Europe-China Eco-Cities Link
中欧低碳生态城市合作项目

Belt and Road Initiative & Industry 4.0

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EC-LINK
中欧生态城
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Preface

Announced in 2013, the Belt and Road Initiative aims to strengthen China's connectivity with the world. It combines new and old projects, covers an expansive geographic scope, and includes efforts to strengthen hard infrastructure, soft infrastructure, and cultural ties. In February 2020, the Plan touched 138 countries with a combined Gross Domestic Product of almost $30 trillion and around 4.5 billion people.

Supporting a diverse array of initiatives that enhance connectivity throughout Eurasia and beyond could serve to strengthen China's economic and security interests while bolstering overseas development. At the first Belt and Road Forum in Beijing in May 2017, President Xi Jinping noted that, "In pursuing the Belt and Road Initiative, we should focus on the fundamental issue of development, release the growth potential of various countries and achieve economic integration and interconnected development and deliver benefits to all."[*]

The essence of a green and sustainable Belt and Road is to integrate green development, ecological and environmental protection into every aspect of the development of the Belt and Road with the principle of energy conservation and environmental protection under the guidance of green development concepts and of sustainable development goals settled by United Nations.

The commitment to monitor and implement BRI initiatives, both by China and by partner countries, is a key prerequisite to reducing the environment impacts of BRI projects. Setting targets that aim to achieve an ambitious proportion of projects that combat climate change would help orient BRI funding toward greater sustainability.

At first sight, China's and the EU's different approaches seem to lead to competition. Yet, China's BRI and the EU's new connectivity strategy also entail complementary aspects that might encourage greater cooperation. Within the current rising trend of protectionism and the raising of individualism, China and the EU provides a link between the world's second and third largest economies, as well as with the wider area of East Asia, indeed the most dynamic region in the world. China and the EU can also use the BRI as a platform to contribute to solving present regional issues and security challenges, thus filling the gap of leadership and offering solutions in global governance.

Toward this end, the EU has developed its own strategy for connectivity in Asia to promote the sustainable urbanization, construction of transport, digital, and energy infrastructure between Europe and Asia. The strategy aims to provide a framework of European standards for connectivity projects and seeks to provide high-quality alternatives. The EU is seeking to provide credible alternatives; given the growing pushback against the BRI in some recipient countries, the EU certainly has an opportunity to present itself as a more attractive partner by offering connectivity projects based on sustainable financing, avoiding debt traps, and taking into account environmental impact.

EC-Link Project has been developing a series of research papers meant to trigger Chinese and EU experts' cooperation to drive the planning of resilient cities and more sustainable projects among BRI:

- Belt and Road Initiative & Sustainable Urbanization
- Belt and Road & Initiative Sustainable Transport
- Belt and Road Initiative & Industry 4.0
- Belt and Road Initiative & Green Finance

Such topics, where chosen by EC-Link Team because seen as mostly relevant and pertinent in view of the future development of the Belt and Road Initiative; taking into account several levels on analysis: national, regional and international, we try to offer recommendations for the improvement of on-going dynamics in view of a better and more sustainable relations in Eurasia market. With each research paper, EC-Link Project wants to contribute not only in providing additional useful information for a better understanding of BRI but also to support an open dialogue on such relevant subject providing a fruitful baseline for further discussion.

* English Translation of http://cpc.people.com.cn/n1/2019/0320/c64094-30984416.html

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Terms and Abbreviations

ABB	Swiss-Swedish Multinational Corporation
AI	Artificial Intelligence
BEMNS	Building energy management systems
CDR	Carbon-dioxide removal
CEN	European Committee for Standardization
CPS	Cyber-physical system
DIN	Deutsches Institut für Normung
GHG	Greenhouse gases
KEP	Knowledge Exchange Platform
IIRA	Industrial Internet Reference Architecture
IoT	Internet of Things
IR	Industrial Revolution
IRT	Institute de Recherche Technologique
MDGs	Millennium Development Goals
MIIT	Ministry of Industry and Information Technology
PV	Solar photovoltaics
SAVs	Shared autonomous vehicles
SDGs	Sustainable Development Goals
SMEs	Small and Medium Enterprises
SRM	Solar radiation management
TEDA	China's Tianjin Economic-Technological Development Area
VDMA	German Engineering Federation
WFP	World Food Programme

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Glossery of Key Terms

Artificial Intelligence	Intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans
Big Data	Very large sets of data that are produced by people using the internet, and that can only be stored, understood, and used with the help of special tools and methods
Blockchain	System used to make a digital record of all the occasions a cryptocurrency is bought or sold, and that is constantly growing as more blocks are added
Cloud computing	Possibility of storing and making available data and computing power in distributed systems.
Cyber Physical Systems	Combination of computer, software and mechanical and electronic components that communicate via a data infrastructure such as the Internet.
Climate Change adaption	Process of adjustment to actual or expected climate and its effects.
Climate Change mitigation	Efforts to reduce emissions and enhance sinks
Climate resilience	Ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate
Data glasses	Glasses relaying environmentally-based data directly into the user's field of vision in real-time
Internet of Services	Everything that is needed to use software applications is available as a service on the Internet, including the software itself, the tools to develop the software, and the platform to run the software.
Internet of Things (IoT)	Collective term for technologies of a global infrastructure of information societies that makes it possible to network physical and virtual objects
Industry 4.0	Intelligent networking of machines and processes in industry with the aid of information and communication technology.
Resilient City	City with capacity to withstand or absorb the impact of a hazard through resistance or adaptation
Smart Cities	Municipality that uses information and communication technologies to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare.
Smart factory	Manufacturing that employs computer-integrated manufacturing, high levels of adaptability and rapid design changes, digital information technology, and more flexible technical workforce training
Standardization	Process of making things of the same type all have the same basic feature
Sustainable Development Goals	Collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all"
4th Industrial revolution	Technologies that combine hardware, software, and biology (cyber-physical systems) and emphasizes advances in communication and connectivity.

1 Executive Summary

The 4th Industrial Revolution (IR) is accelerating. Innovations are being introduced faster and more frequent; becoming more efficient and accessible at local level. Industry 4.0 technologies and systems are gaining in popularity and application. They have the potential to address many of today's key urban issues and will be of particular relevance to the Belt and Road Initiative.

Furthermore, technology is becoming increasingly networked; especially, we are witnessing a fusion of the digital, physical and biological domains. New technologies enable overall social developments by influencing the economy, values, perceptions and opportunities of future generations. This represents a unique opportunity to capitalize this 4IR and the social changes that are taking place and to contribute to tackling the problems of climate change. Industry 4.0 technologies, especially Artificial Intelligence (AI)-enhanced urban transportation, smart grids, renewable energy, waste and water management, and urban farming, will not only reduce CO_2 emissions, but may also improve energy, water and food security, and effectively address other environmental issues.

Nevertheless, the 4IR could also exacerbate existing threats to the global climate and create new problems that need to be considered and addressed. Cities can reinvent themselves through maximizing opportunities from Industry 4.0. For cities to be sustainable, social dimensions such as inclusiveness, cultural adequacy, fairness and gender equality are crucial, in addition to economic, ecological and environmental dimensions. Smart cities, where Industry 4.0 technologies are tested and applied, should aim for integrated solutions that use resources efficiently and effectively, and follow low-carbon and inclusive development pathways. Contributing to mitigation of and adaptation to impacts of climate change in cities can thus be addressed as Industry 4.0 considerations are integrated into Belt and Road Initiative planning.

Relevant areas and potential topics for further cooperation related to BRI, Industry 4.0 and climate change in cities are described in the paper: resource efficiency in production and purchase, urban renewable energy, circular economy, value-added networks, decentralized energy systems, leapfrogging technological development, smart services, new business models and service orientation, decoupling of resource consumption from economic growth, governance for a green industry and cities green industry as well as climate resilient industry and human settlements.

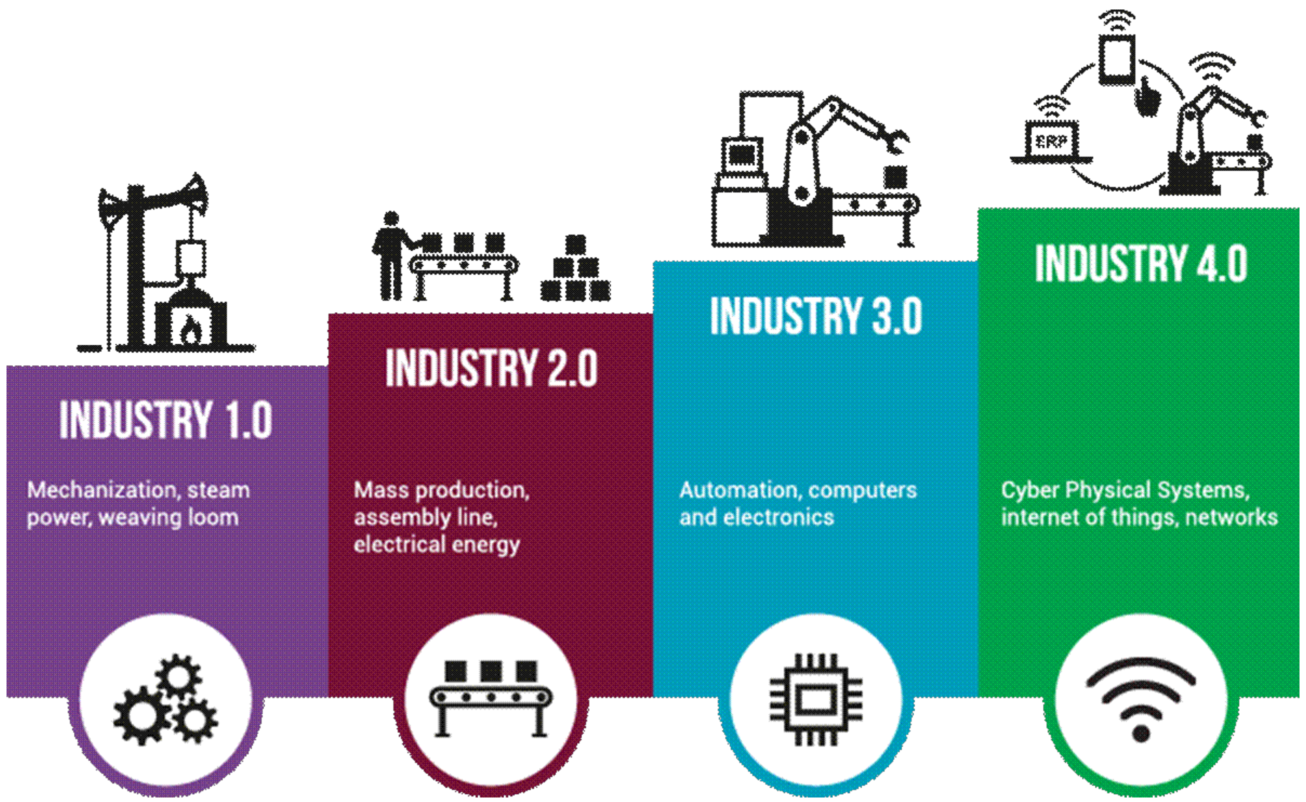
As applied to new developments as part of BRI, there will need to be close governance of I4.0 implementation in order to ensure that expected benefits are realized. Standardization will play an important role in further Industry 4.0 development and the paper explores potential scenarios for how this might influence outcomes.

Based on existing activities and Chinese and European experiences in cities, further cooperation could be linked to the European Smart Cities Initiative, the measurement of Industry 4.0 readiness as well as to Knowledge Exchange Platform activities with the European Committee of the Regions. This activity would also link well to the sustainable financing of investment activities undertaken through the EU-Asia Connectivity Platform.

2 Introduction and Context

Industrialization has led to many of the world's current environmental problems like climate change. The 4th Industrial Revolution (IR) is accelerating. Innovations are being introduced faster and more frequent, becoming more efficient and accessible at local level. Furthermore, technology is becoming increasingly networked; in particular, we are witnessing a fusion of the digital, physical and biological domains. New technologies enable overall social developments by influencing the economy, values, perceptions and opportunities of future generations. This represents a unique opportunity to capitalize the 4IR and the social changes that are taking place and to contribute to tackling the problems of climate change. Nevertheless, the 4IR could also exacerbate existing threats to the global climate and create new problems that need to be considered and addressed (Rashid 2018, WEF 2017).

Cities can reinvent themselves through maximising opportunities from Industry 4.0. But Industry 4.0 is not the only solution. Significant challenges lie ahead, particularly for developing countries. The international community will have to act to reap the benefits of smart city initiatives globally. Industry 4.0 technologies are gaining in popularity and application and have the potential to address many of today's key urban issues and will be of particular relevance to the Belt and Road Initiative.

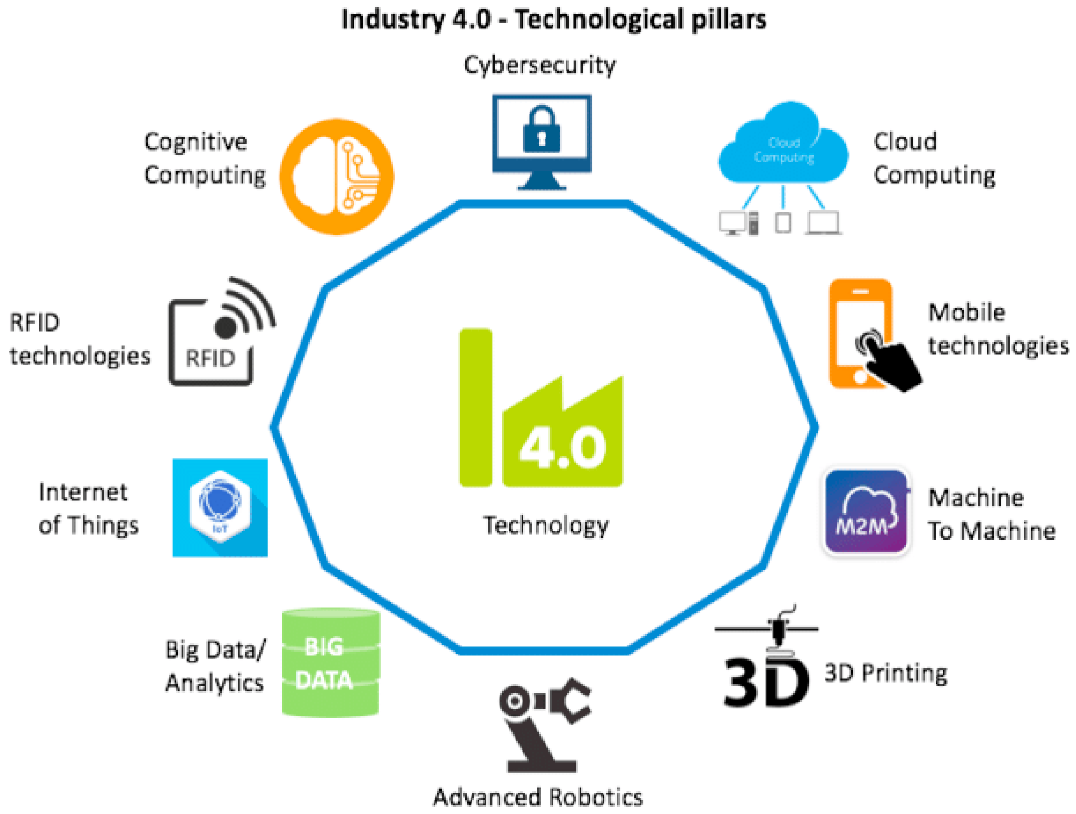


Source: http://www.accountancyresourcinggroup.co.uk/news-and-insights/industry-40-impact-of-digitization-on-finance-and-accountancy/

Increasing urbanization is placing strain on the world's resources and is causing environmental degradation. To play their part in solving these problems, cities will need to become not only smarter and more sustainable, but ultimately more resilient. The adverse impacts of climate change are occurring more frequently and can cause significant damage in cities. The objective of smart cities is not only to reduce pollution, greenhouse gases and other substances, but ultimately to deal with the potential effects of climate change. Contributing to mitigation of and adaptation to impacts of climate change in cities can thus be addressed as Industry 4.0 considerations are integrated into Belt and Road Initiative planning.

