MIDDLE EAST AND
NORTH AFRICA

Background Paper

Transport Decarbonization in Morocco

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

Nabil Samir, Marc Navelet, Clotilde Minster, and Nobuhiko Daito, September 2022

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Executive summary

The carbon footprint of transportation (road and rail) in Morocco is significant and multiple decarbonization techniques can help to reduce it. The transport sector produces around 23% of Morocco's greenhouse gas emissions (GHGs) and accounts for approximately 38% of its energy consumption. Under demographic pressure and the unceasing growth in the rate of motorization (particularly in private cars) due to urban sprawl, carbon emissions of the transport sector will tend to increase if proactive solutions are not taken in consideration to address these emissions. Electrification of transport in Morocco as well as the maximized use of renewable energy for electricity production in the country are key measures to tackle the climate change impact of the transport sector.

The shift to electric mobility can reduce drastically carbon emissions and hydrocarbon demand related to the road transport subsector by 2050. Although the market penetration of electric vehicles (EVs) remains low in Morocco, an ongoing World Bank study confirms that the share of EVs could potentially increase to around 30% of the Moroccan stock by 2050. This substantial increase should be in line with major public-private investments in charging stations combined with regulatory, financial incentives and broad government-funded rebates to encourage and promote the adoption of such vehicles. To follow the gradual shift to electric mobility, Morocco will plausibly continue to import a consequential share of its conventional and electric vehicles mostly from Europe to complement the smaller share of local automotive production sold nationally. In addition to that and given the attractiveness of Morocco as a nearshoring location for big automotive players and the development of technical skills of the local workforce, in the mid-term perspective, the country should be able to produce a share of its EVs needs besides exports. The expected shift to EVs in Morocco by 2050 will reduce carbon emissions to approximately 2.6 Mteq CO2 per year (compared to around 30 Mteq CO2 per year emitted by cars in 2050 in the Business-As-Usual scenario). This reduction of GHGs emissions is expected to be accompanied by a reduction of hydrocarbon demand estimated at about 2 billion liters of fuel per year.

Electrification of rail is a necessary measure but not sufficient to have a strong and consequential decarbonization impact of the railway transport subsector in Morocco. Rail is undeniably one of the most energy-efficient transport modes globally and particularly in Morocco. It presents on the one hand a dynamic passenger transport market that is increasing throughout the years and on the other hand a less dynamic freight market dominated by road transport. In order to cope with the low share of the rail transport of freight and to reduce railway activities' carbon footprint, the Moroccan railway company ONCF is committed to extend and upgrade its network to a more sustainable and technologically advanced one through the 2040 Morocco rail plan, the adoption of energy management and quality standards and the use of renewable energy for its activities. Although electrification of rail in Morocco has shown a substantial potential of reduction of carbon emissions thanks to an assessment carried out by the World Bank, the additional shift in freight transport from road to rail and the greener energy supply would have a greater decarbonization impact of this transport subsector, reducing thus the GHGs emissions of the railway sector by almost 10%. This shift in freight transport can be attained by the increase in the capacity of the conventional network, the development of logistics activities, regulation of road freight transport, and opening up the Moroccan railway transport sector to competition.

Introduction

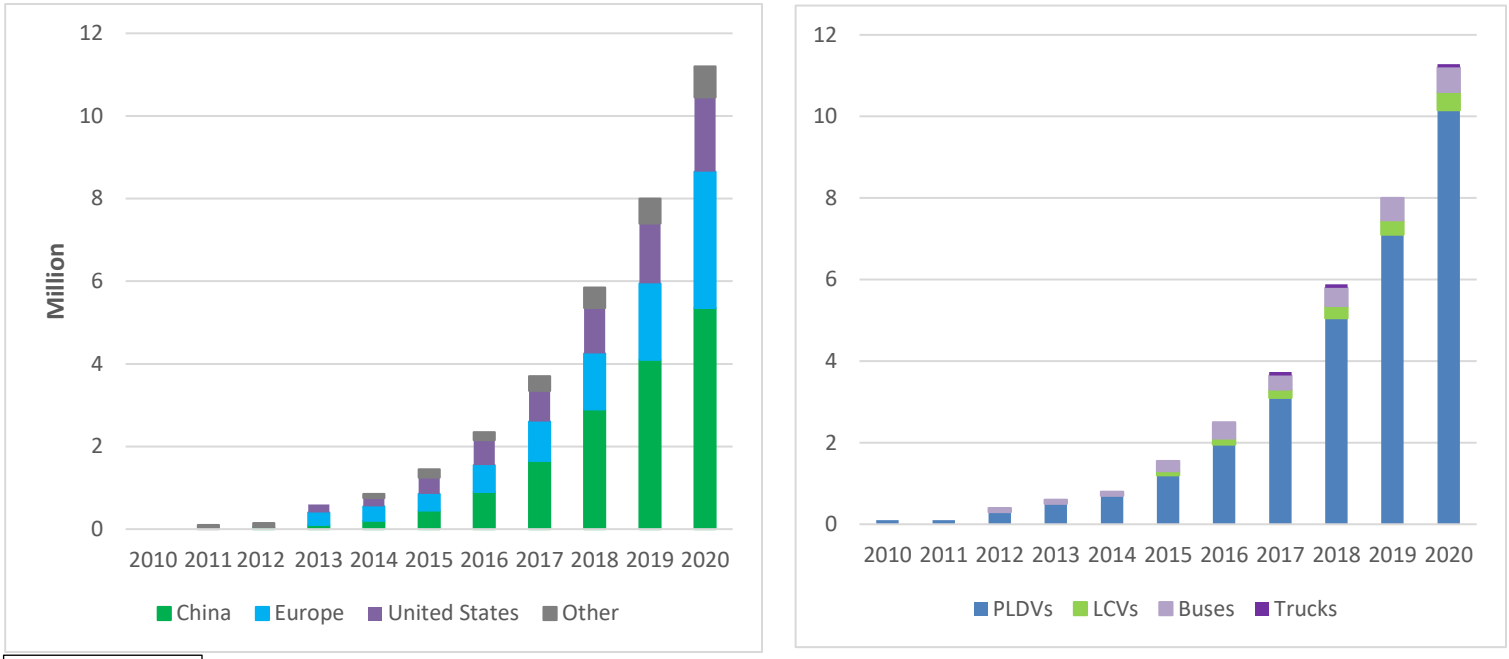
The negative impact of transport in Morocco to climate change is substantial and various decarbonization approaches, including electrification, can contribute to reduce it. The sector accounts for around 38 percent of Morocco's energy consumption (mainly through fossil fuels) and contributes significantly to climate change. It produces around 23 percent of the country's greenhouse gas emissions - GHGs (mainly carbon dioxide - CO2, nitrous oxide - N2O, and methane). Although annual CO2 emissions from this sector are still lower than the majority of middle-income countries at around 15 million metric tons, they are nevertheless increasing at a rapid rate (over 5 percent per year). Most of these emissions are generated in urban areas, with Casablanca accounting for about one-third of national CO2 emissions. Given the current trend of continuous growth in the rate of motorization (particularly of private cars) linked to population growth, rising incomes and the significant increase in travel time due to urban sprawl in most cities, the negative contribution of the transport sector of Morocco to climate change is likely to increase further in the coming decades in the absence of proactive measures. Morocco committed to reducing its GHG emissions in the Paris Agreement, where it submitted its National Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC). The country aims to reduce its GHG emissions by 45.5 percent below business-as-usual (BAU) levels by 2030. Electrification of transport in Morocco, combined with a maximization of the use of renewable energy for electricity generation in the country, can contribute to improving its environmental aspects in general and reduce its climate change impact in particular.

