Jobs in green and healthy transport

Making the green shift

Final

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Acknowledgments

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Executive Summary

This study, commissioned by the Transport Health and Environment Pan-European Programme (THE PEP) Steering Committee through its Partnership on Green and Healthy Jobs in Transport, reviews the economy-wide employment implications of an accelerated shift towards greener land transport in the region of the Economic Commission for Europe (ECE).

Land transport is an important sector for job creation and development. It employs over 60 million workers around the world, representing more than 2 per cent of global employment. Total employment is even higher when considering the indirect jobs that depend on related value chains in the transport sector.

At the same time transport is also a contributor to environmental degradation and worsening health. To meet global and local environmental objectives while promoting decent work, employment and transport development, the environmental sustainability of the sector needs to be at the heart of policy development.

For this report, a macro-economic multiregional input-output based model has been used to analyse the job impacts of four green transport scenarios in the ECE region. A business-as-usual scenario is projected up to 2030 and compared with each of the green transport scenarios in which an accelerated expansion of public transport and the electrification of vehicles is modelled. The scenarios assessed were:

- For public transport:
  - PT.1 Doubling investment in public transportation
  - PT.2 Free public transportation
- For electrification:
  - E.3 Introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric
  - E.4 Ban on internal combustion engines for light-duty business-use vehicles

The results indicate that there is a diversity of job impacts across the ECE region as each country's transport sector is linked through different supply chains to other economic sectors within the countries and across the world.

The analyses presented in this report suggest that employment opportunities do exist in advancing green and healthy transport in the ECE region through facilitating the increased use of public transport and the electrification of private transport. The results show that stimulating the use of public transport through the doubling of investment in the sector (scenario PT.1) and rendering public transport free to users (scenario PT.2) can create a net of at least 2.5 million extra jobs worldwide in green and healthy transport. This increases to at least 5 million jobs when the wider impact on other sectors of the economy is considered. More than half of these will be in the ECE region with the rest spread across the world.

In terms of the electrification of private transport, a cumulative scenario would double count effects of the electrification of personal and light business vehicles. The introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric (Scenario E.3), indicates that a net total of close to 10 million jobs will be added to world employment across all sectors, of which 2.9 million will be in the ECE region alone. When focusing on the transport sectors alone, it is estimated that employment will increase by 0.7 million jobs of which about 0.6 million in the ECE region. Scenario E.4 (Ban on internal combustion engines for light duty business-use vehicles) would lead to a 0.4 million increase in jobs in transport and up to 8.5 million jobs when the impact on other sectors is taken into account. As a result of the current and future locations of jobs in the sector, the ECE region is likely to see a contraction in transport related jobs as the net employment creation that results from these scenarios hides important levels of reallocation, as jobs move away from the manufacture of motor vehicles and petroleum extraction and refinery sectors towards service jobs.

The overall results of the report - pointing to the potential for net employment creation - are mainly driven by a structural shift from fossil fuel consumption and production to increased use of public transport services and electrification of transport modes. Reduced fuel consumption has particular strong positive employment effects for oil importing countries. Money that was previously spent on the fuel industry, which has a very low employment content, is spent on other sectors of the economy with higher employment effects such as public transport.

Following the electrification scenarios that have been modelled as part of this study, industries in electric machinery, appliances and battery production stand to gain whereas employment reductions are expected in the fuel value chains and traditional internal combustion car manufacturing industries. Countries with a strong manufacturing industry for cars with internal combustion engines, and which are not seeking opportunities to switch to electric vehicle production, will face job reallocation to countries that lead the drive towards electric transport.

The figure below summarizes the net job creation (in millions) from policy choices for green and health transport.

Figure 1: Net job creation (in millions) according to the modelled scenarios for transport sector

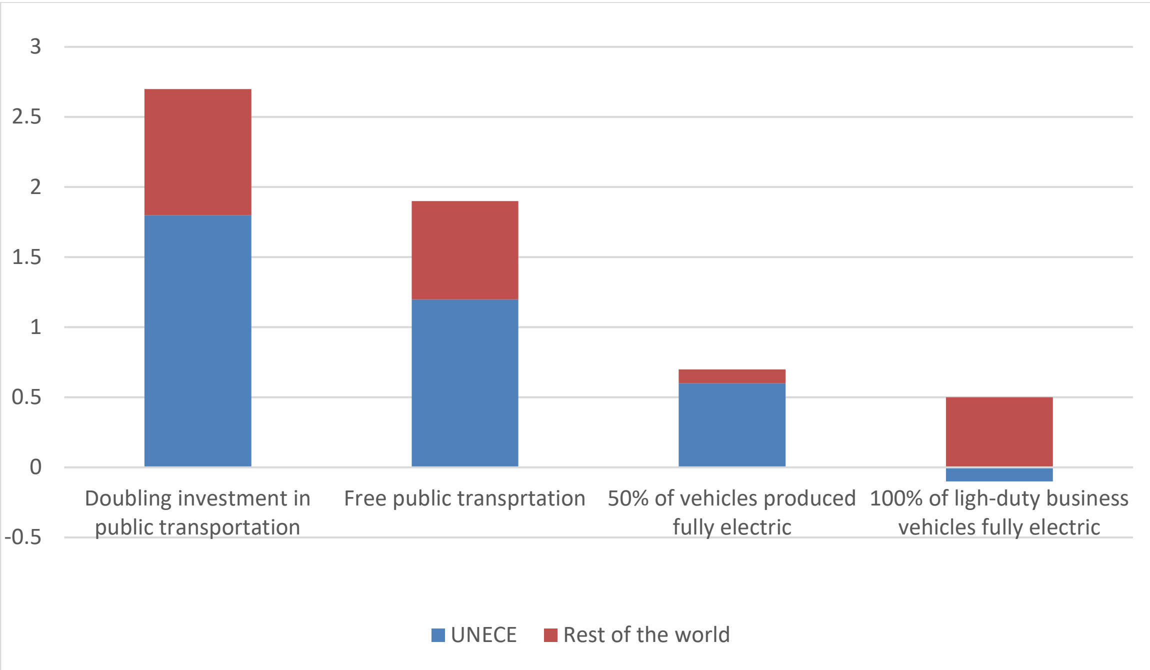
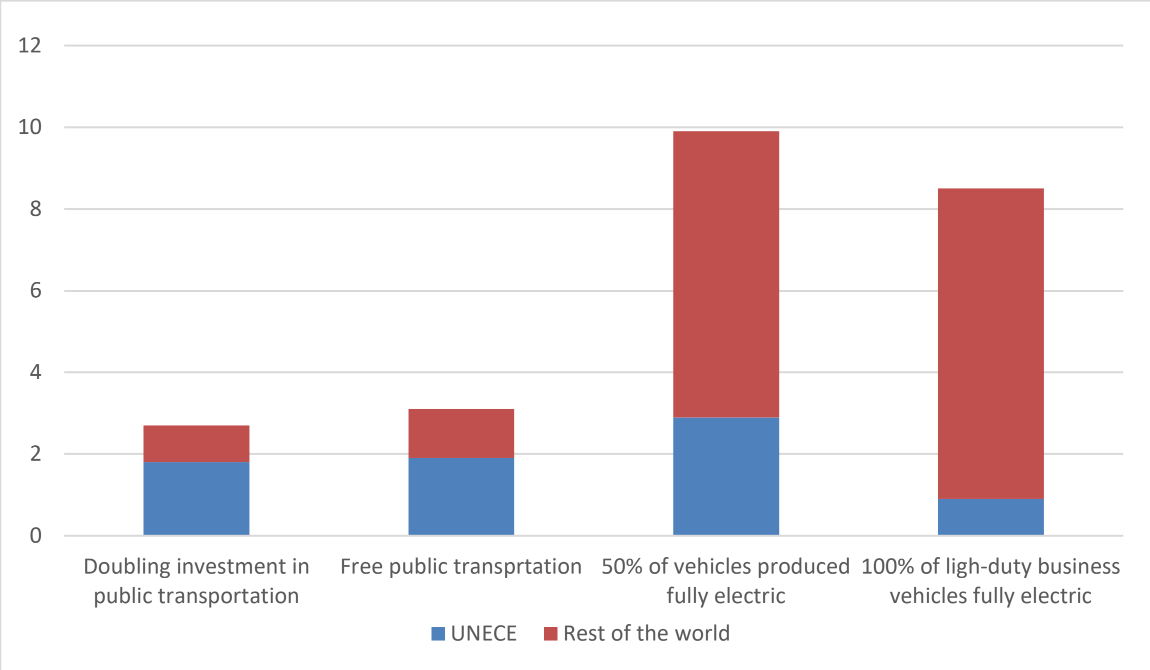


Figure 2: Net job creation (in millions) according to the modelled scenarios for whole economy



To capitalize on the employment opportunities and ensure that the transition is just for workers, enterprises, regions and countries which may face restructuring, a comprehensive package of policies should be implemented alongside any efforts to green the transport sector.

This policy package includes skills development policies, social protection policies, active labour market policies and policies to promote social dialogue, notably when it comes to financing the green transport policies through green taxes, and fundamental rights at work. They also include the deployment of incentives and industrial policy to develop the industries that will grow under a green transport scenario and may be undeveloped in the ECE region.

Advancing sustainability through the expansion of public transport and the electrification of private passenger and freight transport is but one of the drivers by which the future of transport will affect employment throughout the economy. Other drivers include automation, shared mobility, cycling, hyperloop, drone delivery, buy-local or short-circuit economies, among others. These areas could be studied in more detail in future analysis.

I. Introduction

This study is carried out by the International Labour Organization (ILO) in cooperation with the Economic Commission for Europe (ECE), the World Health Organization (WHO) Regional Office for Europe, the United Nations Environment Programme (UNEP) and other organizations in the context of the ongoing Partnership on Jobs in Green and Healthy Transport within the Transport Health and Environment Pan-European Programme (THE PEP). The current study continues the work of THE PEP on evaluating the job creation potential of green and healthy transport (UNEP, 2017; WHO, 2014). It also contributes to activities set up by the ILO, following a request of its Governing Body, to estimate the labour market effects of the transition to environmental sustainability.[2] This report expands the scope of the previous analysis. It shows how the changes towards green and healthy transport alter the structure of sectors and jobs in and across ECE member States,[3] but also that of other parts of the world, since greening the transport sector activates different national, regional and global value chains and employment in different industries and areas of the world.[4]

Transport is a key economic sector in the global economy. It accounts for a relevant portion of an economy's activity (UNEP, 2017). Land transport accounts for more than 60 million direct jobs around the world, representing over 2 per cent of global employment.[5] In enabling the mobility and connectivity of people and goods it sustains the activity of sectors across the economy, creating jobs, adding economic value and advancing social inclusion. Moreover, as the transport sector is linked to other sectors of the economy through local and global value chains, the transport sector sustains the activity of many other sectors and jobs throughout the economy. As such, the transport sector is a key player in advancing the 2030 Agenda for Sustainable Development.

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2 At the ILO, this report adds to its estimation of the employment impact of a transition to sustainability in the energy, agriculture and resource and waste management sectors (ILO, 2018), complementing the policy framework laid out in its 2015 *Guidelines for a Just Transition to Environmentally Sustainable Economies and Societies for All*.

3 The model used in this study represents the world economy in 44 economies and five rest-of-the-world regions: 'AUT' 'BEL' 'BGR' 'CYP' 'CZE' 'DEU' 'DNK' 'EST' 'ESP' 'FIN' 'FRA' 'GRC' 'HRV' 'HUN' 'IRL' 'ITA' 'LTU' 'LUX' 'LVA' 'MLT' 'NLD' 'POL' 'PRT' 'ROM' 'SWE' 'SVN' 'SVK' 'GBR' 'USA' 'JPN' 'CHN' 'CAN' 'KOR' 'BRA' 'IND' 'MEX' 'RUS' 'AUS' 'CHE' 'TUR' 'TWN' 'NOR' 'IDN' 'ZAF' 'Rest of Africa' 'Rest of Latin America' 'Rest of Eastern Europe' 'Rest of Asia' 'Rest of Middle East' This study draws on the 2014 data in EXIOBASE v3 available through the project's website: www.exiobase.eu.

4 As developed in more detail below, this is explained by the global supply chains that transport belongs to. For example, the production of electrical vehicles requires different inputs sourced from different countries when compared to internal combustion engines. Electric vehicles mean, for example, a higher share of imported materials from outside of the ECE region, such as batteries from China. This may in turn reshape the ECE demand for employment.

5 In the United States, for example, transport accounted for 9 per cent of GDP in 2015 and employed about 13 million people, 9 per cent of the labour force, in 2016 (U.S. Department of Transportation, 2018). In the Europe-28 region, in 2016 almost 12 million people, more than 5 per cent of the total workforce, worked in the transport and storage services sector (European Commission, 2018). On average, European households spent 13 per cent of their total expenditure on transport-related items (European Commission, 2018). Transport is also a key player in international trade. The sector represents a significant proportion of export services in several countries in the ECE region. In 2016, transport services contributed to more than 40 per cent of service exports in Belarus, Denmark, Kazakhstan, Lithuania, Latvia, Norway, Tajikistan, and Ukraine (World Bank, 2018).

However, the transport sector generates various adverse impacts on the environment and human health. It is a major contributor to the emission of greenhouse gases (GHG) responsible for climate change as well as a contributor to air pollution, noise, natural resource depletion, habitat fragmentation, and waste generation.[6] As a result, the transport sector contributes to acid rain, eutrophication, ozone depletion, crop and forest damage and degraded living conditions for wildlife. The transport sector also generates significant risks to human health through road injury, air and noise pollution and traffic congestion.[7]

Its current and significant environmental footprint means it can play a major role in advancing an environmentally sustainable, green economy. Indeed, reducing greenhouse gas emissions and air pollution as well as increasing transport safety and improving health outcomes by enhanced active physical mobility are a priority for ECE member States. Green and healthy transport is thus an essential component to achieve the Sustainable Development Goals (WHO, 2018). Acknowledging the fundamental links between transport, health and the environment, the governments of ECE and WHO/Europe member States established the Transport, Health and Environment Pan-European Programme (THE PEP) in 2002 to integrate environmental and health considerations into transport policies and create employment in the process (WHO/UNECE, 2009).[8]

Due to the fundamental links between the environment, health and the transport sector, advancing green and healthy transport will affect jobs in the sector directly. Furthermore, due to the tight links between the transport sector and the rest of the economy, a transition towards green and healthy transport will also affect jobs in other sectors of the economy. As a shift towards green and healthy transport alters the demand for certain modes of transport and this, in turn, affects the demand for related goods and services, green and healthy transport will necessarily involve the creation of jobs in certain sectors and their removal in others. The assessment of jobs impacts of transport sustainability needs to consider both the direct and indirect effects on employment across countries and regions to better inform policymakers in their decisions to invest in green transport and design policies that assist enterprises and protects all workers in the transition.

The first THE PEP publication on Green and Healthy jobs was published in 2011, launching the activities of the Partnership. This was followed by a study in 2016 looking specifically at green and healthy jobs tied to cycling. Guided by the ECE and THE PEP Steering Committee this report evaluates the impacts on jobs towards 2030 under two broad policy scenarios:

(i) the expansion of public transport, and

(ii) the electrification of private passenger and freight transport.

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6 Direct GHG emissions from the transport account for 14 per cent of global emissions (IPCC, 2014). Within each country, and because of the sector's reliance on fossil fuels to meet energy needs, transport, and especially road transport and increasingly private care use, remains one of the main contributors of GHG emissions (OECD/ITF, 2017). Across ECE countries, transport's share of national GHG emissions ranges from under 10 per cent in Kazakhstan to more than 50 per cent in Sweden and Luxembourg. This variation results from both the sector's reliance on fossil fuels and the extent to which other sectors have high GHG emissions (World Bank, 2018).

7 Road injury is ranked as one of the top ten global causes of death in 2016 (WHO, 2016). In 2015 alone, road accidents killed more than 0.1 million people and injured more than 4.7 million people in the ECE region (UNECE, 2016). Traffic noise can cause cardiovascular diseases, cognitive impairment, sleep disturbance, annoyance and tinnitus, which adversely affects human health, productivity and quality of living. It is estimated that at least one million healthy life years are lost annually due to traffic-related noise in Western Europe (WHO, 2011). Moreover, motorised transport also discourages active forms of mobility like walking and cycling.

8 One of the main priority goals of THE PEP is "to contribute to sustainable economic development and stimulate job creation through investment in environment- and health-friendly transport" (WHO/UNECE, 2009).

The policy scenarios are compared to a business-as-usual scenario developed by the International Energy Agency (IEA). The IEA explores several energy and climate scenarios In Energy Technology Perspectives. The business-as-usual scenario is largely a continuation of current trends with current, limited climate and energy action (IEA, 2017). The business-as-usual projections are country and sector specific, including the transport sector and taking into account each country's projected energy demand by sector up to 2030. Each of the public transport and electrification scenarios for the ECE region are then compared to the IEA business-as-usual (baseline) scenario to estimate the net employment difference across countries and sectors. This baseline scenario assumes in 2030 there will be 6.24 billion people employed in all sectors across the world.

The results presented in this report stem from a global model build from a multiregional input–output (MRIO) table, EXIOBASE. The main advantage of adopting such a modelling approach is that it allows the report to study not only the evolution of employment in the transport sector under the different scenarios considered, but also to provide important insights on how the different scenarios in the transport sector will spill over to the rest of the economy and the labour market. Furthermore, given the global nature of the model and data used, these effects can be analysed across countries and regions as well, providing additional insights as to not only in which sectors of the economy jobs are more likely to be created and removed under each scenario, but also in which regions of the world such jobs will created and/or destroyed.[9] While there is a distinction between temporary and permanent and high-skilled and low-skilled jobs in terms of how they contribute to people's well-being and the economy as a whole, for the purpose of this study, this aspect will only be reviewed on a qualitative basis. Future work on the topic is required to shed light on a more in-depth and granular picture of the evolution of employment over time which is out of the scope of this report's analysis.

