GDAŃSK UNIVERSITY OF TECHNOLOGY
FACULTY OF ARCHITECTURE

Student's name: Arleta Olszak
ID: 154167
Postgraduate studies
Mode of study: Full-time studies
Field of study: Architecture

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Supervisor: *signature*	Head of Department *signature*
dr inż. arch. Marek Gawdzik	prof. hab. inż. arch. Lucyna Nyka

Date of thesis submission to faculty office:

GDAŃSK UNIVERSITY OF TECHNOLOGY
FACULTY OF ARCHITECTURE

DECLARATION regarding the diploma thesis titled:

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First name and surname of student: Arleta Olszak
Date and place of birth: 01.10.1995, Puck
ID: 154167
Faculty: Faculty of Architecture
Field of study: architecture
Cycle of studies: postgraduate
Mode of study: Full-time studies
Type of the diploma thesis: master's thesis

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ABSTRACT

This thesis's research problem is to look towards the modern solution regarding the growing problem of utilization, storage, and reuse of garbage from the Władysławowo city and the surrounding areas.

The project aims to present the concept of an ecological waste-to-energy plant, with the necessary facilities nearby, which could solve the garbage problem, produce energy and heating for the city, and break down the stereotypes. The location of the waste incineration plant is the plot of the old landfill, near Władysławowo city. The concept for this area assumes to use the neglected terrain, take care of the environment by reducing CO2 emissions, and obtain alternative energy.

This project could be a step for a sustainable way of thinking and living, and a future carbon-neutral city is vital when we have a tourist seaside area. It can also impact the economy and play an education role – a center for educational tours, workshops, and sustainability conferences.

Keywords: Sustainable architecture, waste-to-energy plant, incinerator, alternative energy, heating in the city, waste management, touristic city, Władysławowo.

STRESZCZENIE

Problem badawczy podjęty w tej pracy polega na poszukiwaniu nowoczesnego rozwiązania dotyczącego rosnącego problemu utylizacji, przechowywania i ponownego wykorzystania śmieci z miasta Władysławowa i okolic, a także braku miejsc służących aktywizacji mieszkańców oraz całorocznych atrakcji turystycznych.

Celem projektu jest przedstawienie koncepcji ekologicznego zakładu przetwarzania odpadów w energię, z niezbędnymi obiektami w pobliżu, które mogłyby rozwiązać problem śmieci, produkować energię i ogrzewanie dla miasta, przełamać stereotypy „spalarni śmieci". Dodatkowa funkcja "Parku Edukacyjnego" pozwoliłaby uatrakcyjnić ofertę edukacyjną i kulturalną Władysławowa oraz zapewnić całoroczne miejsca pracy.

Lokalizacja spalarni odpadów to miejsce starego wysypiska w pobliżu miasta Władysławowo. Koncepcja tego obszaru zakłada wykorzystanie zaniedbanego terenu, dbanie o środowisko poprzez redukcję emisji CO2 i pozyskiwanie energii alternatywnej.

Projekt ten może być krokiem w kierunku zrównoważonego sposobu myślenia i życia oraz przyszłego miasta neutralnego pod względem emisji dwutlenku węgla, co jest bardzo ważne, biorąc pod uwagę turystyczny obszar nadmorski. Może mieć również wpływ na gospodarkę i odgrywać także rolę edukacyjną - centrum wycieczek akademickich, warsztatów i konferencji na temat zrównoważonego rozwoju.

Słowa kluczowe: Architektura zrównoważona, elektrociepłownia, spalarnia, energia alternatywna, ogrzewanie w mieście, gospodarka odpadami, miasto turystyczne, Władysławowo.

TABLE OF CONTENT

1. INTRODUCTION

Waste and the risks associated with it become a severe problem of environmental protection. In Poland, there is an increase in interest in waste management, both in the development of technologies to minimize their quantity and those related to their disposal and economic use. The appearance of educational programs and relevant legal acts regarding the correct handling of waste is also important. The main reason for the excessive generation of waste is irrational resource management. According to GUS (main statistical office) data, currently, around 120 million Mg (tons) of industrial waste is generated annually in Poland. About 80% of it is recycled, 21.7% neutralized (including 17.7% stored!), and 3.4% stored temporarily.[1]

In the south-western part of the country, the largest number is recorded. Europe produces enormous amounts of waste: food and other "bio," construction and destruction, other industrial waste. People throw-away televisions, old cars, electrical appliances, batteries, every kind of plastic bag, bottles, packages, paper, sanitary waste, clothes, and furniture - the list could be endless. The results from our production and consumption patterns have an impact on the amount of generated waste. There is still a vast number of products launched on the market that have plastic bags and packages. Also, cultural and demographic changes increase the amount of waste generated by every household. We buy more and produce more and more waste. It is crucial to reduce generated waste.

Generally, more and more waste in the EU is recycled or neutralized, which reduces the amount of waste sent to landfills, but in other countries, it is still not well organized and developed. EU legislation - the Waste Framework Directive - has an impact on waste management in Union countries. In these documents, we can find the waste management hierarchy: starting with waste prevention, through preparation for reuse, processing and recycling, recovery for disposal. The key is to use already generated waste as resources, avoid overproduction, and minimize waste deposited. Proper waste management can minimalize the impact on climate change and air pollution and save the ecosystem. A massive amount of methane is released into the landfills, a potent greenhouse gas contributing to climate change. Microorganisms and biodegradable waste generate methane.

The landfill can also cause water and soil pollution. After the waste has been collected, it is transported and processed. During transport, carbon dioxide and other greenhouse gases, dust are emitted into the atmosphere. Distance is a huge problem because it wastes energy. Part of the waste, especially mixed ones (which are not recyclable), may be incinerated. The energy generated in the combustion process

[1] *Source: GUS data (main statistical office) at December 31, 2012. „odpady komunalne i utrzymanie czystości i porządku w gminach w 2017 roku."*

can be used to produce heat or electricity and replace energy produced using coal and other fuels. Energy recovery from waste, therefore, helps to reduce greenhouse gas emissions and provides energy recovery.

1.1 Definition of the problems

Waste affects our health, quality of life, and wellbeing. Greenhouse gases contribute to climate change, air pollution is released into the atmosphere, clean, drinkable water resources are running out, plants are cultivated on contaminated soil, and toxic substances get into our food. What we consume and produce in Poland or Europe can generate waste elsewhere in the world. It happens that waste becomes a commodity in legal and illegal cross-border trade. Extracting less raw materials and using existing resources can help avoid some of the impacts that arise in the next stages of a product's life cycle as one of Europe's critical goals is to improve waste management. The most important is high-quality recycling, then eliminating storage, reducing materials unsuitable for recycling, providing other ways for energy recovery, and minimizing waste in the landfill.

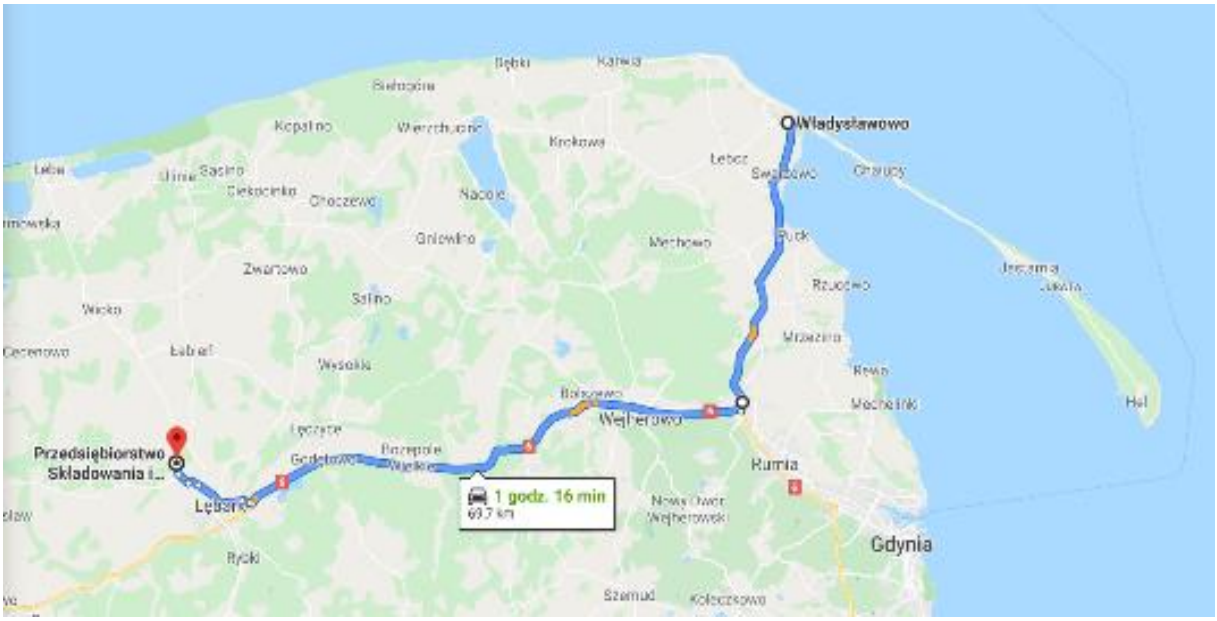


Fig. 1. Long distance to the landfill – near Lębork (about 70 km far) – in this case, garbage transport is a waste of energy.

In Władysławowo, there is a problem with the increasing amount of waste in the summer season. Many tourists came to this seaside city and together with habitants, produce much-mixed garbage. Also, seasonal businesses like restaurants, bars, hotels have a significant impact on that.

The second problem is the waste management system - municipal garbage is transported far away, more than 70 km, to the other city's landfill. It cost a lot of energy, money and it is not economically efficient.

There was one landfill in Władysławowo, but it is not used anymore. There is still a growing problem of utilization, storage, recycle, and reuse waste.
The third problem, both in summer and winter, is burning trashes in house stoves. Unfortunately, despite many loud and emphatic campaigns to protect the environment, some people use garbage as fuel. Along with the smoke, hundreds of harmful substances are released into the air. During the colder months (most of the year), real poison escapes from the villages and cities' chimneys. By throwing garbage into the furnace, people think that they save money - but only seemingly - the amount of heat produced from it is much less than when using high energy materials. Therefore, more rubbish is needed to heat the house, and thus - even more toxic substances are released into the atmosphere.

In Władysławowo, we can barely see any year-round entertainment and culture, education places, or restaurants. There is a lack of places for social activity besides the summer season. Most of the inhabitants are working outside the city and spend free-time in Tri-City. Young people leave Władysławowo to search for a permanent job, not only seasonal – the city has nothing to offer besides the summer touristic value. Educational and economic issues should be more critical and encouraging activity in the city.

2. CONTEXT AND THE AREA

2.1 Władysławowo - introduction

Władysławowo is a small tourist city in the north of Poland, in Pomeranian voivodeship. It has around 10 000 inhabitants. It has been one of the most popular summer resorts for many years. Every year, up to 500,000 guests come here. Tourist infrastructure includes over 200-holiday resorts, hotels, guesthouses as well as campsites, and private accommodation. Of course, the city is the most popular in the summer season and winter.

Fig. 2. Władysławowo – bird view. *Source: https://www.wladyslawowo.info.pl/ [accessed: 10.2020]*

The first mentions of the settlements from which Władysławowo was founded are dated 1277-1284; at the time of Mściwoj II, the settlement was called "Velaves." On March 25, 1376, Wielka Wieś received a location privilege, confirmed on February 25, 1633, by King Władysław IV. In 1407 the Germanized name Grossendorf appeared. In the 17th century, in the face of the expected Swedish invasion, King Władysław IV ordered a war fort near Wielka Wieś. Unfortunately, the unfinished port has undergone the destructive power of the sea.

Fig. 3. Władysławowo beach in summer.
Source:https://turystyka.wp.pl/plaza-wladyslawowo-tlumy-turystow-i-tysiace-parawanow-6280786850269313a [accessed: 10.2020]

Fig. 4. Władysławowo – location in Europe.
Source: author's own study.

2.2 Location of the project area

The location of the project area is near the borders of Władysławowo. The waste landfill in Łebcz has been closed for several years. It is currently undergoing reclamation, which aims to restore degraded areas to new functional and natural values. Meanwhile, many residents have concerns about the reclamation carried out and its impact on the environment. They noticed a bad smell, bringing the municipal waste to a landfill, and creating a threat of water intakes contamination, bringing sewage sludge from sewage treatment plants.

Fig. 5. Location of the area.
Source: https://maps.google.com/

Fig. 6. Władysławowo – old landfill area.
Source: https://kaszuby24.pl/uporczywy-fetor-z-wysypiska-smieci-dokucza-mieszkancom-wladyslawowa-jest-reakcja-wladz/ [accessed: 11.2020]

2.3 Waste management system in Władysławowo

Waste management covers a whole range of activities, from production to management through the recovery of secondary raw materials to environmentally and human safe disposal. The principles of waste management are closely related to the general principles of environmental law in force at the international and European Union level. The EU waste directive establishes a waste hierarchy. It focuses primarily on preventing waste production and reusing recycling, energy recovery (i.e., incineration), and the last – storage.

In 2017 in Poland, the Waste Segregation System was created. It applies throughout the country and defines waste division into four main waste fractions and mixed waste. The system also defines specific requirements that should be met by municipalities. It was created to ensure the possibility of selective waste collection, securing the collected waste for later processing, and replacing waste containers with ones suitable for segregation - of specific colors. These rules are described in the Regulation of the Minister of the Environment of 29 December 2016 n a straightforward method for the selective collection of selected waste fractions *("Rozporządzenie Ministra Środowiska z dnia 29 grudnia 2016 r. w sprawie* szczegółowego sposobu selektywnego zbierania wybranych frakcji odpadów" Dz.U. z 2017 r. poz. 19). According to the Common Waste Segregation System *(WSSO – wspólny system segregacji odpadów)*, municipal waste is divided into four basic fractions: paper (blue), metal

3. ANALITICAL STUDY

3.1 Incineration and waste types

Waste can be classified into many groups based on various criteria such as its origin, harmfulness or toxicity, physical state or chemical composition, or suitability for further processing and use.
Municipal waste - waste generated in households, i.e. directly related to non-industrial human activity. It is characterized by high variability. They are also heterogeneous and unstable, e.g., susceptible to rotting. Disposal consists of subjecting waste to various biological, physical, or chemical processes that transform it into a form that does not endanger human life or health and the environment. The most common way of disposing of the waste is proper storage in landfills. Among the waste disposal methods, we can also distinguish composting, processing into solid fuels, gasification and pyrolysis (anaerobic degradation under the influence of high temperature), the formation of energy piles, and methane fermentation extraordinary chambers and combustion. Incineration involves the combustion of waste at very high temperatures with oxygen.

Modern technology and certified solutions guarantee the utilization of waste without harming the environment. Innovative filters catch all pollution with stringent standards. Of course, only waste that does not undergo composting or recycling goes there. It should be emphasized here that incineration will never replace recycling, composting, or other waste treatment methods. It is only a supplement that can solve the problem of hazardous landfills and contribute to energy saving. The advantage of incineration plants is that they help reduce the amount of waste going to landfills and recover energy.

For now, Poland in waste incineration is below the EU average. In first place in the world, with 2,000 incineration plants, it is Japan. Some of them are even at the small estates - the residents throw the waste into the chute and immediately go to the furnace. In the US, WTE facilities account for approximately 20% of all renewable electricity generation. We can say that the waste-to-energy system is more efficient than wind and solar systems because it provides 24/7 renewable electrical power.

3.2 Incineration and waste to energy – wide context

The concept of waste utilization by incineration in equipment specially designed for this purpose appeared in Europe in the second half of the 19th century. Reasons for building this type of plant are:

- the possibility of producing energy through the use of steam-water generated by incineration plants;
- the need for ""bacteriological sterilization"" of garbage, in fear of the possibility of spreading disease and plague;

- solving the problem of increasing amounts of waste as a result of rapid industrialization and urban development.

Landfills are one of the most significant sources of gas emissions. These emissions contain mainly methane (CH4) and carbon dioxide (CO2), both considered greenhouse gases contributing to global warming. *"Methane is a greenhouse gas 21 times more harmful than carbon dioxide".* [2]

Each year, a large amount of municipal solid waste is generated. The energy in waste is nearly lost, creating mountains of trash, emitting harmful pollutants into our air, water, and soil.

Increased urbanization, population growth, and economic growth could create more and more municipal solid waste. Cities are undergoing a critical situation because of the increasing amount of solid waste they generate and, as a result, growing demand for new sites for final disposal.

Besides the landfills, the most usual option to reduce the generated mixed waste is thermal treatment (incineration, pyrolysis, gasification or plasma). One of the arguments used to seek support for incineration is that it generates renewable energy. Furthermore, the generation of electricity, heat, or biofuels from renewable energy sources has become a priority in energy policy strategies globally.

Nowadays, cities generate immense amounts of CO2 emissions and consume much energy; reducing gas emissions by using waste to generate energy makes sense. According to that, waste has been identified as an environmentally friendly energy source. In this way, the waste to energy (WtE) concept solves two crucial issues: the generation of energy and solid waste valorization that will not accumulate in landfills.

3.3 Waste-to-energy technology

Waste-to-energy (WtE) combusts mixed, non-recyclable waste materials to generate electricity and heat. Modern WtE facilities are a much more advanced form of energy recovery technology than the incineration plant. To prevent the emission of fly ash and harmful gases, advanced control systems are used. In general, WtE facilities are an alternative to landfilling and more economically efficient. They are built to manage waste that cannot be reused or recycled. Waste-to-energy conversion processes are classified into thermal, mechanical and thermal, thermochemical, and biochemical.

[2] *Source: https://www.linkedin.com/pulse/advantages-disadvantages-waste-to-energy-technologies-wijerathna/ [accessed: 11.2020]*

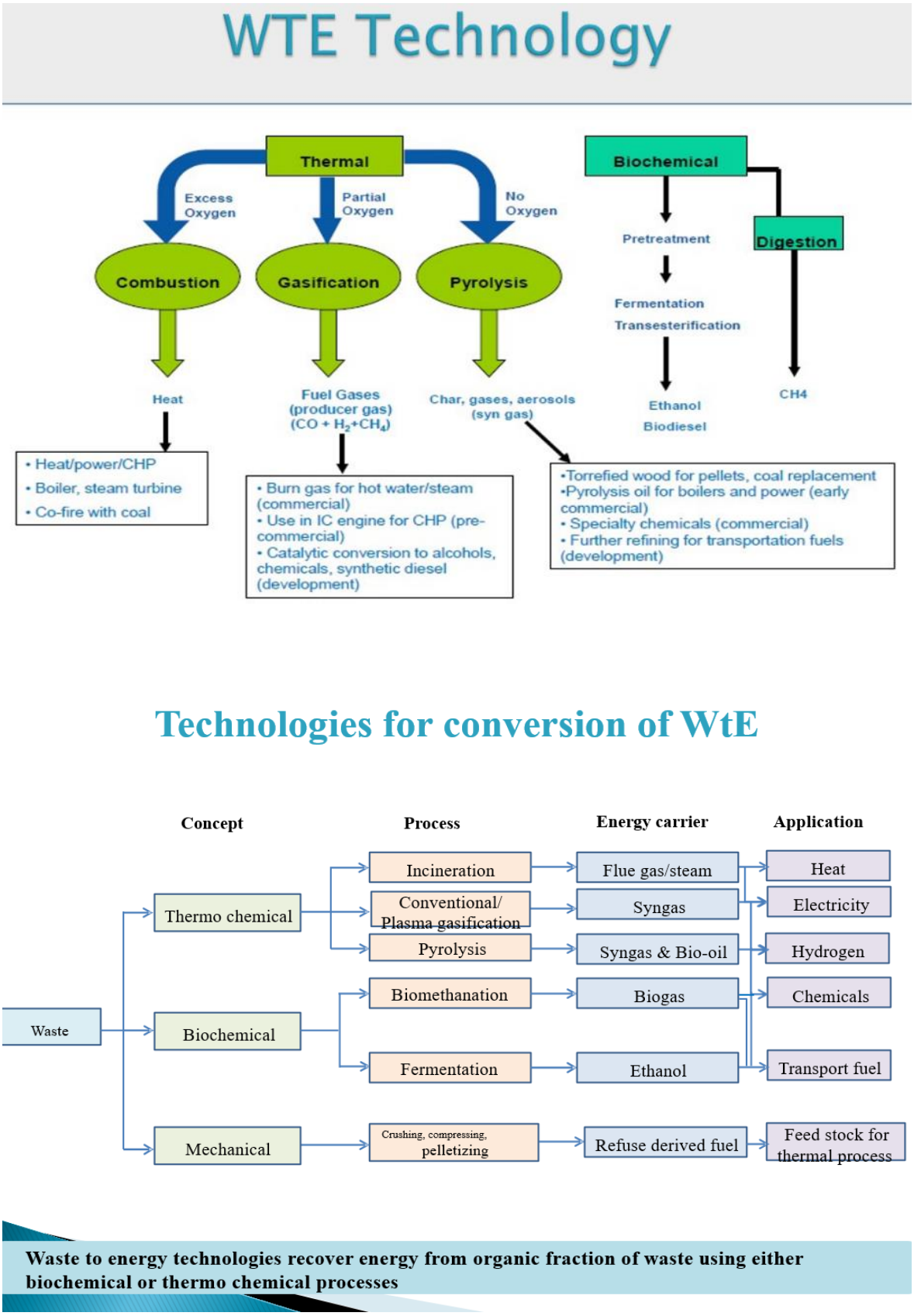


Fig. 7. *Source: waste to energy technology* - ***NARENDRA KUMAR***

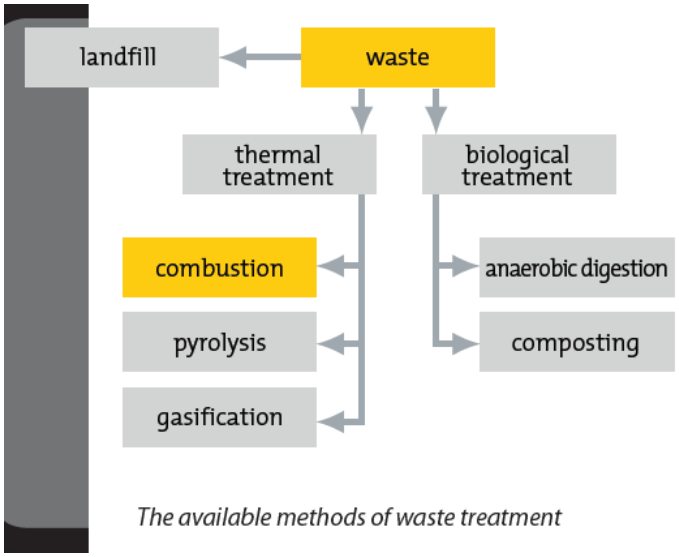


Fig. 8. The available methods of waste management.
Source: "21' Century Advanced Concept"- publication by B&W Volund for Waste-Fired Power Plants[accessed 11.2020]

Waste-to-energy can play a role and create synergies with EU energy and climate policy, but must always be guided by the principles of the EU waste hierarchy:

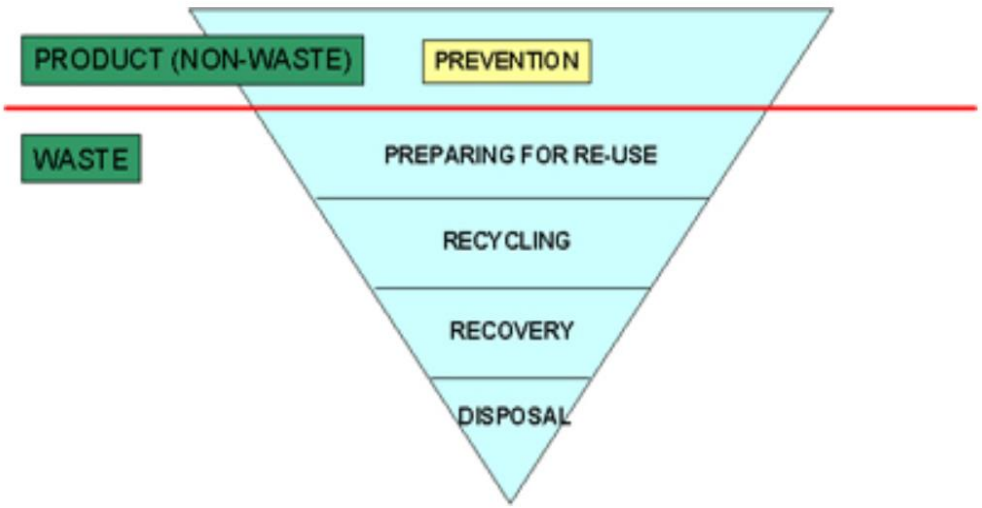


Fig. 9. Waste hierarchy.
Source: Directive 2008/98/EC on waste (Waste Framework Directive)

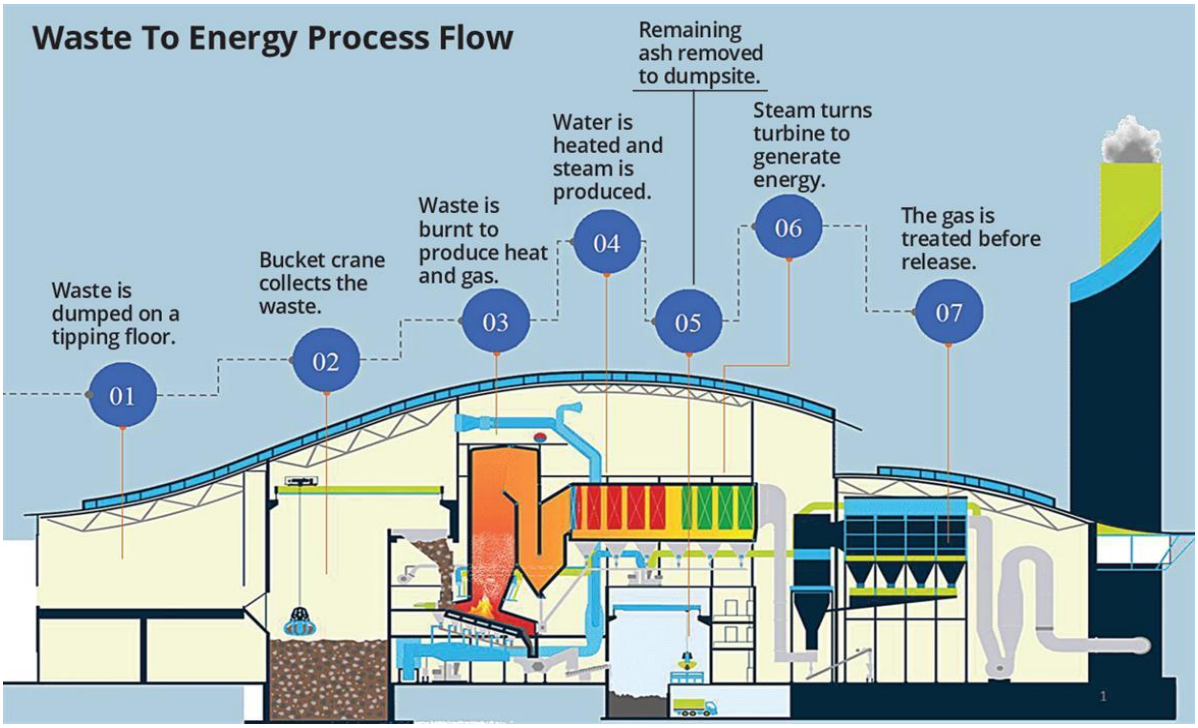


Fig. 10. Waste-to-energy process flow.
Source: http://pacepowersystems.com/infrastructure/solid-waste-management/waste-to-energy-integrated-msw-management/#.X8lmh2hKhPY [accessed 11.2020]

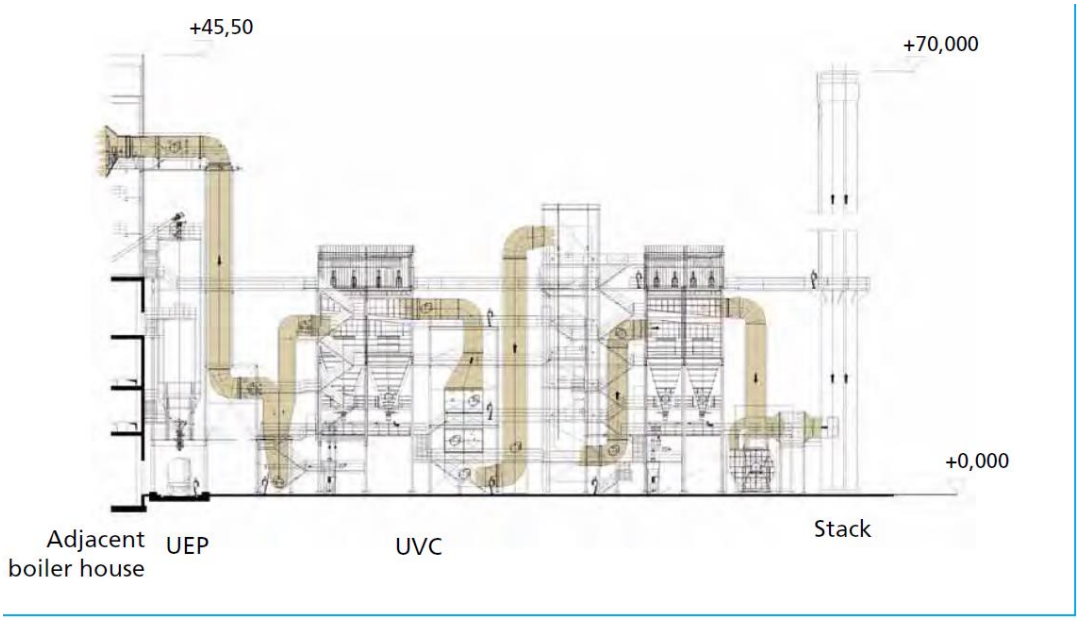
The garbage is weighed before unloading, pushed into the bunker, and then thoroughly mixed. Thanks to negative pressure in the waste storage bunker, odors are captured and destroyed. After entering the combustion chamber, the waste is burned at a temperature above 850 degrees Celsius. When waste is burned, the heat converts the water in the walls lined with steel pipes into steam. The steam drives a turbine to generate electricity and heat. Most of the electricity is exported to the national grid, a small portion being used to power the facility.

