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LUCRARE DE LICENŢĂ

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# Part I - General Aspects

# 1 Introduction

The increasing concers regarding the pollution calls for several measures that need to be implemented in order to improve air quaility. Pollution has many causes and comes in many forms and each affects our life and health. Among them, one of the most notible form of pollution is that caused by vehicles.

This is mostly concerning in the urban settlements, metropols, that are suffocated by the rasising number of cars, averaging close to 1 car per 1-2 people. Passenger cars are a major polluter, accounting for 61% of total CO2 emissions from EU road transport [1].

European Union hopes to reduce drastically the pollution, implementing new legislation aiming to push towards zero CO2 emissions for new vehicles. However, in reality, the evolution is much slower the we have hoped.

The two main ways of reducing CO2 emissions from vehicles are manufacturing more efficient cars and changing fuel type to more eco-friendly ones, ideally green/regenerative energy [1]. Despite the fact that electric and hybrid cars are taking a considerable part of the newly registered vehicles, old vehicles must still be taken into consideration.

Designing a schema to reduce the pollution proves to be a challenging aspect, yet necessary. Such schemas, known as Urban Vehicle Access Regulations have been implemented in many West European cities. (such as low emission zones, zero emission zones, tolling/congestion charging, pedestrian areas, parking schemes and limited traffic zones). These strategies are meant to comply with the newly adopted air quality standards while also improving traffic.

Generally, vehicle categorization and access is based on the vehcile type, fuel ttype and emission class (Euro emission standard). Overmore, such regulations usually impose some form of toll or fee, in order to gain access in a zone.

Out of the many existing forms of Urban vehicle Access Regulations, most of them are known as Low Emission Zones (LEZs), accounting to 73% [2].

Since this concept is very new and still in development, the goal of this application is to improve the user-friendliness of the Low Emission Zones. I consider the implementations of such zones to be essential in the wellnes of our health and future. However, in order for that to happen, people must comply to the restrictions.

The aim is to create an easy to use web application for access in Low Emission Zones throughout Europe. Since this is an ever changing topic, the database system is incorporated to cover the regulations that are effective in July 2024. It has been designed to be adaptive to continous updates, in order to provide valid information to the end-user.

## Low Emission Zones

Low Emission Zones (LEZs) are geographical areas, ususally found in large urban settlements and have proved to be a great method of reducing the air pollution, especially fine particles, like NO2 which is higly correlated to several respiratory diseases.

The first such environmental zones were started in 1996 in Sweden and were initially created to reduce both air pollution and large vehicles noise. They were later replaced by national regulations that comply with EU standards for environmental zones and only cover heavy-duty vehicles [3]. Such examples were later adopted by other countries and are now widely spread throughout western Europe.

The principle behind the functionallity of Low Emission Zones is to restrict as much as possible the access of highly polluting vehicles. This can be done, either by raising the costs of access through fees or tolls, maintainance for residents or by completely forbidding the access. Another option is to retrofit older vehicles to fit modern regulations, usually done by adding diesel particle filter (DPF) which could place the vehile in a lsightly higher emission standard [5].

## 1.2 LEZs throughout Europe

Considering the transformative nature of a Low Emission Zone, defined by it’s main purpose, to reduce pollution by limiting the vehicle access in designated areas, such sollution cannot be implemented overnight.

The United Europe propose a strategy to gradually implement such areas in the following years [4]. This approcach facilitates the acceptance and adoption of a low emission zone and allows each nation to fine-tune the schemas, to better fit the needs and possibilities of the country and the citizens. Local authorities can better manage the reqirements and priorities, enhancing the effectivness to reduce the pollution as much as possible.

While there is no clear recipe for implementing a low emission zone in a big urban settlement, giving free-will for the nations to create and personalize theirs, gave birth to many such forms. On one hand, having more variations of a regulation, means more case-studies and a faster evolution of this field. Even in a short time, the regulations are now found in manny different forms, some more effective than the other and some more simple to use than the other.

While each approach presents its own set of merits and drawbacks, the end objective remains the same. The Low Emission Zone term can be found under a different name, depenending on the national law it has been regulated by. For exmample, in Germany, low emission zones are known as "Umweltzonen", whil in France, it is referred as ZCR ("Zone à Circulation Restreinte"). Both terms define strict criterias in order to sepparate vehicles based on Euro standard. In order to clearly differentiate the categories, a sticker is assigned for each vehicle and it is required to be displayed in the windshield, in order to be visible for the authorities.

Overmore, each locality has the flexibility to implement it’s own restrictions based on the emission stickers displayed on vehicles' windshields.

