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To cite this article: H Ruohomaa and N Ivanova 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **337** 012032

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From solid waste management towards the circular economy and digital driven symbiosis

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Abstract. This article is about regional development based on the principles of circular economy and the industrial symbiosis framework. Nowadays tremendous amount of solid waste from household, industrial and agricultural materials accumulate in the territories of different countries around whole world. Finland has experience in waste techno parks design and in the development of waste branch around the whole country. Finland has considered be one of the leading country in Circular Economy and its government strategic goal is to be the leading country in the world in Circular Economy until 2025. The Finnish experience shows that there has to be close co-operation between companies, universities and authorities, but also common goal and understanding.

The main questions: which are the elements that could be adapted from the Finnish Circular Economy and the resource efficiency thinking, and how to implement ideas into other cultural and industrial environments in Russia. Our researchers together could discuss and decide which are the key elements that can be used and which of them contradict to using industrial symbiosis development in Russia.

1. Introduction

The World Economic Forum report [1] has termed this period of accelerating innovation in science and technology – the transformative change in data and technology capabilities combined with a merging of digital, physical and biological realms and its consequences on society as the Fourth Industrial Revolution. It is not only transforming social networks, scientific research and whole industries; it is also radically reshaping biological and material science innovations. Harnessing these opportunities and proactively managing the risks manifest by the rapid evolution of new science and technologies will inevitably require more creativity and agility in current governance frameworks and financing arrangements.

A crucial role in market evolution is happening by exploring how businesses can use the circular economy to drive arbitrage opportunities across complex, global supply chains [2]. A circular economy is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times. It questions whether with creativity and innovation we can build a restorative economy.

To be successful on new challenges of Industry 4.0 development, enterprise-university partnerships has to be intense and main objective should be a shared learning [3]. Long-term co-operation creates a background for new co-innovation and co- evolution. The technologies of the Fourth Industrial Revolution have generated enormous excitement about the opportunities they offer as well as concern about governance, regulation and ethics [1].



There are as well exciting possibilities: The convergence of new technologies is creating unprecedented opportunities in all aspects, from business-to-business commerce to humanitarian intervention. The melding of artificial intelligence (AI) with big data capabilities – not to mention the actual exponential accumulation of data itself – has created a fascinating world of communications, collaboration and interaction, not just between people but also between machines and between people and machines. Through digital transformation, the use of new technologies like big data, open data, cloud, IoT, platforms, artificial intelligence, and social networks with increasing intelligence and automation enterprises can capitalize on new opportunities and optimize existing operations to achieve significant business improvement [4].

2. Theoretical background

The new approach is the revised legislative proposal on waste. It covers long-term recycling targets for municipal and packaging waste, measures to limit landfilling, and incentives for Member States to use economic instruments at the national level [5]. It also aims to promote cooperation between industries, with waste from one process becoming secondary materials for others, through a simplified legal framework for by-products and end-of-waste status, creating more certainty for operators in these markets. That leads us for an opportunity to build value networks from the point of side flows of waste. It leads to a business opportunity for industrial symbiosis.

The key notice on sustainability is what extent it will be impact to specific business sector and influences on creation of circular economy business and industrial symbiosis. It is an industry-changing paradigm integrating innovation, differentiation and transformation. Tajani [6] has started, that there will be no sustainability without competitiveness, and there will be no long-lasting competitiveness without sustainability and there will be neither of them without a quantum leap in innovation.

Industry 4.0 describes the organization of production processes based on technology and devices autonomously communicating with each other along the value chain. Industry 4.0 architecture takes account of the increased digitalization of various industries where physical objects are seamlessly integrated into the information network, allowing for decentralized production and real-time adaptation in the future [7]. What is characteristics to Industry 4.0 is that it involves connecting products to each other. Industry 4.0 is a closely linked to Cyber-Physical Systems (CPS) [8] and can be defined as transformative technologies, which manage interconnected systems between its physical assets and computational capabilities [9]. To be successful on new challenges of Industry 4.0 development, enterprise-university partnerships has to be intense and main objective should be a shared learning. Long-term co-operation creates a background for new co-innovation and co- evolution. Adapting Industry 4.0 framework as a basis for development activities has expected to provide an opportunity for remarkable competitive advantage for businesses but also for regions [10].

