FUTURE OF TRANSPORT AND GREEN DEAL

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Abstract

The transport system is crucial to European businesses, global supply chains and the movement of people. Transport employing more than 10 million people in Europe and contributing around 5 % to EU GDP. At the same time the huge challenge for transport and our society are: greenhouse gas and pollutant emissions, noise, road crashes and congestion.

The average of the transport emissions is on 25% of the European Union total greenhouse gas emissions with tendency of increasing over recent years. European Union and hers institutions (first of all European Commission) in coordination with Member State of the European Union has goal of being the first climate-neutral continent by 2050 requires ambitious changes in transport. For the achieve to goal of 90% reduction in transport-related greenhouse gas emissions by 2050. To achieve the goal of 90% reduction of transport-related greenhouse gas emissions by 2050, it is necessary to ensure financial capacity, knowledge, infrastructure and human resources. In addition to the above, the European Commission adopted a set of proposals to make the EU's climate, transport, energy and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.

The aim of this paper is to research the literature about transport and Green Deal, hers providing efficient, safe and environmentally friendly transport. Based on these results, the author(s) will contribute to the new knowledge about the transport and Green Deal and offer recommendations for a sustainable, efficient, safe and environmentally friendly transport.

For the purposes of this work, the author(s) used secondary data, analyzing them using the following methods: descriptive research methods, deductive research methods, analysis methods and compilation methods.

Keywords: Green Deal, sustainability, environmentally friendly transport, alternative fuels

1. INTRODUCTORY CONSIDERATIONS

The paper is structured through 7 chapters, three sub-chapters and literature review. First chapter is introduction and view of the structure of the paper. Second chapter was structured by the author(s) through three sub-chapters. The first sub-chapter relates to the Research subject, in which the author(s) introduce readers to the routes of Trans European Transport Network (TEN-T), number of recharging stations and refueling station for alternative fuel vehicles across the European Union. The second sub-chapter relates to the Research goals, in which the author(s) introduce readers to the main goals of this paper. Author(s) are focused on presenting the current situation around installed recharging stations, hydrogen refueling stations, liquefied methane refueling points and other supporting infrastructures and the third sub-chapter relates to the Research methodology. Third chapter refers to the Literature review. Fourth chapter refers to The Green Deal: A game changer for transport. The Green Deal is conceived as a sustainable concept of the modern economy and society. A concept that, with the help of new technologies, knowledge and human resources, will mitigate the impact of industry, transport and breeding of domestic animals (primarily livestock breeding) on climate change and mitigate the consequences of climate change. Significant role in achieving the set goals it has a Directive 2014/94 EU of the European Parliament and of the Council. In addition to the above-mentioned institutions, Member States also play a significant role in the implementation of the Directive, which they should ensure with their national policy frameworks. Author(s) are focus on the researching of the main pollutants in the transport sector and the possibilities of reduction of using fossil fuels as a cause and the consequence to reach climate neutrality by 2050. The challenge is to provide the appropriate number of recharging points and alternative fuel refueling points in the EU for the cars, planes and ships that use them.In this chapter, the author(s) focused their research on the needs in Road transport, Aviation and Ports. Fifth chapter refers to Infrastructure: Building a sustainable trans European transport network (TEN-T). In this chapter the author(s) emphasize the importance of TEN T as crucial transport infrastructure, which includes roads, railways, waterways and airports with the aim of improving transportation efficiency and environmental sustainability across Europe. Under this chapter author(s) presented a detailed view of the old (TEN-T) and new (TEN-T) corridor in table and with the help of maps.

The sixth chapter refers to the Intelligent Transport Systems (ITS). These are advanced applications that, without embodying intelligence in the strict sense, aim to provide innovative services related to different modes of transportation and traffic management and enable different users to use traffic networks in a "smarter" and safer way. Their contribution is ultimately reflected to reduced travel time, reduced travel costs, reduced negative impacts on the environmental performance, energy efficiency, road safety, public safety and the mobility of people and goods, but at the same time and higher level of competitiveness and employment. In this chapter author(s) focused on researching of the implementation of level ITS on the total length of the TEN -T in certain European countries. In this chapter, the author(s) focused on researching of the implementation of level ITS on the total length of the TEN -T in certain European countries, number of Electricity recharging points, number of BEV&PHEV vehicles by type category, number of hydrogen (H2) recharging points (number of H2 vehicles by type category), number of natural Gas CNG & LNG recharging points (number of CNG & LNG vehicles by type category), number of LPG vehicles by type category.

Last chapter in this paper are refers to research limitations, suggestions for further research and concluding remarks.

2. RESEARCH METHODOLOGY

2.1 Research subject

This research focuses on the implementation of fuel sources that will bring about changes, in the transportation system across Europe. It aligns with the goals outlined in the European Green Deal, (European Commission, COM/2021/559 final, 2021), goals outlined in Directive 2014/94 EU of the European Parliament and of the Council, goals outlined in Proposal for a Regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council which aims to create a future. The Trans European Transport Network corridors (TEN-T) are crucial in facilitating this transition. Will serve as a foundation for establishing infrastructure that supports alternative fuel options such, as electricity, hydrogen, CNG&LNG and LPG.

2.2. Research goals

The aim of this paper is to research the literature about Green Deal and and his influence on transformation of transport. The focus of this paper are primarily on alternative fuel infrastructure in road transport. Based on research, the author(s) will contribute to the new knowledge about the Green Deal and green transformation of transport and offer recommendations for a sustainable green transport in the future.

2.3. Data analysis

The data used for this research is primarily divided into two categories; data and policy documents. Secondary data is gathered from publicly accessible sources such, as databases, academic articles, reports on alternative fuel infrastructure and industry publications. This includes information on the number of vehicles using fuels, the availability and distribution of charging stations and the implementation levels of Intelligent Transport Systems (ITS) in selected Member States. Additionally to gain a understanding of the effectiveness of the infrastructure the authors also calculated the ratio of alternative fuel vehicles per charging station. The study examines National

Policy Frameworks (NPFs) and National Implementation Reports (NIRs) provided by EU Member States. These documents are publicly available. Provide insights into government commitments, targets and performance metrics related to adopting alternative fuels. Furthermore additional data was extracted from publications by organizations like the European Commission and other international bodies that produce reports on sustainable transport and energy. It is important to note that all utilized data is publicly available without involving any sensitive information ensuring integrity in conducting this research while offering a comprehensive perspective, on how alternative fuels are influencing European transportation network particularly focusing on TEN-T corridors.

