Treball de Fi de Grau/Màster

Master Energy For Smart Cities

Research, evaluation, and application of sustainability and energy indicators in Transport

MEMÒRIA

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Convocatòria: June 2020

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Abstract

The study evaluates the performance level of energy and sustainability of transport in the EU-28 and its Member States during 2013 to 2017 according to global and European goals. By conducting a research among 21 sources, 394 existing indicators are identified and categorized in 4 dimensions (environment, economic, social and innovation) and 18 themes. These indicators are matched with the 3 policies and roadmaps' goals – IRENA Roadmap, UNSDGs and EU Green Deal - resulting in a shorted list. Consequently, the best indicators are adapted according to the previously mentioned goals and transformed in a scale from 0 to 10. As a result, the combination of 8 final indicators, using the mean average method, proposes the Index for energy and sustainability in transport. The proposed methodology can be applied specifically in the EU and it can be used as a simple tool to understand the strengths and weaknesses of energy and sustainability in transport among the Member States. Furthermore, the Index shows that the EU has a low to moderate performance with an average absolute value of 4 in the 0 to 10 scale regarding energy and sustainability in transport, during the time frame analyzed. Additionally, besides evaluating the Index, for each of the 8 indicators is elaborated comprehensive analysis. It is concluded that the EU transportation can be enhanced and specific points for improvement are identified in the indicators.

Table of Contents

List of Figures

List of Tables

Glossary

BEH – Battery Electric Vehicles
EEA – European Environment Agency
EU – European Union
EU-28 – European Union 28 countries including the United Kingdom
GHG – Greenhouse Gas
IRENA – International Renewable Energy Agency
PHEV – Plug-in Hybrid Electric Vehicles
SDG(s) – Sustainable Development Goal(s)
UN – United Nations
USA – United States of America

1. Introduction

In 2019, the transport sector counted 30,8% of the total consumption of Energy in the EU (1), and as a consequence, transport was responsible for 25 % of the Greenhouse Gas emissions in 2018 (2). Also, the transport sector has the lowest level of Renewable Energy usage (3) which generates an evident link not only between both numbers of energy consumption and Greenhouse Gas mentioned above, but to the general performance of the sector itself.
Additionally, as these numbers have a high impact in our society, environment and energy landscape, the world's most influential institutions and the EU have clear objectives in their pollical agendas in order to tackle such effects. The EU New Green Deal, with the higher goal of making European the first climate neutral continent, states clearly the objective of decreasing 90% of transport's Greenhouse Gas emissions by 2050 (4). Moreover, there is a high diversity in the EU countries when it comes to the transport sector, thus, one of the key solutions to achieve such ambitious objectives can be the collection, treatment and evaluation of data from the EU Member States. This solution can enable decision makers to make the best decisions when guiding the strategy of the EU and its Member States.

1.1. Scope and Objectives

This study aims to research the existent indicators for transport, investigate the current policies connecting transport with energy and sustainability, and lastly, apply the most suitable indicators in order to have comprehensive result and analysis.

The application is done nationally to the European Union 28 Member States including the United Kingdom (EU-28) and to the EU itself. The time frame of application is from 2013 to 2017, yearly, with a total of 5 years. Lastly, the content is focused on transport energy and sustainability. These 3 boundaries from the studied system can be seen in the figure Figure 1 – System boundaries of the study.

Figure 1 – System boundaries of the study

The objective of this study is to identify the evolution and contribution to the future targets set by institutions and governments in the transport sector among the above described scope. The results of this study shall answer in an Index with comprehensive format to what is the level performance of energy and sustainability in transport across the EU-28 according to the global and European goals.

1.2. Methodology

The study is divided in 4 simple and crucial steps inter dependent from each other as it can be seen in Figure 2.

As **step 1**, a research among indicators and indexes related to transport is conducted in order to map and analyze a representative sample of studies and indicators used to evaluate transport. In this analysis, the indicators are identified with dimensions and themes independent from the resources fo (Marquez-Ballesteros, Mora-López, Lloret-Gallego, Sumper, & Sidrach-de-Cardona, 2018)r a consistent and transversal analysis between the different sources.
As **step 2** an analysis of policies related to energy and sustainability in transport is conducted in order to identify the types of assessment needed and where does this assessment can represent an added value.
As **step 3**, an identification of the correspondent indicators from step 1 that can evaluate the energy and sustainability goals in step 2 is performed.
As **step 4**, and last one, the indicators selected in step 3 are applied to the defined system in section 1.1 and together form an index.

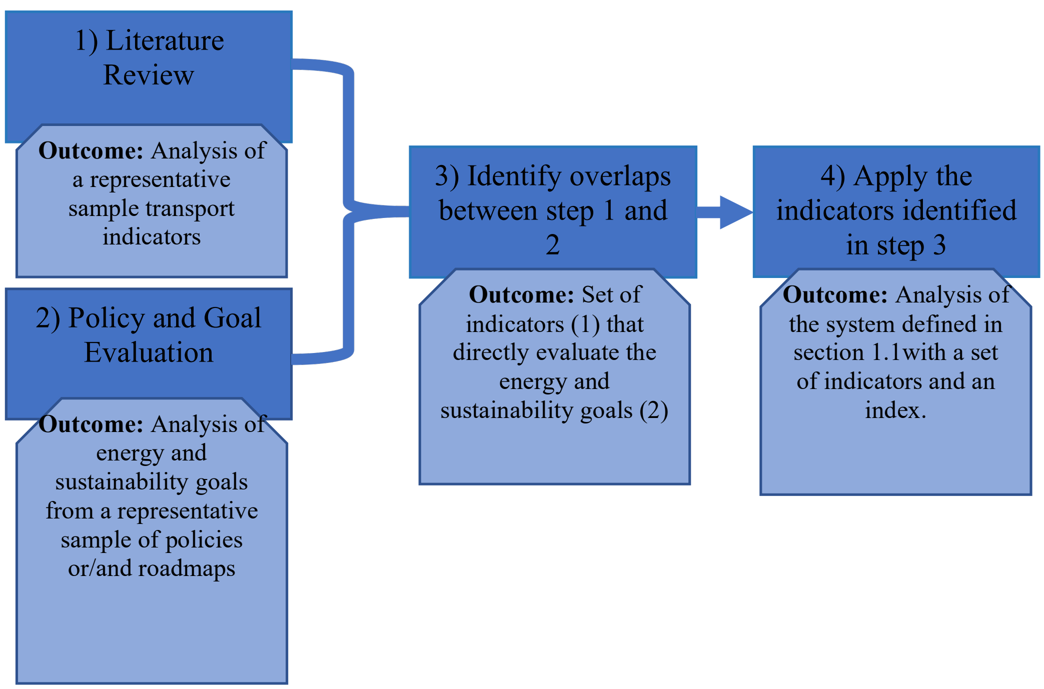

Figure 2 - Study methodology

2. Literature review

The aim of this part of the study is to review, analyze and make conclusions according to the already published studies - indicators and indexes - in the overall transportation field. A total of **21 different resources** were analyzed. Furthermore, a total of **394 indicators** were evaluated and categorized according to their dimension – social, economic, environment and innovation (non-exclusive) – and attributed themes.

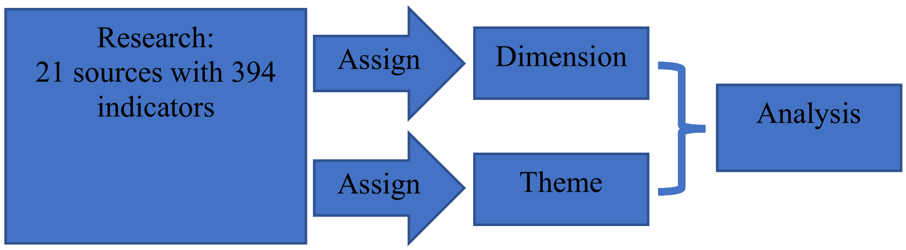

Figure 3 - Literature review methodology

In Figure 3 a comprehensive map of the methodology if this section can be observed.

2.1. Research

The evaluated research was described according to the following criteria:

1. Publication Year
2. Scope – the specific geographic coverage of the elected research – from the city level to the global one.
3. Subject – the applicability and goal of the research made, divided in the three forms:
    a. City – indicators created for urban areas only.
    b. Region – indictors tailored for a specific part of the world.
    c. Country – indicators suitable for a country analysis.
4. Result application (*Applied to*) – number of applications in real cases of the indicators evaluated.
5. Number for indicators – number of indicators in the study.

In addition, in order to have a good representative sample, was aimed and achieved a high diversity among the 5 criteria defined - more information in Table 1.

It was noticed that there was an extremely diverse level of analysis among the 21 sources from the literature review. While some studies described their indicators in detail with goals, definition, parameters and units, others simply framed a factor related to transportation. Furthermore, the same type of discrepancy was observed with the results analysis with some exposing the detailed outcomes of the result application, at the same time as others merely stated what were the application subjects.

The sources of the researched varied from well-known and big organizations worldwide such as the European Union or European Environment Agency to the local governments or universities spread across the globe.

Resource	Reference	Last Publication Year	Scope	Subject	Applied to:	Number of Indicators
Indicators to Assess Sustainability of Transport Activities	(6)	2007	EU	Country	27	55
The GPI Transportation Accounts: Sustainable Transportation In Halifax Regional Municipality	(7)	2008	Nova Scotia	Region	1	8
Methodology and indicator calculation method for sustainable urban mobility	(8)	2016	World	City	6	22
Sustainable Urban Mobility Indicators (SUMI)	(9)	2020	EU	City	-	18
Sustainable Urban Transport Index (SUTI)	(10)	2017	World	City	Multiple cities	10
OECD Transport Indicators	(11)	2020	World	Country	42	90
EcoMobility Shift - Assess, Audit and Label	(12)	2013	Europe	City	6	20
Sustainable Cities Mobility Index 2017 Bold Moves	(13)	2017	World	City	100	23
The Future of Mobility 3.0	(14)	2018	World	City	84	27
Developing Sustainable Transportation Performance Measures For Txdot's Strategic Plan: Technical Report	(15)	2009	USA	Region	6	13
Guide To Sustainable Transportation Performance Measures	(16)	2011	USA	Region	Multiple Cities	12
Transportation-Efficient Land Use Mapping Index (TELUMI), a Tool to Assess Multimodal Transportation Options in Metropolitan Regions	(17)	2011	Seattle	Region	1	9
Sustainable Transportation Performance Indicators (STPI)	(18)	2002	Canada	Country	1	14
Sustainable Urban Transport Assessment in Asian Cities	(19)	2013	Asia	City	21	3
Development And Application Of I_SUM - An Index Of Sustainable Urban Mobility	(20)	2010	Brazil	City	1	87

Resource	Reference	Last Publication Year	Scope	Subject	Applied to:	Number of Indicators
Evaluation of sustainable policy in urban transportation using systemdynamics and world cities data: A case study in Isfahan	(21)	2015	Iran	City	1	9
Sustainable development of energy, water and environment systemsindex for Southeast European cities	(22)	2015	Southeast Asia	City	12	35
Comparative analysis of passenger transport sustainability in Europeancities	(23)	2015	EU	City	23	25
A methodological framework for benchmarking smart transport cities	(24)	2014	World	City	26	21
EEA Transport Indicators	(25)	2019	EU	Country	28	14
Measuring Transportation Investments, The Road to Results	(26)	2011	USA	Region	50	6

Table 1 - Research analysis

2.2. Dimensions

The relevant indicators from the research made were assigned to different dimensions in order to a have consistent and multi-resource analysis. Each single indicator has been identified non-exclusively with at least one of the four dimensions below defined in section 2.2.1. Each dimension's goal is to set an overall perspective of what the indicator is trying to evaluate in a broader level.

2.2.1. Definition

The 4 dimensions thereafter described can have overlaps in some of the indicators.

Environment
This dimension comprises all topics concerning climate, energy and that can have environmental impacts in general. At the climate level it includes direct measures such as air quality and emissions, or indirect ones such as the impact of the different transport modalities (for example bicycles), the use of land or infrastructure. Moreover, at the energy level it includes all measures related to the energy consumption and efficiency. Last but not least, all direct environmental impacts such as waste or hazardous materials, noise or

impacts on ecosystems are included. In addition, indirect environmental measures such as in financial indicators, transport efficiency or in other exceptional cases are also included.

Economic

This dimension comprises all topics concerning financing and resources. From the one hand, all indicators referring to investment, costs or financial capacity are directly linked to this economic dimension. On the other hand, from the resources perspective all indicators referring to infrastructure, available transport services and their efficiency are included. Lastly, in exceptional cases when there is a link some indicators that have an indirect impact on the economy are considered, and an example, strategy and evaluations in the policy level are included.

Social

This dimension can be considered the most representative as it contains indicators with direct and indirect impacts on the society. From the direct side are considered all topics directly linked with the citizens, they can be considered social costs or perks such as the accessibility for mobility and its capacity, the security and safety on transportation, health, the human resources area in the sector, urban planning, policies and the direct financial costs to the citizens. From the indirect perspective, are considered any topics from the other dimensions that may affect the citizens in a secondary level, for example, environmental impacts, investments, new mobility models or infrastructures. Lastly, any other exceptional cases can be considered in case there is a proven direct or indirect link to the citizens.

Innovation

Although dimension is less common on most of the researches, it is here included, as according to Ms. Ursula Von der Leyen, President of the European Commission, speech there is the need to *harness digital technologies to make mobility smart as well as sustainable* (27). Therefore, it is here created to fill the gaps for novel indicators that evaluate new technology systems, transportation models or mechanisms in the transportation sector.

2.2.2. Analysis

According to the definitions in the section 2.2.1 and the number of indicators analyzed there is a clear dominance in terms of absolute number on the social dimension as it can be seen in the Table 2 and a high number of overlaps with the others as it can be seen in the Figure 4. These two facts can be explained by three concrete points: this dimension's definition - *contains indicators with direct and indirect impacts on the society* (section 2.2.1); the non-exclusivity of indicators dimensions; and the focus on most of the research in mobility and urban mobility which has a strong presence of the transportation system impacts on the citizens.

Dimensions	Total
Social	272
Economic	182
Environmental	101
Innovation	39

Table 2 – Total number of indicators assigned in each dimension

Together, the Environmental and Economic dimensions, represent a more equitable division, also, they are mostly overlapping with the social dimension in the Figure 4. Lastly, the innovation dimension is the less present in the analyzed indicators. By evaluating the Figure 4 it is noted the necessity of more indicators for the innovation dimension, not only by itself, but also for social and environmental innovation, as it is mostly combined with the economic dimension due to its relation with infrastructure in the evaluated research sample.

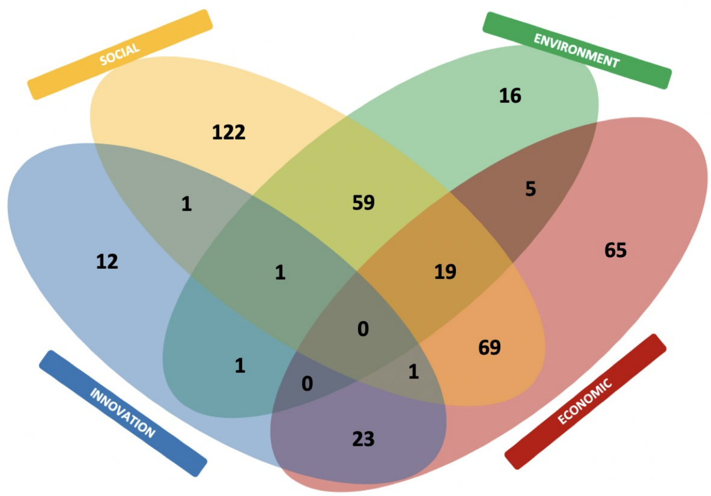

Figure 4 - Wien Diagram for the 4 dimensions analyzed: Social, Economic, Environment and Innovation

2.3. Themes

The relevant indicators from the research made were assigned to exclusively to different themes with the objective of a more in-depth analysis of the research. Nonetheless, the themes are here defined in the section 2.3.1 and assigned transversally to the whole sample of the analyzed indicators.

2.3.1. Definition

Theme	Description
1. Accessibility and Mobility[1]	Quality of transportation and availability of mobility services to the population such as public transport, shared mobility, or any other basic services. Accessibility to transportation directly related to the geographic area, social status or life status (e.g. disadvantaged people)
2. Citizen Engagement	Means of measurement for participation of citizens in in the decision-making process and education of the population on the relevant topics.
3. Emissions	Evaluation of impacts of transportation in the air quality and pollution due to energy sources and transport intensity. It comprises Greenhouse Gas Emissions and air quality hazardous particulates evaluation.
4. Energy	Direct evaluation of energy sources and efficiency of transport. All energy parameters of the different modes' transportation, including fossil fuels and fossil free modes of transportation are included. The parameters included are calculated according to energy production or consumption.
5. Health	Direct evaluation impacts on the health of the citizens such as noise hindrance, or diseases due to pollution. [2]
6. Human Resources	Creation of jobs and social impacts in the employment, expertise and knowledge of the population.
7. Impacts on environmental resources[1]	Impacts in the earth ecosystems and living creatures (fauna and flora), natural disasters or environmental studies.
8. Infrastructure[1]	Measure of classic transportation facilities such as roads, railways, transport stations, parking areas, and all urban and non-urban transportation facilities. It evaluates also all constructed facilities with relation to transport including information and operational systems in place.

[1] Adapted from (6)

[2] Despite mentioning also air quality and pollution as the theme Emissions, the Health theme evaluates the impacts on the population, while the other measures the impacts on the air.

Theme	Description
9. Information & Technology systems and new mobility models	Existence and performance of new information and technology systems for transport such as new mobility models: platforms for mobility sharing services, smart cards, traffic management, and mostly all the smart mobility iniciatives.
10. Land use	Direct measurement of land use and its relation or not to transport. This theme aims to be merely quantitative as no qualitative measures should be included.
11. Multimodality	Evaluation of absolute or relative quantity of the different modes of transportation including traditional as road transport, railways, air transport, maritime transport, and, new modes as cycling for example.
12. Strategy	Public and private institutions joint or sperate strategic initiatives and partnerships. It also includes all policy and legislation topics.
13. Transport Costs and Investments[1]	Includes two sides of finance in transport from the consumer or citizen and from the institutions, governments or transport providers. On the citizen side, it entails all topics related transport costs or incentives and affordability. On the institutions, governments or transport providers side, it includes investments, finance of transport (e.g. subsidies), costs of infrastructure and operation, and returns of investment.
14. Transport Demand and Intensity[1]	Inclusion of two main areas: performance of transport from different perspectives, for example, usage efficiency in time, congestions, occupancy according to mode of transport and area; and frequency of transport utilization or availability by type of user, type of transport.
15. Urban Planning	Both qualitative and quantitative evaluations of urban areas for citizens. It comprises information related to quality of public spaces, availability of facilities, and classical urban planning topics such as block design, density and urban growth.[3]
16. Vehicle Fleet	Vehicle fleet information in absolute and relative formats, combining factors available for vehicles such as type of vehicle, energy mode, age, size, etc…
17. Safety	Accidents and unpredictable negative occurrences that directly affect the citizens while using transportation on private or public modes. It also includes measures of security side related to the before mentioned conditions.
18. Index	A combination of several indicators that weighted generate a final number according to the several individual evaluations. This theme is used for indexes that were considered indicators in studies and not being specific enough to be included in the remaining ones.

Table 3 - Definition of Themes

[3] This theme comprises that indicate the strategy of the urban areas, thus, despite some similarity with Land Use, they both evaluate different goals and specific parameters.