The main difference between the LEZ regulations in Germany and France lies in the criterias selected for classification. In Germany, vehicles can be assigned one of the three available emission stickers based on their Euro emission standards. Green being the cleanest and most environmentally friendly, followed by yellow and then red for the highest emissions. These stickers were first introduced in 2008 and because of the regulaitons in place at that time, a diesel vehicle now needs to be at least EURO 4 to be eligible for the green sticker [6].

On the other hand, France inroduced the Crit'Air vignette system in 2017. Crit'Air stickers are also color-coded and classify vehicles based on emissions. However, France has designated six categories ranging from green, which is only designated for 100% electric and hydrogen vehicles to dark gray for vehicles with high pollution.

While both systems serve a similar purpose of regulating vehicle emissions within urban areas, the specific criteria for classification and the appearance of the stickers differ between the two countries. Crit'Air vignette also comes with a long term strategy to intoduce this schema throughout the cities with more than 150.000 inhabitants [7]. Also, the plan is to gradually tighten the standards as the years advance, by switching the minimum required sticker for access to the next one. As an example, in Paris, regulations in place since 1 June 2021, impose minimum Crit'Air sticker 3 (diesel EURO 4 and EURO2 petrol cars). The year 2025 will impose Crit'Air sticker 2 (minimum diesel EURO 5 and EURO4 petrol cars). Initially this restriction was scheduled to be implemented starting from 1st of July 2023 but had to be postoponed [8].

## 1.3 Current situation in Europe

The European Union legislation encourages member states to establish their own regulations for Urban Vehicle Access Regulations, such as Low Emission Zones (LEZs). The decentralized nature of this approach allows each country to tailor the policies to better fit the circumstances. National authorities must take into account differnet factors such as population density, existing infrastructure, public transport, etc. Furthermore, within each country, the local responsibles set specific regulations within their jurisdiction and the national framework.

This decentralized structure offers several advantages. Firstly, it facilitates the implementation of diverse strategies, providing a range of test cases to evaluate the efficacy of different models in addressing air pollution and promoting sustainable urban mobility. Additionally, it acknowledges that national governments are best positioned to understand their own environmental challenges and devise targeted solutions accordingly.

However, this system can also result in complexity and inconsistency for the population. With regulations varying not only between countries but also among different municipalities within the same country, drivers may encounter a patchwork of rules and requirements as they navigate through different regions. This can lead to confusion and logistical challenges, particularly for individuals who frequently travel between areas with differing regulations.

As exemplified by the contrasting Crit'Air sticker system in France and the Umweltplakette system in Germany, where nine stickers are utilized across two countries, each available exclusively within its respective jurisdiction and governed by distinct criteria, the fragmentation of regulations can exacerbate the burden on the populace. The proliferation of unique standards and administrative processes adds layers of complexity and administrative burden, underscoring the challenges inherent in coordinating environmental policies across diverse geographical and political boundaries.

## 1.4 LEZs in Northern Europe

The varying standards and regulations across these Northern European countries add another layer of complexity for individuals seeking to access low emission zones. This divergence underscores the need for a comprehensive understanding of the specific requirements and sticker systems in place in each country, further complicating the experience for users and necessitating careful planning and compliance measures when traveling across borders.

Considering the aforementioned context, accessing a low emission zone becomes a significant challenge for the average individual. The multitude of European countries that have addopted a form of Low Emission Zone and the diverse range of regulations taken into consideration create a complex navigation landscape.

In addition to the stickers present in countries like France and Germany, the European Low Emisson Zone schema is further compounded by a different strategy in Northern Europe. Nations in this region, such as Denmark (Miljøzone), Sweden(Miljözon) and the Netherlands(Milieuzone) implement their own systems for emission regulations. The core principle remains the same, to reduce pollution by restricting the highly polluting vehicles access in city centers. Also, the entry requirements for low emission zones in each country differ.

Within these frameworks, nationally registered vehicles are automatically included in a nation-central database, drastically facilitating the process of complying and aslo the efficency of the LEZ. However, foreign vehicles, need to register online, typically prior to entering the LEZ to avoid penalties. This registration only enables access to the zone for vehicle that actaully comply with emissions standards set by local authorities.

Northern Europe Low Emission Zones are primarly enforced through camera systems, designed to capture the vehicle’s registration number before entering the designated area. This system cross-references the captured registration number with the central database to verify the vehicle’s eligibility for entry. This automated approach enhances efficiency and accuracy while reducing reliance on and costs for manual inspections.

