

UKRAINIAN CATHOLIC UNIVERSITY

BACHELOR THESIS

**Development of analytical matching
system for waste
generators and disposers based on
aggregated open data**

Author:
Roman STEPANIUK

Supervisor:
Andriy GNAP

*A thesis submitted in fulfillment of the requirements
for the degree of Bachelor of Science*

in the

Department of Computer Sciences
Faculty of Applied Sciences



APPLIED
SCIENCES
FACULTY ●

Lviv 2020

Declaration of Authorship

I, Roman STEPANIUK, declare that this thesis titled, "Development of analytical matching system for waste generators and disposers based on aggregated open data" and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed:

Date:

UKRAINIAN CATHOLIC UNIVERSITY

Faculty of Applied Sciences

Bachelor of Science

**Development of analytical matching system for waste
generators and disposers based on aggregated open data**

by Roman STEPANIUK

Abstract

The purpose of this bachelor's thesis is to create a platform to improve waste management in Ukraine. The service has two main functionalities: the analytics, with all the available aggregated information on waste transactions and its analysis, and B2B marketplace for owners of significant amounts of waste and recycling companies to find the best deals and start new productive partnerships.

Acknowledgements

I want to thank my family for supporting me, my friends for inspiring me and all the people who helped me with this project and over those four years for being there.

Contents

Declaration of Authorship	i
Abstract	ii
Acknowledgements	iii
1 Introduction	1
1.1 Problem Statement	1
1.2 Goals	2
1.3 Motivation	2
2 Related work	3
2.1 Value proposition	3
2.2 Interviews	4
2.3 Existing solutions	4
2.4 User experience	5
3 Data processing	7
3.1 Retrieval	7
3.2 Cleaning and preparation	7
3.3 Other resources	8
3.4 Database structure	8
4 Technologies overview	10
4.1 Back-end	10
4.2 Front-end	11
5 Proposed approach	13
5.1 Analytics	13
5.2 Marketplace	15
5.3 API	16
6 Conclusion	17
6.1 Results	17
6.2 Future work	17
Bibliography	19

List of Figures

2.1	SaveEcoBot example	5
2.2	Waste.UA page example	6
3.1	Example of the first page of waste declaration	8
3.2	Database fields relations	9
4.1	Wagtail custom page creation	11
5.1	The top part of the landing page	13
5.2	Top companies that generate the biggest amount of waste by categories	14
5.3	Map of waste production in different Ukrainian regions	14
5.4	Example of a marketplace page	15

List of Tables

5.1 Registration form for new users	15
---	----

List of Abbreviations

API	Application Programming Interface
AWS	Amazon Web Services
B2B	Business to Business
CMS	Content Management System
DRF	Django Rest Framework
EC2	Elastic-Compute Cloud
EDRPOU	Ukrainian State Registry Legal Entity Identifier
KOATUU	State Classifier of Objects of Administrative and Territorial Structure of Ukraine
MENR	Ministry of Ecology and Natural Resources
MSW	Municipal Solid Waste
MTV	Model-Template-View
PZUW	Indicator of Total Waste Generation
REST	Representational State Transfer
SSSU	State Statistics Service of Ukraine
UI	User Interface
URL	Uniform Resource Locator
UX	User Experience
VPC	Value Proposition Canvas

To my dog I've never had

Chapter 1

Introduction

1.1 Problem Statement

Nowadays, ecology is one of the main concerns of humanity. If we take Ukrainian Karpatian's average mountain's height (1000m) with an approximate steepness angle of 30° and density of sandstone ($2323\text{kg}/\text{m}^2$), we get 2.43 billion tonnes. This number is only 12% greater than the number of tonnes of MSW generated last year[1]. Over 2 billion tons of waste is being produced worldwide every year[2]. Even though more and more rubbish worldwide is being recycled and reused, Ukraine is one of the countries with the biggest problem in this field.

According to the data given by the Ministry of Communities and Territories Development, in 2019, Ukraine produced over 10 million tonnes of MSW[3], which is around 8% more than the previous year. Only 4.1% of those were recycled and 2% incinerated. The rest 93.9% were landfilled, which does much harm to the environment. The rubbish may contain dangerous toxic substances, upon breaking down of which the chemicals get exposed to the nearby water and land. Covered and compacted down organic materials trigger an anaerobic process, which eventually releases methane, a greenhouse gas. This gas is around 25 times more potent than carbon dioxide when averaged out over 100 years. This dramatically impacts climate change, and that is why the greenhouse gas is considered critically dangerous. For comparison, in 2017, Poland had a similar amount of waste generated (11.9 million tonnes). However, only 42% of it was landfilled when in 2006, this number was over 91%. Over the past ten years, Poland drastically improved its waste management system due to new waste and disposal regulations, and we finally can see similar laws being applied in Ukraine.

Another challenge was the inconsistencies in declarations published by waste producers and almost no supervision on this from the government. Organizations are obliged to declare how much waste was produced by them each year with details on what type of waste it was and what they did with it. Even though they end up submitting it to governmental structures every year, nobody pays attention to what they write in these reports and if numbers end up correctly. Because of this, many mistakes are being made in there both intentional and unintentional, which leads to raw data not being suitable for further analysis. It also keeps the door open for the companies that are not faithful in regards to their production of waste and illegally get rid of it.