Road transport in Morocco

1.1 Global context

There is a significant global momentum in electric vehicle markets. Given the renewed urgency to tackle climate change challenges and the significant contribution of the transportation sector to greenhouse gas (GHG) emissions (around 23 percent of global GHG emissions), a global shift toward electric mobility has started in recent years. While the level of market penetration of electric vehicles remains low at less than 1 percent in 2020 (IEA, 2021), it has grown by roughly 40 percent annually from 2016 to 2020 across the globe, with Europe being the fastest growing market for EVs in 2020 (IEA, 2021). Electric vehicle sales managed to increase in 2020 by 41 percent despite a 16 percent pandemic-linked reduction in global car sales. About 3 million electric vehicles were sold globally, representing a 4.6 percent share of sales (resulting in a total of 10 million electric vehicles being in use worldwide by the end of 2020). As confirmed by the International Energy Agency (IEA), EV sales have been resilient in the face of the Covid globally as a result of three main factors: (i) supportive regulatory frameworks, (ii) additional incentives for the purchase of electric vehicles, and (iii) continuous development of the technology resulting in more competitive prices. It should be noted that vehicle manufacturers announced increasingly ambitious electrification plans, with 18 of the 20 world's top vehicle manufacturers planning to widen their portfolio of models and to rapidly scale up the production of light-duty electric vehicles (LDVs). While consumer demand for electric vehicles remains challenging to predict, various scenarios have forecasted the electric vehicles stock across all modes (except two/three-wheelers) to reach between 145 million (around 7 percent of the total vehicle fleet) and 230 million (around 12 percent of the total vehicle stock) by 2030.

Figure 1: Global EV stock by region (left) and transport mode (right), 2010-2020.



Source: IEA

1.2 Demand-side considerations

1.2.1 Current and potential market

The current market for electric vehicles remains very limited in Morocco, with considerable potential in the mid-to-long term. A total of 1,417 electric or hybrid cars have been sold in Morocco in 2019 (versus 1,140 in 2018 and 342 in 2017), which represents less than 1 percent of the total amount of new cars sold during that year (148.189 new cars, according to the Moroccan Association of Vehicles Importers - AIVAM). It is estimated that around 5,000 electric or hybrid cars (almost all of which are less than 5 years old) are currently in circulation in the country. The sales of passenger EVs remain very low mostly due to two factors: (i) the current prices of electric vehicles (with a 50 to 70 percent price difference for regular cars and 15 to 20 percent for sport utility vehicles – SUVs, compared to conventional vehicles[1]), and (ii) their technical characteristics (range, charging time, access to charging infrastructure[2], etc.). The potential to substantially increase the sale and use of electric vehicles in Morocco has been confirmed by an ongoing World Bank study, which has estimated that the share of electric vehicles could realistically increase three-fold by 2050, to around a 30 percent of the stock, with close to 2.5 million cars. The model that has been developed to estimate the share of passenger electric vehicles compared to the total stock of passenger vehicles is based on four main parameters for the country: (i) the population growth, (ii) the motorization rate reaching respectively 130, 180, and 220 until 2050 in the low, basis and high scenarios, (iii) the vehicle decommissioning rate of 5%, and (iv) the share of new EV sales, set respectively at 50, 75 and 100 percent in the low, basis and high scenarios. The results are presented in the figures below.

[1] According to a relatively recent report of the Moroccan Energy Federation.
[2] Around 800,000 electric vehicles for 50,000 charging stations.

Figure 2: Forecast of market uptake of electric vehicles in Morocco until 2050 (million) (World Bank study, 2021)