The constraints of the paper is predominantly quantitative and relies on statistical methods, which inherently carry assumptions that may not fully capture the complexities of the real scenarios and target goals.

3. LITERATURE REVIEW

The European Green Deal was lunched by European Commission (European Council, EUCO 29/19, 2019) in December 2019. Under the Green Deal (European Council & Council of the European Union, European Green Deal, 2023). European Union declared very optimistic goal of becoming the first carbon-neutral region by 2050.

The first reasonable definition of the “Green New Deal” was the idea that with "green" (clean and sustainable) technologies and products, a thorough structural change of the global economy that could prevent dangerous climate change and mitigate the consequences of climate change (Galvin & Healy, 2020).

The concept of the Green New Deal was formulated on the basis of a figurative rhetorical question: "Do we want to justify overcoming the crisis by reviving the existing 'brown' global economy, or do we want to promote global revitalization toward a 'green' economy that avoids ecological damage in the first place?“ (Barbier, 2010).

Reducing the use of fossil fuels in transport is key if the EU is to reach climate neutrality by 2050. In order to achieve this goal, there needs to be enough recharging points and alternative fuel refueling points in the EU for the cars, planes and ships that use them (European Council & Council of the European Union, Infographic - Fit for 55: towards more sustainable transport, 2023).

Significant role in achieving the set goals it has a Directive 2014/94 EU of the European Parliament and of the Council. This Directive establishes a common framework of measures for the deployment of alternative fuels infrastructure in the Union in order to minimize dependence on oil and to mitigate the environmental impact of transport. This Directive sets out minimum requirements for the building-up of alternative fuels infrastructure, including recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and hydrogen, to be implemented by means of Member States national policy frameworks, as well as common technical specifications for such recharging and refueling points, and user information requirements (European Commission, Directive 2014/94/EU, 2014).

In implementing the Directive major roll has the Member States. Member States shall ensure, by means of their national policy frameworks, that an appropriate number of recharging points accessible to the public. Also, Member States which decide to include hydrogen refuelling points accessible to the public in their national policy frameworks shall ensure that, by 31 December 2025, an appropriate number of such points are available, to ensure the circulation of hydrogen-powered motor vehicles, including fuel cell vehicles, within networks determined by those Member States, including, where appropriate, cross-border links. Member States shall ensure, by means of their national policy frameworks, that an appropriate number of refuelling points for LNG are put in place at maritime ports, to enable LNG inland waterway vessels or seagoing ships to circulate throughout the TEN-T Core Network by 31 December 2025. Also, Member States shall cooperate with neighbouring Member States where necessary to ensure adequate coverage of the TEN-T Core Network (European Commission, Directive 2014/94/EU, 2014).

A detailed description of the influence of traffic types (road, aviation: ships, trains, others) on the amount of greenhouse gases produced is presented in the next chapter.

4. GREEN DEAL: A GAME CHANGER FOR TRANSPORT

Most research on new energy vehicles in transportation focuses on small and medium–sized vehicles, although heavy trucks are responsible for most cargo transportation. Heavy trucks generally use diesel engines, which emit high levels of nitrogen oxides and particulate pollutants during operation, posing a threat to human health, contributing to global warming, and negatively impacting ecological sustainability. Therefore, it is necessary and meaningful to include heavy–duty electric trucks to participate in the study of cargo transportation (Lu & Shuang, 2023).

Picture 1 The European Green Deal

Source: Author(s) processed and adapted to: (DNV, 2020) (accessed 04.07.2023.)

According to Picture 1. The European Commission has a plan to provide numerous benefits to its citizens and the next generation in mind:

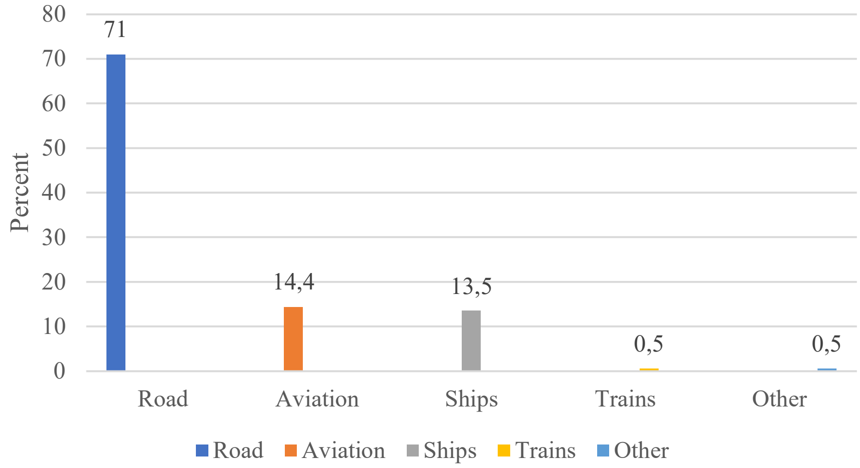
- ✓ fresh air, clean water, healthy soil and biodiversity
- ✓ renovated, energy efficient buildings
- ✓ healthy and affordable food
- ✓ more public transport
- ✓ cleaner energy and cutting-edge clean technological innovation
- ✓ longer lasting products that can be repaired, recycled and re-used
- ✓ future-proof jobs and skills training for the transition
- ✓ globally competitive and resilient industry (European Commission, 2019)

In order to ensure the above, the European Union and its institutions, together with the national institutions of the Union Member States, work diligently in each of the above areas.

For the purpose of this paper author(s) are focus on transport as as a significant factor of negative effects on environment and direct consequences of the generally occurring climate changes.