It is believed that one of the main reasons why Ukraine is currently behind most of the European countries in waste disposal management state is its lack of recycling centers. But actually, this statement is not just incorrect, but quite the opposite: there are over 3000 of entities and they are working on an average of only 60% of their max capacity. Besides, every year over 30 000 tonnes of MSW are imported to Ukraine and headed to these facilities. The reason for that is the absence of the motivation

of big companies to sort their waste and to find the recycling companies that can deal with it. It is a lot easier to pay to already familiar partners, who will load the garbage on a truck and transport it to landfill areas. It is also better for the recyclers to buy already prepared materials from abroad. Given the circumstances, it becomes difficult for recyclers to find constant partners with whom they can have profitable long-standing deals in Ukraine.

1.2 Goals

The terms of open data and digitalization are relatively new for Ukraine and because of that, there are lots of problems with how it is currently working. One of the main problems is a lack of understanding and skill in governmental organizations on how to publish it and make data accessible for the public correctly. This is why this project was aimed to aggregate all the available data from different governmental ministries and make previously almost unaccessible data easy to find for everybody. This is opening opportunities for further investigations for the reporters and journalists who now can study this data and draw some useful conclusions from it.

Nevertheless, this service's primary goal is to decrease the percentage of land-filled MSW and bring some life to the market of waste trading by making one platform for all parties with transparent deals and bringing new players to the promising recycling business.

Europe has been actively moving towards the circular economy model in the past few years. Such a model is based on a few core principles, the first of which is the goal of designing out waste, creating a life cycle for existing products. All the materials should be disassembled, repaired, and reused, so practically there is no such thing as waste. This defines the circular economy and sets it apart from recycling and disposal, where enormous quantities of energy are being lost. Only now Ukraine has started making changes in the old-established linear model of economy and making changes towards the European example

1.3 Motivation

In March of 2019, I took part in a hackathon centered around open data in Ukraine, where for the first time, I have been introduced to the current situation of waste management and data publication. I met people who are still guiding me in this project due to their knowledge of the Ukrainian ecology state. Together we decided that there is so much more that can be done to improve this state, and it is in our power to do this. Since then, we have visited multiple ecology events, dug deeper into the problem of waste recycling, and met more interesting people, who supported us on our idea, gave more insides on it, and inspired us to proceed.

Chapter 2

Related work

2.1 Value proposition

Among critical questions to consider before starting working on the project are:

- is there a need for such a product?
- who will be using it?
- why is it better than alternatives?
- what will the user gain from using this product?

That is what the VPC method is aimed at answering. It is a simple, concise, and compelling technique to describe the main benefits the customers will gain from using the product. When working on the value proposition, we divide it into two parts. First, we are taking a look at the potential customer and then the product.

There are many eco-activists, media reporters, and ordinary people who would appreciate having an opportunity to know what do the big corporations do with their excess, to see what kind of dangerous materials might be used in the production, to trace it from point A to point B. All this data was open for the public, just not accessible. Now, on provided service, they will be able to see the data from the Ministry of Ecology and Natural Resources and the State Statistics Service of Ukraine, as well as some other sources. Data is displayed in the forms of lists with filters, information pages of every waste generating or recycling company, and informative, interactive graphs.

As for generators and recyclers, the problem was a closed market, where there was almost no place for new recycling factories to find clients. Everything was done using direct communication with a closed format. Although many of them might be satisfied with such dealing, **some** want things to change and need a convenient marketplace to do so. They can have this opportunity on our platform, where apart from filling up forms with different types of available waste, they also get recommendations on the closest facilities that operate it in the required amounts.

The improvement of waste management in Ukraine depends mainly on the governmental structures and generators themselves, but we believe it is possible to speed up this process with the right approach. With the data opened to publicity, the new marketplace, and supervision by the community, new changes that are being applied by the government can be tracked faster and more efficiently. Analysis of the above points helped us to realize better and improve the product we need to make.

2.2 Interviews

The conclusions that we made could not have been drawn just by ourselves. To understand the needs and requests of future users, we met with and interviewed different people. Firstly, there were many journalists involved in ecology and willing to share their knowledge and thoughts on its state, whom we met on events in Kyiv and Lviv. From these interviews, we learned many insides and main pains, troubling those people: unavailability of data and statistics, and what would they like to get from it. Thanks to my supervisor, we had the interviews with the representatives of some large companies. Following the preprepared template, we received and noted their suggestions, ideas, and obstacles. Some of them in a short form are listed below:

- **DTEK** is a strategic holding company that develops business in the energy sector. Its companies produce coal and natural gas, generate electric power at the fossil-fuel-fired power plants, and more. Due to the massive production amounts, they do not need such service, since they already have the recycling partnerships for the nearest future. However, they confirmed a lack of such service for smaller scaled businesses and suggested to make a more significant emphasis on them.
- **Coca-Cola Hellenic** is a carbonated soft drink manufacturer that generates large amounts of recyclable plastic waste. Public image is crucial for the company of such an international scale. They are working with 100% recyclable plastic[4] and are interested in the platform where they can showcase their pro-ecological status and recycled waste capacities. Currently, they are following a plan to increase the amount of recycled waste from their products to 35% by 2030 and would like to have a way to keep precise track of this percentage.
- **Green Planet Eco** is a company that owns some of the most massive waste sorting facilities in Kyiv, the main focus of which is sorting of waste paper, plastic, and glass bottles. They are expanding very quickly, so to keep the work at maximum load, they need more ways to find and buy waste easily. They expressed a deep interest in our solution and gave us a better understanding of how this business is currently working.

Apart from the above companies, we also had smaller discussions with some other representatives who also gave us ideas, which we actualized in the final product.

2.3 Existing solutions

As it was already mentioned in the previous sections, currently there are no other services that display waste data in convenient and accessible for community way, but there are some who feature some of the data used in our site. In chatbot **SaveEcoBot**, different data about air quality, environmental pollution, and more can be requested. It also provides access to waste declarations published by MENR, filtered by regions. However, it does not provide any more depth to them. It merely redirects to the declaration's location on MENR's webpage(Figure 2.1).

