ERAI
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ENVIRONMENTAL AGENDA FOR RAIL FREIGHT TRANSPORT

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IMPACT OF CARBON REGULATIONS ON INTERNATIONAL FREIGHT TRANSPORTATION

Global climatic challenge in the context of international freight transportation

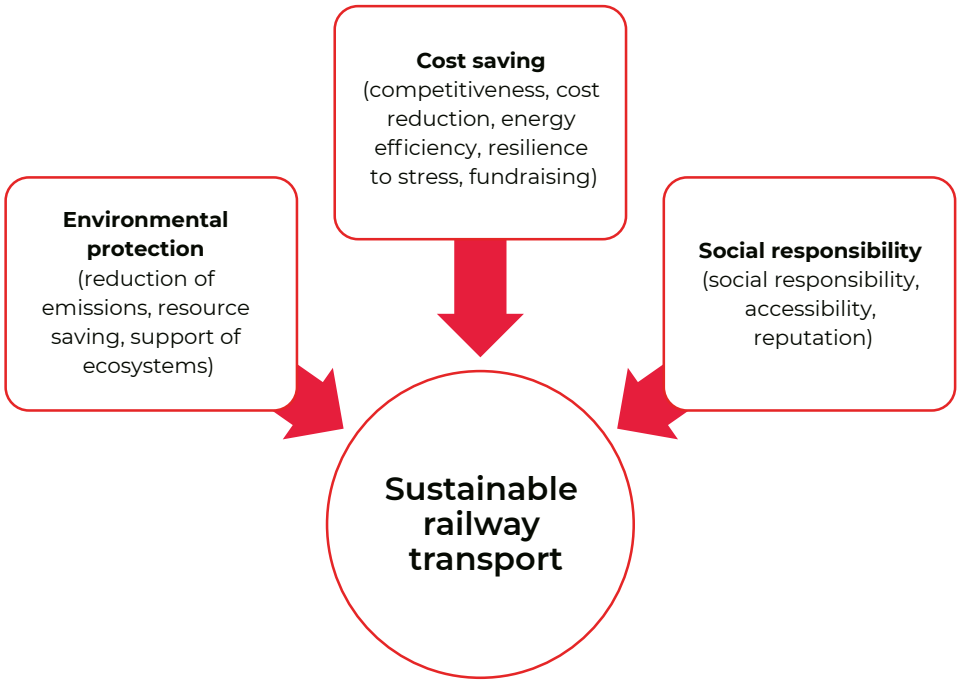
Over the last two centuries, globalization and international trade, via focus on movement of goods, services and people, raised the civilization to a record level of welfare. International freight transportation has always been at the core of global well-being. Sea transportation interconnected the world. Rail transportation has become the epitome of the First industrial revolution that has changed the world. Air transportation has made the world truly globalized.

As a globalization symbol, international freight transportation is increasingly criticized by the green movement for two reasons. Firstly, the transport is responsible for nearly 25% of global CO_2 emissions. Secondly, transport is the main driver of globalization which is also criticized for disproportionate global development. Presently 60% of international trade involves intermediate goods transported via global added value chains, mostly in scope of transnational companies. Therefore, international freight transportation, being a part of the transportation industry, is inevitably influenced by the environmental agenda.

Over the recent decades, global climate change dominates other environmental problems. Greenhouse gases, i.e. carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (N_2O), perfluorocarbons (PFC), hydrofluorocarbons (HFC), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3), have anthropogenic origin and are the main cause of the greenhouse effect. This leads to an increase in the frequency of climatic abnormalities, temperature increase across the planet, glacial melting, flooding of territories below sea level, and damage to the planet's biodiversity. Out of all greenhouse gases, carbon dioxide (CO_2) is the main source of global warming (accounting for more than 60% emissions).

In an attempt to prevent the catastrophe, an increasing number of countries and associations focus their roadmaps on low-carbon development. In scope of this policy, the state creates incentives for development of industries and implementation of innovations where carbon footprint will be negligible or absent. Hence there are state-level carbon regulations being implemented.