2.1 Industry 4.0 Key Technologies

Industry 4.0 refers to the intelligent networking of machines and processes in industry with the aid of information and communication technology. Industry 4.0 is the comprehensive digitisation of industrial production in order to equip it better for the future. The term was first used in 2011 at the Hannover Messe. The idea has since grown into many areas outside of manufacturing. It has become a bigger vision to digitise across industries and has been extrapolated to smart transportation and logistics, smart buildings, etc. as well as smart cities.

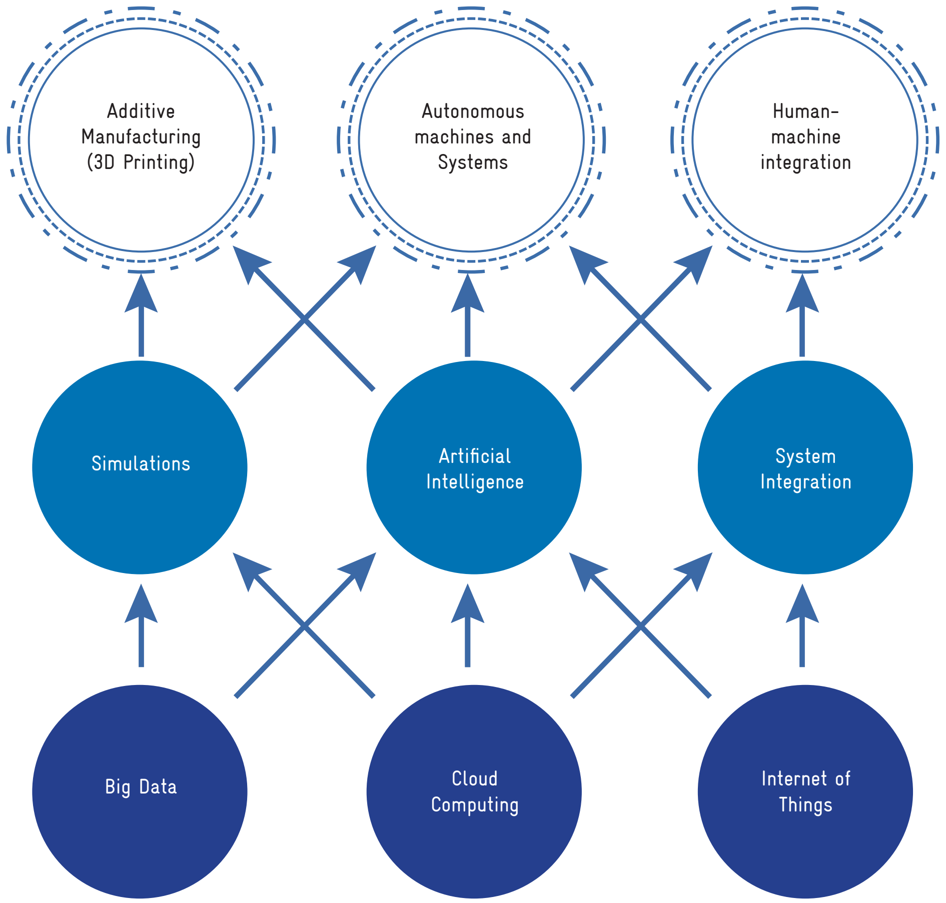


Source: https://www.researchgate.net/figure/Technologies-for-industry-40_fig1_319944621

"New Industry 4.0 technologies, spanning mobile computing to cloud computing, have undergone vast development in the last decade and are now ready to be used as commercially available, interconnected systems within manufacturing – this is Industry 4.0. It holds the key to accessing real-time results and data that will catapult the industry into new levels of lean achievements. Each piece is similar in nature but, when integrated together, create capability that has never before been possible." (Clearpath Team 2018)

Industry 4.0 describes "the connection of the digital world of the Internet with the conventional processes and services of the producing economy. It is a horizontal and vertical networking along the value chain with a shift of control from top to bottom" (BMWi 2019). In addition, it emphasizes the idea of the coherence, digitization and linkage of all productive units in an economy, creating real-world virtualization in a large information system.

Figure 1 presents the interactions between the fundamental enablers of the digital revolution (big data, cloud computing and the Internet of Things) and the main new technologies as applied in industrial processes (additive manufacturing, autonomous machines and systems, and human–machine integration) through which the main productivity-raising effects are generated (Lütkenhorst 2018).



Source: OECD (2017a, p. 78) in Lütkenhorst 2018 p.7

With this in mind, different components and their interaction are relevant:

- **Big Data**

  Big data primarily refers to the processing of large, complex and rapidly changing amounts of data. In connection with industry, however, the term has other meanings as in the mass media as f.e.:

  - Industry's desire to gain a competitive advantage from existing data
  - Automation of production processes
  - Intransparent automation of decision processes in software
  - Use of new technologies instead of standard software (especially in companies with conservative IT often by using Software as a Service to circumvent internal IT restrictions)
  - Development of own software solutions ("in-house IT") instead of the use of "off-the-shelf" software by external companies

- **Smart Factory**

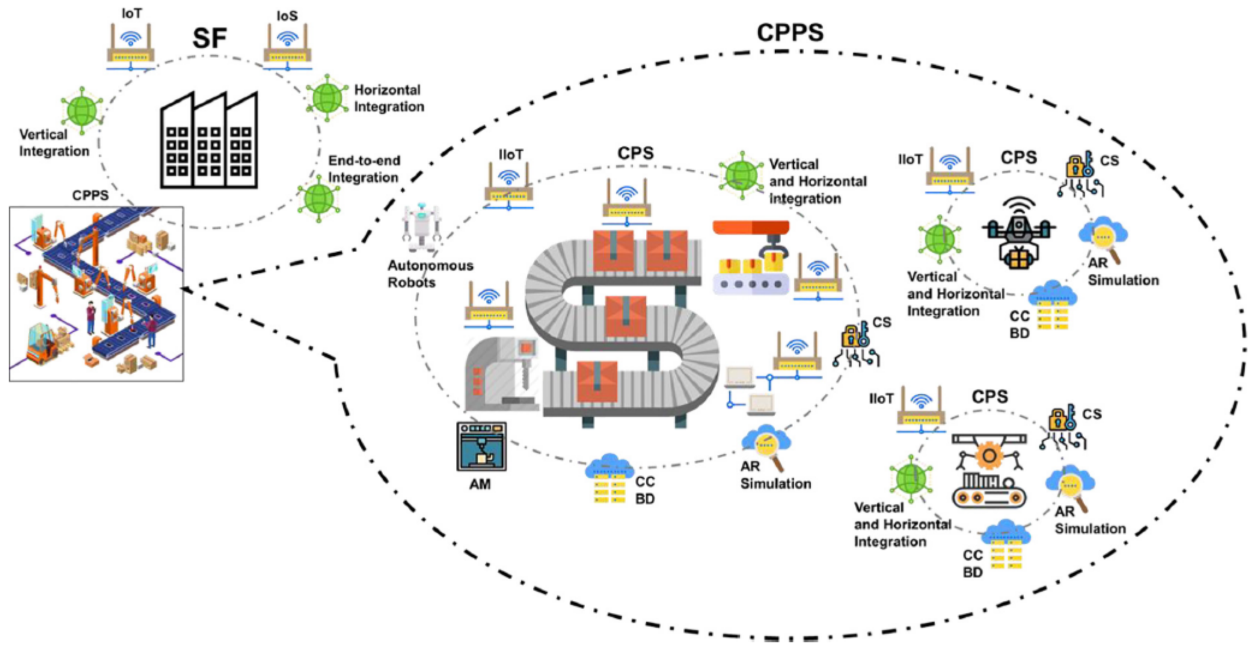
  Smart Factory is a term from research in the field of manufacturing technology. It is part of the German government's high-tech strategy as part of the industry 4.0 project for the future. It describes the vision of a production environment in which production facilities and logistics systems largely organize themselves without human intervention.

- **Cyber Physical Systems**

  A cyber-physical system (CPS) refers to the combination of computer, software and mechanical and electronic components that communicate via a data infrastructure such as the Internet.

- **Internet of Things (IoT)**

  Internet of Things, is a collective term for technologies of a global infrastructure of information societies that makes it possible to network physical and virtual objects with each other and to let them cooperate through information and communication technologies.



Source: V. Alcácer, V. Cruz-Machado / Engineering Science and Technology, an International Journal 22 (2019) 899–919 in https://www.researchgate.net/publication/330780748_Scanning_the_Industry_40_A_Literature_Review_on_Technologies_for_Manufacturing_Systems

- **Cloud computing**

  The possibility of storing and making available data and computing power in distributed systems.

- **Service Oriented Architecture, Internet of Services**

  The possibility of calling distributed functionality via services.

- **Virtual reality, social networks, smart phones, data glasses**

  The possibility to communicate with people via digital communication structures and means.

- **Artificial intelligence**

  The possibility of integrating artificial intelligence into existing production processes.

Further 4IR technology included relevant for climate change mitigation and climate resilience are (see also Rashid 2018):

- **3D Printing**

  To study the effects of climate change, still images and video can be pieced together to form 3D representations and maps that are used to predict events such as sea level rises in coastal areas.

  The ability to print replacement parts may become a critical and inexpensive tool of climate adaptation, particularly in zones of instability and conflict. Additive manufacturing offers the possibility of creating high-performance materials and processes with smaller carbon footprints by addressing the carbon impact of the three major facets of a product's carbon footprint: materials, manufacturing, and transportation[1]."

- **Robotics**

  According to Butler (2019) combating climate change robots can provide the following tangible benefits by monitoring and preventing the release of harmful greenhouse gases, optimising manufacturing processes, minimizing the need for larger less-efficient machines and eliminating product waste.

- **Drones**

  If carefully deployed, drone-based delivery could reduce greenhouse gas emissions and energy use in the freight sector. Drones Consume less energy per package-km than delivery trucks, the additional warehouse energy required and the longer distances traveled by drones per package greatly increase the life-cycle impacts (Stolaroff et al. 2018).

- **Autonomous Vehicles**

  Shared autonomous vehicles (SAVs) could on one side reduce greenhouse gas emissions by driving more efficiently, avoiding traffic congestion, accelerating adoption of alternative fuel vehicles, and charging in alignment with renewable electricity generation. On the other hand, SAVs could induce more vehicle miles traveled (VMT) by lowering the time cost of travel and allowing non-drivers to travel more by car" (Jones, Erick C. and Leibowicz, Benjamin D. (2019)

- **Advanced Materials**

  The production of sustainable and lightweight materials that can replace oil-based products has increased. At the same time, bioplastic production capacities are also increasing. The combination of bioplastics and nanotechnology is an approach that meets the technical demands of replacing oil-based materials with sustainable and renewable ones. Composites have a wide range of applications and add a lot of value towards a sustainable environment. From building materials to aviation materials, effective solutions have been proposed with specific composites.

1 https://medium.com/polyspectra-wavefront/why-3d-printing-is-a-critical-part-of-the-battle-against-climate-change-726e493a3f58

Case Study: Regional Materials, Bregenzerwald region, Austria

All municipalities of the Bregenzerwald region and all policyholders are members and shareholders of the Wälder Versicherung insurance company. Therefore, for the construction of the wooden four-story office building, the regional value-added played a major role. Only regional companies were engaged. For the modern passive house building about 600 cubic metres of wood were processed, about half of it from the direct surroundings. For the facades and the interior construction untreated silver fir timber with rough sawn surfaces was used.

The project is a model example for the engagement of the owner for regional process chains. By renouncing highly processed timber products, CO_2 emissions were directly reduced and the potentials for the use of regional products were increased.

https://www.alpine-space.eu/projects/casco/en/about-casco/alpine-space-regional-timber-award/award-winners/-administration-building-of-the-insurance-company-walder-versicherung-

- **Blockchain**

  According to Füssler et al 2018 "Blockchain technology provides a key to solving some of the critical issues that hinder effective scaling of climate action e.g. Next-generation registries and tracking systems, Digitising Measuring, Reporting and Verification, Decentralised access to clean energy and finance. … Challenges like high power consumption, limited storage space, time lag and network security remain to be solved. Governance for transaction on blockchain based systems must be smartly designed and embedded in national and international regulatory systems".

