The Future of Manufacturing in Europe 2015-2020

The Challenge for Sustainability

Scenario Report (Summary)

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Nanotech backers back off!

Nanobuild Ltd. issues liquidity warning

NANOTECHNOLOGY

New York: Nanobuild, the world's largest nanotech RTD company, was forced to issue a liquidity warning yesterday, as NIG, the association of users of nanoelectronic products, announced their intention to curb funding schemes for nanoelectronics research. The announcement comes as the latest in a series of similar revelations of major manufacturers this year.

"The current situation is anything but easy" said Jan Binkhorst, CEO of Nanobuild, at yesterday's presentation of the half-year results. Nanobuild concentrates on nanodevices for electronic applications. The company's shares fell more than 25% yesterday in late trading. The Advanced Technology Stock Index dropped 8%.

Nanotech research firms have been the high-flyers on the stock markets over the last five years. Now many of them are struggling to keep their research activities going. With almost all Wall-Street-listed nanotechnology firms reporting diminishing returns over the past 12 month, the sector is on the brink to get 'nanomized'.

Analysts say that there are several reasons for the downturn. Andrezej Borkowski, chief analyst with Innovation Unlimited, the Warsaw based research think-tank, explains: "Some of the expectations in nanotechnology are only realistic on the long run. In the current difficult economic climate, firms concentrate more on short-term goals."

After the initial enthusiasm about the potentially unlimited opportunities of nanotechnology, widespread caution is now common among executives and investors. Progress has been made in nanotechnology, especially with regard to smart materials. However, more complex nanotech applications are still far from the marketplace. Nanoelectronic components, for example, lack reliability to be commercially viable. The lack of internationally accepted measurement and testing standards is another reason why producers abstain from investments. "Metrology is one of the areas that governments need to address more aggressively. And the framework for the protection of Intellectual Property needs to be improved", says Borkowski.

However, the recent plunge of stocks seems not to be supported by long term prospects. "Nanotech is the future. A lot of progress has been made with smart, functional materials and health applications. It is primarily in nanoelectronics where we see the market collapse", says Borkowski.

According to analysts, the lesson to be learnt from faltering nanotech stocks, is that the policy framework has to be set right: Pushing the technology with the expectations of quick returns on investments is unrealistic in nanotechnology. First there needs to be strong emphasis on pre-competitive research, as Europe and the US did early in the century.

Moreover, it is worthwhile thinking about the demand side at an early stage and to create lead markets. Here, the comparison between the US and Europe is instructive. "In the US, military funded nanotechnology research addressed clear objectives. They set up programmes for combat textiles and virus-detection tools, for example. This had major impacts on innovation in the health sector. This strategy has paid off", says Borkowski.

The Nanopharma Research Program has been another case of US success. "We can see an increasing market-share of US products in medical technology such as intelligent drug delivery systems", says Borkowski.

But Europe also has its strongholds in nanotechnology, especially in catalysts and hybrid materials. EuroCatalysis provides nanocatalysts for the chemical industry worldwide. "We make good profits with nanocatalysts and help Europe's chemical industry maintain the competitive edge", says EuroCatalysis spokeswoman Ana Oliveira.

US bullet proofs win shoot out

Nantex vests EU force

NEW POLYMERS

Brussels: Europe's UN peace keepers and the Rapid Action Force will soon be equipped with a new generation of functional fabrics for military uses.

Nantex, the US producer of functional fabrics and intelligent textiles, won the bid to deliver high-strength, ultra-lightweight bullet-proof textiles for the 100,000 strong EU force. "This is a big success for us", says Nantex CEO Samuel Edwards, "since the defence goods markets are still very much home matches. This time, though, superior technology won".

Conventional bullet-proof vests and equipment are heavy and often fail to protect soldiers adequately. The new fabrics are ten times lighter than previously used materials. The excellent thermo-physiological properties allow the deployment of the same piece of equipment in both deserts and the arctic alike.

The new clothing uses embedded sensors to monitor and exchange the physiological data of the soldiers with a central command station. The high performance and reliability of the new textiles has already been proven over the past five years in the US army.

"Show me the way to the next … sushi bar"

CNV presents voice-controlled car navigation

AUTOMOBILE INDUSTRY

Paris: The first standard series car with personalised, voice-controlled navigation was introduced at the Paris Motor Show.

The Car Scout of the CNV 8 is fully capable of listening and speaking and has Internet access with personalised re-configurable colour displays mounted in the windscreen by using new smart materials. This brings greater comfort than the visual driver information systems already available for decades in standard cars.

"As soon as you say the name of your favourite sushi bar in town, the navigation system will indicate which is the best way to take to go there, taking into account the real-time traffic situation in your area", says CNV spokeswoman Gordana Jancic. The model offers Internet and a wide range of office tools, such as voice-controlled e-mail and word-processing.

The Car Scout is standard equipment in the CNV 8 model series. In the more economical CNV 4 series customers pay a premium for the extra.

VMS profits hit peak

Demand soars for digital prodution tools

SIMULATION

Warsaw: Net profits of digital planning software provider VMS rose by 25% in 2015.

With innovation and design cycles becoming shorter, industry has widely adopted simulation and virtual planning tools to become more flexible and consumer focused. Erik Larsson of VMS explains: "It is no longer feasible for manufacturers to optimise each production step individually. Companies realise that production as a whole is more than the sum of its parts."

The key to integrated factory planning is the visualisation of data. VMS offers sophisticated computer models that allow for the visualisation of all elements of production. "With a simple command, a production manager can access real time data in a strikingly simple way. At the same time, they can easily simulate change-over and how certain events affect the operation of plants", says Larsson.

