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FORESIGHT AND ROADMAPPING AS INNOVATIVE TOOLS FOR IDENTIFYING THE FUTURE OF NEW MATERIALS[1]

Keywords

Foresight, roadmapping, innovations, new materials, carbon fibres, innovation strategies, nanotechnologies, integrated roadmap.

Abstract

Rapid growth of the new materials sector represents one of the most promising scientific and technological trends on which depends the growth of key sectors of the national economy. This paper focuses on Foresight for the field of new materials and gives special consideration to the case study of prospects of carbon fibres, which is one of the most promising areas of new materials. We suggest using roadmapping as a final stage of Foresight. Integrated roadmap represents a combination of desk research, expert procedures, and scenario development. It provides a comprehensive approach to the strategic development of the subject area within the unique time scale, containing indicators of the quantifying economic effectiveness of the potentially prospective technologies and products that possess high demand potential and attractive consumer properties.

[1] The study was implemented in the framework of The Basic Research Program of the Higher School of Economics in 2013

Introduction

Nowadays, when role of traditional drivers of economic growth are decreasing, searching for new approaches to facilitate rapid development and a strengthen competitiveness of the national economy becomes an extremely significant goal. Innovations have already become the major driver of economic development. To formulate adequate and consistent national innovation policy, it is necessary to set relevant priorities. One of the most effective instruments for it is Foresight. It aims at revealing the most promising S&T and innovation development areas and becomes a main part of government S&T policy [5].

Strategic future-oriented activities are now commonly based on the methodology of Foresight. This approach gives the opportunity to estimate how S&T development could contribute to boosting the competitiveness of the country and meeting the major socio-economic challenges [9]. The sector of new materials as evidenced in a variety of Foresight projects has undoubted significance for successful future development. An instrument for launching special plans of the development in the field of new materials is roadmapping [1, 2, 19].

1. Current understanding

The problem of the development and adoption of new perspective materials has been invariably attracting future explorers' attention during the last decades. There are some examples of such studies using the Delphi method [3, 13, 16, 17]. Additionally, some companies have developed specific roadmaps devoted to development of certain materials [8]. Most of them are aimed at creating a list of prospective technologies and products; however, for example, Japanese Delphi allows researchers to define a set of concrete recommendations for policy forming within the sphere of new materials. The suggested package of measures is the basis of the priority definition of Japan science and technology's Basic Plan, but it provides only rather general recommendations. There is a gap in the publications of using Foresight for the forecasting and planning development of the sphere of new materials that provide a set of special plans, such as a R&D plan, a plan of the implementation of new technologies and products, and a plan for the commercialization of innovative products. The first significant work concerning roadmapping methodology was prepared by Phaal et al [15]. However, there is still a lack of approaches to roadmapping in the sphere of new materials.

2. Research question

The paper answers the question concerning how to use Foresight methods and especially roadmapping for the sphere of advanced materials in a technological and a market sense and how a roadmap as a resulting Foresight document should be included in the process of strategic decision-making at different levels that ensure a sustainable innovation flow. The study aims at providing a sequence of Foresight methods pointed at the development of innovation strategies based on roadmapping.

3. Methodology

The logic of Foresight presupposes an application of a wide portfolio of future analysis methods in a strict succession (Fig. 1). It includes 6 main stages: pre-roadmapping, desk research, expert procedures, creative analysis, interactive discussion making, and roadmapping [12].

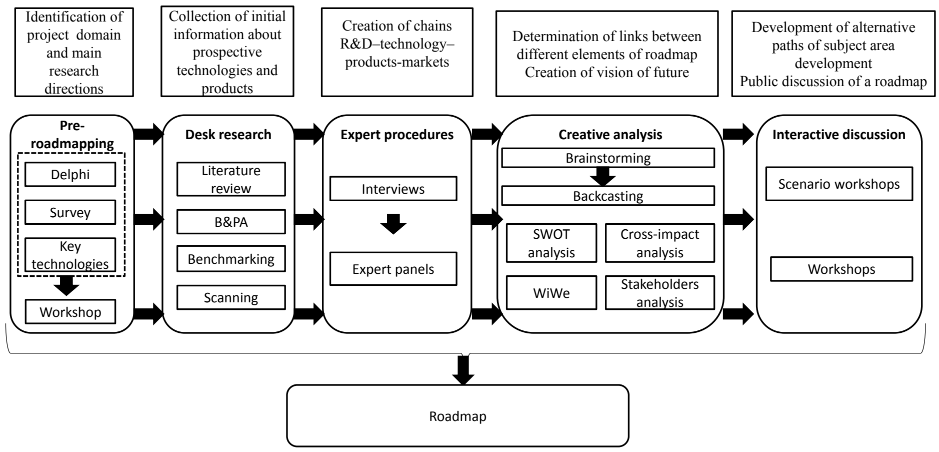

Fig. 1. Basic scheme of Foresight for the sphere of new materials

This methodology has some similarities with traditional approaches, which include phases that are rather comparable with the de Laat paper where the marked preparation step, implementation and follow-up [4], the central layers of an integrated roadmap reflect the main steps of the roadmapping process of the development of the roadmap "Canadian Aircraft Design, Manufacturing, Repair & Overhaul" – market, products and technologies [7].