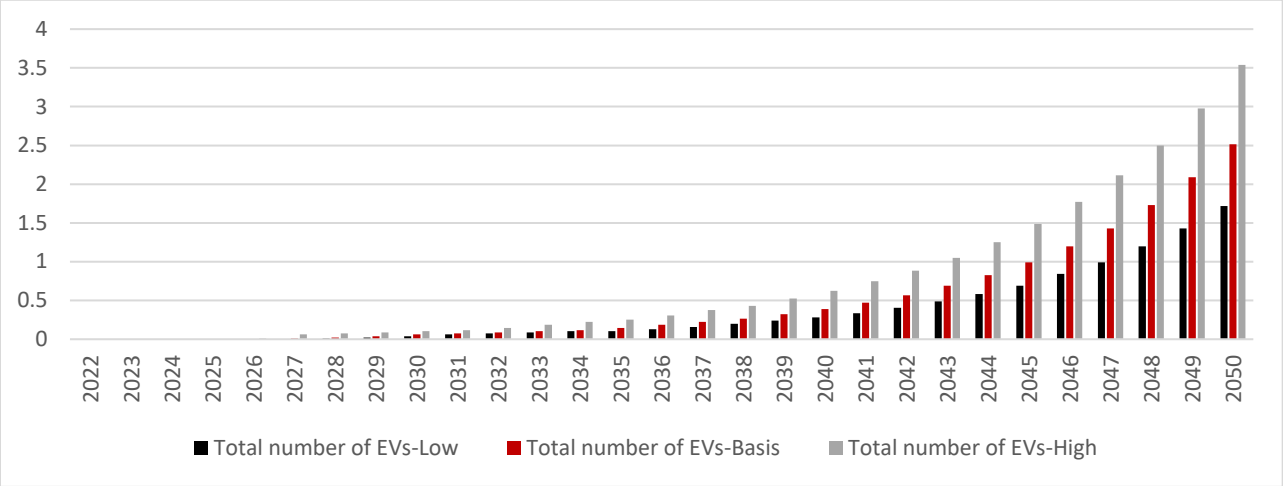
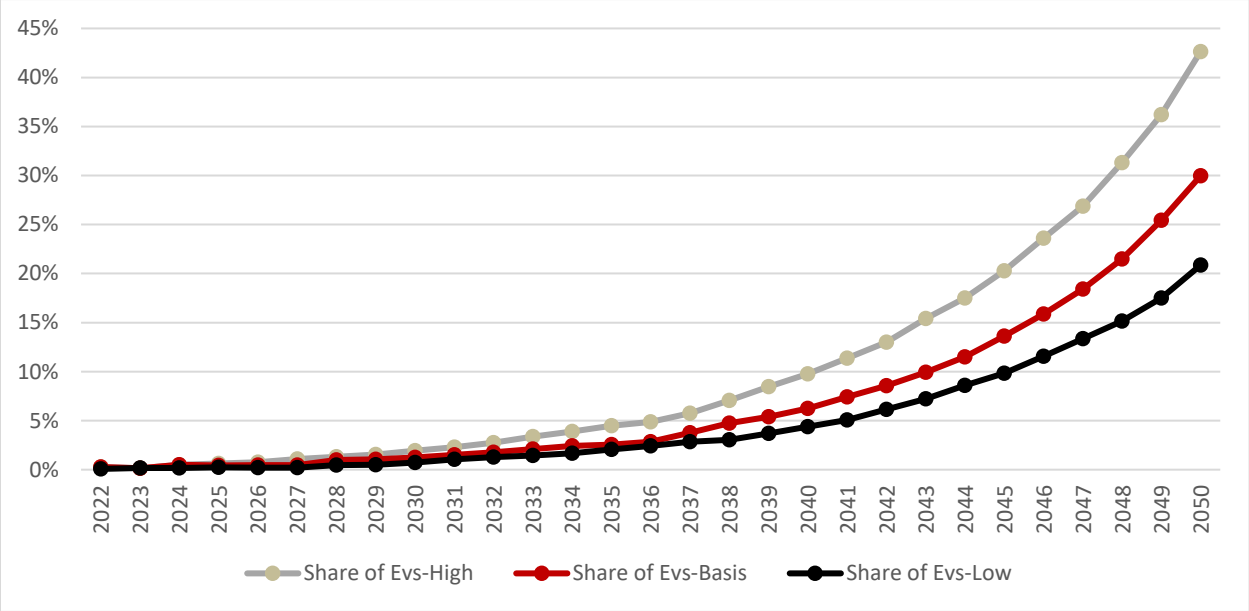


Figure 3: Forecast of market uptake of electric vehicles in Morocco until 2050 (percent) (World Bank study, 2022)



1.2.2 Requirements

In terms of requirements, a substantial increase of charging stations in the country would be required in the next decade. A 2019 study of the Moroccan Energy Federation preliminarily estimated the required number of charging stations needed in Morocco to be around 1,500 (1 per 100 kilometers of road network), from a baseline of only 150 charging stations at this point, mostly located in the Agadir-Tangier Atlantic axis. Applying the ratio of electric vehicle stock to charging stations of France to Morocco and using the above-mentioned projection of electric vehicle stock in Morocco in 2035 results in a need of up to 25,000 charging stations by this date. This would require a large investment from the private sector.

1.2.3 Regulatory aspects

In line with the policies of several comparable countries, Morocco has recently started to use regulations to stimulate the national demand for electric vehicles. In the Budget Law of 2017, Morocco has adopted several

financial incentives that are still in force to encourage the adoption of such vehicles (including hybrid ones), notably the substantial reduction of import duties from 17.5 to 2.5 percent (outside of Europe) and the exemption of vehicle tax ("vignette" in French). Despite these incentives, electric vehicles remain markedly uncompetitive at this stage for most consumers compared to similar conventional models, in the absence of large government-funded rebates as it is increasingly the case in developed countries.

1.3 Supply-side considerations

1.3.1 Capacity to produce and/or procure electric vehicles

Morocco imports a significant share of its conventional vehicles needs and is likely to continue doing so in the future with the expected gradual shift to electric mobility. According to the AIVAM, a total of 148.189 new cars have been sold in the country in 2019 (pre-Covid), of which 104,801 have been imported and 43,388 produced locally. Overall, imports of cars (including used ones) have reached a total of MAD 20.32 billion in 2019 (decreasing by 7.5 percent compared to 2018, due to the increase of local production) according to official trade data. Car imports have originated mostly, in order of importance, from Germany (22.4 percent of total vehicle imports), France (14.6 percent), Turkey (10 percent), the United Kingdom (9.7 percent), Spain (8.6 percent), the Czech Republic (7.4 percent), and other countries (27.3 percent). The electric share of vehicles sold, all of which imported, remains very low in Morocco. In the next decades, the bulk of the vehicles to be sold in Morocco is likely to continue to be imported from Europe mostly, to complement the smaller share of local automotive production sold domestically. This will be particularly relevant for electric vehicles given their higher relative level of sophistication. Morocco's macroeconomic stability (in terms of currency and trade balance), which has spanned the last few decades, should in principle enable the continuation, as needed, of the import of these vehicles from their production hubs.

Morocco's emerging industrial sector is well positioned to benefit from the shift to electric vehicles. Morocco is a growing player in conventional car manufacturing. Morocco benefits from the upward trend among international firms to look to the country as an attractive location for "nearshoring", as the country has successfully positioned itself to become a major Southern Mediterranean hub automotive manufacturing value chain. With its current capacity to produce over 700,000 cars per year, the automotive sector has produced around 400,000 cars in 2019 (out of 350,000 have been exported). In particular, Morocco is increasingly positioned in the electric vehicle space. In 2017, the Chinese electric car manufacturer, BYD, signed an MoU to open an electric vehicle factory in Morocco, which is yet to be developed. In July 2021, STMicroelectronics, one of Europe's leading semiconductor manufacturers, announced the future inauguration of a new production line in Morocco to manufacture electronic chips for Tesla's electric vehicles. Finally, in August 2021, Stellantis (resulting from the merger of PSA and Fiat- Chrysler Automobiles) announced that its subsidiaries Citroen and Opel will produce in the short-term electric vehicles (the Ami and the Rocks-e models respectively) in its Moroccan factory of Kenitra, mostly for export purposes at this stage. Furthermore, a public research platform led by the Institute for Research in Solar Energy and New Energies (IRESEN) developed in Morocco an intelligent charging station (iSmart) for commercial and domestic use, which could be manufactured domestically starting 2022. These activities should contribute to the increase technical skills of the local workforce in such emerging technologies. In the mid-term, this industrial focus should enable the country to produce a share of its electric vehicle needs, on top of exports to Europe, MENA, and Africa.

