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Master thesis

Principles of circular economy in the operation of a school

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Theses guidelines

Objective:
The aim of the thesis is to assess the current situation and make suggestions for application of the principles of circular economy in a grammar school.

Methodological approach:

1. Theoretical background
2. Data collection
3. Data analysis
4. Results
5. Proposals and conclusions

Framework structure:
1. Introduction. Objectives. 2. Review of literature. 3. Methods. 4. Results, potentially discussion. 5. Conclusion. X. References X. List of Annexes (if any) X. Annexes

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Lacy, P., Long, J., & Spindler, W. (2020). *The circular economy handbook: Realizing the circular advantage,* Palgrave Macmillan, UK
Larrumbide Gómez-Rubiera, E., Gallego Sánchez-Torija, J., & Bedoya Frutos, C. (2019). *Zero cost conditioning techniques to improve the indoor environment of school buildings.* Revista de la Construccion, 18(3), 525-535.
Stahel, W. R., & MacArthur, E. (2019). *The circular economy: A user's guide.* Routledge.
Tagliabue, L. C., Consalez, L., Mastrolembo Ventura, S., & Ciribini, A. L. (2016). *The Educational Building in the Circular Economy: an Extended Concept of Asset Quality.* Ciribini A., Alaimo G., Capone P., Daniotti B., Dell'Osso G., Nicolella M., a cura di, BACK TO, 4, 331-340

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STATEMENT

I hereby declare that, in accordance with Article 47b of Act No. 111/1998 Coll. in the valid wording, I agree with the publication of my Master thesis, with deferment for three years to be kept in the Faculty of Economics archive, in electronic form in publicly accessible part of the IS STAG database operated by the University of South Bohemia in České Budějovice accessible through its web pages. Further, I agree to the electronic publication of the comments of my supervisor and thesis opponents and the record of the proceedings and results of the thesis defence in accordance with aforementioned Act No. 111/1998 Coll. I also agree to the comparison of the text of my thesis with the Theses.cz thesis database operated by the National Registry of University Theses and a plagiarism detection system.

I hereby declare that the submitted master thesis is my own work and that I have used only the sources of information acknowledged and referenced in the list of used literature. For the thesis I have used information that cannot be published due to the existence of an agreement between the University of South Bohemia and CIRA Advisory s.r.o. and such information is available exclusively to the members of the committee for the defence of the thesis and to the reviewers.

13.8.2021 *Bc. Markéta Čapková*

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Introduction

7.7 billions people live on one planet Earth. The Organisation for Economic Co-operation and Development (OECD) assumes that the material consumption and its impacts on the environment will double before 2060 without any measures (Ministerstvo životního prostředí České republiky, 2021). According to the United Nations research, by 2050, our population will consume as if there were three planets, and the annual waste generation will increase by 70%. By the same year, big countries also committed to becoming climate neutral and decoupling economic growth from resource use (United Nations).

Over the past decades, there has been a lot of discussions about the relationship between the environment and the economy. As climate change is alarming and some action grows urgent, economies will suffer as a result of moving towards sustainability. But it has become clear that economic prosperity and employment depend in fundamental ways on a stable climate and healthy ecosystems. This is why the interest in the circular economy concept is increasing in popularity, and its principles are becoming part of business plans in many companies. "Green jobs" are future key economic drivers as the world steps into building a low-carbon global economy. Environmental limits, climate change, and the transition to a sustainable, low-carbon, and to circular economy will influence production and consumption patterns, enterprises and workers, institutions, and educational systems. Investing in the environment to increase its productivity, protect its stock of resources and harness its services is indispensable, makes economic sense, and underpins growth.

The United Nations point out sustainable development in their 17 SGs. Paragraph 28 of the 2030 Agenda reads:

"We (Countries) commit to making fundamental changes in the way that our societies produce and consume goods and services. Governments, international organizations, the business sector and other non-state actors and individuals must contribute to changing unsustainable consumption and production patterns, including through the mobilization, from all sources, of financial and technical assistance to strengthen developing countries' scientific, technological and innovative capacities to move towards more sustainable patterns of consumption and production. We encourage the implementation of the 10-Year Framework of Programmes on Sustainable Consumption and Production. All countries take action, with developed countries taking the lead, taking into account the development and capabilities of developing countries (p. 12)."

Moreover, the European Green Deal, a document created by the European Union, launched a strategy with concrete steps for a climate-neutral, resource-efficient and competitive economy. The main goals are: keeping the resource consumption within planetary boundaries, reducing consumption footprint, doing production in a more sustainable way and doubling circular material use rate. It is basically a model of economic growth that respects the planet and gives back to nature more than it takes. The Green Deal and transition towards a circular economy will also be a big and important part of the new EU industrial strategy. It closes irresponsible production and consumption but opens a big door for new business (and not only) opportunities. From the human point of view, citizens will have at their disposal high-quality, local, functional, long-lasting, and safe products which can be reused, repaired, or recycled. New behavioral patterns of no waste production will be developed and adopted by countries, regions, institutions, companies, individuals.

Circularity is an important and essential part of an overall industrial transformation towards climate neutrality, long-term competitiveness, and material savings. The circular economy seeks sustainable production and responsible consumption. Innovation, digitalisation, and collaboration will accelerate the economy and make the world less dependent on primary materials. Transferring to the circular economy model will also upgrade knowledge and skills and create new job opportunities.

All knowledge gain and profiling of our interests start at school. Educational institutions have a big role of mentors of world conception and put things into context. Therefore, they have a big potential in teaching and transferring experience and knowledge in the topic of environmental protection, sustainability, and circular economy. There is a small sample of inspirational case studies about the circular economy in school institutions. Moreover, it is easy to find in literature some analysis of sustainability management at schools in terms of education and reducing environmental footprint in general. However, little focus is on implementation of the circular economy into real business models at school management to go hand in hand with innovation.

This is the reason why this thesis sees the needs of a research in the fild of circular economy in educational institutions, will concentrate on introducing the prinicples of circular economy into practice in terms of daily operation of schools and can stay as a good example, inspiration and motivation for other educational institutions to build a functioning circular economy management. It can also be applied as a foundation stone for further research and studies of the implementation of circular economy principles at schools and improvement of the effectiveness

of the sustainability management processes. Moreover, the proposed methodology can go beyond the boundaries of the education area and can be used as a driving change in other organisations in the service sector that are looking to move towards the circular economy.

1 Theoretical background

Several notions such as “green economy”, “green growth”, and “circular economy” have been developed to support the concept of “sustainable development”. Not all of these terms fully cover the whole idea of sustainable development. In this paper, the focus will be given on the circular economy concept.

Schools as educational institutions are the basis for spreading the idea of sustainable development and the concept of the circular economy into society. It is therefore important to focus on sustainability and the circular economy from an early age. However, schools can be active not only in the education of children, but they can also be an example of good practice and put the principles of the circular economy into practice.

In the course of writing this work, it was found that professional texts, which can be used to address the issue of sustainability and circular economy in the school environment, are very sparse in modern Czech and international literature.

We therefore relied mainly on the official documents of the European Union dealing with sustainability strategies and setting goals for the coming years, which we supplemented with similar available documents issued in the Czech language focusing on strategies in the Czech Republic. These resources contain mainly general information, but are a suitable inspiration and a basis for further research.

1.1 Linear economy

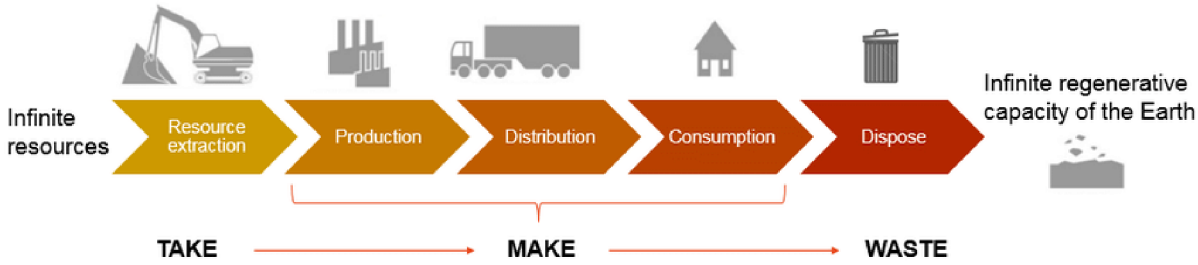
If we go back to history, the economy was always here, but the meaning the society knows it these days lies in the industrial revolution in the 17th century. Thomas Savery developed the first steam engine in 1684 and it started the Industrial Revolution that laid the foundation for how today’s economy operates. Since that time, raw materials and energy were seemingly infinite. For the first time in history, goods were mass produced (Ellen MacArthur Foundation).

As technology and innovation is a very fast developing process, companies can produce more and more products with less and less costs, people want more goods for less money and society started to prefer quantity to quality. Also, people have access to products from all around the world at affordable prices (Ellen MacArthur Foundation).

The linear "take, make, dispose" economic model, which is built on a system of large quantities of cheap, easily accessible materials and energy, has been at the heart of industrial development and has generated an unprecedented level of growth. Nowadays, increased prices, supply chain risks, and growing pressures on resources have pointed out to business leaders and policy makers the necessity of rethinking the supply chain, materials and energy use – to develop the idea of a circular economy (Ellen MacArthur Foundation).

The population keeps expanding and material demands increase, pushing against the limits of what the planet can provide sustainably and runs in the concept of linear economy post-war industrial growth model: take – make – waste. We take material from the ground, we make products that are used and when we no longer want them, we throw them away. Even if big companies make more and more money, the linear economy is a short-sighted growth. The near-future resource sufficiency and heavy costs on the environment, through waste production and greenhouse gas emissions put a big risk on the planet. The overuse of natural resources by humans is increasingly going beyond planetary boundaries. The biggest challenge of today's world is climate change (Ellen MacArthur Foundation).

Figure 1 *Model of linear economy.*



Source: Wautelet (2018), p. 18.

Shifting from the "take – make – consume – dispose" linear economic system towards a circular economy model, where materials and products are reused for the longest possible time in closed-loop systems, represents an instrumental strategy for sustainable development. Circular economy is a concept that introduces a diverse spectrum of complementary strategies to support sustainable resource management from a cradle-to-cradle perspective.[1] Transition from the linear economy to the circular economy model can be achieved by a systemic change, requiring

[1] Cradle to cradle system is explained later.

changes in the economic, political, and socio-cultural patterns (Vasileiou, E., Arvanitidis, S., 2020).

This concept calls for rethinking the production and consumption processes, legislative frameworks, and consumer needs and expectations. The facilitation of the transition to the circular economy is needed to share by businesses, policy-makers, and citizens, where active cooperation between actors is necessary (Mendoza, Gallego-Schmid, Azapagic, 2019).

1.2 Circular economy

1.2.1 Definitions of circular economy

There does not exist any unified definition of what a circular economy is. In 2017, there were more than 100 definitions of the term "circular economy" (Strategický rámec cirkulární ekonomiky České republiky 2040, 2021).

Every source gives different wording and sometimes also a different point of view. Among the definitions, here are some of them:

According to the Ellen MacArthur Foundation:

"A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. Transitioning to a circular economy does not only amount to adjustments aimed at reducing the negative impacts of the linear economy. Rather, it represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits."

The same organisation, Ellen MacArthur Foundation (2015), gives also a little bit different different definition:

"A circular economy is one that is restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. A circular economy addresses mounting resource-related challenges for business and economies, and could generate growth, create jobs, and reduce environmental impacts, including carbon emissions."

The Czech Institute of Circular economy (Institut cirkulární ekonomiky) explains circular economy as:

"A sustainable development concept, which enables for a functional and prosperous relationship between nature and the human society. By closing the loops of materials in perpetuous cycles, circular economy opposes our current linear system, where resources are turned into products, sold, consumed, and after a very short lifespan burned, landfilled or lost in other ways."

Buren, Demmers, Heijden and Witlox (2016) explain that:

"The circular economy (CE) can be defined as a concept whose implementation entails reducing the consumption of raw materials, designing products in such a manner that they can easily be taken apart and reused after use (eco-design), prolonging the lifespan of products through maintenance and repair, using recyclables in products, and recovering raw materials from waste flow (p.647)."

WRAP (2017) in the UK uses the term to describe *"an economy in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life."*

In general, circular economy can be specified as an alternative concept of growth that includes sustainable development and gives waste back to the process into new sources. It is a less wasteful and more resourceful economic model.

There are 3 basic pillars of circular economy:

- regenerate natural systems,
- design out waste and pollution,
- keep products and materials in use.

1.2.2 3R rule

All this concept is also completed by the 3 R rule: "reduce, reuse, recycle" which is one of the results of the G8 Sea Island Summit in June 2004. G8 leaders agreed to launch in 2005 the "Reduce, Reuse, and Recycle Initiative," a plan aimed at cutting down on waste, promoting recycling, reducing barriers to trade in goods and materials for recycled and remanufactured products, and promoting science and technology on relevant technologies.

This rule was then generally extended by "refuse". Nowadays, it is upgraded to 7 R: rethink, refuse, reduce, repurpose, reuse, recycle, rot. And it is even possible to find a 9 R model: refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover. More details are evident in the next infographic which was created during an experiment workshop organised by Julian Kirchherr and Laura Piscicelli in the Netherlands. Students discussed how products could be redesigned to increase their circularity based on the 9R framework.

Figure 2 *9R rule in redesigning products.*

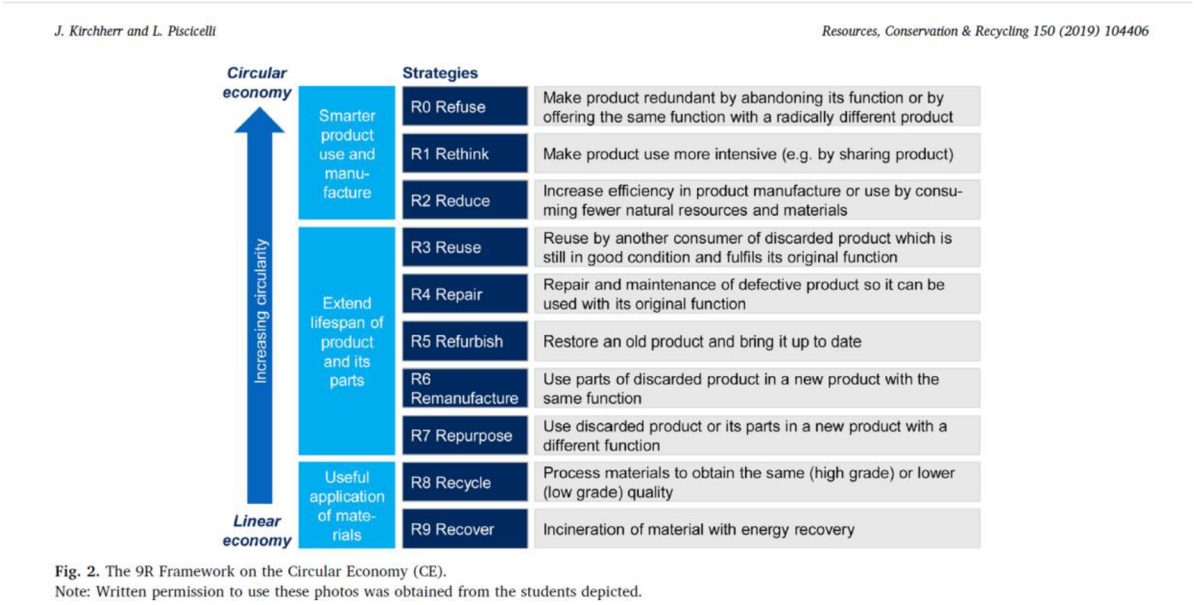


Fig. 2. The 9R Framework on the Circular Economy (CE).
Note: Written permission to use these photos was obtained from the students depicted.

source: Kirchherr, J., & Piscicelli, L. (2019). Towards an education for the circular economy (ECE): five teaching principles and a case study. Resources, Conservation and Recycling, 150, 104406.

It is evident that rethinking the whole consumption concept in today's globalized world, where people in western countries have a big choice of products and are enabled to buy them almost always, is the key solution for circularity. Reducing consumption in general is the basic, reuse and repair of products are the next steps – something that was normal for people a century ago as well as for the generation of our grandparents but is not usual in the daily life of today's generations. Unfortunately, it is also often caused by higher costs of repair service, inaccessibility of spare parts, or laziness of people. Buying a new product at the same price as its repair or even lower is an easier option for consumers. Recycling of materials (when whole products are not able to be reused anymore) is only the penultimate solution, and the last possibility of how to save the used product and keep it in circulation is a recovery of material.

1.2.3 Detailed description of the circular economy

The Ellen Mac Foundation, one of the pilot and nowadays leading organisations in the field of circular economy, finds that the circular economy creates four opportunities for value creation:

- minimising material use (e.g., efficient cycles),
- maximising material use (e.g., long cycles),
- having diversified options (e.g., multiple cycles),
- and the benefits of ensuring uncontaminated material for reuse (e.g., pure cycles).

They predict global material savings valued between $595 and $706 billion per year for fast-moving consumer goods and profits of $172 per tonne of food waste from the transition towards a circular economy (Nunes, Pollard, Burgess, Ellis, De los Rios, & Charnley, 2018).

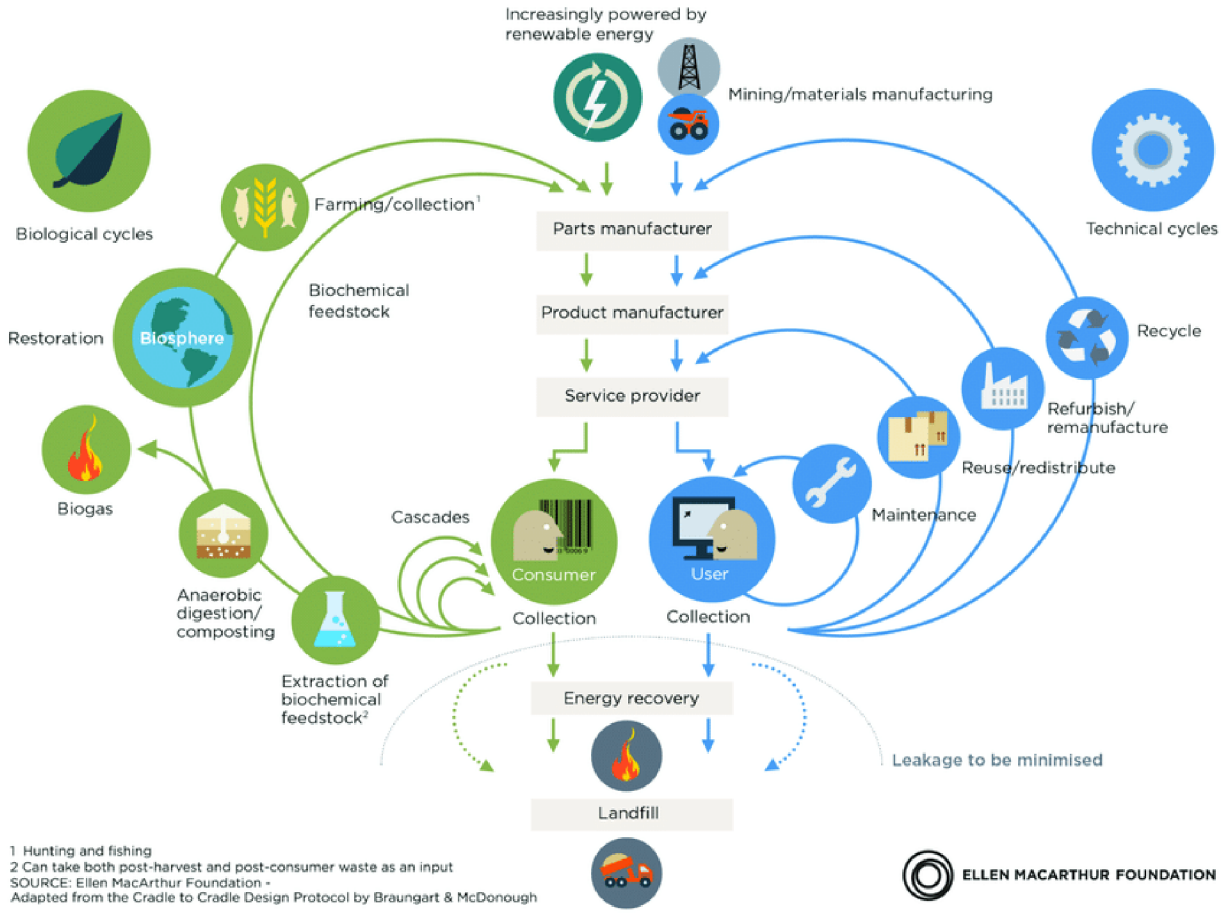
The functioning of the circular economy is very well described in the infographic below. Products are kept in circulation; all parts are used, there is only a small inevitable amount of waste, and the rest is used into new sources of material for new products.

Figure 3 *Model of circular economy.*

source: Institut cirkulární ekonomiky.

Detailed description of the circular economy model is in the following infographic:

Figure 4 *Detailed description of circular economy model.*



source: Ellen MacArthur foundation.

On the basis of previous explanations and infographics, it is evident that one-use products should be avoided. There is no place for them in the circular economy. Circular products have these basic characteristics:

- long lifetime period thanks to its durability and repair ability;
- prolonged lifetime thanks to reuse, service, repair, technical modernisation and combination of all mentioned before;
- production of technical materials that are able to recycle into new materials/products or biological materials that are easily compostable (Ministerstvo životního prostředí České republiky, Strategický rámec cirkulární ekonomiky České republiky 2040, 2021).

In 2020, the European Commission presented a new Action plan for Circular Economy that follows the previous activities of European Commission in previous years. In this strategy, the Commission focuses on the circular economy in many areas that were identified as key areas for the development of the circular economy in the European Union. The New Action plan concentrates therefore on the product politics that will enable sustainable products, services and business models to be standards and consumer behaviour will change in the form that no needless waste will be created .

1.3 United Nations – 17 SDGs

The circular economy could serve as a useful tool for overall sustainable development. Sauvé Bernard and Sloan (2015) confirm this statement but argue that its final goal still seems unclear and certainly narrower than sustainable development. Also, Andersen (2007) identifies the need for the circular economy to extend its focus to include sustainable development in its trajectory.

The international programme Local Agenda 21 (LA21) was signed by 172 countries of the world including the Czech Republic at the Earth Summit held in 1992 and in the Czech Republic, LA21 is included in the State environmental policy and in the Czech Republic Sustainable development strategic framework (Government resolution no. 37/2010). Conclusions adopted at the world summit aim at a strategic management of towns and communities and their practical implementation of the sustainable development principles at the local and regional levels.

The United Nations developed the 2030 17 Sustainable development goals that are connected to the circular economy. It is an internationally recognized strategy that aims at economic growth to be more sustainable. The effort to make the economy more sustainable and circular lies in almost every sustainable goal, here are the most relevant:

Goal 12: Ensure sustainable consumption and production patterns

Target 12.1

"Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries"

It is clear that even developed countries will be the motors of the change. In this case, it is relevant to mention the Czech national strategy "Cirkulární Česko 2040" (Strategický rámec cirkulární ekonomiky České republiky 2040, 2021).