In parallel with carbon regulations, even more effort and public attention is focused on the sustainable development concept. Apart from the environmental component, it also includes social development issues. 17 UN Sustainable Development Goals encompass a large portion of human activities, including transportation industry across several indicators. Environmental problems are solved alongside with implementation of innovations, intensive and qualitative development.



Carbon regulation and low-carbon development have several levels. At the international level, regulation is performed in scope of international contracts under the UN auspices. Establishment of international climatic regulations had two reasons behind it: understanding of critical importance of environmental problems and economic methods as the most effective means of solving them. Kyoto Protocol stipulated the emission credits trading scheme (cap-and-trade), which linked the emissions to the "owner" capable of trading its credits or buying them from others. Under the flexibility mechanism, associations and states have launched their own emission limitations and credits trading schemes, e.g. the European system (EU Emissions Trading System) in force since 2005.

After Kyoto Protocol expiry in 2020, the principal international agreement is the 2015 Paris Agreement. In order to become inclusive and actually global, the agreement does not include any mandatory requirements. Each state has assumed certain voluntary liabilities to reduce emissions and report on goal achievement.

Thus, a new national (supranational) level of carbon regulation is introduced. European Union is leading the go-green initiative. In scope of the so-called Green Deal compared to the "European analogue of landing on the moon", the EU plans to reach carbon neutrality by 2050.

Certain steps have been planned to enable achievement of this goal. Firstly, the European emission credits trading scheme will expand as the emission prices grow. Presently it encompasses about 45% of all CO_2 emission sources in the EU. Air transport, accounting for 2-3% of global CO_2 emissions, is included in the system since 2016; however, due to the implementation of Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) by the International Civil Aviation Organization, the EU system for credits trading included only flights within the European Economic Zone and excluded international flights. This exception will terminate in 2023, when companies will have to buy the right to make additional emissions in auctions.

Within the EU, the discussion is ongoing for inclusion of sea transportation in the emission credits trading scheme. In scope of the plan for the Union's economy recovery from the aftermath of the coronavirus-related crisis, the European Commission hopes to obtain about $10 billion from expansion of the emission credits trading scheme to international air and sea transportation. Based on the European Parliament support, the final decision for expansion can be made as early as next year.

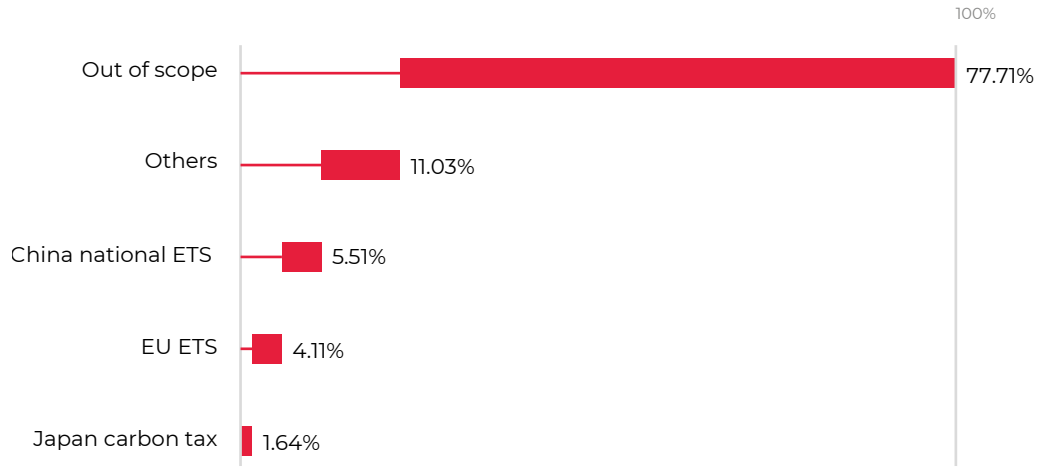
Railway transport is fully incorporated in the system by now. According to the data provided by the Community of European Railway and Infrastructure Companies (CER), railway companies pay about €110 million per year for CO_2 emissions as a fee for indirect emissions due to electrical power generation from dirty energy sources (about 60%). Presently the automotive transport is not included in the system at all, whereas air transportation, due to the statutory withdrawals — only by 15%. Therefore, the railway transport has already migrated to the new reality, and further reinforcement of carbon regulations will extend to other modes of transport, to increase the competitive advantage of railway.