> *"In a modern WtE plant, the waste is first measured and evaluated for its potential to be used before it is fed into a hopper, which could hold the waste for a matter of days before it is combusted. During the incineration, no other fuel is necessary besides the waste itself, as the temperatures reach around 1000°C. Some material will not be combusted and is sorted for further recycling processes. The high temperatures produced in the furnace then heat water running through furnace pipes into steam. This steam pressure is transferred to a turbine and generator to create electricity. "*[3]

The steam from the process is cooled, condensed, and returned to the boiler tubes, making it an efficient system. After incineration, the waste volume is reduced by 90%, leaving ashes and metal. The ash is removed and reused (for example, in road construction), and the metal is recovered for recycling. Rigorous standards ensure air pollution control. Acid gases and heavy metals are neutralized. The plant

[3] *Source: http://large.stanford.edu/courses/2016/ph240/nana-sinkam1/*

controls particulate emissions and uses thousands of modern filters. The exhaust gas is post-treated with water to lower the temperature and remove the hydrogen chloride. Sodium hydroxide solution is used to remove sulfur dioxide.



e 6: Flue gas cleaning unit with ash silo and stack, longitudinal section (example)

Fig. 11. Flue gas cleaning unit – big one.
Source: "Layout Planning of Waste-to-Energy Plants" by Falko Weber

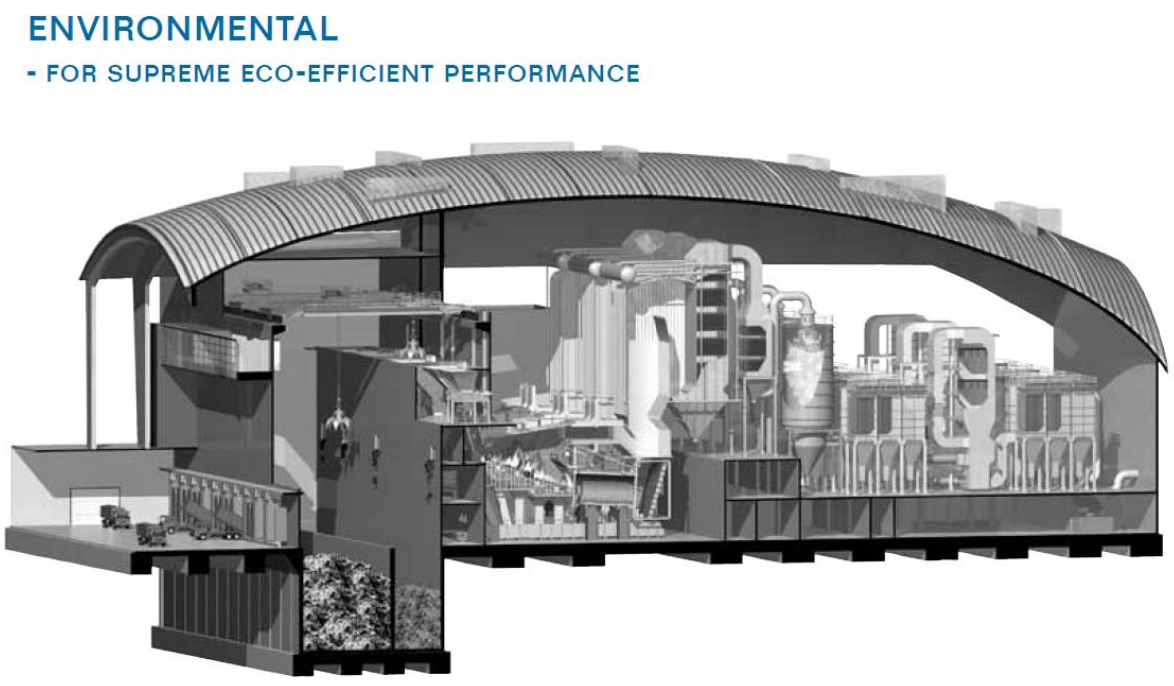


Fig. 12. 3D section – waste-to-energy plant.
Source: "Layout Planning of Waste-to-Energy Plants" by Falko Weber

3.4. Waste-to-energy – pros and cons

Advantages of WtE:

- efficient waste management,
- production of heat and power,
- renewable resource,
- reduces landfills,
- saves on transportation of waste,
- protects clean water supplies,
- reduces air pollution and smog-advanced pollution control of gas emissions and flue gases,
- provides better control over odor and noise,
- reduces ground and surface water pollution,
- reduces greenhouse gases:
    - Carbon dioxide
    - Methane
- operate in every weather, function 24 hours a day,
- occupies relatively small space

Disadvantages of WtE:

- high costs – expensive building process
- possibility of long term consequences
- the risk of burning valuable waste only to produce more energy
- waste as relatively non effective fuel
- the risk of toxic emissions – advanced filters can be changed to cheaper, not effective ones
- the risk of import wastes from other cities or even countries to reach the capacity

Modern plants integrated with community services will sustainably treat non-recyclable waste, generating renewable energy and recovering materials, supporting a low-carbon circular economy. Incineration saves much money on transport waste to landfills and therefore reduces the carbon footprint. Of course, recycling and reducing waste must be considered first. However, there are still some things we cannot reuse or recycle, no matter how hard we try. It is also not easy to change people's thoughts and beliefs that you should segregate waste, not burning them on your private stove. At that point, we can say that incineration as waste-to-energy technology can co-exist with the idea of 4R and complement it by processing the waste that is not suitable for landfill or recycling. The heat and energy

as the "side-product" can be used for municipal heating and electricity systems. In some cases, incineration plants can be cheaper than new sustainable energy - wind and solar – projects.

Technical knowledge and rigid descriptions of cost-effective and environmentally friendly solutions are not enough to justify waste facilities' acceptance. Public acceptance of municipal waste disposal facilities is an integral part of implementing effective waste management strategies; therefore, the process of participation, community activation, talks, and presentations is critical. Proposed solutions should be negotiated based on the nature of the waste problem and the broader social context of decision making. Gathering views from a wide range of stakeholders, public engagement, the whole process of participation including workshops - all this should be done in response to the need for greater integration in the case of disputed technologies.

For example, in the process of "implementing" the Dublin waste-to-energy plant, the city, together with the company and designers and specialists, decided to involve the residents in this process from the very beginning. Leaflets, information brochures, meetings, talks, and even a special website promoting content encouraging ecological approach and recycling were created.

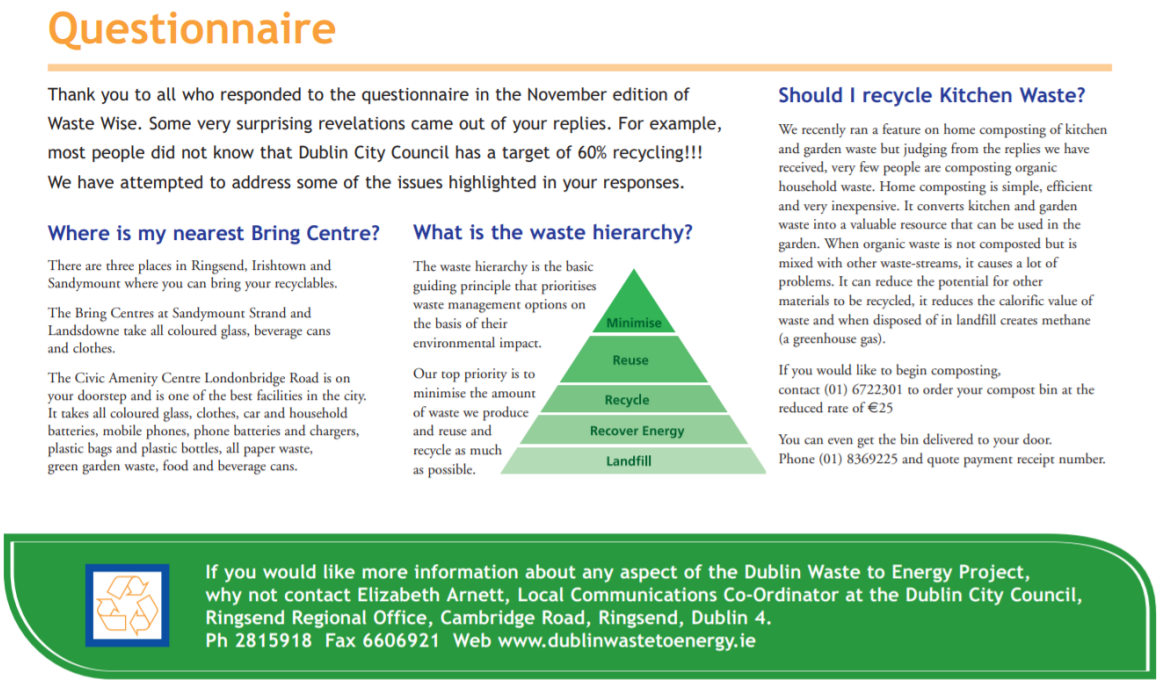


Fig. 13. Leaflet
Source: "Environmental impact statement. Dublin waste-to-energy project." by www.dublinwastetoenergy.ie

4. STUDY CASES

4.1 Copenhill, waste-to-energy plant, Copenhagen, Denmark

Fig. 14. “Copenhill” – waste to energy plant in Copenhagen.
source: www.archdaily.com/925966/copenhill-the-story-of-bigs-iconic-waste-to-energy-plant [accessed: 11.2020]

LOCATION:	Copenhagen, Denmark
ARCHITECTS:	Bjarke Ingels Group (BIG)
YEAR:	2013 - 2019

Copenhill is a power plant that draws energy from waste incineration, located in the center of Copenhagen. The body of the building is 124 m high and 200 m long. The facility belongs to the most modern and environmentally friendly incineration plants in the world. There is space for walking routes, parks, playgrounds, gyms, a fitness club, climbing walls, and leisure places for residents, and even a ski slope has been designed on its roof. It processes 400,000 tonnes of waste annually, produced by 700,000 inhabitants and around 46,000 companies while providing energy for 50,000 households and heating for another 120,000. By using the most modern filters, exhaust gases are reduced to a minimum. 70 tons of waste are burned here per hour. The incineration plant's energy efficiency is 99%, and the reduction of

sulfur emissions is 99.5%.[4] The plant's location is near the city center – from the Opera House, there are around 1,2 km. This shows that the incineration plant can be near households, monuments, public spaces.

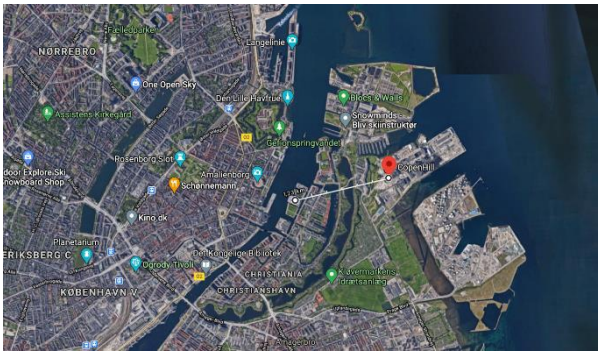


Fig. 15. "Copenhill" – location on the Google map.
Source: maps.google.com

Fig. 16. "Copenhill" – location on the Google map, closer look.
Source: maps.google.com

Fig. 17. "Copenhill" – location on the Google map, 3D view.
Source: GooglePRO Maps

[4] *Source: https://miastojestnasze.org/wielofunkcyjna-spalarnia-odpadow-w-kopenhadze/ and*

TECHNOLOGY:

The facility includes two combustion lines connected to the boiler and a combined turbine and generator system. Each line can burn 35 tons of waste per hour.[5] The waste is lifted with a crane and transferred to a two-lane combustion grate using a hopper. Grates are staggered and mounted on shafts to optimize fuel bed mixing – this system is called DynaGrate[6]. To optimise the heat production, designers used the flue gas cleaning technology, called SCR - selective catalytic reduction. Besides, flue gas condensation allows the reuse of 100,000 tonnes of bottom ash as road material and recovering 100 million water liters.

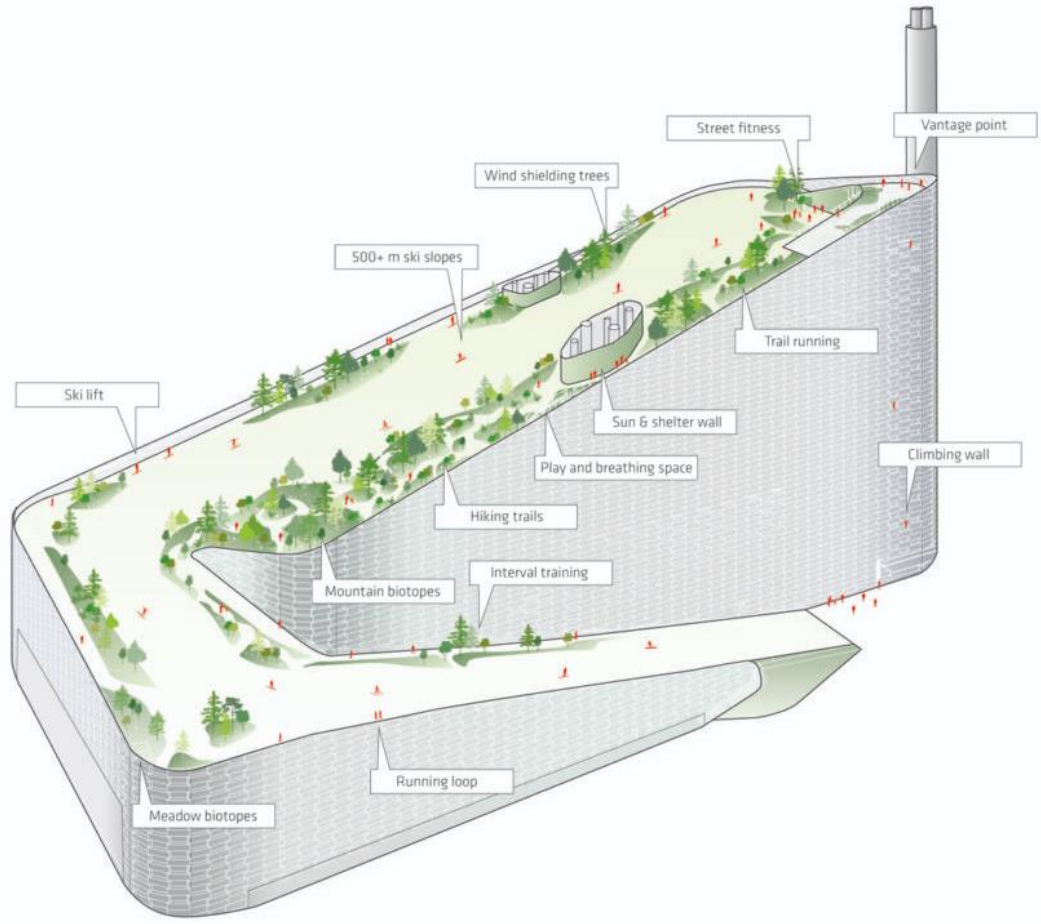


Fig. 18. "Copenhill" – schematic view of the roof.

Source: https://www.inexhibit.com/case-studies/stroke-of-genius-or-gimmick-bjarke-ingels-ski-slope-topped-power-station-in-copenhagen/ [accessed: 11.2020]

[5] *Source: https://www.power-technology.com/projects/amager-bakke-waste-energy-plant/*
[6] *Source: https://www.babcock.com/resources/case-profiles/amager-bakke-copenhill*

DESIGN IDEA:

The idea is to integrate recreational green areas with industrial buildings. On the one hand, we have waste management and energy production, but on the other – a public space for citizens and an impressive architectural landmark. The designers tried to add some different values to the building – Denmark has no mountains, so they use the top of the roof to create a ski slope. It is an excellent opportunity to promote environmental sustainability, also attract inhabitants and tourists.

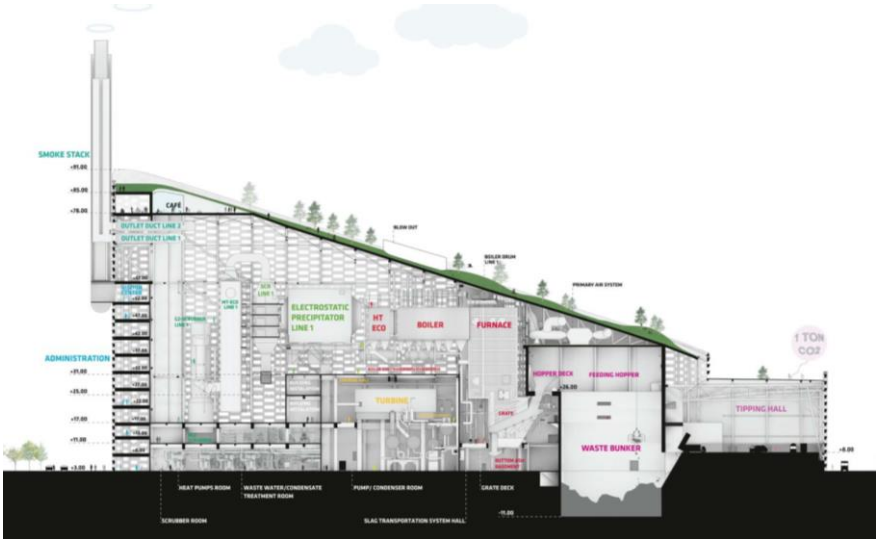


Fig. 19. "Copenhill" – section.

Source: https://www.inexhibit.com/case-studies/stroke-of-genius-or-gimmick-bjarke-ingels-ski-slope-topped-power-station-in-copenhagen/ [accessed: 11.2020]

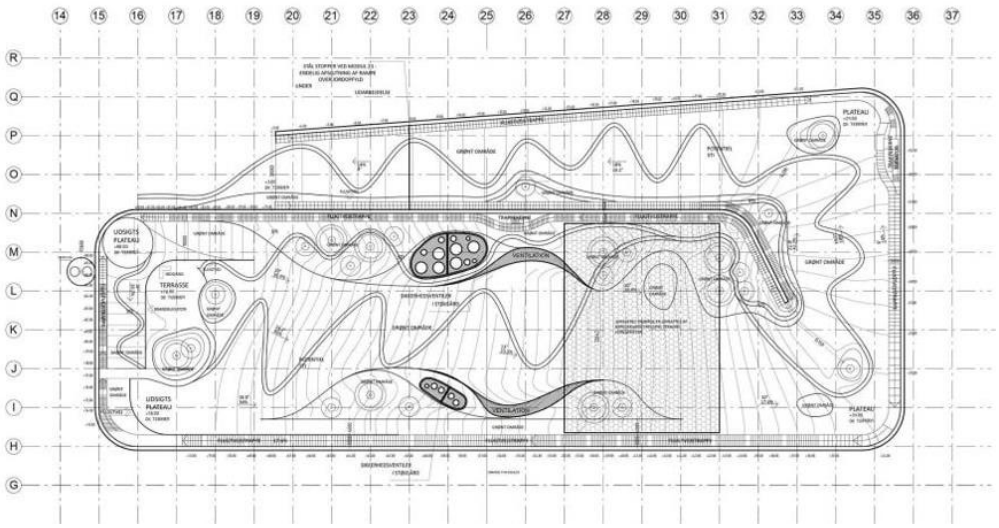


Fig. 20. "Copenhill" – plan.

Source: https://www.inexhibit.com/case-studies/stroke-of-genius-or-gimmick-bjarke-ingels-ski-slope-topped-power-station-in-copenhagen/ [accessed: 11.2020]

4.2 Waste-to-energy plant, Kraków, Poland

LOCATION: Kraków, Poland

ARCHITECTS: arch. Bogusław Wowrzeczka, arch. Michał Teller, arch. Filip Łapiński

YEAR: 2013 - 2015

Fig. 21. Waste incineration plant in Krakow.

Source: https://sztuka-architektury.pl/article/4335/spalarnia-odpadow-w-krakowie-8211-niezwykly-projekt [accessed: 11.2020]

The waste – to – energy plant in Krakow is inspired by the view of fields and folk costumes' decoration. Multi-colored belts are known from Polish folk skirts and became the starting idea for developing a modular building, in which the colors emphasized segment division. Also, the shape of the eco-incineration plant body and its integration into the surroundings is an innovative interpretation of the natural landscape's unity with the city's organism. The plant is located in the south-eastern part of the city of Krakow in District Nowa Huta. The area of land is 56 000 m2, building area: 18 500 m2, usable area: 30,000 m2.[7] Approximately 28 tonnes of waste are burned per hour in the plant.[8] It can process 220,000 tons of municipal waste during the year. It was calculated that from June 27, 2016 to the end of May 2017, the Krakow Eco-incineration plant converted 222,729.41 tons of municipal waste into electricity and heat - during this time it generated 56,670 MWh of electricity and 740,108 GJ of thermal energy[9]. Mixed municipal waste selected by residents and other wastes resulting from mechanical treatment of municipal waste are sent for thermal transformation. Combustion takes place continuously on 2 parallel lines. The energy obtained from the incineration of waste is considered to a large extent as

[7] *Source: https://sztuka-architektury.pl/article/4335/spalarnia-odpadow-w-krakowie-8211-niezwykly-projekt [accessed: 11.2020]*
[8] *Source: https://khk.krakow.pl/pl/ekospalarnia/informacja-o-zakladzie/ [accessed: 11.2020]*
[9] *Source: https://inzynieria.com/energetyka/rankingi/51036,spalarnie-odpadow-w-polsce-ktore-sa-najwieksze [accessed: 11.2020]*

renewable energy. The plant has a very modern installation that meets the BAT (Best Available Techniques) requirements.