Nidumolu, Prahalad and Rangaswami, [11] explain widely why sustainability is now the key driver of innovation. The biggest benefit comes from generating and processing big data. Information technology helps make large amounts of data available for different purposes in the public or private sector with minimum effort and costs [12]. Conradie & Choenni [13] have recognized that the most reliable method how to identify the datasets with big potential is a demand-based approach, which means a close cooperation with potential end users. Every participant in ecosystem has an opportunity to participate on creation of innovations and value, which generally is produced on the boundaries of ecosystem stakeholders [14]. Business ecosystem can be born as group activity or a single company can create it by collaborative activities [15].

3. Research questions and research approach

Nations are struggling with big global challenges like climate change, lack of resources, waste problems etc., but nations and companies are also facing changes because of digitalization at the stage of the fourth industrial devolution.

The role of circular economy and digitalization as a business driver is growing in waste management and as digital symbiosis in industrial innovation platform. The main research questions are

- a) What are the future key factors to solve waste problem on a sustainable way?

- b) How to manage change towards circular economy from waste management?
- c) How to evaluate the profitability of circular economy development investment?

This article introduces a concept model for utilizing circular economy and digitalization as a business and innovation driver to facilitate the transition from waste management towards circular economy and digital symbiosis.

4. Circular economy framework

The circular economy refers to an industrial economy that is restorative by intention; aims to rely on renewable energy; minimizes, tracks, and hopefully eliminates the use of toxic chemicals; and eradicates waste through careful design [2]. The system diagram in **figure 1** illustrates the continuous flow of technical and biological materials through the value network.

The term goes beyond the mechanics of production and consumption of goods and services, in the areas that it seeks to redefine (examples include rebuilding capital including social and natural, and the shift from consumer to user). The concept of the circular economy is grounded in the study of non-linear, particularly living systems [2]. This ensures enhanced flows of goods and services.

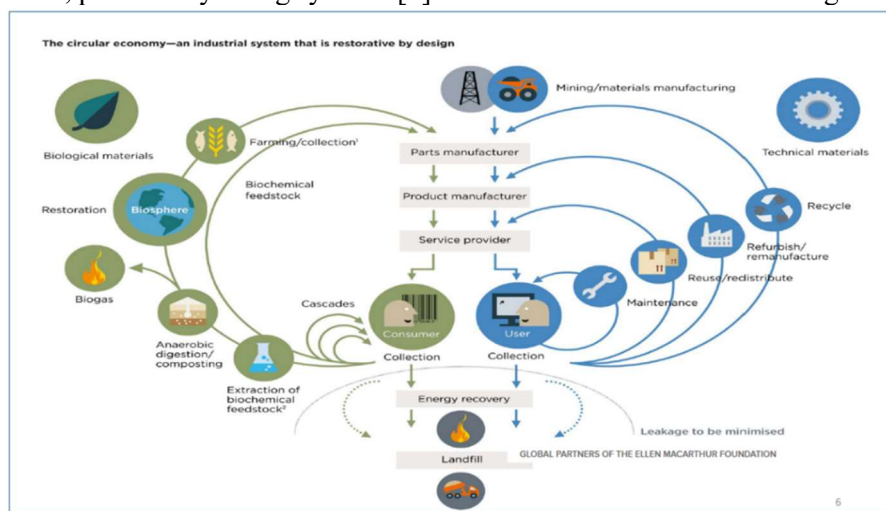


Figure 1. The circular economy - an industrial system that is restorative by design [2].

5. New business via industrial symbiosis

Changing economic structures, intensifying environmental problems and increasing demand-related requirements all mean that companies need to come up with more resource-intensive solutions. These can be achieved through co-operation between companies operating in various sectors, and alongside local authorities and municipalities.

Industrial symbiosis is an industrial ecosystem in which unused or residual resources of one company are used by another. This results in mutual economic, social and environmental benefits. It is a process involving several companies – firms that complement one another provide mutual added value through efficient use of raw materials, technology, services and energy. Joint development of industrial symbiosis provides an efficient way of thinking up, developing and testing product and service innovations. This, in turn, engenders new competencies, on which new business operations can utilize.