The clients of VMS come from every manufacturing sector. "If a manufacturer wants to survive under global competition cutting planning costs is a must", says Larsson. The potential for efficiency improvements is astonishing. "With integrated plant simulation, the time to produce a car has been reduced by 75% over the past two decades. In the chemical industry, too, simulation can improve the operation of plants dramatically", says Larsson.

Local Standard

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The Regional Daily - Business Section

EU Troika signs Industrial Co-operation Pact with Neighbour States

Opportunities for investors in Belarus, Ukraine, and Russia

ENLARGEMENT

Kiev: After three years of negotiation, the EU Troika yesterday signed the Economic Stability and Industrial Development Agreement with its Neighbour States Ukraine, Belarus, and Russia. The breakthrough in the talks happened at the Presidency Summit last December in Nicosia. The East European Member States were finally granted additional funds for infrastructure projects after long lasting resistance within the European Union. The net contributors to the EU budget have been for a long time reluctant to agree on paying the bill.

The pact was warmly received at the European Industry Association headquarters in Brussels. The pact provides development funds worth a total of Euro 300bn over the EU budget planning period 2017-2023. The new agreement provides incentives and financial support for stronger EU industry engagement in the 'New Eastern Europe' economies to catch up with 21st century economic structures.

Apart from transport and communication infrastructure investments, the agreement will provide funds to modernise power-plants, steel works, refineries and chemical sites which account for the most significant share of pollution sources in the Neighbour States. Improving co-operation on industrial research is also an important part of the new agreement.

Henning Schermann, of the European NGO platform CitizenAct, criticised the pact, saying it does not sufficiently take into account environmental and social development issues. "30 years after the Chernobyl disaster, Europe is still not able to support Ukraine to decommission their nuclear power plants", says Schermann.

Fostering diversity vital for innovation, says Cengiz

Governor calls for more active EU

INNOVATION POLICY

Stuttgart: The current president of the Representatives of the European Regions with the European Union, Anne Cengiz, called for a more active and co-ordinated EU innovation policy, to strengthen innovation capabilities and help regions stay competitive.

In yesterday's speech, delivered at the European Automotive Association annual conference, Ms Cengiz stressed the crucial interplay between European and regional level policies. "Europe's regions are role models when it comes to stimulate research and innovation", said Cengiz, "Strong regions and thriving industry clusters are the basis to make innovation happen. However, we must not ignore that local initiatives need backing from Brussels to ensure that regional diversity works for the benefit of European businesses and customers".

Ms Cengiz mentioned the European Commission's new Regional Manufacturing Innovation Partnership programme as an important step forward. "European research needs to bring together the centres of excellence and help create lead markets". More explicitly on automotive production, Cengiz referred to the Distributed Production Platform Initiative (DPPI). This strategic activity was part of the *European Virtual Manufacturing Initiative 2020* initiated by European car producers with EU support. The DDPI is one of the cornerstones of Europe's current leading role in automotive production.

With reference to industry sectors that have less well performed in recent years, Ms Cengiz concluded: "To stay competitive we need more DPPIs in Europe".

Digital production in Europe of the Regions

How global manufacturers cope with Europe´s complexity

PRODUCTION SYSTEMS

Paris: There has been much rhetoric about the Common European Market. However, multilevel governance and having the ear close to European citizens had its price: if one looks carefully, one cannot deny the persisting patchwork of fragmented markets created by specific regulation in the regions that constitute Europe.

For global manufacturers this situation creates a major challenge for supply (and demand) chain management. Producers aim to realise economies of scale without centralising production. With the limitations of congested transport infrastructure in the main industrial regions, and the need to organise production networks locally, the world's leading manufacturers have adopted ICT solutions to manage increasingly complex production networks digitally.

"Manufacturers need to be able to work on the basis of a shared, comprehensive, and transparent pool of data and knowledge to integrate processes, operations, production sites and their relations to suppliers and clients", says Marta Sanchez of Interdata. "The operations of small suppliers are electronically linked in real time to a business integrator", says Sanchez.

Recent advances with self-integrating components and systems have made the new approach feasible. "With this new technology we can at last create a real-time seamless production web, that both allows for central co-ordination, monitoring and management, and – at the same time – enables the flexible delivery of products and services according to local requirements", says Sanchez.

PetroBNL high-capacity cracker site operational

Permits issued after up-hill struggle

CHEMICAL INDUSTRY

Rotterdam: PetroBNL was granted an operating permit for the world's largest and most modern cracker site close to Rotterdam. PetroBNL's CEO Michael Kavanagh clearly expressed his relief after the decision of the appeal panel was announced. "Despite our commitment to sustainable development legal and public relation procedures have been difficult", said Kavanagh. Yesterday's verdict is the punch line for more than three years of planning, negotiations and court procedures between the company, authorities and citizen groups.

With building permissions and operating licences for new plants being subject to tight regulation, the petrochemical industry has witnessed strong spatial concentration in recent years. "Today, there are only few, but hypermodern, chemical industry clusters left. PetroBNL is top of the league", said Kavanagh.

All major European petrochemical plants are now located close to ports to reduce transportation and logistic costs. Over the past two decades industry has also heavily invested in process intensification to modernise production sites. "In economic terms, concentration and plant intensification makes sense. Of course, this needs to be linked with flexible planning and operation tools to meet the needs of our clients", says Kavanagh.

Since European producers have steadily moved towards higher value specialist chemicals, centralised production of petrochemical had to be better integrated with down-stream fine chemical processes.

With increasing demand for small batch specialist chemicals there is strong pressure on the industry to push ahead with miniaturisation of chemical processes and to make production more flexible. "A lot of progress was being made in smart materials, membranes, integrated sensors, microfluids, automation and process control. These were some of the key elements to make microreactors feasible. The positive side effect is, that plants have become more environmental friendly and safer to operate", says Kavanagh.

