A Foresight Study on Future Trends Influencing Material Consumption and Waste Generation in Production

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Abstract

There are boundless upcoming factors that influence future of material waste in production. This broad range of factors needs to be scanned, categorized and analyzed in a structured way. This paper by a foresight study, aims to give an insight and increase awareness about external macro-level future trends concerning raw material consumption and waste generation in production. A limited pilot study indicated that technological forecasting and some reaction upon obvious trends are being taken, although in an ad hoc manner and without structured tools. However, political influences, economic visions and social-cultural shifts were seldom or never discussed. External macro trends and tendencies were examined through PEST analysis to identify potentials and opportunities influencing strategic decisions and innovation initiatives. It is vital to understand the whole picture of possible changes and not only considering the technological trends, but also other relevant development areas that might affect production in different ways.

1. Introduction

In today's innovative, competitive and drenched market, particularly for production industries, satisfying primary requirements of customers is not sufficient anymore. Nowadays, competition is on latent needs of customers and yet sometimes requirements need to be shaped and infused to the customers. Therefore, knowledge about customers' behavior and techniques regarding exploring future opportunities and potentials have become a competitive advantage [1]. It is now understood that a variety of internal and external factors affect prosperity of production. The majority of companies have a great comprehension on their internal factors, however, they mostly fail to adapt to environmental or external changes in an effective and timely way [2]. In fact, for production companies it is common to get caught in internal affairs and goals which cause losing sight of trends and external changes such as customers' perspective, innovation opportunities or market trends. Not only design, product and process innovations, along with production and technological changes are essential to research on, but also social, legal, economic, political, environmental and cultural-based changes and their correlation to market-related business environments and internal organizational environments of the company must be scanned and integrated to future-oriented knowledge in order to add value [1]. In recent years, some external impacts such as oil price growth, was a wakeup call to increase companies' awareness about discontinuities and pertinent external developments [1]. Therefore, an effective mechanism is required that scans and assesses the environmental changes and external factors and updates the knowledge regarding the orientation and significance of upcoming external changes in order to be able to responds to disruptive ones at the right time. A study about future and external factors contributes to strategic innovation, technology leadership, new business models, global presence and product and brand portfolio. Corporate foresight is a mean to identify and discuss possible futures and their directions by analyzing prospect of companies' environment and external factors, market and sales, business decision making, investment strategy, new technologies and their connection to innovation [2, 3]. Corporate foresight leads to expand knowledge related to effects, to add value [2], to early identification and assessment of latent potentials, opportunities and risks as well as supporting innovation management and strategic review of R&D projects and innovation initiatives to prioritize them and re-allocated budgets better towards external changes [1].

On the other hand, resource and material efficiency are absolute future dilemmas. Each year human consumes about 60 billion metric tons of the world's key resources including minerals, ores, fossil fuels and biomass. Total global resource consumption has increased from 6 billion tons in 1900 with 1.6 billion people to 49 billion tons in 2000 with

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around 6 billion people and now is about 60 billion tones with over 7 billion people [4]. International Energy Agency[5] states that by current trend of economic and population growth, the demand of material at least would be doubled by 2050. In addition, the total generated waste from production in 2010 accounted for 280 million tons, around 11% of the total generated waste. In USA, out of 100% of natural capital extracted to produce products, 93% become waste through production and extraction processes and only 7% of materials turn into final products [6]. Hence, total quantity of waste generation and material consumption are vital for ensuring resource availability for future generations, reducing environmental impacts, reducing cost of production and improving the standards of living.

With this background in mind, this paper by exploring futures aims to develop an understanding and broaden knowledge concerning influential upcoming 'macro level' trends related to material waste in production. This research introduces more than 50 identified macro trends that directly or indirectly affect material utilization in production. In addition, through PEST analysis (political, economic, social and technological), their contribution area and circumstances of influence on material consumption and/or waste generation were discussed in order to ease taking them into different strategic decision making procedures and indicate in which way they need to be approached. Companies therefore, based on their industrial activities, requirements, organizational set-up and future visions can consider it as early warning indicator to direct medium and long-term developments, initiate innovation and R&D activities and pursue future perspective of external changes in society, economic and politic which lead to value creation and competitiveness enhancement.

2. RESEARCH DESIGN

To fulfil the research objective, a foresight study with three steps was performed, although the first step was a pre-study to motivate conducting this study on macro-environment future trends influencing material consumption and waste generation in production. The performed foresight study contributes to decision making procedure and supporting innovation initiatives in production companies. This study also provides a platform for further study combining the identified factors with internal organizational factors. As a result, each company based on its industrial activities and future visions can make relevant strategic decisions in order to be able to respond proactively.

