EMISSION REDUCTION POTENTIAL AND DIRECTIONS FOR LONG TERM LOW EMISSION DEVELOPMENT FRAMEWORK OF ARMENIA TRANSPORT SECTOR.

REPORT

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The objective of the report is to outline the assessment of emission reduction potential of Armenia's transport sector; and to recommend the directions for long term low emission development framework for the sector.

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1. Introduction

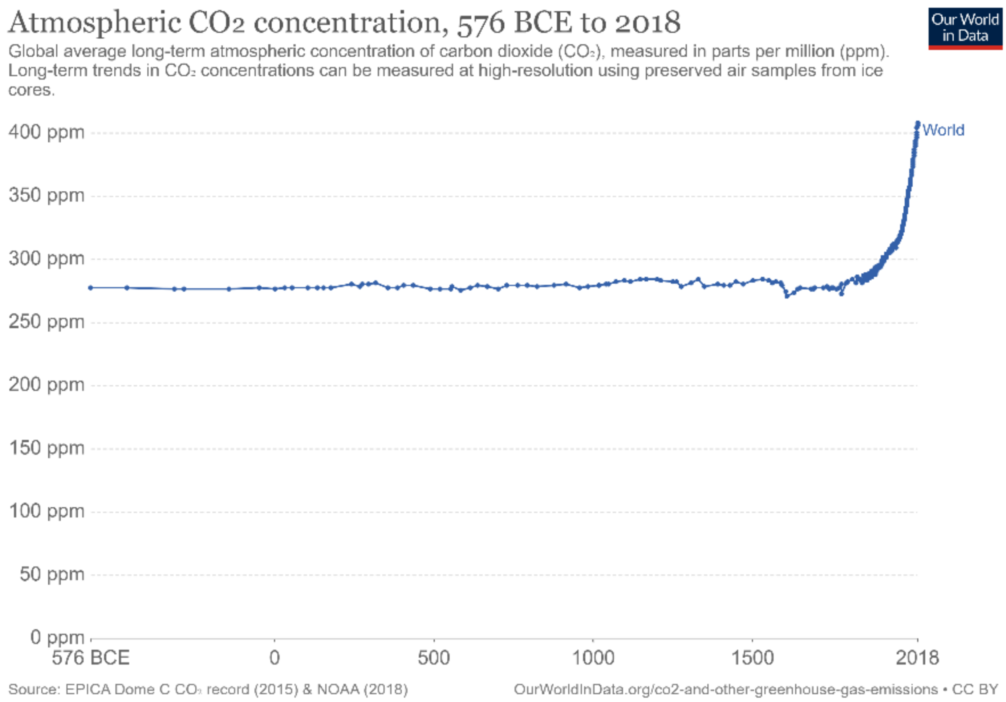
The countries of the world have joined forces under the auspices of the UN Framework Convention on Climate Change (UNFCCC), which was agreed in 1992 and entered into force in 1994, and the Kyoto Protocol to that Convention, which was agreed in 1997 and took effect in 2005. These nations (196 parties to the UNFCCC and 192 parties to the Kyoto Protocol) work within the boundaries of the Framework Convention in order to coordinate measures for mitigation and adaptation to climate change. With mutual concern of all the countries it was decided to restrain the rise in the average temperature of global atmosphere to the maximum of 2 degrees above the pre-industrial levels (year 1850), while at the same time trying to not exceed 1.5 degrees. On February 9, 2017, Doha Amendment to Kyoto Protocol was also ratified. This document allows to continue implementation of projects in the frames of Clean Development Mechanisms, as well as use financing of Adaptation Fund established within the frames of Kyoto protocol.

The Paris Agreement, that came into effect on November 4, 2016, and 189 countries ratified it as of February, 2020, has legal force and imposes climate change restrain measures on all the states worldwide. All parties are invited (Article 4/19) to develop mid-century long-term low greenhouse gas emission development strategies (LEDS). The Article 54 of the Comprehensive and Enhanced Partnership Agreement between the European Union and the European Atomic Energy Community and the Republic of Armenia (CEPA) has envisaged to cooperate, inter alia, in development of a low-carbon development plan, development and implementation of long-term measures to mitigate climate change by addressing emissions of greenhouse gases, taking measures to mainstream climate considerations into sector-specific policies. On February 9, 2017, National Assembly of the Republic of Armenia ratified the Paris Agreement of the UN Framework Convention on Climate Change, which entered into force on April 22, 2017. The Republic of Armenia stated its position on the limitation of greenhouse gas emissions in subsequent national communications to the UNFCCC and in the Republic of Armenia’s Statement on Association with Copenhagen Accords and Intended Nationally Determined Contributions (INDC).

Within the framework of the EU4Climate Programme (Programme) governments in the six EU Eastern Partner countries - Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine must take action against climate change. It supports countries in implementing the Paris Climate Agreement and improving climate policies and legislation. Its ambition is to limit climate change impact on citizens’ lives and make them more resilient to it. As a result of the Programme, UNDP will support the Government of Armenia to develop and approve a low emission development strategy by 2021. The transport sector is considering one of the key and dynamically growing sectors in terms of greenhouse gas (GHG) emissions. Thus, the Programme addresses the sector as part of strategy on long-term low emission development.

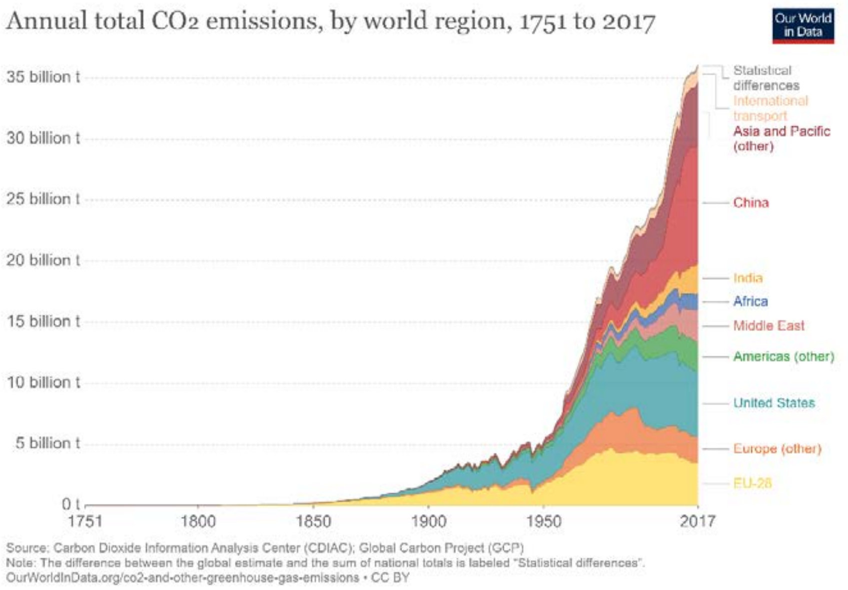
2. Climate Change and GHG emission

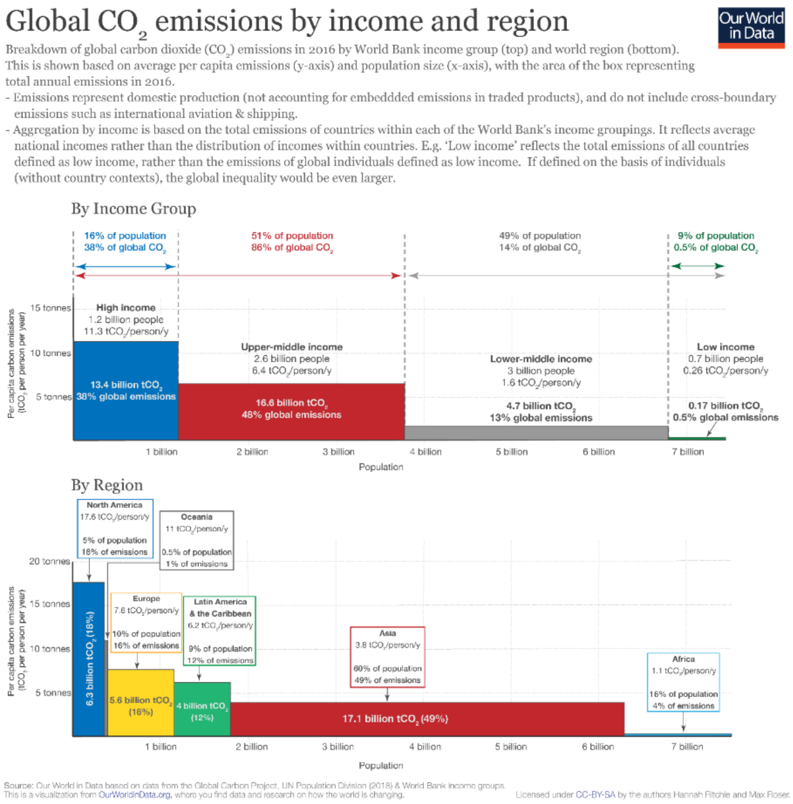
Climate change is currently considered as one of the greatest challenges to mankind in the 21st century. A changing climate has a range of potential ecological, physical and health impacts, including extreme weather events (such as floods, droughts, storms, and heatwaves); sea-level rise; altered crop growth; and disrupted water systems. Over the last few decades, global temperatures have risen sharply - to approximately 0.7℃ higher than our 1961-1990 baseline. The weather study[1], analyzing the temporal and spatial variability of thermal conditions in the Republic of Armenia, highlighted the maximum temperature increase of up to 1,5°C. Negative results have not been observed in Armenia. This rise in global average temperature is attributed to an increase in greenhouse gas (GHG) emissions. Over the long period of 3,000 years, atmospheric concentrations of CO2 did not exceed 300 parts per million (ppm). This changed with the Industrial Revolution and the rise of human emissions of CO2 from burning fossil fuels. We see a rapid rise in global CO2 concentrations over the past few centuries, and in recent decades in particular. Almost all warming can be attributed to human emissions. Climate change is a global issue, and measures designed to reduce it cannot be successful unless the nations of the world act together in a coordinated and harmonious manner. GHG emission volumes differ from different chapters of the Globe.



[1] Long Term Variability of Temperature in Armenia in the Context of Climate Change. Hrachuhi Galstyan, Lucian Sfica, Pavel Ichim. World Academy of Science, Engineering and Technology, International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering Vol:10, No:1, 2016

When aggregated in terms of income, we see in the visualization that the richest half (high and upper-middle income countries) emit 86 percent of global CO2 emissions. The bottom half (low and lower-middle income) only 14%. The very poorest countries (home to 9 percent of the global population) are responsible for just 0.5 percent. This provides a strong indication of the relative sensitivity of global emissions to income versus population. Even several billion additional people in low-income countries — where fertility rates and population growth is already highest — would leave global emissions almost unchanged. 3 or 4 billion low income individuals would only account for a few percent of global CO2. At the other end of the distribution however, adding only one billion high income individuals would increase global emissions by almost one-third[2]. The summary by income is on the basis of country income groupings, rather than that of individuals. These figures therefore don't take account of inequalities in emissions within countries. It's estimated that within-country inequalities in emissions can be as large as those between countries. If to calculate this distribution by the income of individuals, rather than countries, the global inequalities in emissions would be even greater. The richest of the global population would be responsible for an even larger share of global emissions. The richest countries of the world are home to half of the world population, and emit 86 percent of CO2 emissions.



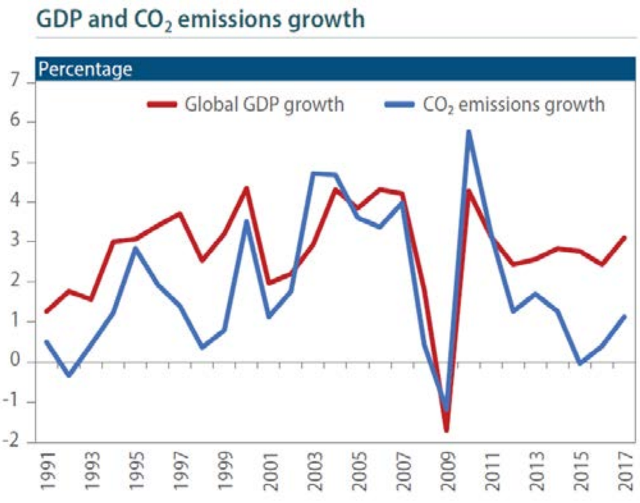


The relationship between per capita GDP and per capita GHG emissions is statistically supported at the highest level of significance. The outcome of an increase in per capita GDP should, according to

[2] Global emissions in 2016 (minus cross-boundary emissions), as the sum of those in the chart, was approximately 34 to 35 billion tons of CO2. Adding one billion individuals with a per capita footprint of 11.3 tCO2 per person per year would equal an addition 11 billion tons of CO2 per year (1 billion*11.3 = 11.3 billion tons). This is equivalent to almost one-third of global emissions in 2016.

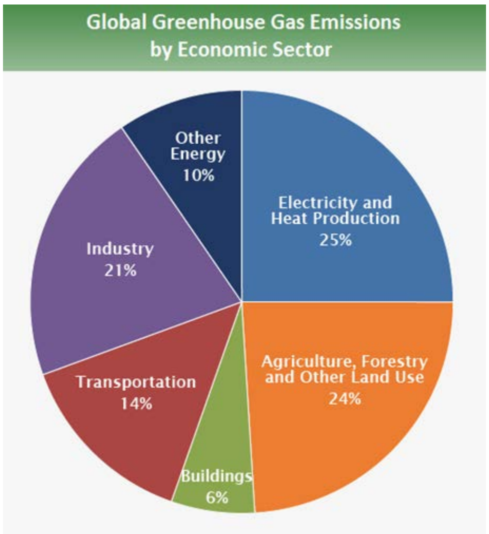
the results of investigations and studies, be an increase in the level of GHG emissions. This suggests an increase in per capita GDP could have different impacts on the GHG emissions in different countries. The differences in the responses to economic growth between economies could be seen form the structural governance and the access to natural resources such as oil and differs greatly globally.

However, the estimation of GDP long-run equation indicated that the CO2 emissions are negative related to the economic growth[3]. The economic growth and the CO2 emissions are co-integrated for the whole panel of countries. The long-run relationship between GDP and CO2 emissions is negative, because the development of new low-carbon technologies enables in the long-run to reach the same production level at lower CO2 emissions, caused by energy-saving and low-carbon technological development of the state of the art economies. However, the short-run relationship between GDP and CO2 emissions is positive, because the fast increase in production can be reached due to more intensive energy use by the existing technologies, then the capacity increases as well the CO2 emissions. The evaluated regression model of GDP includes not only endogenous CO2 emission variable but growth rates of Energy Consumption, growth rates of Gross Fixed Capital in real prices and the significant correction mechanism as well. The finding of different studies suggests that energy consumption is an integral part of economic growth, so the economic growth of analyzed countries is energy-dependent. The energy consumption produces wastes, namely pollutions with CO2 emissions[4].



Source: UN/DESA calculations, based on data from UNSD and PBL Netherlands Environmental Assessment Agency (left) (2013–2016 emissions are estimates)

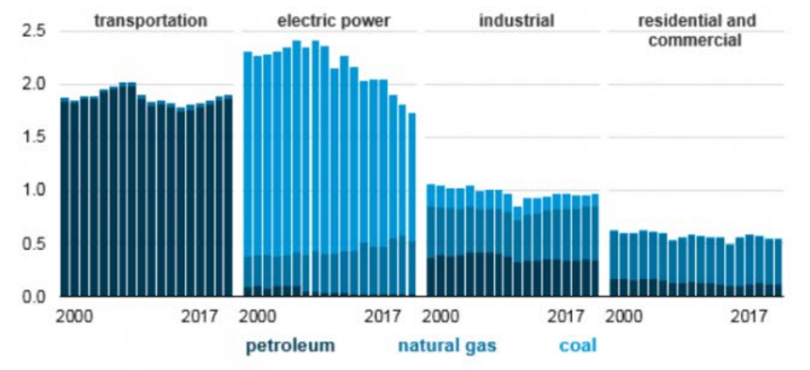
Different sectors of economy have different impact on global GHG emission. Energy consumption is by far the biggest source of human-caused greenhouse gas emissions, responsible for a whopping 73% worldwide. The energy sector includes transportation, electricity and heat, buildings, manufacturing and construction, fugitive emissions and other fuel combustion. Within the energy sector, generation of heat and electricity is responsible for most emissions (15 GtCO2e in 2016, or 30% of total greenhouse gas emissions), followed by transportation (7.9 GtCO2e in 2016, or 15% of total emissions) and manufacturing and construction (6.1 GtCO2e,



[3] An Empirical Study of the Relationships between CO2 Emissions, Economic Growth and Openness, Discussion Paper No. 5304, Institute for the Study of Labor (IZA), November 2010.
[4] Rafał Kasperowicz "Economic growth and CO2 emissions: the ECM analysis", Journal of International Studies, Vol. 8, No 3, 2015, pp. 91-98. DOI: 10.14254/2071-8330.2015/8-3/7

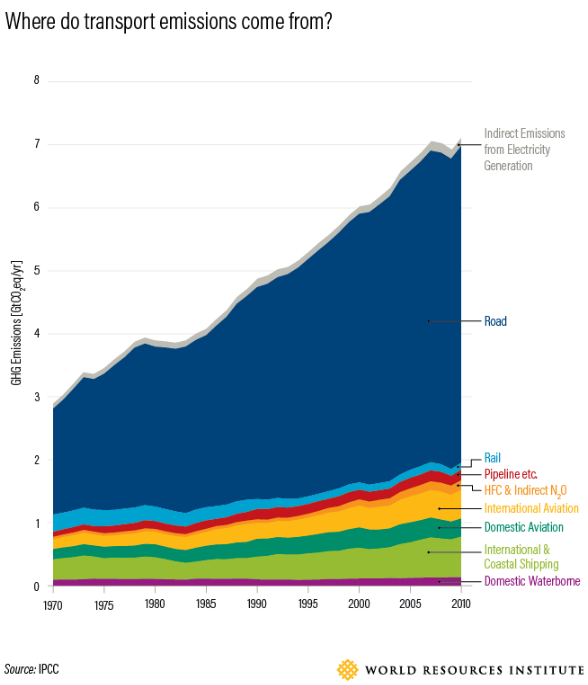
or 12% of total emissions). CO2 emissions associated with energy and industrial production can come from a range of fuel types.

Considering largest contribution for GHG emission from Energy and Transportation sectors it is really important to highlight dependence of volumes of emissions from type of fuel. It is important to note that given figures vary from country to country and from region to region.



3. Transport Sector

Transport, in fact, eats up a significant portion of global carbon budget. Transport emissions — which primarily involve road, rail, air and marine transportation — accounted for over 24% of global CO2 emissions in 2016. They are also expected to grow at a faster rate than that from any other sector, posing a major challenge to efforts to reduce emissions in line with the Paris Agreement and other global goals. Decarbonization of the transport sector would create a cleaner, healthier and more affordable future for everyone. And it can be done without sacrificing the interconnectedness we've come to expect from modernity.