The second step in scope of the European Green Deal will include the EU carbon border adjustment mechanism (CBAM) or carbon tax. CBAM's outreach and framework are still under discussion; it is meant to shuffle off the "carbon burden" to third country producers. Specifically, it is supposed to establish carbon regulation for goods from the countries where environmental legislation is less demanding or absent.

Carbon regulation has already heralded the new reality, despite its limited application within one, albeit advanced, region. In response to the EU actions, especially the pending CBAM whose scope is to be defined as early as the next year, other states have to design similar environmental regulation tools, which is evident from development of the national emission credits trading scheme in Japan, the Republic of Korea, and, in the near future, in China.

SCOPE OF THE GLOBAL EMISSION CREDITS TRADE FOR GREENHOUSE GASES

forecast for 2021 after Chinese system launch



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Railway transport in the context of decarbonization policy

In scope of the low-carbon strategy, the EU attributes the key role to the development of railway transport as one of the most “green” modes of freight transportation. Based on the proposal of the European Commission, 2021 is to become the Year of Railways. Unlike other modes of transport, railway is believed to consistently reduce the quantity of emissions, despite an increase in the share of the transport sector in the EU emissions from 15% in 1990 to 24% today. The European Commission estimates that by 2030 the share of railways in the EU transportation will reach 30%. Thus, the EU demonstrates its long-term commitment to the development of railways.

Emissions from railways depend on a number of contributors. Firstly, environmental friendliness of European railways is determined by their extensive electrification (about 55%). Secondly, environmental impact of the source of energy is crucial for estimation of direct and indirect emissions. In the EU, the share of low-carbon energy sources amounts to about 40%. The share of renewable energy sources is 20.7% (6.1% in 1990). According to RZD, in Russia the “clean” energy share is about 39%.

According to the European experience, provided that other countries and regions follow the Europe’s example of environmental and, specifically, carbon regulation, further extension of these norms can strengthen the position of railway transport in other regions of the world as well, other things being equal. Such a “domino effect” is quite possible, taking into account the international climatic regulation.

Central provisions of such regulations include the principle of material responsibility of the source of pollution (polluter pays) and the principle (user pays). Through such regulation, the states (or the supranational institution) include costs of using a common resource in the costs of the source of pollution. Owing to this mechanism, environment protection stops being just another reputational or risk factor and becomes a part of the company's economy. However, eventually, these costs are carried not by the company but by the direct consumer who can make a conscious and economically justified choice in favor of the environmentally clean mode of transport.

Finally, before actual comparison of the modes of transport, we need to mention the national efforts for promotion of railway transport which will serve as an example for measures at the supranational and national levels. In this regard, one must mention the German Rail Freight Masterplan adopted in 2020. One of the purposes of the strategy is bringing the share of railways in freight transportation of the country from the present 19% to 25% by 2030. The Masterplan includes both infrastructure development and extensive digitization (Digitale Schiene Deutschland) and electrification of railroads.

Apart from the sustainable development plans, railways are being supported via the ban on short-distance flights. French government cooperated with Air France to announce discontinuation of 40% domestic flights in favor of railway alternatives taking less than 2 or 2.5 hours. Similar measures are being discussed in other countries, e.g. Germany, Sweden, and Australia.

