Improving the Environmental Friendliness of Russian Transport Through the Use of Hybrid Vehicles

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Abstract. Environmental problems are a pressing matter; the actual transfer to environmental friendliness of life and production has become possible due to the recently emergent serious achievements of science related to introduction of digital technologies and innovations into all the spheres, including the automotive industry. According to the Strategy, by 2025, the share of electric vehicles in the Russian Federation must reach 5%, which is consistent with their share in the developed countries. Transfer from internal combustion engine (ICE)-powered to hybrid vehicles is a serious step of modernization of the transport system, which requires a comprehensive approach possible when actions of all the parties to the process are coordinated. A roadmap is an instrument that allows identifying the main stages and means of fulfilling innovative goals of the object that require drafting text and graphic documents, and introduction of the information required to make managerial decisions thereto.

1. Introduction
High automobilization rates in the XXI century that resulted in a worse unfavorable environmental situation in cities due to heightened concentration of the substances harmful to humans emitted with car exhausts led to an understanding that environmental safety measures are required. Although environmental problems have been a pressing matter for more than five decades, the actual transfer to environmental friendliness of life and production has become possible due to the recently emergent serious achievements of science related to introduction of digital technologies and innovations into all the spheres, including the automotive industry.

In countries with high environmental standards, such as Germany, the Netherlands, Norway, Austria, etc., better quality of life in cities is becoming possible due to electrification and gasification of vehicles, i.e. due to introduction of electric cars, hybrid vehicles, and use of more environmentally friendly types of fuel. The share of electric cars is not large, but high rate of research and development allows making optimistic predictions to that effect.

Along with well industrially developed countries, China also demonstrates a high rate of transport environmentalization; they developed state programs and finance scientific research in the sphere of innovative transport and construction of infrastructure. Since 2018, up to 6,000 new fuel-filling columns have been being commissioned every month in 160 cities and along regional roads. Plans of development in this sphere are ambitious [1-4].
2. The problem: environmental pollution

Although air is polluted in most Russian cities, the situation is not catastrophic due to specific weather conditions: the westerlies, vast forested areas, strong winds, etc. This is one of the reasons why Russia has a comparatively low transport environmentalization rate. However, high automobilization rate, especially owing to the secondary market may result in a rapid deterioration of the environment in the setting of changing climate conditions, low degree of environmental concern among the population and absence of necessary infrastructure. Furthermore, participation of the Russian Federation in international organizations, alliances and the global context in whole requires the country to conform with international standards and modern trends.

Currently, environmental aspects are considered in many legal and strategic documents of the Russian government. Environmentalization of the automotive industry is required by the Strategy of automotive industry development in the Russian Federation until 2025 (No. 831-p, dated April 28, 2018), according wherefore the transport used in the Russian Federation must be brought in line with the modern requirements of environmental friendliness and energy efficiency.

According to the Strategy, transport electrification technologies involving use of electric cars and hybrid vehicles is a top priority area of innovative development of the automotive industry in the Russian Federation. Along with the measures aimed at improving competitive ability of Russian automotive products and introduction of such products to international markets, the Strategy describes measures to reduce the prime cost of cars, which may be achieved only if the following conditions are met: development of production of car parts in Russia, reduction of costs of raw materials, and improvement in efficiency of production. Production of high-technology car parts for electric cars and hybrid vehicles (hybrid engines, traction motors, and traction batteries) is expected to be launched in the Russian Federation in the medium term. Production of such parts is possible only if the car production output is increased; at the same time, car production is stimulated by high demand. Therefore, to fulfill strategic objectives, the production output must increase, therefore, there must be increased demand for domestic products, particularly for electric cars and hybrid vehicles as more environmentally friendly means of transport.

According to the Strategy, by 2025, the share of electric vehicles in the Russian Federation must reach 5%, which is consistent with their share in the developed countries. For the current year, the share of electrified transport in Russia is lower than one percent. Even though strategic plans involve construction of charging infrastructure, the rate of such construction is clearly not sufficient to ensure a high electrification rate. The whole transport system must be dramatically reformed; this requires a large amount of additional resources. In order to fulfill the set objectives, a transition period is required, wherein hybrid vehicles may play the decisive role. According to experts, 75% of the electric cars currently manufactured around the world are hybrid ones (i.e. vehicles with at least two different power converters (engines) and two different (in-vehicle) power accumulation systems to propel vehicles).

Hybrid cars and vehicles (HV) have been manufactured by car makers for more than twenty years. For instance, Toyota launched the first Prius G21 model in 1997. Commercial production of this model concurred with the Kyoto protocol - an agreement additional to the UN Framework Convention on Climate Change. It made emissions reduction not just an intention, but an obligation of states. That is why commercial production of a hybrid car, whose main advantage was reduced fuel consumption and therefore less emissions, came just in time.

Cost efficiency of a hybrid engine is based on rational fuel consumption, inactivation of the petrol engine and the system's switch to an electric motor if the car stops completely. Unlike batteries of electric cars, in hybrid vehicles batteries may be recharged by the petrol engine to increase the driving distance. Although car makers develop essentially different HV patterns, all of them feature one thing in common - the possibility to drive longer without refueling. This makes hybrid vehicles especially efficient in the urban cycle. Urban traffic is characterized by frequent gridlocks and therefore by frequent stops, during which the engine at idle operates as an electric motor. However, these advantages do not cover high prices of HVs. There are several reasons to that:
1. Only a few major European car makers offer accessible hybrid vehicles in selected markets, yet at higher prices than comparable regular cars.