2.3.2. Analysis

It can be seen a trend to the more traditional measurements of transport in Figure 5, as the Top 5 is composed, respectively, by Infrastructure, Transport Demand and Intensity, Emissions, Transport Costs and Investments, and Accessibility and Mobility. As a consequence of this centralization, amongst the research based on the sources from Table 1 - Research analysis, there were a heavy recurrence of indicators belonging to these 5 themes, what makes it them not only repetitive but also unnecessary for production of new methodology.
Furthermore, and accordingly, there is a clear necessity for a revision of the indicators used to measure transportation different themes in order to increase diversity and therefore identify new inefficiencies to solve.

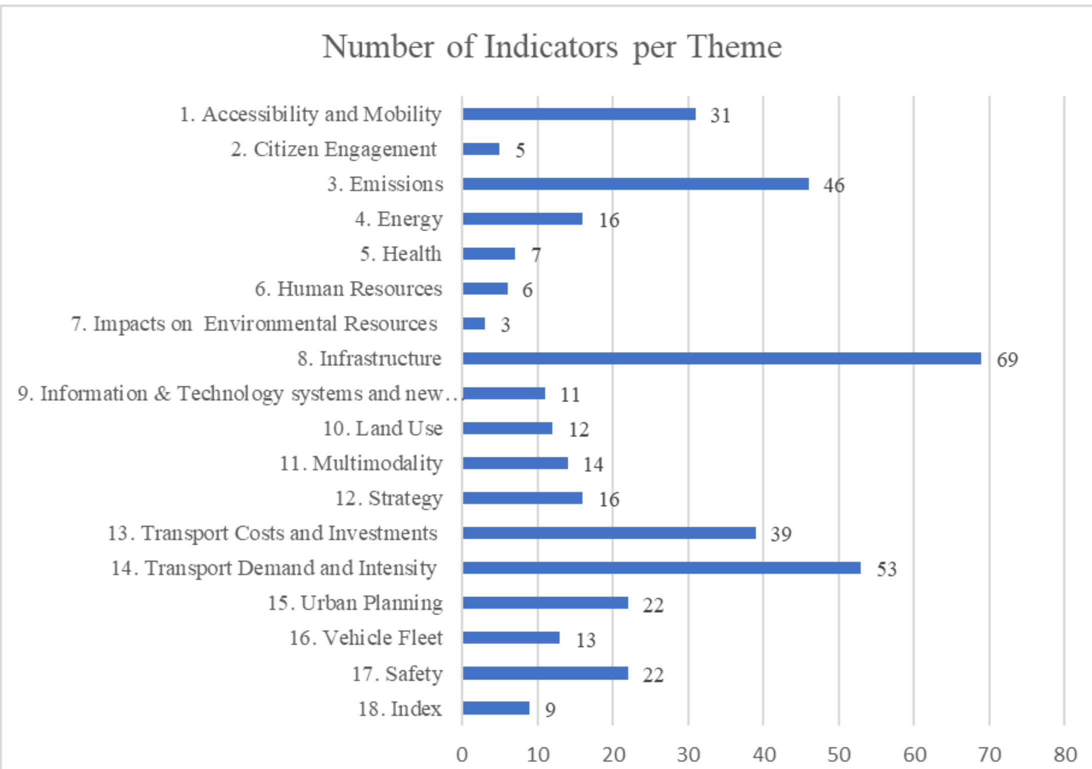

Figure 5 - Number of Indicators assigned to each theme

3. Policy Goals and Indicators' Alignment

In this section three policy/roadmap publications are analyzed and extracted the most important transport related goals or targets are extracted in order to match them with the defined themes at the section 2.3.
Furthermore, a final set of themes supported by the mentioned goals and targets is obtained. This set is assigned to the suitable indicators to be applied from the research (Table 1 - Research analysis) according to the defined criteria in section 3.3.

3.1. Methodology

This section's methodology can be divided in two steps – Figure 6.
In **Step 1** (section 3.2), a selection of policy/roadmap publications is analyzed, and a list of goals extracted from each publication. Then, by identifying each goal with a specific Theme defined in section 2.3, the output of the section is created by this being is a list of Themes with the respective goals' background.
In **Step 2** (section 3.3), these Themes are cross checked with the Indicators List from section 2.1 and according to a defined criteria the final appointed list of indicators is obtained.

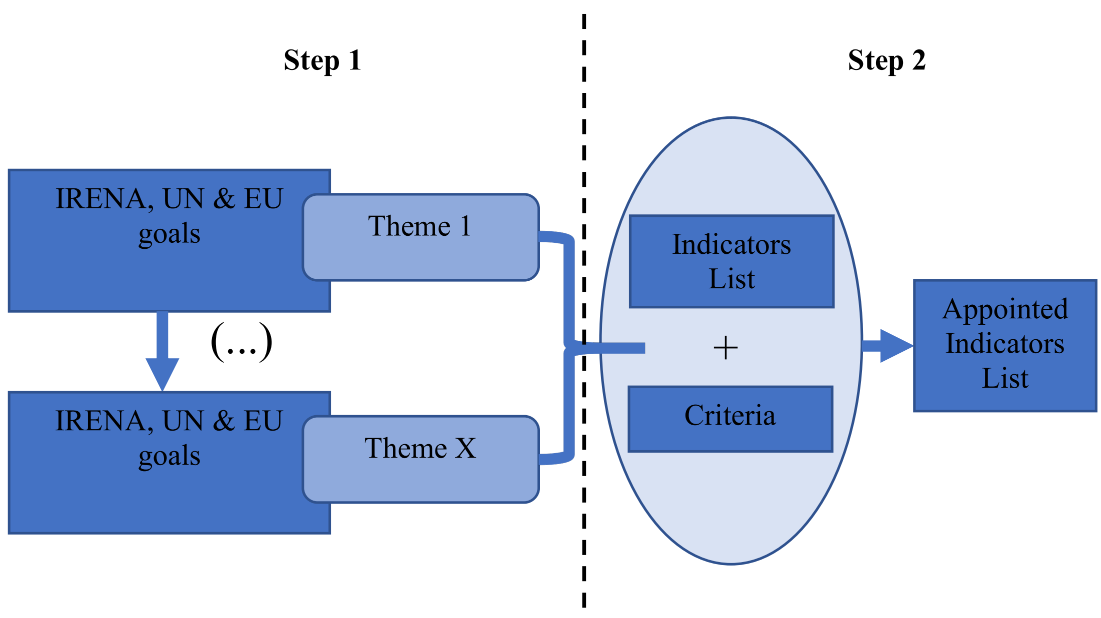

Figure 6 - Methodology for electing the final set of indicators

3.2. Policy Analysis

Three published policy/roadmaps were selected according to the two of the system boundaries defined in this study at section 1.1
In order to cover the content set in section 1.1 – *Sustainability and Energy in Transport* – it was chosen IRENA Global Energy Transformation, A Roadmap to 2050 (28) in order to represent the global interests of the energy sector, and, the United Nations Sustainable Energy Goals (29) in order to represent the global interests of sustainability. Moreover, regarding the geography – *EU-28* – it was selected the EU New Green Deal (4) in order to represent the European Union's interests in Energy and Sustainability.

Each source's goal has been assigned with a code as it can be observed in Table 4. While IRENA and EU have the goals' number assigned sequentially, the UN has them assigned according to the SDGs number.

Source	Code
IRENA, 2018	I[goal number]
United Nations, 2015	UN[goal number]
European Commission, 2019	EU[goal number]

Table 4 - Goal Codes

3.2.1. IRENA Global Energy Transformation, A Roadmap to 2050

In this roadmap, IRENA, identifies the focus areas where policy and decision makers need to act in order to achieve its energy targets. One of its main components is the role of cost-effective decarbonization of transport. In Table 5 the sector of transport in the report is examined, its main goals extracted and then, the Themes defined in section 2.3 are assigned to the text extracts.

Description	Goal(s) (by 2050)	Theme(s)
Under the REmap Case, the transport sector increases the electrification of passenger transport significantly as well as the use of biofuels. The REmap Case also assumes the introduction of hydrogen produced from renewable electricity as a transport fuel. The combination leads to a drop of nearly 70% in oil consumption by 2050 compared to 2015. The share of electricity in all of transport sector energy rises from just above 1% in 2015 to 33% in 2050, 85% of which is renewable. Biofuels increase their share from just below 3% to 22% in the same period.	I1) Decrease oil consumption by 70% I2) Increase share of electricity in transport to 33 % (85% of such Renewable) I3) Increase Biofuels share to 22%I	• Energy

Description	Goal(s) (by 2050)	Theme(s)
Under the REmap Case, in absolute terms, total liquid biofuel production grows from 129 billion litres in 2015 to just over 900 billion litres in 2050. Nearly half of this total would be conventional biofuels, whose production would more than triple, requiring significant upscaling. The other half would be advanced biofuels, which can be produced from a wider variety of feedstocks than conventional biofuels, but which supply just 1% of biofuels today. The steep increase in biofuel production requires careful planning that fully considers the sustainability of biomass supply	I4) Increase biofuels production to 900 billion liters	• Energy
New energy sources, in combination with information and communication technologies (ICT), are changing the entire transport industry. As performance improves and battery costs fall, sales of electric vehicles, electric buses and electric two- and three-wheelers are growing. In 2017 around 3 million electric vehicles were on the road. Under the REmap Case, the number would increase to over 1 billion by 2050. To achieve this, most of the passenger vehicles sold from about 2040 would need to be electric. Under the REmap Case, while about half the stock of passenger vehicles would be electric by 2050, closer to 75% of passenger car activity (passenger-kilometres) would be provided by electric vehicles.	I5) Increase the number of Electric Vehicles to 1 billion I6) Passenger activity provided at the rate of 50% by electric vehicles	• Vehicle Fleet
Nearly USD 14 trillion of total investment would be required under the REmap Case in the transport sector by 2050. Around USD 3.4 trillion would be needed to develop the biofuel (predominantly advanced biofuels) and hydrogen industries. The balance would be needed to develop electrification and energy efficiency.	I7) Investment of 14 trillion USD in transport sector	• Transport Costs and Investments
Analysis shows that the combination of low-carbon technologies proposed in the REmap Case can cut transport emissions to just 3 Gt of CO2 annually by 2050, which represents a 70% reduction compared to current policies in the Reference Case.	I8) Reduction of transport emissions from 7.7 GtCO2/year to 3.1 GtCO2/year	• Emissions

Table 5 . Goals from IRENA Global Energy Transformation, A Roadmap to 2050 and Theme Assignation. Adapted from (28)

3.2.2. United Nations Sustainable Development Goals

The United Nations (UN) is one of the global leading organizations when it comes to promoting sustainable development, thereby, the transportation sector is included in their Sustainable Development Agenda. Consequently, in 2016, the UN launched a call for action by all countries to promote prosperity while protecting the planet and published 17 Sustainable Development Goals (SDG) (29). In the Table 6 the Transport Related SDGs and their sub targets are thereafter identified and assigned to the Themes defined in section 2.3.

Sustainable Development Goal	Target(s)	Theme(s)
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	*9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all*	• Infrastructure • Affordability • Accessibility and Mobility • Transport Costs and Investments
	9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	• Infrastructure • Energy • Emissions
11. Make cities and human settlements inclusive, safe, resilient and sustainable	*11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons*	• Safety • Affordability • Accessibility and Mobility
12. Ensure sustainable consumption and production patterns	*12.C Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities*	• Energy • Transport Costs and Investments

Sustainable Development Goal	Target(s)	Theme(s)
13. Take urgent action to combat climate change and its impacts	*13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*	• Emissions • Impacts on Environmental Resources

Table 6 - United Nations Sustainable Development Goals and sub Targets related to transport and Theme assignation. Adapted from (29)

3.2.3. European Union New Green Deal

The European Green New Deal is the roadmap for making the EU Economy Sustainable taking into consideration the climate and environmental challenges and turning them into opportunities across all policy areas and making the transition just and inclusive for all (4). The EU Green Deal aims to transform EU into a fair and prosperous society and economy with 0 net greenhouse house gas emissions by 2050. The European Commission understands that this roadmap shall be cross sectoral, thus, it comprises a set of elements to be included in the design of transformative policies. According to the objectives of this study the focused sector analyzed from the EU Green Deal will be:

5. Accelerating the shift to sustainable and smart mobility (4)

Thereby, it can be observed in Table 7 the specific goals from this element.

Description	**Goal**	**Theme(s)**
Transport accounts for a quarter of the EU's greenhouse gas emissions, and still growing. To achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050. Road, rail, aviation, and waterborne transport will all have to contribute to the reduction. (...)	EU1) Reduce 90 % of GHG emissions of transportation	• Emissions • Energy
Multimodal transport needs a strong boost. This will increase the efficiency of the transport system. As a matter of priority, a substantial part of the 75% of inland freight carried today by road should shift onto rail and inland waterways. This will require measures to manage better, and to increase the capacity of railways and inland waterways, which the Commission will propose by 2021. (...)	EU2) Reduce the freight road transport and increase multimodality.	• Multimodality
Automated and connected multimodal mobility will play an increasing role, together with smart traffic management systems enabled by digitalisation. The EU transport system and infrastructure will be made fit to support new sustainable mobility services that can reduce congestion and pollution, especially in urban areas. The Commission will help develop smart systems for traffic management and 'Mobility as a Service' solutions, through its funding instruments, such as the Connected Europe Facility.	EU3) Decrease pollution and congestion in cities.	• Emissions • Transport Demand and Intensity
	EU4) Increase of new mobility models (such as MaaS)	• IT systems / New mobility models

Description	**Goal**	**Theme(s)**
The price of transport must reflect the impact it has on the environment and on health. Fossil-fuel subsidies should end and, in the context of the revision of the Energy Taxation Directive, the Commission will look closely at the current tax exemptions including for aviation and maritime fuels and at how best to close any loopholes.	EU5) Increase taxes for fossil fuels and end of subsidies.	• Transport Costs and Investments
(...) The Commission will also give fresh political consideration as to how to achieve effective road pricing in the EU. (...)	EU6) Achieve effective road pricing.	• Transport Costs and Investments
The EU should in parallel ramp-up the production and deployment of sustainable alternative transport fuels. By 2025, about 1 million public recharging and refuelling stations will be needed for the 13 million zero- and low-emission vehicles expected on European roads. (...)	EU7) 1 million public recharging and refueling stations by 2025	• Infrastructure • Energy
The EU should in parallel ramp-up the production and deployment of sustainable alternative transport fuels. By 2025, about 1 million public recharging and refuelling stations will be needed for the 13 million zero- and low-emission vehicles expected on European roads. (...) Transport should become drastically less polluting, especially in cities. The Commission will propose more stringent air pollutant emissions standards for combustion-engine vehicles and revise the legislation on CO2 emission performance standards for cars and vans to ensure a clear pathway from 2025 towards to zero emissions mobility system. It will consider applying European emissions trading to road transport, as a complement to existing and future CO2 emission performance standards for vehicles. (...)	EU8) 13 million zero or low emissions vehicles by 2025	• Vehicle Fleet • Energy
	EU9) Improve air quality and reduce emissions	• Emissions

Table 7 - EU Green Deal Transport Goals identification and Theme assignation. Adapted from (4)

3.2.4. Goal and Theme Aggregation

According to the previous three sections – 3.2.1,3.2.2 & 3.2.3 – the goals from the different sources are aggregated according to the common Themes and a final organization can be observed in Table 8.
The goal EU4 was not included due to the lack of clarity in the policy extract.

Goal	Theme(s)
I8) Reduction of transport emissions from 7.7 GtCO2/year to 3.1 GtCO2/year by 2050 EU1) Reduce 90 % of GHG emissions of transportation EU10) Reduce CO2 emissions EU 9) Improve air quality in cities UN9) Sustainable Development Goal 9, Target 9.4 UN13) Sustainable Development Goal 13, Target 13.1	Emissions
EU2) Reduce the freight road transport and increase multimodality	Multimodality
EU3) Decrease pollution and congestion in cities.	Transport Demand and Intensity
I7) Investment of 14 trillion USD in transport sector by 2050 EU5) Increase taxes for fossil fuels. EU6) Achieve effective road pricing UN9) Sustainable Development Goal 9, Target 9.1 UN12) Sustainable Development Goal 12, Target 12C	Transport Costs and Investments
EU7) 1 million public recharging and refueling stations by 2025 UN9) Sustainable Development Goal 9, Target 9.1 and 9.2	Infrastructure
I5) Increase the number of Electric Vehicles to 1 billion by 2050 I6) Passenger activity provided at the rate of 50% by electric vehicles by 2050 EU8) 13 million zero or low emissions vehicles by 2025	Vehicle Fleet
I1) Decrease oil consumption by 70% I2) Increase share of electricity in transport to 33 % (85% of such Renewable) by 2050 I3) Increase Biofuels share to 22% by 2050 I4) Increase biofuels production to 900 billion liters by 2050 UN9) Sustainable Development Goal 9, Target 9.4 UN12) Sustainable Development Goal 12, Target 12C	Energy

Table 8 - Goal aggregation and assigned Themes

3.3. Indicator Selection

The indicator selection is based on the list of 394 indicators from research (Table 1 - Research analysis), the Themes selected in the section 3.2. and defined below criteria.

The selection of the indicators from the research was based on 4 essential criteria:

1. Indicator Definition
Only indicators with a clear definition, parameters and units were selected. Unspecified indicators were by default excluded.

2. Content
Not only the Theme should match in the indicator and goal but also the goal(s) itself(themselves) should refer to the same information as in the indicator. This enables a narrowing down process from the full list of researched indicators, to a smaller selection according to the theme and then to a final shorted list.

3. Geographic Application
According to the scope of the project the system geographical boundary is the EU-28, therefore, the indicator should be equal or higher in coverage – for example, European or Global used indicators. These criteria are crucial to avoid the risk of misinterpretation of results due to the mismatch of evaluated factors between different parts of the world. Furthermore, the specific application on subject was prioritized for countries as the analysis of this report aims for a national and international evaluation of the transport sector and not only at the urban level.

4. Data Availability
As the next step of this study is to apply the selected indicators, although some of the indicators might have the perfect match in the 3 criteria above mentioned, only indicators with available and complete dataset were selected.

In Table 9 the final selection can be observed.

Goal(s)	Theme(s)	Chosen Indicators from Literature
I8) Reduction of transport emissions from 7.7 GtCO2/year to 3.1 GtCO2/year by 2050 EU1) Reduce 90 % of GHG emissions of transportation EU10) Reduce CO2 emissions EU 9) Improve air quality in cities UN9) Sustainable Development Goal 9, Target 9.4 UN13) Sustainable Development Goal 13, Target 13.1	Emissions	- Greenhouse gas emissions from transport in Europe (25) - Exceedances of air quality limit values due to traffic (25)
EU2) Reduce the freight road transport and increase multimodality	Multimodality	- Road transport (6) - Railway transport (6) - Inland waterway transport (6)
EU3) Decrease pollution and congestion in cities.	Transport Demand and Intensity	- Congestion and Delays (13)
I7) Investment of 14 trillion USD in transport sector by 2050 EU5) Increase taxes for fossil fuels. EU6) Achieve effective road pricing UN9) Sustainable Development Goal 9, Target 9.1 UN12) Sustainable Development Goal 12, Target 12C	Transport Costs and Investments	- Transport fuel prices and taxes in Europe (25)
EU7) 1 million public recharging and refueling stations by 2025 UN9) Sustainable Development Goal 9, Target 9.1 and 9.2	Infrastructure	- Investment in transport infrastructure (per capita by mode/ as share of GDP) (6)
I5) Increase the number of Electric Vehicles to 1 billion by 2050 I6) Passenger activity provided at the rate of 50% by electric vehicles by 2050 EU8) 13 million zero or low emissions vehicles by 2025	Vehicle Fleet	- Electric vehicles as a proportion of the total fleet (25)
I1) Decrease oil consumption by 70% I2) Increase share of electricity in transport to 33 % (85% of such Renewable) by 2050 I3) Increase Biofuels share to 22% by 2050 I4) Increase biofuels production to 900 billion liters by 2050 UN9) Sustainable Development Goal 9, Target 9.4 UN12) Sustainable Development Goal 12, Target 12C	Energy	- Energy Consumption by Transport Mode (6) - Greenhouse gas emissions from transport in Europe (25)

Table 9 - Selected Indicators according to Goals and Themes

4. Data Analysis and Treatment

The indicators selected in the previous section are applied to the EU-28, the results of this application are filtered in a process named in this study as indexation and this gives as a result a data set of dimensionless values in scale of 0 to 10. These values combined will be the input for the final index of energy and sustainability in transportation. The detailed process and elaboration of each Indicator and Index can be observed in this section.
For the data calculation and treatment was used a combination of MATLAB and Microsoft Excel.