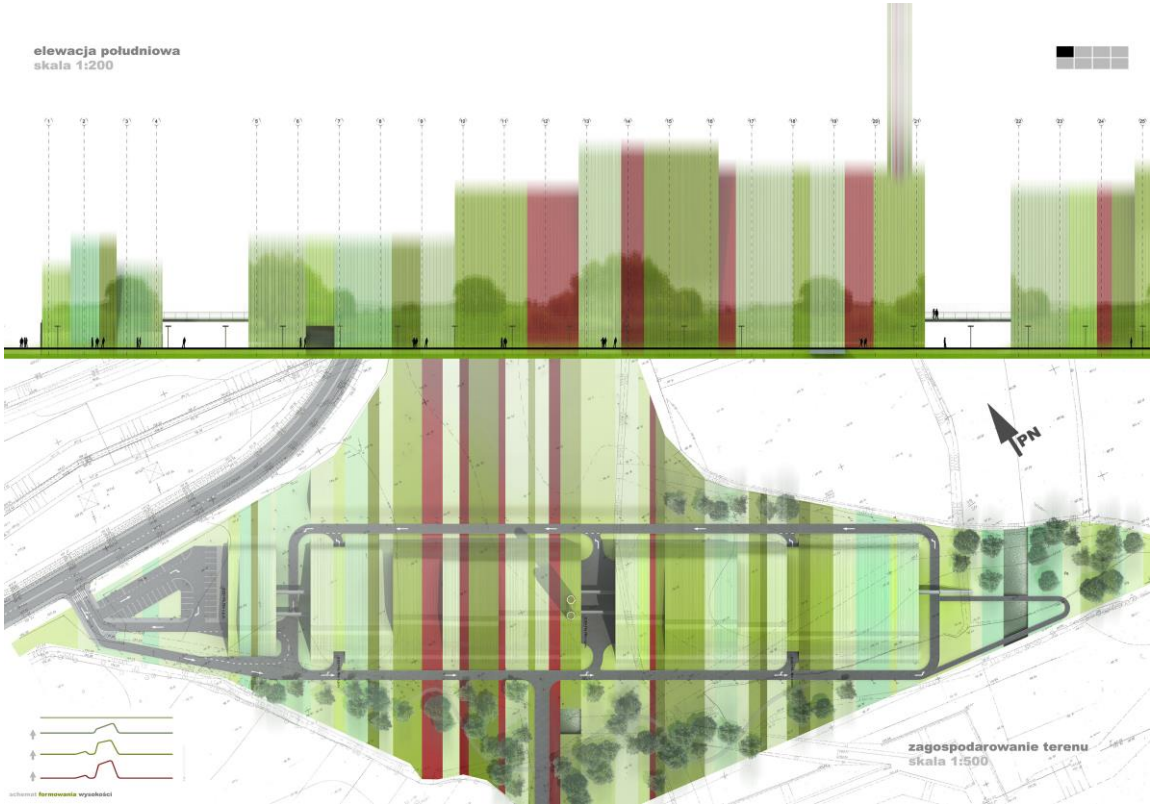


Fig. 22. Waste incineration plant in Krakow – plan and elevation.

Source: https://sztuka-architektury.pl/article/4335/spalarnia-odpadow-w-krakowie-8211-niezwykly-projekt [accessed: 11.2020]

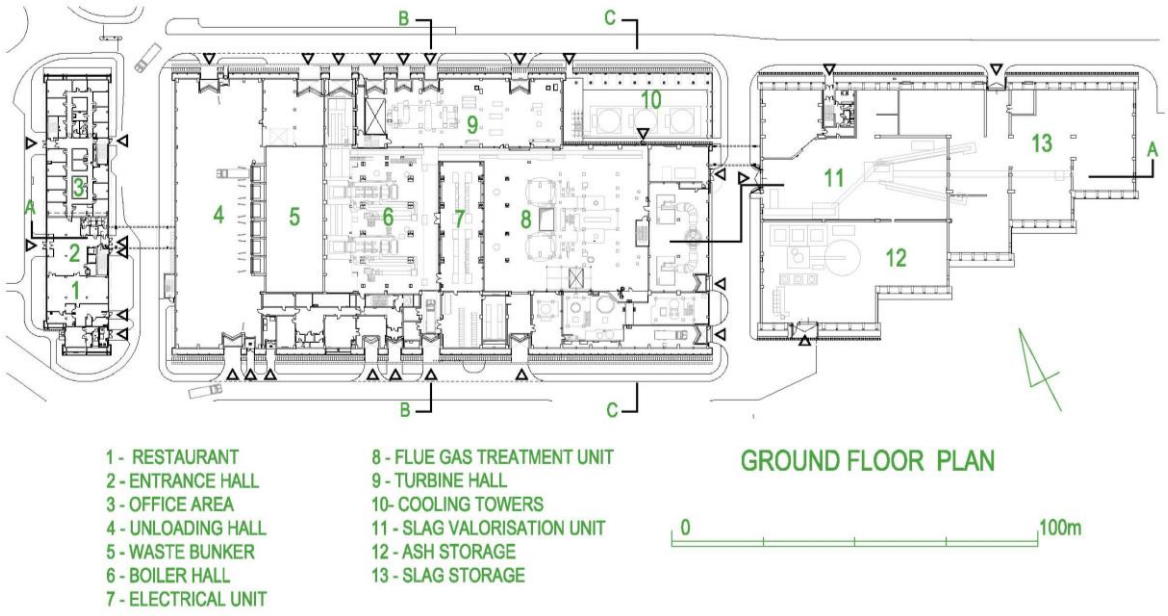


Fig. 23. Waste incineration plant in Krakow – plan.

Source: https://miesarch.com/work/3283 [accessed: 11.2020]

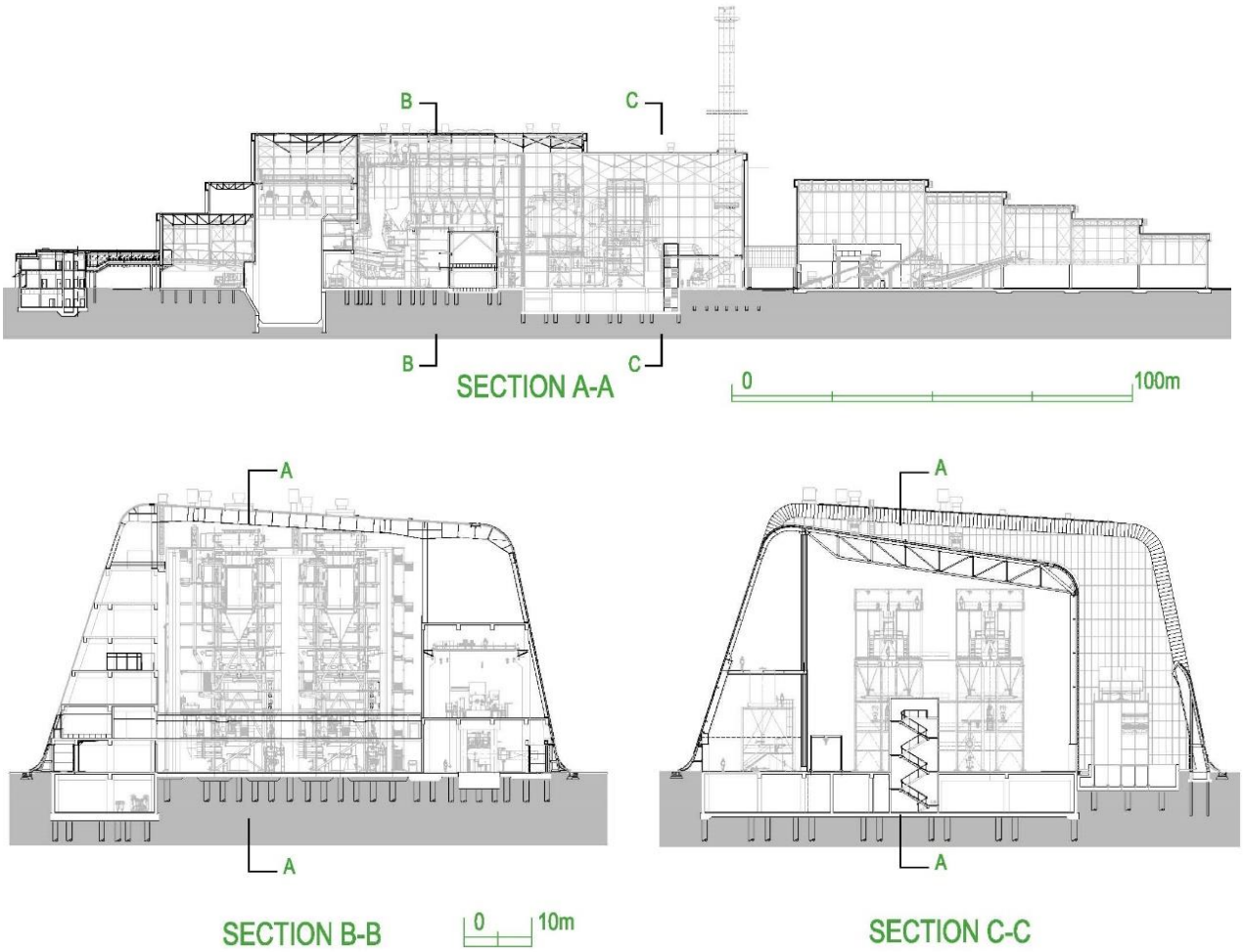


Fig. 24. Waste incineration plant in Krakow – sections.

Source: https://miesarch.com/work/3283 [accessed: 11.2020]

TECHNOLOGY:

The incineration building was designed on a rectangular projection with total dimensions of 47 × 265 m. The spatial arrangement in the plan consists of linearly ordered functional zones. The **entrance zone** consists of an administrative, educational and social team. The **first technological zone** consists of the main process building, in which there are: waste collection, waste incineration, preparation of production factors such as water treatment, air compression, sewage pretreatment, flue gas treatment, production of electricity and heat, reception and storage of reagents, storage of replacement devices, workshop and technological process management zone. The **second technological zone** consists of a process waste management building, in which there is: a slag collection zone, recovery of ferrous, and non-ferrous metals, valorization of slag, acceptance and stabilization solidification of fly ash and flue gas treatment system, social facilities.

In Krakow WTE plant there is also an educational pathway that leads throughout the plant, showing the key elements of the system. In addition, a closed gallery was designed for teaching and educational purposes - organized school groups or guests have the opportunity to familiarize themselves directly with the technological process by passing through all zones of the incineration plant.

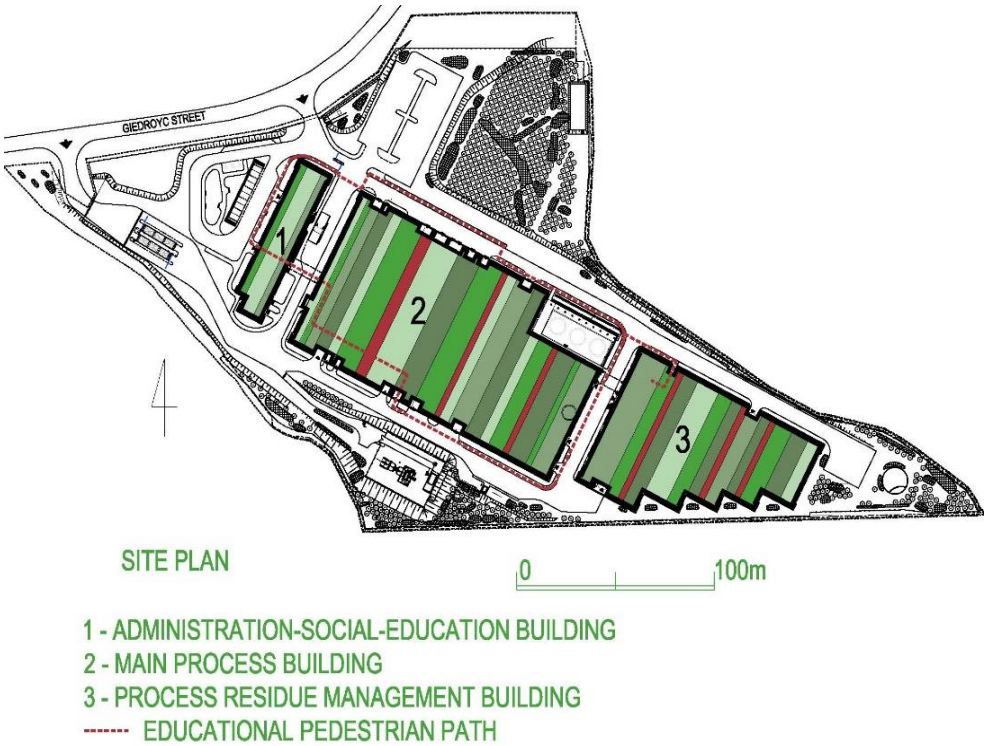


Fig. 25. Waste incineration plant in Krakow – site plan.

Source: https://miesarch.com/work/3283 [accessed: 11.2020]

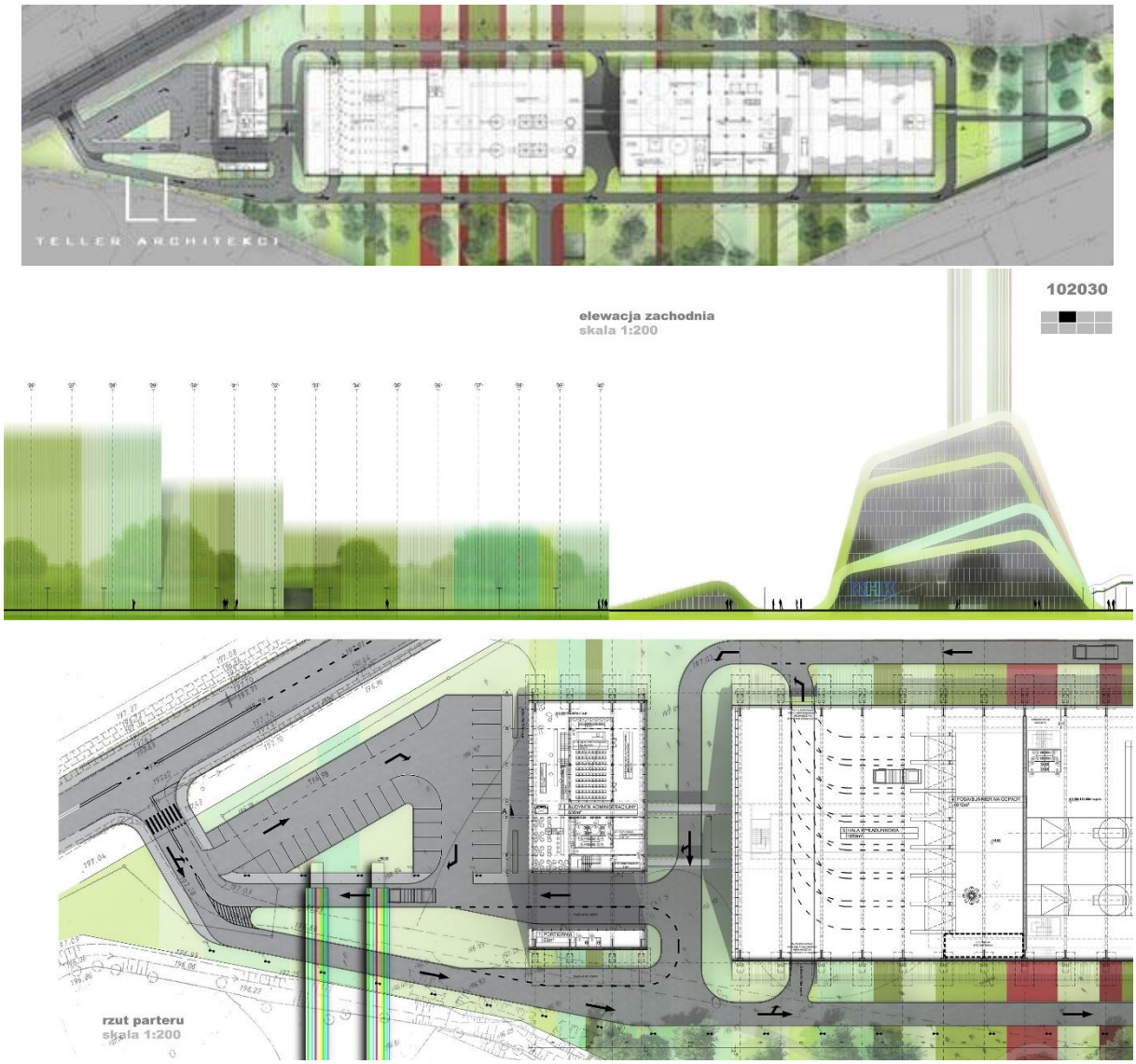


Fig. 26. Waste incineration plant in Krakow – plan and elevation.

Source: https://www.a-ronet.pl/index.php?mod=nagroda&n_id=2149&fbclid=IwAR2EiWNKjb93N-X7Xb6gqBr9O5G6zxdSGVNOjE_4Ke-KIrwuVZ-JS3SvNq4 [accessed: 11.2020]

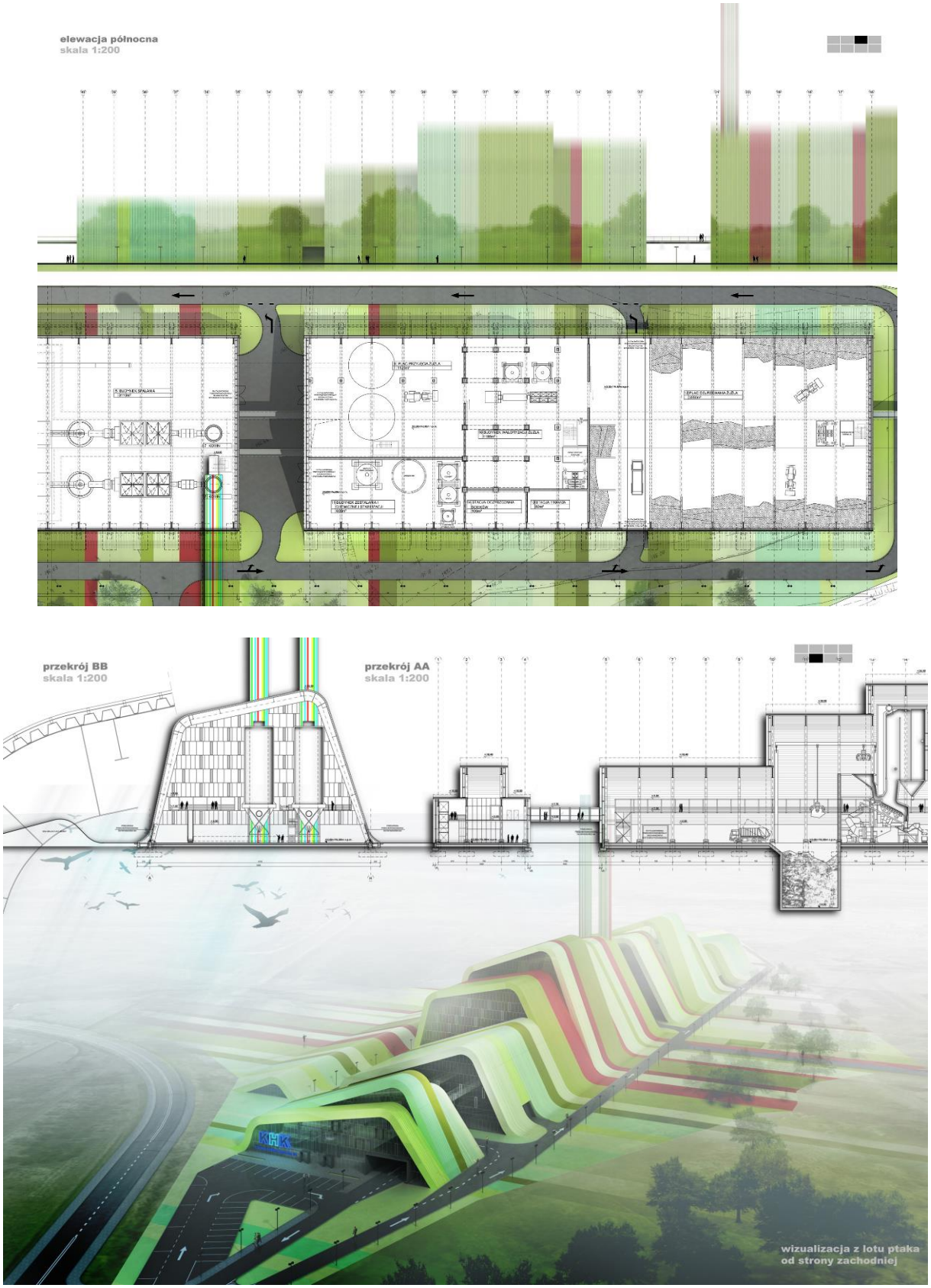


Fig. 27. Waste incineration plant in Krakow – plan and elevation.

Source: https://www.a-ronet.pl/index.php?mod=nagroda&n_id=2149&fbclid=IwAR2EiWNKjb93N-X7Xb6gqBr9O5G6zxdSGVNOjE_4Ke-KIrwuVZ-JS3SvNq4 [accessed: 11.2020]

4.3 Waste-to-energy plant, Dublin, Ireland

LOCATION:	Dublin, Ireland
ARCHITECTS:	Friis & Moltke Architects
YEAR:	2013 - 2015

The Dublin Waste-to-Energy project is a Public-Private Partnership (PPP) between Dublin City Council (acting on behalf of the four Dublin Local Authorities) and Covanta, a world leader in sustainable waste and energy solutions. The plant process at least 600,000 tonnes of solid waste that cannot be recycled. The Dublin Waste-to-Energy provides electricity for 80,000 homes and heating potential for 50,000 homes.

Fig. 28. Dublin waste incineration plant.

Source: https://openhousedublin.com/locations/covanta-dublin-waste-to-energy-facility/ [accessed: 11.2020]

TECHNOLOGY:

The project is one large structure with a steel frame. The solid is 200m x 100m and 52m high (without the 80m high chimney). As the structure is so large, the distinctive cone-shaped building is the local landscape's dominant feature. All corners are rounded, and the building is also curved and sloped upwards, creating a complex geometry of the steel structure. All of this was created with the help of BIM technology.

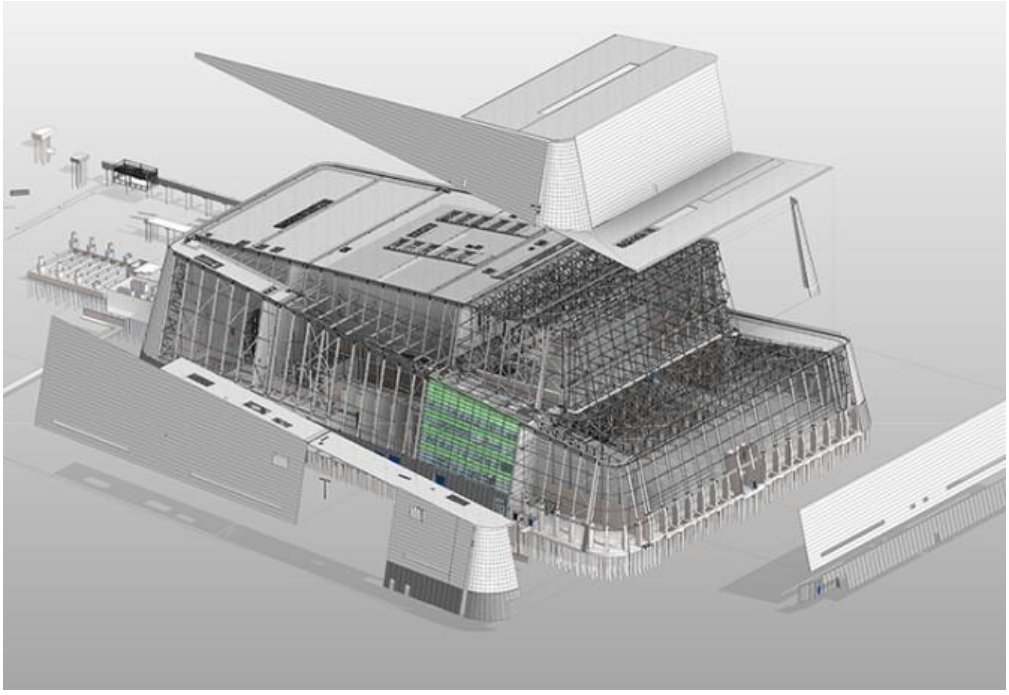


Fig. 29. Dublin waste-to-energy plant – scheme.