Overall, this digital registration and enforcement model streamlines the process for registered vehicles while promoting compliance with LEZ regulations, ensuring effective management of air quality within urban environments.

# 2 Inclusion of the study's domain of interest

## 2.1 Forecasts

According to the report made by statista.com [9], the forecasts expect an expansion of Low Emission Zones (LEZs) throughout Europe, indicating a substantial increase in the number of LEZs, with estimations suggesting a total of 510 zones in 17 countries. This increase highlights the greenlight put by UE on reducing air pollution and promoting sustainable urban development throughout the continent.

|  |  |  |
| --- | --- | --- |
| Country | Number of LEZ in 2022 | Project number of LEZs by 2025 |
| Italy | 172 | 172 |
| Germany | 78 | 78 |
| United Kingdom | 17 | 18 |
| Netherlands | 14 | 14 |
| France | 8 | 42 |
| Sweden | 8 | 8 |
| Austria | 6 | 6 |
| Denmark | 4 | 4 |
| Spain | 3 | 149 |
| Belgium | 3 | 4 |
| Norway | 3 | 3 |
| Czechia | 1 | 1 |
| Finland | 1 | 1 |
| Greece | 1 | 1 |
| Portugal | 1 | 1 |
| Poland | 0 | 2 |
| Bulgaria | 0 | 3 |

Tabel 1Number of low-emissions zones in Europe 2022-2025[9]

## 2.2 Current context regarding LEZs

The multitude of terms used to designate Low Emission Zones (LEZs) across Europe drives up the complexity for regular individuals when navigating these environmental zones. While the purpose for each designation remains to reduce emissions and improve air quality, the linguistic and cultural diversity adds layers of intricacy.

From "Umweltzonen" in Germany to " Miljøzone " in the Denamrk, and " Distintivo Ambienta" in Spain, the wide terminology presents a challenge for users seeking clarity and understanding. This complexity extends with regulations implemented in France, Belgium, England, Denmark, Sweden, Norway, Hungary, and Italy, each with its unique terminology and approach.

The efectiveness of Low Emission Zones is directly linked to both the rigor of the implementation but also the level of compliance. While the establishment of a LEZ is a great proactive first step towards improving air quality in urban settlements, in reality, the impact relies on the degree individuals comply to the regulations enforced in such areas.

It is essential to keep in mind that even the best designed LEZ strategy can fail to reach it’s intended goals if control measures are lacking or if vehicle owners do not comply. As The Deputy Mayor for Transport has confirmed in [10], automated monitoring systems, such as the use of plate recognition cameras, proove to be an effective enforcement strategy.

Overmore, in order to build popularity and trust in any form of Urban Vehicle Access Regulations, public awareness campaigns serve a crucial role in ensuring that LEZ regulations are upheld. All Nations need to pay effort into conveying public that the only objective is not to create inconveniences or to impose financial burden, but rather to mitigate pollution in highly populated urban centers. Such initiatives are part of a long-term plan desigbed to achieve lasting benefits for public health and environment.

For individuals to fully comply and embrace the notion of Urban Vehicle Access Regulations imposed through Low Emission Zones, it is imperative to be provided a clear overview of the existing LEZ structures and their benefits. The large number of LEZs across Europe, navigating across the continent, throughout major cities, can become pretty challenging and may create onfusion and inconvenience for drivers.

# 3 Thesis Statement

## 3.1 Addressing the Complexity of Navigation thorughout LEZs

Taking into consideration the facts outlined above, I have identified a critical gap in the landscape of Urban Vehicle Access Regulations: a lack comprehensive platforms, tailored for the needs of regular individuals, willing to navigate throughout Low Emission Zones (LEZs) with ease and while also repecting the regulations in place. At this time, available resources often fall short in providing users clear details about LEZ restictions and compliance. Considering the inherent complexities and long term evolution within the LEZ landscape, we can identify this gap as a significant opportunity ripe for exploration.

While online resources and information are indeed available, usually the information is dispersed across many different platforms, with segmentation made by countries or even by cities. Fragmented landscapes can be overwhelming for regular users, who would often find themselves spending their significant time navigating through multiple websites when gathering relevant information for their specific situation and needs.

## 3.2 Similar applications

### 3.2.1 Green-Zones.eu

The Green Zones app provides comprehensive information regarding the Low Emission Zones (LEZs) and accessing criterias across Europe. The application is split on both mobile and the web platform, providing valuable resources for individuals seeking to understand and comply to the regulations in LEZs.

