FORESIGHT FOR THE ENABLING TECHNOLOGIES MATERIALS

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ABSTRACT

Europe needs innovations and production on-site in high-tech technologies to obtain prosperity. For a sustainable and stable knowledge-based economy and society it is indispensable to maintain the value-added chain also for enabling technologies inside an area such as Europe or a specific country. The maintenance of prosperity in Europe requires an innovative and stimulating environment. Creating awareness and support from a wide variety of agencies and institutions with regard to he system for enabling technologies (knowledge creation and production) is a challenge. However foresight methodologies provide approaches which can take into account a broad variety of aspects and experts for dealing with such a challenge. Therefore the Austrian Society for Metallurgy and Materials, the Montanuniversität Leoben, and the AIT Austrian Institute of Technology designed and accomplished a foresight project for developing scenarios for the manufacturing bases in Austria regarding structural materials such as steel, non-ferrous metals, polymers, and ceramic each regarded together with their composites for high-tech technologies along the whole value-chain. The emphasis of this contribution is put on the adaptation of the methodology to this specific problem. Foresight is a systematic view of the longer-term future of science, technology, business and society to identify areas for strategic research and technology with the greatest economic and social benefits. The process was organized into three stages. At the first stage the frame was defined in details. Essential elements of the first stage were the following. The advisory board with high representatives from universities, industries, and policy makers was defined and organised. The definition of the experts to be invited for workshops and the adaptation of the scenario method was worked out and discussed with the advisory board. At stage two scenarios in each of the four structural material areas (steel, non-ferrous metal, polymers, ceramic) were developed in several workshops with a strict structured procedure. At stage three a “future conference” discussed the developed scenarios and worked out the topics and actions across all scenarios and lead to three central issues, which were to be pursued in a follow up process. The consortium was optimally composed because of the complementary expertise. The developed procedure managed to involve and reach most of the important people for further support of the thematic outcome.

Key words: technology foresight; enabler technology “materials”, scenarios development, structural materials.

INTRODUCTION AND PURPOSE

Europe needs innovations and production in high-tech technologies on-site to obtain prosperity. For a sustainable and stable knowledge based-economy and society it is indispensable to maintain the value-added chain also for enabling technologies inside an area such as Europe or a specific country. The maintenance of prosperity in Europe requires an innovative and stimulating environment. Creating awareness and support from a wide variety of stakeholders and institutions with regard to systems for enabling technologies (knowledge creation and production) is a challenge. However, foresight methodologies provide approaches which can take into account a broad variety of aspects and experts for dealing with such a challenge. Therefore the Austrian Society for Metallurgy and Materials (ASMET), the Montanuniversität Leoben, and the AIT Austrian Institute of Technology designed and accomplished a foresight project "Materials Foresight" for developing scenarios for the manufacturing bases in Austria regarding structural materials such as steel, non-ferrous metals, polymers, and ceramic each regarded together with their composites for high-tech technologies along the whole value-chain. The emphasis of this contribution is put on the adaptation of the foresight methodology to this specific problem and the lessons learnt out of the project.

MATERIAL SCIENCE AND MATERIALS PRODUCTION IN EUROPE

Europe needs innovation and production of high-tech technologies on-site. This is the prerequisite to maintain wealth in Europe and to obtain prosperity in Europe and Austria for the future of the next generations. There is a significant need for stabilising sustainably the value creation in Europe and in Austria for strengthening the prosperity for the entire population and especially for the preservation of a broad middle class. In order to ensure a stable and sustainable knowledge-based economy and society in Europe it is essential to give security also for research and production of basic technologies in Europe. There is bilateral requirement necessary. Science and research need the cooperation with the production and industry needs science and research for creating and pushing innovations. Furthermore, it has turned out that geographical vicinity is very important for the cooperation between universities, research institutes and industry. The direct exchange of questions and problems on both sides can be discussed efficiently on-site. Trust and confidence are much higher when working together physically and close by. Furthermore innovatory industry creates high-skilled employment which is one important aspect for prosperity.

The current challenges for materials research and production in Europe are manifold. First of all there is the international competitiveness in research and production efficiency in other parts of the world. Iron working and steel processing are very energy intensive. Energy is very expensive in Europe compared to other parts of the world. The energy for the production industry is much cheaper even in the USA than in Europe. Next Europe does not have relatively cost-effective raw materials and resources available for instance of steel or raw materials for manufacturing aluminium. The mining of ore in the relatively small iron deposit in Europe is expensive and thus curd iron is mostly imported from Brazil or China, because the costs for employees, energy, and transport are much cheaper in countries such as Brazil or China. Furthermore, high-tech materials for ICT need rare earth elements, which are not available in Europe. Magnesium is necessary for light-weight construction, but magnesium is also not sufficient and on a competitive basis available in Europe. The latest concept for environment such as CO_2-free production in Europe till 2050 cannot be managed for the traditional steel production procedure. The traditional iron smelting needs coke and similar materials. The current production of plastic needs the resource of oil. Europe cannot compete with cost-effective oil producing with other parts of the world. Europe depends also on third countries regarding the production of plastic.

