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Graduation Work

THE ROLE OF NANOTECHNOLOGY IN INTERNATIONAL ECONOMIC DEVELOPMENT

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Summary

The scale of the impact of nanotechnology on the world economy and the "disruptive" nature of the technology fully merit Government efforts to stimulate industrial activity and academic research in this vital subject.
In this section we talk about the role of nanotechnology in the economic development of world countries. Here is described the years when countries tried to build on an early successful nanotechnology program in order to maintain countries' prominent position in the field.
However, in some countries the levels of investment planned are insufficient to match those of other major international competitors.
Countries have spent billions over six years on related scientific development programs of the countries would have been better spent on the establishment and development of nanofabricated and nanoproduct producing facilities. The Department of Trade and Industry's decision to invite the Regional Development Agencies and Devolved Administrations to participate in the Micro and Nanotechnology Network initiative succeeded in creating a bigger pot of funding for both research and the provision of facilities, but at the cost of a clearly focused strategy.
Universities and academics have, in recent years, been generally slow to respond to the challenge of supporting nanotechnology research developing and some developed countries. The education and training programs are still in progress to be developed. The Research Councils should also take the lead in the funding of research into any environmental and health issues identified as requiring further study.
We also looked at nanotechnology as a case study of innovation policy in Azerbaijan. Countries' R&Ds and development programs which have aimed to match countries strategic interests, we have called for in previous reports. Also many of the barriers to successful innovation still exist.

Introduction

Nanotechnology is more than an exciting new technology. It represents a whole new method of manufacturing, which achieves control at the atomic scale. It is better described a collection of technologies which are genuinely “disruptive” – that is, they will render many existing technologies and processes obsolete and create entirely new types of products. Over the coming years and decades, nanotechnologies are set to make an enormous impact on manufacturing and service industries on electronics, information technology and on many other areas of life, from medicine to energy conservation. Just how large this impact will be is not easily quantifiable, but some forecasts have placed the worldwide market for nanotechnology–related products at around 0.105 billion by 2005and 0.700 billion by 2010. Nanotechnology has been described as a new industrial revolution.

Expert groups advised on the establishment of a strategy specifically designed to support the academic research and industrial capability necessary to allow countries to benefit from the commercial potential of nanotechnology.

In many ways nanotechnology is at a similar stage to the emerging biotechnology industry in the 1980s, a subject that was reported on at the time by Parliamentary Select Committees and has been revisited on a regular basis ever since. Although the science involved is largely different, the problem of turning the science into saleable goods remains the same. We have revisited some of the issues raised in that Report to see how much progress has been made. Our inquiry also coincided with a major re-examination by Government of the way it supports innovation and of the relationship between universities and business. We were able to take account of the implications of these reports for the Government’s nanotechnology strategy in the latter stages of our inquiry.

The focus of this inquiry was very much on the commercial exploitation of nanotechnology in the world countries. We deliberately excluded from our remit the possible risks associated with nanotechnology: the potential social, environmental and health implications of the new technologies.

In the course of the inquiry I held oral evidence sessions with the Ministry of Information and Communication of Azerbaijan, Azerbaijan Technical University (ATU), Baku State University (BSU), Azerbaijan National Academy of Sciences (ANAS) and academic researchers. I have learnt about government investments and research programs with the help of prof. Rufat Gulmammadov head of the Department of Information Society Development in Ministry of Information and Communication. I visited Azerbaijan National Academy of Sciences for research the special program on development of nanotechnology in Azerbaijan. Also for learning about scientific researches on laboratories and works done in marketing research, I met with the chiefs of nanotechnology center departments of BSU and ATU.

I met with the professor of Azerbaijan Pedagogical University prof. Kamal Huseynov which works as a chief of Nanotechnology research department of Azerbaijan Technical University. We discussed objectives of nanotechnology research laboratories of ATU. Prof. Kamal Huseynov introduced me technology and showed how they get nanochemical concentrates, in which industry and how they use this chemicals.

My third session was held in Baku State University, where I have met with the chief of the Nanotechnology Research Center, with prof. Mammad Ali Ramazanov. And I’ve learnt about Research Center’s objectives and work done by them and how much investments were made to this technology.

Then I met with the Orkhan Mikayilzadeh (engineer of SOCAR) and discussed the implications and technological improvements made by nanotechnology to oil industry. He explained me methods and benefits of using this technology.

With the help of those people I got necessary knowledge to complete my work.

1. Importance of Nanotechnology in International Economic Development

The rapid evolution of advanced technology has constantly served up innovation after innovation in super-compressed time frames. Information technology is now playing main role in promoting economies of countries and responsible for more than it was before. This is an astounding metric validating we are entering an era driven by accelerated technology developments that have increasingly a significant economic value. We are in the midst of a large-system paradigm shift driven by accelerated exponential growth of new technology. In 1989 American physicist Richard Feynman stated that many scientific problems will be solved after learning of to work in atomic scale. For the first time it was budgeted in US for the development of this science. Nowadays nanotechnology projects are invested by more than 9 billions USD per year. 80-90% of scientific issues are related with nanoscience. In the world 60 countries accepted state programs in nanotechnology area. Millions of dollars are defined to R&D for these programs.

The benefits of nanotechnology are price competitiveness, performance improvements, stability, consistency, quality of supply, compatibility with existing industrial processes, sufficient regulatory cover, synergy, innovations and etc. Nanotechnology have applied to almost all industries; medicine, energy, chemistry, heavy industry, information and communication, food, military and etc.

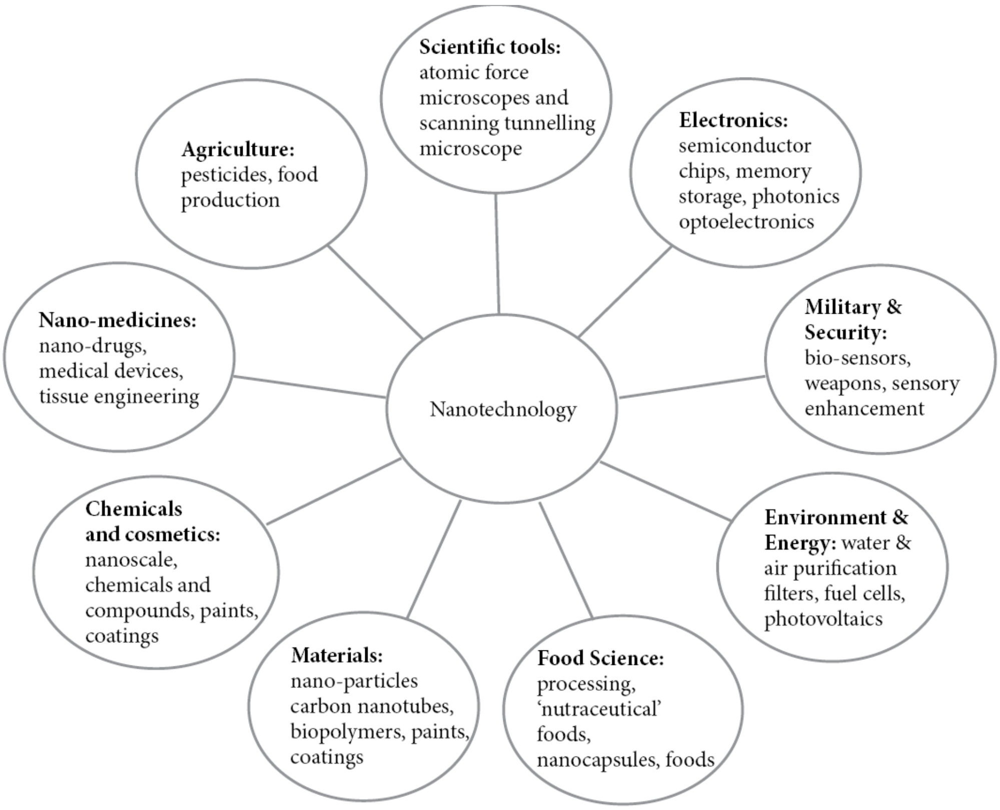

Figure 1: Nanotechnology applications (Source: Hodge & Browman 2006)

It is very widespread in developed countries such as US, Japan, Germany, UK, France and etc. Nanoscience is very young and fast growing science. Technological revolution made by Nanotechnology appealed attention of countries of the world to invest in this technology. Now there are many laboratories and plants which are producing nanoproducts around the world. The huge investments for this science improves that nanotechnology is very important in the development of the world economy.