- **Geo-engineering**

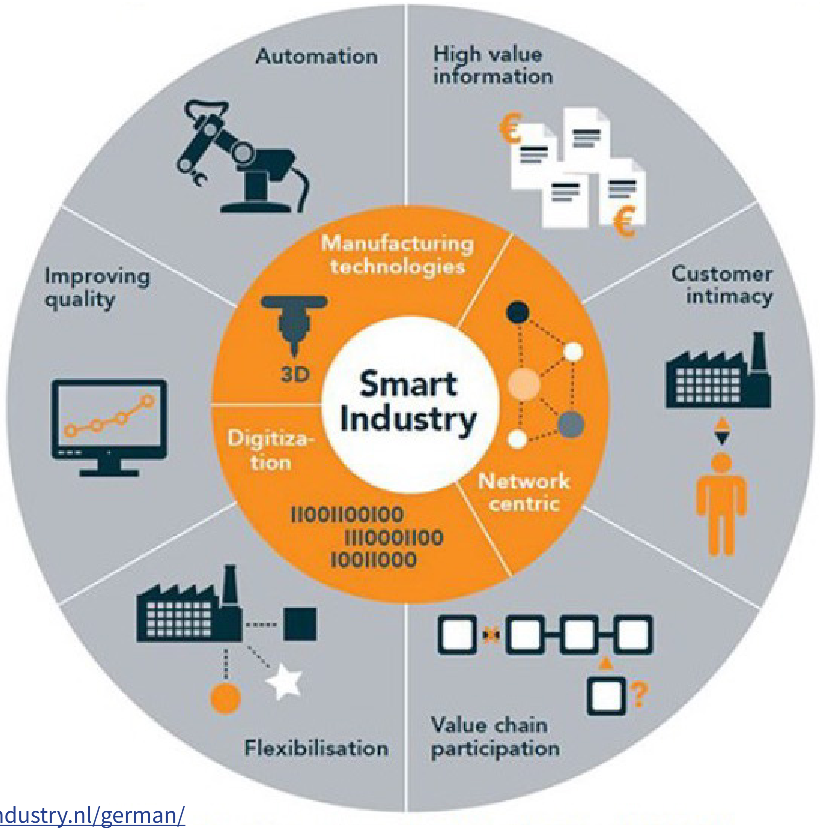
  According to Aouf (2018) there are currently two main approaches under the geoengineering umbrella: carbon-dioxide removal (CDR) and solar radiation management (SRM). CDR tackles the root cause of global warming by removing greenhouse gases from the atmosphere like for example carbon capture and storage. SRM, leaves greenhouse gases untouched, but offsets their impact by reflecting sunlight away from the earth. Geo-engineering is still largely based on theoretical models and has been criticised for being untested and risky.

- **Biotechnologies**

  Biobased chemicals can replace their fossil-based counterparts with significant GHG emissions reductions (OECD, 2011). However it is important to bear in mind that the methods used for the production of raw materials and the crops themselves can generate even more greenhouse gases than fossil fuels. They can cause negative consequences in relation to the production and processing of raw materials and have effects on land (use change), water and biodiversity.

2.1.1 Industry 4.0 Framework and Principles

These concepts and technologies have been brought together in a framework for Industry 4.0 as proposed by Lom et al in 2016.



Source: https://smartindustry.nl/german/

Lom also proposed Six Principles of Industry 4.0:

1) Interoperability: the ability of CPS, humans and Industry 4.0 factories to connect and communicate with each other via Internet of Things and Internet of Services.

2) Virtualization: virtualization means that CPSs are able to monitor physical processes. A virtual copy of the Industry 4.0 factory which is created by linking sensor data (monitoring physical processes) with virtual plant models and simulation models.

3) Decentralization: the rising demand for individual products makes it increasingly difficult to control systems centrally. Decentralization means the ability of CPSs within Industry 4.0 factories to make decisions on their own

4) Real-Time Capability: the capability to collect and analyse data and provide the derived insights immediately. Thus, the plant can react to the failure of a machine and reroute products to another machine.

5) Service Orientation: the services of companies, CPS, and humans are available over the IoS and can be utilized by other participants. They can be offered both internally and across company borders.

6) Modularity: flexible adaptation of Industry 4.0 factories to changing requirements by replacing or expanding individual modules as well as changing requirements by replacing or expanding individual modules. Modular systems can be easily adjusted in case of seasonal fluctuations or changed product characteristics.

The application of these principles in real-world case examples from Europe are discussed at various points below. The examples are designed to be useful in planning BRI type initiatives and in setting frameworks for these.

2.2. Industry 4.0 in China

In 2014, China's State Council unveiled their ten-year national plan, Made-in-China 2025, which was designed to transform China into a world manufacturing power. Made-in-China 2025 is an initiative to comprehensively upgrade China's industry including the manufacturing sector. China is making great developments in its industry, with the addition of automation and robotics in factories, but there is still room for further activity. The Made in China 2025 initiative was designed to bring the Chinese economy to the cutting edge and put in place a high-tech, sustainable manufacturing base.

In the process of developing their manufacturing into a high-tech, automated industry, China is also investing in the creation of sustainable manufacturing. By relying on and using AI, and the digital economy, China is transitioning their manufacturing base to a modern, developed economy. This also reduces the use of heavy industry and relies more on mass customization consumption and makes use of Industry 4.0 practices, thus making this method of manufacturing more sustainable.

In 2017, President Xi Jinping announced that cutting-edge technologies and business practices from the Industry 4.0 would be brought to the BRI. He said, "We should pursue innovation-driven development and intensify cooperation in frontier areas such as digital economy, artificial intelligence, nanotechnology and quantum computing, and advance the development of big data, cloud computing and smart cities so as to turn them into a digital silk road of the 21st century." The "Digital Silk Road" could bring new green technologies and sustainable manufacturing practices to emerging markets. This would help lay the ground work for the development of a more sustainable, and environmentally-conscious global market in the future.

Green manufacturing is a key development and a central trend in China's transitioning manufacturing sector. Moving forward with the Made in China 2025 initiative and the BRI, along with the global environmental and economic forces, manufacturing in China will make a significant shift to become a potential leader in green manufacturing and sustainable industry.

The 4th Industrial Revolution, Made in China 2025, and sustainable manufacturing all pair well together. The digital aspects of the 4th Industrial Revolution and the automation of manufacturing in Made in China 2025 can reduce the waste, energy consumption, and environmental cost of production. Xin Guobin, vice-minister of the Ministry of Industry and Information Technology said that "Green Manufacturing Association of China will also explore a new development mode by connecting green manufacturing and the internet and establish a green manufacturing system and ecosystem for the country's green and sustainable development." By using the Internet of Things and modern software to connect the manufacturing process at all stages waste can be cut down and the production process will be more sustainable in the long term[2].

Example: Industry 4.0 China-The Tianjin Economic-Technological Development Area

China's Tianjin Economic-Technological Development Area (TEDA) is a prime example of the country's Made in China 2025 strategy. TEDA-based companies that specialize in intelligent manufacturing, include industrial robot maker Baolai Industrial Robotic and Yiersu Easy-Robot, which provides automation integration services for industrial systems.

https://www.engineering.com/AdvancedManufacturing/ArticleID/15555/What-Does-Industry-40-Look-Like-in-China.aspx

2 https://et2c.com/sustainability-in-manufacturing/

3 Industry 4.0 and Climate Change Mitigation and Adaptation

3.1 Industry and climate change

3.1.1 Global Greenhouse Gas emissions from industry

According to the UN Intergovernmental Panel on Climate Change (Fischedick et al. 2014) "Industry-related greenhouse gas (GHG) emissions have continued to increase and are higher than GHG emissions from other end-use sectors. Globally, industrial GHG emissions are dominated by the Asia region, which was also the region with the fastest emission growth between 2005 and 2010 (high confidence). Emissions from industry (30 % of total global GHG emissions) arise mainly from material processing, i. e., the conversion of natural resources (ores, oil, biomass) or scrap into materials stocks which are then converted in manufacturing and construction into products. Production of just iron and steel and non-metallic minerals (predominately cement) results in 44% of all carbon dioxide emissions (direct, indirect, and process-related) from industry. Other emission-intensive sectors are chemicals (including plastics) and fertilizers, pulp and paper, non-ferrous metals (in particular aluminium), food processing, and textiles."

Global industrial emissions of carbon dioxide are likely to have risen by 2.7% in 2018 to reach an all-time high, marking a second year of strong growth after a brief period of relatively stable emissions, an international consortium of scientists reports (Global Carbon Project at COP24).

3.1.2 Climate change implications for industry

"Climate change presents a wide range of risks to businesses and the communities on which they depend. Some risks result from direct physical changes to the environment. Others are indirect and result from our collective response to climate change and our efforts to transition to a low-GHG economy". (Chase and Wei 2018)

Industry and commerce depend on the supply of water, energy and a functioning transport infrastructure. This should be guaranteed under changing climatic conditions. Extreme weather events, rising temperatures or changes in precipitation conditions can have a variety of effects, such as:

- Loss or loss of production due to frequent natural catastrophes at the company's own site or at suppliers, even worldwide.
- temporary bottlenecks in the cooling water supply or restriction of the reintroduction of heated cooling water into the rivers
- Increased cooling requirements of workplaces
- increased requirements for the production, storage and transport of perishable foodstuffs

According to Mckinsey "There are, in broad terms, six different kinds of climate risks. These can be divided into two interconnected groups: value-chain risks (physical, prices, product) and external-stakeholder risks (ratings, reputation, regulation)" (Engel et al. 2015).

Value-chain risks:

- Physical risks are those related to damage inflicted on infrastructure and other assets, such as factories and supply-chain operations, by the increased frequency and intensity of extreme weather events, such as wildfires, floods, or hurricanes.
- Price risks refer to the increased price volatility of raw materials and other commodities. Drought can raise the price of water; climate-related regulation can drive up the cost of energy. High-tech and renewable-energy industries, for example, face price risks in the competition for rare earths, which are used in the production of computer hard drives, televisions, wind turbines, solar photovoltaic systems, and electric vehicles.
- Product risks refer to core products becoming unpopular or even unsellable. Effects could range from losing a little market share to going under entirely. Alternative cooling technologies, for example, could conceivably displace air-conditioning systems; ski resorts that no longer can count on snow or cold weather could go under. Regulatory and production costs could raise the price of coal in some markets above that of lower-carbon competition, with ripple effects for mining-equipment manufacturers and related industries.

3.2 Contribution of the concept of Industry to climate change mitigation & adaptation

Increasing urbanization is placing strain on the world's resources and is causing environmental degradation. To play their part in solving these problems, cities will need to become not only smarter and more sustainable, but ultimately more resilient. The adverse impacts of climate change are occurring more frequently and can cause significant damage in cities. The objective of smart cities is not only to reduce pollution, greenhouse gases and other substances, but ultimately to deal with the potential effects of climate change. Contributing to mitigation of and adaptation to impacts of climate change in cities can thus be addressed as Industry 4.0 considerations are integrated into Belt and Road Initiative planning.

"Accelerated urbanization is estimated to result in around 70 per cent of the global population living in urban areas by 2050, with 90 per cent of the urban population growth taking place in Africa and Asia. If rapid urbanization continues, it will put pressure on infrastructure and utilities, for creating decent jobs, for preserving the environment, and for addressing climate change. It will become a major challenge for city planners, policymakers, and the international community in general. Designing sustainable cities using intelligent technological solutions and approaches will be crucial in addressing global challenges and achieving the 2030 Agenda" (UNIDO 2017).

As noted previously, Industry 4.0 emphasizes the idea of the coherence, digitization and linkage of all productive units in an economy, creating real-world virtualization in a large information system. This interconnectivity and continuous massive amounts of data also come with an environmental price: In Denmark for example, the government expects that international data centres will take up 20% of the current national electricity consumption by 2030 (https://ens.dk/sites/ens.dk/files/Analyser/analysis_of_hyperscale_datacentres_in_denmark_-_english_summary_report.pdf). The global electricity consumption for mining cryptocurrency using Blockchain - technology already today exceeds the current national electricity consumption of Finland significantly, according to consumption estimates in a recent issue of The Economist (https://www.economist.com/technology-quarterly/2018/08/30/mining-cryptocurrencies-is-using-up-eye-watering-amounts-of-power_2018).

As part of a recent conference (UNIDO 2017 The belt and road initiative: Industry 4.0 in sustainable and smart cities) UNIDO concluded that:

- Industry 4.0, as part of smart city initiatives, will make cities and human settlements more inclusive, safe, resilient, and sustainable, and will help address global challenges.
- Industry 4.0 has the potential to revitalize cities and create new jobs; many kinds of high-tech clean manufacturing industries have emerged in recent years that allow small-scale production. Decentralized, modularized industrial production will be located in cities, helping to speed up industrial innovation.
- In developing countries with rapid urbanization and premature deindustrialization, there are opportunities to integrate modern industries and leapfrog technological development.

Finally, greater transparency, coordination, and reporting of investment flows would improve the ability to track and understand the direction of investments. It will be difficult to facilitate a shift to more sustainable infrastructure if data on investment flows are not available. Comprehensive, high-quality data can lead to more informed and effective policy and investment decisions.

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4 Challenges for Sustainable Resilient Belt and Road Initiative, Cities and Industrialisation

4.1 Industry 4.0 and Cities

Cities have long been responsible for creating and maintaining environments that are conducive to business prosperity. Climate change has added a new dimension to this responsibility, which, to be managed effectively, requires cooperation across the public and private sectors.

The promise of jobs and prosperity, among other factors, pulls people to cities. Half of the global population already lives in cities, and by 2050 two-thirds of the world's people are expected to live in urban areas. But in cities two of the most pressing problems facing the world today also come together: poverty and environmental degradation. Hence in general threats for cities in relation to the 'fourth industrial revolution' are:

- Intensive urban growth (can lead to greater poverty), with local governments unable to provide services for all people.
- Concentrated energy use leads to greater air pollution with significant impact on human health.
- Automobile exhaust produces elevated lead levels in urban air.
- Large volumes of uncollected waste create multiple health hazards.
- Urban development can magnify the risk of environmental hazards such as flash flooding.
- Pollution and physical barriers to root growth promote loss of urban tree cover.
- Animal populations are inhibited by toxic substances, vehicles, and the loss of habitat and food sources.