1.3.2 Regulatory aspects

Morocco is yet to have a regulatory framework on electric mobility in general and electric vehicles in particular. Specific electric vehicles models are authorized for commercialization by the relevant authorities (with the Ministry of Transport and Logistics) on a case-by-case basis. The National Institute of Standards (IMANOR) is currently developing 55 Moroccan standards based on European standards for electric vehicles, including charging standards. In general, no specific standards with respect to electric vehicles chargers are in force in Morocco as the minimal technical requirements defined by IMANOR, but they are yet to be approved.

1.4 Anticipated impact and benefits

1.4.1 Carbon emissions

Based on the above-mentioned World Bank estimation of electric vehicle stock by 2050, a reduction of carbon emissions resulting from this shift has been forecasted by the present note for Morocco to be around 2,625,000 tons of CO2 per year. The calculation assumes (i) a total electric fleet of around 2.5 million vehicles (around 30 percent of vehicle stock) by 2050, (iii) an average annual driving distance of 15,000 kilometers, and (iii) average emissions per kilometer of 50 and 120 gram of CO2/km for electric vehicles (including their full lifecycle) and conventional vehicles respectively. It should be noted that the carbon footprint of an electric vehicle in a given country depends vastly on the energy source of electricity consumed (which is progressively shifting in Morocco from a coal to renewables) and the origin of the electric vehicle[3] (particularly of its battery).

1.4.2 Electricity demand

The above-mentioned World Bank study on electric vehicles in Morocco has estimated additional electricity consumption resulting from this trend to be around 24.8 GWh per day in 2050. It should be noted that the current peak electricity demand in Morocco is 6.3 GW and the installed electricity generation capacity is 10.6 GW. The base scenario of the study assumed (i) a total electric fleet of around 3,550,000 vehicles (around 44 percent of vehicle stock) by 2035, (ii) daily charging hours per vehicle ranging between 1 to 3 hours, (iii) an average annual driving distance of 15,000 kilometers, (iv) a specific energy consumption of the electric vehicle of 17 kWh/100 km (equivalent to 8 l/100 km for conventional vehicles), and (v) equal distribution of the energy demand over 365 days per year). Electricity demand from EVs accounts for only about 1 percent of current electricity total final consumption worldwide. Electricity demand for EVs is projected to reach 525 TWh in the Stated Policies Scenario and 860 TWh in the Sustainable Development Scenario in 2030, while LDVs account for about two-thirds of demand in both scenarios. By 2030, electricity demand for EVs will account for at least 2 percent of global electricity total final consumption in both scenarios, as illustrated on the table below.

[3] As more carbon is emitted in the production process of electric vehicles than of conventional alternatives.

Table 1: Share of electricity demand for electric vehicles in global electricity consumption in different scenarios (IEA)

Country or region	2020	Stated Policies Scenario 2030	Sustainable Development Scenario 2030
China	1.0%	2%	3%
Europe	0.3%	3%	5%
India	0.0%	2%	2%
Japan	0.1%	2%	3%
United States	0.2%	2%	5%

1.4.3 Hydrocarbon demand

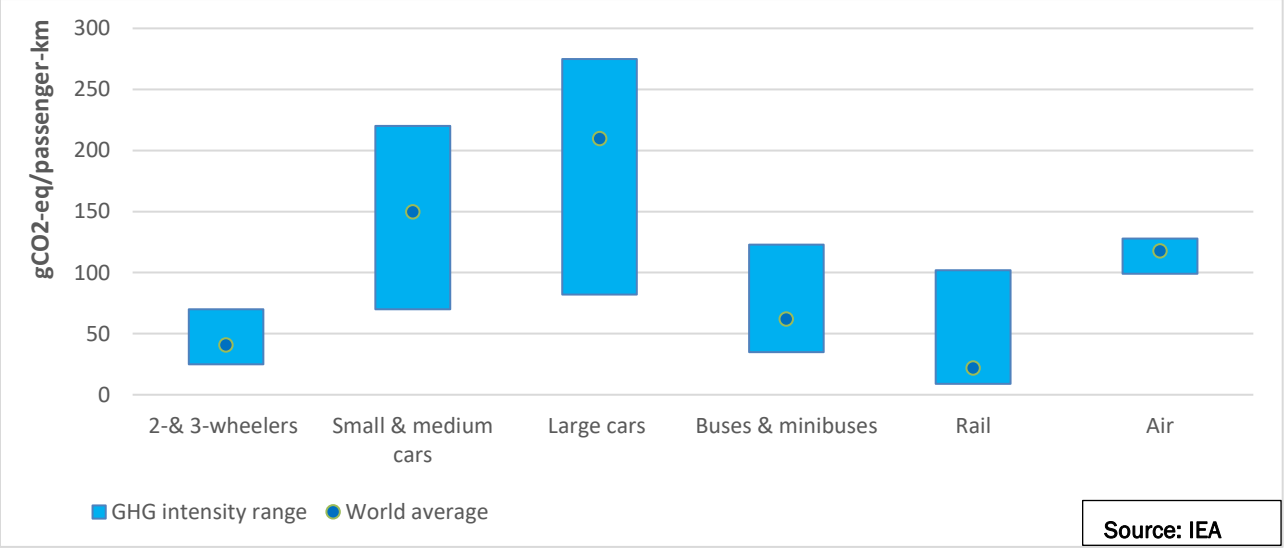
Based on the above-mentioned World Bank estimation of electric vehicle stock by 2050, a reduction of hydrocarbon demand has been forecasted by the present note to be around 1.98 billion liters of fuel per year for Morocco. This estimate assumed, similarly to the above-mentioned estimate of additional electricity demand for Morocco: (i) a total number of electric vehicles of around 1.65 million (around 21 percent of vehicle stock), (ii) an average annual driving distance of 15,000 kilometers, and (iii) a specific energy consumption of the displaced conventional vehicles of 8 liters per 100 kilometers per vehicle. A reduction of hydrocarbon demand of 1.98 billion liters of fuel (around 1.485 million of tons), representing close to 19.8 percent of the current transport fuel consumption of the country (around 7.5 million tons), would reduce Morocco's imports in this category of goods by around USD 1.32 billion. Globally, despite the declining use of gasoline and diesel in passenger cars, the IEA estimates that global oil demand will continue to grow, reaching 105 million barrels per day by 2040, driven by commercial transportation and chemicals demand growth. The IEA estimates that 2.5 million barrels of potential oil consumption could ultimately be displace by electric mobility (based on its forecast of a stock of 280 million electric cars worldwide by 2040, or around 15 percent of the global car fleet). Oil demand for commercial transportation, industrial and petrochemical uses is forecast to increase by five times this amount at about 14 million barrels per day by 2040. This is also expected to occur in Morocco albeit in different proportion

