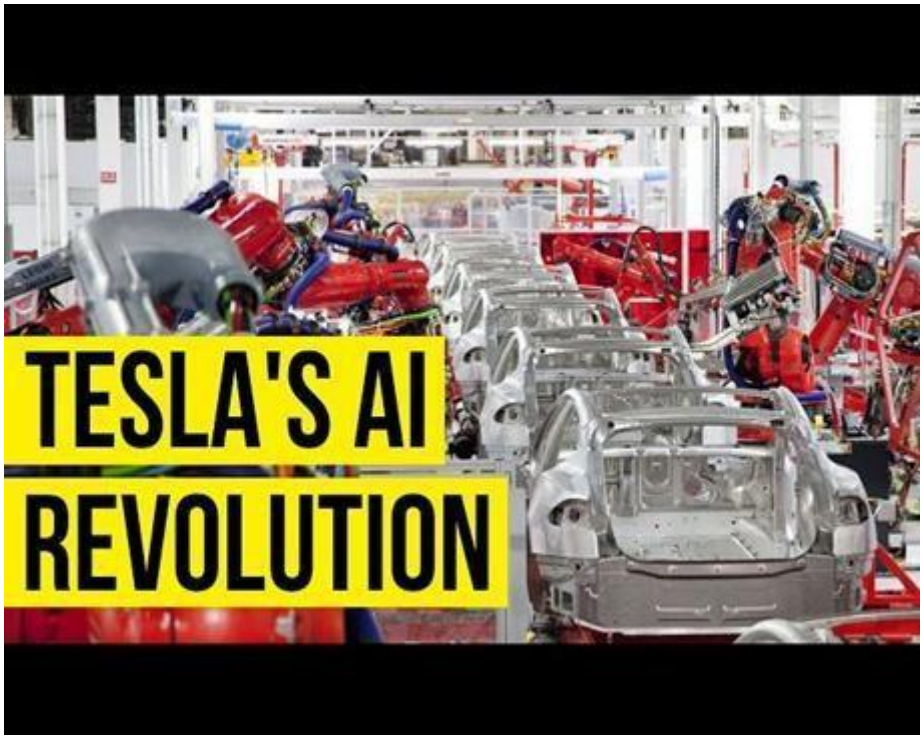
AI and ML also allow companies to analyse large datasets to improve decision-making. For example, predictive maintenance can anticipate machine failures, reducing downtime and repair costs. AI also enables personalisation, boosting customer satisfaction and loyalty.

Examples of AI in Practice:

1. Siemens uses AI in robotics, visual inspection, and electronic assembly to optimise production and enable data-driven decisions. Its industrial AI tools enhance productivity and lower costs.

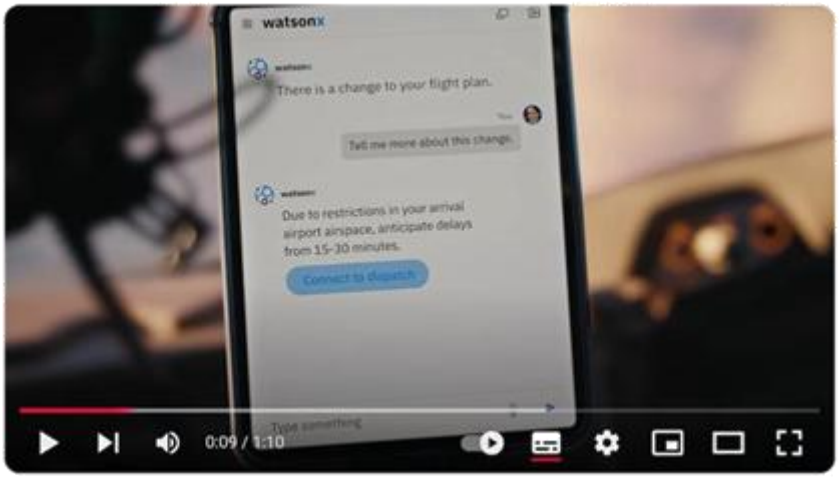
Video: The Siemens Industrial Copilot: A generative AI-powered assistant for the industry

Time approx. 3 minutes:



2. Tesla Integrates AI at multiple stages of car manufacturing to optimise workflows, predict maintenance needs, and monitor quality.
3. IBM Uses IBM Watson to analyse manufacturing data and improve material flow, inventory, and planning—resulting in more efficient operations.

Video: IBM: Deploy AI across any environment with watsonx



Time approx. 1min: https://www.youtube.com/watch?v=CiqQEBWyG1c

Sustainable or "green" manufacturing is another key trend. Digital tools help companies use resources more efficiently and reduce waste through better analysis and process control (Li et al., 2021). This reduces environmental impact and operational costs while meeting consumer demands for eco-conscious brands. It also supports global efforts to tackle climate change and plastic waste.

Key principles of sustainable production:

1. Resource efficiency: Use natural resources wisely and promote circular economy practices—e.g., Contec's reuse of materials from end-of-life tyres.
2. The entire product life cycle: Design products with their full life cycle in mind, from sourcing to recycling.
3. Minimise pollution: Reduce waste and promote safer alternatives to hazardous materials.

Source: Prescient Technologies, 2024

5.2 Challenges and opportunities

This section highlights the key challenges and opportunities in digital manufacturing, focusing on data security, privacy, and the ability to adapt to rapid market changes.

Data security and privacy

As manufacturing systems become more connected, they are increasingly exposed to cyber threats such as ransomware, which can disrupt operations and compromise sensitive data. Implementing strong security measures and regular software updates is essential.

Key recommendations (Mission Secure):

1. Internal & External Threats: Apply a least privilege policy to limit access and reduce risk from both outside attackers and insiders.
2. Monitoring & Analysis: Constant network monitoring helps detect anomalies early and supports rapid incident response.
3. Employee Training: Educating staff on cyber threats enhances the overall security posture.
4. Data Backup: Regular backups minimise data loss and enable quicker recovery from attacks.

Incident Plans: Companies should have clear cyber incident response protocols in place.
Additionally, compliance with data protection regulations like GDPR is essential. Transparent data handling and staff training ensure proper personal data processing. Online resources, such as the GDPR website, offer guidance for legal compliance.

Adapting to rapid market changes
Agility in supply chains and production processes is key to staying competitive. Agile methodologies help companies react quickly to shifting market demands.

Video: Agile Manufacturing| Driving Success in a Dynamic Market

Time approx 3 min: https://www.youtube.com/watch?v=m9llqTSsN5c

Diversifying supply chains helps reduce disruption risks and maintain production continuity. Automated and flexible production processes can quickly adapt to demand, boosting competitiveness (Aderinan et al., 2024). Data analytics plays a crucial role in tracking customer trends and enabling product personalisation, which enhances satisfaction. It also supports accurate demand forecasting and process optimisation. As noted on the Terotam website, data analytics is vital for maintaining efficient, transparent, and responsive manufacturing, while also driving innovation and opening new business opportunities.

Questions

1. What is a major benefit of using AI in digital manufacturing within the context of open innovation?

A) Reduces the need for employee training
B) Eliminates the use of data analytics
C) Enhances efficiency, personalisation, and predictive maintenance
D) Limits product customisation options

✅ Correct answer: C

2. Which of the following is a key principle of sustainable production supported by digital manufacturing?

A) Shortening the product life cycle
B) Exclusive use of new raw materials
C) Resource efficiency and circular economy practices
D) Maximising waste for increased production speed

✅ Correct answer: C

3. True or False:

Diversifying supply chains and using data analytics help manufacturing companies better respond to market changes and improve competitiveness.

✅ Correct answer: True

Glossary of Key Terms

- Digital Manufacturing: Uses technologies like automation, robotics, and data analytics to boost production efficiency, flexibility, and sustainability.
- Data Analytics: Gathers and analyses data (e.g. from sensors or sales) to support decisions, forecast demand, personalise products, and improve processes.
- Artificial Intelligence (AI): Automates tasks, predicts failures, and enhances efficiency through data analysis and smart algorithms.
- Sustainable Production: Reduces environmental impact through resource efficiency, recycling, and green materials, supported by digital tools.
- Cybersecurity: Protects connected manufacturing systems from cyber threats to ensure data safety and operational continuity.