Source: https://www.pmgroup-global.com/our-work/dublin-waste-to-energy/ [accessed: 11.2020]

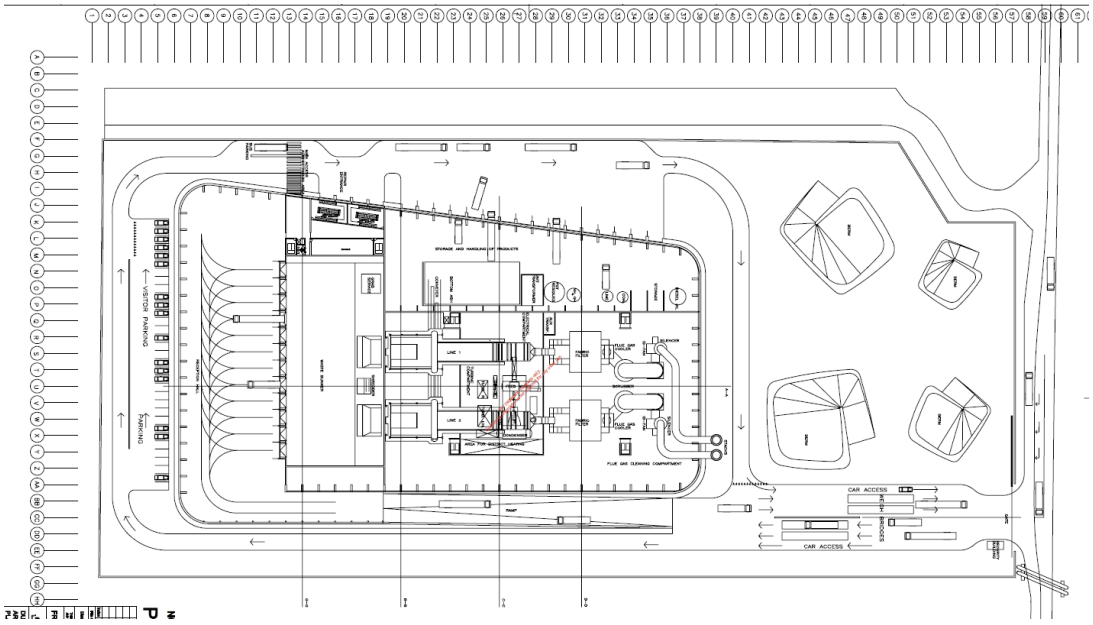


Fig. 30. Dublin WtE plan.
Source: https://www.dublinwastetoenergy.ie/ [accessed: 11.2020]

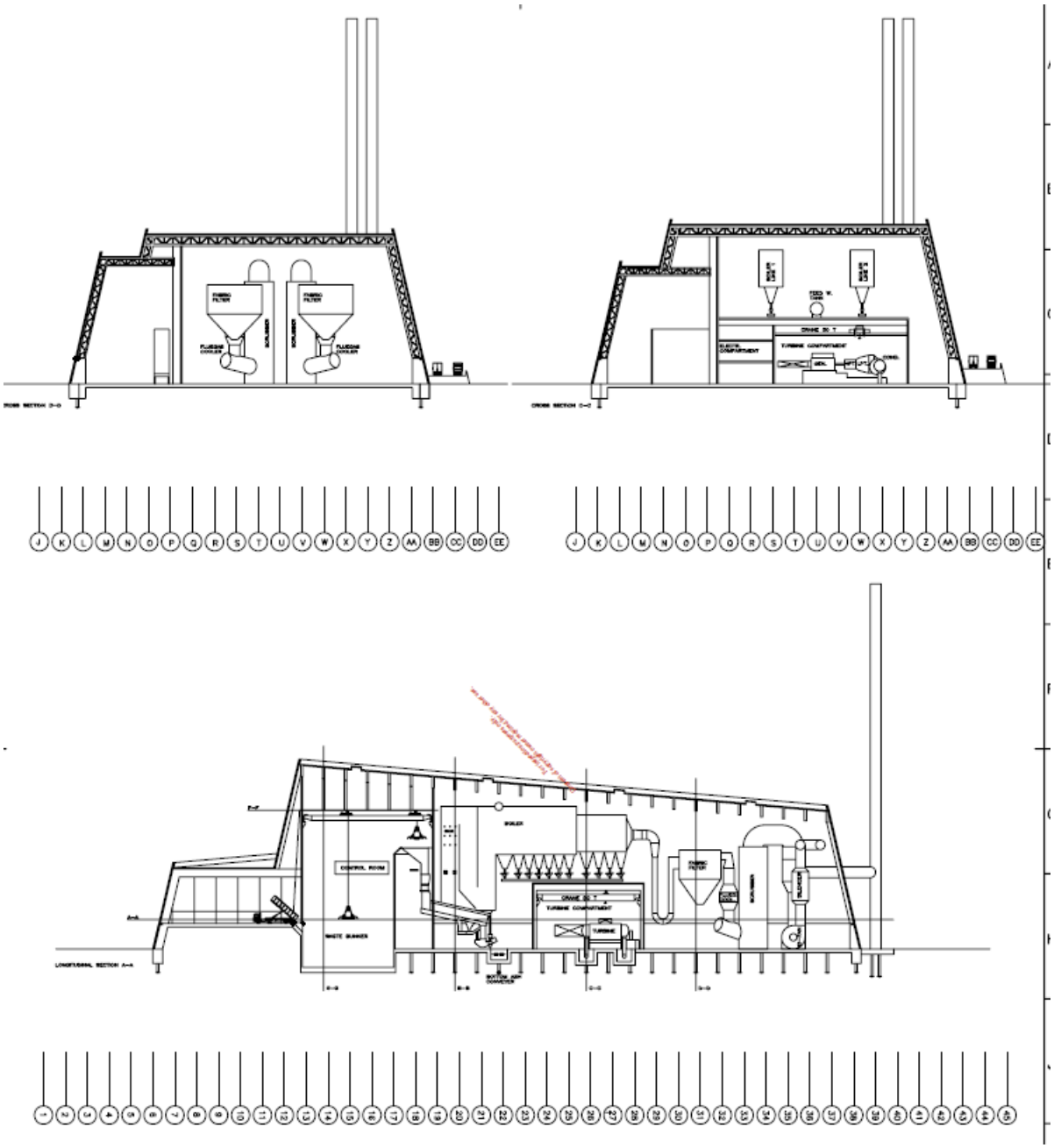


Fig. 31. Dublin WtE section.
Source: https://www.dublinwastetoenergy.ie/ [accessed: 11.2020]

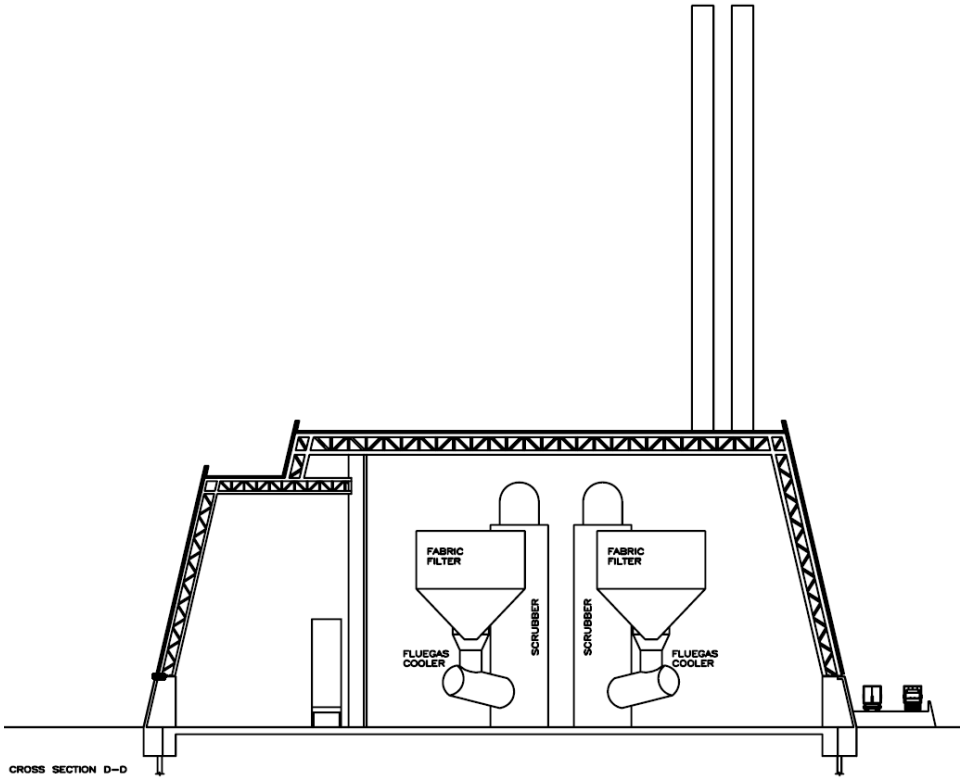


Fig. 32. Dublin WtE section.
Source: https://www.dublinwastetoenergy.ie/ [accessed: 11.2020]

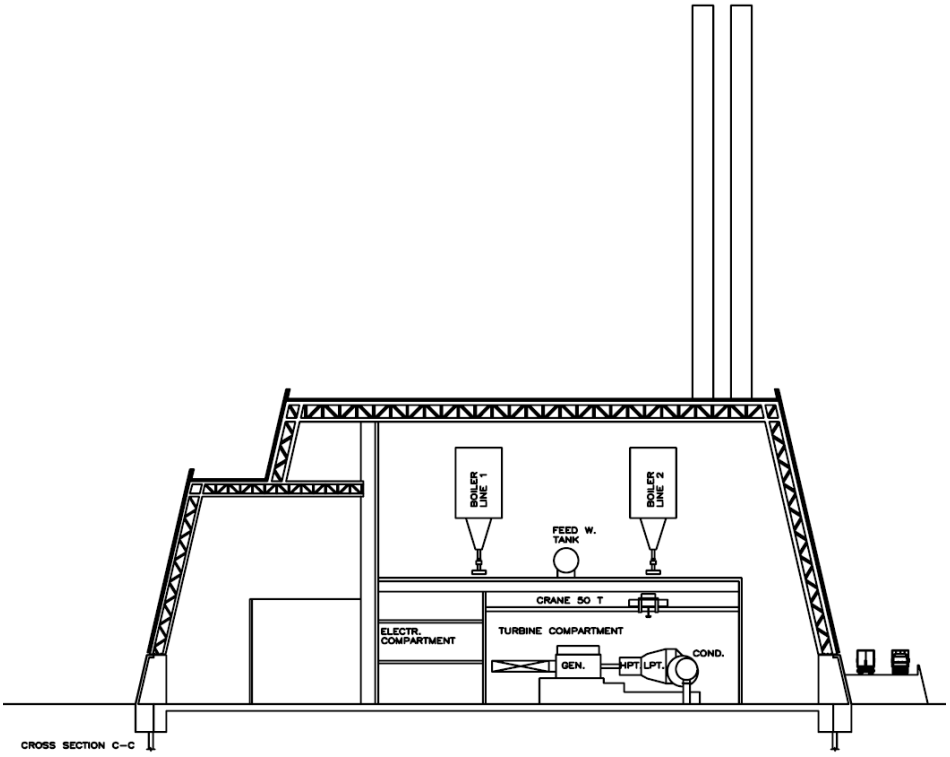


Fig. 33. Dublin WtE section.
Source: https://www.dublinwastetoenergy.ie/ [accessed: 11.2020]

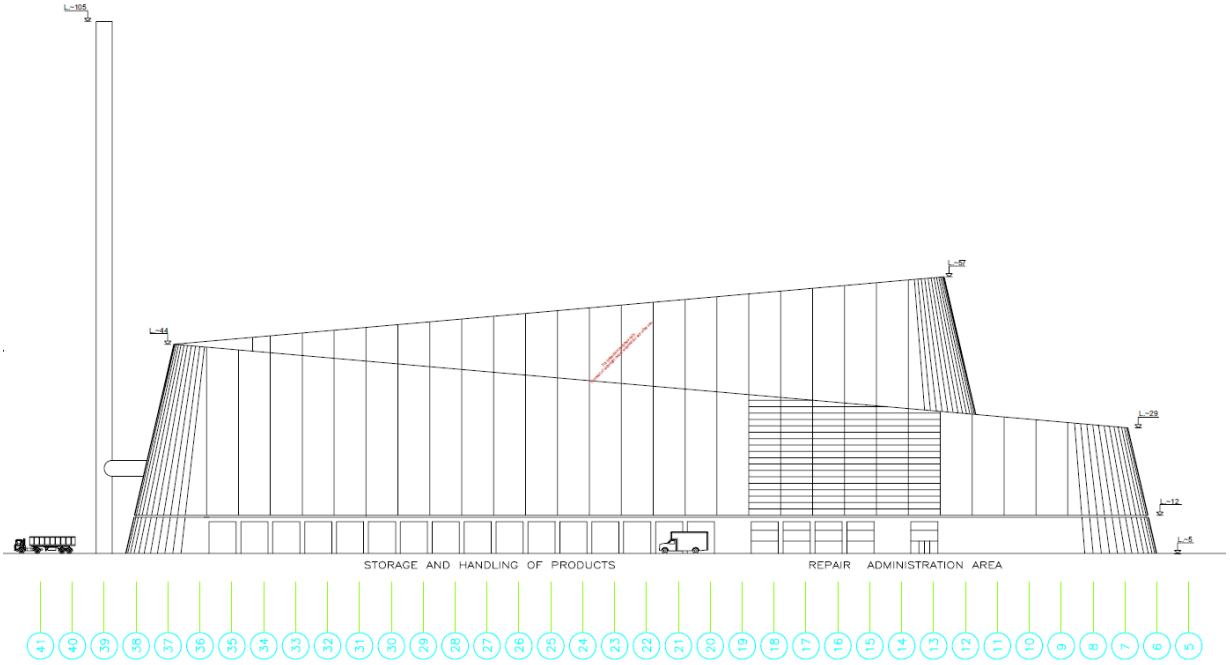


Fig. 34. Dublin WtE section.
Source: https://www.dublinwastetoenergy.ie/ [accessed: 11.2020]

4.4 Bozen waste-to-energy plant, Bolzano, Italy

LOCATION: Bolzano, Italy
ARCHITECTS: Cl&aa Architects
YEAR: 2008-2013

Fig. 35. Waste incineration plant in Bolzano.
Source: https://www.archdaily.com/506227/bozen-waste-to-energy-plant-cl-and-aa-architects?ad_medium=gallery

The plant was designed to process 130,000 tons of waste, and it is designed to provide 20,000 homes with heating (260,000 MWh) and electricity (82,000 Mwh). The complex consists of two central bodies of different heights for a total area of 25,000 square meters, oriented to the highway and river. One of the elevations is screened by green aluminum panels, which is also a noise barrier. The office building has a sloping profile and glazed walls. The Bolzano plant is located at the entrance of the city. The site is surrounded also by mountains and vineyards

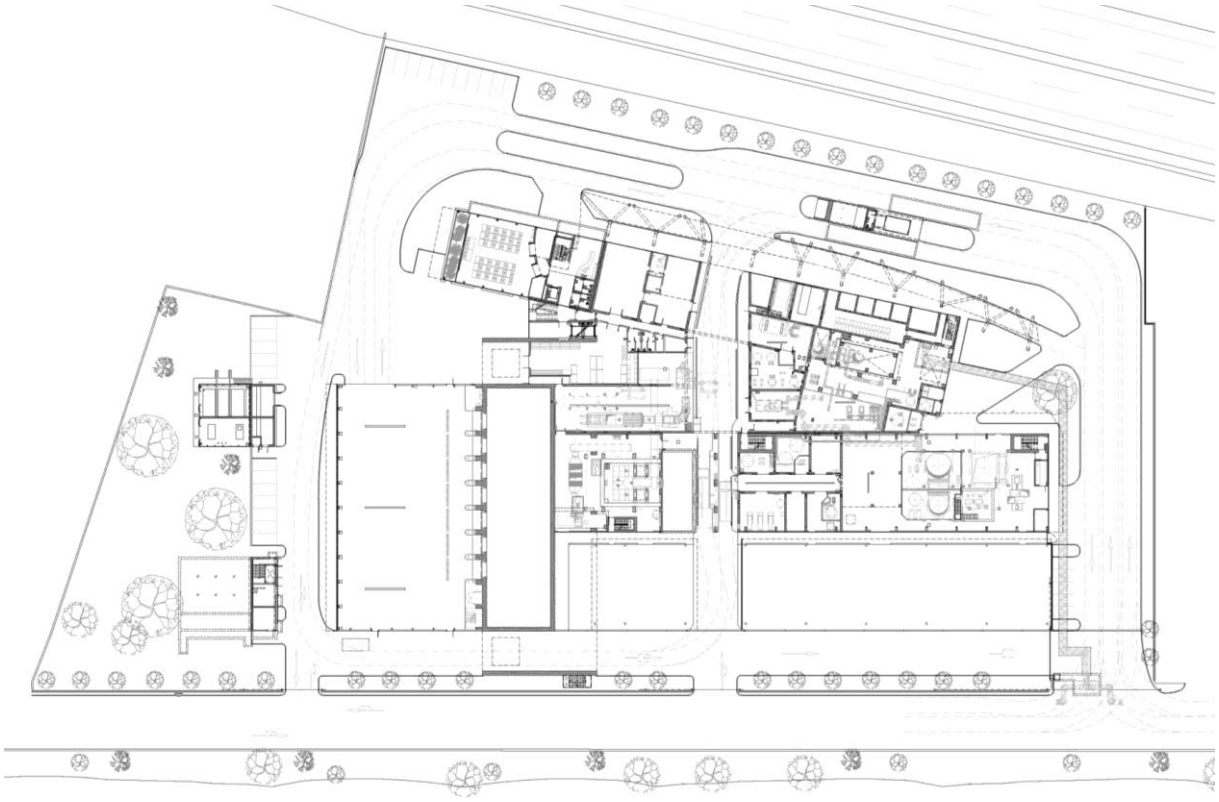


Fig. 36. Waste incineration plant in Bolzano – plan.

Source: https://www.archdaily.com/506227/bozen-waste-to-energy-plant-cl-and-aa-architects?ad_medium=gallery [accessed: 11.2020]

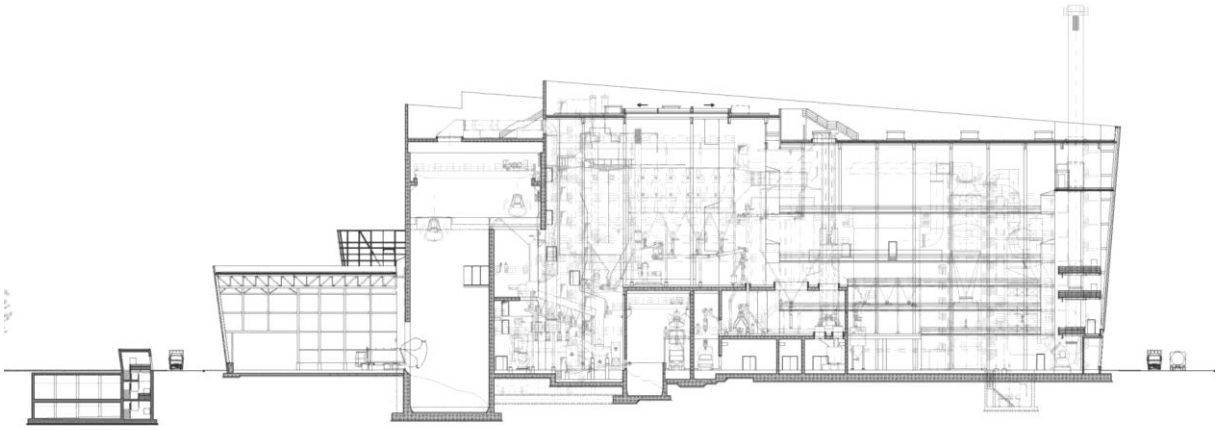


Fig. 37. Waste incineration plant in Bolzano – section.

Source: https://www.archdaily.com/506227/bozen-waste-to-energy-plant-cl-and-aa-architects?ad_medium=gallery [accessed: 11.2020]

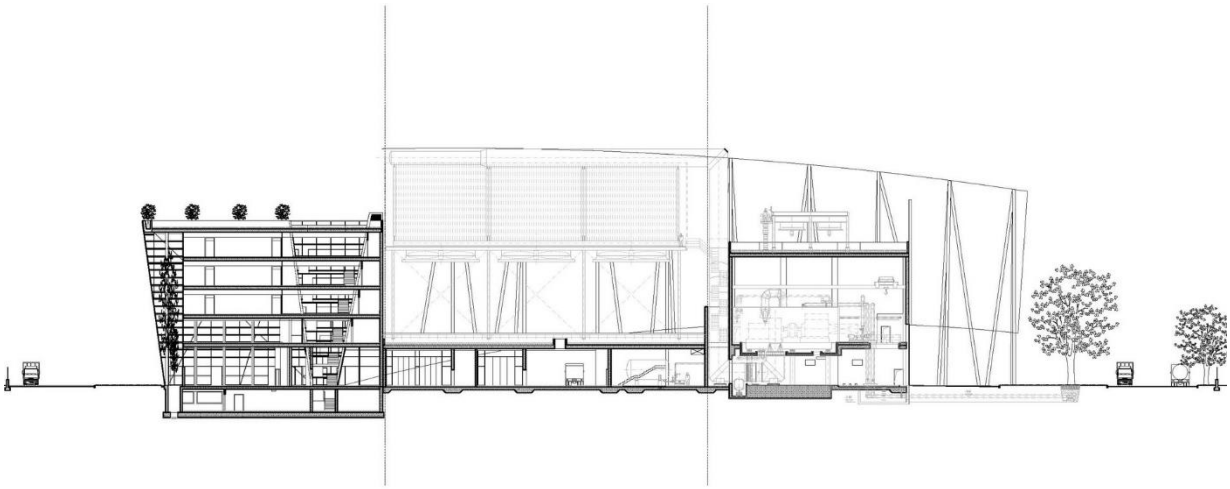


Fig. 38. Waste incineration plant in Bolzano – section.
Source: https://www.archdaily.com/506227/bozen-waste-to-energy-plant-cl-and-aa-architects?ad_medium=gallery [accessed: 11.2020]

TECHNOLOGY:

The process is similar to the previously described examples. After weighing, the waste is transported to the unloading area and then to the bunker, mixed, utilizing two overhead cranes with grab buckets. The process consists of a single incineration line consisting essentially of a waste incineration furnace and an energy recovery boiler. Combustion gases are treated in a purge line. The thermal energy released during combustion is amplified and converted into electricity. The electricity is then sold to the public grid after self-consumption. Thermal energy is also produced, which is then supplied to the city as district heating.

Fig. 39. Waste incineration plant in Bolzano.

Source: https://www.designboom.com/architecture/new-waste-to-energy-plant-in-bozen-by-claa-architects/ [access 11.2020]

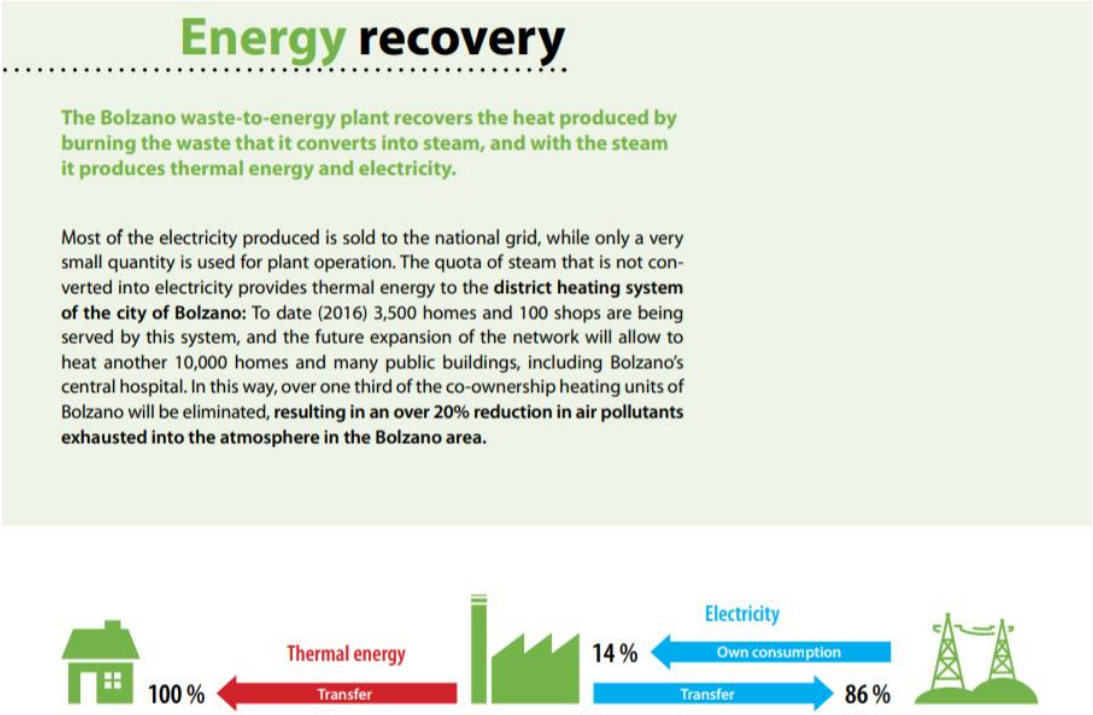


Fig. 40. Waste incineration plant in Bolzano – information leaflet.

Source: https://www.venicesymposium.it/public/documents/brochures/brochuretvaeng.pdf [accessed: 11.2020]

5. ANALYSIS OF STUDY CASES

All of the examples presented above have many similarities, even if they are different at first sight. Waste to energy plant is a specific building, which requires many essential functions inside and outside. Besides the technology part, we also need social areas for workers, administrative buildings, and space for visitors' educational paths. It can even be some commercial space or other attraction as a landmark in the city.

5.1 Location

Incineration plants need to have a specific location. When it comes to distance from the city center, the examples presented above were different. In Copenhagen, the power plant is located in the city, close to the center in the harbor area. In Krakow, it is also in an industrial area, not that far from the city center. In Bolzano, the building is located instead on the outskirts, but the surrounding landscape makes it unique. In Dublin, the area is similar to Copenhagen, but the city center is further away. Basing on this, we can see that location is essential – mostly near the city; it can be even close to the center. It should also be noted that the city heating and electricity network must be connected to the WTE plant, main roads. Land should be relatively flat with good connections from other parts of the city. It should be considered that the big cars like garbage truck could quickly move. Also, a parking space is needed. The car road connections inside the area should be designed carefully. It is okay if there are other environmental possibilities to get eco-energy, such as wind or sun. Industrial areas are the most popular location.

5.2 Form and function

The main design goal in WTE projects is to combine technology and its necessary elements with an exact, functional architecture form. As the examples above show, form, and function determine the building's shape and create different feelings and visual sensations. It can be logical, compact, obvious in reception. However, on the other hand, it can hide its real purpose under the outer "shell," as it is, for example, in Copenhagen – the external skin of the building is the result of the additional function (ski slope on the roof). It consequently determines the structure and form.

In Krakow, the inspiration was taken from the local nature – fields and their shape and color. The hard, rigid technological part was covered with smooth shapes to mix with the local environment. Of course, all necessary technical elements have been carefully designed to integrate the form with function.

There is also a reference to nature in Bolzano, but in some other way than in previous examples. The form is industrial, with glass and steel elements mixed with a green façade. It creates a specific climate, especially when the project needs to face the great mountain and river landscape with the highway infrastructure nearby.

Dublin WTE plant designers focus on a simple form, plain packaging, put into an industrial landscape. Architects said: "The façade is divided into a heavy base, which serves as the building's foundation and anchor, and a light metallic screen, which is folded around the technical facility, like a membrane protecting the building from the elements."[10]

Frank Lloyd Wright said: "form and function are one" – but looking at the examples above, it is not always visible at first sight. These days we can rather say that the form can follow function – the purpose of the building could determine its form. However, the final shape also depends on many different factors, especially ecological ones. As we can see, the waste incinerator can also be a ski slope, but two functions determined the shape of the building even in these cases.

5.3 Plan and structure

Usually, the layout is based on one block or set of blocks covered by a surface. The basic scheme can be divided into a technological part, an office and administrative part, and apart for visitors. The communication service of the entire complex plays a key role. An exemplary spatial scheme of the incineration plant can be presented using zones. Referring to the figure above in the technological part, there are waste delivery and storage, combustion and boiler, flue gas treatment, energy recovery, residue handling, and treatment.