Emissions from the transport sector are a major contributor to climate change — about 20% of annual emissions (including non-CO2 gases) and around a quarter of CO2 emissions from burning fossil fuels. Even more concerning: At a time when global emissions need to be going down, transport emissions are on the rise, with improvements in vehicle efficiency more than offset by greater overall volume of travel. During the last decades In terms of transport modes, 72% of global transport emissions come from road vehicles, which accounted for 80% of the rise in emissions. Emissions have also increased in other transport modes, such as international aviation, domestic aviation and international and coastal shipping. The main exception is railways; powered by a significant share of electricity, rail emissions have actually declined. Oil demand in the transport sector has increased by about 25% [5]; transport remains extremely dependent on oil, and the sector accounted for about two-thirds of global oil consumption in 2015, with road transport alone accounting for half of oil consumption. Electricity share in transport energy consumption has

[5] CO2 Emissions from Fuel Combustion 2018 Highlights; IEA, 2018

increased marginally from 0.7% in 2000 to 1% in 2015 [6]. Interestingly, railways are powered by a significant share of electricity (39%) compared to 56% by oil products. The rest of the energy consumption increase comes from a rise in gasoline, diesel, electricity and other fuel consumption. Energy use in the transport sector will likely continue to increase in both developed and developing countries. Most energy scenarios — including those that take into account existing national commitments under the Paris Agreement — show transport-related energy consumption continuing to increase, and oil continuing to comprise the largest share, through 2050. Transport's reliance on fossil fuels needs to shift dramatically in order to be consistent with a trajectory of limiting global temperature increase below 2 degrees Celsius.

4. Armenia Transport Sector

For better understanding of current situation and perspectives of Armenian Transport Sector overview of correlated aspects between infrastructure and fleet should be considered. The infrastructure legacy at independence was substantial, in both network coverage and capacity. The former Union of Soviet Socialist Republics (former USSR) had a substantial heavy industrial sector with intensive transport of intermediate goods. Such transport has disappeared and the contribution of the transport sector to the economy has fallen dramatically. High volume products became few and border closures hindered trade, resulting in import substitution, as well as infrastructure was deteriorated. In general, network capacity is expected to be sufficient to accommodate traffic growth within 3 decades of 21st century. Location, topography, and geopolitics present a particular transport challenge in the Republic of Armenia (Armenia) situated in the strategically important southern Caucasus [7]. With an average elevation of 1,800 meters (m) and a severe climate, very low winter temperatures, heavy snowfall, and high intensity rainfall are experienced throughout the country, including in key transport routes. The combination of these factors results in high transport costs and expensive infrastructure maintenance and development. Of four bordering countries, only two borders are open: with Georgia to the north and Iran to the south. Closed borders result in: a substantial increase in transport costs; restricted international and transit trading opportunities; limited development of the domestic trucking industry; poor prospects for the logistics sector; and a reduced role for the railway. Both transport infrastructure asset management and operating performance can be strengthened through: vehicle fleet modernization (scrapping of obsolescent vehicles, improving performance, reducing fuel consumption and accidents); improved logistics and distribution, including the provision of "just in time" services; improved road maintenance techniques; developing stronger institutions and policy coordination; improved planning and resourcing; greater stakeholder involvement; and improved regulation of concessions and franchises to ensure that they better serve the national interest.

[6] Energy, transport and environment statistics 2019 edition. Eurostat.
[7] Armenia's Transport Outlook Transport Sector Master Plan TRANSPORT AND COMMUNICATIONS Armenia 2011, ADB.

4.1. Infrastructure

Roads - Armenia's road network is 7,792 km long and comprises 1,735 km of interstate roads, 4,040 km of republican roads, and 2,017 km of local roads. 5 Although there is ambiguity as to the road conditions due to the inadequate road asset management system, about three-quarters of the interstate roads are estimated to be in good to fair condition, and about 60% of local roads need rehabilitation. Starting from early 2000 the government consistently prioritizes transport infrastructure improvements. During the last years route reconstruction resulting significant improvements[8] as: interstate, republican, and local roads built or upgraded by 2018 [500km] (2012 baseline: 0); total length of roads in satisfactory condition (as % of the total length of the road network) increased to 47% by 2018 (2012 baseline: 41%); Percentage of communities with at least one adequate road connecting them to the regional center rises to 50% by 2018 (2013 baseline: 20%); Road maintenance budget increased by 5% annually (2013 baseline: AMD6,310 million). Transport Sector Development Strategy, which has been elaborated by the assistance of the Asian Development Bank defines investment priorities in transport sector. The Strategy pursues improved management, infrastructure, and technology to maximize the transport sector's performance until 2020, and envisages a long-term prosperity through the establishment of efficient, cost effective, and environmentally and socially sustainable transport infrastructure and services. The Strategy entails an Action Plan which comprises a time-bound program of policy reforms and investment and technical assistance projects identified for 2009-2020, totaling about $2.2 billion. The government has requested support to develop a Transport and Trade Facilitation Strategy, 2020–2040 (TTFS) that will contain action plans defining resource allocation and will assign responsibilities for short-term, medium-term, and long-term development. The TTFS and action plans will (i) improve transport infrastructure, (ii) facilitate trade, (iii) improve road safety, and (iv) provide supporting legal and regulatory frameworks. TTFS will be aligned with country partnership strategy for Armenia, 2014–2018 and will serve as a first step toward aligning Armenia's transport sector with the operational priorities of international integration policies and obligations. The TTFS will complement other regional cooperation programs such as the Central Asia Regional Economic Cooperation Program, the Belt and Road Initiative, and the European Commission Trans-European Transport Network. However, the total budget allocated to road network in 2018 correspond to 0,95% of GDP.

Railways - Armenia's railway network plays a crucial role in providing mobility for people and freight. The network includes the metro system that serves commuters in the capital. The Yerevan metro has limited coverage and has lost some of its market share to minibuses. Network expansion describes great potential for improvement of capital transportation system. Armenian Railways was part of the Trans-Caucasus Railway, built during the Soviet era. The system was designed to handle large traffic volumes, and in some cases it served remote areas. Moreover, without the need to consider competition from road transport, the former Soviet Union rarely updated railway technology after the 1960s. Track speed is often limited to 30 km per hour, with rehabilitated sections allowing 90 km per hour. Due to the terrain, there are numerous bridges and tunnels, and some of the large bridges need major repairs. Several lines are little used because of border closures or loss of traffic. About 370km of the 732 km network are fully operational: Yerevan–Georgian border line, the Yerevan–Yeraskh passenger line, and sections of the Yerevan–Azerbaijan/Vardenis lines. Currently

[8] SECTOR ASSESSMENT (SUMMARY): TRANSPORT, Country Partnership Strategy: Armenia, 2014–2018

a subsidiary of Russian Railways, the South Caucasus Railway, is operating the Armenian rail system, invested more than $250 million in upgrading the infrastructure and modernizing the system. In 2012, a contract was awarded to Dubai-based Rasia FZE (a Rasia Group investment company) for the feasibility, design, financing, construction, and operation of a new railway link between Armenia and Iran, called the Southern Armenia Railway project. The feasibility study results indicated that the route will be 305 km. long and would cost approximately $3.5 billion to build. As the key missing link in the International North-South Transport Corridor, the Southern Armenia Railway would create the shortest transportation route from the ports of the Black Sea to the ports of the Persian Gulf.

Aviation – Zvartnots, Shirak and Erebuni airports are all in service. Zvartnots and Shirak are managed and maintained by Armenian International Airports (AIA). AIA have upgraded the main international airport, Zvartnots, and currently the airport has an annual capacity of three million passengers in line with the current forecast in the Zvartnots Master Plan. Traffic growth over the past few years has been much higher than forecast. Although the international recession will slow growth in the short term, the passenger terminal will eventually either operate at a lower level of service or require additional capacity. The airport is currently limited to 15 movements per hour on Runway 09 and five on Runway 27, low for a single runway operation. Shirak, which serves Gyumri and the north, is being upgraded by AIA under the 2007 Concession Agreement. The terminal building is small and in need of repair. Should traffic growth continue, the passenger terminal will need replacing or upgrading. As of 2020, there are 3 airports currently under construction in Armenia, these include: Kapan, Goris and Stepanavan. According to the "open skies" policy, the civil aviation in the country is now open to all airlines that meet international standards.

The following constraints can be seen in infrastructure development:

- Limited financial resources. Currently the share of road infrastructure investments in GDP in Armenia is less than 1% (average in compare to CEEC and WEC countries (between 0.7% and 1.3%) and historically 0.4% average for period of 2005-2015, being 3-5 times less than estimated [9]. Even with plans to increase investment in 2020 share of road infrastructure investment in Armenia will be much lower in compare to Croatia or Romania (1.8%)[10] with comparable quality and length of the roads;
- Limited level of integration of transport infrastructure in international transit routes, because of lacking quality, insufficient furnishing, safety and low speed. Closure of international borders from East (Azerbaijan) and West (Turkey), resulting from Nagorno-Karabakh conflict. This problem shifts considerable transit flows to the alternative routes bypassing Armenia. This reduces the transit traffic intensiveness to the minimum and impacts negatively on the development of transport infrastructure in Armenia;
- Mountainous areas, which provide only limited alternatives and in certain cases even no-alternatives. Armenia is a mountainous country and in some areas large scale transport structures, such as state-of-the-art tunnels, suspension bridges and freeways could significantly improve the situation, but the absence of necessary financial resources, as well

[9] IMPROVING THE SUSTAINABILITY OF ROAD MANAGEMENT AND FINANCING IN ARMENIA, Report No. 66533-AM, WB, 2011
[10] Overview of transport infrastructure expenditures and costs – January 2019; European Commission. Pub: 18.4K83.1344

as absence of funds for their maintenance in case of being constructed, usually forces to abstain from such large-scaled infrastructure development projects;

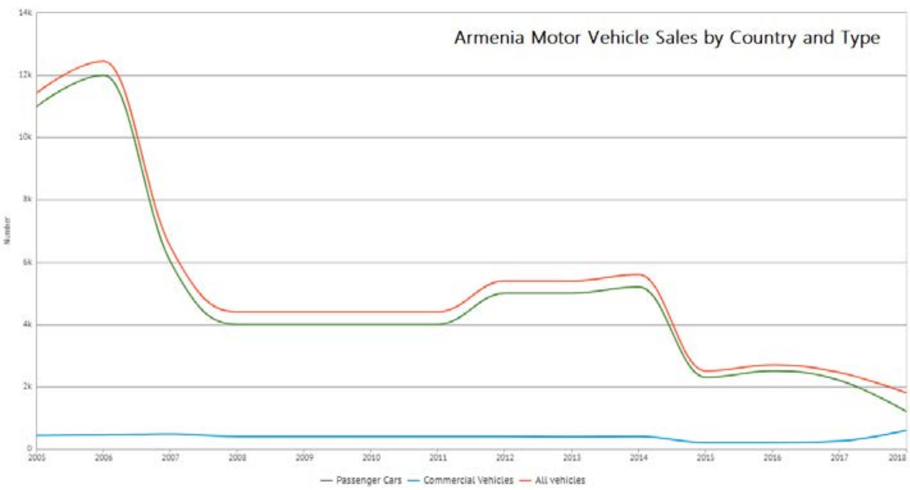
4.2. Fleet

Starting form 2007 number of road and off-road vehicles grows dramatically [11]. Due to actual lack of public transportation, both urban and rural in mobility road transport is dominating.

YEAR	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Registered	282,440	333,038	383,635	434,233	405,575	403,039	420,757	479,249	472,863	483,493	514,176	524,933	622,174	643,602
CMTPL, active	0	0	0	0	392,722	390,266	407,423	464,061	457,878	468,171	497,881	508,297	602,457	558,158
CMTPL, declined	0	0	0	0	12,853	12,773	13,334	15,188	14,985	15,322	16,295	16,636	19,717	21,064
Imported (Total)									15,120	16,851	32,500	64,000	189,019	3,840
Importted, new	9,039	4,201	4,486	4,100	4,740	4,200	4,370	4,545	2,000	2,220	2,450	1,800	1,210	
Imported, used/Georgia				8,000	15,000	18,000	22,000	24,000	12,000	9,000	14,000	29,000	42,800	
Exported, all											6,500		74,000	
GDP, billion US	9.87	10.55	9.06	9.26	9.70	10.40	10.74	11.12	11.47	11.50	12.36	13.01	13.30	
GDP, USD per capita	3,367	3,630	3,137	3,218	3,371	3,604	3,705	3,819	3,919	3,917	4,199	4,407	4,497	
Population	2,932,618	2,907,618	2,888,092	2,877,319	2,876,532	2,887,234	2,897,588	2,912,409	2,925,553	2,936,143	2,944,791	2,951,745	2,957,731	2,963,243
Vehicls per 1000	96	115	133	151	141	135	141	159	157	159	169	172	204	217

Starting form 2010 Armenian government introduces CMTPL - the compulsory insurance of motor third-party liability that compensates for personal or property damages caused to third parties in the result of usage of a vehicle.

LDV – about 90% of all road vehicles in Armenia are cars, SUVs, vans, and light four-wheeled trucks. Due to the low population income combined with limited or no vehicle emissions inspection, the older vehicles with higher volume of CO2 emission and limited emission controls are favored by consumers. Also it is important to note that low humidity climate ensures better preservation of vehicles and extending their typical operation period. Recent trends in 2015 and 2019 indicate that vehicles newer than 2 years old have increased their market share to 2% only of the new registrations, compared to less than 1% in 2008. Nevertheless, 2019 also witnessed a higher share of 16 years and older light duty vehicles to 10%, and reached the level of 62% from the total number of registered vehicles. Therefore, it appears the market is becoming divided as very new and very old light duty vehicles. Back in 2015, Armenia became a full member of the EAEU. Armenia, as a newcomer to the integration association, was granted a 5-year transition period. During this time, Armenia could import a large quantity of goods in accordance with the requirements of national legislation. In particular, during the entire grace period, customs duties on importing cars from third countries at the old tariffs were kept at 10%, while in the EEU countries the rates vary from 30 to 50%. Already in 2020, the so-called grace period ended and the import of cars to Armenia is regulated



[11] Annual Statistic Reports. Armenian Motor Insurers Bureau. www.appa.am

according to the new "Common European" rules. As a result, the number of cars imported to Armenia in 2018 compared to 2017 increased by 71.2%, and compared to 2016 by 298%. So, in 2016, 16887 cars were imported to the republic, in 2017 - 39282, and in 2018 imports reached - 67255. Cars are mainly imported from the USA, Japan, South Korea, Germany and Georgia. This tendency expected to drop sharply from year 2020, when because of EAEU regulations are applicable now without any exemptions. As a result, volume of import and sales of new vehicles in Armenia in 2018-2019 experienced significant decline. The care occupancy rate is approximately 1.5 passengers per car.

HDV – about 1% of all road vehicles in Armenia are busses and 9% are heavy trucks. More than 73% of all HDV are about of 16 years old and older, means fleet renewal rate is dramatically slow. During last couple of years portion of new HDV has a growing tendency mainly because of growing tourist sector as well as number of large road construction projects.

2w and 4w Motorcycles – there are less than 600 unites registered now (less than 0.01% of total number of vehicles) in Armenia, but number of motor vehicles is growing slowly. Actual figures may differ because of big number of motorcycles, mostly from soviet period are not registered. However, this type of vehicles will become more popular in coming decade especially because of growing tourism in Armenia.

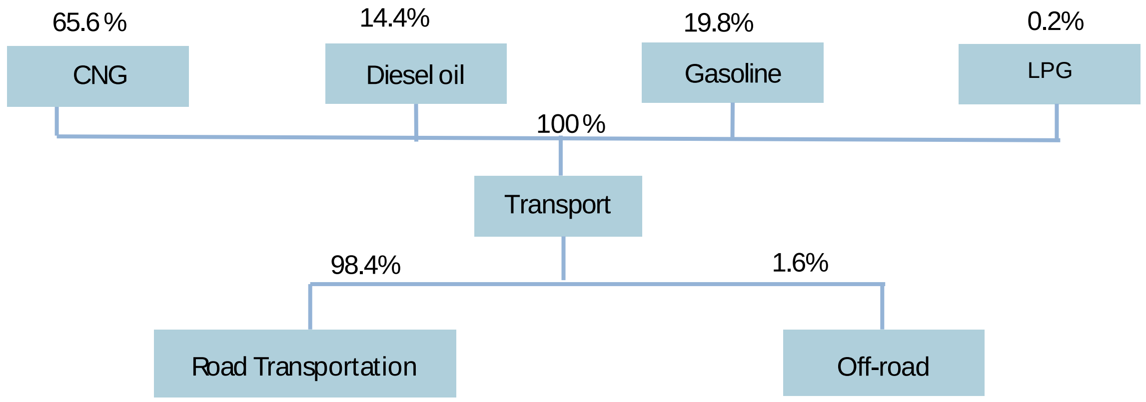
Trains - Armenia's network has 23.5-ton axle loads; is wholly electrified; and has a rolling stock of a basic design, with heavy (tare) weight. The infrastructure and fleet of cars are dated, with most of the electric locomotives around 35 years old and in need of repair or replacement. Even though the development of the rail system faces certain constraints, some progress has already been made. South Caucasus Railways is introducing a new electric train for providing regular rail service between Gyumri and Yerevan. It is a new second-generation EP2D electric train manufactured by Russia. The new trains will run four times a day and the duration of the trip is 2 hours and 10 minutes.

Aircrafts - Although Armenia once had a national airline, Armenian Airlines, it had gone bankrupt by 2003. There are, however, new developments and growth in this transport sector. There is a new Armenia branded airlines, Armenia Aircompany, founded in 2015 as a commercially owned airline. It consists of a two airline fleet and services Georgia, Russia and Israel. In addition, a commercial light aviation company, Atlantis Armenian Airlines, started scheduled flights in the summer 2019. Both are operating flights from Zvartnots to destinations in Europe and the CIS as well as charter flights to the Greek islands. It also plans to operate domestic flights from Zvartnots to the Kapan Airport in Syunik, Armenia and other regional destinations. Moreover, Armenian Helicopters, a Yerevan-based start-up, is set to become Armenia's first commercial helicopter operator.

4.3. Fuel consumption structure

Fuel consumption structure in Armenia for Road Transportation and in Off-road by fuel types is presented below[12] (the percentages were calculated from the total energy equivalent of the all fuel consumed).

[12] National Greenhouse Gas Inventory Report of the Republic of Armenia for 2014



In Armenia fuel consumption structure in the road transport is quite specific, considering the absolute predominance of natural gas which accounted for above 65% of the total fuel consumption in the road transport in 2014. Currently there is a significant increase of the gas-filling stations number exceed 550 operating units in 2020. As per expert analysis performed based on statistic figures on 2020 consumption of natural gas for road transport in Armenia is much higher and estimated on 81% level.

Armenia has experienced a gradual decline in population, which is attributed to factors such as out-migration, notably by the young population; a low birth rate; and an aging population. The increasing population of senior citizens will require public transport systems that cater to them. The concentration of the Armenian population in urban centers, mainly in the capital, Yerevan, will necessitate the construction of an efficient and sustainable urban transport system, not only to meet the increasing demand for mobility and accessibility, but also to support inter-urban economic activities. The social behavior and travel patterns of Armenia's urban population will influence the type of urban transport systems needed.

5. Global Tendencies for GHG emission reduction in transport sector

Reducing global transport greenhouse gas (GHG) emissions will be challenging since the continuing growth in passenger and freight activity could outweigh all mitigation measures unless transport emissions can be strongly decoupled from GDP growth.

The transport sector produced 7.0 GtCO2eq of direct GHG emissions (including non-CO2 gases) in 2017[13] and hence was responsible for approximately 20% of total energy-related CO2 emissions (6.7 GtCO2). Growth in GHG emissions has continued since the Fourth Assessment Report (AR4) [14] in spite of more efficient vehicles (road, rail, water craft, and aircraft) and policies being adopted. Without aggressive and sustained mitigation policies being implemented, transport emissions could increase at a faster rate than emissions from the other energy end-use sectors and reach around 12 Gt CO2eq/y by 2050. Transport demand per capita in developing and emerging economies is far lower than in Organisation for Economic Co-operation and Development (OECD) countries but is expected

[13] TRENDS IN GLOBAL CO2 AND TOTAL GREENHOUSE GAS EMISSIONS; Netherlands Environmental Assessment Agency. 2018 Report

[14] IPCC, 2014: The Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC);

to increase at a much faster rate in the next decades due to rising incomes and development of infrastructure. Analyses of both sectoral and integrated model scenarios suggest a higher emission reduction potential in the transport sector than the levels found possible in AR4 and at lower costs. Since many integrated models do not contain a detailed representation of infrastructural and behavioral changes, their results for transport can possibly be interpreted as conservative. If pricing and other stringent policy options are implemented in all regions, substantial decoupling of transport GHG emissions from gross domestic product (GDP) growth seems possible[15]. A strong slowing of light-duty vehicle (LDV) travel growth per capita has already been observed in several OECD cities suggesting possible saturation.