Section 6: Strategies for the future (20 min)

Introduction

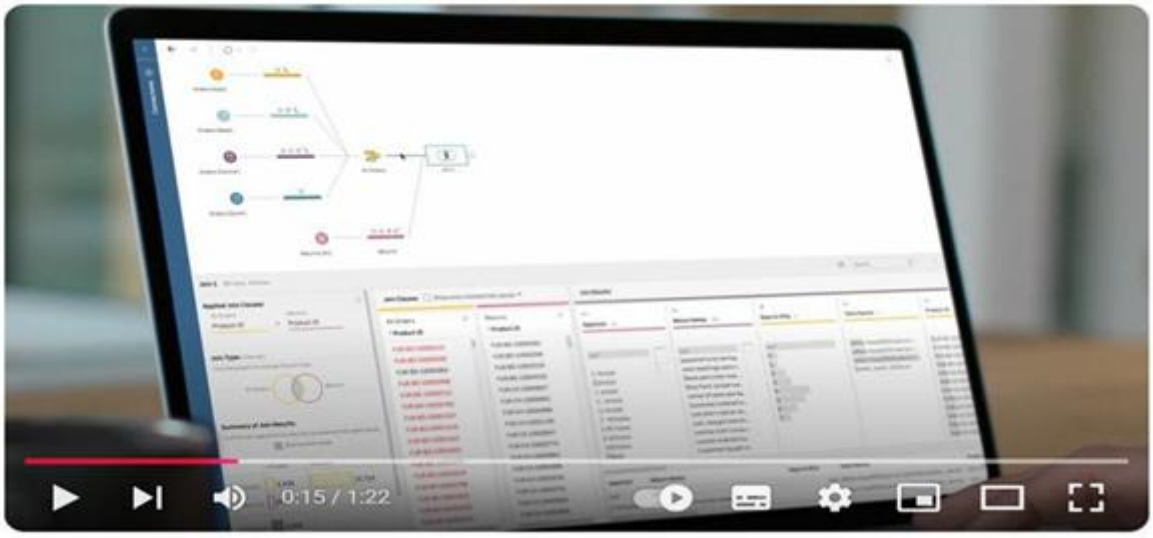
In today's fast-paced business environment, companies must innovate and adapt to remain competitive. This session focuses on strategies such as trend monitoring, fostering innovation, and employee skills development to help organisations succeed in dynamic markets.

6.1 How to adapt and innovate in a dynamic environment

Adapting begins with monitoring technological and market trends. Tools like Google Trends and Tableau help companies analyse data and respond to changing customer needs.

Tableau (2024) is a popular data visualisation tool that helps users analyse, visualise, and share data through interactive dashboards. It supports importing data from various sources—databases, spreadsheets, or cloud storage—to create clear charts, tables, and maps..

Video: Analytics for Manufacturing - Tableau
Time approx. 1 minute: https://www.youtube.com/watch?v=S2e8-Wa6_Kk



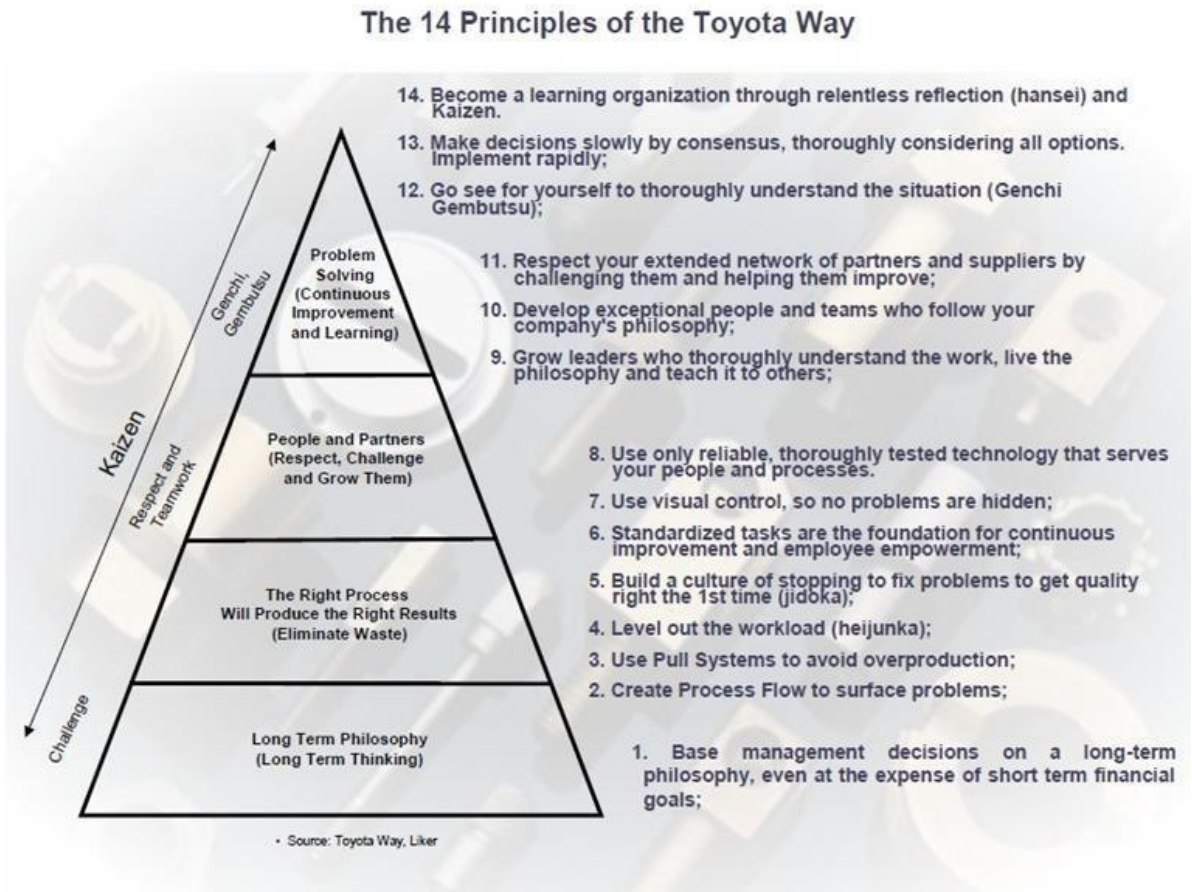
Another key aspect of innovation is developing products and processes. Companies should form interdisciplinary teams to generate ideas, as collaboration across diverse expertise fosters creativity and leads to innovative solutions. This approach also improves speed and flexibility in responding to market and customer needs.

Agile techniques like Scrum and Kanban are now used beyond software, including in manufacturing. Scrum follows an iterative process with short cycles ("sprints") and regular reviews to keep deliverables aligned with market demands. Kanban focuses on visualising work using boards to track progress, spot bottlenecks, and optimise production for better quality (Barcellos et al., 2024; Ndou et al., 2024).

These methods support fast testing and validation of ideas. Early customer feedback helps teams adapt quickly and reduce the risk of late-stage failure.

Source: https://www.workingmouse.com.au/insights/blogs/agile-lean-scrum-kaizen-new-names-same-faces/, 2024

Toyota, for example, increasingly uses agile methods and Kaizen, a strategy focused on continuous improvement and waste reduction. This not only lowers costs but also boosts customer satisfaction through higher product quality.



Source: The 14 principles of the Toyota Way

Bosch, a security systems company, adopted agile techniques to transform its operations following structural changes. To support this shift, it created cross-functional teams and promoted an “agile mindset” through shared processes. In 2020, Bosch moved away from traditional hierarchy, introducing a new organisational model with three value streams focused on camera, fire, and communication systems. Each stream includes dedicated managers and process owners driving continuous improvement. The agile transition improved the work environment significantly—90% of employees reported better team visibility and decision clarity, while engagement rose by 20%. Daily meetings also enhanced team cohesion and communication.. (https://www.theagilethinkers.com/case- study-bosch, 2024)

Video: A New Way of Working at Bosch Security Systems OvrP - Eng. António Pereira, Plant Manager
Time approx. 1 minute: https://www.youtube.com/watch?v=VHDmqLYle5M&t=16s

6.2 Emphasis on training and skills development

In today’s fast-changing economy, employee training and skills development are essential for company success. Lifelong learning is no longer optional—it’s a necessity for adapting to rapid technological and market shifts. Companies should create programmes that support continuous learning for the digital age.

Lifelong learning involves ongoing personal and professional development. Companies that prioritise training tend to have more knowledgeable and efficient employees, contributing to “innovation and efficiency in the digital era” (Jaldemark, 2024).

Video: Continuous Learning Benefits

Time approx. 3 minutes: https://www.youtube.com/watch?v=uxNv-2w75YY

Training should focus not only on technical skills like AI, machine learning, and data analysis, but also on soft skills such as creativity, critical thinking, and collaboration. For example, Google trains employees in machine learning to maintain strong technical capabilities (Google, 2024). IBM reports that “investing in soft skills improves company culture and productivity” (IBM, 2024).

Mentoring and coaching Mentoring and coaching are essential for developing talent in organisations. Programmes that promote knowledge sharing between experienced and newer employees improve team effectiveness, motivation, and overall job satisfaction.

Deloitte, for example, has built a strong mentoring framework reflecting its commitment to employee growth. It includes both formal and informal mentoring, supporting knowledge exchange and career guidance. Formal programmes connect junior staff with experienced professionals through structured check-ins, goal-setting, and feedback sessions.

Deloitte also encourages informal mentoring networks, where employees share advice and experiences more freely. These connections foster “collaboration and innovation across departments,” and create an “inclusive atmosphere where knowledge sharing is a natural part of the company culture.” (Source: Johnson, 2024).

In today’s fast-changing environment, success depends on tracking trends (e.g. with Tableau), building agile teams (Scrum, Kanban), and supporting continuous learning. This includes both technical skills (AI, machine learning, data analytics) and soft skills (creativity, critical thinking, collaboration). Mentoring and coaching strengthen this foundation and prepare companies for future challenges.

Questions

1. What is one key benefit of using agile methodologies like Scrum and Kanban in digital manufacturing?

A) Elimination of team collaboration
B) Focus only on long-term development goals
C) Faster iterations and quicker response to customer feedback
D) Removal of customer involvement from the development process

✅ Correct answer: C

2. According to the document, what is a major advantage of mentoring and coaching programmes in the workplace?

A) They replace the need for formal training.
B) They eliminate performance evaluations.
C) They improve team motivation, collaboration, and job satisfaction.
D) They remove the need for cross-department communication.