The fourth industrial revolution could also exacerbate existing threats to environmental security or create entirely new risks that will need to be considered and managed. According to Rashid (2018) (and including further information) the challenges for industry and global driving trends for Industry 4.0 are:

- Demographic Shifts: Population growth will be impacted the manufacturing field; significant demographic shifts such as the increasing number of population growth in developing countries, a growing middle class, consumer market shifts and an ageing population are influencing future industrial activities.
- Urbanisation: Urban infrastructure is required to support the growing demand; industry 4.0 facilitates more mixed urban development by bringing the factory back to town, even closer to housing areas. This promotes the realisation of the compact city and it is made possible because of two features of the Industry 4.0, diminishing lot sizes and environmentally friendly integrated urban production.
- Knowledge and Talent Gap: The decreasing talent pool possess a real challenge to employers
- Deindustrialisation: Major productivity gains in manufacturing had matured; involves a decrease in the relative size and importance of the industrial sector in an economy. Deindustrialisation will invariably involve developed economies moving towards services-based economies.
- Market Globalisation vs Protectionism: Different approaches divides the already uncertain global manufacturing industry: Technology will continue to be a big enabler of globalisation. Although most economies are more open to trade today, as countries seek to expand manufacturing employment, a surge in protectionism and the undoing of trade agreements will create an institutional environment less supportive to openness.
- Game-Changing Business Models: The changing pace in every industry causes continuous disruption; information technology, operational technology, and global megatrends are on a collision course that demands business owners adopt new ways of thinking and execution.
- Convergence of Technologies: Technology convergence is the key to realise industry 4.0; New technologies are also known as disruptive technologies that include the use of autonomous robots, Internet of Things (IoT), Big Data, augmented-reality-based systems, cyber security, cloud computing, additive manufacturing to horizontal and vertical system integration.
- Robots on the Rise: Smart technology complements; Advancements in information technology (IT), robotics, drones, self-driving cars, machine learning and artificial intelligence (AI) are increasingly allowing machines to take over tasks once performed only by humans and in the process causing economic disruption that will irreversibly change the workforce.
- Cybersecurity; Cybersecurity is an integral part to support the transformation; Central to the Industry 4.0 concept is the free ow of information exchange within the value chain, which includes collecting all data generated for a product throughout its lifecycle phases from conceptualisation, design, ordering, customisation, manufacturing, operation, repair and to even recycling.
- Global Sustainability; Ensuring common goals for the betterment of all; Lack of progress on product design and manufacturing processes which can help facilitate better use of materials.

Further:

- Privacy: IoT applications collect, analyze and relay data without the knowledge or agreement of the user, and thus require clear and enforceable privacy laws to prevent abuse and the infringement of personal rights.
- Infrastructure: stable infrastructure required (reconciling old with the new, such as power supply and broadband internet).
- Local IoT expertise: for adjustments, implementation and maintenance of IoT applications to the special needs of their developing counterparts

Example:

Munich and the Smart Cities Initiative

For Munich the emergence of industry 4.0 and smart city technology has been interpreted as a great opportunity to make the city more energy efficient and more connected. The concept of being a Smart City has found its way into the strategic city development plan, which the city council has put in place. The city hopes to be an example for cities in Europe and has started cooperations with external research institutions as well as economic players and other external stakeholders to develop a new guideline titled "Active and responsible digital transformation".

Cities with existing significant industrial capacities or those that want to attract such investments need to prepare for the changing needs of industry. Challenges in cities related to Industry 4.0 include:

1. More energy needed (the [industrial] computers interacting around the clock need a lot of energy)
2. The need for a secure and comprehensive mobile communications network.
3. Rising unemployment figures in population strata with no or only rudimentary education that are active in the industrial environment. There is no question that frictional unemployment during an adjustment period will occur.
4. An influx of well-trained skilled workers into regions with industrial production sites (this would mean that they would move away from other regions). It is also conceivable, however, that a spatial proximity to production sites will no longer be necessary in the future, so that machine maintenance is also possible from a distance.)

5. Negative impacts of digital technologies on income distribution, inter alia due to the varying impacts on different types and levels of skills. This can take the form of polarisation (hollowing out of the middle-skill, middle-wage segment) or be reflected in mounting downward pressure, in particular on low-wage, low-skill segments of the labour force, which are the most seriously affected by – and vulnerable to – the new digital technologies. (Lütkenhorst 2018)

6. (Location) Advantages for large companies. In general, SMEs lag behind larger enterprises in adopting new digital technologies (Lütkenhorst 2018)

Example: Advanced Manufacturing in Pays de la Loire, France

The French Ministry of economy, industry and digital technology launched in April 2015 the "Industry of the Future" an initiative, which consolidates the initial plans from the 34 sectors, selected in 2013 for the "New Industrial France". Pays de la Loire aims to become a leader in advanced manufacturing, and has developed several programmes. The competitiveness cluster EMC2 is addressing advanced production through quadruple helix cooperation. The Jules Verne Institute of Technology (Institut de Recherche Technologique – IRT) is dedicated to improving advanced manufacturing through the conception of flexible technological building blocks.

5 Industry 4.0 and the Potential for Climate Change Mitigation and Adaptation

5.1. Introduction

China committed to peak its carbon emissions around 2030, with best efforts to peak early, and also to achieve 20% non-fossil energy as a proportion of primary energy supply by 2030. These commitments were included in China's nationally-determined contribution to the 2015 Paris Agreement on climate change (Gallagher et al 2019). In 2016 China published a National Plan on Implementation of the 2030 Agenda, which advocated strong support to the SDGs, and signaled the country's keen interest in building on its impressive successes in relation to the Millennium Development Goals (MDGs). The Plan outlined a coordinated strategy that was to be driven by "innovation" and with an emphasis on "green", "open" and "shared" development (Banik 2019). SDG goal 11 aims on making cities and human settlements inclusive, safe, resilient and sustainable.

Effective implementation of climate change mitigation and adaptation options depends on policies and cooperation at all scales and can be enhanced through integrated responses that link mitigation and adaptation with other societal objectives (IPCC) like the SDGs. At the same time, analysing lock-in inherent in mitigation actions and adaptation pathways can strengthen opportunities to create synergies and reduce trade-offs.

1. Reducing industry's greenhouse gas emissions (Mitigation)

   There are many ways to reduce greenhouse gas emissions from the industrial sector, including energy efficiency, fuel switching, combined heat and power, use of renewable energy, and the more efficient use and recycling of materials; Sustainable energy solutions, Industrial energy efficiency, renewable energy for productive use, green innovation.

2. Climate resilient industry (Adaptation)

   The climate agenda has illustrated the urgent need to move towards climate resilient industry: Building blocks for climate resilient industry include, Technology transfer, fostering innovation for climate resilient entrepreneurship, alert systems, protection against flooding, cooling water security, safe water supply, etc.

3. Synergies and trade-offs between reducing industry's greenhouse gas emissions and Climate resilient industry

   "It is becoming increasingly evident that certain mitigation measures could aggravate vulnerability in another location, while other approaches have clear mutual benefits towards improving resilience. Similarly, many adaptation measures would result in additional GHG emissions from industry, for example, from increased extraction of global resources for construction materials and energy, among others. Effective solutions to climate change require a holistic approach that recognizes the interlinkages and potential trade-offs of different approaches, and leverages the synergies between mitigation and adaptation measures. This can also bring additional benefits such as climate financing that could not have been leveraged if addressed separately." (UNIDO, page 9).

A holistic approach that will harness the synergy between climate mitigation and adaptation measures and anticipate its potential trade-offs globally is an essential ingredient for climate resilient industry. The synergies and tradeoffs of these two strategies revealed increasingly importance on reducing adverse climate effects. Suggestions for practical improvements are:

- Constructing and improving the monitoring and evaluation systems.

- Combining adaptation and mitigation action planning and strategies.

- Mainstreaming adaptation and mitigation in management and policy systems

Example for "mitigation and resilience": "With the right solutions, it can be possible to build large-scale renewable energy projects with significant energy storage components, deploy batteries to stabilize power grids in countries with weak infrastructure, and increase off-grid access to communities that are ready for clean energy with storage. An emergency solar and battery storage power plant is being built in the Gambia" (Worldbank 2019).

5.2. Industry 4.0; reduction of CO_2 and more resilient Cities

The development of sustainable and smart cities requires integrated interventions in planning, investment, and the uptake of new technologies. Industry 4.0 technologies, and especially Artificial Intelligence (AI)-enhanced urban transportation, smart grids, renewable energy, waste and water management, and urban farming, will not only reduce CO_2 emissions, but may also improve energy, water and food security, and effectively address climate change and environmental issues.

For cities to be sustainable, social dimensions such as inclusiveness, cultural adequacy, fairness and gender equality are crucial, in addition to economic, ecological and environmental dimensions. Smart cities, where Industry 4.0 technologies are tested and applied, have to aim for integrated solutions that use resources efficiently and effectively, and follow low-carbon and inclusive development pathways.

The following measures related to Industry 4.0 have a potential for climate change mitigation and adaptation:

5.2.1 Resource efficiency in production/purchase and the low-carbon economy

The transition to a low-carbon economy is one particularly important aspect of the broader goal of reducing the environmental burden of society's resource use. Increasing resource efficiency is essential to sustain socio-economic progress in a world of finite resources and ecosystem capacity, but it is not sufficient. Increasing efficiency is only an indication that output is growing more than resource use and emissions. It does not guarantee a reduction in environmental pressures in absolute terms.

In assessing the sustainability of European systems of production and consumption, it is therefore necessary to move beyond measuring whether production is increasing faster than resource use and related pressures ('relative decoupling'). Rather, there is a need to assess whether there is evidence of 'absolute decoupling', with production increasing while resource use declines. In addition to assessing the relationship of resource use to economic output, it is also important to evaluate whether the environmental impacts resulting from society's resource use are decreasing ('impact decoupling')." (EEA 2016).

In general "The environmental implications … ..are manifold and, when seen in the broader perspective of life cycle assessments of related production processes, can be both positive and negative. Above all, they depend on the materials used and whether single or multiple materials are applied, with complex recyclability challenges appearing in the latter case. Moreover, there are considerable resource demands in both the pre-production stage (composing and preparation of materials) and the post-production stage (treatment/cleaning of 3D printer components) (Lütkenhorst 2018 p.34)."

Nevertheless ", the many possible applications of digital technologies aimed at increasing energy-efficiency are just beginning to be explored. F.e. industrial robots, which are programmed to optimise their movements and speed within a set of rules geared towards saving energy. … .In general, being able to draw on machine-specific real-time data of energy consumption (facilitated by the Internet of Things) opens up a new space for efficiency gains, inter alia through improved energy flows that can reduce machine downtime (Lütkenhorst 2018 p.34)."

Case Study: Improvement of sustainable energy and water management by joining the Energy Data in Catalonia (Spain), Leicester (UK) and Nuremberg (Germany)

The EU project EDI-Net assists in building the city's or region's capacity to more effectively implement sustainable energy policies. Therefore it is analysing short time series metered energy and water data from public buildings, from renewable energy systems and from building energy management systems (BEMNS) in order to reduce energy consumption and to save money. EDI-Net uses new developments in smart metering, energy visualisation techniques and big data to share knowledge and experience of best practice between different cities throughout the world. The initiative also helps visualise energy savings opportunities and makes energy efficiency in public buildings even more relevant to building users, finance managers and politicians." http://www.climatealliance.org/activities/projects/edi-net.html

Topics related to Industry 4.0 (Behrendt and Göll 2018, Rashid 2018):

a) Digital learning methods for tracking and quantifying material and energy savings: Improve the data basis for identifying resource-saving potentials in companies

b) Virtual product development: The model-based development of products reduces the dependency on tests on prototypes and allows resource consumption to be predicted, so that information can flow into the development and design processes as early as the development phase.

c) Efficient use of data through big data analyses: When collecting and analysing data, companies have considerable potential to optimise their processes, such as the utilisation of production machines, the use of usage data to optimise products for more resource-efficient use (eco-design), energy & resource efficiency and reliable planning of maintenance intervals.

d) IoT, AI and Blockchain can help companies and industries monitor, analyse and automate their purchasing patterns. This will help them become smarter in their inventory and supply chain management, in turn minimising deliveries of wasted products.

e) Advanced materials used for intelligent packaging can limit waste creation. The food industry for example defines intelligent packaging materials as "materials and articles that monitor the condition of packaged food or the environment surrounding the food".

f) IoT, advanced sensor platforms, AI and shared data can help cities predict and track municipal and industrial waste generation and collection, analyse types of waste and optimise disposal and recycling.

g) Automated 3D-printing robots can process different forms of waste into building materials

h) Temperature sensors, smart meters and controls for efficiency and to control energy and water use.

5.2.2 Optimising urban renewable energy systems for CO_2 emissions reduction

Energy systems for smart cities will require on the one hand a much higher share of renewable energy sources for heat and electricity and on the other hand a high standard of integration of industry and utilities supplying households and business.

Industry 4.0 and the German Energiewende share a number of common characteristics. Both are transformative in nature, defy the status quo and have to fight against powerful vested interests; both require huge investments by private companies into a range of new technologies and by public authorities into supporting infrastructure; both are faced with high levels of uncertainty regarding the long-term implications for future competitiveness; and both are faced with steep technological learning curves as well as the need to scale up innovations and create entirely new markets. (Lütkenhorst 2018 p33)

“Digital technologies can play an important role in managing renewable energy systems, and thus facilitate the transformation towards sustainability. Smart grids depend critically on the two-way connectivity of decentralised energy generation and consumption through real-time monitoring and control of supply and demand. In the emerging reality of increasingly distributed energy generation, the concept of “virtual power plants” assumes special significance. Simply put, they connect a variety of energy sources, energy storage systems and energy load scenarios into a virtual market, allowing for a cloud-based simulation of possible contracts and their implications (UNIDO, 2017b, p. 27 in Lütkenhorst 2018 p33).”

Also, the time-sensitive and price-sensitive feed-in of, for example, solar and wind power into the electricity grid requires sophisticated digital control units with a view to contributing to grid stability. For many leading players in the renewable energy market, digital control components have become a crucial element in staying competitive. In very practical terms, they represent one of numerous examples of how the capabilities of physical goods (wind turbines or solar PV systems) depend on progress in data management. The International Energy Agency estimates that, in the EU, digital technology-enabled improvements in energy storage and demand management could “reduce curtailment of solar photovoltaics (PV) and wind power from 7 per cent to 1.6 per cent in 2040, avoiding 30 million tonnes of carbon dioxide emissions” (IEA [International Energy Agency], 2017, p. 18 in in Lütkenhorst 2018 p33).

Smart grid management combined with decentralised, renewable energy distribution systems will empower cities and urbanites with more frugal and flexible clean energy systems. Global carbon dioxide (CO_2) emissions from the energy sector can be reduced by 70 per cent by 2050 and completely phased-out by 2060 (IRENA 2017).

“The growing share of renewable energies in the power supply system requires additional flexibility options through storage, load management and grid expansion. Industry plays an important role here. In industrial manufacturing, Industry 4.0 has the potential to play an important role in future intelligent power grids. With the help of intelligent and adaptive energy management, companies can buffer cost-intensive peak loads and make direct use of energy efficiency potential at the production sites (e.g. available renewable energy sources). In pilot projects, the different approaches from energy storage and smart meters to demand side management, virtual power plants and microgrids will be investigated in integrated solutions and corresponding information, communication and automation technologies will be developed” (Behrendt and Göll 2018).