Technology trends also ask for new approaches to multidisciplinary training and research. "It is crucial not only to invest in technology, but also to prepare your staff. At the end of the day, people are the key to sustained success", says Kavanagh.

SUSTAINABLE TIMES

The Daily Global Development Newspaper

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WTO talks on intrusive technology resumed

International accord on consumer protection standards in reach

SOCIETAL IMPACTS

Kuala Lumpur: Daniela Muller, chief negotiator on consumer protection of the Global Consumer Alliance (GCA), called on Governments and the World Industry Council for more flexibility to reach final agreement on internationally binding privacy and data protection standards for intrusive information and communication technologies.

The tripartite discussions of governments, industry, and consumer groups are being resumed after two months of stalled talks that allowed partners to reconsider their positions.

The contentious points still to be solved include the transfer of personal data and self-restriction of industry to abstain from certain intrusive technology solutions.

The talks started two years ago under the patronage of the WTO. They came after the eruption of the surveillance scandal in the US, when surveillance and monitoring data records over behaviour patterns from thousands of employees were used to identify 'untrust-worthy' personnel. On the basis of the analyses, employees profiled as 'security risk' were then unlawfully dismissed.

With the widespread use of personal electronic devices such visual phones, and personal identification tags, a vast range of legal questions has emerged with respect to the collection, use, access, exchange, and combination of personalised data. With people screened and monitored almost everywhere today – by using their mobile phone, PDA, credit card, or by person identification devices in public areas the opportunities for fraud and unauthorised use of personalised data has grown as well.

Up to now, countries have implemented their own standards. With increasing international cooperation on environmental, social and civil society issues global standards seem desirable. However, progress has been slow so far.

In particular, the need to strike the balance between privacy rights and public security complicates the matter. When does the public interest justify the transfer of data to governments? "After the terrorism concerns ten years ago, when almost any infringement of privacy rights was justified as a legitimate means to fight terrorism, we now need to seek a better balance", says Muller.

Jacques Klein, who represents the World Industry Council in the talks, pointed out that a final agreement can be assumed within weeks. "We are getting there", said Klein, "however, we need to make sure that the accord does not impede research and progress in ICT and ambient intelligence technology."

Record bio-feedstock demand for polymers in EU

Bio-based production up 24%

BIORESOURCES

Rotterdam: For the first time in history, the use of bio-feedstock, mainly ethanol derived from bio-mass fermentation, outpaced the use of fossil feedstock for the production of mass-polymers in 2016. The data issued yesterday by the European Polymers Association (EPA) showed a 2.2% increase in production of polymers compared to the previous year, to a total of 383m tonnes. The demand for fossil-oil based feedstock dropped 4.1% in the same period. Bio-mass ethanol production soared 8.7%. "This indicates a major shift towards a more resource conscious mass-polymer production we have been witnessing over the past decade", says EPA president Erkin Basaran.

Also bio-polymers gained market share in 2015, amounting for almost 8% of total polymer production in the EU. Even though the production of bio-polymers still requires non-renewable feedstock, the energy balance clearly speaks for bio-polymers. "Over the past five years the EPA members increased bio-polymer sales at a rate of more than 12% per annum. The plastics producers have made a significant contribution to Europe being able to meet its Kyoto II targets", says Basaran.

Automotive manufacturers agree on fuel cell standards

Fuel cell powered vehicle systems breakthrough expected

FUEL CELLS

Detroit: A standardisation agreement on fuel cell components for motor vehicles has been signed by the three major global automotive manufacturer groups. The move is believed to substantially stimulate market penetration for fuel cell powered cars and trucks and bring down production costs. Changes in legislation that now provide for heavy tax incentives for buyers of zero-emission vehicle seem also have been instrumental for the progress made.

Over the past decade, industry has solved the critical technological issues that impeded the diffusion of fuel cell powered vehicles in the past. Compared to the prototypes available ten years ago, today's fuel cell stacks are built of lightweight materials and a compact, on-board fuel processor. Carbon nanotube technology made lightweight hydrogen storage feasible.

"Major technological improvements were made to make the systems more durable and reliable. This was an indispensable prerequisite to get market acceptance from our clients", said Customised Ride CEO Hermann Schuster. "The manufacturing costs have fallen by 85%. However, all producers have so far used their own standards for fuel cell stacks, chassis design and storage system, which basically tied you to a single supplier", adds Schuster.

The new agreement foresees that the joint standards for fuel cell powered cars will be in place by 2020. By then, the power-train components of new cars will be interchangeable. The vehicle manufacturers themselves will benefit twice from the standards, since virtually all big players have set up mobility provision subsidiaries in recent years.

New EU incentive scheme for global clean production

GLOBALISATION

Brussels: The European Commission has proposed a new incentive scheme to facilitate clean production and discourage the export of industrial risks to countries outside the EU. The proposed scheme suggests tax breaks for companies which can prove that they apply the EU standards on their non-EU production sites. The tax breaks are the bigger, the more the site's emissions fall below the overall industry average in the respective country. WTO's Global Release Inventory for Hazardous Substances, to which all WTO members contribute, serves as reference data source.

The Communication is a firm response on the EU Sustainability Report which concluded that not all is green with Europe's industry, if one takes a careful look at subsidiaries and ventures abroad. "Over the past decade European companies relocated resource and energy intensive production to catch-up economies and developing countries. There, production standards and wages are still much lower. But if we want to be taken seriously with our sustainable development policies, we can't apply double standards", explains Freddy Bosmans of the European Commission.

Electronic waste records show strong improvements

WASTE PREVENTION

London: Electronics manufacturers are among the most successful firms at waste reduction, new data indicates. When the EU Directive on Waste Electrical and Electronic Equipment was introduced, computer manufacturers adopted an ambitious extended product reliability (EPR) scheme. The scheme covers life-cycle management, design for disassembly, leasing and take-back arrangements and waste minimisation partnerships. Making also sophisticated smart materials and composites complying with the scheme proved to be the most challenging issue.