✅ Correct answer: C

3. True or False:

Lifelong learning, including both technical and soft skills, is becoming essential for companies to stay competitive in a fast-changing economy.

✅ Correct answer: True

Glossary of Key Terms:

- Agile: Flexible methods (e.g. Scrum, Kanban) that support fast adaptation and value delivery in short cycles.
- Skills development: Training in technical (AI, data analytics) and soft skills (creativity, critical thinking, teamwork).
- Data analysis: Using tools like Tableau to track trends and support informed decisions.
- Mentoring and coaching: Knowledge sharing between experienced and newer staff to speed up learning and growth.
- Innovation: The ability to adapt and implement new products, processes, and technologies.

Module 4: Green industry innovation and sustainable production technologies

Module Introduction

Welcome to *Green Industry Innovation and Sustainable Production Technologies*! This module dives into the transformative impact of green innovations on industries, equipping you with the knowledge to understand sustainable production technologies and their real-world applications. Through comprehensive reading materials, case studies, and practical activities, you'll gain actionable insights to implement these technologies in your business.

Learning Objectives / Scope of knowledge obtained:

By completing this module, learners will:

1. Understand the principles of green industry innovation.
2. Explore key sustainable production technologies and their applications.
3. Learn from real-world case studies across diverse industries.
4. Identify actionable strategies for implementing green innovations.

Module Structure

Estimated Time for Completion: 120 Minutes

Overview of Sections:

1. Introduction to Green Industry Innovation
   1.1 Circular Economy: Rethinking Waste and Resources
   1.2 Closed-Loop Systems
2. Renewable Energy Integration
3. Eco-Efficiency in Production Processes
4. Sustainable Production Technologies
5. Real-World Case Studies

6. Implementing Green Innovation Strategies 30 minutes
7. The Future of Green Industry (15 minutes)

Unit 1.

Section 1: Introduction to Green Industry Innovation

Green industry innovation aims to integrate environmental sustainability into industrial processes and products while maintaining or improving economic performance. Below are three key concepts driving this innovation:

1.1 Circular Economy: Rethinking Waste and Resources

Circular Economy: Rethinking Waste and Resources

The **circular economy** is a transformative model that moves away from the traditional linear approach of "take-make-dispose." Instead, it is designed to **maximize the value of resources** and **minimize waste** by keeping materials in circulation for as long as possible. This model promotes sustainability, reduces environmental impact, and creates economic opportunities by rethinking how industries produce, consume, and manage resources.

- **Designing for Longevity**
  Products in a circular economy are intentionally designed to last longer. This involves:
  - **Durable Materials**: Using materials that can withstand wear and tear.
  - **Repairability**: Ensuring that components can be replaced or repaired easily.
  - **Modular Design**: Creating products that can be upgraded or adapted over time, rather than being discarded.

1 INTRODUCTION

Circular economy is a topic that has gained a growing interest both in academia and industry in recent years. Questions such as how companies can contribute in the shift from a linear economy to a circular economy have been discussed in many different ways. One framework that has been developed is The 9R Framework by Potting et al. (2017), illustrated and explained in Figure 1, left. Product lifetime extension is illustrated as a solution in the transition towards a circular economy in this framework.

However, instead of striving towards pure product life extension, we would like to argue that product developers should strive towards a specific product longevity, such as an optimal one. Optimal product longevity, also synonymous with optimal product lifetime, is something that is and has been troublesome to define (Van Nes & Cramer,2005), since it depends on many different factors; product, industry, business model, users, only to mention a few. However, this is a topic that remains of interest, and we believe that this can be achieved if product developers can actively consider the key aspects and thus design for this optimal longevity.
This paper is part of a larger study (Carlsson & Mallalieu,2020). The overall goal in this paper is to develop a framework that helps product developers to Design for Longevity, given any durable good (Wikipedia,2021) within the consumer industry. More specifically, this paper aims to define Design for Longevity, but also develop tools that help practitioners to realize it
Circular economy is a topic that has gained a growing interest both in academia and industry in recent years. Questions such as how companies can contribute in the shift from a linear economy to a circular economy have been discussed in many different ways. One framework that has been developed is The9R Framework by Potting et al. (2017), illustrated and explained in Figure 1, left. Product lifetime extension is illustrated as a solution in the transition towards a circular economy in this framework. However, instead of striving towards pure product life extension, we would like to argue that product developers should strive towards a specific

product longevity, such as an optimal one. Optimal product longevity, also synonymous with optimal product lifetime, is something that is and has been trouble some to define (Van Nes & Cramer,2005), since it depends on many different factors; product, industry, business model, users, only to mention a few. However, this is a topic that remains of interest, and we believe that this can be achieved if product developers can actively consider the key aspects and thus design for this optimal longevity. This paper is part of a larger study (Carlsson & Mallalieu, 2020). The overall goal in this paper is to develop a framework that helps product developers to Design for Longevity, given any durable good (Wikipedia,2021) within the consumer industry. More specifically, this paper aims to define Design for Longevity, but also develop tools that help practitioners to realize it.

1.1 Definition of Design for Longevity

A definition of Design for Longevity has been developed based on the collected and analysed literature. The definition aims to help product developers to actively consider product longevity when making decisions regarding the product's design. Design for Longevity includes the careful consideration of how a product's life cycle is defined. Longevity is defined as for how long a product can perform any desired function over a certain period of time, either as a set of resources or as an object that serves as a means to provide a function. Design for Longevity aims at designing products with an optimal lifetime, where optimal means taking the user, the business and there source efficiency perspectives into account when designing the life of a product.

1.2 Design for Longevity Mindset

The definition of Design for Longevity provides product developers with a nuanced view of product longevity in order to actively consider it. However, realizing Design for Longevity is not considered trivial, and it is therefore broken down into smaller blocks. This entails a more wholesome mindset of how Design for Longevity should be anticipated and thus realized, illustrated in Figure 2.

(**Image 1.** - Design for Longevity Mindset: The flowchart illustrates the main blocks of the Design for Longevity Mindset and how it should be anticipated.)

1.2.1 The Adapted Design Strategies and their Relation to the Product Context

The six design strategies provided by Bakker et al. (2019) are included in the framework. The design strategies can have a beneficial impact on a product's life, since they can be used to prolong and redesign a product's life. However, we would also like to state that it is not always beneficial to implement each individual strategy for all products, based on two main reasons. Firstly, it is not possible to implement all strategies on all products, since different products aim to provide different functions.

Secondly, Design for Longevity aims at designing a product to provide a certain function, for a certain period of time, meaning that it is not always desired to prolong the product's lifetime. This highlights the fact that the proposed design strategies should be implemented reasonably, and that companies need to analyse and understand their Product Context, as well as the design strategies. The six strategies were therefore adapted and reformulated before they were included in the framework. In contrast to Bakker et al. (2019), the new descriptions are formulated, in a concise manner, to provide; the purpose of the strategy, an explanation and understanding of the

strategy, and potential benefits and drawbacks. This aims to enable product developers to make justified decisions, with minimum effort, regarding whether and how the design strategies should be implemented when Designing for Longevity. Two of the six new descriptions are provided below to illustrate these formulations.
Design for Attachment and Trust: The strategy is to design the product to evoke attachment and trust between the customer and the product. If the customer associates the product with an own significant value or feeling, it can increase the consciousness of responsibility and obligation to take care of the product. The product's lifetime likely increases because of emotional bonding between the customer and the product. However, there is a risk that an obsolete product remains in the customer's possession for a prolonged period of time, when in fact a replacement of the product would be beneficial from a resource efficiency point of view. Design for Dis- and Reassembly: The strategy is to design the product in order to facilitate the process of disassembly and reassembly of components and material from the product. This can be done through increased accessibility of components and material which makes it easier to recover resources. Product architectures developed for dis- and reassembly influence the placement and connection of components, and material selection, most likely to an expense of complexity. It can also be difficult to optimize the components' design and the product's architecture if the process of dis- and reassembly is considered to be implemented in all aspects.

1.2.2 The Product Context and its Relation to the Optimal Product Lifetime

The Product Context is a situated set of information and will differ depending on the product. This aims to emphasize and remind companies that it is important to consider the product out of three pre-defined aspects while designing it. The user can be defined as the person that actively consumes or uses the product. The business can be defined as the actor that gains value in return of providing the product. Finally, the product both contains and consumes resources as a means to fulfill its function, and the use of these can be measured or discussed in terms of resource efficiency. Furthermore, product lifetime consists of two dimensions; real and desired. The desired product lifetime can and will most likely differ between these three aspects. While trying to homogenize the desired lifetime from the three aspects, it is also important to try and homogenize the two dimensions, real and desired, since a mismatch between these two is non-ideal. Successfully doing this will then result in the Optimal Product Lifetime. Altogether, this entails a theoretical definition of an optimal product lifetime. A product's optimal lifetime is the point where the user's, the business's and the resource efficiency's desired and real product lifetimes coincide.