Topics worthy of further attention (WEF 2017, Rashid 2018):

- IoT, drones and robots, harnessed for sensor-based grid and network management, can help utilities (and cities & industry) monitor and inspect the health of the power system in real-time to reduce losses and improve reliability.
- AI and smart meters, can also help forecast and optimise energy generation and demand
- Advanced materials, emerging battery and biotechnologies offer new ways to generate, store and consume renewable energy in cities by raising capacity, (e.g. by harnessing photosynthesis in plants) and by managing peak demand (especially for solar energy on cloudy days).
- Quad generation technologies can optimise the heat - or in particularly hot climates the ‘coolth’ - provided to industry and homes through central provision and district energy centres, which measure and manage demand by cooperating with heat generation, distribution, use and reuse.
- Blockchain offers some of the most promising opportunities for expanding power access. Such technologies are showing decentralised, renewable power systems are possible with micro- and smart grids and peer-to-peer systems.
- IoT, Blockchain and pay-as-you-go systems also combine to increase accessibility to power in underserved markets. The Sun Exchange leases solar cells to firms and communities in Southern Africa enabled by quick, secure and low cost payments to global investors using Bitcoin.

Case Study: Renewable Energy Regions (RegEnergy) -Strong partnerships to connect urban demand and rural supply

RegEnergy aims to break up existing structures to increase the use of renewable energy in northwestern European regions. Creating renewable energy demand–supply partnerships between urbanised and surrounding rural territories will lead to greenhouse gas emissions reductions. Nine project partners from seven northwestern European countries representing metropolitan regions, cities, rural communities, regional agencies, scientific institutions and renewable energy producers will develop strategies and models to illustrate how such partnerships can be built. In three strategic areas, the missing regional links between demand and supply from renewables will be addressed: The institutional and administrative framework conditions (e.g. cooperation agreements) as well as the main infrastructure (e.g. biogas pipelines) that such partnerships require are as central as the question of required technologies (e.g. smart grids, storage capacities):

http://www.climatealliance.org/activities/projects/regenergy.html

5.2.3 Circular Economy and CO_2 reduction

The circular economy works by extending a product’s lifespan through improved design and servicing, and relocating waste from the end of the supply chain to the beginning - in effect, using resources more efficiently by using them over and over, not only once. Circular use notably of steel, plastics, aluminium and cement can be central to cutting global greenhouse gas emissions (UNFCCC 2019 https://unfccc.int/news/circular-economy-is-crucial-to-paris-goals-study)

“Intelligent reduction and optimised reuse of waste and materials over their life-cycle will be crucial to preserve natural resources, avoid disease outbreaks, contaminated soils and waters, and local environmental degradation in emerging cities” (Rashid 2018).

1. Re-manufacturing and automated dismantling factories
2. Emission-neutral and energy-autonomous factories

Case study: ABB CO_2 Neutral Factory, Luedenscheid, Germany

ABB has unveiled its first CO_2-neutral and energy self-sufficient factory in the world. The facility in Germany will run on a solar photovoltaic system backed by a battery storage system, and any surplus power will be fed back into the grid. It also has EV charging points for staff and visitors. The factory in Luedenscheid manufactures smart energy solutions for homes and buildings, and the solar installation is expected to save about 630 tonnes of CO_2 a year. During peak demand when extra electricity is needed, the factory will source power from guaranteed 100 per cent green energy.

Topics worthy of further discussion(Behrendt and Göll 2018):

- Adaptive load control/demand management: With adaptive load control, factories and machines can save energy and make better use of capacity with Industry 4.0.
- Zero-emission commercial zones: Industry 4.0 can support enterprise-wide energy management, e.g. with regard to peak load regulation, the supply of neighbouring companies with overcapacities or the use of waste heat in the network.
- Smart contracts based on blockchain technology: The blockchain technology is based on a decentralized database in which a chain of consecutive, interdependent transactions is stored in data blocks. It is already being used, among other things, to network the PV electricity production of households. In the future, smart contracts, intelligent contracts that automatically make payments, can be programmed into blockchains.

Case Study: City of Amsterdam: Smart Freight Mobility

To be able to respond to new traffic developments, the municipality has established a Smart Mobility action programme in collaboration with research partners in the city. The programme focuses on 'learning by doing'. AMS is currently developing a self-navigating ship, for example. In future, self-navigating boats might contribute to freight transport by water, to help relieve traffic congestion in the city. (Mobility Plan (in Dutch):

https://assets.amsterdam.nl/publish/pages/868675/2a_actieprogramma_smart_mobility_def.pdf)

5.2.4 Value-added networks and decentralized (energy) production

"Information processing systems have always played an important role in the supply chain. This will increase even further with the further networking of information and goods flows. An example of this is the development around the Internet of Things, which assumes that modern Internet services and information systems will increasingly enable self-controlling shipments and logistics systems. It is expected that the automation of identification systems and the resulting high rationalization effects in the identification of goods and shipments will enable high efficiency advantages in logistics. Beyond this path-dependent optimization, Industry 4.0 allows the reconfiguration of value creation networks with the possibility of decentralized production close to the sales locations, so that the effects on logistics are significantly greater." (Behrendt and Göll 2018)

Topics for further exploration: (Behrendt and Göll 2018):

- Integrated product traceability solutions enable the traceability of all production batches in the production chain and record associated material movements; saving of paths by remote diagnosis
- Self-optimizing logistics has the potential to reduce empty runs
- Renewable, decentralised energy generation such as rooftop solar, city heat networks and peer-to-peer energy systems

Case Study: Blockchain applications for agrifood

Many projects are initiated to realize shorter food chains and peer-to-peer (P2P) economies, such as Delicia, an Estonian based blockchain start-up which aims to connect regional food producers, restaurants, supermarkets, and consumers in networks with the main goal to reduce food waste (2018). Other European start-ups like Ambrosus, OriginTrial, and Te-Food are creating the blockchain-enabled data infrastructure for traceability and food safety in the supply chain, and Dutch start-up Fructus aims to create a blockchain-based marketplace where farmers can directly interact with consumers (Fructus, 2018). Additionally, Backfeed and Odyssey are creating blockchain platforms as well as protocols for decentralized cooperation and decentralized sharing economies respectively, tools which can be leveraged to create open networks of food cooperatives. It can thus be argued that various aspects of the agrifood sector are rapidly being digitized, contributing to decentralized food networks and short food supply chains.

(Source: https://hackernoon.com/leveraging-platform-cooperativism-and-blockchain-technologies-for-decentralized-food-networks-and-28dc5e7c42f1)

5.2.5 Co_2 reduction by leapfrogging technological development

"Developing countries can avoid retracing the development process previously followed by industrialised countries in the past. In other words, developing countries have a choice; they can either mimic industrialised nations and undergo an economic development phase that is dirty, wasteful and creates an enormous legacy of environmental pollution or they can "leapfrog" over some of the steps of development and incorporate currently available modern and efficient technologies into their development process."(Goldemberg, José 2019).

Industry 4.0 can provide technical and financial expertise, resources and consistent energy data.

Topics for further attention (Perkins 2003):

- Designing specific targets for leapfrogging
- Targeting sectors for investment
- Develop leapfrogging capabilities and technologies

5.2.6 Smart Services/New business models and service orientation

Industry 4.0 should not only focus on production and fabrication but also on depicting new business models, value-added processes, and in connection with it, new resource efficient potentials, qualification-requirements and design approaches.

Intelligent data transformation and processing no longer only controls production. It is used in a targeted manner to improve customer benefits and to increase not only customer benefits, but also performance of individual facilities.

Topics for further attention (Behrendt and Göll 2018):

- Product use systems: services to fulfil functions (benefits instead of possession, e.g. leasing of chemicals), preventive maintenance, cost-effective repairs, resource-saving product use and refurbishing.
- Collaborative development of new business models and services: The integration of customers and cooperation with relevant social stakeholders play an important role in the development of sustainable future markets. Especially in newly emerging and young markets, open innovation processes are a success factor for the integration of sustainability requirements (Fablabs, Opensource innovation platforms and networks)

Case Study: City of Oslo: Vulkan EV Charging Garage

Vulkan is one of the largest and most advanced EV charging garages in Norway and Europe. The City of Oslo wants to have more than 200,000 electric vehicles on its streets by 2020. With over 100 EV chargers, quick chargers and additional battery storages for smart charging, Vulkan is an embodiment of the expected fusion between building, energy and transport sectors.

Vulkan serves both residents and companies. During the day, Vulkan operates as a 'Centre of excellence' for professional users of EVs as E-taxis, electric freight vehicles and EVs for craft & services. It provides opportunities for pre-booking of charging time, flexible charging, battery storage, and quick charging. At night, Vulkan offers free residential parking for people living in the neighbourhood. Besides the different day and night users, Vulkan is also a hub for EVs that use overnight charging at home, in combination with (semi-)quick charging during the day. This creates a flexible and cost-efficient site for the promotion of EVs. New professional users of EVs e.g. car sharing, cleaning company and craft and service vehicles, have started their operation from the site.

Example: The Digital Innovation Hub of Friuli Venezia Giulia- A single policy for the digital transformation of businesses

IP4FVG is a Hub & Spoke model that by its very nature extends its activities and services - and consequently its systemic impacts - into a national and international dimension, developing in phases. The 4 entry points are:

- Data Optimisation and simulation
- Advanced Manufacturing solutions
- Data analytics and artificial intelligence
- Internet of Things

It is tested in the first phase at regional level in Friuli Venezia Giulia.

5.2.7 Decoupling of resource consumption from economic growth

"There is the fundamental challenge of promoting a decoupling of resource consumption from economic growth, at least in relative terms (decreasing resource intensity) or ideally in absolute terms (decreasing resource use)". (Lütkenhorst 2018 p32)

In this context, the concept of industry 4.0 according to Kopp (2016) has a "sustainability deficit". According to him it is noticeable that sustainability of industry 4.0 is reduced to the aspect of resource efficiency. The tension between increasing resource efficiency and the resulting rebound effects is not reflected. Characteristic is the strong adaptation of the products under the conditions of highly flexible large-scale production. In this respect, the previous understanding of industry 4.0 continues the existing growth path without having a justified prospect of being able to sufficiently decouple resource consumption from economic growth.

There are also potential rebound-effects to be considered. For this, it is necessary to integrate a dynamic of supply, demand, work and consumption. Solutions that contribute effectively to a reduction of rebound-effects, can only be developed through a systems perspective. Reducing exonerated effects for the environment can primarily be expected where, on the one hand, potentials for resource conservation and climate protection exist and, on the other hand, possible rebound-effects are rather small. Against this background, projections, especially in this sector, need to be identified and promoted.

5.2.8 Governance for a green industry

"Green Industry promotes sustainable patterns of production and consumption i.e. patterns that are resource and energy efficient, low-carbon and low waste, non-polluting and safe, and which produce products that are responsibly managed throughout their lifecycle. The Green Industry agenda covers the greening of industries, under which all industries continuously improve their resource productivity and environmental performance. It also aims to create green industries, that deliver environmental goods and services in an industrial manner, including, for example, waste management and recycling services, renewable energy technologies, and environ-mental analytical and advisory services. From a public policy perspective, the greening of industries is a cross-cutting exercise, which traverses a range of policy streams. These include industrial policy (e.g. technology development), environmental policy (e.g. re-source conservation measures), and regional development policy (e.g. provision of local infrastructures)."(UNIDO 2017)

"Solutions for a green transformation are country-specific and will require a high degree of contextualisation. In some cases, norms and values may change first and then drive policy and technology innovations. In others, new technological options may be in the lead and exert a strong pull. Also, in many cases the economic opportunities associated with emerging green markets will trigger the build-up of new sources of competitiveness and provide new foundations for forward-looking employment creation". (Wilfried Lütkenhorst et al. 2014).

Case Study: Smart cooling system for pharmaceutical processes

Bloodbank's pharmaceutical processes cooled with cold from drinking water infrastructure in Amsterdam

During cold periods in winter, the temperature of drinking water drops lower than desired. This creates an abundance of cold energy which can be extracted and either used directly in pharmaceutical processes or stored in an underground storage facility (a so-called aquifer thermal energy storage: ATES). Blood bank Sanquin and water company Waternet have joined together in the city of Amsterdam to use cold from drinking water infrastructure for their process cooling needs. As a result of the cold extraction the temperature in the drinking water infrastructure rises slightly which means end-users need less energy to heat water. The annual energy yield for the first years is expected to be 20.000 gigajoule, which equals the annual power consumption of about 1.800 households.

In order to get small and medium enterprises (SMEs) on board and to get industry 4.0 balanced, governance is needed that upgrades sustainability aspects and integrates them into innovation processes at an early stage. Potentials and benefits for SMEs of the concept must be assessed realistically, risks estimated and alternative options taken into account.