Therefore Europe faces challenges and trends which might lead to the migration of energy intensive industry to the east or to the north or South America. At that point the environmental concepts for Europe impede also keeping the steel industry in Europe with the current production techniques.

Although such developments have been conceivable for a longer time period, the complex, social, and economic-political coherencies require new and long-term forward looking strategies for materials science and materials production in Europe, since materials science and research and the production of materials are the basis for a broad variety of technologies, industries, and markets. Europe cannot allow depending on Asia and America in this basis for many technology branches.

Hence policy makers, engineers, scientists, the industry, the universities and research institutes have to work out scenarios, visions, strategies, roadmaps, and implementing plans for a flourishing materials research and materials industry in Europe.

WHY A FORESIGHT PROCESS?

The following questions led to the idea of implementing a foresight process. What is the future of materials science, materials industry in Europe? In which way can the future of materials science and industry be shaped? How can the universities and industry be prepared for future scenarios in the field of materials? Foresight is a structured debate on the future. Foresight processes offer a broad variety of methods. Starting with the development of different scenarios, and then formulating a vision, afterwards developing a strategy and a roadmap, and finally compiling an implementation plan would be a classical process for achieving leverage in the problem of question.

A foresight opens new opportunities for a scope of actions for the area of materials, which are already under distress in Europe and therefore also in Austria. Foresight is able to reveal future oriented trajectories for positive developments in the whole field of materials research, materials manufacturing, and materials processing. The foresight process works with the following hypotheses:

Hypothesis 1:

Materials belong to the enabler technologies. Materials build the basis for innovations for instance in automotive, aerospace, engineering, ICT, and medical technology. Materials play a core role in all technologies, in all of our areas in life and at work. The steel industry e.g. in Austria and Germany is part of the international competitive economy. The steel industry plays an important role for the employment and income of the national economy. The iron and steel sector is still an important factor for the national economies and the economy in Europe, which can be seen in the pattern of specialization for foreign trade in machinery, plant manufacturing, and vehicles.

Hypothesis 2:

Foresight processes facilitate combining expertise and expectations of industry, research, and society, as well as merge the perspectives of relevant stakeholders to develop scenarios for the future.

Hypothesis 3:

Carrying out a foresight process requires knowledge and expertise in foresight methodologies, expertise regarding the relevant stakeholders such as scientists and researchers, the relevant representatives in the industries in question, and of course also knowledge concerning materials itself. All these three aspects were represented in the project team with AIT Austrian Institute of Technology for foresight methodology, Austrian Society for Metallurgy and Materials with the platform of more than 100 industry members, and the Montanuniversität Leoben with the competence in materials science.

A foresight process shapes the future. A foresight process brings together stakeholders from industry, the university, policy makers, and in the best case also commoners and therefore creates awareness for the problems in question and starts a dialogue between the different rationalities. This activates comprehension for the foresight in society.

The frame of the project allowed developing different future scenarios with a time span up to 2030.

FORESIGHT IN GENERAL

Foresight is a vision building process. Foresight works with anticipating the future and uses collective intelligence. Foresight experts explain that we are now working with the fifth or even sixth generation of foresight. Foresight started in the 1950s with the focus on technology forecast (first generation). The second generation of foresight focused more on technology and the market in the 1970s. The third generation concentrated on technology, the market, and society in the 1980s. The fourth generation takes into account the whole innovation system. At the moment there are progressions of foresight into a “learning society”, which take into account the whole system of life. Riel Miller expresses the new generation of foresight. He generates, together with colleagues, a theory of anticipation, which comprises criteria for using the future, deals with the theory of collective intelligence and knowledge creation with the aspect of making sense of specificity, and then taking together the theory of anticipation and the theory of collective intelligence Riel Miller[1] develops the Discipline of Anticipation and the capacity to use the future as Futures Literacy.

Futures Literacy is the capacity to tell anticipatory stories using rigorous imagining based on sharing depth of knowledge from across the community. Futures Literacy is a way of internalizing the constant development of our understanding of the potential of the present and of changing anticipatory assumptions.

The approach of Riel Miller and the Future Literacy might be too far away from our concrete research questions regarding the future of materials science and industry in Europe and particular in Austria at least for the time being. The project “Materials Foresight” considered the time span till 2030 and wanted also to derive course of actions, which are necessary already today so that Austria is all set for the future of materials in Europe.

Future oriented thinking is essential for any forward planning, for any policy activity, for shaping the frame of our lives, and above all to be able to meet future challenges proactively. Foresight processes enhance such thinking by gathering anticipatory intelligence from a wide range of knowledge sources in a systematic way and linking it to today’s decision making.

1 see more under http://www.rielmiller.com/papersmethods.html

In the narrower sense of foresight our understanding is based on the theory of Ben Martin. Ben Martin, Professor of Science and Technology Policy Studies at SPRU (Science and Technology Policy Research, University of Sussex) defines foresight in the following way:

> "Foresight is the process involved in systematically attempting to look into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the emerging generic technologies and the underpinning areas of strategic research likely to yield the greatest economic and social benefits."