Target 12.3

"By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses."

For this goal, in the Czech Republic, for now, there are only some initiatives like "Zachraň jídlo", "Nesnězeno" and others which deal with the meals there were not eaten during the day in restaurants and people can purchase them into a box for take away for a lower price. There exists no legislation about food wasting in Czechia for now – nor at a national level, neither for schools.

Target 12.5

"By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse."

Target 12.7

"Promote public procurement practices that are sustainable, in accordance with national policies and priorities."

This goal can be achieved by "Cirkulární zadávání" that is mentioned later in this paper.

Target 12.8

"By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature."

This is the point when schools must take action – in terms of including circular economy in teaching programme as well as being a good example of practice. It is important to educate also teachers who can transmit their experience and knowledge to students.

In the question of circular economy, the UN clearly give this responsibility to more developed countries as defined in goal 8:

Goal 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Target 8.4

"Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead."

More attention put on waste management is specified in goal 11:

Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable

Target 11.6

"By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management."

PAYT – Pay as you throw system – The Ministry of the Environment of the Czech Republic launched a public education about waste management system when particular buildings and households pay only for the municipal waste they actually throw away. Thir programme aims to motivate people to recycle their rubbish and save money.

All goals have their own indicators to measure the level of success. If all nations take the action and develop the general SDGs into their national strategies and individual entities and individuals follow these strategies, the whole society can accept the new concept of economy.

1.4 Waste management as a part of European conclusions about the circular economy

Waste management is one of the most important parts of the circular economy concept and great emphasis is placed on it in this work as well. However, it is just a piece of the whole concept. The European Union is taking the steps to implement the concept of the circular economy in the field of waste by publishing the (UE) 2018/851 Directive, establishing an improvement in waste management in order to protect and preserve the quality of the environment and human health, promoting the principles of circular economy and improving the use of renewable energy.

Mentions about ecology, sustainability, climate, prevention or waste management have always been part of the EU conclusions. Already in the 1992 Treaty on European Union, the creating

document of the EU, there is a part where the Community and Member states undertake the responsibility to create a framework for preventing the waste generation and eliminating the sources of contamination (Treaty on European Union, 1992).

In the Community strategy for waste management from 1997, the Council declared that the waste prevention is the best tool and the main priority of waste management and added that the re-use and recycling principles will be preferred where possible as the best ecological options (Community strategy for waste management, 1997).

Another measure of waste prevention was presented in the Sixth Community Environment Action Programme, promulgated by Decision no. 1600/2002/EC where the sustainable management of sources and wastes is presented as one of its four priority areas. In this Action Plan, there is a need for clear waste legislation precising details of the difference between wastes and non-waste materials, and a call for measures for preventing waste generation and for management of the wastes already produced, with the target setting (Decision No 1600/2002/EC).

The next document Communication from the Commission on the thematic strategy of waste prevention and recycling, COM (2005) 666 criticises the high share of waste dumping (landfilling) and calls for new options of alternative handling of wastes and creation of a waste management hierarchy (A Thematic Strategy on the prevention and recycling of waste, 2005). Finally, in 2014, the wording "circular economy" appears in the connection to the waste management in the a European document concentrated on zero waste. (Towards a circular economy: A zero waste programme for Europe, 2014).

In Europe 2020 – A strategy for smart, sustainable and inclusive growth, the main directions of the EU development towards competitiveness and economic and social advancement are presented: achieving sustainable growth and making the economy less resource-intensive (A strategy for smart, sustainable and inclusive growth, 2010).

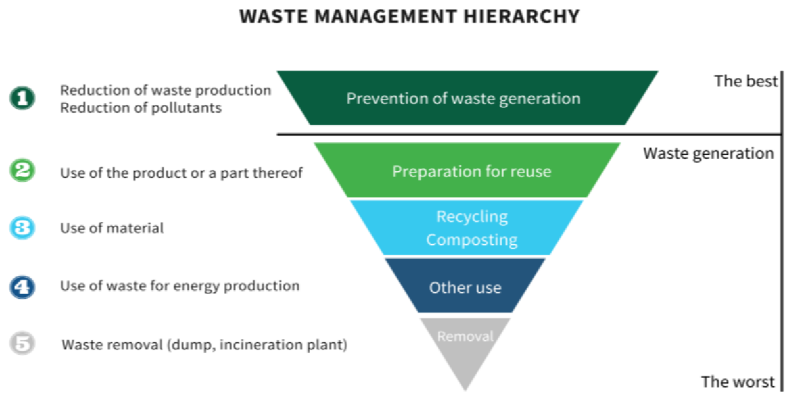
The same year, when the awareness about the waste management problem is visible everywhere, the European Parliament and the Council no. 1386/2013/EU promulgated the Seventh Environment Action Programme – a General Union Environment Action Programme to 2020, entitled "Living well, within the limits of our planet" where the attention is paid to turning waste into a resource, to waste prevention, to the preparation for re-use and recycling, and to gradually phasing out inefficient methods such as landfilling (Living well, within the limits of our planet, 2010).

In all these documents listed below, there is an overall strategy for interrupting the interdependency between economic growth and environmental impacts arising from waste generation. However, theoretical documents are one part of the strategy; the second one consists of changing societal behavioral patterns.

1.4.1 Waste management hierarchy

For good waste management, there exists the so-called waste management hierarchy. It is evident that the best option is to prevent waste generation in general. If there is some necessary waste, its reuse or reuse at least of a part of it should be enabled. If reuse is not possible, recycling or composting (in the case of organic waste) of material should be possible, or waste can also be used for energy production. The worst option and the option that should be used only when it is really necessary is waste removal.

Figure 6 Waste management hierarchy.



source: CIRA Advisory s.r.o.

1.4.2 PAYT – Pay as you throw

According to the Czech Waste law, each municipality is obliged to assure municipal waste-collecting place for the waste produced by its inhabitants who are not in business. The municipality must also arrange spots for recycling. However, the manner of payment depends on the municipality itself. The amounts of waste charges, therefore, vary considerably. The amount of the fee depends, for example, on the location of the place of residence, the contract with the transport company, the city management and other factors. For comparaison: in 2020, inhabitants of Prague paid 2 904 CZK, when people in Brno (the second largest city in the Czech Republic) paid 670 CZK, and people in Sušice (a town in the South-West of Bohemia

of about 10000 inhabitants) paid only 500 CZK (skrblik.cz). Also the amount differs if it is considered as an amount per person, per year or per dustbin.

One of the possibilities that contribute to a better waste management system and to the whole circular economy concept, is the Pay As You Throw system (PAYT). The PAYT system aims at motivating people to reduce their municipal waste because of the price that depends on the amount of waste they produce. The system allows people and households to pay the amount of money only for the waste they really generate and there is no fixed amount. For now, there is no legislation proposed about the PAYT system. The Ministry of the environment of the Czech Republic does not set down concrete rules and requirements for municipalities on how to introduce and run the PAYT system. Conditions can differ in each municipality as the actual waste management does (Ministerstvo životního prostředí České republiky, 2020).

1.4.3 IoT (Internet of Things)

As another option for municipalities, there exists smart waste management systems that are at their beginnings. The connection between hardware and software enables to register and map all dustbins in the municipality/district, control the level of waste in dustbins (thanks to chipping) and plan the waste collection (route optimisation). It is therefore effective both, from the economic and environmental point of view. On the basis of the data collected and analysed from the controlling system, it is possible to add/remove some dustbins, plan the collection more effectively and improve the infrastructure in the whole municipality. The whole dustbin monitoring system assures clean waste collection places, transparent waste flow, effectiveness of waste management and prevention of overflowing dustbins. It is very efficient also in the case of waste that is not filled on a regular basis (such as textile waste, electronics, etc.).

As an example, it is possible to mention the company Sesoneo (https://www.jaknachytreodpady.cz/).

1.5 Barriers for the circular economy transition in the Czech Republic

The level of the circular economy in the Czech Republic is in general lower than in the rest of the EU. Moreover, the Czech Republic does not dispose of an independent strategic framework

for the circular economy that would present a comprehensive plan for future arrangements for the circular economy transition.

Some of reasons are described below as a result of an analysis that was a part of a project "Cirkulární ekonomika jako příležitost pro Českou republiku – Dlouhodobá koncepce pro přechod na oběhové hospodářství" (Circular economy as an opportunity for the Czech Republic – Long Term concept for the transition to the circular economy):

- Legislations do not limit waste generation (for example a low price for dumping)
- Rooted functioning of the linear economy
- Legislative rules do not support sufficiently the product design for repeated usage or recycling
- Low interest and awareness of customers
- Limited demand from the contracting authority
- Low price of primary materials and insufficient legislation for the establishment of second material markets
- Complicated quality guarantee of products made from secondary materials
- Lack of data dealing with linear/circular economy and their impacts
- Limited financial means for circular projects
- Technological difficulty for circular solutions
- High initial investitions
- Low standard of circular products and processes
- Lack of pilot projects (TA ČR project 02000234).

The document "Strategický rámec cirkulární ekonomiky České republiky 2040" (Strategic Framework of the Circular Economy of the Czech Republic 2040) set 10 top priorities for the Czech transitions towards the circular economy in the following 20 years:

- Products and design
- Industry, material, construction and energetics
- Bioeconomy and food
- Consumption and consumers
- Waste management
- Water
- Development, research and innovation
- Education and knowledge

- Economic tools
- Circular cities and infrastructure

Figure 5 *Priority areas on which the strategic framework Cirkulární Česko 2040 focuses.*

Circular economy strategy: Economic tools – Circular cities and infrastructure – Products and design – Industry, raw materials, construction industry, power industry – Bioeconomy and food – Consumption and consumers – Waste management – Watter – Research, development and innovation – Education and knowledge
source: Strategický rámec cirkulární ekonomiky České republiky 2040.

1.6 Notions related to circular economy

1.6.1 Bioeconomy

"The bioeconomy means using renewable biological resources from land and sea, like crops, forests, fish, animals and micro-organisms to produce food, materials and energy" (European Commission).

Bioeconomy, therefore, describes everything that we produce with renewable biomass. Bioeconomy should be used as a tool for the circular economy. Bioeconomy can contribute to the circular economy in several areas – transformation of organic waste into compost, improvement of the ground quality, reduction of food waste, etc. It also has a great potential in innovation, new technologies, new materials and investment.

In the Czech Republic, there is a small connection between circular economy and bioeconomy for now. Bioeconomy should play a more important role in implementing the circular economy. Czech sales in the bioeconomy sector are 40% lower than the European average. There is therefore a big potential to improve the low-carbon economy in Czechia (Strategický rámec cirkulární ekonomiky České republiky 2040, 2021).

One of the discussed topics at the United Nations is the Green economy as a tool for sustainable development. The green economy relates and is connected to the circular economy. Governments agreed at Rio+20 that the green economy is inclusive and can drive economic growth, employment, and poverty eradication whilst maintaining the healthy functioning of the Earth's ecosystems.

1.6.2 Product design

The major problem with linear economy starts at the very beginning of every product. The environmental impacts of all products are already determined at the design phase. The linear pattern of economy "take – make – use – dispose" does not motivate and prepare producers with inducement to make their products circular. The majority of products then break down very easily and quickly. They cannot be repaired or recycled. The most linear products reside in one-use products (European Commission, 2020).

There exist already some legislative initiation for designing products more sustainably and circularly such as Ecodesign Directive, Ecolabel or the EU green public procurement criteria, but there is not any comprehensive and complete list of requirements for ensuring that all products in the EU market are sustainable and circular (European Commission, 2020).

The European Commission will propose a sustainable product policy legislative initiative as an efficient working toll to ensure that products and services fit in a climate neutral, resource-efficient, sustainable and circular economy. Products will improve their durability, reusability, upgradability, recyclability and repairability and will be more energy and resource efficient without any unhealthy chemical materials. This system covered by a legislation will lead to reduction of carbon and environmental footprint, to which the EU undertook for example in the Paris agreement and can be an impulse for other legislative measures in the future. A policy like that would support the systematic adaptation of an environmentally friendly life cycle of products, idea of sustainable innovative business models and of the circular economy as well.

1.6.3 Cradle to Cradle

According to Braungart, McDonough and Bollinger:

"Cradle to cradle production is an approach of intelligent material pooling to achieve eco-effectiveness by viewing all material inputs and outputs either as technical or biological nutrients. Technical nutrients need to be cycled in different streams to biological nutrients which can be readily reintegrated in natural ecosystems." (Braungart, M., McDonough, W., Kälin, A., & Bollinger, A., 2012), p.1337.

They promote a cradle to cradle (C2C) approach based on the idea that resources are ideally never turned into waste but are kept in the loop for as long as possible with minimal loss of quality.

The Cradle to Cradle principle is the basis for the circular economy. The loop of resources is closed, all materials are kept in circularity and all waste is avoided.

1.6.4 Eco-effectiveness

"An eco-effectiveness approach includes the identification of a desired positive outcome and then focuses on the development of products and industrial systems to achieve that target. Braungart et al. explain that the goal of eco-effectiveness is not merely to minimise the cradle to grave flow of materials, but to generate new sustainable cyclical cradle to cradle processes that can enhance the quality of resources. Rather than just focusing on minimising harm, eco-effectiveness seeks to identify the desirable ecological aspects of products and systems (e.g., enhance the quality of materials) and then defines and implements a strategy to achieve that target." (Nunes et al., 2018).

1.6.5 Eco-efficiency

Eco-efficiency is a management strategy of doing more with less. It is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution. Eco-efficiency is a sustainability measure combining environmental and economic performances (Klemeš, 2015).

Some of the approaches stress eco-efficiency as the purpose of the circular economy or even its synonymous. Other approaches consider eco-efficiency as one of the consequences of the circular economy implementation, together with economic value and job creation, reduction in

emissions and waste, improved resource security and decreased price volatility for resources (Kalmykovaa, Sadagopanb, Rosadoc, 2015).

1.7 Circular economy in the built environment

However, in the 70s and 80s, the whole world started to realize the impacts of the population on the environment, and researchers discussed the fact that economic development and profitability can happen without resource depletion, in the 1990s buildings were responsible for 40% of the material and a third of the energy consumed globally. Currently, the built industry is still the world's largest consumer of raw materials and is the cause of 25-40% of global CO_2 emissions. There exist buildings of 30/40 years that are being demolished due to their low quality. This is the reason why there is a lot of pressure from the natural environment on buildings. The role of the circular economy is therefore essential in this case. Circular economy in the built environment means mainly reducing the use of resources, energy and the flow of waste over the life-cycle of products. However, the research in the circular economy focuses on manufactured products or eco-parks, ignoring the big part of daily life – constructions. (Larrumbide, Sánchez-Torija, & Bedoya, 2019).

The building is usually analysed before and during construction in terms of energy incorporated to the materials. The circular economy also thinks about the energy used in buildings through their useful life, as well as considers what happens once the useful life of the building ends. Because it is not the building itself that uses energy and materials, but people and inhabitants do. This is the explanation of the limitation that if users of buildings are not motivated to conserve energy and transfer to the circular economy, there will be no serious progress. For reducing the use of energy in buildings, it is essential to make changes in the society's pattern of living, not only changes in energy use of buildings (Larrumbide, Sánchez-Torija, Bedoya, 2019).

With better management of resources and modification of habits, economic as well as environmental prosperity could be reached. Innovation and technologies can help us to build more sustainable buildings with indisputable benefits for the environment in terms of resource conservation or waste reduction.

In the built environment, there is a lack of the interdisciplinary research and transition complexity that would support understanding and applying the circular economy. Majority of the current published research on built environment sustainability focuses mainly on energy

and carbon (Pomponi and Moncaster, 2016). This approach can leave out other environmental indicators with the risk of shifting environmental burdens from one impact section to another (Pomponi et al., 2016). There is a clear and strong challenge and necessity for behavioural research in built environment sustainability because people, in terms of individuals as well as the whole society, shift towards a new system of circularity, not technologies. The link between society and technology is therefore evident.

It is also important to see building as a complex of several factors influencing the environs. A building includes material used for construction, but also following operation – energy (heating, lighting), water, equipment, waste, ano more. For saving the energy consumption and reducing the CO_2 emissions, energy audit is a useful tool when it comes to approaching intervention measures in an existing building. It analyzes the overall state of the building in energy – walls, floors, ceilings, doors, skylights, and windows (in details: the improvement in the window gap, the increase in the insulation of façades, roofs and floors and the treatment of thermal bridges).

1.8 Circular economy at schools

Childhood and school years consist of the most formative years of each individual. *"Education is the key intervention for bringing change in knowledge, values, behaviors and lifestyles […] required to achieve sustainable development"* (Pandey and Vedak, 2009).

There have been many discussions about the circular economy which has shown to have a significant role in the private sector. However, the educational sector with schools of all levels (primary, secondary, universities, other) can also play an important part. A very limited amount of work dealing with schools' and teachers' roles is in the process.

Educational institutions represent a field of great interest for the circular economy implementation owing to their socioeconomic relevance for the service sector and their influential role in supporting sustainable development in cities and regions worldwide. Educational institutions give a great value to a large and diverse network of stakeholders, counting society and the environment that can be used to raise awareness, motivate students, their parents and all the population behavioural change towards the circular economy functioning. Behavioural change is a key element in the transition towards a circular economy. It was identified as instrumental for success in the uptake of recycling, energy and carbon

reduction, knowledge on low-carbon buildings and technologies, and people's attitude towards reused material (Pomponi, & Moncaster, 2017).

Environmental education and awareness-raising constitutes an indispensable preventative instrument within the process of long-life learning. The aim of environmental education is to systematically influence pupils and students to accept the values and behaviour of environmental protection and care and also to mediate an understanding of the connection between the social, economic and cultural areas. Also, it aims at the powerful motivation for changes towards a healthy and a well-functioning environment. Education plays an essential role in the whole circular economy system. There is a need for more participatory, feedback-rich teaching and learning experiences. Otherwise, the whole education would fail in ineffectively teaching the irrelevant to the uninterested. (Pomponi, F., & Moncaster, A., 2017).

Schools disseminate information and provide education in the environmental protection at school in the form of educational programmes, lectures, training sessions, literature, and other information sources, but also participate in joint events and mediate benefits for a sustainable way of life, environment-friendly behaviour at home, or environment-friendly tourism and, what is important, participate in the implementation of specific projects, in other words put theory into practice and become good examples of the environmental protection, sustainable development and circular economy.

In the Czech Republic, the topic of circular economy is not included in educational programmes. Little attention is paid to component spheres that are included in the circular economy (ecology, protection of the environment, sustainable development, recycling, waste generation prevention, waste management, …). These topics are usually only parts of one superior subject such as civics or health education. Primary schools do not work with the topic of the circular economy as a complex theme. But there exist some programmes such as the Ecoschool programme, which will be discussed later in the text.

The systematic change towards the circular economy cannot be driven only by industry and technological innovation alone. It starts from individual behaviors to collective/cultural adoption of the circular economy principles. Education, from early ages to higher education, is therefore an essential part of switching from the linear economy to the circular economy that respects sustainability and eco-friendly growth. Young people, pupils, and students can become agents of the transition to the circular economy.

For moving towards the circular economy, it is therefore important to teach and discuss sustainability and the dependence of human life to the environment from the very early school years. It should not be limited to "lecture-based" environmental education; children could be involved in concrete environment-protection actions, consumption workshops and other activities. They can find "circular" solutions in their daily life and by using familiar goods (food, toys, school equipment, etc.). The whole working circular economy model will be achieved if society takes the steps to show the values and messages from early childhood (Vasileiou, Arvanitidis, 2020).

Also, education and knowledge is one of the top priorities of the strategy Strategický rámec cirkulární ekonomiky České republiky 2040. The aim is that *"The circular economy as a concept is stably integrated into the entire education system."*

The proposed measures to reach the goals are:

1. *"To support the development of knowledge about circular economy at all levels of the education system and to embed circular economy in educational programs."*
2. *"To motivate schools to participate in the topic of circular economy in teaching and to support the creation of teaching materials."*

1.8.1 School buildings and their potential in the circular economy

Schools, as motors of skills and knowledge, play an important role in launching circular economy approaches into reality and raise sustainable performance. Schools and other institutions of education therefore should not be perceived only as parts of sustainability progress through teaching, research and social outreach activities but also as organisations that apply the circular economy principles in practice in order to become good practice examples. Not much is known and not many publications speak about practical application of the circular economy thinking in schools to improve management of sustainable development processes. Mendoza, Gallego-Schmid, & Azapagic, 2019).

There is a lack of studies analysing practical implementation of circular economy thinking in the education sector. School institutions are strategic in supporting sustainable development through teaching, research and social outreach activities and can also have a role of a good practice. Only few studies have dealt with the problem that schools, as part of the local economy, can contribute to implementing the sustainability practices they teach.

School buildings are usually quite big, have an important resource consumption and waste generation. These buildings are also operations as any other building, some economic strategy is also present there. This is the reason why school buildings have a great potential to put principles of circular economy into daily operation as any other buildings.

Currently, the only form of environmental sustainability effort at schools lies at betterment of resource efficiency by reducing energy consumption and waste generation in order to reduce carbon emissions. There is no evidence of rethinking the current unsustainable processes and establishing a corporate strategy. However, it is necessary to aim that schools contribute to the circular economy because they want and not only do things that are simply 'less bad', rather than delivering positive benefits.

Educational institutions can act as living labs and role models for sustainability. They can also work as monitoring systems – natural, financial, social, and intellectual – their use, appreciation, or depreciation, and their impacts of the circular economy and sustainability-oriented activities and solving real-world problems. They can therefore assist in realising a more sustainable society from the early school years. Schools as living labs for the circular economy and sustainability implementation can be an important aspect for co-design robust data collection and a monitoring system for the development of useful business cases for boosting institutional change and innovation (Mendoza, Gallego-Schmid, & Azapagic, 2019).

Improving resource efficiency through the implementation of the circular economy principles could reduce costs, life cycle carbon emissions and material consumption as well as boost innovation, innovate educational programmes, motivate a behavioural change among students and staff and arrange a community and stakeholder involvement in the circular economy practice. Putting the circular economy principles into practice can increase the school's social responsibility (Mendoza, Gallego-Schmid, & Azapagic, 2019).

The reason for not applying the principles of the circular economy in practice at schools can be explained in lack of awareness and understanding of the circular economy concept and its practical application in the school context among staff, insufficient policies, limited stakeholder discussion and collaboration, and decision-support frameworks, or financial limits. Other challenges and limits of implementation of the circular economy at schools include the lack of access to appropriate decision-support frameworks, data gathering systems, and key performance indicators. Due to all these reasons, there are no initiatives and good practices implemented yet.

Companies and other business bodies work on different working schemes concluding the circular economy principles – renting sare space, operating sharing platforms or offering and using reusable products. Rather than buying particular products, schools can choose renting contracts based on "pay-per-use". Then, they can share it with others. Using these principles and activities in the education sector would push governments to change the current structures, procurement mechanism and behaviour (Mendoza, Gallego-Schmid, & Azapagic, 2019).

In the case of furniture, schools could introduce some furniture reuse centers which would be beneficial also for the whole neighbouring community. Furniture and other equipment would be collected, repaired and redistributed on a local level and refurbished. A monitoring system to inventory, track and check the location, condition and availability of the furniture would be needed (Mendoza, Gallego-Schmid, & Azapagic, 2019).