However, the suggested methodology provides a detailed plan of using a wide portfolio of Foresight methods and integrates market pull and technology push approaches (Table 1).

Table 1. Potentials and limitations of technology push and market pull approaches

Approaches	Author / study	Potentials	Limits
Technology push	Lee et al. (2007); Lichtenthaler (2008); Lee et al. (2009b).	Comprehensive study of innovation technologies and products development.	Insufficient consideration of future market requirements and consumer preferences.
Market pull	Albright and Kappel (2003); Holmes and Ferrill (2005); Industry Canada (2007a) Lee et al. (2009a).	Revelation of possible markets development within several scenarios.	Lack of assessment of technological basis for satisfying market needs.

Emphasis on only one side causes the inability to find necessary resources for manufacturing or to satisfy market demand. Hence, a specific feature of the suggested approach consists in incorporating technology roadmapping, which interrelates the most perspective new products, technologies, and R&Ds in the area of advanced materials into a business map that provides alternative market patterns for these products and technologies. Each stage of the suggested methodology contains features of market pull, technology push, or both approaches. The full sequence of these phases provides the integration of technology push and market pull (Table 2).

Table 2. Integration of market pull and technology push in suggested methodology

Stages	Approach	Results
Pre-roadmapping	Mixed	Project domain and research question identification
Desk research	Technology push	Initial information on prospective technologies and products
Expert procedures	Mixed	R&D–technology–products–markets chains
Creative analysis	Mixed	Links between different elements of the roadmap. Vision of future
Interactive discussion	Market pull	Alternative paths for subject area development

Integrated roadmapping represents a resulting document of a Foresight study. It provides the link between the key technologies, the properties of existing and promising products, and the most perspective products and their potential market niches. Roadmapping explains the structure of demand for innovation products and gives an opportunity to estimate technical capabilities required for their production. It also reveals the most preferable consumer properties, which could provide the significant competitive advantages for innovative goods [10].

4. Findings

As evidenced by a set of projects one of the most prospective areas of new materials is carbon fibres [14, 18]. Given this, it would be reasonable to consider more carefully the experience of the developing of the roadmap “Nanotechnology Applications in Manufacture of Carbon Fibres and Carbon Fibre Products”, that is carried out by the National Research University “Higher School of Economics” on order of JSK “Rusnano” in the context of a set of Foresight studies aimed at the determination of priority trends of nanotechnologies development in Russia [9, 11].

The Roadmap visualization (Fig. 2) illustrates the correlations between the key technologies that the carbon fibre industry’s progress relies on, the properties of current and advanced carbon fibres and carbon fibre composites, and between the prospective products and their respective market shares whose sizes and performance, in its turn, would determine the state of demand for carbon fibres.

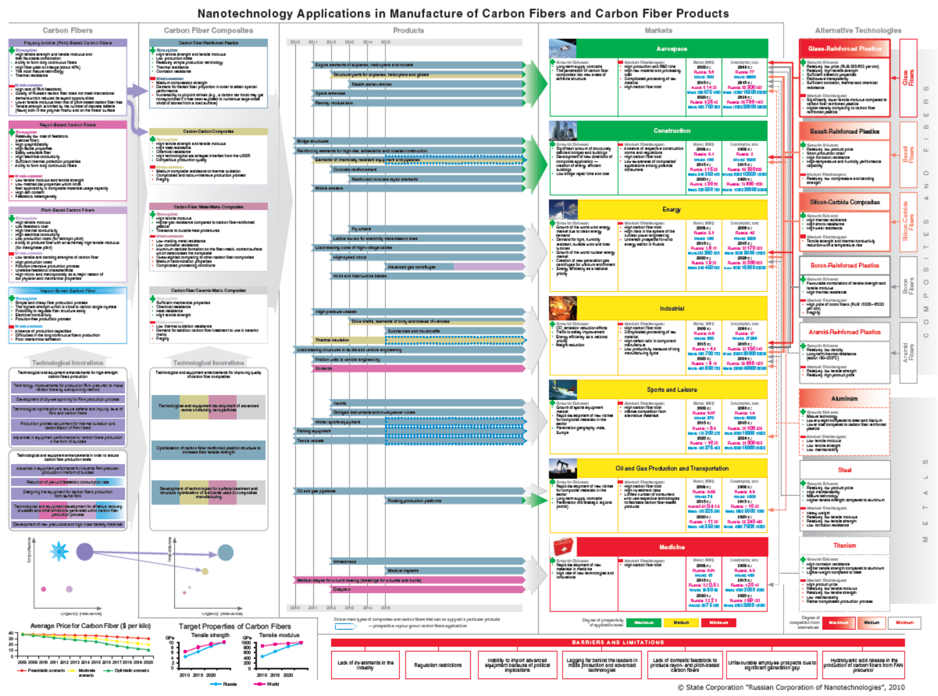

Fig. 2. Visualization of roadmap “Nanotechnology Applications in Manufacture of Carbon Fibres and Carbon Fibre Products”[2]