1. An initial limited qualitative study in three manufacturing companies was executed in early 2013 to get a better understanding on how production companies work with foresight tools such as trend scanning. This study included interviewing production managers and CEOs using mind-mapping as a tool to discuss trends related to PEST analysis.

2. An extensive literature review was performed through scientific papers and reports along with non-academic sources regarding upcoming trends related to raw material consumption and waste generation in production as well as future and foresight study. It is essential to utilize a number of different sources when collecting data, since it increases the validity and reliability of the research results, particularly in a foresight study. The data collection method was based on literature search in scientific data bases and websites. The academic papers were selected through scientific data bases using keywords including "future trends", "roadmap", "future scenario" combined with "production", "material consumption" and "waste generation". The reports and some articles however, were selected through internet search and expert consultancy websites. Furthermore, relevant papers about foresight study and PEST analysis were also selected through literature search in scientific data bases. Despite of performed extensive literature search for ensuring the identification of as many future trends as possible, it is still likely that there are some other trends related to material waste that were not included in this study due to time limitation, multitude number of papers related to the subject and multitude number of facts that might indirectly affect future of waste generation and material consumption in production. The result of the literature review has been summarized in chapter 3.

3. Two workshops among the authors were hold to examine the identified future trends base on PEST analysis. In the first workshop, future trends through a discussion categorized into four area including political, economic and social-cultural and technological shifts. The outcome of first workshop and PEST analysis was then utilized as an input for the second workshop for analysing the future potentials and opportunities. The outcomes of the workshops have been summarized in chapter 4 and 5 respectively.

3. FUTURE TRENDS

3.1. PILOT STUDY

An initial limited but consistent study in three manufacturing companies indicated that technological forecasting and some reaction upon obvious trends are being performed, although in an ad hoc manner and without structured tools.

On the other hand, political influences, economic visions and social-cultural shifts are seldom or never discussed. The pilot study also addressed the lack of holistic understanding and foresight conversations for tomorrow's issues in production. It is vital to understand the whole picture of possible changes and to balance the future study by considering not only technology trends and changes, but also macro-level trends and changes which play a crucial role in long-term success and development of companies [1]. It needs to be established that long-term prosperity of production industries and production embrace not only an effective and efficient management to create value in core functions of production, but also long-term development in society, markets and business environment.

3.2. THEORETICAL FINDINGS

Although there are boundless upcoming trends that influence future development of waste management and material efficiency in production, this section presents a number of trends identified through an extensive literature study. Trends are presented in a general manner in this section, as an introduction to the following section 4, where the trends are categorized according to the PEST analysis. Many of identified future trends are interdependent and may have the same impacts on material waste in production, though some of them are likely to unfold over decades. They may have direct and/or indirect effect on both waste generation and/or material consumption as well.

Growth of global GDP and new sustainable energy sources along with globalisation have led to production growth and consequently rapid increasing material consumption with great quantity of waste generation. Demographic trends including population growth, aging and urbanization will make the matter more crucial in future by affecting both resource consumption and waste generation. Population growth to 9 billion people by 2050 [7] and growth of middle-class consumers by 3 billion people over the next 20 years [8] will call for more products, production and resource consumption. The ecological footprint of the global population in 2030 is anticipated to rise to 130% larger than the Earth's biological production capacity [9]. Population aging will cause human resource losses as new consumers are born, while fewer workforces exist to extract raw material and provide the products. Therefore, production development might decrease or slow down. One solution might be more efficient use of labour (educated and trained) or automation. According to [10], materials' demand will be enhanced significantly, while UN estimates that 140 billion tons of key resources per year are expected to be consumed by 2050. A study by [11] also indicated that waste generation in the Europe will increase by 10-20% in 2020 in comparison to 2005. Imposition of taxation [9, 12] on non-renewable materials might be the solution to prevent scarcity of raw materials, excess usage of current supplies and minimize waste generation. According to [9], some probable effects of taxation is to impose pressure to develop energy-efficient metal production's processes, substitution of energy-intensive metals such as Aluminium, shift the balance of metal utilization to less primary metal and more secondary metal, do more recycling and use more renewable energy sources. In addition, trends such as urbanization and consumers' behaviour changes will push some areas to use more and new material to satisfy the requirements, whereas cause more waste generation.

