Emission reduction strategies for the transport sector in Poland

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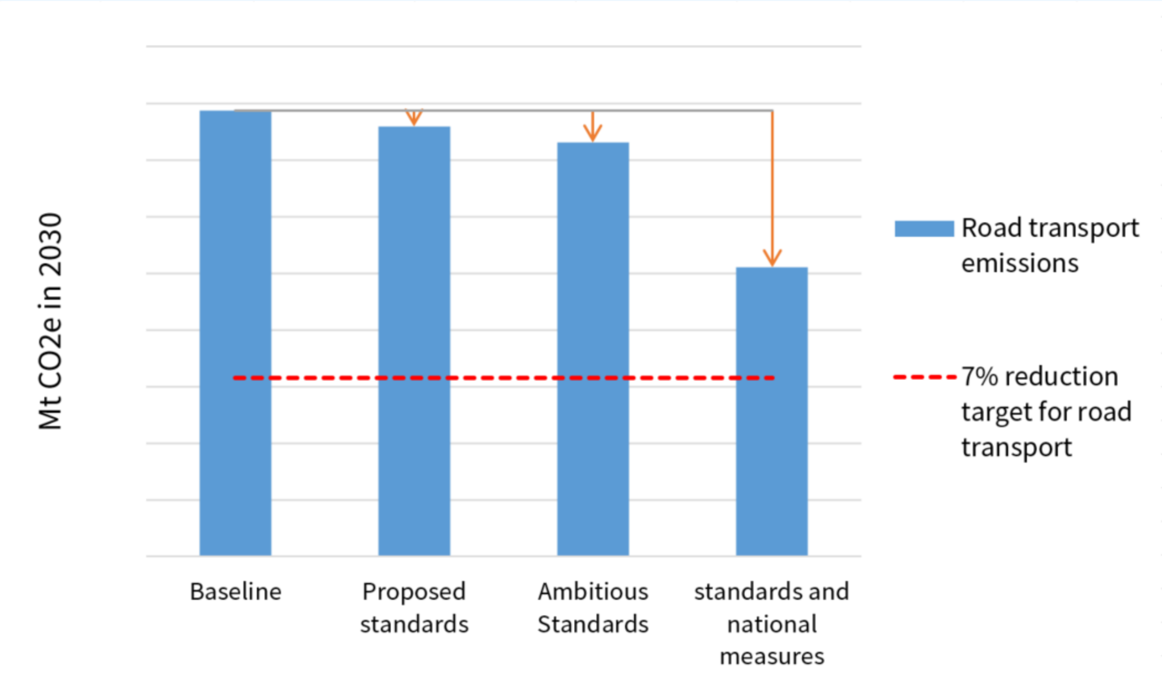
Legal notice

Executive Summary

In Poland, between 1990 and 2016, emissions from transport increased by a factor of 2.5, from 22.4 Mt CO_2eq to 56.0 Mt CO_2eq; in the context of requiring complete decarbonisation by the mid-century under the Paris Agreement, this trend needs to be rapidly reversed. Poland is already experiencing amplified climate change and warming compared to Europe[1]. If no action is taken, Poland risks not meeting their medium term European reduction targets. The objective of this report is to show how Poland can decrease their transport emissions from a broad range of European and national measures. In particular, the report focuses on reductions in road transport emissions that fall under the jurisdiction of the European Climate Action Regulation, which enforces a 7% emissions reduction target in 2030 compared to 2005. Finally, policy recommendations are presented to enable Poland to meet the most ambitious targets.

The effect of mitigating measures such as vehicle efficiency standards, modal shift, and demand reduction, among many others, are calculated using Transport & Environment's in-house transport model, the EUTRM. The main results of the scenarios investigated are shown below. The report shows that Poland will have to find large energy savings in other sectors to meet its overall 2030 climate targets, as ambitious vehicle standards, electrification, and ambitious national measures won't be enough to reduce the expected growth in emissions to hit the target.



The scenarios in detail:

Baseline: If Poland takes no action and the proposed 2030 CO_2 standards for road vehicles are not implemented, Poland will fall short of its 2030 targets by 47.2 Mt of emissions. Under the CAR regulation, this may result in requiring the purchase of up to 297 million allowances. Assuming that the other sectors just meet their target, no flexibilities, and an allowance price of €100/tonne, this would be €30 billion, if loopholes in the regulation are not used.

Proposed Standards: If the European Commission's 2030 CO_2 standards for cars, vans, and trucks are implemented, Poland will fall short of its 2030 targets by 44.5 Mt of emissions; the proposed

[1] https://www.climatechangepost.com/poland/climate-change/

standards would close *the gap* between the target and the projected baseline emissions by only 6%.

Ambitious Standards with Electrification: The European Commission's proposed 2030 CO_2 standards for cars, vans, and trucks are strengthened to their technical and economically viable potential. This means 40% 2030 CO_2 reduction targets for cars and vans; for trucks this would be 43%. Within these standards, the electrification of road transport is encouraged to ensure the eventual full decarbonisation of the sector. In 2030, sales of electric vehicles reach 40% for cars, 40% for vans, and 30% for trucks. In parallel, all new sales of city buses in Poland will be electric. Even with this ramp up of electrification, Poland will still not meet its 2030 targets by 41.5 Mt CO_2eq; ambitious standards and electrification could deliver 12% of the effort required to close the gap.

National measures: There is a wide range of national measures that can help reduce demand and enable shifting to cleaner modes. Measures include shifting car passengers to trains, buses, walking, and cycling; improving road freight logistics and shifting road freight to rail; and getting more people into each car and bus. Taken in isolation, ambitious national measures could close the gap by 46%; combining national measures with ambitious standards and electrification would see Poland falling short of the target by 19.6 Mt, with all measures combined delivering 58% of the effort.

The result of this study shows that Poland needs to employ as much ambition as possible to reduce its reliance on the over achievement of other sectors (particularly in the buildings sector) to make up the projected gap in transport. Otherwise, even more ambitious policies would be required, including a systematic upheaval of the transport sector to fast track electrification and zero emission vehicles.

Policy Recommendations:

This report cites independent research to set the ambitious levels based on technical and economic feasibility. To realise the full potential of these measures only requires political will. Below is a summary of the key policy recommendations for Poland to meet its targets.

EU Level:

- Poland should adopt ambitious vehicle standards, and in particular insist on the 2025 targets. For cars, vans, and trucks this is a real 20% reduction by 2025.

- A separate sales target for zero emission vehicles should be agreed for 2025 to drive the supply of electric vehicles in Europe. This can be done either via a dedicated ZEV mandate or by adding a malus to the currently proposed bonus system for cars.

National Level:

National level policies should aim to reduce the growth in demand of fossil fuel consumption. This can be achieved through fiscal and non-fiscal means. For example, shifting road freight activity to rail will reduce CO_2 emissions per unit of freight, and could be achieved by making trucks pay their fair share for road and fuel use, but also improving rail service by enabling fair access to infrastructure to new entrants. Specifically, Poland should consider and pursue the following policy measures:

- Fuel taxes and tax reform: as a complementary measure to distance-based tolling, Poland should engage in discussions with neighbouring countries to align their diesel tax rate to that of petrol, and look to increase this to be more in line with the EU average. Collaboration on this measure is vital so as to avoid fuel tourism in which truck drivers divert to re-fuel in the country with the lowest fuel tax rate. This not only increases traffic in certain areas, but makes it difficult for neighbouring countries to use fuel tax as a tool to reduce greenhouse gases.

- Road charging: harmonise rates at which vehicles are charged across the whole network, ensure all tolls are inclusive of separate infrastructure and (air and noise) pollution costs so that more polluting vehicles pay more, extend the toll charge for HDVs to secondary roads so that the damage they cause is accounted for wherever they drive. This will additionally prevent HDVs from using secondary roads to avoid the toll, and so relieve congestion on those roads. The additional budget revenues could be directed to further accelerate climate change mitigation action.

- To shift car passengers to buses, trains, riding, and walking, Poland should invest in high quality, affordable public transport and walking and cycling infrastructure, share relevant data with other transport providers and internet mobility platforms to enable Mobility as a Service (MaaS), introduce measures to encourage bike sharing, and reduce the number of car parking spots and increase parking fees.

- To put more passengers in cars, introduce city road pricing and/or congestion zones, facilitate the use of short and long distance car and ride sharing, and adapt fiscal incentives to deter private car use by ending tax benefits for company cars.

- To shift freight from trucks to (electric) trains, the Polish regulator must ensure that the railway infrastructure manager is treating all trains equally regarding track access, explore the idea of obliging the state-owned company to rent unused electric locomotives to new entrants that do not have the access to capital to buy such rolling stock, improve the flexibility and speed of freight services by investing in rail infrastructure that's not as complex or time-consuming as large cranes, and increase competition in the rail freight market.

Outside the CAR:

- For aviation, at a national level, Poland should introduce a ticket tax on flights to generate revenues and stem demand. Ending the sector's kerosene tax exemption can be done domestically and through bilateral agreements (if EU wide unanimity to end it is not achieved) a measure that could be initially phased in with neighbouring countries.

- At the EU level, Poland should support measures that aim to reform the EU ETS as a means of introducing more effective carbon pricing.

- For shipping, Poland should implement tighter air pollution standards for ships calling at Polish ports, consider mandates for zero emission shipping on specific domestic/short-sea shipping routes, make on-shore power supply available, and ensure the transparency and cargo data collection in the EU MRV (when revised) in order to break market barriers to the uptake energy efficiency technologies in shipping.

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1. Introduction and context

1.1. Climate change

Prior to the 1950s, CO_2 concentration levels in the earth's atmosphere hadn't surpassed 280 ppm in the last 800 000 years[i,ii]. On 2 May 2013, the global concentration of CO_2 in the atmosphere reached 400 ppm for the first time over the course of one day[iii]. 400 ppm is significant because it is the central point of the uncertainty zone of the planet for the so-called safe operating space for humanity. According to the same paper, the upper-bound concentration for humanity to thrive is 350 ppm, a level surpassed in the mid-1980s[ivv]. As of June 2018, the seasonally adjusted average concentration stands at approximately 407 ppm[vi], and rising. The increase in CO_2 is the most important of anthropogenic emissions that increases the amount of heat retained in the Earth's atmosphere and results in climate change[vii]. Climate change pertains to increases in the frequency and severity of natural disasters and droughts, to ocean acidification, temperature change, and sea-level rise, to name a few.

On 12 December 2015, 196 nations around the world adopted unanimously the Paris Agreement that aims to mitigate global greenhouse gas emissions. Specifically, the signatories agreed to take measures to hold the increase in temperature 'to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change'[viii]. This would mean limiting the CO_2 concentration to between 450 ppm and 480 ppm. The European Union, and by implication Poland, is signatory to this Agreement. For the EU, the Agreement translates to a full decarbonisation of the economy (i.e. no net CO_2 equivalent emissions) by early 2030 to limit warming by 1.5°C, or by 2050 to limit warming by 2°C, compared to pre-industrialisation levels[ix].

Climate change is a global problem requiring global efforts to combat it, however there are specific threats and costs associated for Poland that have already been observed. Over the period 1961-2010 heat waves in Poland have become more frequent, longer and more severe[x]. In 2015, high temperatures coupled with a lack of rain limited the amount of water available needed to cool coal-fired power plants, prompting national grid operators to limit energy consumption for large energy consumers[xi]. Indeed, Poland has one of the lowest aggregated average freshwater availabilities in Europe (around 1400m³ per capita), which according to the UN places citizens of Poland in water stress[xii]; increasing temperatures and pressure on freshwater resources will exacerbate this[xiii xiv]. Finally, beaches in Poland were closed in the summer of 2018 owing to bacterial colonies breaking out in the unusually warm Baltic Sea[xv].

Climate change is a global problem caused by human activities that has and will have increasing environmental, social, and economic costs. As the 20th largest emitter in the world[xvi], and the 5th largest emitter in Europe[xvii], Poland must play an important and leading role in reducing greenhouse gas emissions to avoid catastrophic climate change. *This report will detail a roadmap that will enable Poland to meet its climate obligations for the sector responsible for the fastest growing emissions: transport.*

1.2. Scope of this report

The main legal framework that this report is based on is the Climate Action Regulation (CAR)[xviii], formally the Effort Sharing Regulation (ESR). As will be described in greater detail, the GHG emissions that fall within this regulation and the focal point of this report is land transport, i.e. passenger transport in cars, trains, and buses and freight transport in trucks and trains. Motorcycles are not considered in this report as they are a small percentage of road transport emissions and they have a clear and proven decarbonisation pathway through battery electric powertrains. The report will look at measures that can be taken to decarbonise these sectors and in particular will use T&E's in-house transport model to show how much reduction is possible from each measure in reaching the 2030 target.

In this sense, the report will show the impact of what is accepted as technically possible in terms of some measures like the fuel efficiency improvement of vehicles, but also what is required to shift or reduce demand of transport. The emissions from shipping and aviation will also be discussed, but their emissions will not be modelled, among other reasons because they are not included under the CAR. Finally, for all of these modes of transport, this report offers pragmatic, technically feasible, and economically viable policy recommendations to pave the pathway for not only the achievement of the Polish 2030 emission reduction targets, but policy that will make the ultimate decarbonisation of transport an attainable reality by the mid-21st century.

1.3. How does this report differ from other reports

As a large consumer of coal - 77 million tonnes of coal consumed per year making the country the second largest coal consumer in the EU, after Germany[xix] - a number of studies have been undertaken to review Poland's decarbonisation potential, particularly in the energy sector. However, these have generally not focused on solutions for transport. Other reports that do focus on transport, tend to look at market operations as opposed to decarbonisation potential. Nonetheless, it is worth mentioning three studies in particular.

First, a country study by the International Energy Agency (2016)[xx] has analysed strategies for a cleaner energy system. The report notes, however, that decarbonisation targets in non-ETS sectors will be difficult to achieve, particularly in the transport sector, which it points out is the fastest growing source of GHG emissions in Poland. One drawback to this report is that it praises the "ambitious" plans for compressed natural gas (CNG) infrastructure and vehicle roll-out in decarbonising the transport sector. On the other hand, it aptly calls for a bonus and malus system (in place of just 'bonus' subsidies and tax deductions) to speed along the development of the EV market in Poland.

Second, a briefing by the European Parliament Environment, Public Health and Food Safety Committee in 2017 has analysed Polish projects and initiatives contributing to climate change mitigation and to the decarbonisation of the economy and clean energy[xxi]. The report highlights a trend for 58% growth in transport emissions between 2005-2030, and rightly points out that decisions regarding the replacement of ageing coal power plants (around two-thirds of which are over 30 years old) will strongly shape the county's future emission trends. No quantifiable recommendations were given, however.

Third, a study commissioned by E3G (2013)[xxii] suggests that technology specific subsidies are needed to diversify the technology mix for a more resilient energy system. Significantly, it finds that more ambition in regards to the deployment of renewables would not be more expensive than relying on nuclear or CCS to deliver decarbonisation. In particular, the study notes that electrical efficiency is a critical strategic policy as the most effective weapon against escalating power system costs. However, the study also points towards significant potential for the reduction of emissions through a switch from coal to gas. As with other studies looking at decarbonisation strategies for Poland, there is a lack of detail in regards to transport policies.

This report by T&E, therefore, fills a gap in the literature by presenting an in-depth analysis of the current transport situation and specific decarbonisation strategies for the transport sector.

1.4. Transport & Environment and the EUKI project

The European Climate Initiative[xxiii] (EUKI, from German Die Europäische Klimaschutzinitiative) is a project financing instrument by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMUB). The overarching goal of EUKI is to foster climate cooperation within the European Union in order to mitigate greenhouse gas emissions. It does so through strengthening cross-border dialogue and cooperation as well as exchange of knowledge and experience[xxiv]. Under the EUKI initiative, T&E is undertaking a project called "Delivering the EU-2030 and Long Term Climate Objectives in Central, Eastern and Southern Europe, with a Specific Focus on Transport"[xxv], which has four overarching objectives, namely:

1. To provide accurate information on the potential of transport decarbonisation measures to meet climate targets in the targeted countries.
2. To foster NGO led development of national climate and energy plans
3. To enhance or create communication and exchanges between national organisations for target countries
4. To Identify additional savings through EU funding and measures - transformational projects in the transport sector

Transport & Environment coordinates this project which involves research and dissemination at national level in close collaboration with some of our national partners in Southern and Eastern EU Member States, specifically Romania, Spain, Italy, Hungary and Poland. Transport & Environment has more than 28 years expertise on transport decarbonisation policies and, thanks to that, T&E is uniquely placed to gather evidence, critically analyse, and recommend clear policy pathways to achieving decarbonisation of the transport sector[xxvi] from an impartial perspective.

1.5. Introduction to EUTRM

Transport & environment has used its in-house model, the European transportation roadmap model (EUTRM) to analyse the effect of different policies on GHG emissions. The EUTRM is a demand driven bottom-up model that can compute GHG emissions in five year intervals, but has recently been modified to compute at yearly intervals for the years between 2016 and 2030. Passenger transport and freight demand are based on purchasing power parity (PPP) adjusted GDP, which is determined by historical and projected gross domestic product (GDP), population, and fuel price for each country. All transport demand within a Member State is met with effectively unlimited transport capacity for freight but with natural limits on motorisation rates for passenger cars through new or second hand sales.

The EUTRM is initialised and calibrated with historical data. For the example of trucks, the vehicle stock and number of new vehicles (both in number and in weight category), mileage, fuel consumption, transport activity, and load factor are considered. The bottom-up structure allows for vehicle based policy changes. Continuing the example of trucks, these can include policy driven modal shift (moving freight from road to rail), engine technology uptake (hybrid, electric, hydrogen), fuel efficiency (efficiency standards or market development), and logistical improvements (increase in load factors, the amount carried by each truck). Therefore, the strength of the EUTRM is in its ability to combine multiple policy decisions and show their effect on the business as usual case, and to quantify the relative importance of policies on GHGs.

Note on modelling fuel efficiency improvements: Cars and vans are type-approved by a laboratory test, known as the New European driving cycle (NEDC), to give a standardised method for determining fuel efficiency. Developed in 1997, a vehicles is placed on a chassis-dyno and the technician follows acceleration and braking patterns from approximated driving profiles based on urban/city driving, country road, and highway driving. The gap between what is measured in the lab during type approval and on the road was about 10% in 2000, however in 2017 it had grown to what appears to be a fleet average ceiling of 42%[xxvii], for a number of reasons[xxviii]. The introduction of the new test cycle (the WLTP, the worldwide harmonised light vehicles test procedure), should partially help this, as the driving profiles are much more representative than in the NEDC. Aligning NEDC fuel consumption results with those measured with WLTP will vary between manufacturers and cars, and will not be known until 2019 and 2020 as the new WLTP regulation comes into force. This is one of the reasons the Commission opted for percentage reductions rather than g CO2/km figure; the efficiency improvements should be as much as possible realworld improvements. When modelling car fuel efficiency in this report, reductions are based on NEDC fuel consumption and the gap kept is kept constant at 42%.