Schools striving for circular material flows need to address procurement and waste management among all stakeholders across the entire value chain – suppliers, partners, contractors. Discussions can enable delivery of products that were designed for disassembly, reuse, repair and with non-toxic materials. Service and repair contracts could then facilitate logistic flows and support repair and reuse of products. This approach would allow diverse material cycles without any loss of quality (Nunes, Pollard, Burgess, Ellis, De los Rios, & Charnley, 2018).

Key parts to reach the school environmental sustainability include energy, water and waste management, sustainable travel, green technical and common spaces, sustainable construction, responsible purchasing, sustainable catering and green infrastructure allocation. For all this, schools require an analysis of the return on investments and measures to overcome risks (Mendoza, Gallego-Schmid, & Azapagic, 2019). The circular economy could reduce costs of maintenance, waste management, energy and carbon footprint. It is important first to evaluate carefully the potential costs for the school as well as savings and then plan a strategy step by step for implementing principles of the circular economy.

1.8.2 Teachers

School management (headteacher, deputy, bursar, school caretaker, etc.) should push for the circular economy implementation, innovation to ensure organisational sustainable development. Conservative thinking should be avoided and old governance structures should open the door for innovation and change. Cooperation with other schools and relevant

stakeholders is needed to ensure a good organisation, be in institutional frameworks and develop a practical functioning (Mendoza, Gallego-Schmid, & Azapagic, 2019).

Putting principles of the circular economy and innovation into practical daily life requires an ongoing iterative process of continuous organisational learning and operational change. It means experiments and piloting, tests of feasibility and suitability of alternative solutions and exploring the transformation of a business model from linear to circular. For this process, schools will have to collaborate with, share with and benefit from stakeholders (partners, suppliers and students, parents) by practising the circular economy and sustainability proactively in the management of school operations (Mendoza, Gallego-Schmid, & Azapagic, 2019).

An important responsibility of the circular economy at schools is therefore given to the teaching staff. They create the context and meaning of the field of study, shaping the information to transmit its importance and maturity. It depends on them how the topic will be delivered to students because the whole theme of circular economy must be also understood. Lack of understanding about the benefits of circular products and reasons for implementing the circular economy is a barrier for sustainable development and an obstacle for businesses and consumers in the sphere.

That is the reason why the investment in teachers' training is essential. These professionals should be supported and trained, so that they understand the key role they play in the whole system of circular and sustainable society, and they have the possibility to develop the necessary skills to teach circularity and sustainability effectively, using contemporary pedagogical methods (Vasileiou, Arvanitidis, 2020).

But not all researchers see the circular economy as a social or behavioural benefit. For example Sauve et al. (2015) do not see the circular economy as having any social objectives, but rather as a system which focuses on reuse and recycling as substitutes for raw virgin materials. But on the other hand, George, Lin and Chen (2015) do see a social goal function which aims to maximise social welfare by optimising resource consumption and pollution. As mentioned before, circular economy principles should be economically profitable. (Pomponi, & Moncaster, 2017).

The strategic and environmental plans that shape the operation of schools should be rethought and replanned. New working groups or jobs can be formed that can identify, enable, and organise finance for potential improvements in material flows. There should exist a team of

teachers/management that would take care of sustainability and would search for new opportunities.

1.9 Public procurements

In Priority Area No. 9 of the Strategický plán cirkulární ekonomiky České republiky 2040, the following principles are stated as principles for the goal *"Accepted economic instruments have long supported the circular economy in the Czech Republic"*:

1. *"Encourage the use of products containing secondary raw materials and recycled materials in public procurement."*
2. *"Consider introducing mandatory circulation issues in (sustainable) public procurement and enforcement."*

Here are 3 possibilities of public procurements that contribute to the circular economy principles. The first one is the Green public procurement, the second one aims at going hand in hand with sustainability, and the last one accepts the whole circular economy concept.

1.9.1 Green public procurement

Green Public Procurement is a tool that enables public organs to make an effort for purchase of products and services with lower negative impact on the environment during the whole life cycle in comparison with products and services with the same primary function that would be purchased without the green public procurement. They integrate environmental aspects with the requirements imposed on public tendering.

1.9.2 Sustainable public procurement

Sustainable Public Procurement is a process where public organs aim at balance attainment among the the pillars of sustainable development – economic, social and environmental – in purchase of products or services.

Figure 7 *Pillars of sustainable development.*

source: Tedeschi, Muir, Riley, & Fox, (2015).

1.9.3 Circular public procurement

Circular Public Procurement is a process where public organs purchase products and services in the form that they contribute to closing of the material and energetic cycles and in the best option to negative impacts of the environment prevention and waste generation prevention in the whole life cycle. Within the circular public procurement, it is possible to identify the following hierarchy of approaches:

- reduction,
- re-use,
- recycle,
- other use.

Every school building has a great number of furniture which is usually purchased from a selection procedure. Not a lot of these procedures also include attention to sustainability and circularity. Schools can actively influence suppliers and manufacturers to deliver resource efficient and more sustainable and circular products by the integration of the circular economy specifications in tendering processes. (https://www.mzp.cz/cz/setrna_verejna_sprava)

1.10 School programmes touching the topic of the circular economy

1.10.1 Škola pro udržitelný rozvoj (School for sustainable development)

The School for Sustainable development (ŠUŽ), running since 2004, is a programme that helps schools with improving the environment and the living quality in their neighbourhood. Pupils, teachers and the local community support sustainable development through smaller projects and students understand the place they live, learn important skills and knowledge. This programme considers that schools are centres of change and experience.

The project teaching uses local topics as a unifying context and all activities head towards a vision of a better living place and subsequently the creation of products that are seminal for the local community. It supports not only the environment, but also social capital and local partnerships. This programme connects primary and secondary schools with municipalities, citizens, NGOs and other initiatives. [2]

1.10.2 Evropský týden udržitelného rozvoje (European week of sustainable development)

This programme is meant for kindergartens, primary and secondary schools. Interested schools can download a lot of materials about ecology, environment and sustainable development and include some interactive activities into their teaching. [3]

1.10.3 Ecoschool

History

After the United Nation Conference in 1992 concentrated on Environment and Development, the Eco-schools programme was developed as a reply to the actual needs. Two years later, the programme started with the support of European Commission in four first countries – Denmark, Germany, Greece and the United Kingdom. In 1999, Eco-Schools received the "Worldaware Award for Global Education" by the North-South Centre of Council of Europe and the National Committee for International Cooperation and Sustainable Development

[2] More information at: https://www.skolaprozivot.cz/O-programu.html
[3] More information at: https://www.tydenudrzitelnosti.cz/pro-skoly/

(NCDO) and four years later, the United Nations Environment Programme (UNEP) identified Eco-schools as a a model initiative for Education for Sustainable Development. In 2006, Eco-Schools International programme reaches: more than 5 million students, 22,000 schools, over 400,000 teachers and more than 4,000 local authorities. In 2017, more than 19 million students in 56 000 schools in 70 countries were involved in Eco-schools programme. [4]

About the programme

The international Ecoschools programme stands on action-based learning. It involves students, teachers as well as the local community to take an action and be active in the protection of the environment. Eco-Schools facilitate contact between participating institutions not just at the national level, but also internationally. These links provide an opportunity for schools to share environmental information.

Activities start in the classroom, thoughts expand to the school and acts eventually foster change in the community at large. Through this programme, young people experience a sense of achievement at being able to have a say in the environmental management policies of their schools, ultimately steering them towards certification and the prestige which comes with being awarded a Green Flag. [5]

[4] More information at: https://www.ecoschools.global/our-history
[5] More information at: https://www.ecoschools.global/how-does-it-work

2 Methodology

The author of this master thesis, Markéta Čapková, decided to discuss the topic of the circular economy on account of her internship in CIRA Advisory s.r.o. (CIRAA) which is a consulting firm dedicated to helping accelerate the transition to a more sustainable and circular economy. CIRAA is a sister organisation of the Czech Institute of Circular Economy (INCIEN), which has been working over the past five years to raise public awareness, support innovation and best practice and provide education in this field in Czechia and Slovakia. Drawing on the experience of INCIEN, CIRAA was created with a mission to put the circular economy into practice and implement circular business models in the private sector.

As a task during the internship, there was a commission to prepare a critique of the current state of one primary school and suggest concrete measures to shift the working of the building to a system that goes hand in hand with the principles of circular economy. This master thesis is therefore based on the gained experience during the internship in CIRAA supported by consultation with colleagues in more specialized issues.

2.1 Introduction and description of the examined subject

As the examined subject for this qualification work, a primary school was chosen. The primary school which is the case of the master thesis is a state school in Prague 3 district with approximately 700 children in the age 6-15 years old. The school has its own school canteen and gymnasium. The school deals with a number of activities for students in the field of sustainability, takes part in the Ecoschool programme and has also been a certified Healthy School Canteen since 2018. Students form action thematic groups called “eco teams” where teachers gather pupils from different classes to form a group that is interested in one environmental topic and do diverse activities during the school year – within the classes as well as in their free time. Pupils can also actively participate in purely practical things such as electricity and water subtractions. Depending on the type of situation and current needs, they are also willing to help the school caretaker with various types of work. Parents are also actively involved in the process and their efforts to support their children are evident.

2.2 Aims and objectives

The aim of this thesis is to appraise the current state of a chosen primary school in Prague 3 district in different areas of relevant interest and to suggest concrete measures with the principles of the circular economy taken into consideration. The practical output of this master thesis will be a list of concrete suggestions for concrete school (in Prague 3 district). The practical output will be completed by a theoretical output that consists of a general manual for primary schools that aim at more circular and sustainable daily working. As the input for these two outputs will stand the data and materials from one primary school in Prague 3 district. The partial aim of the thesis is to find out the current situation, which will become the basis for proposing solutions and increasing the sustainability of the school in the field of **WASTE, WATER, ENERGY, EQUIPMENT and GASTRO operation** (school canteen). Second partial aim is to find out the exact amount of produced types of waste (according to the waste catalog), which will be supplemented by a physical analysis of mixed municipal waste produced in the school, water and energy consumption, describe in detail the current state of the school and suggest concrete arrangement in terms of circular economy – waste minimisation, consumption reduction and investment return.

note: Focus will be given to the waste management while energy and water are touched only tangentially in this work. Water and energy were addressed rather secondarily. Due to the fact that a complete reconstruction of the building is not planned, the processes of use and consumption have already been introduced, so it is not possible to evaluate them significantly at any time, nor to change them in the future.

2.2.1 Research question

This study sought to contribute to the theory in answer to the following research question:
How can the principles of the circular economy be used in daily operation of school buildings?

2.3 Data collection and analysis

To fulfill the aims of this thesis, a statistical data processing method was used, added by two physical visits and additional information from the staff of the school.

Statistical data analysis is a procedure of performing various statistical operations. It is a kind of quantitative research, which seeks to quantify the data, and typically, applies some form of statistical analysis. Quantitative data basically involves descriptive data, such as survey data and observational data.

Statistical data processing includes data collection (from accounting documents), data processing, simple classification, development evaluation of indicators during time, analysis of documents, descriptive statistics.

The school provided invoices for waste collection and orders for goods for the kitchen, which were analyzed and processed according to the needs of this work.

2.3.1 Data collection

Two visits were effectuated at the place of the school. The first one was held on 15 September 2020, and the second one on 23 June 2021. The long period in between the two visits can be explained by the pandemic situation. The school was not in normal regime and results would therefore be incomplete and irrelevant. During the COVID-19 pandemic, the school had some special working conditions (which influenced the operations in the buildings) – for example rotation teaching, online classes, etc.

The first visit in autumn 2020 was focused on energy, water, and equipment issues. The second one concentrated on waste management and gastro operation. Some basic pictures were taken at the place for a better illustration of the situation and concrete recommendations. Missing information was added by an explanation from the school caretaker or head of the school canteen. During the second visit, a physical analysis of waste took place.

Regarding accounting documents in the field of waste management (invoices from the collection company Pražské služby), documents for the last three years (2017-2019) were provided by the school management (sent by email). Subsequently, they were sorted and the data put into tables.

In the case of gastronomy, menus, numbers of ordered portions and invoices from various food suppliers were available from the period from 19 May 2021 to 4 June 2021. Namely: fruits and vegetables (Petr Kamenský FRUIT - VEGETABLES), meat (Prominent CZ, KAMABY plus), dairy products (Alimpex FOOD), frozen foods (Bidfood) and perishable foods (CANO, KASIA vera, CMS Consulting). All documents were provided by the head of the canteen in

paper form and photographed during the physical visit to the school. The documents were supplemented by information provided by the canteen staff (e.g. a large amount of gastro waste, sufficient frequency of delivery of fresh ingredients, etc.) and visual inspection (packaging materials, waste containers, storage, etc.)

2.3.2 Data analysis

Based on the analyzed accounting documents of waste management, it was possible to evaluate the amount of waste produced and its division into mixed municipal waste and sorted components, including waste codes, quantities and financial aspects. Also, data were gathered by years (2017-2019). Subsequently, the growing tendency of the produced sorted waste and the constant level of mixed municipal waste were evaluated. The evaluation of the analysis was processed in the form of a graph.

In the case of the operation of the school canteen, the number of portions by days and the delivery of individual types of food in terms of frequency were analyzed. Also, type of food was evaluated (vegetarian, special diet, meat inculded, fresh fruits and vegetables, etc.) in order to see particular ingredients and possible waste.

Many photographs were taken during the physical visit. The headteacher provided detailed information mainly in the field of energy, water and equipment. The school caretaker provided a tour of the entire school, including the garden, and answered any additional questions, especially regarding waste management (sufficient frequency of collection, location of waste containers, etc.). The head of the school canteen then added details from the gastronomic operation.

Physical analysis of waste

The physical analysis of waste aims to determine the state of waste in school and to determine what is the percentage of individual waste components (plastic, paper, glass, biowaste, etc.) in the total number of mixed municipal waste.

The reason for sampling is finding out the current state of municipal waste sorting, i.e., the composition of mixed municipal waste and the potential for its sorting. Waste analysis was further made in order to re-evaluate waste policy and introduce the principles of circular economy. The analyzed sample, in this case, consisted of approximately two full containers of mixed municipal waste.

On 23 June 2021, a physical analysis of the waste took place in the rear part of the primary school building in Prague 3 district. These included manual analysis of containers for mixed municipal waste from the school and canteen operations, and visual inspection of sorted waste (paper, plastics, beverage cartons, and biowaste). The analysis revealed the production of individual types of waste in mixed municipal waste and the purity of sorted components of municipal waste. The results of the analysis will also make it possible to determine the production potential of individual types of waste in buildings. The waste analysis was performed on a representative sample of about 70 kg of mixed municipal waste. All pictures are pictures taken at the place during the physical analysis. The waste sampling methodology is based on the Methodological Instruction of the Ministry of the Environment of the Czech Republic on waste sampling from 2008, which was modified in the sense of the purpose of analysis. The analysis of mixed municipal waste is performed in order to determine the detailed composition and weight ratios of specific components. The results of the analysis will enable the prediction of possible directions of waste management, or reveal another potential for waste separation. The main goal is to check the contents of collection containers for mixed municipal waste. Secondly, the analysis of waste is to tell the facts about the behavior of pupils and school staff, concerning the total production of individual types of waste in mixed municipal waste. The abbreviated procedure based on the sampling plan was manual sorting of a representative sample of mixed municipal waste, from which the following catalog numbers or groups of waste were sorted: paper (containing cardboard + cardboard, printed matter), beverage carton, PET bottles, other plastics, GDP hard plastics (detergents), foils, electrical waste, garden greenery, kitchen waste (gastro waste), textiles + footwear, construction waste, glass, tires, infectious / non-infectious waste (intimate hygiene, diapers, plasters, bandages), metals, mixed municipal waste (no longer usable).

Figure 8 *Waste sample weighing process, dumping waste from the dustbin before sorting.*

2.4 Methodology of writing a manual

Another goal of this thesis is to create a general manual dedicated to management of schools on how to transform the operation of a school into a more sustainable working with circular economy principles taken into consideration. The Manual for circular school is a guide that is divided into several parts that follow the structure of the analytical part of this thesis and recommend concerete solutions for change in chosen areas (energy, water, equipment, waste management, gastro operation).

A manual (in other words, a guide, handbook or user manual) is a textual, visual or audiovisual document that provides the basic information needed to use an object or system or describes the course of a work process or procedure. The instructions are primarily oriented to the addressee who is to follow them, and the main purpose of the text is to inform about how to handle something, how to make or do something. When writing the manual, it is necessary to assume that the user has never come into contact with the described object and on the basis of the manual the user should get acquainted with all conceivable aspects of working with this product. The writer of the manual should be free from presumptions regarding the reader's previous knowledge or skills, as well as should not assume that the reader is studying procedures or instructions from other sources. The manual should be created in order to provide complete and uniform information. When writing the manual, the author should not try to estimate the intended nature of the reader. The instructions should be easy to understand for all potential users without distinction. It is therefore advisable to try not to take into account the expected circle of future readers when writing the instructions, it is desirable to strive for maximum neutrality and universality of the text. It is also appropriate to assume complete ignorance of the issue on the part of the user and to take it into account when writing the manual (Čechová et al., 2008).

Procedure of creating a manual

The first and logical step that needs to be taken when writing the instructions is the author's personal acquaintance with the described subject, if possible physically and in real time. When writing instructions, it is necessary to think carefully about the composition of the whole text in advance (Čechová et al., 2008). In this case, it was gaining experience and drawing knowledge during internship, training in the field of circular economy and inspiration from previous case studies.

When describing the work with a product/programme, it is necessary to start with the most general and basic things and gradually move on to the more complex and less important ones (Čechová et al., 2008). In the manual for circular schools, it means an explanation of the basic concepts and differences between linear and circular economies, the determination of key areas suitable for change. This was followed by specific recommendations for individual areas with additional explanations and justifications for individual measures. The description of all available tools is necessary for the application of measures in practice and their descending order of the highest importance and effectiveness to be another necessary step in the creation of the manual. At the same time, it is necessary to mention which measures are more demanding on initial costs and they can be taken into account only in the overall reconstruction of the building, or their implementation is a matter of changing existing habits and can be used almost immediately without any or only with minimal costs.

Another feature that the manual was supposed to have is a suitable modification. The instructions should ideally be clearly divided, which means dividing the text into clearly named and defined paragraphs, chapters, or otherwise selected segments. The horizontal division of the text was taken into account. When using images or other graphics, everything must be adequately described and marked. Easy orientation in the text is a key element for each manual. One of the last things that pays to create at the end of creating a manual is the table of contents. Although it is usually created at the very end, it is advisable to place the table of contents at the beginning of the manual, so that the reader can get acquainted with the outline of what they will learn in the manual and, where appropriate, where specific information can be found in the text. It is ideal to generate the content (if it is digital) so that the individual items in the list are also direct links to chapters in the text (which is possible with most commonly used text editors today).

3 Results

The section results is divided into several parts (waste, energy, water, equipment and gastro operation) and in each part, the current state is described and explained and concrete suggestions are recommended for the chosen primary school in Prague 3 district based on data collection, analysis, physical visit and waste analysis.

The second part of the section results consists of Manual for circular school – a guide that was created on the basis of results obtained from the primary school in Prague 3 district. Basic rules and recommendations are mentioned there and the structure follows the sections mentioned before (waste, energy, water, equipment and gastro operation).

3.1 Waste management

This part of the study is devoted to the issue of waste, mainly to the one that has the character of mixed municipal waste. The analysis contains a brief description of the functioning of waste management in the primary school in Prague 3 district. The analysis summarizes information about the location of waste containers at school, the collection frequency of containers for waste, as well as an overview of collection companies that are responsible for the disposal of waste produced. It also summarizes information on the production of individual types of waste for the last three years and methods of their management. A physical analysis of waste (mixed municipal waste) was performed, the results of which were used to estimate the production potential of particular types of waste. The last part deals with the shortcomings that were identified in the analysis and specific proposals that will lead to the improvement of the current situation.

3.1.1 Waste management: Cleaning, waste containers, waste collection

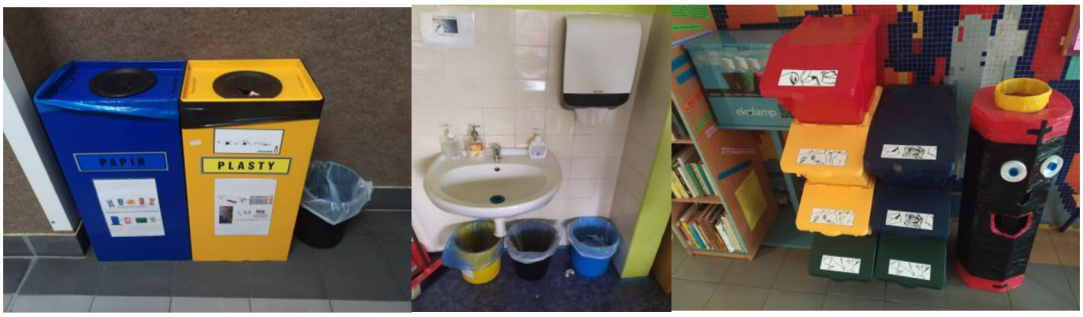
Cleaning, placement of waste bins

The cleaning of the whole school building is provided by the permanent staff of eight cleaners and also by a school caretaker. They have clearly assigned competencies as well as the areas of the school for which they are responsible. There is good communication and coordination between the staff. Everyone is very interested in the good functioning and proper sorting of waste.

During a physical visit to the school building, one of the cleaners said that she was even sorting out some waste from containers for the mixed municipal waste she takes out of the classrooms. If he sees waste that can be sorted, she does not hesitate to set it aside. There is, therefore, an obvious interest of staff in good waste management and their own efforts. They follow the motto: “Start with yourself and lead by example.”

In the school building, waste bins are arranged in classrooms, in corridors, and also in toilets. Each class has bins for plastic, paper, and mixed municipal waste. Classroom waste is taken to outdoor containers by cleaners. There are also bins for sorted waste (paper, plastic, glass) on each floor in the corridors. The school caretaker is responsible for taking them out and also for taking the waste out of the school canteen and the kitchen (he takes them out the day before the waste collection). At the main entrance of the school there are also containers for metals, flashlights, electrical waste, and an outdoor container for textiles. Only the container for sorting beverage cartons is missing in the school but can be found in the area where all waste containers are placed.

Figure 9 *Bins for sorted and mixed waste in the school building in the corridors and in the classroom.*



The outdoor areas of the school (garden and playground) have only mixed waste bins available.

Figure 10 *Outdoor bins for mixed waste.*

Number and collection of containers for mixed municipal waste and sorted components

Waste from bins is taken to outdoor waste containers. There is 1x 1100 litres container for mixed municipal waste (1 container is designed for the kitchen and school canteen), 1x 1100 litres for plastics, 1x 1100 litres for paper, 1x 240 litres for biowaste, 1x 240 litres for beverage cartons and also one container for textiles. There are also three smaller garden composters in the school garden area. The container for beverage cartons is currently not actively used. Also biowaste container and garden composters, which are used for grass, leaves, and biowaste from the kitchen, are used rather rarely (seasonally). Students put some fruit and vegetable leftovers in the composters rather occasionally. The rest of the organic waste, which has no more space in the composter in the school garden, is then placed into a biowaste container. According to the school caretaker, the biowaste container has been stolen twice by homeless people in the past.