Source: Carlsson, Simon; Mallalieu, Adam; Almefelt, Lars; Malmqvist, Johan. DESIGN FOR LONGEVITY - A FRAMEWORK TO SUPPORT THE DESIGNING OF A PRODUCT'S OPTIMAL LIFETIME. ResearchGate, August 2021.

1.2 Closed-Loop Systems:

Closed-loop systems are an integral part of the circular economy, aiming to minimize waste by transforming it into valuable inputs for other processes. This collaborative approach ensures that materials and by-products from one industry are not discarded but instead reused within the production cycle of another. These systems exemplify the principle of "waste equals resource," promoting sustainability, efficiency, and economic growth.
What is an economy?
Youtube video! No1.

An economy that is restorative and regenerative by design.
In a circular economy economic activity builds and rebuilds overall system health. The concept recognises the importance of the economy needing to work effectively at all scales – for big and small businesses, for organisations and individuals, globally and locally.
It is based on three principles:

- Eliminate waste and pollution
- Circulate products and materials
- Regenerate nature

Circulate products and materials
Youtube video! No2.
Source: The circular economy in detail. Ellen MacArthur Foundation. 16. 09. 2019.

(**Image 2**: Circular Economy)

Technical cycle
The most effective way of retaining the value of products is to maintain and reuse them. Take a phone for example: it is far more valuable as a phone than as a pile of components and materials. So, the first steps in the technical cycle are focused on keeping products whole to retain the maximum possible value. This could include business models based on sharing, so users get access to a product rather than owning it and more people get to use it over time. It could involve reuse through resale. It could mean cycles of maintenance, repair, and refurbishment.

Eventually, when the product can no longer be used, its components can be remanufactured. Parts that cannot be remanufactured can be broken down into their constituent materials and recycled. While recycling is the option of last resort because it means the embedded value in products and components are lost, it is vitally important as the final step that allows materials to stay in the economy and not end up as waste.

Biological cycle
Biodegradable materials that cannot be reused, like some food byproducts, can be circulated back into the economy in the biological cycle. By composting or anaerobically digesting organic materials, valuable nutrients, such as nitrogen, phosphorous, potassium, and micronutrients, can be used to help regenerate the land so we can grow more food or renewable materials like cotton and wood. Some products, like cotton clothing or wooden furniture, can be circulated through both the technical and biological cycle. They can be maintained, reused, repaired, and sometimes even recycled, but eventually they can be returned to the biological cycle from which they came. Composted or anaerobically digested, they can feed the soil to grow new cotton or wood.

Design is key to success
In order for products to successfully be circulated in either the biological or the technical cycle, it is essential they have been designed with their eventual circulation in mind. There are many products in our current economy that cannot be circulated in either cycle and end up as waste. There are products that fuse technical and biological materials in such a way that we can't separate them and circulate them – for example, textiles that blend natural and plastic fibres.

If designers thought about how their product could fit into the technical or biological cycles after use, that product could be made with that onward path in mind. For example, products destined for technical cycles would benefit from being easy to repair and maintain, easy to take apart, and made of modular components that can be replaced. They could be durable enough to withstand the wear and tear of many users. And they could be made from materials that are easily recycled.

If products like wooden furniture were designed – as well as to be easy to maintain and repair – with the biological cycle in mind, their biodegradable materials (like wood) would be easily separated from their technical materials (like screws) and if glues and paints were used they would be biodegradable. Other products, like takeaway food containers, can be designed to be compostable after one use so that they increase the chances of the food scraps they contain returning to the soil.

Examples of companies designing for circulation
There are many innovative companies already designing their products with recirculation in mind. Ecovative makes compostable packaging from agricultural byproducts (the parts of crops that cannot be eaten) and mycelium (mushroom roots). The packaging works like expanded polystyrene to protect fragile items in transit, but it is from a renewable source and does not contribute to plastic waste. Mycelium is a fungal network of threadlike cells that acts like a natural, self-assembling glue. It grows in 5-7 days without needing any light or water, digesting agricultural by-products and binding into any shape needed. At the end of the process, the material goes through a dehydration and heat-treating process to stop the growth and to ensure the absence of spores or allergens. Once used, it can be safely composted and returned to the soil.
Source: Circulate products and materials. Ellen MacArthur Foundation. 16. 02. 2022.

Example: Do we need more examples?
The furniture company IKEA collects used furniture from customers, refurbishes it, and resells it. This initiative reduces waste while keeping materials in circulation.

Questions (Unit 1.):
1. What is the goal of the circular economy?
a) Increasing the capacity of landfills
b) Efficiently reusing waste and resources
c) Reducing production costs in all industries
Correct answer: b) Efficiently reusing waste and resources.

2. What is the concept of "Design for Longevity"?
a) Designing products to last long, taking into account user, business, and resource efficiency perspectives
b) Encouraging the rapid obsolescence of products to bring new ones to the market
c) Designing products to consume as little energy as possible during manufacturing
Correct answer: a) Designing products to last long, taking into account user, business, and resource efficiency perspectives.

3. What characterizes closed-loop systems in the circular economy?
a) The use of waste and by-products between industries for new production processes
b) Storing and neutralizing waste generated during production processes
c) The exclusive underground transformation of biological products
Correct answer: a) The use of waste and by-products between industries for new production processes.

Unit 2.

Section 2. Renewable Energy Integration

Renewable energy is at the forefront of green innovation and sustainability. As industries face the pressing need to reduce their carbon footprints and mitigate climate change, the transition from fossil fuels to renewable energy sources such as solar, wind, and hydropower has become a vital strategy. This shift helps lower greenhouse gas emissions and reduces dependency on finite resources, driving both economic and environmental benefits.

Key Benefits of Renewable Energy in Manufacturing:

- **Cost Reduction:** One of the most compelling reasons for manufacturing companies to invest in renewable energy is the significant potential for long-term cost savings. While the initial investment in renewable energy infrastructure such as solar panels or wind turbines can be high, the ongoing operational costs are relatively low. Once these systems are installed, the energy they generate is essentially free, providing companies with a predictable and stable energy supply.
- **Environmental Impact:** The manufacturing sector is one of the largest contributors to greenhouse gas emissions. By integrating renewable energy into operations, manufacturers can drastically reduce their carbon footprints. Solar, wind, and hydropower generate electricity without emitting carbon dioxide, significantly decreasing the environmental impact compared to traditional fossil fuels.
- **Energy Independence:** Renewable energy allows companies to gain control over their energy sources, reducing their dependency on external providers and insulating them from energy price volatility. This independence is especially valuable in industries with high energy demands, where price fluctuations can lead to significant financial uncertainty.

Example:
Google powers its global operations with 100% renewable energy by investing in solar farms and wind farms. Its data centers, which require vast amounts of energy, now operate with a net-zero carbon footprint. (Source: Google Sustainability Report 2023)
Video: How Renewable Energy Saves Google Money

The Role of Renewable Energy in Reducing Carbon Footprints: The transition to renewable energy plays a critical role in the overall effort to reduce global carbon emissions. Manufacturing processes, which often rely heavily on fossil fuels for energy, contribute substantially to climate change. By adopting renewable energy solutions, manufacturers can significantly reduce emissions and contribute to the broader global goals of mitigating climate change.

Example: Apple has been using 100% renewable energy for its global corporate operations since 2018. The company has reduced its carbon footprint significantly by powering its data centers, retail stores, and manufacturing processes with renewable energy. Apple has also been working on reducing emissions throughout its entire supply chain, contributing to its goal of becoming carbon neutral by 2030. (Source: Apple Environmental Progress Report 2023)

Conclusion: Renewable energy offers significant benefits for the manufacturing sector, including cost reduction, environmental sustainability, and energy independence. By adopting renewable energy solutions, companies can reduce their carbon footprints, lower operational costs, and contribute to a sustainable future. As the world moves towards cleaner energy, integrating renewable energy into manufacturing will become an increasingly critical strategy for success.

Section 3. Eco-Efficiency in Production Processes

Eco-efficiency refers to achieving greater productivity while using fewer resources. The concept is central to sustainable production practices, emphasizing the optimization of operations to maximize output while minimizing resource consumption, energy use, water usage, and waste generation. As industries strive to meet environmental and economic challenges, eco-efficiency becomes increasingly crucial for improving sustainability.

Practical Applications:

1. **Reducing packaging materials without compromising quality.**

Example Case Study: **Unilever**, one of the world's largest consumer goods companies, has made significant strides in reducing packaging waste as part of its sustainability efforts. The company has developed packaging that uses fewer materials without compromising product protection. Unilever's initiatives have included using lighter packaging and eliminating unnecessary plastic in packaging, particularly for its food and home care products.
Key Results:

- Unilever reduced the weight of packaging for several product lines by up to 20%.
- The company committed to making all of its packaging recyclable, reusable, or compostable by 2035.

(Source: Unilever - Unilever Sustainability - Sustainable Living – Plastics)

2. **Optimizing supply chains to reduce unnecessary transportation.**

Example Case Study: **IKEA**, the global furniture retailer, has focused on optimizing its supply chains to reduce carbon emissions and improve efficiency. By working with suppliers to reduce transportation distances and adopting more energy-efficient shipping methods, IKEA has significantly reduced its environmental impact.
Key Results:

- IKEA reduced the carbon footprint of its products by optimizing its transportation routes.
- The company has also introduced more localized manufacturing to reduce transportation distances, minimizing the need for long-haul freight.