Advancing sustainability through the expansion of public transport and the electrification of private and freight transport is but one of the drivers by which the future of transport will affect employment throughout the economy. Other drivers include automation, shared mobility, cycling, hyperloop, drone delivery, buy-local or short-circuit economies, among others. Though potentially relevant from the perspective of jobs in green and healthy transport, they are outside the scope of this study, which THE PEP Steering Committee decided should be focused on public transport and the electrification of private transport, but could be considered in future work in this area.

Several opportunities exist to enhance transport sustainability. Freight and passenger transport via road, rail, waterway and aviation can all play an important role in the sector's transition. Major, but not exclusive, tools to advance this transition in the freight transport sector include increased energy efficiency, alternative clean and renewable fuels, modal shifts and electrification, especially when a large share of electricity is generated from renewables.

9 A detailed description of EXIOBASE and its labour accounts can be found in the online supporting information from Stadler et al. (2018). Details on the model and methodology used can be found in the Annex and Montt et al. (2018).

Many technologies exist to enhance the fuel efficiency and reduce emissions of new and in-use road freight transport vehicles (through the adoption of alternative fuels (to substitute for diesel), engine upgrades, improved aerodynamics and drag reduction, electrification, reduced weight, material and other improvements for heavy and light-duty trucks, as well as logistic management improvements via information and communication technologies), but adoption still lags behind despite their sound business case (Roeth et al., 2013), (Aditjandra et al., 2016). In private, passenger transport, though efforts have been made to improve fuel efficiency and encourage modal shifts such as reducing private motorised use in favour of public transport, cycling and walking in some cities (UNEP, 2017), there are still ample opportunities to improve energy efficiency and promote modal shift. Currently, the large majority of passenger transport takes place in fossil-fuel powered cars (European Commission, 2018).[10]

Previous work by THE PEP has shown that certain actions aimed at advancing towards green and healthy transport, such as the promotion of cycling, will lead to net job gains, advancing SDG 8 on decent work and economic growth (through the promotion of work opportunities) (UNEP, 2017; WHO, 2014). This report expands on this work by evaluating whether advancing cleaner transport, notably through increased public transport and the electrification of private transport, in the ECE region can also advance employment opportunities and assist in achieving SDG 8 in the region and across the world.

It is important to stress that this report's analysis focuses on job creation, reallocation and potential job losses. Though of critical importance to advance a socially sustainable transformation, green and healthy transport must also advance decent work. The extent to which the job creation identified in this report contributes to decent work is out of the scope of the present report, but the advancement of decent work should be a key priority to ensure that green and healthy transport contributes fully to social development and sustainability as well.

[10] The analyses in this report focus on land (road and rail) passenger and freight transport, which accounts for the majority of employment in the transport sector. This does not mean that there are no opportunities to enhance the sustainability of other freight modes. For inland waterway freight transport, solutions to improve fuel efficiency range from switching from oil to natural gas, retrofitting, and installing equipment for efficient cargo loading and unloading, as well as using larger, more energy-efficient cargo vessels. There also exists potential for energy saving and efficiency in transmission between ports and terminals among different transport modes. For maritime shipping, there is potential to reduce the high volume of black carbon emissions from the sector, which stem from the low quality fuel used (Comer et al., 2017). Potential to reduce black carbon lies in switching from residual to distillate fuels, and switching from residual or distillate fuels to lower sulphur fuels and alternative fuels such as natural gases and biofuels, installing exhaust gas cleaning systems on ships and diesel particulate filters (Comer et al., 2017). Improving the sustainability of maritime shipping also involves improving the quality of the infrastructure and regional port facilities (Global Green Freight, 2018a). The aviation sector has opportunities to advance sustainability through new aircraft designs, the use of composite lightweight materials, improved engines, retrofitting engines and winglets replacement, as well as the use of alternative jet fuels. Improvements in operations can also reduce emissions and fuel of the aviation sector through the reduction of time delays, ensuring that aircrafts operate at optimal elevations and use the most direct flight paths (Global Green Freight, 2018b).

I. The employment effects of the expansion of public transport in the ECE region

Driven by the evidenced environmental and health benefits of public transport (WHO, 2018) and heightened ECE countries' interest, this chapter starts with a discussion of the different channels through which an expansion of public transport will affect employment. The discussion is framed around experiences in ECE countries and cities that observed significant increases in public transport. In a second part of the chapter, the public transport scenarios are developed and specified. Finally, the two scenarios are compared to the business-as-usual scenario using a global model built from the multiregional input–output (MRIO) table, EXIOBASE.

The chapter focuses its analysis on the results of the employment projections under two different scenarios that could lead to an increase in public transport:

- Scenario PT.1: Doubling investment in public transportation
- Scenario PT.2: Free public transportation.

A. How the expansion of public transport affects employment

Increased utilization of public transport may reduce private motorised vehicle use. The increase in public transportation will increase employment in the public transportation sector and related industries, but reduce employment in sectors related to private car use (e.g. retail sale of fuel, production, sale and maintenance of motor vehicles).[11]

Recent policies, like the establishment of Limited Traffic Zones in several cities in the ECE region, have discouraged car use in favour of public transport and active modes of mobility, though there is still scope and need for the expansion of public transport in Europe and elsewhere around the world.[12] The growth rate of car use (measured in passenger-kilometres) has declined in several countries in the ECE region (UNECE, 2018). In Europe in 2014, the demand for public transport was higher than pre-2008 levels, observing almost 50 billion journeys on local buses, trams and metros, the highest recorded figure since 2000 (UITP, 2016). The modal share of private car use is expected to decrease in developed countries, due to stringent policies, infrastructure investment and behavioural change. These three components are expected to offset car-use growth along with factors such as population. Aging may also reverse the trend, as will income growth (ITF, 2017). However, in a few cities, the rise of ride hailing companies has changed the public transit landscape. In some cases, they have substituted public transport and in others complementing the public transit system, highlighting the complex role that technology and policies have in shaping the future of transport (Hall et al., 2018).

[11] THE PEP's previous work provides concept and case studies highlighting the importance of public transport as a significant employer (WHO, 2014). For example, the report estimates that the share of (direct and indirect) jobs associated with the rail, light rail, bus, coach and cycling industries in the United Kingdom represents 38 per cent of all transport jobs in the country (WHO, 2014). However, it is not clear how the expansion of public transport might lead to job destruction in other sectors, for example, due to reduced demand in private transport.

[12] Not discussed are the health effects of such policies. The health benefits of an increased modal share of public transport are well documented for cities in Europe and the United States (Grabow Maggie L. et al., 2012; Holm et al., 2012; Rojas-Rueda et al., 2013; Woodcock et al., 2013). For example, Rojas-Rueda et al. (2013) find that replacing 40 per cent of short and long car trips by bike rides and public transport would reduce a variety of diseases among travellers and the general population, particularly cardiovascular disease and Type 2 diabetes. Labour productivity tends to increase with lower levels of illness-related absenteeism.

Globally, annual capital expenditures on transport are between US$ 1.4 trillion and 2.1 trillion, with public investment contributing to between US$ 569 billion and 905 billion of that total amount.

About three quarters of public transportation investment takes place in high-income countries (Lefevre et al., 2014) and given the projected increase in demand, investment in public transport is expected to increase by more than 50 per cent by 2030 (Dulac, 2013).

The International Transport Forum (2017) has analysed scenarios associated with the expansion of public transport. It projects future transport demand by mode for all regions of the world up to 2050 along three scenarios: the baseline, the robust governance and the integrated land-use and transport planning scenarios. The robust governance scenario assumes the adoption of pricing and regulatory policies by local governments to slow down ownership and the use of personal vehicles. The integrated land-use and transport planning scenario assumes joint land-use and sustainable urban transport policies with higher supply of public transport, mass transit and restrictions on urban sprawl in cities in addition to the local governments' role assumed in the robust governance scenario. The report projects that public transport's demand share in Europe will increase from 19 per cent in 2015 to 25 per cent, 50 per cent and 53 per cent in the 2050 baseline, robust governance and integrated land-use scenarios, respectively (ITF, 2017).

Changes to the public transport system will naturally affect employment in the sector (direct effects). Public transport is a major employer in itself. Urban public transport represents about 20 per cent of the output of the transport sector, and worldwide about 13 million people are employed by public transport services (UITP, 2013a). Direct investments in multimodal and public transport create a net employment gain compared to investment in private car-based transport (Gouldson et al., 2018).

Although a transition away from private cars to public transport would generate employment losses in industries such as automobile manufacturing, petroleum refinery and distribution, it generally promotes employment in rail infrastructure construction, as well as the manufacture of public transport vehicles (indirect effects). Service jobs maintain and run public transport systems; they are a major source of employment. In fact, ECE public transport companies are among the biggest employers. In 2017, for example, 310,000 employees worked for the DB Group, 740,000 for Russian Railways,[13] 27,000 for London Underground and 61,000 for the RATP Group in Paris. These industries, in turn, have considerable value chains relying on indirect employment in supply industries. Ernst and Sarabia (2015), for example, calculate the jobs created by investment in the construction sector. For every US$ 1 million invested in the sector, 8.5 jobs are created in Belgium, 39.8 in Turkey and 114.9 in the Russian Federation. Some of the temporary construction jobs will stay in maintenance work of the infrastructure. The estimates represent the construction sector as a whole rather than specifying public transport infrastructure. However, the expansion of transport infrastructure implies a significant amount of employment due to the industries high employment ratio. It is this link that motivates the approach taken in the report and the employment generating potential of public transport expansion (Cats et al., 2017).

In addition, an expansion of public transport, if accompanied by a modal shift from private car use to public transport, reduces households' expenditures on fuel. This will increase disposable household income due to higher cost of private transport as compared to public transport. Households may spend part of the savings which will create more jobs through increased consumption in other, non-transport related goods (induced effect). The reason why more jobs are created is because the fuel industry is based on oil extraction and refinery which are highly capital-intensive sectors with little employment involved. Using input-output tables, for example, Chmelynski (2008) estimates that one million US$ spent by households on petrol and other private vehicle expenses generate about 13 jobs, while the same amount of expenditure could generate

[13] Note that the DB Group and Russian Railways figures include a significant share employed in the transportation of freight, with the DB Group also including road freight.

about 17 and 31 jobs if spent on public transportation and a typical bundle of goods purchased by a household respectively.

The overall employment effects of the public transport's expansion will depend on the extent of the linkages of the sector to others in the economy, the extent to which they in turn create jobs and the extent to which the inputs for public transport are sourced from within the national economy. As a result, the expansion of public transport in ECE member States can have a variety of direct and indirect implications on jobs within and outside the region. This is a key reason why this report adopted a global model built from the multiregional input–output (MRIO) table, as it allows the analysis of such linkages, and hence allows for estimates of the impact of the scenarios analysed on employment levels across the whole economy.

As discussed above, in addition to improving health and environmental outcomes, the expansion of public transport will have both direct and indirect employment effects that stem from changes in demand for public transport and its supply chain. But in addition to those effects, an increase in the usage of public transport will have still more indirect effects. For instance, public transit plays an important role in efficient urban mobility. Accessible, connected and inclusive public transit systems have shown to be significant factors in improving employment accessibility and labour (Sanchez, 1999, Johnson et al., 2017; Matas et al., 2010). Using cross-sectional census data in Britain, Johnson et al. (2017) find that areas with shorter public transport times were associated with higher employment levels. In Barcelona and Madrid, low job accessibility by public transport affects female employment more than male employment, increasing gender inequalities (Matas et al., 2010). These so-called forward linkages and impacts on jobs are, however, not analysed here as further modelling is required.

In general terms, as described above, the expansion of public transport affects employment through the creation of jobs associated to the public transportation sector as well as the development of infrastructure to support it (direct effects), and the provision of inputs to the public transportation sector (indirect effects). Furthermore, given that urban public transport is cheaper than private transport for many households, it can also lead to increased household consumption in other goods and services (induced effects). In parallel, the shift in transport demand away from private vehicles, reduces the demand for vehicles, for fuel and related services.

In preparing the analysis for the public transport scenarios a number of possible options were discussed initially between ECE and ILO and subsequently with the Green and Healthy Jobs in Transport Partnership and THE PEP Steering Committee. From these discussions the following scenarios were identified to be modelled as part of the analysis:

- Public Transport 1 (PT.1) Doubling investment in public transportation
- Public Transport 2 (PT.2) Free public transportation
- Public Transport 3 (PT.3) Doubling of public transport services.
- Public Transport 4 (PT.4) Ban on internal combustion engines in passenger transport within cities

Subsequently an analysis was undertaken by the ILO modelling team on the viability of each of these scenarios. During this analysis the team identified that for modelling reasons PT.3 would give the same results as PT.1 and therefore would not be modelled and that PT.4 would be considered only in the context of the analysis on the electrification of private transport. As a result, only PT.1 and PT.2 were actually modelled for this study.

The two public transport scenarios explored in this study point to mixed overall employment effects of the expansion of public transportation. As shown below, the expansion of public transport, creates jobs in the public transportation sector, but can destroy jobs in different sectors as a result through the financing scheme's effect on other sectors. Importantly, the jobs created are not necessarily in the same sector or country, promoting the need for complementary policies to meet the increased demand for jobs in the sectors and countries that hold them, and to protect and support workers in those industries and regions that may experience job losses. (Appendix I provides the methodological details that underlie the estimation).

B. Scenario specification PT.1: Doubling investment in public transportation

Following discussions with the Partnership and THE PEP Steering Committee, the increase in investments into public transport was selected as the first scenario. It is inspired by other research of the transport economy such as Dulac (2013a) and the International Transport Forum (ITF, 2017). Dulac, for example, estimates that investment in public transport is expected to increase by more than 50 per cent towards 2030. The International Transport Forum projects public transport's demand share, in Europe as well as North America, to more than double under their robust governance scenario (ITF, 2017).

The Public Transport (PT.1) policy scenario developed here assumes a doubling of investments in public transport. This investment takes the form of increased spending in two main sectors of the transport economy: building of public transport infrastructure and the manufacturing of rolling stock. In the first step of the scenario, each country's investment in fixed capital stock is increased in terms of rail infrastructure, locomotives, carriers, busses and tramways. Investment in rolling stock considers depreciation and is capped at the total value of the rolling stock required for an approximate modal share split of public and private kilometres observed in the most advanced ECE countries.[14] In a second step of the scenario, the operation and maintenance of the additional public transport capacity is modelled in terms of increased public services, required energy supply and related public transport activities.

The scenario assumes that transport infrastructure investment is financed through a reallocation of funds from roads to rail. The financing of the additional rolling stock investments is paid for by higher fuel prices (e.g. through taxes paid at the pump) and to a lesser extent to higher vehicle prices (e.g. through taxes for new vehicles), reducing the overall demand for fuel and moderately reducing private vehicle purchases. This in turn reduces employment in the value chain associated with private car use (e.g. fuel production and refinery, retail sale of fuel, repair and maintenance and to a small extend the manufacture of the vehicles).

In order to account for uncertainties and to provide for a range of low and high estimates, the PT.1 scenario is further altered and the doubling of investment in the respective sectors is reduced or increased by an additional 10 per cent. For example, the low estimate means that the doubling of investment is reduced by 10 per cent while the high estimate models an additional increase of the doubling by 10 per cent.

The PT.1 policy scenario is then compared to a business-as-usual scenario. As explained above, the business-as-usual scenario, developed by the International Energy Agency (IEA), is largely a continuation of historic trends of sectoral economic growth patterns. It projects current limited climate and energy action up to 2030 and was thus selected as the baseline (IEA, 2017). The business-as-usual projections are country and sector specific, include the transport sector and take into account each country's projected energy demand by sector up to 2030.

[14] Regarding the modal share of railways, Switzerland is taken as the ECE country with the highest share while in terms of bus use, Turkey is considered as the ECE country with the highest penetration. For the scenario, in all ECE countries the doubling of investment is capped once the level of Switzerland and Turkey is reached.