Regarding the marketplace, there is a service **Waste.UA** that operates as the platform for the contacts exchange between the seller and buyer. It has a pretty short application form where the waste and the amounts of it are described, and the user's contact information is given. The filtration on keywords, region, and seller's name

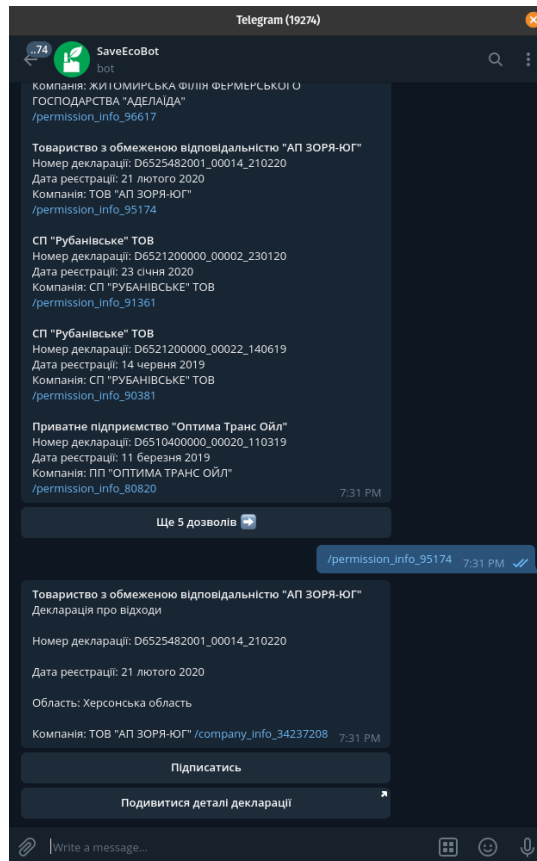


FIGURE 2.1: SaveEcoBot example

can also be applied. Unfortunately, this is all the features this service has to provide. One of the things worth remarking is the UI of Waste.UA. It is very simplistic and 90-ties looking, which in this case is a bad thing (Figure 2.2). It makes the site look very bland and hard to navigate through. Also, limited features it provides make it outdated and not match the criteria set by today's needs.

Similar services are currently working in many countries around the world, so here are some of them to showcase how they look and what are their main functionalities.

- Italy | **"InSymbio"** - B2B-marketplace aiming to transform organic waste from one company into raw material for another;
- USA | **"Waste Analytics LLC"** - company rating in oil and gas waste management. Estimated Environmental Liability (EEL);
- The Netherlands | <https://excessmaterialsexchange.com/> "The Excess Materials Exchange" - a digital market where companies exchange any extra raw materials and products.

2.4 User experience

Emphasis on the user-centered design was very significant during the development of our service. With an unsuccessful example in the form of Waste.UA, the problems that the users complained about we tried to avoid and solve in our project. We put less uninformative text on the pages, making the interface more appealing

The screenshot shows the Waste.UA website interface. At the top, there is a search bar and a navigation menu with items like 'Главная', 'Объявления', 'Каталог предприятий', 'Войти в систему', 'Регистрация', 'Реклама на сайте', 'Как пользоваться', and 'О нас'. Below the navigation, there is a 'Быстрый поиск:' section with a search bar and filters for 'Автор' (All), 'Страна/Город' (Ukraine), and 'Искать в тексте:'. The main content is a table of announcements.

Дата	Тип	Объявление	Автор	Страна	Город
12.04.2020	Ищу	Закупаем лом пластмасс и дробильный полистирол (городской и полигоновый сбор, отходы)	Денской Дмитрий Анатольевич	Украина	Камениское, Днепропетровская обл.
22.04.2020	Ищу	Куплю б/у ленту, трубух капельного орошения	Порядин Евгений Викторович	Украина	Херсон
16.04.2020	Ищу	Дорого закупаем лом пластмасс с полигона, городской сбор, ПС, АБС, ПП, ПНД	Назаренко Вадим Анатольевич	Украина	Камениское, Днепропетровская обл.
05.05.2020	Ищу	Ордуны пластмасс с полигона навалом, литник, ПС, ПП, ПНД, ПВХ, стирей, т/у пленки	Корбанков Митрофан Иванович	Украина	Кривой Рог, Днепропетровская обл.
05.05.2020	Предлагаю	Трубный полиэтилен ПЭ-100, ПЭ-80, ПЭ-69, ПС (УМТ), ПП (РР), АБ, ПНД-273, 277, 276	Корбанков Митрофан Иванович	Украина	Кривой Рог, Днепропетровская обл.
28.04.2020	Ищу	Куплю отходы полиэтилена	Флекс, ООО	Украина	Харьковская область
12.04.2020	Ищу	Уплотнитель оконный	Немченко Сергей Александрович	Украина	Харьков
08.05.2020	Ищу	Закупаем макулатуру, бумажные носовики	Назаренко Алексей Анатольевич	Украина	Днепропетровск

FIGURE 2.2: Waste.UA page example

and clear. Also, the addition of more useful functionalities makes it easier to navigate through. The design was being kept simple but, at the same time, modern and mobile-friendly, which is a must in the current world.

The analytics section of the service contains multiple interactive charts to help users comprehend the data. As the Aberdeen Group study proves[5], when using the visualizations user is 28% more likely to find timely information than those who use dashboards and tables. Also, the graphical representation can help to realize the scale of the numbers better and compare different objects with each other.