1.1 What is Nanotechnology?

Nanoscience is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers. Where nanotechnologies are the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale. Encompassing nanoscale science, engineering, and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale. A nanometer is one-billionth of a meter. A sheet of paper is about 100,000 nanometers thick; a single gold atom is about a third of a nanometer in diameter. Dimensions between approximately 1 and 100 nanometers are known as the nanoscale. Unusual physical, chemical, and biological properties can emerge in materials at the nanoscale. These properties may differ in important ways from the properties of bulk materials and single atoms or molecules.
There has been much debate on the future implications of nanotechnology. Nanotechnology has the potential to create many new materials and devices with a vast range of applications, such as in medicine, electronics and energy production. On the other hand, nanotechnology raises many of the same issues as with any introduction of new technology, including concerns about the toxicity and environmental impact of nanomaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

Thus now, at the beginning of a new century, three powerful technologies have met on a common scale — the nanoscale — with the promise of revolutionizing both the worlds of electronics and of biology. This new field, which we refer to as biomolecular nanotechnology, holds many possibilities from fundamental research in molecular biology and biophysics to applications in biosensing, biocontrol, bioinformatics, genomics, medicine, computing, information storage and energy conversion.

The first observations and size measurements of nano-particles was made during the first decade of the 20th century. They are mostly associated with Richard Adolf Zsigmondy who made a detailed study of gold sols and other nanomaterials with sizes down to 10 nm and less.

There have been many significant developments during the 20th century in characterizing nanomaterials and related phenomena, belonging to the field of interface and colloid science. There are many other discoveries that serve as the scientific basis for the modern nanotechnology. Areas of physics such as nanoelectronics, nanomechanics and nanophotonics have evolved during the last few decades to provide a basic scientific foundation of nanotechnology.

Two main approaches are used in nanotechnology. In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. In the "top-down" approach, nano-objects are constructed from larger entities without atomic-level control. We will cover approaches used in nanotechnology more detailed in previous questions.

History of Nanotechnology

The term "nanotechnology" was first defined by Norio Taniguchi of the Tokyo Science University in a 1974 paper as follows: "'Nano-technology' mainly consists of the processing of, separation, consolidation, and deformation of materials by one atom or one molecule." Since that time the definition of nanotechnology has generally been extended to include features as large as 100 nm. Additionally, the idea that nanotechnology embraces structures exhibiting quantum mechanical aspects, such as quantum dots, has further evolved its definition.

Nanotechnology and nanoscience got a boost in the early 1980s with two major developments: the birth of cluster science and the invention of the scanning tunneling microscope (STM). This development led to the discovery of fullerenes in 1985 and the structural assignment of carbon nanotubes a few years later. In another development, the synthesis and properties of semiconductor nanocrystals were studied. This led to a fast increasing number of semiconductor nanoparticles of quantum dots. The atomic force microscope (AFM or SFM) was invented six years after the STM was invented. In 2000, the United States National Nanotechnology Initiative was founded to coordinate Federal nanotechnology research and development.

1.2 Related Industries of Nanotechnology.

With nanotechnology, a large set of materials and improved products rely on a change in the physical properties when the feature sizes are shrunk. Thus influences industries to shift their technology to nanotechnology. Consumers buy the nanoproducts and take more benefit because the features are large and price of a good is less than ordinary products. That gives incentives to buyers to buy the nanoproduct. But sometimes the price is higher than the market price. One of the reason may be the product is new in the market.
Therefore, an increasing societal benefit of nanoparticles can be expected. Nanotechnologically enhanced materials will enable a weight reduction accompanied by an increase in stability and an improved functionality. Many industries use nanotechnology in their business cycling.

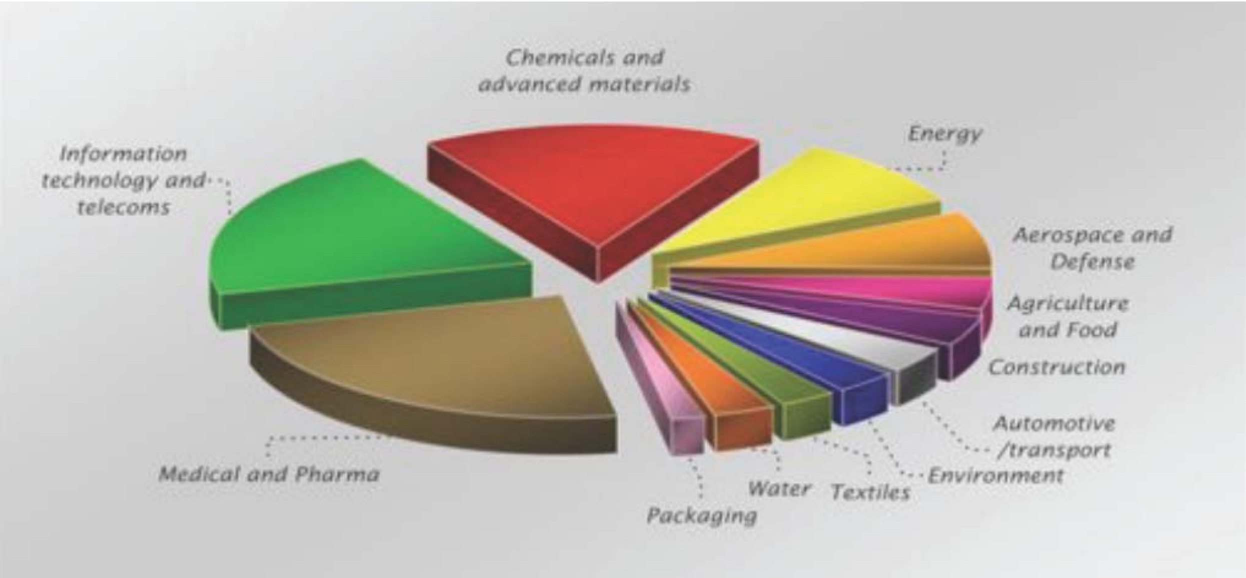

Figure 2: Numbers of Companies by Activity (Source: Cientifica Ltd)

Medicine

The biological and medical research communities have exploited the unique properties of nanomaterials for various applications (e.g., contrast agents for cell imaging and therapeutics for treating cancer). Terms such as biomedical nanotechnology, nanobiotechnology, and nanomedicine are used to describe this hybrid field. Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures. Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

Diagnostics: Nanotechnology-on-a-chip is one more dimension of lab-on-a-chip technology. Magnetic nanoparticles, bound to a suitable antibody, are used to label specific molecules, structures or microorganisms. Gold nanoparticles tagged with short segments of DNA can be used for detection of genetic sequence in a sample. Multicolor optical coding for biological assays has been achieved by embedding different-sized quantum dots into polymeric microbeads. Nanopore technology for analysis of nucleic acids converts strings of nucleotides directly into electronic signatures.

Drug delivery: Nanotechnology has been a boom in medical field by delivering drugs to specific cells using nanoparticles. The overall drug consumption and side-effects can be lowered significantly by depositing the active agent in the morbid region only and in no higher dose than needed. This highly selective approach reduces costs and human suffering. An example can be found in dendrimers and nanoporous materials. Another example is to use block co-polymers, which form micelles for drug encapsulation. They could hold small drug molecules transporting them to the desired location. Another vision is based on small electromechanical systems; NEMS are being investigated for the active release of drugs. Some potentially important applications include cancer treatment with iron nanoparticles or gold shells. A targeted or personalized medicine reduces the drug consumption and treatment expenses resulting in an overall societal benefit by reducing the costs to the public health system. Nanotechnology is also opening up new opportunities in implantable delivery systems, which are often preferable to the use of injectable drugs, because the latter frequently display first-order kinetics (the blood concentration goes up rapidly, but drops exponentially over time). This rapid rise may cause difficulties with toxicity, and drug efficacy can diminish as the drug concentration falls below the targeted range.