According to the available information transport is responsible for almost 25% of greenhouse gas (GHG)[1] emissions in the EU. If we look the Figure 1. we can se the share of emissions per transport type.

Figure 4 Share of emissions per transport type



Source: Author(s) processed and adapted to: (European Council & Council of the European Union, Infographic - Fit for 55: towards more sustainable transport, 2023), *(accessed 04.07.2023.)*

Share of emissions per transport type the road transport (71%) has most negative effects on nature. Under the road transport the most polution in 2019. year of GHG coming from the cars (60.6%), heavy duty trucks (27.1%), light duty trucks (11%), motorcycles (1.3%) (European Parliament, CO2 emissions from cars: facts and figures (infographics), 2019). On the second place is aviation with 14.4% and ships with 13.5% of GHG. Trains and other type of transport have the least impact on the environment (0.5 %).

For example the cars and vans represent the biggest share of CO_2 emissions in transport in absolute terms, and average emissions from internal combustion engine cars are rising. The rollout of charging and refuelling infrastructure for alternative drive systems, in conjunction with the new CO_2 emission standards, and in particular the ramping up of electro-mobility, to be a key condition for achieving the climate targets at European, national and regional level. the transformation of the European automotive industry towards zero-emission vehicles is the most comprehensive structural change in the sector to date, with a multitude of impacts on workers, suppliers and car manufacturing groups in Europe. Necessity of establish, by the European Commission, European Mechanism for a just transition of the automotive sector and regions" which should draw on European funds and make sure it addresses

[1] GHG = Greenhouse gases (also known as GHGs) are gases in the earth's atmosphere that trap heat. Available at: (National Grid, 2023)

challenges in the regions most affected by the transformation and reaches all SMEs in the supply chain to adapt to the changes in the automotive value chain (European Commitee of the Regions, 2022).

One of solution for the future sustainability of transport and minimizing impact of GHG for sure are more vehicles powered by electricity and alternative fuels. According to the available information in the EU there are over 13.4 million alternative fuel cars and vans. Today, it's less than 5% of total fleet but it is estimated that the percentage of all cars and vans in the EU that run on alternative fuels will grow tenfold by 2050 (European Council & Council of the European Union, 2023).

In addition to the electric vehicles, it is necessary to provide the accompanying infrastructure, there needs to be enough recharging points and alternative fuel refueling points for the cars, planes and ships that use them.

The needs in *Road transport* are reflected in recharging stations. The EU plan is to install at least one recharging stations on every 60 km on the main roads (core TEN-T[2] network) for passenger cars and trucks below 3.5 tonnes by the end of 2025 and for trucks heavier than 3.5 tonnes by the end of 2030. Every year, the total power output provided through recharging stations grows with the number of registered cars. For trucks above 3.5 tonnes at least two recharging points in each safe and secure parking area (end of 2027) and four by end of 2030 (European Council & Council of the European Union, 2023).

Plan for the hydrogen refuelling stations is at least every 200 km on main roads (end of 2030), at least one refuelling station in every urban node. Every refuelling station will have a designed capacity to provide 1 tonne of hydrogen per day, at 700 bar (European Council & Council of the European Union, 2023).

Also the plan for liquefied methane refuelling points is at least one along main roads to allow vehicles using methane to circulate throughout the EU (European Council & Council of the European Union, 2023).

The new infrastructure will have to: allow ad-hoc charging, accept electronic payments and clearly inform users about pricing options (European Council & Council of the European Union, 2023).

The needs in *Ports* (especially in the busiest sea ports) are reflected in at least 90% of container ships and passenger ships to have access to shore-side electricity supply (European Council & Council of the European Union, 2023).

In most of the inland waterway ports at least one installation providing shore-side electricity (by 2030) (European Council & Council of the European Union, 2023).

The needs in *Aviation* are reflected in electricity supply for all aircraft stands next to the terminal by 2025 and all remote stands by 2030 with an exception for the

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[2] „along the TEN-T road network' means:

(a) with regard to electric recharging stations: that they are located on the TEN-T road network or within 3 km driving distance from the nearest exit of a TEN-T road; and

(b) with regard to hydrogen refuelling stations: that they are located on the TEN-T road network or within 10 km driving distance from the nearest exit of a TEN-T road". (11454/23, p.60 https://data.consilium.europa.eu/doc/document/ST-11454-2023-INIT/EN/pdf) (2021/0223(COD) 11454/23, 2023), (accessed 02.07.2023.)

airports with fewer than 10 000 flights per year may use a derogation for remote stands (European Council & Council of the European Union, 2023).

5. INFRASTRUCTURE: BUILDING A SUSTAINABLE TRANS-EUROPEAN TRANSPORT NETWORK (TEN-T)

The Trans European Transport Network (TEN-T) is a transportation infrastructure network designed to connect all regions of Europe in a way that supports travel. It includes roads, railways, waterways and airports with the aim of improving transportation efficiency and environmental sustainability across the continent.

The role of TEN-T, in the success of the Green Deal cannot be overstated. By promoting transportation methods and reducing reliance on fuels TEN-T plays a vital part in achieving the goals outlined by the Green Deal. A connected and sustainable transport network has the potential to reduce congestion, lower emissions and enhance quality of life for citizens.

As we strive to lessen our dependence on fuels alternative fuels are becoming increasingly important. Fuels like biofuels, electricity and hydrogen offer benefits such as reduced emissions and enhanced energy security.

However there are challenges associated with adopting these fuels. One major obstacle is the lack of infrastructure to support their use. This includes having charging stations for vehicles as well as refueling stations, for hydrogen powered vehicles. Additionally issues related to production and distribution need to be addressed in order to facilitate adoption and utilization of these fuels.

The updated Trans European Transport Network (TEN-T) takes an approach, to the transportation infrastructure in Europe. Unlike the version, which mainly focused on connecting cities and ports the new TEN-T aims to establish a network that covers all regions of Europe effectively. The framework consists of two layers; the network and the core network.

The core network consists of nine corridors that support modes of transportation. These corridors, listed in the Table 1 and Pictures 1 and 2 below play a role in achieving the objectives of the TEN-T network, such as improving connectivity reducing congestion and promoting friendly transportation methods. They seamlessly integrate road, rail, air and maritime transport systems to facilitate movement between member states.