(Source: IKEA Sustainability Report FY23 – IKEA Global)

3. **Implementing water recycling systems in production plants.**

Example Case Study: **Coca-Cola** has adopted water recycling systems at its bottling plants, where treated wastewater is used for landscaping and irrigation around its production sites. By

using treated water for non-potable purposes, the company significantly reduces its environmental footprint.
Key Results:

- Coca-Cola saved millions of liters of freshwater annually by reusing treated wastewater.
- This practice also reduced the company's wastewater discharge to local water bodies.

(Source: Coca-Cola Sustainability – Water Stewardship)

Conclusion: Eco-efficiency is essential for achieving sustainable production by optimizing the use of resources, energy, and water, while minimizing waste generation. By focusing on reducing waste, improving operational processes, and reusing valuable resources, industries can significantly lower their environmental impact while enhancing productivity. These actions contribute to both sustainability and operational efficiency, setting a benchmark for industries to follow in their efforts toward a more sustainable future.

Section 4. Sustainable Production Technologies

Sustainable production technologies are at the core of green innovation, driving significant advancements in reducing the environmental footprint of industries. These technologies enable companies to optimize resource use, minimize waste, and lower energy consumption, contributing to a more sustainable future. By integrating eco-friendly practices into manufacturing processes, industries can achieve a balance between economic growth and environmental responsibility. Furthermore, sustainable production technologies foster operational efficiency, helping businesses reduce costs while meeting stringent environmental regulations and consumer demand for greener products.
Below are three transformative technologies:

4.1. AI for Predictive Maintenance

AI technology uses data from sensors installed in machines to predict when a component is likely to fail. By addressing potential issues before they cause breakdowns, manufacturers can save costs and reduce waste.
How It Works:

- Sensors collect data such as temperature, vibrations, and operating speed.
- AI algorithms analyze the data to detect anomalies or patterns that indicate potential failure.
- Maintenance teams receive alerts to schedule repairs before the machine breaks down.

Key Benefits:

- Prevents unplanned downtime, saving money and resources.
- Extends the lifespan of machinery.
- Reduces energy waste by ensuring machines operate at peak efficiency.

Example:
Siemens uses AI-driven predictive maintenance in its manufacturing facilities, reducing maintenance costs by 20% and improving operational uptime by 15%.

4.2. 3D Printing for Sustainable Production

Also known as additive manufacturing, 3D printing builds products layer by layer, using only the required materials. This approach minimizes waste compared to traditional subtractive manufacturing, which involves cutting away material.
Applications in Industry:

- Prototyping: Businesses can quickly create prototypes without wasting materials on molds or tools.
- Custom Manufacturing: Products are tailored to specific needs, reducing overproduction.
- Material Efficiency: Recycled plastics and metals are often used in 3D printers.

Example:
Boeing uses 3D printing to manufacture lightweight parts for airplanes, reducing material usage and improving fuel efficiency.

4.3. Waste-to-Energy Systems

Waste-to-energy (WTE) systems convert non-recyclable waste into usable energy, such as electricity or heat. These systems address two critical issues: waste management and energy generation.

How It Works:

- Waste is incinerated at high temperatures.
- The heat generates steam, which powers turbines to produce electricity.
- Advanced filtration systems ensure minimal emissions.

Section 5. Real-World Case Studies

Real-world examples demonstrate how companies are successfully adopting green innovations:

1., Tesla (Automotive Industry)
Innovation: *Electric Vehicles (EVs)*
Tesla revolutionized the automotive industry by producing fully electric vehicles that aim to reduce carbon emissions. Their innovation includes high-efficiency batteries, autonomous driving technology, and a focus on sustainable manufacturing processes.

2., Unilever (Consumer Goods)
Innovation: *Sustainable Sourcing and Circular Economy Practices*
Unilever has committed to reducing plastic waste and sourcing 100% of its agricultural raw materials sustainably. They introduced the “Clean Future” program, focusing on zero-carbon manufacturing and transitioning to recyclable or reusable packaging.

3., Patagonia (Apparel Industry)
Innovation: *Environmentally Friendly Fabrics*
Patagonia is known for its sustainable business practices, such as using recycled materials like plastic bottles to make jackets, and organic cotton for clothing. They also promote repair and reuse of products through their "Worn Wear" program.

4., IKEA (Retail and Furniture)
Innovation: *Circular Business Model and Renewable Energy Investments*
IKEA has shifted to a more circular model by designing products with sustainability in mind, ensuring materials can be reused or recycled. The company also invests heavily in renewable energy, including solar panel installations in their stores and distribution centers.

5., Ørsted (Energy Industry)
Innovation: *Offshore Wind Farms*
Ørsted is one of the world leaders in offshore wind energy, having transitioned from fossil fuels to renewable energy. They have built large-scale wind farms to provide clean, sustainable energy and have pledged to be carbon-neutral by 2025.

6., Nike (Sportswear and Footwear)

Innovation: *Flyleather and Sustainable Manufacturing Processes*
Nike introduced Flyleather, a new sustainable material made with at least 50% recycled natural leather fiber. They also focus on reducing water usage and increasing energy efficiency in their production facilities through sustainable manufacturing.

7., Microsoft (Technology)
Innovation: *Carbon Negative Operations*
Microsoft has committed to becoming carbon negative by 2030. This includes using renewable energy in its data centers, investing in carbon capture technology, and purchasing carbon offsets to counteract emissions.

8., BASF (Chemical Industry)
Innovation: *Sustainable Chemical Solutions and Carbon Capture*
BASF is leading the way in developing chemicals that help reduce the environmental impact of manufacturing and construction. Their innovations include biodegradable products and advanced carbon capture technologies to reduce emissions in industrial processes.

9., Samsung Electronics (Consumer Electronics)
Innovation: *Eco-friendly Packaging and Energy-Efficient Products*
Samsung has committed to reducing the environmental impact of its products, using sustainable materials for packaging and increasing the energy efficiency of its devices. They aim to eliminate plastic packaging and ensure all products are recyclable.

10., Coca-Cola (Food and Beverage)
Innovation: *Water Stewardship and Recycled Packaging*
Coca-Cola has made significant strides in water conservation and waste reduction, with initiatives to recycle water used in production. They also introduced bottles made from 100% recycled plastic to reduce reliance on new plastic production.

Activity: Example?
Quiz: Match the company with its green innovation.
Tesla → Electric vehicles and sustainable energy storage solutions
Unilever → Sustainable sourcing, circular economy practices, and plastic waste reduction
Patagonia → Recycled materials and repair/reuse programs for clothing
IKEA → Circular business model, products designed sustainably
Ørsted → Offshore wind farms and commitment to carbon neutrality
Nike → Flyleather and sustainable manufacturing processes for sportswear
Microsoft → Carbon negative operations
BASF → Sustainable chemicals, biodegradable products, and carbon capture technology
Samsung Electronics → Eco-friendly packaging, energy-efficient products
Coca-Cola → Water stewardship and bottles made from 100% recycled plastic

Questions (Unit 2.):

1. What is one of the primary benefits of integrating renewable energy into manufacturing operations?
a) Increased carbon emissions
b) Long-term cost savings
c) Greater reliance on fossil fuels

Answer: b) Long-term cost savings.

2. Which company has been using 100% renewable energy for its global corporate operations since 2018?
a) Google
b) Apple
c) Coca-Cola
Answer: b) Apple.

3. How does AI-driven predictive maintenance benefit manufacturing operations?
a) It increases the frequency of equipment breakdowns
b) It reduces maintenance costs and extends machinery lifespan
c) It requires more energy to operate
Answer: b) It reduces maintenance costs and extends machinery lifespan.

Unit 3.

Section 6. Implementing Green Innovation Strategies (30 minutes)
Small and medium-sized enterprises (SMEs) are increasingly recognizing the importance of green innovation strategies. Implementing these strategies not only helps reduce environmental impact but can also lead to cost savings and enhanced reputation. Below is a detailed guide for SMEs on how to adopt green practices through a structured approach.

6.1. Conduct Sustainability Audits
A sustainability audit is the first step for SMEs aiming to adopt green practices. This audit helps businesses assess their current environmental impact by examining key areas like energy consumption, waste production, resource usage, and carbon emissions. The goal is to identify opportunities to improve efficiency and reduce environmental harm.
Why is it important?
Conducting a sustainability audit enables businesses to:

- Identify inefficiencies in processes that lead to energy waste or excessive resource consumption.
- Understand their carbon footprint, which is crucial for setting environmental goals.
- Comply with environmental regulations and avoid potential fines or reputational damage.

There are several types of audits, such as energy, water, waste, and carbon audits, depending on the areas an SME wishes to focus on. An audit typically includes:

- Data collection on energy use, waste management, and other relevant metrics.
- Identifying areas where improvements can be made (e.g., energy-efficient equipment, waste recycling programs).
- Reviewing current practices and setting benchmarks for performance.

Useful sources for sustainability audits:

- **ISO 14001:** The ISO 14001 standard helps companies assess their environmental impacts, manage resource use, and monitor environmental performance through regular audits.