Tissue engineering: Nanotechnology can help to reproduce or to repair damaged tissue. “Tissue engineering” makes use of artificially stimulated cell proliferation by using suitable nanomaterial-based scaffolds and growth factors. Tissue engineering might replace today’s conventional treatments like organ transplants or artificial implants. Advanced forms of tissue engineering may lead to life extension.

For patients with end-state organ failure, there may not be enough healthy cells for expansion and transplantation into the ECM (extracellular matrix). In this case, pluripotent stem cells are needed. One potential source for these cells is iPS (induced Pluripontent Stem cells); these are ordinary cells from the patients own body that are reprogrammed into a pluripotent state, and has

the advantage of avoiding rejection (and the potentially life-threatening complications associated with immunosuppressive treatments). Another potential source of pluripotent cells is from embryos, but this has two disadvantages: 1) It requires that we solve the problem of cloning, which is technically very difficult (especially preventing abnormalities). 2) It requires the harvesting of embryos. Given that each one of us was once an embryo, this source is claimed by some to be ethically problematic.

Chemistry and Environment

Chemical catalysis and filtration techniques are two prominent examples where nanotechnology already plays a role. The synthesis provides novel materials with tailored features and chemical properties: for example, nanoparticles with a distinct chemical surrounding (ligands), or specific optical properties. In this sense, chemistry is indeed a basic nanoscience.

In a short-term perspective, chemistry will provide novel “nanomaterials” and in the long run, superior processes such as “self-assembly” will enable energy and time preserving strategies. In a sense, all chemical synthesis can be understood in terms of nanotechnology, because of its ability to manufacture certain molecules. Thus, chemistry forms a base for nanotechnology providing tailor-made molecules, polymers, etcetera, as well as clusters and nanoparticles.

Catalysis: Chemical catalysis benefits especially from nanoparticles, due to the extremely large surface to volume ratio. The application potential of nanoparticles in catalysis ranges from fuel cell to catalytic converters and photocatalytic devices. Catalysis is also important for the production of chemicals.
Platinum nanoparticles are now being considered in the next generation of automotive catalytic converters because the very high surface area of nanoparticles could reduce the amount of platinum required. However, some concerns have been raised due to experiments demonstrating that they will spontaneously combust if methane is mixed with the ambient air. Ongoing research at the Centre National de la Recherche Scientifique (CNRS) in France may resolve their true usefulness for catalytic applications. Nanofiltration may come to be an important application, although future research must be careful to investigate possible toxicity.

Filtration: A strong influence of nanochemistry on waste-water treatment, air purification and energy storage devices is to be expected. Mechanical or chemical methods can be used for effective filtration techniques. One class of filtration techniques is based on the use of membranes with suitable hole sizes, whereby the liquid is pressed through the membrane. Nanoporous membranes are suitable for a mechanical filtration with extremely small pores smaller than 10 nm (“nanofiltration”) and may be composed of nanotubes. Nanofiltration is mainly used for the removal of ions or the separation of different fluids. On a larger scale, the membrane filtration

technique is named ultrafiltration, which works down to between 10 and 100 nm. One important field of application for ultrafiltration is medical purposes as can be found in renal dialysis. Magnetic nanoparticles offer an effective and reliable method to remove heavy metal contaminants from waste water by making use of magnetic separation techniques. Using nanoscale particles increases the efficiency to absorb the contaminants and is comparatively inexpensive compared to traditional precipitation and filtration methods.
Some water-treatment devices incorporating nanotechnology are already on the market, with more in development. Low-cost nanostructured separation membranes methods have been shown to be effective in producing potable water in a recent study.

Energy

The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving (by better thermal insulation for example), and enhanced renewable energy sources

Reduction of energy consumption: A reduction of energy consumption can be reached by better insulation systems, by the use of more efficient lighting or combustion systems, and by use of lighter and stronger materials in the transportation sector. Currently used light bulbs only convert approximately 5% of the electrical energy into light. Nanotechnological approaches like light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination.

Increasing the efficiency of energy production: Today's best solar cells have layers of several different semiconductors stacked together to absorb light at different energies but they still only manage to use 40 percent of the Sun's energy. Commercially available solar cells have much lower efficiencies (15-20%). Nanotechnology could help increase the efficiency of light conversion by using nanostructures with a continuum of bandgaps. The degree of efficiency of the internal combustion engine is about 30-40% at the moment. Nanotechnology could improve combustion by designing specific catalysts with maximized surface area. In 2005, scientists at the University of Toronto developed a spray-on nanoparticle substance that, when applied to a surface, instantly transforms it into a solar collector.

The use of more environmentally friendly energy systems: An example for an environmentally friendly form of energy is the use of fuel cells powered by hydrogen, which is ideally produced by renewable energies. Probably the most prominent nanostructured material in fuel cells is the catalyst consisting of carbon supported noble metal particles with diameters of 1-5 nm. Suitable materials for hydrogen storage contain a large number of small nanosized pores. Therefore many nanostructured materials like nanotubes, zeolites or alanates are under investigation. Nanotechnology can contribute to the further reduction of combustion engine pollutants by nanoporous filters, which can clean the exhaust mechanically, by catalytic converters based on nanoscale noble metal particles or by catalytic coatings on cylinder walls and catalytic nanoparticles as additive for fuels.

Recycling of batteries: Because of the relatively low energy density of batteries the operating time is limited and a replacement or recharging is needed. The huge number of spent batteries and accumulators represent a disposal problem. The use of batteries with higher energy content or the use of rechargeable batteries or supercapacitors with higher rate of recharging using nanomaterials could be helpful for the battery disposal problem.

Information and communication

Current high-technology production processes are based on traditional top down strategies, where nanotechnology has already been introduced silently. The critical length scale of integrated circuits is already at the nanoscale (50 nm and below) regarding the gate length of transistors in CPUs or DRAM devices.

Memory storage: Electronic memory designs in the past have largely relied on the formation of transistors. However, research into crossbar switch based electronics have offered an alternative using reconfigurable interconnections between vertical and horizontal wiring arrays to create ultra high density memories. Two leaders in this area are Nantero which has developed a carbon nanotube based crossbar memory called Nano-RAM and Hewlett-Packard which has proposed the use of memristor material as a future replacement of Flash memory.

Novel semiconductor devices: An example of such novel devices is based on spintronics.The dependence of the resistance of a material (due to the spin of the electrons) on an external field is called magnetoresistance. This effect can be significantly amplified (GMR - Giant Magneto-Resistance) for nanosized objects, for example when two ferromagnetic layers are separated by a nonmagnetic layer, which is several nanometers thick (e.g. Co-Cu-Co). The GMR effect has led to a strong increase in the data storage density of hard disks and made the gigabyte range possible. The so called tunneling magnetoresistance (TMR) is very similar to GMR and based on the spin dependent tunneling of electrons through adjacent ferromagnetic layers. Both GMR and TMR effects can be used to create a non-volatile main memory for computers, such as the so called magnetic random access memory or MRAM.
In 1999, the ultimate CMOS transistor developed at the Laboratory for Electronics and Information Technology in Grenoble, France, tested the limits of the principles of the MOSFET transistor with a diameter of 18 nm

(approximately 70 atoms placed side by side). This was almost one tenth the size of the smallest industrial transistor in 2003 (130 nm in 2003, 90 nm in 2004, 65 nm in 2005 and 45 nm in 2007). It enabled the theoretical integration of seven billion junctions on a €1 coin. However, the CMOS transistor, which was created in 1999, was not a simple research experiment to study how CMOS technology functions, but rather a demonstration of how this technology functions now that we ourselves are getting ever closer to working on a molecular scale. Today it would be impossible to master the coordinated assembly of a large number of these transistors on a circuit and it would also be impossible to create this on an industrial level.