The graphic below shows the framework for Germany's Industry 4.0 policy initiative (Klitou, Johannes et al. 2017)

Fact box for Germany's Industrie 4.0 policy initiative

Policy Lever(s)	Publicly-backed and steered initiative that is implemented through stakeholder dialogue
Funding Model	Mixing public funding with private financial and in-kind contributions; offering between a two to one or five to one ration between private to public investment
Target audience(s)	Manufacturers/producers, SMEs and policy-makers
Impact & Focus Areas	Digital innovation and ICT market; transformation of business models and product/ service delivery
Key drivers	Idea development by research actors, reform experience in production and pro-active unions
Key barriers	Competition among leading ICT players and shop-floor-level involvement
Implementation strategy	Comprehensive research agenda an I40 platform as a network foundation for digital transformation
Results achieved	Reducing industry segregation, transforming research agenda into practice, developing reference architecture and launch of platform with 150 members
Budget	EUR 200 million from BMBF and BMWI that is complemented by financial and in-kind contributions from industry
Uniqueness factor	Rapid transformation from research agenda into mainstream practice and platform constitute the largest and most diverse I40 network globally
Value-added for policy makers	A strategic initiative for consolidating technological leadership in mechanical engineering and for helping policy-makers to push forward I40 at all levels
Expected Impact	Provide a consistent and reliable framework for developing Germany's competitive position in manufacturing through recommendations and actions

Source: DTM Digital transformation Monitor 2017

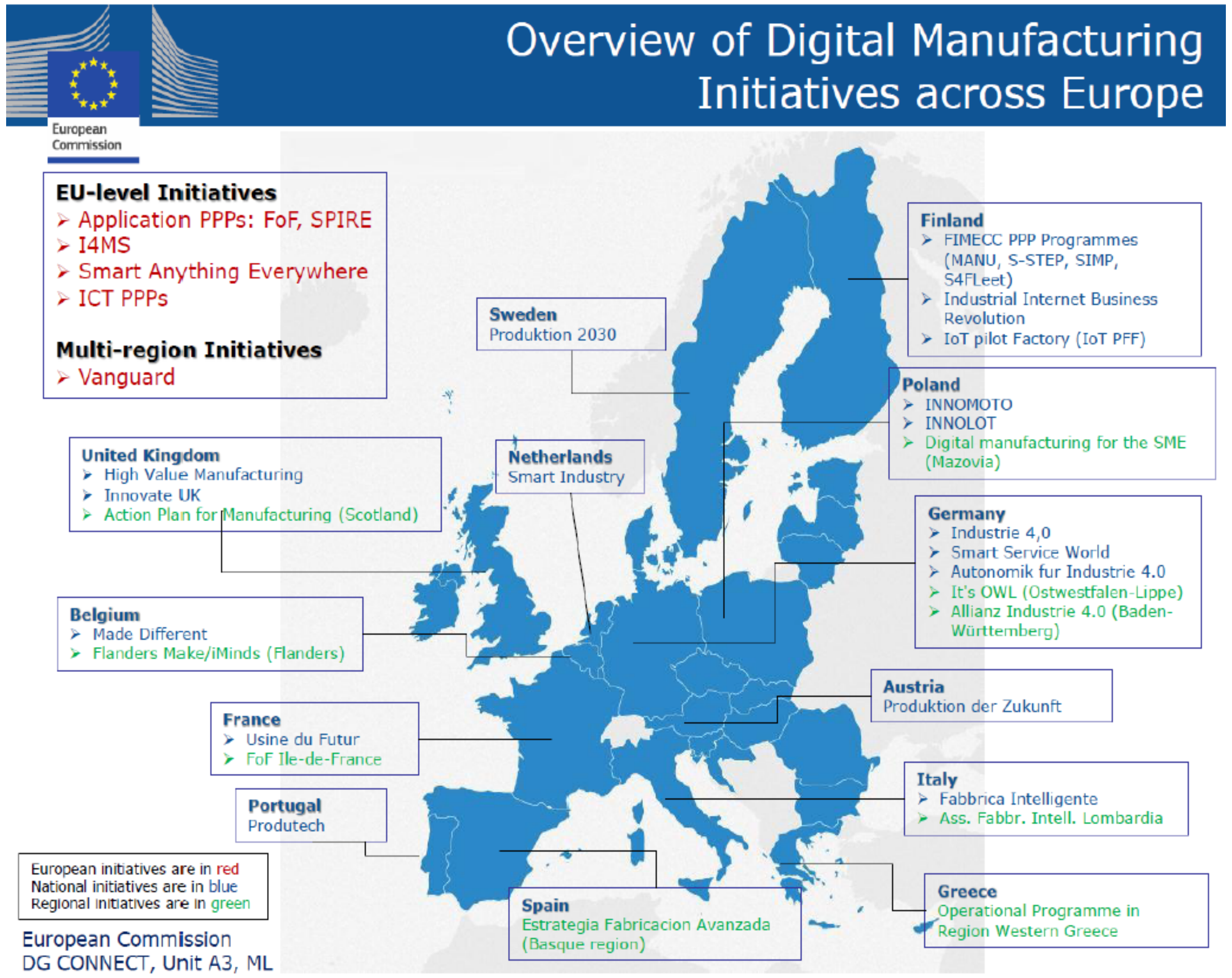
Topics in this context are (Behrendt and Göll 2018):

- Research funding to link industry 4.0 with the green economy: the topics should be linked together and integrated into future research programmes.
- Networking of consulting services for industry 4.0 and resource conservation especially for SMEs"
- Supporting LCA: Industries generate products or outputs which degrade the environment in one way or another – either from manufacturing processes, their later use, or disposal. Current policies have tended to focus largely on point-sources of pollution, such as industrial emissions and waste management issues, rather than the products themselves and how they contribute to environmental degradation.
- Use of Resource-focussed product labels.

Case Study: Netherlands - Self-Organizing Logistics in Distribution (SOLiD)

Based on an experiment in the parcel delivery system, SOLiD investigates the possible role of technology in making parts of the logistics system autonomous and intelligent, and what a good self-organizing logistics system would be under a mixed central / decentralized form of control. In doing so, SOLiD looks at the effects on performance indicators such as service quality, logistics costs, flexibility, robustness, number of vehicle kilometers, emissions and asset utilization.

The experiment consists of four concrete cases in the package delivery system. The first case involves experimenting with the dynamic planning of delivery areas. In the second case, local intelligence is added so that handling during loading of the delivery vans is reduced by projecting the location in the delivery van and photos of the packages on a device. The third case involves experimenting with the rescheduling of routes based on data from recipients. The fourth case focuses on the question how local intelligence of a high-performing driver can be made available to others.



As more and more cities join the global urbanisation trend, numerous negative environmental consequences appear larger than ever, rendering green urbanisation an urgent public policy agenda.

Effective, efficient, innovative, and adaptable governance is a necessary condition for cities seeking a transition to sustainability. The challenges of sustainable transition require that cities develop responsive corresponding governance capacities.

Topics are:

- Community participation

Case Study: Interreg NWE funded project - Climate Active Neighbourhoods

The Climate Active Neighbourhoods project aimed to increase the capacity of municipalities to implement their climate action strategies more effectively using a neighbourhood approach. It aimed at bottom-up participation addressing energy consumption paradigms on a neighbourhood level, with a special focus on deprived areas in need of energy retrofits. It empowered residents within the neighbourhoods to take measures on climate action. Strategic incentives for energy retrofits, increasing energy efficiency and behaviour change have been offered. This approach ensured coherence between bottom-up activities and city-wide strategies. The Practice Cube is a online collection of best practices and is targeted towards municipalities, who are looking for successful climate actions.

- Standardization

Governments can play a key role in boosting technological progress by defining and promoting standards for products made by firms and by facilitating quality control to help firms comply with standards.

Case Study: Nuremburg CO_2 emissions Accounting

The City of Nuremberg has set itself the goal of achieving a 40 percent reduction in CO_2 emissions by 2020 and an 80 percent reduction by 2050 compared with 1990. In 2009/2010, following the climate protection report 2006 and the climate protection roadmap 2010-2020 (2007), a system was developed for the city of Nuremberg which makes it possible to record and present both the development of energy consumption and the development of CO_2 emissions in the city of Nuremberg. In the current analysis, the years 2013 to 2015 were compared with the base year 1990.

The generally accepted "accounting system for municipalities in Germany (BISKO standard)" was used. This is a standardized instrument approach for balancing, potential determination and scenario development for local authorities. The use of a uniform methodology is intended to ensure comparable balance sheets in the respective local authorities with a comparable high quality standard. The BISKO system no longer balances CO_2 emissions, but greenhouse gas emissions.

- Public procurement

Public procurement is recognised as an important instrument of innovation policy. Beyond bringing existing low-carbon solutions to market today, it can create 'lead' markets, for instance where government demand is significant (e.g. transport, construction). Through the sheer size of their expenditures, governments are major actors in countries' economic lives. Public procurement accounted for 13% of the gross domestic product of OECD countries in 2013, and more in some emerging and developing countries. According to OECD (2016) "A number of practical solutions can make green procurement more effective, including for low-carbon innovation even in sectors and products that are indirectly involved in procurement contracts (e.g. construction materials). Tenders now include life-cycle costing in value-for-money assessments, i.e. including the cost of externalities such as CO_2. Market dialogues help both procurers and potential suppliers in formulating innovative tenders. Public procurement can also encourage new business models through the provision of services, rather than products, that could support lower material use and environmental impacts. There may also be opportunities to increase the impact of procurement through international collaboration".

- Climate emergency

Current targets at national and international levels are not sufficient to meet the ambition of the Paris Agreement. Declaring a climate emergency locally is a way to show that our cities, towns and regions are taking climate issues seriously. That is why cities are preparing and agreeing upon its own Climate Emergency Declaration.

It is worthy of note that the European Committee of the Regions has prepared an opinion on a place based approach to the EU industrial policy strategy.[3] This contains five key messages for policymakers:

1. A competitive European industry requires a combined approach in which a place-based regional policy is accompanied by inter-regional collaboration
2. As major societal challenges often require collaboration between European regions, regional governments play a crucial role in mission-oriented initiatives and in bringing sectoral policies into practice
3. Regional and local authorities should ensure the availability of skills to support the transition of industry, facilitating industry-educational institutes collaboration, supported by a European strategy

Case Study: Plymouth City Council Climate Emergency Declaration

The City Council resolves to:

(1) Declare a 'Climate Emergency'

(2) Pledge to make Plymouth carbon neutral by 2030, and commit to working with other councils with similar ambitions

(3) Request the Leader to write to the Secretary of State for Environment, Food and Rural Affairs to provide the powers and resources to make the 2030 target possible; and commit to working with other councils with similar ambitions

(4) Work with other governments (both within the UK and internationally) to determine and implement best practice methods to limit Global Warming to less than 1.5° C

(5) Continue to work with partners across the city and region to deliver this new goal through all relevant strategies and plans

(6) Report to Full Council within six months with a climate emergency action plan and new corporate carbon reduction plan

(7) Request the Leader to write to the Chancellor of the Exchequer stating the concern of the Council with respect to the above, the likely national impact on the economy and on the wellbeing of citizens, and requesting Government funding be made available to implement swift appropriate actions in response"

3 https://cor.europa.eu/en/news/Pages/supporting-european-industry-to-face-the-future.aspx

4. European industry and governments need to show leadership in becoming more sustainable by taking action
5. Regional innovation-oriented strategic public/private partnerships are crucial to enhance the uptake of new technologies by industry

5.2.9 Climate resilient industry and human settlements

Globally, all cities are vulnerable to severe impacts from a range of shocks and stresses that can be both natural and human made. Today, cities and city inhabitants are facing additional and amplified challenges as a result of rapid urbanization, climate change and political instability. (UNHabitat).

"Once cities assess climate change risks, they are extremely likely to take action. While cities and business must work more closely to align their understanding and response to climate change risks, it is significant that cities are recognizing – and acting upon – the most severe risks identified by businesses. This mutual recognition of climate change risks is an important step to taking action that creates safe, resilient cities that are also attractive places to do business, invest and innovate. (Bulla, Larissa, et. al. 2015)"

"Real-time, integrated and adaptive urban management systems and change management to better adapt to, learn from and respond to shocks" (Rashid 2018):

Topics for further consideration:

- Promoting value chain based approach for climate resilient industry: The scarcity of resources and the direct impact of climate-related disasters could result in a "bottleneck" for vulnerable value chains. It is therefore important to assess a whole value chain to understand the impacts of climate change (UNIDO 2017).
- "Urban labs"; Cities are knowledge and innovation hubs, and we can use this to our advantage. One example of this the Rotterdam Solar-Powered Floating Pavilion.
- Alert systems; like in Venice "Acua alta" information center: Source http://www.veniceforyou.com/highwaterprev.html)
- Flood, heat, quake and storm- resistant 3D printed structures for shelters and home, like the first European family house in Nantes, France:
- Source https://www.bbc.com/news/technology-44709534
- Drone deliveries for (climate) disaster response; As hardware advancements converge with exploding AI capabilities, disaster relief robots are graduating from assistance roles to fully autonomous responders.
- Advanced Materials, smart concrete to reinforce structures and vulnerable assets, Memory metals, Nanotechnologies and other material science technologies, which can produce materials with significantly improved or completely new functionality, including lighter weight, stronger, more conductive materials, higher electrical storage
- Artificial Intelligence; Machine- automated disaster risk prediction, monitoring and assessment
- Proactive and reactive security intelligence, Traffic rerouting in emergencies
- Unmanned disaster response support into danger zones'
- Blockchain, Relief payments; The United Nations World Food Programme (WFP) is deploying blockchain technology to make cash-based transfers faster, cheaper and more secure.
- https://www1.wfp.org/news/blockchain-against-hunger-harnessing-technology-support-syrian-refugees
- Adaptive energy, Mobile emergency power, like in Toyota City Vehicle batteries can also be used as a power source in times of emergency by manually setting the electricity flow to supply power from the vehicle's drive battery through the charging stand to a home's lights and power outlets. https://www2.toyota.co.jp/en/news/12/06/0604.html
- Virtual, Augmented and Mixed Realities, for disaster simulation, VR-based games for citizen emergency preparedness (see also Rashid 2018)

Case Study: Access to data for adaptation actions in "response" to climate change in Rhône-Alpes, France

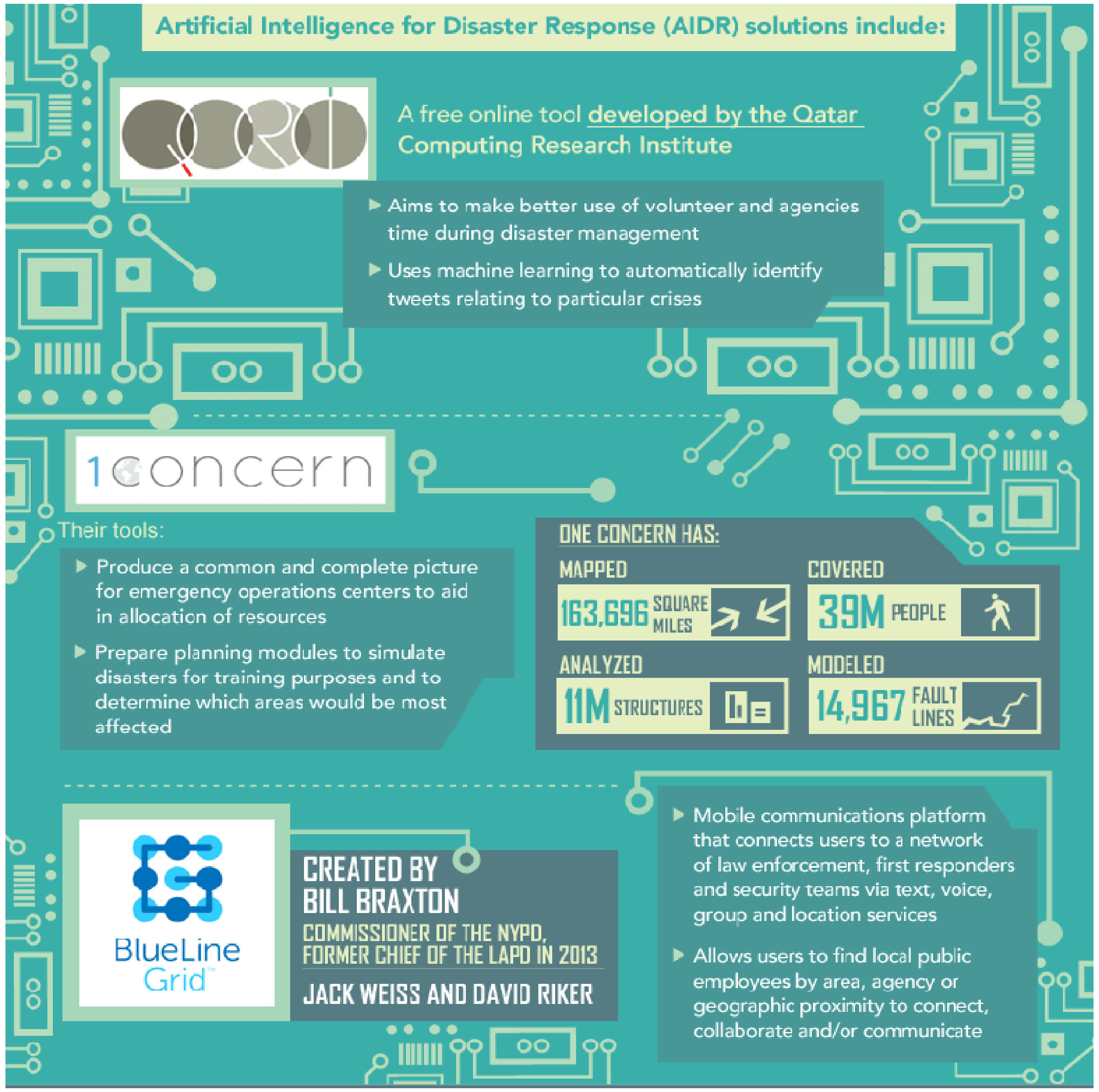
Warming of the climate is ongoing, and the preparation work for the Regional Climate Air and Energy Scheme of Rhône-Alpes highlighted its already observed effects and their likely intensification in the future: rising average temperatures, melting glaciers, changing rainfall patterns. The need to improve and disseminate knowledge on climate change and its effects in the region transpired as a priority in the strategic climate risk assessment which took the form of the creation of a regional observatory of climate change.