Avoided journeys and modal shifts due to behavioral change, uptake of improved vehicle and engine performance technologies, low-carbon fuels, investments in related infrastructure, and changes in the built environment, together offer high mitigation potential.

Direct (tank-to-wheel) GHG emissions from passenger and freight transport can be reduced by:

- ✓ avoiding journeys where possible - by, for example, densifying urban landscapes, sourcing localized products, internet shopping, restructuring freight logistics systems, and utilizing advanced information and communication technologies (ICT);
- ✓ modal shift to lower-carbon transport systems - encouraged by increasing investment in public transport, walking and cycling infrastructure, and modifying roads, airports, ports, and railways to become more attractive for users and minimize travel time and distance;
- ✓ lowering energy intensity (MJ/passenger km or MJ/ton km) - by enhancing vehicle and engine performance, using lightweight materials, increasing freight load factors and passenger occupancy rates, deploying new technologies such as electric 3-wheelers;
- ✓ reducing carbon intensity of fuels (CO2eq/MJ) - by substituting oil-based products with natural gas, bio-methane, or biofuels, electricity or hydrogen produced from low GHG sources.

In addition, indirect GHG emissions arise during the construction of infrastructure, manufacture of vehicles, and provision of fuels (well-to-tank).

5.1. Both short- and long-term transport mitigation strategies are essential if deep GHG reduction ambitions are to be achieved.

Short-term mitigation measures could overcome barriers to low-carbon transport options and help avoid future lock-in effects resulting, for example, from the slow turnover of vehicle stock and infrastructure and expanding urban sprawl. Changing behavior of consumers and businesses will likely play an important role but is challenging and the possible outcomes, including modal shift, are difficult to quantify. Business initiatives to decarbonize freight transport have begun, but need support from policies that encourage shifting to low-carbon modes such as rail or waterborne options where feasible, and improving logistics. The impact of projected growth in world trade on freight transport emissions may be partly offset in the near term by more efficient vehicles, operational changes, ‘slow

[15] Effect of economic growth on CO2 emission in developing countries: Evidence from a dynamic panel threshold model. Goodness C. Aye ORCID Icon &Prosper Ebruvwiyo Edoja| Lanouar Charfeddine (Reviewing Editor). Article: 1379239, Published online:24 Sep 2017

steaming' of ships, eco-driving and fuel switching. Other short-term mitigation strategies include reducing aviation contrails and emissions of particulate matter (including black carbon), tropospheric ozone and aerosol precursors (including NOx) that can have human health and mitigation co-benefits in the short term.

Methane-based fuels are already increasing their share for road vehicles and waterborne craft. Electricity produced from low-carbon sources has near-term potential for electric rail and short- to medium-term potential as electric buses, light-duty and 2-wheel road vehicles are deployed. Hydrogen fuels from low-carbon sources constitute longer-term options. Gaseous and liquid-biofuels can provide co-benefits. Their mitigation potential depends on technology advances (particularly advanced 'drop-in' fuels for aircraft and other vehicles) and sustainable feedstock.

The technical potential exists to substantially reduce the current CO2eq emissions per passenger or ton kilometer for all modes by 2030 and beyond. Energy efficiency and vehicle performance improvements range from 30–50 % relative to 2010 depending on mode and vehicle type. Realizing this efficiency potential will depend on large investments by vehicle manufacturers, which may require strong incentives and regulatory policies in order to achieve GHG emissions reduction goals.

Over the medium-term (up to 2030) to long-term (to 2050 and beyond), urban (re)development and investments in new infrastructure, linked with integrated urban planning, transit-oriented development and more compact urban form that supports cycling and walking can all lead to modal shifts. Such mitigation measures could evolve to possibly reduce GHG intensity by 20–50 % below 2010 baseline by 2050. Although high potential improvements for aircraft efficiency are projected, improvement rates are expected to be slow due to long aircraft life, and fuel switching options being limited, apart from biofuels. Widespread construction of high-speed rail systems could partially reduce short-to-medium-haul air travel demand. For the transport sector, a reduction in total CO2eq emissions of 15–40 % could be plausible compared to baseline activity growth in 2050.

5.2. Barriers to decarbonizing transport for all modes differ across regions, but can be overcome in part by reducing the marginal mitigation.

Financial, institutional, cultural, and legal barriers constrain low-car- bon technology uptake and behavioral change. All of these barriers include the high investment costs needed to build low-emissions transport systems, the slow turnover of stock and infrastructure, and the limited impact of a carbon price on petroleum fuels already heavily taxed. Other barriers can be overcome by communities, cities, and national governments which can implement a mix of behavioral measures, technological advances, and infrastructural changes. Infrastructure investments (USD/tCO2 avoided) may appear expensive at the margin, but sustainable urban planning and related policies can gain support when co-benefits, such as improved health and accessibility, can be shown to offset some or all of the mitigation costs.

Oil price trends, price instruments on emissions, and other measures such as road pricing and airport charges can provide strong economic incentives for consumers to adopt mitigation measures. Regional differences, however, will likely occur due to cost and policy constraints. Some near term mitigation measures are available at low marginal costs but several longer-term options may prove more expensive. Full societal mitigation costs (USD/tCO2eq) of deep reductions by 2030 remain uncertain but range from very low or negative (such as efficiency improvements for LDVs, long-haul heavy-duty vehicles (HDVs) and ships) to more than 100 USD/tCO2eq for some electric vehicles, aircraft, and possibly high-speed rail. Such costs may be significantly reduced in the future but the magnitude of mitigation cost reductions is uncertain.

5.3. There are regional differences in transport mitigation pathways with major opportunities to shape transport systems and infrastructure around low-carbon options, particularly in developing and emerging countries where most future urban growth will occur.

Transport can be an agent of sustained urban development that prioritizes goals for equity and emphasizes accessibility, traffic safety, and time-savings for the poor while reducing emissions, with minimal detriment to the environment and human health. Transformative trajectories vary with region and country due to differences in the dynamics of motorization, age and type of vehicle fleets, existing infrastructure, and urban development processes. Prioritizing access to pedestrians and integrating non-motorized and public transit services can result in higher levels of economic and social prosperity in all regions. Good opportunities exist for both structural and technological change around low-carbon transport systems in most countries but particularly in fast growing emerging economies where investments in mass transit and other low-carbon transport infrastructure can help avoid future lock- in to carbon intensive modes. Mechanisms to accelerate the transfer and adoption of improved vehicle efficiency and low-carbon fuels to all economies, and reducing the carbon intensity of freight particularly in emerging markets, could offset much of the growth in non-OECD emissions by 2030. It appears possible for LDV travel per capita in OECD countries to peak around 2035, whereas in non-OECD countries it will likely continue to increase dramatically from a very low average today. However, growth will eventually need to be slowed in all countries.

5.4. A range of strong and mutually-supportive policies will be needed for the transport sector to decarbonize and for the co- benefits to be exploited.

Decarbonizing the transport sector is likely to be more challenging than for other sectors, given the continuing growth in global demand, the rapid increase in demand for faster transport modes in developing and emerging economies, and the lack of progress to date in slowing growth of global transport emissions in many OECD countries. Transport strategies associated with broader non-climate policies at all government levels can usually target several objectives simultaneously to give lower travel costs, improved mobility, better health, greater energy security, improved safety, and time savings. Realizing the co-benefits depends on the regional context in terms of economic, social, and political feasibility as well as having access to appropriate and cost-effective advanced technologies.

In rapidly growing developing economies, good opportunities exist for both structural and technological change around low-carbon transport. Established infrastructure may limit the options for modal shift and lead to a greater reliance on advanced vehicle technologies. Policy changes can maximize the mitigation potential by overcoming the barriers to achieving deep carbon reductions and optimizing the synergies. Pricing strategies, when supported by education policies to help create social acceptance, can help reduce travel demand and increase the demand for more efficient vehicles (for example, where fuel economy standards exist) and induce a shift to low-carbon modes (where good modal choice is available). For freight, a range of fiscal, regulatory, and advisory policies can be used to incentivize businesses to reduce the carbon intensity of their logistical systems. Since rebound effects can reduce the CO2 benefits of efficiency improvements and undermine a particular policy, a balanced package of policies, including pricing initiatives, could help to achieve stable price signals, avoid unintended outcomes, and improve access, mobility, productivity, safety, and health. There is a lack of comprehensive and consistent assessments of the worldwide potential for GHG emission reduction and especially costs of mitigation from the transport sector. Within this context, the potential reduction is much less certain for freight than for passenger modes. For LDVs, the long-term costs and high energy density potential for on-board energy storage is not well understood. Also requiring evaluation is how best to manage the tradeoffs for electric vehicles between performance, driving range and recharging time, and how to create successful business models.

Another area that requires additional research is in the behavioral economic analysis of the implications of norms, biases, and social learning in decision making, and of the relationship between trans- port and lifestyle. For example, how and when people will choose to use new types of low-carbon transport and avoid making unnecessary journeys is unknown. Consequently, the outcomes of both positive and negative climate change impacts on transport services and scheduled timetables have not been determined, nor have the cost-effectiveness of carbon-reducing measures in the freight sector and their possible rebound effects. Changes in the transport of materials as a result of the decarbonization of other sectors and adaptation of the built environment are unknown.

Key developments in the transport sector since the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (IPCC, 2007) include:

- ✓ continued increase in annual average passenger km per capita, but signs that LDV [16] ownership and use may have peaked in some OECD countries;
- ✓ deployment of technologies to reduce particulate matter and black carbon, particularly in OECD countries;
- ✓ renewed interest in natural gas as a fuel, compressed for road vehicles and liquefied for ships;
- ✓ increased number of electric vehicles (including 2-wheelers) and bus rapid transit systems, but from a low base;
- ✓ increased use of sustainably produced biofuels including for aviation;
- ✓ greater access to mobility services in developing countries;
- ✓ reduced carbon intensity of operations by freight logistics companies, the slow-steaming of ships, and the maritime industry imposing GHG emission mandates;
- ✓ improved comprehension that urban planning and developing infrastructure for pedestrians, bicycles, buses and light-rail can impact on modal choice while also addressing broader sustainability concerns such as health, accessibility and safety;

[16] LDVs are motorized vehicles (passenger cars and commercial vans) below approximately 2.5 – 3.0 t net weight with HDVs (heavy duty vehicles or “trucks” or “lorries”) usually heavier.

- ✓ better analysis of comparative passenger and freight transport costs between modes;
- ✓ emerging policies that slow the rapid growth of LDVs (especially for group of countries), including investing in non-motorized transport systems;
- ✓ more fuel economy standards (MJ/km) and GHG emission vehicle performance standards implemented for light and heavy duty vehicles (LDVs and HDVs); and
- ✓ widely implemented local transport management policies to reduce air pollution and traffic congestion.

For each mode of transport, direct GHG emissions can be decomposed into:

Activity - total passenger-km/yr. or freight ton-km/yr. having a positive feedback loop to the state of the economy but, in part, influenced by behavioral issues such as journey avoidance and restructuring freight logistics systems;

System infrastructure and modal choice;

Energy intensity—directly related to vehicle and engine design efficiency, driver behavior during operation, and usage patterns; and

Fuel carbon intensity—varies for different transport fuels including electricity and hydrogen.

Deep long-term emission reductions also require pricing signals and interactions between the emission factors. Regional differences exist such as the limited modal choice available in some developing countries and the varying densities and scales of cities, intercity activity and internal tourism activities.

Over 53 % of global primary oil consumption in 2015 was used to meet 94 % of the total transport energy demand[17], with biofuels supplying approximately 2 %, electricity 1 %, and natural gas and other fuels 3%. LDVs consumed around half of total transport energy. Aviation accounted for 51 % of all international passenger arrivals in 2011 and 17 % of all tourist travel in 2005. This gave 43 % of all tourism transport CO2eq emissions, a share forecast to increase to over 50 % by 2035. Buses and trains carried about 34 % of world tourists, private cars around 48 %, and water- borne craft only a very small portion. Freight transport consumed almost 45 % of total transport energy in 2009 with HDVs using over half of that. Ships carried around 80 % (8.7 Gt) of internationally traded goods in 2011 and produced about 2.7 % of global CO2 emissions.

«Sustainable transport», arising from the concept of sustainable development, aims to provide accessibility for all to help meet the basic daily mobility needs consistent with human and ecosystem health, but to constrain GHG emissions by, for example, decoupling mobility from oil dependence and LDV use. Annual transport emissions per capita correlate strongly with annual income, both within and between countries but can differ widely even for regions with similar income per capita. In least developed countries (LDCs), increased motorized mobility will produce large increases in GHG emissions but give significant social benefits such as better access to markets and opportunities to improve education and health. There is limited evidence that reductions to date in carbon intensity,

[17] Global Transportation Demand Development with Impacts on the Energy Demand and Greenhouse Gas Emissions in a Climate-Constrained World; School of Energy Systems, LUT University, Finland, 2019

energy intensity, and activity, as demonstrated in China, Japan, and Europe, have adequately constrained transport GHG emissions growth in the context of mitigation targets. Recent trends suggest that economic, lifestyle, and cultural changes will be insufficient to mitigate global increases in transport emissions without stringent policy instruments, incentives, or other interventions being needed.

5.5. The major drivers that affect transport trends are travel time budgets, costs and prices, increased personal income, and social and cultural factors.

Travel time budget - are usually fixed and tied to both travel costs and time costs. Urban planners tend to try to adapt land use planning to enable speeds of around 5 km/h for walking, 20–30 km/h for mass transit, and 40–50 km/h for LDVs, though subject to great variability. Infrastructure and urban areas are usually planned for walking, mass transit, or LDVs so that destinations can be reached in half an hour on average. Urban travel time budgets for a typical commute between work and home average around 1.1–1.3 hours per traveler per day in both developed and developing economies. Higher residential density can save fuel for LDVs, but leads to more congested commutes. While new road construction can reduce LDV travel time in the short run, it also encourages increased LDV demand, which typically leads to increases in travel time to a similar level as before. Moreover, land uses quickly adapt to any new road transport infrastructure so that a similar travel time eventually resumes. Regional freight movements do not have the same fixed time demands, but rather are based more on the need to remain competitive by limiting transport costs to a small proportion of the total costs of the goods.

Costs and prices - The relative decline of transport costs as a share of increasing personal expenditure has been the major driver of increased transport demand in OECD countries throughout the last century and more recently in non-OECD countries. The price of fuel, together with the development of mass transit systems and non-motorized transport infrastructure, are major factors in determining the level of LDV use versus choosing public transport, cycling, or walking. Transport fuel prices, heavily influenced by taxes, also impact on the competition between road and rail freight. The costs of operating HDVs, aircraft, and boats increase dramatically when fuel costs go up given that fuel costs are a relatively high share of total costs. This has promulgated the designs of more fuel efficient engines and vehicle designs. Although the average life of aircraft and marine engines is two to three decades and fleet turnover is slower than for road vehicles and small boats, improving their fuel efficiency still makes good economic sense.

Social and cultural factors. Population growth and changes in demographics are major drivers for increased transport demand. At the household level, once a motorized vehicle becomes affordable, even in relatively poor households, then it becomes a major item of expenditure; however, ownership has still proven to be increasingly popular with each new generation. Thus, there is a high growth rate in ownership of LDVs and two-wheel vehicles evident in developing countries. The development of large shopping centers and malls usually located outside the city center allows many products to be purchased by a consumer following a single journey but the travel distance to these large shopping complexes has tended to increase. For freight transport, economic globalization has increased the volume and distance of movement of goods and materials. Another example is that in some societies, owning and driving a LDV can provide a symbolic function of status and a basis for sociability and networking through various sign-values such as speed, safety, success, career achievement, freedom, masculinity, and emancipation of women. In such cases, the feeling of power and superiority associated with owning and using a LDV may influence driver behavior, for example, speeding without a concern for safety, or without a concern about fuel consumption, noise, or emissions.

Lifestyle and behavioral factors are important for any assessment of potential change to low-carbon transport options and additional research is needed to assess the willingness of people to change. Disruptive technologies such as driverless cars and consumer-based manufacturing could impact on future transport demands but these are difficult to predict. Likewise, the impact of new information technology (IT) applications and telecommuting could potentially change travel patterns, reduce trips, or facilitate interactions with the mode of choice. Conversely, increased demand for tourism is expected to continue to be a driver for all transport modes.

5.6. Technological improvements and new technology-related practices can make substantial contributions to climate change mitigation in the transport sector:

Energy intensity reduction - incremental vehicle technologies. There is substantial potential for improving internal combustion engines (ICEs) with both conventional and hybrid drive-trains. Recent estimates suggest substantial additional, unrealized potentials exist compared to similar-sized, typical 2007–2010 vehicles, with up to 50 % improvements in vehicle fuel economy (in MJ/km or liters/100km units, or equal to 100 % when measured as km/MJ, km/l). Similar or slightly lower potentials exist for HDVs, waterborne craft, and aircraft.

[18] For LDVs drive-train redesign is continuously insuring yield reductions in fuel consumption and GHG emissions of 25 % or more but mostly results on developed countries. In developing countries, vehicle technology levels are typically lower, although average fuel economy can be similar since vehicle size, weight, and power levels are also typically lower. Hybrid drive-trains provides reductions up to 35 % compared to similar non-hybridized vehicles and have become mainstream in many countries, but with only a small share of annual sales over the last decade except few countries, like Japan. However, is often a time lag between when new technologies first appear in OECD countries and when they

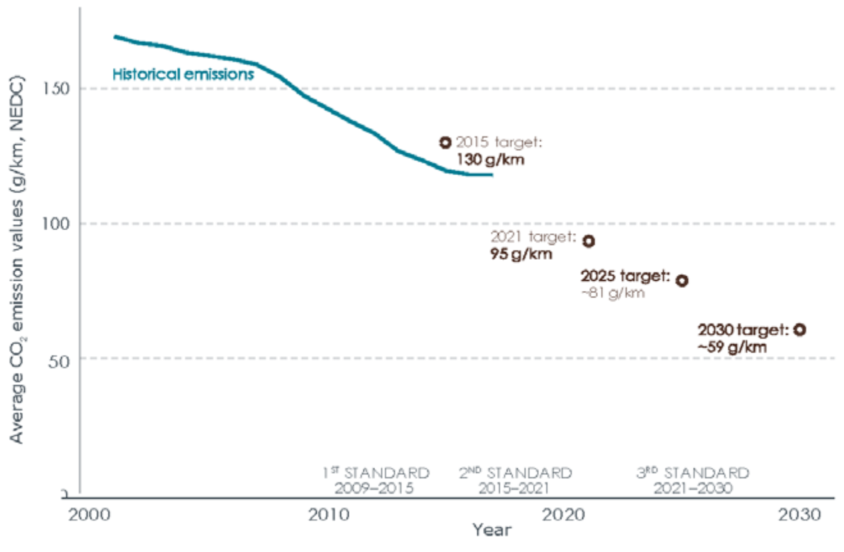


Figure LDV. Average historical CO_2 emission values and adopted CO_2 standards for new passenger cars in the EU. All CO_2 values refer to New European Driving Cycle (NEDC) measurements.