Thus, the impact of environmental agenda on international freight transportation in general and on rail in particular is increasing. Note that the penetration of environmental agenda is not uniform: apart from the differences in emissions depending on the mode of transport, the trend is pressured by the spread of carbon regulation at the international, supranational and national levels. It stimulates the transition to low-carbon development and strengthens the advantages of railway transport. Nevertheless, this effect is discrete due to various technological and economical factors that would be discussed further.

ENVIRONMENTAL ADVANTAGES AND CONSTRAINTS OF RAILWAY TRANSPORT

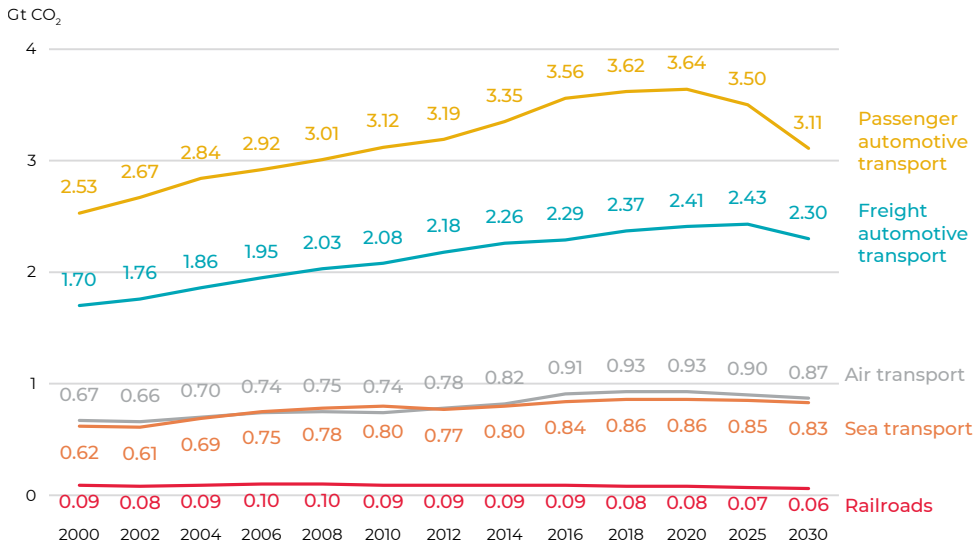
Relative advantages and constraints of railway transport

The structure of international transportation conventionally includes several main modes of transport, each having its special features: sea transportation (low speed, low cost), air transportation (high speed, high cost), railway transportation (medium speed, medium cost). With each mode having its advantages, railways are believed to be the most environmentally friendly, which gives them a certain edge due to the penetration of the environmental agenda.

According to the International Energy Agency, railways are one of the most energy efficient modes of transport: they accommodate 7% of international freight transportation volume, and only 3% energy used by the global transportation industry. In 2019, railways accounted for 0.6 million barrels of oil, which amounts to 0.6% global consumption, and about 280 terawatt-hours of electricity, i.e. 1.2% global consumption. Along with that, direct contribution of railways in carbon dioxide emissions to the atmosphere is only 0.3% from global.

CO_2 EMISSIONS BY MODES OF TRANSPORT

2020, 2025 and 2030 forecast assumes sustainable development



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However, the advantages of railroad transportation have specific contingencies. Firstly, environmental friendliness depends on the source of energy. Most of the freight shipments are performed by diesel-powered autonomous locomotives. Their use is caused by poor electrification of regional and local destinations, high cost of electrification and its infrastructure maintenance in low-utilization itineraries. Direct emissions from diesel locomotives amount to appr. 25 to 60 gram CO_2 per ton-kilometer, depending on the locomotive characteristics. Conversely, emissions scatter from an electric locomotive is from appr. 10 to 25 gram CO_2 per ton-kilometer. However, even such scatter is significant for carbon regulation and presents an objective advantage of the railroad transport.