The Observatory enables all stakeholders, including local authorities in charge of local climate action plans to access data and share methodologies for adaptation actions in "response" to climate change. As an awareness-raising tool, ORECC is designed to benefit all: actors in the public sphere, associations, economic actors, academics, the general public.

http://orecc.auvergnerhonealpes.fr/fr/observatoire-des-effets-du-changement-climatique.html

Case Study: Floating Pavilion in Rotterdam, Netherlands

In an effort to address the challenges of climate change and sea level rise, the City of Rotterdam has started to build some intriguing floating structures. The first pilot project is a catalyst for climate change-proof architecture called the Floating Pavilion that consists of three connected hemispheres that look like bubbles anchored within the Dutch city's old harbor. An initiative of Rotterdam Climate Proof (part of the Rotterdam Climate Initiative), the mixed-use pavilion sets an unprecedented example for innovative, sustainable and climate-proof architecture.



Source: Qatar Computing Research Institute (QCRI) http://aidr.qcri.org/

5.3. Implementation of Industry 4.0 technologies in BRI

China's Belt and Road Initiative (BRI) involves a trillion-dollar investment programme to enhance economic interconnectivity and facilitate development across Eurasia, East Africa and close to 100 partner countries (Wenyan 2018)(see also map). According to Wenyan (2018) the "Digital Silk Road" could potentially bring a green transformation to both infrastructure and economic models in emerging markets:

- adding new technologies, the Digital Silk Road will help make the new infrastructure the most competitive, efficient and sustainable.
- bring advanced IT infrastructure to the BRI countries, such as broadband networks, e-commerce hubs and smart cities.
- connecting more and more medium and small merchants to global trading via digital networks, the Digital Silk Road can also support them with a smart cross-border logistics system
- and through the harnessing and application of big data to directly solve environmental challenges (for example to better respond to water security issues, climate change and natural disasters.

Regarding the implementation of the mentioned technologies, UNIDO (2017) in the summary of the BRI session on urban industrial solutions recommends e.g.:

- cities need to formulate clear visions and strategies, to best utilize available technologies.
- formulate KPIs so that progress in the adoption of Industry 4.0 technologies in a smart city context
- infrastructure, education, and qualified human resources are key to achieving and taking up new technologies.
- integrated interventions in the planning, investment, and uptake of new technologies are required for the development of sustainable and smart cities.

China has also taken measures to implement these directives. One is the International Coalition for Green Development on the Belt and Road, a multi-stakeholder platform convened by the ministry of ecology and the environment (see WEF, 2017). This platform is open to multilateral organizations, government departments, corporations and think tanks from around the world, and has a mission to share good practices and provide policy solutions to sustainable development.

Another initiative is the Green Investment Principles for the Belt and Road, a set of voluntary guidelines currently under development by a consortium of global-minded organizations led by the Green Finance Committee of the China Society for Finance and Banking and the Green Finance Initiative of City of London.

The World Economic Forum(2018) suggest three key measures to environmental friendliness, climate resilience and social inclusiveness are built into the new investment projects and daily business operations in the Belt and Road region:

Firstly, China should consider taking mandatory measures to enhance social responsibility in Chinese corporations. In past years, various Chinese government departments and industry associations issued voluntary guidelines for responsible overseas investment. To improve the effectiveness of these guidelines, we need to give them teeth. Some mandatory requirements are needed for responsible investment overseas. For example, the Ministry of Commerce can consider including a complete environmental impact assessment as part of its approval requirement for overseas investment projects.

Secondly, "greening" investment and business operations in the Belt and Road will only happen through joint efforts from investors and recipients. Host countries should, therefore, create a conducive and stable environment for green investment. This requires countries along the Belt and Road to "green" their fiscal, regulatory and financial systems, including introducing more stringent environmental policies and their improving enforcement, making fiscal and taxation policies friendly to green business, developing green finance guidelines and products, and encouraging accounting for the entire lifecycle in the supply chain.

Thirdly, underlining all of the above is the ability to design systems and develop instruments in government departments, financial institutions and corporations. Multilateral efforts are needed to support the development of platforms for sharing knowledge and experience in green investment. A good example of this type of capacity-building platform is the Global Green Finance Leadership Programme, hosted by the Centre for Finance and Development of Tsinghua University, the IFC-supported Sustainable Banking Network (SBN) and China Council for International Cooperation on Environment and Development (CCICED). At its launch event in May 2018, more than 120 government regulators and financial executives from 35 countries in the Belt and Road participated in a week of knowledge-sharing workshops in China.

BRI has the potential to be a win-win solution for development and sustainability, and China and other investing countries could make a great contribution to the green transition to sustainability in countries along the ancient Silk Road.

6 Industry 4.0 Standardisation

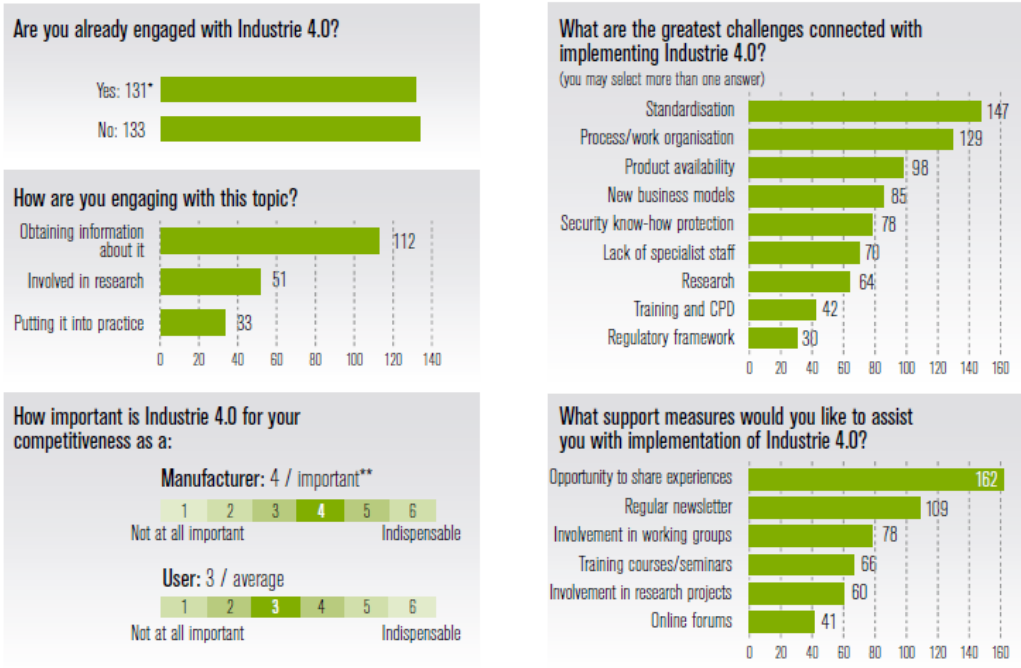
Industry 4.0 has the potential of becoming the global language of production (GTAI 2014). Each process used in an Industry 4.0 system integrates existing and proven technologies with new technologies and applications to address manufacturing problems. As such, the introduction of a uniform industry standard is especially important (GTAI 2014).

A survey of 278 German companies in 2013 (see figure below), identified standardisation as the greatest challenge to wider adoption of Industry 4.0.

A global level of effort is required to develop a standardisation process to ensure successful implementation of the strategic vision of Industry 4.0. International cooperation efforts and a system-level perspective are needed to address the Industry 4.0-related standardisation (Lin et al. 2013; Wang et al. 2018). For example, a set of uniform technical standards are required so that a network that connects different factories and companies can be realised (Zhou, Liu, and Zhou 2015).

Different organizations have developed reference architectures to align standards in the context of I4.0. In Germany, the Deutsches Institut für Normung (DIN) along with other organizations, published the "Reference Architecture Model for Industry 4.0 (RAMI 4.0)". In the United States, the National Institute of Standards and Technology (NIST) published a "Standards Landscape for Smart Manufacturing Systems". In China, the Ministry of Industry and Information Technology (MIIT) and the Standardization Administration of China (SAC) published the "National Smart Manufacturing Standards Architecture Construction Guidance". All these reference

Figure 5:
Results of survey on Industrie 4.0 trends (January 2013)



278 companies took part in the survey, mainly from the machinery and plant manufacturing industry. 205 of the companies that took part had fewer than 500 employees.

* The figures refer to the number of companies ** Average score based on answers provided by all companies Source: BITKOM, VDMA, ZVEI 2013

Source: Forschungsunion and Acatech 2013 architectures pursue the common objective of providing a road-map for the use of standards for smart factories. Emphasis in is put on the interoperability of the standards and the alignment with the processes in the factories.

Currently, the standardisation of Industry 4.0 is off to a good start. Researchers have addressed the standardisation issues concerning technologies such as IoT and CPS that support Industry 4.0 implementation.

Two main standardisation efforts have been reported:

The Reference Architecture Model for Industry 4.0 (RAMI 4.0), a key standard for Industry 4.0, has been introduced by the German Electrical and Electronic Manufacturers' Association (Rojko 2017). RAMI 4.0 introduces a three-dimensional coordinate system that describes all crucial components of Industry 4.0. Within this system, complex and complicated interrelations can be decomposed into subsystems, clusters, or modules (DIN 2018, VDI/VDE-Gesellschaft Mess- und Automatisierungstechnik 2015; Gøtze 2016).

The Industrial Internet Reference Architecture (IIRA) is a standards-based open architecture defined by the Industrial Internet Consortium (IIC) (2017). The objective of IIRA is to create a capability to manage interoperability, map applicable technologies, and guide technology and standards development. The IIRA supports several aspects related to the standardisation. Recently version 1.8 of the IIRA was released. This new version incorporated emerging Industrial Internet of Things (IIoT) technologies, concepts, and applications.

The rapid evolution of IoT makes standardisation more challenging. , standardisation will play an important role in the future development IoT.

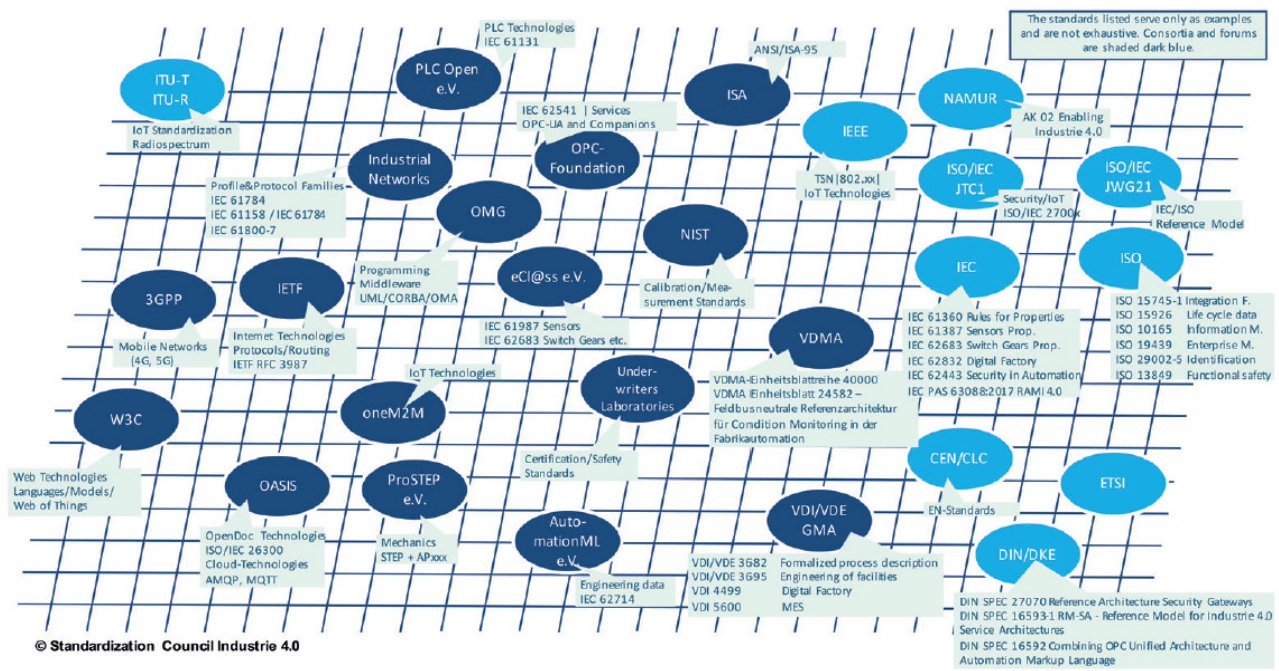


Figure: Bodies and Councils from around the world of relevance to Industry 4.0 (Source DIN 2015)

7 Scenarios for Industry 4.0 Integration into BRI

7.1 Scenario 1 Base Case – Individual countries pursue I4.0 strategy

As noted above, without the interoperability enabled by standardization between different parts of one supply chain, between regions and nations etc., then the full potential of I4.0 in BRI and smart cities will not be realised.