The mobile app offers the users the possibility to conveniently add relevant details about their vehicle. Than, in order to check compliance with a LEZ, the user needs to select one of the points highlighted on the map. This feature is offered free of charge and accessible to all users. Additionally, the app provides air quality information on a number of cities, which is a an important factor taken into consideration when evaluationg the efficiency of a LEZ.

However, to access additional features and services, like saving different vehicles to an account, users are required create a subscription based account, which require a monthly fee. While the premium services offer added functionality, this is rather usefull for enterprise users.

For regular users who only plan a few trips each year, the associated subscription fee could cause significant drawbacks. While the app offers valuable features and services, like the vehicle registration, the app only promises the latest data on for the three available subscription plans. In many cases, the subscription fee may outweigh the benefits for individuals thath rarely travel through Low Emission Zones. This subscription-based model may discourage casual users who seek to information regarding LEZ regulations compliance.

The web platform is a great comlement to the mobile app, and is designed to provide comprehensive information about Urban Vehicle Access Regulations, such as LEZs, actual environmental regulations. The website can also be used to purchase registrations for a number of countires which have LEZ schemas active.

Overall, the Green Zones app offers a user-friendly interface and valuable features for navigating LEZs and promoting environmental awareness. However, the subscription-based model may present a barrier to entry for some users, particularly those who do not require frequent access to premium features.

### 3.2.2 Urban Regulations

UrbanAccessRegulations.eu is designed as a comprehensive online platform for information on different urban access regulations throughout Europe. A significant advantage is the fact that the website offers a wealth of information, organized in an intuitive manner, accessible to anyone with internet access. The website covers the complete range of regulations, from Low Emission Zones (LEZs) to road tolls and emergency schemas, creating a place to find relevant information for any situation.

One very notable feature of UrbanAccessRegulations.eu is the extensive and well-structured database. Users can navigate easily across different categories to find the information relevant to their specific situation or curiosity. Overmore, the website offers very detailed information for different categories of vehicles, which assures accessibility for a wide range of users.

However, while offering a comprehensive coverage, the UrbanAccessRegulations.eu may overwhelm some users with the extensive volume of information at hand. While the strucutre is well-organized, users might need to spend long periods of time diving deep into the website in order to find the specific details for their needs. Further, the addition of personalization features, such as the saving vehicle details and registrations, would expend the possibilities of the website's appeal to users. The large variety of vehicles and regulations could be eased by a tailored application for individual circumstances.

Another positive note, UrbanAccessRegulations.eu offers the infodmation and services free of charge, available online to all users regardless of their financial resources. This free of cost model creates a tremendous advantage, as it eases access to crucial information about Low Emission Zones. Providing so much information at no cost, the website drops financial burdens and facilitates the learning about LEZs. This serves as a fundamental step towards fostering compliance. As individuals become more informed about LEZs, they are better prepared to adhere to regulations, therefore improving the effectiveness of the already existing LEZs and potentially creating a social context for the establishment of additional zones in the future.

In summary, UrbanAccessRegulations.eu provides a large amount of valuable resources for users seeking information on urban access regulations throughout Europe. While the offer compounds comprehensive coverage and is free to use, the website's diverse volume of information and less user-friendly navigation may pose challenges for some unexperienced web users.

## 3.3 Thesis Impact: Contributions and Implications

The development of a new web-based application arises from the identification of a specific niche within the market, tailored for to the needs of regular individuals. This app has been purposefully designed to be intuitive and accessible to everyday users, creating a seamless experience that is both user-friendly and based on a cost-free model. The goal of creating the app is to eliminate all barriers of entry, such as subscription fees or even prior expertise in the domain, in order to democratize access to information about Low Emission Zones. This will empower a wider audience to make informed decisions before buying a new vehicle, while also expanding the impact and reach of LEZs.

One of the key aspects of this app is the emphasis on tailored-solutions, allowing users to create accounts and customize their experience according to their needs. Through account creation, users will save their vehicles to the platform and make use of the route planner feature in order to facillitate navigation across European LEZs. This personalized approach enhances user engagement and ensures that individuals can access relevant information tailored to their specific needs.

In line with the user-centric design, the app adopts a guided interface, streamlining the user experience while also reducing the time required to obtain relevant information for the situation at hand. The intuitive design allows users to quickly obtain the information they require without navigating through extensive pages of content. Overmore, the app features informative text-based pages, for comprehensive insights into LEZs.