The achievements have been compelling: Fifteen years ago, each European citizen disposed 14 kg of electronic waste per year, of which a considerable amount contained hazardous substances. Today, the average European 'produces' a mere 1.5 kg per year.

Focus Europe

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Cleantech sweeps China in environmental technology scoop

Deal worth 350bn euro signed to revamp manufacturing sites in Liaoning

CLEAN TECHNOLOGY

Benxi: Times have not always been so rosy for European engineering companies as they are now. Yesterday, Cleantech CEO Nikola Dobrev, and the Governor of the Province of Liaoning, Yu Chuan Ping, signed the biggest environmental technology export deal between the EU and China so far.

The deal will safeguard thousands of engineering jobs in Europe and gives a fresh boost to increased technological cooperation with the largest Asian economy.

Over the next ten years Cleantech will provide cutting-edge environmental know-how and technology for clean production, emission control equipment, sensor technology and recycling know-how to help modernise production sites in the pollution-stricken Liaoning province.

Since the economic reforms of the 1980s and the creation of the Economic and Technological Development Zones (ETDZ), foreign investment and industrial activity soared in China. However, economic success came at a high environmental and social price. Manufacturers still use outdated technology and pollution in cities has become almost unbearable.

Among the bidders were three other European-led consortia, as well as two US providers and the Japanese company Mitsubishi. Europe's leading position in advanced environmental production technology and its ability to offer integrated solutions turned the balance to the Cleantech consortia.

It is hard to believe, but only a decade ago, many European process technology firms such as Cleantech had been close to economic collapse. The acceptance of the Commission's proposal to introduce strict energy and resource efficiency standards even after the US pulled out of Kyoto, unwilling to negotiate any further international accord on environmental social and issues, gave exporters a hard time.

"More than once we asked ourselves: Are we really going in the right direction with our high environmental conscience, or are we only losing out on business opportunities to our competitors overseas?", Dobrev says in hindsight.

"Europe on the one side and the US and Asia on the other were going in completely different ways, after it became clear that oil resources are not going to run dry and energy prices would stay low, at least in the short and medium term", Dobrev says.

In those years of transition, stimulating demand for environmental technology on the home market was crucial. With support from European research funding schemes and an active industrial policy orientated towards long-term sustainable growth, Europe was able to create lead markets for innovative, environmentally friendly industrial processes.

"A lot of progress has been made in the last decade to increase energy and resource efficiency in the basic process industries. Hazardous substances have been phased out and integrated product design has become more than a buzz-word", says Terttu Valtonen of the European Industry Sustainability Forum (EISF).

The turning point came with increased awareness of industrial pollution in the US and the vastly growing economies in the Far East. For some years, the export market has been booming, a development that first took many analysts by surprise. The explanation is simple though: "Europe has superior technology to offer and we will see a sustained boom in export for some time to come", concludes Valtonen.

Semiconductor boom in Europe

EU leads the clean system-on-chip market

ELECTRONICS

Copenhagen: For many years, critics have rallied against the high European environment and health standards compared to those in the US or Asia. It seems however, that regulation can also stimulate innovative solutions, as the recent semiconductor boom suggests.

It was feared that strict EU regulation on toxic chemical use would drive semiconductors production out of Europe.

Against all odds, however, the industry has flourished over the past years. "We succeeded with product design and processes that have a clear advantage for the environment", says Jens Frederik Laursen from EMS European Micro Systems. "Dedicated research on polymer transistors led Europe to become world leader", says Laursen. Polymer components are more resource efficient and require less hazardous materials than their silicon based counterparts. Although prices are higher, they do have functional advantages.

Europe's stronghold in semiconductors is in the higher price range. Europe provides system-on-chip products that integrate sensors and sophisticated software for the automotive sector, health care, industrial automation and environmental monitoring.

Automation and process integration in manufacturing can be driven far beyond the limits ten years ago with the available technology. Each single device in a factory – regardless whether part of a robot, a pump, a nozzle, or a quality control instrument – reports its status continuously to the control station. It reports either 'I am feeling fine today', or 'I had a small problem, though I checked that myself and here is the report', or 'I need maintenance'.

Besides the EU's ambitious environmental policy, the proactive approach towards setting standards for industrial software tools for embedded systems was instrumental in the boom in the industry.

"A shared software language makes components, tools and production systems communicate digitally. The network effects by working on the basis of a common industry standard are huge", says Laursen.

ITS network in Rome opened

Clean cars and ICT to ease traffic problems

URBAN TRANSPORT

Rome: One of the most ancient among Europe's capital cities, Rome, now has its 21st century Intelligent Transport System (ITS). The Eternal City has been notorious for its chaotic traffic for decades – the result of legions of cars, trucks and scooters that populate the city day in, day out. Driving in Rome has been risky, noisy, and dirty: a real gladiatorial endeavour!

In the follow up of the EU CIVITAS initiative for the promotion of clean urban transport, Rome has up-graded public transport facilities and set up the Rome Metropolitan Traffic Management and Control Authority. Among the measures taken are zero-emission car-only access and congestion pricing. Residents owning cars are eligible for a seasonal public transport ticket.

To access Rome by car vehicles need to comply with the European zero-emission vehicle specifications. The movements of all vehicles are automatically monitored and drivers are charged according to vehicle type, the distance travelled, traffic situation and pollution levels. New pattern recognition technology makes it possible to charge also according of the number of people in the car.

"We expect a more efficient use of our traffic infrastructure and better balance between public and private transport", said Paola Pellegrini, the Mayor of Rome, at the official opening. "Citizens and our guests should be able to enjoying the city, regardless whether they travel by car, taxi, metro or bus."