Ben Martin works out his approach and aspects in his article "Technology foresight in a rapidly globalizing economy" in 2001 (in his work for UNIDO). He talks about six important aspects to his definition above. First, foresight is not a technique or even a set of techniques but a *process* that, if well designed, brings together key participants from different stakeholder groups such as the scientific community, government, industry, NGOs and other public interest or consumer groups to discuss what sort of world they would like to create in coming decades. Secondly, the attempts to look into the future must be *systematic* to come under the heading of foresight. Thirdly, those attempts must be considered within a *longer-term* by which a typical horizon of ten or more years is necessary. Fourthly, successful foresight identifies likely demands relating to the *economy and society* as well as potential scientific and technological opportunities. Fifthly, the focus is on the identification of *emerging generic technologies*, which means technologies that are still at a precompetitive stage. And sixthly, the attention must be given to the likely *social benefits* of new technologies including the impact on the environment and not just their impact on industry and the economy.

Technology foresight supports technology policy and so policy makers, because a technology foresight should take into account the current main drivers of change in the global economy:

- increasing competition
- increasing constraints on public expenditure
- increasing complexity (closer interactions of systems of a variety of forms such as local, national, global systems in economics, science, environment, culture, private and public)
- increasing importance of scientific and technological competencies

These factors also underlie the boost of interest in foresight, giving rise to its emergence as a global concept and policy tool.

A good overview about foresight is given by the European Foresight Platform under the link http://www.foresight-platform.eu/community/forlearn/.

Ian Miles and Michael Keenan also present a short survey of foresight methods in their paper "Overview of Methods used in Foresight" (Ian Miles and Michael Keenan, PREST, Institute of Innovation Research, University of Manchester, UK, 2003). In addition Michael Keen deals with technology foresight and what it is good for in his article "Technology Foresight: An Introduction", 2002.

Foresight uses a constructivist approach. Instead of deriving the knowledge from the past and present as a consequence as deductive methodologies and deduction do, foresight processes work with constructive approaches. Constructivism creates its own realities and dimensions that arise from its own recognition of realities, dimensions or skills only. In this way each person perceives the world differently. Since the subconscious of each human being highlights different things or brings new viewpoints and new aspects into the process. Therefore a good balanced participation of stakeholders in the foresight process is crucial and needs to be prepared very well. Ben Martin and Kerstin Cuhls summarises the requirements for stakeholders in foresight workshops as the five Cs: Communication, Concentration on the longer term, Coordination, Consensus, and Commitment.

- *Communication*: Professionals and stakeholders must be brought together on a new forum where they can exchange ideas.
- *Concentration on the long-term orientation*: Participants have to support each other in looking into long-term future in such a way they would not be able to do this alone.
- *Coordination*: The various stakeholders have to take up constructively concrete challenges in science, technology, and innovation.
- *Consensus*: It should be possible to create a picture of the future in consensus with the stakeholders.
- *Commitment*: It must be ensured that stakeholders in a foresight process are able to participate entirely and to draw and implement necessary conclusions in the sense of the foresight process. The individuals involved have to be able to understand and grasp the changes affecting their business, their profession, their faculty or discipline, and overlook what this means for their organizations and for themselves.

But foresight has also limits. These limits depend on the topics, the complexity, and the dynamics of the respective field. Some fields are so complex or develop such dynamic that too many assumptions or no justifiable derivations can be taken. In other fields developments are very clear, so almost predictions seem possible.

THE METHODOLOGY IN THE PROJECT “MATERIALS FORESIGHT”

The challenge was to address all four structural materials such as steel, non-ferrous metals, polymers, and ceramic each regarded together with their composites for high-tech technologies along with the whole value-chain. Furthermore for each of the four structural materials there was only one available day for the stakeholder workshop for developing the scenarios. Nevertheless, the methodology for the project is based on

- The organisational structure of the project with the core project team, the advisory board, the expert team
- The procedure for the whole project and the process applied in the workshops
- The involvement of a broader community via conference and the media

The organisational structure of the project is shown in Figure 1. The purchaser of the project was the Federal Ministry for Innovation and Technology. The execution of the project was done by the project team with the necessary competences: AIT Austrian Institute of Technology with competences for foresight methodology, Austrian Society for Metallurgy and Materials with the platform of more than 100 industry members, and the Montanuniversität Leoben with the competence in materials science. The Advisory Board consisted of highly recognized personalities namely: principals from the two most important universities in the field of material science in Austria, further very highly recognized professors, highly recognized entrepreneurs, and members of the board of the most important iron industry, with a foresight expert, the person in charge of materials and production in the ministry. The advisory board met twice and supported the project very well and contributed successfully so that the results of the project can get awareness in the community and in the policy environment.