- **European Union Eco-Management and Audit Scheme (EMAS):** EMAS is a voluntary environmental management tool developed by the European Union. It is one of the most demanding and rigorous environmental audit systems in the world. It helps businesses reduce environmental impacts, comply with regulations, and demonstrate their commitment to sustainability.
- **The EU Green Deal & EU Taxonomy for Sustainable Activities:** they provide specific guidelines for assessing and classifying sustainability practices, and these can be incorporated into the audit process.
- **The Global Reporting Initiative (GRI):** GRI offers a global framework for sustainability disclosures and is relevant for European businesses looking to report their sustainability efforts. GRI standards help companies assess and disclose environmental, social, and governance (ESG) impacts, facilitating sustainability audits and assessments.

6.2. Set Measurable Goals

Setting clear, measurable sustainability goals is crucial for any green innovation strategy. Goals should be specific, achievable, and based on the data obtained from sustainability audits.
Key Steps in Setting Goals:

- Identify key performance indicators (KPIs) that reflect environmental impact, such as energy use, water consumption, waste generation, and carbon emissions.
- Make goals SMART (Specific, Measurable, Achievable, Relevant, Time-bound). For example: "Reduce carbon emissions by 20% over the next 5 years."
- Monitor progress towards these goals regularly and adjust strategies as needed.

Having measurable goals enables SMEs to track progress and motivate employees. It also serves as a way to showcase achievements to stakeholders and customers, enhancing brand reputation and customer loyalty. Furthermore, it allows companies to meet environmental regulations and certifications, improving their market competitiveness.
Sources:

- *Science Based Targets Initiative (SBTi)* – Framework for businesses to set science-based emissions reduction targets (https://sciencebasedtargets.org).
- *UN Global Compact: Business Ambition for 1.5°C* – A campaign to encourage companies to set science-based targets (https://unglobalcompact.org/take-action/events/climate-action-summit-2019/business-ambition).

6.3. Engage Employees and Stakeholders

One of the most effective ways for SMEs to implement green practices is through the engagement of employees and stakeholders. This engagement fosters a culture of sustainability and ensures that everyone in the organization is aligned with the business's green goals.
Employee Engagement:

- **Training and education**: Employees should be informed about sustainability initiatives and how they can contribute, whether through reducing waste, improving energy efficiency, or promoting sustainable practices.
- **Incentives**: Offering incentives, such as rewards for energy-saving ideas or reaching sustainability milestones, can motivate employees to participate actively in green initiatives.

Stakeholder Engagement:

- **Communication**: Regularly communicate sustainability goals, progress, and challenges to stakeholders (customers, investors, and suppliers). This transparency builds trust and can lead to stronger partnerships.
- **Collaboration**: Work with suppliers and customers to implement green practices across the supply chain. This could include sourcing sustainable materials or encouraging customers to use eco-friendly products.

Useful sites:

- Trellis Group (formerly GreenBiz)
- OBJ

7. The Future of Green Industry (15 minutes)

The future of the green industry is defined by sustainable practices that integrate innovative technologies, reduce carbon footprints, and promote circular economies. As the world increasingly focuses on combating climate change, several key trends are shaping the future of the green industry, including smart factories, bio-based materials, and carbon capture technologies. These advancements not only support environmental goals but also help businesses thrive in a rapidly changing landscape.

7.1. Smart factories

Smart factories, powered by Industry 4.0 technologies, are revolutionizing manufacturing processes. These factories leverage IoT (Internet of Things) sensors, artificial intelligence, robotics, and big data to optimize production efficiency, reduce waste, and minimize energy consumption. The key advantage of smart factories is their ability to monitor and adjust production processes in real-time, ensuring minimal environmental impact.

For example, manufacturers can use AI to predict equipment failures, schedule maintenance, and reduce downtime, leading to more efficient use of resources. According to a report from McKinsey, smart factory solutions can potentially reduce energy consumption by 30% and improve operational efficiency by up to 25% (*McKinsey & Company, 2022*). This shift towards automation not only cuts costs but also aligns with sustainability goals by reducing energy use and waste generation.

Source: (McKinsey & Company, " What are Industry 4.0, the Fourth Industrial Revolution, and 4IR?" McKinsey & Company, 2022.)

7.2. Bio-Based Materials

Another critical trend is the growing use of bio-based materials as alternatives to traditional, petroleum-derived ones. Bio-based materials are derived from renewable resources such as plants, algae, and waste. They can replace plastic, synthetic fibers, and chemicals used in industries like packaging, construction, and fashion. One major advantage is their ability to be biodegradable or recyclable, reducing the environmental impact of products at the end of their life cycle.

For instance, in the construction sector, bio-based materials like hempcrete, made from hemp fibers and lime, are becoming increasingly popular. These materials offer a low-carbon alternative to conventional concrete. Bio-based plastics made from materials like corn starch or sugarcane are also gaining traction as a sustainable replacement for traditional plastics.

Research from the European Bioplastics Association shows that the global market for bio-based plastics is expected to reach 7.43 million tons by 2027 (*European Bioplastics, 2023*). As consumer demand for environmentally friendly products rises, the use of bio-based materials in various industries will likely expand, contributing to greener manufacturing practices.

Source: (European Bioplastics, "Bioplastics Market Data," European Bioplastics, 2023.)

7.3. Carbon Capture Technologies

Carbon capture, utilization, and storage (CCUS) technologies are essential for reducing greenhouse gas emissions and mitigating climate change. CCUS technologies capture CO2 emissions directly from industrial processes or the atmosphere and store them underground or use them in products such as fuels, chemicals, or building materials. This technology plays a crucial role in decarbonizing industries such as cement, steel, and oil and gas, which are difficult to electrify.

A notable example is the world's largest carbon capture plant, the *Net Zero Teesside* project in the UK, which is set to capture and store up to 10 million tons of CO2 per year (*Net Zero Teesside, 2024*). The global market for CCUS technologies is growing rapidly, with investments from both government and private sectors aiming to scale up its application.

Video: Net Zero Teeside Video

Sources: (*Net Zero Teesside*, "The UK's Largest Carbon Capture Project," Net Zero Teesside, 2024.)

Conclusion: The future of the green industry will rely heavily on technological advancements that help businesses and nations transition to sustainable practices. These technologies represent the cutting edge of this **transition**. As industries embrace these innovations, the potential for reducing environmental impacts and creating a sustainable future grows. Businesses that adopt these green technologies early will not only contribute to a healthier planet but will also benefit from operational efficiencies, new markets, and enhanced consumer loyalty.

Questions (Unit 3.):

1. Why is conducting a sustainability audit important for SMEs?

a) It helps businesses identify opportunities to reduce costs and increase energy consumption.
b) It allows businesses to assess their environmental impact and identify areas for improvement.
c) It focuses solely on reducing product prices and enhancing marketing strategies.
Answer: b) It allows businesses to assess their environmental impact and identify areas for improvement.

2. What is a key advantage of smart factories in the context of green innovation?

a) They increase operational efficiency while reducing energy consumption and waste.
b) They reduce the need for employee training and engagement in sustainability practices.
c) They focus exclusively on improving product quality without considering environmental impact.
Answer: a) They increase operational efficiency while reducing energy consumption and waste.

3. What role do bio-based materials play in promoting sustainability in various industries?

a) They provide alternatives to petroleum-based materials, offering biodegradable and recyclable options.
b) They are only used for packaging, with no significant impact on other industries.
c) They are primarily designed to replace synthetic materials in the fashion industry only.
Answer: a) They provide alternatives to petroleum-based materials, offering biodegradable and recyclable options.

Final Quiz Questions

1. What is a circular economy?
2. How does AI predict maintenance needs?
3. What makes 3D printing more sustainable than traditional manufacturing?

Module 5: Funding Gaps - Reaching Private Capital by Performing Equity Investment Readiness - Supporting Tool

Module 5: Funding Gaps – Reaching Private Capital by Performing Equity Investment Readiness – Supporting Tool

Module Introduction

This module provides essential strategies and tools to bridge funding gaps and attract private capital. By focusing on equity investment readiness, participants will learn how to evaluate and enhance their investment potential through structured frameworks, case studies and strategic insights.

Securing funding is a critical challenge for businesses, particularly in their early stages of development. Understanding funding gaps and addressing them is essential for business sustainability and growth. This module provides essential insights, tools, and strategies to help businesses bridge funding gaps and attract private capital.

By focusing on equity investment readiness, participants will explore practical frameworks and tools to assess, improve, and present their business or project as an attractive investment opportunity. Through real-world case studies and structured learning, this module will equip businesses with the knowledge and confidence to engage with private investors effectively.

Learning Objectives / Scope of Knowledge Obtained

1. Understand the concept of funding gaps and how they can hinder business growth.
2. Assess investment readiness using practical tools and frameworks.
3. Develop strategies to effectively engage with private investors and create compelling investment proposals.
4. Gain insights into overcoming common funding challenges in business development.

Module Structure

- **Estimated Time for Completion:** 120 minutes
- **Overview of Sections:**

Unit 1: Introduction to Funding Gaps and Private Capital
Unit 2: Equity Investment Readiness – Frameworks and Tools
Unit 3: Strategies for Engaging Private Capital
Unit 4: Structuring and Sustaining Investment Relationships

Unit 1: Introduction to Funding Gaps and Private Capital

A funding gap refers to the amount of capital a business requires to sustain its operations or fund future growth that is not covered by cash flow, equity, or debt financing. Businesses frequently encounter funding caps during critical phases, such as research and development, market expansion, or operational scaling.