Introduction

About the FutMan scenarios

The FutMan scenarios were developed between June and October 2002 in four interactive workshops, drawing on the subjective views and judgements of the more than fifty experts from industry, academia, and policy makers. The FutMan scenario exercise formed part of the Accompanying Measure project "The Future of Manufacturing in Europe 2015-2020: The Challenge of Sustainability (FutMan)", funded by the European Commission, DG Research under Fifth Framework Programme and coordinated by IPC-Irish Productivity Centre (project reference: G1MA-CT-2001-00010). The full scenario report is published in the IPTS Technical Report Series (EUR 20705EN).

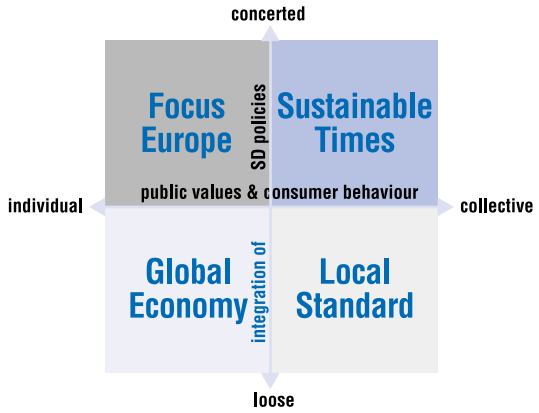
Aims and objectives of the FutMan scenarios

The scenarios on the Future of Manufacturing in Europe 2015-2020 (FutMan) aim to offer imaginative pictures about potential socio-economic developments and future technologies that are likely to shape the European manufacturing sector over the coming years. The scenarios highlight important trends, possible trend-breaks, critical challenges and opportunities and present four possible visions of manufacturing in Europe in 2015-2020.

The FutMan scenarios are not meant to provide mutually exclusive futures. Some of the technological and socio-economic issues described in one scenario might also happen in other scenarios. The scenarios principally aim to map the space for developments in the coming years based on the personal views and judgements of the expert group involved in the scenario building exercise. The FutMan scenarios should be used as a tool to stimulate and support strategic thinking about policy options in order to be prepared for the manufacturing challenges ahead. Since the FutMan scenario exercise focused on four manufacturing sectors – electronic components; measuring, precision and control instruments; basic industrial chemicals; and motor vehicles – most of the information provided in the scenarios refers to these sectors. Important developments in other manufacturing sectors currently emerging (for example in the aeronautics sector, textile industry, food and beverages, pharmaceutical, and medical instruments) might therefore not be adequately covered by the FutMan scenarios.

The scenarios are structured along two qualitative dimensions of change. The first dimension relates to the modality of policy making. It includes issues such as geo-political developments, the balance between central decision-making and subsidiarity in Europe, and the rate of co-ordination between different policy areas. The second dimension refers to prevailing public values, consumer behaviour and demand patterns. The dimension also includes issues of public acceptance of new technology and backing of policies in support of sustainable development.

Figure 1: The scenarios on the future of manufacturing in Europe 2015-2020



The FutMan scenarios

Each FutMan scenario consists of a detailed description of the socio-economic context and technological developments and trends that might occur under the given framework. Additional information is provided on the state of manufacturing in the scenarios. In addition, each FutMan scenario is illustrated in form of a purely fictional 2016 business newspaper front page that aims to help the reader to understand the scenario, and highlight specific socio-economic and technological developments.

Global Economy: In this scenario, consumers have pursued personal utility without paying too much attention to environmental and social impacts of production and consumption. The free market has been considered the most effective way to allocate resources and to achieve sustainable development. The World Trade Organisation and the interests of large multinational companies shape international trade policies. The European Union´s and Member states' influence on global level is rather weak. Policy-making principally aims to strengthen market mechanisms and competition. Policy objectives have been set on specific levels with little emphasis on the integration across institutions or policy fields. In technology areas in which global competitors have financed large mission orientated RTD programmes, Europe is at risk of falling behind. Technology progress has been uneven and progress in nanotechnology has not fully lived up to expectations. The private car has retained its principal role as status symbol and means of mobility. Manufacturers focus on customisation and individualisation of products. New ICT tools have increased the efficiency of product and process design. Environmental progress has been made incrementally as companies have aimed to cut costs by making more efficient use of energy and resources.

Industry structure will be highly specialised and diverse in the Global Economy scenario. Product liability compensates for safety and environmental standards. Court litigation becomes a source of product innovation – and a reason for the lack of it. Voluntary industrial agreements and self-compliance of industry on basic environmental and safety standards are the main policy instruments to stimulate sustainability. The engineering processes are assumed to be quick and flexible. The adoption of nanotechnology is rather slow because there are no incentives to establish international standards. There are few incentives for the industry to achieve compatibility between devices and different platforms. The scenario favours short-term industrial research activities. Energy intensity of production remains relatively high, though energy and resource efficiency improve since manufacturers aim for cost reductions. There is little prospect for the adoption of radically new approaches such as hydrogen fuel cell technology. Problems in the enforcement of recycling practices inhibit the adoption of recycling.

Local Standard: In this scenario, local authorities have gained new powers. Regional governments determine policy priorities and drive regulation. European institutions are not in a position to co-ordinate the diverse interests of regions and Member States effectively. The civil society, represented by a wide range of NGOs, has become an important player in policy-making processes. Consumer and citizen groups push their agendas on local and environmental issues. The transport network has been suffering from gridlocks due to shortfalls in investment and opposition to new infrastructure projects. The economic disparities between European regions and between Europe and its neighbours remain high. However, at local level diverse and creative regional clusters – new sources of innovation – have emerged. Multiple local markets have surfaced, linked and co-ordinated through ICT. Complex systems management tools help industry to cope with a challenging business environment. Some risky industry sectors face public opposition to the construction of new plants and witness the relocation of production abroad. However, strict

environmental regulation has also lead in some regions to the fast adoption of radically new manufacturing approaches and concentration of manufacturing activities in industrial clusters to retain production: localised alternative energy production concepts have been realised and new small-scale production systems have reached application stage.