Figure 11 *Containers for sorted waste and mixed municipal waste, garden composter.*

Collection of sorted components and mixed municipal waste is provided by the collection company **Pražské služby a.s.** with the frequency given in the table below. According to the school caretaker, the capacity of the containers and the frequency of collection are adequate for all components and there is no need to increase or decrease the frequency of collection.

Table 1 *Number of containers and frequency of collection.*

Type of waste	Number of containers	Volume of containers (in litres)	Monthly collection
Mixed waste	3	1100 l	Twice a week (Monday, Thursday)
Plastics	1	1100 l	Twice a week (Tuesday, Thursday)
Paper and cardboard	1	1100 l	Twice a week (Tuesday, Thursday)
Organic waste	1	240 l	Once in 14 days

3.1.2 Waste production

This chapter contains an overview of the quantity of particular types of waste produced in 2017, 2018, and 2019 in the chosen primary school. As the process of collecting data started already in 2020, data from this year is not considered. The data is based on invoicing information from the collection company Pražské služby a.s.

Table 2 *Waste generation by type of waste in 2017-2019 (in tones).*

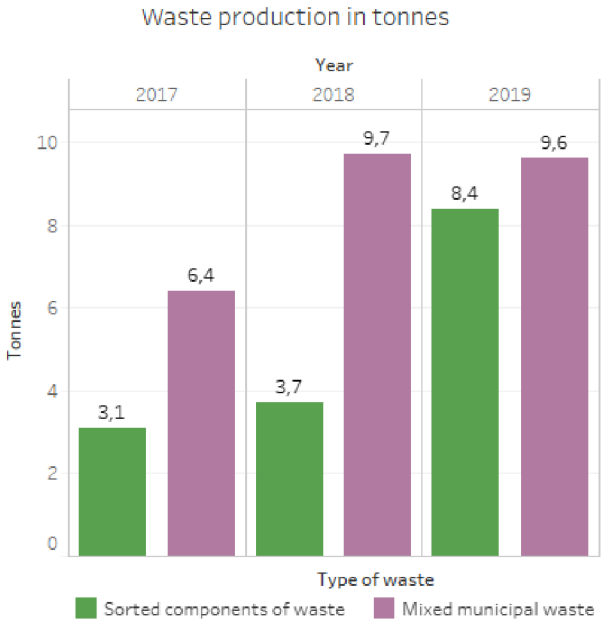
Waste catalog number	Type of waste	Waste production (t)		
		2017	2018	2019
150101	Paper and cardboard packaging	1,389 t	1,553 t	1,403 t
150102	Plastic packaging	1,329 t	1,289 t	1,392 t
190809	Fats and oils	1,37 t	-	5,22 t
200201	Biodegradable waste	0,401 t	0,809 t	0,418 t
200301	Mixed municipal waste	6,362 t	9,713 t	9,551 t
TOTAL		**10,851 t**	**13,364 t**	**17,984 t**

For simplicity, all sorted components of waste (paper, plastics, fats and oils and biowaste) are classified into one category "sorted component" and mixed municipal waste is the second group. A simplified overview of waste production is below.

Table 3 *Sorted components of waste and mixed municipal waste (2017-2019).*

Type of waste	**2017**	**2018**	**2019**
Sorted components of waste	3,1 t	3,7 t	8,4 t
Mixed municipal waste	6,4 t	9,7 t	9,6 t
TOTAL	**9,5 t**	**13,4 t**	**17,9 t**

Figure 12 *Waste production in comparison sorted components of waste and mixed municipal waste in tonnes (2017-2019).*



The table 3 and the figure 12 here above show that total waste production has an increasing tendency. The amount of mixed municipal waste is around 10 tons per year and production has

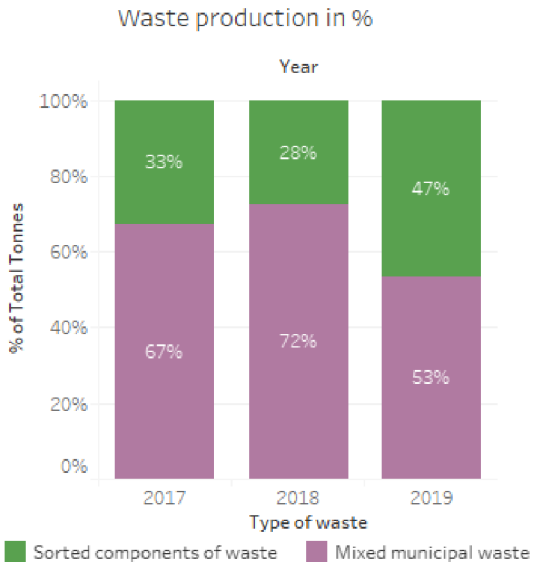
remained stable in the last two years. On the contrary, the total weight of the sorted components produced increases every year. It is good to see that waste sorting is improving at school, but unfortunately this also means that consumption is increased and thus costs.

The percentage representation of individual groups in the total waste production for a given year is in the following table 4 and graph.

Table 4 *Sorted components of waste and mixed municipal waste in % (2017-2019).*

Type of waste	**2017**	**2018**	**2019**
Sorted components of waste	33 %	27 %	47 %
Mixed municipal waste	67 %	73 %	53 %
TOTAL	100 %	100 %	100 %

Figure 13 *Waste production in comparison sorted components of waste and mixed municipal waste in % (2017-2019).*



While in 2017 and 2018 the mixed municipal waste represented almost ¾ of total production, in 2019 it was only a half.

3.1.3 Physical analysis of waste – results

An analysis of two separate samples of mixed municipal waste from the school operation (1 container 1100 l) and also from the school canteen operation (3 bags) with a total weight of 74 kg was performed. This corresponds to the amount that was produced 2 days after the last pickup. In total, the following data was analyzed:

- Containers for **mixed municipal waste**: 1.5 containers with a volume of 1100 l – manual sorting [6]
- Containers for **paper**: 1 container with a volume of 1100 l – visual inspection
- Containers for **plastics**: 1 container with a volume of 1100 l – visual inspection
- Containers for **beverage cartons**: 1 container with a volume of 240 l – visual inspection
- Containers for **biowaste**: 1 container with a volume of 240 l – visual inspection

The main goal of the analysis was to check the content of containers for mixed municipal waste – what types of waste are in the containers and in what weight ratio. At the same time, an analysis of the containers for sorted waste was performed in order to determine the purity of the sorted components and their weight. During the physical analysis, photo documentation was taken, which is a supplement to the above results.

Figure 14 *Waste bins in the school area.*

During manual sorting of mixed municipal waste, the following types of waste or groups of waste were sorted: **paper** (containing cardboard, paperboard, office paper, printed material), **beverage cardboard, plastics** (hard plastics, soft plastics, foils, PET bottles)**, liquids, reuse waste, kitchen compostable waste** (biowaste)**, kitchen waste, glass, textiles, metals, infectious waste** (used paper napkins and towels, feminine hygiene supplies, disinfection supplies) and **mixed municipal waste** (waste that can no longer be used as a material). As part

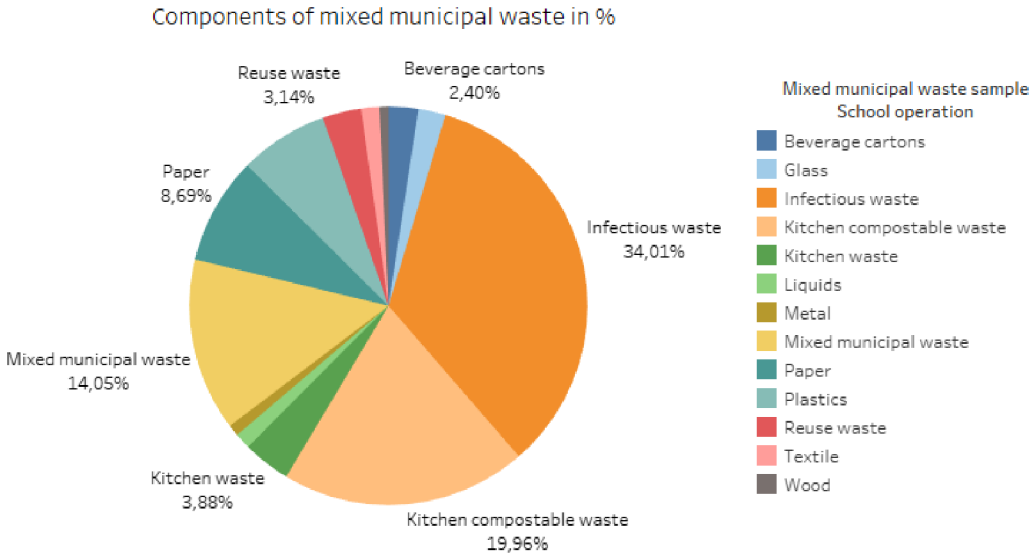
[6] In this section, only one container of 1100 litres will be analysed. The waste from the school canteen is the subject of research in the section Gastro operation.

of the analysis, two separate samples were analyzed – mixed waste from the school operation and from the canteen operation. The total weight of the analyzed sample from the school operation (1x 1100 l) was 54 kg of mixed municipal waste. This amount of production corresponds to 2 days of operation. The results of the analysis of containers intended for mixed municipal waste are given in the following table and described in the following graph.

Table 5 *Composition of mixed municipal waste as results of the physical analysis of waste.*

Mixed municipal waste sample – School operation	**Total weight (kg)**	**%**
Kitchen compostable waste	**10,8**	**19,9 %**
Kitchen waste	**2,1**	**3,9 %**
Plastics	**3,9**	**7,2 %**
Paper	**4,7**	**8,8 %**
Glass	**1,2**	**2,3 %**
Reuse waste	**1,7**	**3,1 %**
Textile	**0,8**	**1,4 %**
Metal	**0,5**	**0,9 %**
Wood	**0,4**	**0,7 %**
Beverage cartons	**1,3**	**2,4 %**
Liquids	**0,7**	**1,4 %**
Infectious waste	**18,4**	**34,0 %**
Mixed municipal waste	**7,6**	**14,1 %**
TOTAL	**54**	**100 %**

Figure 15 *Composition of mixed municipal waste as results of the physical analysis of waste in %.*



The most represented component was **infectious waste** (34%), which includes handkerchiefs, veils, feminine hygiene items and paper towels from the bathroom. Paper towels were the vast majority of this waste. To reduce waste from paper towels, it is possible to install electric hand dryers. If the towels are not infectious, it is possible to compost them together with biowaste. The initial investment in dryers will pay off not only by eliminating the cost of paper towels, but also by reducing the price of mixed municipal waste.

Figure 16 *Sorted infectious waste.*

The second most frequent component was **biowaste**, which represented 24%. According to its nature, biowaste is divided into two subgroups, namely kitchen waste and compostable kitchen waste. **Kitchen waste** includes heat-treated foods, such as pastries, leftovers, but also foods of animal origin (eggs, milk, meat, cheese, etc.). This waste must be treated in accordance with stricter hygiene standards: waste should be sorted into special containers and ideally disposed of at biogas plants. It was a smaller part, 3.9% (21 kg) of the total amount.

Figure 17 *Non-compostable kitchen waste, leftovers.*

Compostable kitchen waste is the second part of biowaste, representing almost ⅕ of the total weight of the analyzed sample (19.9%). In practice, these are residues of vegetables and fruits from food preparation, flowers, coffee grounds and tea, kitchen scraps, etc. This waste can be used for composting in industrial as well as garden composters.

The school has a fruit and vegetable program for schools.[7] The aim of the "Fruit and Vegetables for Schools" project is, among other things, to increase the popularity of fruit, vegetable and banana products, contribute to a permanent increase in fruit and vegetable consumption, develop eating habits in children's nutrition, improve the health of young people, fight the childhood obesity epidemic and reverse the declining consumption of fruits and vegetables. The "Fruit and Vegetables for Schools" project falls within the competence of the Ministry of Agriculture of the Czech Republic and the Czech State Agricultural Intervention Fund. The Ministry of Education, Youth and Sports of the Czech Republic, the Ministry of Health of the Czech Republic, and the Ministry of Finance of the Czech Republic also took part in the preparation process. Funds for this project are provided by the European Union by 73% and the Czech Republic by 27%. With this programme, the school supports both the healthy

[7] more information at: https://www.ovoceazeleninadoskol.cz/index.php?page=ovoce-do-skol

lifestyle of children and local production and consumption, which goes hand in hand with sustainability.

However, snacks, skins and other residues of fruit and vegetables should definitely not end up in mixed municipal waste, but should be used for composting or sorted into biowaste.

Figure 18 *Compostable kitchen waste, leftovers.*

Paper such as newspapers, magazines, office paper, or cardboard boxes accounted for a total of 8.8%. The school has a separate container for paper waste, which a collecting company regularly exports. This waste could therefore be placed in a recycling container.

According to the school caretaker, the paper collection in a big container was canceled a few years ago. It was not effective and did not pay off in its time. Free export of the container was possible only when at least half of it was filled. Otherwise, the transport was financially demanding. It is recommended to re-examine the cost and benefits of collecting paper now.

Figure 19 *Paper waste.*

Plastic was present in a similar amount of 7.2%. This category is divided into 4 groups: PET bottles (2.8%); hard plastics (0.7%); soft plastics (1.3%) and foils (2.4%). Although bins for

sorting paper and plastic packaging are located at the school, it is evident that there is still great potential for improvement.

Figure 20 *Sorted plastic waste.*

Although **beverage cartons** did not represent a significant amount by weight (2.4%) like other components, but only due to the lightness of this material. There were a large number of drink boxes in the sample.

There is a school milk program at this primary school.[8] The aim of the project is to reduce the calcium deficit in the child population, improve children's eating habits, educate consumers and ensure the sale of milk from farmers. Pupils are guaranteed regular deliveries of drinking milk or unflavoured dairy products free of charge. With a supplement, they can also take flavored dairy products. In addition to the supply of dairy products, the project also includes accompanying training measures, which are provided by approved suppliers. Excursions, educational events, tastings and competitions promoting the consumption of milk and dairy products are supported. This programme, therefore, supports the healthy lifestyle of children as well as local production and consumption, which is also the principle of sustainability.

Regular delivery of milk is also, unfortunately, the cause of waste. In this case, children receive dairy products mainly in beverage cartons. If the receipt of such goods is on a regular basis, it is good to consider the operation of the beverage cartons bin.

[8] more info: http://mlekodoskol.szif.cz/

Figure 21 *Beverage cartons.*

Reuse waste, or waste that has other uses (books, dishes, decorative items, etc.), accounted for 3.1%. The school certainly generates a larger amount of this type of waste. It does not need to end up in a mixed waste bin, but it can be donated for further use to reuse centers or charities and thrift shops; there are many of them in Prague.

Figure 22 *Reuse waste.*

Glass was in the analyzed mixed waste in a negligible amount (2.3%). This indicates good practice in sorting this type of waste, but also probably less demand of the school building on this type of waste. The volume of the glass is not large enough to require a separate glass bin. The school caretaker therefore takes the individual components of the glass waste to a public bin in the street.

Figure 23 *Glass waste.*

Textiles accounted for 1.4%. There were mainly pieces of fabric, curtains and drapes, probably remains of art education. Even this material, if not contaminated, can be sorted for further use as and recycling. This primary school even has a container for textiles available.

Figure 24 *Textile waste.*

Beverage cans belong to the group of metals and represented 0.9% of the analyzed sample. Although there is a container at school, the cans unfortunately still end up in mixed waste.

Figure 25 *Beverage cans.*

A wooden box (0.7%) and liquids (1.4%) also appeared in the sample.

Figure 26 *Wooden box, liquids in beverage cartons and a plastic bottle.*

Mixed municipal waste, i.e. waste that cannot be used as material anymore, together with infectious waste and liquids, is a component that should end up in mixed municipal waste containers, as it has no further use. Mixed municipal waste represented 14.1% of the total

amount of the analyzed sample. Mixed municipal waste includes, for example, nonwovens, composite materials that cannot be sorted for recycling, cigarette boxes, greasy and soiled plastics or paper, etc.

Figure 27 *Mixed municipal waste.*

If we focus on what should be in the containers for mixed municipal waste, we will find that out of the total amount, only 49% of the original content would remain there (by weight). On the contrary, waste that does not belong in the containers for mixed municipal waste, because it can be sorted and otherwise used (biowaste, paper, plastics, textiles, glass, metals, beverage cartons, reuse waste) accounted for 51% of the total weight of the analyzed sample. Thus, there is great potential for improvement, which indicates that the current production of mixed municipal waste can be reduced by as much as ½.

3.1.4 Results of the analysis of sorted waste components

There was also a visual inspection of containers for sorted components – paper, plastic, biowaste and beverage cartons. Both paper and plastic were well sorted without contamination by other wastes. However, the amount in the containers was very small.

The biowaste container and beverage cartons are not currently used. The beverage carton container was contaminated by other waste and the biowaste container was empty. Although the school has the option of sorting these components, the results of physical analysis have shown that a significant amount of biowaste and tetrapack (beverage cartons) incorrectly ends up in mixed municipal waste containers.

3.1.5 Estimation of waste production potential

From the report on waste production it was found that currently (2019) 17.98 tons of waste are produced annually in a selected primary school in Prague 3, of which 47% (8.43 t) are sorted

components and 53% (9.55 t) is mixed municipal waste. However, the physical analysis results show clearly that mixed municipal waste still contains a large amount (51%) of waste that can be sorted and recycled. This chapter, therefore, deals with the specific potential for sorting components such as plastics, paper, metals, etc. from mixed municipal waste. It examines, how much the total amount of mixed municipal waste could be reduced through a 100% sorting rate in individual offices.

The physical analysis results helped us also to determine the ratio of individual usable components represented in mixed municipal waste. By applying this percentage to the total amount of mixed municipal waste produced today at a selected primary school in Prague 3, it is possible to determine the amount of individual materials that can still be sorted. More details are in the following table.

Table 6 *Percentage of individual waste components and estimation of waste production potential in tonnes.*

Type of waste	BIO	Paper	Plastics	Other sorted components in total (textile, metal, glass, tetrapack, wood, reuse)	Unsortable components (mixed municipal waste, infectious, liquids)
Percentage of components in mixed municipal waste	23,8%	8,8%	7,2%	10,7%	49,5%
Estimation of waste production potential (t)	2,27 t	0,84 t	0,69 t	1,02 t	4,73 t

If usable components such as biowaste, paper, plastic, glass, metals, textiles and beverage cartons were sorted, it would be possible to reduce the annual production of mixed municipal waste by almost ½ or from 9.6 tons to 4.7 tons per year.

3.1.6 Summary of the most important information

- The inner area of the primary school is very well equipped with bins for sorted waste. Containers for paper, plastics, glass, metals, batteries, electrical waste and textiles are available. Only containers for beverage cartons (tetrapack) are missing. In the outdoor parts of the school there are only bins for mixed waste.
- The system of school cleaning, sorting and removal of bins is effectively set up and includes good coordination between the cleaning staff and the school caretaker.
- The school has a regular and well-functioning collection of containers for plastics, paper, biowaste and mixed municipal waste. However, the biowaste container does not fully utilize its capacity. The container for beverage cartons is not used at all. According to the visual inspection, both paper and plastics are sorted well without contamination by other wastes. There are three garden composters available in the school garden, which are used more seasonally. Containers for mixed municipal waste, paper and plastics have a suitable capacity and frequency of collection.
- The total annual waste production has had a growing trend in the last three years (2017-2019). However, the production of mixed municipal waste is kept at a stable amount of around 10 tons per year. On the contrary, the number of sorted components is growing. This testifies to the effectively set up waste management of the primary school.
- Mixed municipal waste in 2019 represented only half of the total waste production, while in 2017 it was three quarters.
- Physical analysis of the waste revealed that half of the mixed municipal waste from the school's operation is usable components that can be sorted. So there is a potential for improvement.
- The share of mixed municipal waste was: biowaste (24%), infectious waste, which consists mainly of paper towels, represents 34% of the total production of mixed municipal waste. Paper, plastics, and other sorted components then accounted for 27%.
- With the maximum sorting of usable components (biowaste, paper, plastic, glass, metals, textiles, and beverage cartons), it would be possible to reduce the annual production of mixed municipal waste by almost half, in other words from 9.6 tons to 4.7 tons per year. By diverting paper towels, which make up the majority of infectious waste, it would then be possible to reduce annual production to just 1.5 tonnes of mixed municipal waste.

3.1.7 Proposed solutions in the field of waste

The design solutions are based on primary school visits, revision of documents related to waste management, and physical analysis of mixed municipal waste containers and sorted components.

Reducing the amount of mixed municipal waste produced

The primary school in Prague 3 currently produces about 18 tons of waste per year. 53% of this total amount is mixed municipal waste. However, a physical analysis of the waste showed that there was the potential to reduce this amount. This is possible either due to better sorting of usable components or as a part of waste prevention. Below are options in more detail.

1) **Biowaste**

Biodegradable waste (kitchen and kitchen compostable waste) represents almost a quarter (23.8%) of mixed municipal waste. That is about 2.3 tons of waste per year. From the point of view of the circular economy, it is important to sort and process this waste separately, for several reasons. When biowaste is mixed with mixed municipal waste and landfilled, anaerobic processes produce greenhouse gases such as CO_2 and methane. When incinerated in energy recovery plants, biowaste reduces the flammability of the material and thus the efficiency of incinerators due to its high water content. In both cases, the energy potential of this material is not used and the necessary nutrients from biowaste are not returned to the soil. These are the reasons why it is important to sort biowaste and then process it at biogas plants or composting plants.

It is also important to mention that the amount of biowaste produced, which ends up in the mixed municipal waste bin, is large. Its additional sorting would therefore bring significant economic savings for waste disposal. Moreover, composting the kitchen compostable waste meets the basic principles of bioeconomy.

Currently, the primary school has a container for the collection of biowaste and also its own garden composters. But neither of them is fully utilized. The composter is not only a device suitable for composting grass from green maintenance, but also for the compostable part of biowaste from school and kitchen operations. All cuttings from food preparation, leftover fruits and vegetables, or flowers can be discarded very well in the garden composter. Kitchen compostable waste, which makes up 20% of mixed municipal waste from school operations

and up to 65% of mixed municipal waste from the canteen, can be disposed of within the school's capacity, free of charge, at no extra cost.

Kitchen waste represents 3% of mixed municipal waste from school and 9% from the canteen. This waste, apart from pastries, is not suitable for composting.

It is therefore recommended to improve the sorting of compostable waste (especially in the kitchen) and to start to use the capacity of our own composters and biowaste containers.

2) Paper towels

Another material that is also suitable for composting is paper towels from the kitchen or bathrooms. This material accounted for the absolute majority of infectious waste, which represents 34% of the total production of mixed municipal waste. In particular, paper napkins used in the kitchen to prepare meals are not dangerous infectious material in terms of the nature of the waste, and can be thrown away along with vegetable and fruit scraps at a local composter. If the resulting compost is used, for example, for mulching the lawn or trees, it is possible to handle paper towels from the bathrooms in the same way. In this way, up to 34% (3.2 tons) of mixed municipal waste could be diverted per year, which also points to significant economic savings.