Table 4 TEN-T Network of Corridors

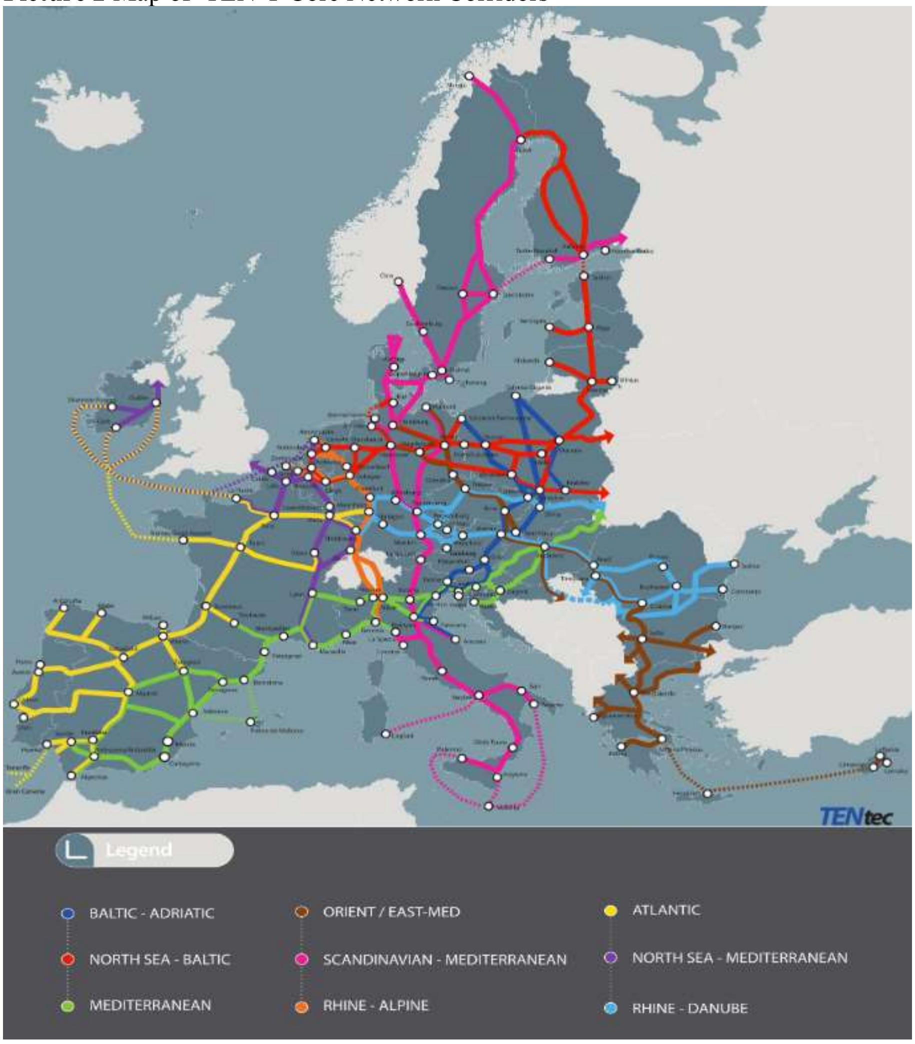
TEN-T Network Corridors	New TEN-T Network Corridors
1. Atlantic	1. Atlantic
2. Baltic-Adriatic	2. Baltic-Adriatic
3. Mediterranean	3. Mediterranean
4. North Sea-Baltic	4. North Sea-Baltic
5. North Sea-Mediterranean	5. North Sea-Rhine-Mediterranean
6. Scandinavian-Mediterranean	6. Scandinavian-Mediterranean
7. Rhine-Danube	7. Rhine-Danube
8. Orient/East-Med	8. Western Balkans-East Mediterranean
9. Rhine-Alpine	9. Baltic sea-Black sea-Aegean sea

Source: (European Commission, Mobility and Transport, 2023), (accessed 04.07.2023.)

Each corridor is meticulously planned to incorporate modes of transport and connect hubs, ports and cities within the European Union. Serving as the backbone of the TEN-T network these corridors are expected to be fully operational by 2030.

The Comprehensive Network goes beyond the core network by ensuring that remote regions are well integrated into Europes transportation landscape. This comprehensive network is projected to be completed by 2050 and aims to provide high quality connections, for all modes of transport while preventing any region from being isolated.