1.6. Baseline situation, modelling assumptions and projections

Projecting Poland's emissions in 2030 relies on the historically observed relationship between wealth and transport demand[xxix]. As will be shown, holding this assumption and without explicit measures to reduce the fuel efficiency of vehicles, an increase in the economy will lead to an increase in transport activity and thus an increase in emissions. The key socio economic assumptions that are exogenous and static inputs to the EUTRM are detailed in Table 1 below. These assumptions are in line with the Commission's Reference Scenario[xxx] although in 2050 the activity levels in the EUTRM are 5-10% higher. In 2016, the inputs are calibrated closely with the data from the Statistical Pocketbook: EU Transport in Figures, 2018 (with 204 billion passenger kilometres, expressed as Gpkm, in passenger cars, and 154 billion tonne kilometres, expressed as G tkm, of road freight, measured by territoriality[xxxi]).

Along with these assumptions, the oil price is kept constant. This assumption alone is the single most import difference between the projections of the Commission's 2016 Reference Scenario and the EUTRM in 2050: an increase in oil price makes transport more expensive, limiting demand and according to the report incentivises manufacturers of cars and trucks (OEMs, original equipment manufacturers) to produce more efficient vehicles, despite no historical evidence of this[xxxii]. The oil price is kept constant in the EUTRM for two main reasons, firstly, to negate an otherwise uncontrollable and external influence on transport demand, and secondly, as if the EU and indeed the world do begin to take a trajectory of decarbonisation, the demand for oil will decrease, and from simple economic principles, price will not go up.

Table 1: Main socio-economic assumptions in the EUTRM.

Metric	2016	2020	2030	2050
Population (millions)	38	38	37	35
GDP (2013 € billions)	429	498	629	802
Passenger car activity (G p-km)	217	283	399	435
Road Freight activity (G t-km)	146	177	241	349

In the baseline, only fully legislated policies are included. The only law directly pertaining to the efficiency are the 2021 car and 2020 vans standards; these standards are included in the model. The monitoring and reporting regulation (MRV), a measure that will allow hauliers to compare like trucks against each other and choose the most fuel efficient for their operations, is assumed to increase large truck (>16t) fuel efficiency by 10% between 2010 to 2030[xxxiii] and 6% for smaller trucks[xxxiv][xxxv]. Other proposed legislation, such as the Commission's proposal on truck CO_2 standards and the 2030 standards for cars are still being debated in the European Parliament and Council. As they are still subject to change, these are not considered in the business-as-usual baseline. In terms of national law, despite the many options available, Poland has not implemented any law that will work to decarbonise transport. These options and their implementation will be explored in the following sections. In short, the baseline presents a business-as-usual scenario; there will be no transformational and disruptive changes to the transport system, but a steady increase in demand and thus emissions will be observed by all modes.

1.7. Who should read this report

National level NGOs

NGOs that represent civil society with a focus on climate change and decarbonisation of the economy, ideally with experience on national and EU climate regulations. This report should be considered as a handbook on how to navigate the often complex legislation concerning climate, decarbonisation and sustainable transport with an aim contributing actively and positively to decision-making processes on these matters.

Decision and policy-makers at national, regional and local level.

Lawmakers at all levels have the responsibility to design and implement policies that must deliver greenhouse gas emission reductions in order to achieve the nation's and the EU's climate commitments.

This report should for them be seen as technical and policy input, which offers accurate, positive, plausible options for the decarbonisation of the transport sector.

Private sector and individuals
European companies are world leaders in clean technology, to remain so requires ambitious regulatory framework that will not only keep European companies there, but will push for innovation and novel solutions.

Individuals, ultimately, hold the most power. Voting either at the ballot box or with your wallet gives signals to lawmakers and private companies that a sustainable, decarbonised future is what we need and what we want in order to secure our future. In a world full of information, this report aims to gives honest, accurate accounts and recommendations for an ambitious but feasible roadmap for 2030 and to the mid-century.

2. Environmental and political climate in Poland

2.1. The rise and fall of emissions in Poland

This section will describe the last quarter of a century of emissions in Poland, the dominant and fast growing sectors, and the upcoming legislated targets and decarbonisation ambitions. Compared to 1990, Polish greenhouse gas (GHG) emissions from all sectors (including 'bunkers', those emissions from international aviation and shipping) could be said to have been steadily decreasing from 444 Mt CO_2eq to 375 Mt CO_2eq, or 15.5% (Figure 1). This reduction has come about mainly from the public electricity and heat sector, as well as waste and agriculture. However this long term trend belies a low point in emissions in 2002 (358.8 Mt CO_2eq), and thus over the last 14 years of available data, Polish emissions have increased by 4.7%, a figure that may be higher had there been no economy contraction with the global financial crisis, with demand for goods, transport, and electricity and heating reduced along with their associated emissions. The last 3 years in particular have seen an uptick in emissions. Crucially, from here on in, will Polish emissions continue this increase? The fastest growing sector is transport with a 15% share in 2016, from which 14% is generated from domestic transport (i.e. road, rail, and domestic aviation and shipping). This represents a marked change from 1990 where the transport emission share was only 5%. Since 1990, domestic transport emissions have grown 260% and international bunker emissions have grown 40%.

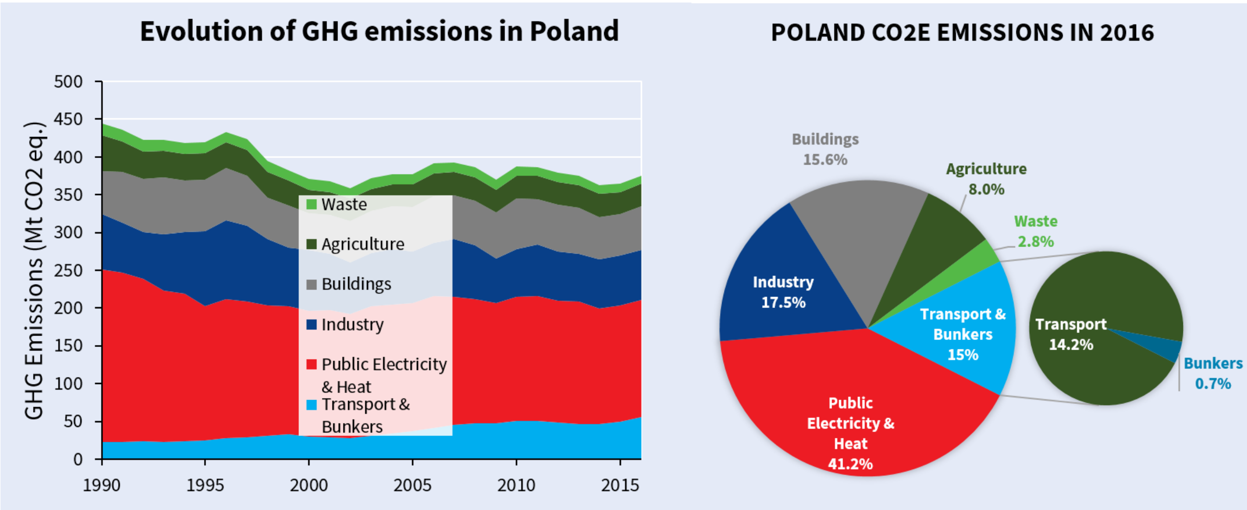

Figure 1: Evolution and 2016 share of Polish CO2e emissions. Source: UNFCCC reporting[xxxvi].

2.2. European climate law for GHG emissions

In this section the environmental laws applied by the European Union that Poland must abide to are introduced and discussed. In general, the laws set Member States or specific installations targets, with fines or severe expenses incurred for not meeting the reduction target.

2.2.1. Emission trading scheme (ETS)

The European Union emissions trading system (EU ETS) is a scheme to reduce CO_2 emissions by trading and selling emissions permits on a free market where the availability of permits (and hence allowable emissions, reduces over time. The system operates in 31 countries (all 28 EU countries plus Iceland, Liechtenstein and Norway) and limits emissions from more than 11,000 heavy energy-using installations (such as power stations and metal factories) and, since 2012, airlines, although only for flights within Europe. The most relevant sector to this report are those emissions emitted by aviation. As shown in Figure 2, Polish power generators appear to be at risk of not meeting a 20% reduction by 2020, implying that electricity prices in Poland will become more expensive as the sector has to buy a proportionally high number of ETS allowances, which will be passed onto the consumers in Poland.

In terms of aviation, most of the Polish aviation emissions are covered by the ETS, as discussed further on in the report. The busiest airport in Poland is Warszawa/Chopina, with 147 thousand flights in 2016, the 26th busiest in the EU, carrying 12.85 million passengers, a 14.5% increase on 2015[xxxvii]. This type of growth is clearly unsustainable. Should carbon allowances in the ETS cover all aviation and ever reach a price that significantly impacts the price of domestic aviation, Poland should ensure that it is well placed to fulfil the travel demand with cleaner modes. It is likely that other measures for aviation, as described below, will need to compliment the ETS.

2.2.2. Effort Sharing Decision (ESD)

The Effort Sharing Decision, one of the key instruments of the EU to mitigate climate change, was established in 2009 and sets emission reduction targets for each Member State for the sectors not covered under the EU Emissions trading system. The law is in force for the period 2013-2020. The collective reduction target for the EU as a whole is 10% by 2020 compared to 2005; within this framework, Poland were able to increase their emissions by 14%. The targets were established based on GDP of the countries[xxxviii,xxxix]. This means some richer countries have reduction targets of 20% while other countries had to limit their emissions growth to 20%. Member States must ensure that their emissions are less than the trajectory made from the average of their 2008, 2009 and 2010 emissions in 2013, then tracing a straight line to the 2020 target[xl]. As shown in Figure 2, Poland is approaching its target and may be in danger of exceeding it. Cumulatively, Poland has overachieved from 2013 to 2016 by 34.6 Mt CO2. On the other hand, the trajectory of the last three years looks likely to not only compromise the 2020 target, but will be required to tap into a significant amount of their banked allowances. If the emissions trends continue in this direction, meeting the reductions over 2021 to 2030 will be much harder, as seen in the following section.

2.2.3. Climate Action Regulation (CAR)

The EU has just finalised the process on the piece of legislation that continues the ESD and sets the emission reduction targets for member states for the period 2021-2030[xli]. This time however the emission reduction targets are tighter - the overall reduction target for the EU in 2030 for the non-ETS sectors is 30% by 2030 compared to 2005 levels. Poland has a national target of 7%. The regulation includes flexibilities such as using ETS allowances and access to credits from the land use sector[xlii]. Poland can reduce its target by 1.2% from this flexibility alone[xliii]. While flexibilities make it easier for Member States to achieve their targets, they are worse for the climate because it will be by credits, not real emission reductions, to meet the targets.

The banking and borrowing mechanism of the CAR is based on comparing reported emissions for a given year compared to a straight line drawn to the 2030 target. If emissions are below the line, the country is overachieving its emission reduction objectives and can bank (or sell) a part of the difference. Similarly, if reported emissions are above the line, a country can borrow (or buy) a limited part of the future allowances to comply with the yearly target.

A complexity of the CAR is the so-called starting point for calculating where to start drawing this straight line - the trajectory to the 2030 target from which the annual balance will be calculated. This seemingly irrelevant technical detail will determine how many emission allowances a country will be able to bank from the first year, 2021. In April 2018, the decision on how to compute the starting point for emission allocation was formalised[xliv]. The starting point baseline (i.e. the amount of emissions) is computed as the average of greenhouse gas emissions during 2016, 2017 and 2018. The starting point also has a time dimension. This will be either the reported average emissions in May 2019, or the average of 2016, 2017, and 2018 emissions in 2020, whichever results in a lower allocation. If the Polish ESD emissions continue to increase, it will be the former of these options, and this could put Poland in the position of needing to borrow emissions from 2021. Taking the starting point resulting in the lowest allocation is positive for the climate but difficult for Poland, as urgent measures will be required to avoid having to buy emission allowances from overachieving countries.

Finally, the CAR includes an extra flexibility instrument called Safety Reserve, which is essentially a pool of credits worth 105 Mt CO_2eq. To access it, Member States have to meet a series of requirements, namely: have a 2013 GDP per capita below the EU average; not exceed their emission allocations in the period 2013-2020 (i.e. overachieve their targets); and exhaust the other available flexibilities. If these conditions are met, the country can access an amount of the credits in the safety reserve, not exceeding 20% of its overall overachievement in the period 2013-2020. Based on these conditions, Poland will only be able to gain access to this flexibility mechanism if it keeps its emissions in check to 2020.

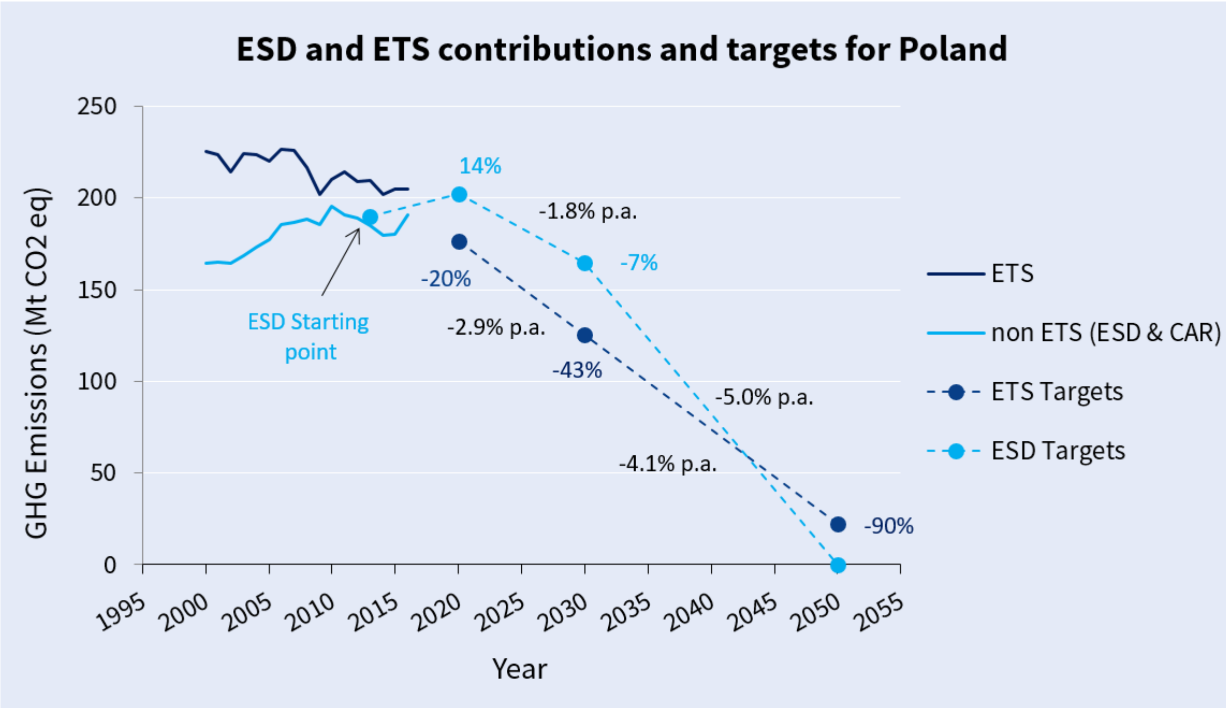

Figure 2: Evolution of Polish ETS and ESD emissions. Source: UNFCCC reporting and EEA contributions of sector allocations.

2.2.4. Renewable Energy Directive (RED)

The Renewable Energy Directive (RED)[xlv] established a policy for the production and promotion of energy from renewable sources in the EU[xlvi]. The relevance for transport is that all EU countries must ensure that at least 10% of the energy used in transport (via biofuels or electrification) come from renewable sources by 2020. Although the RED is not specifically a climate law, its goal of increasing the share of renewable energy will see benefits for the climate. The REDII, which formally ended negotiations in June 2018, is the revision of the RED and will apply from 2021 to 2030. The REDII sets a binding target for advanced fuels, which include advanced biofuels, renewable electricity, hydrogen, etc., in an attempt to promote the use of sustainable and cleaner forms of transport. In addition, the EU is slowly moving away from food-based biofuels that are unsustainable and have negative impacts on climate and environment[xlvii], by eliminating a binding target for food-based biofuels and setting a limit on their use.

The use of advanced fuels will be promoted thanks to the binding target of 7% established on the REDII. Furthermore, the use of advanced biofuels and electricity will be multiplied by 2 and 4 times respectively, to make it more attractive for Member States and boost the support. Importantly, in terms of CO_2 emission accounting, renewable fuels are zero rated.

It is up to each Member State to decide the policies to pursue to reach (or exceed) this target; to date, Poland has not indicated an intention to exceed this target. In 2016, Poland's overall renewable energy share in transport fuels was 3.9%, a sharp reduction from the 2011-2015 average share of 6.4%[xlviii]. Table 2 shows the current shares by energy and percentage contribution to the target. This seems to be due to a reduction in crop based biofuels, which make 100% of the biofuels share. Several variables have led to this: some refining companies ceased to fulfil the National Indicative Target obligation because it was too expensive, exporting in Europe was more profitable and coincided with the US market of selling bio-components closing[xlix], and the Polish authorities struggle against the illegal "carousel VAT" mechanism could reduce the reported production. The contribution from these biofuels was 457 ktoe, or 2.8% of energy, so under half of the 7% cap. Renewable electricity in rail was 69.8 ktoe while in road it was 0.6 ktoe. Applying the corresponding multipliers to these values, and considering the denominator of 16 362 ktoe, makes the total renewable energy share (RES). In this report the biofuel share is assumed to stay constant from 2016 levels. An exploration of the best ways for Poland to reach its 2030 REDII target is beyond the scope of this report.

Table 2: Summary of renewable energy in transport in Poland, 2016, by fuel type.

Transport Energy type (2016)	Energy Consumed (ktoe)	RES-T Share (with multipliers)
Ren. electricity in road transport	0.59	0.02%
Ren. electricity in rail transport	69.84	1.07%
Ren. electricity in all other transport modes	7.18	0.04%
Compliant biofuels*	457.41	2.80%

2.3. Global law for aviation and shipping

2.3.1. Maritime and IMO

Despite having the fifth longest inland waterway network in Europe at 3 655 km (behind only Germany, Finland, France and the Netherlands), Poland has one of the lowest of the bloc's inland shipping activity because only 214.1 km of the ways have the parameters necessary for modern shipping[l]. Moreover, Poland accounts for only one of the top 40 ranked ports in Europe for tonnes of freight loaded and unloaded with its port of Gdansk (ranked 26th)[li]. Although inland shipping is less carbon intensive than road transport, there must be careful consideration to the environmental impacts of expanding shipping lanes along river systems.

In terms of emissions, 2016 domestic and international emissions totalled 0.6 Mt CO_2e, less than half the emissions of 1990. This reduction may owe to greater competition from Belgian, Dutch, and German ports where goods can then be easily carted by surface transport. As UNFCCC reported figures are based on fuel sales reported by ports, they are likely to be an underestimate of the emissions that could be associated to Poland, as ships do not necessarily have to refuel while in port. Unlike domestic shipping, which is covered by the EU submission[lii] of nationally determined contributions (NDCs) and the CAR, the GHG emissions from international maritime activity is not covered by any European measure. In May 2018, the International Maritime Organisation (IMO) agreed an initial decision to reduce ship emissions by 50% in 2050 compared to 2005. Although emissions have been reducing in this sector, transformational policy and investment will be required to update and future proof Polish ports to accommodate electric vessels.