As noted earlier, electric propulsion poses three questions. The first is – the nature of the source of energy: was electricity generated by renewable or fossil sources. The second is – recording of indirect emissions from the railway infrastructure. The third is – costs of electrification and maintenance of its infrastructure. Apparently, due to the objective presence of itineraries with low utilization, full electrification would be cost ineffective.

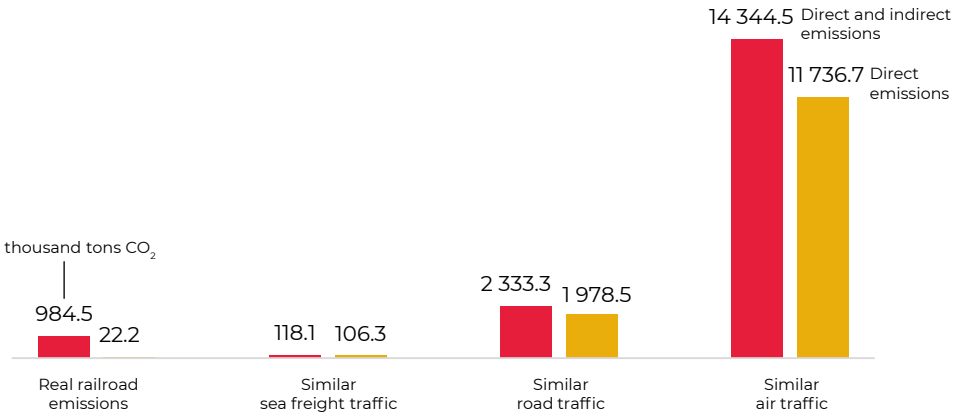
Therefore, the second specific factor related to the environmental advantages of railroad transport is – presence of transport corridors with continuous flow of goods. Railway infrastructure development is costly vs. e.g. road infrastructure. Besides, its development is often related to political issues and risks due to the international or continental nature of railroad transportation. The economic and environmental advantages of railway transport best work on well-established routes with high utilization and high predictability of cargo flows.

An instance of economically successful project with obvious environmental advantages due to the use of railway transport is the Eurasian transit corridor (Kazakhstan, Russia, Belarus) in the direction China–Europe–China. Owing to the strategic political agreements, thorough long-term efforts for development of the route and objective continental advantages of the railroad transport, the itinerary has taken over more than 90% of the volume of cargo moving via the transit railway corridors in this destination.

In line with the environmental trend, the ERAI index portal dedicated to this corridor has launched a CO_2 Counter, enabling visual representation of environmental advantages provided by the railroad transport. In H1 2020, freight transportation by rail produced 14.9 thousand tons of direct CO_2 emissions, which is almost 5 times less than it would have been by sea, 89 times less than by road and 528 times less than by air.

CUMULATIVE VOLUME OF EMISSIONS FROM FREIGHT TRANSPORTATION VIA RAILROAD ITINERARY

China ¾ Europe in 2019 (333 021 TEU)



The main environmental competitor of railroads is sea transportation accounting for ¾ of global freight traffic. Direct emissions from an ocean-going container vessel are 15 to 25 gram CO_2 per ton-kilometer. Despite high energy efficiency, sea freight shipment before the corona crisis kept increasing their annual emissions and in 2019 reached the record mark of 714 t CO2-equiv., i.e. about 2.2% of anthropogenic CO_2 emissions. On top of emissions, another drawback of sea transport is related to waste and pollution of sea ecosystems in high traffic areas, e.g. the Strait of Malacca.

In response to the spread of low-carbon agenda and intensification of carbon regulation, the UN International Maritime Organization (IMO) was compelled to adopt the emissions reduction strategy in 2018. The new roadmap suggests that all vessels should comply with mandatory requirements in terms of engine energy efficiency, and since 2019 all vessels will be obliged to collect data on fuel consumption to make emissions assessment more accurate. Additionally, since 2020, new limitations were established for sulfur content in fuel (maximum 0.5%), in order to reduce emissions of sulfur dioxide into the atmosphere. According to the strategy, by 2050 emissions from sea transport will go 50% down versus the baseline 2008.