There are several causes of funding gaps, including (Investopedia, 2024):

- High Research & Development Costs: Many businesses, especially in technology and pharmaceutical industries, require substantial upfront investment in R&D before they can generate revenue.
- Mistimed Cash Flows: An imbalance between accounts receivable and accounts payable can create short-term liquidity shortages.
- Government Budget Shortfalls: Businesses that rely on public funding may struggle when governments cut budgets or reallocate resources.
- Seasonal Revenue Fluctuations: Industries such as tourism and retail often face cash flow gaps during low seasons.
- Underfunded Rapid Growth: Businesses that scale too quickly may find themselves spending more than they can generate, leading to financial strain.
- Inefficient Inventory Management: Overstocking or supply chain delays can tie up capital, creating funding shortages.

Private capital plays a vital role in closing funding gaps and accelerating business growth. Investors such as venture capital firms, angel investors, and private equity funds provide funding in exchange for equity stakes, allowing businesses to expand without the immediate pressure of repaying loans.

However, securing private capital is competitive, and investors look for businesses that demonstrate strong financial viability, market potential, and scalability. Companies must ensure they are investment-ready by having clear financial projections, growth strategies, and risk mitigation plans before approaching investors.

- Embedded Video: What is Private Capital?
- Visualization Methods: [What is Private Capital Chart. Retrieved from Allvue.com]

The modern private capital landscape has evolved significantly over the past century. In 1901, J.P. Morgan orchestrated what is considered the first leveraged buyout with the acquisition of Carnegie Steel for $480 million. This event marked the theoretical birth of private equity strategies. The industry saw the establishment of the first true private equity firms in 1946, with the founding of the American Research and Development Company and J.H. Whitney. The 1980s marked a significant shift with the growth of private equity, leading to the development of various asset classes within private capital. The Global Financial Crisis in 2008 further accelerated the expansion of these strategies, as investors sought more diversified and less volatile investment options. Understanding this historical context provides valuable insights into the current landscape and future potential of private capital investments (Allevuesystems.com, 2022).

Types of Private Capital (Kaka, 2024)

- Venture Capital: Investments focused on early-stage companies with high growth potential.
- Private Equity: Investments in established companies, often involving buyouts or significant ownership stakes. Often used for expansion or restructuring.
- Private Dept: Non-bank lending to companies, including direct lending and mezzanine financing.
- Real Estate: Investments in properties and developments that generate income through rents and long-term appreciation.
- Infrastructure: Investments in essential physical systems and facilities, such as transportation networks, utilities, and communication systems.
- Natural Resources: Investments in assets related to extracting and producing natural commodities such as oil, gas, minerals, and timber.

Each type of private capital serves distinct purposes and caters to different stages of a company's lifecycle. For instance, venture capital is crucial for startups needing seed funding, while private equity is often involved in scaling mature businesses or facilitating ownership transitions.

The Challenge of Undervaluing Natural Capital

The private sector has historically exploited natural resources due to government policies that prioritize economic growth over environmental sustainability. This has led to significant financial gains for industries that extract and deplete natural capital without considering long-term ecological consequences. However, there is growing recognition that protecting natural capital—such as forests, water sources, and biodiversity—requires substantial investment, which could be leveraged through sustainable business practices. The implementation of natural capital accounting (NCA) has emerged as a key solution, helping businesses and policymakers recognize the economic value of natural assets and integrate them into financial decision-making. Initiatives like the World Bank's WAVES program and the Natural Capital Declaration launched in 2012 are working to standardize reporting on ecosystem services, emphasizing the necessity of preserving natural resources through structured investment. Additionally, organizations such as The Natural Capital Project and The Economics of Ecosystems & Biodiversity (TEEB) are developing frameworks and analytical tools to quantify the economic benefits of conservation. Despite these advancements, shifting away from "business-as-usual" models remains a major challenge. Many industries rely on low-cost resource extraction, and the long-term benefits of conservation investments are difficult to measure in financial terms, making them less appealing to traditional investors. Conservation finance, while increasingly recognized as essential in combating climate change and promoting sustainable development, still suffers from inadequate funding and policy support. Addressing this issue requires a collaborative approach between governments, financial institutions, and the private sector to ensure that natural capital is valued, protected, and integrated into mainstream economic systems (Clark et al., 2017).

- Embedded Video: The Value of Natural Capital

Sian Leake emphasizes in her TEDx Talk the critical need to integrate environmental considerations into economic and financial decision-making. She argues that traditional accounting methods often overlook the economic value of natural resources, leading to their

degradation and loss. By adopting natural capital accounting, businesses and governments can assign economic value to ecosystems, promoting sustainable practices and long-term environmental stewardship.

Investor Motivations (Roundy et al, 2017)

Investors evaluate businesses based on their specific goals, expected returns, and investment philosophies. Traditional investors such as venture capitalists (VCs), angel investors, and private equity firms focus primarily on financial returns, while impact investors seek a dual return – financial and social/environmental impact. Key criteria investors consider include

- Financial Viability – Investors assess profitability, revenue models, cash flow projections, and potential return on investment (ROI);
- Scalability & Growth Potential – Businesses must demonstrate the ability to expand in the market and achieve long-term growth.
- Market Opportunity & Competitive Advantage – Investors look for strong industry positioning and differentiation from competitors.
- Management & Leadership Team – A competent and experienced team increases confidence in a company's success.
- Risk & Exit Strategy – Investors consider risk mitigation strategies and viable exit plans, such as acquisition or initial public offering (IPO).
- Social & Environmental Impact – Impact investors prioritize measurable social or environmental benefits alongside financial returns.

Investor Type	Primary Focus	Risk Appetite	Investment Horizon	Involvement	Social Impact Consideration
Venture Capitalists	High financial returns	High	5-10 years	Strategic	Low
Angel Investors	Startup growth	Medium to High	5-7 years	Hands-on	Moderate
Private Equity Firms	Mature Companies	Medium	3-7 years	Operational	Low
Impact Investors	Financial & Social ROI	Medium	Long-term (> 10 years)	Strategic	High

Understanding the type of investor a business is targeting is essential for securing funding. While traditional investors prioritize financial growth and ROI, impact investors seek a balance between profitability and positive societal impact. Entrepreneurs should tailor their business plans, financial models and impact narratives accordingly to attract the right investors.

- Self-Assessment:
- How often do you consider the environmental impact of economic or business decisions?

  Frequently; Sometimes; Rarely; Never
- What steps can you take to increase your awareness and engagement with natural capital?
- Suggestions:
- Learn the basics of Natural Capital Accounting and how it integrates into financial and environmental reporting frameworks.
- Attend webinars, online courses, or events focused on sustainability finance and ecosystem services.

- Use tools like the Sustainable Business Model Canvas to map out how your business interacts with natural systems.
- Which of the following best describes how natural capital is valued in your workplace or industry?
  It is a key part of decision-making and strategy; It is considered but not systematically applied; It is rarely discussed or integrated into financial planning; I am unsure how my organization values natural capital.

Quiz:

A funding gap only occurs due to poor inventory management. (True/**False**)

- Which of the following is a type of private capital?
- Public bonds
- **Angel investment**
- Government grants
- Bank savings
- Private equity is primarily aimed at startups in early growth stages (True/**False**)
- What is the primary focus of impact investors?
- High ROI only
- Environmental impact only
- **Financial return plus social/environmental impact**
- Quick returns

Unit 2: Equity Investment Readiness – Frameworks and Tools

Before approaching investors, businesses need to assess whether they are truly investment-read. An investment-ready business has a clear financial structure, a viable growth plan, and a well-defined market opportunity. Investors expect businesses to have:

- a scalable business model with clear revenue streams,
- strong financial projects, including revenue forecasts and cost structures,
- a competitive market position with a clear value proposition,
- a solid legal and compliance framework to protect investor interests.

Green Finance Institute Investment Readiness Toolkit (https://hive.greenfinanceinstitute.com/gfihive/toolkit/)

The Green Finance's Investment Readiness Toolkit provides a structured approach to securing private investment. Originally designed for nature-based projects, its eight-step framework applies broadly to businesses preparing for investment. Businesses that follow a structured investment readiness approach increase their chances of securing private capital and achieving long-term growth.

1. **Project Scoping & Defining the Investment Case**

- Clearly outline the business model, market opportunity, and expected impact to attract investors.
- Establish how the business aligns with investor priorities, whether for financial returns, sustainability, or social impact.

2. **Stakeholder Engagement & Partnerships**
- Engage investors, regulators, and key partners early to build credibility and secure commitments.
- Form strategic partnerships that enhance business scalability and reduce investment risks.

3. **Market & Revenue Model Development**
- Validate market demand through customer research and competitive analysis.
- Develop a clear revenue model demonstrating sustainable long-term profitability.

4. **Risk Assessment & Mitigation Strategies**
- Identify key financial, operational, and market risks that could impact investor confidence.
- Develop contingency plans and risk mitigation strategies to address uncertainties.

5. **Legal Structure & Governance Readiness**
- Ensure proper legal structures, ownership agreements, and regulatory compliance are in place.
- Implement strong governance practices to align with investor expectations.