Paper towels can also be replaced with electric dryers. Their operating costs and ecological footprint are usually lower than with disposable napkins. And that is why most new operations choose automatic hand dryers instead of paper towels.

3) Beverage cartons and other sorted components

Paper, plastics, beverage cartons, metals and other sorted components accounted for 27% of the analyzed sample of mixed municipal waste. With better sorting of this component, it would be possible to divert up to 2.5 tons of waste per year.

It is recommended to introduce the sorting of beverage cartons, for which there are currently no containers in the school. In the operation of the dining room and at children's snacks, beverage cartons are a frequently used packaging so it is a type of waste in the school premises, which occurs in large quantities.

4) Other

It is also recommended to consider expanding the bins to separate components in the outdoor areas of the school (playground and garden), where only bins for mixed waste are available today. Children who properly sort waste at school have to throw everything in mixed bins

outside. Thanks to this, not only is the production of mixed municipal waste growing, but it also disrupts the consistency of the efficient system that primary schools strive for.

It is also suggested to start a discussion with the municipality of Prague 3 about the introduction of the Pay As You Throw system or smart waste management Internet of Things system.

The above-mentioned recommendations will help to drastically reduce the amount of mixed municipal waste that this primary school produces. As mentioned in the chapter Estimation of waste production potential, with 100% sorting of usable components, mass production will be reduced by up to half from 9.6 to 4.7 tons per year. Thanks to the replacement of paper towels, or their diversion from mixed municipal waste (for example to a garden composter), it would be possible to reduce the annual production to only 1.5 tons of mixed municipal waste. Thanks to the reduction of the production of mixed municipal waste, it is possible to reduce the frequency of its collection, which has a positive impact on the costs of waste management in the primary school in Prague 3 district.

3.2 Energy

Figure 28 *View of the school building from the main entrance, school facade from the back of the building – thermally insulated, insulating windows and window blinds.*

3.2.1 Current state

The building is equipped with thermal insulation – a contact thermal insulation system. The windows of the building are plastic with insulating double glazing, for part of the building equipped with window blinds, it is a financially achievable and at the same time very efficiently economical solution. Better savings can be achieved with insulating triple glazing and quality

frames, so it is directly desirable to include other parameters in the input criteria, including quality, associated warranty, service, and the use of recycled material in the input raw material.

Heating and hot water are provided by a central heat supply. Classroom heating is controlled by the ENESA clever system.[9] Each radiator is scanned and set for 21-22°C. The headteacher decides the investments of the school if they cost up to 200 000 CZK, for more extensive investments the decision goes to the Prague 3 municipality.

Significant consumers of electricity include lighting, which is realized using fluorescent tubes. Gradually, the lighting is being modernized, which consists of installing a better reflective surface in the luminaire.

Figure 29 *Lighting of common areas and classrooms using tubular fluorescent lamps.*

The school does not use renewable energy sources. Approximately 10 years ago, a feasibility study was carried out for the installation of a photovoltaic power plant on the roof of a building. However, it was found to be unprofitable and technically infeasible (excessive load on the statics of the roof) due to the fact that it was planned to install a metal structure that would ensure the southern orientation of the photovoltaic panels.

Air conditioning is introduced only in the dining room. In areas where teaching takes place, forced air exchange with recuperation is not introduced.

[9] reference: http://www.enesa.cz/aktuality_detail.php?id=104

Figure 30 *View of the roof where there is great potential for the location of a photovoltaic power plant.*

Many energy-saving measures have already been implemented in the school building – facade insulation, replacement of windows and doors, regulation of the heating system, etc. The potential for improvement in energy management lies mainly in 2 areas – lighting and renewable energy sources.

3.2.2 Suggestions

General recommendations

The motto of the basic principle of energy is: "The most sustainable energy is the saved energy."

When managing a building, it is important to rely on information related to the operation, so it is advisable to regularly perform an energy evaluation so that it is possible to compare the periods and evaluate any losses or savings.

Renewable energy sources

The school building offers a potential for the installation of a photovoltaic power plant. The building has a flat roof on which it would be possible to place the power plant. Around 2010, the intention to build a photovoltaic power plant was assessed, but this project was not found to be economically viable. Updating the feasibility study for the construction of a photovoltaic power plant is suggested because over the last 10 years there has been a significant decrease in investment costs for the installation of photovoltaic power plants (up to 80%) and the photovoltaic technology itself has made significant technological progress. An investment in a

photovoltaic power plant on the roof of the school could now turn out to be economically viable and technologically feasible. However, detailed analysis of profitability is not within the scope of this work.Nowadays, only 26% of the total energy consumption comes from renewable energy sources (according to the International Energy Agency) According to the International Energy Agency, buildings in European cities contribute 36% to total greenhouse gas emissions. To meet the targets of the Paris Agreement, emissions will need to be reduced by 80% by 2050.[10]

One of the most effective ways to reduce emissions is the decentralization of energy, it means electricity production directly at the point of consumption. The installation of decentralized energy production directly in/on buildings is quite expensive, and the expenditure balance is balanced during long-term operation. Decentralization measures that can be considered for complete reconstruction include the installation of a photovoltaic power plant, solar thermal collectors, a heat pump, a biomass boiler, the use of a cogeneration unit (combined heat and power) and a recovery unit that allows the use of waste heat. Nowadays, photovoltaic panels can be integrated into buildings not only in the form of fixed installation of common panels on the roof or facade, but also by using special photovoltaic panels, which form the facade itself, the so-called BIPV (Building Integrated Photovoltaics). For example, according to the company E.ON, an energy distributor, a photovoltaic panel with an output of 320 Wp can be bought for about 3,500 CZK.[11] The cost of their installation must be added to the price of the panels. Thanks to the state subsidy, the investment in a small solar power plant can return in 6 to 10 years. The roof of the school is an ideal place to install solar panels that can be used for both energy production and water heating. The declared service life of most photovoltaic panels is 20 years and their real service life should be even higher under standard conditions. According to the difficulty and complexity of energy decentralisation, the transition to so-called green energy is therefore often a more interesting and easier way in becoming more energy-efficient and reducing carbon footprint without much investment. This is the purchase of energy that is from renewable sources. With this simple change, the development of energy innovations (that are also ecological) is supported. It is also a well-communicable topic, helping to educate and meet the school's goals, which may include reducing CO_2. Green energy is offered by a wide range of energy suppliers. It is important to verify who the

[10] https://www.iea.org/fuels-and-technologies/renewables
[11] https://www.eon.cz/radce/zelena-energie/solarni-energie/kolik-stoji-solarni-panely/

current contractor is and start a discussion on this topic, choose the optimal tariff from the supplier with an emphasis on the supply of green energy.

Heating system

An effective solution for reducing energy consumption is streamlining the heating system (thermoregulation valves, hydraulic balancing of the heating system). It is recommended to set a uniform temperature in all rooms. If there are more people in the room using computers, etc., which increase the heat in the rooms, it is not necessary to have a higher temperature set. By lowering the temperature every one degree, about 6% of heat is saved. If no one uses the room, it is not necessary to heat it.

Maintaining a constant water temperature (often unnecessarily high) then increases energy consumption. The same claim stands for days when hot water is not needed at all at school. It is always more economical to turn off the heating and reheat the water before use (e.g. at night from Sunday to Monday). The same principle can be applied in the case of overall building heating.

Ventilation

Ventilation is closely related to heating. Hygienic and operational criteria for individual factors of the internal environment are based on government regulations and ordinances, especially on the Decree No. 343/2009 Coll. It is especially important for education relating to the school environment. It deals with microclimatic conditions (temperature, relative humidity, air flow rate), lighting and ventilation. Therefore, in order to ensure a healthy environment, the room must be ventilated.

Ventilation, especially abundant, reduces accumulated CO_2 concentrations, the increase of which results in excessive fatigue and lack of concentration and can also lead to minor health problems. It is therefore important not to forget the need to replace the indoor exhaust air with fresh air. The direct proportion is that the more energy-efficient a building is, the greater the need to ensure proper ventilation. On the other hand, ventilation is a very energy-intensive measure.

Lighting

Fluorescent lights are used as light sources in the school building. Currently, it is possible to achieve the required lighting with lower electricity consumption using LED technology.

Fluorescent tubes have the disadvantage that they shine in all directions and require directing the luminous flux, which reduces efficiency. Fluorescent lamps start with a certain delay and their service life depends on the number of cycles. Fluorescent lamps also often suffer from ailments such as stroboscopic flickering or sound effects. Fluorescent lamps contain dangerous mercury and must be disposed of accordingly at the end of their service life.

Fluorescent lighting can be replaced by LED technology, either by purchasing completely new light fixtures or by replacing fluorescent tubes with LED tubes and only renovating existing fixtures. The advantage of LED technology is its energy efficiency, the luminous flux can be better directed, they do not mind repeated switching, which can be used in areas with automatic lighting. The start of the LED lighting is immediate. From the point of view of disposal of obsolete equipment, LED lights, unlike fluorescent lamps, do not contain hazardous substances. LED lighting is also good for cincentration during the day.

Other suggestions for saving energy:

- Make the most of the potential for energy savings and the use of waste energy.
- Get involved into PPP (Veřejně soukromé partnerství – Public-private partnership) or Energy Performance Contracting (EPC) projects.
- Use financial sources from the public assistance.
- Use other support from the state – EU funds, soft loans, etc.
- Create a modern (intelligent, low-emission, low-cost, ...) building / New generation building (healthy – flexible – recyclable – preserving its value).

3.3 Water

There was a reconstruction of the building in 1999. It rains about 900 m³ on the roof every year. There is a waste crusher in the kitchen and La-pol (Lapol of fats is a device used to separate fats from wastewater. It is a plastic sedimentation tank in which the wastewater is gradually freed of fats and oils and cleaned of these substances flows further into the sewer).

3.3.1 Current state

Currently, the primary school building treats water on several different levels. In total, the average annual consumption of drinking water in the building is 3,000.8 m³ (average for last five billing periods), which is divided into water needed for hygienic, irrigation, and drinking

purposes, and consumed by the gastronomic operation (school canteen). These consumptions are not distinguishable at the moment because a separate water meter is missing for the gastronomic establishment. Drinking water is consumed by 700 people (pupils, teachers and other school staff), especially for hygienic purposes. A part is used for drinking and depending on the season, a part of the water is also used for irrigation (this is, however, most of the time represented by rainwater). This consumption is the main goal of reducing drinking water consumption, which is discussed in detail below in this document. The kitchen cooks approximately 700 portions a day. However, the number of portions is not a general daily rule (see the chapter Gastro operation), the drinking water consumed in the gastronomy depends on the exact number of portions to be prepared, and it is beyond the scope of this thesis to assess the potential savings in this area.

Rainwater in the area can be captured only by gutters from the largest roof area before draining into the sewer. At the moment, this is happening at two of the eight eaves from the largest roof area. Rainwater is captured by gutters leading from the roof to the barrel and then used to water the school garden. According to PVK, a.s. (Prague water supply and sewerage), the annual total of rainwater is on average 2045 m^3.

It is also necessary to mention the popularization activity in the field of water, which prevails at the school, both on the part of teachers and pupils. The interior of the school is often equipped with educational tables or notice boards with the theme of water. The last annual report of the school mentions 5 different class projects focusing on water treatment in our country or in the world.

Figure 31 *Washbasins and urinals in the school building.*

3.3.2 Drinking water consumption analysis

According to data from similar establishments, the real water consumption in the school canteen is 3.5 liters of hot water and 2.72 liters of cold water per meal. For the primary school in Prague 3 district, the estimated annual consumption is 853 m³ for 700 meals a day for 196 school days. As mentioned above, analyzing this part of consumption is not within the scope of this thesis. In general, however, water consumption in school canteens is relatively low compared to other gastronomic establishments and is in reality much lower than the value of 22 liters per meal, which is stated in the standard according to Decree 120/2011 Coll.

The remaining consumption of drinking water is then mainly used for drinking, flushing and personal hygiene. The consumption for watering is left aside, because there is an effort to cover it from rainwater. According to the distribution of consumption, the largest part is used for flushing, where there is also the biggest potential of saving drinking water in the building.

3.3.3 Suggestions

A good option for determining consumption is the installation of operational water meters, for which it is possible to set an own warning of exceeding consumption. For example, the tightness of the taps is very important, one “little” dripping tap (only 10 drops / min.) Drips about 160 liters of water per month. And when it comes to hot water, it's even a loss of 11 kWh of energy.

A great solution is to install water flow regulators or aerators on taps. In both cases, water wastage is reduced. Economical aerators reduce water flow due to their design. The tap water mixes with the air and directs its flow, thus reducing consumption. At full flow, 20 liters of water flow out of the tap in 1 minute, that is 1,200 liters per hour. With a conventional aerator, the flow is up to 25 l / min, while the economical aerator can reduce it to 6, 8, 10 or 12 l / min. Another solution is in the form of thermostatic faucets, whose huge advantage is the almost immediate setting of water to the desired temperature. For comparison, setting to a comfortable temperature on the faucet takes an average of 12 seconds, on the lever 7 seconds and on the thermostat only 3 seconds. Modern installation solutions in the form of self-regulating heating cables, which are attached to the pipes and compensate for heat losses in places where it is needed, will also help to eliminate completely unnecessary water consumption. This solution is especially suitable for larger systems.

Table 7 *Estimation of losses of dripping faucet and flowing toilets.*

	fripping	litres per day	m^3 per year	Czech crowns per year
dripping faucet	faintly	24	8,76	464
dripping faucet	strongly	54	19,71	1 045
flowing toilet flush	faintly	150-1000	54,75-365	2900-19350
flowing toilet flush	strongly	1000-2000	365-730	19350-38700

Source: Moravská vodárenská (https://www.smv.cz/zakaznici/mereni-spotreby-a-odecty/jak-setrit-vodou2/kolik-stoji-pripadny-unik-vody/)

Saving drinking water for the primary school in Prague 3 district could be realized by replacing consumer equipment with saving ones. Currently, there are 157 flushing toilets, 105 washbasins and 30 urinals in the building. Urinals are a very economical element even when rinsing with drinking water. The so-called Waterless urinals are expensive to install and consume disinfectants and electricity to the fans instead of water. On washbasins, economical aerators are installed in the building and their consumption is thus reduced to a reasonable extent. The largest consumers are flush toilets, which do not have so-called double flushing installed. With these devices, it is possible to set the volume of large and small flushes. Installing double flushing on all toilets with a small flush of 4.5 liters would reduce drinking water consumption by up to 580 m³ per year. Setting a small flush of 3 liters of water reduces consumption by up to 840 m³. Annual savings are thus between CZK 49,500 and CZK 71,800. It is possible to do this simply by installing the so-called “toilet stop” equipment, which is priced around CZK 300 per piece, or, of course, the reconstruction and replacement of entire toilet facilities.

3.3.4 Alternative water sources

Drinking water can be replaced by non-potable (service) water for certain uses. Its use is by law limited to flushing and watering. However, flushing is an important part of the consumption, according to the model for the chosen primary school in Prague 3 district. Non-

potable water can be taken from suppliers or treated rainwater and possibly gray water can be used.

According to Pražské vodovody a kanalizace records, the primary school in Prague 3 district charges annual sewage for 2045 m³ of rainwater. On the roof area of the main building, according to hydrometeorological data, 860 m³ of rainwater is available annually, which could be used for flushing. The use of service water for flushing is permitted by the hygienic station. However, the main obstacle in the case of this building is the necessary investment in double distribution systems and rainwater storage tanks, which in this case are not possible to implement. In the case of a major reconstruction of the building, it is suggested to consider this variant of rainwater treatment and perform a cost analysis in detail. In addition to the saved water, the benefit will also be the saved part of the sewage from rainwater. The limit (in the case of the use of all rainwater from the roof of the main building) is CZK 73,465 per year in water and sewerage, the realistic estimate is halved, mainly due to the limitation of the capacity of the reservoirs.

Alternatively, it is possible to approach rainwater through two other sustainable routes, thus reducing sewerage payments from rainwater:

- Soak up rainwater on the school grounds by means of seepage channels
    - In the current distribution of drains from the roof of the main building, 2 gutters were found, from which rainwater is already collected, the other two gutters (corner on the side to the playground) are usable and it is relatively easy to collect water from them. From the remaining gutters, heading to the side of the street, collection is difficult. In total, it would be possible to capture up to half of the rainwater from the roof area. In this case, it would be necessary for its direct infiltration on the land to install seepage channels with an area of 588 m². The channels are placed to a depth of 0.3-2 m. In this case, it would be necessary to survey the subsoil. In urban areas with distribution networks, it is often impossible to install manholes due to water and gas.
- Create a green infiltration area on the roof (so-called green roof)
    - Due to the difficult accessibility of the roof, its potential use for the placement of solar panels and due to its load-bearing capacity, the creation of an infiltration area is not recommended.

Figure 32 *Infographics on the corridors and in bathrooms speaking about saving water.*

3.4 Equipment

In a school building, there is a lot of equipment being used on a daily basis. This section concentrates on school supplies and equipment from a more ecological and sustainable point of view.

3.4.1 Document printing

At primary school, a big part of the agenda is still kept in paper form. To effectively reduce the frequency of printing any documents, it is important to digitize the agenda as much as possible. There are currently many tools of digitization available.

When comparing digitization and printing in terms of emission data for calculating the Scope 3 carbon footprint,[12] it is clear that the printer's emission factors are 1000 times greater than IT services, which are concentrated in one place and can even be operated from renewable sources. Nevertheless, it is necessary to pay attention to the digital carbon footprint and the associated electricity consumption. So it is a good idea to strike a balance between printed and electronic documents, while guarding the excess of unnecessary documents that no longer need to be physically printed or digitally stored – reducing both the physical and digital carbon footprint. Therefore, in order for this process to be successful, it is recommended to support this process in an educational workshop form. Printing efficiency can be increased by printing software that allows users to assign user accounts, define access to features and budgets for users, better analyze print frequency and history, prevent the loss of sent print reports, and last but not least, secure printing. This measure would require an initial analysis and subsequent more detailed analysis to find a suitable solution. At the same time, communication with employees will need to be taken into account so that they do not feel the implementation of user accounts as control,

[12] https://www.epa.gov/climateleadership/scope-3-inventory-guidance

but as a meaningful solution for more sustainable and efficient operation. The correct default setting on the printer driver or print server leads to a lower environmental footprint. And only thanks to a few simple measures, which otherwise the user must reset on the computer for the needs of one print job with other parameters, when the next print job is again in the default settings. These measures include: two-sided and black-and-white ink-saving printing. Black and white printing must really be set to black and white even with a color printer, otherwise it consumes additional colors to obtain gray. Other environmentally friendly and used solutions include professional refurbishment of print cartridges and their reuse, it is recommended to occasionally buy new cartridges. The same principle of spreading the printing material can be chosen for recycled papers with certification, on which it is possible to print without worrying about the technical condition of the device. It can be used especially for black and white and technically less demanding printers. When shredding a document, it is a good idea to think about whether there is real recycling or shredding. Professional shredding thanks to the shredding container and subsequent recycling is recommended. Simple indirect measures that reduce the environmental footprint of the press include the introduction of an electronic signature for employees who have the right to sign, or the use of a data box. A simple and effective recommendation is to use and accept various forms of proofreaders even on official documents.

General rules for gentle printing

- Information for employees – whether it is necessary to print every paper and email, the ideal condition is everything digitized and with the least possible need for printing.
- Check printer settings and divide traffic clearly and distinctly into black and white and color printing.
- Default settings for black and white and duplexing – Use color and single-sided printing only when necessary.
- Print on recycled or at least PEFC (Programme for the Endorsement of Forest Certification) paper made in the Czech Republic.
- Customize graphics – for example, the logo can be black and white or partially black and white with only one color.
- Request the return, recycling and repair of toners and cartridges from their suppliers.

3.4.2 Electronics

Electronics equipment is a common office type. These are mainly PCs, laptops, monitors, keyboards, mouses for staff and other school equipment. Disposal of used electronics takes place through a collection yard.

- It is recommended to consider buying refurbished PCs and mobile phones instead of brand new products – for saving money while maintaining high quality and often a full two-year or even extended warranty.
- Find out the real demands of employees on computer technology and align them with the quantity and capacity of available technical equipment and define the standard of technical equipment per employee and its observance.
- Train employees on the correct technical and energy use of computer technology.
- Select a technique that allows easy repair and/or replacement of parts, especially memory (so that it can be replaced or expanded), hard disk, and battery.
- The quality of computer technology can be found out by meeting the TCO Development standard.[13] This marking for computer technology is developed by a Swedish institution (Tjänstemännens Centralorganisation – Confederation of Professional Employees), which also grants TCO certificates until the early 1990s, and denotes the environmental friendliness of personal computers.

3.4.3 School/office supplies and shopping

All office supplies are purchased according to the current requirements of employees. Office supplies and electronics are used for as long as possible, then disposed of and cannot be resold, which is based on safety regulations of state institutions. Because the requirements for circularity and sustainability of purchases are not defined, it is suggested to develop a methodology for selecting partners and suppliers that meet aspects of the circular economy, as well as a list of recommended suppliers, including criteria for selecting them. The way to choose the right partners and suppliers is to award circular contracts.

Responsible public procurement

The Amendment to the Public Procurement Act (Novela zákona o veřejných zakázkách) will help with responsible procurement itself. Amendment to Act No. 134/2016 Coll. was approved

[13] https://tcocertified.com/criteria-overview/

on 1 December and from 1.1.2021 de facto introduces the obligation of socially and environmentally responsible public procurement.

