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CIRCULAR ECONOMY IN SUSTAINABLE DEVELOPMENT OF CITIES

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ABSTRACT: The closed-loop economy, its opportunities and challenges, are of high interest to a growing number of organizations, especially industrial ones. However, an important role has to be played by the cities that spatially link different types of activities. Besides, local authorities have the potential to initiate and coordinate cooperation by connecting the activities of residents with the municipal economy and many industries. The purpose of this paper is to enhance awareness of the process of transforming the cities for circularity. It aims to provide some guidelines to the complexity of the process presenting the mixture of economic, management, environmental and social instruments. The main research methods were case studies analysis followed by literature and document review. The article explores the good practices of building an urban circular economy. It presents theoretical and application conclusions and recommendations. Special attention has been paid to the current activities in the Polish cities.

KEY WORDS: circular economy, local development, sustainable development, cities

Introduction

Cities play a crucial role in climate adaptation and mitigation. They are expected to be at the forefront of the battle with climate change. Urban areas account for a generation of more than 70% of global greenhouse gas (GHG) emissions worldwide. Climate adaptation needs a huge infrastructural transformation. Estimates show that the current needs of cities in meeting their infrastructural targets are 4.3 trillion \$ per year and an additional amount of 1.1 trillion \$ is required to ensure a low carbon future (CCFLA Report, 2015).

Nevertheless, new infrastructure and money are not enough. City leaders need to rethink and implement new urban models to minimize the use of energy, water and land in urban areas. Mental change is essential. Discussion on the green transformation derives from the need of a change of the general paradigm shift in economics. For decades numerous organizations and academics have been building the ground for a wider debate, from the Club of Rome reports, school of ecological economics and its steady-state economics (Daly, 1977) to prosperity without growth (Jackson, 2009) and Ostrom's research of the commons (Ostrom, 1990).

The current and urgent challenge is a system of circularity in resource flows. The circular economy introduces so called cradle to cradle philosophy. It incorporates resource utilization and efficiency, water efficiency and energy efficiency. The idea seems to be presented as a panacea for all the ecological problems of the Earth. The direction is good, but thinking of a circular economy as a technical solution for all the environmental problems is an utopia. The key challenge is reducing the consumption of resources. What is more, circularity model needs to incorporate aspects of health and social responsibility.

Urban transformation to a circular economy is under a policy of the global leading organizations. The United Nations and the European Union both have undertaken steps to make it real. In the UN policy, the Sustainable Development Goals adopted by the member states in 2015, include many aims related to circularity (<https://www.un.org/sustainabledevelopment/sustainable-development-goals/>). Moving to a circular economy is a crucial direction allowing societies to meet the goals of the Paris Agreement on Climate Action. Circular transformation can contribute to achieving the 2030 EU target to reduce greenhouse gas emissions by 40% i.e. 62 Mt of CO₂ eq per year (Meyer, 2011). Circular economy is part of UE policy to deliver the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth (European Commission, 2010). The European Union has endorsed the concept of a circular economy through recycling and waste management legislation and associated laws and regulations (European

Commission, 2014). The UE has also implemented the Ecodesign Working Plan to foster material reuse and resource efficiency (European Commission, 2016). In order to boost markets to circularity, some voluntary tools have been supplemented, such as the EU Ecolabel or Green Public Procurement criteria (European Commission, 2019).

Circular transformation is on its way. In 2016, four million people were employed in sectors related to the circular economy such as repair, reuse or recycling. Circular activities generated almost €147 billion of revenue and €17.5 billion worth of investments (<https://www.un.org/development/desa/en/news/sustainable/good-practice-circular-economy.html>). More intensive use of resources could also represent an overall savings potential of €630 billion per year for the European industry (Greenovate, 2012). The complex material cost-saving opportunities for the EU industry from circular economy approaches can boost EU GDP by up to 3.9% (Ellen MacArthur Foundation, 2012). It is estimated that resource efficiency improvements all along the value chains could reduce material inputs needs by 17%-24% by 2030 (Meyer, 2011). At the same time, a potential for a change is huge, as only 9% of materials are reused globally (Circle Economy, 2019).