Novel optoelectronic devices: In the modern communication technology traditional analog electrical devices are increasingly replaced by optical or optoelectronic devices due to their enormous bandwidth and capacity, respectively. Two promising examples are photonic crystals and quantum dots. Photonic crystals are materials with a periodic variation in the refractive index with a lattice constant that is half the wavelength of the light used. They offer a selectable band gap for the propagation of a certain wavelength, thus they resemble a semiconductor, but for light or photons instead of electrons. Quantum dots are nanoscaled objects, which can be used, among many other things, for the construction of lasers. The advantage of a quantum dot laser over the traditional semiconductor laser is that their emitted wavelength depends on the diameter of the dot. Quantum dot lasers are cheaper and offer a higher beam quality than conventional laser diodes.

Displays: The production of displays with low energy consumption could be accomplished using carbon nanotubes (CNT). Carbon nanotubes are electrically conductive and due to their small diameter of several nanometers, they can be used as field emitters with extremely high efficiency for field emission displays (FED). The principle of operation resembles that of the cathode ray tube, but on a much smaller length scale.

Quantum computers: Entirely new approaches for computing exploit the laws of quantum mechanics for novel quantum computers, which enable the use of fast quantum algorithms. The Quantum computer has quantum bit memory space termed "Qubit" for several computations at the same time. This facility may improve the performance of the older systems.

Heavy Industry

An inevitable use of nanotechnology will be in heavy industry

Aerospace: Lighter and stronger materials will be of immense use to aircraft manufacturers, leading to increased performance. Spacecraft will also benefit, where weight is a major factor. Nanotechnology would help to reduce the size of equipment and thereby decrease fuel-consumption required to get it airborne.

Hang gliders may be able to halve their weight while increasing their strength and toughness through the use of nanotech materials. Nanotech is lowering the mass of supercapacitors that will increasingly be used to give power to assistive electrical motors for launching hang gliders off flatland to thermal-chasing altitudes.

Construction: Nanotechnology has the potential to make construction faster, cheaper, safer, and more varied. Automation of nanotechnology construction can allow for the creation of structures from advanced homes to massive skyscrapers much more quickly and at much lower cost.

Refineries: Using nanotech applications, refineries producing materials such as steel and aluminum will be able to remove any impurities in the materials they create.

Vehicle manufacturers: Much like aerospace, lighter and stronger materials will be useful for creating vehicles that are both faster and safer. Combustion engines will also benefit from parts that are more hard-wearing and more heat-resistant.

Consumer goods

Nanotechnology is already impacting the field of consumer goods, providing products with novel functions ranging from easy-to-clean to scratch-resistant. Modern textiles are wrinkle-resistant and stain-repellent; in the mid-term clothes will become “smart”, through embedded “wearable electronics”. Already in use are different nanoparticle improved products. Especially in the field of cosmetics, such novel products have a promising potential.

Foods: Complex set of engineering and scientific challenges in the food and bioprocessing industry for manufacturing high quality and safe food through efficient and sustainable means can be solved through nanotechnology. Bacteria identification and food quality monitoring using biosensors; intelligent, active, and smart food packaging systems; nanoencapsulation of bioactive food compounds are few examples of emerging applications of nanotechnology for the food industry. Nanotechnology can be applied in the production, processing, safety and packaging of food. A nanocomposite coating process could improve food packaging by placing anti-microbial agents directly on the surface of the coated film. Nanocomposites could increase or decrease gas permeability of different fillers as is needed for different products. They can also improve the mechanical and heat-resistance properties and lower the oxygen transmission rate. Research is being performed to apply nanotechnology to the detection of chemical and biological substances for sensanges in foods.

- **Nano-foods:** New consumer products Emerging Nanotechnologies (PEN), based on an inventory it has drawn up of 609 known or claimed nano-products.

On PEN's list are three foods -- a brand of canola cooking oil called Canola Active Oil, a tea called Nanotea and a chocolate diet shake called Nanoceuticals Slim Shake Chocolate.

According to company information, the canola oil, by Shemen Industries of Israel, contains an additive called "nanodrops" designed to carry vitamins, minerals and phytochemicals through the digestive system and urea

The shake, according to U.S. manufacturer RBC Life Sciences Inc., uses cocoa infused "NanoClusters" to enhance the taste and health benefits of cocoa without the need for extra sugar.

Household: The most prominent application of nanotechnology in the household is self-cleaning or “easy-to-clean” surfaces on ceramics or glasses. Nanoceramic particles have improved the smoothness and heat resistance of common household equipment such as the flat iron.

Optics: The first sunglasses using protective and anti-reflective ultrathin polymer coatings are on the market. For optics, nanotechnology also offers scratch resistant surface coatings based on nanocomposites. Nano-optics could allow for an increase in precision of pupil repair and other types of laser eye surgery.

Textiles: The use of engineered nanofibers already makes clothes water- and stain-repellent or wrinkle-free. Textiles with a nanotechnological finish can be washed less frequently and at lower temperatures. Nanotechnology has been used to integrate tiny carbon particles membrane and guarantee full-surface protection from electrostatic charges for the wearer. Many other applications have been developed by research institutions such as the Textiles Nanotechnology Laboratory at Cornell University

Cosmetics: One field of application is in sunscreens. The traditional chemical UV protection approach suffers from its poor long-term stability. A sunscreen based on mineral nanoparticles such as titanium dioxide offer several advantages. Titanium oxide nanoparticles have a comparable UV protection property as the bulk material, but lose the cosmetically undesirable whitening as the particle size is decreased.

Agriculture: Applications of nanotechnology have the potential to change the entire agriculture sector and food industry chain from production to conservation, processing, packaging, transportation, and even waste treatment. NanoScience concepts and Nanotechnology applications have the potential to redesign the production cycle, restructure the processing and conservation processes and redefine the food habits of the people. Major Challenges related to agriculture like Low productivity in cultivable areas, Large uncultivable areas, Shrinkage of cultivable lands, Wastage of inputs like water, fertilizers, pesticides, Wastage of products and of course Food security for growing numbers can be addressed through various applications of nanotechnology.

1.3 In which countries' economy nanotechnology was applied

Although nanotechnology is an emerging and high technology, it is still technology or, in other words, it has an instrumental nature and in order to study its effect on societies we have to consider the role of instruments' evolution in societies and study nanotechnology as the most recent part of this trend. It is important to know the nature of modern technologies, role of technology based economy on different social and political aspects of developing countries; we have a review on the concept of social and political modernity and describe how development of nanotechnology will accelerate those countries' modernization from social and political point of view in addition to modernizing their economy. There are two different scenarios about the future of nanotechnology. One is the proof of radical nanotechnology and the other is the acceptance of the claim that nanotechnology is only an enabling technology.

Technological development plays the most important role in societies' and countries' development in the past two or three centuries.

All kinds of technologies and applied sciences have sociopolitical consequences but the situation of nanotechnology is different because Nanotechnology refers, not to one discrete branch of applied science but, to a set of diverse techniques that involve a variety of scientific disciplines. Of course, effects of such a technology will be broader and more complex. It seems that most of technology researchers confirmed such a convergence. If we try to see this issue from a more technical point of view we have to explain that as nano-scale manipulations are now possible and, as the basic components of both living and non-living matter exist on the nano-scale, it is now possible to converge technologies (and to converge scientific disciplines) to an unprecedented degree. Technological convergence, enabled by nanotechnology and its tools, can involve biology and biotechnology, physics, material sciences, chemistry, cognitive sciences, informatics, applied mathematics, electronics and robotics, among others.

If technical part of the socio-technical system of developing countries changes from backward industrial companies and exportation of raw materials to nanotechnology as the convergence of modern technologies, the socio-political part and cultural meaning around will become modern.

The main part of government expenditures and investment on R&D of nanotechnology are allocated among developed countries such as USA, Japan, UK, Germany, Netherland and etc.

Here are some important indicators that show importance of nanotechnology in those countries.