Rail transport in Morocco

2.1 Global context

Vast electrification in parallel with extensive expansion of urban and high-speed rail has occurred over the past decade, with China leading the way. The necessity to align with the Net Zero Emissions Scenario and thus mitigate the global consequences of climate change calls for a fast shift from carbon- intensive modes such as private cars, trucks and airplanes to rail, and higher shares of low-carbon fuels in total rail subsector energy consumption by 2030. Indeed, rail is one of the most energy-efficient transport modes, responsible for 9 percent of global motorized passenger movement and 7 percent of freight but only 3 percent of transport energy use. Urban and high-speed rail infrastructure has expanded rapidly over the past decade, laying the foundation for convenient, low-emissions transport within and between cities. For example, China, who had virtually no high-speed rails a decade ago, has now two out of three high-speed lines globally. The country revealed plans to double its high-speed rail network from 36 000 kilometers to 70 000 kilometers over the next 15 years, thus connecting all cities with populations greater than 200 000 with rail line connections. India has also announced plans to electrify broad-gauge routes to achieve 100 percent electrification by 2023 and net zero emissions by 2030. So far, 45 881 route kilometers have been electrified and, despite the Covid-19 pandemic, Indian Railways recorded the highest-ever electrification of sections across its network during 2020 and 2021.

Figure 4: Well-to-wheel GHG intensity of motorized passenger transport modes (IEA, 2021)



Despite rail being the most electrified transport subsector, it remains heavily powered by fossil fuels. Oil accounted for 55 percent of total energy consumption in rail and powered 28 percent of all passenger rail transport activity in 2020. Rail transport consumes about 600,000 barrels of oil per day (i.e., 0.6% of world consumption) and nearly 290 TWh of electricity per year (a little over 1% of world consumption). Efforts are being made to reduce the overall carbon footprint of rail, with countries developing different strategies. For example, the US have been pushing for the use of battery-electric or hydrogen-powered locomotives, while looking into increasing network capacity via technology as a way to improve rail service and encourage more volumes to rail from truck, instead of pushing for the electrification of tracks.

The latter varies significantly depending on the country as illustrated in the case of Europe, which reaches an average of about 56 percent of electrified track. In parallel, hydrogen train deployment remains in its early stage in most countries, and projects combining the use of hydrogen and electricity are led, amongst others, by the European venture FCH2RAIL including Germany, Spain, Belgium and Portugal. In all cases, and to abide by the Net Zero Scenario, electricity and hydrogen should sustain almost 100 percent of total passenger rail activity as soon as 2030. According to the International Energy Agency (IEA), even on rail lines where throughput is too low to make electrification economically viable, hydrogen or battery electric trains coupled with partial track electrification and well-located charging points will need to replace diesel trains to achieve the Net Zero objectives.

Graph 1: Percentage of the railway lines in use in Europe in 2019 which were electrified, by country

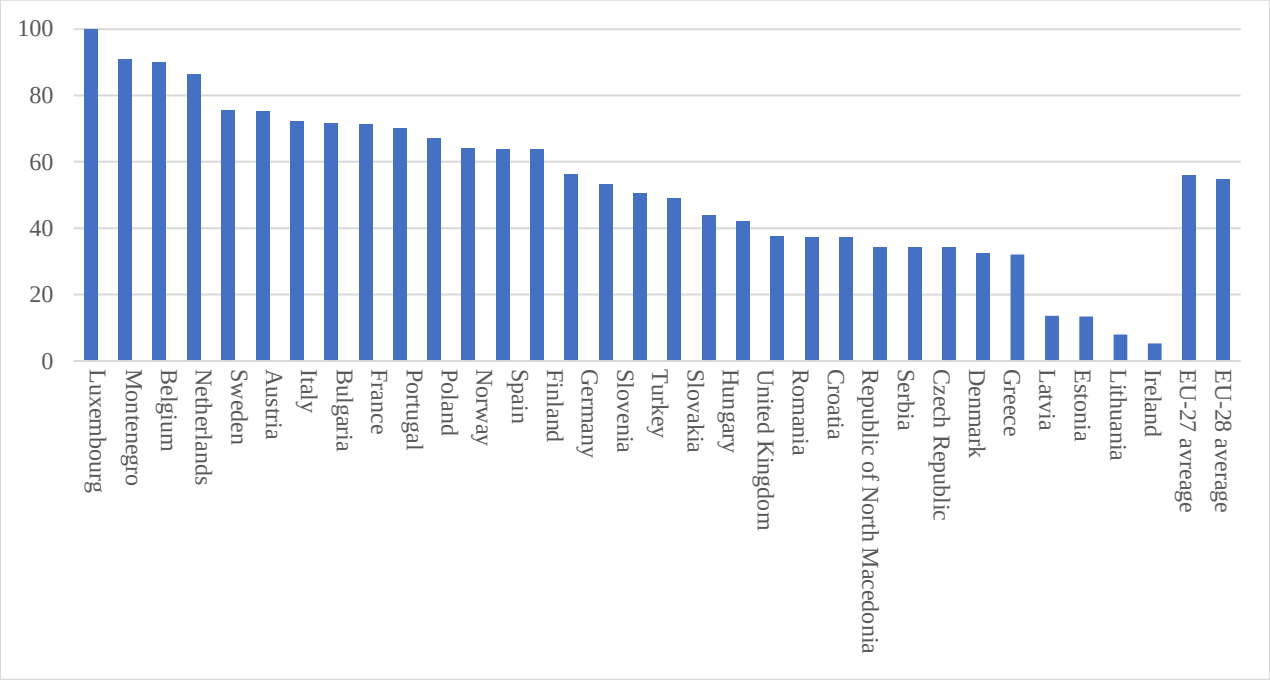


Table 2: Deployment of hydrogen trains (IEA, 2021 rail report)

Country	Entry into operation (or expected deployment)	Number of trains
Germany	2018	2
Austria	2020	1
Netherlands	2020 (2024)	1 (4)
China	2021	1
Sweden	2021	1
UK	2021	1
Korea	2022	1
Japan	2022 (testing phase)	1
Italy	2023	6
Spain	2023	1
France	2023 (testing phase)	12
US	2024	1
Canada	To be announced	1

2.2 Demand-side considerations

2.2.1 Overview of the rail sector in Morocco

Morocco has the second largest railway network of Africa after South Africa and a dynamic passenger transport market, thus presenting a potential for railway electrification. The network consists of 3800 kilometers of lines, 2300 kilometers of which are operational, including 200 kilometers of high-speed lines. About 800 kilometers are double tracks lines and about 60 percent are electrified. Rolling stocks consists of about 250 locomotives (half of which are electric, with an average age of 27 years for electric units and 29 years for diesel units), 680 passenger's cars and about 5000 freight wagons. While the railway passenger transport market is quite dynamic, with an increase of about 9 percent over the past ten years (reaching 4800 million of passenger-kilometer in 2019), the freight market is less dynamic, partly because of the increasing importance of the phosphate transport by pipeline that has reduce the modal share of railway transport. In 2019, ONCF freight transport volume (excluding phosphate) represents 938 million of tons-kilometers, while road transport represents more than 75 percent of the total freight volume.

