WHAT DOES INDUSTRY 4.0 MEAN FOR SUSTAINABLE DEVELOPMENT?

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Abstract: *Sustainable development is an integral part of economic development in all countries, even when attention is driven away from it. The balance between the need of humanity to produce and the desire to not destroy the planet in the process is constantly questioned and shaken. With the disruptive new models that Industry 4.0 has shown to the world, and with the constantly expanding opportunities for technologies, production, and improvement of the way businesses function, the question of sustainability stands. How will the new business models affect sustainable development, and will they manage to put humanity's future in the spotlight? This paper explores the opportunities to sustainable development, introduced by Industry 4.0.*

Keywords: SUSTAINABLE DEVELOPMENT, INDUSTRY 4.0, BUSINESS MODELS

1. Introduction

Industry 4.0 – the fourth industrial revolution, is changing how the world of business functions. Baldassari and Roux[1] summarize that this new revolution of not only production, but also way of creation and design of products, processes and organizations, has come to existence because of the inclusion of various new actors into the way society and business function: artificial intelligence, machine learning, the combination of potential of hardware, software, and humans.

As this rapid transformation of businesses is creating a new atmosphere – one with more efficient manufacturing methods[2], collaborative industrial networks and optimized supply-chain processes[3] to start off, one with a new outlook on design and execution of production – there should also follow the question of how sustainable development fits into the unfamiliar and unique environment.

Sustainable development (SD) – the idea of living, working and developing as a society, while preserving the planet at least in its current condition, is one that more and more businesses and individuals consider as crucial. In this new setting, with abundant opportunities arising for businesses, the question of sustainable development remains.

This paper aims to showcase the threats, which should be tackled and the questions answered for SD to work, as well as the opportunities, which Industry 4.0 presents for SD.

2. Sustainable development in Industry 4.0

In order to understand how sustainable development can fit in the framework of Industry 4.0 the paper will compare the defining elements of Industry 4.0 with the challenges SD is currently facing. In finding the meeting points of the two, the best-case developments can be uncovered. The comparative analysis below is based on research in various countries and conclusions drawn in the last 5 years.

2.1. Elements of Industry 4.0

According to the Boston Consulting Group's 2015 report[4] on Industry 4.0, there are specifically nine technological advances, which have created the fourth revolution: autonomous robots, simulation, horizontal and vertical system integration, the industrial Internet of Things, cybersecurity, the cloud, additive manufacturing, augmented reality, and big data and analytics. Below, all these elements are more thoroughly discussed to give a better idea of how they could be used later in solving the challenges of SD.

- **Robotics** (which includes autonomous robots, as well as expert systems, digital assistants) is a constantly growing market all over the world[5]. Because of the vast capabilities in storing information, together with the possibility of using that information in increasingly intelligent ways (thanks to AI), improved human-computer interactions, as well as a stronger presence from the digital to the physical world (for example 3D printing), robotics are gaining traction in all fields and with countless applications – from manufacturing, to services, to personal development and beyond.

- **Modeling and simulation technologies** are a key factor for the development of Industry 4.0. They are crucial for the modern design, piloting and support of new products.[6] The new possibilities of virtual prototyping, as well as automation in manufacturing industries, increase efficiency and improve the quality of production.

- **Horizontal and vertical system integration** portray an integration between different value chains and between functional layers in an organization.[7] This integration allows for a greater understanding of all processes, as well as improved synergies in and between organizations.