The Local Standard scenario implies both the centralisation and the decentralisation of manufacturing operations depending on sectors, processes and products. Regional demand structures require new solutions for flexible specialisation in manufacturing. Industry adopts new design strategies to focus on modular, simpler, and robust components. Intelligent logistics plays a key role. In some regions consumer choice drives manufacturers towards flexible specialisation and cleaner, more socially responsible production. At regional level specialised advanced technology clusters emerge, though overall public acceptance of new technology which might cause negative second order effects remains rather low. Since there is little trans-regional co-ordination of policies broader transitions such as the hydrogen economy are unlikely to materialise in this scenario.

Sustainable Times: In this scenario, European citizens support government co-ordination to reconcile the economic, environmental, and social dimensions of sustainability. A global governance system has emerged that promotes sustainable development. The European Union defines and implements clear sustainability policies based on broad stakeholder participation, globally and between national governments. Both market incentives (e.g. energy taxes, emission charges, other financial incentives) and regulation (market regulation, performance and direct regulation) are used as policy tools to foster sustainability. Industry is an active partner, closely collaborating with governments and the civil society. Emphasis is given to socially responsible technology development. European manufacturing has been able to break the links between growth and resource use. Industrial change has been occurring at a fast pace, enabled by linking successfully technological opportunities with organisational and social change. The energy system is undergoing the transformation towards renewable resources. Large infrastructure investments have been made to create the hydrogen economy. Bio-resources have begun to replace partly non-renewable materials. New forms of mobility systems have emerged and the dominance of the internal combustion engine has been challenged by fuel cell technology. Manufacturing companies focus on the provision of services rather than selling products.

In the Sustainable Times scenario the notion of competitiveness is broadened and takes into account environmental and social aspects of production and consumption. Industry seeks major technological breakthroughs in order to de-couple material and energy use from production (e.g. bio-materials, renewable resources). Renewable energy and bio-resources help reduce greenhouse gas emissions. The industry strives for the optimisation of product life-cycles, introducing full lifetime control and management for their products. The manufacturing industry strongly pursues service-orientation in product design, and the product becomes less important within the value chain. The scenario requires a highly qualified labour force with new skills to operate and manage sustainable production systems. Rebound effects due to lack of public acceptance of new technology (e.g. ICT applications or nanotechnology) are unlikely since governments and industry pay attention to the environmental and social implications of new technology when designing and implementing their strategies.

Focus Europe: In this scenario, citizens make governments responsible for the achievement of sustainable development. Individualist values prevail. Europe has emerged as powerful actor to guide societies towards sustainability. Europe has pursued a strategically targeted industrial policy, aimed at creating lead markets for sustainable technologies. This approach proved to be successful, creating new export opportunities for European manufacturing industries. Strong emphasis is given to integrated utility of policy measures (i.e. balance economic,

environmental, and social utility in sustainable development). Discussions between regulators and industry about adequate performance goals (i.e. What is Best Available Technology?) and the most appropriate means to implement policies (regulation, self-regulation, standards, taxation, fiscal incentives etc.) have led to rather slow policy implementation processes. At international level, Europe is confronted with new competitors, especially from Asia (e.g. China and India). The WTO has facilitated international trade, though there has been little willingness of WTO members outside Europe to take environmental and social issues on board. Since behaviour patterns of consumers have not changed significantly, the scope for broader socio-technical innovations is limited. Application of new technology follows more traditional trajectories and does not break societal, technological or infrastructural lock-ins. For example, the zero-emission-car based on the internal combustion engine has become reality but the problems associated with car-use prevail. Advanced ICT is implemented in both the public (e.g. intelligent transport systems) and the private and industrial sphere (e.g. for control, surveillance and tracing applications).

In the Focus Europe scenario, regulation provides incentives for industry to invest in sustainable manufacturing solutions. Innovation is geared towards resource efficiency and clean production. Well designed and coordinated policies drive technology development towards lower carbon dioxide-intensity. Strong policy support for large scale European research leads to more top-down innovations. However, the scenario favours developments along existing application trajectories. Opportunities offered by new technology cannot be fully exploited, since short-term cost-effectiveness does not favour radical innovation for sustainability and consumer attitudes do not support them either. The priority given to strategically important sustainable technology development strengthens Europe's competitive advantage in advanced manufacturing technologies. Industry works hard to attract and keep personnel experienced in using advanced manufacturing tools, managing virtual factories, using simulation methods, etc.

Table 1: Socio-economic features of the scenarios on the future of manufacturing in Europe 2015-2020