[18] CO2 emission standards for passenger cars and light-commercial vehicles in European Union (EU); INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION, January 2019

reach developing countries, which import mostly second-hand vehicles. Lower fuel consumption can be achieved by reducing the loads that the engine must overcome, such as aerodynamic forces, auxiliary components (including lighting and air conditioners), and rolling resistance. Changes that reduce energy loads include improved aerodynamics, more efficient auxiliaries, lower rolling-resistance tires, and weight reduction. With vehicle performance held constant, reducing vehicle weight by 10 % gives a fuel economy improvement of about 7%. Combined with improved engines and drive-train systems, overall LDV fuel consumption for new ICE-powered vehicles could be reduced by at least half by 2035 compared to 2005. This predicted reduction is consistent with the Global Fuel Economy Initiative target for new LDVs of a 50% reduction in average fuel use per kilometer in 2030 compared to 2005.

For HDVs situation is close, but some specific aspects must be considered. For HDV equipped with modern engines (both ICE [19] and CIE [20]) aerodynamic drag can also be reduced using other modifications offering up to 10 % reduction in fuel consumption. In non-OECD countries, many older trucks with relatively inefficient (and highly polluting) engines are common. Truck modernization, along with better engine, tire, and vehicle maintenance, can significantly improve fuel economy in many cases. Medium and HDVs in the United States can achieve a reduction in energy intensity of 30–50 % by 2020 by using a range of technology and operational improvements (NRC, 2010a). Few similar estimates are available in non-OECD countries, but most technologies eventually will be applicable for HDVs around the world. Expanding the carrying capacity of HDVs in terms of both volume and weight can yield significant net reductions in the energy intensity of trucks so long as the additional capacity is well utilized. Higher capacity vehicles can significantly reduce CO2 emissions per t-km. The use of long combination vehicles rather than single trailer vehicles has been shown to cut direct GHG emissions by up to 32%. Trucks and buses that operate largely in urban areas with a lot of stop-and-go travel can achieve substantial benefits from using electric hybrid or hydraulic hybrid drive-trains. Typically, a 20–30 % reduction in fuel consumption can be achieved via hybridization.

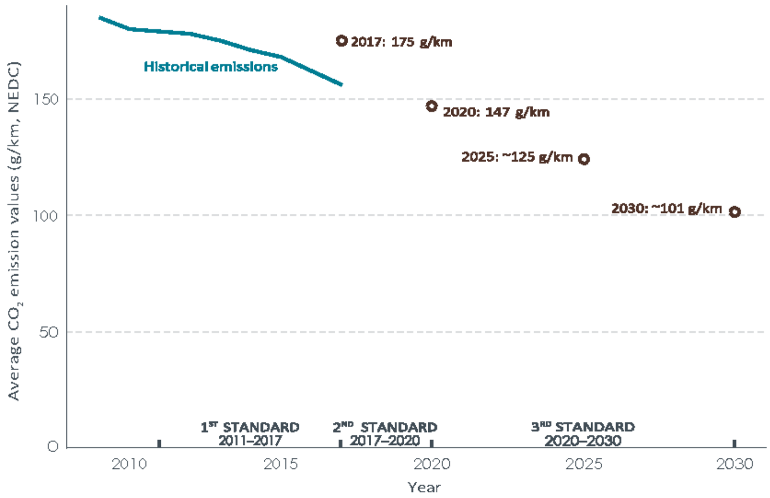


Figure HDV. Average historical CO_2 emission values and adopted CO_2 standards for new vans in the EU. All CO_2 values refer to New European Driving Cycle (NEDC) measurements.

There is a potential also to decrease CO2 emission on rail, shipping and air transportation, those are generally energy efficient, however multiple drive-trains and load-reduction measures for rail, size, weight reduction and load efficiency factors for specific motorized craft, have potential for future CO2 emission improvement. Efficiency of new-built vessels and trains can be improved by 5–30 % through changes in engine and transmission technologies, waste heat recovery, auxiliary power

[19] ICE is the gasoline engine, also known as an internal combustion engine.
[20] CIE is the diesel engine also known as a compression-ignition or CI engine.

systems, propeller and rot-or systems, aerodynamics and hydrodynamics of the hull structure, air lubrication systems, electronically controlled engine systems to ensure fuel efficient speeds.

Energy intensity reduction - advanced propulsion systems include electric motors powered by batteries or fuel cells, turbines (particularly for rail), and various hybridized concepts. All offer significant potential reductions in GHG, but will require considerable time to penetrate the vehicle fleet due to slow stock turnover rates.

Battery electric vehicles (BEVs) emit no tailpipe emissions and have potentially very low fuel-production emissions (when using low-car bon electricity generation). BEVs operate at a drive-train efficiency of around 80 % compared with about 20–35 % for conventional ICE LDVs. At present, commercially available BEVs typically have a limited driving range of about 200–400km, long recharge times of four hours or more (except with fast-charging or battery switching systems), and high battery costs that lead to relatively high vehicle retail prices. Lithium ion (Li-ion) batteries will likely improve but new battery technologies (e. g., Li-air, Li-metal, Li-Sulphur) and ultra-capacitors may be required to achieve much higher energy and power densities. Compressed air as an energy storage medium for LDVs is thermo-dynamically inefficient and would require high storage volume.

Plug-in hybrid electric vehicles (PHEVs) capable of grid recharging typically can operate on battery electricity for 50 to 80 km, but emit CO_2 when their ICE is operating. The electric range of PHEVs is heavily dependent on the size of battery, design architectures, and control strategies for the operation of each mode. For HDVs, the use of BEVs is most applicable to light-medium duty urban vehicles such as delivery vans or garbage collection trucks whose drive cycles involve frequent stops and starts and do not need a long range. Transit buses are also good candidates for electrification either with batteries or more commonly using overhead wire systems.

Fuel cell vehicles (FCVs) can be configured with conventional, hybrid, or plug-in hybrid drive-trains. The fuel cells generate electricity from hydrogen that may be generated on-board (by reforming natural gas, methanol, ammonia, or other hydrogen-containing fuel), or produced externally and stored on-board after refueling. FCVs produce no tailpipe emissions except water and can offer a driving range similar to today’s gasoline/diesel LDVs, but with a high cost increment. Fuel cells typically operate with a conversion efficiency of 54–61 % (significantly better than ICEs can achieve), giving an overall fuel-cycle efficiency of about 35–49 % for an LDV.

Fuel carbon intensity reduction - In principle, low-carbon fuels from natural gas, electricity, hydrogen, and biofuels (including biomethane) could all enable transport systems to be operated with low direct fuel-cycle CO_2eq emissions, but this would depend heavily on their feedstock and conversion processes. Natural gas (primarily methane) can be compressed (CNG) to replace gasoline in Otto-cycle (spark ignition) vehicle engines after minor modifications to fuel and control systems. CNG can also be used to replace diesel in compression ignition engines but significant modifications are needed. Denser storage can be achieved by liquefaction of natural gas (LNG), which is successfully being used for long-haul HDVs and ships. Driving on CNG cause a reduction of up to 25 % in tailpipe emissions (CO_2/km) because of differences in fuel carbon intensity, however lifecycle GHG analysis suggests lower net reductions, in the range of 10–15 % for natural gas fuel systems. Using electricity generated from nuclear or renewable energy power plants, or from fossil fuel plants with carbon dioxide capture and storage (CCS), near-zero fuel-cycle emissions could result for BEV[21]s. The numbers of EVs in any country are unlikely to reach levels that significantly affect national electricity demand for at least one to two decades, during which time electricity systems could be at least partially decarbonized and modified to accommodate many EVs. Hydrogen used in FCVs, or directly in modified ICEs, can be produced by the reforming of biomass, coal or natural gas (steam methane reforming is well-established in commercial plants); via commercial but relatively expensive electrolysis using electricity from a range of sources including renewable; or from biological processes. The mix of feedstocks largely determines the well-to-wheel GHG emissions of FCVs. Advanced, high-temperature and photo-electrochemical technologies could eventually become viable pathways. However, deployment of FCVs needs to be accompanied by large, geographically focused, investments into hydrogen production and distribution and vehicle refueling infrastructure. A variety of liquid and gaseous biofuels can be produced from various biomass feedstock using a range of conversion pathways. The ability to produce and integrate large volumes of biofuels cost-effectively and sustainably are primary concerns of which policy makers should be aware. In contrast to electricity and hydrogen, liquid biofuels are relatively energy-dense and are, at least in certain forms and blend quantities, compatible with the existing petroleum fuel infrastructure and with all types of ICEs installed in LDVs, HDVs, waterborne craft, and aircraft. Ethanol and biodiesel (fatty-acid-methyl-ester, FAME) can be blended at low levels (10–15 %) with petroleum fuels for use in unmodified ICEs. New ICEs can be cheaply modified during manufacture to accommodate much higher blends as exemplified by 'flex-fuel' gasoline engines where ethanol can reach 85 % of the fuel blend. However, ethanol has about a 35 % lower energy density than gasoline, which reduces vehicle range - particularly at high blend levels— that can be a problem especially for aircraft. Technologies to produce advanced bio-fuels are in development, but may need another decade or more to achieve widespread commercial use. Bio-methane from suitably purified biogas or landfill gas can also be used in natural gas vehicles. Biofuels have direct, fuel-cycle GHG emissions that are typically 30–90 % lower per kilometer travelled than those for gasoline or diesel fuels. However, since for some biofuels, indirect emissions—including from land use change—can lead to greater total emissions than when using petroleum products, policy support needs to be considered on a case by case basis.

Behavioral aspects - The successful uptake of more efficient vehicles, advanced technologies, new fuels, and the use of these fuels and vehicles in 'real life' conditions, involves behavioral aspects. There is often a lack of interest in purchasing more fuel efficient vehicles due to imperfect information, information overload in decision making, and consumer uncertainty about future fuel prices and vehicle life. This suggests that in order to promote the most efficient vehicles, purchaser behavior must be developed, based on strong policies such as fuel economy standards, sliding-scale vehicle tax systems, or Feebate[22] systems with a variable tax based on fuel economy or CO2 emissions may be needed. Vehicle characteristics are largely determined by the desires of new-car buyers in wealthier countries, so there may be a five-year or longer lag before new technologies reach second-hand vehicle markets in large quantities, particularly through imports to many developing countries. The fuel economy of a vehicle as quoted from independent testing can be up to 30% better than that actually achieved by an average driver on the road. A significant reduction in the gap may

[21] BEV - A battery electric vehicle (BEV), pure electric vehicle, only-electric vehicle or all-electric vehicle
[22] Feebate is a system of charges and rebates whereby energy-efficient or environmentally friendly practices are rewarded while failure to adhere to such practices is penalized

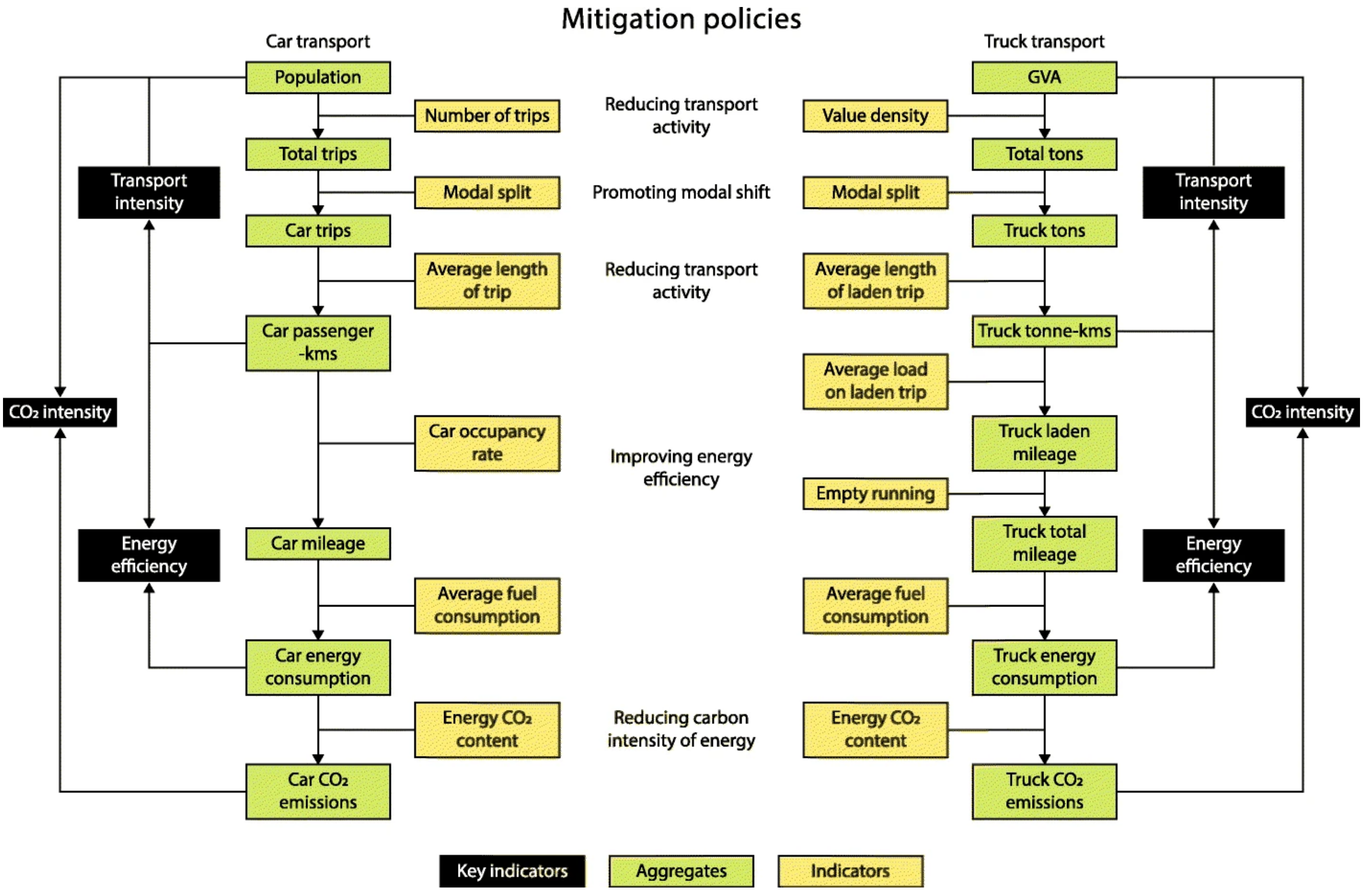
be achievable by an 'integrated approach' that includes better traffic management, intelligent transport systems, and improved vehicle and road maintenance. A 5–10 % improvement in on-road fuel economy can be achieved for LDVs through efforts to promote 'eco-driving'.

Transport Infrastructure - The inter-linkages between transport infrastructure and the built environment establish path dependencies, which inform long-term transport-related mitigation options. GHG emissions per passenger-kilometer (p-km) or per ton-kilometer (t-km) depend on the intensity of use of the infrastructure and the share of tunnels, bridges, runways, etc. Opportunities exist to substantially reduce this infrastructure related emissions, for instance by up to 40 % in rail, by the increased deployment of low-carbon materials and recycling of rail track materials at their end-of-life. Transport demand and land use are closely inter-linked. In low-density developments with extensive road infrastructure, LDVs will likely dominate modal choice for most types of trips. Walking and cycling can be made easier and safer where high accessibility to a variety of activities are located within relative short distances and when safe cycle infrastructure and pedestrian pathways are provided. Sustainable urban planning offers tremendous opportunities (reduced transport demand, improved public health from non-motorized transport (NMT), less air pollution, and less land use externalities. Urban population density inversely correlates with GHG emissions from land transport. There exists a non-linear relationship between urban density and modal choice. Transport options that can be used in low density areas include para-transit [23]and car-sharing, both of which can complement individualized motorized transport more efficiently and with greater customer satisfaction than can public transit. Demand-responsive, flexible transit, and car sharing services can have lower GHG emissions per passenger kilometer with higher quality service than regional public transport.

Transport is impacted by climate change both positively and negatively. These impacts are dependent on regional variations in the nature and degree of climate change and the nature of local transport infrastructure and systems. Adapting transport systems to the effects of climate in some cases complement mitigations efforts while in others they have a counteracting effect. Little research has so far been conducted on the inter-relationship between adaptation and mitigation strategies in the transport sector. Overall, the transport sector will be highly exposed to climate change and will require extensive adaptation of infrastructure, operations, and service provision. It will also be indirectly affected by the adaptation and decarbonization of the other sectors that it serves. Within the transport sector there will be a complex interaction between adaptation and mitigation efforts. Some forms of adaptation, such as infrastructural climate proofing, will be likely to generate more freight and personal movement, while others, such as the NSR, could substantially cut transport distances and related emissions.

[23] Para-transit, also called «community-transit», is where flexible passenger transport minibuses, shared taxis, and jitneys operate in areas with low population density without following fixed routes or schedules.

It is important to note that reach potential decrease of GHG emission complex approach and effective combination of different measures, steps and technologies is needed. Drawing is showing how different mitigation actuals and measures may support governments to achieve climate change positive targets and goals.



5.7. Aggressive policy intervention in different sectors (Sectoral policy) is needed to significantly reduce fuel carbon intensity and energy intensity of modes, encourage travel by the most efficient modes, and cut activity growth where possible and reasonable:

Policies to support sustainable transport can simultaneously provide co-benefits such as improving local transport services and enhancing the quality of environment and urban living, while boosting both climate change mitigation and energy security. The type of policies, their timing, and chance of successful implementation are context dependent. Market-based instruments, such as carbon cap and trade, are effective at incentivizing all mitigation options simultaneously. Vehicle and fuel suppliers as well as end-users, tend to react weakly to fuel price signals, such as fuel carbon taxes, especially for passenger travel, so in fact market policies are economically more efficient at reducing emissions than fuel carbon intensity standards. However, financial instruments, such as carbon taxes, must be relatively large to achieve reductions equivalent to those possible with regulatory instruments. As a result, to gain large emissions reductions a suite of policy instruments will be needed), including voluntary schemes, which have been successful in some circumstances.

Road transport - A wide array of policies and strategies has been employed in different circumstances to restrain private LDV use, promote mass transit modes, manage traffic congestion and promote new fuels in order to reduce fossil fuel use, air pollution, and GHG emissions. These policies and strategies overlap considerably, often synergistically. In regions and countries presently with low levels of LDV ownership, opportunities exist for local and national governments to manage future rising road vehicle demand in ways that support economic growth, provide broad social benefits and keep GHG emissions in bounds, however if non-OECD countries pursue strategies and policies that encourage LDV use for a variety of economic, social, and environmental motivations, per capita LDV travel in 2050 could remain far below OECD countries. Many countries have significant motor fuel taxes that, typically, have changed little in recent years. This indicates that such a market instrument is not a policy tool being used predominantly to reduce GHG emissions. The typical approach increasingly being used is a suite of regulatory and other complementary policies with separate instruments for vehicles and for fuels. The challenge is to make them consistent and coherent. For instance, the fuel efficiency and GHG emission standards for vehicles in Europe and the United States give multiple credits to plug-in electric vehicles (PEVs) and fuel cell vehicles (FCVs). The following main measures could be effective while considering effective policy creating for road transport:

Fuel choice and carbon intensity - Flexible fuel standards that combine regulatory and market features (as Californian low-carbon fuel standard (LCFS) and EU fuel quality directive (FQD)), ensuring fuel carbon intensity reduction by increasing use of low-carbon biofuels, hydrogen, and electricity.