4.1. Methodology

The process can be divided in 3 comprehensive steps has it can be observed in Figure 7.

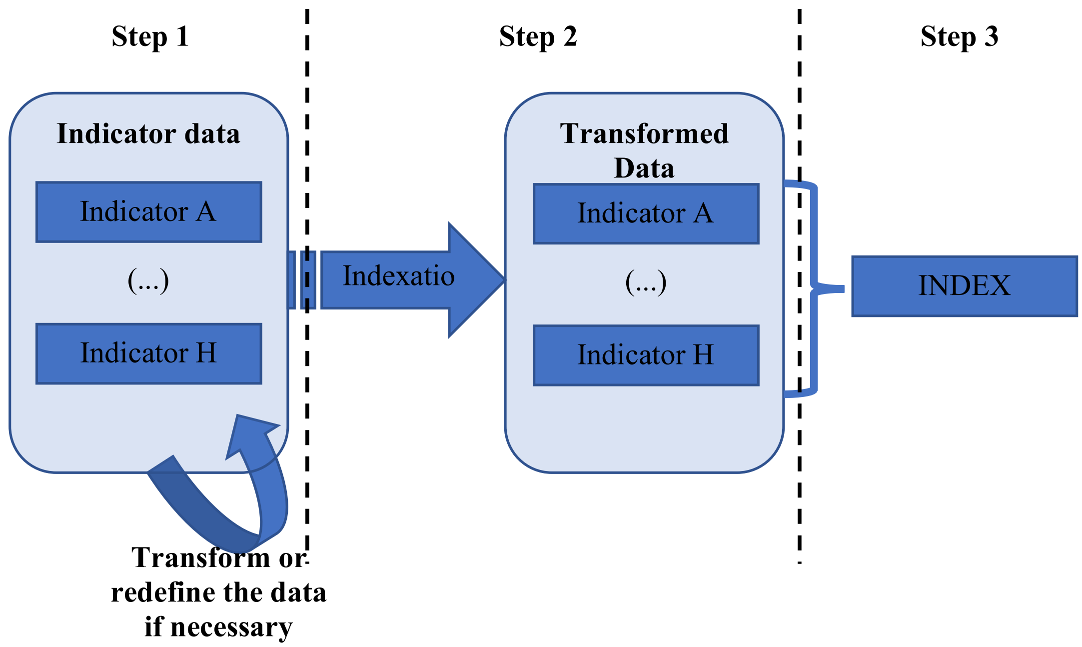

Figure 7 - Methodology of creation of the index

In **Step 1**, the indicators final dataset is collected if already available. In case of non-availability the data source is used to calculate the indicator is used for recalculation and, in some cases, a redefinition of the indicator for more tailored solution for the goals defined in section 3 is made - Table 10.

Research Indicator	Final Indicator	Code
Greenhouse gas emissions from transport in Europe **(30)**	Greenhouse Gas Emissions from Transport	A
Exceedances of air quality limit values due to traffic **(31)**	Exceedances of Air Quality limit due to Traffic	B
Road transport **(6)** Railway transport **(6)** Inland waterway transport **(6)**	Multimodality in freight transport	C
Congestion and Delays (Arcadis, 2017)	Congestion and Delays	D
Transport fuel prices and taxes in Europe **(25)**	Transport Fuel Consumer Prices and Taxes in Europe	E
Investment in transport infrastructure (per capita by mode/ as share of GDP) **(6)**	Investment in Transport Infrastructure (according to GDP)	F
Electric vehicles as a proportion of the total fleet **(25)**	Electric Vehicles as a Proportion of the total fleet	G
Energy Consumption by Transport Mode **(6)**	Energy Consumption – Electricity and Biofuels	H

Table 10 - Final Indicators adopted

In **Step 2**, the final result is transformed through the process named in this study as indexation. It consists on the transformation, according to each individual case and by applying an indicated conversion, of the final data from the indicator in the respective unit (e.g. percentage, grams per square meter, etc.) to a scale from 0 to 10.
It is a quantitative scale for illustrating the quality of each subject of evaluation (EU-28 in this case) at the correspondent indicator. The scale is from 0, as being terrible, to 10, as being excellent and varying linearly in between.

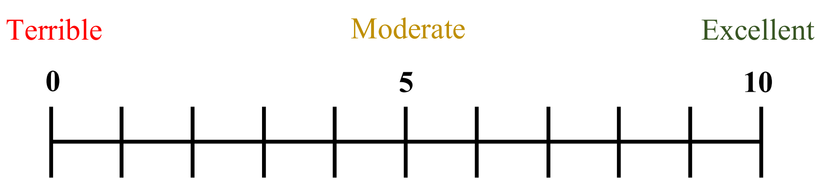

Figure 8 – Index and transformed indicators scale

In **step 3**, in order to simplify the study at the same time as having concrete results, the mean average (equal weights of 0,125) of the 8 indicators considered is calculated giving the final value per each country in the EU-28 and the EU itself.

$$INDEX = \frac{A+B+C+D+E+F+G+H}{8} \qquad \text{Equation 4.1.1}$$

4.2. Indicators

Each indicator is described in 4 distinct parts:

- Definition: Concrete explanation of what the indicator is evaluating.
- Parameter: variables analyzed in the indicator.
- Units: Units of the used final data set before indexation
- Data Source(s): Data source(s) used in the indicator
- Indexation: Definition of the tailored transformation process to the 0 to 10 scale.

4.2.1. A - Greenhouse Gas Emissions from Transport

Definition: Total greenhouse gas emissions from transport, namely: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbon (HFC), perfluorinated compound (PFC), Nitrogen trifluoride (NF_3), and unspecified mix of HFCs and PFCs are analyzed in this indicator (Adapted from European Environment Agency, 2019).

Parameter: The indicator is expressed in CO_2 equivalent (CO_{2E}) according to the substance. The results are analyzed per year and per country. The factors can be observed in the table below:

Greenhouse Gas (GHG)	Global Warming Potential (multiplied factor for CO_{2E})
CO_2	1
CH_4	25
N_2O	298
SF_6	22800
HFC	Reported in CO_{2E}
PFC	Reported in CO_{2E}
NF_3	17200
Unspecified mix of HFCs and PFCs	Reported in CO_{2E}

Table 11 - Greenhouse gases conversion into CO2 equivalent (30)

CO_{2E} = (CO_2) + (25 CH_4) + (298 N_2O) + (22800 SF_6) + (HFC) + (PFC) + (17200 NF_3) + unspecified mix of HFC and PFC (30)

Units: Gigagrams of CO_{2E} or Thousands of Tonnes

Data Source: European Environment Agency, 2020 (31)

Indexation: The indicator is evaluated according to the deviation of the yearly value of GHG emissions from the value of emissions in 1990 (31) – Equation 4.2.1. According to the deviation from this value there is an integration in the 0 to 10 scale. On the one hand, from the positive side, in case the deviation value is 100 % it is attributed the value 0 in the scale, meaning that the GHG emissions increased 100%. On the other hand, from the negative side, in case the deviation is is -100% it is attributed the value 10, meaning that the GHG decreased 100%. In between such values, the indexation varies linearly as it can be seen in the equation below. These details can be observed in equations 4.2.2-4.2.4 and in Figure 9.

Reference Value of GHG Emissions in 1990 = GHG_{1990} ;

$$Deviation = \frac{GHG_{YEAR} - GHG_{1990}}{GHG_{1990}} * 100\%$$ *Equation 4.2.1*

$$A = -5 * Deviation + 5\ ;\ A \in [0,10], Deviation \in [-100,100]$$ *Equation 4.2.2*

$$A = 0\ ; Deviation \in [100, +\infty]$$ *Equation 4.2.3*

$$A = 10\ ; Deviation \in [-\infty, -100]$$ *Equation 4.2.4*

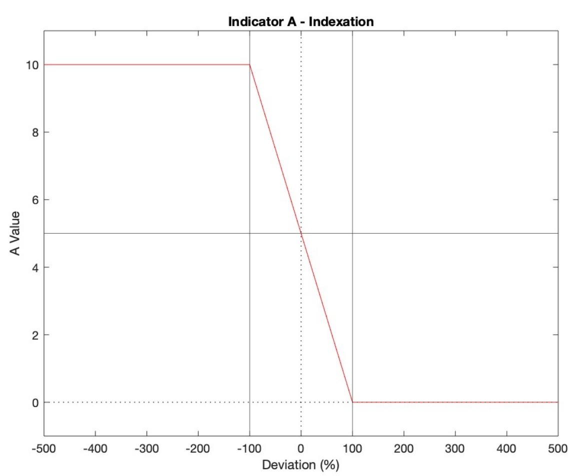

Figure 9 - Transformation into 0 to 10 scale.

4.2.2. B – Exceedances of Air Quality limit due to Traffic

Definition: Population weighted annual mean concentration of particulate matter at urban background stations in agglomerations. There are two particulates analyzed:

1. *Fine and coarse particulates (PM_{10}), i.e. particulates whose diameters are less than 10 micrometers, can be carried deep into the lungs where they can cause inflammation and exacerbate the condition of people suffering heart and lung diseases* (32)
2. *Fine particulates ($PM_{2.5}$) are those whose diameters are less than 2.5 micrometers. They are therefore a subset of the PM10 particles. Their deleterious health impacts are more serious than PM10 as they can be drawn further into the lungs and may be more toxic* (32)

Parameter: This indicator expresses the yearly weight of the mentioned particle ($PM_{2.5}$ or PM_{10}) per volume per country. According to the European Environement Agency, 2019, the EU ambient air quality limit values set by Directive 2008/50/EC (33) for the protection of human health and the Who Air Quality Guidelines (34) the

$PM_{2.5}$	
Annual mean concentration (µg/m3)	**Quality Label**
$[0, 10]$	Very Good
$]10, 20]$	Good
$]20, 25]$	Bad
$]25, 30]$	Very Bad
$]30, +\infty[$	Terrible
PM_{10}	
Annual mean concentration (µg/m3)	**Quality Label**
$[0, 20]$	Very Good
$]20, 40]$	Good
$]40, 50]$	Bad
$]50, 75]$	Very Bad
$]75, +\infty[$	Terrible

Table 12 - Annual Concentration of $PM_{2.5}$ and PM_{10} relation to air quality with labels (Adapted from (34) and (33))

Unit: µg/m3

Data Source: Eurostat, 2020 (32)

Indexation: For the two parts of the indicator ($PM_{2.5}$ and PM_{10}) were translated the results to the 0 to 10 scale independently due its different conditions of evaluation. For the final calculation of the index value, was calculated a mean average of both values – Equation

4.2.9. The calculations for $PM_{2.5}$ are expressed in Equations 4.2.5-4.2.6 and Figure 10, and the calculations for PM_{10} are expressed in Equations 4.2.7-4.2.8 and Figure 11.

$PM_{2.5}$

$$B_{PM2.5} = -\frac{1}{3} * PM_{2.5} + 10\ ;\ B \in [0,10], PM_{2.5} \in [0,30]$$ *Equation 4.2.5*

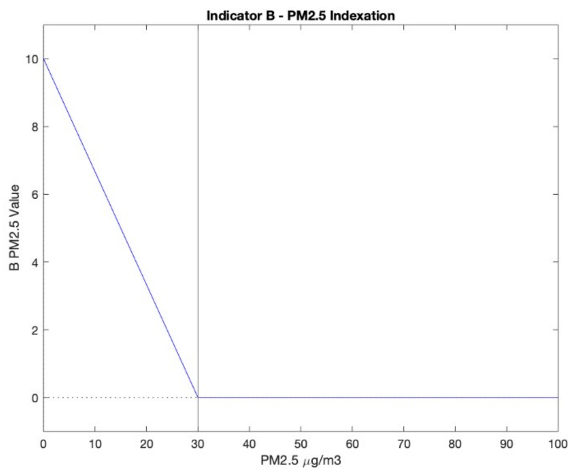

Figure 10 – Transformation of $PM_{2.5}$ into 0 to 10 scale

$B - 0\ ; PM_{2.5}\ \in\ [30, +\infty]$ *Equation 4.2.6*

PM_{10}

$$B_{PM10} = -\frac{2}{15} * PM_{10} + 10\ ;\ B \in [0,10], PM_{10} \in [0,75]$$ *Equation 4.2.7*

$$B = 0\ ; PM_{10}\ \in\ [75, +\infty]$$ *Equation 4.2.8*

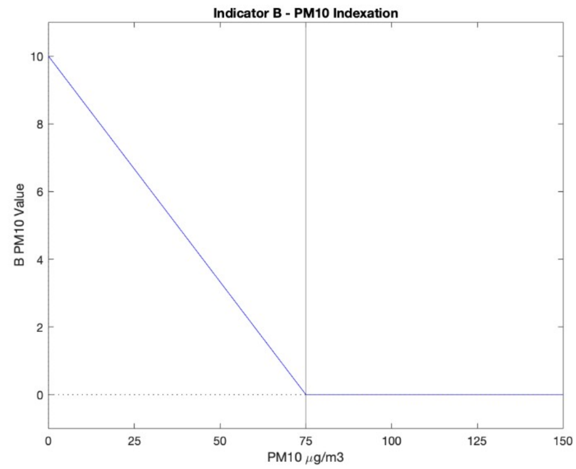

Figure 11 - Transformation of PM_{10} into 0 to 10 scale

Indicator – B Value

$$B = \frac{B_{PM2.5} + B_{PM10}}{2}$$ *Equation 4.2.9*

4.2.3. C – Multimodality in freight transport

Definition: Road transport is based on all movements of vehicles registered in the reporting country. Rail and Inland waterways transport is generally based on movements on national territory, regardless of the nationality of the vehicle or vessel, but there are some variations in definitions from country to country (35).

Parameter: Percentage share of Road Transport in total inland freight transport expressed in tonne-kilometres (tkm) per year and per country. It includes transport by road, rail and inland waterways.

Unit: Percentage (%)

Data Source: Eurostat, 2020 (35)

Indexation: According to Table 9 there is the need of the substantial shift from road freight transport to increase multimodality, and according to Eurostat, 2020, there is the average percentage of road freight transport is 75% and the remaining 25% for rail and inland waterways.
To the value of 75%, current average value for road freight transport, was attributed the value 0 on the 0 to 10 scale as it represents the state that policies precisely aim to modify, and thus the worst scenario. All numbers above 75% are also considered 0 – Equation 4.1.12. To the value of 25%, current average value for road freight transport, was attributed the value 10 as it represents the total shift of modalities. All numbers below 25% are also considered 10 – Equation 4.2.11. In between these values, a linear evolution was assumed – Equation 4.2.10. The overall evolution can be observed in Figure 12.

$$C = -\frac{1}{5} * \%_{Road\ transport} + 15\ ;\ C \in [0,10], \%_{Road\ transport} \in [25,75]$$ *Equation 4.2.10*

$$C = 10\ ;\ \%_{Road\ transport} \in [0, 25]$$ *Equation 4.2.11*

$$C = 0\ ;\ \%_{Road\ transport} \in [75, 100]$$ *Equation 4.2.12*

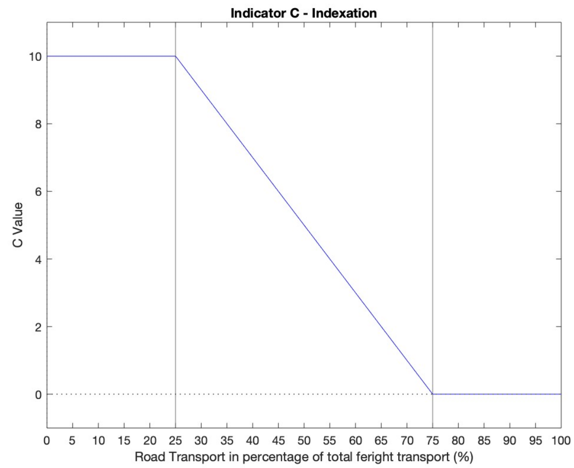

Figure 12 - Transformation of Percentage of Road Transport into 0 to 10 scale

4.2.4. D – Congestion and Delays

Definition: Multilevel indication of the traffic performance in an urban area.

Parameter: A composition of separate indicators, namely, time consumed in traffic due to job commute, estimation of time consumption dissatisfaction, CO_2 consumption due to congestions, and overall inefficiencies in the traffic system.

Unit: Dimensionless

Data Source: Numbeo, 2020 (36)

Indexation: According to Numbeo, 2020, the lower the value, the less congestion the country has, thus, by analyzing the dataset values it was assumed that the value 50 or lower would correspond to the value 10 on the 0 to 10 scale – Equation 4.2.14. Furthermore, the value 200 or higher would correspond to the value 0 on the 0 to 10 scale – Equation 4.2.15. In between these values, a linear evolution is considered – Equation 4.2.13. $D_{Congestion}$ represents the congestion and delays dimensionless factor and the overall evolution of this variable value's transformation can be observed in Figure 13.

$$D = -\frac{1}{15} * D_{Congestion} + \frac{40}{3} \ ; \ D \in [0,10], D_{Congestion} \in [50,200] \quad \textit{Equation 4.2.13}$$

$$D = 10 \ ; D_{Congestion} \in [0, 50] \qquad \textit{Equation 4.2.14}$$

$$D = 0 \ ; D_{Congestion} \in [200, +\infty] \qquad \textit{Equation 4.2.15}$$

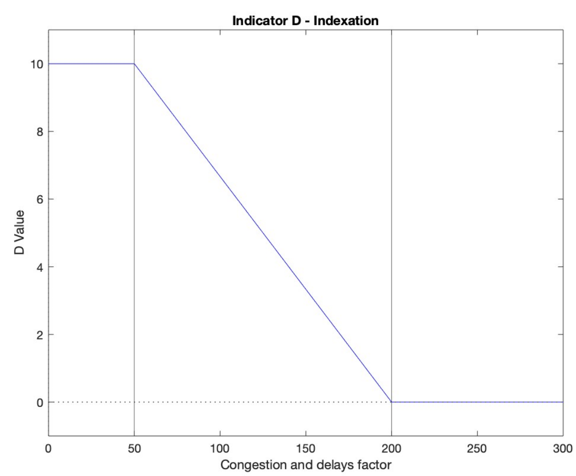

Figure 13 - Transformation of congestion and delays factor into 0 to 10 scale

4.2.5. E - Transport Fuel Consumer Prices and Taxes in Europe

Definition: A quantitative evaluation of consumer fuel prices and taxes.

Parameter: Percentage of taxes including VAT, excise duties and other indirect taxes for petroleum products in EU countries in the total price per fuel type for consumers per year and per country.