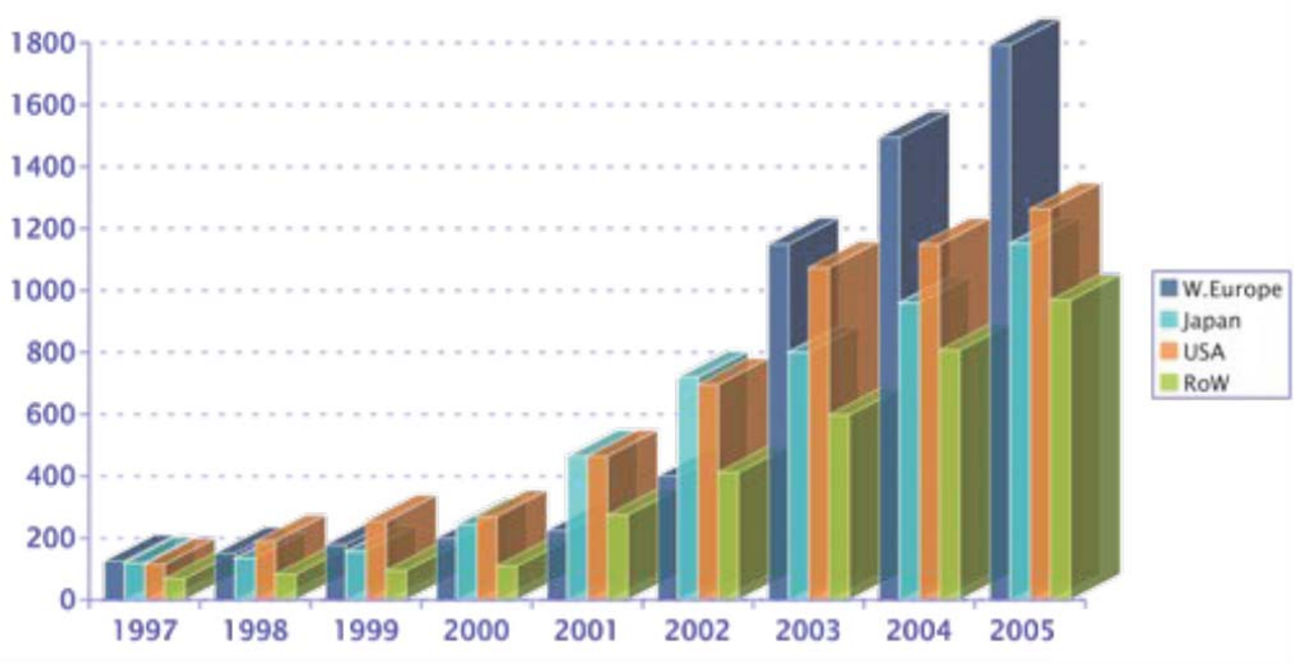

Figure 3: Government Funding of Nanotechnologies

In the graph we see that in 1997 government spending of the countries was less but by the time those countries increased the amount of investment because of increasing importance of nanotechnology in the world. As a country, USA is a leader in the amount of funding of nanotechnology (note that; the column of W. Europe shows sum of the regions countries portion)

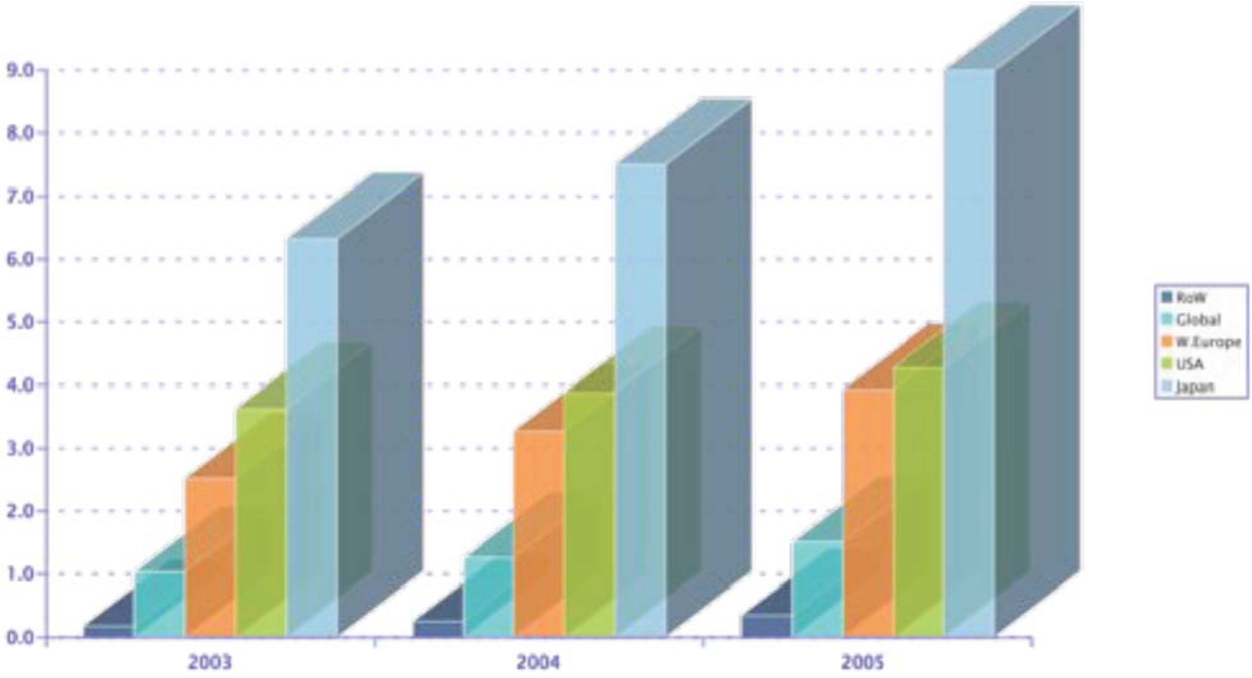

Figure 4: Government spending per capita (in USD)

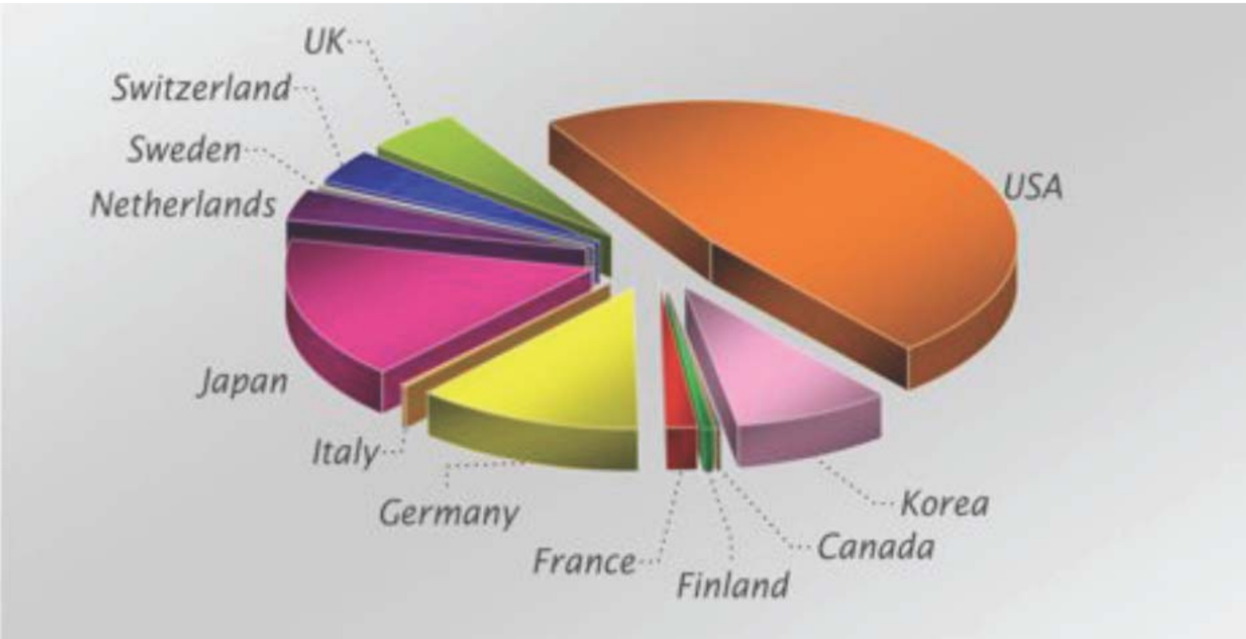

Figure 5: Private nanotech spend by Country (2005)

There is shown distribution of private sector's spending on nanotechnology among countries. And USA is leader in private sectors' spending.