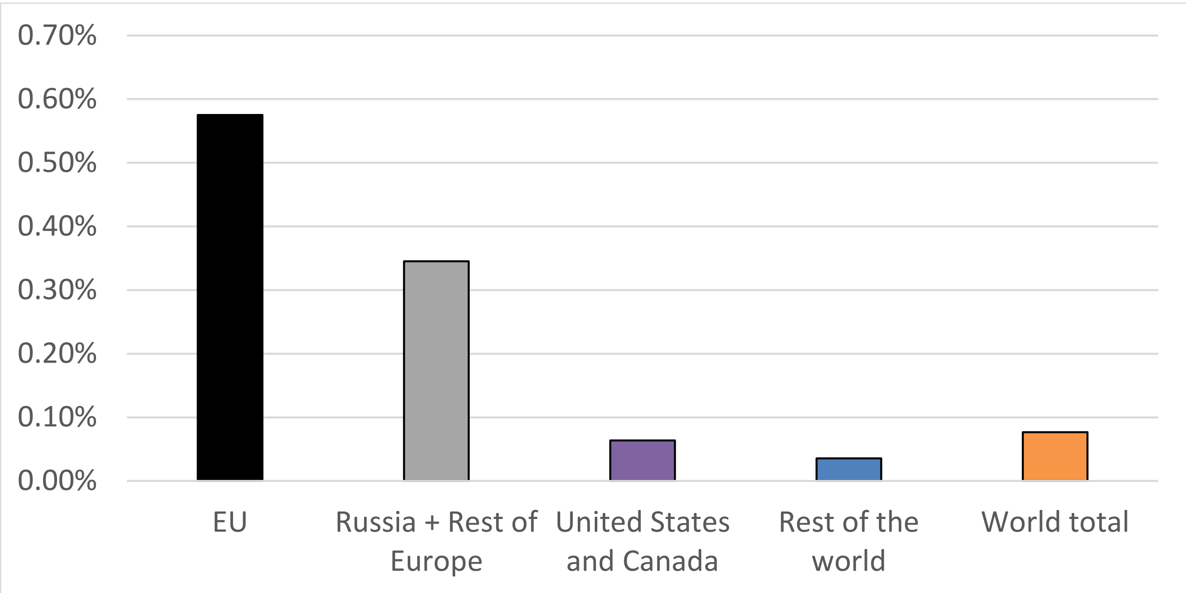
C. Scenario PT.1 results

In the PT 1 scenario, the increase in public transport investment requires employment in the construction sector to build the infrastructure (mostly temporary and lower-skilled jobs) and the value chain associated with the manufacturing of rolling stock (mostly permanent and higher-skilled jobs). Increased investment in public transport subsequently increases the availability of transport and promotes service employment in the sector itself (permanent and higher-skilled jobs). It may also promote public transport use, offering an alternative to car use and if accompanied by adequate policy measures, consequently, a modal shift away from private car use.

If investment in public transport projected to 2030 is doubled, expected aggregate employment effects across the ECE region are positive. In terms of infrastructure investment, the scenario assumes, however, that there is no overall increase in public infrastructure spending, but that spending is shifting within the infrastructure sector. More specifically, investment in motorways and road infrastructure (excluding maintenance) is now directed to public transport, thereby not affecting overall employment. Employment in the construction sector or the associated value chains is not differently impacted and is treated as if investment within the sector had not shifted.

In terms of the manufacturing of rolling stock, capacity is increased and investment is therefore doubled, thereby promoting employment in the manufacture of buses and trains and the associated value chains. While public transport investment only minimally affects car purchases and manufacturing (Beaudoin and Lin Lawell, 2018), additional production across the rolling stock value chain (e.g. the manufacture of vehicles and transport equipment) will have overall positive employment effects. The reason is that this investment is only moderately substituting for the manufacture of private cars. Figure 3 shows the region-specific employment effects associated with doubling investment in the transport sector in the ECE region. The vertical axis shows the employment difference in percentage comparing the policy scenario with the business-as-usual scenario. For example, a positive value close to 0.1 per cent for the world total means that, compared to a business-as-usual scenario, the doubling of investment in public transport in the ECE region will increase global employment by 0.1 per cent.

Figure 3: Employment levels in PT.1 compared to the business-as-usual scenario, 2030 (percentage)

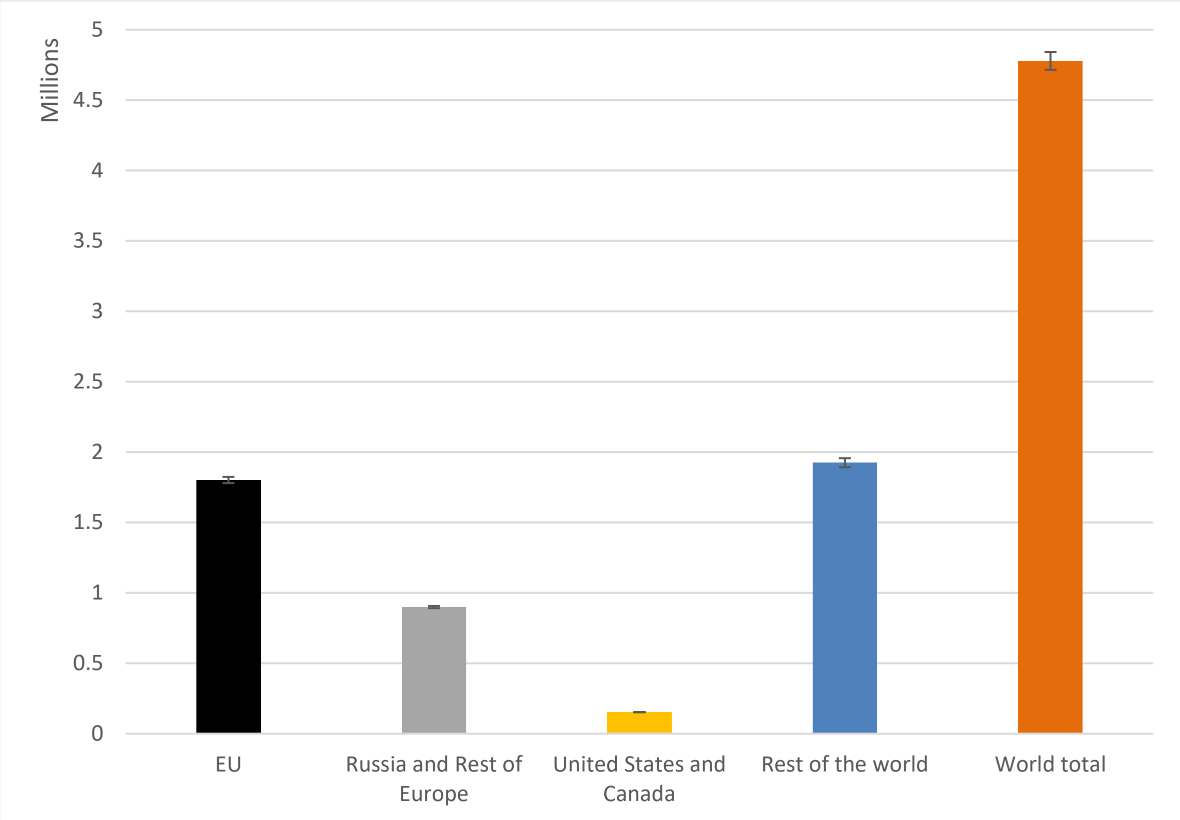


Source: ILO estimates based on Exiobase v3.

Figure 4 shows the absolute number of jobs, which translates the, for example, 0.1 percentage increase in global employment, to around 4.8 million jobs created across all sectors. This is a small change across the world, but different regions should expect different levels of net job creation and destruction. In the European Union, for example, employment under this scenario is expected to be 0.6 per cent higher, or a net creation of 1.8 million jobs, than in the business-as-usual scenario and around 0.4 per cent higher, or a 0.9 million net job creation, in the Russian Federation and the rest of Europe. In the United States of America and Canada, the employment effect is minor, less than 0.1 per cent.[15] The jobs created are most likely to be permanent jobs in running the transport service or manufacturing the rolling stock. Skills levels are also expected to be in the middle range of occupations as technicians, train and bus drivers, engineers and related fields of expertise are required.

The error bars in figure 4 show the job effects of a 10 per cent variation of investments in addition to the PT.1 policy scenario. For example, an additional spending of 10 per cent in the European Union (EU) would add a further 22,000 jobs. Across the world, if the increase of public transport investment were 10 per cent lower than in the scenario assumed, job creation would be 63,000 less. In terms of industry implications, as can be expected, most variation would happen in the transport sector itself as well as in the direct supplying industry of the manufacturing of rolling stock.[16]

Figure 4: Difference in number of jobs in PT.1 compared to the business-as-usual scenario, 2030 (absolute)



Source: ILO estimates based on Exiobase v3.

15 These effects are generally small, particularly if they are spread over a 10-year period. As noted by Montt et al. (2018) the average national economic growth per year is of 1.2 per cent.

16 It should be noted that the low and high estimates refer to a 10 per cent higher or lower final demand for bus manufacturing, bus services, train manufacturing, train services and fuel.

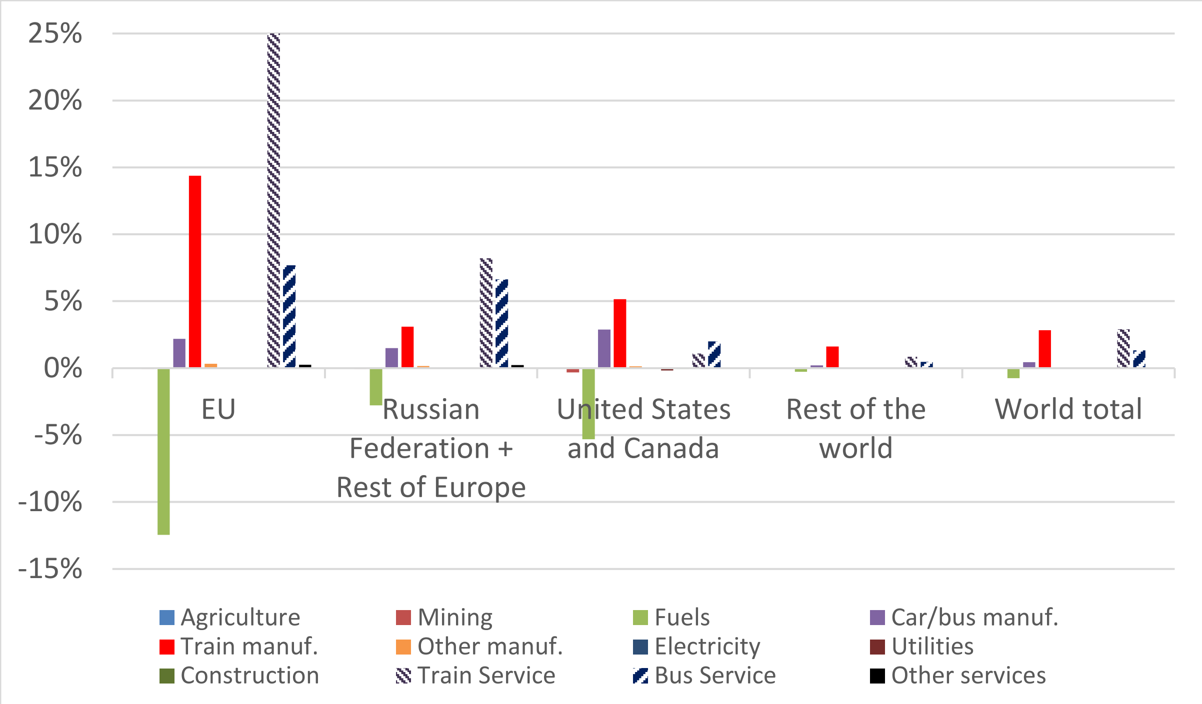
Figure 5 shows the job difference between the doubling of public transport and business-as-usual scenario at the industry level and specifically the direct job impacts in the transport industry itself. As can be expected, job creation is led by the public transport sector and the manufacture of rolling stock, notably in the European Union and the United States of America. In the European Union, employment in train and bus service increases by over 25 and 8 per cent, respectively, or around 267,000 and 570,000 jobs. The effect is similarly positive in the Russian Federation and rest of Europe adding some 80,000 jobs to train services and 430,000 jobs to bus transport. In the United States of America and Canada employment generation is much smaller, which is due to their current lower level of services. A total of around 30,000 jobs can be expected in bus and train services. Taken together, close to 1.4 million additional jobs could be created in the rail and bus service industry across the ECE region.

The train and bus manufacturing industry will add between 2 and 15 per cent of new jobs to their workforce across ECE countries, or around 165,000 jobs in bus manufacturing and 340,000 jobs in train making. With the current strong manufacturing base in the EU, the United States of America and Canada, employment gains are highest in those countries that would expand their production.

As bus and car manufacturing is taking place in the same industry, an overall increase masks within industry employment shifts from manufacture of cars to bus coaches and related sectors. Employment in public transport and related industries in the Russian Federation, the United States of America and Canada also shows positive effects, but to a smaller extent than in the European Union. Transport service and manufacturing employment increases between 3 and 8 per cent and between 2 and 5 percent, respectively.

Employment losses will be significant in the fuel industry across the ECE region with an up to 10 per cent reduction. The European Union would lose around 29,000 jobs, the United States of America and Canada around 23,000 jobs and the Russian Federation and rest of Europe 55,000 jobs. These results stem from the fact that the scenario assumes that additional investments are fiscally neutral and entirely paid for by taxes to vehicle use (fuel consumption) and partly new-vehicle purchases. These factors explain the employment effects across industries and the ECE region. Tax funded policies, such as modelled here, may have smaller employment effects as compared to debt funded ones. While tax instruments typically reduce consumers' and enterprises' demand for the taxed goods or services and redirect spending to other intended sectors, debt or monetary expansion, at least in the short run, will add to aggregate demand without necessarily reducing consumption. The short to medium term employment effects may thus be larger if debt instruments are considered to finance the expansion of green transport. However, in the long run, debt need to be financed in the future and thus have potentially longer-term negative employment effects. In addition, if the objective is to reduce carbon emissions the taxing of fossil fuels can contribute to achieve the double win of reducing emissions while increasing green transport and jobs.

Figure 5: Difference in employment level by industry in PT.1 compared to the business-as-usual scenario, 2030 (in percentage)



Source: ILO estimates based on Exiobase v3.

As a result, it can be seen that, under the assumptions of this scenario, a net total of about 4.8 million jobs will be added to world employment across all sectors as a result of this scenario, of which 2.9 million will be in the ECE region alone. When focusing on the transport-specific sectors alone, it is estimated that employment will increase 2.7 million jobs of which just over 1.8 million will be created in the ECE region.

D. Scenario specification PT.2: Free public transportation

The second scenario developed here draws on existing policies and an emerging debate in ECE countries to make public city transport free. Today, for many cities, public transportation is funded in part by fares paid by users and in part by public subsidies financed by local taxes to polluters, car users or beneficiaries (e.g. urban tolls, congestion pricing, pollution charges, parking charges and fuel taxes or charges to those who benefit the most from public transport, such as employers, retailers and real-estate owners). Financing can also come from public-private partnerships and/or secondary revenue streams (e.g. advertisement, retail space) (UITP, 2013b). To attract passengers to public transportation, certain cities have discussed the possibility of making public transportation free for users and, in some cases, it has been adopted.

In France the provision of free public transport has been considered for the Île-de-France region through a study[17] commissioned by the President of the Île-de-France region and of Île-de-France Mobilités with the aim of investigating its feasibility and to provide policy recommendations. The report reviews the current situation, evaluates the potential for a policy on free public transport, and provides some policy recommendations. More details are provided in Box 1 below.

[17] www.iledefrance-mobilites.fr/wp-content/uploads/2018/10/Rapport-Comit%C3%A9-sur-la-faisabilit%C3%A9-de-la-gratuit%C3%A9-des-transports-en-commun-en-%C3%8Ele-de-France-leur-financement-et-la-politique-de-tarification.pdf - October 2018.

Box 1: Report of the Committee on the feasibility of free public transport in Île-de-France, their financing and the pricing policy, 2 October 2018

The study sets out why passengers prefer car use to public transport, stating that it is quality, rather than price, that is the most important factor. From this standpoint, the report asserts that a free public transport system would only reduce automobile traffic by 2 per cent, concluding that the effects of this policy on automobile pollution and road congestion would be minimal. In addition, the policy would contribute to a reduction of the quality of public transport services through increased overcrowding – the ultimate reason why the public transport modal share is low – and would not meet social equity goals, since it would disproportionately benefit those who can already pay for public transport. These insights are particularly important given the intense investment needs of this policy, which could create funding problems.

Alternatively, proposals are made to make public transport more efficient, increase its modal share and consequently address the negative externalities posed by road transport. In general terms, the report recommends, first, a more rational use of the car through the development of car-sharing schemes and the use of less polluting vehicles. Secondly, the report argues for a better funding mechanism for public transport based on a progressive pricing system, which would be more equitable and that reduces the burden on taxpayers. Along these lines, some of the specific recommended policies are the expansion of the limited traffic zone in Paris, prohibition of all diesel vehicles by 2024, establishment of dedicated lanes for shared vehicles, or the reintroduction of distance as a component in price determination.

It is concluded that if such recommendations are taken into account, bold action to foster public transport system use and the reduction of road-derived air pollution and congestion would reach the objectives of the Urban Transport Plan of Ile-de-France 2017-2020 roadmap and help to achieve a more sustainable transport system.

The case studies on free public transport point to different effects on passenger demand, depending on the city, region, current share of modal split, etc. Drawing on the existing evidence of fare-free public transportation that are in actual operation in the case studies on Belgium, Estonia and the Netherlands, the policy scenario developed here assumes that fare-free public transport leads to a 14 per cent increase in public transport demand. In the framework of this scenario analysis, this translates into 14 per cent increase in public transport with no additional investment in infrastructure or rolling stock as the demand is met under the assumption that spare capacity exists.

Box 2: Case study of free public transport in Belgium, Estonia and the Netherlands

In 2013, Tallinn, Estonia, became the largest city to adopt fare-free public transport with the objective of promoting a modal shift to public transportation and supporting the mobility needs of vulnerable population groups. In 2012, ticket sales covered only one-third of the system's operational costs, a lower share than other public transport systems in Europe. The immediate (three months after implementation) effect of the policy was a 1.2 per cent increase in passenger demand, to a large extent shifting people from walking to public transportation. One year after implementation, public transport usage increased by 14 per cent, a comparatively low effect due to the already high market share of public transportation (Cats et al., 2017).