Under this base case, with individual suppliers and countries pursuing multiple standards, then supply chains become fractured, implementation of processes and procedures becomes more complex and requires a higher degree of human intervention and the improvements in productivity and efficiency in use and re-use of resources is not realised.

Different national standards and regulations, so-called "non-tariff barriers to trade", can hinder the movement of goods - in some cases no less drastically than customs duties or import quotas (http://www.eu-info.de/europa/EU-Binnenmarkt/).

7.2 Scenario 2 Stretch Case – Standardisation/Interoperability of Industry 4.0 systems

Under a stretch case, international standardisation efforts proceed more effectively and there is greater interoperability between I4.0 systems and operations. This enables accelerated and more widespread roll out of I4.0 solutions across BRI cities (and beyond). Considering global interdependencies alongside global supply chains, completely new governance approaches will be necessary to link sustainable value chains on different spatial levels. Productivity and efficiency gains benefit local economies along BRI corridors and China's position as a global manufacturing powerhouse is reinforced.

The battles between process variations and standardization have to be balanced. On one side limits to uniformity and variability reduction pursuits, pulling towards zero have to be taken into account. Room for diversity and variations cannot be reduced to zero. Advancements in the implementation of standardization include a context for advocating when and where to pursue standardization.

On the other side creating process variations should always be approached with care in order to reduce unnecessary complexities and inefficiencies. According to Seselj (2018) organizations can follow the following steps to establish effective process variation management:

1. Establish a global standard process (provides the foundation upon which all variations are built and provides a benchmark against which to measure KPIs. It becomes possible to accurately monitor and manage local process variations).

2. Create justified local variations (variations must be highlighted so they're clearly visible against the standard).

3. Ensure visibility of all variations on standard processes (robust reporting and comparison capabilities facilitate the discovery and review of all adaptations per process).

4. Provide intuitive access to processes (users are automatically routed to the right process variations for their location, business unit or other relevant characteristic)

5. Issue change management notifications (Local process owners of variations are notified of adjustments to the standard process. They can either reverse those changes or incorporate them into their variation).

6. Facilitate global reporting (this allows global to review — and approve or reject — the lists of variations for each process).

7. Collect time and cost metrics (tracking and analysing these metrics enables the comparison of variations against standard processes).

Already existing internationally valid EMAS and ISO standards can be made even more demanding and checked more effectively if digitalized monitoring and control procedures are applied and consistently integrated. The results of the conferences of the World Circular Economy Forum (2017 and 2018) offer starting points for establishing internationally valid standards on a digitally optimized certification strategy for corporate environmental management (WBGU 2019).

7.3 Scenario 3
Pioneering – I4.0 integration to deliver sustainable BRI implementation

Building on the scenario above, within a pioneering scenario, full I4.0 implementation is linked tightly with sustainability principles and circular economy and industrial strategy in China and the EU benefit as a result. BRI cities fully embrace smart city principles, with smart transport, demand side energy management and smart buildings, smart grids able to accommodate high proportions of renewably generated electricity and effective re-use of materials and products all widespread.

BRI city resilience to economic, social and environmental pressures is increased and the model of planning and development used is exported to other regions. Therefore the use of digital technologies needs to be embedded in a sustainable development strategy for it to make a positive contribution to common digital future. This requires even looking beyond 2030, the target year of the UN Sustainable Development Goals (SDGs). New normative questions concerning the relationship between human beings and machines will arise. In order to meet these challenges, societal dialogue processes could support to staking out desirable futures (WPGU 2019).

The figure below (from the European Construction Technology Platform) shows the benefits of digitization (and hence I4.0) on the quality of the built environment and the way in which these improvements link to the Sustainable Development Goals. Under this pioneering scenario, these benefits would be most fully realised in BRI cities and the principles of sustainable development would be more clearly reflected.

International Standards can be used also as tools to help implement climate change mitigation and adaptation action. The ISO 14080, Greenhouse gas management and related activities – Framework and principles for methodologies on climate actions, supports the Paris Agreement. The standard provides a common framework for local and national governments to take appropriate actions for the mitigation and adaptation to climate change and helps them develop consistent, compatible and comparable policies and measures (ISO 2018). The framework aims to increase transparency related to measurement, reporting and verification (MRV), and to reduce risks for cooperative mitigation and adaptation actions. It recognizes the importance of international cooperation on adaptation and mitigation efforts and of taking into account the needs of developing countries.

European Committee for Standardisation (CEN) developed “guidance tools which ensure climate adaptation is embedded in all future European standardisation activities” (CEN-CENELEC, 2016). CEN defines a standard as “a set of recommendations or preferences recommended by a featured user group.” The Guide provides guidance on addressing aspects of climate change adaptation in European standardization documents. The Guide is applicable to product (including design), service, infrastructure and testing standards.

Ranges of climatic conditions have always been determined and specified for the proper functioning of products. Hence the climatic parameter values relevant to a product have been based on the climatic conditions prevailing in the area where the product will be used. Experience gained in the past years all over the world have shown that analysis of the past and current climate is not sufficient for being protected against climate change impacts. Design decisions that do not take account of climate based risks throughout the whole life may result in products that are not fit for purpose. Therefore product standards that ignore the effects of climate change may be failing at their main objective of ensuring fitness for purpose, further embedding vulnerability into our infrastructure and economy (CEN 2016).

RESIN (Hanania, Serene et al. 2018), has developed both information and tools to support climate change adaptation which have the potential to become formally and/or informally standardised. It provides an outline of the urban standardisation landscape in Europe, covering the benefits of (and barriers to) using standards for local climate change adaptation, outlining existing relevant standards for local governments, busting persistent myths about using them, and concluding with a set of recommendations for local governments and creators of standards.

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8 Recommendations – Linking Chinese and European Experiences

Based on existing activities Chinese and European experiences in cities could be linked in the following areas:

Smart Cities Initiative

The European innovation partnership on smart cities and communities (EIP-SCC) is an initiative supported by the European Commission that brings together cities, industry, small business (SMEs), banks, research and others. It aims to improve urban life through more sustainable integrated solutions and addresses city-specific challenges from different policy areas such as energy, mobility and transport, and ICT. It builds on the engagement of the public, industry and other interested groups to develop innovative solutions and participate in city governance.

At the same time nearly two-thirds of the world's population falls within the scope of the BRI, so it has the potential to change the lives of billions of people for the better and offer them new economic opportunities. There are multiple synergies in the conjunction of the Smart City Initiative, the concept of Industry 4.0 with 'Made in China 2025'.

Key conclusions are (UNIDO, 2017a):

- New technologies could help bridge some gaps and improve the functioning of existing infrastructure
- Partnerships are essential for bringing Industry 4.0 technologies to cities to transform them into smart cities.
- There are countless opportunities to make cities smarter through Industry 4.0 technologies, but the goal should always be to improve the quality of life in cities, rather than implement a purely technologically driven process.

Measure Industry 4.0 readiness of Industry and Cities

Cities with existing significant industrial capacities or the ones who want to attract such investments need to prepare for the changing needs of the industry and of their citizens. One of the core questions of this paper is if businesses and Cities are ready to harness the full potential of Industry 4.0 to benefit their clients, their communities and society more broadly?

There are multiple indexes, reports and rankings created and published that are measuring the competitiveness of a specific geographic unit from different angles. However there is a need for a special purpose index that focuses on the readiness of cities of the coming changes including the forth industrial revolution and climate change.

Regarding readiness of Industry the "Industry 4.0 Readiness" study commissioned by the IMPULS Foundation of the German Engineering Federation (VDMA) could serve for discussion. The Online Self-Check is broken down into six dimensions of Industry 4.0, each containing questions on a different set of issues(Lichtblau Karl et al. , 2015):

- **Strategy and organization:** To what extent is Industry 4.0 established and implemented in your company's strategy?
- **Smart factory:** To what extent does your company have digitally integrated and automated production based on cyber-physical systems?
- **Smart operations:** To what extent are the processes and products in your company digitally modeled and capable of being controlled through ICT systems and algorithms in a virtual world?
- **Smart products:** To what extent can your products be controlled with IT, making it possible for them to communicate and interact with higher-level systems along the value chain?
- **Datadriven services:** To what extent do you offer data-driven services that are possible only through the integration of products, production, and customers?
- **Employees:** Does your company possess the skills it needs to implement Industry 4.0 concepts?

These six dimensions are used to develop a six-level model for measuring Industry 4.0 readiness. Each of the six readiness levels (0 to 5) includes minimum requirements that must be met in order to complete the level. Level 0 is the outsiders – those companies that have done nothing or very little to plan or implement Industry 4.0 activities. Level 5 describes the top performers – those companies that have successfully implemented all Industry 4.0 activities.

Knowledge Exchange Platform activities in the field of Industry 4.0

The Knowledge Exchange Platform (KEP) is a form of cooperation between the European Committee of the Regions (CoR) and the European Commission's DG for Research and Innovation (DG RTD). Its main objective is to present new R&I solutions, innovative products and best practice in response to the numerous societal challenges facing local and regional authorities (LRAs) in Europe today. Important European policy goals depend on the timely availability of new technologies and innovation. Regions and local actors also play an important role in supporting innovative eco-systems through co-investment and different types of collaboration. Because of the high investment-intensive nature of the processes where Industry 4.0 is applied, the specific interest of regional and local governments in engaging in such processes must be explored in detail. KEP actions will be implemented in 2019 in the thematic research and innovation areas of Industry 4.0 (seminars, peer-to-peer visits, showcasing events).

Final remark

As the Industry 4.0 review that was conducted for the European Parliament's ITRE Committee noted:

"Industry 4.0 will only succeed [in Europe] if certain key requirements are met: standardisation of systems, platforms, protocols; changes in work organisation reflecting new business models; digital security and protection of know-how; availability of appropriately skilled workers; research and investment; and, a common EU legal framework to support the dissemination of Industry 4.0 in the Internal Market. If successfully implemented, the potential benefits of Industry 4.0 relate to productivity gains, revenue growth, and competitiveness".

As applied to new developments as part of BRI, there will need to be close governance of I4.0 implementation in order to ensure that expected benefits are realised.

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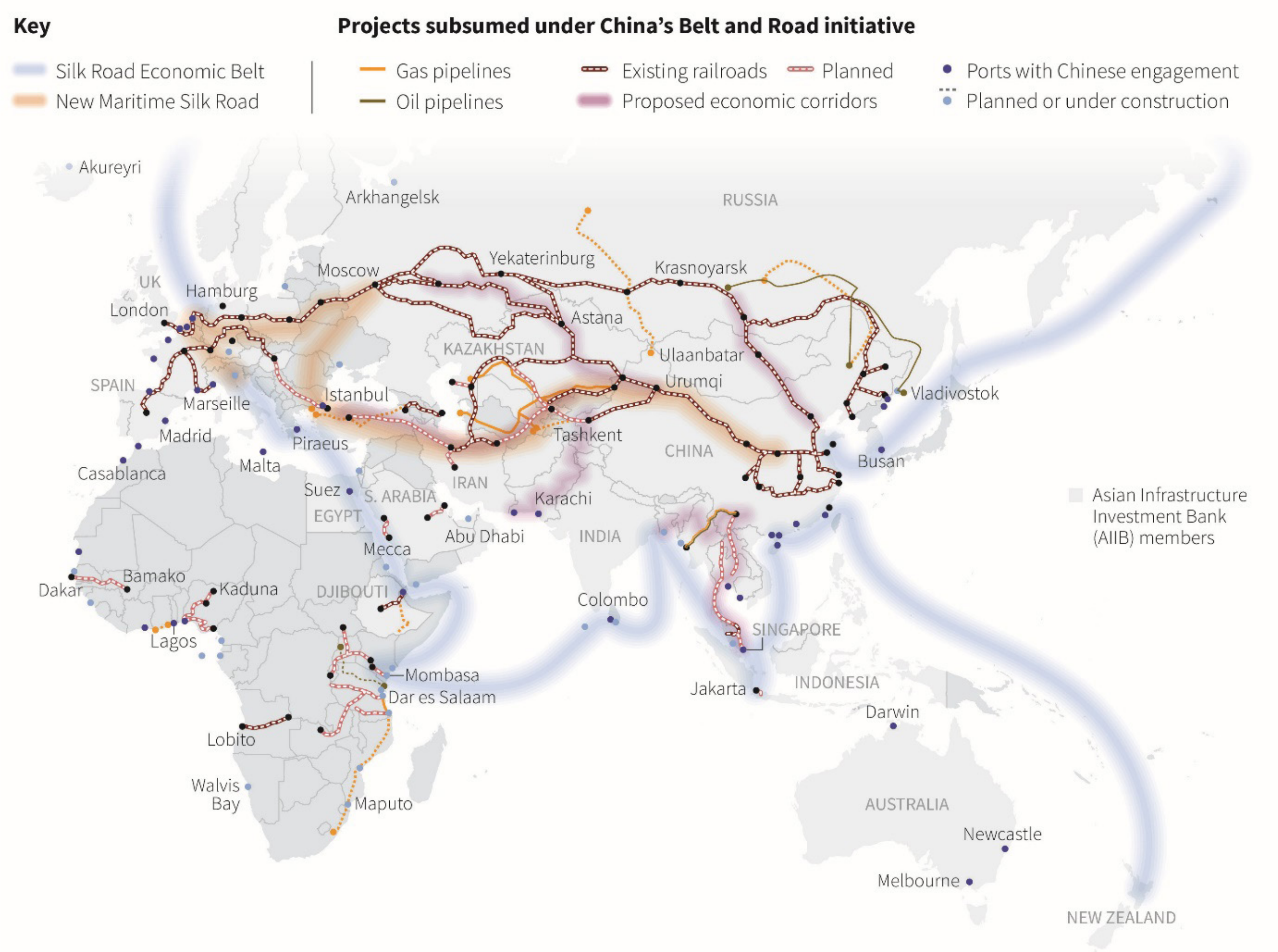
Reviving the Silk Road

Announced by Chinese President Xi Jinping in 2013, the Silk Road initiative, also known as China's Belt and Road initiative, aims to invest in infrastructure projects, including railways and power grids, in central, west and southern Asia, as well as Africa and Europe.



Source: Mercator Institute for China Studies.

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