Welfare improvements lead to new requirements, product demand enhancement and more consumption, which they in turn affect costs and prices. An increase in product demand means increase of production activities. Growth of production activities increases raw material consumption that further results in quantitative shortage and scarcity of raw materials which in turn, entails price enhancement. The prices are also dependent on future carbon taxes, particularly for Aluminium, Steel, Lead, Copper and Nickel. Furthermore, the reason behind the growth of products and materials prices, especially industrial raw materials, might lies in the fact of economic growth of Asia and particularly China. While the growing market of innovative products needs more raw materials, monopoly position of China by dominating 95% world market of mining and processing of key elements [13-16] may cause some limitations and pressure. Exports of such elements are highly restricted, while the scarcities of other deposits in other countries and/or uneconomical worth mining have doubled the problem. Hence global power shifts, production localization and material substitution are some of the anticipated consequences. Developing countries such as China and India provoke competitiveness against developed countries with high-tech products and traditional production. New economies utilize new technologies and materials, innovations and modern sciences along with cheaper labour costs to challenge the developed countries. The consequence of such global competition though, is shortening of innovation cycle time which leads to increase the launches of new products into the market, higher obsolescence of old products and consequently, more raw material, energy and resources consumption, in addition to more waste generation [11].

The pace of change has increased during the last decades due to new breakthroughs in products, technologies, materials and production methods. These changes cause behavioural changes in producers and consumers [17, 18] and development of new business models. *Product Service Systems* and *reverse logistics* can be named as recent business models, whereas enhancement of purchasing environmental friendly products [17] is the proof of changes in behaviours. Producing new innovative and smart products implies emerging innovative technologies, new production approaches and new advanced composites and material. The most important innovative technological development areas in future are biotechnologies and nanotechnologies, photonics, information and communications technology (ICT) and photovoltaic. Beside of cutting-edge technologies, the production approaches has been also developed and grown during the last decades [19], such as agile manufacturing, virtual and digital manufacturing and additive manufacturing. In such context, growth of automation, digitalization, computerization and utilizing of ICT are foreseen in future where production becomes more efficient and cheaper. Such trends may lead to a more accurate production with less spill and material waste. Number of blue- and white-collar will be also affected in a way that more people working on offices are increasing and more service businesses are emerging. Due to automation and mechanization, robots will take care of hazardous and toxic conditions. Reduction of people on shop floors means more robots working continuously with more precision. More precision and programming also can be interpreted as less waste material and more sorting for recycling. Furthermore, 3D printing and additive manufacturing is expected to increase by 50% by 2020 [20]. Additive manufacturing contributes in sustainability in the way that in contrast to current machines and subtractive technologies using to carve plastics and metals into the appropriate shape, less raw material is used [21], less waste materials are generated i.e. no scrap, milling, or sanding requirement [20] and waste material, unused powder and existing objects can be recycled [22]. According to [23], in some application associated with 3-D printing particularly in metal sector, waste of raw materials reduced by up to 40% while 95% - 98% of waste material (powder that is not fused) can be recycled. It can also imply local recycling facility [21, 22] instead of take-back infrastructures and transportations to collect and recycle the products or materials. As a result of local recycling and using of recycled materials and products, carbon footprint would be reduced as well [22]. Reduction of transportation, both for delivering the products and collecting the scraped or waste materials and products, leads even to product price reduction.

Advanced materials such as biomaterials and complex composites have been substituted with hazardous materials in manufacturing in order to improve the quality, decrease environmental effects and satisfy market requirements. New complex composites and innovative smart products, technologies and production approaches are highly dependent on particular raw materials (critical materials and rare earth elements), which a limited number of countries such as China have the majority of resources [13-16]. This dependence has made Europe to be affiliated to supply from those countries. Annual rate of rare earth metals' application is expected to increase in average by 8 – 11% [13] and therefore global competition on such resources is foreseen. In global perspective, current supply can satisfy the future demands of the majority of materials in short term. However, in long-term perspective assuming to have constant increasing production rate, innovation, new application and development, current reserves may not be sufficient to respond to the demands. In addition, new technologies, production approaches and materials has reduced the interval between the innovation and application [17], whereas recycling infrastructure and logistics has not improved with the same pace. In such situation, efficiency in production and material consumption, developing recycling infrastructures, forming a competence network with recyclers, manufacturers and politicians and adapting a legal framework in order to climb the waste hierarchy from landfill and incineration towards reduction and prevention are the key paths to hinder abovementioned issues [13].