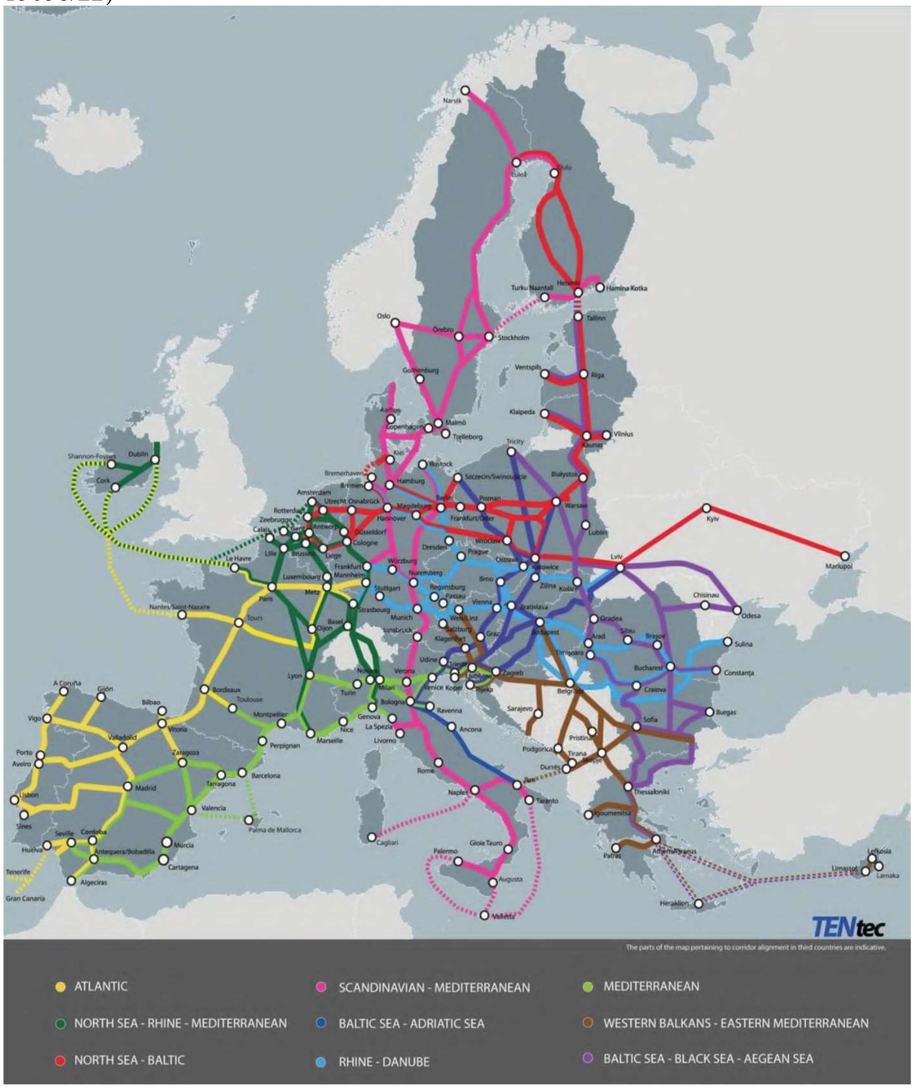
Picture 2 Map of TEN-T Core Network Corridors



Source: (European Commission, TEN-T Interactive Map Viewer, 2023), (accessed 04.07.2023.)

According to the Picture 2. TEN-T Core Network Corridors it is made up of ninen strategic transport corridors (Baltic -Adriatic, North sea – Baltic, Mediterranean, Orient/Est-Med, Scandinavian – Mediterranean, Rhine – Alpine, Atlantic, North sea – Mediterranean, Rhine – Danube).

Picture 3 Map of TEN-T Core Network Corridors as adopted by the Transport Council for the revision of the TEN-T Regulation on 5 December 2022 (ST 15058/22)



Source:
https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/729314/EPRS_BRI%282022%29729314_EN.pdf (accessed 05.07.2023.)

According to the Picture 3. Map of TEN-T Core Network Corridors as adopted by the Transport Council for the revision of the TEN-T Regulation some changes have been made compared to Picture 2. TEN-T Core Network Corridors. Corridor Orient/East-Med has been replaced by the Western Balkans-East Mediterranean and corridor Rhine-Alpine has been replaced by the Baltic sea-Black sea-Aegean sea. The changes made in the corridors contributed to the strengthening of the traffic importance of the eastern and southern parts of Europe.

6. INTELLIGENT TRANSPORT SYSTEMS (ITS)

The term Intelligent Transport Systems (ITS) has been introduced in transport and traffic engineering during the 1990s (Mandžuka et al., 2013).

Due to the increase in road traffic in the Member States of the European Union in the context of economic growth and mobility needs of citizens is the main cause of increasing congestion of road infrastructure and energy consumption, as well as a source of environmental and social problems, was introduced the need for intelligent transport systems (ITS).

Intelligent Transport Systems (ITS) are advanced applications that, without embodying intelligence in the strict sense, aim to provide innovative services related to the different modes of transport and traffic management, and to allow the different users to be better informed and to use transport networks in a safer, more coordinated and "smarter" way.

ITS integrate telecommunications, electronics, and information technologies with transportation engineering to plan, design, operate, maintain, and manage transportation systems. The application of information and communication technologies to the road transport sector and its interfaces with other transport modes will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, road safety, including the transport of dangerous goods, public safety and the mobility of people and goods, while ensuring the functioning of the internal market and a higher level of competitiveness and employment. However, the applications of ITS should not affect matters related to national security or necessary in the interest of defence.

Progress in the application of information and communication technologies to other modes of transport should now be reflected in developments in the road transport sector, particularly with regard to greater integration between road transport and other modes of transport.

In some Member States, these technologies are already being deployed at national level in the road transport sector (Directive 2010/40/EU).

The improvements associated with the use of ITS usually manifest themselves in reduced travel time, reduced travel costs, reduced incidents, reduced negative impacts on the environment, increased pedestrian comfort and satisfaction, increased capacity, and industry development. (Šimunović et al., 2009)

This indicator describes the deployment of Intelligent Transport Systems on the Pan European Road Network. The values show in Figure 2. the proportion of the road network equipped with different levels of ITS. The levels range from Level 0 to Level 4 as shown below and are based on the Easy Way Deployment Guidelines.