Public commitments are ongoing to extend and upgrade the network to a more sustainable and technologically advanced one. The 2040 Morocco Rail Plan (MRP) includes an extension of the conventional network of 1600 kilometers for MAD 87 billion (USD 9.29 billion), 1100 kilometers of high- speed rails for 134 billion MAD (USD 14.31 billion), and an enhancement of 1610 kilometers of existing rails for MAD 30 billion (USD 3.2 billion). In parallel to the setting of the MRP, the Moroccan railway company Office National des Chemins de Fer (ONCF) took significant steps towards the reduction of its activities' carbon footprint. Indeed, ONCF decided in 2016 to adopt the ISO 14001 standard for all its stations by 2020, aiming at a reduction in the energy bill of 63.24 million Dirhams, or 20 percent of the current energy cost. This measure was intended to avoid about 2.5 million Teq CO2 over 30 years of operation of the line, thus reaching carbon neutrality within 13 years of operation. In the meantime, ONCF has also adopted an energy management system conforming to the ISO 50001 standard to control the consumption of priority energy-consuming stations. Four pilot sites were selected, and each experienced a reduction of 5 to 20 percent in its energy bill. In addition to that, ONCF was committed to using 50 percent renewable energy by the end of 2020[4] and 100 percent eventually. This ecological transformation provides for an increase in the share of renewable resources to more than 52% of the installed capacity by 2030, making the Kingdom one of the most committed emerging countries in the development of wind and solar energy[5].

2.2.2 Requirements

Morocco needs to increase the capacity of the conventional network for freight train and to further develop logistics activities. As Tangier Med became the leading container transshipment port in Morocco and Africa in 2018, ONCF should concentrate its effort to develop the container market. Estimations prepared under a World Bank technical assistance (TA) established that the container rail traffic between the Tangier Med and Casablanca, Marrakech, Fez and Meknes regions has not yet fulfilled its potential: 31 402 TEUs could be transported on a Tangier Med/ Casablanca and return service, while ONCF transported 18,133 TEUs in 2018.

[4] The objective was delayed due to the pandemic crisis, as ONCF reached 25 percent of green energy usage in 2022 and postponed the 50 percent goal to 2023.

[5] On the occasion of COP22, ONCF signed a memorandum of understanding with Nareva for the purchase of Wind Energy, which should cover 50 percent of the Office's needs (40 Gwh in 2017; 70 Gwh in 2018; 40 Gwh in 2019 and 160 Gwh per year for the period 2019/2039) and reduce its greenhouse gas emissions by 25 percent.

The above-mentionned TA also recommended the opening of the market for competition in specific cases and for specific logistic services, as well as the following measures to enable an increase of the modal share of railway transport:

(i) A presence of two distinct markets: containers and international road transport (TIR);
(ii) The development and/or adaptation of infrastructures: operational resources for each market;
(iii) An extended range of logistics services to meet customer requirements;
(iv) An increase in equipment and technical resources for freight to achieve the set objectives;
(v) The separation of freight from passenger activities and a greater autonomy of resources given to freight;
(vi) An increase of the visibility of rail freight with public authorities

2.2.3 Regulatory aspects

After the rail sector has substantially suffered from the deregulation of road freight, significant measures were undertaken to allow ONCF to adapt to a more competitive market. In the general context of transport market deregulation already underway in road transport, the government has handed over control to the management of ONCF, which has moved quickly to rationalize passenger rail services by removing poor quality and low intensity services during its first series of major reform in 1994. However, the rail sector remains more regulated than its road equivalent, leading to approximately 75 percent of national freight transport (excluding phosphates) and 35 percent of intercity passenger flows carried by road (ITF-OECD, 2021).

2.3 Supply-side considerations

2.3.1 Capacity to produce and/or procure electric rolling stock

Morocco imports a significant share of its rolling stock and is likely to continue doing so in the future. Morocco has reliable supply sources for electric rolling stock and corresponding infrastructure. ONCF relies on ALSTOM, SCIF, RATP DEV, TRANSDEV et INFRAWAY, to name a few, for the maintenance and construction of its infrastructure, as well as for the production of its rolling stock. The railway company replenishes its supplies frequently enough to maintain an average age below 30 years for its rolling stock. The railway company also tries to keep up with the technological advances of the sector, its latest purchase being 30 units of the Prima M4 electric locomotives, which started to be delivered by Alstom in 2019. The construction of the high-speed rails also strengthened the collaboration with the French counterparts SNCF and Alstom. In the next decades, the rolling stock and rail infrastructure to be sold in Morocco is likely to continue to be imported from France specifically and Europe mostly, to complement the smaller share of production sold domestically. Morocco's macroeconomic stability (in terms of currency and trade balance), which has spanned the last few decades, should in principle enable the continuation, as needed, of the import of these vehicles from their production hubs.

Morocco's industrial sector is well positioned to benefit from the electrification and shift to freight rail. Creating a real rail industry in Morocco is one of the major projects of the railway sector. The Société Chérifienne de matériel Industriel et Ferroviaire (SCIF), in which ONCF is a shareholder, is a privileged test laboratory. SCIF expanded its field of activity to include the manufacture of electric locomotives since the 1980s. At present, the company has a 100,000 m^2 industrial facility, enabling it to be an integrated global operator for the railway industry and to strengthen its export competitiveness in Africa. SCIF has had activities in Gabon, Tunisia and Mauritania. As of today, it is the only factory equipped to manufacture cars and freight wagons, from the design stage to commissioning. It also carries out the renovation of railway equipment. Since 2007, 340 aluminum wagons for the transport of phosphates, 90 wagons for the transport of coal and more than 200 passenger cars have been produced in its factory, and the company has manufactured more than 5,000 wagons in a variety of business segments.

SCIF is positioning itself as an overall integrator. ONCF's ambition is to encourage the creation of centers of expertise in the railway industry, following the example of the automotive and aeronautical industries. It also developed strategic alliances with world leaders that facilitated the local manufacture of passenger railway equipment.

2.3.2 Regulatory aspects

The Moroccan rail transport sector is in the process of opening up to competition. ONCF is the midst of the second most important reform since its creation, leading to the introduction of Specialized Rail Transport Operators. The recent draft rail law provided by the World Bank in the context of a TA recommended opening up the rail transport market to other operators: Specialized Rail Transport Operators (SRTOs). The latter recommendation has been kept in the new governance scheme considered by the Moroccan government. Its objectives are to introduce competition pushing ONCF towards the continuous improvement of its services and to allow ONCF to mobilize private financing by creating specialized transport subsidiaries and thus lighten its investment burden. It should be noted that the proposed mechanism for opening up to competition via SRTOs is designed to avoid the confiscation of profits by new entrants in the profitable market segments currently served by ONCF, as it will maintain the role of infrastructure manager for the entire network and remain the main transport operator for passenger and freight.