6. **Financial Structuring & Capital Planning**
- Define funding needs, capital allocation, and expected investor returns.
- Develop a comprehensive financial model, including revenue projections and break-even analysis.

7. **Measuring & Reporting Impact (For ESG & Impact Investors)**
- Establish key performance indicators (KPIs) to track sustainability and social impact.
- Align reporting frameworks with Environmental, Social, and Governance (ESG) standards.

8. **Securing Investors & Finalizing Agreements**
- Present a compelling investment pitch, backed by financial projections and market validation.
- Negotiate and finalize investment terms, equity structure, and exit strategies.

Use the playbook provided on the B2GreenHub!
The playbook provides free and paid resources to help businesses structure their investment readiness journey:

Free Tools & Resources:
- Sustainable Business Model Canvas – helps integrate sustainability into business strategy.
- Basic Market Research Tool – guides businesses in assessing industry trends and market demand.
- Target Group Segmentation Tool – helps identify the ideal customer base for strategic positioning.

Paid Tools & Advanced Templates:

- Virtual Business Card
- Market & Customer Analysis
- Financials
- Risk Mitigation & Legal Considerations
- Valuation & Pricing
- Key Elements of a Successful Pitch
- Quiz:
- Which is NOT part of the Green Finance 8-step framework?
- Stakeholder Engagement
- Financial Structuring
- **Product Manufacturing**
- Impact Reporting
- A business can be considered investment-ready without clear revenue streams. (True/**False**)
- What is the purpose of governance readiness?
- Minimizing taxes
- **Ensuring ethical leadership and compliance**
- Attracting customers
- Designing product packaging
- What is one way businesses can align with investor expectations in private equity deals?
- Ignoring sustainability and ESG (Environmental, Social, and Governance) considerations.
- Implementing cost-cutting measures that compromise long-term viability.
- **Adopting governance structures and compliance policies that meet investor standards.**
- Prioritizing executive bonuses over business reinvestment.

Unit 3: Strategies for Engaging Private Capital

Securing private capital is essential for businesses looking to bridge funding gaps and scale operations. Investors seek opportunities that offer financial returns, market stability, and, in some cases, social or environmental impact. This unit explores key strategies businesses can use to secure private investment, manage risks, and enhance their investment attractiveness through various financial mechanisms, risk mitigation approaches, and policy alignment.

Strategies for Bridging Funding Gaps ((https://pilot.com/glossary/funding-gap#:~:text=Causes%20of%20Funding%20Gaps&text=Mistimed%20cash%20inflows%20and%20outflows,leading%20to%20a%20funding%20gap.)

When faced with a funding gap, businesses can employ various strategies to secure the necessary capital. One of the most common approaches is to seek investment from venture capital firms or angel investors, who may provide funding in exchange for equity in the company. Alternatively, businesses can issue equity sales, secure debt financing through bank loans, or explore hybrid financing models that combine different capital sources.

Effective methods to close funding gaps include …

- accurately estimating future operating expenses to prevent cash flow shortages,

- increasing revenues and optimizing cost structures to reduce reliance on external funding,
- utilizing strategic cash flow management by aligning accounts receivable and payable to avoid liquidity shortfalls,
- exploring working capital financing and inventory optimization to ensure financial stability.

Crafting a Compelling Pitch

A well-structured investment pitch is critical to capturing investor interest and building confidence in a business's potential. The first step is to clearly define the problem the business aims to solve and how its product or service presents a unique solution. nvestors want to see not only an innovative idea but also a demonstrable market opportunity with a sizable, addressable customer base. Providing data on market trends, growth potential, and competitive positioning strengthens the investment case.

Beyond proving demand, businesses must showcase traction and progress, such as successful product launches, initial sales, strategic partnerships, or notable endorsements. Investors also evaluate the business model to understand how the company plans to generate revenue and scale over time. Financial projections play a key role in investment decisions, as investors expect detailed revenue forecasts, cost structures, and return-on-investment expectations. In addition, the strength of the leadership team can be a determining factor in securing funding; investors look for experienced and adaptable professionals who can successfully execute the business plan. Lastly, businesses should outline a clear exit strategy, whether through an acquisition, initial public offering (IPO), or other liquidity events, as investors seek a path to realizing their returns.

- Embedded Video: https://www.youtube.com/watch?v=O-HzZTe79GU

This video explores how certain private equity firms acquire companies using leveraged buyouts (LBOs), where they take on significant debt secured against the acquired company. While private equity investments can drive growth and operational efficiency, some firms engage in high-risk financial strategies that prioritize short-term profit over long-term business stability. The video highlights how excessive debt burdens, aggressive cost-cutting and asset-stripping practices can push companies into financial distress and bankruptcy, ultimately harming employees, customers, and other stakeholders. It also discusses regulatory gaps and potential reforms to prevent exploitative private equity practices while still allowing responsible investment to support business growth.

Quiz:

What is a key factor in securing private equity investment?

a) **Demonstrating a strong business model with clear revenue streams.**
b) Avoiding transparency with investors to maintain negotiation leverage.
c) Prioritizing short-term cost-cutting over long-term scalability.
d) Relying solely on government funding instead of private capital.
e) How can a company mitigate investor concerns about financial risk?
f) By taking on excessive debt to finance expansion.

By presenting detailed financial projections and risk mitigation strategies.

a) By avoiding discussions about potential financial challenges.
b) By offering unrealistic return expectations to investors.
c) What is a risk associated with engaging with certain private equity firms?
d) Enhanced access to global markets.

Excessive debt burdens that can lead to financial instability.

a) Increased long-term investment in innovation.
b) Greater autonomy in financial decision-making.
c) Why is it important for businesses to explore alternative funding sources in addition to private equity?
d) To avoid private equity firms altogether.
e) **To diversify capital sources and reduce reliance on a single funding mechanism.**
f) To increase financial uncertainty for stakeholders.
g) To speed up the acquisition process without investor oversight.
h) Private equity always guarantees long-term business stability. (True/**False**)

Unit 4: Structuring and Sustaining Investment Relationships

Investor due diligence is a vital step in the investment process where investors thoroughly evaluate a company's financial, legal, and operational standing before committing capital. This investigation ensures the accuracy of information, identifies potential risks, and helps investors make informed decisions that align with their strategic goals. Preparing effectively for due diligence – by organizing financial documents, legal contracts, and market data – can significantly improve a company's credibility and investment readiness.

Investor Due Diligence Preparation

Due diligence is the steps an organization takes to investigate and verify an entity before initiating a business arrangement, whether that's with a vendor, a third party or a client. In the investment decision process due diligence is an important stage. Investors undertake this comprehensive process before committing to a financial transaction. It involves a thorough examination of all relevant aspects of the investment, aiming to confirm the accuracy of the information provided, assess potential risks, and gain a comprehensive understanding of the investment's viability and potential returns. This process is crucial in minimizing unforeseen issues and ensuring that the investment aligns with the investor's goals and expectations. The goal of due diligence is to make informed decisions that lead to successful and profitable investments (Chen, 2024).

Preparing for investor due diligence involves organizing and reviewing all relevant documentation and information related to the investment opportunity. This may include financial statements, legal contracts, market research, and other pertinent data. It is essential to be transparent and ready to address any potential questions or concerns raised during the due diligence process (Chen, 2024).

The B2GreenHub Private Equity Investment Readiness Tool provides a due diligence questionnaire which is an organized way to analyze a company that you are acquiring through sale, merger, or another method. By following this checklist, you can learn about a company's assets, liabilities, contracts, benefits, and potential problems. A well-organized data room is critical for conducting a thorough due diligence process during mergers, acquisitions, or investment rounds.

Post-Investment Relationship Management

Embedded Video: How to manage investor relations

This short explainer video introduces the concept of due diligence within the context of mergers and acquisitions. It outlines how investors assess a target company by verifying legal, financial, and operational details before finalizing a deal – helping them make informed, low-risk investment decisions.

Post-investment relationships between founders and investors are crucial for long-term value creation. Investors often provide not just capital but also unique, hard-to-replicate resources such as experience, strategic input, and access to networks. This contribution spans three types of intellectual capital: social (networks and reputation), human (skills and knowledge), and organizational (business models and operational frameworks). Investors may act strategically or operationally – as mentors, advisors, or even temporary managers. Their involvement strengthens the company's capabilities and competitive edge (Fili & Grünberg, 2016).

Monitoring is also a key post-investment activity. It includes formal elements like reporting systems and informal interactions such as meetings and calls. This oversight helps investors assess progress, reduce relational and market risk and support more effective decision-making. Together value-adding contributions and systematic monitoring increase a venture's chances of success (Berggren & Fili, 2008).

Quiz:

The main goal of investor due diligence is to verify legal compliance for marketing purposes only. (True/**False**)

What is the primary purpose of due diligence in the investment process?

a) To prepare a sales pitch
b) To minimize tax obligations
c) **To assess investment risks and validate information**
d) To finalize employment contracts

Which of the following is commonly included in investor due diligence documentation?

a) Social media reports
b) Team-building event plans
c) **Financial statements and legal contracts**
d) Internal memos and office policies

Why is transparency important during the due diligence process?

a) It saves time by skipping documentation reviews
b) **It increases trust and helps address investor concerns**
c) It allows the business to inflate its valuation
d) It avoids external legal reviews