Vehicle energy intensity - The element of transport that shows the greatest promise of being on a trajectory to achieve large reductions in GHG emissions by 2050 is reducing the energy and fuel carbon intensities of LDVs. Regulatory standards focused on fuel consumption and GHG emissions vary in their design and stringency. Some strongly stimulate reductions in vehicle size (as in Europe) and others provide strong incentives to reduce vehicle weight (as in the United States). There are examples when authorities had implemented taxes on LDVs wholly or partially related to CO2 emissions. Fuel and vehicle purchase taxes and circulation taxes that can limit rebound effects or revenue-neutral Feebate schemes (a combination of rebates awarded to purchasers of low carbon emission vehicles and fees charged to purchasers of less efficient vehicles). Annual registration fees can have similar effects if linked directly with carbon emissions or with related vehicle attributes such as engine displacement, engine power, or vehicle weight. One concern with market-based policies is their differential impact across population groups. Standards are likely to spur major changes in vehicle technology, but in isolation are unlikely to motivate significant shifts away from petroleum-fueled ICE vehicles. A more explicit regulatory instrument to promote EVs and other new, potentially very-low carbon propulsion technologies is a zero emission vehicle mandate, as originally adopted by California in 1990 to improve local air quality, and which now covers almost 30% of the United States market. This policy, now premised on reducing GHGs, requires about 15 % of new vehicles in 2025 to be a mix of PEVs and FCVs. There are large potential efficiency improvements possible for medium and heavy-duty vehicles (HDVs), but policies to pursue these opportunities have lagged those for LDVs. Truck types, loads, applications, and driving cycles are much more varied than for LDVs and engines are matched with very different designs and loads, thereby complicating policy-making, however there are number of successful examples for HDVs as well.

Activity reduction - A vast and diverse mix of policies is used to restrain and reduce the use of LDVs, primarily by focusing on land use patterns, public transport options, and pricing. Other policy strategies to reduce activity include improving traffic management, better truck routing systems, and smart real-time information to reduce time searching for a parking space. Greater support for innovative services using information and communication technologies, such as dynamic ride sharing and demand-responsive para-transit services, creates still further opportunities to shift toward more energy efficient modes of travel. There are different restrictive experiences showing positive impact on LDVs number and operation pattern as limiting the ownership of LDVs by establishing an expensive license auction, built fewer new roads, and investing more in public transport (Shanghai), or curtailed vehicle use by forbidding cars to be used one day per week, and sharply limited the number of new license plates issued each year (Beijing). The overall effectiveness of initiatives to reduce or restrain road vehicle use varies dramatically depending on local commitment and local circumstances, and the ability to adopt synergistic policies and practices by combining pricing, land use management, and public transport measures. Pricing instruments such as congestion charges, vehicle registration fees, road tolls and parking management can reduce LDV travel by inducing trip chaining, modal shifts, and reduced use of cars.

System efficiency – mainly introducing contribution for low carbon ground transportation in cities and conglomerates by implementing different policies and measures to extend percentage of use of non-motorized ground transportation together with implementation of green vehicle practices as hybrid, hydrogen or biofuels. Moving balance of investments from roads in to the public transport (bus rapid transit and rail transit) along with increasing support for bicycle use could be very effective.

Rail transport - Policies to further improve system efficiency may improve competitiveness and opportunities for modal shift to rail. Specific energy and carbon intensities of rail transport are relatively small compared to some other modes. System efficiency can also be assisted through train driver education and training policies:

Fuel intensity - Roughly one third of all rail transport is driven by diesel and two-thirds by electricity. Policies to reduce fuel carbon intensity are therefore linked to a large extent to those for decarbonizing electricity production.

Energy intensity - Driven largely by corporate strategies, the energy intensity of rail transport has been reduced by more than 60%. Overall reduction opportunities of 45–50 % are possible for passenger transport in the EU and 40–50 % for freight. Recent national policies in the United Kingdom and Germany appear to have resulted in 73 % rail freight growth over the period 1995–2007, partly shifted from road freight.

System efficiency - China, Europe, Japan, Russia, United States and several Middle-eastern and Northern African countries continue (or are planning) to invest in high-speed rail (HSR). It is envisaged that the worldwide track length of about 15,000 km in 2012 will nearly triple by 2025 due to government supporting policies, allowing HSR to better compete with medium haul aviation.

Aviation - Policy options in place or under consideration include regulatory instruments (fuel efficiency and emission standards at aircraft or system levels); market-based approaches (emission trading under caps, fuel taxes, emission taxes, subsidies for fuel efficient technologies); and voluntary measures including emission offsets. Environmental capacity constraints on airports also exist and may change both overall volumes of air transport and modal choice. National policies affect mainly domestic aviation, which covers about 30–35 % of total air transport (IATA, 2009). A nationwide cap- and-trade policy could have the unintended consequence of slowing aircraft fleet turnover and, through diverted revenue, of delaying technological upgrades, which would slow GHG reductions, though to what degree is uncertain. Also industry groups including airport companies, aircraft manufacturers and airlines has developed a strategy for reducing GHG emissions across the industry. Taxing fuels, tickets, or emissions may reduce air transport volume with elasticities varying between – 0.3 to – 1.1 at national and international levels, but with strong regional differences.

Fuel carbon intensity - Policies do not yet exist to introduce low-carbon biofuels. However, the projected GHG emission reductions from the possible future use of biofuels, as assumed by the aviation industry, vary between 19 % of its adopted total emission reduction goal to over 50 %, depending on the assumptions made for the other reduction options that include energy efficiency, improved operation and trading emission permits.

Energy intensity - The energy efficiency of aircraft has improved historically without any policies in force, but with the rate of fuel consumption reducing over time from an initial 3–6 % in the 1950s to between 1 % and 2 % per year at the beginning of the 21st century. This slower rate of fuel reduction is possibly due to increasing lead-times required to develop, certify, and introduce new technology.

System efficiency - The interconnectedness of aviation services can be a complicating factor in adopting policies, but also lends itself to global agreements. For example, regional and national air traffic controllers have the ability to influence operational efficiencies. The use of market policies to reduce GHG emissions is compelling because it introduces a price signal that influences mitigation actions across the entire system. But like other aspects of the passenger transport system, a large price signal is needed with aviation fuels to gain significant reductions in energy use and emissions. Complementary policies to induce system efficiencies include measures to divert tourists to more efficient modes such as high-speed rail. However, since short- and medium-haul aircraft now have similar energy efficiencies per passenger km compared to LDVs, encouraging people to take shorter journeys (hence by road instead of by air), thereby reducing tourism total travel, has become more important.

Infrastructure and urban planning - Urban form has a direct effect on transport activity. As a consequence, infrastructure policies and urban planning can provide major contributions to mitigation. A modal shift from LDVs to other surface transport modes could be partly incentivized by policy measures that impose physical restrictions as well as pricing regimes. For example, LDV parking management is a simple form of cost effective, pricing instrument. Dedicated bus lanes, possibly in combination with a vehicle access charge for LDVs, can be strong instruments to achieving rapid shifts to public transport. Policies that support the integration of moderate to high density urban property development with transit-oriented development strategies that mix residential, employment, and shopping facilities can encourage pedestrians and cyclists, thereby giving the dual benefits of reducing car dependence and preventing urban sprawl. GHG emissions savings could result in co-benefits of health, productivity, and social opportunity if LDV trips could be reduced using polycentric city design and comprehensive smart- growth policies. Policies to support the building of more roads, airports, and other infrastructure can help relieve congestion in the short term, but can also induce travel demand and create GHG emissions from construction.

6. Best Practices. Comparative analyses

In order for the world to stay within the safety threshold of a 2º C increase in average temperature agreed by virtually all governments, the transport sector needs to be decarbonized. The two main obstacles that have prevented this from happening have been the absence of a global legally binding deal and the high relative cost of clean vehicle/energy technologies. The Paris Agreement, which commits countries to reductions of GHG emissions, has virtually solved the first problem and paved the way for countries to implement environmental taxes and subsidies in order to change the relative costs of clean alternatives, which would solve the second problem. These policy actions combined with investment in clean infrastructure and regulation can decarbonize the transport sector.

Since the United Nations Framework Convention on Climate Change(UNFCCC) came into force in 1994, global CO2 emissions have continued to increase, with some regions of the world increasing their total emissions substantially, such as India and China, and others decreasing theirs, such as Europe. Even in those regions where CO2 emissions from other sectors are generally falling, those from transport have continued to increase. In Europe, for example, between 1990 and 2012, total GHG emissions decreased by almost 18% but those from transport increased by about 14%. Reducing emissions in transport is more costly than in other sectors, such as the electricity sector, and the reason for this is that transport still heavily relies on fossil fuels. However, staying under 2º C, let alone 1.5º C, will require a decarbonization of transport. Two barriers have prevented substantial reductions of GHG emissions in general and in transport in particular: incomplete international agreements and the high cost of (transport) clean technologies. Within the UNFCCC, the first attempt to a global deal was the Kyoto Protocol, which came into effect in 2005. It was bound to have a limited impact, as it only required developed countries to take action. On top of this, the US never ratified it, Canada pulled out before the end of the first commitment period, which ended in 2012, and Russia, Japan and New Zealand are not taking part in the second commitment period. As a result, the Kyoto Protocol second commitment period, from 2013 to 2020, only applies to around 14% of the world's GHG emissions.

No international organization, not even the United Nations, has the power to develop and enforce environmental policy, and this poses a big environmental governance problem. However, proving that convincing virtually all the countries of the world to unite forces and commit to GHG emission reductions was not as utopic as it first appeared, the Paris Agreement, the second attempt to a global deal, was adopted in December 2015 at the 21st session of the Conference of Parties (COP21) to the UNFCCC, which was held in Paris at the end of 2015. The Paris Agreement commits developed and developing countries alike to keeping global warming below 2ºC, and aspiring to a target of 1.5º C. The Agreement also states that developing countries will receive financial support from developed country Parties to help them with mitigation and adaptation.

The Agreement came into force on 4 November 2016. The countries ratifying the Agreement, before or after it came into force, include the four largest emitters in absolute terms: China, the US, the EU and India. Japan, number six on the rank, has also ratified the Agreement as well as Russia, number five. The Paris Agreement requires all Parties to put forward their emission reduction targets, or 'nationally determined contributions' (NDCs) and to strengthen these efforts in the future. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. Furthermore, the Agreement also has a long-term goal of net zero emissions, which would effectively phase out fossil fuels. This will entail a complete decarbonization of the transport sector. The Paris Agreement, an unprecedented diplomatic success that contrasted sharply with the failure of COP15 in Copenhagen in 2009, promised to set the world on a path towards substantially reducing GHG emissions.

The Europe 2020 Strategy for smart, sustainable and inclusive growth includes five headline targets that set out where the EU should be in 2020. One of them relates to climate and energy: Member States have committed themselves to reducing greenhouse gas emissions (GHG) by 20%, increasing the share of renewables in the EU's energy mix to 20%, and achieving the 20% energy efficiency target by 2020. The EU is currently on track to meet two of those targets, but will not meet its energy efficiency target unless further efforts are made. Hence, the priority remains to achieve all the targets already set for 2020. In order to keep climate change below 2ºC, the European Council reconfirmed in February 2011 the EU objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990, in the context of necessary reductions according to the Intergovernmental Panel on Climate Change by developed countries as a group. This is in line with the position endorsed by world leaders in the Copenhagen and the Cancun Agreements. These agreements include the commitment to deliver long-term low carbon development strategies. Some Member States have already made steps in this direction, or are in the process of doing so, including setting emission reduction objectives for 2050. The Roadmap for possible action up to 2050 was developed to enable the EU to deliver greenhouse gas reductions in line with the 80 to 95% target agreed.

Definitely every county must develop own mitigation policies and measures, considering national specifics, level and risks of emission growth from different sectors of national economies, as well as minimizing negative impact from those actions on sustainable economic growth. Especially for transport sector mitigation initiatives are differ being however part of common tendencies. How much would it cost to move beyond business as usual and come within striking distance of net-zero emissions by 2050? To answer this question, it’s important to distinguish between short- and long-term costs. In the short term, there are some inexpensive ways to reduce emissions, but deeper cuts run up against quickly rising costs. However, some activities - especially those involving fledgling low-carbon technologies - that appear expensive in the short term may actually turn out to be low-cost approaches in the long term, because of induced innovation. This insight suggests that the longer-term cost of mitigation may be lower than is widely assumed.

Technological innovation can help the transition to a more efficient and sustainable European transport system by acting on 3 main factors: vehicle efficiency through new engines, materials and design; cleaner energy use through new fuels and propulsion systems; better use of networks and safer and more secure operation through information and communication systems. The White Paper on Transport will provide a comprehensive and combined set of measures to increase the sustainability of the transport system.

Up until 2025, the main driver for reversing the trend of increasing greenhouse gas emissions in this sector is likely to remain improved fuel efficiency. Emissions from road, rail and inland waterways could in fact be brought back to below 1990 levels in 2030, in combination with measures such as pricing schemes to tackle congestion and air pollution, infrastructure charging, intelligent city planning and improving public transport, whilst securing affordable mobility. Improved efficiency and better demand-side management, fostered through CO2 standards and smart taxation systems, should also advance the development of hybrid engine technologies and facilitate the gradual transition towards large-scale penetration of cleaner vehicles in all transport modes, including plug-in hybrids and electric vehicles (powered by batteries or fuel cells) at a later stage.

The synergies with other sustainability objectives such as the reduction of oil dependence, the competitiveness of Europe's automotive industry as well as health benefits, especially improved air quality in cities, make a compelling case for the EU to step up its efforts to accelerate the development and early deployment of electrification, and in general, of alternative fuels and propulsion methods, for the whole transport system. In this respect, it is not surprising to see also automotive industries in the US, Japan, Korea and China increasing their investments in battery technology, electric vehicles and fuel cells.

Sustainable biofuels could be used as an alternative fuel especially in aviation and heavy duty trucks, with strong growth in these sectors after 2030. In case electrification would not be deployed on a large-scale, biofuels and other alternative fuels would need to play a greater role to achieve the same level of emissions reduction in the transport sector. For biofuels this could lead, directly or indirectly, to a decrease of the net greenhouse gas benefits and increased pressure on bio-diversity, water management and the environment in general. This reinforces the need to advance in 2nd and 3rd generation biofuels and to proceed with the ongoing work on indirect land use change and sustainability.

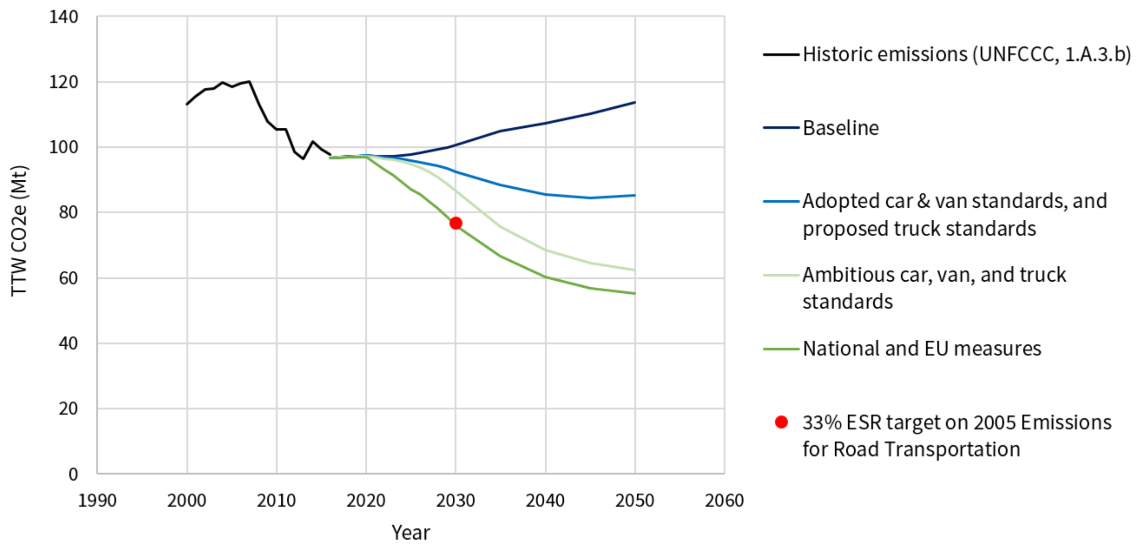
It is also absolutely clear that for countries and regions with historically high GHG emission levels it is relatively easier to perform practical actions under the mitigation policies, because typically those countries have high economical potential. However, during last decade fossil fuel dependence and as a result of growing mobility and freight demand CO2 emission level continues growing fast. Even though the EU was on the target path until 2014, it exceeded the projected downward target trend in 2015 and 2016, due to an increase in energy consumption in road transport and international aviation. Transport oil consumption will need to fall by more than two-thirds to meet the objectives of a 70 % reduction of oil consumption by 2050.

Under the Renewable Energy Directive, all EU Member States must achieve a 10 % share in renewable energy consumption by 2020 in the transport sector. Only those biofuels complying with the sustainability criteria under the Renewable Energy Directive and the Fuel Quality Directive are considered for this target. According to preliminary EEA estimates for 2017, the proportion of renewable energy use in transport grew from 7.1 % in 2016 to 7.2 % in 2017. At the EU level, the trend in renewable share remains well below the target path to reach the 2020 goal. The share of renewable energy in transport varied across countries, from 30 % (Sweden) to close to 0.4 % (Estonia). **Austria** and **Sweden** are the only two Member States which have already reached the goal of a 10 % share of energy from renewable sources in transport by 2020. Renewable energy in this sector comes overwhelmingly from biofuels (close to 90 %), with electricity still playing a limited role. A higher share of renewable electricity use in the transport sector would reduce the pressure on biofuels to reach the EU's 10 % target.

Electric cars are slowly penetrating the EU market. BEVs comprised 0.6 % of total new passenger car registrations in the EU in 2017. This is a 51 % increase in just one year. Sales of PHEVs increased by 35 % in 2017 compared with 2016. PHEVs represented 0.8 % of total new passenger car registrations in the EU in 2017. Most Member States in Europe have introduced financial incentives for the purchase of electrically charging vehicles and are encouraging consumers to choose cleaner vehicles. Among Member States, Sweden, Belgium, Finland had the highest sales of BEVs and PHEVs in new passenger car fleet.

Monitoring of CO2 emissions from new vans started in 2012. In 2017[24], according to provisional data, average emissions decreased by 7.7 g CO2/km compared with 2016, which is the largest annual decrease since 2012. During the 2012-2017 period, average specific emissions decreased by 24 g CO2/km or 13 %. In order to meet the 2021 target of 95 g CO2/km for passenger cars and the 2020 target of 147 g CO2/km for vans, average CO2 emissions will need to decrease further by almost 20 % for new passenger cars and around 6 % for vans.

Tendency of contributing CO2 emission decrease by implementing traditional instruments, as facilitation of EV, increase fuel efficiency, shifting car passengers to buses, trains, riding, and walking and behavioral changes are in different volumes supported by major of countries. However, few countries together with regular measures are introducing extraordinary initiatives as well. **Italy** focusing on 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 standardized 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. 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, but could be absolutely effective in long-term perspective.