2.3.2. Aviation and CORSIA

Domestic and intra-EU flights are covered by the EU-ETS, a system which continues to under-price carbon and whose declining cap remains out of sync with the reductions required by the Paris Agreement. Flights to and from third countries (outside the EU) are not covered by any climate measure. Rather, parties to the International Civil Aviation Organisation (ICAO), the UN aviation agency, agreed to adopt a global market-based mechanism (CORSIA; carbon offset and reduction scheme for international aviation) to offset aviation emissions above 2020 levels. CORSIA will not reduce emissions from the aviation sector - the objective is to purchase emission reductions from other sectors. However even that limited objective won't be achieved, as the system is likely to be flooded with worthless offset credits and airlines will be permitted to burn biofuels with few sustainability criteria in place. Offsetting has been proven to be a discredited mitigation measure. The European Commission's own research[liii] has found that only 2% of offset projects actually delivered emission reductions"

In 2016, the number of passengers in Poland (arrivals and departures) whose journey would have been covered by CORSIA was approximately 5.8 million, compared to 26.5 million domestic and intra-EU passengers[liv]. These passengers represent 18% of passenger numbers and in terms of emissions they are responsible for approximately 24% of all aviation emissions[2]. Most intra-EU passengers fly to and from the UK (7.1 Million passengers in 2016) and Germany (3.8 million passengers). While these passengers pay the air passenger duty (APD) of £13 when departing the UK and the *Luftverkehrabgabe* of €7.46 from Germany, raising substantial revenues for those countries, flights from Poland have no such tax and thus Poland loses considerable revenues. A ticket tax will have the benefit of raising revenues which could be used as a Pigouvian tax, where revenues are invested into climate mitigation solutions for the sector. At the intra-EU rate of the German ticket tax, Poland could have earnt €127 million on all of its departing flights (assuming no change in passenger demand).

2.4. History of climate mitigation in Poland

2.4.1. National law and transport measures

Measures have been implemented in Poland to reduce emissions in the non-ETS sectors. Looking at the transport measures, Poland has invested in or implemented several measures, namely:

- The Clean Transport Package. Signed by the President of the Republic of Poland on July 10, 2018, this group of documents ultimately implements the 2014 EU directive on deployment of alternative fuels infrastructure. The Package updates previous legislation including: the E-mobility Development Plan, the National Framework for the Development of Alternative Fuel Infrastructure Policy and the Act on Electromobility and Alternative Fuels, as well as the Act on Biocomponents and Liquid Biofuels[3]. To facilitate the implementation of the above, the Low-Carbon Transport Fund (FNT) was created. With revenue from the state budget (incl. 1.5% from excise duty on motor fuels and 15% of broadcasting fee), and a budget of around PLN 6.7 billion until 2027 the Fund aims to support a range of projects, including: production of biocomponents, liquid biofuels or other renewable fuels; local governments investing in clean public transport, and entities planning new vehicle purchases, as well as promotion and education on use of alternative fuels infrastructure[4].

- Alternative Fuels Infrastructure Directive, "AFI Directive": approved on 16 December 2016 and published on 13 January 2017, the directive mandates Member States to publish their National Policy Framework detailing the plans for the development of the national infrastructure to supply alternative fuels (electricity, LPG, CNG, hydrogen and biofuels). According to the directive, by the end of 2020, there should be an adequate number of public electric vehicle re-charging stations, in accordance with the forecasted number of electric vehicles circulating. Poland's National Policy Framework for AFI (part of the Clean Transport Package, see above) was adopted on 29 March 2017. It provides for the assessment of the current state and possibilities of future market development with respect to alternative fuels in the transport sector, and includes specific objectives regarding the development of infrastructure for, importantly, charging electric vehicles. Refueling natural gas in the form of CNG and LNG as well as the market for vehicles powered by these fuels will be developed too, however natural gas is not a pathway to decarbonisation[lv].

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[2] T&E analysis based on ETS and UNFCCC reported emissions, Eurostat and WTO passenger numbers, Plane Finder transponder data

[3] http://cop24.gov.pl/presidency/

[4] https://www.euractiv.com/section/electric-cars/opinion/polands-transport-sector-searches-for-top-gear/

Electromobility has been allocated PLN 10 billion under the FNT[lvi]. Targets include: by 2020, in 32 selected agglomerations, the deployment of 6,000 EV charging points, and 400 fast charging points, at least 50,000 EVs on the road; 70 refuelling points for compressed natural gas (CNG), and at least 3,000 CNG vehicles on the road; by 2025, 32 generally available filling stations for compressed natural gas (CNG) and 14 refueling liquefied natural gas (LNG) points along the road TEN-T base network and installations for bunkering liquefied natural gas LNG in ports: Gdańsk, Gdynia, Szczecin, Świnoujście. The NPF ultimately envisages: the creation by local governments of clean transport zones in cities, to which it is possible to restrict the entry of vehicles with traditional motor drive. In line with this, it provides for an issuance fee of PLN 80 per 1000 liters of fuels introduced to the Polish market, including gas and diesel oil, which will be charged to producers and importers of engine fuels. The funds from this fee will be shared between the NFOŚiGW [governmental body] (85%) and the FNT (15%).

- Along with the AFI Directive, a new regulation for electromobility, the Electromobility Development Plan[lvii], was adopted and signed by the President (as part of the Clean Transport Package, above). This includes a target of 6,859 public charging points by 2020 for a future estimated 77,000 EVs. Beyond 2020, Poland has defined an ambitious target of reaching 1 million EVs on the roads by 2025. Additionally, the Plan aims to replace some of the vehicles owned by central authorities and local self-government units with electric vehicles (excluding hybrids), setting the share of electric vehicles in the fleet of used vehicles to 10% starting from 1 January 2020 and subsequently increasing it to 20% from 1 January 2023[lviii].

- Electric Bus Programme (program-e-bus-polski-autobus-elektryczny)[lix]. An important element in the first ('Re-industrialisation') of 5 economic growth pillars identified in Poland's Responsible Development Plan (2016)[lx]. The programme has the following targets for 2025: e-bus market with a value of at least PLN 2.5 billion annually, which can be translated into approximately 1000 electric buses; a competitive, global e-bus market in terms of technical and financial parameters; development of new technologies and business models. It aims to put Poland on the path to be a leader in zero-emission public transport. The Act on electromobility and alternative fuels imposes the obligation to develop ecological transport on territorial self-government units. The order covers about 80 communes and counties with a population exceeding 50,000 residents. The required share of zero-emission buses in fleets is expected to amount to 5% by 2021 and 30% by 2028. Under the Polish Development Fund, by 2023, there should be 1,500 electric buses in cities (around 13% of the entire fleet).

- Polish Energy Policy 2040 (Polityka Energetyczna Polski Do 2040 Roku)[lxi]. A new Polish energy policy (PEP) (to replace the existing strategy "Energy Security and the Environment 2020") was announced 23 November 2018, with the aim of ensuring the energy security of the country in the competitiveness of the economy and its energy efficiency as well as environmental protection. The strategy assumes a slow shift away from coal with about 60% of electricity and heat to be produced from coal in 2030 and 30% in 2040, while renewables are expected to make up just 21% of gross final energy consumption in 2030. In addition, a national energy and climate plan (KPEiK) (2030) will be presented to the European Commission for approval by the end of the year. Together with these documents, an energy mix and a plan to reduce greenhouse gas emissions should be presented, consistent both with the Winter Package (and the Commission's guidelines for the development of KPEiK) and with the EU decarbonisation strategy prepared by the Commission at COP-24 in Katowice.

- Program for the hard coal mining sector in Poland 2030 (2018). Replacing the previous programme that ended in 2015, to create conditions conducive to the construction of a profitable, effective and modern hard coal mining sector, based on cooperation, knowledge and innovation, contributing to the energy independence of Poland and supporting the competitiveness of our economy. Estimates suggest that from 2016 to 2020, the total demand for mining subsidies to finance tasks resulting from decisions already made total over PLN 10 billion. Ten specific goals include stabilisation of profitability and financial liquidity by adjusting production to market needs, continuing integration of mining with energy, ensuring coverage of domestic needs, investments in reaching new deposits and improving extraction efficiency, developing employee competencies, supporting and developing clean coal technologies, innovation and improving safety in mines, diversification of industrial use of hard coal, unification and simplification of the remuneration system in mining and completion of restructuring activities.

- Poland will host the annual climate conference (COP 24) in Katowice this year. An early release of a joint statement by Polish trade unions and Polish government representatives suggests the country sees the continued reliance on fossil fuels as a priority[lxii]. The statement calls for all energy carriers to be treated equally and moreover suggests that each state "for the sake of its safety and sovereignty" should be allowed to produce energy from the fuels owned on its territory to ensure cheaper heat and electricity. Further, it states that the existing climate policy should not inhibit the development of industry in any given country by generating excessive costs resulting from this policy "and thereby reducing the competitiveness of its economy in relation to other countries".

2.4.2. Road charging

Poland has one of the oldest vehicle fleets in Europe with passenger cars averaging 17.3 years and medium and heavy-duty vehicles averaging 16.6 years (where the EU average is 11 years and 12 years, respectively)[lxiii]. Recent research shows that in 2017 alone 350 000 second-hand diesels were exported to Poland. Smart tolling could provide a solution to this growing air quality problem[lxiv].

Covering a total toll road network of around 3,660 km[lxv], toll charges in Poland generally depend on the size of the vehicle (i.e. weight, number of axles), the route taken, and EURO class[lxvi]. Poland is one of fifteen EU countries that apply distance-based charging (since 2011)[lxvii], meaning that a vehicle is charged per kilometre of tolled road it travels. Distance-based charging has been shown to encourage more efficient driving behaviour than the alternative time-based, "vignette", charging system. Vignettes charge users for a certain time-period, allowing users to drive as much as possible during that time. As such they do not encourage drivers to be efficient in their driving, and so do not help to reduce congestion or pollution.

Toll roads are managed either by the government or private companies through public-private partnerships (PPP). While some roads differentiate charges according to EURO class[lxviii], others do not (focusing just on vehicle weight and axle number)[lxix]. This lack of consistency in tolling could be affecting the uptake of cleaner vehicles. ViaToll reports that there are more EURO III class registered vehicles on the road (16.57%) than EURO VI (16.31%)[lxx]. And while EURO V class vehicles account for the majority of vehicles on the road (38.81%), a sizeable proportion (15.58%) are either EURO 0, EURO I, or EURO II. Ensuring that all tolled roads differentiate according to EURO class would ensure a consistent message to hauliers and road users that less polluting vehicles are favoured. Moreover, roads managed by ViaToll that do differentiate according to EURO class do so only partly. Categories are split into four groupings: Group 1 is vehicles up to EURO II; Group 2 for EURO III; Group 3 for EURO IV; and Group 4 for at least EURO V[lxxi]. Moreover, while 15.58% of vehicles are EURO 0 - EURO II, over half (8.15%) of those are EURO 0. There is an incremental increase are being seen in the uptake of so-called 'cleaner' diesels (EURO V - EURO VI), nevertheless differentiating tariffs within this lower EURO category could go a long way to reducing pollution.

What's more, 62.18% of vehicles registered with ViaToll are over 12 tonnes[lxxii]. In total, one estimate suggests there are 3 203 256 trucks on the roads in Poland[lxxiii]. A study performed for T&E showed that in the EU, heavy duty trucks are responsible for €143 billion in external and infrastructure costs but only cover 30% of such costs[lxxiv]. One solution to this, is to extend the toll road network for HDVs. In Poland, tolled roads currently account for roughly 15% of the entire road network[lxxv]. Extending the tolled road network for heavy-duty vehicles would ensure that the damage caused by these vehicles (in terms of infrastructure and pollution) is accounted for wherever they drive (and better apply the polluter pays principle ensuring that those who pollute more, pay more). Without toll differentiation for EURO class, however, the cost for the external damage caused by vehicles falls to the State, meaning it will be paid by all, and not just by those that pollute (as is currently the case for those roads that do not charge according to EURO class). Therefore, the Polish government should extend the tolled road network for HDVs to all roads, and additionally ensure that all tolled roads differentiate according to EURO class so as to incentivise the uptake of cleaner vehicles and ensure that those who pollute more, pay more. In the era of universal GPS and ICT technology, there is a clear technological pathway for road charging on all roads.

2.4.3. Environmental performance of transport

In this last piece of historical analysis, a closer look at how Poland has decarbonised its economy, if at all. Historically speaking, economic growth (that may be measured by gross domestic product) leads to an increase of transport activity. Figure 3 below shows exactly this trend: a GDP that increased four-fold from 1995, both passenger transport (measured in passenger kilometres, pkm) and road freight activity (measured in tonne kilometres, tkm) increased. The road freight activity shows the effect of Poland joining the EU in 2004. From 2005, Polish trucks rapidly increased their activity abroad (TOT, for total emissions), whereas those emissions occurring within the Polish territory (TER) increased less and incline with the recorded HDV emissions for trucks in Poland.

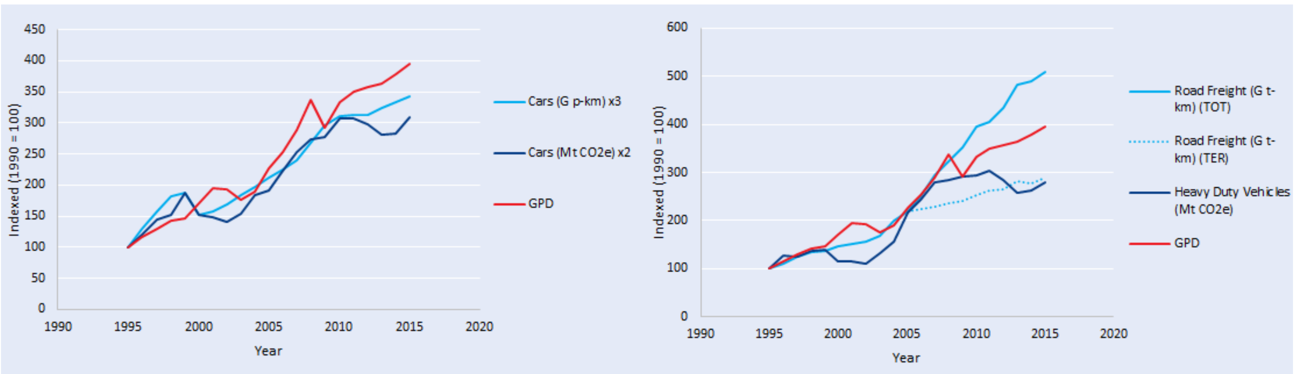

Figure 3: Evolution of Polish GDP, transport activity and emissions. Note that the car passenger activity has been scaled with a factor of 3, car emissions with a factor of 2, to aid visual comparison.

In order to see if a decoupling of emissions and activity has actually occurred in the last 20 years, the environmental transport performance is shown in Figure 4. While in the EU28 as a whole the passenger km of activity per emission has been steadily increasing (i.e., more passenger movements per unit of fuel burnt), the Polish car fleet has seen the opposite trend and achieves 7.8 pkm/kg CO2e compared to 9 pkm/kg CO2e in the EU in 2015. For road freight, the Polish environmental performance as measured by these statistics has changed rather dramatically: in the year 2001, almost twice the amount of freight was moved per emission compared to the EU average; from 2005 onwards, the environmental performance hovered around the EU average before increasing markedly in the last 3 years of available data. In 2015, Poland achieved close to 10.6 tkm/kg CO2e in 2015 compared to 8 tkm/kg/CO2e in the EU.

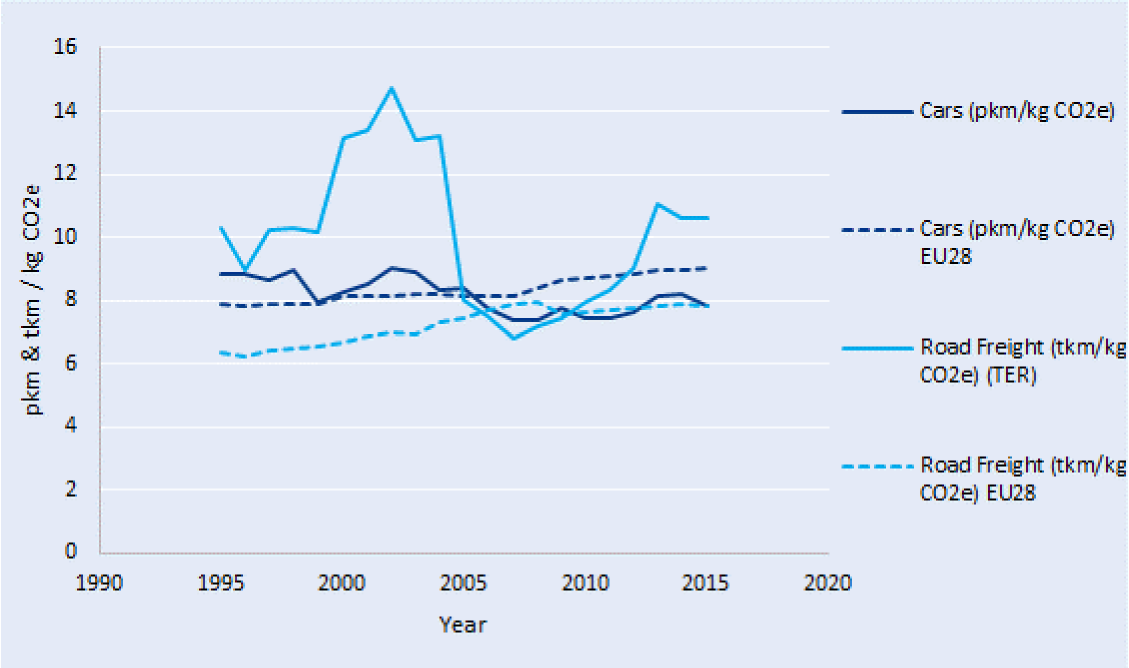

Figure 4: Comparison of the evolution of Polish environmental transport performance against EU 28 average.

2.5. Where will Poland transport be if no action is taken?

In terms of emissions, road transport in Poland[5] is on a trajectory to exceed its 7% CAR reduction by 47.2 Mt (Figure 5) in a business-as-usual scenario. Here lies another important assumption of this report: the equal distribution of reduction effort across sectors in the CAR. In publications released by the European Commission, it is stated that transport in the EU should only reduce its emissions by between 18% and 20%. As the biggest sector in the CAR (in the EU, second biggest in Poland), and a sector where clear technological pathways exist for decarbonisation, it is surprising that the industry and building sectors need to reduce their emissions more than transport. The authors of this report would argue that transport should achieve *at least* the CAR target, and beyond where possible.

[5] Not including emissions from motorcycles

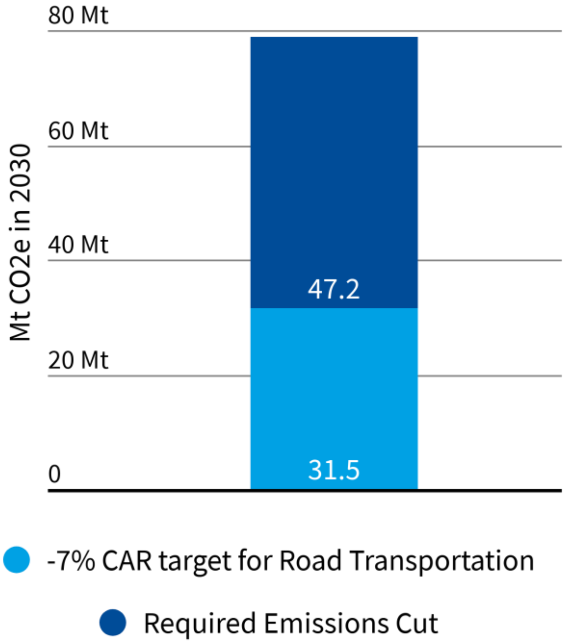

Figure 5: Baseline projection of road transport emissions in Poland will reach almost 79 Mt CO_2e, compared to the CAR reduction target of 31.5 Mt CO_2e. Poland must reduce its projected 2030 road transport emissions by 47.2 Mt CO_2e.