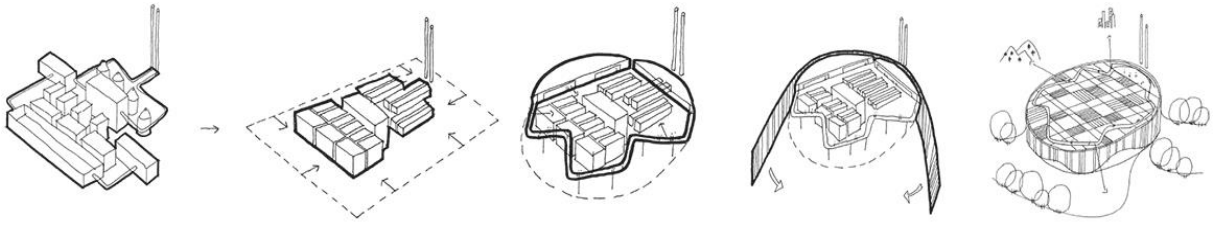


Fig. 41. Waste incineration plant in Shenzhen – conceptual scheme.
Source: https://www.shl.dk/shenzhen-east-waste-to-energy-plant/ [accessed: 11.2020]

[10] *Source: https://friis-moltke.com/architecture/civic/dublin-waste-to-energy/ [accessed: 11.2020]*

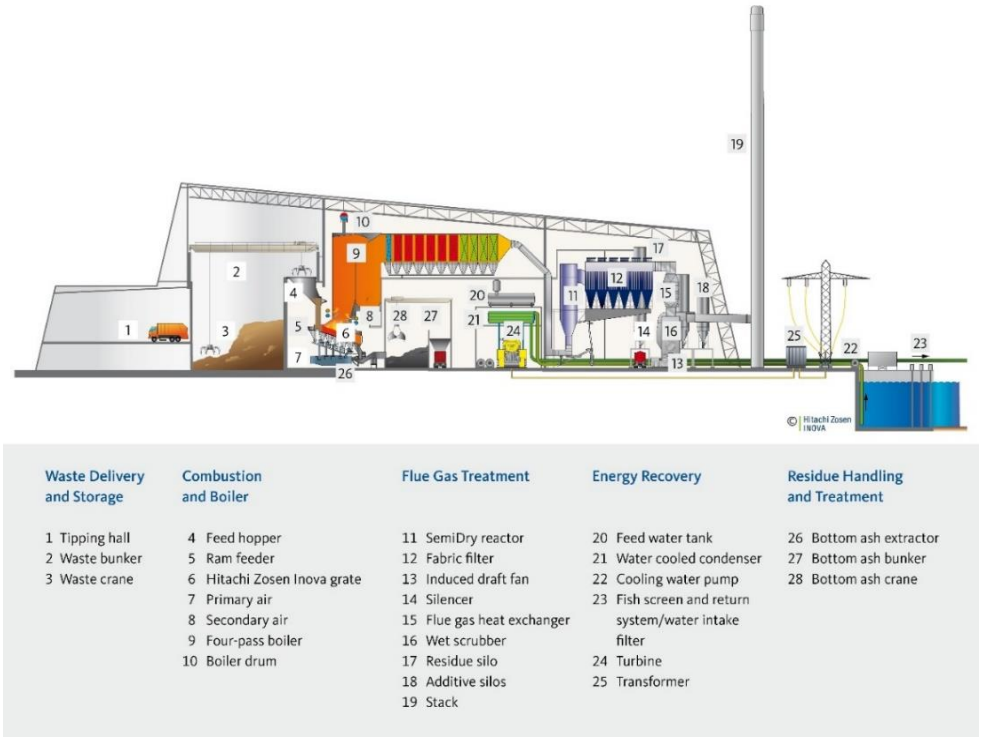


Fig. 42. Waste incineration plant in Dublin– scheme.

Source: http://covanta-csr.com/stories/case-study-dublin-energy-from-waste/ [accessed: 11.2020]

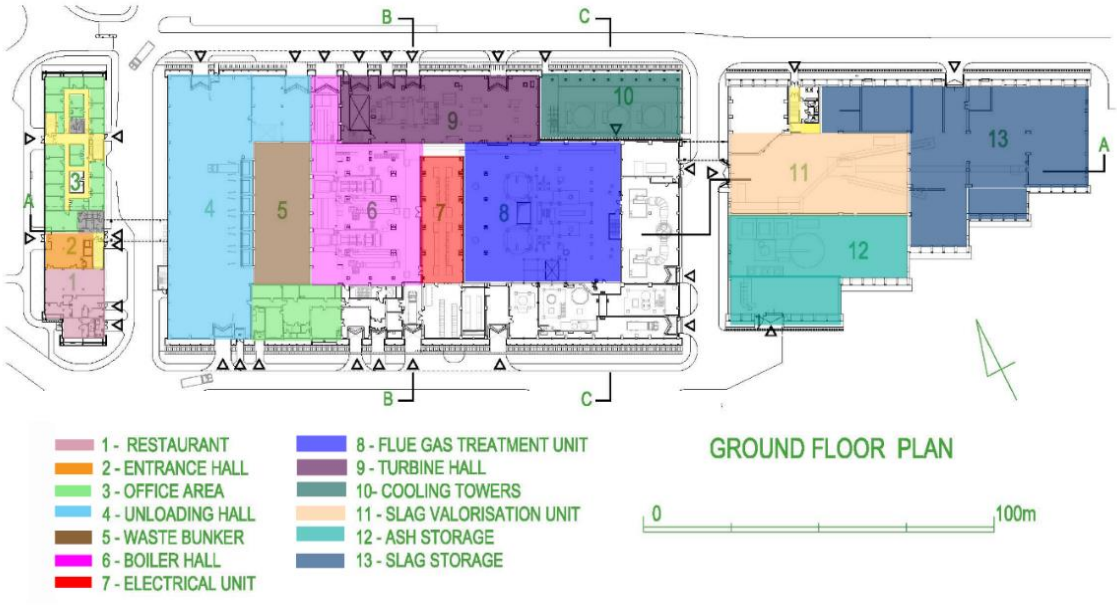


Fig. 43. Waste incineration plant in Krakow – functional scheme.

Source: author's own study.

6. PROJECT LOCATION ANALYSIS

6.1 Władysławowo – short history

The history of Władysławowo goes back to the early Middle Ages. In the 13th-14th centuries, a fishing town called Wielka Wieś was mentioned in the documents. In the years 1546-1676, there was a visible development of the village. At that time, the inhabitants of Wielka Wieś dealt mainly with fishing and agriculture. Over time, the attractive location, picturesque terrain, proximity to the open sea and bays, beaches, and communication values created excellent tourism development conditions. After 2000 tourism in Władysławowo begins to play a vital role. Large holiday homes, modern villas, guesthouses, hotels, and apartments are beginning to grow in the Cetniewo and Hallerowo districts. Bars, cafes, taverns, all kinds of small "boxes" with souvenirs or ice cream, more and more people visit the city – everything creates a specific atmosphere during the summer season.

Fig. 44. Władysławowo – maps from 1931 and 2000.
Source: http://maps.mapywig.org/m/Russian_and_Soviet_maps/series/050K/N-34-37-G_(PUTCIG)_1943_400dpi_amwig.jpg [accessed: 11.2020]

Fig. 45. Władysławowo – bird view.
Source:https://pl.wikipedia.org/wiki/W%C5%82adys%C5%82awowo [accessed: 11.2020]

Fig. 46. Władysławowo – bird view on the sea.
Source: wladyslawowo.info.pl [accessed: 11.2020]

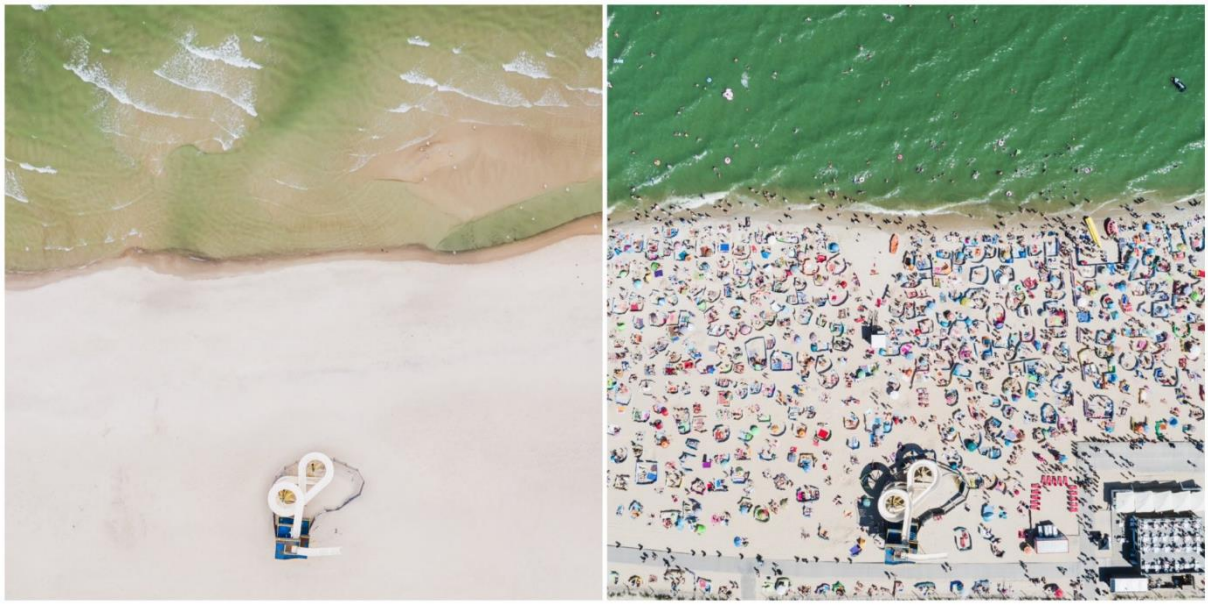


Fig. 47. Władysławowo: winter and summer season; fot. Bałtyk Projekct

Source: https://www.facebook.com/projektbaltyk/photos/905170723254224

Nowadays, the city of Władysławowo is one of the most critical places on the Polish coast. It has an excellent location, situated at the crossroads of Wejcherowo - Hel - Jastrzębia Góra, not far from several other attractive towns. It is a good starting point for cycling and hiking trips. It is a good starting point for cycling and hiking trips. It has a very nice fishing port and beautiful beaches that attract vacationers. The area of the city is 12.6 km² and it has 10 037 people[11]. Administratively, the city is divided into five districts: Cetniewo, Hallerowo, Śródmieście, Szotland, Żwirowa.

[11] *Source: GUS data: https://www.polskawliczbach.pl/Wladyslawowo [accessed: 11.2020]*

6.2 Environmental conditions

6.2.1 Macro scale

The Study of the Conditions and Directions of the Spatial Development of the Commune is a document prepared for the entire commune area, defining in a general way the spatial policy and local development rules.

"The main goal of the development of Władysławowo [...] is to create an ecologically clean space that is open to the world and Europe, which is competitive, innovative and effective. The general assumption and the motive behind the selection of strategic goals is the formation of mechanisms generating economically effective socio-economic development, gradual improvement of the civilization standard of the society, protection and rational shaping of the natural and cultural environment, integrated into the processes of socio-economic development and spatial management, leading to the implementation of eco-development."[12]

The study contains much valuable information; this work tries to consider the provisions of this document. The emphasis on development and the willingness to use modern technologies is the key. Many local values of the environment, economic and tourist potential of the area are highlighted. As threats, among others, illegal landfills or pollution of beaches and coastal areas are listed.

In the document, can also be found that landfills, especially those with an unregulated formal and legal situation, are an essential source of surface and groundwater pollution, soil, air pollution; they eliminate or disturb the aesthetic and landscape values, often occupy agricultural or forest areas, and disturb the topography. Therefore, the phenomenon of the creation of illegal landfills and the presence of private coal-fired boiler houses is a burning problem that requires quick solutions. According to the study, the surroundings of the planned area are designated as an area of particular economic activity and a multifunctional area:

[12] Quote from the Study of the Conditions and Directions of Spatial Development in the Władysławowo City Commune.

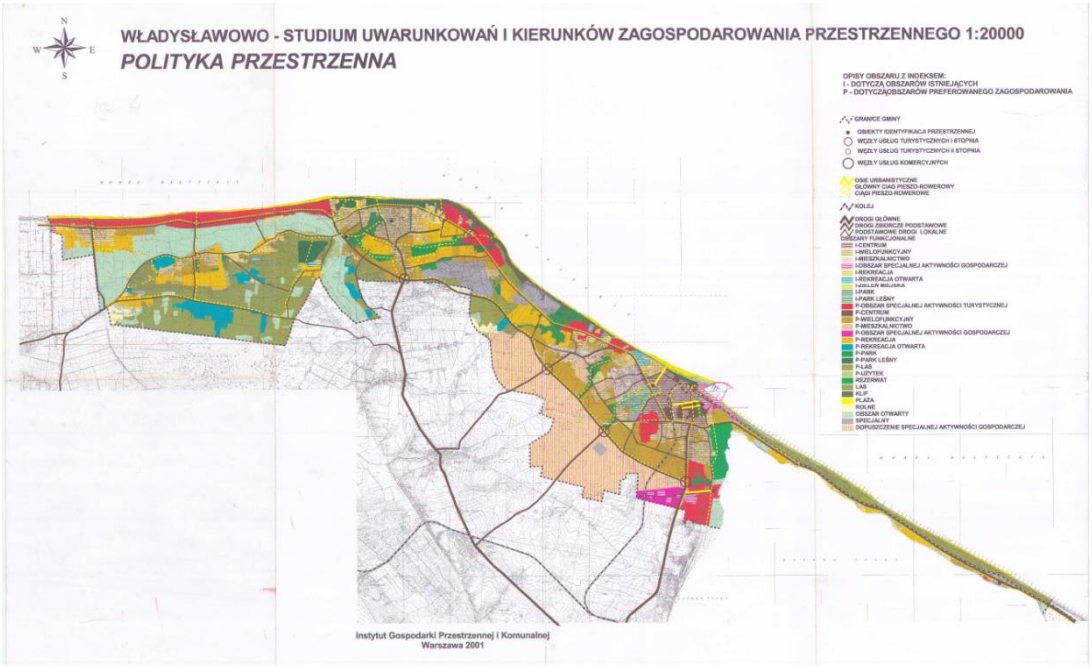


Fig. 48. Study of the Conditions and Directions of Spatial Development of the Władysławowo City Commune

Source: https://bip.wladyslawowo.pl/m,774,studium-zagospodarowania-przestrzennego-miasta-wladyslawowo.html

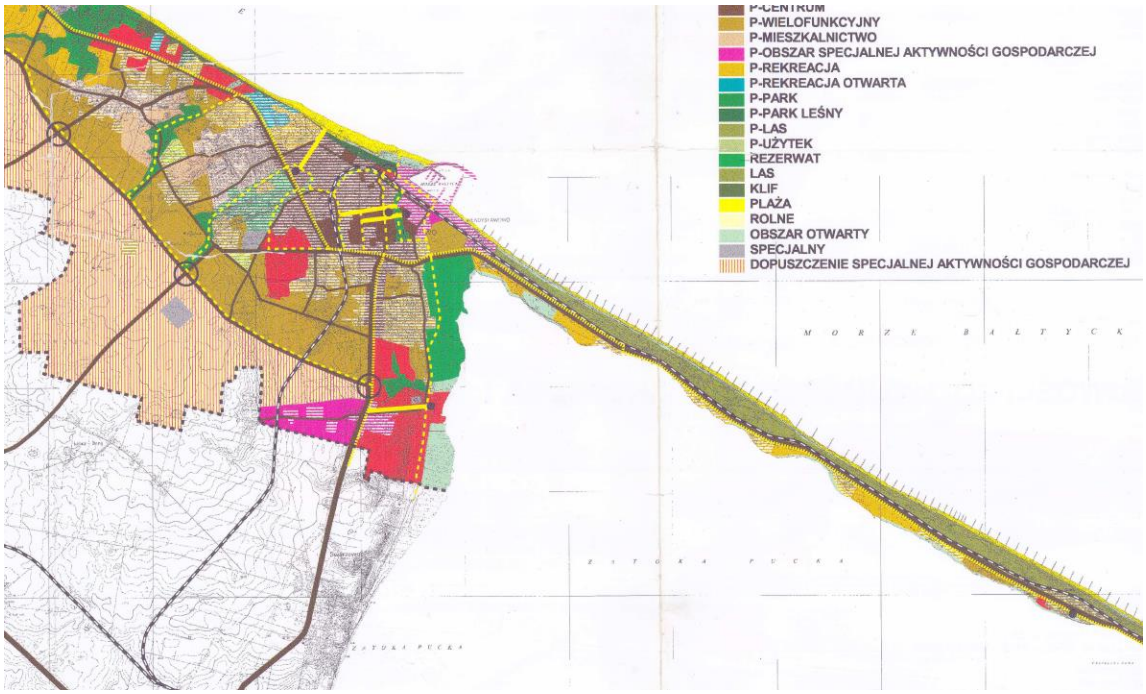


Fig. 49. Zoom: Study of the Conditions and Directions of Spatial Development of the Władysławowo City Commune

Source: https://bip.wladyslawowo.pl/m,774,studium-zagospodarowania-przestrzennego-miasta-wladyslawowo.html

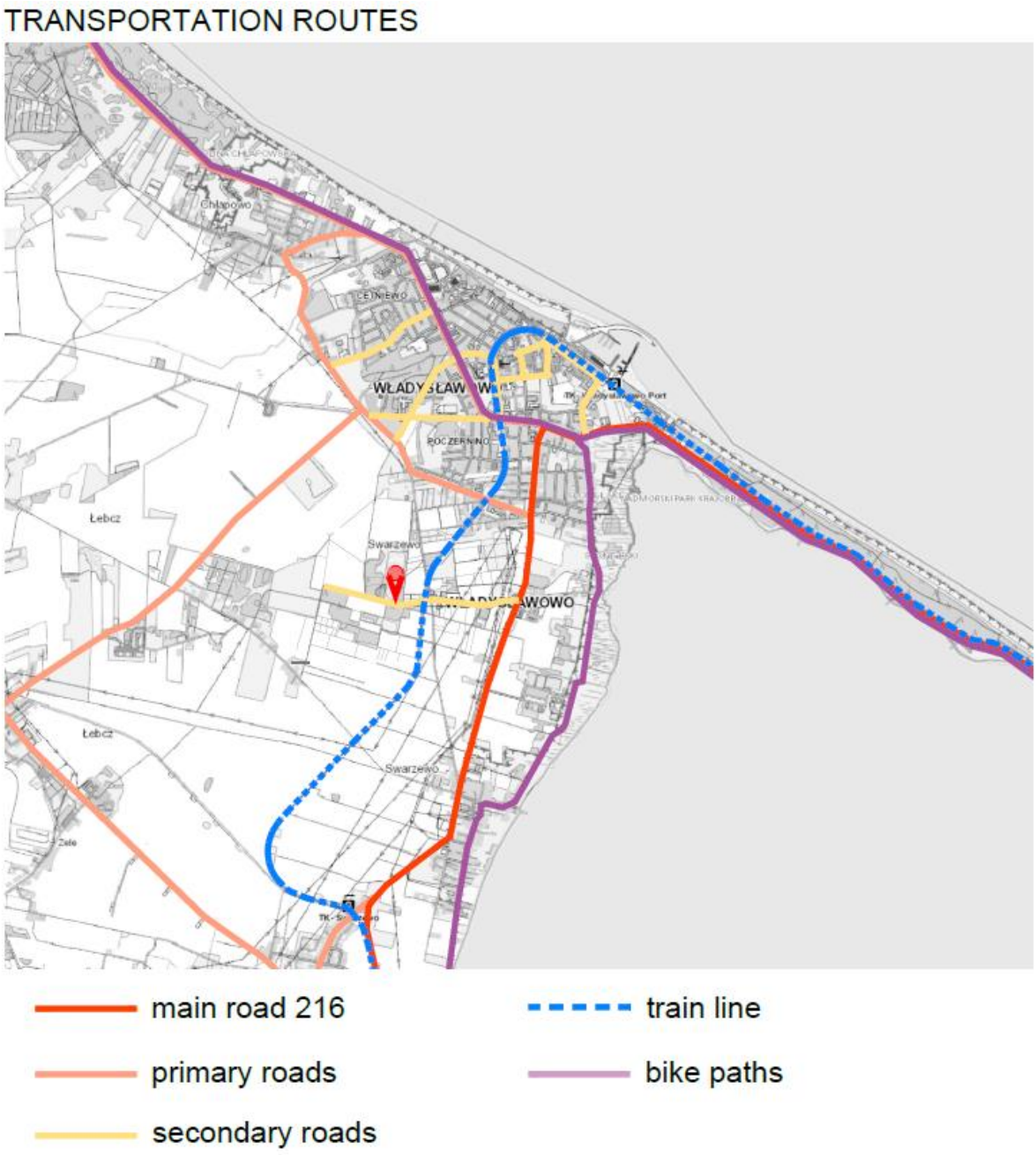


Fig. 50. Transportation routes around Władysławowo.

Source: author's own study

The city is located in the northern part of the Pomeranian Voivodeship, in the Puck poviat, in the Władysławowo commune. The analyzed plot is located between two communes – Puck and Władysławowo, so in this analysis, I would like to look wider. Main road no. 216 is going to Hel through the Władysławowo from Reda (near Tricity). Primary road 215 is going from Władysławowo through Karwia to Krokowa. There is also a possibility of public transport – the PKS buses are going through the 216 and 215 street.

There is two railway station in the city: a "Władysławowo" and "Władysławowo Port"; as well as a bus station and a TAXI stop. There are also a few bike roads. The existing railway line is close to the analyzed area. Therefore there is a possibility of building a station there in the future. This would undoubtedly have a positive impact on the development of the surrounding areas and infrastructure and would also allow for the development of areas around the constantly growing city of Władysławowo. Guiding the city's development in the right direction by the urbanists and city architects would avoid crushing the space with small land plots for tourism purposes (small summer houses and plots like "chocolate bar," as it is going now). It would also allow introducing a business, industrial, and other vital functions in the urban tissue.

Fig. 51. Main roads.
Source: author's own study

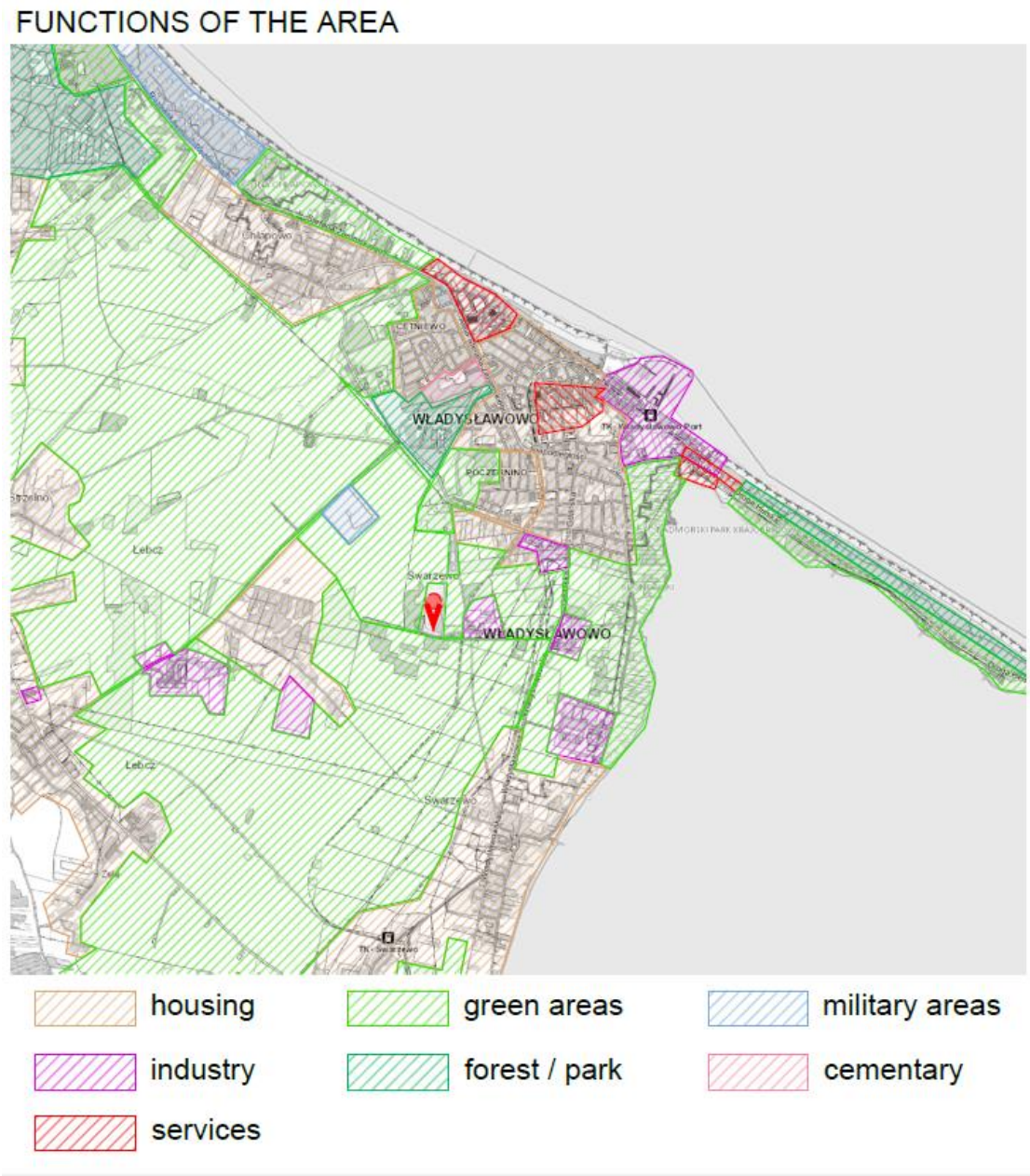


Fig. 52. Functions of the area.

Source: author's own study

In Władysławowo, the city center buildings are relatively uniform and consist mainly of buildings up to four stories high with a service function, mainly a guest house. We can also find their blocks of flats, especially in the Hallera Street area. The buildings in the frontage of the center's main streets have a gastronomic or commercial function, which in the summer is intensified by additional temporary service pavilions. The industrial development is concentrated in the north-eastern part of the city, near the port, related to the fish processing activities and warehouses "Szkuner" and the company "Energobaltic." However, also in the western part of the analyzed area (formally, it is already the Puck commune), we can find such production plants as the "Dr. Oetker" factory or the "Drewex" sawmill.