Application of electrical and electronic equipment (EEE) is growing and expanding, probably owing to IT revolution and requirement of interactions among various things. Automation, ICT application, utilization of electrical and electronic equipment devices, embedded systems and e-mobility, hybrid and small engine vehicles has increased dramatically during the last decade. This trend embraces integration of electronic and automotive industries. Considering the dissipative and widespread applications of electrical and electronic equipment and solar cells, UNEP (United Nations Environment Programme) pinpoints the enormous potential of recycling where 20 to 50 million tons of EEE wastes are generated each year – 3 to 7 kg per person year. In Europe, the amount of such waste is about 12 million tons per year and it is foreseen to grow in the coming decades at a rate of at least four per cent annually. Constitution of competence networks for waste and production influence future of material consumption and waste generation. New multidisciplinary waste management approaches such *industrial ecology*; *eco-industrial parks* and *industrial symbiosis* have been developed during the last years to provide both economic and environmental advantages. These approaches aim at sharing and exchanging raw material, energy, by-products, water and waste flows among various companies through geographic proximity in order to manage their resource and environmental issues. Reuse, recycling, remanufacturing and composting operations are the main strategies in such areas which lead to less raw material consumption and waste generation. In addition, light weighting of end-products e.g. vehicles, and production equipment e.g. industrial robots is being rapidly developed to make the production industries more energy efficient. Light weighting also contributes in material efficiency, although it has a tiny improvement scope [10, 24].

Manufacturing has 33% of total global energy consumption and 38% of direct and indirect CO_2 emissions generation, while these figures are the biggest proportion in both areas in comparison to transport, household and service sections [25]. Oil prices in future can be affected with new technologies of oil extractions as well as new energy resources and substitutions such as shale gas. It is also vulnerable to global energy demand which is about to increase by more than a third by 2035 owing to growth of China, India and Middle east [26]. Increasing trend of production in future due to wealth and GDP growth, entail serious consequences with direct contribution to global warming and climate changes. Hence, global regulation along with legislation and vision to achieve sustainable energy sources, efficient production processes and collaborative frameworks and management to decrease energy consumption will cause some limitation in production which contribute in lower production activities and consequently lower material consumption and waste generation. However, this global regulation, legislation and visions might be in future more directed towards collective environmental action regarding the reduction and extinction of resources. Waste generation-related or raw material consumption-related agreements might be forged in future, due to the facts that raw material extraction is greatly energy intensive and we don't have resources in long-term perspective.

Economic crises affect production and markets by decreasing the investments and R&D projects as well as reducing production rates and sells. Since production activities have direct contribution to waste generation and material consumption, economic crises influence material waste area as well. Economic cycles happened now and then, due to oil price chocks and wars and conflicts; these economic crisis and financial debt do not only affect the production area, but also infrastructures including recycling, education, employment, transportation, health and standard of living. Future human health requires less environmental pollution load, climate changes, clean drinking water, minimization of waste and better waste treatment; and all these requirements are related to future production capacity, legislations, economic condition of people and prices.

Price enhancement, high environmental pollution, increasing demand of raw material, scarcity of material, new compositions, carbon footprints for extracting material, China's domination of some raw material, substitution difficulties and role of some materials as by-products during extraction are the main drivers regarding increasing recycling [9], while growing requirement of raw materials will continue. Therefore, sufficient and efficient collection, segregation and recycling infrastructures, along with effective legislations and standards and imposition of right and feasible visions and objectives not only by European Council, but globally is strongly needed to prevent waste generation [18], excessive raw material consumption and hinder GHG emission and global warming. UNEP believes reconsidering of recycling practices due to tenfold global metals demand growth in future [27, 28].

4. PEST ANALYSIS

PEST analysis is a method for investigating macro-level business and market regarding political, economic, social and technological perspectives [29-31]. The macro-environmental trends include external changes which affect the business operation beyond the control of the business [32]. Political factors consist of government's intervention, legislations and tax policies among others whilst economic factors represent financial issues such as national and international investments, exchanges rates, material prices, labour costs, deflation and inflation. Social factors encompass socio-cultural characteristics, demographics issues, education, etc. while technological factors comprise innovations in technologies and science among others [33]. Considering all macro-environment factors with regarding to the property of the PEST analysis, supports organizations and managements in decision making procedures and affect organizational capacity to produce value [34, 35]. It helps to see the future directions and their effects on the business whilst providing a foundation to analysis of benefits, harms and potentials [32].