Unit: Percentage (%)

Data Source: European Comission, 2020 (37)

Indexation: This indicator has been evaluated by comparison amongst the values from the EU-28 countries in the time frame studied (2013-2017). Therefore, it has been considered the highest value, 71,34%, as the 10 on the scale of 0 to 10 and 42,56% the lowest representing 0 at the same scale. Higher values than 71,34% and lower values than 42,56% are not considered for this study. In between such values, it is considered that the values evolve linearly – Equation 4.2.16 and Figure 14. Furthermore, for the simplification of the index calculation and according to the policy goals analyzed in section 3, it is assumed that a higher percentage of taxes is a positive factor.

$$E = 0{,}3475 * E_{\%} - 14{,}79;\ E \in [0{,}10], E_{\%} \in [42{,}56\ ; 71{,}34]$$ *Equation 4.2.16*

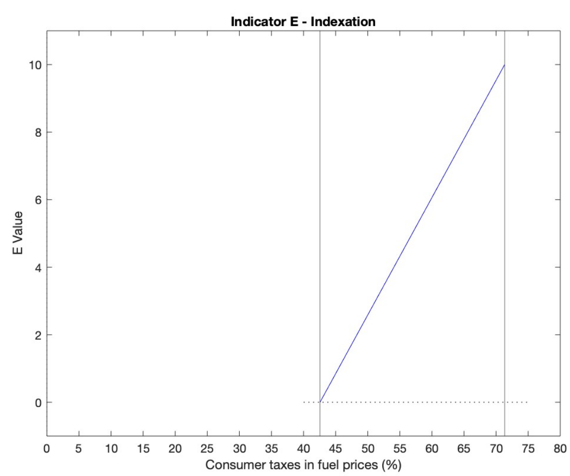

Figure 14 - Transformation of consumer taxes on fuel prices into 0 to 10 scale

4.2.6. F – Investment in Transport Infrastructure (according to GDP)

Definition: A quantitative analysis of the transport infrastructure investment according to GDP.

Parameter: Value in Euros invested in transport per year divided by the same year's GDP of the respective country or area.

Unit: Percentage (%)

Data Source: OECD.stat, 2020 (38)

Indexation: This index parameter has been done by comparison amongst the values from the EU countries in the time frame studied. Therefore, it has been considered the highest value, 2,499%, as the 10 on the scale of 0 to 10 and 0,145% the lowest representing 0 at the same scale. Higher values than 2,499% and lower values than 0,145% are not considered for this study, nevertheless, they would be considered 10 and 0, respectively. In between such values, it is considered that the values evolve linearly. The complete overview can be seen in Equation 4.2.17 and Figure 15.

$$F = 4{,}24726 * F_{\%} - 0{,}614 \; ; \; F \in [0{,}10], F_{\%} \in [0{,}145 \; ; 2{,}499] \quad \textit{Equation 4.2.17}$$

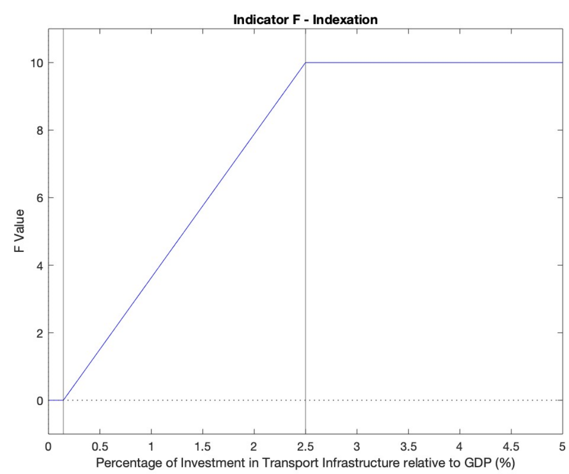

Figure 15 - Transformation of percentage of transport investment in infrastructure into 0 to 10 scale

4.2.7. G – Electric Vehicles as a Proportion of the total fleet

Definition: A quantitative analysis of the number of electric vehicles in relation the total vehicle fleet battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) (adapted from European Environment Agency, 2019).

Parameter: Number of yearly registered cars and light commercial vehicles divided by the total yearly registered cars per country.

Unit: Percentage (%)

Data Source: Enerdata Odyssee, 2020 (39)

Indexation: This indicator evaluates a slow penetration of electric vehicles into the market, thus, in order for a have visible evolution in minor value variations of percentage, a logarithmic scale with base 1000 was used for transformation of the indicator into the scale of 0 to 10 – Equation 4.2.18 and Figure 16. All values equal or lower than 0,1% are considered 0 in the scale (Equation 4.2.19), and 100% is considered 10.

$$G = 10 * log_{1000}(10 * G_{\%}) \; ; G_{\%} \in [0{,}1 \; ; 100]$$ *Equation 4.2.18*

$$G = 0; \; G_{\%} \in [0; 0{,}1]$$ *Equation 4.2.19*

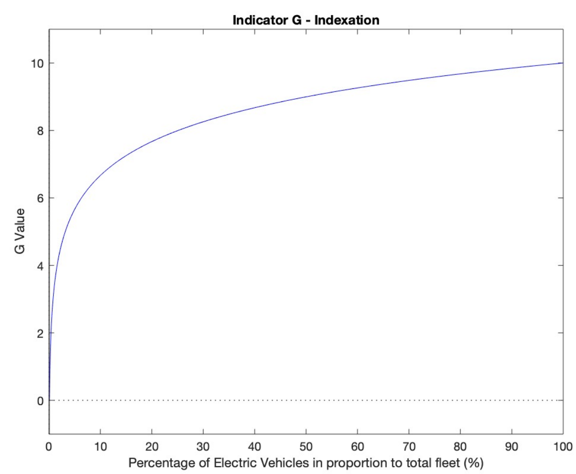

Figure 16 - Transformation of percentage of Electric Vehicles into 0 to 10 scale

4.2.8. H – Energy Consumption – Electricity and Biofuels

Definition: A quantitative analysis of the transport energy consumption by type of energy: oil products, gas, biofuel and electricity.

Parameter: Combined electricity and biofuels consumed compared to the total energy consumption in transport. The consumed energy is expressed in megatonne of oil equivalent per type of energy consumed, per year and per country.

Unit: Percentage (%)

Data Source: Enerdata Odyssee, 2020 (39)

Indexation: This indicator evaluates a slow penetration of a certain type of energy into the transport system, thus, in order for a have notable evolution in minor value variations of percentage, a logarithmic scale with base 100 was used for integration the indicator in the scale from 0 to 10 – Equation 4.2.20 and Figure 17. All values equal or smaller than 1% are considered 0 in the scale (Equation 4.2.21), and 100% is considered 10.

$H = 10 * log_{100}(H_{\%}) \; ; H_{\%} \in [1 \, ; 100]$ *Equation 4.2.20*

$H = 0; \; H_{\%} \in [0; 1]$ *Equation 4.2.21*

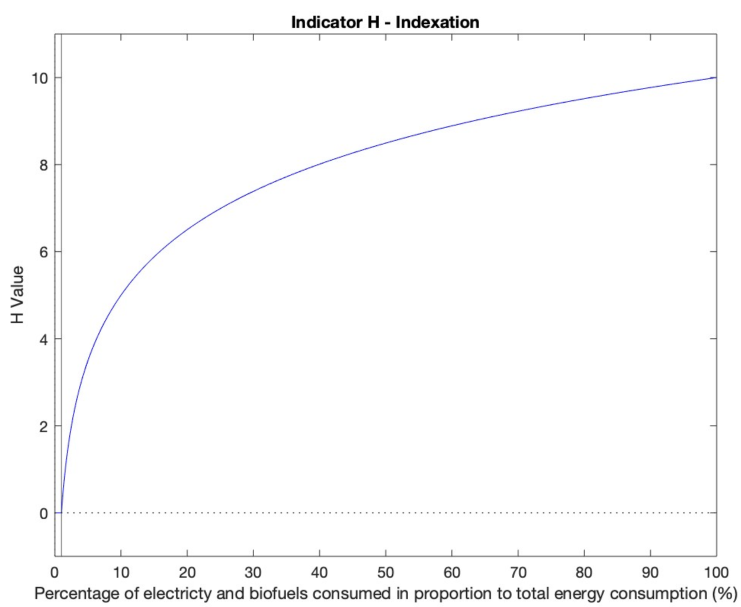

Figure 17 - Transformation of percentage of electricity and biofuels consumed into 0 to 10 scale

5. Results

The results of this study are conducted by applying the indicators described in the section 4 and the respective final Index. In both the data used and analyzed belongs to the EU-28 from 2013 to 2017. The full extensive results in table format can be found in the sections Annex 1 – Indicator Results and Annex 2 - INDEX.

5.1. Index

The Index for sustainability and energy in transport results for the EU-28 are valued at lower than Moderate (Figure 8). Although a peak to 4,03 in 2015, in Figure 18 it can be observed an almost non-existent evolution over the 5 years analyzed as the values vary between 3,60 and 3,81 with no clear growth or drop. The higher value among the Member States is also seen with the same evolution although approximately with the absolute value of 5, which indicates the best EU-28 Member State as Moderate. Lastly, as for the lower values among the Member States it can be seen in Figure 18 an increase from values close to 0 to approximately 2.

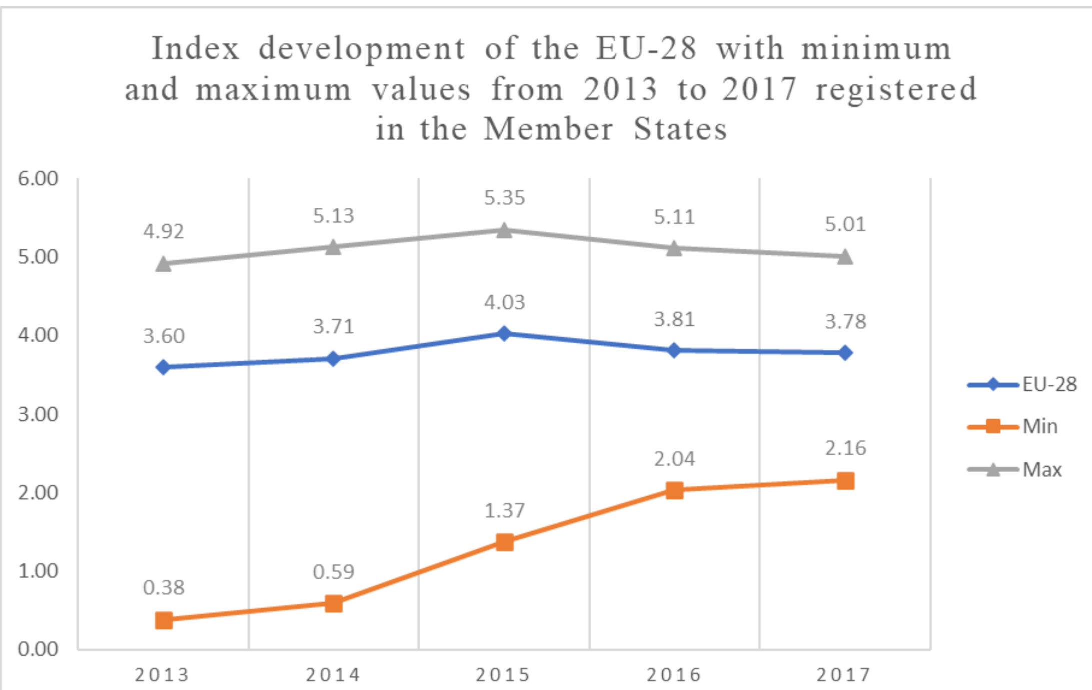

Figure 18 - Index development of the EU-28 with minimum and maximum values from 2013 to 2017 registered in the Member States

The Member State with the lowest results was always Malta, while, the maximum value was awarded to 4 different Member States as it can be noted in Table 13 with Sweden as last and last two years (2016-2017) consecutively assuring the best result.

Value	2013	2014	2015	2016	2017
Minimum	Malta	Malta	Malta	Malta	Malta
Maximum	Lithuania	Latvia	Netherlands	Sweden	Sweden

Table 13 - Minimum and Maximum Values of Index among the Member States from 2013 to 2017

Moreover, according to the Index results, the EU-28 sustainability and energy in transport landscape in the last of the analyzed years (2017) is far from its best performance. According to Figure 19 it can be observed a close to homogeneous scenario among the colors in the map (mainly orange) which represents almost all the Member States by being lower than Moderate (lower than 5) in the Index scale. Only a few exceptions are made, in Northern Europe and in the Netherlands, however, with absolute values near 5 which is represented with the yellow color on the map.

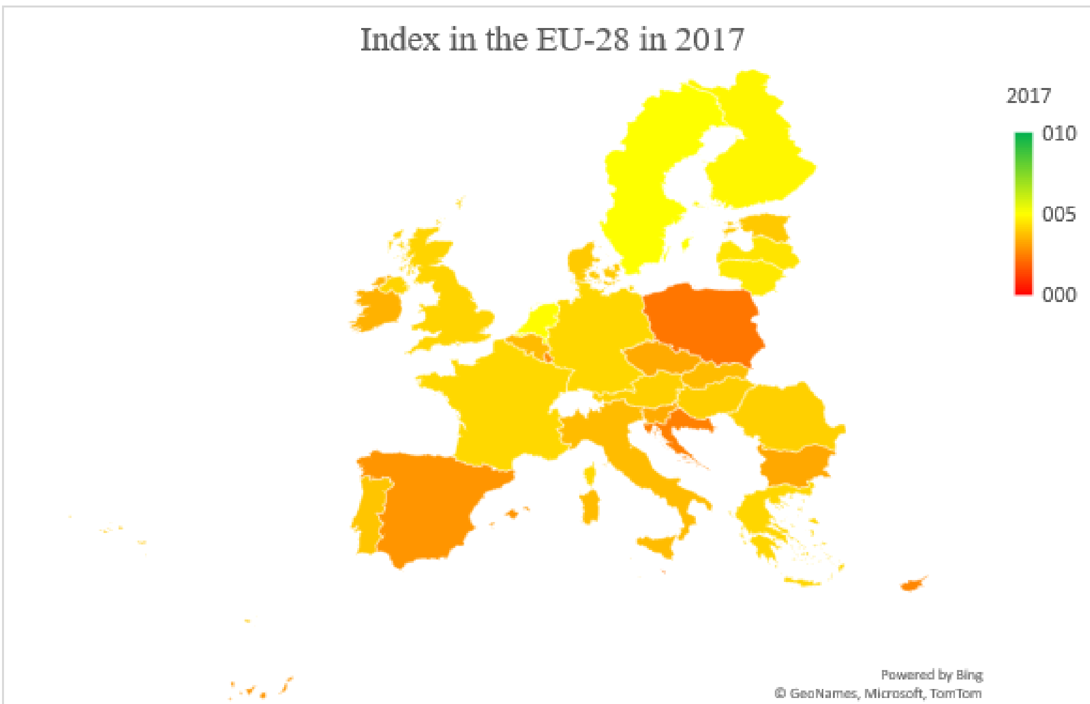

Figure 19 - Index Map: EU-28 in 2017

Additionally, in Figure 20 can be noticed the different general contributions from each individual indicator to the Index. The indicator C (Multimodality in freight transport) is the lowest one and thereby making the highest negative impact. The indicators B (Exceedances of Air Quality limit due to traffic), D (Congestions and Delays) and E (Transport Fuel Consumer taxes and prices in Europe) are the highest and, therefore, impacting the growth of the absolute value of the index. Also, among the indicators it cannot be noticed a pattern of evolution over the 5 years of evaluation which shows volatility. Further elaboration on the individual indicators can be observed in section 5.2.

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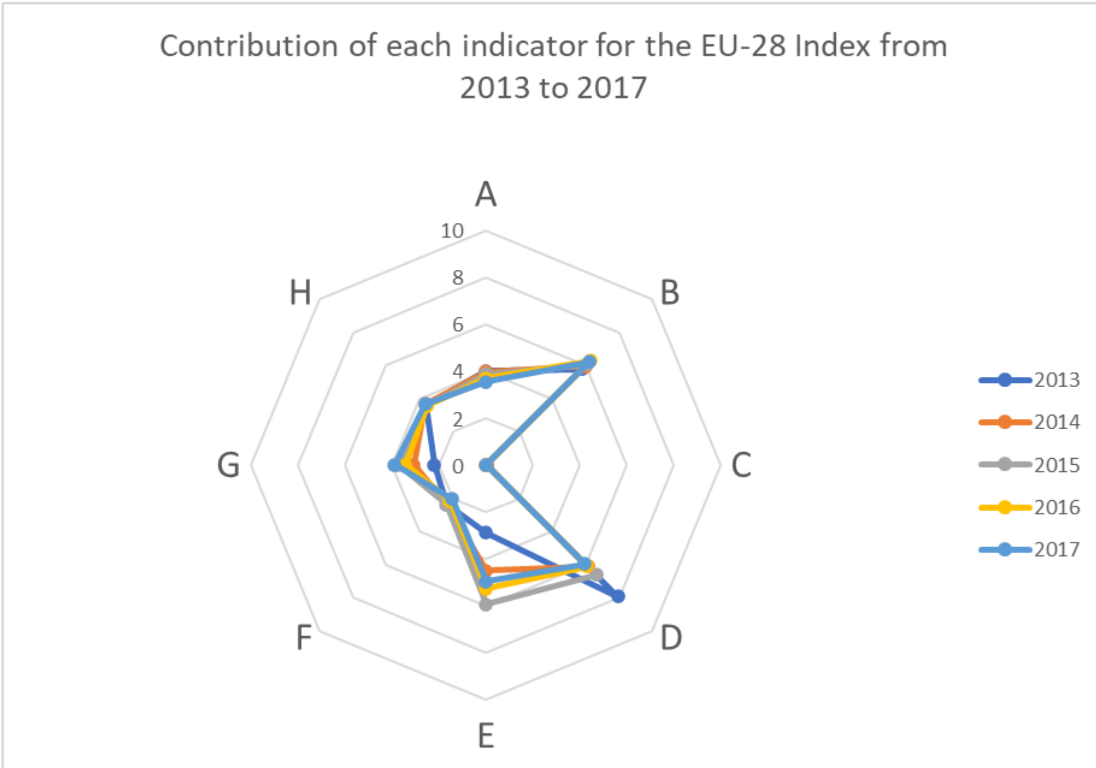

Figure 20 - Contribution of each indicator for the EU-28 Index from 2013 to 2017

Lastly, by analyzing Figure 21, besides observing the low values achieved by the Member States in the Index, it can also be also seen that there is no clear pattern of evolution in each country over the time frame of the evaluation. Thereby, the energy and sustainability in transport is at a lower than moderate level and according to the index there are no clear signs of improvement.