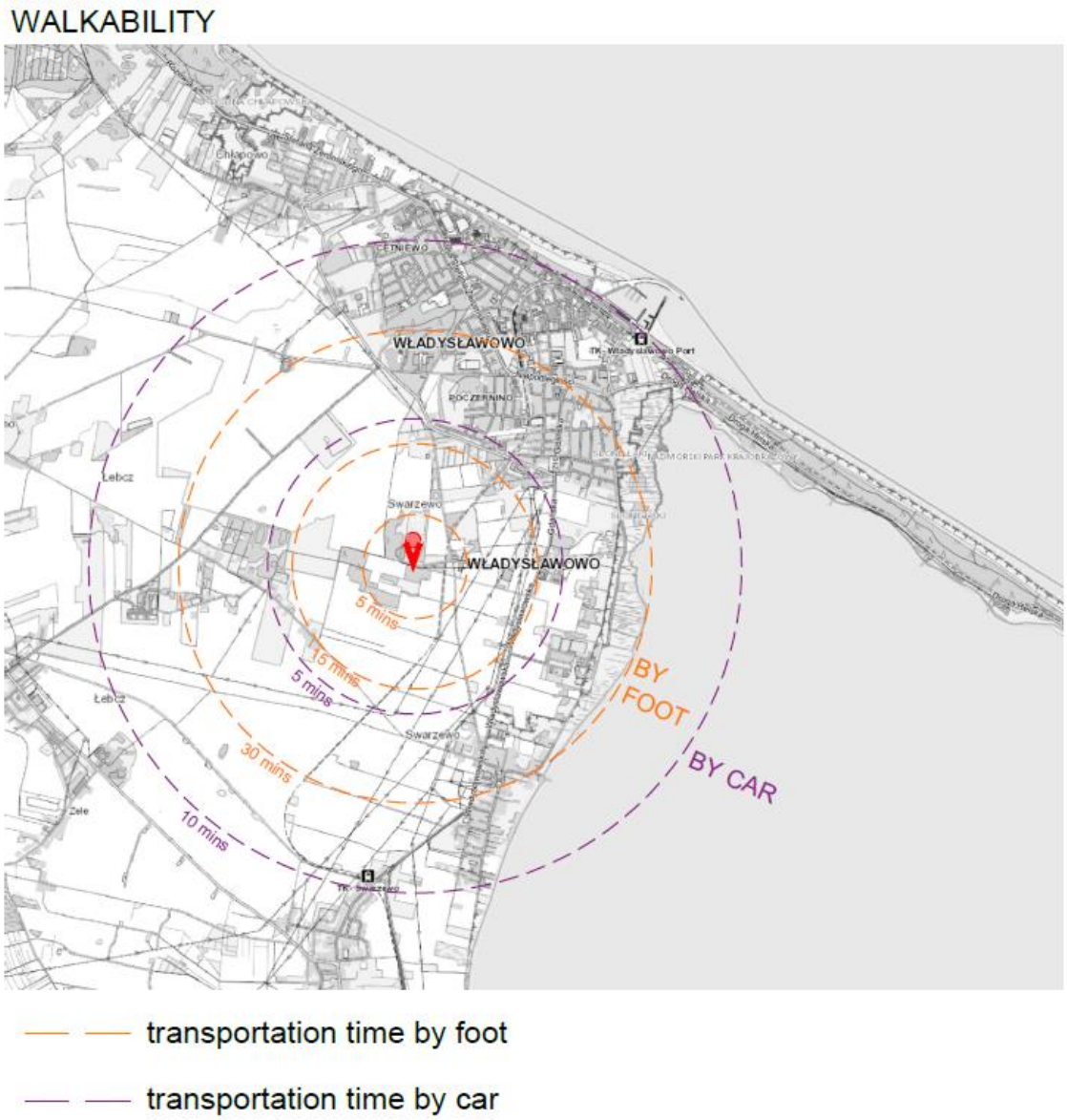


Fig. 53. Neighborhood: walkability.

Source: author's own study

From the analyzed terrain to the center of Władysławowo, there is a possibility to walk on foot for around 30 minutes one way. On the fig. 44 we can see the time walking by foot or going by car from the designed area. From the railway station “Władysławowo” there is around 30 mins by walk and around 6 mins by car from the analyzed plot. The nearest BUS stop, which is on the Gdańska (216) Street, is around 15 mins walking.

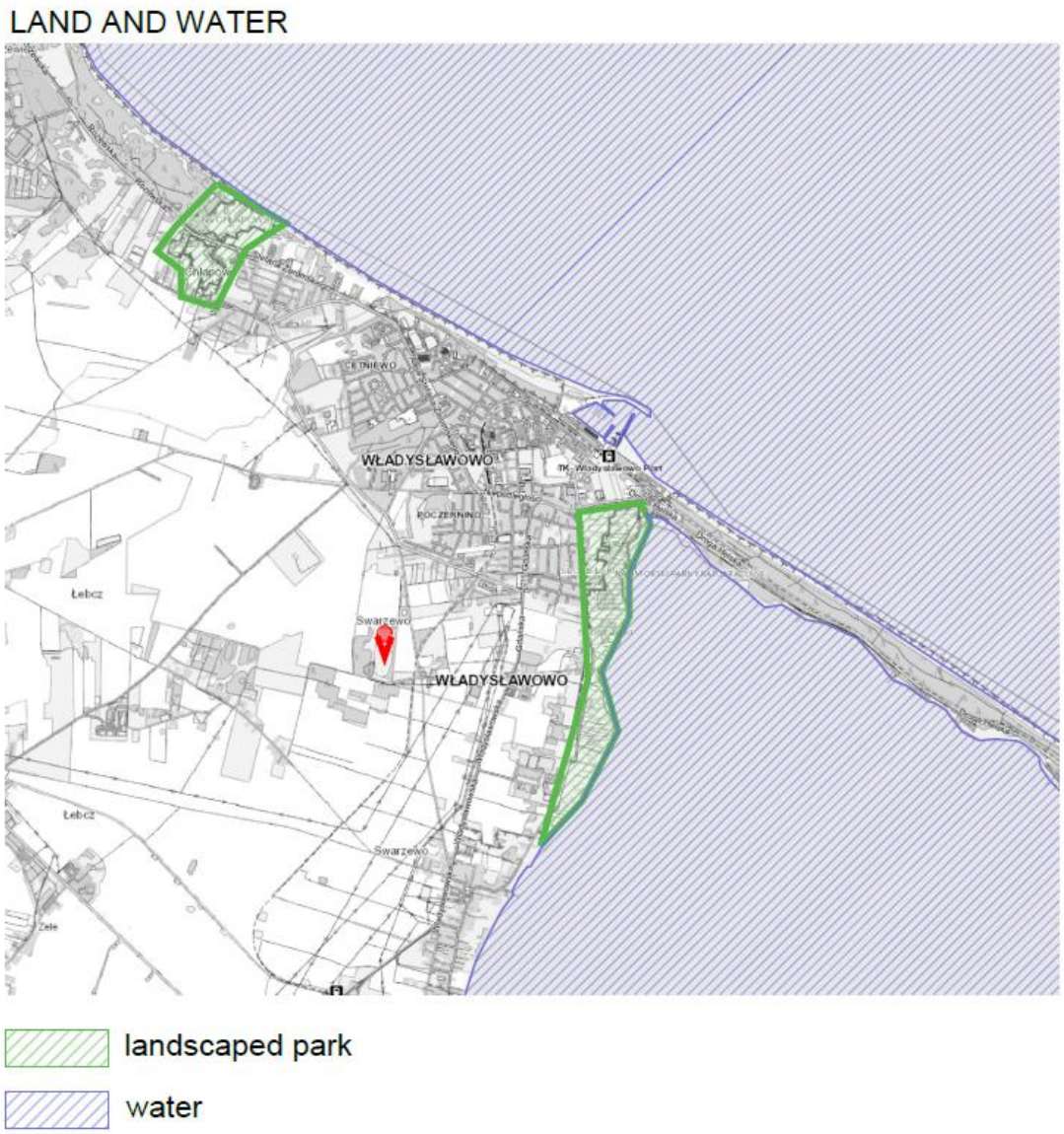


Fig. 54. Lnadscaped parks and water.

Source: author's own study

The plot is located in a place with extraordinary communication potential, but also recreational and natural reference. The waters of the Baltic Sea surrounds the city on both sides. Near the Bay of Puck, on the east side, there is the border of the Coastal Landscape Park with "Słone Łąki" nature reserve; also, on the west side, there is "Przyądek Rozewski" nature reserve. Future investments in the area should be agreed upon and designed to cause damage to the natural environment. There are many restrictions connected to these specific terrains to get permission to build. One of the acts of law is the decision on environmental conditions and it is required for projects that may significantly affect the environment. Before it is issued, an environmental impact assessment is carried out, under which the investor is obliged to prepare a report on the environmental impact of the project. Public consultations are also carried out. The decision on the environmental conditions should be obtained before, among others, getting the building permit.

Fig. 55. Władysławowo: main industry facilities.

Source: author's own study

Several industrial companies are located in Władysławowo. They are mostly connected with the fishing industry – production and manufacture. In the port of Władysławowo, fish processing is carried out, and an ice and fish meal factory and a repair shipyard. Sports yachts and sailboats moor at its quay from May to October. There is one sewage treatment plant and one waste-sorting plant on the outskirts (green color).

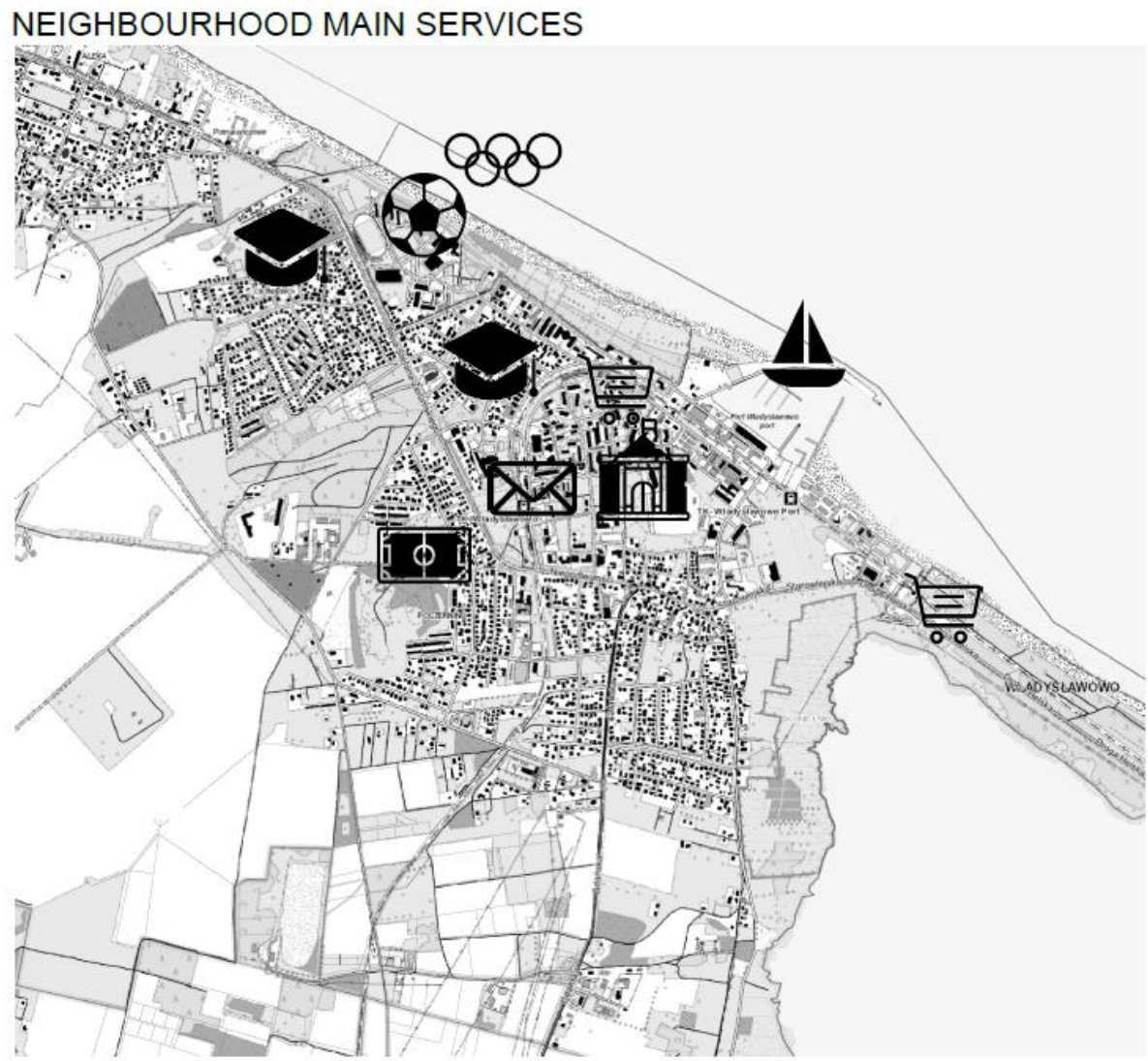


Fig. 56. Władysławowo: main services in the city.

Source: author's own study

There are several characteristic buildings and charming places in Władysławowo; these include the building of the City Hall with a lookout tower (Fisherman's House – Dom Rybaka), the building of the Church of the Assumption of the Blessed Virgin Mary, the building of the Maloves hotel, the Gwiazda Morza hotel, the Central Sports Center complex (Cetniewo), the Avenue of Stars. These are also places that define the city center and set its urban framework.

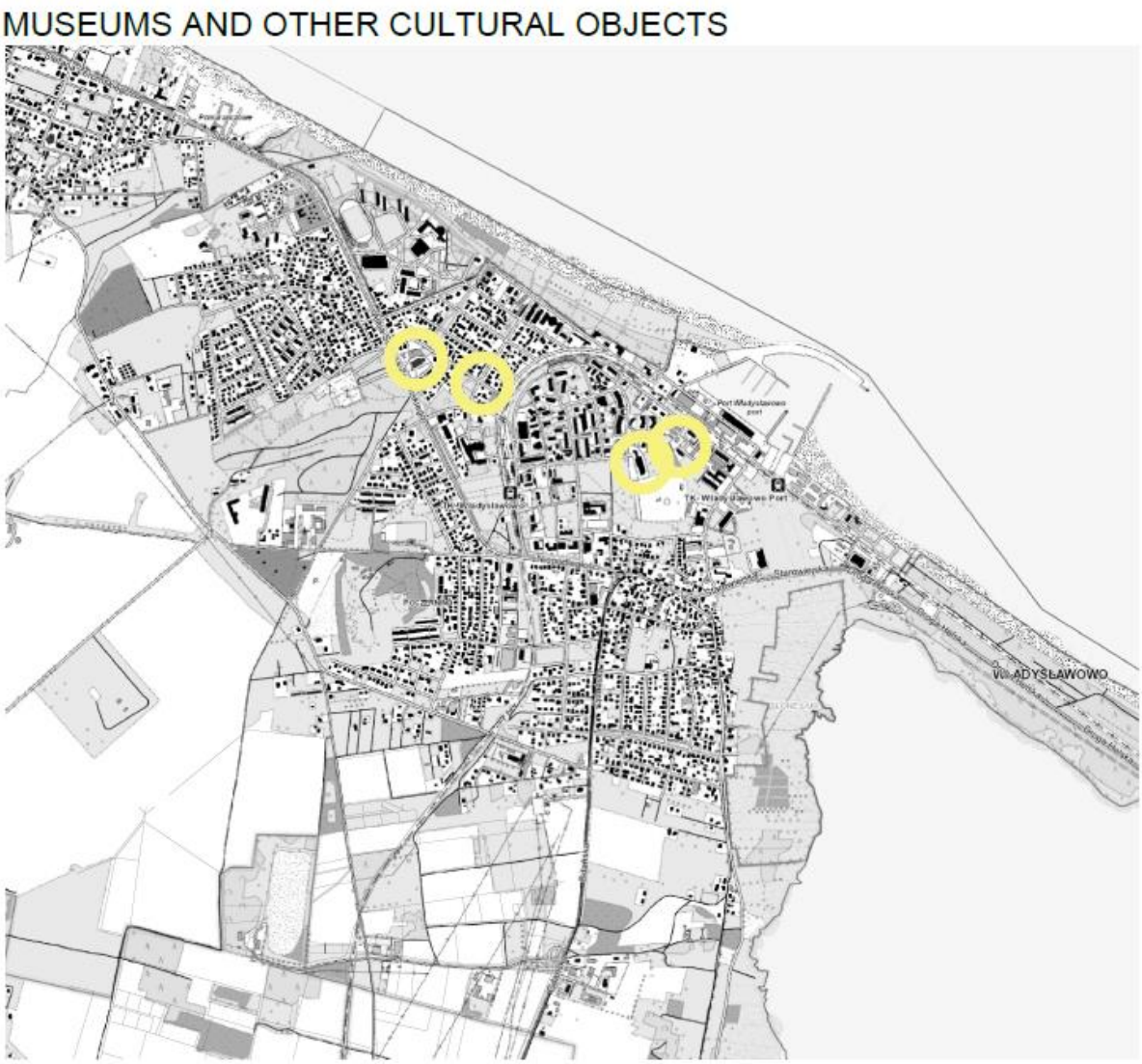


Fig. 57. Władysławowo: main cultural objects.

Source: author's own study

Several cultural events take place in the city every year, mostly in the summer season. Throughout the year, there are only a few places like the Private Butterfly Museum, the Natural Museum of the Coastal Landscape Park, General Haller, and the Blue Army Memorial Center (Hallerówka). Occasionally, there are some cultural events in the building of the City Hall. There is a lack of educational and cultural places that would encourage residents to be more active and social. Now, schools have to organize distant trips to the Tri-City to find the opportunity to participate in enjoyable, practical activities. There is a need for space for workshops, laboratories, and field work for young people and business and co-working places.

Fig. 58. Władysławowo: year-round restaurants.

Source: author's own study

There are only several year-round restaurants in Władysławowo. These are, among others: Skipper Restaurant, Restaurant at Hotel Gwiazda Morza (private – only for hotel guests), Restaurant at the Central Sports Center (only for hotel guests), IKA Bar in the city center, and Swojskie Jadło Inn.

Unfortunately, Władysławowo does not have a wide gastronomic offer outside the summer season. The city is even ahead of the nearby town of Jastrzębia Góra, which, despite its small size (village), offers much more. There is a visible need for places to eat and meet, including business meetings. Władysławowo needs a place that would attract with its culinary offer.

6.2.2 Micro scale

Fig. 59. The plot location.

Source: geoportal.gov.pl & author's own study

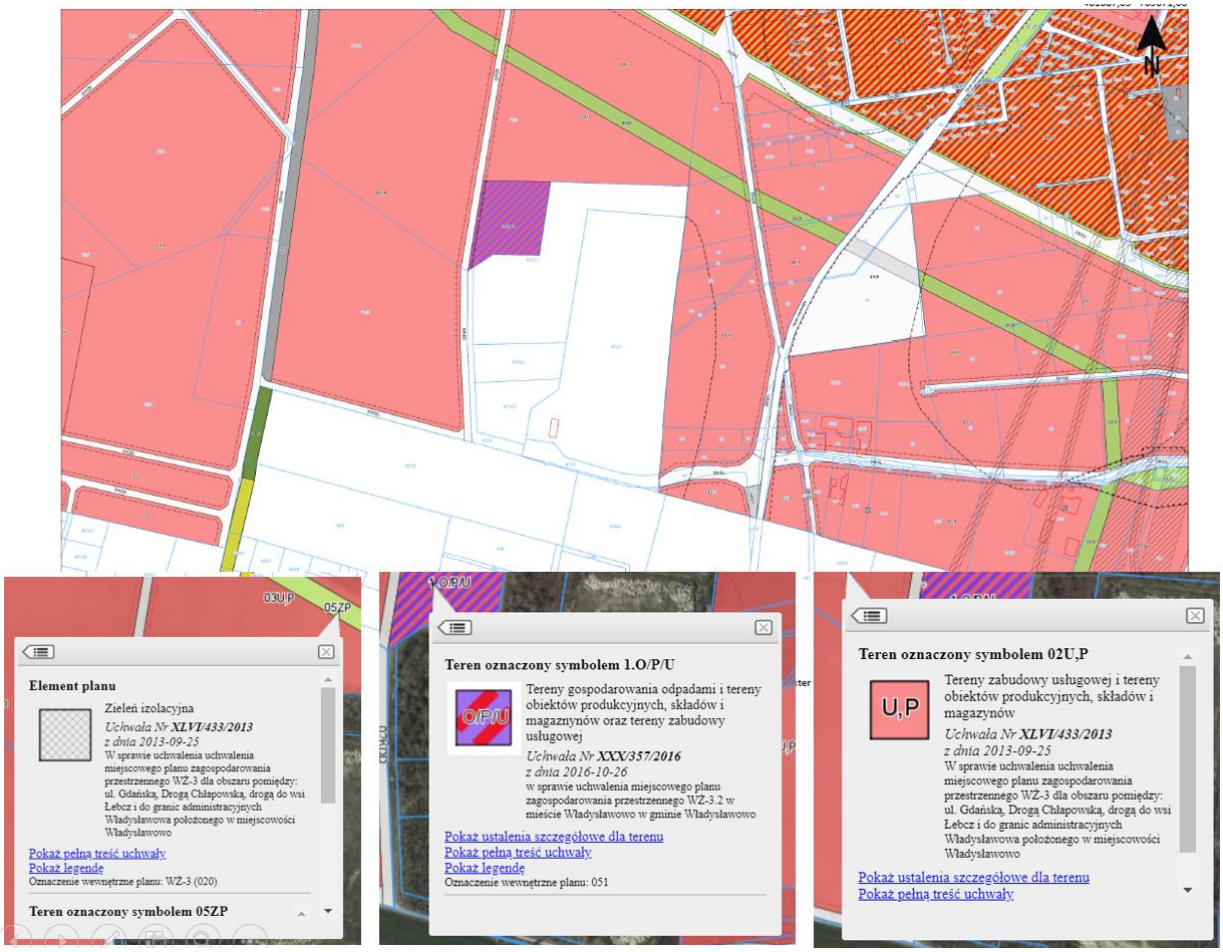


Fig.60. Informations from the local spatial development plan.

Source: BIP Władysławowo & author's own study

The chosen plot has the number 472/3, and its area in the land register is (ha) 8.39. In the local spatial development plan, we can find information about the intended use of the areas around the plot: waste management areas and areas of production facilities, warehouses and storage facilities, and service development areas. There is also a designated protective green belt there. This record was probably made connected with the former landfill and created a barrier between the services and residential areas. The minimum percentage of the biologically active area is 5%, the intensity of development is not specified, the maximum size of the building area concerning the plot area is 40%. The buildings' height is defined as 10 m, with 10% of the area allowed for high-rise buildings, but the height can be determined based on technological needs. Neither the type nor the angle of the roof nor the coverage is specified. It is allowed to re-design the area for communication purposes. There is access to all utilities, such as electricity, water, sewage. Any investment more generous than 50 m height is subject to agreement with the air traffic service. For the waste management function and production facilities, warehouses and warehouses: minimum one (1) parking space for each commenced 500 m2 of usable space, and minimum one (1) parking space per two (2) employees. The area has access to the public roads.

Pedestrian access to the plot can be from the main Gdańska Street, through the Skandynawska Street, but there is also a possibility to walk west, over the gravel road, to the nearby village – Łebcz. These areas are not too much built-up yet; it is possible to plan future development and adapt it to the proposed intention. It is worth noting the path's potential connecting the designed area with the Seaside Landscape Park (in the east). The connection from the northern side leads to the city center through the Cetniewo and Żwirowa district.

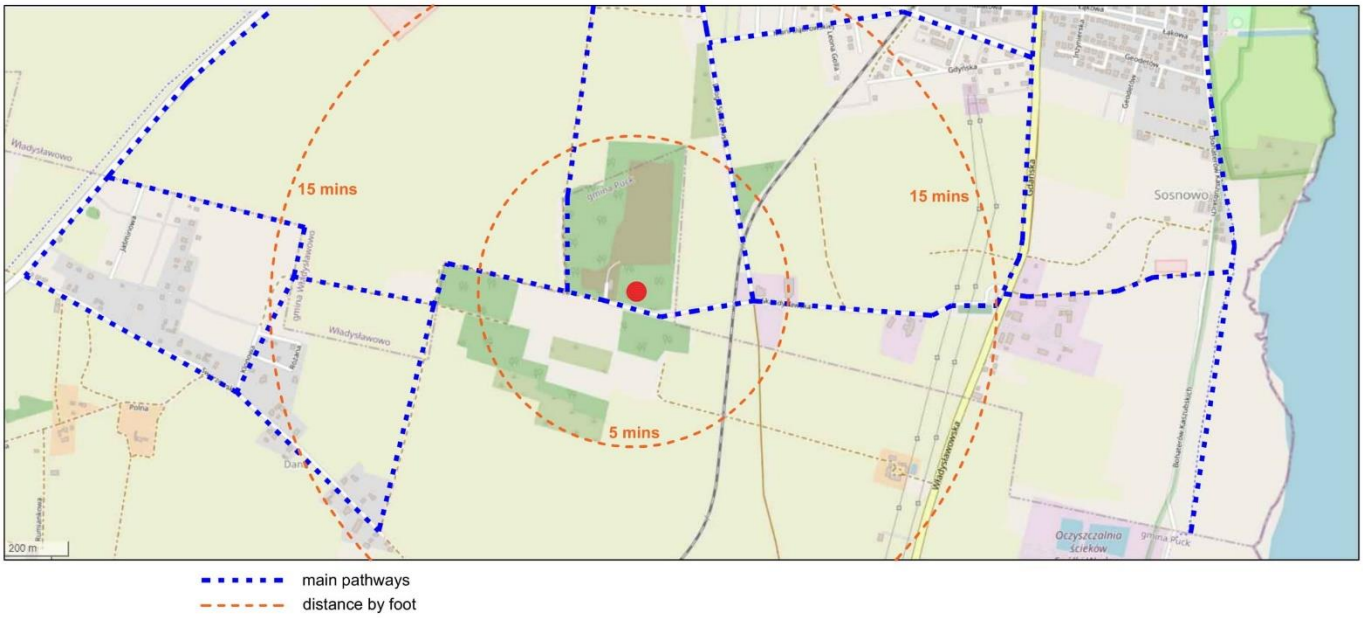


Fig. 61. Walkability of the area.