In the Netherlands, the implementation of fare-free public transportation on two bus routes doubled passenger use within 1 year of the programme's implementation. The growth in these routes comes from a modal shift from cars (45 per cent), bicycles (10 per cent), other public transport services (30 per cent) and new trips (16 per cent).18

In Hasselt, Belgium, the fare-free public transport resulted in an increase in demand for public transport explained by a modal shift from cars (16 per cent), bicycles (12 per cent), walking (9 per cent) and new trips (63 per cent) (van Goeverden et al., 2006).

Of the total increase in public transport use, and following the experiences noted above, only 13 per cent of this increase is attributed to a modal shift away from car use.[19] This means that, by and large, free public transport seems to provide very limited incentives to car users to switch their mode of transport. In terms of financing, the scenario assumes that public transport fares are replaced, as a public transport financing component, by an increase in household fuel prices (e.g. a fuel tax paid at the pump) and, to a minor extent, a specific tax on new vehicles, which reduce car use and new car purchases as per the observed long-run fuel and new car price elasticities.[20] As households no longer spend money on public transport, the savings accrued are directed to consumption in other goods and services as per average household consumer basket.

E. Scenario PT.2 results

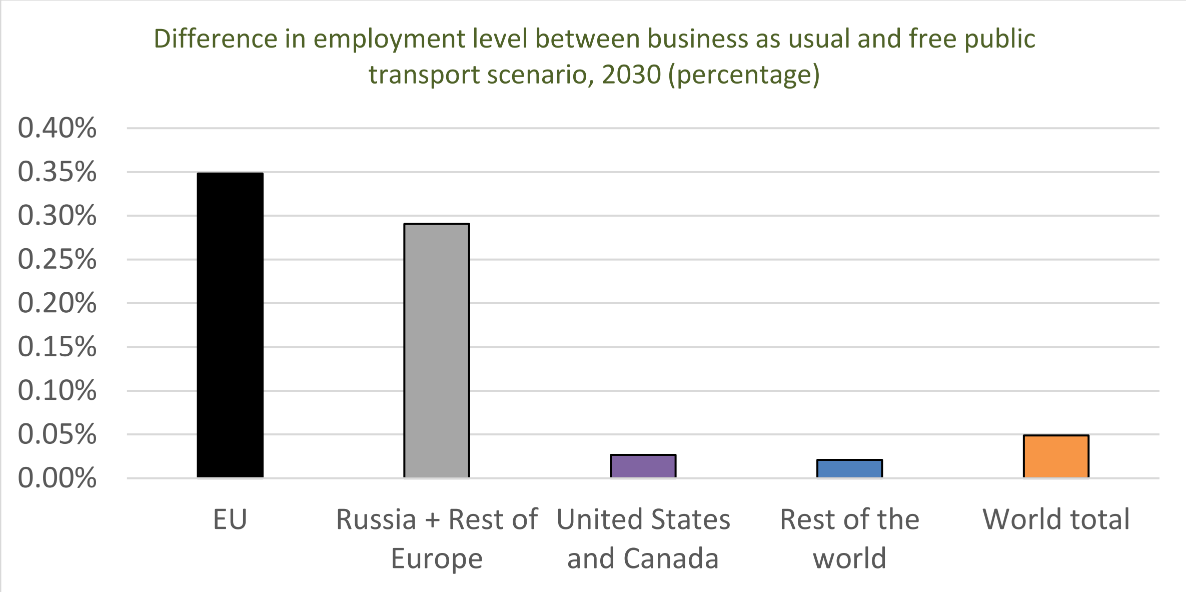
Comparing the scenario PT.2 to the business-as-usual (baseline) scenario, introduced earlier in the report, fare-free public transport would increase employment in the ECE region by only a small amount, less than 0.35 per cent. The effect is driven by the fuel tax which reduces demand and hence employment in the fuel industry but increases employment in the public transport industry due to governments' redirected spending of the fuel tax to fund fare-free public transport. In total, and compared to a baseline business-as-usual scenario, a fare-free public transport scenario in the ECE region leads to a small positive employment effect on the worldwide economy (figure 6).

[18] See Free Fare Public Transport accessed May 2019: https://freepublictransport.info/wp-content/uploads/sites/7/2015/07/Fare_Free_Public_Transport_Dr_Michel_van_Hulten.pdf.

[19] By most accounts these are conservative estimates.

[20] Zeleke (2016) provides gasoline and diesel price elasticities for the European Union countries. For non-European Union countries in the ECE region, the scenario draws on Baranzini and Weber (2013), Havranek and Kokes (2015), Huntington et al. (2017) and Odeck and Johansen (2016). McCarthy (1996) provides the new car price elasticities.

Figure 6: Employment level in PT.2 compared to the business-as-usual scenario, 2030 (percentage)

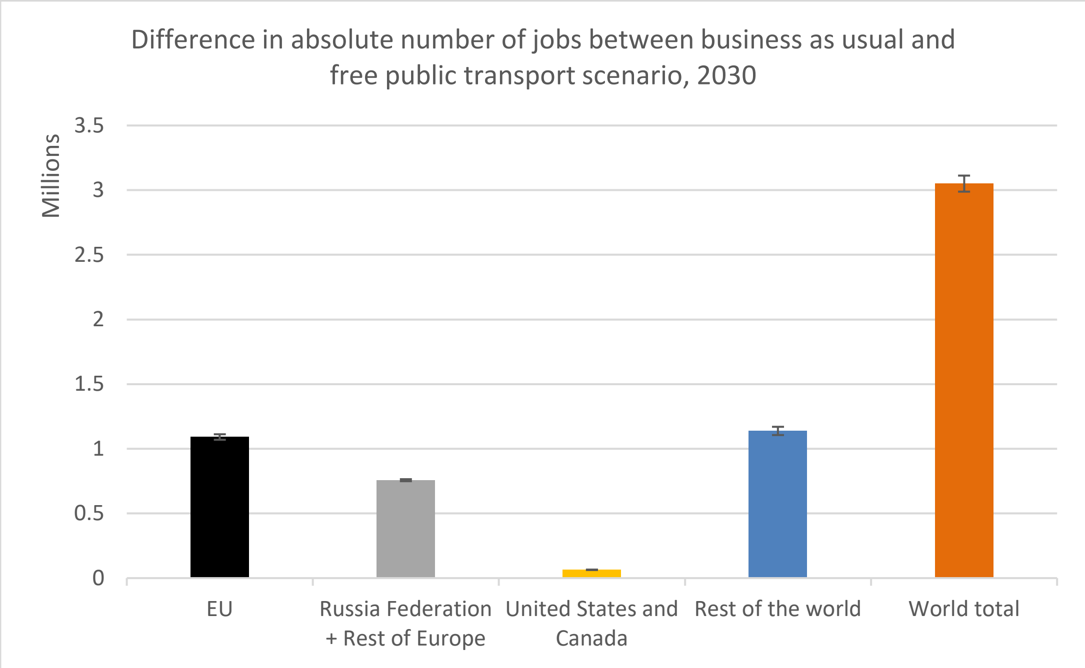


Source: ILO estimates based on Exiobase v3.

Figure 7 shows the absolute number of jobs comparing the free public transport to the business-as-usual scenario. A net gain of around 1 million jobs is expected in the European Union, while the Russian Federation and the rest of Europe would gain around half a million jobs. Jobs are expected to be permanent as they are mostly found in the public transport operation and maintenance sector (see industry employment effects below). In the United States of America and Canada, there is no difference between the baseline and PT.2 scenario.

An additional 10 per cent increase or decrease of the PT.2 scenario provides some indication on a range of low and high estimates. It reveals little variation due to the already small initial effect. The error bars indicate an additional or reduced spending of 10 per cent. Across the world the absolute difference would be close to 60,000.

Figure 7: Employment effect in PT.2 compared to the business-as-usual scenario, 2030 (absolute)

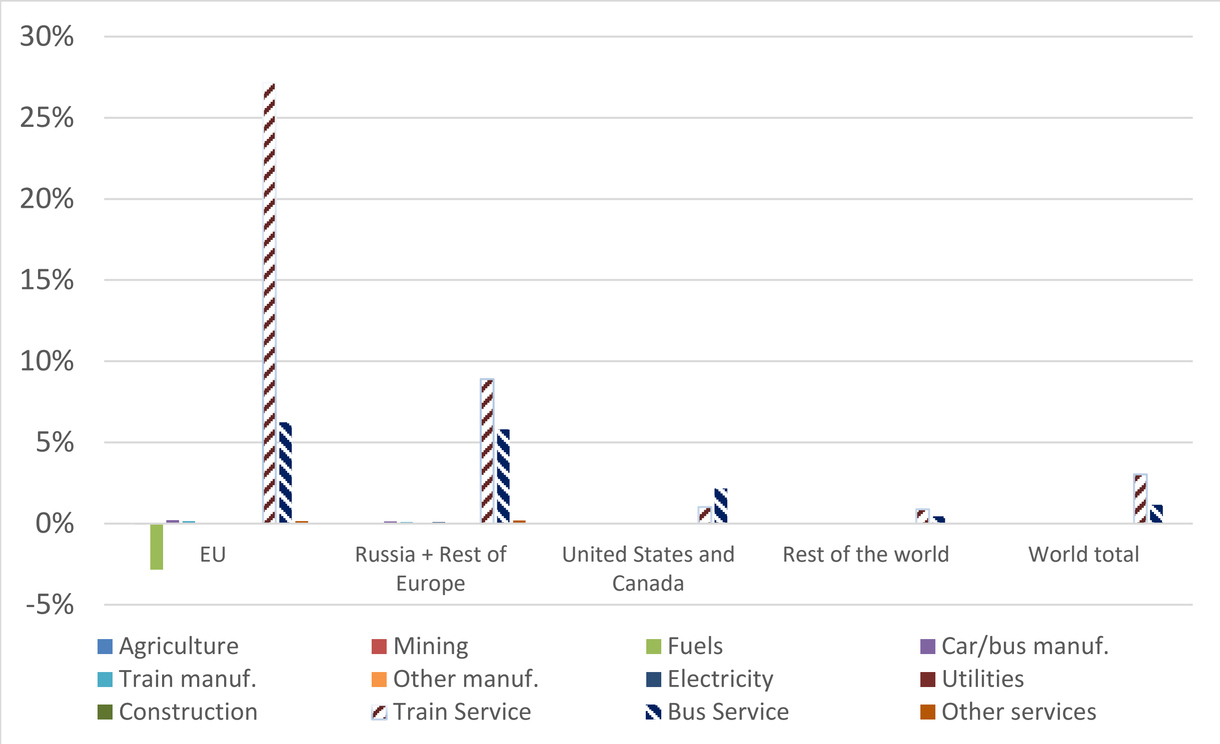


Source: ILO estimates based on Exiobase v3.

Figure 8 provides for the employment effects at industry level. As expected, job creation is led by the public transport sector in urban rail and bus services. Thereby, it can be expected that the majority of jobs will be permanent. While in the European Union train and bus service industry jobs would increase between 5 and 20 per cent, jobs in public transport in the United States of America and Canada would increase by 2 to 3 per cent. In the Russian Federation and rest of Europe, employment effects in the transport industry are expected to range between 5 and 10 per cent. This results in rail service jobs growing by around 1.3 million jobs globally. Those jobs are also most likely to be permanent jobs with limited number of temporary jobs as this scenario does not assume additional construction of public transport infrastructure.

Job losses, which are projected to be lower than job creation in the ECE region as well as globally, are led by employment losses in the fuel industry. Overall employment effects in this scenario are small due to the fact that no additional investment in public transport infrastructure or rolling stock is undertaken. This also means that financing needs of Government are much smaller than in the doubling public transport scenario. In turn, the fuel tax is lower and the reduction in car use and fuel consumption limited.

Figure 8: Employment level in PT.2 compared to a business-as-usual scenario by industry, 2030 (percentage)



Source: ILO estimates based on Exiobase v3.

As a result, it can be seen that, under the assumptions of this scenario, a net total of about 3.1 million jobs will be added to world employment across the all sectors as a result of this scenario, of which 1.9 million will be in the ECE region alone. When focusing on the transport specific sectors alone, it is estimated that employment will increase by 1.9 million jobs of which just over 1.2 million will be created in the ECE region.

While it is not possible to calculate the exact cumulative effect of these two scenarios as the model does not allow it, it is possible to assume that if these two scenarios were to be considered together at least 2.5 million jobs would be created in the transport sector in the ECE region.

F. Public transport expansion employment effects to 2050

The employment effects evaluated in these scenarios compare a business-as-usual trajectory with one that implements the scenario in 2030. Specific projections beyond 2030 become difficult as technology and policy driven economic and employment trends become too uncertain to produce meaningful results. Notwithstanding these limitations, and considering the small but positive effects of the expansion of public transportation on the sector's employment by 2030 observed in the two scenarios, these effects are likely to continue towards 2050.

Barring any radical change in mobility patterns by 2050, such as autonomous driving, positive employment changes are expected from a further shift to Green and Healthy Transport. This is due to the fact that a large part of the employment effects of the expansion of public transportation occur through the financing of the investments needed to support the expansion of the transport service. If the financing scheme discourages demand for sectors of the economy with lower overall employment content (e.g. fuel versus public transport service) then the overall employment effect will be slightly positive.

As a second important component of the expansion of public transport deals with investment in construction and investment in rolling stock. The extent to which the value chains in these two forms of investment remain within a particular country is key to understanding their employment effects. Jobs in infrastructure development are likely to remain within the country but be of short-term or temporary nature, apart from jobs dealing with the maintenance of the network. The service of an expanded public transportation sector will create long-term jobs as will the manufacture of the rolling stock, benefiting countries that have a current manufacturing base. Unless new countries grow in their position in the manufacture of rolling stock and/or the provision of inputs to support this manufacture, the results observed here should hold to 2050. Importantly, countries seeking to expand public transportation while maximising the employment benefits, should seek to enhance their position in the value chain of the construction of physical infrastructure, of the rolling stock and the provision of transport services in terms of accessibility, comfort, cleanness, security and to ensure that any employment creation potential remains within the boundaries of the country.

II. The employment effects of the electrification of private transport in the ECE region

This chapter draws on recent policies in ECE countries, such as in France and the United Kingdom, as well as in Asia and notably China, to significantly reduce or even ban the internal combustion engine. It is widely acknowledged that the vehicle electrification of both private passenger and freight transport can also contribute to sustainability in the transport sector, especially when the electricity to power these vehicles is sourced from renewable energy. Less known are the effects of how the production, maintenance and use of electric vehicles will alter the global production structures and value chains, and how employment will be affected in different sectors and regions when compared to internal combustion engines.

In preparing the analysis for the electrification scenarios a number of possible options were discussed initially between ECE and ILO and subsequently with the Green and Healthy Jobs in Transport Partnership and THE PEP Steering Committee. From these discussions the following scenarios were identified to be modelled as part of the analysis:

- Electrification 1 (E.1) Ban on internal combustion engines in (private) passenger transport in cities
- Electrification 2 (E.2) Introduction of a 100 per cent requirement for public transport vehicles to have no internal combustion engines
- Electrification 3 (E.3) E.3 Introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric
- Electrification 4 (E.4) E.4 Ban on internal combustion engines for light-duty business-use vehicles.

Subsequently an analysis was undertaken by the ILO modelling team on the viability of each of these scenarios. During this analysis the team identified that E.1 did not give different results in the modelling from E.3 and that due to the workings of the model it was not possible to model E.2. As a result, only E.3 and E.4 were actually modelled for this study.

These two electrification scenarios are developed for the ECE region and projected up to 2030 to analyse how such a transition may impact employment within ECE countries and the region and across the world. First, the different channels through which the electrification of transport will affect employment outcomes will be discussed and related research offered. Second, the scenarios are presented. Finally, the two scenarios are compared to the business-as-usual scenario using the same multi-regional input-output based model previously presented:

- Scenario E.3: Introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric
- Scenario E.4: Ban on internal combustion engines for light-duty business-use vehicles.

A. The electrification of private car and freight transport and its employment effects

The electrification of private passenger transport can enhance energy efficiency and energy security and reduce the transport sector’s carbon and environmental footprint, especially when the electricity to power these vehicles is generated from renewable energy sources. Adopting electric vehicles (EVs) in the ECE region will have both direct, indirect and induced employment effects in the region and beyond, as the value chain related to the manufacture, operation and maintenance of EVs spreads across boundaries and is different from that of internal combustion engine (ICE) vehicles.