The paper presents good practices in the field of urban circular economy and gives the key insights from the Polish experiences. The research is based on mixed methods. Case studies analysis was followed by a literature and documents review. The analysis was supplemented by interviews in the examined cities. Finally, based on synthetic overlook it provides a list of recommendations on how to support the process of circular economy in cities.

The idea of circular economy

The term circular economy has been coined to many environmental problems of the planet. A circular economy is about a systemic change. It requires a selection of priority areas where innovation is most needed to achieve deep decarbonization (fossil fuels) and effective adaptation. It supports to face the challenges of overconsumption. The initiative combines an approach of consuming less with an approach of consuming differently i.e. ecologically friendly. The orientation towards closed-loops in an urban economy is also associated with economic goals. It results from the optimization of the management process and the search for solutions improving the financial outcome.

Energy self-sufficiency is very often the driving force behind the transformation towards a circular economy. The prerequisites for independence

from energy suppliers are related to safety and economic criteria as a result of rising energy prices.

An urban circular economy is often limited to waste management. This is a particularly important sector of a municipal economy in this area. The circular economy model often uses the so called 3-R strategy (Reduction, Reuse, Recycling). This means returning the waste stream and processing it. The transformation of waste management to secondary raw material management is one of the cores in a circular economy. The complexity of the system also assumes a need for responsible and economical management of resources and their multiple use processes of exchange and new applications. This strategy therefore, includes direction to sustainable or green procurement, sustainable production and consumption or sharing economy.

The transition from a linear system to circularity requires a reformulation of a sequence of processes, which until now are commonly carried out in the following way: extraction-processing-using-disposing. This results in complex negative externalities, including pollution and waste. However, these by-products of consumption and production process do not have to be a ballast. They can become valuable secondary raw materials. Closing the cycles and introducing cradle to cradle concept requires a systemic approach to the functioning of socio-economic processes.

Many challenges for a transition to circularity have been identified. There are some which cut across many fields and seems to be crucial. These are a lack of political support, joined-up regulatory framework and common standards, data and institutional capacity (Williams, 2019).

A circular economy in cities – international practices

More and more cities in Europe face the challenge of creating a circular economy. Some cities already have advanced experience in this field. These include Glasgow, Barcelona, Brussels, Gothenburg, Ljubljana, Paris, Peterborough, Amsterdam, London, Helsinki, Cremona. These cities introduce many innovative solutions combining biological, technical, economic aspects as well as in the field of education and social impact. A lot of attention is paid to the promotion of knowledge about urban circular economy and indicating the role of the local community in this process.

One of the leaders of good practice in Europe is the municipal company Snaga from Ljubljana with over a hundred years of experience in waste management (<http://www.snaga.si/en>). The company is an example of a systemic approach to resource management in practice. Individually and in cooperation with the partners from the network is involved in the develop-

ment of a closed-loop system in Ljubljana and its surroundings and implementation of a “zero waste” strategy. A strong emphasis in the company’s activities is put on the education of the inhabitants and their involvement in conducted activities.

In Amsterdam, great achievements in co-creating the urban circular system are due to the original use of the game’s formula for involving citizens (Games for cities: circular Amsterdam). Local authorities and municipal companies indicate that the basis for successes is cooperation and the use of innovative tools of social impact. Through various games in the field of recycling, water-saving, energy conservation and the use of organic waste many partners are involved, in particular, the local community.

The game formula is also used by Recyclebank organization which has been developing since 2004. Recyclebank is a kind of social venture where recycling and reuse of valuable secondary raw materials are developed through social media and networking. A network of actors from different sectors combines activities for sustainable development. The activities are primarily focused on residents. The axis of the strategy of social impact is related to information and education policy. Raising ecological awareness is supported by a system of social impact by rewarding positive behaviors. Engagement with Recyclebank is rewarded with points from partners that can be exchanged for dedicated prizes, services or shopping discounts. The number of points is determined by RFID (Radio Frequency Identification) sensors installed on the recycling containers. Since its creation, Recyclebank has grown rapidly and now operates in several hundred cities, involving more than 3 million households (<https://www.recyclebank.com/>). Recyclebank is an example of a business model integrated with social and environmental goals.