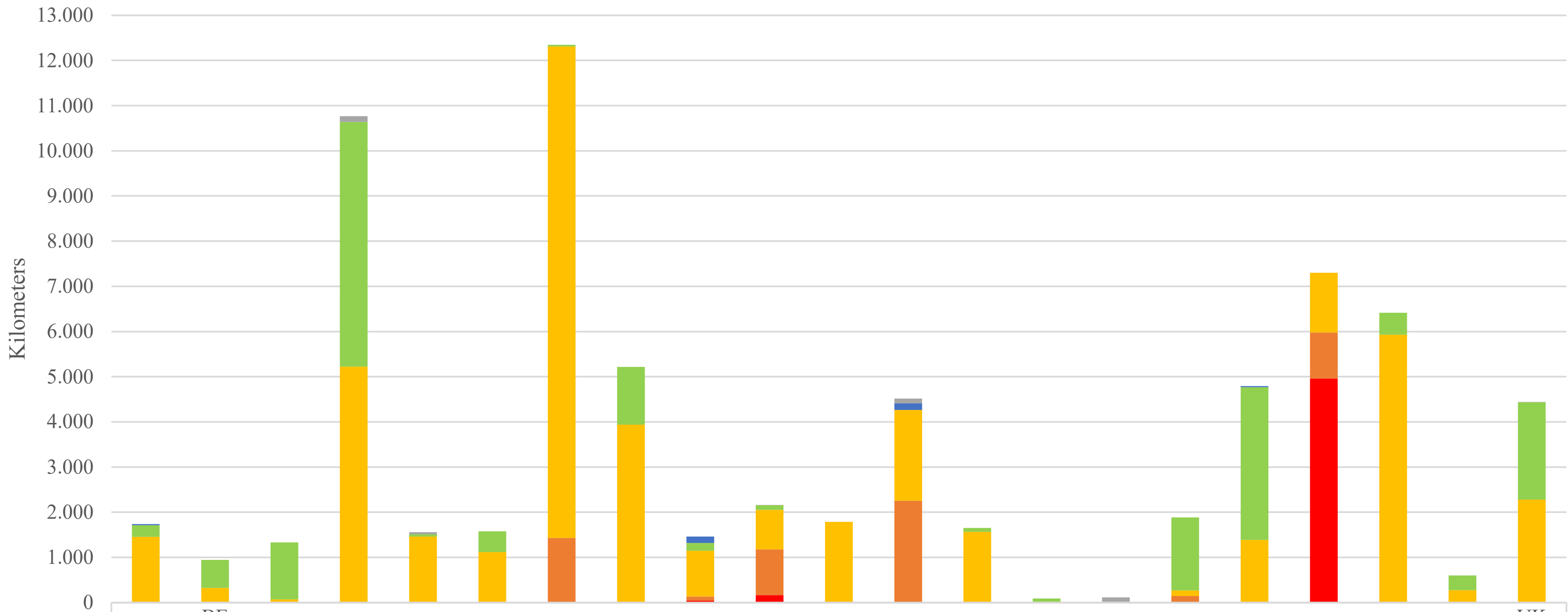
Table 5 Levels of use Intelligent Transport Systems based

Level 0	None
Level 1	Monitoring system (e.g. real-time data about traffic/weather conditions is collected by or on behalf of the road administration)
Level 2	Traffic information system (road administration passively manages the network e.g. information about traffic/weather conditions is provided to road users)
Level 3	Traffic management system (road administration actively manages the network e.g. variable speed limits, dynamic lane management, ramp metering)
Level 4	Cooperative ITS (i.e. vehicle-to-vehicle or infrastructure-to-vehicle information)

Source: *(Pettersson, et al., 2022)*, (accessed 04.07.2023.)

The implementation of level ITS on the total length of the TEN-T network for 2021 shows that most countries have implemented level 2 with 43,036 km or 60% of the total length, followed by level 3, which has been implemented with almost 24.5% 17,807 km and is longest in absolute terms in Denmark with 5,415 km, Norway with 3,380 km, England with 2,159 km and the Netherlands with 1,615 km. Luxembourg has 89 km of fully covered level 3 roads ITS, while Switzerland has 94.6% coverage. Poland has the highest number of roads with no ITS system implemented, 4,958 km, and 1,024 with Level 1. Significant investments are expected to be made in the implementation of ITS. Interestingly, only four countries have implemented Level 4: Italy, Hungary, Austria, and Norway, with the relatively highest percentage in Hungary at 9.9% (Figure 2).

Figure 5 Length of the Pan European Road Network Featuring Different Levels of ITS in 2021



	AT	BE (Flanders)	CH	DE	DK	ES	ES	FI	HU	IE	IS	IT	LT	LU	MT	NL	NO	PL	SE	SI	UK (England)
No Data	0	0	0	127	49	0	0	0	0	6	0	102	0	0	114	0	0	0	0	0	3
Level 4	25	0	0	0	0	0	0	0	144	0	0	148	0	0	0	0	21	0	0	0	0
Level 3	261	623	1261	5415	49	465	39	1278	167	108	0	0	84	89	0	1615	3380	0	490	324	2159
Level 2	1454	325	72	5225	1461	1116	10880	3939	1019	868	1786	2009	1568	0	0	125	1389	1319	5927	275	2278
Level 1	0	0	0	0	0	0	1429	0	91	1015	0	2255	0	0	0	146	0	1024	0	0	0
Level 0	0	0	0	0	0	0	0	0	41	166	0	0	0	0	0	0	0	4958	0	0	0

Level 0 Level 1 Level 2 Level 3 Level 4 No Data

Source: Author(s) adopted to: *(Pettersson, et al., 2022)* 2021 Pan European Road Network Performance Report p. 74, (accessed 04.07.2023.)

Table 6 Electricity recharging points, number of BEV&PHEV vehicles by type category

	AC	DC	Total	Number of BEV&PHEV vehicles per charging station	Number of BEV&PHEV vehicles	Number of BEV vehicles	Number of PHEV vehicles	Passenger cars (M1)		Light Commercial Vehicles (N1)		Buses (M2 & M3)		Trucks (N2 & N3)	
								BEV	PHEV	BEV	PHEV	BEV	PHEV	BEV	PHEV
2012	*	*	10,507	3.75	39,424	35,712	3,712	25,891	3,712	9,527	-	286	-	8	-
2013	*	*	17,850	7.27	129,781	68,805	60,976	52,130	60,880	13,175	-	2,756	96	744	-
2014	*	*	26,536	7.07	187,637	103,236	84,401	79,899	84,304	19,374	-	3,052	97	911	-
2015	*	*	49,363	6.31	311,295	160,514	150,781	127,194	150,582	29,249	-	3,192	199	879	-
2016	*	*	77,038	5.78	445,590	230,404	215,186	184,431	214,811	41,704	1	3,332	335	937	39
2017	*	*	109,896	5.62	617,742	338,629	279,113	278,066	278,613	55,808	1	3,131	459	1,624	40
2018	*	*	123,727	6.58	813,578	444,624	368,954	365,924	368,380	72,372	1	3,918	533	2,410	40
2019	*	*	133,947	8.86	1,186,314	698,587	487,727	600,394	487,004	89,503	117	5,328	568	3,362	38
2020	156,779	18,267	175,046	12.46	2,181,432	1,220,208	961,224	1,098,849	959,584	111,237	1,054	6,909	557	3,213	29
2021	279,838	23,340	303,178	12.81	3,883,156	2,088,952	1,794,204	1,928,307	1,790,873	146,961	2,733	9,432	554	4,252	44
2022	400,913	46,186	447,099	13.54	6,052,598	3,302,829	2,749,769	3,063,203	2,743,867	224,214	4,909	11,673	878	3,739	115
2025	N/A	N/A	1,000,000 T	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2030	N/A	N/A	6,800,000 T	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Data counting methodology until 2019 did not did not take into account the type of charging station
T- Target value
Source: Author(s) adopted and calculated to: EAFO (accessed 15.07.2023.)