Given the above assumptions of the contribution that should be made by the transport sector, Poland will exceed its target by 150% for road transport. If the cost of CO_2 allowances were to be €100/tonne, this would translate to €4.7 billion in 2030 alone. However, the actual loss will be far greater, because of the aforementioned yearly targets. With the starting point assumed to be at May 2019, the cumulative allowances (tonnes of CO_2) that Poland would be liable to pay for would amount to 297 million (without the use of flexibilities or safety reserve). At the assumed price of €100/tonne, this equates to a sum or €30 billion in the period 2020-2030, an amount only for the transport sector, unless other CAR sectors would decrease their emissions considerably and beyond those of the target. If the EU and Poland were not to take any action on GHG emission mitigation, consequences to the environment aside, this could result in a significant financial burden for Poland and would require a reduction in emissions of 3.9 Mt CO_2e per year in transport to decarbonise the sector by 2050 from 2030. A secondary effect of reducing GHG is to reduce oil dependency: In 2017, 68.3% of total petroleum products imported to Poland were of Russian origin. This means that a significant portion of the money that Poles pay at the pump leaves the country and the European Union; with reduced fossil fuel demand this amount would reduce.

3. How the EU can help

It was shown that road transport was the second biggest sector of CAR emissions. Figure 6 further breaks road transport down into its constituent parts. As can be seen, the largest share of emissions in 2016 was from passenger cars, followed by those from heavy duty trucks and buses[6]. In this section, the specific EU mechanisms to ratchet up climate ambition in transport will be explored. Firstly, a look at the current proposals (under negotiation) and how much they can help Poland reduce their emissions. Secondly, more ambitious targets based on technical and economic analysis will be explored to see what EU CO_2 vehicle standards *should be*. Note: In this report, the emissions from motorbikes are not considered for measures to reduce emissions or in the calculation of targets and trajectories.

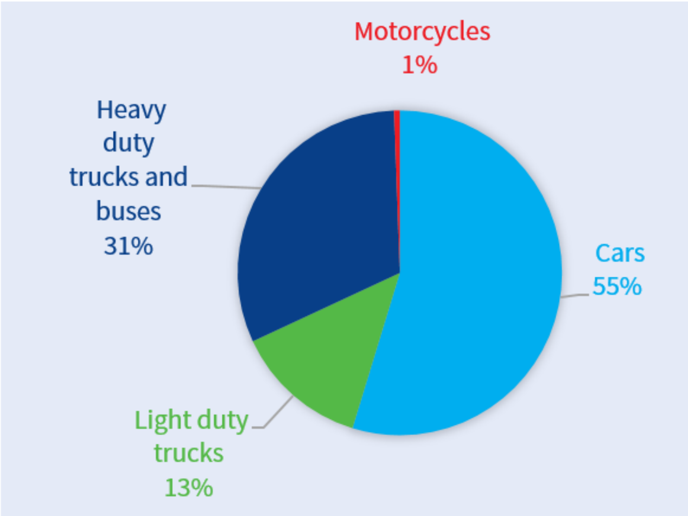

Figure 6: Road transport split by mode in Poland 2016[lxxvi].

3.1. Proposed EU measures for transport

In November 2017, the European Commission released a proposal for car and van CO2 standards for 2025 and 2030. The proposed reductions for cars are 15% in 2025 and 30% in 2030 compared to 2021. Although there was no zero emission vehicle (ZEV) mandate in the proposal, a bonus system is included whereby car manufacturers are able to reduce their fleet-wide CO2 targets if they sell more zero and low emission vehicles than the sales benchmark proposed (15% sales in 2025 and 30% in 2030). For example, if 16% of sales were zero and low emission vehicles (ZLEVs), the CO2 standards could be reduced by 1%, making the target easier to reach[lxxvii]. The bonus is capped at 5% reduction. There is however no malus or penalty if a manufacturer sells less ZLEVs than the benchmark. The proposed van standards are also 15% reduction in 2025 and 30% reduction by 2030 (with baseline year of 2020) with the ZLEV bonus system. Unlike the 2020 and 2021 targets that were given in gCO2/km, the percentage reduction allows for the change to the new driving test cycle (WLTP) from the existing one (NEDC).

In May 2018, the Commission proposed truck fuel efficiency standards. The truck standards do not include CO2 improvements from modifications to the trailer (for example from better aerodynamics), only the tractor. Furthermore, the truck standards apply to only a select subgroup of trucks ('regulated categories', 4, 5, 9, and 10) which cover approximately 80% of truck emissions in terms of CO2 emissions per year and historical sales (Figure 7[lxxviii]). Under the proposal which, like for cars and vans, is currently being debated, these regulated truck sales must reduce their emissions by 15% in 2025 and at least 30% in 2030 (the latter to be revised by 2022), compared to 2019. Similar to the cars and vans draft, no ZEV mandate is proposed but rather a somewhat weak system of supercredits, a point which will be discussed further on in the report.

[6] The UNFCCC category *1.A.3.b.ii. light duty trucks* are mostly vans, i.e. light duty vehicles used to carry up to 8 passengers or with a maximum permissible mass of 3.5 tonnes, including load.

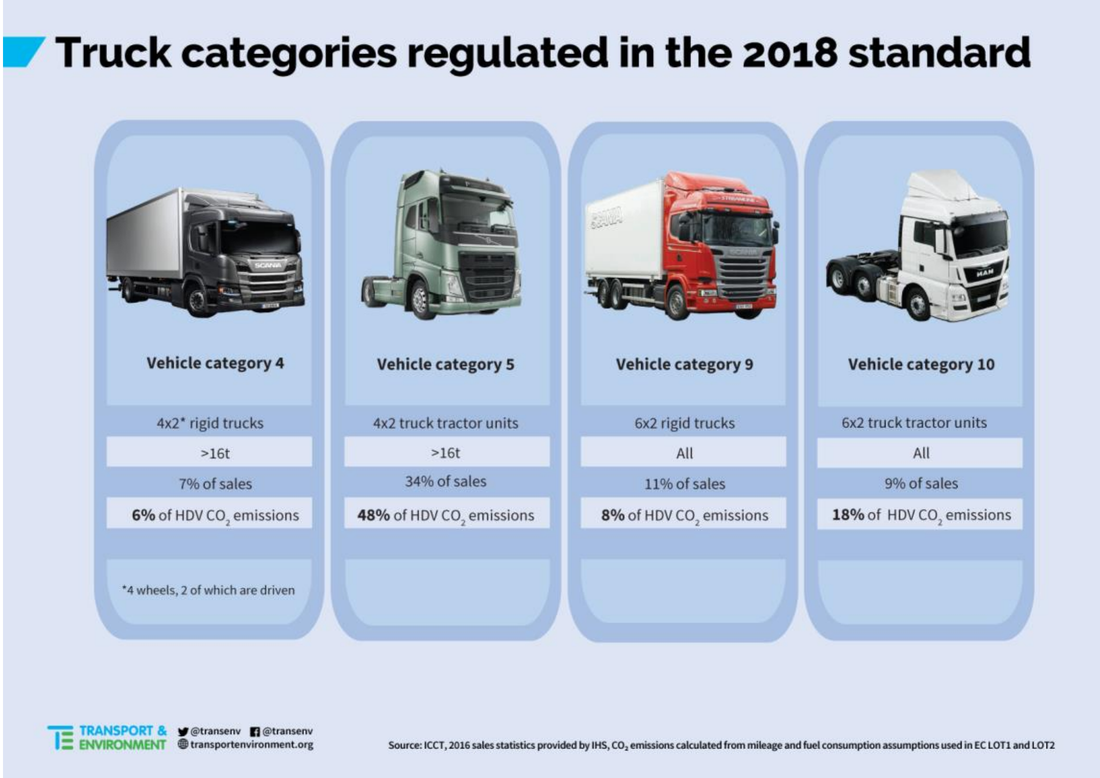

Figure 7**: Regulated trucks in the Commission's truck CO2 standards proposal**

If vehicle makers meet the Commission's proposals, but don't exceed them, it will only deliver 6% of the required cuts for all of road transport, or 2.8 Mt of the required 47.2 Mt CO_2e (see Figure 8). The reduction in emissions does not equal the reduction in new vehicle efficiency owing to the time taken for fleet renewal. From the fleet of approximately 25.5 million, there were 486 thousand new vehicle registrations in 2017[lxxix], or a 2% of the fleet. The Polish vehicle fleet is among the oldest in the EU with an average car age of 17.3 years compared to an EU average of 11.0 years[lxxx]. This means that older, more polluting vehicles tend to remain in the fleet longer than for other Western European countries. Therefore, in the situation that only the proposed CO_2 standards for road vehicles were to be implemented, Poland would have to come up with a range of national measures to be able to cut the remaining 44.5 Mt of emissions. Clearly, more has to be done and can be done, at the EU level before having to revert to national measures.

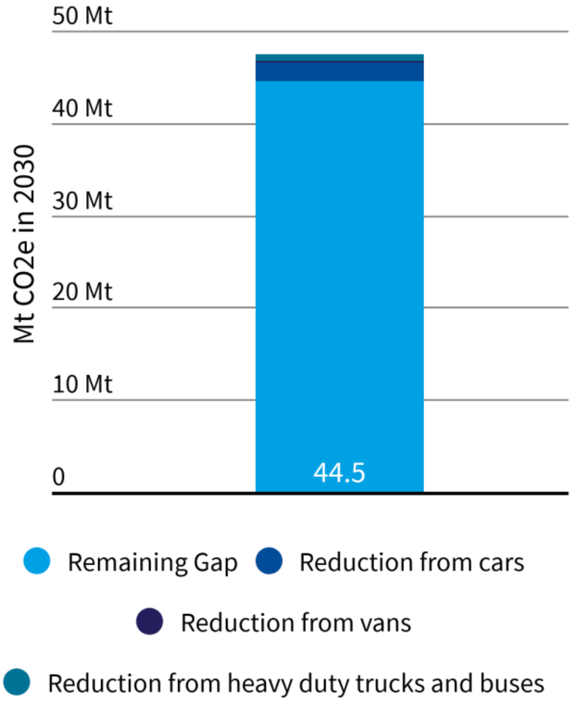

Figure 8: Reduction in road transport emissions from Commission proposals on car, van, and truck fuel efficiency standards for 2030

3.2. What ambitious and feasible EU measures in Poland can deliver

3.2.1. Ambitious CO_2 standards and electrification

CO_2 emissions of new cars can feasibly be reduced by over 50% by 2030 as shown by International Council on Clean Transportation (ICCT)[lxxxi]. This is also more in line with the ambition levels necessary for transport to deliver the Paris Agreement goals. Van CO_2 standards were shown to be optimum in the Commission impact assessment[lxxxii] at a 40% reduction, by comparing the required investment in technology from the OEMs and the fuel savings that would generate for consumers - typically businesses and tradespeople. As regards ZEV vans, there is a clear lack of models and choice on EU market[lxxxiii], which the bespoke ZEV sales target for new vans in 2025 and 2030 is indispensable to address.

The truck fuel efficiency proposal should eventually include the trailers and non-regulated trucks. Owing to the large variety of trucks and their operations, fuel efficiency will be calculated with the simulation tool VECTO (Vehicle Energy Consumption Calculation Tool)[lxxxiv]. This tool could be easily and feasibly modified to not only account for all categories of trucks, but their trailers as well. This will allow manufacturers to have a holistic approach to reducing the real world emissions of the truck. If this were the case, the ICCT shows that a 24% reduction (tractor unit only) is economically viable and technically feasible by 2025, increasing to a 45% reduction (with trailers included) in 2030[lxxxv] compared to a 2015 fleet average truck. Trailers are not included in the 2025 reduction target, so the Commission proposal of a 2025 reduction of 15% for regulated trucks is assumed to remain. The “at least” 30% target for 2030, on the other hand will be reviewed and finalised no later than 2022. After trailers are regulated in the early 2020s, T&E expects that total reductions from tractor and trailer (where applicable) should average 45% compared to a 2015 baseline (or approximately a 43% reduction compared to the 2019 baseline). There is currently very little information on applying vehicles standards to coaches[7]. However, it seems reasonable to expect that the

[7] We consider buses to fall under two broad categories: coaches, for intercity travel, and city buses; those that operate under a fixed timetable in metropolitan areas.

technology improvements leading to efficiency gains employed in trucks could be utilised in coaches. Therefore, we assume that the efficiency gains proposed by the Commission for trucks could feasibly be applied to coaches (i.e. a 15% by 2025; at least 30% in 2030, compared to 2019).

The other main mechanism available to Europe is a zero emissions vehicle (ZEV) sales target (also known as a benchmark or mandate). There are also complementary measures to promote electrification of the fleet, for example by accelerating standardisation and deployment of EU charging infrastructure. The renewable electricity share in transport (RES-T) target is also one such mechanism, however with a multiplier of 4 recently agreed on in the revision of the Renewable Energy Directive, this will not necessarily lead to a large uptake. Finally, there are some modes, particularly vans[lxxxvi] and buses[lxxxvii] where evidence suggests that electrified versions are already economically viable on a total cost basis; all that is missing is the supply from European OEMs[lxxxviii]. Importantly, an uptake in electrification should not allow OEMs to reduce ambition on internal combustion engines; selling an EV should not reduce the efficiency of the other vehicles.

For passenger cars, there remains a constrained supply and choice of plug-in vehicles (PHEVs and BEVs) in Europe; as carmakers in Europe are lacking a regulatory push to invest in sufficient capacity and increase sales[lxxxix]. But an increased offering is expected in 2019/20 as carmakers have to meet their 2021 CO2 targets. The complexity of PHEV dual drivetrain systems will eventually be too expensive to compete with BEVs in the context of rapidly falling battery prices and no investment required for pollutant suppression. A clear ZEV sales target (or mandate) would create volume certainty and ensure OEMs invest and offer sufficient supply of appropriate ZEV models in the future. The target of at least 20% sales in 2025 and over 40% in 2030 is in line with carmakers' own projections[xc]. This would spur the investment in OEM factories and supply chain (e.g. battery cells) in Europe, as well as recharging networks, and enable power companies to anticipate the future electricity demand that will help investment of clean renewable energy. Alongside a ZEV mandate for cars to stimulate supply, the best practices of other European countries as detailed by the ICCT[xci]. These include tax exemptions, priority parking and priority lanes, and zero emission zones in cities (discussed in the national measures section) that help promote ZEVs on the one hand and restrict ICE vehicles on the other.

Given that 80% of installed electricity capacity in Poland is generated from coal[xcii,xciii], the move towards electro-mobility needs to be in conjunction with the decarbonisation of the electricity grid.

Electric buses are a well proven technology, the salient example being Shenzhen in China where 100% of the city bus fleet (16 400 buses) were replaced with electric. In Europe, electric urban buses are gaining traction, according to an independent market monitoring and analysis orders for electric buses doubled in 2017 compared to 2016 reaching around 10% of the total European city bus market. New electric bus suppliers are emerging in Europe, Poland has become a leader in electric bus manufacturing thanks to the company Solaris which has been supplying electric buses to several dozen European cities since 2011. Their flagship electric bus, the Solaris Urbino 12 electric, was named "Bus of the Year 2017" (the first time in the history of the competition that the award goes to a battery-driven vehicle). Solaris has already delivered close to 300 electric buses and has more than 300 buses on order (included trolley buses with batteries)[8]. Solaris is a genuine Polish success story[9] as it is the second manufacturer for number of electric buses delivered in Europe after the Chinese giant BYD (includes BYD ADL cooperation) and thus the biggest European electric bus manufacturer. Ursus is another notable Polish electric bus manufacturer that focuses solely on e-buses. Other major European electric bus manufacturers include Volvo, Irizar (Spain) and VDL (Netherlands).

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[8] Market delivery and order data provided by Stefan Baguette, ADL market analyst and product manager

[9] The Sale of Solaris to Construcciones y Auxiliar de Ferrocarriles (CAF) was finalised in September 2018.

At the time of writing, the electric bus fleet in Poland is around 100 battery electric (and another 111 battery electric buses are on order), which makes it the 4th European market for electric buses (after Netherlands, the UK, and France. According to an industry survey by UITP data, 41% of city buses procured in the EU by 2025 will be zero emission, rising to 62% by 2030[xciv]. Joachim Drees, CEO of MAN Trucks and Buses, has proven to be more ambitious and expects that European cities will only procure electric buses from 2025 onward[xcv] while the proposal for the Revision of the Clean Vehicle Directive suggests that Polish cities will have to procure 37% "clean buses" by 2025 and 56% by 2030[xcvi]. However, based on the favourable total cost of ownership compared to diesel and gas buses and the desire for municipalities to improve air quality and reduce noise, it is unlikely that cities would procure expensive and polluting buses that rely on imported oil or gas after 2030[xcviixcviii]. Therefore, based on the above we assume 50% of new city buses purchased in Poland will be zero emission from 2025 and 100% from 2030[10].

Small electric vans are already economically viable as shown by example of the success of the Street Scooter and independent studies[xcix]. As small vans make up approximately 40% of total van sales, the main limitation is the number of models available. We assume BEV sales of vans (no PHEVs, owing to their expense and the price sensitivity of business operators) reach sales of 50% by 2030.

Finally, there has been an increasing number of battery electric trucks (BETs) in most weight categories in China, the US, and in Europe. They have been shown to have a favourable total cost of ownership (TCO) in many operations today[c] or within the next decade[cicii]. In Poland, 30% of vehicle km and 25% of tkm are journeys less than 300 km, and 45% of road freight movements are less 500 km[ciii]. These types of journeys could feasibly be covered by battery electric trucks with today's technology (in terms of battery energy density).

Another technology that is currently undergoing significant testing and offers a pathway to electrifying road freight is the e-highway[civ]. This is charge-on-the-move technology, where trucks connect to overhead wires with a pantograph on arterial routes. Hybrid versions or on board battery storage can be used off the e-highway grid[cv]. This technology would require an EU wide coordinated and standardised roll-out to reap maximum benefit. According to the German Ministry of Environment, e-highways are the cheapest option to electrify heavy duty road transport[cvi]. Indirect forms of electrical power are more inefficient. Hydrogen and power-to-liquid technology require from 3 to 5 times more electrical energy than for direct use of electricity[cvii]. Additionally, these e-fuels are much further from maturity and much more expensive, and this may hinder any significant market share before the late 2020s, too late to be deployed to achieve the 2030 climate goals.

As is the case for cars, a ZEV mandate spurs investment in new technology and will lead to a diverse option of trucks with electric drivetrains. We assume that a significant portion of these journeys will be electrified in BETs, with 20% of new truck sales <16t and 10% truck sales >16t being battery electric trucks by 2030. This is close to the TNO analysis[cviii] under which 33% of new truck sales (in categories 4, 5, 9 and 10) must be zero emission in 2030 to meet the EU climate targets. The results of adding ZEV mandates for cars, vans and trucks and their promotion are shown in Figure 9.

[10] Urban vkm from the model TREMOVE are used as a proxy for possible sales.