Business ecosystems based on industrial symbiosis provide more added value by using fewer natural resources than traditional industrial value chains. This means more efficient energy and water consumption, and reduced waste. In industrial symbiosis, industrial operations, energy production, primary production, waste processing and the services supporting these combine to form an entity that provides products and services for end-user needs, while optimizing resource use. [19]

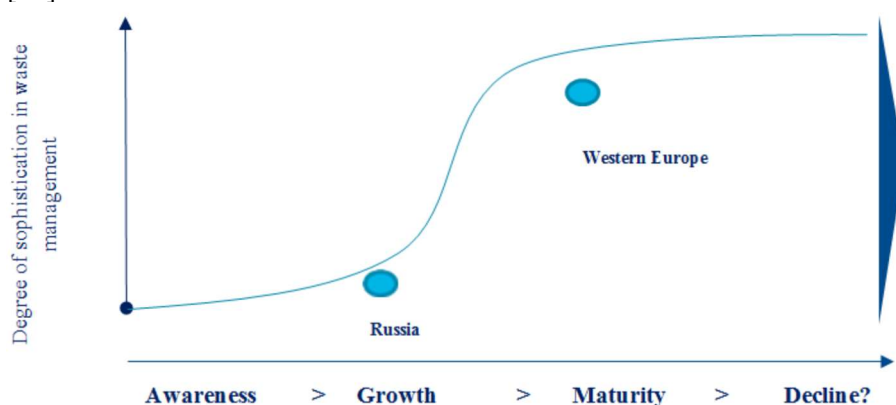
6. Challenges and opportunities in Russia

21st century is characterized as the first Urban Century in the history of humankind.

In Russia waste management was a challenge already in Soviet times, but since the beginning of 2000ies it has become one of the most critical economic and environmental problems in Russia. For many years, the Russian government's priorities focused on oil and gas, defence and heavy industries, while waste management was considered to be an issue for future generations and continuously neglected.

Russia has a legal and regulatory framework in the environmental area, but responsibilities are distributed between many bodies that enforce and control the regulations poorly. As a result, environmental protection in general and waste management in particular, is an increasing concern.

With recent changes in lifestyle, increasing waste volumes to such high levels that current facilities and outdated technologies are insufficient, the problem becomes definitely crucial. Experts believe that poor environmental situation contribute to a also short life expectancy at birth in Russian Federation [18].



Source: Frost & Sullivan

Figure 2. There is huge potential to develop circular economy in Russia [18].

Anyhow, comparison to western European development can be misleading, because of size of country or the structure of industry or the consumer habits. Eg. in case of Finland, all the waste is not collected and treated in a proper way because of long distances.

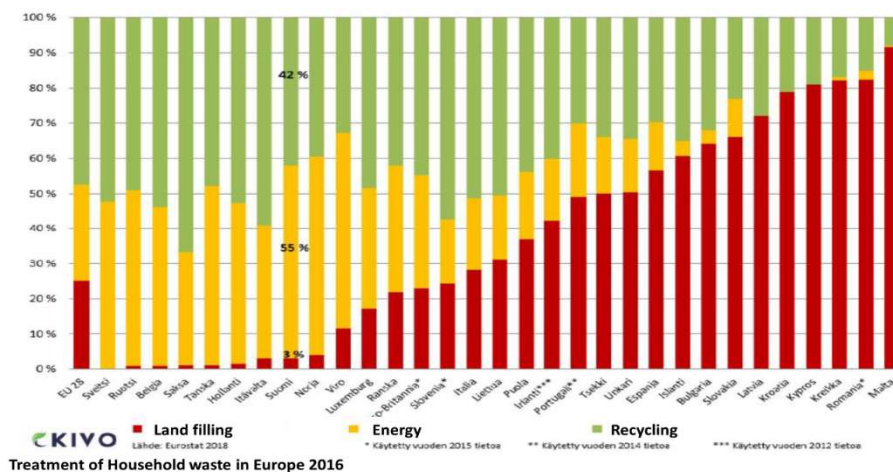


Figure 3. Treatment of Household waste in European countries in year 2016 [19].

Circular Economy concept has also a very strong strategic approach for many countries. Since some materials, which are needed in high-tech products, are running short and availability from the ground is decreasing. Therefore, those strategic materials, which are needed, are mainly in the products, which we use now.

In case of Finland, circular economy is a part of Finnish innovation policy and Finland wants be the leading country in circular economy in the year 2025.

Experiences coming from Finland show that joint development of industrial symbiosis provides an efficient way of thinking, developing and testing product and service innovations. This, in turn, engenders new competencies, on which new business operations can be based.