Another feature available is a news feed that updates users with new relevant information regarding waste management and environmental pollution. These posts will be created by the admins of the site and easily accessed from the landing page.

Chapter 3

Data processing

3.1 Retrieval

On February 18th of 2016, the decree of Cabinet of Ministers of Ukraine had been passed, which states that all economic entities that have higher PZUW than 50 are obliged to submit waste declarations every year[6]. Those declarations have a pre-defined form on the official website of MENR and are stored **there**, open to the public. Unfortunately, the access is available only to the scan copies of the declarations saved in PDF format and PDF files generated by filling the form online(Figure 3.1), which always duplicate each other. The only available option to search for a particular document is by entering the unique declaration code it has. This code consists of three numbers divided with a dash:

- KOATUU code
- the sequence number, which indicates the order index of submitted declaration this year in this region
- the date when the declaration was submitted

After writing a short script for downloading over 50 000 PDF files from the source, they had to be read and split into different tables. For this purpose, a tabula-python library[7] was used. It is a wrapper of a tabula-java library[8] that reads tables from PDF and converts it into panda's DataFrame[9]. Since all of the computer-generated declarations follow the same structure, we were able to retrieve all data split into three tables:

- information about the owner of the document, with the name, EDRPOU code, KOATUU code, address and contact information
- summary of produced waste amounts in tonnes by four classes of danger and PZUW for the past year and forecast for the next one
- a detailed description of every generated type of waste with information on who was it transferred to and what operation was used to dispose of it

3.2 Cleaning and preparation

The form provided by MENR for declaration submission had almost none validators on the available fields which, inevitably lead to a high number of inaccuracies being made in the process. Another problem was regarding UX, where due to the lack of explanation, users often did not fully understand what exactly had to be entered in

**ДЕКЛАРАЦІЯ
про відходи**

№ D6325156400_00488_050320

Назва суб'єкта господарювання:	Дочірнє підприємство "Грикар-А.П.С."
Код згідно з ЄДРПОУ:	31465149
Код згідно з КОАТУУ:	6325156400
Юридична адреса суб'єкта господарювання:	62495, Харківська обл., Харківський р-н, смт Васищево, вул. Овочева, 14
Електронна пошта /Телефон:	/757 60 39

Показник загального утворення відходів*

Період утворення відходів	Показник загального утворення відходів (Пзув)	Обсяг утворення відходів I класу небезпеки, тонн	Обсяг утворення відходів II класу небезпеки, тонн	Обсяг утворення відходів III класу небезпеки, тонн	Обсяг утворення відходів IV класу небезпеки, тонн
За 2019 (звітний) рік	321.44	0.03	0	0.028	170.04
За 2020 (поточний) рік	620.99	0.045	0	0.412	375.39
		(x5000)	(x500)	(x50)	(x1)

*Розрахунок показника загального утворення відходів (Пзув) наведено у пункті 8 Порядку ведення реєстру об'єктів утворення, оброблення та утилізації відходів, затвердженого постановою Кабінету Міністрів України від 31 серпня 1998 р. № 1360 (Офіційний вісник України, 1998 р., № 35, ст. 1307)

FIGURE 3.1: Example of the first page of waste declaration

the current field. Most commonly, this is noticeable in forecast fields of the second table. This led to the decision to completely ignore these numbers as they have very little value in them.

Due to the significant number of mistakes in the text fields of the first table, the decision was made to use OpenDataBot API[10]. This service provides the newest updated information on the entity by EDRPOU code, which we used from the declarations to bind these tables. Through simple GET requests, the actual information on every generating and recycling company is received.

Other anomalies in data were fixed through a detailed examination, which often led to a manual comparison between the scanned document and the computer-generated one.

3.3 Other resources

Apart from the declarations submitted every year to MENR, there is another decree, approved on August 19th of 2014. It requires another form regarding waste production to be submitted every year to SSSU. This data contains less entries but still can be used for the comparison between two declaration types since the numbers, for the most part, should be the same. To retrieve it, we met the responsible people from the SSSU who provided us with available data in DBF format and description to it. On our website, users can switch between two data sources with a simple button click.

During the development of the service, many other datasets were preprocessed at different stages. Nevertheless, they did not find any usage in the current version, but still might be used in the future for some analysis.

3.4 Database structure

Before starting web development, a new database structure had to be organized. Thus three tables from MENR's declarations were remerged into four tables(Figure

3.2). The service is running with the PostgreSQL database[11].



FIGURE 3.2: Database fields relations

Chapter 4

Technologies overview

Both data preparation and web back-end were completed using Python programming language. The tasks that were set up required a good understanding of the applied technologies and creative approach.

4.1 Back-end

The back-end of our platform is built with Django[12], a high-level Python Web framework, which follows the MTV architectural pattern. It is excellent for developing database-driven websites. Also, Django is one of the most popular frameworks to build web applications. Among the core advantages of it are:

- support of many extras that extend its functionality
- high-performance speed reliable security system
- a vast range of usage in different kinds of applications
- exceeding scalability

Django contains a registry of installed applications, which are responsible for some individual sets of features. Currently, the app is deployed on AWS EC2 t2.micro instance **free tier**. Due to large amounts of different data and multiple functionalities of the service, Django was a perfect framework for this project

To create a RESTful API in our project, we are using Django Rest Framework (DRF)[13]. REST is an architectural style that is followed when RESTful API for a particular app is being created. When a user requests something service returns a list of results, this is basically how the RESTful API works. In Django, it is implemented with an installable `rest_framework` module. After accurate updating of views, providing URL patterns, and creating serializers of `ModelSerializer` class, DRF should be set up.