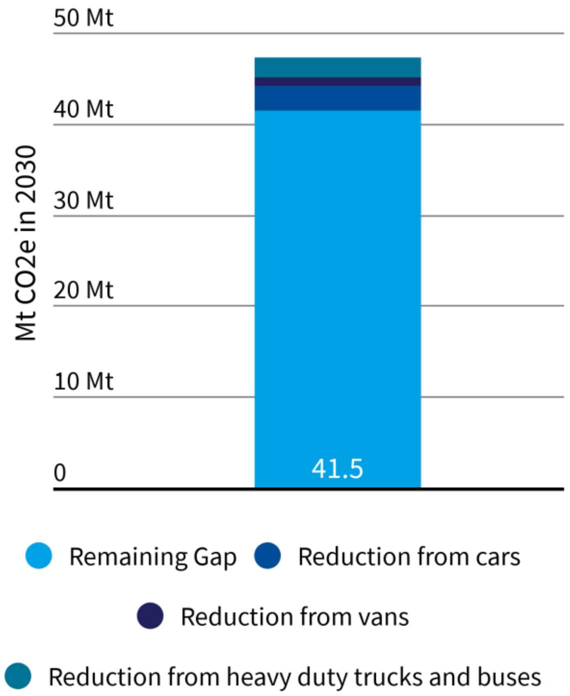

Figure 9: Combination of ambitious 2025 and 2030 standards, and ZEV mandates and promotion

3.2.2. Other EU measures

Other measures that fall under the jurisdiction of the EU include *Eurovignette*[11] (road charging for trucks) and the ongoing construction of the TEN-T network with harmonisation in the EU with respect to signalling (ETRMS) and rail gauge. These measures will indeed help with incentivising and facilitating modal shift, demand reduction, and logistic efficiency, however it will largely be up to each Member State to implement and lever these frameworks to maximise the benefits. These, among many more options, are described in the following section.

[11] Directive 2011/76/EU

4. What national measures are needed in Poland to achieve the 2030 GHG reduction targets

4.1. What has been proposed or considered in Poland

In this section, the various mechanisms available to Poland will be discussed. Although some measures have quantifiable impacts, the effect of the full combination of measures that may partially overlap is difficult and arguably futile. Thus, each measure is discussed and analysed and a thorough assessment given as to how the measures may reduce GHG emissions. All inputs into the model are summarised towards the end of the section.

4.1.1. Fuel taxes and tax reform

In 2011, the VAT in Poland increased from 22% to 23%[cix], affecting the price paid at the pump, however trucks do not pay VAT on fuel because as businesses, they are VAT exempt. The changes described here are thus related to the excise duty. Figure 10 shows that, in real terms, the excise duty applied to fuel in Poland has been decreasing since 2008[12] from a sales weighted average of about €0.45/l to €0.35/l in 2016; Note that when expressed in Polish Złoty, this trend is also observed but where diesel tax has remained largely constant at 2.3 PLN/l, petrol excise duty in 2008 was 2.8 PLN/l to 2.5 PLN/l in 2016. The Polish taxation rate is significantly lower than the €0.55/l European average. As is the case in the EU, there is a significant difference between the taxation of petrol and diesel. In 2016, the Polish state collected €6 billion from fuel duty; had the diesel duty been the same as the petrol duty, revenues would have been €0.6 billion, or 10% more, all else being equal. Similarly, if Polish taxes were not only equalised but also €0.20/l higher to be in line with the current EU average, with the same level of consumption, revenues would be €9.3 billion, 58% more than they were. As the price of fuel paid at the pump is not just excise duty, but the price of fuel itself (including refining, distribution, and profit) and VAT, the relative increase paid at the pump would be around 17% for petrol and 23% for diesel.

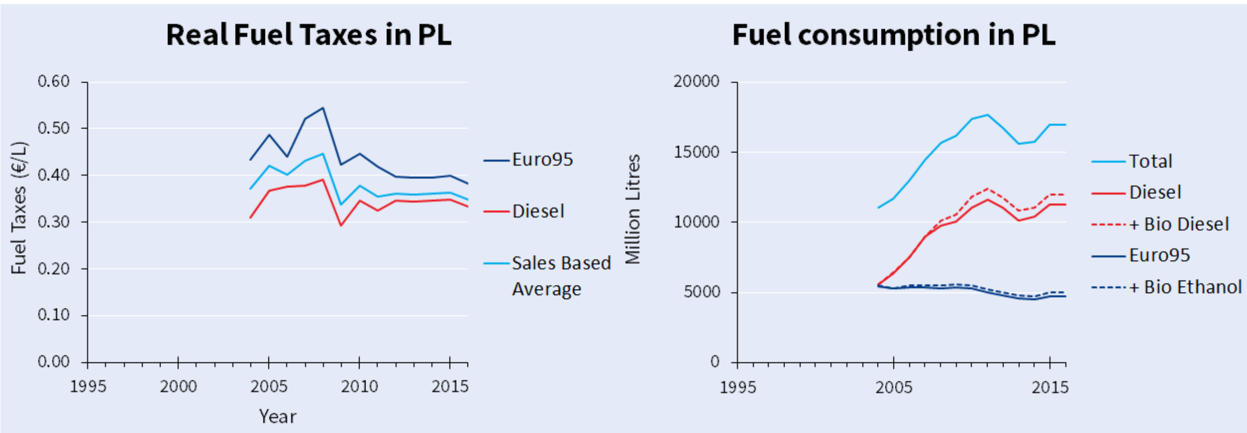

Figure 10: Evolution of fuel taxes and fuel consumption in Poland.

Fuel taxation is not only a means to earn money for the state, it helps internalise the externalities of transport (societal costs of infrastructure, congestion, health problems related to pollution, injuries and loss of life due to accidents) and more significantly, it influences the long term behaviour and choices of passengers and freight operators. Several studies have investigated the price elasticity demand for fuel in Poland, with on the one hand[cx] long term elasticities of -0.84, or on the other hand[cxi] long term elasticities for petrol of -0.262 and diesel of -0.051. If we take a middle ground of these estimates and assume a long term elasticity of -0.4 for car use, to take an example, the decrease in ICE vehicle activity based on the implementation of tax harmonisation with the EU level would be around 8% - demand in EVs would remain unchanged. However, it may have other effects such as increasing carpooling or modal shift to bus or train.

[12] T&E analysis on the Fuel bulletin database and Eurostat data.

In terms of the change in freight movements, this could lead to a preference of more efficient vehicles (which would only be available with the European standards) and an improvement in logistics efficiency. According to Ricardo, the EU average elasticity for trucks and vans is -0.3. These types of measures would reduce the transport activity of road modes, and with appropriate policy can enable cleaner modes such as rail to increase their share of transport.

4.1.2. Facilitate and encourage electromobility

The vehicles carmakers place on the market across EU countries, or supply, in EU is governed by the car and van CO_2 standards. Including the ZEV sales target into the 2025 standards currently under discussion as described under EU measures will help Poland to develop a bigger offer of ZEV models in addition to making them more affordable due to economies of scale. But this cannot and should not occur in a policy vacuum in the Member States. The share of EVs in the Polish car fleet is very low today, but the government has adopted targets for future EV deployment in its Electromobility Development Plan. A target has been set for 76 900 EVs and 2,000 electric buses on the road by 2020, in addition to a target for one million EVs on the road by 2025[cxii]. Poland has relatively little ambition on electro-mobility in their national plan for the deployment of alternative fuels infrastructure (under the Directive 2014/94/EU) for 2020[cxiii]. It includes a target of 6,859 public charging points by 2020 for an estimate of about 77,000 EVs. However, beyond 2020, Poland defined an ambitious target of reaching 1 million EVs on the roads by 2025. At the time of writing, about 1 700 electric vehicles are on the road in Poland[cxiv] and about 550 public charging points are available. According to Cambridge Econometrics[cxv], a total of 126,000 charging points will be needed by 2020 and about 1 million points in 2025 (including public and private chargers). The cumulative cost of charging infrastructure would be almost €2.6 billion by 2030. However, according to EAFO, Poland currently doesn't have any national incentives for electro-mobility. The country clearly needs more ambition if it wants to solve air quality problems in its cities and reach its 2025 target. For this, financial support and regulatory measures are needed to provide certainty for market actors and investors.

Unfortunately, the Polish National Policy Framework puts some emphasis on the development of the market for CNG cars even though Poland already has a sufficient network of public CNG refuelling stations today and for the close future. This poses many risks to the cross-border continuity of Europe's roads and jeopardises the transition towards a low-carbon economy and away from dependence on foreign fossil fuel imports.

Poland will have a difficult time to meet its CAR targets in transport, and it must show more ambition. In 2030, the assumption is made that 50% of all new cars sold in Poland will be electric. This is on top of what the ambitious standards would likely bring, and thus will require the timely implementation of measures to encourage electromobility to help reach this target.

4.1.3. Road charging and low emission zones

As discussed previously, the share of EURO 0 – EURO IV vehicles on Polish roads is particularly high. To a large extent this accounts for Poland's poor air quality in cities which rank among the most polluted in the EU; emissions from road transport in Poland are the second-largest contributor to smog after emissions related to the heating of individual buildings[cxvi]. Indeed, out of 50 of the most polluting cities in the EU, Poland accounts for 33. In addition to this, Poland tops the list for most congested small city in Europe with Łódź where 178 hours a year are lost per person due to congestion[cxvii]. Moreover, another four Polish cities feature in the top 20 TomTom ranking (Lublin ranked 6th, Kraków at 8th, Wrocław at 15th, and Poznań at 18th)[cxviii].

Smart tolling could help relieve both of these issues. Indeed, the introduction of a smart toll system in Germany has shown not only a decrease in heavy truck empty headings[cxix], encouraging efficient transport behaviour, but in addition has increased the purchase of cleaner trucks, which benefit from a lower toll rate than dirtier models[cxx]. The external costs of trucking can be significant in terms of pollution[13], and for infrastructure wear and tear, noise, and congestion[cxxi]. Tolling can play complementary role in the uptake of cleaner, more fuel efficient vehicles and ZEVs. Firstly, applying CO2 differentiation of road charges based on tailpipe emissions would complement and gradually replace differentiation based on air pollution. For cars Euro class differentiation should play a role but it must be based on Real Driving Emission test results and not on the discredited laboratory tests. A 75% toll discount for all zero emission trucks across Europe would provide a financial incentive to encourage the purchase of zero emission trucks, which would help create a bigger market for zero emission vehicles.

Finally, tolls can be used to reduce congestion and to create zero emission zones. Cars spend a lot of time in cities, but a disproportionate amount of that time is spent parked. A duration based charging system, whereby users pay per hour of city access, can reduce the amount of cars in city centres without limiting mobility. In Łódź, for example, the pedestrianisation of the touristic Piotrkowska Street restricts access to residents[cxxii]. Such a system encourages collective mobility (i.e. train, bus, or carpooling) and allows for more space to become available for better cycling/walking infrastructure or parks. Congestion charges could be further differentiated to promote the use of cleaner vehicles so that those vehicles that do continue to enter cities are more likely to emit less. In Wroclaw, for example, free parking in zones B & C (outer city zones) for electric vehicle car sharing encourages clean driving and reduces congestion in the inner city centre[cxxiii]. What's more, incentives encourage the use of zero emission vehicles in the city centre including discounts for parking in *Zone A*, use of bus lanes and access to streets prohibited to internal combustion vehicles. Systems such as this should be extended to other cities to further encourage the shift towards a zero emission fleet. For congestion, a higher price can be charged for trucks driving in the busiest periods of the day. This can help reduce traffic during peak hours as trucks adapt to plan deliveries off-peak.

4.1.4. Shifting car passengers to buses, trains, cycling, and walking

Shifting passengers from cars to buses and trains can be divided into two broad categories, intercity and metropolitan. Despite being quite a large country, domestic aviation demand has strong competition from cleaner modes such as railways and coaches. Railways connect the largest cities to the capital, with the fastest connections less than 3 hours, such as Warsaw-Krakow (2h23min), Warsaw-Lodz (1h25min), and Warsaw-Gdansk (2h45min)[cxxiv]. The existence of rail in itself does not induce passengers to use it, however. Train schedules must be reliable, pricing fair and competitive with other modes, punctual services, and finally, modern and well-maintained rolling stock that can offer services such as wifi and clean toilets. The acquisition of 20 Pendolino train-sets delivered in 2015 is a positive development for Polish railways to improve the speed, reliability, and passenger comfort. Long distance coach journeys have also seen a rapid expansion in Europe with competition and market liberalisation[cxxv]. Companies like Flixbus have expanded rapidly offering regular services that are reliable, easy to book, and cheap[cxxvi]. Coaches do not only compete with car transport; they can offer cheaper services than rail owing to their comparatively low costs such as infrastructure and vehicle costs compared to rail. Coaches should therefore not be granted discounts to road charging or exemptions to any future vehicles standards to ensure that they both do not too heavily undercut rail but also pay their fair share of infrastructure and societal costs (CO_2, pollutant, and noise emissions).

In cities, in order to shift car passengers to public transport, an essential component is appropriate infrastructure for walking and cycling. While a journey by car is typically characterised by door to door transport, a public transport journey is often part of a multimodal trip, and may involve walking or cycling to a bus stop, a bus trip to the metro station, a metro trip, and then a walk to reach the final destination from the metro station. Although walking in itself will not be able to offer the same transport capacity as cars, it is an integral element of facilitating the journey. Cycling enables short distance trips to be

[13] For pre-Euro 6 vehicles.

completely replaced, especially with the generalization of electric bikes, making cycling a transport solution for more people.

In 2016, the Poland-wide modal split of passenger transport in terms of passenger km (not by trips made) was 77.2% by car, 13.9% by bus and coach, 7.3% by rail, and 1.6% by tram and metro[cxxvii]. From Table 1, car transport is projected to be around 400 billion pkm; shifting 5% of this activity to rail would imply doubling of rail capacity. To put this into context, from 1990 to 2014, passenger rail activity dropped by almost 70% from 50.4 billion pkm to 16.0 billion pkm. However, since this low, rail activity has increased 20%, which coincides with the new rolling stock and upgrades to major lines. Although the 10% per year increase is unlikely to be a long term trend, the implication here is that a 5% shift is feasible but very optimistic, requiring year on year increases in passenger activity of 5%. Poland will need to see continued and increased investment and policy choices to make it happen.

The most successful cities and countries (such as the Netherlands and Copenhagen) have high cycling rates owing to extensive infrastructure that is separate from the road that gives cyclists priority over cars. Often left off cycling lists, Warsaw is part of the fifth-largest bike-sharing system in Europe with more than 300 bike stations, 5,000 bikes and roughly 310 miles of cycling routes under Veturilo[cxxviii]. What's more, many city based bike sharing programs are in use in different cities around Poland, such as Wavelo in Krakow, Szamotuły Bike in Szamotuły, and Stalowa Wola Miasto Rowerów in Stalowa Wola. However, these are fairly recent developments; historically, Poland has ranked in the bottom ten on the European Cycling Federations 'popularity' barometer[cxxix]. Moreover, several barriers to the uptake of cycling remain. According to the TomTom Congestion Index[cxxx], Warsaw is 11th most congested city in Europe with average daily congestion levels of 37% (reaching 65% in the mornings and 72% in the evenings). More active travelling, such as cycling, could help relieve this congestion, but at the same time prevents its uptake due to safety concerns. In one study in Warsaw, fear of injury was by far the largest deterrent (74%) to cycling with respondents in particular citing a car-oriented culture and little respect for cyclists' rights[cxxxi]. Indeed, in 2016 Poland had the third highest cyclist death rate in Europe behind Germany and Italy[cxxxii]. It follows that well-connected bike lanes, separate from traffic, are needed to advance cycling as a form of transport. Further, proper bike-lane maintenance, particularly in winter, has been highlighted as a barrier for even the most experienced of cyclists[cxxxiii].

Alongside cycling and walking, the public transport itself must also be reliable and affordable. Monthly ticket prices are relatively cheap in comparison to other Eastern European countries costing €26.91 in Warsaw compared to €48.20 in Vilna, Lithuania, for example (major cities in Europe average €64 per month)[cxxxiv]. However, Warsaw is currently the only city to have a metro; though several cities are considering the introduction of underground lines, including Krakow (which tendered out a feasibility study due end 2019)[cxxxv], Wroclaw (where a study has already shown that a metro is possible, but expensive)[cxxxvi] and Lodz (where the underground connection of two train stations is being tipped as the start of a metro line)[cxxxvii]. Although there could be a significant potential for this energy efficient mode of transport, the costs and passengership must be weighed up and compared with metro-buses and trams with traffic priority, which can offer reliable mass transit at typically lower prices.

4.1.5. Putting more passengers in each car and sharing resources

The transport system is on the verge of a paradigm shift from the tradition of private car ownership to models around sharing and mobility as a service (MaaS). This has largely been through a revolution in digitalisation and application based services (Blablacar, Uber), and business models that facilitate infrastructure sharing (Car2go, DriveNow, Zity). Evidence[cxxxviii] shows that these developments can lead to a significant reduction of single occupancy private car use and an increase of public transport use, leading to a strong reduction in congestion, local air pollution, and CO_2 emissions[cxxxix][cxl]. The French environment and energy management agency (ADEME) found that each shared car replaces in average 5 to 6 private vehicles, while freeing up at least 2 parking places.[cxli] These benefits will occur when more vehicles are shared and private car ownership is reduced; when these shared vehicles are electric, the benefits are even greater. Modelling by the International Transport Forum found that in Lisbon ridesharing services could make public transport more efficient and thus end congestion, reduce traffic emissions by one third, and decrease required parking space[cxlii]. Survey by the Pew Research Center[cxliii] and work by the Union Internationale des Transports Publics (UITP)[cxliv] indicate that car and ride sharing complement public transport, but do not replace it. As citizens abandon their cars and opt for shared resources, more active forms of transport (walking and cycling) become attractive as streets are cleared of congestion and cars, liberating space for appropriate footpaths and cycling paths. The technology behind these applications can enable more passengers per car, as pooling services are enabled. This can be reinforced with favourable conditions for cars with multiple (more than 2) occupants on key city roads. While the development of shared mobility seems unstoppable, whether the transition from ownership models to sharing will lead to short term increase in congestion because of induced demand will largely vary from city to city.[cxlv]

4.1.6. Eco-driving, speed limit reduction, communicating intelligent transport systems (C-ITS), and connected vehicles

Eco-driving is a program for drivers that can reduce CO2 emissions from cars, vans, trucks and buses by training drivers to reduce speeds, anticipate traffic situations to maintain more constant speeds, and reduce the severity of accelerations or braking. One source with authors from the industry[cxlvi] has shown that the benefits of eco-driving is highly dependent on how many eco-drivers there are and the level of congestion. It showed that in congested roads, eco-driving has a maximum benefit of 4% if all drivers adopted and use eco-driving practices, while in free flowing traffic, the benefit ranges from a 4% benefit, if 25% of drivers employ eco-driving, up to 15% in the ambitious scenario of all drivers employ eco-driving. Other studies from car manufacturers showed that eco-driving could bring a potential saving[cxlvii]. However, the JRC[cxlviii] and others[cxlix] found that the impacts of eco-driving tends to decrease over time. This implies that the benefits would require extensive and repetitive training programs of all drivers to see appreciable benefit. Although this may be feasible for professional drivers where the burden may fall on transport companies, such a broad program for all drivers is unlikely.