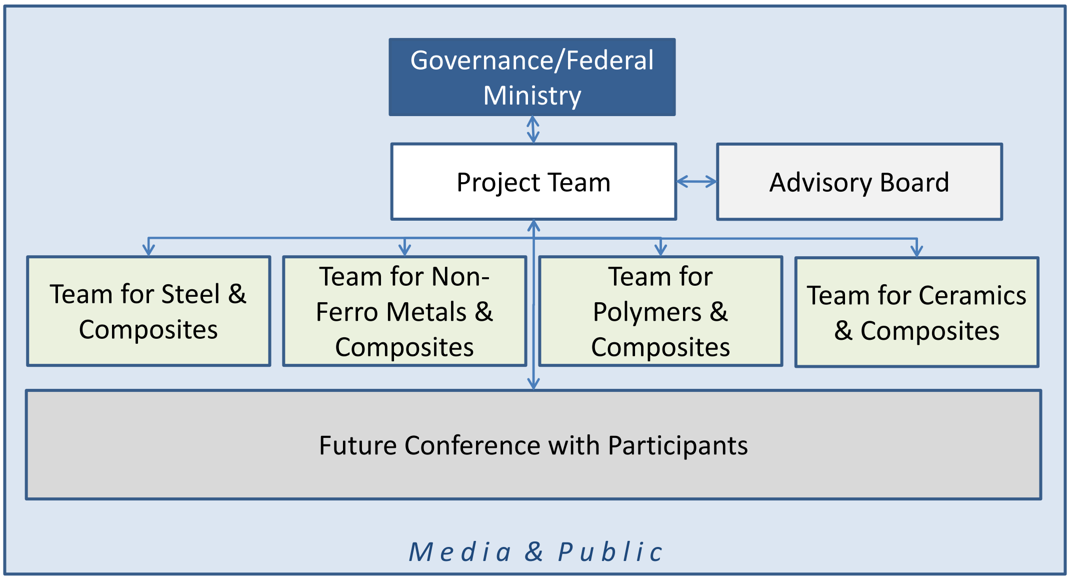

Figure 1. Organisational structure of the project.

The work was organised in three phases. Figure 2 presents the main tasks in each phase. It shows that the core of the process was the development of future scenarios, which was accompanied by an environmental analysis in the first phase (preparation), by constructive discussions with the advisory board, and the future conference and constitutive work with stakeholders in the shaping phase.

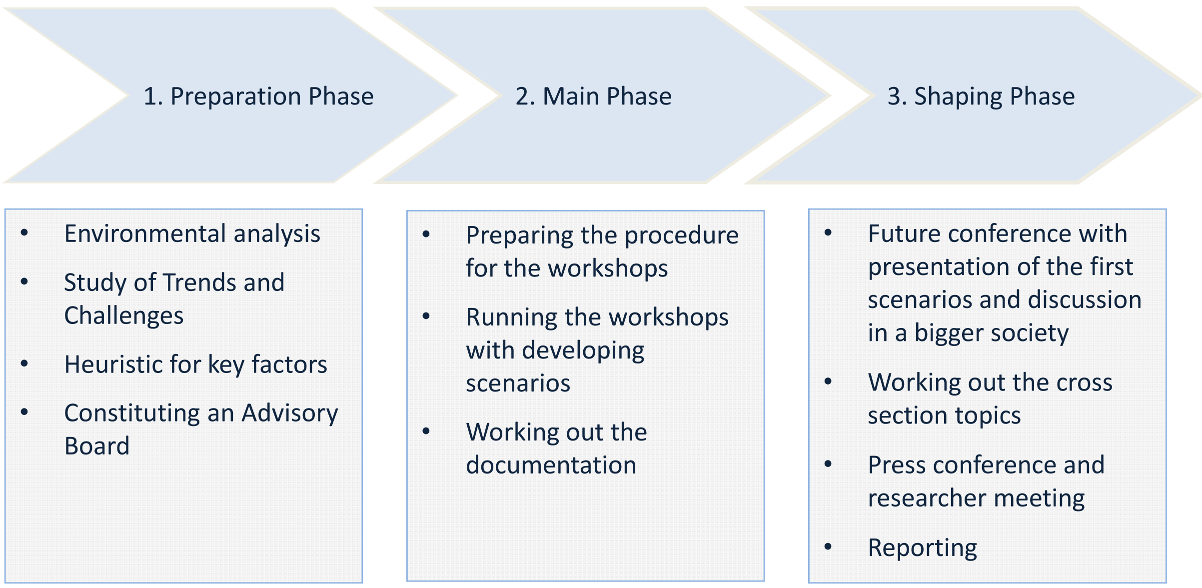

Figure 2. Phases of the project.

An important part of the project was the development of future scenarios by application of the well-known and approved scenario planning. Scenario planning, also called scenario, is a strategic planning method for making flexible long-term plans. It is for the most part an adaptation and generalization of classic methods used by military intelligence. Since the early 70s, the scenario planning has increasingly gained importance in the field of economics and politics. At that time it became clear that common forecasting methods are no longer adequate to cope with the fast changing conditions of the environment (impact areas). Considering environmental aspects and disturbances such as political and social developments, legislative action, shorter product life cycles, as well as government intervention in the economy (e.g. environmental conditions) the methodology of scenario developments starting with the analysis of such key factors, are an adequate procedure, because scenario planning

- provides a profound analysis of the current situation,
- investigates and works out quantitative and qualitative information, as well as the identification of the main key factors,
- facilitates the processing of disturbing events, and
- results in the development of consistent future pictures (scenarios).