Overall, EVs require less manufacturing, maintenance and repair labour than internal combustion engine vehicles as their engines have fewer moving parts (UBS Research, 2017). Though certain vehicle parts are the same as those of ICE vehicles, EVs require batteries and more electrical components, promoting activity in their corresponding supply chains. This activity involves the extraction and refinery of copper, lithium, cobalt and nickel. Powered by electricity, the use of EVs does not require gasoline or diesel (UBS Research, 2017). As a result, the adoption of EVs over ICE vehicles for private passenger transport will bring about job gains in certain sectors (e.g. electricity, battery manufacturing, manufacture of electrical parts and machinery, charging station infrastructure) and job losses in others (e.g. fuel production and refinery, retail sale of automotive fuel, repair of motor vehicles) (ECF, 2018). Furthermore, lower maintenance costs and longer life cycles in addition to a potential reduction in fuel expenditure will reduce households' transportation spending, allowing households to divert this spending to other goods and services, increasing demand and activating employment in those sectors.[21]

A rapid shift to a low-carbon emission, private transport in the EU including battery and hybrid electric vehicles is estimated to generate a net employment gain of between 850,000 and 1.1 million jobs in Europe in 2030 (ECF, 2018). Though the batteries of electric vehicles require less labour to produce than ICE, hybrid electric engines are, by contrast, more labour intensive. The scenario explored by ECF (2018) considers different technologies in which a 2030 European new car fleet that is at most 50 per cent ICE vehicles, with the scenarios varying on the share of new ICE vehicles sold and the technologies of the remaining vehicles (distributed between plug-in hybrid, hybrid, battery electric, and fuel-cell electric vehicles). In this scenario, job creation is led by the jobs in the construction, electricity, hydrogen, services and manufacturing sectors. This scenario also identifies jobs losses in sectors that include conventional automobile manufacturing, petroleum and gas (FTI Consulting, 2018). Box 3 elaborates these examples further, exploring the employment impacts of different low-carbon vehicle technologies.[22]

21 Increased energy efficiency and resulting lower operating and maintenance costs of EVs might generate rebound effects. Rebound effects predict that, because of lower costs, individuals would use their cars more. The rebound effect of transport efficiency, particularly with regards to passenger vehicles, has been studied, for example in (Aasness and Odeck, 2015; Vivanco et al., 2014). If the rebound effect is dominant, it will increase employment in electric vehicle manufacture, maintenance, and other linked sectors, but also increase congestion, electricity use, and the private sector's carbon footprint as part of the car fleet remains powered by fossil fuels. Accounting for the rebound effect is beyond the scope of this report. We assume that this effect is minimal, and energy efficiency will generate increased household disposable income, stimulating economic activity and employment in other sectors (induced effects).

22 In anticipating the skill demand for EV-related manufacture and services, the European Union-funded E-GOMOTION project targets high school students to raise awareness of potential opportunities relating to electrification of road transport.

Box 3: The employment effects of different low-carbon vehicle technologies in Europe

The scenarios explored in this report model and analyse the employment impacts of a set of policies to increase the penetration of full-electric vehicles. However, other types of low-carbon vehicles can also contribute to significant CO_2 and other pollutant emission reductions, energy efficiency gains, and net job creation in the ECE region. These technologies include hybrid-electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and fuel-cell electric vehicles (FCEVs).

One of the main employment impacts on the economy of the transition away from ICE vehicles is through the reduction in the demand for petroleum and diesel, which consequently decreases the region's dependence on fossil fuel imports and increases demand for domestically produced hydrogen or electricity. Indeed, Europe and many other ECE countries, with the exception of the Russian Federation and a few Central Asian economies, are net importers of oil. Also, Europe is a net exporter of automobiles and automobile parts to other parts of the world, affecting the value chains related to vehicle parts (ECF, 2018).

A transition to low-carbon vehicles will also involve the deployment of more charging and refuelling infrastructure, and alter the interactions between the transport and the power system within the domestic economy (ECF, 2018). In addition, although non-European brands have a significant share of the market, the majority of their cars are produced in Europe due to the close proximity to regional auto manufactures (ECF, 2018). The shift towards high penetration of low- and zero-carbon vehicles will hence maintain or generate more economic activities and jobs within the European economy.

Using four different policy and technology development scenarios, ECF (2018) estimates that in Europe between 501,000 and 1.1 million net additional jobs could be generated by 2030 and between 1.4 and 2.3 million net additional jobs would be created by 2050. In particular, in a scenario where the fleet becomes more efficient with more hybrids (50% ICE and 50% HEV new car fleet by 2030), 286,000 jobs would be created from direct and indirect jobs in the auto value chain while 374,000 jobs would be created through avoided oil use in the economy as a whole. In a more ambitious scenario where fleet shifts rapidly to HEVs, PHEVs, BEVs and FCEVs (5% ICE, 15% HEV, 45% PHEV, 20% BEV, and 15% FCEV by 2030), 591,200 direct and indirect jobs would be created within the auto value chain and 508,800 jobs would be created through avoided oil use. Job gains come from the shifting towards more domestic economic activities (GDP gain, induced effect) and towards activities that have higher job intensity (from fossil fuel to automobile, direct and indirect effects). Hence, a green transition of the transport sector towards a variety of low- and zero-carbon vehicles (not only full-electric) will have significant impact on the number of jobs created, carbon footprints reduced, and energy security.

In the United States, several studies also project net employment gains by shifting to electric vehicles, though estimates differ depending on the assumptions of electric vehicles' market penetration. In a scenario where 40 per cent of the U.S. light-duty vehicle household market is shared by plug-in electric vehicles (PEV) and 20 per cent of miles travelled are electric, Winebrake and Green (2009) estimate that the reduction in gasoline demand and household expenses would lead to a creation of between 162,000 to 863,000 jobs in the country. Projecting a large-scale PEV market share, Melaina et al. (2016) estimate that fuel savings resulting from the adoption of PEVs could lead to an annual average employment gain of up to 147,000 jobs during the 2015-2040 period driven by household fuel savings, reductions in petroleum imports, and increased domestic electricity consumption.

Country studies presented above, along with other existing literature, indicate that the electrification of private transport will have positive and negative, direct, indirect and induced as well as country-specific job impacts. First, employment is affected through the creation of jobs associated to the manufacture of EVs and electricity generation to power them (direct effects). The provision of inputs to EV manufacture and electricity generation will have indirect effects through the supply chains. Furthermore, given that electricity is cheaper than gasoline or diesel for households and businesses, the increased consumption in other goods and services will lead to induced effects. In parallel, the shift in transport demand away from ICE vehicles, reduces the demand for these vehicles and their inputs, for fossil fuels and related services. Oil producing and refining countries will face reduced demand and jobs in related industries. Countries with a strong industrial base in electric components and machinery, such as China, will attract future demand. On the other hand, countries with a strong ICE car manufacturing industry, and which are not seeking opportunities to switch to electric vehicle production, will face job reallocation to countries which lead the electric transport market.

Overall, the scenarios point to positive employment effects as a result of the electrification of private transport, highlighting that, overall, job creation is concentrated in developing and manufacturing electrical equipment and battery technology, as well as in construction and electricity generation. Combined, and not only looking at the direct jobs in car manufacturing which require less labour than the ICE, these industries tend to employ more people than the industries that will lose out. These scenarios identify the sectors that will require policy attention to meet the resulting demand for labour and support workers and communities in the midst of potential job losses and reallocation. It also identifies the sectors that will most benefit from the electrification of private cars in the ECE region, underscoring where industrial policy efforts should take place to develop these industries and ensure that the job creation potential of electrification in the ECE region stays in the region. (As noted earlier, Appendix I provides the methodological details that underlie the estimation.)

B. Scenario specification E.3: Introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric

This scenario follows ECE countries' interest and implementation of pilot regulations specifying that a certain share of automobile sales are zero-emission vehicles (see Box 3). The scenario developed here draws inspiration from existing policies and introduces a voluntary or mandated target of 50 per cent of vehicles produced to be full electric across all countries in the ECE region by 2030. Such policy will send signals to automobile manufactures and other stakeholders of a long-term shift from a production of mainly ICE vehicles to EVs. Employment effects of the changing input structure of automobile production and use will be analysed, and the scenario compared to a business-as-usual scenario.

Under this scenario projected ICE vehicle production in the ECE region is substituted by EVs. The production structure of vehicle manufacture is altered to reflect the higher content of electrical parts and batteries, amounting to up to 50 per cent of the vehicle input and production cost. Employment requirements for the production of EV is also adapted following the consequent changes to the automobile production value chain from the EV to the ICE vehicle value chain (UBS 2017).

It is further assumed that electric cars are perfect substitutes for internal combustion engine vehicles and that the number of electric vehicles produced in the ECE region retain their share among global vehicle sales. This is a strong assumption as Asian markets are currently leading the electric vehicle market. To retain the current share of global car manufacturing in an electric vehicle future would require a shift in industrial policy in the ECE region. The scenario, however, also considers the global nature of the inputs to both EVs and ICE vehicles to remain the same and, hence, does not alter the current global trade structure. This means that while today a majority of electric components and batteries are imported from Asia, the relative trade share of today is used and projected into the future driving the employment effects related to supply chains and vehicle production.

Box 4 - The adoption of mandate on Zero Emission Vehicles

The Zero Emission Vehicle (ZEV) mandate was first adopted in California (United States of America) in 1990 as part of the California Air Resources Board's Low Emission Vehicle Program. The mandate regulates the share of ZEV sales for light-duty vehicle manufactures with annual California sales above a certain threshold through a credit system. The system allows manufacturers to bank their credit surpluses for later use, transfer credits, and make up credit shortfall within specified timeframes.[23] The policy, though criticised and modified several times over the years, has contributed to an increase of ZEV sales and the development of low emission vehicle technologies in California (California Air Resources Board, 2018; U.S. Energy Information Administration, 2017). The minimum ZEV credit requirement, for example, was 2 per cent in 1998. It will increase to 9.5 per cent in 2020 and 22 per cent in 2025 and beyond (California Air Resources Board, 2018).

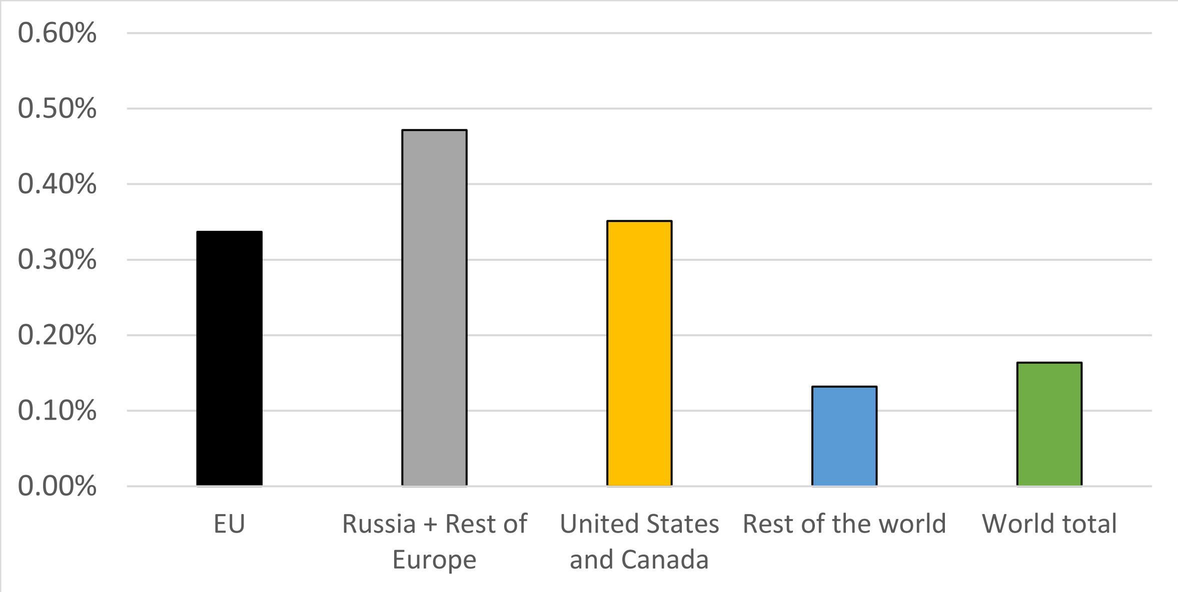
California's ZEV mandate has been picked up and implemented in nine other states: Connecticut, Massachusetts, Maryland, Maine, New Jersey, New York, Oregon, Rhode Island and Vermont. In Canada, Quebec became the first province to adopt the mandate in early 2018. Quebec's mandate requires automakers to sell ZEVs, either electric or hydrogen-powered, as 15 percent of their sales by 2025 (Government of Quebec, 2018). These 11 regional actors, in addition to Germany, the Netherlands, Norway and the United Kingdom, form the International Zero-Emission Vehicle Alliance that aims to reduce GHG emissions from the transport sector through accelerating ZEV deployment. The alliance participants have set the goal to make all passenger vehicle ZEVs in their jurisdictions as fast as possible, and no later than 2050 (International ZEV Alliance, 2015). Another of the Alliance's goal is to recruit more countries to join the alliance, as studies point out that the free-ride benefit of ZEV is low, implying that regions seeking low-carbon transportation need to implement their own stringent policies (Sykes and Axsen, 2017).

C. Scenario E.3 results

Overall, the requirement for EV vehicle production in the ECE region to be 50 per cent of total production by 2030 would lead to worldwide net job creation of close to 0.2 per cent compared to a business-as-usual scenario. This translates into around 10 million more jobs worldwide compared to a world without such a ECE wide requirement. As shown in figure 9, as a result of such a mandate or voluntary target, all regions experience a relative growth of overall employment of between 0.3 and close to 0.5 per cent in the European Union and the Russian Federation and the rest of Europe respectively. In the United States of America and Canada, employment is expected to be higher by between 0.3-0.4 per cent as compared to a business-as-usual scenario.

23 For detailed calculation of ZEV credits, see (U.S. Energy Information Administration, 2017).

Figure 9: Difference in employment level between business as usual and 50 per cent full electric vehicles scenario E.3, 2030 and business as usual



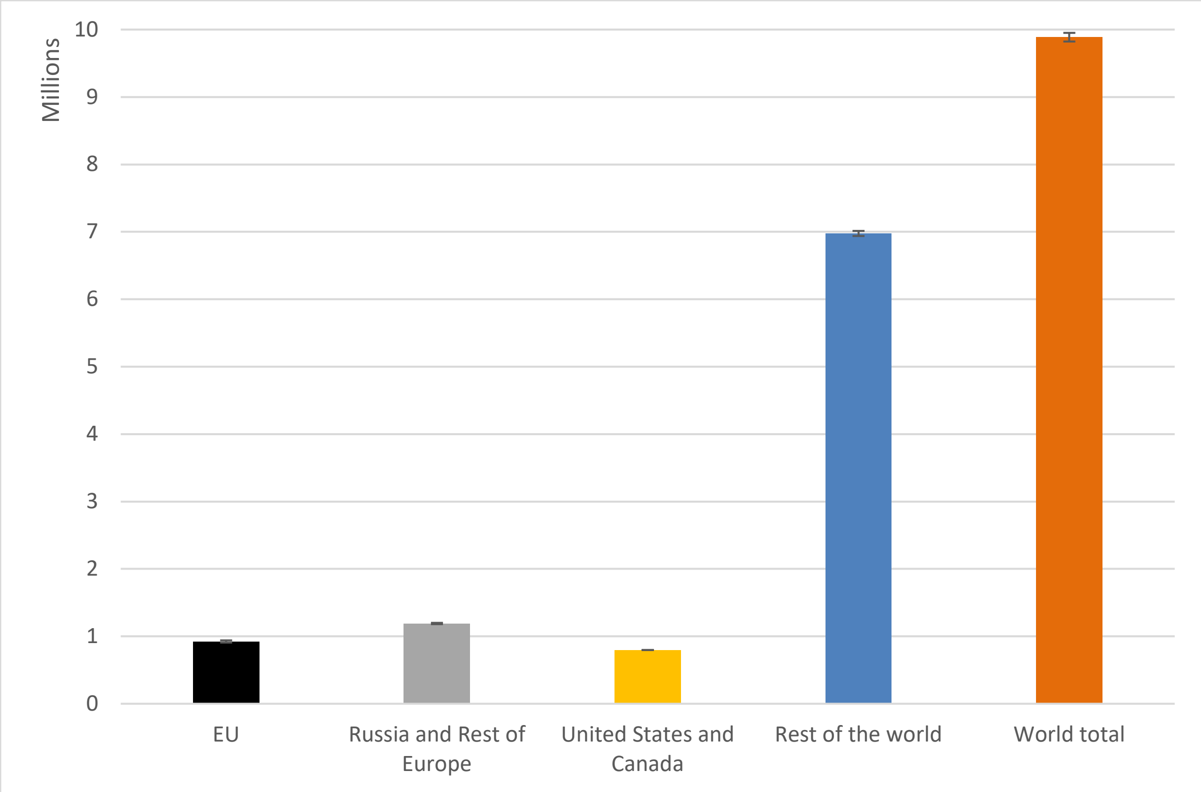
Source: ILO estimates based on Exiobase v3.

Figure 10 shows the absolute number of jobs. It clearly shows that the majority of jobs will be created outside the ECE region, around 7 million. This is due to the fact that the scenario assumes a continuation of the current trade structure and reflects the comparative advantage Asia currently enjoys in the manufacturing of electric components and batteries. Jobs are likely to be permanent and middle-skilled jobs as they are found in electric machinery and vehicle manufacturing.

Jobs in the European Union and the Russian Federation and the rest of Europe increase by around 0.9 million and over a million jobs respectively and close to 0.8 million in the United States of America and Canada. The scenario is further altered by plus or minus 10 per cent of final demand for vehicles, electrical machinery and associated electricity and fuel consumption to account for uncertainties and to provide for a range of high and low estimates. The difference at a global scale is around 65,000 jobs and around 40,000 jobs for countries outside the ECE region (rest of the world). The difference in the ECE region in relation to this sensitivity test is small (16,000 jobs in the European Union, 10,000 in the Russian Federation and rest of Europe and less than 1,000 in the United States of America and Canada). This is due to the fact, as indicated, that electric components and batteries are mainly imported from outside the ECE region, notably Asia, and that job gains and losses cancel out in the ECE region.[24]

[24] The additional 10 per cent variation for the low and high estimate does not involve the entire changes performed for the initial scenario. Notably it does not include the reallocated household spending from fuel savings. This adds to the reason why effects are relatively small.