A circular economy in cities – practices in Poland

In Poland, a process of building a circular economy is still at a low level. The outstanding project includes the pilot program by the Ministry of Entrepreneurship and Technology, Ministry of Environment and National Fund for Environmental Protection and Water Management implemented in Wieluń, in the Łódź voivodeship¹. In this commune of 23,000 inhabitants, as the first since July 2018 is implementing a governmental project testing various solutions that fit into a local circular economy. These solutions in a systemic way

¹ The program implemented within inter-ministerial team for innovation entitled “Road map of the circular economy for Poland”. Apart from Wieluń, the municipalities of Krasnobród, Łukowica, Sokoły and Tuczno took part in a pilotage. Their task is to develop good practices in urban circular economy. A program budget is PLN 40 million.

link eco-innovative infrastructure with technological instruments, as well as economic and social impact. The program implemented in Wieluń placed great emphasis on environmental education. It is also pointed out that the pro-social character is important for the final success.

The most important infrastructural task is the construction of a composting plant in the vicinity of the waste segregation line in Ruda and the waste sorting line. The recycling of secondary raw materials in the production process is mainly based on their selective collection at source. In the urban space, underground containers have been located, from which waste is directed to further segregation at the RIPOK area (Regional Plant for Processing of Municipal Waste). The costs of selective collection are financed by the fees paid by the plastic recycler operating in Wielun. The inhabitants, who are the main actors in the process are supported by appropriate infrastructure and motivated by instruments of social impact. They have at their disposal an EcoTech System IT platform, mobile application and vending machines for the return of recyclable materials. There are 30 Reverse-Vending Machine (RVM) in the city that accept cans, plastic and glass. Similarly to the Recycle-bank model described above, participation in the selective collection of recyclable materials is scored. The collected points are settled, e.g. in fees for water and sewage, but not only. Moreover, the EcoTech platform is connected to a system of discounts offered by the city and the partners – for the swimming pool, cinema or shopping in local shops. System EcoTech records the disposal of waste into the vending machine. In return, it assigns points to the particular resident on the electronic card and mobile application.

As part of a circular economy system in Wieluń, the city has signed a contract for the collection of so called alternative fuel (Refuse Derived Fuel – RDF) with a cement plant located 200 km away from Wieluń. It is also planned that water from sewage treatment plant will drive a small hydropower plant. The sewage sludge will be used as an input for the biogas plant. The commune also wants to collect rainfall from the urban area in a small retention reservoir. The energy efficiency will be improved by LED street lightning in a whole municipality, as well as in schools and municipal institutions. Besides, 8 out of 10 city busses will be replaced with electric ones. A rental of electric bicycles ordered from the local manufacturer is also planned. The energy driving these vehicles will be produced in the city. Part of an investment program is a geothermal borehole and under favorable conditions a geothermal heat and power plant. What is more, a biomass heat and power plant and a photovoltaic farm are planned on an area of above 1,5 ha (installation of photovoltaic panels above a parking lot for the entire industrial zone). Each parking lot will have a charging station for electric cars. According to forecasts, by 2022 Wieluń will be energetically self-sufficient and all the energy consumed

by the municipality will be from renewable sources (http://samorzad.pap.pl/depesze/dobre_praktyki/177833/Gmina-z-GOZ--Burmistrz-Wielunia-w-5-lat-wdrozymy-gospodarke-o-obiegu-zamkniety).