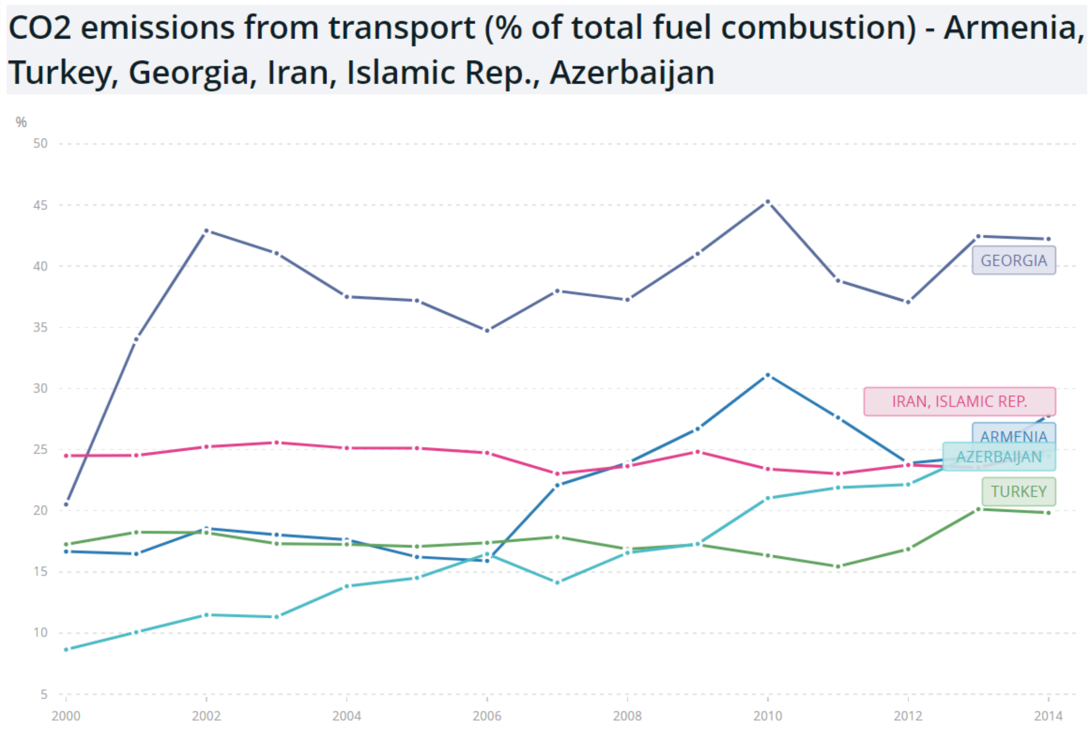


[24] IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

Depending on number of reasons national or regional level measures are appreciated to achieve positive results from different mitigation initiatives around the world. Although the **U.S.** reduction seems low percentage-wise, it translates to a total annual reduction of about 760 million metric tons since 2005, almost as much as the reduction in the European Union as a whole (770 million metric tons). For comparison, the United States has emitted 6,000 – 7,300 million metric tons of CO2 equivalent each year between 1990 and 2014. Second place in absolute emissions decline in that period goes to the United Kingdom, with a reduction of 170 million metric tons, nearly a quarter of total U.S. reductions. Within the United States, there is a lot of variation between the states on how much progress they have made in reducing their greenhouse gas emissions. Between 2000 and 2015, Washington, DC, and 41 states, including Maine and Ohio, managed to reduce their emissions, but nine states, including Nebraska and Montana, increased their emissions. The emission reductions mostly occurred at the end of the 15-year period, likely due to the impact of the Great Recession and higher gasoline prices, both of which lowered energy consumption. The increasing use of natural gas also played a major role (fracking has made it cheaper than coal, and it emits less carbon dioxide than coal when burned), as did the falling prices of wind and solar installations as well as policies encouraging renewable energy use. Indeed, state policies play an important role, and help explain why some states are lagging behind while others have substantially reduced their emissions. States participating in the Regional Greenhouse Gas Initiative (RGGI), for example, are obligated to cap CO2 emissions from the power sector at 91 million tons annually, and then achieve a 10 percent reduction in these emissions by 2020. Since the implementation of RGGI, CO2 emissions from the power sector in participating states have decreased by more than 30 percent from baseline levels - though not all of that decrease can be attributed to the RGGI. In January 2018, California signed an executive order committing the state to a fleet of five million zero-emission vehicles in use by 2030, upgrading the previous goal of 1.5 million electric vehicles (EVs) on the road by 2025. The order also includes a budget of $2.5 billion to spend on encouraging the purchase of EVs. Furthermore, California has an Advanced Clean Cars Program to reduce pollution from cars. Initiatives like this are a great step in reducing greenhouse gas emissions, as the transportation sector is one of the biggest contributors of greenhouse gas emissions.

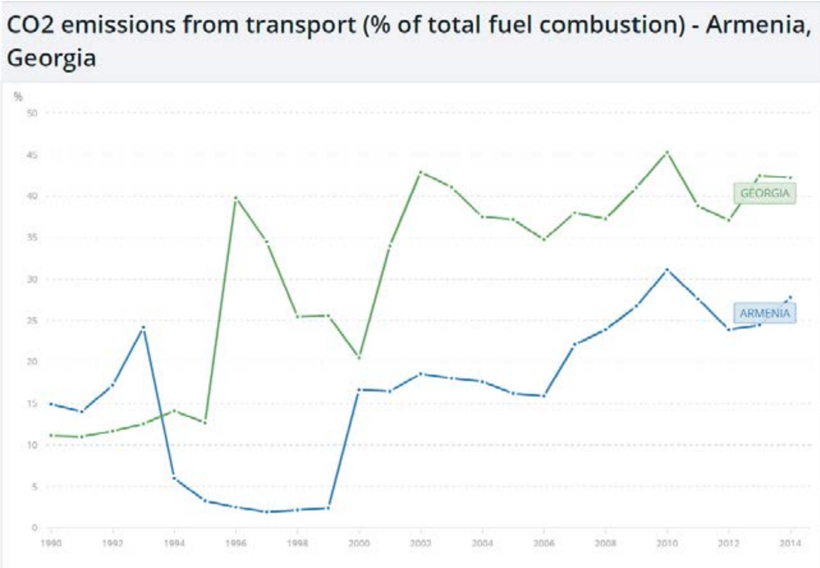
There are number of regional GHG emission decrease and decarbonization practices, extrapolated to the national level. **Cyprus** performed the study of an empirical analysis of the contributions of the land transport sector in CO2 emissions at macro (EE-IOA) level and micro (urban isle) level. The results of the EE-IOA model indicate the large direct and indirect CO2 emissions of the land transport sector in Cyprus as well as the relatively low economic backward linkages with the rest sectors of the economy. On the contrary the water transport sector and the air transport sector create high backward linkages and multiplier effects with the rest sectors of the economy with relatively low CO2 emissions. It was found that the transportation sector and the food manufacturing industry are the sectors with the highest backward linkages in the Cypriot economy overtime, i.e., in both economic growth and crisis periods. The urban isle located in the built-up area of the center of Limassol, which is the second largest city in Cyprus, was considered as a micro element or Cyprus, finally results of empiric investigation was extrapolated on national level. Statistical analysis indicates a weak negative correlation (-0.21) between the economic output and CO2 multipliers for Cyprus. These findings reveal that the production sectors in Cyprus can create strong economic backward linkages in the economy and invigorate economic growth without substantially increasing their CO2 emissions. The launch of the 4th Old Vehicle Scrapping and Replacement Scheme was announced on 11 October 2010, whereas the scheme was implemented in 2011. The 4th Scheme related to the payment of a grant equal to EUR 1 800 and covered the scrapping of M1 category motor vehicles, older than 15 years old, under the condition that a new car with CO2 mass emissions lower or equal to 165gr/km would be purchased.

Western Asia and Caucasus regions, neighboring with Armenia are really challenging in terms of GHG mitigation and decarbonization perspectives. The region hosts countries with the different economic, political, cultural and behavioral ecosystems. Courtiers are introducing different altitude to the global climate stabilization and mitigation initiatives.

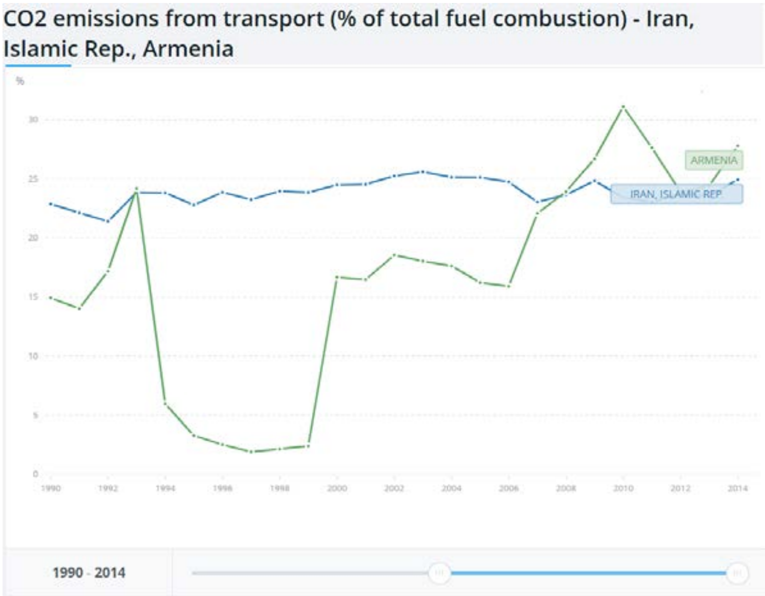


Georgia as a Non-Annex I country to UNFCCC is eligible to participate in only one of the three mechanisms defined by the Kyoto Protocol, such as the Clean Development Mechanism (CDM). In Georgia, 7 CDM projects are registered and the forecasted reduction rate is 1.84 mln.t of CO2 eq annually. On September 25, 2015, Georgia submitted a document “Intended Nationally Determined Contributions” will be updated by the end of 2020. By the preliminary estimates, Georgia undertakes an unconditional responsibility that greenhouse gas emissions will not exceed 66% of the 1990 levels (32,143 Gg of CO2 eq.) by 2030, and in case of financial and technological support this figure will be reduced by 8% (4,317 Gg CO2 eq.). In 2016, the EU-Georgia Association Agreement has entered into force, which emphasizes the necessity of collaboration in the following areas: climate change mitigation, adaptation to climate change, emissions trading, integration of climate change in industrial policy and clean technology development. The Agreement underlines the inevitability of cooperation in the process of transferring the technologies based on the Low Emission Development Strategies

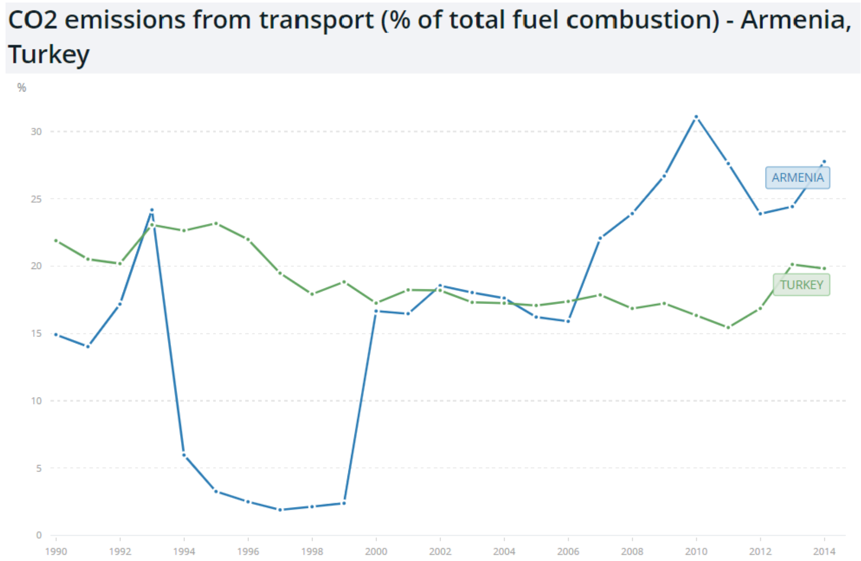
(LEDS), Nationally Appropriate Mitigation Action (NAMA) and Technology Needs Assessment. Besides strategies at a national level, local strategic documents are as well important, for instance, Sustainable Energy Action Plan (SEAP) elaborated by municipalities within the framework of Covenant of Mayors – the initiative of European Union. Covenant of Mayors was joined by 23 towns/municipalities of Georgia, and they undertook the obligation to reduce greenhouse gas emissions in a range 20%-30% by 2020 and by 2030 respectively. 11 municipalities have already submitted SEAPs, which suggests emissions reduction mainly from transport, public and domestic sectors. Georgia has received significant assistance from donors during the last 10 years in climate change field. During 2000- 2015, GHGs emissions from the industry and transport sectors increased about 1.6 and 4.4 times respectively. In the transport sector, GHG emissions increased due to the growing auto-park and a majority share of second-hand cars in the park. In Georgia, the number of motor vehicles in 2002-2016 period increased from 319,600 to 1,126,4703. Tbilisi municipality prepared sustainable urban transport strategy 2015-2030. The strategy covers the following main areas: (i) Urban master plan, (ii) Quality of life, competitiveness, economic growth and tourism attractiveness, (iii) Urban morphology, urban regeneration, mixed land use and local identity, (iv) Topography, natural and artificial barriers, (v) Universal accessibility, social and gender equity, (vi) Innovative financing mechanisms and increased private sector participation, (vii) Transit oriented development, increased density and mixed land-use along mass transit corridors and stations. Georgia’s National Road Safety Strategy with its action plan was adopted in 2017. The strategy includes the following measures: introducing lower speed limits on motorways, expecting to decrease in injury crashes and save fuel consumption; developing and improving of National Video Surveillance System and "Contactless Patrol" system; arrangement of average speed control sections on the roads; establishing a regional training center for raising professional competence; installing street lights within the East-West Highway Improvement projects. For effective implementation of the strategy and its action plan development of secondary legislation and regulations will be prepared in near future. However now Georgia remains the country with the highest CO2 emission level in a region.



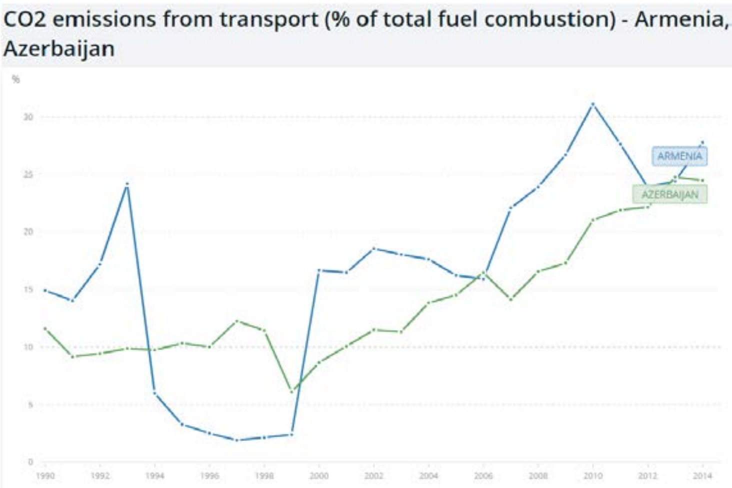
In **Iran**, local air pollution in the major cities, particularly in the capital city of Tehran, is mostly because of emissions from transportation sector. In this sector, the demand for gasoline is more than the amount produced by oil refineries and the government is compelled to import huge amounts of gasoline daily. About 99% of total gasoline is consumed by the transportation sector. It is because of the increasing in the number of manufactured cars, high average age of the cars, their low efficiency and old technology. In 2007, this sector consumed the largest share of energy subsides amounted to 42%. Transportation sector consists of 4 main parts: road, air, rail and sea. Among them, road transportation is the main emission source of CO2 and other pollutants. In 2007, transportation sector's value added to GDP and CO2 emission were amounted to 45 thousand milliard Rials and 95 million tons, indicating 8% and 4.9% annual growths during the period. Iran's energy prices are among the lowest in the world due to energy subsidies. According to the International Energy Agency (IEA), Iran is the world's largest subsidizer of energy, spending over US$ 55 billion a year. Low energy price on one hand, leaded on high and inefficient consumption without any attention to the amount of energy consumed, and on the other hand, this low cost intensifies the consuming habits of the people that cause more energy use. Also, as the energy prices are well below those of most neighboring countries, the subsidy system has encouraged smuggling of fuel products. Drawing on the international experience, energy price liberalization in Iran should include all primary energy prices as well as electricity prices. In recent years the government is doing measures with the aim of eliminating energy subsidies by 2020. There is a rising global attention to co-optimization of Enhanced Oil Recovery (EOR) and CO2 sequestration. Enhanced oil recovery using carbon dioxide (CO2-EOR) is a method that can increase oil production beyond what are typically achievable using conventional recovery methods while facilitating the storage of carbon dioxide (CO2) in the oil reservoir. Synchronization between these two objectives is promising through CO2 Capture and Storage (CCS) projects where CO2 is captured from large emission sources like as power plants and then stored in safe geological structures. Recently, there is a growing interest in Iranian oil industry to utilize CO2 for EOR projects. Before 2020 the increasing price of crude oil coupled with a stable demand and declining production, has made CO2-EOR and storage a favorable option.



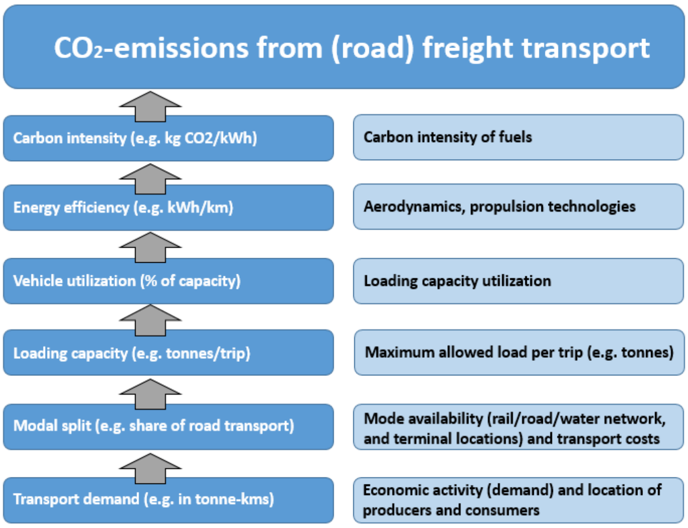
Turkey is a major economy which straddles Europe and Asia. It is the world's 20th largest emitter of greenhouse gases (GHGs). However, within the UN climate negotiations, it has an unusual position: it is a middle income country with low historic emissions, but it is also among the club of generally developed countries which form the OECD (Organisation for Economic Co-operation and Development). Turkey has also long been criticized for its lack of action on climate change. This is another barrier to EU entry as it must align its policies with the bloc to satisfy EU membership conditions. A recent communication from the European Commission noted that Turkey has not yet adopted a national strategy consistent with the EU's 2030 climate and energy framework. Turkey is one of only a few countries – and the largest emitter – which does not sit in any of the formal negotiating blocs at the international climate talks overseen by the United Nations Framework Convention on Climate Change. Turkey submitted a climate pledge ("nationally determined contribution", or NDC) to the UNFCCC in 2015, in the lead up to the Paris Agreement being made. Turkey expects its emissions to continue to rise steeply. Its NDC pledge to cut emissions by "up to 21%" by 2030, including LULUCF, compared to a business-as-usual (BAU) scenario. Particularly in Transport sector Turkey contributed the following measures for decarbonization and GHG emission volumes reduction: (a) Ensuring balanced utilization of transport modes in freight and passenger transport by reducing the share of road transport and increasing the share of maritime and rail transport; (b) Enhancing combined transport; (c) Implementing sustainable transport approaches in urban areas; (d) Promoting alternative fuels and clean vehicles; (e) Reducing fuel consumption and emissions of road transport with National Intelligent Transport Systems Strategy Document (2014-2023) and its Action Plan (2014-2016); (f) Realizing high speed railway projects; (g) Increasing urban railway systems; (h) Achieving fuel savings by tunnel projects; (i) Scraping of old vehicles from traffic; (j) Implementing green port and green airport projects to ensure energy efficiency; (k) Implementing special consumption tax exemptions for maritime transport.