Source: author's own study

6.3 Existing incineration plants in Poland – map

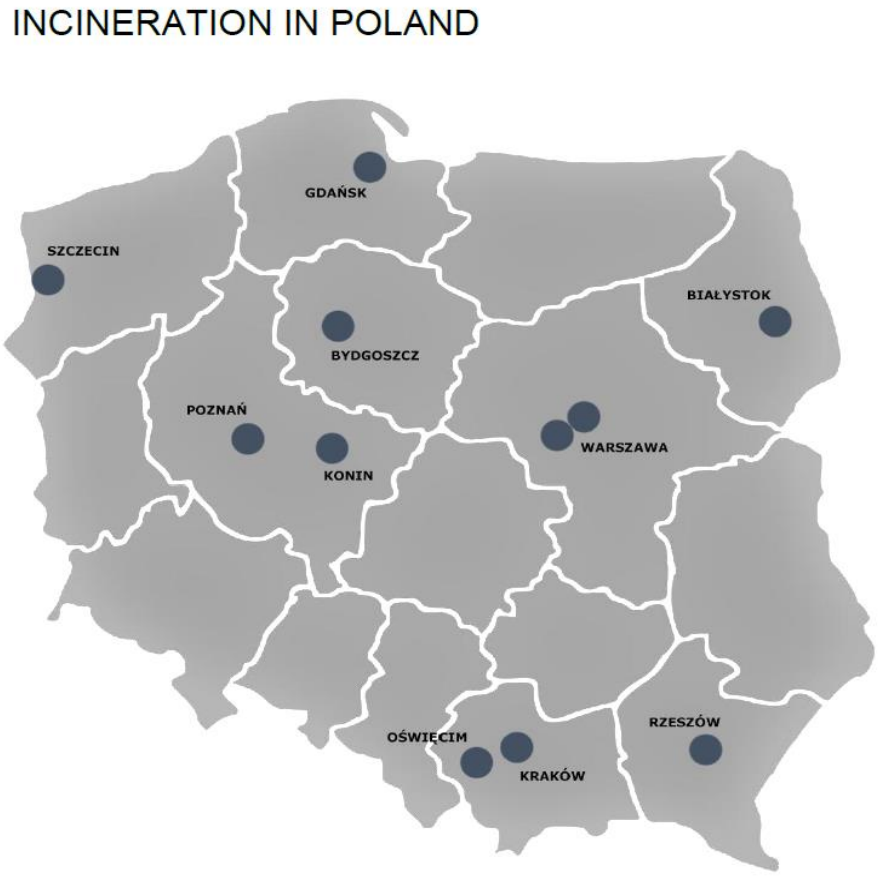


Fig. 62. Incineration: waste-to-energy in Poland.

Source: author's own study

In Poland, nine (9) plants are operating in 2020, another one in Olsztyn is under construction and also investments in Gdańsk and Radom are close to commencement. The first two investments are made with the support of EU funds. The incineration plant in Gdańsk will probably be the last investment supported by EU funds.

In our country, according to various estimates, there are currently between 20 and 27 million tons of the so-called the caloric fraction of waste[13]. This waste is not recyclable and can only be thermally processed (incinerated in incineration plants[14]). However, the energy fraction of waste cannot be deposited in landfills (as stated in the regulation of the Polish law from 2015), although most landfills have received high-calorific waste since 2013, when the waste management system in Poland changed. Since then, the

[13] *Source: https://portalkomunalny.pl/spalarnia-w-kazdym-wojewodztwie-miliony-ton-odpadow-czekaja-396769/2/?amp=1 [accessed: 11.2020]*

[14] *Source: Rozporządzenie Ministra Gospodarki z dnia 16 lipca 2015 r. w sprawie dopuszczania odpadów do składowania na składowiskach http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20150001277 [accessed: 11.2020]*

prices for its receipt were too high or there were no companies willing to process the energy fraction. Another problem was that, according to the law, waste could only be managed within the voivodeship.

Unfortunately, where high-calorie waste was left, the way to "manage" it turned out to be "self-ignition" and waste fires. The problem of undeveloped calorific waste is growing. Illegal landfills will continue to burn if we do not have places to process the high-calorie fraction. EU requirements set more generous limits on the amount of landfilled waste ever, so solutions that can help manage waste from landfills should be implemented. Opponents of the incinerator claim that the incinerator emits harmful compounds into the atmosphere, while supporters of the installation emphasize that the emission requirements are stricter than in the case of many already operating facilities, such as coal-fired power plants.[15]

[15] *Source: https://www.google.com/amp/s/forsal.pl/artykuly/1476346,spalarnie-smieci-wracaja-do-lask-nawet-100-takich-inwestycji-czeka-na-rozpatrzenie.html.amp [accessed: 11.2020]*

7. CONCEPT PROPOSAL

7.1 Design idea

The design aims to solve the problem of an increasing amount of waste, change the system of waste management, energy, and resource saving and change the “incineration” stereotype by implementing the building's different function.

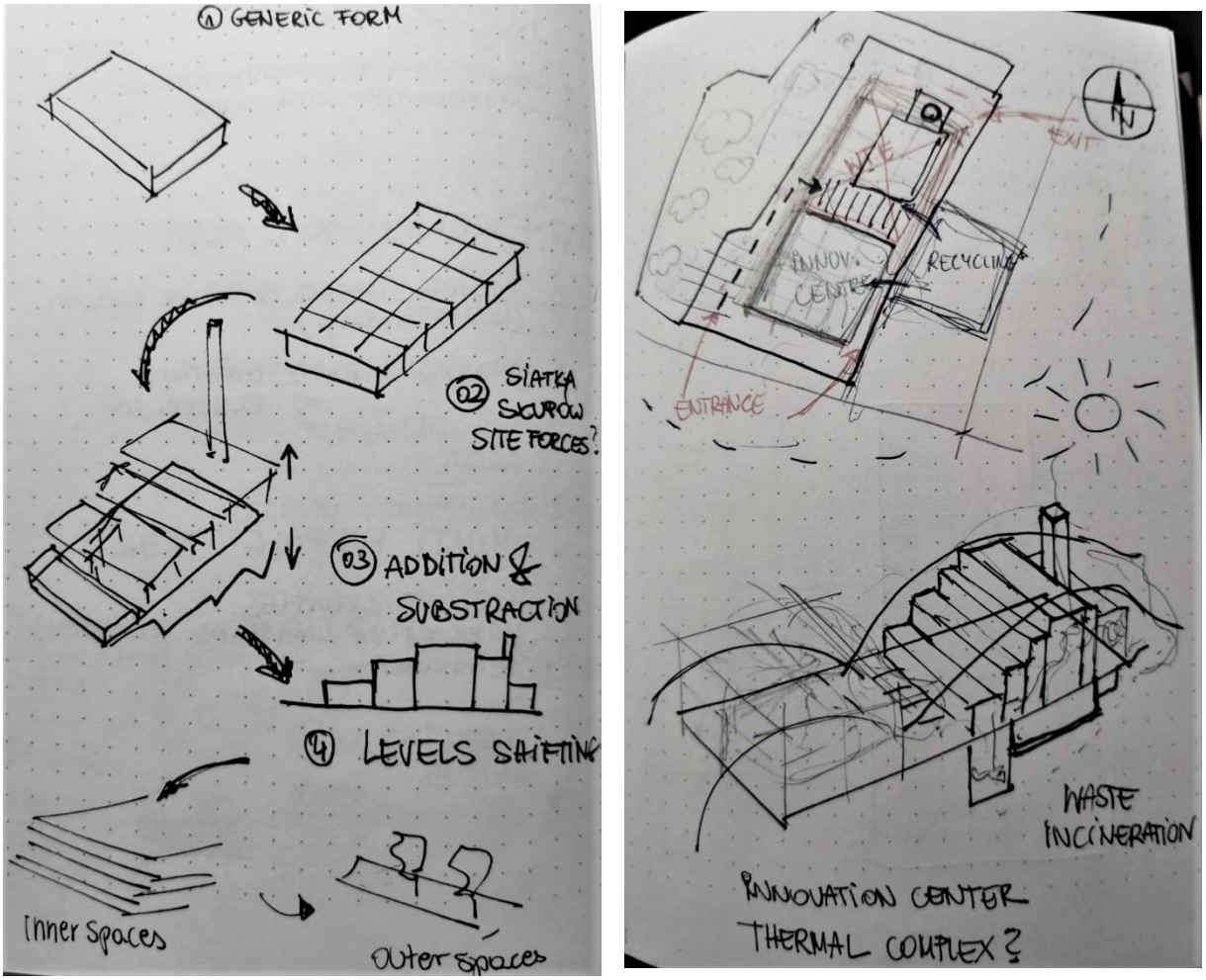


Fig. 63. Sketches – form.

Source: author's own study

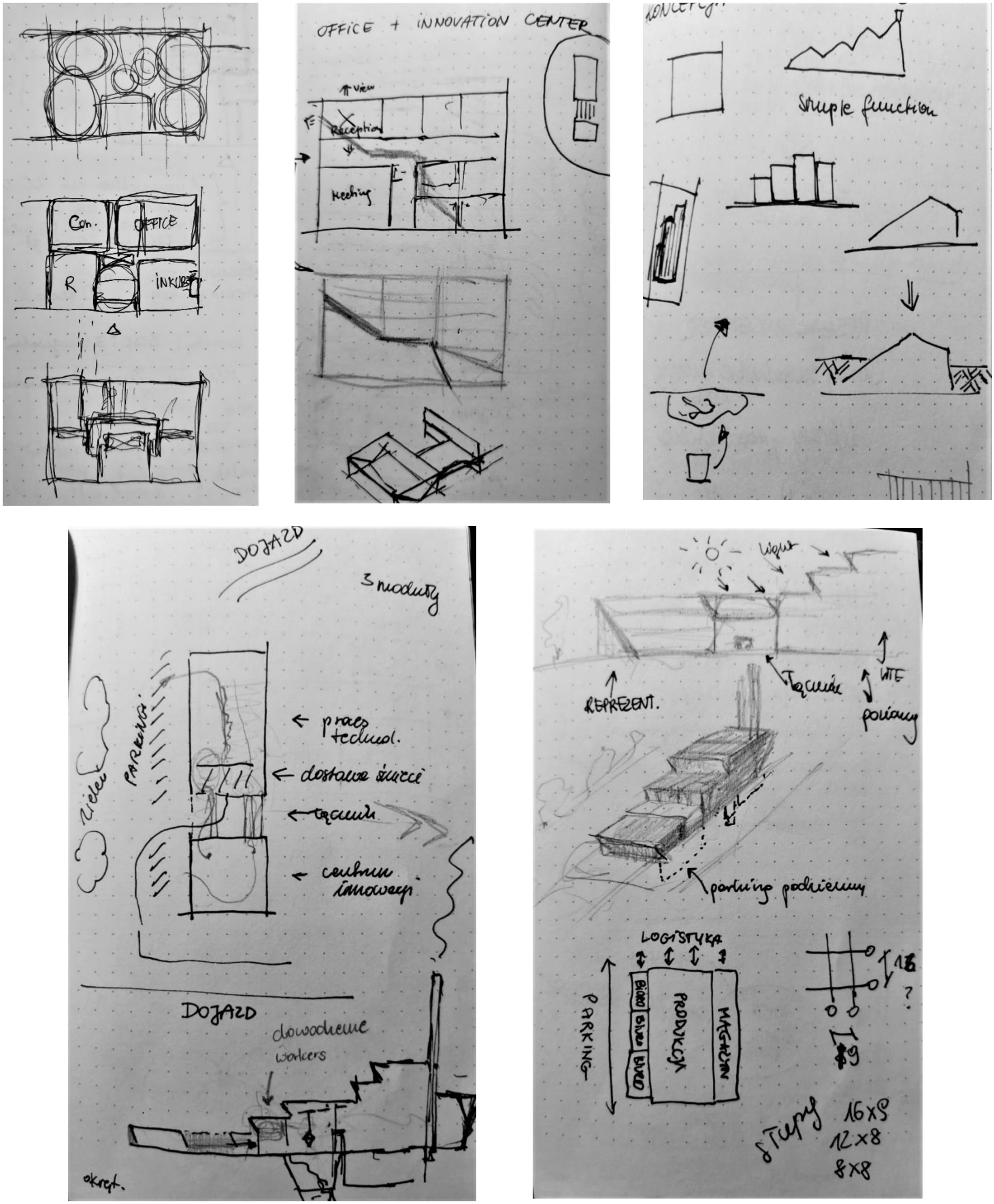


Fig. 64. Sketches – form.

Source: author's own study

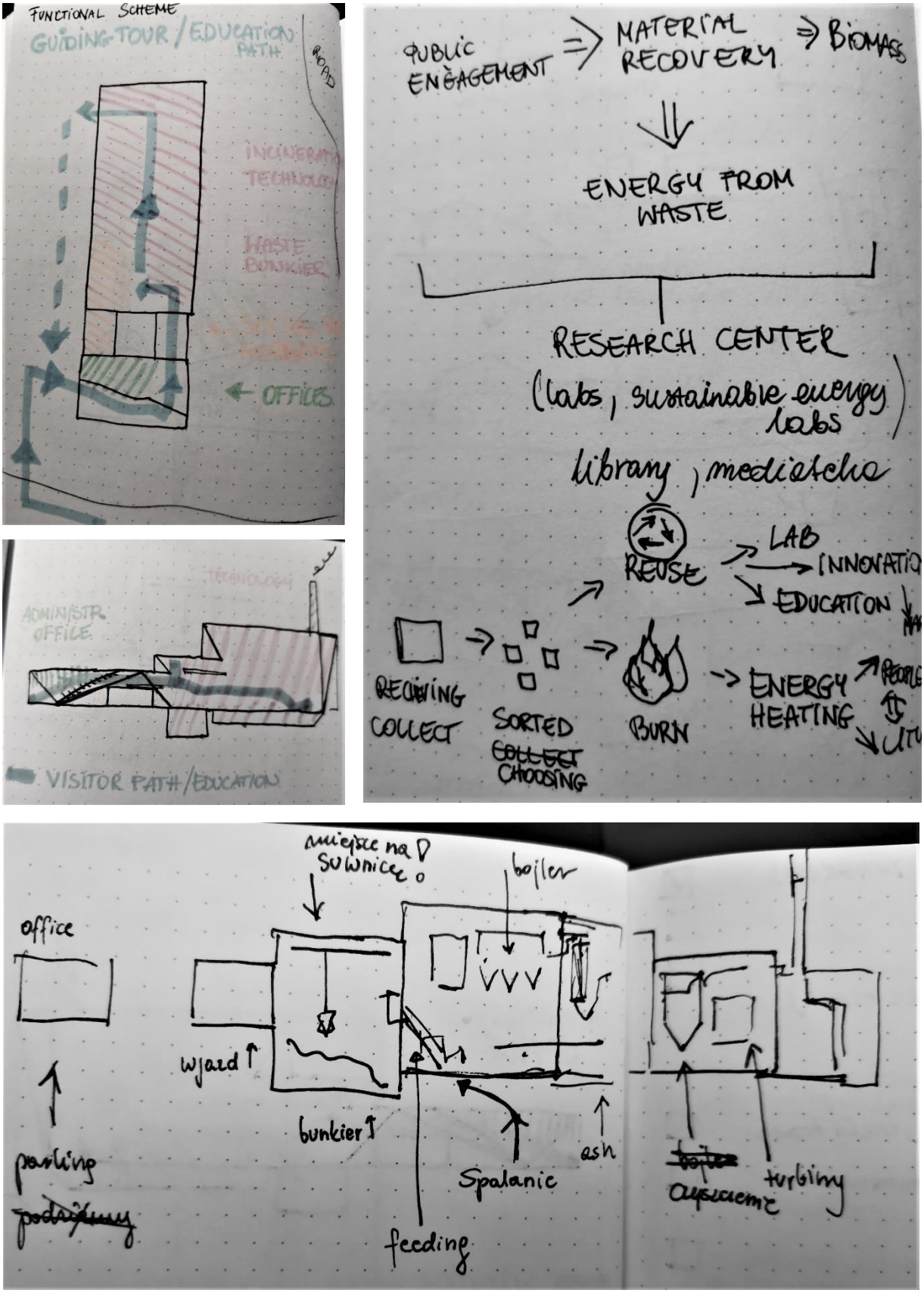


Fig. 65. Sketches – function.

Source: author's own study

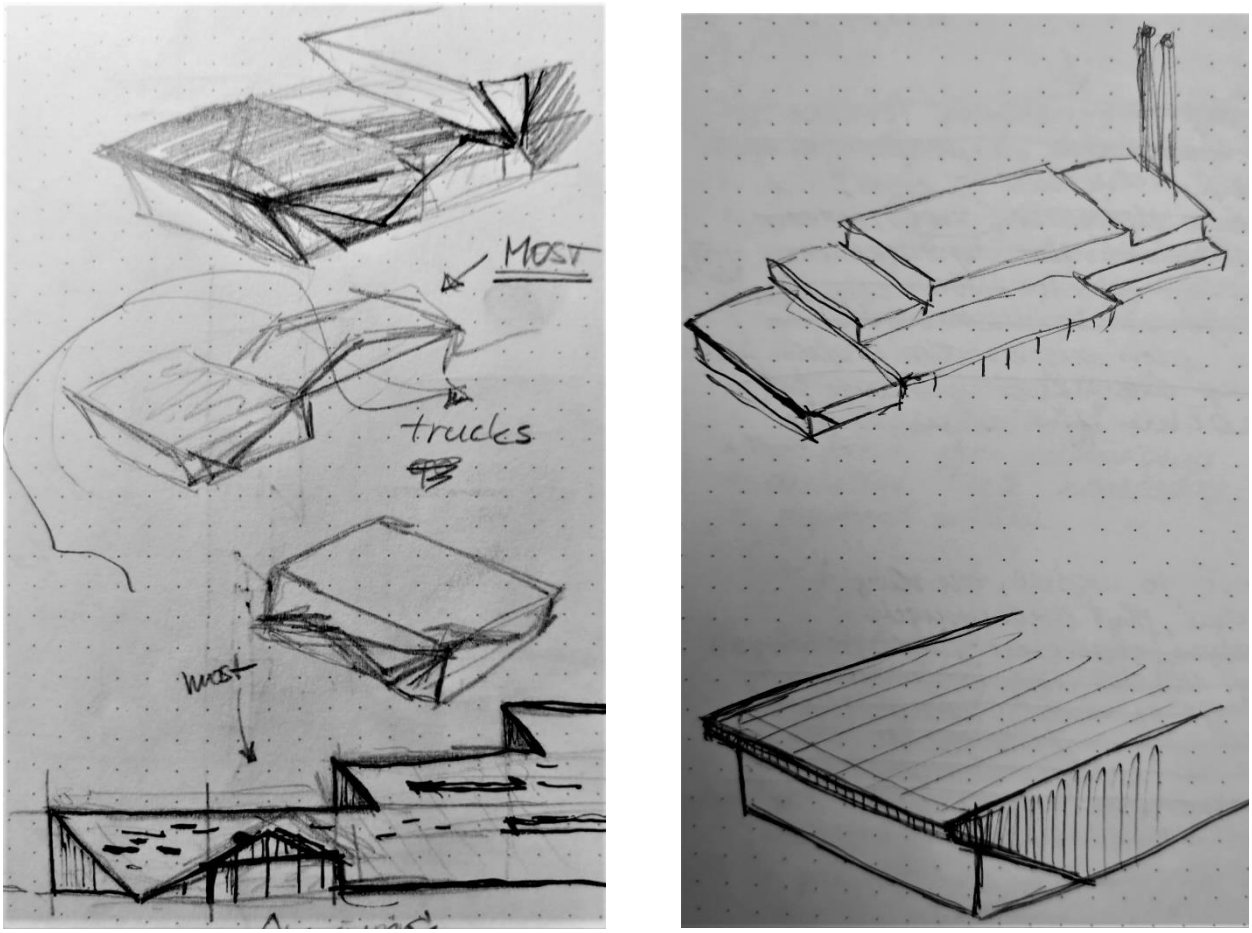


Fig. 66. Sketches – shape.

Source: author's own study

7.2 Concept

The developed area is located in Łebcz near Władysławowo city. It is a big, around 8 ha, site of the former landfill. It is currently undergoing reclamation, which aims to restore degraded areas to new functional and natural values. The plot has an entrance from the southern side, from Skandynawska street. For this project, two main entrances were designed – one for cars and one for trucks. According to the technical and fire protection conditions, the third – fire exit – was designed with a fire road near the building. Also, a fire tank was designed on the west side of the plot. Parking plots are calculated according to all requirements. There are around 80 parking plots for cars and 10 for trucks. The area is vast, so it was needed to have a giant botanical garden with water and an exterior concert shell with a flat audience in front of the building. The design assumes maintaining a large amount of greenery and plant new spices.

The idea was to design a simple industrial shape – "form follows function" that will be visible from long distance and "fit" into the landscape. Rectangular plan with some steps in the section view creates simple and straightforward divisions and allows sunlight to get into the building. The shape is divided into two main parts: industrial (WTE) part with all machinery and technical equipment and educational part with offices and conference hall. There is a waste bunker in between these parts – a place where the trucks are dropping wastes. It is also visible from the site of the educational (office) part. The plan is based on the grid 16mx16m on the "industrial" part of the building and 12mx12m on the "office" part. The structure system was designed with a steel structure in a truss system and concrete columns and walls. The foundations are on the piles. The height is divided – the office part is single-story, designed with an idea of universal design. On the industrial part – different heights are adapted to a sample technological scheme of the technical part of the waste-to-energy plant (following Dublin's example). The main entrance is located on the southern side of the building. Inside, on the right from the main entrance, there is a canteen restaurant. Near the kitchen backroom, there is a social space for workers and office space for the WTE management. We can also get to the auditorium (conference hall) and the lobby's main exhibition open space. Then there is a straightforward entrance to the exposition area when there is a platform from which it is possible to observe the waste bunker. It should be mentioned that disabled people can see everything clearly from the ground floor thanks to extraordinary, lower glazing. In this area, there are also workshop rooms available for educational presentations and classes. There is an office open space area on the west side of the building, with an independent entrance. The idea is to create a sharing space for groups, teams but also for individual workers. The second part of the whole shape is the incineration and technology line area with all necessary auxiliary space. On the east side, there is a big hangar where the trucks can move to the dropping point and collect ash and other products that will be reuse in other ways.

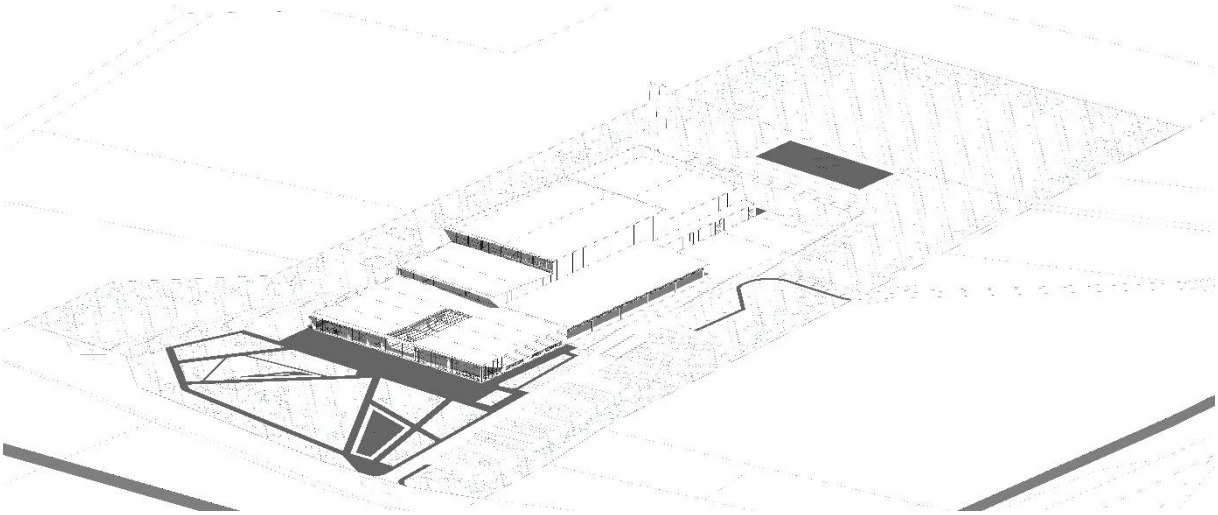


Fig. 67. 3D model of the project.

Source: author's own study

Fig. 67. Visualization of the project.

Source: author's own study

7.3 The way of adjusting the architectural form to the surrounding buildings and landscape

Fig. 68. Dr. Oetker Company, Łebcz, around 3,6 km from the designed area.
Source: *https://www.oetker.pl/pl-pl/kariera/dr-oetker-jako-pracodawca/nasze-siedziby*

Fig. 69. Bowil Biotech Company, Władysławowo, around 800 m from the designed area.
Source: *https://bowil.pl/*

Fig. 70. “Rafa” Fish Processing Company, Władysławowo, around 400 m from the designed area.
Source: *http://www.budmor.pl/portfolio-view/przetworstwo-rybne/*

The buildings in the area are mainly industrial architecture. Cuboidal forms are mainly determined by the functions of a given building. There are both larger complexes, such as the building of the "Dr Oetker" company, which is constantly expanding, but also single blocks such as the building of the "Bowil Biotech" company. The nearest residential buildings are located about 1 km from the planned area.

The designed shape of the building was mainly created from the waste-to-energy function, but its shape also fits and refers to nearby buildings.

8. SUMMARY

We need to take care of our planet and our lives. Waste problems can be solved using new technology systems like waste-to-energy plants. Heating and water recovery can be used to minimize the use of resources. Economic and ecological aspects are connecting. Investments like WTE are more and more common. This kind of industrial buildings can solve the problem of waste production and storage.

9. TECHNICAL DESCRIPTION

9.1 Subject and scope of the study

Object: Waste-to-energy plant

Adress: Skandynawska 21, 84-103 Łebcz, Poland

9.1.1 BASE OF THE STUDY

- The study area is not covered by the Local Spatial Development Plan, therefore it is not one of the guidelines. However, the surrounding areas are covered by such a plan and some needed information has been taken from it,
- photographic documentation of the existing state

9.2 Location

The construction will be carried out on the site of the former landfill plot number 472/3 in Łebcz, next to the seaside town Władysławowo in Pomeranian viovodeship, Poland.

9.3 Land development - the existing state:

9.3.1 INVESTMENT AREA:

The investment area is the unused site of the former landfill in Łebcz. There is one small office building on the south site of area, the rest of the area is unbuilt.

9.3.2 TOPOGRAPHY AND GREENERY:

The area is mostly flat, there is an existing high and low greenery.

9.3.3 COMMUNICATION SYSTEM:

The entrance to the site is from the south, from Skandynawska Street.

9.3.4 NEIGHBORHOOD:

The adjacent plots are undeveloped fields. On the south side, there is a Skandynawska Street. On the north and west side, there are unbuilt plots – fields. On the east side there is existing plot, also field, but there is also a planned road (existing in land development plan).