Paragraph 4 was added to § 6, which stipulates:

- *"The contracting authority is obliged to observe the principles of socially responsible procurement, environmentally responsible procurement and innovation in the procedure under this Act, namely when creating tender conditions, evaluating tenders and selecting suppliers. within the meaning of this Act. The contracting authority is obliged to duly justify its procedure."*

In § 28 paragraph 1, there is written:

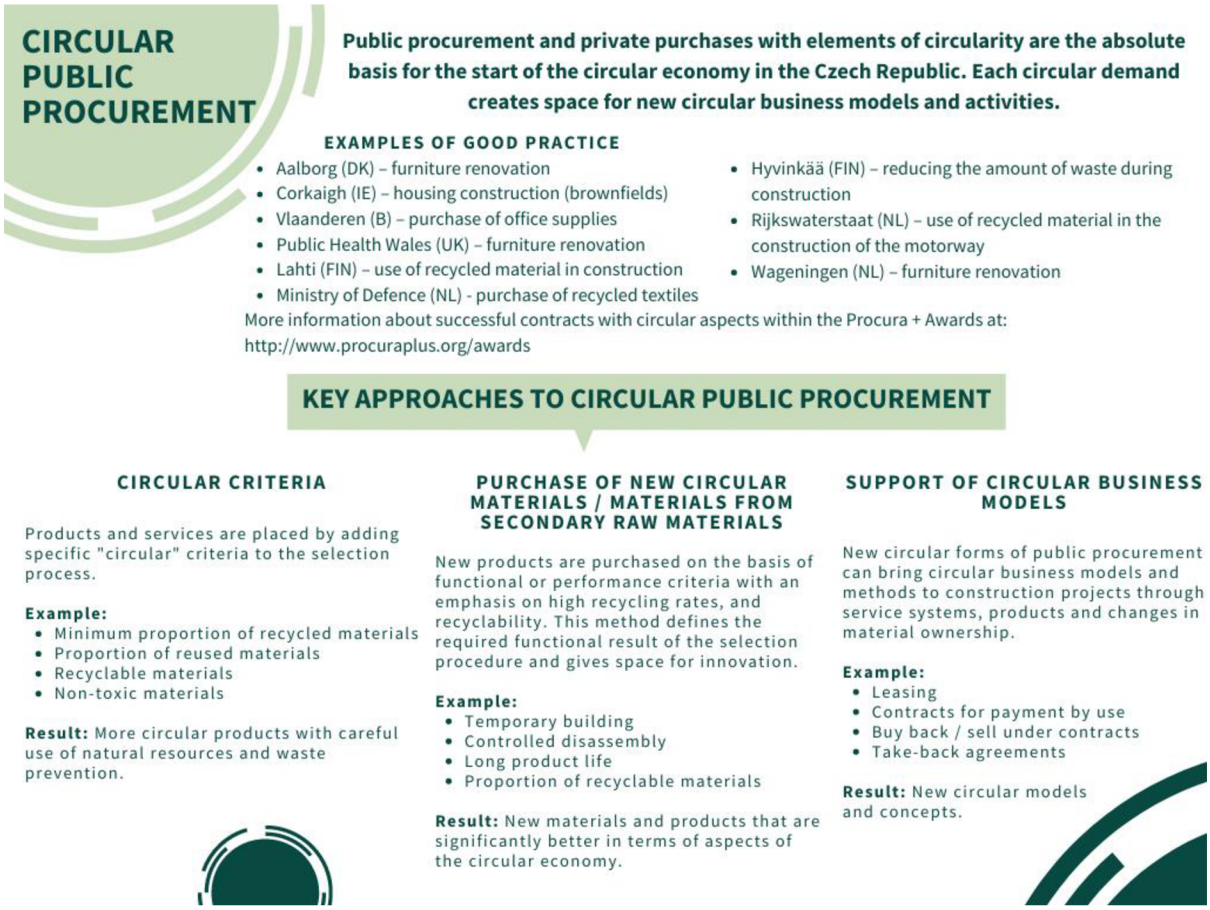
- in letter p) *"socially responsible procurement is a procedure under this Act in which the contracting authority is obliged to take into account, for example, job opportunities, social inclusion, decent working conditions and other socially relevant aspects related to the public contract,"*
- in letter q) *"environmentally responsible procurement is a procedure under this Act in which the contracting authority is obliged to take into account, for example, environmental impact, sustainable development, life cycle of supply, services or works and other environmentally relevant aspects related to public procurement,"*
- in point (r) *"innovation of the implementation of a new or significantly improved product, service or process related to the subject of the public contract."*

The consideration of environmental aspects in public procurement is explicitly supported by Directive No. 2014/24/EU and is also taken into account by Government Resolution No. 531 of 24 July 2017, which declared efforts to:

1. Reduction of energy consumption,
2. reduction of water consumption,
3. reduction of raw material consumption,
4. reduction of the production of pollutants released into the air, water and soil,
5. reduction of waste production,
6. limiting the carbon footprint.

The way to choose the right partners and suppliers is to place a circular contract based on circular public procurement. Instructions on how to place such orders can be found in the infographics below:

Figure 33 *Circular public procurement.*



Source: Odpadové fórum 10_2019, Škola odpovědného veřejného zadávání přináší inspiraci, Mgr. Regina Hulmanová, Ministerstvo práce a sociálních věcí ČR.

Recommendations in case of office supplies

- Choose refillable pencils, markers and markers and make sure they are free of aromatic and alcoholic solvents.
- For adhesives, prefer starch, dextrin, or protein-based adhesives and choose those that are water-soluble.

Furniture and other equipment

- Make sure that it is made of natural and recycled materials, or of one type of plastic from health certifications.
- Give priority to reusing existing furniture, or renovation of existing furniture.
- Within the circularity you can use a furniture bank or bazaars.

3.4.3 Cleaning detergents

In the case of buying detergents, it is important to check the sources with the supplier cleaning company. Subsequently, it is possible to propose an amendment to the contract and the use of community bottling/weighing plants for packaging-free detergents – such as soap, spring for dishes, gel for the dishwasher, air fresheners, disinfectants or hygienic detergents for toilets.

- It is advisable to require concentrated products that are dilutable with water;
- Find out if the cleaning products are eco-labeled or have comparable properties so that the biodegradability is declared.
- Require that the cleaning service be certified according to the ČSN EN ISO 14001 standard and be registered in the EMAS programme or a similar environmental management system.

General recommendations for equipment of school

In general, the following applies to means and equipment:

- To be marked with the "Environmentally friendly product" or "EU Ecolabel" logo.
- Where wood is used, select the "FSC" and "PEFC" logos (this is an eco-certified wood product), or currently require bark wood.
- In general, a good rule of thumb is a product with a simple design that allows damaged parts to be repaired or replaced.
- Eliminate the amount of waste, for example by buying in larger packages, or buying concentrates, or buying in reusable packaging.
- Request different variants, have selected samples and models imagined.
- Prefer local products and services.
- A good product should have a guaranteed take-back.
- Ensure economic viability by assessing the ratio of life-cycle costs to product and service quality (LCC – Life Cycle Costing)[14].
- Think about buying a new product with consideration of sustainable product design. Avoid one-use products.

[14] https://ec.europa.eu/environment/gpp/lcc.htm

Figure 34 *Certificates: Environmentally friendly product, EU Ecolabel, FSC.*

Environmentally friendly product and EU Ecolabel

Products bearing the trademark – the eco-label "Environmentally friendly product" – give consumers a national guarantee that the products have minimized the adverse effects on the environment and natural resources arising from its production, use and disposal, and at the same time meet other quality criteria and standards.

Similarly, the "EU Ecolabel" programme, to which the Czech Republic joined in 2004. Both programs are in accordance with the provisions of the technical standard ČSN ISO 14024 Environmental labels and declarations – Type I environmental labeling. Under these programmes, the Ministry of the Environment of the Czech Republic grants producers of environmentally friendly products and services that meet the set criteria for environmental impact, the right to use the Ecologically friendly product / service logo and the EU Ecolabel.

Environmentally friendly principles can be applied in purchases:

- renewable electricity,
- office supplies,
- furniture and outdoor furniture,
- computers and office equipment,
- vehicles and employee mobility,
- lighting,
- refreshments/meals,
- cleaning detergents,
- also for services such as cleaning, green maintenance, waste collection and recycling, printing services,
- further construction work, including small constructions or building modifications.

3.5 Gastro operation (school canteen)

In this part of the study, the current state of waste production in the school canteen is analyzed, and also the functioning of the gastronomic operation is evaluated from the point of view of the circular economy. The analysis is based on internal documents provided by the canteen (menus, number of ordered portions, evidence of waste produced from the fat separator and evidence of waste produced for the entire primary school, invoices from individual food suppliers) and photo documentation obtained during a personal visit to the canteen. All findings are then summarized in specific recommendations, which aim to streamline waste management in the canteen and an overall approach to the principles of the circular economy.

3.5.1 Current state

The primary school canteen provides lunches for local pupils and staff every day, from Monday to Friday. There are a total of 650 boarders, according to the analyzed menus (in the period January and February 2020), however, the daily number boarders, i.e. a specific number of ordered portions, is around 500 to 570. The school canteen cooks four types of food every day, two of which are adapted for special diets – gluten-free and lactose-free. One of the dishes is also often vegetarian.

Waste production in gastro operation

The school canteen is involved in the production of almost all types of waste generated at school. Exceptions are the categories of reuse waste, textiles and wood. Due to the large volume of raw materials that gastronomy processes, the volume of waste produced is also significant. According to the staff, the canteen produces a larger quantity of sorted waste than the rest of the school.

3.5.2 Results of physical analysis of waste from the school canteen

The total weight of the analyzed waste from the school canteen was 19.5 kg of mixed municipal waste. These were three large bags that were produced in two days of operation. The largest part, 65.2% (12.7 kg), was kitchen compostable waste. The second most important component, 10.2% (2 kg), was infectious / non-infectious waste. Non-compostable kitchen waste (gastro waste) was the third most abundant component. However, compared to compostable organic waste, it accounted for a significantly smaller share of 9.2% (1.8 kg). Mixed municipal waste, a component that is no longer separable, accounted for only 6.8% (1.32 kg). The paper

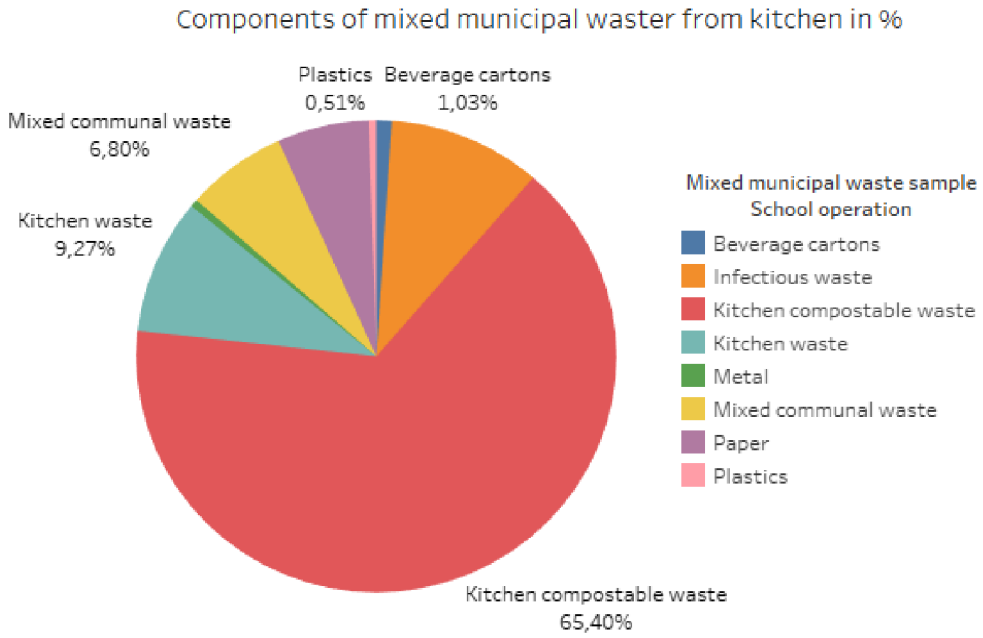
accounted for 6.2% (1.2 kg) of the total volume. Other categories of sorted waste already made a relatively negligible amount. Beverage cartons were only 1.1% by volume (0.2%), plastics 0.7% (0.1 kg) and metal 0.6% (0.1 kg).

Figure 35 *Waste containers from the school canteen, sorted waste in school canteen area, physical analysis of waste.*

Table 8 *Composition of mixed municipal waste from school canteen as results of physical analysis of waste in kilograms and %.*

Mixed municipal waste sample – School canteen	Total weight (kg)	%
Kitchen compostable waste	12,7	65,2 %
Kitchen waste	1,8	9,2 %
Plastics	0,1	0,7 %
Paper	1,2	6,2 %
Metal	0,1	0,6 %
Beverage cartons	0,2	1,1 %
Infectious waste	2,0	10,2 %
Mixed communal waste	1,32	6,8 %
TOTAL	19,5	100,0 %

Figure 36 *Composition of mixed municipal waste from school canteen as results of physical analysis of waste in %.*



The largest share of the total volume of mixed municipal waste was **kitchen compostable waste**, 65.2% (12.7 kg). There were mainly cuttings and skins of vegetables and fruits (cauliflower leaves and brooms, onion and garlic skins, melon skins, etc.), but also egg shells or herb stems. All this waste is compostable so it can be easily processed directly on the school grounds in its own composter, or sorted into a biowaste container. Given that this type of waste accounted for almost two thirds of the weight of all mixed municipal waste produced by the canteen, the potential for reducing the amount of mixed municipal waste and for economic savings is considerable. Moreover, composting the kitchen compostable waste meets the basic principles of bioeconomy.

Figure 37 *Kitchen compostable waste.*

Infectious waste represented 10.2% (2 kg) of the total volume of mixed municipal waste. These were mainly paper towels and napkins, but also disposable gloves. High consumption of paper towels is a problem of almost every gastronomic operation. Their excessive use not only significantly increases the amount of waste produced, it also means additional financial costs. In many cases, however, it is replaceable with cloths or wipes that can be used repeatedly. It mainly depends on setting up own internal practice in operation and the habits of employees. If paper towels are not infectious, they can be composted.

Figure 38 *Infectious waste (paper towels).*

The third most produced waste was **kitchen waste**, i.e. heat-treated foods, such as pastries and leftovers, and food of animal origin. In mixed municipal waste, it occupied 9.2% (1.8 kg) and consisted mainly of bread crumbs and scraps and meat residues. This type of waste should be properly sorted in the gastro-waste container. The school canteen produces a large amount of this type of waste, according to the canteen manager, this is the largest part of the waste that is produced in operation of the school canteen. However, the vast majority is processed in a waste shredder.

Figure 39 *Kitchen waste.*

All types of **paper** (cardboard, office paper, printed matter) were sorted from the sample of the mixed municipal waste by 6.2% (1.2 kg). There were mainly packages, for example from flour or boxes from food products, but also office papers, etc. The school canteen processes a large amount of raw materials, which are packaged in paper. Most of these materials are sorted, but due to the results of the analysis, there is still potential of improvement.

Figure 40 *Paper packaging of flour.*

1.1% (0.2 kg) of mixed municipal waste consisted of **beverage cartons**, specifically boxes of milk and cream. Unfortunately, they are not sorted neither in the school operation, nor in the gastronomic operation. Although this is a relatively low percentage of the total weight of the mixed municipal waste analyzed, this volume is not negligible in volume. In addition, a container for beverage cartons has been set up on the school grounds and is ready for collection.

Figure 41 *Beverage cartons from the analysis of mixed municipal waste.*

The **plastic** represented 0.7% (0.1 kg). It consisted mainly of soft plastics and plastic foils from food packaging. There were pure, non-degraded plastics, so it is important that these components are also sorted consistently.

Figure 42 *Plastic waste from the physical analysis of waste.*

The **metal** represented only 0.6% (0.1 kg). It was a single can. Although this is a minimal amount, this material should also be sorted. There is a container for sorting metals in the school building.

Figure 43 *Metal waste from the analysis.*

Furthermore, **unsorted mixed municipal waste** accounted for 6.8% (1.32 kg) of the total volume of the analyzed sample. In this case, it was mainly food and fat contaminated materials and packaging. Together with infectious waste, which also belongs to mixed municipal waste, it was only 17%. More than ⅘ of the mixed municipal waste generated in the school canteen is therefore waste that could and should be sorted and recycled.

Figure 44 *Mixed municipal waste from the analysis of mixed municipal waste.*

3.5.3 Waste sorting in the school kitchen

The school canteen operation has its own container for mixed waste, the sorted components are processed together with the sorted waste produced by the school operation. There is a mixed waste bin directly in the kitchen. Separated waste is thrown away separately, but some of it incorrectly ends up in a mixed waste bin, which is more accessible. These are mainly smaller pieces of waste, such as beverage cartons from milk or paper bags from flour. Larger types of waste, such as crates or jars, were placed next to the mixed waste container and were prepared for taking out. Better distribution of bins and greater availability of containers for sorted waste could therefore be an important step for more efficient sorting. A good solution for gastronomic establishments is to place containers for all types of waste directly in the kitchen. So that the bins for sorted waste and mixed waste stand side by side and the workers are maximally motivated to throw the waste in the right bin. If the space capacity of the kitchen is limited, placing at least two bins is recommended – one for mixed waste, the other for all sorted waste, which is later sorted according to individual types.

Figure 45 *The contents of the mixed waste bin in the kitchen.*

Waste from packaging materials

The largest part of the waste produced in most gastronomic operations consists of packaging materials. Their elimination is not easy, as the current wholesale for gastronomy does not offer many alternatives. However, based on the analysis of invoices and raw materials used and in-service analysis, at least several recommendations were defined on how to reduce the amount of packaging materials produced and thus reduce the overall production of waste.

As part of the analysis of the gastronomic operation, invoices were available for the purchase of basic food from 19 May to 4 June 2021. According to these documents, the purchase of raw

ingredients takes place through several regular suppliers. Fruits and vegetables are supplied by Petr Kamenský FRUIT – VEGETABLES, the frequency of delivery is usually every 2 to 3 days (invoices from 19.5., 24.5., 26.5., 28.5, 31.5., 2.6. were analyzed). Meat products are purchased from Prominent CZ (May 19 and May 28) and KAMABY plus (May 20 and May 31). Alimpex FOOD supplies dairy products, eggs and yeast every 5 days (20.5., 24.5., 28.5., 3.6.). Frozen food is provided primarily by Bidfood, along with refrigerated products such as vegetables, flavorings, certain types of cheese, meat products, and also long-life foods. The frequency of delivery is approximately once a week (21.5., 26.5., 31.5., 4.6.). Some types of durable food are supplied by CANO, especially canned pasta, tomatoes and beans, etc. During the analyzed period, there was only one delivery (26.5.) KASIA vera (2.6.) and CMS Consulting (2.6.), mainly dry foods such as flour, sugar, rice or spices, but also oils and other products (cream, dumplings).

From the available invoices, it is clear that a large part of products (such as pasta, fresh milk, some types of dairy products, frying oil, frozen vegetables, seasonings or spices) can be purchased in larger (gastro) packaging. Especially with fresh milk, it is very good that it is delivered in buckets with a volume of 10 liters. Thanks to this, a total of 130 pieces of beverage cartons or PET bottles, in which milk is most often sold, were saved during the analyzed period (19 May to 4 June 2021). In addition, according to the head of the canteen, empty buckets are usually dismantled by employees who continue to use them in their own gardens. Unfortunately, a larger volume of purchased milk consists of durable milk, packed in beverage cartons with a volume of 1 liter. During this period, 216 liters, i.e. 216 pieces of beverage cartons, were purchased. In addition, they are not properly sorted and recycled and end up in mixed waste.

Figure 46 *Packaged food on the shelves in the kitchen.*

Most vegetables, fruits, and meat are bought by weight, not in smaller packages, which helps to significantly eliminate the amount of waste. However, it is clear from the invoices that only the company Prominent CZ delivers products in returnable, back-up crates. This system is also recommended for other types of goods, such as fruit and vegetables that are, after inspecting the warehouse, delivered in boxes but not returnable. They, therefore, produce unnecessary waste, which could be prevented thanks to returnable boxes. In these cases, it is often sufficient to agree with the supplier on a system of change. Many of them already meet the needs of customers today. Despite the fact that returnable crates save a lot of waste and money for both parties.

Figure 47 *Kitchen warehouse for storing food.*

To eliminate the amount of waste, it is generally recommended to prefer larger packaging for the maximum number of products (except for fresh products, which risk not being consumed in time in larger quantities and will be disposed unnecessarily). The potential for change has fow example flour, which is normally supplied in packages larger than 1 kg. A similar example is some types of pasta, olive and sunflower oil, butter, sugar or salt. It is also better to prefer the purchase and use of basic ingredients and products and to reduce the consumption of semi-finished and industrially processed foods which usually also means a large amount of packaging materials – not only in a given operation, but within the entire process of their processing and production.

Concerning the individual types of packaging materials, according to the head of the canteen, the largest part of the waste is paper, mainly cardboard boxes. They are successfully sorted, but

part of the paper, as found out from the physical analysis of waste, ends up in mixed municipal waste, for example bags of flour. It is therefore important to pay attention to the sorting of these (smaller) pieces of paper as well.

A large part of the packaging waste consists of beverage cartons, which have already been mentioned above. For this type of waste, it is recommended not only the total elimination, but mainly the introduction of its sorting, which does not work for now being either in the canteen or in the school building.

Figure 48 *Shelves with food supplies.*

A number of purchased groceries is also packaged in plastic, mostly soft plastics and foils, which form a small part of the total volume of waste produced. However, not all of them are, according to the results of the physical analysis of waste, thoroughly sorted. So there is a space for improvement here too. A smaller proportion of plastic waste consists of PET bottles and hard plastics, which can be sorted without problems.

Glass is used in gastronomy in relatively small quantities. There are only some products in glass jars, such as pickles, pesto, cranberries or olive oil in glass bottles. Although it is a small amount (and some large glasses are often taken by employees), this type of waste should also be sorted and recycled. However, the primary school does not have a glass container.

The similar situation applies for metals. A small part of food products is bought in metal cans, such as peeled tomatoes, some types of legumes or compote fruit. Their total production is therefore relatively low. However, even with this type of material, there is no container that would allow their sorting and recycling. At the same time, it is possible to eliminate this waste by changing the purchased assortment and prefere only fresh products (for example, legumes).

Kitchen waste

According to the kitchen staff, the largest part of the waste produced by the operation is kitchen waste, or the leftovers of heat-treated meals and food of animal origin, up to 80 liters every day. The school canteen does not have containers for gastro-waste. Due to the large volume of this type of waste, its collection would be very expensive, which the school cannot afford in the current conditions. At the same time, it is a very susceptible type of waste, which requires frequent collection and the establishment of a cold room where it could be safely stored. Also, the canteen is not able to finance these steps. Despite the fact that it is a waste of high weight and its management in large volumes is demanding. Moreover only women work in the kitchen who often do not lift waste containers.

The kitchen uses a waste shredder to process kitchen waste. Most of the kitchen waste that the operation produces therefore ends up in the wastewater. However, the use of shredders for the processing of this type of waste in gastronomic operations is far from an ideal solution. The installation of new waste shredders is in conflict with the Act No. 254/2001 Coll., On Waters and Amendments to Certain Acts (Water Act) and with Act No. 274/2001 Coll., On Water Supply and Sewerage for Public Use and on the Amendment of Certain Acts (Water Supply and Sewerage Act).

Also the sewerage regulations of the Prague Water Management Company a.s. considers the installation of waste shredders to be a prohibited activity. The Sewerage Code defines solid waste, including kitchen waste, whether in solid or comminuted form (e.g. waste from kitchen waste shredders, cat litter, etc.), which can be disposed of in the so-called “dry way”, as substances that must not enter the sewerage networks, unless they are part of waste water within the scope of permitted water management. According to the Water Act (254/2001 Coll.), In the case of using waste crushers, it is necessary to observe the discharge limit of a maximum of 500 mg of insoluble organic residues per 1 l of water.

It is therefore necessary to dispose of biodegradable waste in accordance with the Waste Act. This does not apply to companies connected to a wastewater treatment plant or cesspool without a drain. With regard to the above-mentioned regulations, it is not a question of discharging waste water but of waste into the sewerage system. The crushed residues are not dissolved (small particles remain) and sediment in the sewer. This waste is not disposable in wastewater treatment plants and must be taken away for special disposal. If an accident occurs, the procedure is in accordance with Act No. 274/2001 Coll. – violation of wastewater disposal,

compensation for damage, etc. The right solution is to store the residues in containers and hand them over to a specialized company for professional disposal. In addition, in this type of treatment of biodegradable waste, there is a large consumption of water, when it is mixed with kitchen waste and subsequently discharged into wastewater.