The co-operation between government, enterprise and universities is essential to succeed in co-evolution, when building up cumulative competence in creation of solutions for circular economy by benefiting digitalization in it. It is also essential to have a common vision to direct the local operation and funding. Otherwise, the activities can splinter as small pieces and do not form parts of the whole vision.

In rapidly changing operational environment, it a clear and commonly understood vision is required.

7. Forming triangle - Industrial symbiosis, digitalization and legislation

On the above mentioned, we can suppose that triangle consists of the industrial symbiosis, digitalization and legislation. This industrial symbiosis can involve stakeholders at all levels (companies, authorities of different levels and municipalities, smart and digital technologies and legislation agencies and experts) to develop a methodology and software platform to facilitate the exchange of information that can support industrial symbiosis networks, create and support pilot projects and replicate their results at local and regional levels.

Such model has to be designed on the triangle presented on the Figure 4 and, considering Economical Environmental and social issues during whole companies' lifecycle, it can lead to use fewer natural resources and more benefit. Applying these models can create new business and new challenges for companies and economy.

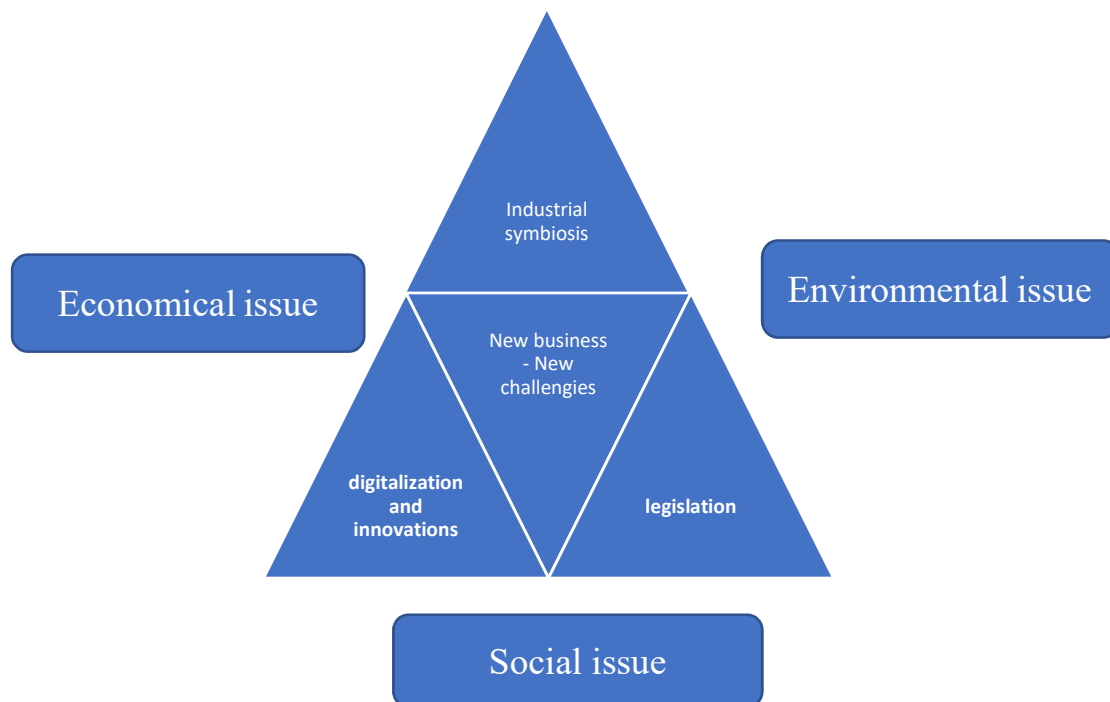


Figure 4. Industrial symbiosis, digitalization and legislation as forming triangle

8. Towards the opportunities of new material sources

Megacities are facing challenges in its waste management. On the other hand megacities have not yet been active to take use the latest concepts in circular economy thinking. Including this, in the fast

development of digitalisation, there will be new technical solutions in market, which can provide new possibilities and business models.