Azerbaijan participated to The ITF's Decarbonizing Transport in Emerging Economies (DTEE) project helps governments of emerging nations (Argentina, Azerbaijan, India and Morocco) to identify ways to reduce their transport CO2 emissions and meet their climate goals. Azerbaijan is expected to develop country-specific policy and scenarios will help the participating them to implement ambitious CO_2-reduction initiatives for their transport sectors. The four participating countries represent a wide range of challenges for the decarbonization of transport in emerging economies. They differ with regard to world region, economic specificities and infrastructure characteristics. They share similarities in that all four have lower transport CO_2 emissions per capita than the OECD average, but higher growth rates of transport activity. In all of them, meeting increasing transport demand while reducing CO_2 emissions is a critical challenge for policy makers. The Azerbaijan authorities aim to mitigate 35% of total emissions by 2030 compared to the base year 1990. Transport is one of the focal areas for mitigation efforts. Transport is the biggest CO2-emitting sector in the country, accounting for around 25% of total fuel combustion emissions. Transport CO2 emissions per capita have more than doubled in recent years, from 0.26 tons CO2eq per inhabitant in the year 2000 to 0.54 CO2eq in 2010. Projections see a continued rise transport activity in Azerbaijan. Freight and passenger transport volumes will see annual increases of 3% between 2015 and 2030 according to estimates by the ITF. This is above the OECD average projected for the same period. The challenge for Azerbaijan's transport sector is to keep CO2 emissions in check while rapidly enhancing its transport infrastructure network. Azerbaijan aspires to become a major regional transport hub for East-West trade, and Azerbaijan's authorities are developing the transport services and the logistical centers to meet this goal. Enhanced transport infrastructure is also necessary to meet the growing demand for passenger transport in the country. Between 2007 and 2017, the number of passengers using urban transport increased by almost 30%. Azerbaijan has stressed the importance of environmentally friendly forms of transport. These include: introduction of electric vehicles for public transportation; electrification of railway lines; improved transport management system; better metro transport (e.g. increasing metro stations); elimination of traffic congestions by constructing road junctions; and construction of underground and surface pedestrian crossings (GoA, 2015). Under the project "Baku Sustainable Urban Transport Investment Program", the ADB, the Ministry of Transport and the Baku Metro Company worked together to improve its urban transport system and provide technical and financial support to upgrade the urban infrastructure in Baku and strengthen the urban transport sector. Tasks included: (i) assessing all major features of urban transport system of the city, and formulating a Sustainable Urban Transport Sector Roadmap; (ii) developing a Policy and Reform Framework, amongst others (ADB, 2012). The ADB also committed to supporting a project "Second Road Network Programme" that aims to contribute to eliminating traffic congestions and increasing efficiency in transport for freight and passengers. While few projects related to climate action in the sector have been identified, it should be noted that Azerbaijan allocated a significant amount of domestic funding to the 16 development of the transport sector, including USD 8.5 billion in 2008, and another USD 2 billion in 2010. Nonetheless, the majority of the funding went into the development of highway infrastructure, which was not climate-related. In 2018 State Oil Company of Azerbaijan Republic (SOCAR) initiated project to facilities with energy-saving equipment and environmentally friendly appliances. Energy consumption fall by 35 per cent and expect CO2 emissions to drop by 200 tons per year, the equivalent of taking 30 cars off the road. This effort also showcases how transport can be more environmentally friendly. In 2018, energy-efficient driving techniques and cars that transform energy from fuel combustion into electric energy were introduced at SOCAR.



Both passenger cars and freight transport by road are significant causes of CO2-emissions in the **Nordic countries**. While for passenger cars, policy measures aimed at reducing CO2-emissions have started to sort effect, this is much less the case for freight transport. This poses a challenge in light of the ambitious climate objectives to which both the EU and the Nordic countries have committed, and resulted in a call by the Nordic Council of Ministers. Although the Nordic countries vary in the degree to which climate objectives are translated from the economy as a whole to the transport sector, it is clear that transport is counted upon to contribute to significant CO2-reductions in both the medium-term (2030) and the long-term (2050 and beyond). Sweden and Finland have for example set ambitious objectives through official statements, aiming at 70% and 50% reductions in CO2-emissions by 2030, compared to 2010 and 2005 respectively, while Norway wants the transport sector to contribute a "sufficient share" in light of the Paris Agreement and Norway's objective of reducing non-ETS CO2-emissions with 40% by 2030, compared to 2005. Although climate commitments with a focus on freight transport are less concrete, e.g. Norway's National Transport Plan includes ambitious objectives for the future share of alternative propulsion systems in new freight vehicle sales, whereas this is not the case for the other countries. For the longer-term however, all Nordic countries have a Climate Change Act, outlining a set of climate objectives towards 2050. Common for these Acts is the objective to turn the countries into lower emission societies by 2045 (Sweden) and beyond 2050. Cooperation on regional bases demonstrates great role of locomotive economies in CO2 emission reduction.



7. Recommendations for GHG emission reduction in Armenia

To develop effective and viable GHG emission mitigation policy and practice measures the following macroeconomic estimations and forecast inputs should be considered, based on available actual figures:

Armenia's Nominal GDP Per Capita is forecasted to be 4,759 USD in Dec 2020 as reported by International Monetary Fund. It records an increase from the last reported number of 4,528 USD in Dec 2019. Looking ahead, Armenia's Nominal GDP Per Capita is projected to stand at 6,044 USD in Dec 2024[25].

The annual growth rate of the population in Armenia has been wavering on both sides of zero since the turn of the century, gaining numbers just to lose some a few years later leading to little overall change. As of 2019, the population was close to a standstill growing at just 0.09% a year. Net migration is relatively low, yet negative, and the largest contributing factor to the low amount has been the below-average birth rate of 1.61 children being born to the average Armenian woman. The birth rate was even lower in the 1990s, meaning that there are not many people around child-bearing age around at present. That in combination with socio-economic factors have not inspired people to start large families. The decrease in the annual growth rate of Armenia is expected to continue in the coming years, beginning to see a decrease in numbers as soon as the year 2024. Current projections go out to the year 2050 and believe that the net migration will regularly be at least -5,000 annually and the birth rate will remain below the worldwide average, staying close to 1.51, which is not conducive to growth. If these factors remain as expected, the annual growth rate should get down to

[25] CEIC under World Trend Plus's Country Forecast – Table IMF

-0.47% by 2050, and the population of Armenia will be roughly 2,938,679 in 2020, 2,907,463 in 2030, 2,818,399 in 2040 and 2,600,184 by 2050 [26].

In the latest reports, Armenia's Visitor Arrivals recorded 1,894,377.0 persons in the year of Dec 2019. Armenia's Visitor Arrivals grew 14.7 % in Dec 2019, compared with an increase of 10.5 % in the previous year. Armenia's Visitor Arrivals Growth rate data is updated yearly, available from Dec 1996 to Dec 2019. The data reached an all-time high of 173.3 % in Dec 2001 and a record low of -1.0 % in Dec 2015 [27]*. Government of Armenia has developed and approved the 2020-2030 tourism development strategy. The strategy's implementation is expected to ensure an annual 10% average growth of international visits by 2030.*

The residential sector was the largest energy consumer in 2013, responsible for one-third of the final energy consumption. The second biggest consumer was the transport sector (25%), followed by industry (17%). A recent report by USAID [28] *projects that in 2036 the respective sectors' shares will grow to 45.6% for the residential sector, 29.8% for industry and 21.1% for the commercial sector.*

Number of road vehicles was doubled since 2007 especially from import of used vehicles. During the same period average age of road vehicle grown up from 13.2 to 16.7 years. Before 1 January 2020 the grace period for national taxation for road vehicle import applies, supporting used vehicles import to Armenia. During the translation period from 2018 to 2019 more than 200000 used vehicles was delivered to Armenia and only small part was exported to different countries, increasing vehicles per capita rate in Armenia form 96 (in year 2007) up to 200 (in year 2019). Legislation on electric cars comes to force in the second half of 2019 exempts imported electric cars from VAT which brings a huge difference comparing the import figures of electric vehicles of the same period of 2018. However, luck of charging stations all over Armenia as well as because of electric vehicles (EV) are significantly more expensive in compare to conventional, internal combustion engine (ICE) vehicle, as well as relatively limited daily driving distances and competitive prices for gasoline and diesel do not support EV mass sales in Armenia. More than 80% of road vehicle fleet with ICE operated with compressed natural gas (CNG). Due to the poor quality of diesel is more typical for HDV in Armenia.

Mobility demand rate remains very high in Armenia and demonstrates significant growing tendency during last decade. According to statistics published by the Statistical Committee on February 5, 2020, the number of tourists arriving in Armenia has increased by about 1 million 300 thousand over the ten years from 2009-2019. In 2009, about 587 thousand tourists came to Armenia, and in 2019, the number of tourists reached 1.9 million. Nearly half of the tourists in Armenia are attracted to cultural tourism, 19% come to see the nature of Armenia, 16% come for leisure. Business, adventure and health tourism are preferred by 13 percent, and 3 percent come to Armenia for long-term tourism.

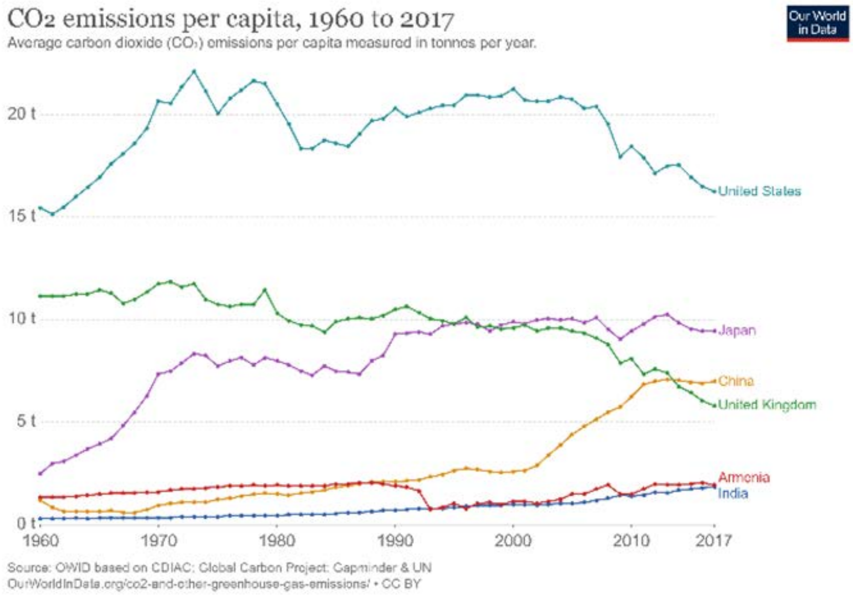
[26] The 2019 Revision of World Population. Population Division of the Department of Economic and Social Affairs of the United Nations.
[27] CEIC Data based on report from Statistical Committee of the Republic of Armenia
[28] Armenia Least-cost Energy Development Plan, USAID LEDS, 2015

MAIN INDICATORS OF GENERAL PURPOSE TRANSPORT	2014	2015	2016	2017	2018	2019
Freights shipped, 1000 t, including:	**10,157.60**	**11,052.60**	**20,483.80**	**28,133.10**	**29,182.90**	
by railroad lines	3,057.60	2,531.70	2,610.90	2,640.00	2,880.30	
by motor vehicles	5,384.00	6,864.90	16,248.80	23,683.90	24,519.00	
by air transport	10.40	10.20	18.30	22.40	18.10	
by pipeline	1,705.60	1,645.80	1,605.80	1,786.80	1,765.50	
Freight turnover, mln. tons-km, including:	**4,232.70**	**3,746.00**	**3,881.20**	**4,249.60**	**4,382.80**	
railroad lines	786.10	640.30	657.70	689.50	731.80	
motor vehicles	726.40	479.40	675.90	725.10	850.00	
air transport	2.00	-	0.00	0.20	0.10	
trunk pipeline	2,718.20	2,626.30	2,547.60	2,834.80	2,800.90	
Passengers carried, mln. passengers	**225.80**	**208.90**	**206.30**	**200.50**	**186.50**	
by railroad lines	0.40	0.40	0.40	0.40	0.40	
by motor vehicles	201.90	185.30	182.60	175.70	159.00	
of which: by pessenger taxi	12.80	10.30	8.70	7.70	6.70	
by air transport	2.10	1.90	2.10	2.60	2.90	
by trolley-bus	5.40	5.30	5.70	5.30	5.20	
by underground lines	15.80	15.80	15.30	16.20	18.50	
by rope-ways	0.20	0.20	0.20	0.30	0.50	
Passengers turnover, mln, including:	**3,008.50**	**2,525.00**	**2,597.70**	**2,665.50**	**2,504.10**	
railroad lines	51.00	44.30	49.70	55.40	59.90	
motor vehicles	2,535.60	2,395.90	2,436.50	2,403.40	2,227.50	
of which: by pessenger taxi	114.70	88.30	71.20	66.70	83.90	
air transport	336.00	-	27.40	119.70	121.20	
trolley-bus	24.00	23.80	25.00	24.00	23.50	
underground lines	60.10	60.00	58.20	61.50	70.20	
rope-ways	0.90	1.00	0.90	1.50	1.80	

Stretching over 550 kilometers, the North-South Road Corridor is one of Armenia's most strategic pieces of infrastructure. It will extend the trans-European transport network and connect the full length of Armenia, from Iran to Georgia and beyond. This high-capacity highway will drive Armenia's economic growth and integration with the world. Most of Armenia's imports and exports are transported by roads; improving travel times and reducing costs means lower prices and greater competitiveness, however will contribute to significant increase of volume of road traffic, with negatively effect on GHG emission pattern in Armenia.

Inefficient urban and rural public transport infrastructure, together with cost attractive taxi services as well as different shared transportation schemas are facilitating growing demand for personal car use in Armenia. This demand is also stimulated by cultural aspects. Armenia is a typical mountainous country. About 90% of its territory is over 1000m above sea level, including 40% - over 2000m. Average height of territory makes 1830m, the highest - 4090m, the lowest - 350m. Geographical situation of Armenia, complex mountain relief and high-altitude zoning of territory, together with dry highland climate, accompanied with poor urban adaptation for cycling do not support modal shifting in Armenian transportation.

In 2018, CO2 emissions per capita for Armenia was 1.97 metric tons. Though Armenia CO2 emissions per capita fluctuated substantially in recent years, it tended to increase through 1999 - 2018 period ending at 1.97 metric tons in 2018. In its Intended Nationally Determined Contribution (INDC), Armenia describes its approach to establishing a level of GHG emissions of 633 MtCO2e that it will not exceed during the period 2015-2050. This is based on Armenia's estimate of 1990 global average emissions of 189 tons per capita, multiplied by Armenia's 1990 population of 3.35 million. The INDC notes Armenia's 2010 GHG emissions of 2.14 tons per capita. It also states that Armenia will strive to achieve GHG emissions of 2.07 tons of CO2e/capita per year in 2050 if it receives adequate international financial, technological and capacity-building assistance. If Armenia's emissions do not exceed 633 MtCO2e or average annual emissions of 5.4 tons of CO2e/capita, the INDC asserts that Armenia can credit its non-utilized reduction to the carbon market or transfer it to the balance of emissions limitation envisaged for the period of 2050-2100. GHG mitigation will be mainly from renewable energy and energy efficiency, development of electrical transport, urban development (buildings and construction), IP (construction materials and chemical production), waste management, and afforestation, forest protection, and carbon storage in soil [29].



Transport accounted for around 20% of carbon emissions in 2018, which cannot be ignored in terms of global greenhouse gas (GHG) emissions and climate change. Although it might seem GHG emissions from Armenia transport sector are below world average reasonable and effective measures for GHG emission reduction from transport now could be less stressing for Armenian economy. In the transport sector, light-duty passenger vehicles are the major contributor to transport-related GHG emissions. With levels of urbanization and motorization increasing rapidly, carbon emitted in the transport sector, especially passenger traffic, is projected to keep growing. Without the implementation of aggressive and sustained policy interventions, transport-related GHG emissions could increase at a faster rate than emissions from the energy end-use sectors, with the potential to double by 2050. Because the continuing growth in traffic activities could outweigh all mitigation measures unless transport emissions can be strongly decoupled from gross domestic product (GDP) growth, decarbonizing the transport sector will be more challenging than for other sectors. It has been proposed that transport-related GHG emissions are bound up with economic development, technological change, travel behavior, transport policy, and energy efficiency improvements. Therefore, the key factors influencing global passenger transport, including travel mode and technological details, need to be taken into account to estimate long-term transport-related GHG

[29] Republic of Armenia. Armenia's Intended Nationally Determined Contribution (INDC) to the UNFCCC, 2015.

emission pathways. Success of transport decarbonization initiatives directly influenced by how easy Armenia may access to the soft financing instruments as well as level of regional and international cooperation and collaboration within the global frameworks and initiatives.

Based on results of investigation as well as considering best international practices The following measures reflects potential for GHG emission reduction in Armenia (as per their priorities and estimated positive impact):

7.1. System infrastructure and modal choice

Public Transportation - Creation of multimodal urban and rural transportation infrastructure based on integrated concept with implementation of smart transportation technologies and solutions, focusing on fleet operation on GHG emission reduction friendly technologies as Compressed Natural Gas and Electric power. Dedicated bus lanes, possibly in combination with a vehicle access charge for LDVs, can be strong instruments to achieving rapid shifts to public transport.

Multimodal chains - Move toward sustainable transportation and create positive change in order to improve the quality of life for the people of Armenia. A key component of sustainable transportation is to conceptualize, plan and create specialized hubs i.e. a new Government Hub, the International Airport Transport Hub and a Yerevan City Center Hub, and define or create new linkages and interconnectedness as the basis for an innovative, sustainable transport system. Creating transport chains together with the improvement of transportation quality should be considered as a key driver for modal shift by public transport displacing private motor vehicle use.

Urban planning - Urban planning as an effective instrument for environment friendly model by reducing private motor vehicle use through parking and traffic restraint. Immediate impacts on traffic density observed. Significant reductions only where quality transport alternatives are available, as a result could be implemented as a policy measure in parallel to improvement and creation of sustainable countrywide transport structure.

Modal Shift - Construction of new railroad in the Southern regions of Armenia which leads towards Iran, building the 305-kilometer-long Armenian section of the railway to connect to Iran railway to operate as a shortest way connecting Persian Gulf with the Black Sea. Rail freight plays a crucial role in supporting transit of goods across the country. Without more rail freight services will be complicated to meet CO_2, air pollution reduction and productivity targets.

7.2. Fuel carbon intensity

Biofuels - Armenia to introduce long term taxation and regulation policy to reduce pollution by imposing a tax on pollution-causing activities. Biofuels (liquid or gaseous transport fuels such as biodiesel and bioethanol) made from biomass as a renewable alternative to fossil fuels for transport sector, helping to reduce greenhouse gas emissions and improve the Armenia security of supply. Policy must contribute percentage of replacement of fossil fuel by pure biofuels within next decade as well as facilitation of gradual increase of pure, blended (10-20%) liquid and gaseous fuel in transport sector of Armenia. By 2030, Armenia aims to have 10% of the transport fuel produced from renewable sources such as biofuels or blend liquid fuels. Taxes on pollution are preferable to mandates for additional fuel, because this allows market effects to work in the right direction, namely by increasing the price of pollution-causing activities, which decreases demand, rather than the wrong direction by lowering fuel prices and increasing demand. Mandates are more politically palatable than taxes because mandates offer concentrated benefits to a small group of low-carbon fuel suppliers in the short term, while taxes require concentrated costs and offer diffuse benefits to society over the long term. In the case of biofuels, mandates are unlikely to reduce GHG emissions unless there is a radical breakthrough in technology that greatly lowers their carbon intensity.