A one day workshop was conducted to analyse the determined external trends introduced in section 3 through PEST analysis. First, the macro-level future trends were presented to the participants and then, they were asked to reflect upon the determined future trends. Afterwards, they were asked to interpret the identified trends using PEST analysis in order to structure and categorize them into political, social, economic and technological sections. Finally, with comparison of performed classifications, the consensus upon trends and categorizations were achieved. The workshop's result is presented in table 1 that waste material related trends are mapped according to the PEST criteria. There are some megatrends [36, 37] that will very likely influence different areas tremendously over decades. Some of them identified by [17, 19, 36-39], has been written in the middle of the table since authors believe that these trends will affect material consumption and waste generation from all PEST perspectives. Although other megatrends and some trends might also influence two or more areas, the effects on material waste and consumption would not be immediate.

This systematic approach was used to provide a framework and better understanding of external macro-environment trends related to raw material usage and waste generation according to the property of the PEST analysis. The PEST approach has been found to ease the analysis of potentials, opportunities and threats influencing strategic decisions and innovation initiatives [34, 40], while opening a discussion about monitoring and evaluation of future changes to apprise companies and authorities [39].

Table 1. PEST analysis of macro-level future trends.

Political	Economic
China's plans for rare earth metals [13-16] Global shared responsibilities [16] Recycling infrastructure [13, 41] Carbon tax [9, 12] Regulation, legislations and standards [17] World energy consumption growth [26] Waste hierarchy from landfill to prevention [18] Conflicts and wars Growth in renewable energy sources (20% by 2020) [7, 18, 42, 43] Improvement in energy efficiency (20% by 2020) [7, 18, 42, 43] CO_2 reduction (60% by 2050) [7, 18, 42, 43] Greenhouse gas reduction (80% by 2050 and 20% by 2020) [7, 18, 42, 43] Global competition for resources [39] Growth of global competition [17] Global power shifts [39] Global regulations and governance [39] Safety for data, humans and processes [41]	Wealth growth [39, 44] Global GDP growth [36, 44, 45] Higher price of products and raw materials [14] New energy sources for factories and energy autonomous factories [11, 17, 41] Oil economy/ peak oil [46, 47] Business models of lifecycle thinking and opportunities concerning waste management [11, 17, 41] Financial crises/boom [41]

Holistic value understanding [2]
Climate change, global warming [17, 37, 39]
Global knowledge society [36, 37]
Scarcity of raw material [19, 37, 39]
Globalization [36, 37, 41]

Social	Technology
Key resource consumption [4, 19, 48] Global middle class wave [8, 37, 49] World population growth [7, 17, 39, 41] Worker/labour costs growth in developing countries [50] Ageing population [16, 17, 19, 37, 39, 41] Less blue collars, more with collars [51] Behaviour changes in producers and consumers [17, 18] Social networks for production [41] Social networks for waste [13, 52] Individualism [36, 41] Health and disease [36, 39, 45] Urbanization [36, 37, 41]	Information and communications technology (ICT) [19, 36, 41] Quicker innovation cycles [17] Growth of material complexity[14, 19] Photovoltaic capacity enhancement and price reduction [13, 53] Nanotechnologies, Micro and Nano-electronics [17, 19, 36, 37, 41] Photonic [17, 19, 37, 41] biotechnology, bio materials, bio-degradable, bio-composites [17, 19, 36, 37, 41] Agile manufacturing [17, 36, 41] E-mobility, hybrid and small engine vehicles [37, 41] Mass customization, 3D printing and additive manufacturing [17, 20, 21, 54-56] Growth of automation [17, 57, 58] Integration of electronic and automotive [41, 58-60] E-learning and e-education [41] Localization of production [41] Substitution of materials [17, 61-63] Light-weighting [10, 24] Virtual and digital manufacturing [17, 41, 58]

5. Discussion on potentials and opportunities

By analyzing the pilot study, reviewing the literature and concluding the PEST analysis, this section discusses the potentials and opportunities for production companies to have a holistic understanding and foresight conversations of tomorrow's issues. The pilot study revealed lack of knowledge and implementation in foresight methodology as well as negligent of macro-level standpoint in decision making procedures. Future conversations are rarely taking place, and if it does, it would be informal without any formal documentation. For instance trends such as demographic changes, cultural invasions, mobility behavior shifts and consumer behavior changes that can result in great differences in product designs, markets and innovations are not acknowledged in strategies and decision makings. In recent years, we have seen how production and market were imposed by technology pushes and market pulls that caused slow free falls and various difficulties. Large and successful companies, such as Kodak and Nokia, have been left behind due to their failure to adjust to the reality, and their hesitation and fear to renew their existing businesses for the sake of the future. As a result, potential of facilitating future conversations, having systemic viewpoint and considering the external factors in decision making is high [64] and there is a potential to enhance companies' capabilities by understanding of the interdependency of factors and possible futures.