Referring to the methodologies developed by von Reibnitz 1992, van der Heijden 1996, or Geschka 1983, the procedure for the scenarios development was carried out in our project.

Preparation Phase

Environmental analysis and heuristic for key factors

An environmental analysis was accomplished. For doing so the following aspects were investigated and reviewed regarding the impact of the field “materials (industry and research)”. The leading research question was: In which way does the project have to take into account aspects of:

a. Global Grand Challenges
b. Megatrends
c. Aspects from futurologists: Generation Y, fourth industrial revolution[2]
d. Rough analysis of the EU framework programme NMP (nano-science, nano-technologies, materials and new products technologies)

Global Grand Challenges: The Millennium Project[3] (http://www.millennium-project.org/index.html) has worked out 15 global grand challenges. A challenge is defined as a desirable objective, e.g. clean water for each human being on the earth.

2 The first industrial revolution was the mechanization of production using water and steam power, it was followed by the second industrial revolution which introduced mass production with the help of electric power, followed by the digital revolution, the use of electronics and IT to further automate production

3 The Millennium Project is now an independent non-profit global participatory futures research think tank of futurists, scholars, business planners, and policy makers who work for international organizations, governments, corporations, NGOs, and universities. It was founded in 1996 and was created through a three-year feasibility study funded by the U.S. EPA, UNDP, and UNESCO, in which participated over 200 futurists and scholars from about 50 countries. For more details see http://www.millennium-project.org/millennium/overview.html.

Megatrends: A Megatrend is a fact which can be observed and even measured, e.g. climate change, or digital culture.

Aspects from futurologists: Generation Y, fourth industrial revolution:

Generation Y, also known as Millennial4, is the demographic cohort following Generation X5. Millennial characteristics vary by region, depending on social and economic conditions. There is a marked increase in use and familiarity with communication, media, and digital technologies. In most parts of the world its upbringing was marked by an increase in a neoliberal approach to politics and economics. The effects of this environment are disputed.

The fourth industrial revolution[6] is characterized by adaptability, resource efficiency and ergonomics as well as the integration of customers and business partners in business and value processes. The goal is the intelligent factory or Smart Factory. Technological basis are cyber-physical systems and the Internet of Things. The first industrial revolution was the mechanization of production using water and steam power. It was followed by the second industrial revolution which introduced mass production with the help of electric power, followed by the digital revolution, the use of electronics and IT to further automate production.

The EU programme NMP: A rough analysis about the collaboration network of Austria in this framework programme should reveal the position of Austrian's organisation in research in the EU framework programme.

Each of these aspects provided inputs for the heuristic for the key factors.

Advisory Board

Important stakeholders could be attracted for working in the advisory board. Principals from the two most important universities in the field of material science in Austria, further very highly recognized professors, highly recognized entrepreneurs, and members of the board of the most important iron industry, with a foresight expert, the person in charge of materials and production in the ministry together with the core project team (three members) met three times during the 18 months of the project. Firstly in the middle of the preparation phase the environmental key factors and their influence for materials were discussed. Secondly after the scenario developments and the first summary of the results before the presentation of the first results to the participants of the future conference, lastly at the end of the project where the highlights and next steps where presented to the media. The support of the advisory board was very important and helped the project to its success. The opinions, views, and experience of the advisory board members sharpened the procedure in the project, brightened the presentation of the procedure and later the results for the public, and supported the work in the project so that the results in the community, in the Federal Ministry, and in the public news are recognized.

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4 Authors William Strauss and Neil Howe wrote about the Millennials in Generations: The History of America's Future, 1584 to 2069, and they released an entire book devoted to them, titled Millennials Rising: The Next Great Generation. Strauss and Howe are "widely credited with naming the Millennials" according to journalist Bruce Horovitz. In 1987, they coined the term "around the time 1982-born children were entering preschool and the media were first identifying their prospective link to the millennial year 2000". Strauss and Howe use 1982 as the Millennials' starting birth year and 2004 as the last birth year.

5 Generation X is the generation born after the Western Post–World War II baby boom. Demographers, historians, and commentators use beginning birth dates ranging from the early 1960s to the early 1980s.

6 In Germany and also in Austria they use the term Industry 4.0 for the fourth industrial revolution. Industry 4.0 is a project in the high-tech strategy of the German government, which promotes the computerization of the manufacturing industry.

Heuristic for key factors

There are various heuristics for structuring the key factors of the environmental analysis. The project team decided to work with the STEEP (Society, Technology, Economics, Environment, and Politics)[7] structure, because it comprised the requirements of the discussions in the first phase. Table 1 shows the key factors applied in the project to all four different materials (steel, non- ferrous metals, polymers, ceramic). In each material field these factors were discussed separately and some key factors depending on the field were added, e.g. "Info Tech Cyborg" to "Technology" in the field steel.