For custom news pages creation, Wagtail CMS[14] was used. This is an open-source CMS built on Django, focused primarily on UX. Wagtail offers precise control for the developers and designers. It is widely used by tens of thousands of organizations, who are powering their digital estates with it. With an easy to get around UI, Wagtail is a prominent solution that offers a rapid development environment and can be easily integrated into the system. In our case, it is used for easy homepage management with effortless creation of news pages(Figure 4.1). The links to these news pages can be custom added to the top of the landing page so that users can spot it right away.

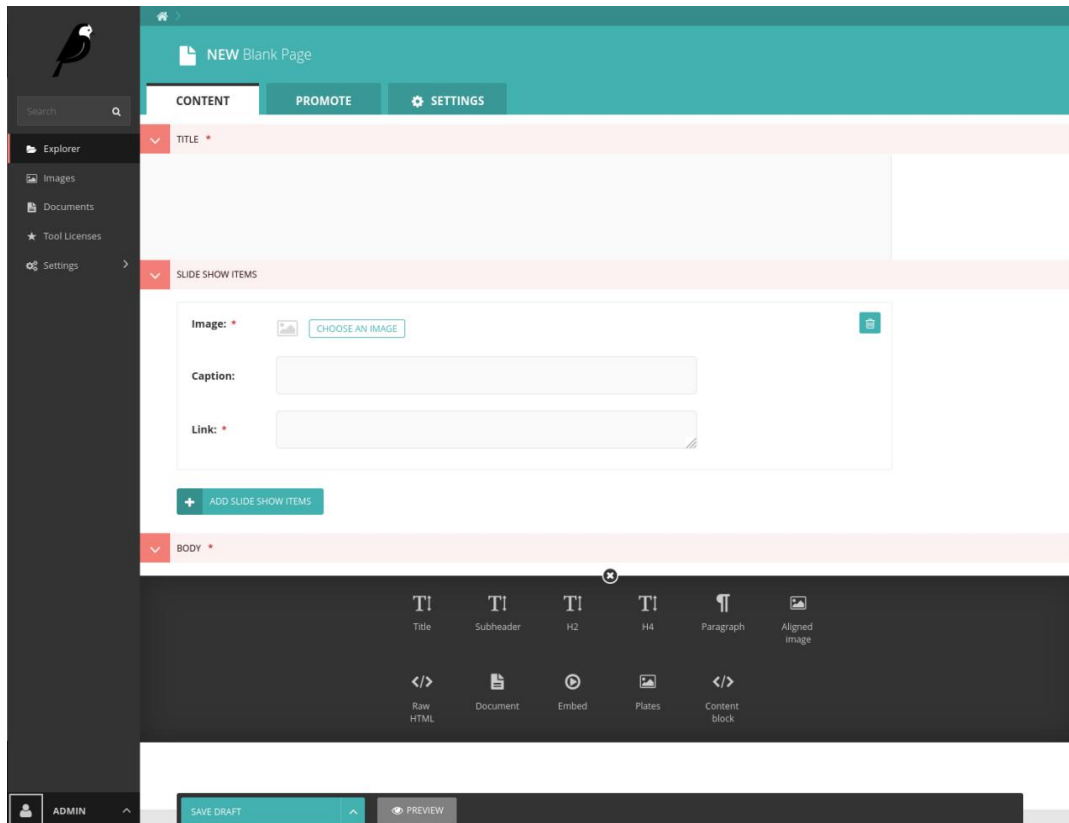


FIGURE 4.1: Wagtail custom page creation

4.2 Front-end

With the help of continuous feedback from the users, we deliver friendly UX. To provide interactivity on the website, we were using JQuery[15] that is a fast, small, and feature-rich JavaScript library. It simplifies a lot of more complicated things from JavaScript like manipulation with HTML document, AJAX calls, event handling, and animation. Also, JQuery's extensibility and versatility make it the most popular JavaScript library in the world, with the usage on 73.8% of all the websites, as investigated by W3Techs[16].

One of the critical components on the analytical part of our service are the interactive charts that can be used to find information on different regions, companies, get overall data statistics, and compare them. To achieve the best and most flexible results, another JavaScript library was applied - D3.js[17], which stands for Data-Driven Documents. It is a set of tools that, with the use of HTML, CSS, and SVG, helps to visualize different types of data and bring it to life. It consists of tens of smaller modules, where each is responsible for different tasks. Some of the main advantages of D3.js are:

- a transparent direct connection between data and its representation;
- its deep focus on data, most importantly the inclusion of built-in reusable functions and function factories;
- due to it being very lightweight D3.js is very fast;
- ability to work with large datasets efficiently;

- interactivity that can be achieved without too much effort;
- full control of usage that allows a wide variety of different non-standard charts to be created;

Because of the significant amount of data available and the possibility of different useful and exciting charts being made out of it, D3.js was a perfect fit for our tasks.

FreshChat[18] is a live chat product that is commonly used for interactions between the customer and the service administrators. It is displayed in the form of the small widget in the bottom right corner of the screen. Using it allows the customer to communicate directly with the website's support. It is integrated with different social networks like WhatsApp, Facebook Messenger, LINE, and Apple Business Chat. When a user sends the message from the widget, the administration will immediately receive the notification in the corresponding app they use. To set this feature up, only one relatively small snippet of code has to be inserted to the default page's file. The example of such code can be seen below:

```
1 <script>
2   function initFreshChat() {
3     window.fcWidget.init({
4       token: "YOUR-TOKEN",
5       host: "https://wchat.freshchat.com"
6     });
7   }
8   function initialize(i,t){
9     var e;
10    i.getElementById(t)?initFreshChat():((e=
11      i.createElement("script")).id=t,e.async=!0,e.src=
12      "https://wchat.freshchat.com/js/widget.js",e.onload=
13      initFreshChat,i.head.appendChild(e))
14  }
15  function initiateCall(){
16    initialize(document,"freshchat-js-sdk")
17  }
18  window.addEventListener?window.addEventListener("load",initiateCall
19    ,!1):
20  window.attachEvent("load",initiateCall,!1);
</script>
```

The rest is done on the official page of FreshChat. The value that this brings to the service compared to the effort necessary to install it make it an excellent decision for the business centered around communication with their customers.