Reducing speed can have a significant impact on CO_2 emissions, particularly at highway speeds, as aerodynamic drag increases proportionally to the square of a vehicle's speed. With full compliance of speed limits, the EEA reports that modern cars could reduce their CO_2 emissions per kilometre by up to 12% (in line with findings from Ricardo[cl]), but in a more realistic scenario, it would more likely be 3%[cli]. Imposing lower speed limits comes under the jurisdiction of the Autonomous Communities, and there has been precedent in the EU (in France[clii] and Belgium[cliii]). Reducing speed limits in cities improve pedestrian and cyclist safety with less severe injuries and smaller probability of fatalities[cliv]. Indeed, despite some good progress, Poland continues to report a high number of road fatalities when compared to the EU average[clv]. What's more, in 2015, 26% of car accidents involved pedestrians and 14% involved cyclists[clvi]. Better adapted speed restrictions could help reduce this. However, the CO_2 savings will generally not be as significant.

In addition to pricing pressure, technology can play a role in making transport more efficient. The flow of real time information regarding cargo space and arrival time is underutilised in road haulage. Internet applications are being developed and increasingly used, enabling road haulage companies to be more aware of goods available to be transported near their trucks. These tools can help to eradicate dead mileage and reduce empty legs. Increasing the cost of road transport will increase the uptake of such technologies as road is currently too cheap for this technology to be adopted at the extent necessary to have an impact on logistic efficiency

Both Ricardo 2016[clvii] and the European Commission[clviii] state that widespread and rapid deployment of C-ITS can deliver reduce the fleet emissions from cars by 1.0%, buses by 1.7%, vans by 0.8%, and 0.7% for trucks. The maximum potential for each mode does not exceed 4.5% (for buses) in 2050, which gives an indication of improvements to new vehicles.

4.1.7. Shifting freight from trucks to trains

Modal shift has long been lauded and promoted as a key driver to decarbonize freight transport. The railway network in Europe is largely electric and far more energy efficient than today's truck transport[clix]. In 2011, 86% of train-km for freight were performed on electric traction in the EU. However, only 60% of freight railway total energy consumption is performed by electric traction. Out of a total rail network length of 18 429 km (the third longest in Europe behind Germany, 38 990 km, and France, 28 364 km), 11 786 km (64.0%) of Polish lines are electrified (compared to an EU average of 53.7%)[clx]. Poland is already above the EU average for freight shares on rail, at 22.3% and 50.7 billion tkm.

Although in the EU as a whole, 50% of rail freight is international or transit, in Poland, international undertakings represent only 26.7% of tkm[clxi]. Clearly, the priorities of the TEN-T network to enable smoother international freight, particularly to and via Germany to other large EU Member States is vital for rail freights viability. However, attaining this potential is not at all simple, as described in greater detail by the Rail Freight platform coordinated by T&E[clxii].

Rail is highly dependent on the type of goods being transported in the country. As shown in Figure 11, Polish rail freight is dominated by the transports of fossil fuels such as coal (44.3% of activity) and bulk products. The structure of goods transported by rail freight has gradually been changing over the years from heavy to lighter goods, particularly over longer distances. However, the market remains dominated by the volume of transported weight of such goods as hard-coal, lignite, crude oil and natural gas at 41.27% and 91.7 million tonnes (90.6 million tonnes of which is hard coal)[clxiii]. When we consider distance travelled, these goods still take first place at a 29.65% market share and 15 billion tkm (14.6 billion tkm of which is accounted for by hard coal); though goods such as metal ores and other mining and quarrying products come close with 24.76% of the market, and coke, briquettes, refined petroleum products and manufactured gas with 17.28%.

In the context of a decarbonising energy, the amount of coal transported should begin to decline to zero, reducing rail freight activity. On the one hand, this may open up more slots for other rail freight. On the flip side, a lot of this transport is on dedicated lines that go directly to the power stations, and thus will likely be unused. Secondly, a distance of 300 km and below is where road transport is typically superior to rail in terms of flexibility and operational costs (i.e. infrastructure charges, loading costs, fuel taxes, driver costs, and capital costs for purchase of equipment). For rail freight to and from Warsaw, this distance essentially covers most of the country. Furthermore, road transport is comparatively trouble-free when crossing borders.

Figure 11: Evolution of freight carried by rail by type of goods carried and Poland with a 300 km radius area centred on Warsaw[clxiv], overlaid.

Despite being one of Europe's largest rail freight markets, second only to Germany in freight tonne-kilometres (50.7 billion tkm compared to 116.2 billion tkm in 2016), *road* freight still massively dominates the market at 154.2 billion tkm (in 2015)[clxv]. Moreover, rail freight modal share decreased in Poland by over 20% between 2000 and 2013[clxvi]. Indeed, rail freight faces a number of barriers to its expansion. The largest of these is a highly competitive road transport system. Access charges to rail infrastructure in Poland are among the highest in the EU (notably for freight operators) while the opposite is true for roads[clxvii]. Railway undertakings pay an 'infrastructure charge' to infrastructure managers for the use of railway lines in a similar way that some road users are required to pay a 'toll' for using a particular road, or bridge. However, the rail infrastructure charge is paid on all 18,000 km of railway, whereas the road toll only applies to 3,600 km of road[clxviii] (about 15% of the road network)[clxix]. The European Court of Auditors notes in particular that the expansion of the road toll charge for heavy duty vehicles in Germany (combined with a relatively independent regulatory body and strong industry) explains the comparatively high share of rail freight in this country[clxx]. Given these conditions, high expenditure on rail infrastructure will yield limited results in shifting freight from road to rail, as road will invariably remain the cheaper means of transport. This is of course unless road transport is taxed fairly.

Another barrier to the uptake of rail is a lack of competition. Although 69 companies were in operation on Polish rail in 2015, three undertakings - PKP Cargo, DB Cargo Polska and Lotos Kolej - accounted for 80% of the market in 2016 (though this fell from a 90% market share in 2015)[clxxi]. Effective market competition is vital to driving the price of rail operations down and making it competitive with road transport. On top of this, capacity allocation rules disadvantage rail freight operators compared to others. Rail operators have to book a path with the infrastructure manager; this is either done in advance or using an ad hoc system for the remaining capacity. The system disadvantages the rail freight sector though as the booking is generally required 1 year in advance, and whereas passenger trains can predict these times, it is harder for freight operators to predict demand so far in advance, particularly smaller freight companies. As a result rail freight operators tend to rely on the ad hoc system; indeed, in Poland, 90% of smaller operators use this system[clxxii]. This is problematic because priority categories (necessary under Articles 39 and 47 of Directive 2012/34/EU) used in the case of conflict where two or more operators request the same path, disadvantage freight operators. In Poland, out of 8 priority categories, freight trains list as 6th and 7th priority (the eighth being empty passenger trains)[clxxiii]. This once again makes the transport of freight by trains less competitive in comparison to road.

Finally, a lack of sufficient terminal facilities for intermodal freight operations prevents the use of freight in combination with other transport to improve efficiency[clxxiv]. What's more, the average commercial speed in freight trains (which saw a drop in 2014 to 23 km/h from 25.6 km/h in 2012) is quite low in Poland - though this is generally considered a pan European problem. This has an additional negative impact on rail transport competitiveness.

Whatever potential growth that is possible for rail is unlikely to materialise without improvements in rail capability and greater customer service by rail freight operators. This shift in business model (i.e. a more customer-oriented and international vision) will come from a better environment for competition whereby more train operators can compete fairly with the state-owned operators. This also is somewhat reliant on road charging, as the cost of road has to increase significantly so that the external costs of road transport (such as air pollution, GHG emissions and infrastructure costs) are internalised.

4.2. What national measures can deliver in Poland

The previous sections described and quantified where possible the potential impacts of policy on transport demand, modal shift to cleaner transport, and policies to increase the efficiency of the transport system. These policies can have complex interactions and do not necessarily result in accumulative benefits. Therefore, these inputs are based on careful consideration of each measure so as not to overstate the potential of any given measure or combination of measures. On the other hand, these measures could be seen as targets that Poland would need to achieve in order to meet its climate targets while designing policy. For example, to ensure car passengers are shifted to walking and cycling by the amount stated below, impact assessments should investigate how to achieve this, and what type of policy and investment is required to get there. In Table 3, the inputs to the model are detailed along with a brief justification and the policy levers required. Note that rebound effects of more efficient vehicles and lower fuel costs for electric vehicles (where reduced costs induce more demand), are not considered in this study, as the combination of other measures are assumed to be designed to negate this effect.

Table 3: Summary of inputs of Polish National level policies

Policy Lever	Reduction by 2030 (* 2025)	Measure	Main policy interactions and justification
1	4.00%	SHARE OF LDV ACTIVITY SHIFTED TO BUS (%)	Fuel tax normalisation, new electric buses being able to offer cheaper services, congestion zones blocking cars, coach market expansion.
2	10.00%	BUS LOAD FACTOR INCREASE (PASSENGERS/ VEHICLE)	As more passengers are lured onto buses (policy lever 1), buses will tend to be filled, increasing efficiency. This will be supported by service improvements (that will follow from increased ridership), pricing, and multimodal ticketing.
3	5.00%	SHARE OF LDV ACTIVITY SHIFTED TO RAIL (%)	This represents a 47% increase of current tram, metro and train ridership. This will be facilitated from fuel tax normalisation, TEN-T network implementation, inter-modality, and train pricing and improved punctuality, competition offering new and more attractive services. This is a more conservative shift than described above.
4	3.00%	MODE SHIFT FROM LDV TO WALK/BIKE (%)	As part of a city infrastructure investment (foot and bike paths), congestion charges that reduce traffic in order to reclaim space, more people willing to take public transport.
5	25.00%	LDV LOAD FACTOR INCREASE (PASSENGERS/ VEHICLE)	Car sharing, priority access to carpooling cars. High congestion charge for single occupancy vehicles, higher vehicle registration tax, low emission zones, higher fuel prices and taxes, car ownership not a status symbol anymore (social justification)
6	8.00%	LDV ACTIVITY - REDUCTION FROM BASE CASE (%)	Combination of fuel tax harmonisation with the EU, low emission zones, congestion zones, toll roads and distance based charging. Some of the reduction in demand has been through modal shift (policy levers 1,3,4)
7	5.00%*	FREIGHT TRUCK LOGISTICS IMPROVEMENTS (%)	Fuel taxes normalisation and ending rebate to truckers, road charging, digitalisation.
8	10.00%	SHARE OF HHDV ACTIVITY SHIFTED TO RAIL (%)**	Combination of diverse measures required to enable rail freight to be more competitive. Trucks should be charged for their pollution and infrastructure damage through fuel taxes and road charging. Improved connections with Germany, the Baltics, and Austria with the TEN-T.

9	6.25%*	FREIGHT TRUCK PAYLOAD INCREASE (METRIC TONS/VEHICLE)	Eurovignette and distance based charging, digitalisation.
10	5.00%	REDUCTION IN IN-USE FUEL CONSUMPTION OF ON-ROAD VEHICLES	C-ITS, eco-driving, congestion relief through time based charging, reduced and heavily enforced speed limits.
11	50.0%	LDV EV SALES	A national target implemented above ambitious standards, from charging infrastructure implementation, road charging, low emission zones, national targets. Note that this measure overlaps with EU ambitious standards, reducing the effect of CO_2 standards owing to the additional EV sales implied here.

Figure 12 shows the result of applying only these national measures, without the EU measures on CO_2 standards and electrification. As standalone measures, they amount to about 21.6 Mt CO_2e reduction compared to the baseline. This illustrates that Poland, and the rest of Europe, do benefit a great deal from EU measures such as CO_2 standards and electrification.

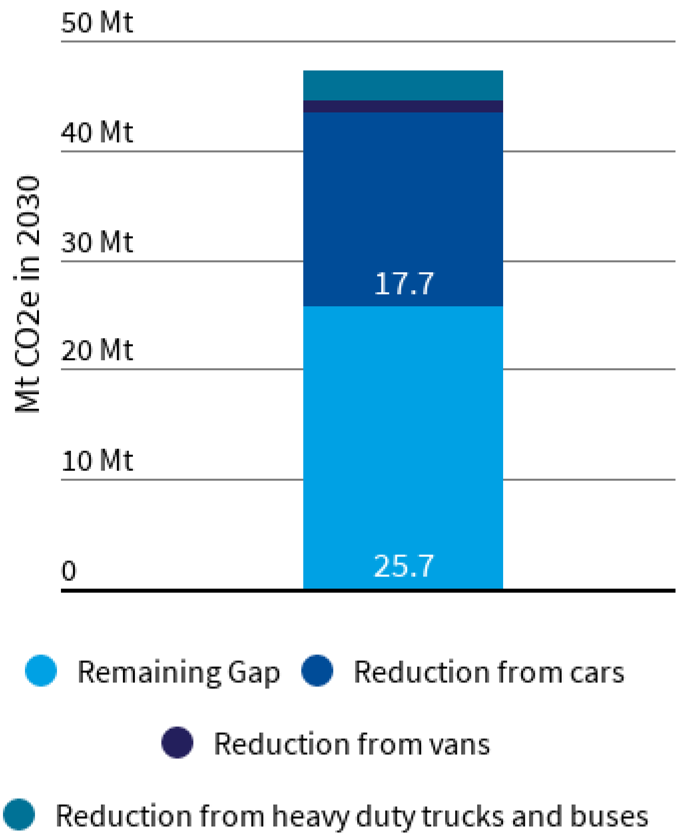

Figure 12: What national measures can deliver on their own in Poland, without EU standards and EV sales targets.

Figure 13 shows the combination of ambitious standards, and national measures. The measures together do not completely close the gap, but reduce it by 58%. Although the measures described to reach this goal are ambitious, no measure goes beyond what independent research says is technically and economically feasible. These results indicate that between 2020 and 2030, an average reduction in emissions of 0.75 Mt

CO_2e per year (or 1.2% per annum) compared to the 2020 is possible; to meet the target would require reductions in this decade of 2.7 Mt. This is in sharp contrast to the emissions recorded between 2014 and 2016 that have seen an average increase of 3 Mt CO_2e.

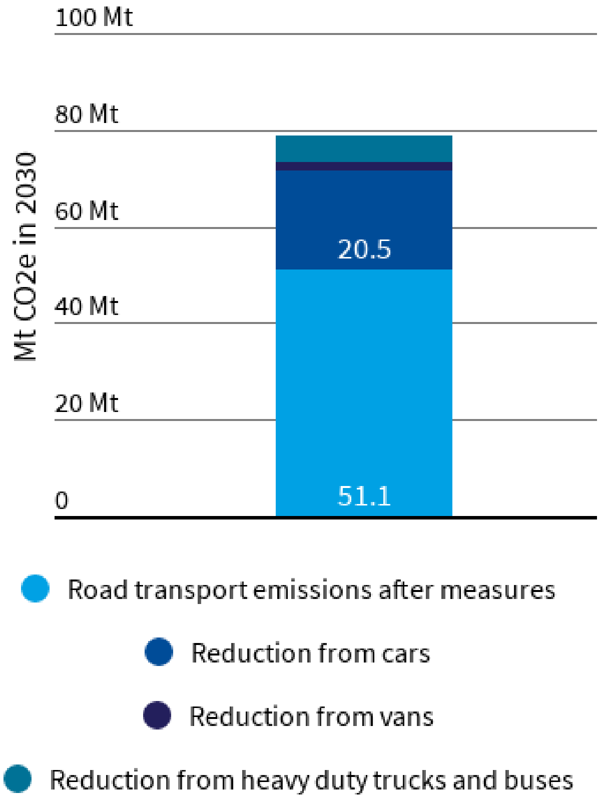

Figure 13: Combination of European and Polish measures to achieve 2030 targets.

5. Long term impacts of climate change mitigation policies in transport

Figure 14 shows the projections of the different scenarios discussed in this paper, until 2030. In all scenarios, the policies and consumer behaviour are again frozen in time, as was the case when defining the baseline for the modelling projections. This perspective shows the benefit in exceeding the 2030 target: in the scenario with all ambitious measures in place, the emissions can almost be extended with a straight line to zero emissions in 2050. What is sure is that beyond 2030, *even more effort* will be required to reach full decarbonisation by the mid-century, necessary to abide by the Paris Agreement. Full electrification of the vehicle fleet will be necessary, and the electricity grid in the meantime will need to phase out fossil fuel generation.

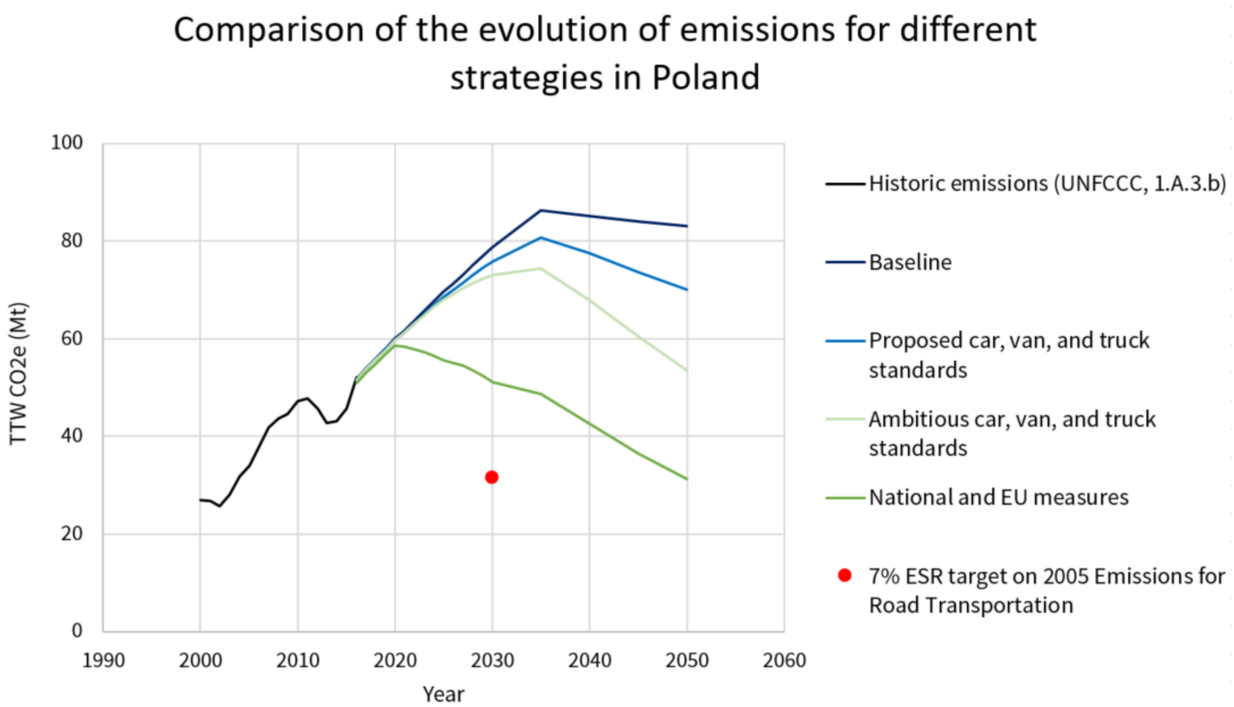

Figure 14: Long term trajectories of tank-to-wheel CO2 emissions in Poland, compared to the 7% reduction target on 2005 levels.