		Drive train/Fuel	GHG reduction (%)	Barriers
ICE	Fossil fuel	Gasoline (2010)	12-16	
		Diesel	16-24	Emissions (NO_x, PM)
		CNG	15-25	Infrastructure, storage
		G-HEV	20-52	Cost, battery
		D-HEV	29-57	Cost
	Biofuel	Ethanol-Cereal	30-65	Cost, availability (biomass, land), competition with food
		Ethanol-Sugar	79-87	
		Biodiesel	47-78	
		Advanced biofuel (cellulosic ethanol)	70-95	Technology, cost, environmental impact, competition with usage of other sectors
	H_2	H_2-ICE	6-16	H2 storage, cost / Cost, infrastructure, deregulation
FCV		FCEV	43-59	
		FCEV+H_2ccs	78-86	Technology (stack, storage), cost, durability
		FCEV+RE-H_2	89-99	

Reduction of Well-to-wheels GHG emissions for various drive train/fuel combinations

Electric Vehicles - Incentives have historically been important for the introduction of alternative fuel vehicles, but are also crucial for the adoption of EVs as such purchases are considered risky, unfamiliar and expensive compared to ICEVs. Armenia may introduce additional incentives for electric and hybrid vehicles to increase number of climate friendly fleet within next decades. Together with current VAT exemption law, effective form 2019, new introduced incentive will support to decrease gradually cost or ownership by deducting property tax up to 80% within 5 years of continues operation for pure Electric Vehicles and up to 60% within 10 years for Hybrid Vehicles. As an additional incentive for promoting electric vehicle culture in Armenia free parking on municipal public parking for EVs and hydrogen cars could be introduced. Sectoral incentives could be introduced for pure electric HDV vehicles, operating mining sector in Armenia, as well as for tourism sector by withholding property and environmental tax.

7.3. Energy intensity

Railways - traction energy absorbed from the power supply system is mainly consumed at the auxiliary system, overcoming the resistance, traction loss and the braking loss. For most rail systems, the train's kinetic energy can be converted back to electric energy when trains apply regenerative braking or powered by reversible substations. The part of regenerative energy can be reused by itself, stored in on-board energy storage systems or be transmitted backwards to the overhead catenary or the third rail and utilized by other trains, i.e., the regenerative energy could be reused in the systems. Armenia must develop and approve long-term strategy for reduction of energy consumption in rail transport (railways and metro), covering two main directions (a)cutting down the losses and (b) increasing the reused regenerative energy. For any capital investment ensured by rail transport extended depreciation period may apply to support climate friendly traction in Armenia (Regenerative brake, Reversible substation, On board HVAC[30]). Clear progressive targets for energy efficiency and CO_2 reductions in rail systems should be approved.

Engine type incentive - Average fuel consumption and CO_2 emission by a motor car depended on its engine displacement. Due to the mountain relief, property and environment tax policies as well as symbolic function of status large engine displacement vehicles are much appreciated in Armenia. Progressive property and environmental tax legislation do not facilitate small to medium engine size displacement. Technology oriented incentive may facilitate smaller engine displacement in Armenia resulting better performance with lower CO_2 emission. Providing 50% extra incentive on road vehicles with turbo engines should be considered as a short-term and very effective measure for mitigation of GHG emission from Armenian transport sector.

Eco-Tires - Tires account for 20-30 % of a vehicle's fuel consumption, largely due to their rolling resistance, so energy savings in this area can make a considerable difference to the headline goal of CO_2 emission reduction and fuel efficiency for all types of road vehicles. The development of incentives and legislative initiatives facilitating import and driving road vehicles with the tires with low rolling resistance or high fuel efficiency class should be considered.

7.4. Activity and Behavioral Issues

Eco-Driving - Fuel consumption of vehicles can be reduced through changes in driving practices. Fuel-efficient driving practices, with conventional combustion vehicles, include smoother deceleration and acceleration, keeping engine revolutions low, shutting off the engine when idling, reducing maximum speeds and maintaining proper tire pressure. Results from best practices possible improvement of 5–20% in fuel economy from eco-driving training might be expected. The mitigation costs of CO_2 by eco-driving training were mostly estimated to be negative. Eco-driving training can be attained with formal training programs or on-board technology aids. It applies to drivers of all types of vehicles, from minicars to heavy-duty trucks. The major challenge is how to motivate drivers to participate in the program, and how to make drivers maintain an efficient driving style long after participating. As an initial stage eco-driving training must be provided as part of driving school curricula in Armenia.

[30] Heating, Ventilating and Air Conditioning, mainly for passenger railway fleet

7.5. Cooperation Frameworks

Regional cooperation between the countries of Caucasus region is currently of particular importance not only for the development of mitigation policy and CO2 emission reduction development of all countries, but also on a larger scale, including Russia and other countries in region. At the level of international platform as The Eastern Partnership (EaP) a joint policy initiative which aims to deepen and strengthen relations between the European Union (EU), its Member States and its six Eastern neighbors: Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine, demonstrates the potential in a wider context to support delivery on key global policy goals set by the **UN 2030 Sustainable Development Goals** and the **Paris Agreement on Climate Change**. That covers infrastructure planning and helps attract and make good use of financial instruments, knowledge and experience that will support and facilitate closer cooperation in terms of global climate change and mitigation policies. Regional cooperation opportunities in the area are not limited by EaP framework should be extended also to the framework of Armenia other political and economic alliances as Eurasian Economic Union (EEU). The existing cooperation in the area of infrastructure development should be extended to joint action in the area of developing energy efficiency and RE, e.g. decarbonization of the transport sector and use of renewable energy (RE) (e.g. electricity and biofuels) in transport, as these are challenging issues for all countries in Caucasus region. Furthermore, when developing long-term energy policy plans, e.g. for 2030 and beyond, there should be a possibility for mutual exchange of experience and knowledge, which would help choose the most suitable tools and actions for reaching specific goals. The priority should be to transfer and share knowledge about the reduction of carbon emissions and promotion of energy efficiency.

8. Monitoring and Reporting

In order to ensure appropriate implementation of mitigation policies and incentives it is necessary to establish an efficient monitoring and reporting system in Armenia that lays down the authorities responsible for ensuring compliance with the monitoring and reporting obligations as well as the procedure for data and information exchange to avoid repeated collection and assessment of data and information that is already available.

State authority should be appointed currently to include provisions for assessing the progress achieved in meeting GHG emission and CO2 removal targets and biannual reports on the progress — report on the progress, measures and projections — as well as provide for the national system for the greenhouse gas inventory and the national system for preparing greenhouse gas projections. In order to ensure appropriate implementation of the integrated monitoring and reporting system, it is necessary to designate a single direct state administration authority — a competent authority subordinated to the Government that will perform the monitoring and collect and analyses the data and information required. Since monitoring and reporting data have to be completely coordinated in all the dimensions, the respective authority should also provide monitoring and reporting functions with regard to GHG emissions and CO2 removals. Whereas if the respective authority will not be able to ensure monitoring of certain data or if such monitoring is already being carried out, the authority will receive, process, and include these data in the integrated report. If there is no such authority with specific competence and expert knowledge at the time of developing and approving mitigation plan, it is necessary to extend the scope of obligations and capacity of an existing authority. Establishment and implementation of the integrated monitoring and reporting system will require additional financial resources, and attraction of financing from international sources is possible for this purpose. To minimize the impact on the state budget and avoid establishing new authorities, it is possible to designate an authority subordinated to the Government as the competent authority for performing the functions of the integrated monitoring and reporting system.

The ArmStat [31] is proposed to be the entity, which would provide most of the data needed for inventory purposes. If needed, other entities such as industry associations can be a good source of data that are not reported to the ArmStat. Currently, the ArmStat collects many of the data relevant for the preparation of GHG inventory. However, some data are not collected or are not in the proper format needed for inventory purposes. Therefore, modification of data collection templates will be needed and capacity building of the ArmStat personnel involved in data collection is important. Given the fact that data is already collected by the ArmStat from different ministries, building on the existing system would be more cost effective than establishment of a new data collection system. Data that is collected by the ArmStat should be subject to quality control procedures by all departments involved in data collection. A quality control plan should be developed and made mandatory for all departments to follow. All data used for inventory purposes should be validated and checked.

Different ministries/entities implementing mitigation and adaptation activities are proposed to be the providers for data required to monitor such actions. This is a dynamic process as new entities are always added whenever a mitigation or adaptation action on a national or sectoral level is implemented. Ongoing capacity building should be offered to such entities to be able to collect the required data and perform any required analysis before submitting the data to the coordinating entity.

[31] Statistical Committee of the Republic of Armenia

9. Conclusions

In order for the Armenia to reach CO2-emission reduction targets in the years to come, a strong trend change is needed. This report pinpoints that it is obvious that changes must come from within several areas. The policy review shows that it is difficult to achieve a greater reduction in transport demand. The average GHG reduction potential of freight transport modal shift is higher than that of passenger transport, since the difference in emissions per unit of volume are higher for freight. However, for Armenia modal shifting on passenger transportation form road vehicle to public carries the potential for CO2 emission reduction as well as for health. The same applies to the extent to which authorities can influence the utilization of vehicles, unless physical framework conditions such as vehicle length and maximum permissible total weight, are increased. The latter instrument will, however, improve the competitiveness of road compared to rail transport, which in turn could lead to more goods being transferred from rail to road transport. Therefore, in order to achieve estimated emission reduction targets, it is clear that a technological change is necessary. This change may in part come from increased use of lower-carbon fuels, such as biodiesel, biogas, and bio-ethanol. Although there is still a potential to expand the supply of biofuels, the availability (and often price) of such biofuels is expected to remain a bottleneck, as demand will likely materially outweigh supply, particularly for advanced biofuels. Remaining CO2-reductions will therefore have to come from vehicles with low- or zero-emission propulsion technologies. Currently, such vehicles are expensive, and only available to a limited extent on the market. Particularly for heavier trucks, the few currently available trucks are rebuilt versions of combustion engine vehicles, to electric powertrains. To achieve a change of trend, alternative solutions have to be attractive and cost effective compared to today's transport solutions. Of the abovementioned policy measures, it is primarily only increased vehicle dimensions that provide a cost-incentive in itself. For all other measures, incentives are needed, at least in an early phase. This applies both to freight transfers through modal shifts, but also to low-carbon fuels or alternative propulsion systems. For vehicles using either lower-carbon fuels or alternative propulsion systems, there is currently an additional cost element that is either distance-dependent (biofuels) and/or time-dependent, as investment costs for alternative propulsion vehicles are much higher than corresponding vehicles with internal combustion engines.

Efficiency measures in the transport sector can be more cost effective than some measures in other sectors, if measures altering behavior of consumers are taken into account. Fuel savings typically compensate part of, or even all, additional costs. There exists a range of cheap technological options to increase fuel efficiency, but these options are limited in scope and their costs tend to increase sharply beyond a certain threshold. Behavioral changes are, however, difficult to enforce through environmental policies. The role of the price mechanism is limited as price elasticities tend to be a factor 1.5 to 3 lower than the income elasticities of demand.

Long term, clear whole life cycle targets and measures, aligned with technology pathways that can be applied across the transport sector are imperative to successful reduction of road transport CO2. However, public behavior and attitudes must be influenced appropriately, and any reduction of utility or increases in cost which may occur due to new technologies must be compensated for so mobility is not unfairly compromised.

References

1. Technologies for Climate Change Mitigation; Transport Sector; UNEP Risø Centre on Energy, Climate and Sustainable Development, DTU National Laboratory for Sustainable Energy, Denmark.
2. IPCC. AR5 Climate Change 2014: Mitigation of Climate Change; Transport
3. CO EMISSION STANDARDS FOR PASSENGER CARS AND LIGHT-COMMERCIAL VEHICLES IN THE EUROPEAN UNION. INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION. 2019
4. Low-emission Development Strategies and Nationally Appropriate Mitigation Actions: Eastern Europe and CIS. UNDP, 2010
5. Road transport and CO2 emissions: What are the challenges? Georgina Santos, School of Geography and Planning, Cardiff University, King Edward VII Avenue, CF10 3WA, United Kingdom, 2017
6. Transport-related CO2 Emissions of the Tourism Sector – Modelling Results, World Tourism Organization (UNWTO) and International Transport Forum (ITF), 2019
7. Balancing Tourism's Economic Benefit and CO2 Emissions: An Insight from Input–Output and Tourism Satellite Account Analysis, School of Economics and Management, Beihang University, Beijing, China; 2019
8. CO2 emissions from cars: The facts; Transport & Environment; European Federation for Transport and Environment AISBL. 2019
9. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A Roadmap for moving to a competitive low carbon economy in 2050. COM (2011) 112 final
10. An Empirical Study of the Relationships between CO2 Emissions, Economic Growth and Openness. Discussion Paper No. 5304. Institute for the Study of Labor (IZA); 2010
11. EBRD Transport Sector Strategy (2019-2024) As approved by the Board of Directors on 30 October 2019
12. Reducing Carbon Emissions from Transport Projects. Evaluation Study. Asian Development Bank. 2010
13. Global Transportation Demand Development with Impacts on the Energy Demand and Greenhouse Gas Emissions in a Climate-Constrained World. School of Energy Systems, LUT University, Finland; 2019
14. Energy, transport and environment statistics 2019 edition. Eurostat. 2019
15. Global Energy and CO2 Status Report 2018; International Energy Agency; IEA 2019
16. Reducing CO2 emissions from road transport in the European Union: An evaluation of policy options. INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION; WORKING PAPER 2016
17. IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
18. Overview of transport infrastructure expenditures and costs; Delft, CE Delft; Within the project "Sustainable Transport Infrastructure Charging and Internalization of Transport Externalities"; 2019.
19. TRENDS IN GLOBAL CO2 AND TOTAL GREENHOUSE GAS EMISSIONS 2018 Report; PBL Netherlands Environmental Assessment Agency; 2018
20. REDUCING FUEL CONSUMPTION AND CO2 EMISSION IN MOTOR CARS; ISSN 1648-4142 print / ISSN 1648-3480; TRANSPORT – 2007, Vol XXII, No 3, 160–163; 2007
21. Success stories within the road transport sector on reducing greenhouse gas emission and producing ancillary benefits; EEA Technical Report No 2/2008.

22. Smart Transportation CO2 Emission Reduction Strategies; S Tarulescu et al 2017 IOP Conf. Ser.: Mater. Sci. Eng. 252 012051; Transilvania University of Brasov, Romania; 2017
23. Reducing CO2 emissions from freight; Recent developments in freight transport in the Nordic countries and instruments for CO2 reductions; Nordic Council of Ministers; 2018.
24. CO2 reduction costs and benefits in transport: socio-technical scenarios. Heikki Liimatainen, Markus Pöllänen, Riku Viri; European Journal of Futures Research volume 6, Article number: 22 (2018).
25. NATIONAL ENERGY AND CLIMATE PLAN OF LATVIA 2021–2030; DRAFT FOR SUBMITTING TO THE EUROPEAN COMMISSION FOR EVALUATION; 2018
26. Transport & Environment; Emission Reduction Strategies for the Transport Sector in Italy. Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); 2019
27. Georgia’s Second Biennial Update Report; Ministry of Environmental Protection and Agriculture of Georgia; 2019.
28. REGIONAL HUB FOR CAR TRADE Georgia’s Auto Business Sector; Galt & Taggart Research; Georgia 2019
29. CO2 reduction costs and benefits in transport: socio-technical scenarios; European Journal of Futures Research; Heikki Liimatainen, Markus Pöllänen; Riku Viri; 2018
30. THE LOW-CARBON DEVELOPMENT STRATEGY OF CYPRUS to 2050; Ministry of Agriculture, Natural Resources and Environment; 2014.
31. Land Transport and CO2 Emissions in Cyprus: Smart Decarbonization Strategies for Climate Change Mitigation; E. Giannakis1, D. Serghides1, S. Dimitriou1, G. Zittis; The Cyprus Institute, Energy Environment and Water Research Center, Cyprus; 2018.
32. 7th National Communication and 3rd Biennial report under the UNFCCC of Cyprus; 2018.
33. Yerevan Green City Action Plan; City of Yerevan by an international team of experts led by Ernst & Young, s.r.o. (Czech Republic). Other members of the consortium included GEOtest, SWECO, SEVEn and local experts; 2017.
34. Transport and Communications; Statistical Yearbook of Armenia 2019; Statistical Committee of the Republic of Armenia; 2019
35. COUNTRY PARTNERSHIP FRAMEWORK FOR THE REPUBLIC OF ARMENIA FOR THE PERIOD FY19–FY23; The World Bank Group; 2019.
36. IMPROVING THE SUSTAINABILITY OF ROAD MANAGEMENT AND FINANCING IN ARMENIA; THE WORLD BANK; Report No. 66533-AM; 2011
37. Logistics Processes and Motorways of the Sea II; LOGMOS Master Plan – Annex 9.1 Country Profile/Armenia; Egis International / Dornier Consulting; 2013.
38. Long Term Variability of Temperature in Armenia in the Context of Climate Change; World Academy of Science, Engineering and Technology International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering Vol:10, No:1, 2016.
39. Intended Nationally Determined Contribution of the Republic of Armenia under the UN Climate Change Framework Convention; Protocol Decision No 41, Government of the Republic of Armenia; 2015.
40. Armenia’s Second Biennial Update Report on Climate Change; Ministry of Nature Protection of the Republic of Armenia; 2018.
41. Armenia Development Strategy for 2014-2025; RA Government Decree # 442-N; 2014.
42. Armenia’s Transport Outlook Transport Sector Master Plan; TRANSPORT AND COMMUNICATIONS; Asian Development Bank; 2011.
43. Armenia: Transport and Trade Facilitation Strategy 2020-2040; Inception Report; Asian Development Bank; 2020.
44. GHG National Inventory Report of the Republic of Armenia is prepared under coordination of the Ministry of Nature Protection of RA; 2017.
45. Annual Reports and Statistics. Armenian Motor Insurers Bureau. Armenia. 2020

46. Online resources and visualization:

https://www.wri.org/climate/expert-perspective/marching-toward-2050-purpose-and-elements-long-term-low-greenhouse-gas

https://www.nature.com/articles/s41558-019-0442-8

https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions

https://tradingeconomics.com/armenia/gdp-growth-annual

https://www.statista.com/statistics/242204/energy-related-global-co2-emissions-by-fuel/

https://www.wri.org/blog/2020/02/greenhouse-gas-emissions-by-country-sector

https://www.eea.europa.eu/themes/climate/eu-greenhouse-gas-inventory/eu-greenhouse-gas-inventory-for

https://www.europarl.europa.eu/news/en/headlines/society/20190313STO31218/co2-emissions-from-cars-facts-and-figures-infographics

https://www.americanprogress.org/issues/green/reports/2017/01/20/296906/policies-to-decarbonize-transportation/

https://link.springer.com/article/10.1186/s40309-018-0151-y

https://www.wri.org/blog/2019/10/everything-you-need-know-about-fastest-growing-source-global-emissions-transport

https://www.iea.org/reports/tracking-transport-2019

https://www.evnreport.com/economy/revitalizing-armenia-s-transport-system

https://www.climatewatchdata.org/ndcs/country/ARM/full?document=ndc-EN

https://armenianweekly.com/2015/06/08/transportation-modes-in-armenia/

https://www.eesi.org/articles/view/carbon-removal-strategies-a-broad-overview

https://publications.iadb.org/publications/english/document/Mitigation-Strategies-and-Accounting-Methods-for-Greenhouse-Gas-Emissions-from-Transportation.pdf

https://www.nationalgeographic.com/environment/2019/09/climate-change-report-card-co2-emissions/

https://www.unwto.org/news/tourisms-carbon-emissions-measured-in-landmark-report-launched-at-cop25

https://www.intechopen.com/books/air-pollution-a-comprehensive-perspective/pollutants-and-greenhouse-gases-emissions-produced-by-tourism-life-cycle-possible-solutions-to-reduc

https://www.sustainabletourism2030.com/ten-ways-to-reduce-the-carbon-footprint-of-your-tourism-business/