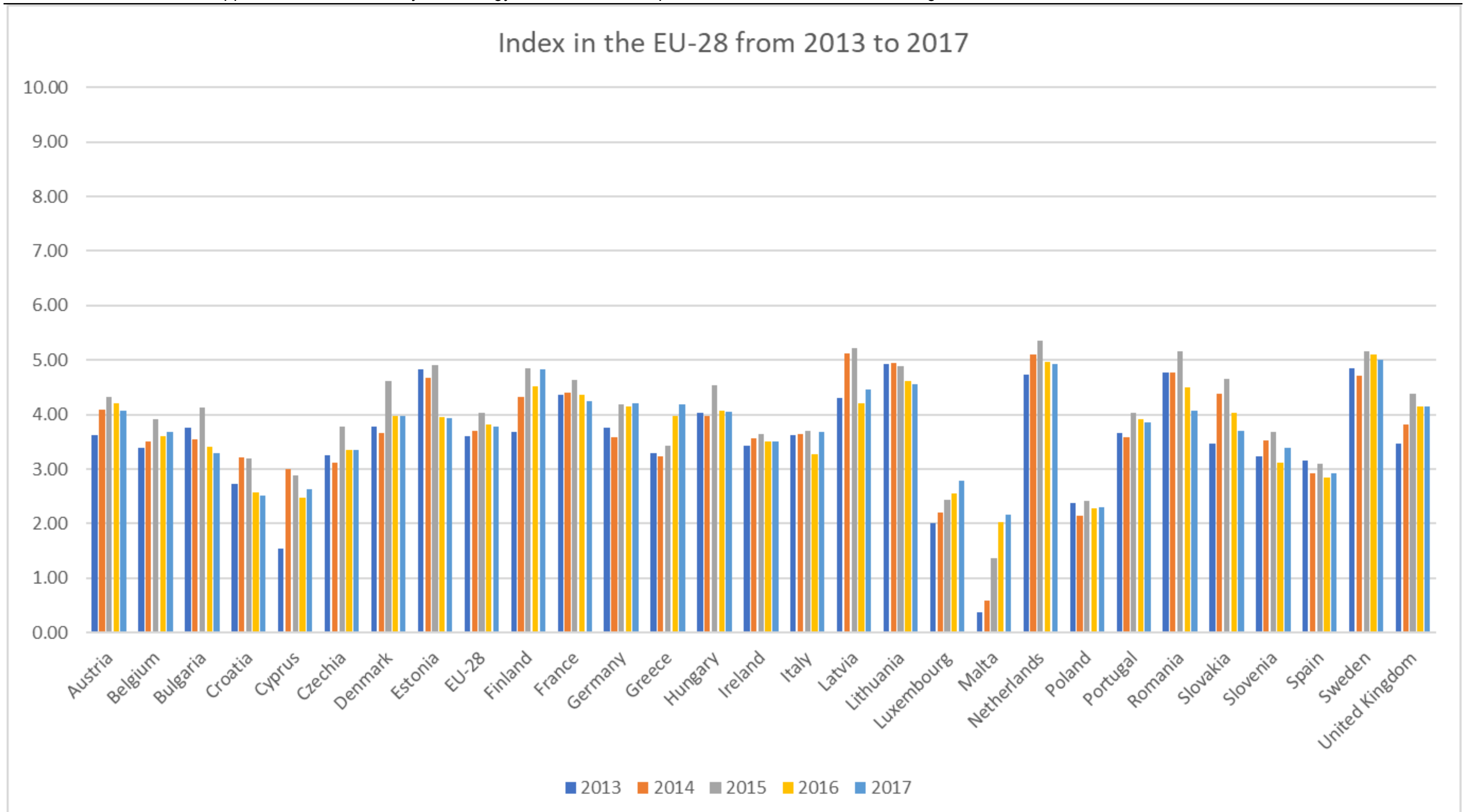

Figure 21 - Index in the EU-28 yearly from 2013 to 2017

5.2. Indicators

The indicators are represented dimensionless according to the methodology described in section 4.

5.2.1. A - Greenhouse Gas Emissions from Transport

According to Figure 22 it can be observed a very negative scenario in the EU-28 for Greenhouse Gas emissions. The areas with the best results are Western and Northern Europe; however, they are far from good outcomes. Therefore, it can be seen a concrete need for improvement in this factor. Furthermore, it can be observed in Figure 23 that over the five years analyzed only four Member States passed over the value 5, Finland, Latvia, Lithuania, and Slovakia (only 2014), which means that only these 4 countries were able to decrease their GHG emissions in transport in comparison from 1990 among the entire EU-28. Lastly, the general EU-28 value decreased never being bigger than 4, meaning that the emissions have increased along the time frame analyzed.

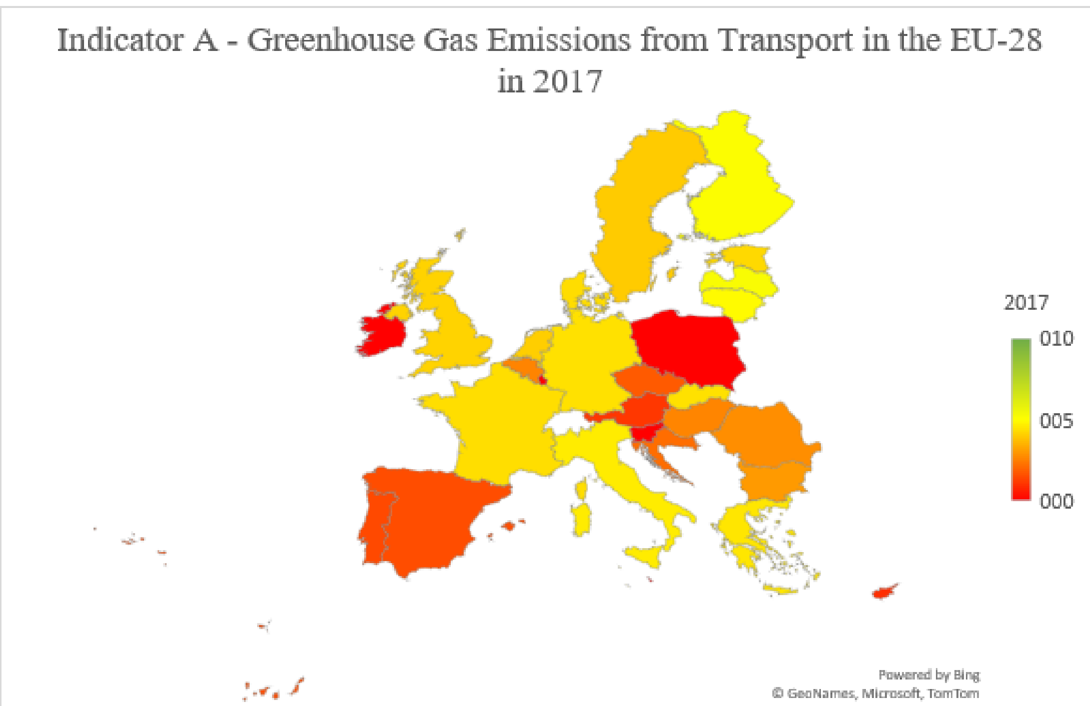

Figure 22 - Indicator A Map: Greenhouse Gas Emissions from Transport in the EU-28 in 2017

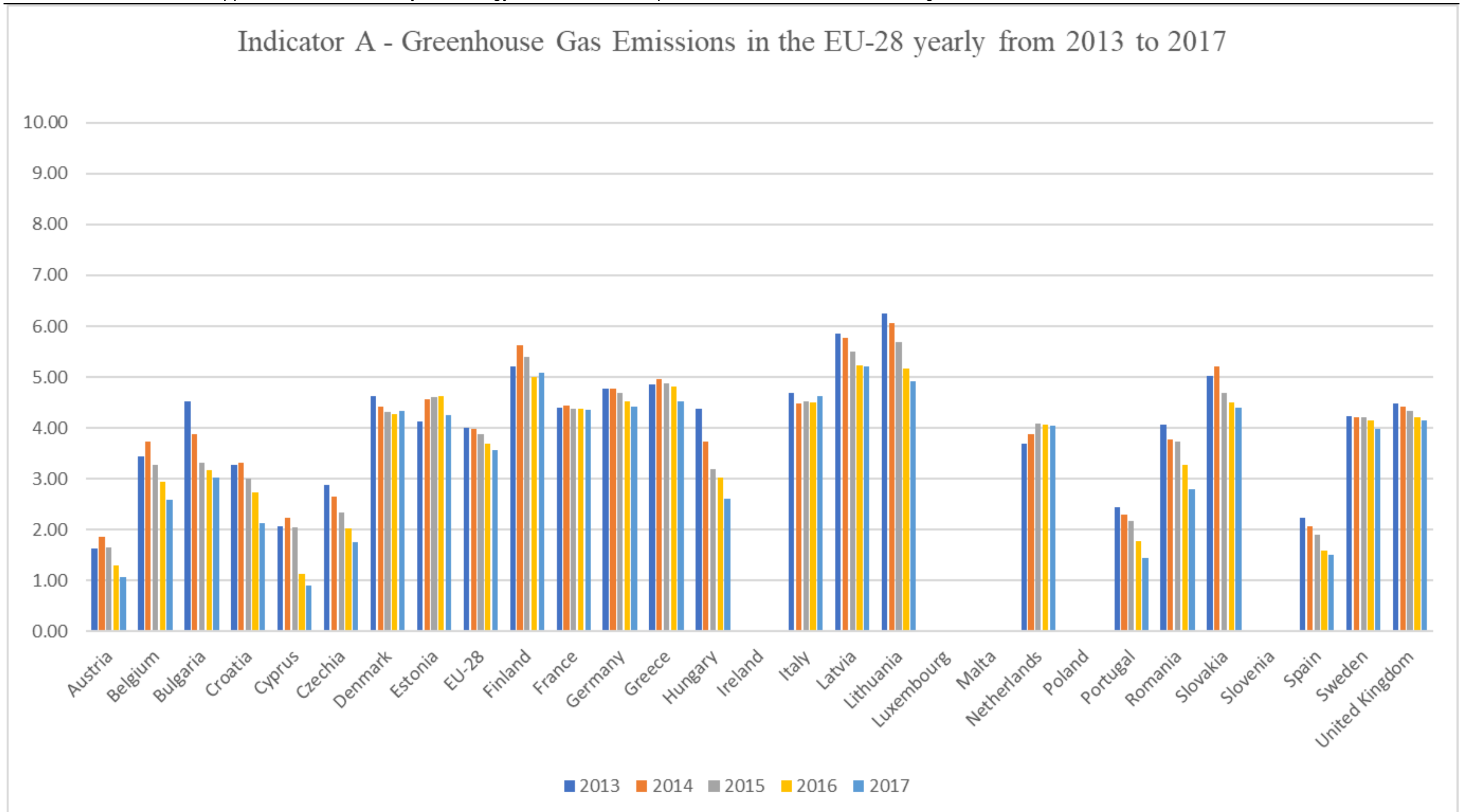

Figure 23 - Indicator A: Greenhouse Gas Emissions from Transport in the EU-28 yearly from 2013 to 2017

5.2.2. B – Exceedances of Air Quality limit due to Traffic

According to Figure 24 it can be observed a trend for better air quality and less impacts in Northern and Western Europe and Eastern Europe with more troubles on this matter.

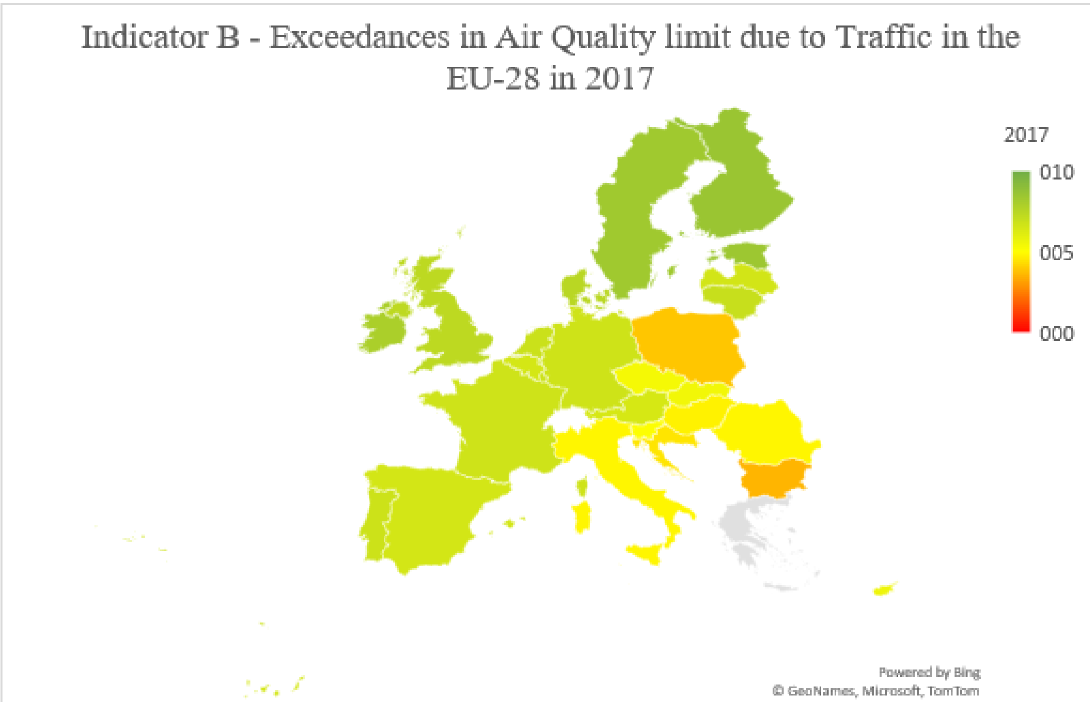

Figure 24 - Indicator B Map: Exceedances in Air Quality due to Traffic in the EU-28 in 2017

Furthermore, by analyzing Figure 25 it can be overserved an average value for the EU-28 around 6 with a small deviation from its Member States, although Bulgaria, Croatia and Poland having values around 4 or lower which represents a concerning point for such countries. Also, although in most of the Member States there is a slight improvement f between 2013 and 2017, there is not evident evolution to achieve the goals identified in section 3.2.

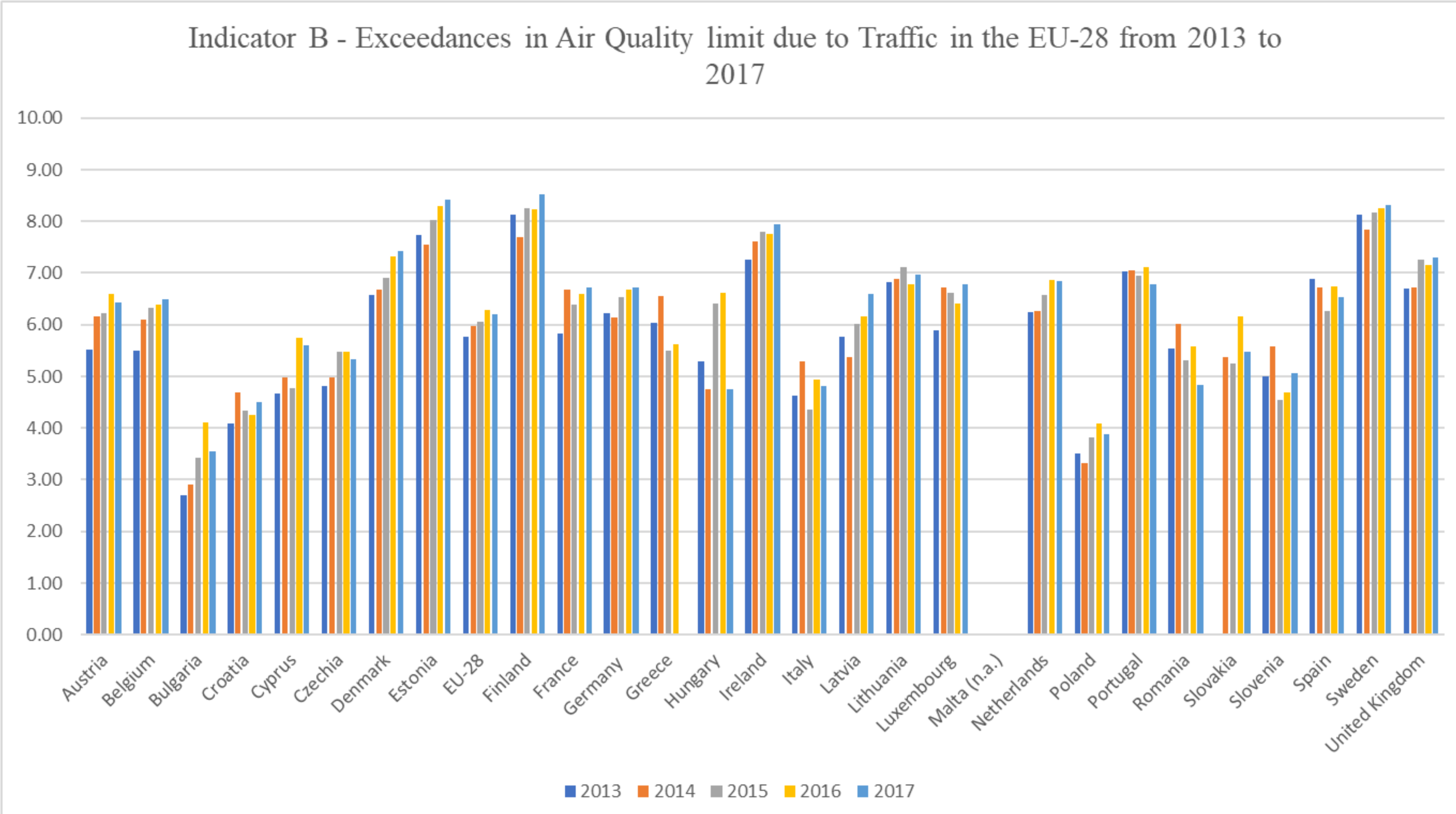

Figure 25 - Indicator B: Exceedances in Air Quality due to Traffic in the EU-28 yearly from 2013 to 2017

5.2.3. C - Multimodality in freight transport

According to Figure 26 it can be observed a negative scenario in the EU-28 as most of the Member States are red, representing a terrible evaluation on freight transport multimodality. It can be understood that there is a high dependence on road transport for freight transport in the EU-28.

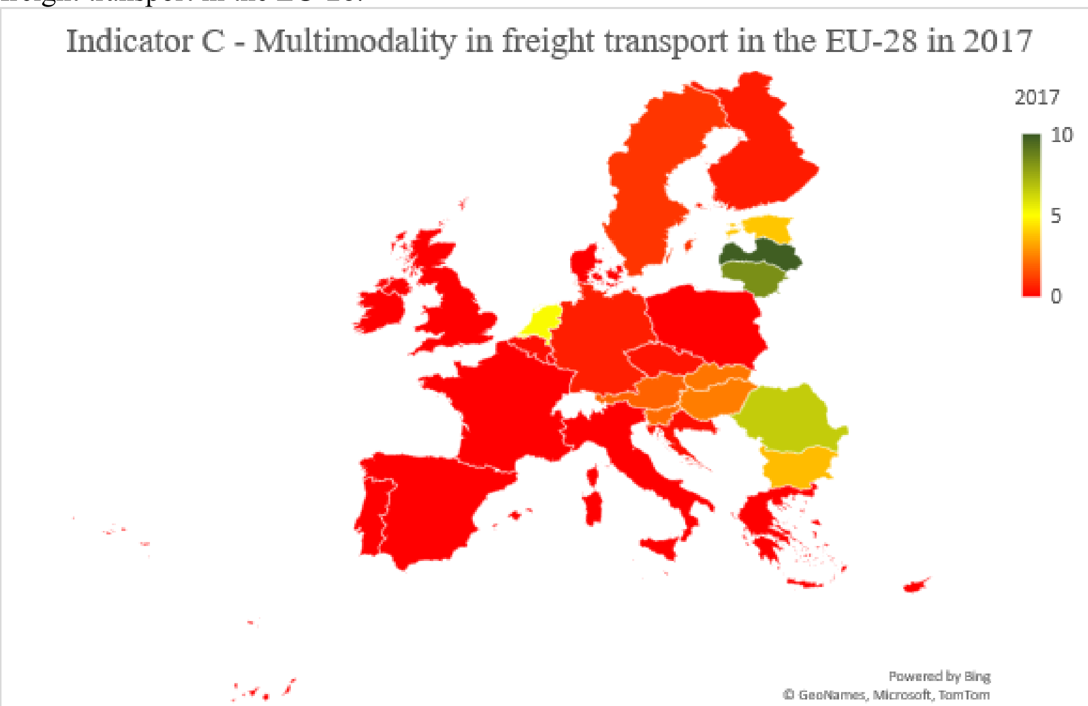

Figure 26 - Indicator C Map: Multimodality in freight transport in the EU-28 in 2017

Moreover, almost in severe contrast as can also be proved by Figure 27, Latvia (with a perfect score), Lithuania, Romania and Estonia (only in 2013) have a proven high independency from road transport. Nevertheless, the EU-28 cannot be higher than 0,5 even having 0 in some years, which represents a high necessity for improvement in freight transportation. Lastly, the evolution between 2013 and 2017, it is very minor as it is shown Figure 27 and no clear pattern can be extracted.