Due to the fact that the installation of a new shredder will no longer be possible during any changes or reconstructions, the kitchen should start to solve the situation with kitchen waste and search for alternatives to using a waste shredder. The first step in this case is to try to prevent food waste as much as possible. Whether by adjusting the menu, optimizing portions, streamlining processes in the kitchen or looking for ways to further utilize unreleased portions. The second step is to set up a waste management system that will be effective both in terms of circular economy and financially.

In addition to the above-mentioned kitchen waste, compostable kitchen waste is also produced in the school canteen. This formed the largest part of mixed municipal waste – from the physical analysis it was found that the compostable components in mixed waste were 65.2%, i.e. almost two thirds of the total volume. Due to the fact that the primary school has a bin for biowaste, it is possible to hand over all this waste for collection to the collection company. At the same time, the school has its own composters at its disposal, so compostable waste can be easily and free of charge processed directly on the school grounds. In both cases, it is important to start sorting this type of waste correctly within the kitchen and then set up a functional system for its processing (biowaste/composter).

3.5.4 Summary & recommendations in gastro operation

- The school canteen at the primary school in Prague 3 produces almost all types of waste that are generated at the school, i.e. mixed municipal waste, kitchen waste, kitchen compostable waste, paper, plastic, beverage carton, glass and metal.
- The canteen has its own bin for mixed municipal waste, other types of waste are collected together with waste from the rest of the school.
- Almost two thirds (65.2%) of the mixed municipal waste from the school canteen was kitchen compostable waste. Only 17% of the total volume were further unsortable components (kitchen waste, mixed municipal waste and infectious waste). The potential for reducing mixed waste production is therefore more than ⅘.
- There are no bins for all types of sorted waste in the kitchen, or at least a bin for mixed waste and sorted waste (which is further sorted). In addition to the mixed waste bin in

the kitchen, it is suggested to place also a sorted waste bin to ensure consistent separation already in the kitchen and to reduce the amount of mixed municipal waste produced.

- The gastro operation also does not sort beverage cartons, nor glass and metal. Part of the paper (6.2%) and plastic (0.7%) waste is not sorted and ends up in mixed waste.
- Kitchen waste is the most important component of the waste produced, but it is not separated into gastro-waste bins, but processed in a waste crusher.
- Kitchen compostable waste ends up in mixed municipal waste (or shredders), despite the fact that the school has a biowaste bin and its own compost. Recommendation is to sort biodegradable kitchen waste into a gastro-waste bin and hand it over to collection companies for subsequent use in a biogas plant.
- A large part of the food used is purchased in large (gastro) packaging. Thanks to this, the operation manages to eliminate a considerable amount of packaging materials. Vegetables, fruits and meats are successfully bought in boxes (but most of the time they are not returnable, back-up crates).
- The gasto operation should prefer larger packaging of basic products, and thus eliminate the amount of packaging waste produced, prefer buying bread, fruits and vegetables in returnable crates – and therefore without unnecessary packaging.

3.6 Manual for circular school

Another goal of this work is to create a comprehensible manual and thus make the principles of the circular economy accessible to as many primary schools as possible, especially to those who are on their way to the circular economy at the very beginning, want to contribute to the concept but do not know how to start. The Manual for circular school offers a unified and comprehensive framework for those who want to move their school forward in terms of sustainability and circularity.

The basis for the creation of the manual is primarily the current state, analysis and suggestions given to the primary school that is the subject of this Master thesis where sufficient information was obtained about the need to create this manual. On the basis of the results from the chosen primary school in Prague 3 district, similar results can be expected to be reached in primary schools of similar size. It is therefore possible to generalize basic instruments on how to put principles of circular economy into practice. Manual for circular school was created as

instructions for other schools. All recommendations are results of the analysis and general suggestions that go hand in hand with circular economy theory.

The manual should be understandable and user-friendly for schools (headteacher, management, teachers, other staff) that are at the very beginning of the circular economy. Thanks to this manual, the topics of circular economy and sustainability will be clearer, easier to grasp and better communicable for all new, existing and potential schools that would like to participate in the concept of circular economy.

The author of this paper decided to achieve the set goals mainly through an internship in a consulting company, continue to educate about the circular economy in many resources and also use an own experience gained during internships and specific client cases. The manual describes how the individual sub-steps lead to more sustainable and circular operation of the school in key areas: energy, water, equipment, waste management and gastronomic operation. It continues to describe the effectiveness of individual measures, which go hand in hand with the principles of circular economy. This manual also includes the waste management hierarchy already mentioned in this work. At the end of the manual, there are ten basic rules for the sustainable operation of the school. Everything is accompanied by illustrative infographics.

The Manual for circular school begins with an introduction explaining the difference between linear and circular economy joined by arguments why the society should leave the way of linear economy and start to think about our future in terms of sustainability where circular economy is a suitable solution. The manual continues with a table of content where there are clearly divided parts into blocks of one topic dealing with the circular economy: energy, water, school facility, waste and gastro operation. These parts copy the structure of the analytical part of this thesis. Each part includes a short description of the theme with explanation of basic terms and spheres of interest, and it is followed by a set of recommendations of diverse level – some of them need a big economical input and are considerable only with a big reconstruction of the building, some of them can be put into practice almost immediately, only with a change of habits and behaviour. Some parts are also completed by infographics or other illustration pictures. The manual is concluded by a set of 10 basic rules for circular schools that summarize general basic steps of the transforming process towards a circular economy model and a more sustainable operation of a school building.

MANUAL for CIRCULAR SCHOOL

Table of Contents

Introduction

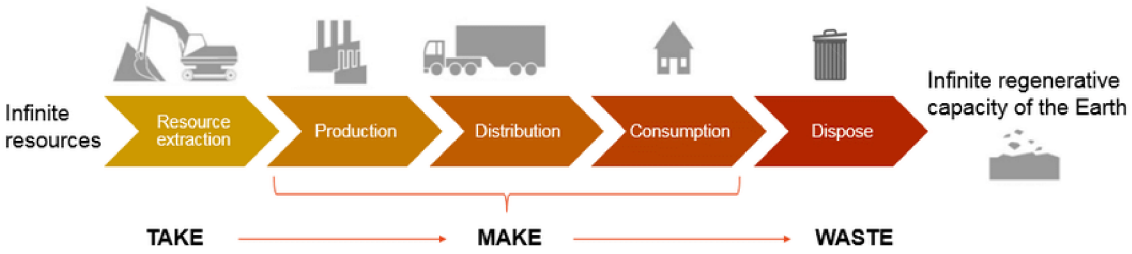
The Circular School Manual serves as a guide for school facilities to put the principles of the circular economy into practice and increase the sustainability of educational institutions. The manual is divided into several sections, each of which focuses on one area of circular economy: water, energy, school operations, gastronomy and waste management.

From linear to circular economy

In order to ensure sufficient resources for continued long-term growth, it is necessary to abandon the path of linear inputs and outputs and move to a circular economy, where outputs are also inputs.

LINEAR ECONOMY

In a linear economy, we mine the raw materials from which we make products and discard them after their use. The principle of take-make-throw.



In a circular economy, we close the circles in which raw materials, components and products lose their value as little as possible. We use renewable resources and the basis is system thinking.

The main activity of school facilities is always education. Education of pupils and students in the field of ecology, sustainability and circular economy is very important. In addition to adding these topics to the school programmes, there is the possibility of participating in various events – such as Earth Day, Clean the Czechia, etc.

ENERGY

"The most sustainable energy is the energy saved."

Decentralization, green energy

One of the most effective ways to reduce emissions is decentralization of energy, ie. electricity production directly at the point of consumption. Installation of decentralized energy production directly in / on buildings is costly, but the expenditure balance will be balanced during long-term operation. The next step in becoming more environmentally efficient in the field of energy and reducing the carbon footprint is the transition to so-called green energy. This is the purchase of energy that is from renewable sources.

- Decentralization measures that can be considered for a complete renovation include the installation of **a photovoltaic power plant, solar thermal collectors, a heat pump, a biomass boiler, the use of a cogeneration unit (combined heat and power) and a recovery unit** that allows the use of waste heat. Today, photovoltaic panels can be integrated into buildings not only in the form of fixed installation of common panels on the roof or facade, but also by using special **PV panels**, which form the facade itself, the so-called **BIPV** (Building Integrated Photovoltaics).
- Get an **updated power state**. Monitor energy consumption regularly.
- When reducing power consumption, always focus primarily on the **largest items**.
- Start a discussion with the founder of the school on the topic of energy. Choose the **optimal tariff** from your supplier with an emphasis on the supply of **green energy**.

Insulation

Part of effective energy saving solutions is quality insulation. In many cases, it is possible to replace the casing of the entire perimeter, including the roof. In the city's buildings or in historic buildings, partial external insulation is carried out (roofing is replaced) or internal insulation in the weakest escape points. The right solution is always proposed by a professional company based on an energy audit. The proposed solution should always be aimed at reducing heat leakage and thus unnecessary energy consumption.

- Secure the **sealing windows and doors properly**.
- **Insulate the building** – facade and roof.
- **Replace or re-insulate existing windows and doors**. Higher savings can be achieved with insulating triple glazing and quality frames, so it is directly desirable to include other parameters in the input criteria, including quality, associated warranty, service and the use of recycled material in the input raw material.

Heating system

Easily achievable energy savings can be achieved with an efficiently set heating system. It is important to ensure that the consumption corresponds to the real need, ie that there is no overheating or insufficient heating at any point.

- **Streamline the heating system** (thermoregulating valves, hydraulic balancing of the heating system)**.**
- Set **a uniform temperature in all rooms**. If there are more people in the room using computers, etc., which increase the heat in the rooms, it is not necessary to have a higher temperature set. If no one uses the room, it is not necessary to heat it.
- Reducing the room temperature by 1 ° C reduces energy consumption by up to 6%. Pay attention to **good central adjustment and setting of the entire heating system**.
- **Increase radiator output.**

    - Remove covers and other obstructions that would impede the flow of warm air into the room.
    - Add reflective foil.
    - Insulate the manifolds.
    - Install the thermostatic heads.
- Set the **optimum water heating temperature**. The energy intensity of heating and supply of 1 m^3 of hot water, heated from 10 ° C to 55 ° C, is 52.3 kWh (= 0.19 GJ) at the outlet of the heat source.
    - Use mixer taps that ensure a sufficient ratio of hot and cold water and can be fixed.
    - Install instantaneous heaters that ensure that only the required amount is heated.
    - It is always more economical to switch off the heating and reheat the water before use (eg at night from Sunday to Monday). The same principle can be applied to building heating.

Ventilation

Ventilation is related to heating. To ensure a safe environment, the room must be ventilated. Ventilation reduces accumulated CO_2 concentrations, the increase of which results in excessive fatigue and lack of concentration, and can also lead to minor health problems. The direct proportion is that the more energy-efficient a building is, the greater the need to ensure proper ventilation.

- **Recuperation** (forced air exchange) is an effective way to recover heat from the exhaust air for further use. Using a simple heat exchanger, the supplied fresh air is already preheated to the inlet temperature. Thanks to the simplicity of the principle, the recuperation unit can be successfully used in individual rooms, such as dining rooms or gyms, which, among other things, eliminates the need to distribute air conditioning throughout the building.
- **Ventilate properly – circulate.**
    - Short and intensive ventilation is the best: 5 – 10 minutes when all windows are open.
    - When ventilating, remove the heating system to avoid unnecessary losses.

Lighting

Nowadays, the criterion of sufficient room lighting can also be met with an economical solution. Fluorescent lighting can be replaced by LED technology, either by purchasing completely new light fixtures, or by replacing fluorescent tubes with LED tubes and only renovating existing fixtures. The advantage of LED technology is its energy efficiency, the luminous flux can be better directed and they do not mind repeated switching. The start of the LED lighting is immediate. From the point of view of disposal of obsolete equipment, LED lights do not contain dangerous substances, unlike fluorescent lamps.

- Keep the lights on only where it is really needed.
- Replace bulbs with **compact fluorescents or LEDs**.

WATER

Consumption overview

Having a basic overview of the flow of individual water meters, but also for the entire building as a whole, is the absolute basis.

- A good option for determining consumption is the **installation of operating water meters**, for which it is possible to set your own warning of exceeding consumption.
- Determine **basic ratios**, such as consumption per m^2 of floor space or consumption per number of people, so that you can meaningfully compare each other.
- Set **consumption limits**. To ensure unwanted water leaks, it is advisable to set a warning for flow detection when no one is using the building.
- Carry out a **flow check**. All you need is a measuring container and a stopwatch. In the case of standard washbasins for toilets, the flow rates are around 15 l / min. At the same time, a flow rate of 2 l / min for hand washing, 4 l / min for sinks, 6 – 8 l / min for showers is ample.

Toilets

The flowing tank can flow up to 16,000 liters per year.

- Use **classic urinals**, which are in themselves a very economical element even when rinsing with drinking water. (So-called waterless urinals are expensive to install and consume disinfectants and electricity to the fans instead of water, so they are not recommended).
- Install so-called **double flushing**. With these devices it is possible to set the volume of large (6-10 liters of water) and small (2-4 liters of water) flushing.

Washbasins

Excessive consumption can be affected by the appropriate installation of faucets. One "low" dripping tap (only 10 drops / min) drips about 160 liters of water per month. In the case of hot water, it is a loss of even 11 kWh of energy.

- Regularly **check the water taps for leaks and condition**.
- Install **water flow regulators** or **aerators** on the taps. In both cases, water wastage is reduced. (At full flow, 20 liters of water flow out of the tap in 1 minute, 1,200 liters per hour, with an ordinary aerator the flow is up to 25 l / min, while the economical aerator can reduce it to 6, 8, 10 or 12 l / min). For older toilets, it is possible to take flush stops.
- A suitable solution is also the **installation of lever faucets**, which can be supplemented with a separate heat regulator at the outlet.
- Another solution is in the form of **thermostatic mixers**, whose huge advantage is the almost immediate setting of the water to the desired temperature. (For comparison: setting to a pleasant temperature on the tap faucet takes on average 12 seconds, on the lever 7 seconds and on the thermostat only 3 seconds).

Alternative water sources

Drinking water can be replaced by service water for certain uses. Its use is by law limited to flushing and watering. However, flushing is a significant part of water consumption.

- **Rinse with non-potable water.** Non-potable water can be taken from suppliers, or treated rainwater or gray water can be used. The main obstacle is the necessary investment in double distribution systems and rainwater storage tanks. Therefore, in the case of a major renovation of a building, it is good to consider this variant of rainwater treatment and perform a cost analysis in detail.

Alternatively, it is possible to approach rainwater through two other sustainable routes, thus reducing sewerage payments from rainwater:

- Soak up rainwater on school grounds using **soaks**.
- Create a **green infiltration area** (so-called green roof) on the roof.
- Set the use of rainwater at least for **watering flowers** in the building.

Stop soiling the water & Do not waste water

- Replace washing powders with phosphates.
- Avoid soaps and microplastic shower gels. Use **gentle dishwashing detergents** and **environmentally degradable materials**.
- Do not let the water tun. Complete the toilets as well as the kitchenettes with a simple **infographic** with a recommendation to turn off the water if you don't need it at the moment.
- In all tenders or purchases of technologies related to water consumption, consider the **intensity of consumption as one of the selection criteria**.
- Do not buy bottled water and **drink tap water**. Use carafes in dining rooms and choirs.
- Offer more **vegan and vegetarian dishes** – these generally have a lower water footprint (consumption during their production and processing) and are one of the important elements in reducing the carbon footprint.

SCHOOL FACILITY

Equipment and furniture

Furniture is an essential part of the equipment of all classrooms, classrooms, offices. To reduce costs, help protect the environment and human health, prefer furniture:

- made of **solid wood** and other natural materials;
- made of **recycled materials**;
- possibly from **one type of plastic** from health safety certifications;

- marked with the "**Environmentally friendly product**" logo (such products guarantee consumers a minimum of adverse effects on the environment that arise during their production, use and disposal) or the **EU Ecolabel**;

- marked with the "**FSC**" logo (this is wood furniture that has an ecological certification);
- from a **furniture bank or bazaar**;
- made **in the Czech Republic**;
- with a **simple design** that allows damaged parts to be repaired or replaced;
- **free of hazardous chemicals,** eg. flame retardants (polybrominated biphenyl ethers), paint aldehydes.

Paper

One tonne of paper made from 100% recycled paper saves 4,100 kW / h of electricity, 26.5 thousand liters of water, 27 kilograms of air pollutants and 2.7 m^3 of landfill space compared to unused paper.

Change of the teaching model – online teaching – teach children to work with online materials.

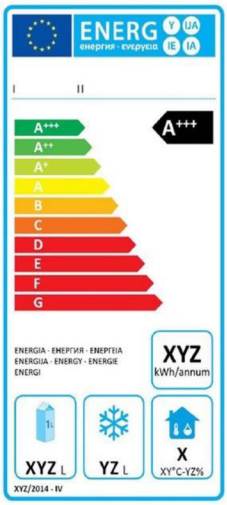
Even with the development of modern information and communication technologies, paper remains the main working medium. Low printing costs, increasing print quality, its easy availability and also the high preference for printed materials are the reason why printed documents still form an integral part of work in schools. However, teach children to work with online materials and involve technology in teaching.

- Keep the **documentation in electronic form**.
- **Do not accumulate** unnecessary paper folders.
- Set up **automatic two-sided and black-and-white printing** on printers.
- If the printed paper on the other side is blank, **reuse** it.
- Request the **return, recycling, and remanufacturing** of toners and cartridges from their suppliers.
- Adjust **the font and page layout** (smaller margins and font size, two A4 pages on one,…).
- **Common printer** for several employees (eg place the printer in the corridor so that all employees and pupils on the floor have access to it).
- **Limit the number of printable pages** to a specific period.
- If possible, print on **recycled, PEFC, or FSC paper**.
- Use **infographics** and educational materials to help you save paper.

Electronics

In the operation of schools, there are small appliances for daily use and computer equipment in various places – such as a computer, laptop, printer, copier, scanner or refrigerator. All of these

appliances are difficult to manufacture, contain a lot of precious metals, consume a considerable amount of energy – and also very quickly "become obsolete", are no longer modern and powerful enough. The purchase and replacement of each appliance should be carefully considered and look for those that have low energy consumption and will last as long as possible. Ecological disposal of end-of-life appliances is a matter of course.



How to choose office equipment?
The service life of the device should be as long as possible. Therefore, give preference to products that can be retrofitted with accessories and their non-functional parts can be easily replaced or repaired. The long warranty period of the device indicates a long service life.
When buying electrical appliances, also pay attention to energy classes).
COLORED BARS use similar symbolism as traffic lights at pedestrian crossings. The richest greenery means the most economical operation. The richest red means extreme difficulty. The **ENERGY CLASS** complements the relevant color bar with a written mark. The most economical (greenest) devices are marked **A +++**, while the most wasteful (reddest) pieces are marked with an energy label by the letter G. **ANNUAL ENERGY CONSUMPTION** specifies the previous information by the number of energy units that the purchased device consumes over a time interval: for example kWh / year.

- When buying new equipment, **follow the energy labels**, choose the appliances with the lowest consumption. Choose only **energy-efficient appliances and eco-friendly electronics**.
- Choose a technique that allows easy **repair and / or replacement of parts**.
- Set the devices to **turn off automatically** when not in use.
- Turn off older screens, hi-fi towers, and similar appliances with a power switch or by unplugging the power cord. Left in STAND-BY mode, they often have almost the same power consumption as on. For example, an appliance with an input of only 10 W per year consumes over 80 kWh (CZK 370 / year – at an average price of CZK 4.64) when it is not in use at all.

Office and school supplies

Writing accessories

- Use **pencils and crayons as an alternative to alcohol- and solvent-based ink markers** and highlighters. Markers based on aromatic solvents are toxic. Use markers and highlighters with **non-toxic water-based refills**.
- Use **replaceable ballpoint pens and replaceable pencil pens**.
- Prefer pencils and crayons with an **unpainted wooden handle**.
- Do not use disposable pens.

Adhesives

- Use **water-soluble** adhesives.
- Prefer **starch, dextrin, or protein-based** adhesives.

Chemist's and cleaning products

- When purchasing cleaning products, it is important to check the sources with the supplier cleaning company. Subsequently, it is possible to propose an amendment to the contract and the use of **community bottling plants and weighing drugstores**.
- It is advisable to require **concentrated products** that are dilutable with water.
- Find out if the cleaning products are **eco-labeled** and have a declared **biodegradability**.

Purchase

- Select those suppliers who meet the **sustainability triad** (environmental, social and economic).
- The ideal procedure is to consult the selection criteria with a potential supplier already in the pre-selection phase by means of a preliminary market consultation or the presentation of a public procurement plan.
- Create a **Green Team** – a team responsible for the implementation of the circular economy and compliance with the established rules (Green Housekeeping, Green Food, Eco Purchasing, Green Office).
- **Inform** about the possibilities and procedures of careful use of those products that reduce environmental pollution.

10 rules for purchases

PURCHASES

5R RULE.

Refuse, reduce, reuse, repair, recycle.
We are handed out and buy only what we need, we let functional things last and do not create unnecessary waste. We give non-functional things for repair, we put objects out of date (eg. old computers with old software) for overhaul (upgrade) to prolong their life.
We prefer unnecessary things to those who can still use them, and if this is not possible so that at least the material from them can be reused..

CLIMATE, RESOURCE AND ENERGY SAVING PRODUCTS.

We prefer such products, the production and operation of which use raw materials and energy with maximum efficiency and have the least possible impact on the Earth's climate system. By purchasing local products, we support local tradesmen, and thus the prosperity of the region. We persuade management to make more use of renewable energy sources - sun, water, wind, biomass - eg. by purchasing electricity from renewable sources.

BIODEGRADABLE, RECYCLED AND RECYCLABLE MATERIALS.

We prefer products (including their packaging) that are biodegradable or at least recyclable with the possibility of handing them over for recycling in our municipality. We prefer products and packaging from recycled materials.

TAKING INTO ACCOUNT SOCIAL ASPECTS.

We prefer products or services of sheltered workshops and similar organizations with a social program - for example, the employment of disadvantaged people, the long-term unemployed, graduates without experience, people with parental leave, older than 55 years. We demand guarantees for the working conditions of employees in the companies we hire. We think of facilitating entry and movement for disabled people.

THE FEWER PACKAGES, THE BETTER.

Large packaging saves packaging material and reduces waste. The optimal packaging is returnable, reusable and refillable. Disposable packaging is the unsuitable opposite. Also, preferring concentrates means less packaging waste, for example in detergents.

PRODUCTS FROM ORGANIC FARMS AND SUSTAINABLY MANAGED FORESTS.

We purchase products of organic farming, which avoids the use of fertilizers and pesticides. We make sure that wooden products come from carefully managed stands and not from tropical forests or other places (eg. FSC standard).

PRODUCTS WITH THE LOWEST POSSIBLE CONTENT OF SUBSTANCES HARMFUL TO THE ENVIRONMENT AND HUMAN HEALTH.

We do not purchase products containing poisons, organic solvents and other substances that are released into the environment, accumulate in body tissues and are difficult to degrade. A good example is the repair of furniture with water-based paints and varnishes.