- The **Industrial Internet of Things** is the increased connectivity of technology in the worlds of manufacturing, agriculture, mining, transportation, healthcare, etc. The integration and connectivity within those fields creates an entirely new relationship between humans and computers, and lays the groundwork for a completely different way of work with innovative job positions for all sectors – namely, decrease of jobs, which are unsafe and have low skill qualification needs, while more energy would be needed in engineering, data management and analysis, etc. [8]

- **Cybersecurity** in Industry 4.0 more than ever before comes to the forefront of businesses. Novel issues arise constantly, putting at risk not only brands but design, creation, continuous manufacturing of products. A wholly innovative approach is needed to deal with cybersecurity in Industry 4.0 – one that involves not only the basis of security and reactivity, but vigilant resilience, a proactive effort to keep security at the only acceptable level in Industry 4.0 – impeccable.[9]

- **Cloud technologies** are not only a way to integrate services and cut costs in IT expenses – they are an enabler of disruptive innovation and a path-creator for a so-called business fast-lane. In

[1] Baldassari, P. and Roux, J. D. (2017) Industry 4.0: Preparing for the Future of Work. People & Strategy. Summer2017, 40(3), pp. 20-23

[2] Kocsi, B. and Oláh, J. (2017) Potential Connections Of Unique Manufacturing And Industry 4.0. LogForum, 2017, 13(4), pp. 389-400.

[3] Ivanov, D. et al (2016) A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0. International Journal of Production Research, Jan2016, 54(2), pp. 386-402.

[4] Rüßmann, M. et al (2015) Industry 4.0: The Future of Productivity and Growth in Manufacturing Industries. The Boston Consulting Group.

[5] Violino, B. (2016) Robotics and Industry 4.0: Reshaping the way things are made. ZdNet.com

[6] Lopez, J. (2017) Industry 4.0 and the Internet of Simulations. IoTOne.

[7] Rathfelder, C. and Lanting, C. (2014) Smart Systems Integration in Industry 4.0. EPOSS General Assembly Annual Forum 2014.

[8] World Economic Forum (2015) Industrial Internet of Things: Unleashing the Potential of Connected Products and Services.

[9] Deloitte University Press (2017) Industry 4.0 and Cybersecurity.

manufacturing, but also everywhere else in business, cloud technologies are changing the processes and the people, which operate them, opening the doors for approaches and results never imagined before. It could even be said that cloud technology "democratizes" access to information, learning and communication.[10]

- **Additive manufacturing**, which portrays development in the world of design, testing, manufacturing, etc. such as 3D printing. This idea of true and effective, fast connectivity between customer, data, and production, is shifting the way products, as well as their separate pieces, are being made. Through rapid prototyping, solid free-form fabrication and 3D printing itself, additive manufacturing is changing processes, planning, design ideas, opportunity for creation, and not lastly – rapidly lowering costs all around this manufacturing line. Additive manufacturing is still spreading through its capabilities and it is yet to be seen what other opportunities will arise through it. [11]

- **Augmented reality** creates a bridge between virtual reality and data, which has been gathered with physical methods of analysis. This allows for a new approach to designing and repairing components and whole products. Through the creation of a suitable digital toolbox, designers, engineers, or technicians can improve their problem-solving capabilities, as well as vastly expand on their options for optimizing products and processes. Augmented reality also helps with connecting customers with their desired products more effectively, through the ability to see the possibilities with all necessary technical specifications, for example.[12]

- **Big data and analytics** are taking on newer meanings and new depths constantly. It has been noted multiple times by media and academics that data is the driver of the century, a commodity more valuable than oil.[13] With the increased capabilities of collecting vast amounts of data and even more than that – analyzing it in faster and smarter ways, big data and analytics pave the way for a transformation of understanding, producing, selling, etc. Now, more than historical data – real-time physical data like vibrations, noise levels and pressure is used in factories, as well as predictions, data on similar processes and various out-of-field innovations.[14]

These nine elements of Industry 4.0 work in synergy to incorporate each other in all aspects of all scopes of business, and slowly – all facets of life. Focus is starting to shift overall from labor-intensive jobs to high-qualified positions, which demand managing systems, still beyond the imagination of humanity.

With this in mind, it is not impossible to imagine that the new technologies and amazing capabilities, which are being developed, could be key for solving some of the world's most important problems.

2.2. Challenges for Sustainable development

Even though challenges for SD could be defined in many ways and though many approaches, the universally accepted measure of SD improvement and challenges is the UN's General Assembly's Resolution and Agenda on Sustainable Development.