	Global Economy	Local Standard	Sustainable Times	Focus Europe
Global governance	WTO enforces free competition. Global social and environmental accords watered down.	Limits to globalisation due to lack of public acceptance. Emergence of new regional protectionism.	Emergence of global governance bodies to promote sustainable development (SD).	WTO governs international trade. EU sets goals and pursues SD without international backing.
EU policy integration	Low integration of SD policies. Reliance on market mechanisms and industry actions	Low integration of SD policies. Regional interests set policy agendas and priorities.	Strong integration of SD policies between levels of governments. Regulation and market incentives.	Integration of SD policies with strong role of EU. Emphasis on cost-effectiveness of policies.
Consumer behaviour	Individualism and pursuit of personal utility. Highly individualised demand patterns.	Strong perception that community values and local dimension are crucial to achieve SD.	Community values and global dimension emphasised. Demand shifts from products to services.	Individualistic values dominate. Regulation corrects 'distorted preferences' of economic actors.
Innovation policy focus	Strengthen competitiveness and innovative capabilities of industry.	Create and strengthen regional and local innovation systems.	Tackle key societal challenges related to sustainable development.	Concentrate on strategically important research related to SD.
Transport / energy	Liberalised, oligopolistic markets. Low energy prices. Little emphasis on renewable resource use.	Regional monopolies. High energy prices. Fragmented transport infrastructure and gridlocks.	Mixed public-private markets. High energy prices. Heavy investments in renewables.	Liberalised markets. Low energy costs. Little public investments in infrastructure for renewables.
Sustainable development	Strong emphasis on the economic pillar of SD. Growth seen as the prerequisite for SD improvements.	Policies mainly responses to local pressures by various interest groups. Regionally patchy picture.	Strong emphasis on the environmental and social pillars of SD guided by precautionary principle.	Aim to balance SD pillars through integrated policy assessment tools. Strong technology focus of SD.
Education system	Partial privatisation of the public education and training system. Multitude of private schemes.	Regional responsibility for education co-ordination. Industry involved in training schemes.	Governments retain lead role in education. Strong emphasis to strengthen EU knowledge base.	Co-ordination of public and private education schemes to improve the economy's knowledge base.
Higher education	Strong emphasis on scientific excellence along traditional disciplinary boundaries.	Diversity in education and training schemes, reflecting regional legacy and diversity.	Strong emphasis on interdisciplinary training, soft-skills, and problem solving capabilities.	Strong emphasis on scientific excellence, cross-cutting traditional boundaries of disciplines.
Labour market	Little co-ordination of labour market and migration policies. Widening spread of labour costs.	Regional initiatives to balance labour supply and demand. Large regional labour cost differences.	Co-ordination of labour market and migration policies. Emphasis on tackling labour market imbalances.	Labour market and migration policies co-ordinated by EU. Increase of overall labour mobility.
Social security	Social security is increasingly left to the individual's choice and responsibility.	Regional differences prevail. Social security becomes part of compensation schemes.	Harmonisation of social security system at EU level. Social security remains in the public sector.	Mixed public and privatised social security system within a compulsory framework.

Scenario implications and conclusions

The scenarios on the Future of Manufacturing in Europe 2015-2020 highlight important developments, trends, challenges and opportunities for sustainable European manufacturing in the future. The FutMan scenarios suggest that the interplay of a variety of key drivers – most notably related to globalisation, new technology, market demand, public values, fiscal measures, regulation and overall societal change – will contribute to shaping the future landscape of manufacturing in Europe. While certain drivers, for example global developments, are largely independent of the European policy arena, other factors can be shaped and influenced by policy measures at European level to support of achievement of the goals and objectives laid down in the European strategy for sustainable development.

The conclusion to be drawn from the analysis of the scenarios is: Whether sustainable manufacturing will become a reality seems to be hardly a question of technological opportunities alone. New technology, socio-economic factors, and the policy framework will jointly determine the dynamics of change. The scenarios indicate that progress towards sustainability will depend on the successful alignment of technological, organisational, and societal factors that are required for 'system changes' towards sustainability in European manufacturing. The scenarios suggest that the main obstacles to achieve progress towards sustainable manufacturing seem to be primarily located in the political and market arena, rather than being caused by a lack of technological opportunities.

The interfaces between the various technological, socio-economic, and policy factors presented in the scenarios point to potential triggers for system changes towards a more sustainable manufacturing future. The analysis of the scenarios suggests the following conclusions to be drawn:

Sustainable manufacturing will only become a reality if lead markets can be created

The scenarios indicate that the approach manufacturers will adopt to strike the balance between the three pillars of sustainability might vary considerably depending on the socio-economic framework. European manufacturers will actively pursue sustainability objectives only if they can anticipate new market opportunities. Without new market and policy incentives, manufacturers are more likely to concentrate on short-term economic performance improvements, rather than on long-term sustainability considerations. As a consequence, sustainability in manufacturing might be compromised or it will emerge as the unintended side effect rather than being the results of a balanced industrial policy approach. The creation of market opportunities for sustainable products and services will require the successful alignment of technological, organisational and social innovations to overcome rigidities and technological lock-ins.

Different policy priorities support different technology trajectories

The scenarios suggest that the future technological and market challenges for manufacturers can be quite clearly defined on a fifteen-year time horizon. The socio-economic framework will shape the adoption and the specific characteristics of new technology in future manufacturing solutions. Application of technology will mirror industry's approaches to tackle and balance competing challenges (i.e. related to global, economic, regulatory, and consumer pressures). The scenarios point to different possible development paths that might be followed in the future. The scenarios challenge the idea that new technology is the sole driver for socio-economic development and imperatively revolutionises the way Europe produces and consumes. The stories

presented in the scenarios argue that without sufficient policy or consumer stimulus, traditional practices in manufacturing might direct technology development along existing technological paradigms, rather than to the creation of new and more sustainable technological regimes. Undoubtedly, there is still significant potential for improving the sustainability record of industry along existing trajectories, even though investments may show diminishing returns in the future. More radical manufacturing innovations will require socio-economic and policy changes to accompany technological change (e.g. transformation towards renewable resources, mini-plant manufacturing, etc.). The transition from supply-side (i.e. selling products) to demand-side (i.e. deliver services) manufacturing, in particular, requires policy stimuli in order to gain momentum. Environmental and market regulation and public support for the provision of new infrastructure are critical issues to make system change happen.

Exploit the strengths of Europe's manufacturing industry

The scenarios point to promising strengths of Europe's manufacturers that help realise the vision of sustainable development. In the scenario exercise the automotive industry and the chemicals sector emerged in particular as precursors for sustainable manufacturing. Europe can build on its competitive advantages and help industries create lead markets for more innovative sustainable products and services. Concerted European policies can foster the creation of lead markets by stimulating demand, fiscal incentives, (environmental) regulation and by reducing investment and market uncertainties (i.e. investment in new infrastructure).