5.1. Co-benefits

Reducing GHG emissions from transport is first and foremost a positive for the environment. As discussed in the opening paragraphs of these reports, Poland is already experiencing climate change that is amplified compared to what is being observed in the rest of Europe. Environment aside, there are other compelling arguments to reduce fossil fuel use. Most of the EU's oil is imported, thus the energy security of the continent is dependent on unstable regions in the world and on top of this, and money is flowing out of the EU economy to these regions[clxxv].

Dependence on foreign oil will be reduced. The electric revolution can bring a lot of jobs in the EU - more jobs if we take the lead. This is particularly important in Poland as it has 1.10% of its active employment ratio (or 187 334 people) directly employed in the automotive industry[clxxvi], which could see its economy thrive with the right investments. Electric cars do not have emit pollutants, a huge benefit for air quality, health, reduction in noise pollution and liveable cities.

6. Policy recommendations

This report has shown the potential of a wide range of European and Polish specific measures that can be met on technical and economically viable metrics based on independent research. The main barrier to their uptake would be a political one. With strong political ambition, Poland can invest in future technologies that are beneficial for the society and the environment. In this section, we outline the key and concrete actions that Poland can take to make it happen.

6.1. Vehicle standards

Cars and Vans

- Agree without a delay a binding and ambitious 2025 CO_2 standard for new cars and vans of at least 20% in 2025. This is the key policy that will reduce CO_2 emissions from cars and vans in the coming decade, as well as driving investments into zero emission vehicles and more fuel efficient petrol and diesel cars. The 2025 target is indispensable to help Poland achieve its Climate Action Regulation goals in 2030.
- To ensure CO_2 reductions are achieved on the road and the current gap between laboratory results and the real-world decreases, a not-to-exceed limit should be set for all manufacturers in 2021. This limit should be verified using either a newly developed Real-world Driving Emissions test for CO_2 or the Fuel Consumption meters.

Trucks

- Agree without a delay a binding and ambitious 2025 CO_2 standard for regulated trucks of at least 20% effective reductions in 2025. Similarly for light duty vehicles, this is the key policy that will reduce CO2 emissions from trucks in the coming decade, as well as driving investments into zero emission vehicles.
- In the 2022 review, Poland should push for trailers to be included in the regulation, along with ambitious standards for all truck categories. The efficiency improvement targets should be set as close as possible to the technical and economically feasible potential, which is 43% reduction for the tractor and trailer. For tractor trucks this means the 2030 target should be set at least 30% effective reductions.
- Monitor and report carbon emissions and fuel consumption of buses and trucks. Transparent fuel consumption information enable public authorities and truck hauliers to make more informed choices based on total-cost of ownership and actual fuel consumption

6.2. ZEV mandate and promotion

Poland should support the Commission in the creation of a joint undertaking for the research and development of battery technologies. Such a joint venture could be half funded by the EU budget and half funded by industry stakeholders. The EU could then use such a body to improve the European market for battery technologies while also researching how to reduce the environmental impact of the supply chain, as well as the best means to integrate electromobility into smart electricity grids. For Poland, locally produced batteries could help the large car manufacturing industry there.

Cars and Vans

- As part of the EU CO_2 standards for cars and vans, the separate sales target for zero emission vehicles should be agreed for 2025 to drive the supply of electric cars in Europe. This can be done either via a dedicated ZEV mandate or by adding a malus to the currently proposed bonus system. This will spur innovation into electric powertrains and the supply chain in Europe, driving better offer and more affordable choice of clean cars. While plug-in hybrid cars should be included they should be rewarded less than zero emission vehicles such as battery cars, in line with their CO2 emissions.

- Poland should without delay finalise its National Policy Framework on the infrastructure for alternatively fuelled vehicles such as plug-in cars. An ambitious target for the number of publicly accessible recharging infrastructure would speed up the sales and uptake of plug-in cars while providing market certainty to electro-mobility players. This requires a joint approach to all levels of government to ensure infrastructure is rolled out rapidly and in the right locations, in a demand-driven way with innovative business models promoted.
- Sustainable and reliable support schemes and financial incentives to boost demand for plug-in cars should be put in place. Notably, the bonus-malus tax system which in a revenue neutral way helps the purchase of zero emission cars should be seriously considered.

Trucks and buses

- Poland should push for Europe to introduce a well-designed benchmark system with a bonus and a malus or a mandate for zero emission trucks of 5-10% by 2025 and 25-35% by 2030 and for buses of at least 50% by 2025 and 100% by 2030
- Poland should consider reducing rates for electricity for transport in the short term to help enable the uptake of battery electric trucks and buses.
- Within the Weights & Dimensions Directive (96/53/EC), an additional one tonne of legally permissible weight for trucks up to 26 tonnes that are powered by "alternative fuels", including electric powertrains. This allowance does not apply to tractor trailer trucks, however. Poland should push to change this law so that all trucks can benefit from additional tonnage to account for the alternative technology. As the batteries can range from 1t to 4t, Poland may consider pushing for a small increase in gross vehicle weight (GVW) to accommodate these technologies so there is no or reduced penalty on the payload. The Commission is also expected to progress the implementation of rounder, more aerodynamic truck cabs during 2018. This will be a benefit to both battery electric trucks and to the new best in class ICEs.
- Cities across Europe have significant potential to push investment to electric trucks and to shift their urban buses fleet to zero emission. This bottom-up pressure will further incentivise vehicle makers to invest in zero emission trucks and buses, as a coalition of cities can constitute the majority of the population on the continent.
- Require 100% of newly publicly procured buses and trucks to be zero emission from 2030. This should be reflected in the review of the Clean Vehicles Directive.

6.3. Fuel taxes and tax reform

- Poland should align their diesel tax rate to that of petrol, and should consider increasing excise duty to be more in line with the EU average.

6.4. Road charging

- Reassess toll charging for those concessions that are ending soon to ensure tariffs are set at a fair rate. Ideally, the rates at which vehicles are charged should be consistent across the whole network.
- Reassess toll charging for those concessions that are ending soon to ensure tariffs are set at a fair rate. Ideally, the rates at which vehicles are charged should be consistent across the whole network.
- Ensure all tolls are inclusive of separate infrastructure and (air and noise) pollution costs. Toll rates should be differentiated so that more polluting vehicles pay more than cleaner vehicles on the road.
- Extend the toll charge for HDVs to secondary roads so that the damage they cause is accounted for wherever they drive. This will additionally prevent HDVs from using secondary roads to avoid the toll, and so relieve congestion on those roads.
- Tolls have additional benefits for road transport as they improve logistic efficiency and can be used to encourage the uptake of cleaner vehicles provided rates are differentiated according to the environmental performance of a vehicle

6.5. Shifting car passengers to buses, trains, riding, and walking

- Invest in high quality, affordable public transport. Share relevant data with other transport providers and internet mobility platforms to enable Mobility as a Service (MaaS) and offer a real alternative to private car ownership.
- Improve the city infrastructure to encourage walking and cycling. This should lead to public space reallocation with less road space for cars, and more bike lanes.
- Introduce measures to encourage bike sharing, including appropriate locations for shared bikes, larger bike lanes, adequate street signs.
- Reduced the number of car parking slots and increase parking fees to incentivise the use of public transport.

6.6. Putting more passengers in cars

- Introduce city road pricing and/or congestion zones as a policy to reduce private car use.
- Facilitate the use of short and long distance car and ride sharing, as the occupancy of these vehicles is above average.
- Adapt fiscal incentives to deter private car use: end tax benefits for company cars, equalise taxation between petrol and diesel

6.7. Eco-driving, speed limits and communicating intelligent transport systems (C-ITS)

- As shown in this report, eco-driving has a potential to reduce CO_2 emissions from vehicles but to be effective, most or all drivers need to employ eco-driving, especially on the long term that would require regular trainings or better, mandatory use of eco-driving modes on cars that would moderate how the car is driven to maximise efficiency. Car manufacturers have been pushing the European Commission to qualify eco-driving as an eco-innovation. However, it does not qualify as an eco-innovation as there is no guarantee that the driver will use or respect it, creating here an important loophole. A mandatory system would however qualify. A simpler approach to encourage eco-driving is simply to rigorously enforce speed limits that achieves similar benefits.

6.8. Shifting freight from trucks to trains

Shifting freight to trains, and ideally electrified trains, requires a holistic and concerted approach for policy and investment. If Poland wants to shift more freight from road to rail then there are a number of measures that can help to achieve that.

- Apply a moderate toll to reduce the distance that rail becomes cost-competitive with road. Trains pay per kilometre of track access, and rail is more costly than road due to the increased requirements regarding labour and infrastructure, as well as the prices that rail companies set for their service.
- The Polish regulator must ensure that the railway infrastructure manager is treating all trains equally regarding track access. This means equal treatment for new entrants and foreign trains. An independent and unbiased infrastructure manager is essential to a well-functioning railway market.
- Explore the idea of obliging the state-owned company to rent unused electric locomotives to new entrants that do not have the access to capital to buy such rolling stock and, therefore, use cheaper and more polluting diesel locomotives
- Improve the flexibility and speed of freight services by investing in rail infrastructure that's not as complex or time-consuming as large cranes. For example, a company in Switzerland has developed a system[clxxvii][clxxviii] whereby special trucks can quickly load containers and trailers from trucks to trains and vice-versa. The infrastructure is not expensive but there's a lot of potential to improve the ease at which trains are loaded.

- Increase competition in the rail freight market. A common issue across Europe is that new entrants compete for pre-existing rail freight volumes rather than trying to get the business of freight that's being moved by road. This is indicative of how rail is often reserved for captured markets and rarely tries to adapt services to compete with road freight.

6.9. Aviation and Maritime

Although these modes were not explicitly modelled and fall out of the framework of the CAR, aviation and maritime activity and their associated emissions are significant in the Polish transport sector; in the case of aviation, emissions have risen 3-fold since 1990. Poland can push for the following measures to ensure that these emissions are properly regulated and kept at bay.

Aviation:

- A ticket tax on flights could yield significant revenues (€127 million based on 2016 departing passenger numbers).
- Retain and reform the EU ETS as a means of introducing more effective carbon pricing and put the sector on a long-term path to decarbonisation
- End the sector's kerosene tax exemption, starting with domestic aviation, and using Article 14 of the Energy Taxation Directive to begin ending the exemption for international flights on a regional basis.

Shipping:

- Implement tighter air pollution standards for ships calling at Polish ports, both for SOx and NOx emissions;
- Electrify Ro-Ro ships (passenger and cargo) involved in short-sea shipping;
- Making on-shore power supply available, especially for RoRo and cruise ship terminals;
- Consider mandates[clxxix] for zero emission shipping on specific domestic/short-sea shipping routes which can switch to batteries/hydrogen fuel cells in the immediate future;
- Ensure the transparency and cargo data collection in the EU MRV (when revised) in order to break market barriers to the uptake energy efficiency technologies in shipping;
- LNG as maritime fuel will make the decarbonisation of Polish shipping very painful because of insignificant GHG benefits at the expense of huge infrastructure and ship retrofitting costs[clxxx].

References

[i] Graphic: The relentless rise of carbon dioxide. *NASA*.
https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/
[ii] scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-bluemoon/graphs/co2_800k.png
[iii] For first time, Earth's single-day CO_2 tops 400 ppm (2013, 9 May) *NASA*.
https://climate.nasa.gov/news/916/for-first-time-earths-single-day-co2-tops-400-ppm/
[iv] Why is 400 an important number? *Climate Stewards*.
https://www.climatestewards.org/resources/atmospheric-co2/
[v] Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M. Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., Sörlin, S. (2015) Planetary boundaries: Guiding human development on a changing planet. *Science.* Vol. 347, Issue 6223,
DOI: 10.1126/science.1259855.
http://science.sciencemag.org/content/347/6223/1259855
[vi] NOAA Earth System Research Laboratory. Recent Global CO_2. Accessed June 2018.
https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html
[vii] Le Quéré, C. (2013) Past, current and projected changes of global GHG emissions and concentrations. *IPCC AR5 Working Group 1*. Chapter 6 [presentation]
https://unfccc.int/sites/default/files/6_lequere13sed2.pdf
[viii] Paris Agreement, Article 2(a). Available :
https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[ix] Graichen, J. (2016) Targets for the non-ETS sectors in 2040 and 2050. Report prepared for Transport & Environment by Öko-Institut e.V.
https://www.transportenvironment.org/sites/te/files/publications/2050%20ESR%20targets%20v5.pdf
[x] Climate change in Poland. *ClimateChangePost*. Accessed August 2018:
https://www.climatechangepost.com/poland/climate-change/
[xi] https://www.reuters.com/article/poland-energy-heatwave/update-2-polish-heatwave-cuts-power-supply-to-industry-idUSL5N10L2QJ20150810
[xii] http://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20171005-1?inheritRedirect=true
[xiii] https://www.climatechangepost.com/poland/fresh-water-resources/
[xiv] http://ec.europa.eu/eurostat/statistics-explained/index.php/Water_statistics
[xv] https://apnews.com/9db0ece961604537a4334480052f45ce
[xvi] CO_2 time series 1990-2015 per region/country. *European Commission*. Accessed: June 2018.
http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2015&sort=des9
[xvii] UNFCCC emissions as reported by member states.
https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018
[xviii] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2018-0097+0+DOC+XML+V0//EN&language=EN#BKMD-8
[xix] http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/607335/IPOL_BRI(2017)607335_EN.pdf
[xx] iea.org/publications/freepublications/publication/Energy_Policies_of_IEA_Countries_Poland_2016_Review.pdf
[xxi] http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/607335/IPOL_BRI(2017)607335_EN.pdf
[xxii] Briefing: https://www.e3g.org/docs/E3G_Poland_briefing_note_-_230513_ENG__2_.pdf
Final Results: https://www.e3g.org/docs/E3G_Poland_-_Full_Pack_results_280513_ENG.pdf
[xxiii] http://www.euki.de/
[xxiv] https://www.transportenvironment.org/what-we-do/effort-sharing-regulation/implementation-euki-project
[xxv] http://www.euki.de/delivering-the-eu-2030-and-long-term-climate-objectives-in-central-eastern-and-southern-europe-with-a-specific-focus-on-transport/?lang=en
[xxvi] https://www.transportenvironment.org/about-us
[xxvii] https://www.theicct.org/news/EU-real-world-vehicle-fuel-consumption-gap-all-time-high
[xxviii] Transport & Environment (2016) Mind the Gap.

https://www.transportenvironment.org/publications/mind-gap-2016-report
[xxix] For example:
https://www.eea.europa.eu/data-and-maps/indicators/freight-transport-demand-version-2/assessment-7
and
https://www.eea.europa.eu/data-and-maps/indicators/passenger-transport-demand-version-2/assessment-9
[xxx] EU Reference Scenario 2016: Energy, transport and GHG emissions Trends to 2050
https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf
[xxxi] Statistical pocketbook 2018. EU Transport in figures
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[xxxii]www.transportenvironment.org/sites/te/files/2016_09_Blog_20_years_no_progress_methodological_note_final.pdf
[xxxiii] https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/ec_hdv_ghg_strategy_en.pdf (p.192)
[xxxiv] Umwelt Bundesamt (2015) Zukünftige Maßnahmen zur Kraftstoffeinsparung und Treibhausgasminderung bei schweren Nutzfahrzeugen
https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_32_2015_kraftstoffeinsparung_bei_nutzfahrzeugen.pdf
[xxxv] Transport & Environment (2017) Roadmap to climate-friendly land freight and buses in Europe
https://www.transportenvironment.org/publications/roadmap-climate-friendly-land-freight-and-buses-europe
[xxxvi] National Inventory Submissions 2018. *United Nations Climate Change.*
https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018
[xxxvii] Statistical pocketbook 2018. EU Transport in figures
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[xxxviii] European Parliament Position P8_TC1-COD(2016)0231
http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2018-0097+0+DOC+XML+V0//EN&language=EN#BKMD-8
[xxxix] Effort sharing: Member States' emission targets. *European Commission*.
https://ec.europa.eu/clima/policies/effort_en#tab-0-3
[xl] Effort sharing 2021-2030: Annual emission allocations 2013-2020 and flexibilities
https://ec.europa.eu/clima/policies/effort/framework_en
[xli] European Parliament Position P8_TC1-COD(2016)0231
http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2018-0097+0+DOC+XML+V0//EN&language=EN#BKMD-8
[xlii] Effort sharing 2021-2030: targets and flexibilities
https://ec.europa.eu/clima/policies/effort/proposal_en
[xliii] Effort sharing 2021-2030: targets and flexibilities
https://ec.europa.eu/clima/policies/effort/proposal_en
[xliv] P8_TC1-COD(2016)0231, Article 18. Accessed:
http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2018-0097+0+DOC+XML+V0//EN&language=EN#BKMD-8
[xlv] http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0028
[xlvi] https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive
[xlvii] https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf
and T&E analysis:
https://www.transportenvironment.org/publications/globiom-basis-biofuel-policy-post-2020
[xlviii] Eurostat SHARES database. Available:
http://ec.europa.eu/eurostat/web/energy/data/shares
[xlix] Adam Stępień (2017), director in the Polish Oil Producers Association and the National Biofuel Chamber: "The issue of importing esters from other continents to the European Union - this is a serious problem for the European market, because the imported goods are much cheaper, and this disturbs not only the functioning of the plants, but also destroys any profitability calculations or affects the drastic drops in product prices. Stępień showed very puzzling statistics, which results in a sharp jump in the growth of esters' purchases to the EU in 2017 against previous levels. He also noted that the US has recently closed its market for biocomponents from abroad, and this coincided with the opening of European markets and the abolition of previously functioning barriers."