In 2015, when setting the major goals for 2030, the UN outlined specifically 17 major goals with 169 targets for humanity with the overarching goal to "end poverty, protect the planet, and ensure prosperity for all"[15]. Accepted by world leaders and formulated as a continuation of the Millennium Development Goals, these goals are separated into five major categories: People, Planet, Prosperity, Peace, Partnership.

The categories are illustrated in the table below:

Table 1: SD goals

People	• No poverty • Zero hunger • Good health and well-being • Quality education • Access to clean water and sanitation • Gender equality • Reduced inequalities
Planet	• Climate action • Life below water • Life on land
Prosperity	• Affordable and clean energy • Decent work and economic growth • Industry, innovation and infrastructure • Sustainable cities and communities • Responsible consumption and production
Peace	• Peace, justice and strong institutions
Partnership	• Partnerships for the goals

The challenges for achieving the set goals in these categories vary. Some of the goals and targets are believed to be **too optimistic**, **too vague**, or just **unachievable** for the span of time, laid out in the goals. Compared to their predecessors, it should be noted, the goals are extremely **wide in scope** and cover a far greater amount of actions needed.

Even focusing on a single thought stream from the goals – for example, something very related to production, namely – limiting CO^2 emissions and finding alternative sources of energy – brings on a plethora of unanswered questions. This issue is often regarded as the biggest challenge for SD because of the scale in which this problem affects the planet and society's dependence on energy, produced by coal and other non-green energy sources.

As Meléndez-Ortiz[16] points out, this challenge has even bigger implications when taking into account the changing consumer patterns around the world and specifically in developing countries such as China and India. Even with emerging green energy sources, this challenge remains as valid as ever to the idea and goals of SD.

On a different note, as Singh[17] discusses, other key challenges for the timely achievement of the set goals are: **lack of substantial leadership** (to inspire not only policy change, but also investment, inclusion, awareness, and mobilization towards the goals), an **understanding of** the underlying tones of **the goals** (meaning an overall shift in the way people work, produce, consume, and spend their time), as well as **unification of** some of **the targets** for all countries (for example, setting universal standards for clean water, clean air, etc.).

[10] Oracle (2016) Cloud: Opening up the road to Industry 4.0

[11] Lopes da Silva, J. (2016) Industry 4.0 and Additive Manufacturing. Cepal, May 2016

[12] Wehle, H. (2016) Augmented Reality and the Internet of Things (IoT) / Industry 4.0.

[13] The Economist (2017) The world's most valuable resource is no longer oil, but data. The Economist, May 2017.

[14] Lee, J. et al (2014) Service innovation and smart analytics for Industry 4.0 and big data environment. 6th CIRP Conference on Industrial Product-Service Systems

[15] UN General Assembly (2015) Resolution adopted by the General Assembly on 25 September 2015.

[16] Meléndez-Ortiz, R. (2013) Trade and the Challenges of sustainable development. International Trade Forum 2013, 2, pp. 16-18.

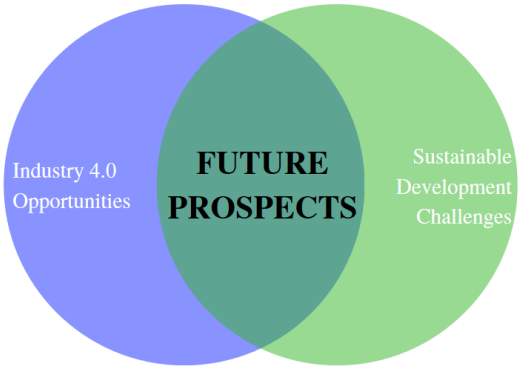
[17] Singh, Z. (2016) Sustainable development goals: Challenges and opportunities. Indian Journal of Public Health, 60 (4), pp. 247-250.