Figure 10: Difference in absolute number of jobs between business as usual and 50 per cent full electric vehicles scenario, 2030 and business as usual

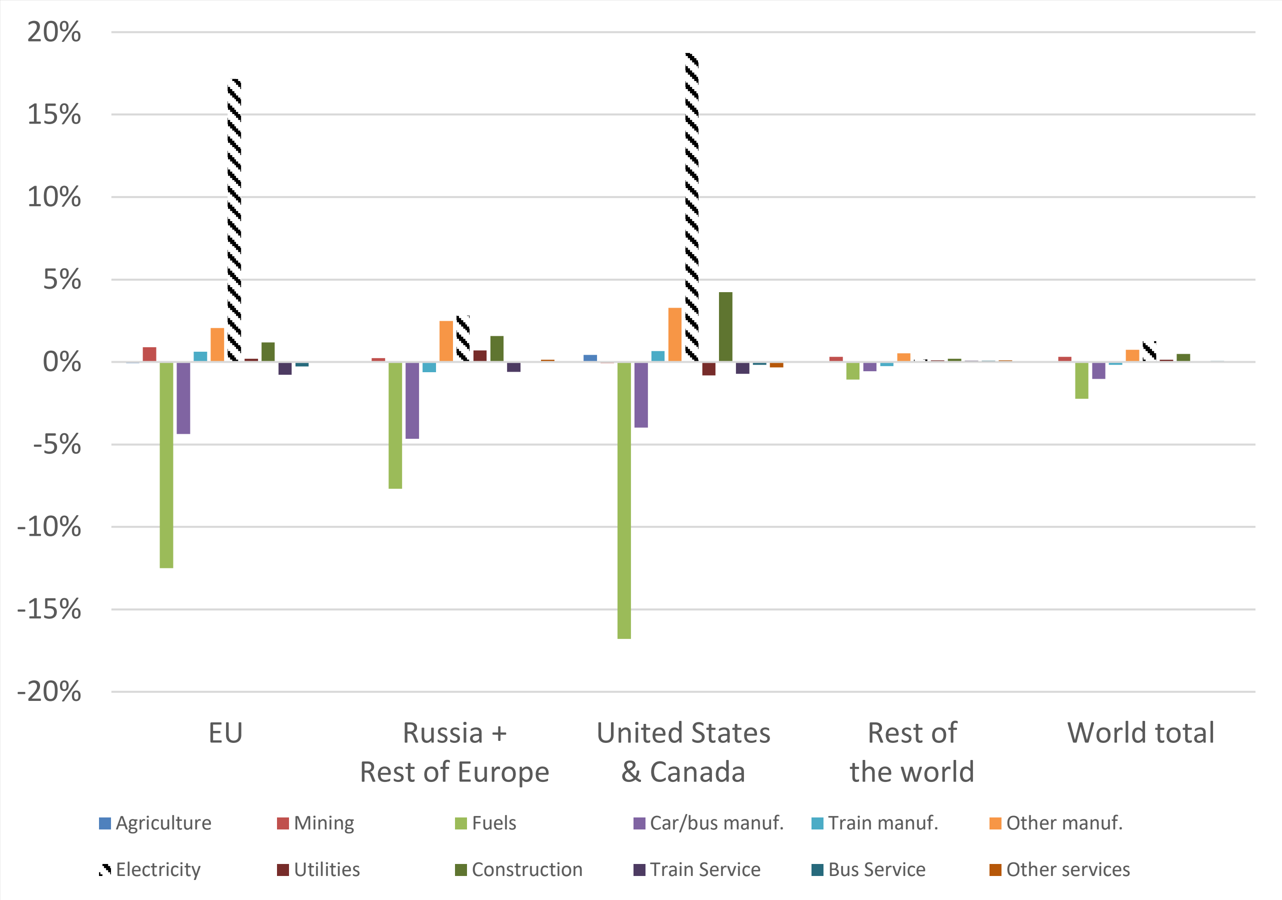


Source: ILO estimates based on Exiobase v3.

In the production stage, this scenario will lead to an increase in the EVs industry and hence activate employment throughout the global value chain. Once the vehicles are on the market and start to be used, a reduction in household fuel consumption and an increase in electricity demand will occur. This will further alter economies' relative production structure and employment. Given the value chains involved in the production of EVs and electricity, in comparison to the production of ICE vehicles and fuel, and given these industries' forward and backward linkages to other industries, total job creation in the ECE region is also driven by the production of electricity (by renewables and fossil fuels[25]) and redirected spending from fuel savings. As a result of the higher demand for electricity, and electricity generated from renewable sources, the construction sector also expects job creation. Outside the ECE region, employment is expected to grow in the manufacture of electrical machinery, construction and mining of copper ores. Figure 11 shows these employment effects by industry.

25 The scenario E.3 assumes the production mix of electricity generation to follow the historic trend and projections by the business-as usual-scenario up to 2030. For example, this includes electricity produced by coal and gas.

Figure 11: Difference in employment level between business as usual and 50 per cent full electric vehicles scenario and business as usual by industry, 2030 (percentage)



Source: ILO estimates based on Exiobase v3.

By contrast, job losses across the world are concentrated in the manufacture of motor vehicles and petroleum extraction and refinery sectors. Across the ECE countries some 355,000 jobs could be lost in the ICE car manufacturing industry with the biggest loss in United States of America and Canada (168,000) followed by the European Union (132,000) and the Russian Federation and non-European Union Europe (55,000).

Some job losses are expected in the services sector in the European Union and North America, largely due to the linkages between the service sector (maintenance and repair) and the manufacture of motor vehicles industry and, to a smaller extent, as a result in the reduction in value added across these economies. Indeed, the motor vehicle industry has tighter linkages to the services sector than the manufacture of electrical machinery does, and because the loss in value added feeds back into a reduction in household expenditure for services. Similarly, the increase in value added outside the ECE region leads to an increase in the demand for services.

In this scenario, fossil fuel demand by households decreases, replaced by higher electricity use for mobility. However, GHG emissions may not necessarily go down in this scenario because many countries still rely on fossil fuels to produce the electricity that powers electric vehicles. In addition, the production of electrical machinery to support electric vehicles also embeds CO_2 emissions. In this scenario, the business-as-usual energy mix is assumed. However, alternatives are possible and coherence between transport and climate policies may require electric transport to rely on renewable energy which would reduce emissions from the sector and stimulate employment in the renewables sector.

As a result, it can be seen that, under the assumptions of this scenario, a net total of about 9.9 million jobs will be added to world employment across all sectors as a result of this scenario, of which 2.9 million will be in the ECE region alone. When focusing on the transport specific sectors alone, it is estimated that employment will increase by 0.7 million jobs of which about 0.6 million in the ECE region.

D. Scenario specification E.4: Ban on internal combustion engines for light-duty business-use vehicles

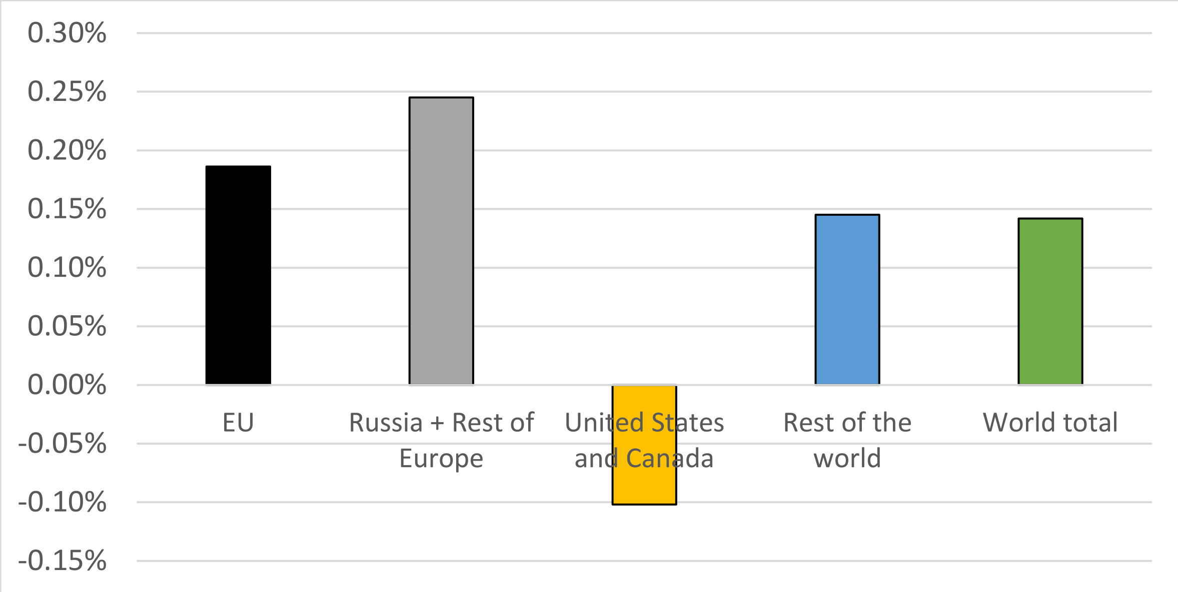
This scenario is a further variation and extension of the previous electric vehicles scenario focussing on light-duty business-use vehicles. It assumes that the overall demand for vehicles and vehicle use does not change as a result of the policy, but that the policy promotes a shift of business transport towards EVs, with the corresponding shift from fossil-fuel energy demand to demand for electricity.

The scenario assumes a complete ban on internal combustion engines for light-duty business-use vehicles taking full effect in 2030. Such policy would produce a shift towards EVs for business use, in a similar manner to the scenario that reduces private ICE vehicle use. However, as global and regional production and use of light-duty business vehicles differs, (for example the share of light-duty business vehicles is much higher in the United States of America and Canada) employment effects are expected to be different. Similar to the other scenario, however, such a measure would have local positive externalities across all countries, and contribute to reduce air and noise pollution in cities. It may contribute to a reduction in the emissions of GHGs and other gases, especially if the electricity to power these vehicles is sourced from renewable energy sources (Requia et al., 2018).

E. Scenario E.4 results

According to the model, in this scenario, world employment is 0.15 per cent higher than in a business-as-usual scenario, and close to 0.2 per cent in the European Union and 0.25 per cent in the Russian Federation and the non-European Union European countries. A small reduction in employment, of around 0.1 per cent, is expected in the United States and Canada, apparently due to the high share of business vehicles in total car stock, requiring a significant and accelerated rate of replacement and increased imports of electric business vehicles (figure 12).

Figure 12: Difference in employment level between business as usual and 100 per cent full electric light-duty business vehicles scenario and business as usual, 2030 (percentage)

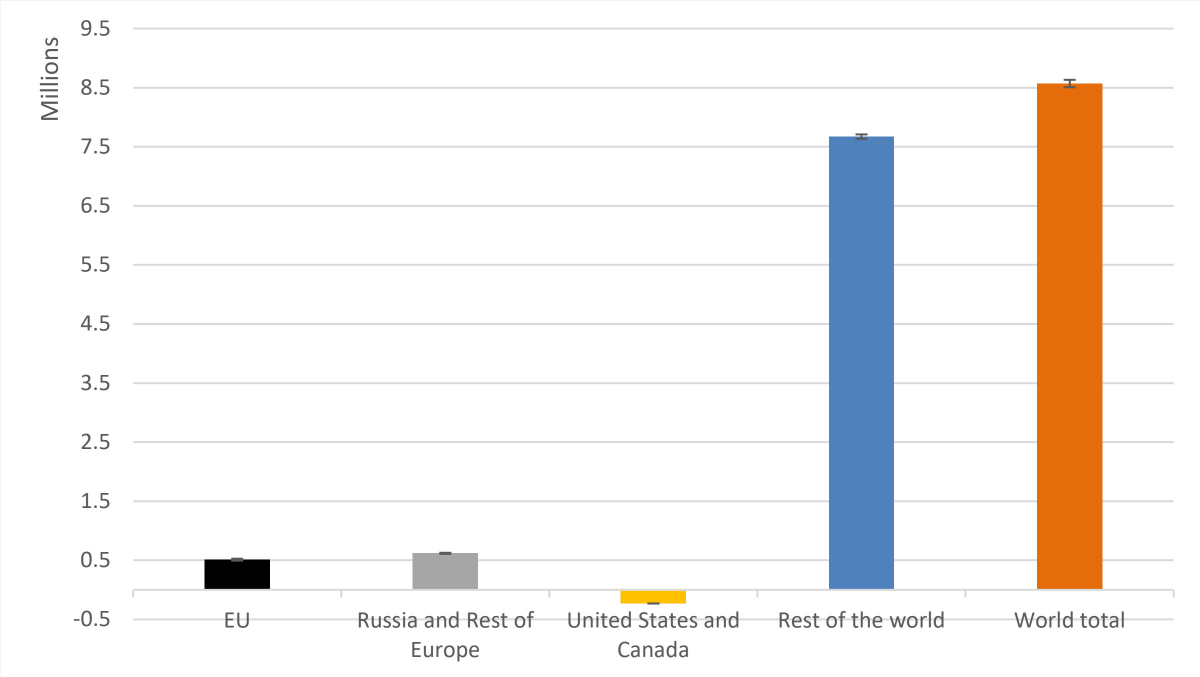


Source: ILO estimates based on Exiobase v3.

Figure 13 shows the absolute difference in the number of jobs between business as usual and 100 per cent full electric light business vehicles scenario by 2030. Net employment creation is expected to reach around 8.5 million across the world, with around half a million of those jobs created in Europe, around 0.7 million in the rest of Europe and almost 8 million more of them outside the ECE region (rest of the world). Jobs tend to be permanent and middle level-skilled found in the manufacturing of electric machinery and vehicles production.

The strong job creation outside the ECE region is driven by the current trade and production structure in which most electric components and batteries are imported from Asia. As it is assumed that Asia will keep the current comparative advantage in the electric industry up to 2030, a strong electric transport policy by ECE countries would, however, generate most employment outside the region. An additional estimate of plus or minus 10 per cent to the policy scenario confirms the results and interpretation. The sensitivity is highest outside the ECE region, showing a variation of around 37,000 jobs between the low and medium estimates. Strong industrial policy may alter the share of global electric components, battery and machinery production and result in different employment outcomes.

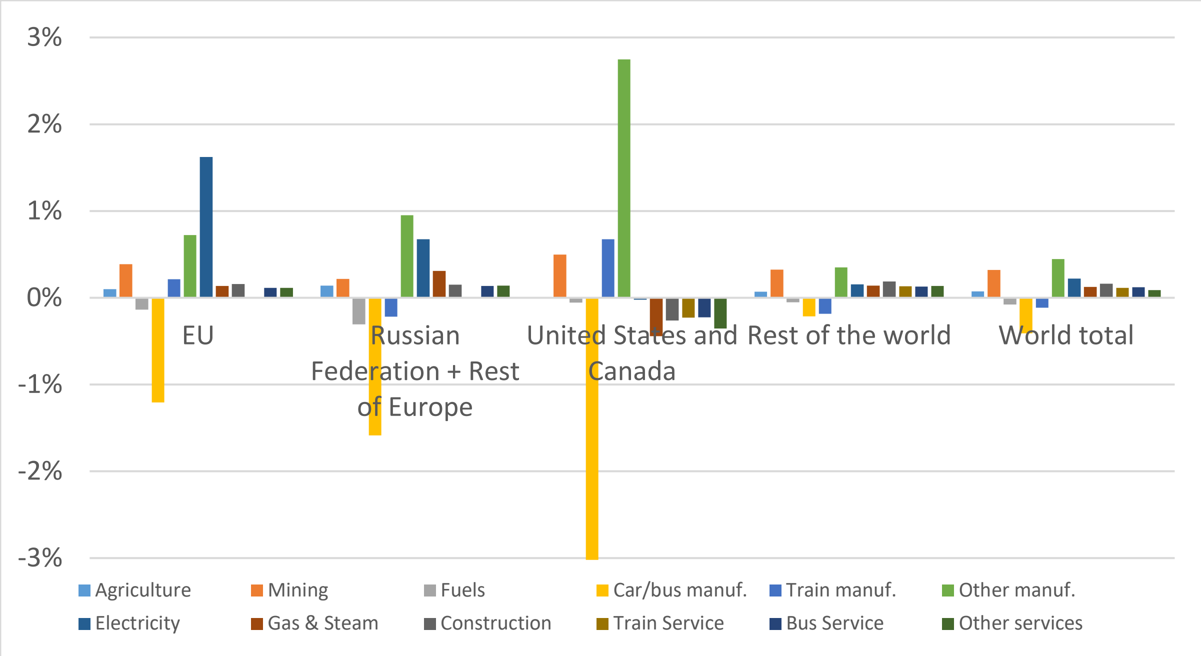
Figure 13: Difference in number of jobs between business as usual and 100 per cent full electric light-duty business vehicles scenario and business as usual, 2030 (absolute)



Source: ILO estimates based on Exiobase v3.

Following the global trade structure, employment effects across industries and regions show a significant difference (figure 14). Job creation in the ECE region, however small, is led by the electricity sector, as well as by the sale, maintenance and repair of motor vehicles. As this scenario promotes a higher value added across the economy, in particular across Europe, it promotes household consumption for goods and services across other industries. Job destruction in the ECE region results primarily in the manufacture of motor vehicles and the value chain related to ICE vehicles due to the lower jobs requirement of electric vehicle manufacturing and ranging between minus 1 to minus 4 per cent of total jobs in the industry. This translates into a loss of jobs between 36,000, 50,000 and 57,000 jobs in the European Union, the United States of America and Canada and the Russian Federation and non-European Union Europe, respectively.

Figure 14: Difference in employment level between the business-as-usual scenario and 100 per cent light-duty business vehicles scenario by industry, 2030



Source: ILO estimates based on Exiobase v3.