2.4 Anticipated impact and benefits

2.4.1 Carbon emissions

An impact assessment focused on two pilot corridors to be electrified demonstrated a substantial potential of reduction of carbon emissions. A Carbon Emission Impact Assessment was carried by the World Bank for the electrification of the two corridors at the East of the network: Fès – Oujda (354 kilometers) and Taourirt – Nador (111 kilometers). The latter are both served by passenger and freight trains. Railway electrification typically improves railway service quality vis a vis service frequency among others, hence the analysis comes with the caveat that it does not account for modal shift aspect. Based on the World Bank's prototype railway investment GHG emissions model and assuming (i) no change in demand due to the electrification per se and (ii) annual growth of freight and passenger traffic at 1 percent and 3 percent respectively, the assessment established that the emissions from the mentioned corridors would increase by 48 percent and 50 percent from 2020 to 2050 respectively. Electrification of these corridors would reduce 2050 emissions by 30 percent and 24 percent, respectively, as the results are presented in Table 3 and Table 4.

Table 3: ONCF Passenger and Freight Rail Operation Carbon Emissions: Fès - Oujda

Year	BAU (Diesel), tCO2e	Electric, tCO2e	Abatement, tCO2e
2020	11,400	7,900	3,500
2050	16,800	11,700	5,000

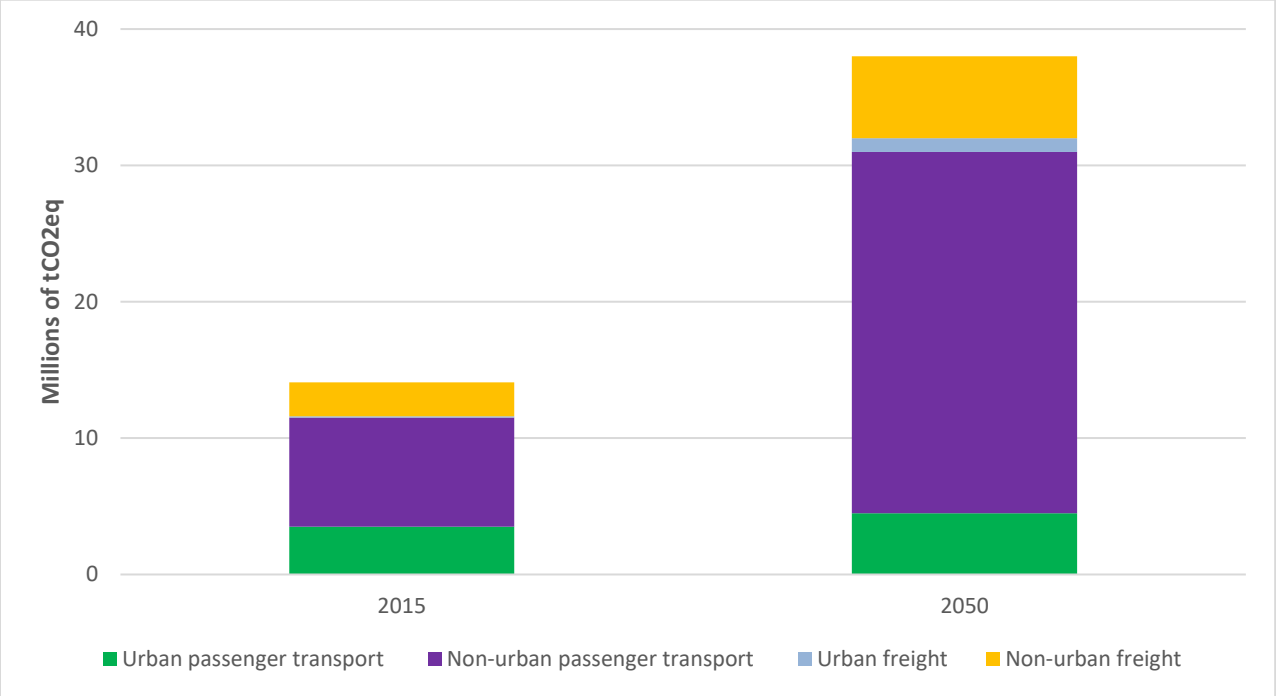
Table 4: ONCF Passenger and Freight Rail Operation Carbon Emission: Tarourirt – Nador

Year	BAU (Diesel), tCO2e	Electric, tCO2e	Abatement, tCO2e
2020	4,500	3,400	1,100

2050	6,700	5,000	1,600

The shift in freight transport from road to rail would have a strong decarbonization impact. Railway sector in Morocco is responsible for only 2 percent to 4 percent of GHG emission, while road transport represents 60 percent of total GHG emission. As an example, a passenger train could transport the equivalent of 160 cars with 93 percent less diesel emission per kilometer compared to a bus. At the same time, Morocco authorities would like to reduce the emission of the railway sector by providing 50 percent of the energy consumption through green energies. All these efforts could contribute to reduce by 10 percent the GHG emission of the railway sector in 2030 compared to 2016. These combined actions, focusing on the modal shift and the greener energy supply, are all the more crucial since the average annual growth in Moroccan transport CO2 emissions is forecasted to reach about 3.7 percent, while OECD countries will decrease their transport emissions. This increase results of the multiplication by 4 of passenger and freight transport volume and an increase of transport sector GHG emission from 15 million tons in 2015 to more than 35 in 2050, leading to the results illustrated in Figure 5.

Figure 5: Projected trends of GHG emissions related to transport activities in Morocco (2015-2050)



2.4.2 Electricity demand

The electrification of the two above-mentioned pilot corridors would result in an annual additional electricity consumption of 14 GWh in 2050. It should be noted that the current peak electricity demand in Morocco is 6.3 GW and the installed electricity generation capacity is 10.6 GW. The base scenario of the study used the data provided by the ONCF assumed (i) no change in demand due to the electrification per se and (ii) annual growth of freight and passenger traffic at 1 percent and 3 percent respectively (iii) 245 and 246 working days per corridor a year. The Fès-Oujda corridor would consume 4 GWh per year, and the Taourirt-Nador 10 GWh per year. Furthermore, with electric consumptions of about 46 kWh/1000 gtkm for passenger trains and 17 kWh/1000 gtkm for freight on the Taourirt-Nador corridor and 38 kWh/1000 gtkm for passenger trains and 23 kWh/1000 gtkm for freight on the Fès-Oujda corridor, meant to decrease with the future technological advances, rail transport remains substantially less energy- consuming than e-trucks for which energy consumption is about 130 kWh per 100 kilometers. By additional way of comparison, a bus consumes

between 80 and 400 Wh per passenger-kilometer and a plane between 360 and 450 Wh per passenger-kilometer.