International cooperation is important on development of nanotechnology. Many agencies and representatives participate in many international activities, including bilateral and multilateral cooperative programs, monitoring of foreign nanotechnology R&D, and promotion of the trade and commercial interests of the countries. Cooperation and collaboration with other nations on nanoscale science and technology R&D, particularly in pre-competitive and non-competitive research areas, can further the progress of the nanotechnology programs while helping international partners achieve their own goals. World countries seek to foster mutually beneficial relationships with other countries, in order to establish a framework for the safe, secure, and responsible use of nanotechnology worldwide.

In keeping with the nanotechnology programs' goal of supporting responsible development of nanotechnology, international environmental, safety and security concerns surrounding the use of nanotechnology-enabled products are appropriately addressed by the global scientific community and relevant regulatory agencies. Effective communication among scientists, regulators, policy makers, consumers, industrial leaders, and other stakeholders also will be enhanced by cooperation with international partners. The development of a healthy global marketplace for nanotechnology products and ideas will require the establishment of consumer confidence, common approaches to nanotechnology environmental, health, and safety issues, efficient and effective regulatory schemes, and equitable trade paces for nanotechnology, not just in the United States, but worldwide.

The NSET Subcommittee's Global Issues in Nanotechnology (GIN) Working Group coordinates international activities in nanotechnology, monitors foreign nanotechnology programs, and seeks to broaden international cooperation and communication with respect to nanotechnology R&D. The working group has representatives from all Federal agencies that have active nanotechnology R&D programs as well as from numerous agencies that have oversight roles in international affairs.

There are many nanotechnology related government and non-governmental organizations and programs in the world that are investing huge amount of money in research and development of nanotechnology. Some of them are shown below:

- National Center for Nanoscience and Technology (China)
- National Institute for Nanotechnology (Canada)
- Iranian Nanotechnology Laboratory Network
- EU Seventh Framework Programme and Action Plan for Nanosciences and Nanotechnologies 2005-2009
- Russian Nanotechnology Corporation
- Nanotechnology Development Program (Azerbaijan)
- National Nanotechnology Center (NANOTEC), Thailand
- National Nanotechnology Initiative (United States)

Nanotechnology Development Program of Azerbaijan Republic (NDPAR or NDP)

NDP is mainly government budgeted program with the aim of initiating and developing the nanotechnology in Azerbaijan. The main purpose of the scientific program of nanomaterials and nanotechnology in the Republic of Azerbaijan is to prepare base level for the education and technology. Program should provide integration of nanotechnology to the world's developed countries and develop it in Azerbaijan. The main goals of NDP are:

- Nanotechnology in the field of human potential development.
- Organization and preparation nanotechnology and nanoscience R&D works for raising these field’s R&D to the level of world standards.
- Development and improvement of competitive nanotechnology product section in world markets.
- By improving nanotechnology in the field of military equipment and special material supply issues.
- Establishment of new medical methods of diagnostics and preparation of pharmaceutical items based on application of nanomaterials in various diseases prevention, diagnostics and treatment of the development of bases.

- Application of nanotechnology in environmental safety and environmental problems.
- Application of scientific bases for the development of technology for the oil nanomaterials.
- Preparation of integrated circuits and discrete semiconductor devices on the basis of Nanostructures.
- Application of nanotechnology-based products in the solution of problems of operations against the terrorist actions.

National Nanotechnology Initiative (USA)

The National Nanotechnology Initiative (NNI) is a multi-agency U.S Government program initiated in 2001 aimed at accelerating the discovery, development and deployment of nanometer-scale science, engineering and technology. The NNI is a coordinated program involving nanotechnology-related activities of 26 Federal agencies and 13 of which have budgets for nanotechnology R&D for 2008.

The vision of the NNI is a future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry. The current NNI Strategic Plan specifies four goals aimed at achieving that overall vision:

1. Maintain a world-class R&D program aimed at realizing the full potential of nanotechnology
2. Facilitate transfer of new technologies into products for economic growth, jobs and other public benefit
3. Develop educational resources, a skilled workforce and development of nanotechnology.

Towards these goals, the NNI agencies have:

- Funded thousands of individual R&D projects since the NNI's inception, contributing to U.S. world leadership in share of citations in leading nanoscience and nanotechnologies journals

- “Produced significant advances in a variety of potential application areas and are progressing from fundamental discovery to technological applications and commercialization“as reported by National Academies
- Funded almost $200 million in nanotechnology-related Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) projects between 2004 and 2006 to aid in the commercialization of nanotechnology

National Center for Nanoscience and Technology (China)
The National Center for Nanoscience and Technology (NCNST) of China is co-founded by Chinese Academy of Sciences (CAS) and Ministry of Education . It is a subsidiary non-profit organization of CAS which is financed with a status of independent non-profit legal entity. It will have 155 formal employees. The center was officially founded on December 31, 2003, with CAS, Peking University and Tsinghua University as its initiators and co-founders.

In NCNST, basic and applied researches in nanoscience have been positioned as the main research directions. Its objective is to build a public technological platform and research base for nanoscience, which is featured with state of the art equipments and is open to both domestic and international users.

The NCNST mainly consists of following branches:

- Laboratory for nanodevice
- Laboratory for nanomaterials
- Laboratory for biological effects of nanomaterials and nanosafety
- Laboratory for nanocharacterization
- Laboratory for nanostandardization
- Laboratory for nanomanufacture and applications
- Testing laboratory for nanostructures
- Nanofabrication laboratory
- Coordination laboratories

- Website and some databases for nanoscience

The NCNST scientist mainly research on the laboratories and testing laboratories for nanomaterials, nanofabrication, nanodevices, biological effects of nanomaterials, nanostandardization, nanomanufacture and applications divisions.

In the area of international collaborations and exchanges, NCNST has kept in touch with many countries including Germany, France, UK, Switzerland, Denmark, Finland, United States, Russia, South Korea, Japan and etc.

National Institute for Nanotechnology (Canada)

The National Institute for Nanotechnology (NINT) is a Government of Canada research institution located on the University of Alberta main campus, in Edmonton, Alberta, Canada. Its primary purpose is nanotechnological research.

The institute was established in 2001 as a partnership between the National Research Council of Canada, the University of Alberta, and the Government of Alberta. It is administered as an institute of the National Research Council of Canada (NRC), and governed by a Board of Trustees nominated by the partners. Its core funding comes from the Government of Canada and additional funding and research support comes from the university, Government of Alberta, and various federal and provincial funding agencies.

In June 2006, the institute moved into its present 20,000 square metre facility, designed to be one of the world's largest buildings for nanotechnological research. There are at most two or three other facilities worldwide matching the new building in scale and capacity.