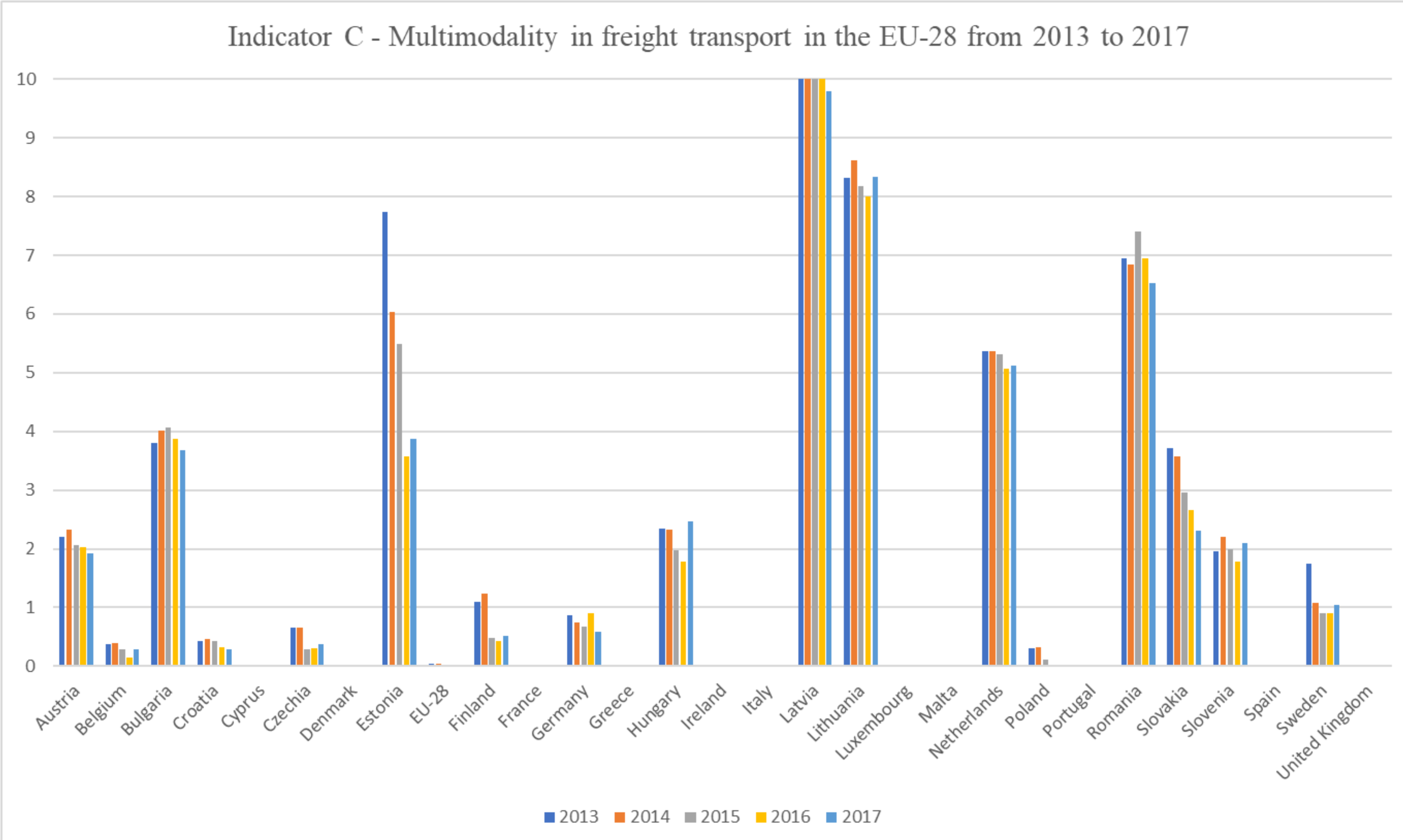

Figure 27 - Indicator C: Multimodality in freight transport in the EU-28 yearly from 2013 to 2017

5.2.4. D – Congestion and Delays

The scenario for Congestion and Delays in the EU-28 it can be understood as moderate in the general overview. In Figure 28 it is possible to see some homogenous graph in terms of color with some exception for the positive side – green – in Central and Northern Europe.

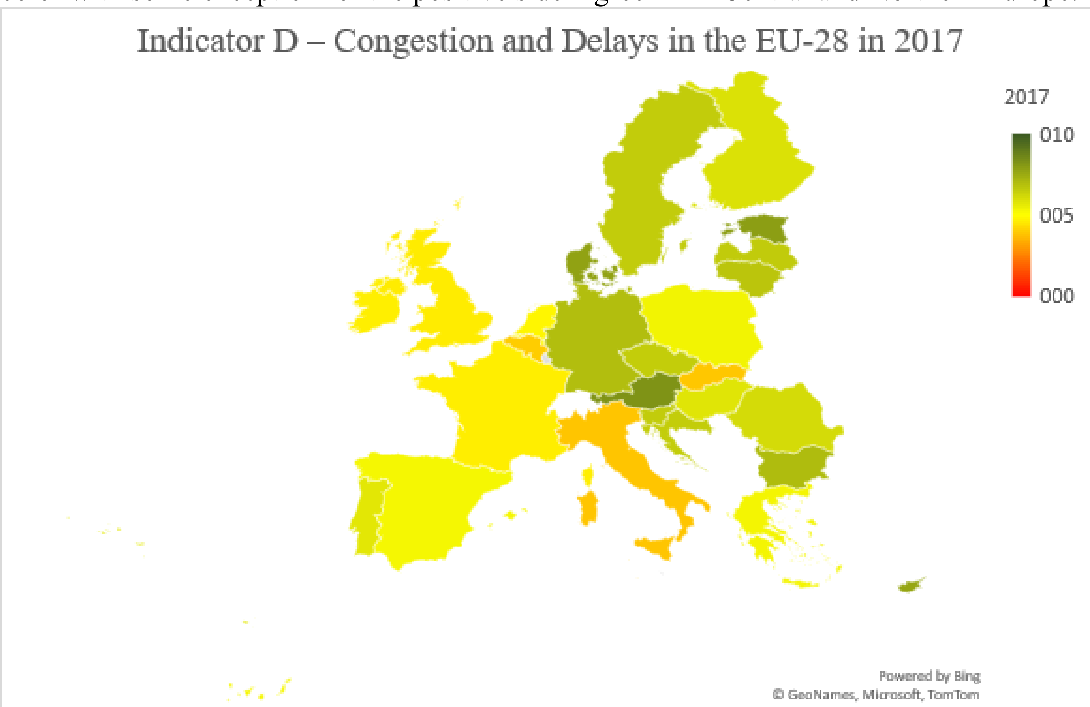

Figure 28 - Indicator D Map: Congestion and Delays in the EU-28 in 2017

Additionally, by analyzing the results from 2013 to 2017 in Figure 29, the analyzed indicator ca be seen as volatile as it can have oscillations of almost 6 in absolute value at the given scale. Also, to note that 2013 had remarkably positive results with 8 countries to achieve results higher than 9. Lastly, the EU-28 stands relatively stable around 6 (with the exception of 2013) which evaluates it as good moderate level.

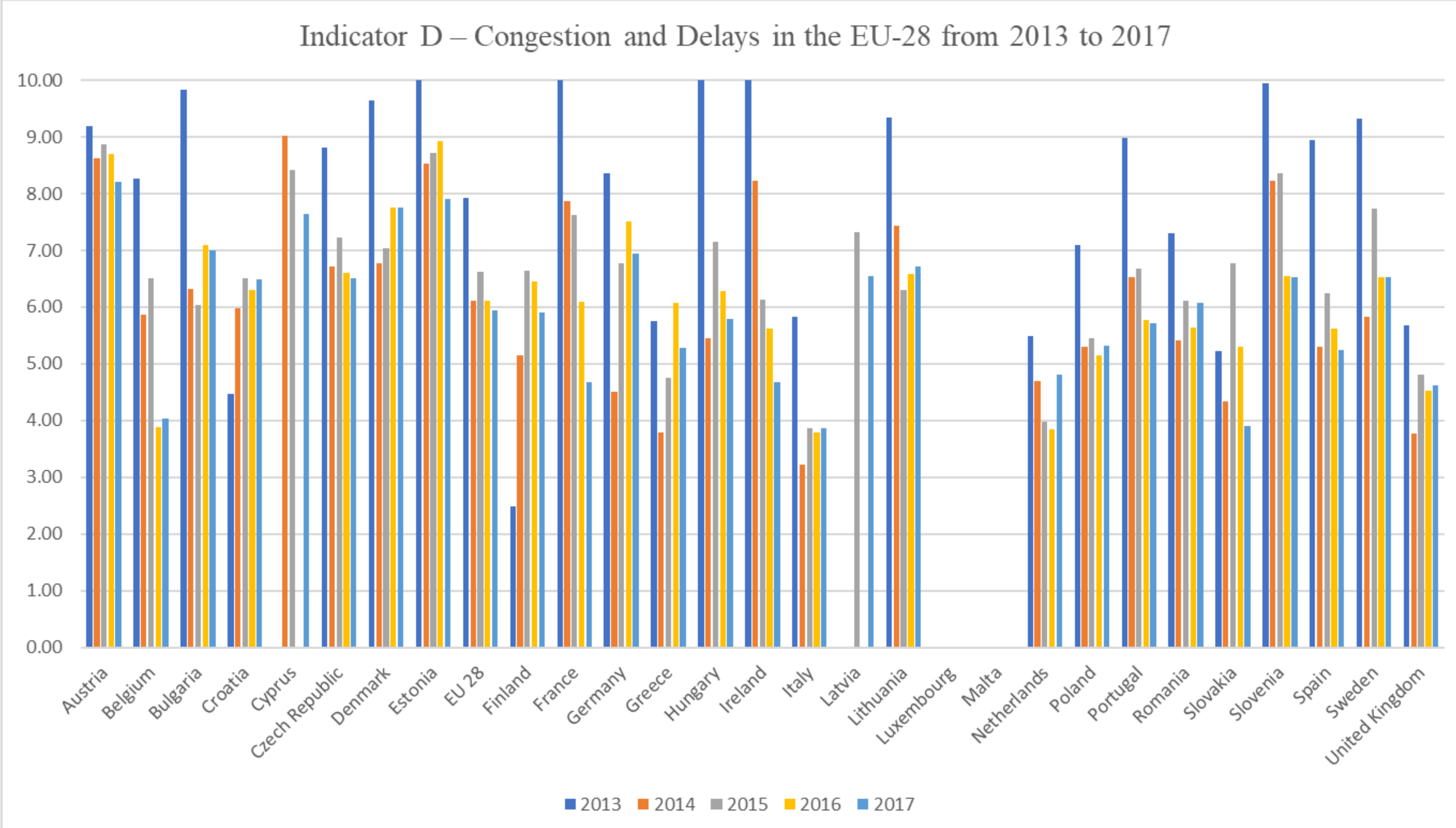

Figure 29 - Indicator D: Congestion and Delays in the EU-28 yearly from 2013 to 2017

5.2.5. E – Transport Fuel Consumer Prices and Taxes in Europe

The landscape in the EU-28 for consumer taxes and prices in transport fuel can be seen as divided in two parts, the Central and Northern with a higher taxation in fuel price as the results are higher than 5 in absolute value, and the Southern (excepting Italy), Western and Eastern, with lower taxes comparably to the rest of Europe has they have results lower then 5 in absolute value.

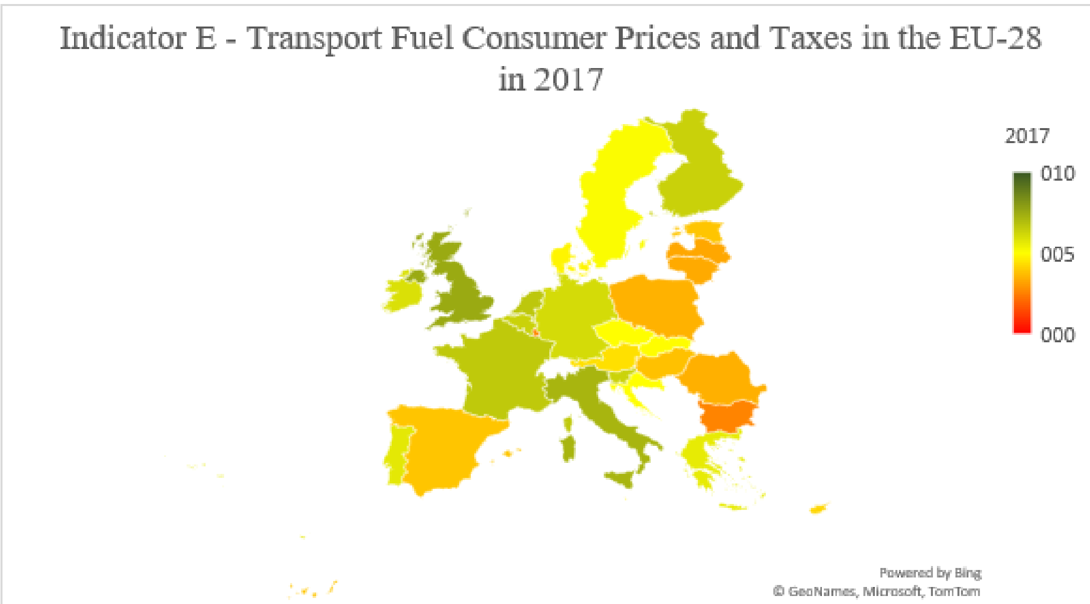

Figure 30 - Indicator E Map: Transport Fuel Consumer Prices and Taxes in the EU-28 in 2017

Moreover, according to Figure 31, the Prices and Taxes have suffered quite an oscillation during the evaluated years, having deviations approximately in the absolute value of 3. As a consequence, the EU-28 result had the same deviation, nonetheless, stabilizing around the moderate level as it is expected due to this indicator definition of being a relative one among the EU-28.

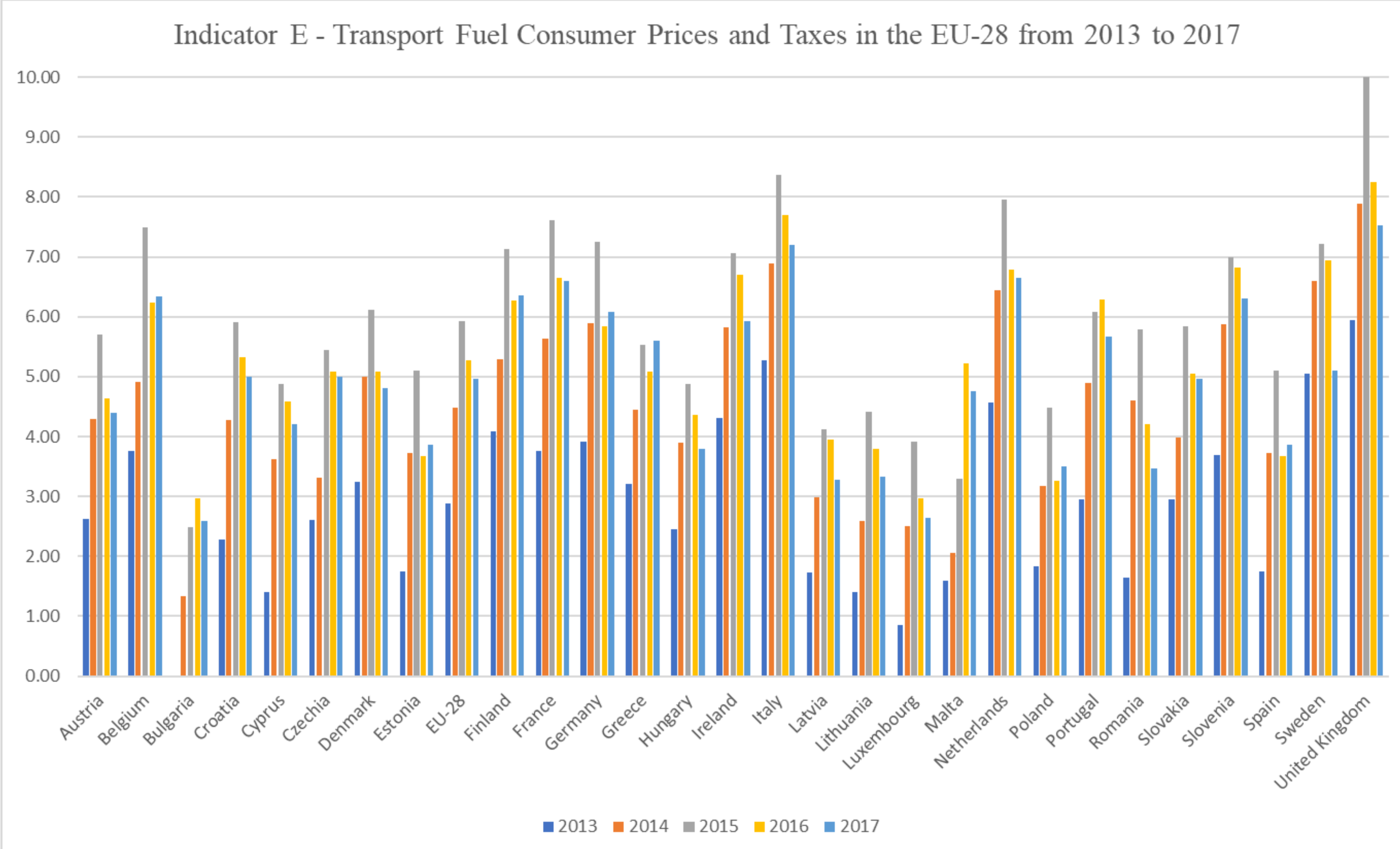

Figure 31 - Indicator E: Transport Fuel Consumer Prices and Taxes in the EU-28 yearly from 2013 to 2017

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5.2.6. F – Investment in Transport Infrastructure (according to GDP)

The investment in transport infrastructure according to GDP is mostly low in the EU as it can be understood from the Figure 32. Although in 2017, Greece had a high investment it contrasts with the remaining EU-28 Member States.

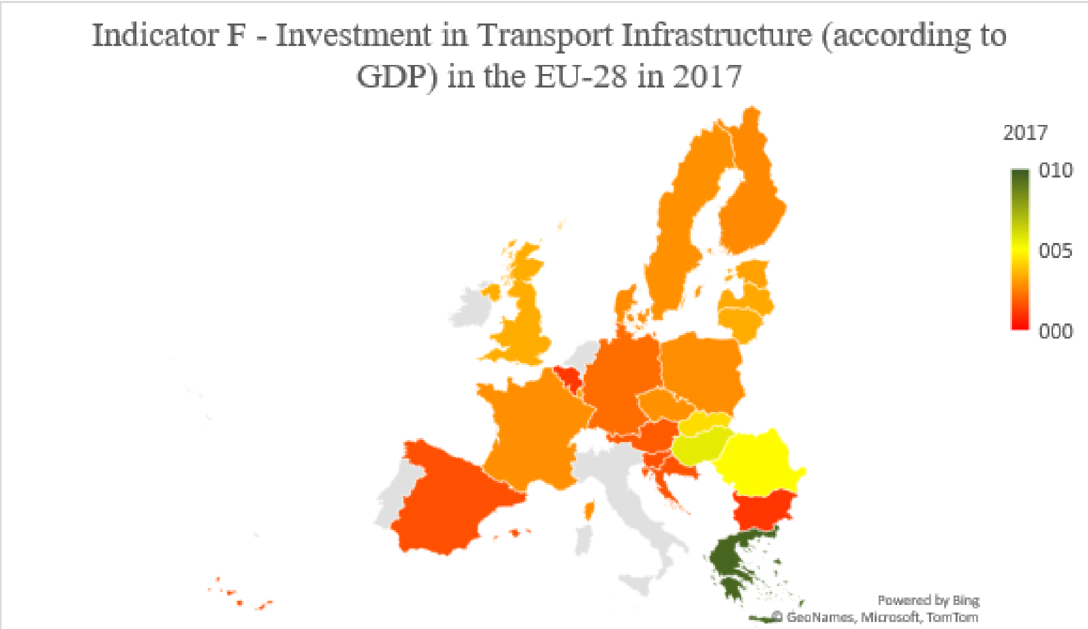

Figure 32 – Indicator F Map: Investment in Transport Infrastructure in the EU-28 in 2017

Furthermore, by analyzing the Figure 33, it can be seen a low investment in transport infrastructure in the most of the EU-28 Member States, reflected in the EU-28 value itself. Some exceptions can be observed, namely the high values in some of the years evaluated of Bulgaria, Greece, Hungary, Romania and Czech Republic, showing a strong focus on this topic In the Eastern region of the EU.