At the core, the application makes use of a robust database and extensive algorithms for assigning the correct registration to a vehicle and LEZ access validation. These technical features ensure the accuracy, reliability, timeliness and relevance of the provided information, in oreder to ensure confidence in users and promote compliance to LEZs regulations. While the app is designed to be oriented towards individual consumers, the database model and it’s free-to-use nature are also well-suited for enterprises, accommodating a larger number of scenarios, vehicles and rotues within the same or different accounts.

Despite the main focus set on simplicity and accessibility, the app keeps the same high standards for information quality, consistent with the other applications already established on the market. The purpose is to deliver up-to-date, accurate information, while the application also contributes to raising awareness about Low Emission Zones and spreading the culture of environmental responsibility through it’s users. Essentially, the implementation of this applicatoin takes a significant step by advancing the effectiveness and accessibility of Low Emission Zones. Through it’s unique manner, the application ultimately contributes to the larger scope of improving air quality in European cities by promoting sustainable mobility.

# 4 Technical Documentation

## 4.1 Software Technologies

### 4.1.1 Hypertext Markup Language

Hypertext Markup Language (HTML) is designed as the core foundation of web application development, and is used to create the structure and content of the web pages. As a markup language, HTML makes use of a sytem based on tags and codes inserted inside the text to indicate the way of displaying the text or how software applications should process it. The tags are generally enclosed within angle brackets (</>) and contain attributes to specify additional information or charcteristics about the content.

HTML is used in web documents to define the semantics and layout because it enables developers to compose structured documents, making use of elements such as headings, paragraphs, forms, lists, images, anchortags, etc. Having a clear and concise syntax, HTML facilitates the processof creating well structured and user-friendly web pages that can be interpreted by most web browsers and across all available devices and platforms. Being the backbone of the web applications, HTML creates a strong foundation for building visually appealing and interactive web applications, laying the groundwork for integrating dynamic features with other technologies like CSS and JavaScript.

HTML5 represents the latest evolution of the HTML standard, adding new modern features and capabilities designed to enhance web applications development. Among the newer elements introduced by HTML5 count <header>, <nav>, <article>, and <footer>. Using these tags excels in providing a better organzied structure and a more clear meaning to web documents. Additionally, HTML5 offers support for multimedia elements, with the tags like <video> or <audio>, but also brings advanced form controls and APIs for geolocation [13] and many other functionalities. This latest HTML itteration, allows developers to leavrage it’s capabiolities in oder to create interactive online applications, implementing a seamless user experience across different devices.

Markup languages are commonly used in various contexts, including web development, document processing, and data interchange. For example, HTML (Hypertext Markup Language) is a markup language used to create and structure web pages, defining elements such as headings, paragraphs, links, images, and forms. XML (Extensible Markup Language) is another widely used markup language that allows users to define their own tags and document structures, making it suitable for data storage, document interchange, and configuration files.

Markup languages provide a standardized way to represent and communicate information, enabling interoperability between different software systems and platforms. By separating content from presentation, markup languages facilitate the creation of structured and semantically meaningful documents that can be easily processed, interpreted, and displayed by software applications.

### 4.1.2 Python

Python is a very powerful programming language known for its simplicity in sintax and yet very versatile and reliable, making it an excellent choice for a wide selection of applications. Taking advantage of an extensive standard library and vast ecosystem of third-party packages, Python allows developers to tackle, in a very efficient manner, diverse tasks from data analysis to artificial intelligence and automation to web development.

One of Python's key aspects lies in its flexibility and ease of use, allowing developers to quickly test ideas and implemate solutions. The clean and intuitive syntax helps goes for readability and maintainability, making it accessible to both junior and seniot programmers alike. Overmore, Python's dynamic typing and automatic memory management simplify development, reducing the time and resources required to build and manage complex systems.

When it comes to web development, Python shines as a robust and scalable backend solution. It’s main web frameworks are Django and Flask, which provide developers with powerful tools for building secure web applications with lots of features. Python's asynchronous programming capabilities, supported by frameworks like asyncio, enable efficient handling of concurrent requests and high-performance web services. Furthermore, Python's extensive support for database integration and RESTful APIs makes it well-suited for developing backend systems that seamlessly interact with frontend interfaces and external services. Overall, Python's versatility, simplicity, and comprehensive ecosystem make it an ideal choice for backend development, offering developers the flexibility and power to create sophisticated and reliable web applications.

### 4.1.3 Flask

### 4.1.4 SQLite

### 4.1.5 Javascript

### 4.1.6 APIs

## 4.2 Backend Development

## 4.3 Frontend Development

## 4.2 Software Tools and Technologies

## 4.3 Development Frameworks and Platforms

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