Significant risks for the sea sector are related to the stiffening carbon regulations. As noted above, in 2018 the EU has already bound maritime companies operating within its borders to report their emissions. Not earlier than in 2022, sea traffic is expected to be included in the European emission credits trading scheme, as the European Commission insists. According to experts, the environmental transformation of sea transport will face certain difficulties: according to the sustainable development scenario, CO_2 emissions in 2030 should not exceed 670 t CO_2-equiv., however with the present momentum it will require additional effort once the "carbon price" is inevitably established in the markets mid-term.

Air transportation is considered to be the least environmentally safe means of freight shipment. Direct emissions from a long-haul cargo liner, the most "green" mode of air transportation, are 250 to 900 gram CO_2 per ton-kilometer. Obviously, the decarbonization agenda poses a fundamental challenge to air transportation, since the available technology cannot radically change the volume of emissions.

Possible areas of "green" transformation of the industry can be related to either the fuel constituent or new industrial design of aircraft. Despite the experiments with biofuel (sustainable aviation fuels, SAF), jet kerosene substitutes cannot provide sufficient energy release and specific power to match it (they are used as fuel additives); besides, they are only capable of – reducing but not eliminating CO_2 emissions. Development prototypes of electric aircraft keep being designed, but there is still a long way to go until their full-fledged commercial use.

Radical fleet upgrade or introduction of conceptually new aircraft is still economically unfeasible. Air transportation is a highly competitive sphere with relatively low profitability: the average profit amounts to appr. 6-8%. Therefore, most operators and producers cannot afford a revolutionary fleet upgrade. Most aircraft designs surface evolutionally through energy efficiency increase and use of composite materials, but that is as far as it goes.

It is highly likely that air transport will not be able to meet the sustainable development goals in any development scenario. Initiatives of international industry organization for transition to more environmentally safe development of the industry, e.g. the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) of the International Civil Aviation Organization (ICAO) are important steps, as well as the operational improvements and use of biofuels. Environmentalization of the industry is hindered by objective technological and economical constraints.

Stiffening carbon regulations and industry transformation challenge are extremely disadvantageous for air transportation sector. However, air freight still has its specific merits which will help it retain a portion of its niche, even despite the growing costs due to the "polluter pays" and "use pays" principles.

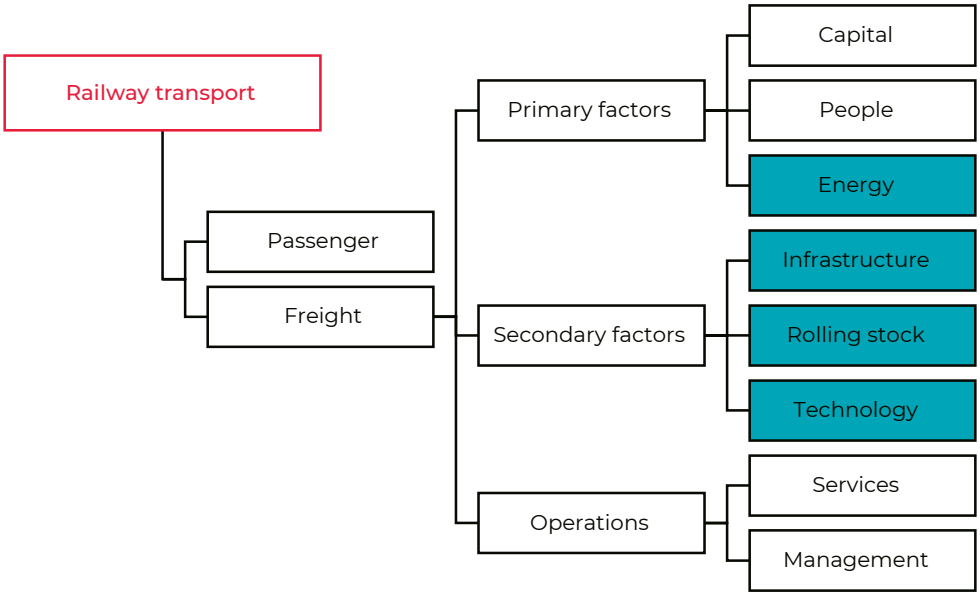
Railway transport can take the most advantage from the air industry's plight as the closest counterpart in terms of cargo delivery speed. However, its capabilities depend on the degree of complementarity which varies from region to region. So, the corona crisis has revealed that in the China–Europe–China route, the railway transport has been able to take over some of the cargo flows.