The example of the city of Tychy in the Silesian voivodeship is also worth disseminating. Unlike Wieluń, Tychy has a bottom-up, self-government initiative to build an urban circular economy. The Tyski model is based on a synergy of industries such as: waste management, water supply and sewage disposal, transport and energy. The main cooperation partners are Master Waste and Energy, Regional Center for Water and Sewage Management (Regionalne Centrum Gospodarki Wodno-Ściekowej S.A. w Tychach – RCGW), The City of Tychy Transportation Company (Przedsiębiorstwo Komunikacji Miejskiej w Tychach – PKM). The cooperation consists of a systemic connection of the production processes, in which by-products or even ballast of activity for some become valuable resources for the others. Cooperation within the circular economy implemented in Tychy is called SymbioTychy energy area. It is worth noting that environmental education is an important element of the Tychy circular economy model.

The Master company specializes primarily in the collection, transportation and management of municipal waste as well as selective waste collection. It also develops activities in the field of renewable energy, production of alternative RDF fuels, as well as the production of high-quality compost for soil improvements. Master serves 190 thousand inhabitants and manages the waste stream from eight stakeholder municipalities including: Tychy, Imielin, Chełm Śląski, Łędziny, Bieruń, Bojszowy, Wyry and Kobiór. The main indicators of the Master waste management process include: recovered secondary raw materials sent for reuse and recycling 11000 Mg/ year (12%); production of alternative fuel 8000 Mg/ year (9%); production of compost 4000 Mg/ year (5%); reduction of biodegradable waste used for biogas production (about 25%). At the beginning of 2018, the Company launched a compost under the market name KOMPO-MASTER. Processing organic material into fertilizer and compost production means returning valuable organics in the form of humus to the soil. The compost produced by Master improves the physical and chemical properties of the soil. It can be used in agricultural and energy crops. It can also be used to reclaim degraded agricultural land, as well as to set slopes and roadside embankments.

Another partner, RCGW, owns more than 400 km of sewage and sanitary network, 34 pumping stations and operates the Tychy-Urbnowice sewage treatment plant. It is the first passive sewage treatment plant in Poland and the leader in terms of energy balance among water and sewage companies in Europe. The begging of co-fermentation in RCGW date back to 2009. This year the dosing of waste whey and waste from a nearby dairy plant started.

The energy self-sufficiency of the sewage treatment plant in Tychy is 120-150%². The caloric value of biogas obtained is 16,7 – 23 MJ/m³ and the caloric value of pure methane is 35,7 MJ/m³. In 2015-2016 RCGW was the leader of the OMEGA research and development project under the GEKON initiative entitled “Development of the system solution for energy recovery from sewage sludge with the use of gasification process”. The result of the project is the production of so-called biocarbon, which average energy value is 12 MJ/kg of dry sludge. RCGW is also the investor and operator of the Tychy Water Park, which is fully supplied with electricity and heat from a self-sufficient energy system of the sewage treatment plant.

The third leader of the Tychy consortium is PKM, which is the owner of the largest fleet of CNG (Compressed Natural Gas) bus in Poland (75 buses). PKM is one of the leaders in the city transportation industry in the field of environmental transformation. The methane used to drive the bus fleet of the Company is obtained from partners i.e. Master and RCGW. In their plants, the production process gives biogas in the amount of 1,6 mln m³ (methane content 56,6%) and 6 mln m³ (62%), respectively. The share of alternative fuels in PKM is 55% (demand – 2,9 mln CNG Nm³). The target for 2021 is 100% (demand – 4700000 CNG Nm³). PKM Tychy reduces the negative impact also by reducing noise level (reduction of around 40%) and exhaust emissions generated by the bus fleet. The achieved emission reductions are as follows: CO – 82%, NMHC – 100%, NO_x – 52%, PM – 70%, CO₂ – 20%.

Way to circular transition – conclusions

In terms of circular transition, cities are a problem and a solution at the same time. Adaptation and transformation in production and consumption patterns are part of the international discourse in sustainable development. There is an emerging recognition of the importance of cities within the sustainability debate. Improvements in resource efficiency performance are within reach and can bring major economic benefits.