Chapter 5

Proposed approach

The whole service is split into two parts: marketplace and analytical. They have different purposes and functionality but serve a common goal. On the landing page(Figure 5.1) are news blocks which redirect the user to a custom news page on our service. Additionally, there is information on the current state of waste management in Ukraine and details about the project.

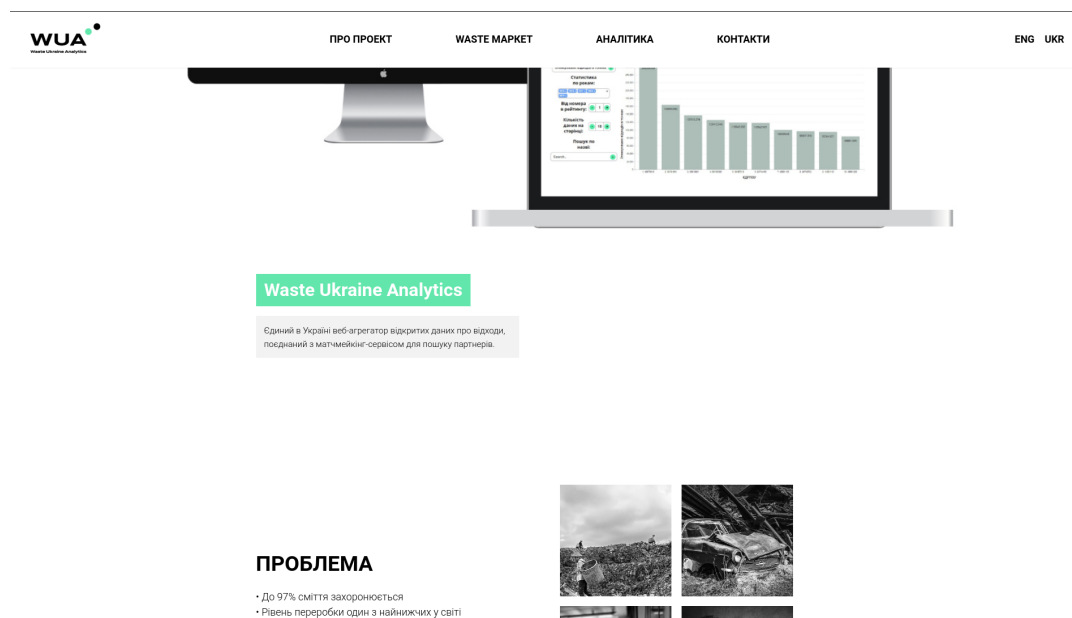


FIGURE 5.1: The top part of the landing page

5.1 Analytics

The analytics section consists of multiple visualizations based on waste management in Ukraine. Most of the data used in them is aggregated from declarations posted on MENR's website. The first one is a bar chart(Figure 5.2) with all the generators of waste sorted by the amount of produced waste. Users can choose by which type of waste should the list be sorted out and how many entities should be displayed on the chart at the same time. The visualization can be filtered out by region and year. Also, it is possible to look for and filter companies using their name.

Map visualization(Figure 5.3) displays the production capacities and air pollution in different regions of Ukraine via tooltip. There are similar filters available to the previous one. Other than that there are a couple of other smaller charts that display information on capacities of production of different dangerous waste, largest

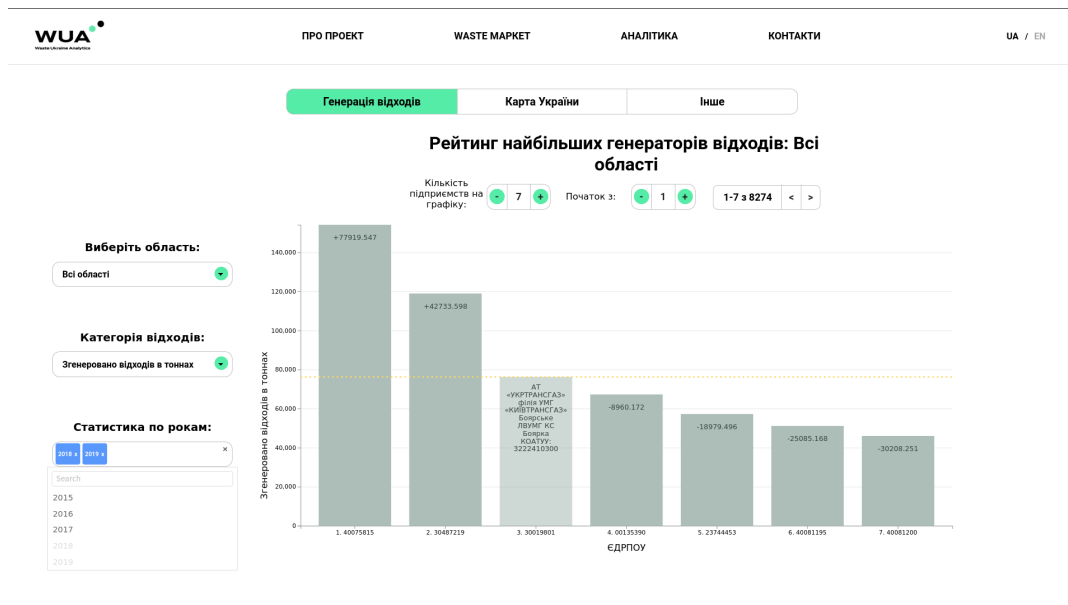


FIGURE 5.2: Top companies that generate the biggest amount of waste by categories

recycling companies, and density of recycling or sorting companies in different regions of Ukraine