As a result, it can be seen that, under the assumptions of this scenario, a net total of about 8.6 million jobs will be added to world employment across the all sectors as a result of this scenario, of which 0.9 million will be in the ECE region alone. When focusing on the transport specific sectors alone, it is estimated that employment will increase by 0.4 million jobs, although, in the ECE region, employment is likely to fall by about 0.1 million jobs where, as seen from the figure above, this fall is primarily as a result of the falls in the United States and Canada and to a lesser extent the Russian Federation and non-European Union Europe.

Given the intrinsic overlap that there is between these two scenarios, E.3 and E.4, it is not possible to prepare a cumulative scenario for the electrification of private transport assessment.

F. Electrification employment effects to 2050

Similar to the scenarios for public transport expansion, projecting specific employment impacts of transport electrification beyond 2030 is limited due to the high uncertainty of technology and policy choices affecting employment and economic trends after this point. Aside from a projected expansion of the electric car fleet, which would continue or accentuate the trends identified above, certain additional trends will affect the employment effects of electrification to 2050.

The lifespan of lithium-ion batteries, a key component of electric car vehicles is limited to 8-10 years. The expansion of lithium-ion batteries has raised concerns about future waste management (Winslow et al., 2018). The replacement of ICEs by electric vehicles from up to 2030 will structurally change the manufacture of vehicles. Between 2030 and 2050, the batteries in EVs produced today will need to be discarded and replaced. Unless alternative energy storage devices are invented, a large number of lithium-ion batteries will enter the waste stream after 2030 under these scenarios (Winslow et al., 2018), suggesting the need for employment opportunities in the vehicle disassembly and waste management sectors up to and beyond 2050 to safely dispose or recycle these batteries.[26] In addition, demand will likely grow in the construction of recycling infrastructure to recover high-value materials from multiple battery chemistries (Richa et al., 2014) as well as research and development for waste collection and repurposing technologies.

The scenarios explored assume constant labour productivities. As the manufacture of electric vehicles is still an emergent industry, as the industry consolidates, labour productivity will likely increase further on to 2030. Though this will still create jobs as demand for electric vehicles increases, the job creation rate for this growth in demand will decline as labour productivity increases. The scenarios also assume no behavioural changes, aside from those included in the current consumption elasticities incorporated into the model. Towards 2050, there is a higher likelihood of behavioural change to take place. Therefore, in addition to policy supporting the supply of EVs, policy that encourages lifestyle changes can further support the main drivers behind such change, which are changes in social norms and attitude towards travel as well as cultural shifts away from motorisation to cycling/walking and from mobility to accessibility (Brand et al., 2018).

[26] Based on the projection of EV sales worldwide from different sources, Richa et al. (2014) estimate that the waste stream of lithium-ion batteries could be between 0.83 and 2.97 million packs per year by 2040. Of these, between 27 and 35 per cent would be coming from all-electric and plug-in hybrid EVs, and the remaining 65–73 per cent would come from hybrid EVs.

Conclusions

Advancing environmentally-sustainable and inclusive societies is equivalent to a structural transformation. It entails changes in the products and services demanded by an economy and changes to an economy's production processes (Bowen et al., 2016; Bowen and Kuralbayeva, 2015). As any structural transformation, it can create employment and decent work and protect workers if accompanied by the appropriate policies (ILO, 2015a; Salazar-Xirinanchs et al., 2014). This applies to a transformation of the transport sector as well.

An environment-friendly transition to green and healthy transport will not necessarily produce positive employment outcomes in all industries. In fact, it may lead to employment losses in fossil fuel-based industries and value chains while creating opportunities in green transport. To enable a just transition for all jobs and industries, employment-friendly outcomes will happen only by design. Advancing sustainability in the transport sector requires attention to employment outcomes and to policies that promote employment creation and decent work.

This report has studied the employment impact of two possible approaches to increasing the sustainability of transport through the use of a multiregional input-output table (EXIOBASE). The methodology brings the important value added of allowing the possibility to estimate such employment effects not only in the transport sector, as the core of the analysis, but also the indirect effects it can have in all other sectors of the economy.

The analyses presented in this report suggest that employment opportunities do exist in advancing green and healthy transport in the ECE region through facilitating the increased use of public transport and the electrification of private transport. The scenarios assessed were:

- For public transport:
  - PT.1 Doubling investment in public transportation
  - PT.2 Free public transportation
- For electrification
  - E.3 Introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric
  - E.4 Ban on internal combustion engines for light-duty business-use vehicles.

The results show that stimulating the use of public transport through the doubling of investment in the sector and rendering public transport free to users can create at least a net of at least 2.5 million extra jobs worldwide in green and healthy transport. This increases to at least 5 million jobs when the wider impact on other sectors of the economy are considered. More than half of these will be in the ECE region.

In terms of the electrification of private transport, a cumulative scenario would double count effects of the electrification of personal and light business vehicles. The introduction of a voluntary or mandated target of 50 per cent of vehicles produced to be full electric (Scenario E.3), indicates that a net total of close to 10 million jobs will be added to world employment across all sectors, of which 2.9 million will be in the ECE region alone. When focusing on the transport sectors alone, it is estimated that employment will increase by 0.7 million jobs of which about 0.6 million in the ECE region. Scenario E.4 (Ban on internal combustion engines for light duty business-use vehicles) would lead to a 0.4 million increase in jobs in transport and up to 8.5 million jobs when the impact on other sectors is taken into account. In this case the ECE region actually sees a contraction. The net employment creation that results from these scenarios hides important levels of reallocation, as jobs move away from the manufacture of motor vehicles, petroleum extraction and refinery sectors.

In order to capitalise on the employment opportunities brought about by electrification and by the expansion of public transport, countries in the region must adopt complementary skills development policies to ensure that the workforce has the skills to meet the emergent demand which could also include employment to reflect the need to recycle batteries appropriately.

An important finding in the analyses is that the larger part of the employment opportunities that arise from advancing the electrification of private cars and light-duty business vehicles in the ECE region will be located outside the ECE region: this is because the ECE region has not currently developed electric vehicle components and battery industries to the extent necessary, or they have been outsourced outside the region. In order to increase the employment opportunities in the region, green and healthy transport needs to be accompanied with appropriate industrial policy such as in battery and electric machinery production, rail and rolling stock expansion, as well as employment and labour market policy to ensure that the jobs created are decent jobs.

The transition to green and healthy transport will remove jobs in certain sectors. This situation also highlights the importance of enacting complementary policies like the provision of adequate social protection and active labour market policies. They will help protect workers and communities that may lose out from the transition and facilitate their transition to emerging sectors, ensuring a path to sustainability that is also just. Appendix II, based on the ILO's (2015a) Guidelines for a just transition to environmentally sustainable economies and societies for all, provides more details on the appropriate policy response to ensure that the transition to environmentally-sustainable economies enhances employment opportunities and promotes decent work

The findings in this report focus on job creation and destruction. Though of critical importance to advance a socially-sustainable transformation, green and healthy transport must also advance decent work. The extent to which the job creation identified in this report contributes to decent work is out of the scope of the present report, but the advancement of decent work should be a key priority to ensure that green and healthy transport contributes fully to social sustainability as well.[27]

[27] Decent work, as defined by the ILO, is articulated around four pillars: social dialogue, social protection, rights at work and employment. In short, it is work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men.

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Appendix I – Methodology

The results presented in this report stem from global, economy-wide scenarios of technology and demand change. They compare each of the public transport and electrification scenarios in the ECE region to a baseline, business-as-usual scenario to estimate the net employment creation across countries and sectors.

Following the methodology used by Montt et al. (2018), the scenarios draw on EXIOBASE, a multiregional input-output (MRIO) table that reports the interlinkages between final consumption, the flow of intermediate and final goods and factor inputs into production. EXIOBASE includes environmental and socioeconomic extensions which include, among others, GHG emissions and the number of people employed in each sector. A detailed description of EXIOBASE and its labour accounts can be found in the online supporting information from Stadler et al. (2018). EXIOBASE includes information for 163 industries in each of the 44 economies and five rest-of-the-world regions. This study draws on the 2014 data in EXIOBASE v3.[28] The data is projected to 2030 by combining the International Monetary Fund (IMF) GDP projections to 2022 with the International Energy Agency (IEA) regional growth projections to 2030 (IEA, 2016; IMF, 2017). Partial equilibrium behavioural response models are used to model changes in transport choices that result from policy interventions to inform the coefficient changes to the MRIO.

Changes in the transport sector affect economic activity and employment in the sector itself as well as in other industries, as the transport sector is linked (through forward and backward linkages) to other sectors in the economy. As an MRIO tracks the flow of goods and services across the world economy, it can be used to identify how changes in the transport sector affect other sectors in the economy.

Results from MRIO scenarios presented here are first-order direct and indirect effects. As is common in input-output studies that estimate employment effects (see, for example, Garrett-Peltier, 2017; ILO, 2018; Montt, Wiebe, et al., 2018), the results in this study do not consider effects of substitution elasticities, utility and profit maximization, price equilibrium, etc. Some key assumptions, common to input-output scenario exercises, include (i) relative prices between products and economies do not change (i.e. prices are not endogenised), (ii) all changes implemented in the model are exogenous, and (iii) market shares and bilateral trade shares remain constant. As described in Montt et al. (2018), these assumptions mean that firms and sectors are able to immediately absorb changes in demand. They also mean that there are no price or factor substitutions that result from changes in prices. These assumptions also mean that productivity increases in emerging industries are not taken into account or that the effects of completely new technologies or products that currently do not exist are not considered. Finally, these assumptions mean that the models do not consider labour-related adjustment effect (e.g. owing to skills mismatch or other rigidities in the labour market it may take longer for employment to adjust to changes in the demand for goods and services).

I. Adapting EXIOBASE to better represent the transport sector

EXIOBASE identifies 163 sectors. Transport is represented through “Transport via railways”, “Other land transport”, “Transport via pipelines”, “Sea and coastal water transport”, “Inland water transport” and “Air transport”. This study uses “Transport via railways and “Other land transport” to represent rail and road transportation. To better represent the transport sector and better capture the employment implications of the scenarios, this study disaggregates the original rail and road transport sectors into five sectors, to represent road and rail passenger and freight transport. This disaggregation is carried out by reweighing the original road and rail sectors by the output, gross operating surplus, wages, energy use (by type) and employment shares that correspond to the passenger and freight sectors. Data for this disaggregation is

[28] EXIOBASE is available through the project’s website: www.exiobase.eu.

sourced from the Eurostat Structural Business Statistics, the ECE Transport Statistics Database, national statistical offices (e.g. Russia Statistical Yearbook and the United States Census for Transportation and Warehousing), national rail transport companies' financial statements, International Energy Agency Statistics and the Transport Energy Data Book.

In certain cases, original data is unavailable to disaggregate the transport sector. This missing data is imputed. A regression analysis is used to predict the values for the missing data considering the observed transport data, countries' GDP per capita (PPP), population and urbanization (as a percentage of total population).

II. Scenarios implemented in the report

The sections below detail the methodological decisions taken to implement each of the scenarios in the study. In each scenario, the section details the broad concept driving the scenario as well as the changes it implies in the input-output system.

A. Scenario PT.1 Doubling investment in public transportation

Basic principles: Public investment increases in the rolling stock of passenger rail and passenger buses including tram, metro and trolley busses. Infrastructure for public transportation is double in 2030 than that in the business-as-usual scenario; a doubling which is progressively implemented annually between 2016 and 2030. This implies an increase in the building of public transport infrastructure and in the rolling stock, the latter is used as a proxy for transport capacity. The scenario assumes that the investment in infrastructure is diverted from the investment in motorways and that the investment in rolling stock is paid for by taxes to retail fuel and new cars. Investment is doubled until a cap, assumed at the level of Switzerland for passenger rail and Turkey for passenger buses, is reached. Switzerland and Turkey had both the highest observed number of passenger trains per capita and passenger buses per capita, respectively. A minimum investment level is added to rule out any decrease in the rolling stock between 2016 and 2030. This investment and higher fuel and new car prices then increases the use of public transportation, with a concurrent reduction in private car use, fuel consumption and private car purchases.

Input-output changes: A doubling of the transport sector demand for rolling stock. No change in the demand in the general construction sector as the shift is internal to the sector. Increase in final household demand for transport services commensurate to the individual countries' modal split and share of kilometres travelled per public transport infrastructure. Reduction in final household demand for retail fuel and manufactured cars to finance investments into the doubling of the rolling stock. Increase in household expenditure as a result of savings. These changes apply only to ECE countries. Effects are analysed in ECE and non-ECE regions.

Magnitude of changes: The yearly investment in public transportation rolling stock in each country is estimated as the year-to-year differences in rolling stock (UNECE, 2018), adjusted for the depreciation rate of trains and buses. This depreciation rate equals 3.75 per cent for trains and 8.5 per cent for buses (DETEC, 2011).[29] Formally, we compute past investments as:

$$investment_{it}^{v} = stock_{it}^{v} - stock_{it-1}^{v}(1 - \delta^{v})$$

[29] These numbers are the average between the stated maximum and minimum depreciation rates by type of vehicle.

Where v denotes the type of vehicle: train or bus. We obtain an investment for year 2016, $investment^{v}_{i2016}$. Future investment is double 2016 investment, unless doubling it would lead the resulting 2030 stock (in per capita terms) to be larger than the maximum observed across all countries for each type of vehicle in 2016, as discussed above. We also introduce lower-bounds in order to rule out absolute terms decreases in rolling stocks. Through these calculations we obtain $investment^{v}_{i2016}$, where the subscript F stands for future.

2030 stocks are given by

$$y_{i2030} = stock_{i2016}(1-\delta)^{14} + investment^{v}_{i,F}(1-(1-\delta)^{14})/\delta$$

The effect of increased public transport rolling stock on both public transport use and car use is modelled based on estimates from the literature. The relationship between capacity, or rolling stock, and use is the service elasticity. Table A1 lists the origin and magnitude of service elasticities used for these analyses. The author's "preferred estimate" in each paper is used. If no preferred estimate is identified, the average of the various estimates presented is used. We then apply these estimates to the scenario's change in stock (that we use as a proxy of capacity) and obtain predicted changes in usage.[30]

Table A1 - Literature estimates of service elasticity

Article	Description	Service elasticity estimates
Effect of bus capacity on bus use		
Evans (2004)	"Before-after" analysis, arc service elasticities based on data from in the United-States, Canada and Norway.	+0.5 on average
Effect of train capacity on train use		
Evans (2004)	"Before-after" analysis, arc service elasticities based on data from the United States.	+0.67 on average

30 In the case of cars, we apply the average of the listed estimates to the average increase in train and bus stock at the national level.

Effect of public transport capacity on car use

Duranton and Turner (2011)
LIML estimates based on a panel of U.S. metropolitan areas. Public transport considered: bus.
~0 (not significant)

Lalive, Luechinger and Schmutzler (2017)
Instrumental variable approach based on natural experiment. German individual data. Public transport considered: rail.
-0.15 on average[31]

Beaudouin and Lawell (2018)
Instrumental variable approach based on United States data. Public transport considered: all.
+0.04, preferred long-run estimate

The effect of public transport capacity on car ownership and use is also important, reflecting potential modal shifts that can advance green and healthy transport. Unfortunately, few if any estimates in the literature present findings in a way that is applicable to the present study. Therefore, we estimate the relationship based on national data using fixed effect panel regression over years 2000-2016.

The financing of these investments is modelled as follows: 80 per cent from fuel taxation and 20 per cent from taxation on new car purchases. This brings about a lower demand for private cars as a result of higher purchasing costs. The reduction is equivalent to 20 per cent of the total investment multiplied by the estimated new car price elasticity, as calculated by McCarthy (1996), this in turn modifies car use, beyond the model presented above. For car use, the change in usage is further modified by the taxation of fuel, which is equivalent to 80 per cent of the total investment multiplied by the estimated fuel price elasticity, as estimated in the academic literature (see, for example, Baranzini and Weber, 2013; Havranek and Kokes, 2015; Huntington et al., 2017; Odeck and Johansen, 2016; Zeleke, 2016)

The resulting changes implemented in the MRIO system are shown in table A3

[31] The paper estimates a semi-elasticity of likelihood of using a car given an increase in train capacity. We derive the elasticity by dividing their estimates by the German modal split.