According to Lucci[18], some of the major challenges in the way of achieving the SD goals are **lack of access to information** of governments, **low quality of prioritizing** of the existing goals, as well as **lack of capacity of governments** to face the scale of the SD goals. As the cited article discusses, governments find many difficulties in fighting for the achievement of the goals because of lack of structured and abundant data globally, but also inside their own borders – how cities truly function, what the life is in the less-developed parts, etc. Without that data, as well as without the needed capacity of governments to even plan correctly the needs of their citizens for getting closer to the targets, the goals cannot be achieved.

The challenges for the achievement of the 2030 SD goals seem many and some of them – unsurmountable. However, another way to see the goals is as ambitious, and – fundamentally – as created with the goal to lead the planet and all its inhabitants to a better reality and better future. In the following sections, this paper will explore the intersections between the opportunities, provided by the development of Industry 4.0 and the challenges to SD, identified here. Through this, the paper aims to showcase how Industry 4.0 can assist the achievement of the SD goals.

2.3. Intersection of Elements of Industry 4.0 and Challenges of SD

As was already discussed, the developments, related to the emergence of Industry 4.0 can be related to the challenges of SD in an effort to solve the latter.



In the following table, the proposed solutions to challenges of sustainable development will be presented, in order to be later discussed in depth.

Table 2: Practical solutions for SD challenges

SD Challenge	Possible Practical Industry 4.0 Solution
Phrasing of goals: vagueness, overly optimistic targets, etc.	Robotics Modeling and simulation technologies (virtual prototyping)
Scope of goals	Robotics Augmented reality Big data and analytics
Lack of leadership	
Lack of understanding of the goals	Robotics Virtual prototyping
Lack of unified standards	System integration Cloud technologies Big data and analytics
Lack of access to information	Big data and analytics System integration Cloud technologies Augmented reality
Low quality prioritizing	Virtual prototyping Big data and analytics
Lack of governmental capacity	Robotics System integration Cloud technologies Augmented reality

As Industry 4.0 exemplifies interconnectivity, it stands to reason that more than one of its elements would constitute a possible solution, many times in synergy with others.

Robotics appears with either virtual prototyping or augmented reality as complementary elements. While the computational powers of robotics can create many options, virtual prototyping in this context can play out the created scenarios for easier decision-making. Augmented reality, on the other hand, will create a much clearer picture not only of the current state of the art, but will shine a light on the depth of the created possibilities – clear out the scope of the goals for policy-makers, for example, or demand fewer human resources for governments to handle the planning and execution of those plans.

Big data and analytics adds to this with the unlimited opportunities for gathering and analyzing data. This availability, if applied correctly, can be the key to solving some of the challenges even as a stand-alone tool: namely the lack of access to information, and the lack of unified standards. Big data and the powerful analytical capabilities, inherent in Industry 4.0, together with virtual prototyping can also create an easy-to-use way for policy makers to prioritize the SD goals according to the state their country is currently in, as well as to better understand the situation they are facing.

System integration can be the source of amazing synergies to help expand the capacities of governments, but also to combine information from many different fractions, which should be more integrated, but still are not. This will bring unification of standards – naturally – but also more transparency and greater availability of information across the border.

Finally, cloud technologies – they, of course, lower costs and provide wider accessibility, while making many processes, related to improving capacity, easier, faster, and significantly more effective. In that way, cloud technologies create staggering opportunities for the effective and efficient achievement of the SD goals – by providing wide and affordable availability of solutions for unification, awareness raising, spreading of information, processing, etc.

The penetration of Industry 4.0 is still ongoing and more and more of these processes and opportunities are still not completely available to governments for the achievement of the SD goals, which stand before all nations. Moreover, finding a solution for the lack of substantial leadership and motivation for investment, awareness, etc. is possibly one of the few challenges in front of SD, which have to be tackled not by advancements of technology, but by people themselves.

However, there already are examples of solutions, related to the innovations of Industry 4.0, which help along with making societies better, saving lives, creating efficiencies, interconnectivity, and ultimately - sustainable development.