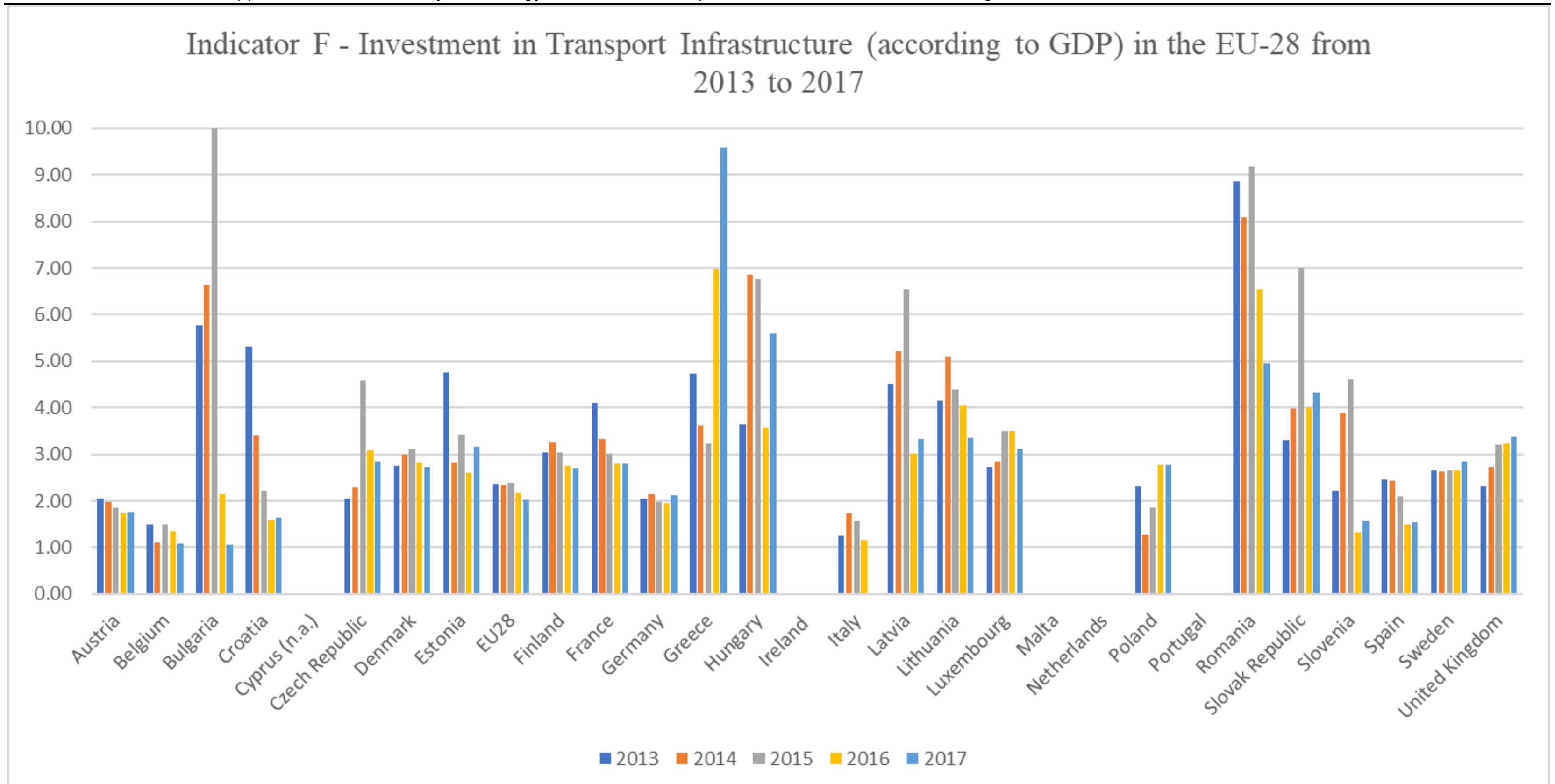

Figure 33 - Indicator F - Investment in Transport Infrastructure in the EU-28 yearly from 2013 to 2017

5.2.7. G – Electric Vehicles as a Proportion of the total fleet

The Electric Vehicles as a proportion total fleet, despite to be evolving in different levels, have mostly increased in the EU-28 as it can be observed in Figure 35. As a consequence, the year with better results turns to be 2017. Nevertheless, as it can be observed in Figure 34, in this year Western and Northern Europe lead the results, however, with a moderate level in the indicator absolute value.

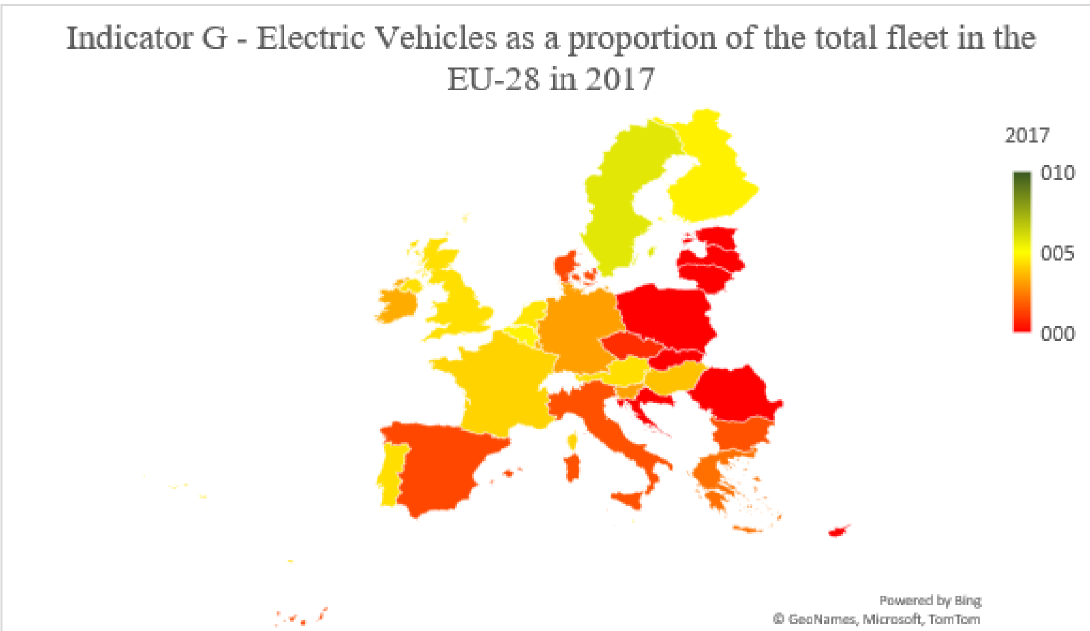

Figure 34 - Indicator G Map: Electric Vehicles as a proportion of the total fleet in the EU-28 in 2017

Moreover, by observing the Member States in Figure 35 it can be observed that 10 countries managed to have absolute values superior to 4 and only Denmark, Sweden and Netherlands above 5.

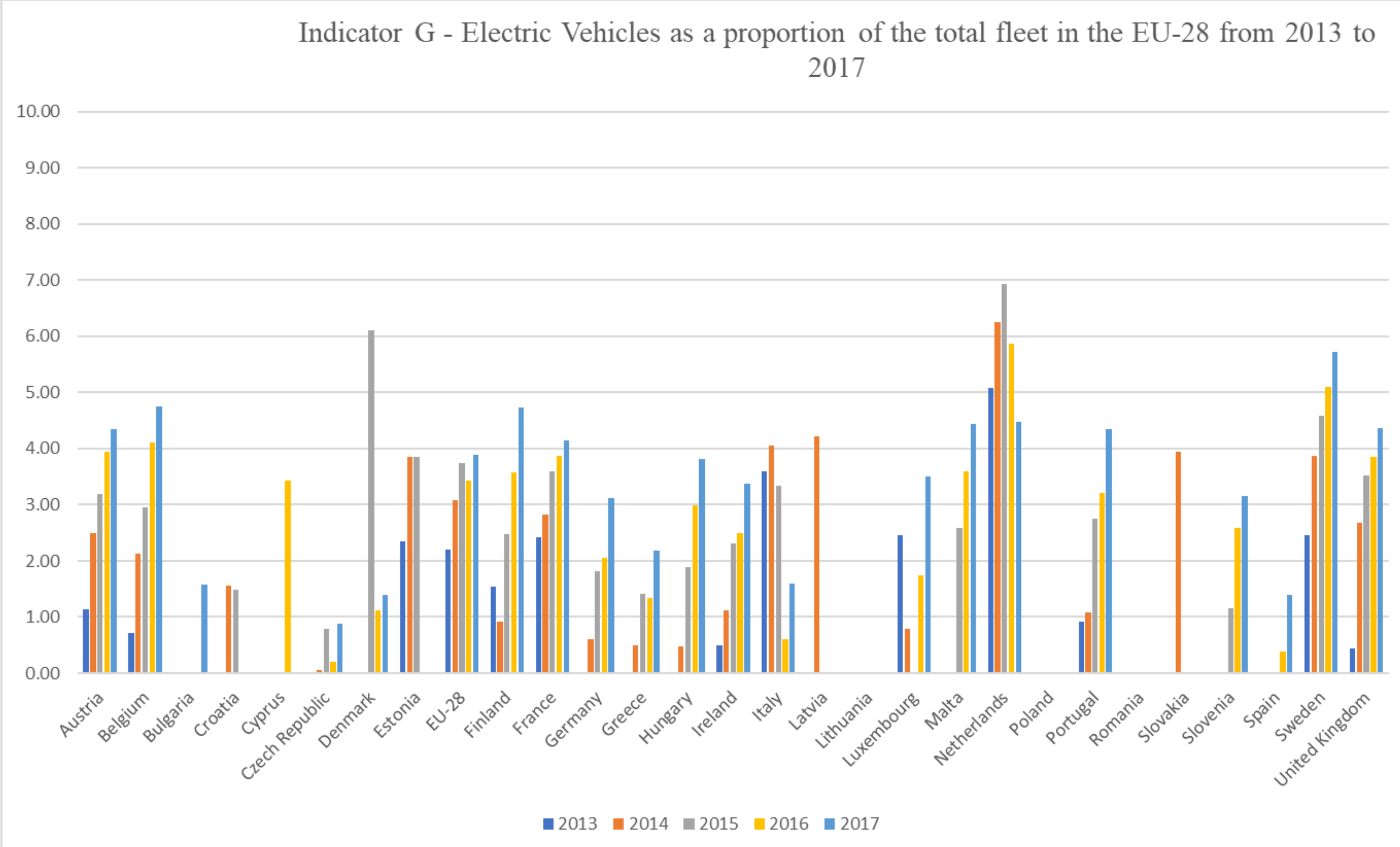

Figure 35 - Indicator G - Electric Vehicles as a proportion of the total fleet in the EU-28 yearly from 2013 to 2017

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5.2.8. H – Energy Consumption – Electricity and Biofuels

In 2017, the Electricity and Biofuels consumption can be seen as a lower than moderate landscape. By observing Figure 36, it is shown a clear dominance of dark yellow and red colors which represents a lower value of the EU countries on this matter.

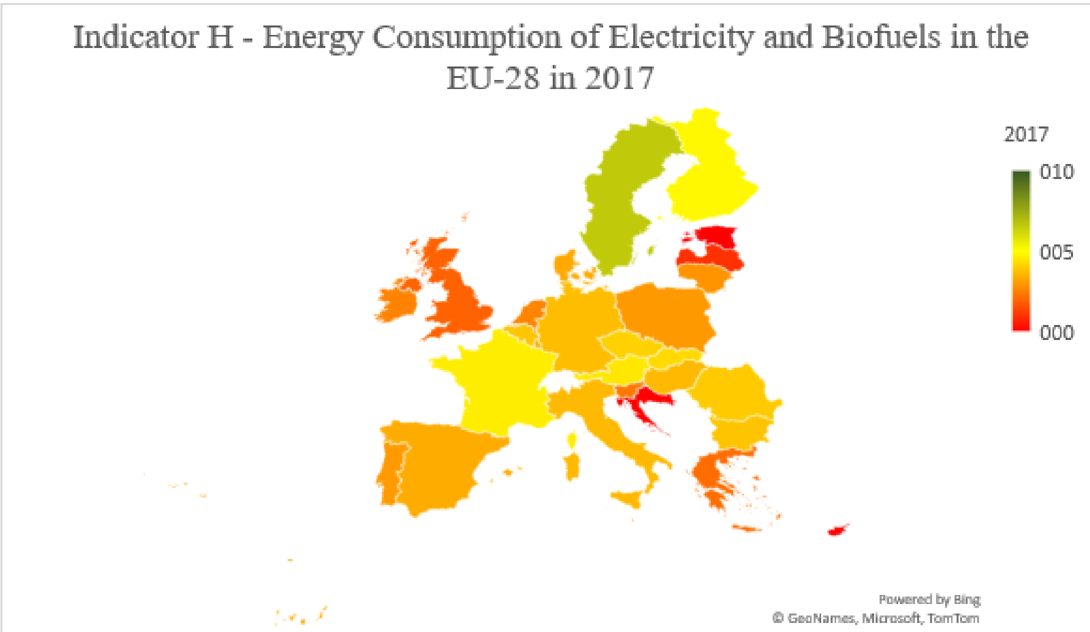

Figure 36 - Indicator H Map: Energy Consumption of Electricity and Biofuels in the EU-28 in 2017

An exception can be noted, as Sweden is the only country with a green tone in Figure 36 and the clear leader in the EU community with approximately a 6.5 absolute value and a clear evolution over the 5 years analyzed as it can be demonstrated in Figure 37. Furthermore, only in Luxembourg and Spain (small deviation) can be observed a positive and linear evolution in the time frame studied. Lastly, the EU-28 has a stable value of approximately 3.5 from 2013 to 2017, demonstrating also the minor evolution of its Member States.

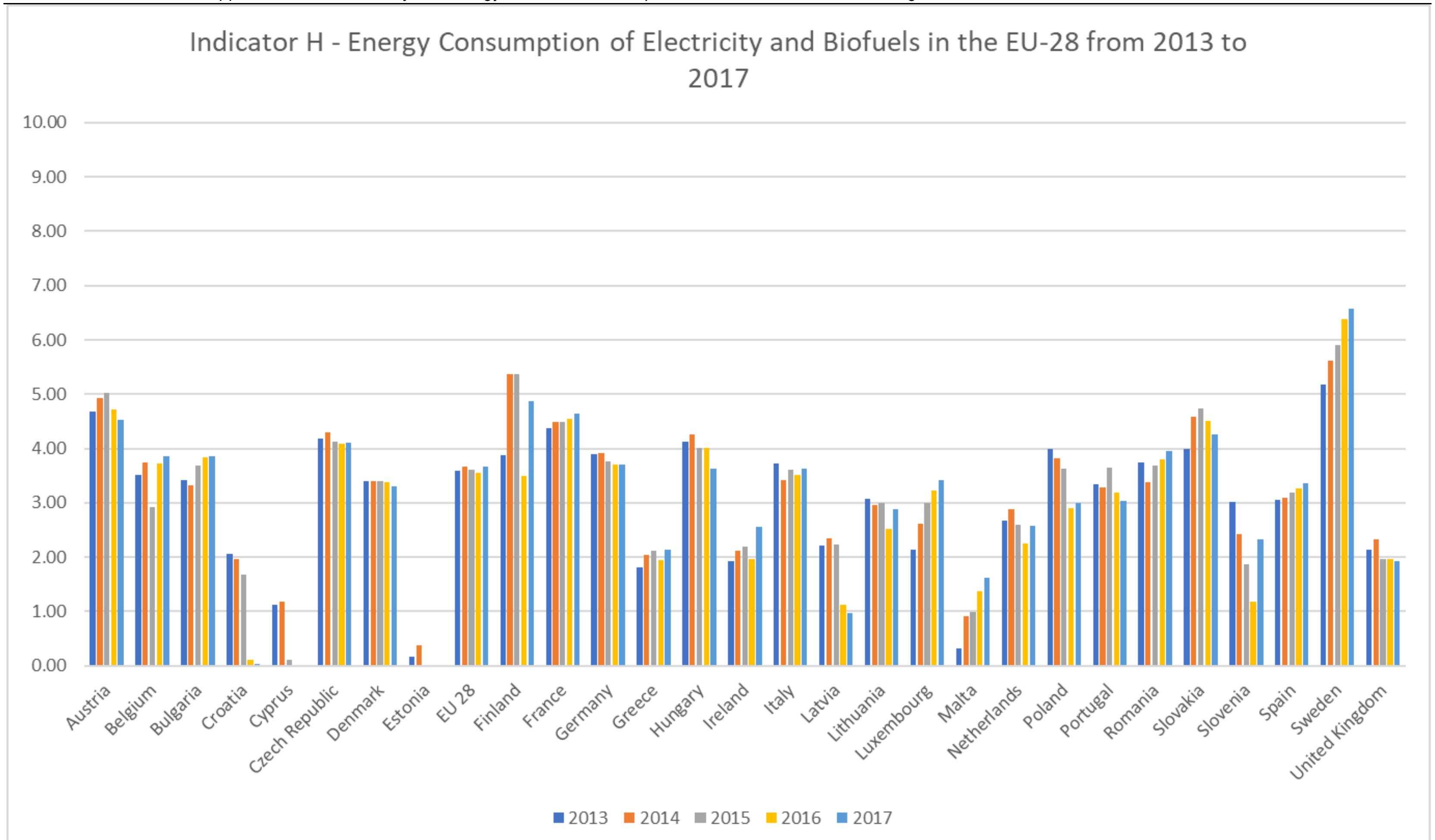

Figure 37 - Indicator H - Energy Consumption of Electricity and Biofuels in the EU-28 yearly from 2013 to 2017

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Discussion

The EU-28 was evaluated as low moderate with an average absolute value approximated to 4 in the final Index scale. This result supports the argument for extreme need of improvement of energy and sustainability in the EU transportation sector. Additionally, the amount of inequalities among the EU-28 Member States can be considered low, which aligns with the EU strategy and principles. Nevertheless, some trends could be marked such as the better performance of Northern Europe.

These results can be used be a source for understanding where in the EU transport finds the most challenges and point specific areas or topics further research in more in-depth format, increasing time and resource efficiency.

Furthermore, some limitations can be considered. Firstly, when assigning dimensions and themes in section 0, the former was not further used directly into the study, however serving for guidance on appointed the latter. Nonetheless, there was a high difficulty on the single appointment of themes in the research, and although their concrete definition, there is always space for subjectivity. In another aspect, in order to make the evaluation transversal in all Member States there were assumptions made when performing the indexation, namely on indicators E and F. At these parameters, due to their financial character, in order to avoid complex modelling, the indexation was based in comparison terms among the 28 Member States which can prevent them for the most accurate results. Lastly, there were some Member States that due to the low data quality and availability might have some influence in the overall results. Malta was considered the country with the lowest Index value, however, in 3 of the indicators it had no information available and in the remaining ones the used data quality can be considered questionable.