Sustainable urban development and linked urban circular economy are part of systemic thinking. This implies a complex change, and innovation, in technologies, organization and societies. It emphasizes interdisciplinary dependence of social, economic and environmental components and processes. A circular economy requires changes throughout different value chains, from product design to new production and consumption.

² The average value according to IGWP in 2016 was 40,86% for large enterprises and 47,71% for medium enterprises.

Building a circular economy implies a definition of the economics' foundations in its basic assumptions. These range from economic development, environmental policy instruments to combating energy poverty or the promotion of civic education and sustainable consumption. Confronting consumption and life styles with production solutions is increasingly important in terms of the sustainable development of cities. It requires aligning the consumer behavior with cultural context and promotion of urban eco-friendly policy.

Among the key interdependent directions of transformation towards urban circular economy, the following actions should be included:

- Optimizing the use of raw materials in the biological and technical cycle – Solutions include composting, CO₂ sequestration in the ground, fermentation and transformation of waste into compost and other products (search for innovative applications). There are great opportunities to reduce the amount of landfilled waste and reuse – about 30% of the total mass of municipal waste is organic, so called bio. They can be used to improve soil properties and biogas production. It is postulated to increase the use of biogas in a household, transport, agriculture production, e.g. food waste to food (greenhouses).
- Social education – The level of civic awareness, including ecological awareness translates into a real involvement of residents in the process of co-creating of city circular system. It is necessary to strengthen communication and information with particular reference to local conditions and the role of residents. It is important to clarify the direct interrelations between various local processes and the importance of individual users of urban services. Educational activities should be implemented systematically, using many forms and instruments depending on the target group. Social impact tools and positive incentives included in sustainable development strategy bring real changes beneficial to the society, economy and environment. A special role is played by locally oriented social campaigns i.e. involving schools, educational institutions and locally targeted raising awareness of social benefits from a circular economy.
- Impact on social processes – Increase of bio-waste collection from households and gastronomy and simultaneous improvement of monitoring and enforcement of environmental regulations. Increased pressure and control, e.g. a system of photographing and not collecting unsorted waste. Introduction of incentive programs and a deposit system. It is postulated to implement a deposit system that increases the share of material recycling (in Lithuania, the collection rate increased from 7 to 33%).
- Economic impact – Introduction of mechanisms for extended producers responsibility (EPR). The European Union calls for at least 50% of waste

management costs to be transferred to packaging waste producers. Establishing guidance on the possibilities offered by the new public procurement directives in the field of Green Public Procurement (GPP), and a recommendation on monitoring Member States' performance in achieving the indicative 50% GPP target (European Commission, 2008).

Conclusions

Environmental impacts arising from the scale of overpopulation and overconsumption are important reasons for new solutions, especially in urban areas. The pace of economic development, an increase in the level of wealth and consumption and a growing number of people requires rationalization of social and economic processes. The limits are the potential of natural resources and the absorptive capacity of the Earth ecosystems (Ripple et al., 2017).

Poland is looking for its own way of implementing a circular economy. Current urban policy misconstrues the relationships between resource flow and production and the long-term consumption in the cities. While waste management is not all about a circular economy, the amount of waste in urban areas makes the subject very urgent. A circular economy model means a high increase in the reuse of secondary raw materials in urban areas.

In Poland, an insufficient share of selectively collected waste at source was recognized as the basic problem of waste management. As a result, there is little progress in recycling. This situation is a loss both in economic and environmental terms.

The presented examples suggest that cities can make strong efforts to limit the consumption and environmental pressure of the cities. The example of Wieluń shows that it is an early testing phase based on the adaptation of mechanisms from other countries. New infrastructure and technological solutions are undoubtedly necessary for the success of the entire system. However, in Poland particular emphasis should be placed on educational activities and instruments of social impact. Residents become agents of change, and the role of authorities, institutions and business is to provide mechanisms of transition from linear to a circular economy. Their understanding of the idea of the system and motivation supported by economic incentives is crucial for the process of building the urban circular economy in Poland.

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