2. European manufacturers design internal combustion-powered cars with extended transmission gears, direct petrol injection and turbo-ramjet drives to combine energy efficiency and high performance. Therefore, ICE-powered cars successfully compete with hybrid vehicles.

3. Attractive hybrid vehicles made in Japan are available in a limited number markets in a limited amount.

4. Car dealers around the world are not motivated to sell hybrid vehicles.

Internal demand must be stimulated by government measures. In the current economic circumstances when the risk of a hybrid vehicle's prime cost reduction is limited, such measures may include replacement of the vehicles used by state organizations with domestic cars and stricter requirements to the vehicles sold and used in the Russian Federation. It is also necessary to develop expertise in the sphere of research and development of parts for hybrid cargo vehicles and commercial light hybrid motor vehicles to reduce their prime cost and improve performance.

Transfer from internal combustion engine (ICE)-powered to hybrid vehicles is a serious step of modernization of the transport system, which requires a comprehensive approach possible when actions of all the parties to the process are coordinated. Such an interaction requires developing techniques and methods to promote such a coordination. Roadmapping (RM) or technology roadmapping (TRM) is one of such coordination-promoting tools.

3. Research methods

Roadmaps have been used by foreign companies for more than 40 years. A TRM is an instrument that allows identifying the main stages and means of fulfilling innovative goals of the object that require drafting text and graphic documents, and introduction of the information required to make managerial decisions thereto. The primary advantage of this instrument consists in the possibility of ensuring connection between the vision (mission), the strategy, and technologies, and coordination of the process in whole.

The use of the TRM tool for transport conversion to HVs is reasonable, because it is necessary to ensure coordination between direct and indirect participants, programs and terms of completion thereof, business processes, plans, and strategies.

4. Results

Development of a TRM is a labor-intensive process and requires a large amount of data, time, and intellectual resources. The depth of a TRM may vary depending on the objectives thereof. Specialists of the Department of Transport Machinery and Transport-Technological Processes of the Far Eastern State University attempted to develop a conceptual roadmap for replacing the currently used transport with hybrid engine-powered vehicles. It was important for developers to determine whether the Strategy of automotive industry development in the Russian Federation until 2025 may be fulfilled so far as hybrid vehicles may be concerned and on what conditions.

To do that, they had to compare the current trends, deadlines of engineering projects of the major Russian car makers, the time required to prepare infrastructure elements and human resources.
A TRM for replacing company’s ICE-powered vehicles with HVs was developed in several stages. At the first stage, we identified groups of participants in the process and defined their functions. All the participants were divided into four groups:

1) the "state" represented by executive and legislative authorities;
2) the "science" represented by R&D structures and projects closely associated with production;
3) the "production" - automotive companies in whole; they define technical capabilities of replacing older models with more environmentally friendly vehicles;
4) "transport companies" - the companies representing the object of the activity that the transport environmentalization stimulation policy is aimed at.

At the second stage, we defined the primary layers of the map. To define them, we used the traditional approach to the standard T-plan roadmapping process proposed by R. Phaal in 2001. According to the plan, all the three main layers are developed: product, technology, and business. If necessary, other layers promoting optimal solution of the set objectives may added to the map. In this case, additional layers include the "market" layer, because activities of automotive companies define the possibilities of hybridization of car fleets of transport companies.

The main layers include:

1. The "product" layer - results required to fulfill the strategy of replacing current cars with HVs. These are the actual results that must be provided by process participants (actors) - the documents to be drafted, established structures, engineering and production samples, etc. The product layer includes all the products developed to modernize transport by all process participants: the state, R&D, automotive and transport companies. For instance, the product of the automotive industry is defined as commercial production of Russian hybrid cargo vehicles. The product of research and development (R&D) is defined as completed engineering projects aimed at increasing battery capacity and improving battery durability.

**Figure 1. Technology roadmap.**
2. The "technology" layer includes all the technologies associated with replacing the transport with HVs. Above all others, these include hybrid creation technologies, service outlet creation technologies, as well as technologies of drafting regulatory and legal documents to support the legal foundation of HV demand stimulation.

3. The "market" is an important additional layer to be included. Success of the proposed measures to replace the transport with HVs is to a large extent connected with surmounting technical disadvantages of the currently used batteries. Numerous designers and engineers employed by automotive companies work to improve battery properties. It is important to know when manufacturers are going to produce cheaper and lighter batteries.

The third stage of TRM is intended to determine the main elements and the list of works, establish and approve terms of execution.

Graphic representations of roadmaps must contain parameters to control the process of implementation. Failure to follow this rule results in delays or even breach of a schedule of works or utter disregard of the intentions elaborated in the Strategy [17-20].

5. Conclusion

The roadmap analysis demonstrates that:
- current companies' car fleets may be replaced with hybrid vehicles only after 2021 if the stated deadlines of commercial production of Russian cargo HVs are met;
- it is necessary to develop a system of non-monetary methods of stimulating environmentalization of car fleets and purchasing of Russian electric motor-powered vehicles, including hybrid vehicles;
- it is necessary to introduce the system of training development and further education for all the services along with the research and development to improve properties and reduce cost of car parts in order to ensure sufficient expertise and safety of use of electric motor-powered vehicles;
- altogether, the transport electrification transition period in the Russian Federation may be started with the spread of hybrid vehicles.

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