Thus, the environmental agenda penetration, primarily in the part of carbon regulation, changes the established competitive landscape in the sphere of international freight transportation. The "green" trend gives a competitive edge to railroad transport. However, this effect is discrete and depends on a number of other factors, e.g. success of other modes of transport in responding to the new environmental agenda. Additional opportunities for railways lie in technological innovations which can support the objective environmental advantages of this mode of transport.

Ecological and technological future of railways

In scope of the Paris Agreement for Climate, the signing countries have assumed a voluntary obligation to reduce the greenhouse gases emissions. Carbon regulations stiffening by a number of countries and associations calls for a transformation of the global transportation industry and transition to the low-carbon model of development. In this context, the railway transport has inherent advantages as the least carbon-intensive mode of transport, other conditions being equal.

A focus on development of railways and introduction of such regulatory mechanisms as “polluter pays” and “user pays” principles facilitate takeover of cargo flows from carbon-intensive sectors e.g. air and road transportation. Nevertheless, to take the best from the railway’s intrinsic advantages, impactful innovations are required.



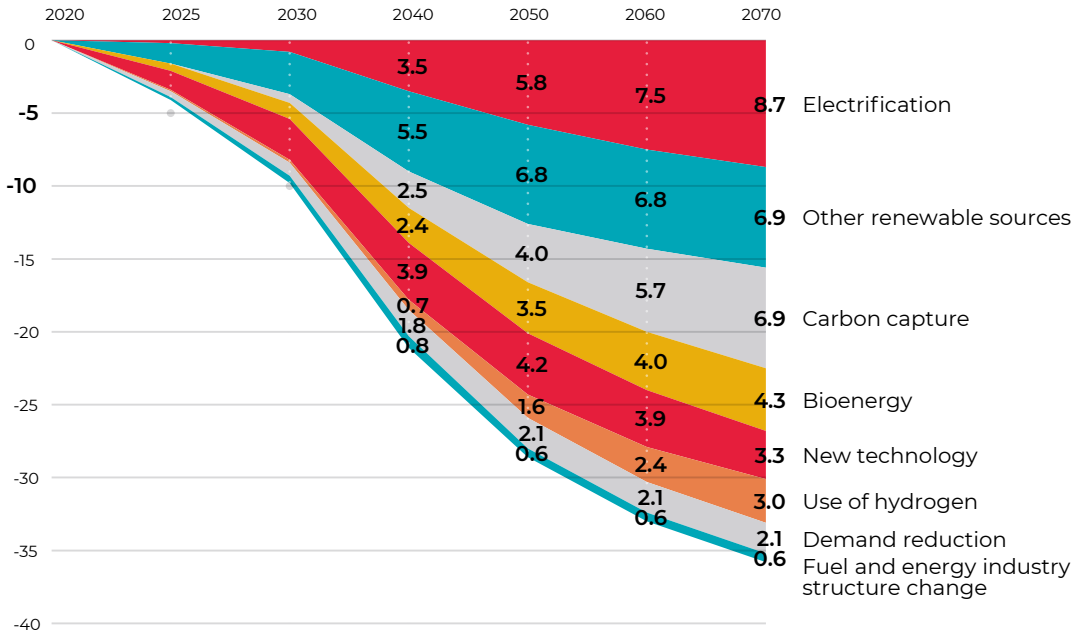
“Green” transformation will impact such primary factor of production as energy. In terms of railroad development, this aspect should be enabled via electrification of the highest utilization routes with steady cargo flow. This roadmap has already been adopted by Germany, the European Union as a whole, China, and Russia.