Battery electric vehicles (BEVs) are fully electric meaning they don't have an internal combustion engine. They solely rely on their batteries, which you can charge from a power source. On the hand plug in hybrid electric vehicles (PHEVs) have both a motor and a conventional combustion engine. They can operate using electricity for distances and switch to the internal combustion engine for trips. Like BEVs PHEVs can charge their battery either from a power outlet or, by using the internal combustion engine. The main differences between these two types of vehicles lie in their range capabilities refueling infrastructure options and CO2 emissions. When it comes to range BEVs generally offer an all driving range compared to PHEVs. However PHEVs have the advantage of range thanks, to their gasoline engines. In terms of refueling infrastructure options BEVs rely on electric charging stations for recharging their batteries. On the hand PHEVs have the flexibility of being able to use both charging stations and conventional gasoline fueling stations. One important distinction is that when powered by electricity BEVs are considered zero emission vehicles since they do not produce any emissions during operation. However it's worth noting that PHEVs may still generate emissions when their internal combustion engines are running. To charge the batteries of vehicles efficiently with current (DC) converters are required to convert alternating current (AC) into DC power. Typically AC chargers are used at home overnight for charging your vehicle. They have some characteristics, including a price and a slower charging speed compared to DC chargers. DC chargers on the hand charge the vehicles battery faster and are typically used while, on the road. This can pose challenges due to time constraints and the limitations of infrastructure and power grid. The dominance of passenger cars in the category of BEV highlights the shift in consumer preference towards vehicles for use. Data indicates an adoption of both BEVs and PHEVs with a focus on passenger cars. While BEVs are gaining popularity across all vehicle categories PHEVs are commonly found in passenger cars suggesting patterns of adoption for these two types of electric vehicles. Based on data until 2022 the usage of battery vehicles in N2 and N3 categories is still at an early stage but shows signs of growth potential. By 2022 there will be an increase in BEV trucks within these categories. 206 trucks compared to 4 in 2016. Despite starting from a base this growth reflects increasing interest and investment in electrifying heavy duty vehicles. Electric trucks within these categories offer benefits such as reduced operating costs, lower emissions and compliance, with regulations. While the figures may not be as high, as those seen in vehicle sectors it seems that the logistics and heavy duty industries are gradually embracing environmentally friendly energy choices. As sustainability and reducing emissions become more important we can anticipate these numbers to keep growing in the future. This growth will be fueled by advancements, in battery technology and the development of charging infrastructure (Table 3).

Table 7 Hydrogen (H2) recharging points, number of H2 vehicles by type category

	High pressure (700 bar)	Low pressure (350 bar)	H2 vehicles per stations (high pressure)	H2 vehicles per stations (low pressure)	Number of H2 vehicles				
						Passenger cars (M1)	Light Commercial Vehicles (N1)	Buses (M2 & M3)	Trucks (N2 & N3)
2016	20	15	28.20	37.60	564	366	162	32	4
2017	24	15	31.83	50.93	764	531	186	41	6
2018	24	15	43.46	69.53	1,043	718	280	40	5
2019	100	13	15.10	116.15	1,510	1,182	280	41	7
2020	105	19	21.39	118.21	2,246	1,842	303	92	9
2021	108	28	29.55	113.96	3,191	2,706	306	165	14
2022	132	44	34.55	103.64	4,560	3,993	306	206	55
2025	300^{T}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2030	1,000^{T}	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

T- Target value
Source: Author(s) adopted and calculated to: EAFO, (ACEA, 2021), (accessed 15.07.2023.)

The analysis of hydrogen fueling station infrastructure, between 2016 and 2022 reveals growth. Pressure (700 bar) stations have experienced a compound growth rate (CAGR) of around 37% increasing from 20 to 132 stations. Additionally there has been a CAGR of 24% for low pressure (350 bar) fueling stations indicating a deliberate effort to expand the infrastructure. Based on the vehicle to station ratio high pressure stations are moderately utilized while low pressure stations are in demand suggesting a need for expansion in the latter.

Some countries have set more specific targets related to production volume or share of fuel cell vehicles (Belgium, Czechia), share of fuel consumption (Germany, Hungary, Italy, Slovakia, Slovenia) or number of refuelling stations (Czechia, France). In general, specificity implies a low degree of comparability (Wolf & Zander, 2021).

The penetration of hydrogen vehicles has seen an increase across all categories. The highest penetration is observed in passenger cars (M1) accounting for 3,993 out of the total of 4,560 hydrogen vehicles in 2022. There is also promising growth in vehicles (N1) buses (M2 & M3) and trucks (N2 & N3) albeit at a slightly slower pace. This suggests that hydrogen vehicles are not gaining popularity among consumers but also making their way, into the public transport sectors (Table 4).