Identified external trends can be interpreted as favourable or un-favourable for individual industries, companies and organizations according to their business and criteria. Based on external future trends and tendencies, and depending on industry, history and organizational set-up companies can adopt different visions, concepts, tools and strategies in order to pave the way for necessary and future-oriented endeavour to succeed in business. These trends should be discussed in decision making processes to direct medium to long-term developments, future R&D activities, future- and customer-oriented prioritisation of innovative ideas and pursue future perspective of external changes in society and market related to company [1]. Effective measurements and assessment of such trends provide unique opportunities to respond and reflect upon direct and indirect future changes to add value and increase future competitiveness. It helps companies that based on the upcoming changes, get prepared for an uncertain future by identifying potential risks and opportunities, planning, informing strategic decision making and matching capabilities and resources to overcome the challenges. When companies perceive an external change or potential future development that would affect the business, proactive action plans integrated with market situation and customer requirements need to be defined and implemented.

Although it is difficult to say when, how and to what extent external trends will affect material waste in the future, it is clear that several important trends will definitely influence the requirements on raw material and industrial waste management. Legislations, societal perception, material and energy costs, business models, technical and organizational structures, information handling, goals and visions along with incentives vary greatly over time. Market actors also vary depending on material type and geographical region. This variation drives complexity, uncertainty and a correlated reduction of material efficiency. Production industries need to be aware of how these drivers affect the production, overall profitability and respectively, other production dimension such as material input and output. For instance, scarcity of raw material, legislations, demographic changes and carbon taxes in Europe might hinder or decelerate production, which respectively decrease waste generation and material consumption. On the other hand, enhancing recycling capacities, efficiency of current processes, and utilization of advanced technologies along with behavioural changes of producers and consumers and localization of new productions might accelerate material consumption while retard waste generation. Such complexity in waste generation and raw material consumption needs to be reduced or structured intelligently by identifying and considering different variations. Then, and only then, can companies reach their full potential regarding resource and material efficiency, recycling and waste management. A systemic view allows companies see the whole picture of upcoming events to direct efforts to move upwards the waste hierarchy, to assess potential and limitation of future production as well as to provide them the ability to work proactively in waste management and recycling initiatives. Considering possible future changes in decision making enables developing more efficient waste management solutions and recycling flows for the industry, reduction of carbon emissions, solid industrial waste, and the need for virgin raw materials.

6. CONCLUSION

Previous authors [11, 17] have pinpointed that waste generation and material consumption need high attention for research and development in future. This paper presented a foresight study on influential external upcoming trends concerning raw material consumption and waste generation in production. The aim was to inform production industries and ease decision making regarding future plans, initiatives and investments related to material waste. Nowadays, environmental challenges and management options are being developed by global drivers that already influencing both production and environment and will continue to do. The analysis of trends and future influential factors therefore, should be done in longer-term and iterative processes. The identified trends have direct and indirect consequences on material consumption and waste production, and the links between trends and impacts are complicated and uncertain. As identified future trends are “macro-level”, they are to some extent general and abstract for a specific production industry and particular business decision. However, corporate foresight study should be seen from user’s perspective [2], therefore, identified trends can be utilized by individual production firms (users) to comprehend a holistic view of possible upcoming trends and their impacts on individual firms. This systemic view, integrated with organizational structure within companies, lead to value creation and companies’ competitiveness enhancement. Companies, organizations and industries based on their requirements and visions can use the results as early warning indicators or to define future scenarios, as well as to integrate it into the strategic plans and business level decisions. The analysis of trends suggests that management of raw material consumption and waste generation in production will be developed and more recognized among industries, organizations and society. Future production can be seen as key enabling technologies and advanced knowledge-based production with high tech value-oriented sustainable processes integrated with lean philosophy and life-cycle thinking that also support human productivity, knowledge sharing and competence growth. Moreover, environmental policies and legislations will be applied globally and harmonized with economic drivers that ease climbing the waste hierarchy.

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