The frame of this contribution does not allow discussing the key factors in detail. However, each key factor was discussed regarding meaning and effect within the core team, with the advisory board, and with all workshop participants.

Table 1: Key factors in the structure of STEEP.

STEEP	Key Factors
Society	Values development
	Demography
	Social peace
	Qualification
	New pattern of mobility
	Health
	New forms of living
	Competent staff
Technology	ICT
	Production and manufacturing
	Raw materials for the production
	Developments in other material areas
	Product concepts
Environment	Climate change
	Stability
Economy	Competition
	Globalization
	Financial market

7 There are several more heuristics such as:
- STEP: Society, Technology, Economics, and Politics
- STEEP: Society, Technology, Economics, Environment, and Politics
- SCEPTIC: Society, Culture, Environment, Politics, Technology, Infrastructure, and Commerce.
- PLANET: Politics, Law, Arts, Nature, Economics
- PEST: Politics, Economics, Society, Technology

STEEP	Key Factors
	Economic growth
	Owner philosophy
	Transport sector
	Building industry
	Mechanical engineering
	Energy and Power Plant Construction
Politics	Conflicts (War and Peace)
	Legislation
	Energy
	World politics
	Environmental legislation
	Global governance
	National research and industrial policy

Main Phase

Workshop participants

During the main phase a list for inviting the workshop participants was worked out. For doing so experts in materials, in industry and in science were needed. Since this project was rather a technology foresight, the project had to focus more on experts, although the views of e.g. social scientists, of the youth, of artists, etc. would enrich the work, the financial frame of the project did not allow paying travel costs or even fees. Therefore materials industry, materials science, economic chamber and clusters, and government were represented.

Scenarios

For the development of scenarios only one workshop day for each field (steel, non- ferrous metals, polymer, and ceramic) was possible. Therefore the day had to be very well structured. Of course, the scenario horn in Figure 3 helped to prepare the participants for their work.

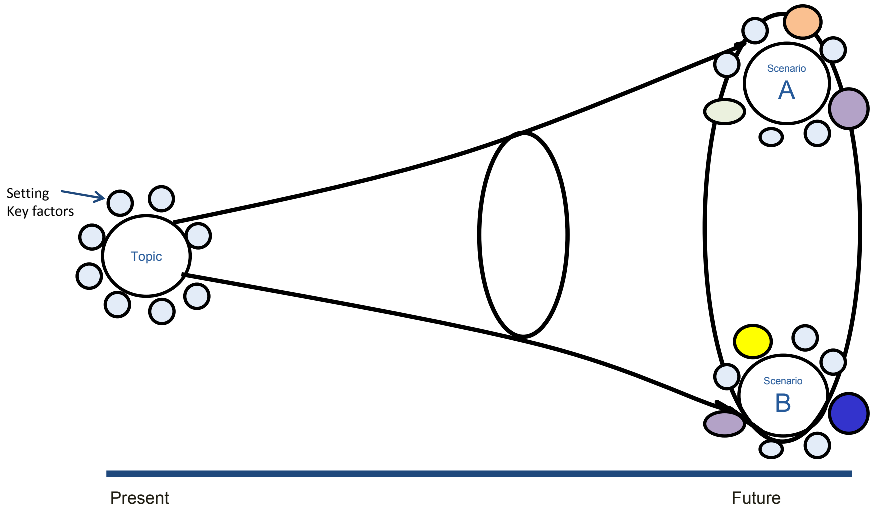

Figure 3. The scenario horn.

Each of the four scenario workshops was planned very carefully. The structure is presented in Figure 4.

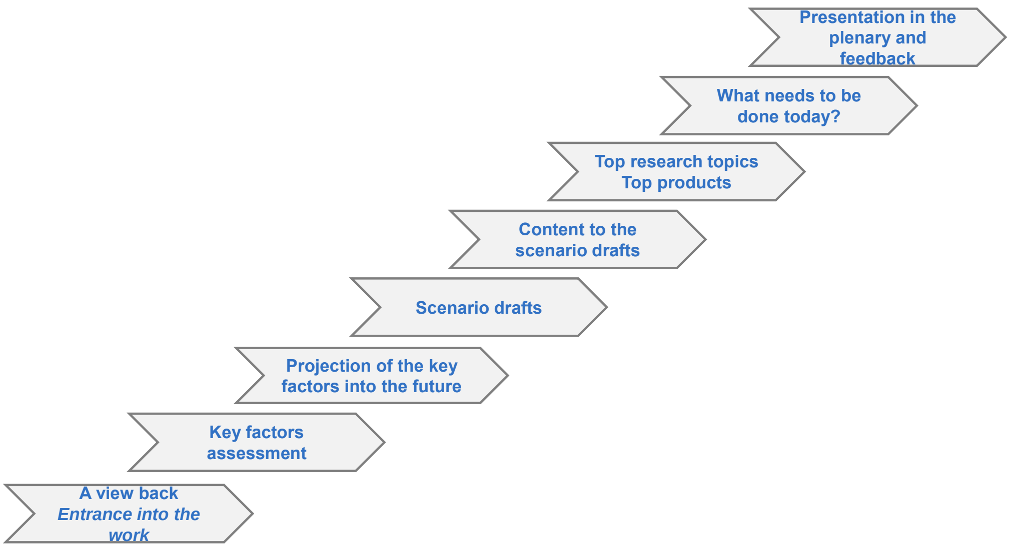

Figure 4. The workshop structure for the scenario developments.