Table 8 Natural Gas CNG & LNG recharging points, number of CNG & LNG vehicles by type category

	CNG stations	LNG stations	Total CNG& LNG station	Natural gas vehicles per natural gas refuelling point	Number of CNG & LNG vehicles				
						Passenger cars (M1)	Light Commercial Vehicles (N1)	Buses (M2 & M3)	Trucks (N2 & N3)
2015	2,957	63	3,020	401.63	1,212,936	1,058,992	132,072	17,242	4,630
2016	3,091	80	3,171	391.84	1,242,530	1,089,608	126,082	20,809	6,031
2017	3,111	110	3,221	425.64	1,371,001	1,113,587	226,450	21,457	9,507
2018	3,216	133	3,349	399.52	1,337,997	1,160,998	136,735	22,680	17,584
2019	3,490	237	3,727	375.71	1,400,254	1,201,812	157,914	20,078	20,450
2020	3,642	332	3,974	363.49	1,444,506	1,233,197	163,146	22,119	26,044
2021	3,778	421	4,199	343.29	1,441,483	1,224,651	163,244	23,523	30,065
2025	5,579[T]	396[T]	5,975[T]	N/A	N/A	N/A	N/A	N/A	N/A
2030	7,257[T]	1,335[T]	8,592[T]	N/A	N/A	N/A	N/A	N/A	N/A

T- Target value
Source: Author(s) adopted and calculated to: EAFO, (Prussi, Julea, Lonza, & Thiel, 2021), (accessed 15.07.2023.)

The use of gas has seen growth particularly in the development of CNG refueling stations. As of 2021 there are 3,778 CNG fueling stations compared to 421 LNG stations. This indicates a focus, on expanding the CNG infrastructure possibly due to its range of applications and lower costs for implementation. When it comes to vehicles passenger cars (M1) dominate the CNG market with 1,224,651 units in 2021. This accounts for a portion of the number of CNG vehicles which stands at 1,441,483. Light commercial vehicles and buses have also experienced growth with figures reaching 163,244 and 23,523 units respectively in the year. Furthermore there has been an increase in the number of trucks powered by gas which is expected to reach 30,065 units in 2021. This suggests a growing acceptance within the logistics and heavy duty vehicle sectors. Overall there has been an expansion in the natural gas infrastructure accompanied by growth across all vehicle categories. CNG fueling stations dominate the infrastructure landscape while passenger vehicles lead in terms of adoption. The decreasing ratio between vehicles and fueling stations indicates scaling of infrastructure. These trends collectively confirm the maturity and diversity, within the natural gas ecosystem (Table 5).

Table 9 Liquefied Petroleum Gas LPG recharging points, number of LPG vehicles by type category

	LPG Refuelling stations	Number of vehicles per LPG refuelling stations	Number of LPG vehicles	Passenger cars (M1)	Light Commercial Vehicles (N1)	Buses (M2 & M3)	Trucks (N2 & N3)
2014	28,263	252.89	7,147,532	6,924,669	210,366	799	11,698
2015	28,723	254.87	7,320,633	7,084,604	224,224	788	11,017
2016	28,959	257.70	7,462,713	7,225,795	224,696	825	11,397
2017	30,264	249.66	7,555,775	7,258,780	284,601	801	11,593
2018	31,286	253.42	7,928,357	7,625,967	289,701	1,010	11,679
2019	32,710	246.21	8,053,482	7,749,321	291,456	780	11,925
2020	31,541	253.40	7,992,641	7,690,119	289,725	799	11,998
2021	30,744	259.74	7,985,303	7,685,643	286,659	798	12,203
2025	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2030	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Remark: The member states different approaches make it impossible to obtain the target values.
Source: Author(s) adopted and calculated to: EAFO (accessed 18.07.2023.)

The total count of LPG stations has generally gone up over the years. It reached its point in 2019 with 32,710 stations. Slightly decreased to 30,744 stations in 2021. When it comes to vehicle categories, passenger cars (M1) take the lead with a

7,685,643 vehicles in 2021. They make up the majority of the LPG vehicles at 7,985,303. These numbers have consistently increased over time showing that consumers strongly prefer using LPG for their transportation needs. In terms of vehicles (N1) they set a record breaking number. Are not as numerous, as passenger cars. In 2021 there were 286,659 vehicles. As for buses (M2 & M3) and trucks (N2 & N3) these categories are relatively smaller in comparison. In 2021 there were a total of 798 buses and 12,203 trucks. Although the number of refueling stations has been relatively stable recently the increasing ratio of vehicles, to refueling stations indicates that existing infrastructure is being utilized efficiently and effectively. While passenger cars make up the majority of LPG usage other vehicle categories also show stability to some extent (Table 6).

7. RESEARCH LIMITATIONS, SUGGESTIONS FOR THE FUTURE RESEARCH AND CONCLUDING REMARKS

7.1 Research Limitations

The examination of National Policy Frameworks (NPFs) and National Implementation Reports (NIRs) is limited to the documents that are currently accessible and publicly available. It's important to note that these documents may not offer an overview of all the initiatives or future plans.

7.2 Suggestions for Further Research

Adding a perspective, to the research, which includes analyzing the Return on Investment (ROI) for the private, public and state stakeholders, would provide another valuable dimension to the study.

7.3 Concluding remarks

The transportation industry finds itself at a crossroads with both possibilities and daunting challenges particularly in the shift, towards electric and hydrogen powered cars and trucks. One major hurdle is the need for infrastructure investment in the form of electric and hydrogen charging stations. Achieving this objective will require efforts from governments, businesses and other stakeholders to ensure the development and expansion of this infrastructure. Another challenge lies in influencing consumer behavior to embrace these modes of transportation. Accomplishing this transformation will necessitate targeted campaigns and incentives that make electric and hydrogen options more appealing and accessible to the public.

The transition to electricity and hydrogen as fuels is creating opportunities for innovation while giving rise to new business models within the transportation sector. The European Green Deal is already driving advancements in charging infrastructure. Moreover both the EU, as a whole and its member states are allocating resources towards promoting eco logistics presenting companies with an opportunity to overhaul their supply chain operations.

However it's important to acknowledge that transitioning to these fuels comes with complexities. At present it takes three hours for a truck to fully charge while hydrogen refueling takes even longer.

These extended refueling durations have consequences, for logistics, impacting areas such as inventory control, route mapping and the overall efficiency of supply chains. To ensure a transition, to energy sources companies must incorporate these logistical considerations into their planning.

To sum up as we focus on utilizing electricity and hydrogen to power vehicles it is crucial to adopt an multifaceted strategy. This strategy should prioritize enhancing infrastructure addressing obstacles and capitalizing on the opportunities presented by this shift towards a more sustainable transportation network.

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