[2] http://en.rusnano.com/upload/OldNews/Files/28677/current.pdf

The roadmap was formed on the principle of layered groupings of its elements (Fig. 3). By "layer" we understand a complex of one-type elements of a roadmap – products, technologic solutions, scientific research results – that are examined in connection with a unified time scale. It gives an opportunity to identify the expected time of the appearance of innovative technologies and products, to reveal potential dynamics of segments of the carbon fibre market and to make conclusions about the need of carrying out necessary R&D.

Therefore, the first layer provides a description of advantages and disadvantages of different types of carbon fibres, taking into account the potential broadness of their employment. For every type of fibre, there have been defined the most prospective materials that can be made on their foundation, (for example, such materials as widespread carbon fibre reinforced plastics). With experts' participation, it was defined a number of problems that must be solved for the creation of corresponding industries in Russia.

The central layer of the roadmap includes an expert assessment of long-term prospects of the carbon fibre market development at different segments that are existing for present moment or will appear in future. Taking into consideration the long-term character of the roadmap, the assessment of market development was realized through a scenario analysis. The roadmap reveals three possible ways the market segments may development – pessimistic, moderate, and optimistic – formed after an examination of factors that will determine the future of the carbon fibre market. There are different kinds of factors that vary consumer preferences, regulatory restrictions, and even political factors.

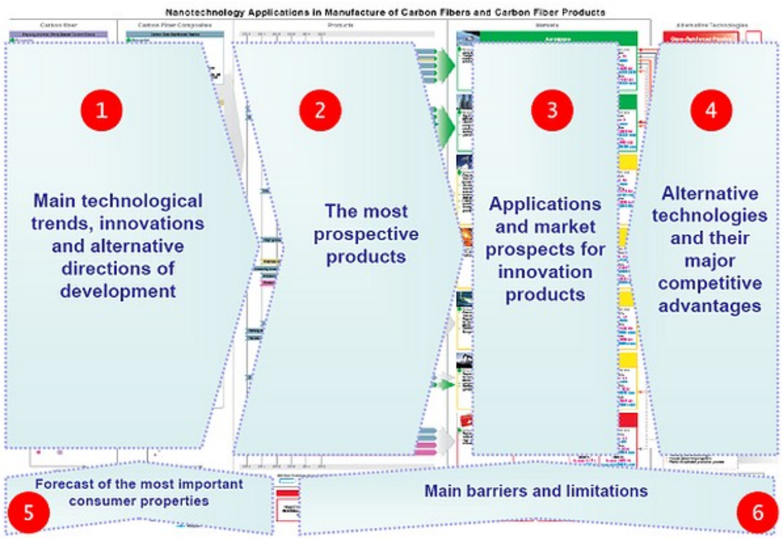

Fig. 3. Structure of roadmap “Nanotechnology Applications in Manufacture of Carbon Fibres and Carbon Fibre Products”

During the development of the roadmap, particular attention was paid to the analysis of alternative types of new materials that compete with carbon fibre. The research was focused on innovative composites (e.g. basalt plastic based on basalt fibre) and traditional materials (e.g. aluminium and steel).

To compare potential effect of using carbon fibres and their alternatives, a forecast of the dynamics of the most significant technological and economic characteristics of carbon fibres was also made (Layer 5).

An analysis of technological and market prospects of carbon fibre production in Russia was supplemented with a study of risks, barriers, and the restrictions that create obstacles for the development of this field (Layer 6). This analysis can be helpful for the early prevention of possible obstacles that should be taken into consideration while investing in a new technological field.

The integrated roadmap has a wide practical application resulting in subsequent formation of investment projects for the sphere of new materials in Russia. The important application of the roadmap is the development of paths (R&D – technology – product – market) on their basis. Such trajectories are aimed at a detailed description of possible strategies of commercialization on concrete markets, this includes which innovation products should be created, what level of their consumer properties will allow them to compete with other similar goods (including imported ones) each moment in time, and what kind of new technologies should be introduced to obtain the required product properties. These results can be useful for different actors of innovation policy in Russia: Rusnano, federal authorities, industry associations, research institutes, companies, and technology platforms (Fig. 4).