Transition towards renewable resources will require sustained public backing

Whilst raising resource efficiency is clearly in the interest of the manufacturing industry and progress is likely to materialise in all scenarios, the transition towards renewable materials and energy resources will be far more challenging. Improvements in industrial resource efficiency are likely to materialise in the future even if energy and resource prices remain low over the next fifteen to twenty years. Plenty of efficiency improvement measures do not require new energy or material sources: modelling and simulation, micro-production technology and improved process technology will help industry to reap the benefits of new technology. In contrast, raising the use of renewables is likely to depend on high energy prices. The transition towards renewables will also require strong public commitment, especially to finance infrastructure, and is likely to continue far beyond the 2020 time horizon. In the medium term, bio-resources are more likely to substitute non-renewables in existing production chains rather than building the starting point for radically new manufacturing processes. If Europe wants to increase the use of bio-resources significantly it will have to adapt its regulatory schemes and create incentives to allocate RTD and infrastructure investments accordingly.

Widespread technological and organisational change in manufacturing through nanotechnology might happen beyond the 2015-2020 time horizon

Both due to envisaged technological limitations and legacy structures in the economy and society, nanotechnology seems to be unlikely to radically change the patterns of manufacturing on the 2015-2020 time horizon. Whilst on the long term, nanotechnology has the potential to alter production patterns dramatically and provide strong support for sustainable development, on the short and medium-term the expectations about nanotechnology's contributions to sustainable development should not be overstated. Nevertheless, nanotechnology research proves of utmost strategic importance for Europe.

Stimulate a dialogue between governments, industry and society on new technology

The potential risks of new technology need to be taken into account to ensure public acceptance

in the future. The scenarios confirm the high potential of ICT (on the short and medium term) and nanotechnology (on the long term) on manufacturing processes and the future organisation of the industry. However, new technological progress in ICT and nanotechnology will undoubtedly create new challenges and risks too. Policies towards sustainable manufacturing need to take into account issues related to the potential risks of new technology. Among the questions that need to be addressed are: How does ubiquitous computing and ambient intelligence increase the risks for unlawful and intrusive practices? What are the effects of ICT in future production processes and embedded in product devices on privacy and identity? Where are the potential conflict lines between public security and privacy? What are the risks for the environment of the widespread use of nanostructured materials? What are the consequences of the hydrogen economy for occupational health and safety and public hazard management? How does the increased complexity of new materials and smart devices affect resource efficiency, life-cycles, recyclability and waste treatment? What are the long-term consequences of the transition towards renewable resources? Policy makers need to pay attention to these questions. Second-order-effects of new technology must not be omitted. If industry and governments fail to engender trust among consumers and citizens, public opposition may impede the adoption of technology. The adoption of the precautionary principle in technology development may help avoid unintended negative effects in the future.

Globalisation means that sustainable manufacturing has a strong global dimension

Sustainable manufacturing in Europe is affected by various global factors and has a strong international dimension. The scenarios indicate that global drivers of change can potentially both ease or reinforce international and European disparities. If global governance of trade (e.g. by WTO) remains mainly confined to open markets and facilitate global competition, existing strengths and weaknesses of nations and regions might become even more pronounced in the future than they are today. By the same token, progress towards sustainability might be limited. In contrast, if environmental and social issues become part of global economic and trade agreements, the global exchange of products, services and new ideas can contribute to a more balanced and sustainable industrial development.

Innovation for sustainable manufacturing requires addressing the interfaces between RTD policies with other critical policy fields

It goes without saying that RTD policies can only be one element in a broader, concerted policy approach needed to make sustainable development happen. Strong emphasis needs to be placed upon the management of the interfaces between RTD policy and other policy realms (e.g. competition policy, intellectual property rights, standardisation, education and training, environmental policy, labour market, employment and social policy) to facilitate the creation of a truly sustainable European manufacturing industry. Both diversity and excellence in European research will back sustainable development. On the one hand, diversity of academic and industrial research can create innovative local clusters. On the other hand, policies shall promote critical mass research, scientific excellence, and the transfer of knowledge within Europe. Strong regional policies combined with co-ordination of strategically important RTD topics at European level provide the best prospects for industrial innovation in support of sustainable development.

Standardisation, metrology, and intellectual property rights will be critical enablers for the successful adoption of new manufacturing technology

Industrial standardisation, metrology and intellectual property rights (IPR) emerged as future

key challenges to be meet for the successful exploitation of new technology. Innovation processes will become increasingly multidisciplinary. The need for knowledge exchange and networking in RTD across organisational boundaries will increase the pressure on the current IPR framework. Tackling future metrology needs, especially related to nanotechnology (i.e. standards on measurement, testing, quality and performance of nanotechnology devices) are certainly critical issues for instrument engineering and the electronic industry. Other industries are affected too: in the automotive sector standardisation, for example, and interface management seem to be crucial for the long term success of alternative propulsion systems.

Multidisciplinarity is key to achieve radical technology breakthroughs

The FutMan scenarios point to a variety of technological opportunities which can only be taken advantage of if new skills and competencies can be made available. Sustainable manufacturing will require highly trained scientists and engineers who are able to co-operate with colleagues from other scientific backgrounds. In this respect, the notion of interdisciplinarity should not be defined too narrowly and aim to include socio-economic, market and policy research to overcome the existing barriers towards sustainability. Sustainable development is hardly conceivable without a broad problem sensitivity of those in industry, research, governments and the civil society who contribute to the shaping of innovation. University education and vocational training schemes should raise the awareness and problem solving capacity of students for integrating 'non-technical' issues in research questions and pay more attention to the transmission of 'soft skills'.