The view back gave awareness what happened in the last 100 years in the specific field. It made clear that engineers are not always aware how industry distributes the products and how the market will develop e.g. for the mobile phone industry. Afterwards the participants had to assess the key factors. Those key factors with the highest value for influence and uncertainty were chosen for the projection process, where the workshop participants in smaller groups worked out the projection of the selected key factors for 2030. The next step was to bring together consistent scenario drafts based on these projections. These drafts were once more assessed and if necessary completed. Subsequently the scenario drafts were filled with content. The following template (Figure 5) helped to work effectively in a short time:

Scenario scheme

Name of the scenario:	
News in 2030 about this scenario	
Opportunities in this scenario	Risks in this scenario
Top research topics in 2030	Top products in 2030

Figure 5. The workshop structure for the scenario developments.

The question "what needs to be done today so that we are prepared for that scenario" was important for policy makers. Therefore it was taken into account. The workshop day was finished with the presentation of the scenarios in the plenary with giving feedback.

The work of the day was documented in details and sent to the participants for completion. In this way a lot of information could be collected.

Shaping Phase

Since ASMET[8] , one of the core project partners, organised a conference for materials science with international representatives the project had an excellent platform for presenting and discussing the results of the scenario workshops. Before the conference the results were discussed and sharpened in the advisory board to check the wording of the presentation. More than 300 participants of the conference could be informed and could attend discussions, which helped to disseminate awareness, results, and new ways of thinking.

A press conference could create awareness of the problems and results in the media. A last meeting with the advisory board and some further experts could work out a plan for the next steps.

RESULTS

Each of the project phases gained results for each materials field. As the core idea of this paper lies in the description of the project concept, the chapter "results" gives only some short surveys. Since the report is just in the process of approval before it is published, this contribution can present some general summaries.

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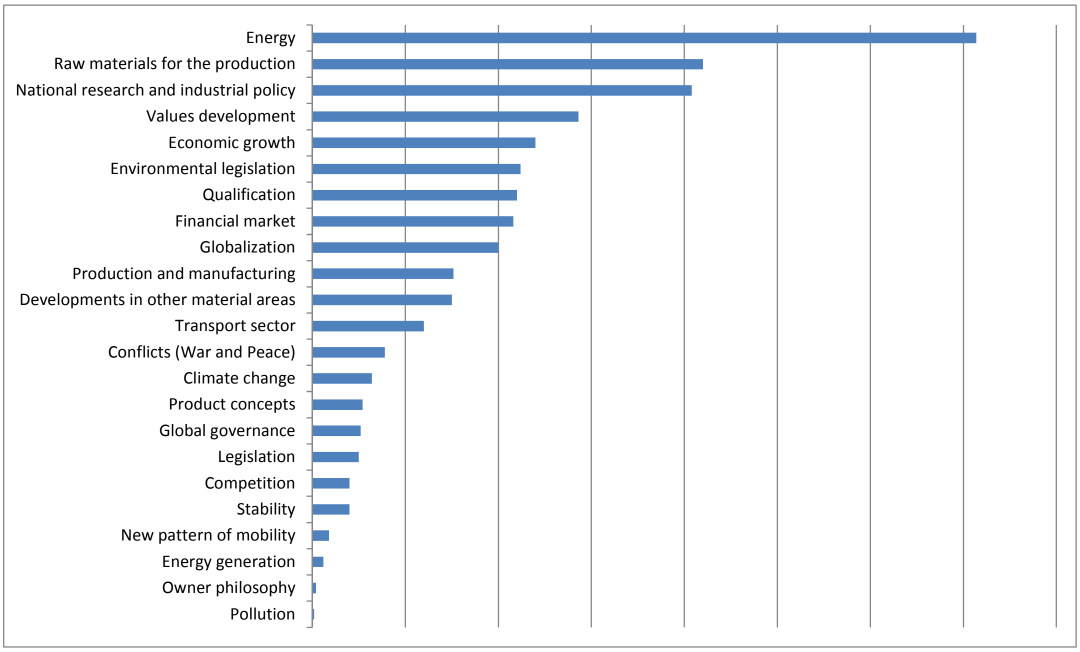

Figure 7. Summary of all assessed key factors.