Significant impact of the environmental agenda is felt in terms of the secondary production factors such as infrastructure, rolling stock and technology.The actual changes are comprehensive and interrelated. New technologies are aimed at increasing energy efficiency, promoting environmentalization and gaining additional ecological advantages.

According to the structure of planned reductions of global CO_2 emissions from the energy sector, the railroad industry will experience long-term influence of electrification and transition to the new types of fuel. Presently the only alternatives to diesel locomotives and electric locomotives that are actually being tested are liquified gas and hydrogen.

PLANNED REDUCTION OF GLOBAL CO2 EMISSIONS FROM THE ENERGY SECTOR BY TYPE

Gt CO_2 per year



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Use of hydrogen in transportation is, primarily, associated with high cost of production of this type of fuel. The second factor is explosion hazard associated with hydrogen, which will require time-consuming improvement of the technology to enable its practical use. The third factor is – absence of the necessary infrastructure at the moment. Nevertheless, in scope of Mireo Plus H, a €12 million worth joint project between Germany and Canada, funded by the German government with Siemens participation, a usable hydrogen drive is scheduled to be designed by 2021. It is expected that use of the hydrogen engine will require less maintenance cost at the same efficiency, while CO_2 emissions will be totally absent.

Gas engine locomotives have already been tested in Russia (TEM19-001 in Sverdlovsk railway) and in Spain. The technology is under development since 1980s. Still, as is the case with hydrogen, use of LNG is still problematic and requires further testing. One of the problems is insufficient LNG infrastructure and high cost of this type of fuel vs. diesel.

RZD is building mainline gas turbine locomotives (GT1h-002) and gas engine locomotives (TEM19h) fueled by LNG. 40 mainline gas turbine locomotives are scheduled for commissioning until the end of 2020. As tests have shown, gas turbine locomotive lifecycle cost is appr. 30% less than that of diesel locomotives, and CO_2 emissions level is significantly lower.

Another, more slow-response area of rolling stock development is extensive use of hybrid locomotives, i.e. electric diesel locomotives. So, Siemens has been contracted by DB Cargo to supply 100 new Vectron Dual Mode electric diesel locomotives, which will constitute 70% of the company's fleet in the future. According to the operator's calculations, use of hybrid locomotives will help reduce fuel consumption and bring down CO_2 emissions by the company by 17 thousand tons per year.

Advantages of the environmental agenda may be constrained by long cycles of technological adaptation at the railroad. According to Oliver Wyman (consulting company), the average age of locomotives is 18.4 years, whereas their updating cycle can reach 30 years. It shrinks the opportunity for quick transition to the new development model and slows down the new technology adaptation.

Rolling stock and infrastructure update in favor of improved environmental safety will help reduce indirect emissions from railways, thereby cutting down the “carbon price”. In order to gain the most out of the aforementioned transformations, the states need to continue their incentives in the area of transition to low-carbon development.

Finally, digitization will indirectly work to reduce the carbon footprint. Introduction of state-of-the-art digital technology will optimize operations and help better integration, both within the railroad system and with other modes of transport. Digital solutions require a dedicated review and are capable of speeding up decarbonization of railway and increasing the appeal of railroads as a reliable and environmentally friendly type of transport.

In the 19th century, railroads have become the symbol of industrial revolution. In the 21st century, railroad, along with the other modes of transport, undergoes a major change. At the same time, it is positioned, yet again, in vanguard of development. The environmental agenda and decarbonization policy give new advantages to the railway transport that are very much worth looking into.