According to NINT's research plan, the institute's research focus is in the following areas:

- Synthesis and characterization of nanocrystals and nanowires
- Synthesis of supramolecular-based nanomaterials

- Fabrication and characterization of molecular-scale devices and nanosensors
- Development of nano-scaled materials for catalysis and directed chemical reactions at semiconductor surfaces
- Development of nano-electronic and nano-fluidic systems to interface devices to the outside world
- Theory, modeling, and simulation of nanosystems on multiple length scales
- Development of quantitative imaging and characterization techniques that support nanotechnology research
- Examination of the ethical, environmental, economic, legal and social issues of nanotechnology
- Research on nano-bioengineering such as protein design and genetic engineering of novel behaviours
- Development of nanoelectricalmechanical systems (NEMS), such as lab-on-a-chip devices

Russian Nanotechnology Corporation

Russian Nanotechnology Corporation is a Russian non-profit state owned corporation, which has been created according to the law "On the Russian Nanotechnology Corporation. The upper house, the Federation Council, approved it on July 6. The corporation is expected to ensure interaction between government, business, and scientists in the implementation of state policy in nanotechnology and the nano-industry. It offers numerous benefits under tax and commercial legislation. Russian government is planning to allocate more than US$ 5 billion. The main function of Nano technology Corporation of Russia is to interact between business, government and scientists for implementing the state policy in nano industry and nano technology. It also provides financial and organizational assistance for nano projects and programs.

Action Plan for Nanosciences and Nanotechnologies (EU)

On the 12th May 2004, the European Commission adopted the Communication “Towards a European Strategy for Nanotechnology”. It seeks to bring the discussion on nanoscience and nanotechnology to an institutional level and proposes an integrated and responsible strategy for Europe.

On the 7th June 2005, the European Commission adopted the Action Plan "Nanosciences and nanotechnologies: An action plan for Europe 2005-2009". This Action Plan defines a series of articulated and interconnected actions for the immediate implementation of a safe, integrated and responsible strategy for nanosciences and nanotechnologies, based on the priority areas identified in the above-mentioned Communication.

Elements of the nanotechnology Action Plan

1. Research, development and innovation: European needs knowledge

For more information see EU funding and Information about projects

2. Infrastructures and European Poles of Excellence

For more information see Financing and Innovation

3. Interdisciplinary human resources: Europe needs creativity

For more information, see Education and Mobility

4. Industrial Innovation: From knowledge to the market

For more information, see Financing and Innovation

5. Integrating the societal dimension: Adressing expectations and concerns

For more information, see Communication and Debate

6. Public health, safety, environmental and consumer protection

For more information, see Safety Aspects

7. International cooperation

For more information, see International Co-operation

The Council of the European Union discussed the European strategy for nanotechnology in its session on 24th September 2004 in a public debate.

It endorsed the integrated and responsible strategy proposed in the Communication.

The Single Market, Production and Consumption section of the European Economic and Social Committee (EESC) adopted a positive opinion on the Commission's strategy on nanotechnology and a positive opinion on the action plan on nanotechnology:

- Opinion of the EESC on Towards a European strategy for nanotechnology
- Opinion of the EESC on Nanosciences and nanotechnologies: An action plan for Europe 2005-2009

On 28 September 2006, the European Parliament adopted a resolution on the action plan on nanotechnology.

Nanotechnology education

Nanotechnology education is being offered by more and more universities around the world. The first program involving nanotechnology was offered by the University of Toronto's Engineering Science program, where nanotechnology could be taken as an option. Generally, nanotechnology education involves a multidisciplinary natural science education with courses in nanotechnology, physics, chemistry, math and molecular biology. There are shown countries, which their universities offering nanotechnology education

Azerbaijan, Brazil, Mexico, Belgium, Czech Republic, Denmark, France, Germany, Greece, Israel, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom, Turkey, United States, Australia, New Zealand, Canada, India, Hong Kong, Singapore, Thailand, Malaysia, Japan and other countries.

Promotion and support of Nanotechnology in the world

In the U.S. large industry currently supports about half of the R&D in nanotechnology—about $2 billion per year. The other half comes from small business and investors, as well as Federal, state and local governments.

Federal research grants are defined and awarded by individual government departments and agencies, in accordance with their respective missions.

In addition to grants are special programs designed to seed commercialization activity that facilitates economic growth. These programs support small business collaboration with universities and other research institutions.

Facilitating business partnerships, state and regional funding and a positive business environment are goals of economic development initiatives that have formed across the country specifically for nanotechnology.

Tech-Net, sponsored by the U.S. Small Business Administration, is an Internet-based database of information containing Small Business Innovation Research (SBIR) awards, Small Business Technology Transfer (STTR) awards, Advanced Technology Program (ATP) awards, and Manufacturing Extension Partners (MEP) centers. It is a free service for those seeking small business partners, small business contractors and subcontractors, leading edge technology research, research partners (small businesses, universities, federal labs and non-profit organizations), manufacturing centers and investment opportunities.

NNI agencies will continue to make use of existing mechanisms for technology transfer and commercial development, such as the Small Business Innovation Research (SBIR) program, the Small Business Technology Transfer (STTR) program, and the Manufacturing Technology (MANTECH) program.

Participating Departments and Agencies

Departments and agencies currently participating in the SBIR program are: the National Institutes of Health, Departments of Agriculture (USDA), Defense (DOD), Education (DoED), Energy (DOE), and Transportation (DOT); the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Institute of Standards and Technology (NIST) SBIR and NIST Technology Innovation

Program (TIP) and the National Science Foundation (NSF). DARPA, the Air Force, Navy and Army have their own SBIR/STTR sites.

Federal agencies with extramural R&D budgets over $1 billion are required to administer STTR programs using an annual set-aside of 0.15%. The set-aside will increase to 0.3 percent in FY 2004. Currently, five Federal agencies participate in the STTR program: DOD, DOE, DHHS (NIH), NASA and NSF.

Laws covering these funding programs include the Small Business Innovation Development Act of 1982, the Small Business Research and Development Enhancement Act of 1992, and the Small Business Innovation Research Program Reauthorization Act of 2000.

The **Small Business Innovation Research Program (SBIR)** is a highly competitive program that encourages small business to explore their technological potential and provides the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

The **Technology Innovation Program (TIP)** supports, promotes, and accelerates innovation in the United States through high-risk, high-reward research in areas of critical national need. TIP has the agility and flexibility to make targeted investments in transformational R&D that will ensure our Nation’s future through sustained technological leadership.

The **Small Business Technology Transfer Program (STTR)** is an important small business program that expands funding opportunities in the federal innovation R&D arena. Central to the program is expanding the public/private sector partnership to include joint venture opportunities for small business and the nation's premier nonprofit research institutions.

The **Experimental Program to Stimulate Competitive Research (EPSCoR)** is a joint program of the National Science Foundation (NSF) and several U.S. states and territories. The program promotes the development of the states' science and technology (S&T) resources through partnerships involving a state's universities, industry, and government, and the Federal research and development (R&D) enterprise.

The Department of Defense (DoD) program, Defense Experimental Program to Stimulate Competitive Research (DEPSCoR), (under construction) is designed to expand research opportunities in states that have traditionally received the least funding in federal support for university research.
The Air Force Office of Scientific Research, the Army Research Office, the Office of Naval Research, and the Advanced Technology Development Directorate of the Missile Defense Agency solicit proposals using a defense-wide broad agency announcement.

2. Perspectives of Nanotechnology in World Economy

Recent developments in emerging technology and its impact on business and economics would indicate that forecasts are less than accurate in predicting the future. Few would have accurately forecasted innovations such as of the Internet, wireless communications or the mapping of the Human Genome. Also, there have been numerous wild forecasts that have historically seemed more like science fiction than fact. Predictions about nanotechnology have fueled the imagination. Much of this is still imagination but the future looks promising. Nevertheless, new innovations in technology are reshaping the global economy at a dizzying speed. It would be prudent to consider the possible economic outcomes given the accelerated emergence of advanced technology.

It is with this in mind that we turn to nanotechnology. Why is the potential economic impact of nanotechnology so important to consider? Nanotechnology is a fundamental design science that may well provide us with the tools to engineer inorganic and organic matter at the atomic level. Nanotechnology, if even partially realized, over the next few decades has the potential to realign society, business and economics at the structural level. Nanotechnology will touch all aspects of economics: wages, employment, purchasing; pricing, capital, exchange rates, currencies, markets, supply and demand. Nanotechnology may well drive economic prosperity or at the least be an enabling factor in shaping productivity and global competitiveness.