The assessment of the key factors as a summary of all four materials fields in Figure 7 shows that energy (in availability and hence in price) is the most important factor for the materials industry. The cost effective availability is the second most important factor, which influences research and production of materials technologies. Rank three is a political issue, namely the public support in research. The next important factor is the value development of society. The values of a society have thus a big influence on the materials technologies. The fifth rank goes to economic growth. The next ranks can be seen in Figure 7.

The developed scenarios are, of course, described in the report. The frame of this paper does not allow going into such detail. Nevertheless we summarised the cross-section research topics which play an important role in each of the four materials fields (steel, non-ferrous metals, polymers, ceramic).

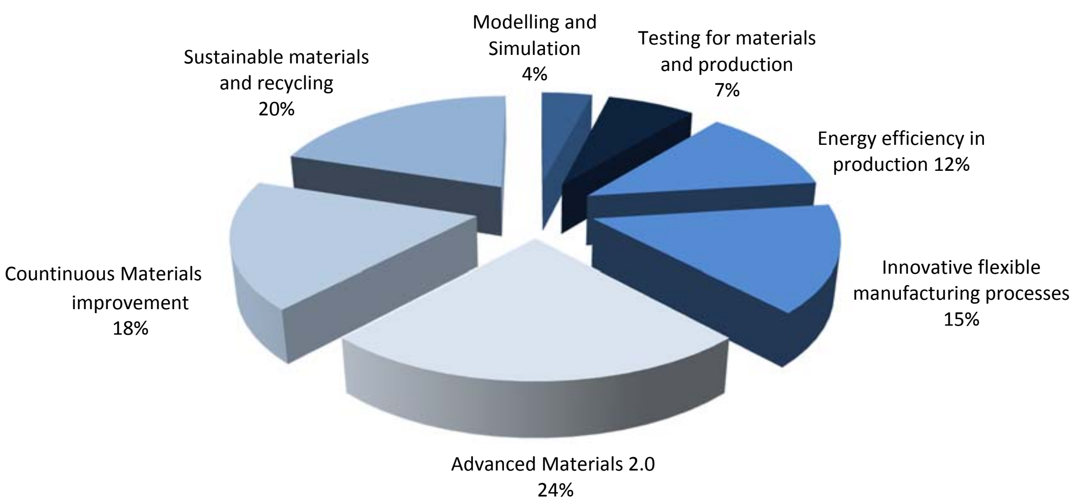

Figure 8. Cross-section topics.

Advanced Materials 2.0 means a next generation of materials with new features, also new hybrid materials with new applications. As Figure 8 shows Advanced Materials 2.0 presents the biggest share of all cross-section topics, followed by sustainable materials and recycling. The third rank goes to continuous materials Improvement followed by innovative flexible manufacturing processes and then energy efficiency in production. Testing for materials and production and modelling and simulation are also important cross-section topics.

This is a small selection of all results, but should give you only some idea.

The different directions have been discussed with people in charge and the next steps for actions have started.

DISCUSSION

Foresight experts might argue that the applied scenario planning in this project is standard and not new. The authors agree with that argument. However the very well-structured scenario planning meets the way how engineers work. The engineers and material scientists involved in the project stepped into the project work easily and could be very creative during their work.

Besides the long term verified scenario planning, this specific foresight project proved that a very well-developed concept for the whole project is a key success factor. The excellence in each of the three aspects of the concept (see Figure 6), methodology expertise, materials expertise, and network and knowledge about the stakeholders in materials industry, in materials science, as well as in politics and how one can get even support from the most important and influential people is the secret of the success of this project.

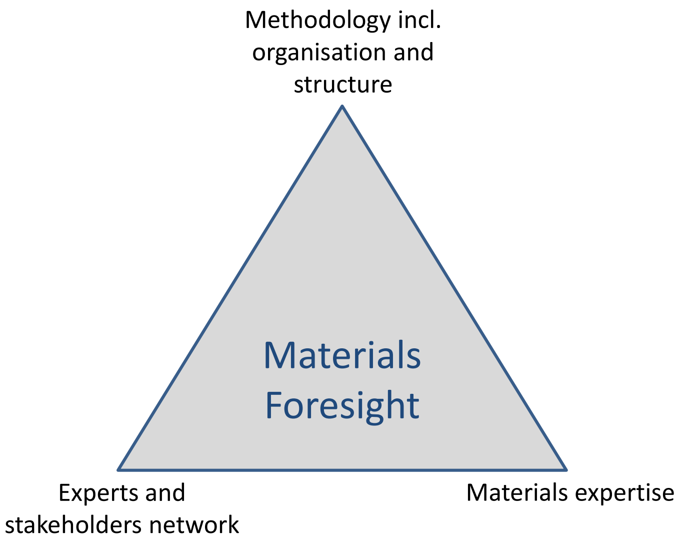

Figure 9. Scheme of project concept.

The three aspects in Figure 9 were very well represented in the project with the Austrian Society for Metallurgy and Materials (ASMET) with focus on experts and stakeholders networks including the important people, the Montanuniversität Leoben with the competence in materials, and the AIT Austrian Institute of Technology with methodology experience. However, only the cooperation of all three organisations and the willingness to learn from each other made the project successful.

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