FAIR TRADE PRODUCTS, ETHICAL SHOPPING.

FAIR TRADE

We purchase fair trade products or fair trade goods, which guarantee the careful management of the territory and fair earnings for people in developing countries. For refreshments, we demand fair trade coffee and tea, "fair" electronics for offices, ethically acquired work clothes.

THE WATER CONSUMPTION IS TAKEN INTO ACCOUNT WHEN BUYING.

In all tenders or purchases of technologies related to water consumption, we will take into account the intensity of consumption as one of the selection criteria. Toilets, dishwashers, faucets, but also, for example, humidifiers, machine cooling, etc.

PRODUCTS WITH A QUALITY LABEL.

We purchase and demand products with the eco-label, a certificate proving the quality of the impact on the environment and health. Products marked with the "CE - Conformité Européenne" (European conformity) logo - these products meet health, safety, environmental and consumer protection requirements.

CIRAA

WASTE

Different types of waste have different characteristics. For example, biowaste, glass or textiles are very heavy, even in small quantities. On the contrary, plastics, beverage cartons or beverage cans do not have a large weight even in a considerable amount, but they are very bulky. It is important to implement the principles of circular economy in practice in the field of waste management.

Waste sorting

By properly sorting the waste and minimizing mixed waste, large financial savings are usually achieved in its collection. If the individual components, which have further potential for further use, are properly separated, the amount of mixed waste is automatically reduced. Thanks to this, it is then possible to reduce the collection frequency or the size of the container. Collection of mixed municipal waste is usually the most expensive item; collection companies generally charge mixed waste more expensive than sorted waste. Lower collection costs for sorted material are therefore a clear financial motivation for separating waste.

- **Sort up usable components** such as biowaste, paper, plastic, glass, metals, textiles, and beverage cartons to the maximum, thus reducing your annual production of mixed municipal waste. Thanks to the reduction of mixed municipal waste production, it is possible to reduce the frequency of its collection, which has a positive impact on the economic costs of waste management. **Reduce mixed municipal waste production** – either as part of waste prevention or as a better sort of usable commodities.
- For the best possible sorting of waste, **remove all bins for mixed waste from each class**. Relocate mixed waste containers to common areas in corridors. In contrast, **place only containers for the "most popular" sorted waste, i.e. plastic and paper, in each class**. In addition to mixed waste, place containers for less frequent sorted waste, such as biowaste, beverage cartons, glass, metal and batteries with small electricity, in the corridor. It is ideal to choose specific places for the joint placement of these containers so that they are not scattered in any corner.
- Describe all waste containers with simple **infographics** – what belongs where.15

- Place bins for sorted waste in the **outdoor areas of the school** (playground and garden).
- **Textiles** can be used either within **the charity network or for material recycling**. This waste should not end up in the SKO, from where it goes to a landfill or to a facility for

15 Note: The colors of the individual sorted types of waste listed in the infographic correspond to the Czech standard and may vary from country to country.

energy recovery of waste. The material can be stored in special containers designed for this purpose. These containers and their operation and collection are usually set up free of charge by various associations.

- In the operation of the canteen and at children's snacks, **beverage cartons** are a frequently used packaging, which is why it is a type of waste at school, which is abundant. Give the possibility to sort it.
- A certain possibility for improvement within the framework of lower waste production and economic measures is the **efficient use of bags in waste bins**. Garbage bags should not be only partially full. This automatically increases their consumption and also the cost of buying new bags.

Biowaste

Due to its large weight, biowaste usually represents a significant part of mixed waste. If biowaste is mixed with mixed municipal waste and deposited in a landfill, greenhouse gases such as CO_2 and methane are generated here due to anaerobic processes. Due to its high water content, biowaste reduces the flammability of the material and thus the efficiency of incinerators when incinerated in energy recovery plants. In both cases, the energy potential of this material is not used and the necessary nutrients from biowaste are not returned to the soil. These are the reasons why it is important to sort biowaste and then process it at biogas plants or composting plants. The composter is not only a device suitable for composting grass from green maintenance, but also for the compostable part of biowaste from school and kitchen operations. All cuttings from food preparation, leftover fruits and vegetables, or even flowers can be stored very well in the garden composter. This also reduces the financial costs associated with the removal of mixed municipal waste.

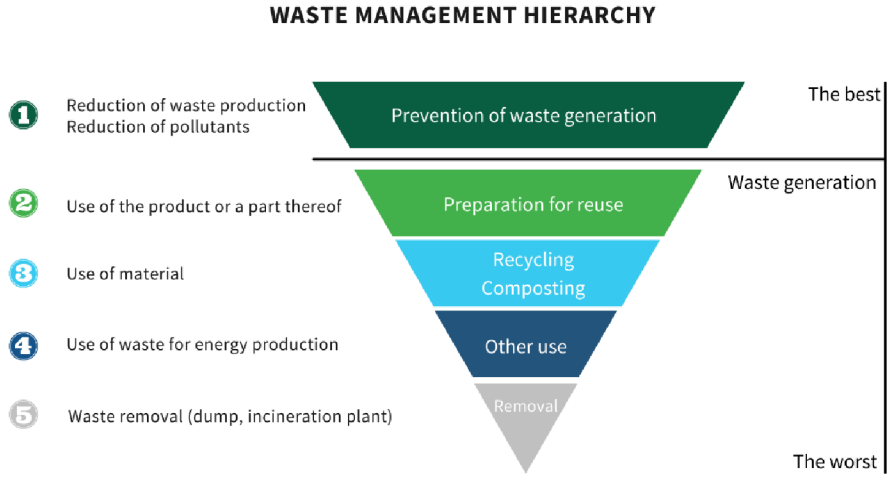
- **Sort biowaste, kitchen compostable waste and leftovers** from the “Fruit and Vegetables for schools” programme, preferably **in your own composter on the school grounds**. Thanks to the garden composter, biowaste can be disposed of within the school's capacity, free of charge, without additional costs.
- **Paper towels from kitchens or bathrooms** are also a suitable material for **composting**, as long as they are not hazardous infectious material from the point of view of waste and can be thrown together with vegetable and fruit scraps on a local composter.
- Ideally, replace paper towels in toilets with **electric dryers**. Their operating costs and ecological footprint are usually lower than with disposable napkins. The excess consumption of the napkin produced, distributed and subsequently disposed of is much greater than the short-lived electricity used to produce the air stream.

Organization of waste management at school

- **Do not contaminate already sorted waste** with other waste. Any contamination of the sorted components prevents their recycling. Contamination is therefore a major problem for collection and sorting lines, which could impose sanctions on a given producer of contaminated waste if repeated frequently.
- Set up an **effective school cleaning system**. Train responsible cleaning staff. Proper operation and good setting of processes in sorting in the operation of the kitchen and in the removal of waste are the basis of good waste management.
- **Ensure regular and well-functioning collection of containers for a wide range of waste** – plastic, paper, glass, biowaste, beverage cartons, textiles, electrical waste, metal, mixed municipal waste.
- If a school uses several different collection companies to collect waste and also has contracts with these companies, it is possible that some of them provide a collection service for more types of waste, and this may lead to duplication with another company. **Review individual contracts and select companies that provide the best conditions** according to the customer's needs. Other contracts should be terminated.
- Negotiate with the collection company about the possibility of setting up payments according to the waste produced, the so-called "**Pay as you throw**," or at least open a discussion on the effectiveness of payments.

Hierarchy of waste management

Below in the picture, there is the so-called **hierarchy of waste management**, which is stable in expressing how to properly manage waste. The best possible way is to prevent the generation of waste. Once the waste is generated, try to reuse it, then recycle it, compost it and, in the case of unusable components, use it in an energy recovery facility.
Waste cargo is often an unnecessary cargo. Evaluate the economic and environmental impacts that a gradual transition to circular models would bring you.



Waste management procedure

- Place containers for the “most popular” sorted waste in each assembly room and classroom.
- Move other sorted waste and mixed municipalities to common areas.
- Describe in simple infographics all waste containers – what belongs where.
- Equip the kitchen with a biowaste container, get a composter or apply for a biowaste container.

GASTRO OPERATION

The school canteen usually participates in the production of almost all types of waste that are generated at the school. Exceptions may be the categories of reuse waste, textiles and wood. Due to the large volume of raw materials that gastronomy processes, the volume of waste produced is also significant.

- Recommendation: **Order food from local and circular suppliers, fair & organic stores and packaging products**.

Mixed municipal waste

In gastronomy, the term unsorted mixed municipal waste means materials and packaging contaminated with food and fat. This waste belongs to the mixed municipal waste container.

Kitchen compostable waste

The largest share of the total volume of SKO is often kitchen compostable waste. These are mainly cuttings and skins of vegetables and fruits, but also eggshells or herb stems. Given that this type of waste makes up a large part of the weight of all mixed municipal waste produced by the canteen, the potential for reducing the amount of mixed municipal waste is considerable and the economic incentive to reduce the cost of transporting mixed municipal waste is significant.

- **Sort kitchen compostable waste in a biowaste container or composter** in your own composter directly on the school grounds.
- It is important to **start sorting this type of waste correctly already in the kitchen** and then **set up a functional system** for its processing (biowaste / composter).

Paper towels

Infectious waste consists mainly of paper towels and napkins, but also disposable gloves. High consumption of paper towels is a problem of almost every gastronomic operation. Their excessive use not only significantly increases the amount of waste produced, but it also means additional financial costs.

- **Substitute paper towels with reusable wipes or cloths**.
- Set up **your own practice** in operation and give your employees the opportunity to change their daily habits.
- If paper towels and tea towels are not infectious, they can be **composted**.

Kitchen waste

Kitchen waste, i.e. heat-treated foods such as pastries, food scraps and food of animal origin, occupies a substantial part in mixed municipal waste. The use of shredders for the processing of this type of waste in gastronomic operations is not an ideal solution, the waste ends up in wastewater and is often even in conflict with the laws on water, water supply and sewerage. At the same time, it is a very susceptible type of waste, which requires frequent collection and the establishment of a cold room where it could be safely stored. However, school canteens are often unable to finance these steps. In addition, it is a high-weight waste and its handling in large volumes is demanding. All the more so when women usually work in the operation, who often do not lift waste containers.

- This type of waste should be properly sorted in the **gastro-waste container**.
- Try to **prevent food waste** as much as possible. Whether by adjusting the menu, optimizing portions, streamlining processes in the kitchen or looking for ways to further utilize unreleased portions.
- **Avoid using waste shredders**. Set up a waste management system that is effective both in terms of circular economy and financially.

Paper, plastic, metal, beverage cartons

environmental pressures and impacts on the planet. The European Commission and member
A substantial part of the waste produced in most gastronomic operations consists of food packaging materials – flour, milk, canned food, plastic containers and more. Their elimination is not easy, as the current wholesale for gastronomy does not offer many alternatives.

- Prefer a **larger package of ingredients**. This eliminates the amount of packaging waste produced (except for short-lived raw materials, which risk not being consumed in large quantities in time and will be discarded unnecessarily).
- **Prefer the purchase and use of primary raw materials** and **reduce the consumption of semi-finished and industrially processed foods**. These usually mean a larger amount of packaging materials – not only in each operation, but within the entire process of their processing and production.
- Buy vegetables, fruits and meat **by weight**, not in smaller packages, which helps to significantly eliminate the amount of waste. **Returnable backed-up boxes** are a great option. Non-backed-up boxes produce unnecessary waste, which could be prevented

thanks to returnable crates. In these cases, it is often sufficient to agree with the supplier on a system change. Returnable boxes save a lot of waste and money for both parties.

- **Distribute the bins well and ensure that the containers for sorted waste are more accessible**. A good solution for gastronomic establishments is to place containers for all types of waste directly in the kitchen so that containers for sorted waste and mixed waste stand side by side and workers are maximally motivated to throw waste in the right bin. If the space capacity of the kitchen is limited, place at least two bins – one for mixed waste, the other for all sorted waste, which is later sorted according to individual types.
- **Re-train canteen staff** on good waste sorting practices.

TEN CIRCULAR RULES

Finally, everything can be summarized in 10 points, which can serve as **navigation for circular schools**. The following ten are used for school management and teachers to make a **better transition to circular economy**:

4 Discussion

The aim of this master thesis was to find out current regulations and methodologies on circular economy for the educational institutions and how the operation of school can put principles of the circular economy into their daily operation of the building.

The topic of circular economy is high on the political agenda and it is expected to promote economic growth by creating new businesses and job opportunities, saving materials'cost, dampening price volatility, improving security of supply while at the same time reducing environmental pressures and impacts on the planet. The European Commission and member states governments are developing agendas, policy documents and investment strategies which promote the circular economy concept.

However the European Union, the United Nations or the Ministry of the Envrionment of the Czech Republic publish reports (such as A new Circular Economy Action Plan, Strategický rámec cirkulární ekonomiky České republiky 2040 or Sustainable Development goals) about the bad situation concerning the pollution and climate change, none of them proposed concrete steps on how to transfrom the current system of linear economy into the circular functionning. Majority of the relevant literature is published in the form of scope documents and initiatives from governments. These publications consider concept formation, vision creation and formulation of general strategies. In each document, there is a call for action and expected results. Sometimes, the industrial sector is mentionned but schools remain laying only the role of educator, transmitter of knowledge and tutor in the field of sustainability, ecology and circular economy, not the implementor and holder of good practice. No analysis of the available circular economy implementation strategies and experience have been developed yet.

Kalmykovaa, Sadagopanb and Rosadocargue (2018) argue that dissemination of the circular economy is hampered because the whole topic is currently populated by diverging approaches. Therefore, they have developed a database with litterature and relevant case studies in the filed of circular economy. It is evident that researchers boost the development of circular economy as well because no concrete instructions have been published on practical interpretation of the circular economy in daily working. Only long term strategies have been published.

„To exploit the potential for increasing material efficiency and reducing climate impacts, the Commission will launch a new comprehensive Strategy for a Sustainable Built Environment. This Strategy will ensure coherence across the relevant policy areas such as climate, energy

and resource efficiency, management of construction and demolition waste, accessibility, digitalisation and skills." (European Commission, 2020). These sentences appeared in the Circular Economy Action Plan published by teh European Commission. However, there is no mention about the actual operation of the buildings and neither about some tools or manuals. A building is a living structure that needs care and the circular economy does not stop at the moment of its contruction or demolition. Thierry Breton, EU Commissioner for Internal Market, said in December 2020 that the Commission still intended to put forward a holistic approach for the built environment in 2021 or 2022.

Firms and the business sphere in general already implement some sustainability measures, however, in many cases, there is a very thin border between taking the protection of the environment into production and greenwashing. While the measures taken by the private sector could be easily transferrrable into state educational (or other) institutions. Moreover, the monitoring of the progress and outcomes of the circular economy implementation is extremely importnat for further developement of the whole concept and also for innovation in the field. There is a significant need for concrete measures, tool, instructions and manuals that complete general strategic plans.

5 Conclusion

The aim of this master thesis was to appraise the current state of a chosen primary school in Prague 3 district in different areas of relevant interest and to suggest concrete measures with the principles of the circular economy taken into consideration. These fields consist of energy, water, equipment, gastro operation, and waste management. Thus, with the help of the research carried out, it was possible to examine how one primary school can put principles of the circular economy into the daily practice of its operation and can become more sustainable. Moreover, this primary school stands as an example of good practice for other schools that would like to use the circular economy in their work. On the basis of the results obtained at the chosen primary school, a general manual for other interested institutions was created.

The master thesis is divided into several parts. In the first part, there is a literature review of existing material dealing with the topic of circular economy. It includes general extracts from official documents and treaties concluded by the European Union, the Czech Republic, the United Nations or other institutions where countries undertake to lower their CO_2 emission and prepare a strategy for the gradual transition towards a more sustainable, environmentally friendly and circular economy. The second part concentrates on methodology of writing this master thesis, data collection and processing, research question and methodology of writing a manual. Details about physical analysis of waste can be found there. The third part deals with one chosen primary school in Prague 3 district and its analysis. The analytical part is divided into several sections: energy, water, equipment, waste management and gastro operation. The focus was given mainly to the waste management as the physical analysis of mixed municipal waste took place. Less attention was given to energy and water as these parts are not in the scope of this paper and the school is not planning a big overall reconstruction of the building.

It was found out that this primary school in Prague 3 district has a great potential of transitioning to the energy from renewable resources in terms of installing a solar plant on the straight roof of the building. For better management, control and saving of water consumption, double rinsing or WC stop technology is recommended and using of rain water at least for garden purposes is advised. In the case of school supplies and equipment, tips for reuse, repair or eco products are proposed and the explanation of circular public procurement is shown.

From the physical analysis of mixed municipal waste emerged that approximately 50% of the mixed waste in the container is a recyclable waste that could be still sorted. The waste of the biggest volume was infectious waste that consisted of paper towels. It was therefore suggested

to buy electric dryers or to compost the towels if they are not contaminated. The biowaste has a big potential to be composted for free on the estate of the school in their own composter which is now used rather seasonally. A container for beverage cartons is advised to place in the school and dustbins for sorted components of waste in the outdoor area of the school as well.

For the operation of the school canteen, there was also a physical analysis of waste effectuated. It follows from it that the majority of the waste thrown away that was incorrectly in the mixed waste, was the kitchen compostable waste that could be easily composted for free on the space of the school in local composter. Also, there should be bins for all sorted waste in the kitchen in disposition. It would also considerably lower the costs of the mixed municipal waste collection. Paper towels should be substituted by reusable clothes and all ingredients for cooking could be bought in larger packages. Fruits, vegetables and other fresh items could be delivered in refundable boxes – this arrangement would be advantageous not only for the school canteen and sustainability, but also for the supplier. Some substitution for a waste shredder should be found.

The research question „How can the principles of the circular economy be used in daily operation of school buildings?“ is widely answered in the chapter of results, particularly through the suggested manual for schools.[KP1]

Specific suggestions for each area of recommendation are provided in the Results section at the end of each section. Concrete detailed conclusions with explanations and recommended solutions are therefore to be found in each section: waste management, water, energy, equipment and gastro operation.

The next part of the section results is composed by a general manual for other primary (but also other) schools that have the motivation and effort to change the operation of the school building into more sustainable and with principles of circular economy taken into consideration, but miss some kind of tool or isntructions coming from the governmental institutions. The results of the chosen primary school in Prague 3 district gave basis for creating a Manual for circular school. Similar results can be expected to be reached in primary schools of similar size. Basic instruments on putting principles of the circular economy into practice were generalized and put together into one manual that stands as instructions for other schools. The Manual for circular school is a starting document that can stand as the first step for every school.

Based on the results obtained, it can be concluded that school buildings have a great potential in transformation into the circular economy, but there are no suitable manuals, tools or concrete

strategies for them. When the European Union creates a lot of documents full of visions, the Czech Republic does not dispose of any concrete steps for educational institutions that would like to not only teach the important topics of environmental protection, ecology or sustainable development, but also want to be holders of putting principles of the circular economy into practice.

As far as limitations of this research are concerned, the research is limited by the number of examined objects, so it provides results only for one primary school with the size of approximately 700 students, its own school canteen and gymnasium. Even so, we believe that this master thesis contributes to the overall consideration of the potential of (primary) schools as actors in the circular economy transformation. We can explain the main reason for not applying the principles of the circular economy in practice at schools by the lack of awareness and understanding of the circular economy concept and its practical application in the school context among staff, insufficient policies, limited stakeholder discussion, and collaboration and decision-support frameworks, or financial limits. Other challenges and limitations of implementation of the circular economy at schools include the lack of access to appropriate decision-support frameworks, data gathering systems and key performance indicators. Due to all these reasons, there are no initiatives and good practices implemented yet.

On the basis of this thesis, further research is recommended in the field of gastronomic working at schools – food waste prevention and alternatives for waste shredders, potential use of gray water, possibilities of renewable energy usage at the roof of school buildings, paper collection in big containers profitability and putting the Pay As You Throw or Internet Of Things Smart Waste Management system into practice. Also, wider range of schools of different sizes, different levels of education (primary/secondary/vocational schools, universities, other educational institutions), with different facilities (with/without a school canteen, with/without gymnasium, with/without accomodation) in different parts of cities/towns/regions is a great potential for further research.

Based on the results obtained from the chosen primary school in Prague 3 district, schools are improving in the circular economy topic without any management coming from policymakers or other governmental institutions. Those who require implementing the principles of circular economy in practice go their own way and create their own methodologies. Primary (and probably also secondary and other) school buildings have a big potential in putting the principles of the circular economy into practice, but there is a lack of methodology, manuals, and tools coming from the side of the government, ministries, as well as municipalities as

founders of primary schools. The activities of the European Union for the circular economy implementation consist of publishing strategic documents for next years without any concrete specific plans and the Czech Republic does not seem very active even in publishing similar national strategies with concrete plan of steps. Schools therefore have no concrete motivation from the side of governments, but motivate themselves to hold the title of good example of what they teach.Schools need some manuals, methodologies, procedures, and good management on how to go hand in hand with environmental rules. Currently, they work on the method of trial and error and work with methods and materials they ascertain. It depends on the management of the school, how the daily operation works and how sustainability is taken into account into teaching and/or operational methods. The Czech Ministries of environment, of education, youth and sports, and of regional development should prepare directions and regulations with concrete steps for municipalities as founders of primary schools on how to proceed to run an operation of a school in a more sustainable way with putting principles of the circular economy into daily practice.

To sum up, using the principles of circular economy in the operation of institutional buildings would ensure some autonomy of school, while reducing bills and decreasing losses. In the case of a school canteen, it is important to maximise the value of the food waste. For lighting and heating, renewable energy sources are recommended. In water issues, attention should be put on wastewater treatment, grey water harvesting and other water efficiency solutions. For waste management, the maximum sorting of waste and the overall waste prevention should be assured. The principles of the circular economy have big potential in future ecological, sustainable as well as economical operation of buildings and school building can stand as leading good exmaples and inspirational cases.

6 Summary

This master thesis aims to find out the current state of a chosen primary school in Prague 3 district in different areas of relevant interest and to suggest concrete measures with the principles of the circular economy taken into consideration. These fields reside in energy, water, equipment, gastro operation and waste management. The master thesis consists of the following chapters: theoretical background, methodology, results and discussion.

The literature review provides a general view into the politics of the European Union and the Czech official strategic documents dealing with the topic of the circular economy. In the methodology part, the aim and objectives of the research, data collection and analysis are explained and explained as well as detailed description of the physical analysis of waste. Next chapter presents and interprets the results obtained by the research, the current state of things at the chosen primary school in Prague 3 district in the chosen areas and concrete suggestions on how to improve their operation in terms of the circular economy. These recommendations take into account both environmental and economic impacts. The discussion focuses on general statements about available tools for schools about transition towards the circular economy.

This research points out that the operation of schools have a big potential in putting the principles of the circular economy into practice, but miss available tools of manuals for particular steps. A Manual for circular school was therefore created on the basis of the results obtained in the research that were generalized.

6.1 Keywords

Circular economy, primary school, European Union, sustainability, public procurement, United Nations, Sustainable Development Goals, waste management, school operation, renewable resources of energy, waste collection, sorted components of waste.

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8 List of tables and figures

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8.2 Figures