[l] See p.35-36: https://stat.gov.pl/en/topics/transport-and-communications/transport/inland-waterways-transport-in-poland-in-2010-2013,2,2.html
[li] EU Transport in Figures, 2018. Available: https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[lii] www4.unfccc.int/Submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf
[liii] https://ec.europa.eu/clima/sites/clima/files/ets/docs/clean_dev_mechanism_en.pdf
[liv] Eurostat, accessed August 2018. Table: avia_paoc.
[lv] Transport & Environment (2018) Natural gas-powered vehicles and ships – the facts. Available: https://www.transportenvironment.org/publications/natural-gas-powered-vehicles-and-ships-%E2%80%93-facts
[lvi] http://www.pzpm.org.pl/en/Publications/Newsletter/2018/01_18-New-perspectives-for-Polish-electromobility-the-Sejm-adopted-the-act-on-electromobility-and-alternative-fuels
[lvii] http://bip.me.gov.pl/node/26453
[lviii] http://www.pzpm.org.pl/en/Publications/Newsletter/2018/01_18-New-perspectives-for-Polish-electromobility-the-Sejm-adopted-the-act-on-electromobility-and-alternative-fuels
[lix] https://www.mpit.gov.pl/strony/strategia-na-rzecz-odpowiedzialnego-rozwoju/kluczowe-projekty/program-e-bus-polski-autobus-elektryczny/
[lx] https://www.miir.gov.pl/media/14873/Responsible_Development_Plan.pdf
[lxi] https://www.gov.pl/documents/33372/436746/PEP2040_projekt_v12_2018-11-23.pdf/ee3374f4-10c3-5ad8-1843-f58dae119936?utm_source=POLITICO.EU
[lxii] https://www.precop24.eu/fileadmin/user_files/precop/stanowiska/statement_of_trade_unions.pdf
[lxiii] https://www.acea.be/statistics/tag/category/average-vehicle-age
[lxiv] Transport & Environment (2018) Dirty diesels heading East: Polish edition. https://www.transportenvironment.org/publications/dirty-diesels-heading-east-polish-edition
[lxv] https://www.viatoll.pl/upload/files/2018_03_prezentacja.pdf
[lxvi] http://www.dziennikzachodni.pl/motofakty/na-drogach/a/platne-autostrady-w-polsce-ceny-ile-kosztuje-a1-a2-a4-za-przejazd-mapa-drogi-ekspresowe-to-ciekawa-alternatywa-dla-platnych,13093379/
[lxvii] Transport & Environment (2017) The Economic Impacts of Road Tolls https://www.transportenvironment.org/sites/te/files/publications/2017_04_road_tolls_report_briefing.pdf
[lxviii] http://www.viatoll.pl/pl/pojazdy-ciezarowe/platnosci-i-stawki/stawki-oplat
[lxix] https://www.autostrada-a2.pl/payments
[lxx] https://www.viatoll.pl/upload/files/2018_03_prezentacja.pdf
[lxxi] http://www.viatoll.pl/pl/pojazdy-ciezarowe/platnosci-i-stawki/stawki-oplat
[lxxii] https://www.viatoll.pl/upload/files/2018_03_prezentacja.pdf p.12
[lxxiii] http://orka2.sejm.gov.pl/INT8.nsf/klucz/658C47EF/$FILE/i12856-o1_7.pdf
[lxxiv] Transport & Environment (2017) Are Trucks taking their Toll II https://www.transportenvironment.org/publications/are-trucks-taking-their-toll-ii
[lxxv] https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[lxxvi] UNFCCC reporting by Member States. Accessible: https://unfccc.int/process/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/national-inventory-submissions-2018
[lxxvii] https://www.theicct.org/sites/default/files/publications/ICCT_EU-CO2-proposal_briefing_20180109.pdf
[lxxviii] Sources for Figure X: ICCT, 2016 sales statistics provided by IHS Markit, CO_2 emissions calculated from mileage and fuel consumption assumptions used in "Reduction and Testing of Greenhouse Gas Emissions from Heavy Duty Vehicles" (LOT1, Ricardo-AEA Ltd, 2011; LOT2, TU Graz, 2012)
[lxxix] The Automobile Industry Pocket Guide 2017-2018 - pages 22 and 41. Available: http://www.acea.be/publications/article/acea-pocket-guide
[lxxx] https://www.acea.be/statistics/tag/category/average-vehicle-age
[lxxxi] ICCT (2017) https://www.theicct.org/sites/default/files/publications/ICCT_Post-2020-CO2-stds-EU_briefing_20171026_rev20171129.pdf
[lxxxii] European Commission, 2017, https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/swd_2017_650_p1_en.pdf
[lxxxiii] CE Delft, 2018. Available:

www.transportenvironment.org/sites/te/files/publications/CE_Delft_4L06_Van_use_in_Europe_def.pdf
[lxxxiv] ec.europa.eu/jrc/en/publication/report-vecto-technology-simulation-capabilities-and-future-outlook
[lxxxv] Delgado, O., Rodriguez, F., Muncrief, R. (2017) Fuel Efficiency Technology in European Heavy-Duty Vehicles: Baseline and Potential for the 2020–2030 Time Frame
www.theicct.org/sites/default/files/publications/EU-HDV-Tech-Potential_ICCT-white-paper_14072017_vF.pdf
[lxxxvi] van Bokhorst, M., van Wijngaarden, L., Otten, M., Hoen, A. (2018) Van use in Europe and their environmental impact. *CE Delft.* Available:
https://www.transportenvironment.org/publications/co2-emissions-vans-time-put-them-back-track
[lxxxvii] Bloomberg New Energy Finance (2018) Electric Buses in Cities Driving Towards Cleaner Air and Lower CO_2
https://data.bloomberglp.com/bnef/sites/14/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf
[lxxxviii] Transport & Environment (2018) Small electric vans cost the same as dirty diesel ones today but are in short supply
https://www.transportenvironment.org/press/small-electric-vans-cost-same-dirty-diesel-ones-today-are-short-supply
[lxxxix] Transport & Environment (2018) European carmakers invest seven times more in EV production in China than at home
www.transportenvironment.org/press/european-carmakers-invest-seven-times-more-ev-production-china-home
[xc] Transport & Environment (2018) EU playing catch-up: China leading the race for electric car investments
https://www.transportenvironment.org/publications/eu-playing-catch-china-leading-race-electric-car-investments
[xci] https://www.theicct.org/sites/default/files/publications/EV_Government_WhitePaper_20180514.pdf
[xcii] https://wysokienapiecie.pl/8002-udzial_wegla_w_produkcji_energii_elektrycznej_w_polsce/
Polish Geological Institute:
https://www.pgi.gov.pl/psg-1/psg-2/informacja-i-szkolenia/wiadomosci-surowcowe/10414-zapotrzebowanie-na-wegiel-kamienny-w-polsce.html
[xciii] World Energy Council (2017) World Energy Issues Monitor 2017. Available:
https://www.worldenergy.org/wp-content/uploads/2017/04/1.-World-Energy-Issues-Monitor-2017-Full-Report.pdf
[xciv] http://zeeus.eu/uploads/publications/documents/zeeus-ebus-report-2.pdf
[xcv] https://fleet.ie/we-are-on-the-brink-of-radical-change-joachim-drees-man-truck-bus/
[xcvi] https://eur-lex.europa.eu/resource.html?uri=cellar:ef8ec14a-c55d-11e7-9b01-01aa75ed71a1.0001.02/DOC_2&format=PDF
[xcvii] https://data.bloomberglp.com/bnef/sites/14/2018/05/Electric-Buses-in-Cities-Report-BNEF-C40-Citi.pdf
[xcviii] http://zeeus.eu/
[xcix] van Bokhorst, M., van Wijngaarden, L., Otten, M., Hoen, A. (2018) Van use in Europe and their environmental impact. *CE Delft.* Available:
https://www.transportenvironment.org/publications/co2-emissions-vans-time-put-them-back-track
[c] Earl, T., Mathieu, L., Cornelis, S., Kenny, S., Calvo Ambel, C., Nix, J. (2018) Analysis of long hauls battery electric trucks in the EU. *8th Commercial Vehicles Workshop, Graz, Austria. 17-18 May.* Available:
https://www.transportenvironment.org/publications/analysis-long-haul-battery-electric-trucks-eu
[ci] TNO (2018) Assessments with respect to the EU HDV CO_2 legislation: work in support of the Dutch position on EU regulation on the CO_2 emissions of heavy-duty vehicles. Available:
https://repository.tudelft.nl/view/tno/uuid:cdc11c45-1636-431a-8016-5f582769c1c3/
[cii] Moultak, M., Lutsey, L., Hall, D. (2017) Transitioning to zero-emission heavy-duty freight vehicles. *The ICCT*
https://www.theicct.org/publications/transitioning-zero-emission-heavy-duty-freight-vehicles
[ciii] Eurostat. Road freight transport statistics. Accessed: June 2018
http://ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_statistics
[civ] eHighway – Electrification of road freight transport. Siemens.
www.siemens.com/global/en/home/products/mobility/road-solutions/electromobility/ehighway.html
[cv] Transport & Environment (2017) Roadmap to climate-friendly land freight and buses in Europe
www.transportenvironment.org/publications/roadmap-climate-friendly-land-freight-and-buses-europe
[cvi] www.umweltbundesamt.de/sites/default/files/medien/377/publikationen/2016-11-10_endbericht_energieversorgung_des_verkehrs_2050_final.pdf
[cvii] Transport & Environment (2017) Roadmap to climate-friendly land freight and buses in Europe
www.transportenvironment.org/publications/roadmap-climate-friendly-land-freight-and-buses-europe

[cviii] Heavy Duty Vehicles - support for preparation of impactassessment for CO2 emissions standards https://publications.tno.nl/publication/34620445/oCrCGA/TNO-2016-R10449.pdf
[cix] https://www.oecd.org/tax/consumption/consumption-tax-trends-poland.pdf
[cx] https://wneiz.pl/nauka_wneiz/frfu/68-2014/FRFU-68-57.pdf
[cxi] a Aklilu, A. Z. (2016) Gasoline and diesel demand elasticities: A consistent estimate across the EU-28. *Working Paper 11/2016.* Available:
https://pub.epsilon.slu.se/13860/1/zeleke_a_161205.pdf
[cxii] IEA (2016)
http://www.iea.org/publications/freepublications/publication/Energy_Policies_of_IEA_Countries_Poland_2016_Review.pdf
[cxiii] Platform for electromobility (2017) How EU Member States roll-out electric-mobility: Electric Charging Infrastructure in 2020 and beyond. Availbale:
https://www.transportenvironment.org/sites/te/files/publications/Emobility%20Platform%20AFID%20analysis.pdf
[cxiv] http://www.eafo.eu/europe December 2017
[cxv] http://fppe.pl/wp-content/uploads/2018/03/Nap%C4%99dzamy-Polsk%C4%85-Przysz%C5%82o%C5%9B%C4%87-eng.pdf
[cxvi] http://fppe.pl/wp-content/uploads/2018/03/Nap%C4%99dzamy-Polsk%C4%85-Przysz%C5%82o%C5%9B%C4%87-eng.pdf
[cxvii] https://www.tomtom.com/en_gb/trafficindex/list?citySize=SMALL&continent=EU&country=ALL
[cxviii] https://www.tomtom.com/en_gb/trafficindex/list?citySize=SMALL&continent=EU&country=ALL
[cxix] Transport & Environment (2017) The Economic Impacts of Road Tolls
https://www.transportenvironment.org/sites/te/files/publications/2017_04_road_tolls_report_briefing.pdf
[cxx] Transport & Environment (2017) The Economic Impacts of Road Tolls
https://www.transportenvironment.org/sites/te/files/publications/2017_04_road_tolls_report_briefing.pdf
[cxxi] Transport & Environment (2017) Are Trucks taking their Toll II
https://www.transportenvironment.org/publications/are-trucks-taking-their-toll-ii
[cxxii] http://urbanaccessregulations.eu/countries-mainmenu-147/poland/lodz
[cxxiii] https://cleantechnica.com/files/2018/04/EV-Charging-Infrastructure-Guidelines-for-Cities.pdf
[cxxiv] https://www.polrail.com/en
[cxxv] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32009R1073
[cxxvi] http://www.dw.com/en/flixbus-europes-hottest-bus-operator-turns-5/a-42562177
[cxxvii] Statistical pocketbook 2018. EU Transport in figures.
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[cxxviii] https://www.ozy.com/good-sht/the-bike-friendly-city-in-europe-you-havent-heard-about/80758
[cxxix] https://ecf.com/resources/cycling-facts-and-figures
[cxxx] https://www.tomtom.com/en_gb/trafficindex/list?citySize=LARGE&continent=EU&country=ALL
[cxxxi] Iwińska, K., Blicharska,M., Pierotti, L., Tainio, M., de Nazelle, A. (2018) Cycling in Warsaw, Poland – Perceived enablers and barriers according to cyclists and non-cyclists. *Transportation Research Part A: Policy and Practice*.
https://www.sciencedirect.com/science/article/pii/S0965856417308054
[cxxxii] Statistical pocketbook 2018. EU Transport in figures.
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[cxxxiii] Iwińska, K., Blicharska,M., Pierotti, L., Tainio, M., de Nazelle, A. (2018) Cycling in Warsaw, Poland – Perceived enablers and barriers according to cyclists and non-cyclists. *Transportation Research Part A: Policy and Practice*.
https://www.sciencedirect.com/science/article/pii/S0965856417308054
[cxxxiv] https://www.20minutos.es/noticia/2866621/0/cuanto-cuesta-la-movilidad-en-europa/
[cxxxv] https://www.railwaypro.com/wp/krakow-city-could-build-a-metro-line/
[cxxxvi] http://www.gazetawroclawska.pl/artykul/3926691,wroclaw-ma-realne-szanse-na-metro-potwierdzaja-to-naukowcy,id,t.html
[cxxxvii] https://uml.lodz.pl/aktualnosci/artykul/poczatek-lodzkiego-metra-bedzie-tunel-pomiedzy-dworcami-lodz-fabryczna-i-kaliska-id5836/2017/9/18/
[cxxxviii] ITF (2017) A New Paradigm for Urban Mobility How Fleets of Shared Vehicles Can End the Car Dependency of Cities https://www.itf-oecd.org/sites/default/files/docs/cop-pdf-03.pdf

[cxxxix] Finger, Bert, Kupfer, Montero, Wolek, (2017) Research for TRAN Committee – Infrastructure funding challenges in the sharing economy, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels
http://www.europarl.europa.eu/RegData/etudes/STUD/2017/601970/IPOL_STU(2017)601970_EN.pdf
[cxl] Rao, S. (2016) London's new late night alternative: The Night Tube + Uber
https://medium.com/uber-under-the-hood/londons-new-late-night-alternative-the-night-tube-uber-8f38e56de983
[cxli] 6t-bureau de recherche. 2016. Enquête Nationale sur l'Autopartage – Edition 2016 – Etat des lieux technique et méthodologique. ADEME. 53 pages.
http://www.ademe.fr/sites/default/files/assets/documents/enquete-nationale-autopartage-ena1bis-2017-etats-lieux.pdf
[cxlii] ITF (2017) Transition to Shared Mobility. How large cities can deliver inclusive transport services.
https://www.itf-oecd.org/sites/default/files/docs/transition-shared-mobility.pdf
[cxliii] Pew Research Center (2016) On-demand: Ride-hailing apps
http://www.pewinternet.org/2016/05/19/on-demand-ride-hailing-apps/
[cxliv] UC Davis (2017) Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States
https://www.uitp.org/publication/integrated-mobility-solution
[cxlv] UC Davis, 2017
http://www.trb.org/Main/Blurbs/176762.aspx
[cxlvi] Morello, E. Toffolo, S., Magra, G. (2016) Impact analysis of eco-driving behaviour using suitable simulation platform (ICT-EMISSIONS project). Transportation Research Procedia 14 (2016) 3119–3128
[cxlvii]
http://www.eltis.org/sites/default/files/trainingmaterials/quantifying_the_effects_of_sustainable_urban_mobility_plans.pdf
[cxlviii] http://ftp.jrc.es/EURdoc/JRC40598.pdf
[cxlix] Catarina C. Rolima,*, Patricia C. Baptistaa ; Gonçalo O. Duartea , Tiago L. Farias (2014) Impacts of on-board devices and training on Light Duty Vehicle Driving Behavior. Procedia - Social and Behavioral Sciences 111 (2014) 711 – 720 https://www.sciencedirect.com/science/article/pii/S1877042814001062
[cl] Hill, N. (2016) SULTAN modelling to explore the wider potential impacts of transport GHG reduction policies in 2030. *Report for the European Climate Foundation*. Ref. DG-1509-55582.
https://europeanclimate.org/wp-content/uploads/2016/02/ECF-Transport-GHG-reduction-for-2030_Final_Issue21.pdf
[cli] European Environmental Agency (2011) Do lower speed limits on motorways reduce fuel consumption and pollutant emissions?
https://www.eea.europa.eu/themes/transport/speed-limits
[clii] http://www.securite-routiere.gouv.fr/connaitre-les-regles/reglementation-et-sanctions/baisse-de-la-vitesse-maximale-autorisee-de-90-a-80-km-h
[cliii] https://www.vlaanderen.be/nl/mobiliteit-en-openbare-werken/wegen/70-kmuur-buiten-de-bebouwde-kom-vlaanderen
[cliv] [cliv] L.T. Aarts, J.J.F. Commandeur, R. Welsh, S. Niesen, M. Lerner, P. Thomas, N. Bos, R. J. Davidse (2016) Study on Serious Road Traffic Injuries in the EU. MOVE/C4/SER/2015- 162/SI2.714669
https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/injuries_study_2016.pdf
[clv] http://europa.eu/rapid/press-release_MEMO-18-2762_en.pdf
[clvi] https://www.matec-conferences.org/articles/matecconf/pdf/2017/36/matecconf_gambit2017_01005.pdf
[clvii] Hill, N. (2016) SULTAN modelling to explore the wider potential impacts of transport GHG reduction policies in 2030. *Report for the European Climate Foundation*. Ref. DG-1509-55582.
https://europeanclimate.org/wp-content/uploads/2016/02/ECF-Transport-GHG-reduction-for-2030_Final_Issue21.pdf
[clviii] C-ITS Platform (2016) Final Report.
ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf
[clix] European Environmental Agency (2017) Energy efficiency and specific CO_2 emissions
https://www.eea.europa.eu/data-and-maps/indicators/energy-efficiency-and-specific-co2-emissions/energy-efficiency-and-specific-co2-9
[clx] Statistical pocketbook 2018. EU Transport in figures.
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en

[clxi] Eurostat data, database: rail_go_typeall. Accessed: August 2018.
[clxii] http://lowcarbonfreight.eu/
[clxiii] https://utk.gov.pl/download/3/41709/Reportonrailtransportmarketoperationsin20162.pdf
[clxiv] https://www.freemaptools.com/radius-around-point.htm
[clxv] Statistical pocketbook 2018. EU Transport in figures.
https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2018_en
[clxvi] EUROPEAN COURT OF AUDITORS (2016) Special Report Rail freight transport in the EU: still not on the right track.
https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[clxvii] https://bankwatch.org/wp-content/uploads/2013/02/shadow-PL-transport.pdf
[clxviii] https://www.viatoll.pl/upload/files/2018_03_prezentacja.pdf
[clxix] EUROPEAN COURT OF AUDITORS (2016) Special Report Rail freight transport in the EU: still not on the right track.
https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[clxx] EUROPEAN COURT OF AUDITORS (2016) Special Report Rail freight transport in the EU: still not on the right track.
https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[clxxi] https://utk.gov.pl/download/3/41709/Reportonrailtransportmarketoperationsin20162.pdf
[clxxii] EUROPEAN COURT OF AUDITORS (2016) Special Report Rail freight transport in the EU: still not on the right track.
https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[clxxiii] https://www.eca.europa.eu/Lists/ECADocuments/SR16_08/SR_RAIL_FREIGHT_EN.pdf
[clxxiv] http://www.railjournal.com/index.php/policy/what-future-for-polands-railways.html
[clxxv] Transport & Environment (2016) 80% of EU oil imports now supplied by non-European companies study. Available:
https://www.transportenvironment.org/press/80-eu-oil-imports-now-supplied-non-european-companies-%E2%80%93-study
[clxxvi] https://www.acea.be/uploads/publications/ACEA_Pocket_Guide_2018-2019.pdf
[clxxvii] an den Bold (2018) LOADING CONTAINERS IN A FEW MINUTES AND REDUCING CO_2 EMISSIONS AS A RESULT: THE POTENTIAL OF A NEW TECHNIQUE
http://lowcarbonfreight.eu/blogs/loading-containers-minutes-reducing-co2-emissions-result-potential-new-technique/
[clxxviii] http://www.innovatrain.ch/
[clxxix] Ship & bunker (2018) Norway Mandates World's First Zero-Emission ECA for No Later Than 2026.
https://shipandbunker.com/news/emea/186487-norway-mandates-worlds-first-zero-emission-eca-for-no-later-than-2026
[clxxx] Transport & Environment (2018) Natural gas is a $22bn distraction for EU shipping that won't decarbonise the sector – study
https://www.transportenvironment.org/press/natural-gas-22bn-distraction-eu-shipping-won%E2%80%99t-decarbonise-sector-%E2%80%93-study