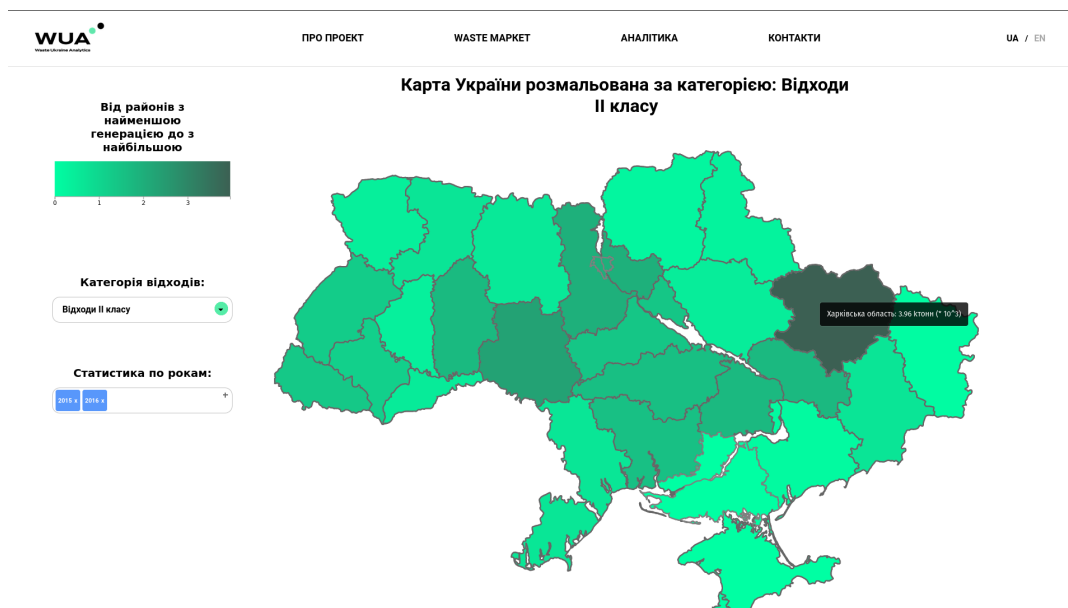


FIGURE 5.3: Map of waste production in different Ukrainian regions

On the companies listing page of our service is available information about every company and their waste production from the declarations they have posted. For every organization that posted more than two declarations are visible individual graphs that show the changes in production amounts through the years. There the user can also go to the pages of the disposal companies that have dealt with current excesses and see all the operations they did that are officially documented.

5.2 Marketplace

To be able to view or post anything on the marketplace (Figure 5.4) user has to be logged in. The registration form is short and requires:

Field name	Description
First name	The first name of the user
Last name	Last name of the user
Organization	An organization the user is a part of
Job title	Current job position of the user
Email	User's email
Phone	Active user's phone number
Password	Password user will use to login to the website. Has to contain eight or more symbols and at least one number and capital letter
Password confirmation	Repeat the password entered in previous field

TABLE 5.1: Registration form for new users

After the user has signed in, he can then view available entries, get their contact information, or create a notice about the waste he has available. To do the last, he once again has to fill up the form with all the necessary details on it. Upon finishing, the user is shown a list of services that, in the past, worked with such waste type. He can then contact them himself right away. If the notice has been on the site for a month, it is deactivated, unless the user confirms that he still did not find what he was looking for. He gets an email stating this a week before deactivation, and on the same day, deactivation is going to happen.

With the help of various different filters in the top part of the screen, the customer can find what he needs more efficiently. The filters are region, waste type, and the keyword in the notice.

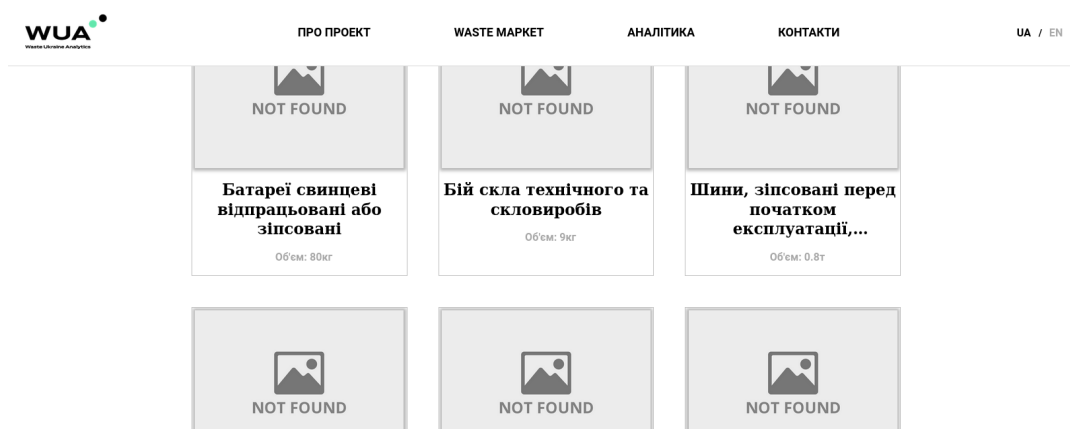


FIGURE 5.4: Example of a marketplace page

5.3 API

Through our service's RESTful API, users will be able to get information that we aggregated from waste declarations and posted under the analytics section of the website. In the list of currently available GET request commands are the following actions:

- **get.generator_show(*edrpou: str*)** - returns information on the waste generator by the given EDRPOU
- **get.disposer_show(*edrpou: str*)** - returns information on waste disposer by the given EDRPOU
- **get.declaration_show(*code: str*)** - returns data of the declaration with the given declaration number
- **get.recent_declarations_show(*koatuu: str*)** - returns a list of 20 of the latest declarations in the given region by its KOATUU, if None given the whole country is selected

Chapter 6

Conclusion

This service has been our passion for the past year, and we believe that with the constant support from our side, it will have its chance to grow and make a positive impact on the state of waste management in Ukraine. The experience and knowledge gained from it will help in future projects.

6.1 Results

The current version of the is successfully deployed at wua.digital. The overall page loading time can sometimes be slower than average, but we are currently working on the improvement of its efficiency. The analytical pages are, for the most part, complete and require constant updates to the database, news feed, and visualization charts. The marketplace's primary functions are working, but there are more improvements to be made, which are described in the next section.

6.2 Future work

Admittedly, there are still many things to be changed and added as the service only recently started working. It will require constant support and maintenance on our part. However, we also have some other ideas in mind that would be great to have implemented into the service. Firstly, some other actions are going to be added soon that will be available through our API. This will allow other ecology-related projects to use the data we have aggregated more efficiently and productively.

Currently, due to the time restrictions and legal reason, the marketplace operates only as a place to find the best corresponding partner. Still, our number one priority at the moment is to allow all the make and confirm deals right there on the same page. With the ability to make transactions right there, we can start gaining some income, which will help speed up the growth of the project and engage more people to it. Regarding the monetization system, we have currently two options on our mind:

- taking a small percentage out of every transaction, the sum of which exceeds the threshold;
- monthly subscription fee for waste recycling and sorting companies who are highly interested in being part of such service since they are looking for more ways to load their production capacities.

This task requires time, but in a couple of months, we are expecting such a feature to be part of the service.

After around six months of successful deployment, we have been planning to involve another vital part of the waste management system - transportation. Adding

separate ability to order a truck that will load materials and transport them to the destination, as proven by interviews, would be a great problem solver that users are likely to use often.[4]

This way, all parts of the waste disposal process will be covered in one place, making it the single most convenient service to deal with them quickly and efficiently.

Bibliography

- [1] *A world of waste*. 2020. URL: <https://www.theworldcounts.com/challenges/planet-earth/state-of-the-planet/world-waste-facts>.
- [2] Cody Ellis. *World Bank: Global waste generation could increase 70% by 2050*. 2018. URL: <https://www.wastedive.com/news/world-bank-global-waste-generation-2050/533031/>.
- [3] Ministry of Communities and Territories Development of Ukraine. *2019 Waste Management Report*. 2020. URL: <https://www.minregion.gov.ua/napryamki-diyalnosti/zkh/terretory/stan-sfery-povodzhennya-z-pobutovymi-vi/>.
- [4] Coca-Cola Ukraine. *Coca-ola announces about new investments in 'World Without Waste'*. 2020. URL: <https://www.coca-cola.ua/do-good/world-without-waste/our-strategy/coca-cola-announces-new-investments-in-enhanced-recycling>.
- [5] David White, Aberdeen Group Inc. *Visualization. Set Your Analytics Users Free*. 2013. URL: <https://www.tableau.com/sites/default/files/media/8604-ra-business-intelligence-analytics.pdf>.
- [6] Cabinet of Ministers of Ukraine. 2016. URL: <https://zakon.rada.gov.ua/laws/show/118-2016-%D0%BF>.
- [7] Aki Ariga. *tabula-py: Read tables in a PDF into DataFrame*. 2019. URL: <https://tabula-py.readthedocs.io/en/latest/>.
- [8] Manuel Aristarán. *tabula-java Library*. 2018. URL: <https://github.com/tabulapdf/tabula-java>.
- [9] Pandas Development Team. *pandas.DataFrame Documentation*. 2014. URL: <https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFrame.html>.
- [10] *OpenDataBot API*. 2020. URL: <https://opendatabot.ua/api>.
- [11] The PostgreSQL Global Development Group. *PostgreSQL: The World's Most Advanced Open Source Relational Database*. 2020. URL: <https://www.postgresql.org/>.
- [12] Django Software Foundation. *Why Django?* 2020. URL: <https://www.djangoproject.com/start/overview/>.
- [13] Encode OSS Ltd. *Django REST framework Docs*. 2020. URL: <https://www.django-rest-framework.org/>.
- [14] Wagtail Team. *Wagtail, the powerful CMS for modern websites*. 2020. URL: <https://wagtail.io/>.
- [15] The jQuery Foundation. *jQuery Library*. 2020. URL: <https://jquery.com/>.
- [16] W3Tech. *Usage statistics of JavaScript libraries for websites*. 2020. URL: https://w3techs.com/technologies/overview/javascript_library.

-
- [17] Mike Bostock. *D3 - Data-Driven Documents*. 2019. URL: <https://d3js.org/>.
- [18] Freshworks Inc. *FreshChat - Multiple Channels, Unified Destination*. 2020. URL: <https://www.freshworks.com/live-chat-software/messaging-channels/?source=homepage>.