According to the results and methodology used, it can be confirmed that the process is the most important part of the study because, only by following it fully, it can be possible to understand the full scope of creating an indicator or an index. Nevertheless, when defining new indicators or adapting existent ones, making tests with more than one methodology and data source can improve the final results.

Finally, by making an extensive review of indicators it was found the clear need for new types of measurement as most of the ones analyzed are repeated in numerous reports. Thus, as it was noticed in section 0, there is a clear need for Innovation indicators that can create new results and subsequently conclusions.

Conclusion

This study aims to identify the level of performance in an Index format of energy and sustainability in the transportation sector. Therefore, by making a research with 21 sources and analyzing 394 transport indicators, selecting the suitable indicators according to global and European goals, and adapting them into a transversal and comprehensive format this study has shown that the EU-28 has a low to moderate performance (approximately 4 in absolute value) in the mentioned domains of the transport sector. In the fields of multimodality of freight transport and investment in transport infrastructure there is a clear necessity of improvement, while the field of congestion and delays has proven to be already at good level.

Given the fact that the data analyzed was from 2013 to 2017 and the policies used for the indicators scale refer to goals for the next 10 to 30 years from the date of this publication, the results match the expectations of an EU-28 far from peak evaluation. Nonetheless, what is important to note by using this methodology, are the different oscillations in the adopted scale according to Member State and Indicator, this identification is an added value when creating measures for improving energy and sustainability in transport.

It is important to identify the role of the methodology of the entire study not only in its final outcome but also in the lessons learned in the different milestones during the approach. It has shown in the

Literature review the positive and negative aspects of the existent research which allows to identify the repetitiveness of traditional indicators such as for infrastructure, at the same time as the lack of others specifically to cover the innovation and new transport models. Additionally, analyzing different policies and goals has identified from one side the ambition,and from another the lack of specification. Lastly, performing the data analysis has shown the quantity of data available, however, still the diversity and quality can be improved.

Based on this study, further research can be developed to determine the how other novel indicators such as new mobility models or innovation can influence definition of policies and demand for new types of data, and therefore, reach new results.

In conclusion, this study can make a quick assessment of key points in the energy and sustainability of the transportation sector in very intuitive and clear format, avoiding unnecessary complexity found in the Literature review.

Acknowledgements

I would like to thank Maria Marín for all the support given during this academic year in the Universitat Politècnica de Catalunya context.
I would like to thank my supervisor, Andreas Sumper, for the concrete and realistic support during my master thesis.
I would like to thank Hedy Mahmoudi for the productive discussions that made me overcome several challenges along the way.

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Annexes

Annex 1 – Indicator Results

A – Greenhous Gas Emissions from Transport

Country	2013	2014	2015	2016	2017
Austria	1,63	1,86	1,66	1,30	1,08
Belgium	3,44	3,73	3,28	2,95	2,60
Bulgaria	4,52	3,87	3,31	3,17	3,03
Croatia	3,27	3,32	3,00	2,73	2,13
Cyprus	2,06	2,23	2,04	1,12	0,90
Czechia	2,88	2,65	2,33	2,02	1,76
Denmark	4,63	4,41	4,32	4,28	4,34
Estonia	4,12	4,56	4,60	4,63	4,25
Finland	5,21	5,63	5,40	5,00	5,09
France	4,39	4,43	4,38	4,38	4,35
Germany	4,77	4,78	4,69	4,52	4,41
Greece	4,86	4,95	4,89	4,82	4,51
Hungary	4,37	3,73	3,18	3,02	2,62
Ireland	0,00	0,00	0,00	0,00	0,00
Italy	4,69	4,48	4,53	4,51	4,62
Latvia	5,85	5,77	5,50	5,22	5,20
Lithuania	6,25	6,06	5,70	5,16	4,93
Luxembourg	0,00	0,00	0,00	0,00	0,00
Malta	0,00	0,00	0,00	0,00	0,00
Netherlands	3,69	3,87	4,07	4,07	4,04
Poland	0,00	0,00	0,00	0,00	0,00
Portugal	2,43	2,30	2,16	1,78	1,43
Romania	4,07	3,78	3,74	3,27	2,79
Slovakia	5,03	5,21	4,68	4,50	4,40
Slovenia	0,00	0,00	0,00	0,00	0,00
Spain	2,24	2,06	1,90	1,58	1,51
Sweden	4,24	4,22	4,21	4,15	3,98
United Kingdom	4,49	4,41	4,33	4,22	4,14
EU-28	**4,01**	**3,98**	**3,87**	**3,70**	**3,56**

Table 14 - Indicator A: Extensive Data

B – Exceedances of Air Quality limit due to traffic

Country	2013	2014	2015	2016	2017
Austria	5,52	6,16	6,21	6,59	6,42
Belgium	5,50	6,11	6,32	6,39	6,49
Bulgaria	2,70	2,90	3,42	4,11	3,55
Croatia	4,08	4,69	4,33	4,25	4,49
Cyprus	4,67	4,97	4,77	5,75	5,60
Czechia	4,81	4,99	5,48	5,48	5,34
Denmark	6,57	6,69	6,90	7,33	7,43
Estonia	7,73	7,55	8,02	8,29	8,42
Finland	8,12	7,69	8,25	8,24	8,52
France	5,82	6,69	6,38	6,60	6,73
Germany	6,21	6,14	6,52	6,69	6,72
Greece	6,04	6,56	5,50	5,62	n.a.
Hungary	5,30	4,75	6,41	6,63	4,75
Ireland	7,25	7,61	7,80	7,75	7,95
Italy	4,64	5,30	4,37	4,94	4,82
Latvia	5,77	5,37	6,02	6,17	6,59
Lithuania	6,81	6,88	7,11	6,79	6,96
Luxembourg	5,90	6,72	6,62	6,40	6,78
Malta	n.a.	n.a.	n.a.	n.a.	n.a.
Netherlands	6,25	6,27	6,57	6,87	6,84
Poland	3,51	3,33	3,83	4,09	3,89
Portugal	7,02	7,05	6,96	7,12	6,78
Romania	5,54	6,02	5,30	5,57	4,83
Slovakia	n.a.	5,37	5,24	6,17	5,47
Slovenia	4,99	5,58	4,55	4,69	5,06
Spain	6,89	6,72	6,27	6,74	6,52
Sweden	8,12	7,85	8,17	8,25	8,31
United Kingdom	6,69	6,72	7,26	7,16	7,29
EU-28	5,78	5,97	6,05	6,29	6,21

Table 15 - Indicator B: Extensive Data

C – Multimodality in freight transport

Country	2013	2014	2015	2016	2017
Austria	2,2	2,32	2,06	2,02	1,92
Belgium	0,38	0,4	0,28	0,14	0,28
Bulgaria	3,8	4,02	4,06	3,88	3,68
Croatia	0,42	0,46	0,42	0,32	0,28
Cyprus	0	0	0	0	0
Czechia	0,66	0,66	0,28	0,3	0,38
Denmark	0	0	0	0	0
Estonia	7,74	6,04	5,48	3,58	3,88
Finland	1,1	1,24	0,48	0,42	0,52
France	0	0	0	0	0
Germany	0,86	0,74	0,68	0,9	0,58
Greece	0	0	0	0	0
Hungary	2,34	2,32	1,98	1,78	2,46
Ireland	0	0	0	0	0
Italy	0	0	0	0	0
Latvia	10	10	10	10	9,8
Lithuania	8,32	8,62	8,18	8	8,34
Luxembourg	0	0	0	0	0
Malta	0	0	0	0	0
Netherlands	5,36	5,36	5,32	5,06	5,12
Poland	0,3	0,32	0,12	0	0
Portugal	0	0	0	0	0
Romania	6,94	6,84	7,4	6,94	6,52
Slovakia	3,72	3,58	2,96	2,66	2,3
Slovenia	1,96	2,2	2	1,78	2,1
Spain	0	0	0	0	0
Sweden	1,74	1,08	0,9	0,9	1,04
United Kingdom	0	0	0	0	0
EU-28	**0,04**	**0,04**	**0**	**0**	**0**

Table 16 - Indicator C: Extensive Data

D – Congestion and Delays

Country	2013	2014	2015	2016	2017
Austria	9,19	8,62	8,88	8,71	8,20
Belgium	8,26	5,87	6,50	3,88	4,03
Bulgaria	9,83	6,33	6,03	7,10	7,01
Croatia	4,47	5,97	6,51	6,29	6,50
Cyprus	n.a.	9,03	8,42	n.a.	7,64
Czech Republic	8,82	6,72	7,22	6,60	6,50
Denmark	9,65	6,78	7,04	7,75	7,76
Estonia	10,00	8,53	8,72	8,92	7,90
Finland	2,49	5,15	6,64	6,44	5,90
France	10,00	7,86	7,62	6,09	4,67
Germany	8,36	4,51	6,77	7,50	6,94
Greece	5,74	3,79	4,75	6,08	5,29
Hungary	10,00	5,46	7,14	6,27	5,79
Ireland	10,00	8,23	6,13	5,61	4,68
Italy	5,82	3,22	3,86	3,78	3,87
Latvia	n.a.	n.a.	7,33	n.a.	6,55
Lithuania	9,35	7,43	6,31	6,59	6,71
Luxembourg	n.a.	n.a.	n.a.	n.a.	n.a.
Malta	n.a.	n.a.	n.a.	n.a.	n.a.
Netherlands	5,48	4,69	3,97	3,85	4,82
Poland	7,09	5,30	5,46	5,15	5,32
Portugal	8,99	6,53	6,68	5,78	5,71
Romania	7,31	5,41	6,12	5,65	6,07
Slovakia	5,22	4,33	6,78	5,29	3,91
Slovenia	9,94	8,23	8,36	6,54	6,53
Spain	8,94	5,31	6,24	5,61	5,25
Sweden	9,33	5,83	7,73	6,52	6,53
United Kingdom	5,67	3,77	4,82	4,53	4,62
EU 28	**7,92**	**6,12**	**6,62**	**6,11**	**5,95**

Table 17 - Indicator D: Extensive Data

E – Transport Fuel Consumer Prices and Taxes in Europe

Country	2013	2014	2015	2016	2017
Austria	2,62	4,29	5,70	4,64	4,39
Belgium	3,77	4,92	7,50	6,23	6,34
Bulgaria	0,00	1,34	2,48	2,97	2,60
Croatia	2,28	4,28	5,90	5,33	5,00
Cyprus	1,39	3,62	4,87	4,58	4,20
Czechia	2,60	3,32	5,44	5,09	4,99
Denmark	3,25	4,99	6,12	5,08	4,80
Estonia	1,75	3,72	5,09	3,67	3,86
Finland	4,09	5,29	7,14	6,26	6,36
France	3,77	5,63	7,61	6,65	6,60
Germany	3,92	5,89	7,25	5,84	6,08
Greece	3,22	4,45	5,53	5,09	5,60
Hungary	2,45	3,90	4,88	4,36	3,79
Ireland	4,30	5,83	7,07	6,71	5,93
Italy	5,28	6,90	8,38	7,70	7,20
Latvia	1,74	2,99	4,12	3,94	3,28
Lithuania	1,40	2,60	4,41	3,80	3,34
Luxembourg	0,85	2,51	3,91	2,97	2,64
Malta	1,60	2,05	3,30	5,23	4,75
Netherlands	4,56	6,44	7,96	6,78	6,65
Poland	1,83	3,17	4,47	3,26	3,50
Portugal	2,94	4,90	6,08	6,29	5,67
Romania	1,64	4,60	5,79	4,20	3,46
Slovakia	2,95	3,98	5,84	5,05	4,97
Slovenia	3,68	5,87	6,99	6,82	6,30
Spain	1,75	3,72	5,09	3,67	3,86
Sweden	5,05	6,60	7,22	6,94	5,10
United Kingdom	5,94	7,88	10,00	8,25	7,53
EU-28	2,88	4,49	5,93	5,26	4,96

Table 18 - Indicator E: Extensive Data

F – Investment in Transport Infrastructure

Country	2013	2014	2015	2016	2017
Austria	2,04	1,97	1,86	1,73	1,76
Belgium	1,50	1,10	1,50	1,35	1,07
Bulgaria	5,76	6,63	10,00	2,15	1,07
Croatia	5,30	3,40	2,23	1,59	1,63
Cyprus	n.a.	n.a.	n.a.	n.a.	n.a.
Czech Republic	2,05	2,28	4,59	3,10	2,84
Denmark	2,74	3,00	3,11	2,81	2,72
Estonia	4,76	2,82	3,44	2,60	3,15
Finland	3,04	3,25	3,03	2,74	2,70
France	4,09	3,32	3,01	2,80	2,80
Germany	2,06	2,14	1,98	1,95	2,11
Greece	4,74	3,61	3,23	6,97	9,59
Hungary	3,65	6,87	6,76	3,57	5,60
Ireland	n.a.	n.a.	n.a.	n.a.	n.a.
Italy	1,25	1,72	1,57	1,16	n.a.
Latvia	4,52	5,20	6,55	3,01	3,32
Lithuania	4,16	5,09	4,38	4,05	3,34
Luxembourg	2,73	2,85	3,50	3,50	3,11
Malta	n.a.	n.a.	n.a.	n.a.	n.a.
Netherlands	n.a.	n.a.	n.a.	n.a.	n.a.
Poland	2,32	1,28	1,86	2,77	2,77
Portugal	n.a.	n.a.	n.a.	n.a.	n.a.
Romania	8,85	8,09	9,18	6,53	4,93
Slovak Republic	3,30	3,99	7,00	4,01	4,32
Slovenia	2,23	3,88	4,61	1,33	1,56
Spain	2,45	2,43	2,09	1,50	1,54
Sweden	2,66	2,62	2,64	2,65	2,84
United Kingdom	2,31	2,72	3,20	3,24	3,36
EU-28	**2,35**	**2,34**	**2,39**	**2,17**	**2,03**

Table 19 - Indicator F: Extensive Data

G – Electric Vehicles as Proportion of Total Fleet

Country	2013	2014	2015	2016	2017
Austria	1,14	2,50	3,19	3,94	4,34
Belgium	0,72	2,13	2,96	4,10	4,75
Bulgaria	0,00	0,00	0,00	0,00	1,57
Croatia	0,00	1,56	1,49	0,00	0,00
Cyprus	0,00	0,00	0,00	3,43	0,00
Czech Republic	0,00	0,06	0,80	0,21	0,88
Denmark	0,00	0,00	6,10	1,12	1,40
Estonia	2,35	3,84	3,84	0,00	0,00
Finland	1,54	0,92	2,47	3,57	4,72
France	2,42	2,82	3,59	3,87	4,14
Germany	0,00	0,60	1,81	2,06	3,11
Greece	0,00	0,50	1,41	1,35	2,19
Hungary	0,00	0,48	1,89	2,99	3,81
Ireland	0,49	1,12	2,32	2,50	3,37
Italy	3,60	4,05	3,33	0,60	1,59
Latvia	0,00	4,23	0,00	0,00	0,00
Lithuania	0,00	0,00	0,00	0,00	0,00
Luxembourg	2,47	0,79	0,00	1,74	3,50
Malta	0,00	0,00	2,58	3,59	4,43
Netherlands	5,09	6,25	6,94	5,87	4,47
Poland	0,00	0,00	0,00	0,00	0,00
Portugal	0,92	1,07	2,76	3,21	4,36
Romania	0,00	0,00	0,00	0,00	0,00
Slovakia	0,00	3,94	0,00	0,00	0,00
Slovenia	0,00	0,00	1,15	2,58	3,16
Spain	0,00	0,00	0,00	0,38	1,39
Sweden	2,46	3,87	4,59	5,11	5,72
United Kingdom	0,45	2,67	3,52	3,86	4,37
EU-28	**2,21**	**3,07**	**3,75**	**3,42**	**3,89**

Table 20 - Indicator G: Extensive Data

H – Energy Consumption – Electricity and Biofuels

Country	2013	2014	2015	2016	2017
Austria	4,67	4,93	5,02	4,71	4,52
Belgium	3,51	3,75	2,92	3,72	3,86
Bulgaria	3,42	3,31	3,69	3,83	3,85
Croatia	2,05	1,96	1,67	0,12	0,02
Cyprus	1,12	1,18	0,10	0,00	0,00
Czech Republic	4,19	4,29	4,13	4,09	4,10
Denmark	3,40	3,40	3,40	3,37	3,31
Estonia	0,16	0,37	0,00	0,00	0,00
Finland	3,88	5,37	5,36	3,50	4,87
France	4,37	4,49	4,49	4,55	4,65
Germany	3,89	3,91	3,76	3,70	3,71
Greece	1,81	2,04	2,12	1,94	2,14
Hungary	4,13	4,26	4,01	4,02	3,63
Ireland	1,93	2,11	2,20	1,96	2,56
Italy	3,73	3,42	3,60	3,52	3,63
Latvia	2,21	2,34	2,23	1,11	0,96
Lithuania	3,08	2,96	3,00	2,52	2,88
Luxembourg	2,14	2,61	3,00	3,23	3,41
Malta	0,31	0,90	0,98	1,36	1,62
Netherlands	2,67	2,88	2,58	2,25	2,58
Poland	4,00	3,81	3,63	2,90	3,00
Portugal	3,33	3,27	3,64	3,19	3,04
Romania	3,74	3,37	3,69	3,80	3,96
Slovakia	3,99	4,59	4,73	4,50	4,26
Slovenia	3,02	2,42	1,87	1,17	2,33
Spain	3,05	3,08	3,19	3,27	3,36
Sweden	5,17	5,61	5,89	6,38	6,57
United Kingdom	2,13	2,33	1,96	1,96	1,92
EU-28	**3,59**	**3,67**	**3,62**	**3,55**	**3,67**

Table 21 - Indicator H: Extensive Data

Annex 2 - INDEX

Country	2013	2014	2015	2016	2017
Austria	3,63	4,08	4,32	4,21	4,08
Belgium	3,38	3,50	3,91	3,60	3,68
Bulgaria	3,75	3,55	4,12	3,40	3,29
Croatia	2,73	3,21	3,19	2,58	2,51
Cyprus	1,54	3,00	2,89	2,48	2,62
Czechia	3,25	3,12	3,78	3,36	3,35
Denmark	3,78	3,66	4,62	3,97	3,97
Estonia	4,83	4,68	4,90	3,96	3,93
Finland	3,68	4,32	4,85	4,52	4,84
France	4,36	4,40	4,64	4,37	4,24
Germany	3,76	3,59	4,18	4,14	4,21
Greece	3,30	3,24	3,43	3,98	4,19
Hungary	4,03	3,97	4,53	4,08	4,05
Ireland	3,42	3,56	3,65	3,51	3,50
Italy	3,63	3,64	3,70	3,28	3,68
Latvia	4,30	5,13	5,22	4,21	4,46
Lithuania	4,92	4,95	4,88	4,61	4,56
Luxembourg	2,01	2,21	2,43	2,55	2,78
Malta	0,38	0,59	1,37	2,04	2,16
Netherlands	4,73	5,11	5,35	4,96	4,93
Poland	2,38	2,15	2,42	2,27	2,31
Portugal	3,66	3,59	4,04	3,91	3,86
Romania	4,76	4,76	5,15	4,50	4,07
Slovakia	3,46	4,37	4,65	4,02	3,70
Slovenia	3,23	3,52	3,69	3,11	3,38
Spain	3,16	2,91	3,10	2,84	2,93
Sweden	4,85	4,71	5,17	5,11	5,01
United Kingdom	3,46	3,81	4,39	4,15	4,15
EU-28	**3,60**	**3,71**	**4,03**	**3,81**	**3,78**

Table 22 - INDEX: Extensive Data