9.4 Land development - the designed state:

9.4.1 TOPOGRAPHY AND GREENERY:

The area is mostly flat, there is an existing and designed high and low greenery.

9.4.2 COMMUNICATION SYSTEM:

Main entrance to the site will be from the south, from Skandynawska Street. The entrance for trucks will be from the east, the fire road will be located on the south-west side.

9.4.3 NEIGHBOURHOOD:

The adjacent plots are undeveloped fields. On the south side, there is a Skandynawska Street which will be the main entrance road for cars, and also there will be a fire-road exit. On the north and west side, there are unbuilt plots – fields. On the east side there is existing plot, also field, but there is also a planned road (existing in land development plan), so the design provides entrance for trucks from this side, and this new-designed road.

9.5 Purpose, utility program of the objects and their characteristic parameters

9.5.1 PURPOSE OF THE OBJECT

The following facilities are designed in the area of the investment:

- The Waste-to-energy building with science & entertainment center with office, education, exhibition, business parts
- Fire-fighting pumping station building with a water reservoir for fire-fighting purposes
- Two gatehouse buildings (two exits)

In the area of the planned investment there will also be accompanying infrastructure in the form of:

- The designed internal roads and paved squares, including a fire road and two fire entrances
- Projected external installations within the plot: water, sanitary sewage, rainwater drainage, electricity, low-voltage, heating system
- Projected outdoor lighting on building facades
- The designed retention and evaporation reservoir
- The planned fence, including gates and barriers

All installations and technology equipment designed according to a separate study.

9.5.2 FUNCTIONAL UTILITY PROGRAM AND CHARACTERISTIC PARAMETERS

9.5.2.1 The designed waste-to-energy hall consists of two main parts:

- technological part:
    - unloading and storage area (hangar - roofed maneuvering yard, bunker unloading gates, emergency exit doors, communication, separate technical part);
    - the area of the incineration plant and all technology (bunkers, production lines, boilers, furnaces, filters, chimneys, transformers, turbines, etc.)
- exhibition and office part:
    - social and office space intended for service employees along with a cloakroom and a toilet
    - social and office space and facilities for restaurant employees with a cloakroom and a toilet
    - restaurant with facilities
    - an exhibition (open space) and an auditorium and conference rooms
    - office and co-working area
    - public toilets
    - educational and laboratory part

All hygienic and sanitary rooms as toilets, cloakrooms, washrooms, rooms for eating your own meals, cleaning rooms and passageways are designed as easily washable floor surfaces and walls up to a height of 2.2m.

A technical part has also been designed in the WtE hall, which will be separated from the hall by means of walls and a ceiling with an appropriate fire resistance class. These rooms are designed as single-storey rooms without a basement. The following rooms are designed in these parts:

- MV and LV main switchgear room,
- transformer room,
- server room
- warehouse
- technical rooms (tank rooms, bottom ash, etc.)

9.5.2.2 Characteristic parameters of the waste-to-energy plant production and warehouse hall:

- number of overground storeys: One
- number of underground levels: none, only lowering for the bunker
- building area: 11 662.6 m^2,
- averaged height (technological part): 15 m,
- averaged height (office part): 7 m,
- cubic capacity: 117 247,55 m^3,
- height group: medium high (SW).

9.5.2.3 The technological part of WtE:

The technological part is designed based on few examples of waste-to-energy plants from Europe and Poland. This work would is rather about architecture form and could require a separate project for a technology – other industry than architecture. In this case, I assume sample data and solutions, based on project examples from Europe and Poland.

There are two lines of production, the example scheme of operation area is presented below.

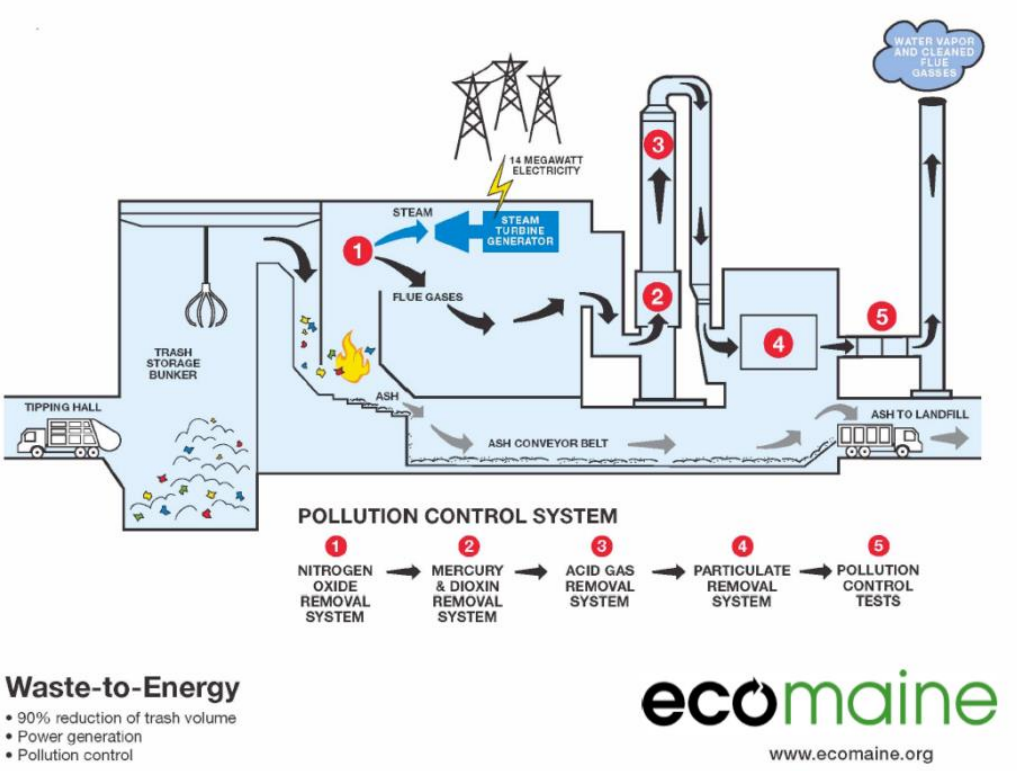


Fig. 71. Incineration: waste-to-energy process scheme.

Source: https://www.ecomaine.org/our-facility/waste-to-energy-plant/

The installation consists of two incineration lines, fed with waste from a waste bunker common for both technological lines. Unsorted municipal waste and other mixed waste will be imported to the installation. The project assume, each of the designed combustion lines has a designed capacity of 10Mg / h, with the reference calorific value of waste at the level of 10,500 kJ / kg.[16]

The imported waste is directed directly to the bunker, and then to the furnace hopper. The waste incineration process under normal operating conditions will not require an additional source of support (fuels, etc.). Energy recovery allows you to generate steam with parameters of about 400 degrees Celsius and 40 bar.[17] The steam energy will be used to produce electricity and heat. The installation was designed as a system of collectors, with a turbine and a generator. The energy generated in the process is partially used by the plant and the surplus is fed to the power grid.

During the combustion process, a minimum temperature of 850 degrees Celsius[18] is ensured. The temperature and residence time of the exhaust gases in the chamber (minimum two seconds) are an important element of the so-called primary methods of reducing the emission of dioxanes and furans, which decompose at temperatures of about 700 ° C and above. An integral part of the installation is multi-stage, effective flue gas cleaning system that guarantees the highest standards in the field of filtration and removal of hazardous chemicals.

<u>The following zones are distinguished:</u>

- NODE FOR RECEIVING AND TEMPORARY STORAGE OF WASTE
    - entrance gates

The entrance to the plant is from the eastern side through the main entrance gate for trucks. Cameras for monitoring vehicles are installed at the gate.

On average, 100 vehicles per day can arrive at the plant, with the following schedule:

- 95 vehicles with delivered waste,
- 5 vehicles with other materials and post-process waste.

Transport takes place on working days from Monday to Friday for 10 hours a day, which is an average of 10 vehicles / hour.[19]

    - Gatehouse and weighbridges.

The gatehouse is located at the main entrance. The weight of the imported waste and other materials is controlled by weighbridges. Weighbridges are in the area of the hangar – unloading hall.

    - Unloading hall

The unloading hall is designed as a fully closed structure with exit gates and emergency exits. The gates are included in the automatic traffic control system with appropriate traffic lights, informing the driver

[16] The proposed parameters are presented in line with the example of an incinerator in Dublin.
[17] The proposed parameters are presented in line with the example of an incinerator in Szczecin.
[18] The combustion temperature is strictly defined by the standards and norms, for municipal waste it is a minimum of 850 degrees Celsius, *source: https://spalarnie-odpadow.pl/prawo/*
[19] The proposed parameters are presented in line with the example of an incinerator in Szczecin.

which unloading station at the waste bunker is assigned to him. Truck maneuvering before entering the selected unloading station takes place on the hangar and square in front of the unloading hall.
The dimensions of the hall allow for unloading sets up to 16.5 m long. To reduce the possibility of odors spreading outside the hall, the entrance gates remain closed during unloading. The air is sucked into the bunker from where it will go to the furnace.

- Waste bunker

The waste bunker is made of waterproof reinforced concrete. Materials resistant to chemically and biologically aggressive environments were used. The bottom of the bunker is 7 m deep, 48 m wide and around 24 m long. The capacity of the bunker should allow for the storage of waste in an amount allowing the installation to operate for 6 days[20]. A track for the crane was built over the bunker, based on reinforced concrete pillars. The capacity of one crane is sufficient to provide the waste for incineration and mixing the waste in the bunker. The overhead cranes are controlled from the console located in the central dispatch room on the side of the unloading hall. The cranes are equipped with mass measurements of the delivered waste.
The crane operator uses a shell gripper to mix the waste (in order to average the composition) and feed it to two hoppers for grate furnaces. The negative pressure system in the unloading hall and in the bunker prevents the emission of unpleasant odors to the outside.
Longer storage of waste (caused, for example, by periodic inspections or breakdowns, etc.) should be provided for and adequately protected against fire (spontaneous combustion). To reduce the occurrence of such a situation, the waste is constantly mixed and also there are provided: thermal imaging cameras for monitoring waste temperature, sprinkler protection under the ceiling of the waste bunker, water curtains, ventilation and smoke extraction.
The fire water supply network is supplied from the fire pump station together with the tank and will ensure the firefighting operation in the object.

- COMBUSTION AND HEAT RECOVERY NODE
  - Waste incineration and heat recovery node

Each line is equipped with a mechanical grate with air cooling. The processes of drying, degassing, gasifying, burning and burning waste take place in the grate. The waste thrown into the hopper falls onto the grate, where it is subjected to thermal treatment.
The combustion products are flue gas directed to the boiler and slag directed to the deslagger. The ashes from the grate discharge points are also directed to the slag remover.

[20] The proposed parameters are presented in line with the example of an incinerator in Dublin.

- Boiler

A steam boiler with natural circulation, integrated with the furnace grate was used. i.e. located above the grate. The grate is integrated with the steam boiler with a natural circulation, in which the energy from the flue gas is transferred to the boiler's water and steam circuit. The boiler is made in the sheet piling technology and is a self-supporting unit, set on a steel structure. The boiler is installed in the boiler house. Before the flue gas leaves the plant after heating the boiler, it passes through a series of process units in which they are stripped of harmful gaseous substances and dust to a degree that guarantees complete safety for the environment and people.

- Ash and slag storage

The so-called non-flammable fractions, i.e. grate ash and slag from the grate, are directed to the wet slagging system. The cooled slag is transported by a conveyor belt to the preliminary processing room (metal removal, screening) and then to the seasoning under the shelter. The slag can be used to produce aggregates used in road construction.

Fly ash from individual sections of the boiler, dust from the electrostatic precipitator, used activated carbon and sludge from the wastewater treatment system - in accordance with the environmental decision - are transferred for processing (i.e. recovery or neutralization) to specialized companies.

Fire pumping station building with a water reservoir for fire purposes.

The designed pumping station building will be a technical one-storey building without a basement, intended for fire protection of the production and warehouse hall.

Characteristic parameters of the fire pumping station building with the water reserve tank for fire purposes:

Pumping station building:

- number of overground storeys: One,
- number of underground levels: none,
- building area with the tank: 216.34 m2,
- building height to the highest point of the flat roof: approx. 4.20 m,
- internal surface: 71.25 m2,
- averaged internal height: 3.63m,
- volume: 258.63 m3,
- height group: Low (N).

Water reserve tank for fire-fighting purposes:

- Diameter: 12.99 m,
- Height: 8.52 m,
- Total capacity: 1,064.00 m3,

- Usable volume: 1,015.00 m3.

The designed pumping station building will be separated from the water reservoir by a fire separation wall with REI 120 fire resistance.

The gatehouse building.

The gatehouse will be a single-storey building without a basement, intended for employees monitoring the premises of the facility - porters.

Characteristic parameters of the gatehouse:

- number of overground storeys: One,
- number of underground levels: none,
- building area: 17.70 m2,
- internal surface: 15.95 m2,
- internal height: 2.96 m,
- volume: 47.21 m3,
- height: approx. 3.70 m,
- height group: low (N).

9.7 Area balance:

9.7.1 EXISTING [M²]

The area of the plot	82 337,53
Paved area	0
Built-up area	393
Biologically active surface	81 944,52

9.7.2 PROJECTED [M²]

The area of the plot	82 337,53
Paved area	20 254,45
Built-up area	13 972,81
Biologically active surface	48 110,26

9.8 Construction

The analyzed object is a single-storey building set on pile foundations. The walls in the underground part of the building are 30 cm thick reinforced concrete. Construction columns with a section of 60x60. Due to the considerable dimensions of the technological part of the incineration hall, expansion joints are anticipated. The overground part of the building with a steel structure in a truss system, supported on the walls. Construction walls 30 cm thick, pillars with a section of 60x60 cm.

9.9 Facade and interior walls

The facade is predominantly made of sandwich panels. Architectural concrete was also used on the facade of part of the science center. Internal silicate walls, 24 and 12 cm thick. System, glazed partition walls.

Roof of production and warehouse halls, roof of the gatehouse, roof of the pumping station:

The roofing of buildings is made of trapezoidal sheet, coated on both sides. The sheet is based on the steel structure of the roof (details according to the later, more detailed, construction design.) PE foil vapor barrier is laid on the trapezoidal sheet with min. 30.0 cm, then thermal insulation made of hard mineral wool, arranged in two layers, 13.0 cm thick (halls and pumping station building) and 20.0 cm thick (gatehouse building). Covering the roof with a 1.2mm PVC roof membrane.

Roof water drainage: The roof of the warehouse hall is designed with drainage in a vacuum system. Additionally, emergency overflows have been designed in the attics of the warehouse. The roofs of the gatehouse and pumping stations are gravity drained.

Floor:

Production hall:

- broadcast hardening in the amount of 4-5 kg / m².
- 17.0 cm reinforced concrete slab, C25 / 30 reinforced concrete.
- 2x PE foil th. 0.20mm.
- 35.0 cm foundation
- Native soil

Social and office rooms in the hall:

- Gres tiles 30.0 x 30.0 cm (sanitary facilities, corridors) and PVC or carpet flooring (offices).
- 7.0 ÷ 8.0 cm- cement screed.
- 2x PE foil th. 0.20mm.
- 12,0 cm- EPS polystyrene.
- 0.4mm- anti-moisture insulation.
- 15.0 cm - reinforced concrete slab.
- 5.0 cm - lean concrete.
- Substructure.

Ceilings:

In the hall, the ceiling is a visible steel structure and the roof trapezoidal sheet is coated on both sides. In the social and office rooms, the main roofing of the rooms was made of trapezoidal sheet according to the construction design. Additionally, from the side of the rooms, suspended ceilings with a visible structure were designed.

9.10 Ventilation

Mechanical ventilation is planned in the building. Ventilation rooms and the technical part are located in the technological hall. Launchers and air intake are located on the roof. Indoor ventilation will be led under the ceiling.

9.10 Installations

Sewage will be discharged to the sanitary sewage system, and rainwater will be discharged into the rainwater sewage system. Electricity and water installation, as well as water intake for the fire protection installation, will be made within the connection to the municipal network.

9.11 Employment

The following number of people is expected in the WtE building:

Part of the building	Number of people – workers (permanent, >4h)	Numer of people – visitors (<2h)
Technology part	40	-
Office part	20-30	15-20
Exhibition part	-	50
Restaurant	10	40
Audytorium	-	150

In the fire pumping station building and in the technical part:

In the pumping station building and in the technical part, there are no rooms intended for permanent stay of people - the stay of the same people in them is less than 2 hours a day.

9.11 Fire protection

The technological part of the incinerator classified to the PM zone, part of the science center in the ZL III zone. The building will be equipped with a sprinkler system, powered from a fire tank with a capacity of 131m³. The width of the corridors and galleries allow for the correct evacuation of people from all zones of the complex. The designed facility meets the fire safety requirements of structures, fire zones and evacuation that are imposed on such facilities.

Smoking and the use of open fire is strictly prohibited in the landfill. In the event of breakdown or improper use of vehicles located on the premises of the incineration plant, ignition of flammable materials and substances is possible. It is forbidden to perform fire-hazardous work without adequate protection and failure to comply with the rules. No fire-hazardous substances will be stored on the site. The explosive gases will be neutralized. Detailed classification of individual parts of the building with regard to their intended use depends on the individual characteristics of the buildings. On the other hand, the general classification is similar for all waste incineration plants.

Tabela 1. Klasyfikacja podstawowych części obiektów termicznego przekształcania odpadów
Table 1. Classification of the main parts of the waste incineration facilities

Strefa/ Zone	Opis / Description	Przeznaczenie / Destination
1	Hala rozładunku i bunkier na odpady* / Unloading dock and waste bunker	PM > 4000 MJ/m², lub osobno, wtedy hala PM<500 MJ/m² / PM > 4000 MJ/m² or separately, then unloading dock PM< 500 MJ/m²)
2	Hala kotłów, obszar oczyszczania spalin / Boiler room, exhaust gas treatment	PM < 500 MJ/m²
3	Maszynownia / Machinery space	PM < 500 MJ/m²
4	Obszar elektryczny / Electrical area	PM < 500 MJ/m², lub nie budynek (or not building)
5	Budynek biurowo-socjalny / Office building	ZL I, ZL III
6	Waloryzacja żużla / Slag valorization	PM < 500 MJ/m²
7	Składowanie zbelowanych odpadów / Baled waste storage	PM > 4000 MJ/m² , budynek lub składowisko (building or landfill)
8	Budynek obsługi wag, portiernia / Scales building, consierge desk	ZL III

* W przypadku bunkra odpadów i hali wyładunkowej zdarzają się w praktyce podziały na strefy pożarowe między tymi częściami oraz w zależności od indywidualnych warunków brzegowych przyjęcie klasyfikacji budynku bunkra jako budynku PM o gęstości obciążenia ogniowego < 4.000 MJ/m² / Sometimes waste bunker halls and unloading docks are divided into fire zones and, depending on the individual boarder conditions, classifying the area of the bunker as a PM building of < 4.000 MJ/m² fire load density.

Fig. 61. Universal classification of the main parts of the waste incineration facilities.

Source: "Fire Safety of Municipal Waste Incineration Building - Case Study" publication

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Tabela 2. Klasa odporności pożarowej (KOP) stref pożarowych w spalarniach odpadów
Table 2. Fire resistance class (FRC) of fire zones in municipal waste incineration buildings

Strefa/ Zone	Opis / Description	Grupa wysokości / Height class	KOP / FRC
1	Hala rozładunku i bunkier na odpady / Unloading dock and wastebunker	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	**E**, pierwotnie **A** **E**, originally **A**
2	Hala kotłów, oczyszczanie spalin / Boiler room, exhaust gas treatment	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	E
3	Maszynownia / Machinery space	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	**E**
4	Obszar elektryczny / Electrical area	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	**E**
5	Budynek biurowo-socjalny /Office building	średniowysoki (SW), wielokond. / Medium-high, multi-storey	**B**
6	Waloryzacja żużla / Slag valorization	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	**E**
7	Składowanie zbelowanych odpadów / Baled waste storage	1 kond., bez ogr. wysokości / 1 floor, without height restrictions	**A**, lub **E** - tryskacze **A** or **E** - sprinklers
8	Budynek obsługi wag, portiernia / Scales building, consierge desk	1 kond., niski (N) / 1 floor, low (N)	**D**

Fig. 62. Fire resistance class (FRC) of fire zones in municipal waste incineration buildings.

Source: "Fire Safety of Municipal Waste Incineration Building - Case Study" publication

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Plants where electricity is produced (including waste incineration plants) should be divided into fire zones as specified in the construction design. These zones are to limit the spread of fire, protect personnel and minimize damage to technological installations.

Plants where electricity is produced (including waste incineration plants) should be divided into fire zones, as specified in the construction design. These zones are to limit the spread of fire, protect personnel and minimize damage to technological installations.

The principles of division into fire zones should be determined after analysis:

- type, quantity, compaction and distribution of combustible materials,
- location and configuration of plant equipment,
- consequences of losses in plant equipment,
- location and type of fire protection devices.

The fire resistance class of the elements of fire separation should be at least 2 hours. All openings in the fire separation elements should be secured by fire doors, fire dampers, fire protection of installation culverts or other established fire protection measures made in the appropriate fire resistance class. Windows in fire barriers should be equipped with automatic fire curtains or sprinkler curtains.

In the event of a fire, the window surface will be cooled by the sprayed water as protection against thermal radiation. The sprinkler installation will be constructed of stainless steel pipes, fittings and spray nozzles.

9.12 Accessibility for people with disabilities

The design has been adapted for use by people with disabilities. All entrances are designed to be non-threshold. All public toilets will be adapted to the needs of disabled people.

9.14 Determination of the area of object impact

9.14.1 BUILDING LOCATION – DISTANCES, SHADING

The WtE building is located at the safe distances from other structures and the border of the building plot. There are no buildings in the closest neighborhood area. The gatehouse building is located at the safe distances from other structures and the border of the building plot. The pumping station building and the water reservoir are located at the safe distances from other structures and the border of the building plot. Every distances and location is presented on the site plan.

9.14.2 PARKING SPACES FOR CARS

The designed number of parking spaces and their location meet the requirements of the law, and thus does not limit the possibility of building development in the neighboring areas and does not violate the regulations on permissible distances.

- The 137 parking spaces was designed, including 14 for disabled people.
- The 44 bike parking spaces was designed.

Communication will be provided from the Skandynawska street and planned local road.

9.14.3 GREENERY

In the study area, there is high and low greenery. The project assumes the maximum preservation of the existing greenery. Some fountains were added. In the central part – the main entrance to the building, the botanical garden is designed.

10. AREA LIST

List of areas		
Number	Name	Area
1	NAIN GARBAGE INCINERATOR HALL	5561.82 m²
2	WASTE BUNKER	1246.68 m²
3	COM.	34.74 m²
4	COM.	93.72 m²
5	SECURITY	15.65 m²
6	ADMINISTRATION	16.65 m²
7	WAITING ROOM	13.03 m²
8	DRIVERS REST ROOM	7.97 m²
9	WC	3.45 m²
10	RECEPTION	25.11 m²
11	VESTIBULE	12.17 m²
12	CONFERENCE	22.11 m²
13	OFFICE	12.91 m²
14	DIRECTOR'S OFFICE	16.65 m²
15	MANAGER'S OFFICE	16.19 m²
16	SOCIAL ROOM	53.41 m²
17	MEN'S CLOAKROOM	31.95 m²
18	WASH.	10.09 m²
19	SHOWER	15.33 m²
20	WC	9.85 m²
21	WOMEN'S CLOAKROOM	12.65 m²
22	WASH	5.58 m²
23	WC	2.13 m²
24	SHOWER	4.63 m²
25	WASH.	2.55 m²

26	WASH.	2.55 m²
27	WC	4.50 m²
28	WC	4.70 m²
29	COM.	16.44 m²
30	STORAGE	34.63 m²
31	ARCHIVES	18.97 m²
32	SERVER	8.42 m²
33	SERVICE ROOM	8.82 m²
34	COM.	36.05 m²
35	COM.	21.75 m²
36	PREPARATION	19.60 m²
37	KITCHEN	32.70 m²
38	DISTRIBUTION	11.95 m²
39	SCULLERY	8.49 m²
40	SERV.	1.79 m²
41	STOR.	7.77 m²
42	STOR.	10.61 m²
43	STOR.	8.84 m²
44	SOCIAL ROOM	17.51 m²
45	CLOACKRM.	6.00 m²
46	WC	6.30 m²
47	RESTAURANT & BAR	194.44 m²
48	COM.	6.16 m²
49	WC DIS.	3.16 m²
50	WASH.	2.80 m²
51	WASH.	2.69 m²
52	WC M	4.72 m²
53	WC W	4.53 m²
54	SCIENCE CENTER LOBBY	195.84 m²
55	MAIN EXHIBITION	557.17 m²
56	CONFERENCE ROOM	380.79 m²
57	EDUCATIONAL HALL + EXPOSITION	582.84 m²
58	WAREHOUSE	93.17 m²
59	EDUCATIONAL ROOM CHEMISTRY	39.18 m²
60	EDUCATIONAL ROOM TECHNOLOGY	42.05 m²

61	WORKSHOP ROOM	40.03 m²
62	WASH.	6.74 m²
63	WC DISBL.	4.51 m²
64	WASH.	6.81 m²
65	WC M	10.87 m²
66	WC W	10.94 m²
67	OPEN SPACE OFFICE	585.58 m²
68	OFFICE	105.24 m²
69	ARCHIVES	11.42 m²
70	SERVER + TECHN. ROOM	12.19 m²
71	SERVICE ROOM	13.46 m²
72	WASH.	6.74 m²
73	WC W	10.94 m²
74	WC DISBL.	4.51 m²
75	WASH.	6.67 m²
76	WC M	10.72 m²
77	TECHNICAL ROOM	40.19 m²
78	BOTTOM ASH	405.07 m²
79	ELECTR. SWITCH- BOARD	13.57 m²
80	TRANS.	16.00 m²
81	ELECTR. SWITCH- BOARD	14.16 m²
82	STORAGE	27.00 m²
83	TANK ROOM	29.05 m²
84	STORAGE	27.73 m²
85	STORAGE	32.31 m²
86	STORAGE	25.96 m²
87	STORAGE	64.90 m²
88	TANK ROOM	71.69 m²

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LIST OF FIGURES

ANNEX: A3 BOARDS