Table A3 - The relationship between rolling stock and passenger kilometres by mode

CNT	**Increase in investment**		**Increase in household demand**		**Reduction in household car ownership**	
	Rail	Road	Rail	Road	Due to investment in PT	Due to investment in PT
AUT	-0.359	0.761	0.00	4.62	6.04	3.04
BEL	0.506	0.761	0.00	0.00	-7.92	2.95

BGR

-0.142
0.236
31.40
1.27
-9.13
2.95

CAN

0.903
0.389
17.28
0.00
-38.74
2.72

CHE

4.582
-1.398
0.00
82.49
2.36
2.97

CYP

0.009
0.492
0.00
0.00
-43.54
0.00

CZE

0.557
0.761
24.24
0.00
26.48
3.18

DEU

2.013
0.761
0.00
54.64
-21.33
2.82

DNK

1.076
0.401
14.66
0.00
-32.51
2.77

ESP

0.907
0.761
0.00
18.36
27.71
3.17

EST	
	-1.721
	0.741
	10.33
	0.00
	-34.35
	2.76
FIN	
	1.101
	1.162
	0.00
	0.00
	-32.29
	2.77
FRA	
	1.221
	0.761
	0.00
	0.00
	-16.58
	2.88
GBR	
	1.587
	0.807
	0.00
	139.73
	-23.02
	2.77

GRC

0.593
0.146
188.67
0.00
-10.92
2.98

HRV

1.279
0.761
141.61
33.71
43.44
3.30

HUN

0.994
0.761
0.00
6.09
9.73
3.06

IRL

0.098
1.367
0.00
0.00
-34.82
2.75

ITA

0.200
0.761
0.00
0.00
-27.43
2.80

LTU

0.572
0.542
5.47
55.38
-34.35
2.72

LUX

0.401
1.125
0.00
0.00
-47.45
2.65

LVA

-0.090
0.284
0.00
1.65
-7.38
2.95

MLT

0.217
1.038
0.00
0.00
-51.80
0.00

NLD

0.543
0.761
45.66
0.00
-1.85
3.01

NOR

0.344
-0.262
0.00
71.60
-46.89
2.61

POL

0.589
1.162
0.00
39.95
26.56
3.15

PRT

	-0.447
	0.471
	0.00
	82.15
	1.46
	2.97

ROU

	1.570
	0.761
	0.00
	51.77
	42.44
	3.24

RUS

	0.069
	1.358
	0.00
	0.00
	69.06
	3.43

SVK

	-0.214
	0.761
	0.00
	18.44
	55.92
	3.34

SVN

	0.331
	0.761
	95.93
	0.00
	-28.85
	2.83

SWE

	2.111
	-0.047
	10.31
	21.73
	-13.59
	2.90

TUR

	0.697
	1.301
	0.00
	27.89
	78.21
	3.46

USA

	-24.009
	0.749
	0.00
	0.00
	-47.99
	2.64

B. Scenario PT.2 - Free public transportation

Basic principle: Public transportation becomes free for users (i.e. fare-free public transport). This shifts the private household expenditure on public transportation to government expenditure. As a result of lower (no) prices to consumers, fare-free public transport increases the use of public transportation and reduces fuel consumption and new car ownership. The scenario assumes that the total increase in government expenditure on public transportation comes from taxes applied to retail fuel (financing 80 per cent of additional government expenditure) and taxes applied to new cars (financing the remaining 20 per cent of additional government expenditure). These changes are applied only to ECE countries and effects estimated on ECE and non-ECE countries.

Input-output changes: Increase in government expenditure on transport. Reduction of household expenditure on transport. Reduction in household consumption for fuel. Reduction in household consumption of new vehicles. Increased household spending on non-transport uses.

Magnitude of change: All private household expenditure on the transport sector is shifted to government expenditure as government will pay for transport services. An additional 14 per cent of expenditure is envisioned following a 14 per cent higher demand for transport services as it becomes free for users (Cats et al., 2017). The growth in demand for public transport is partially explained by a modal shift away from cars: demand for retail fuel falls by the equivalent of 16 per cent of the increase in public transport (Cats et al., 2017). As the scenario assumes that the increased government expenditure is paid for by taxes to fuel and cars, the scenario assumes a reduction in retail fuel consumption by the part of household, proportional to the fuel price elasticity estimated in the academic literature (see, for example, Baranzini and Weber, 2013; Havranek and Kokes, 2015; Huntington et al., 2017; Odeck and Johansen, 2016; Zeleke, 2016). The scenario also assumes a reduction in household purchase of new vehicles, is equivalent to 20 per cent of the total increase in government expenditure multiplied by the estimated new car price elasticity, as calculated by McCarthy (1996).

Scenario E.3 Introduction of a mandated 50 per cent of vehicles produced to be full electric

Basic principles: Some 50 per cent of the vehicle manufacture in the ECE region is electric. This implies a change in the technology of vehicle production – and input structure – to account for the difference between internal combustion engine vehicles (ICE) and electric vehicles (EV). It also implies a change in the inputs required in the use of such vehicles, shifting expenditure from retail fuel to electricity. The scenario assumes that ICE and EV are perfect substitutes for each other. These changes are applied only to ECE countries and effects estimated on ECE and non-ECE countries.

Input-output changes: Change the input structure of vehicle manufacture to account for 50 per cent of vehicles manufactured using the inputs identified by UBS Research (2017). Change in expenditures associated to vehicle use from retail fuel to electricity and reduce the demand for repair services. Any savings accrued are spend equally on the remaining goods and services.

Magnitude of changes: Changes in intermediate coefficients corresponds to those identified by UBS Research (2017). All automotive production countries are assumed to produce 50 per cent of electric vehicles.

Scenario E.4 Ban on internal combustion engines for light-duty business-use vehicles

Basic principles: Commercial light-duty business vehicles become electric. The demand for commercial land transport as a whole does not change, nor does vehicle use. The depreciation rate of cars and light business duty vehicles is high (20 per cent according to the Internal Revenue Service of the United States of America), while the one of buses is somewhat lower (8.5 per cent according to DETEC, 2011). In any case, if implemented immediately this policy would virtually lead to a total renewal of the vehicle fleet at the 2030 horizon. Therefore, we can consider 2030 as an equilibrium situation where all commercial transport is electric.

Input-output changes: Similar to the scenario mandating 50 per cent of electrical vehicle production in the ECE region, this scenario changes the technology used to produce the cars bought in the ECE region (intermediate demand coefficients based on UBS Research (2017), similar to scenario E.1.). The change is so that it represents a share of sales that corresponds to commercial vehicle ownership in cities. Change in expenditures associated to vehicle use from retail fuel to electricity and reduce the demand for repair services. Any savings accrued are spent equally on the remaining goods and services.

Magnitude of changes: Changes in intermediate coefficients correspond to those identified by UBS Research (2017) with up to 50 per cent of cost structure allocated to the electric components industry. The demand for EVs in each country is changed so that it is equal to the share of business transport in each country in the ECE region. That is a 100 per cent replacement of all light-duty business vehicles by 2030.

Appendix II – Policies to make green and healthy transport employment friendly

The advancement of green and healthy transport brings with it changes to employment in the form of job creation, reallocation and destruction. Whether big or small, these changes will affect individual workers, enterprises and, in certain cases, entire regions and communities that depend heavily on one industrial activity that is affected by these changes. Efforts to advance sustainability in other domains have been shown to bring relevant employment effects (e.g. through a transition to clean energy, to sustainable agriculture or to the circular economy, as developed by the ILO (2018)).

Policies specific to the transport sector may advance sustainability in the sector itself, but complementary policies are needed to ensure that workers have the skills required to make the transition happen or to ensure protection for workers and communities that may be negatively affected from a transition to green and healthy transport. The Guidelines for a just transition to environmentally sustainable economies and societies for all (ILO, 2015a) provide a policy framework to identify the complementary policies to ensure that a transition towards sustainability promotes decent work.

In the context of the promotion of green and healthy transport and the employment effects projected to 2030 and beyond, and as developed in more detail below, policies to consolidate fundamental principles of work, industrial policy, skills development policies, social protection and active labour market policies and policies to promote social dialogue should complement any efforts to advance sustainability in the transport sector.

I. Fundamental principles and rights at work

International Labour Standards (ILS) provide a regulatory framework for the social pillar of a green and healthy transport. Developing this social pillar is paramount because as a result of the transition to green and healthy transport, demand for work in certain industries will increase, particularly in the public transportation and mining sectors which can bring with it decent work challenges in certain countries where this work is of an informal nature. Where labour codes have not incorporated these principles advancing ILS as a complementary measure to advancing green and healthy transport allows to ensure the fundamental principles and rights at work in these growing and emerging industries. Where the transport sector in the ECE region involves trade with other nations, the ECE can promote the advancement of decent work principles through the inclusion labour provisions consistent with ILS in trade and investment agreements that involve inputs to green and healthy transport (ILO, 2015b, 2016).

Appendix III provides a list of the relevant ILS in the context of advancing green and healthy transport. The strengthening of legal framework around these principles can facilitate a just transition.

II. Industrial policy

Advancing green and healthy transport implies promoting policies in the transport sector that will necessarily affect the demand for other products and services. Given that most of the world's batteries are currently produced outside the ECE region and that planned production in China exceeds that in the rest of the world (Ma et al., 2018), part of the jobs associated to vehicle manufacturing supply chains may move outside the ECE region. The models developed in this report assume that the current trade structure remains constant over time. This means that, unless capacity to produce these inputs internally within the ECE region, jobs to produce them may move out of the ECE region. Given the importance of the mining for copper ores sectors, an opportunity presents itself in the ECE region by sourcing copper not from the extraction of natural resources but by the adoption of circular economy principles (ILO, 2018).

An industrial policy that accounts for the increase in the demand for inputs that results from both the expansion of public transport and the electrification of vehicles can develop the supply chains within the ECE region, promoting employment creation in the region. Industrial policy that favours these intermediate industries can help ensure that the advancement of green and healthy transport is also employment-friendly within the ECE region. This is what the European Union is beginning to do, by, for example, announcing funding for the deployment of electric battery plants and the development of the corresponding value chain (Toplensky, 2018).

III. Skills for the greening of the transport sector

Advancing a green and healthy transport affects employment in the transport sector itself as well as throughout the economy. The change in the production structure of and the demand for transport services affects employment in transport, manufacturing and other sectors. All the sectors that will see an increase in demand require a skilled labour force. Anticipating these skill needs and creating the institutional linkages to develop them in time are key policy objectives to achieve a green and healthy transport in the ECE region that promotes employment within the region (ILO, 2018; Strietska-Ilina et al., 2011).

As public transport expands, employment opportunities in public transportation and related services increases, prompting adequate training of workers to satisfy increase in demand for public transportation and maintenance workers as well as for infrastructure construction workers. It also implies generating the skills for occupational safety and health technicians who verify the compliance of the public sector equipment or transport flow managers and modellers, technicians to minimize transport's impact and encourage modal shifts. The growth in public transportation will require more bus drivers, train conductors and public transport managers with the skills to make use of new technologies such as satellite navigation, radio frequency identification or the Rapid Urban Flexible system, if they are implemented as part of the development of public transportation systems (Strietska-Ilina et al., 2011).

As noted by Strietska-Ilina et al. (2011), efforts to lower vehicle fuel consumption will require fuel retrofitting and conversion technicians, supervisors and workshop technicians, engineers, developers and craftspeople such as welders. Car mechanics, or car mechatronics, knowledgeable about the workings of electric vehicles will be in high demand, requiring high-level problem-solving skills and technical diagnostic skills. Electric-powered vehicles will also alter the skills profile of fuel station workers. Growth in the manufacture of electrical machinery and the construction sectors, as predicted by some of the scenarios in this report, will require an effective an adequate policy response for workers to be available to meet the surging demand which can include the retraining of workers in the motor vehicle and other industries experiencing job losses.

IV. Social protection and active labour market policies

Social protection policies are the first line of defence for workers faced with risks to their income security (ILO, 2017). In the context of efforts to advance green and healthy transport, social protection policies serve to protect workers who may lose out as a result of the reduction in demand in specific sectors. Unemployment protection, social assistance or public employment programmes can support workers whose livelihoods depend, directly or indirectly, on less environmentally friendly practices and are put at risk when advancing sustainability in the transport sector (ILO, 2018).

By guaranteeing unemployed workers' and their families' income security in the event of job loss, unemployment protection schemes contribute to preventing poverty, reducing vulnerability and facilitating the transition to new jobs, particularly if they are combined with skills development, job placement support, and relocation grants. Unemployment protection is a fundamental measure in any social protection system, as recognized in the Social Protection Floors Recommendation, 2012 (N°202) and the Social Security (Minimum Standards) Convention, 1952 (No. 102). Unemployment protection schemes are usually coupled with active labour market policies (ALMPs). Linked to ALMPs, unemployment benefits are coupled with the provision of employment services, such as job matching and counselling, entrepreneurship support and access to enhance, update and develop skills necessary for workers transitioning from unsustainable means of livelihood to new jobs (Card et al., 2010, 2018, ILO, 2014, 2017; Peyron Bista and Carter, 2017). ALMPs can also take the form of public employment programmes, which can be designed to also advance sustainability through employment in infrastructure construction, environmental conservation or ecosystem restoration (ILO, 2018).

The potential of unemployment protection schemes to support the transition to greener economies is severely limited by the fact that such schemes do not yet exist in many countries. On average, 57 per cent of unemployed workers in Eastern Europe receive unemployment benefits, with this figure reaching 46 per cent in Northern, Southern and Western Europe, 28 per cent in Northern America, and only 12 per cent in Central and Western Asia.

The transition towards sustainability is limited by the lack of social protection schemes, as the downsizing of environmentally damaging industries requires social protection schemes to be socially and politically viable. These policies will be necessary to protect and help workers in the motor vehicle manufacture and related industries to transfer to other and new emerging sectors. In the Philippines, for example, efforts to close coal mines has been put on hold until appropriate compensation measures are put in place. This example shows how the lack of safeguards for workers who may lose out may block efforts to advance sustainability (ILO, 2018).

V. Social dialogue

Social dialogue includes "all types of negotiation, consultation or information exchange among representatives of governments, employers and workers or between those of employers and workers on issues of common interest relating to economic and social policy" (ILO, 2013b, p. 12). It can facilitate and accelerate the implementation of policies that enables a just transition, as has been the case in Barbados, France, South Africa and Spain, among others. The dialogue can facilitate the prompt identification of skills needed for a successful transition to green and healthy and the deployment of effective development programmes. Social dialogue can also help promote the adoption of sustainable practices within a firm, through collective agreements that include "green" provisions or the institutionalization of an environmental delegate from within workers who supervises and ensures compliance with environmental regulation and identifies opportunities within the firm to enhance sustainability (ILO, 2018; Montt, Harsdorff, et al., 2018; Montt, Karimova, et al., 2018).

In advancing sustainability in the transport sector, social dialogue can facilitate a just transition for displaced workers, can generate a consensus for the direction and specific measures industries can take to advance an employment-friendly green and healthy transport (e.g. car manufacture moving towards electrification). Social dialogue is a key instance to confirm a commitment to sustainable development and assess the social and economic implications of the corresponding industrial transformation allowing for the identification of opportunities to protect workers and advance decent work with coherent policies (ILO, 2012).

Such is the case of the global framework agreement signed in 2017 between PSA Peugeot-Citroën and the IndustriALL global union. It expresses, in particular, the commitment to a development that is respectful of the environment and places social dialogue at the heart of any effort to achieve it. This includes the measurement of its footprint – and the carrying of efforts to reduce it – as well as the development of products that are environmentally friendly, raising awareness to promote environmental protection among its customers, suppliers and other stakeholders and the development of skills from within its workforce to advance these goals. Similarly, in the agreement between Ford and the International Metalworkers' Federation, signed in 2012, Ford commits to respect the natural environment and help preserve it for future generations through the reduction of the environmental activity of its business. The Renault Group commits, in its agreement signed with IndustriALL, to promote sustainable transport by improving the carbon and environmental footprint of its vehicles and their life cycle, particularly through its range of electric vehicles. Similar principles are included in the international framework agreements signed by Bosch, Saab, and ZF Friedrichshafen, each with IndustriAll.[32]

[32] The agreements signed by IndustriALL and Daimler, the Man Group, Siemens or Volkswagen do not include such environmental provisions. These agreements as well as others signed by IndustriAll are available at www.industriall-union.org/issues/confronting-global-capital/global-framework-agreements. Environmental clauses are also missing in the agreements signed between major transport infrastructure constructors and the the Buildering and Wood Workers International (BWI) global union; the agreements between BWI and each of Lafarge, Salini Impregilo and Veidekke are one of the few multinational construction companies to include a mention to improving the environmental performance of its activities. These agreements, and others signed by BWI and multinational construction companies, are available at http://connect.bwint.org/default.asp?Issue=Multinationals&Language=EN.

Appendix III – International Labour Standards relevant for green and healthy transport

These ILS include the following Conventions on fundamental principles and rights at work:

- Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87)
- Right to Organise and Collective Bargaining Convention, 1949 (No. 98)
- Forced Labour Convention, 1930 (No. 29)
- Abolition of Forced Labour Convention, 1957 (No. 105)
- Equal Remuneration Convention, 1951 (No. 100)
- Discrimination (Employment and Occupation) Convention, 1958 (No. 111)
- Minimum Age Convention, 1973 (No. 138)
- Worst Forms of Child Labour Convention, 1999 (No. 182)

They also include the following governance Conventions:

- Employment Policy Convention, 1964 (No. 122)
- Labour Inspection Convention, 1947 (No. 81)
- Tripartite Consultation (International Labour Standards) Convention, 1976 (No. 144)
- Labour Inspection (Agriculture) Convention, 1969 (No. 129)

They include the following technical Conventions:

- Social Security (Minimum Standards) Convention, 1952 (No. 102)
- Social Policy (Basic Aims and Standards) Convention, 1962 (No. 117)
- Paid Educational Leave Convention, 1974 (No. 140)
- Human Resources Development Convention, 1975 (No. 142)
- Working Environment (Air Pollution, Noise and Vibration) Convention, 1977 (No. 148)
- Labour Administration Convention, 1978 (No. 150)
- Labour Relations (Public Service) Convention, 1978 (No. 151)
- Collective Bargaining Convention, 1981 (No. 154)
- Occupational Safety and Health Convention, 1981 (No. 155)
- Occupational Health Services Convention, 1985 (No. 161)
- Chemicals Convention, 1990 (No. 170)
- Prevention of Major Industrial Accidents Convention, 1993 (No. 174)
- Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) D. Recommendations

They include the following Recommendations and Resolutions:

- Human Resources Development Recommendation, 2004 (No. 195)
- Social Protection Floors Recommendation, 2012 (No. 202)
- Resolution concerning the promotion of sustainable enterprises – International Labour Conference, June 2007
- Resolution concerning promotion of rural employment for poverty reduction – International Labour Conference, June 2008.