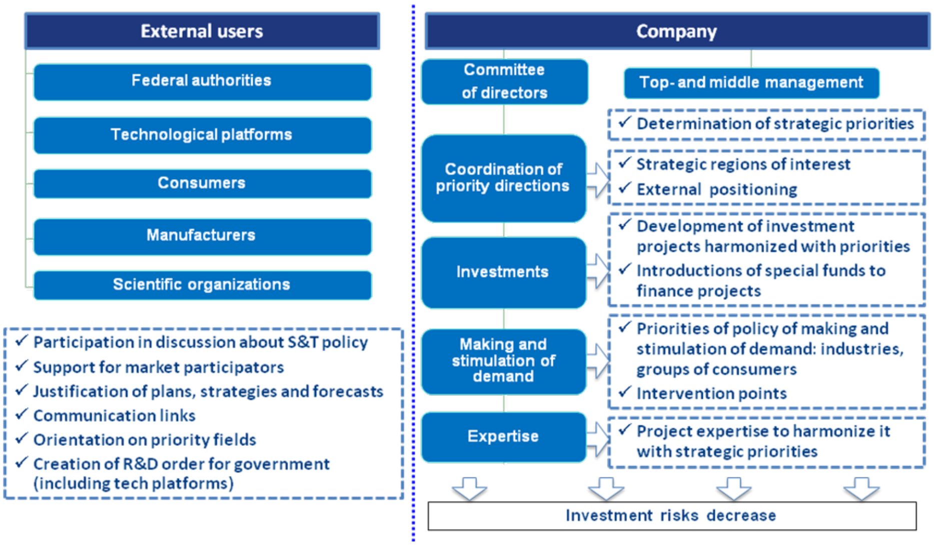

Fig. 4. Stakeholders of roadmap "Nanotechnology Applications in Manufacture of Carbon Fibres and Carbon Fibre Products"

Launching of the Roadmap helps to generalize the expert community views on innovative development ways in different areas. It provides an example of an advanced communication platform discovering the possibilities to reveal and discuss actual problems in the sphere of economic and technological development, to set shared goals and control activities of the research groups, manufacturers, distributors, and consumers of innovative products. This Foresight exercise could help the government and public companies to array strategic priorities for their research and technology policy in the field of advanced materials in a view of scenario-related international, national, and industrial technological and market developments. Finally, the Roadmap provides practical measures of government support for selected priorities, e.g. calls for projects and target project finance.

Conclusion

The development of an integrated roadmap devoted to carbon fibres makes it possible to generalize experts' views on the ways of an innovative development of the sector of new materials. The project favoured the creation of concerted views on approaches of further actions at the level of all key organizations connected to the field of R&D and to a real sector of economy.

It is expected that the examined document will favour the formation of civil markets for carbon fibre products and will help to systematically improve its consumer characteristics to satisfy future demand. At the expense of carbon price reduction, it will become possible to extend fields of its appliance. A rise in the quality of composite materials, in turn, will allow increasing the competitiveness of domestic carbon fibres in comparison with foreign analogues, providing the possibility to create new types of final products including new generation aircrafts.

To conclude, it should be noticed that international Russian practice is indicative of the appropriateness of Foresight research development in the field of new materials, and the efficiency of such works will depend on at what extent their recommendation will be externalized in concrete management decisions concerning common priorities of innovative development and mechanisms of their realization primarily in investment projects.

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Foresight oraz roadmapping jako innowacyjne narzędzia identyfikacji trendów rozwoju nowych materiałów

Słowa kluczowe

Foresight, roadmapping, innowacje, nowe materiały, włókna węglowe, strategie innowacyjne, nanotechnologie, zintegrowana mapa drogowa.

Streszczenie

Dynamiczny rozwój sektora nowych materiałów reprezentuje jeden z najbardziej obiecujących trendów rozwoju nauki i technologii, który stymuluje rozwój kluczowych sektorów gospodarki narodowej. W artykule zaprezentowano zastosowanie Foresightu w obszarze nowych materiałów i zwrócono szczególną uwagę na analizę studium przypadku w identyfikacji trendów rozwoju włókien węglowych, które stanowią perspektywiczny kierunek rozwoju nowych materiałów. Autorzy rekomendują zastosowanie mapy drogowej jako finalnego etapu Foresightu. Zintegrowana mapa drogowa stanowi reprezentację danych uzyskanych z wykorzystaniem metody *desk research*, badań eksperckich oraz metody scenariuszowej. Mapy drogowe stanowią narzędzie prezentacji rozwoju strategicznego przedmiotowego obszaru badań w kontekście przyjętego horyzontu czasowego oraz wskaźników kwantyfikujących efektywność ekonomiczną przyszłościowych technologii i produktów charakteryzujących się wysokim potencjałem komercyjnym.