Below, some of those examples are discussed as good practices before reaching the conclusions of the paper.

3. The future of Sustainable development

The future of SD has already started to unfold through the opportunities, which Industry 4.0 is providing.

[18] Lucci, P. (2015) Five challenges the sustainable development goals present to city leaders. CityMetric

For example, machine learning (AI) and an algorithm which collects and analyses data have identified a sex trafficking ring, thanks to the work of Rebecca Portnoff[19]. Through the combination of tracking transactions of bitcoin and using machine learning, Portnoff achieved results, which are undoubtedly resonant with the SD goals, as a part of her PhD thesis. The full potential of the software – but also of the ideas, which lie in the basis of this discovery, are yet to be discovered.

Another example of Industry 4.0 already assisting in the efforts to improve human lives and health is the AI, which together with augmented reality diagnoses patients with heart disease and gives them an estimate about their future condition[20]. This, the AI achieves with the help and based on aggregate data from many patients, historical data for the specific patient, as well as current data being collected on the vitals of the patient. Based on the diagnosis and the in-depth analysis, doctors can prescribe better treatment and improve the chances of patients to live. This technology may also be translatable to a wider scope of health irregularities, not only for heart conditions.

Not to be missed is also the developing notion and action of predictive policing – the assistance of big data and analysis to law enforcement, which prevents crime.[21] When implemented, big data can generate possible crime centres in the future, which can enable police to act before any harm has been done. This, as the cited article discusses, lowers restitutions and crime rates, and keeps communities calmer and safer. Further, predictive policing – in softwares such as PredPol or HunchLab, use various metrics and differing approaches to reach the same goal, and this means that there is still wide field for evolution. As of late, predictive policing is starting to be used internally, with bigger integration. instead of like a third-party software – like it has so far.[22] This suggests not only its advancements, but also developments of new features, such as software tactics suggestions and further Industry 4.0 upgrades.

As for government use of the benefits of Industry 4.0 – steps are being undertaken to get most governments ready for the cloud space[23], for example. Though this step, many more could be taken to immerse government in the vast possibilities of the new revolution. The current manifestation of this process is based on considerations on one of the less mentioned in this article elements of Industry 4.0 – cybersecurity. As governments are very aware of the potential risks of cloud computing, many measures are being considered and undertaken as part of a complete transfer.

Overall, there is no denying that Industry 4.0 is the future for many, if not all areas of life, including sustainable development. The many doors, connecting the increasing capabilities of technology and the innovative nature of humans can bring about countless opportunities for growth and success in achieving humanity's set goals. More than that – the future has already started and is evolving rapidly, involving more parts of life and showing more signs of consideration of the future to come.

4. Conclusions

This paper explored the connection of future prospects, created by the needs and challenges of sustainable development and the available opportunities, presented by Industry 4.0. Through comparing the two sides, the paper drew the attention to:

1) The importance of achieving the sustainable development goals;
2) The unexplored opportunities, presented by the existence of the Fourth Industrial Revolution.

As was discussed, there are many prospects, which are already being explored in this direction. However, what should be kept in mind is the number of targets of the 2030 SD goals, as well as the needed time period to test and integrate many of the possible solutions. These considerations show the pressing imperative of connecting Industry 4.0 and sustainable development.

[19] Portnoff, R. et al (2017) Tools for Automated Analysis of Cybercriminal Markets. Proceedings of the 26th International Conference on World Wide Web, pp. 657-666

[20] Furness, D. (2017) Artificial intelligence can now predict heart failure, and that may save lives. Digital trends, Computing.

[21] Phillips, A. (2017) Big Data Law Enforcement and the Rise of Predictive Policing. InsideBigData, Analytics.

[22] Shapiro, A. (2017) Reform predictive policing. Nature.com Comment.

[23] Melhem, S. and Kim, S. (2016) Flying to the Cloud: Governments Seek Gains from Cloud Computing. Connections note, The World Bank.