Therefore, there are new tools and concepts to build up the future approach and strategy to solve waste problem or, in the other words, take benefit to circulate material and use the waste for the materials of new products or turn into energy. One proposed approach is to take full use of the concept of circular economy and learn the best practices from other countries. Anyhow, learning the best practices does not mean simply coping ideas from other countries and bringing copies. In these cases, we should see learning so that we are able to implement the best practices, so that they fit into local environment and traditions.

In this case, the approach will be related to circular economy and digitalisation, there will be need for large and long-lasting cooperation between government, universities and enterprises to be able to manage the change. Anyhow, this change has to be seen so that it creates huge amount new innovation and build-up new business models and business.

The expenses of circular economy development should not be calculated in short turn business profit basis but it should be seen as long term strategic investment which will bring long term benefits to different sectors of society.

9. Discussion and Conclusions

Circular economy and industrial symbiosis should not be seen only the way to solve the waste management problem, but it can also be seen as the part of social and economic development. The change towards circular economy takes time and it needs actions from different sectors (universities, government and private sector).

Digital ecosystems and industrial symbiosis should be seen as continuous developing entirety, which will change and renew themselves thus maintaining their competitiveness.

Digitalization, circular economy and industrial symbiosis are the key drivers, which will change the business environments, a way to act and create innovation. Innovations will need “real life” (transdisciplinary) piloting environments. Both, resource efficiency and digitalization are directing towards service business and environments.

The expenses of circular economy development should not be calculated in short turn business profit basis but circular economy development should be seen as long term strategic investment which will bring long term benefits to different sectors of society.

References

- [1] Fourth Industrial Revolution for the Earth Series 2018 Harnessing the Fourth Industrial Revolution for Life on Land *Towards an Inclusive Bio-Economy*. World Economic Forum, January 2018, Geneva, Switzerland
- [2] Towards the Circular Economy 2014 Accelerating the scale-up across global supply chains World Economic Forum Report, February 2014, Geneva, Switzerland
- [3] Ruohomaa H, Mäntyneva M, Salminen V 2018 Renewing a University to Support Smart Manufacturing within a Region *Digital Transformation in Smart Manufacturing*
- [4] Salminen V, Kantola J, Ruohomaa H 2016 Digitalization and Big Data Supporting Responsible Business Co-Evolution *2nd International Co- Evolute Conference on Human Factors, Business Management and Society (Inside AHFE 2016)*, Orlando, USA July 27-31, 2016.
- [5] European Commission 02.03.2016 <https://kumu.io/ellenmacarthurfoundation/educational-resources#circular-economy-educational-resources/key-for-general-resources-map/intro-to-the-circular-economy>
- [6] EU Environment 2016 Taking Europe closer to the circular economy *Magazine Environment for Europeans*
- [7] European parliament, briefing (Sept 2015) 4.0 Industry digitalization for productivity and growth. <http://www.europarl.europa.eu/thinktank> (internet)
- [8] Deloitte (2015) Industry 4.0 challenge: Challenges and solutions for the digital transformation

- and use of exponential technologies
- [9] PwC (2016) 4.0 Industry: Building the digital enterprise. Global Industry Survey
 - [10] Ruohomaa H, Kantola J, Salminen V 2017 *Value Network Development in Industry 4.0 Environment Advances in Human Factors, Business Management and Leadership* (Cham: Springer International Publishing AG)
 - [11] Nidumolu R, Prahalad C K, Rangaswami M R 2009 Why Sustainability is Now the Key Driver of Innovation *Harvard Business Review*
 - [12] Kitchin R 2014 Big Data, new epistemologies and paradigm shifts *Big Data and Society*, April–June
 - [13] Conradie P, Choenni S 2014 On the Barriers for Local Government Releasing Open Data *Government Information Quarterly* **31** <https://www.researchgate.net/publication/261989071> (March 1,2018)
 - [14] Iansiti M, Levien R 2004 *The keystone advantage: what the new dynamics of business ecosystems mean for strategy, innovation, and sustainability* (Boston: Harvard Business School Press)
 - [15] Järvi K et al 2013 Ecosystem architecture design: Endogenous and exogenous structural properties *Acta Universitatis Lappeenrantaensis*
 - [16] 2018 Industrial Symbiosis - One man's waste is another man's raw material. *Sitra* <https://www.sitra.fi/en/topics/industrial-symbiosis/#what-is-it-about>
 - [17] Future of waste management in Russia 2018 Tekes, Helsinki, Finland Eurostad 2018, graph by CEWEP