2.4.3 Hydrocarbon demand

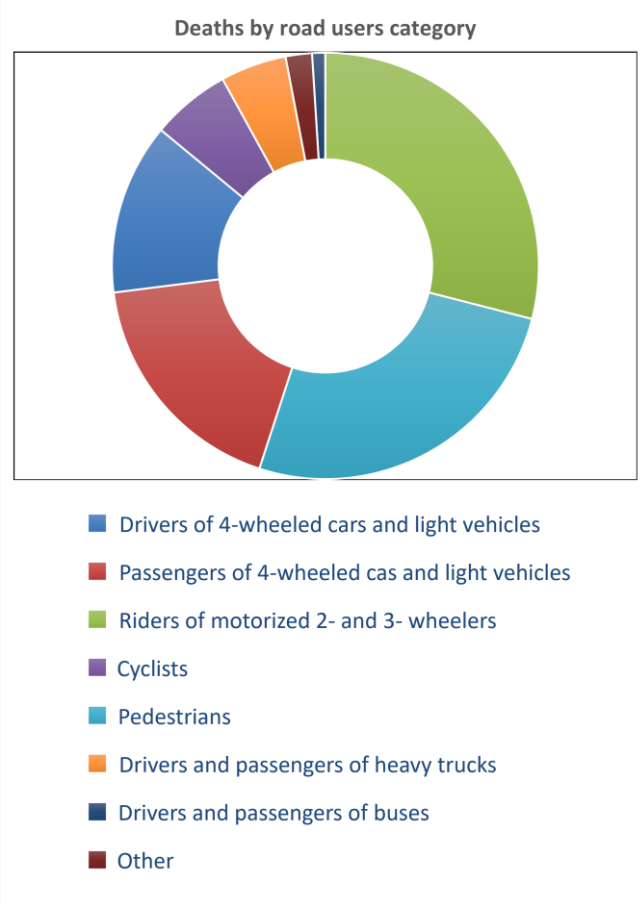
Based on the above-mentioned World Bank electrification assessment, a reduction of the Moroccan hydrocarbon demand of 7.4 million of liters of fuel has been forecasted by the present note for the electrification of the pilot corridors. The base scenario of the study assumed: (i) no change in demand due to the electrification per se; (ii) annual growth of freight and passenger traffic at 1 percent and 3 percent respectively; and (iii) 245 and 246 working days a year for each corridor respectively. A reduction of hydrocarbon demand of 7.4 million liters of fuel (around 5550 tons), representing close to 0.07 percent of the current transport fuel consumption of the country (around 7.5 million tons). The modal shift from truck to rail would also significantly impact the hydrocarbon demand. In fact, a diesel freight train could also transfer the equivalent of 50-60 lorries with 78 percent less diesel consumption per kilometer. Knowing the Moroccan energy mix for electricity production, an electric train could transfer the same amount with 87.1 percent less of diesel consumption per kilometer. Globally, despite the declining use of gasoline and diesel in rail and passenger cars, the IEA estimates that global oil demand will continue to grow, reaching 105 million barrels per day by 2040, driven by commercial transportation and chemicals demand growth. Oil demand for commercial transportation, industrial and petrochemical uses is forecast to increase at about 14 million barrels per day by 2040. This is also expected to occur in Morocco albeit in different proportions.

2.4.4 Road casualties and infrastructure maintenance

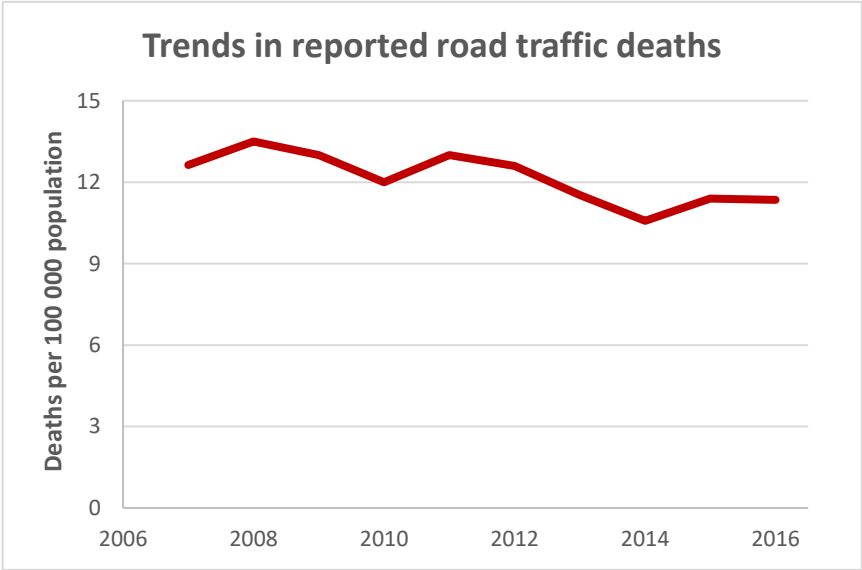
The modal shift from road to rail will significantly decrease the number of casualties and costs of road maintenance. Road freight transport is responsible for congestion and road fatalities which are very high in Morocco compared to other similar countries. Data from the WHO[6] shows that Morocco accounts for 6 917 estimated road traffic fatalities (2016) while only 3 785 are reported from the Directorate of Roads within 30 days of crashes. In 2016, 80,680 bodily injury accidents happened on Moroccan roads, resulting in 122,947 victims. The WHO estimated rate per 100 000 populations (2016) is 19.6. In the same year, Moroccan railways were the scene of only 55 incidents, resulting in 24 deaths. It is also worth noting that ONCF has maintained its efforts to reduce the number of crossings, dropping it by 193 since 2010, in addition to various measures meant to enhance the safety of its activities. Furthermore, reduction of road freight transport will also result in reducing the maintenance and rehabilitation cost of the road network, compensating for the loss of income from fuel levies. Morocco has invested in the expansion and modernization of the road network massively in the recent years, and freight users are generally responsible for the rapid deterioration of the road network because of the infringement to the regulation of the heavy limits. Considering the tremendous increase of road freight volumes, this will result in an important increase of road expenditures for maintenance and rehabilitation, while transferring freight volumes on railway transport will contribute to maintain road assets and reduce road expenditures.

[6] Global status report on road safety (World Health Organization, 2018).

Figure 6: Road traffic deaths in Morocco (WHO global status report on road safety, 2018)



Source : 2016, Directorate of Roads



Source : Directorate of Roads (death data) and High-Comission for Planning (population data)