If developments in nanotechnology reach a critical mass in supplying radically innovative breakthroughs in automated self-assembly, as one example, most vertical industries will be influenced. Most industrial and post-industrial supply chains will be touched. Most value chains, supportive linkages, alliances and channels of distribution will be altered. Institutions of learning, financial services and certainly manufacturing will be reshaped. The issues that remain are to consider in what timeline what actions might be taken. How might we prepare as a society for these changes? Will there be radical dislocations or a smooth coordinated adaptation? We must plan for multiple scenarios. Radical nanotechnology innovations potentially unleashed on immature markets, fragile economies and a business community ill prepared for rapid post-industrial transformation would be problematic.

Imagine the emergence of a nanochip that tomorrow would deliver over 50 gigahertz of speed with the processing power of ten supercomputers for the price of a quartz watch and smaller than a key chain. What might the economic impact on the computer industry be overnight?

Imagine a super-strong and inexpensive material to be used for construction and manufacturing that would eliminate the market for steel and plastics. How might that influence the economy?

In a world being reshaped daily by innovations, the absurd today is reality tomorrow. But with the intimate inter-linkage of markets, industries and economies radical breakthrough technologies will have a widespread and far reaching impact--positive and negative. It is entirely possible, that just as computers and the Internet have become vital linchpins woven into the fundamental economic landscape of today's strong economy that nanotechnology will emerge as the technology that shapes the future economy. Many of the necessary factors are in place to drive this scenario: widespread potential cross-industry applications; fast track R&D; government investment. The risks in not preparing for and examining the economic and business impact are too large to consider. Nations today, ill prepared to capitalize on the Internet, the transformation of supply chains or the mobile commerce sparked by advanced telecommunications are playing catch up and it has hampered their productivity, GDP and competitiveness.

The Nanotechnology in Business Study

In 1999 the Institute for Global Futures deployed a privately funded study to assess the general awareness and readiness of the business community regarding the economic and business impact of nanotechnology. A series of interviews with a broad range of business executives in health care, manufacturing, medicine, real estate, information technology, consumer goods, entertainment and financial services was conducted, and is still being conducted at this time.

The Institute for Global Futures, a ten year old San Francisco organization advises the Fortune 1000 and government on the impact of leading-edge technology on markets, society, customers and the economy. The Institute covers telecommunications, robotics, computers, life sciences, the Internet, software, artificial intelligence and a host of other technologies and forecasts trends and conducts strategic planning impacting on over thirty vertical industries worldwide.

Nanotechnology Economic Scenarios: How Nations Prepare

In addition to this survey of business executives another activity has been undertaken as a integral part of this study. Given the relative and varying levels of social adaptation, we examined what might the potential scenarios be given the contrasting readiness factors of a society. The following scenarios are briefly described as a way to generate further exploration and discussion. The value of these scenarios maybe viewed as a catalyst for mapping future impact on an economy and society.

An attempt was made here to incorporate the key drivers that would shape the scenarios explored. Readiness is viewed as a precursor to these scenarios. The relative nature of socio-economic readiness, awareness and preparation will pre-determine these scenarios and others yet to be envisioned here. This is a work in progress and will be updated as new information becomes available. Societal readiness was defined as the awareness and ability to take action. It is viewed as a mission-essential driver of economic and industrial adaptation. As Nanotechnology may translate into the sustainability of nations, organizations and entire industries--readiness, the preparation and planning process becomes vitally important.

Scenario One: Brave New World

Timeline: 2010-2050

Economic Environment: Nanotechnology comprehensively integrated into the economy due to high readiness, effective strategic planning and widespread investments by business, education, labor and government. Accelerated national policy and investments producing economic agility and rapid widespread large system change management. An understanding of the strategic economic value on the nation and the role on global leadership. Numerous benefits from nanotechnology applications. Comprehensive social and industry-wide adoption has led to a positive impact on national productivity and an enhanced quality of life.

Key Characteristics: Robust gross national product; high productivity; global trade leadership; sustainable economic growth; global patent leadership; superior industrial competitiveness; integrated education and training resources; strong investment climate; plentiful capital liquidity; high investment on R&D; low unemployment; high government and industry collaboration.

Future Outlook: Very positive. An ever escalating predominance in key markets and industries leading to increased investments and innovations. An accelerated progressive and confident growth prognosis for the economy, and an enhanced quality of life for the nation. Global leadership and empowerment of third world and developing nations increasing. Accelerated investment in R&D and continued coordination with all sectors of society.

Scenario Two: Playing Catch-up

Timeline: 2010-2050

Economic Environment: Nanotechnology partially integrated into the economy due to low readiness and inadequate strategic planning. Economy playing catch-up. Slow social and industry-wide nanotechnology adoption. Reactive cultural reaction to investment and organizational and industry leadership for accelerated national change management. Not

a full commitment and investment in national nanotechnology policy.
Key Characteristics: Partial loss of leadership in key markets and industries; Lack of skilled talent; poor education and training; growing but still low investment in R&D; fragmented industry support; poor investment climate; liquidity insufficient; fragmented government and industry collaboration.
Outlook: Optimistic if rapid and strategic widespread large-systems change is undertaken in a concerted effort by business and government partnership. Difficult to regain ground in certain markets, but partial leadership in key markets is a success to be built on for the future.

Scenario Three: The Bumpy Road
Timeline: 2010-2050
Economic Environment: Absence of comprehensive nanotechnology integration, adoption and readiness leading to a drastic reduction in post-industrial growth, poor performance in global competitiveness with a negative growth impact on the overall economy. Denial of the strategic value and importance. Inability to invest in the actions required to manage comprehensive large-system socio-economic change.
Key Characteristics: Loss of key markets and industries; rising unemployment; chaos in selected sectors; brain drain going offshore; lack of investment liquidity; low investment in R&D; fragmented business and government collaboration; flight capital moving offshore; educational support low.
Outlook: Moving forward into the future, it will be difficult to seize and attain market and industry leadership without a significant investment in R&D, education, training and private/government collaboration. A commanding market share in key industries and global leadership will have been sacrificed. Regaining this ground, certainly global leadership, will be a massive undertaking certain to strain capital and human resources.
An acceptance of a less involved global leadership role will be the probable outcome.

Towards the Evolution of a Nanoeconomy and the Future Wealth of Nations

As the global economy is continues to be transformed by new technology, there will become a keen competition for talent, intellectual property, capital and technical expertise. We see many of these factors responsible for shaping how nations today compete, interact and trade. Technical innovations will increasingly shape economies and market robustness. Technology will continue to drive global and domestic GDP. Competition will be fueled increasingly by fast breaking innovations in technology. Today this is obvious as rapid technological changes in telecommunications, life sciences, and the Internet demonstrates the emergence of entirely new economic and business realities. If the proliferation of today's technologies to form new business models is any indication of the speed and power of change in the economy, future nanotechnologies will make for an even more dramatic paradigm shift. The evolution of a nano-economy as contrasted by a petro-economy of today is an intriguing idea. How might an economy not dependent on oil realign itself? More study will be need to conducted understand and map these scenarios. Fundamental nanotechnology innovations, yet to come will set the timeline for this economic transformation. Or, nanotechnology may just become integrated into industries such as health care, manufacturing and energy much like artificial intelligence became an embedded component of new products.

In conclusion, the readiness of a nation to prepare for large-scale economic change is a challenging task. Nevertheless, the future wealth of nations, certainly the economic sustainability of nations will be shaped by the preparations we make today. The coordinated large-systems strategic planning efforts that may well shape our ability to adapt. Strategically important decisions will need to be made. Huge cultural issues related to managing large-scale change will need to be better understood and plans formulated.

Nanotechnology provides a stimulating and somewhat awesome challenge to meet. If we had the knowledge in the 1960’s and 1970’s to prepare for the impact of computers or telecom in the 1990’s how might we have prepared the nation? Today we have real-time examples and a history of rapid accelerated economic change due to new technology to learn from, in preparing for the future. The business community needs to be enabled and invited into the strategic planning process to support nanotechnology.

2.1 Main Directions of Nanotechnology in modern time

In this section we talk about main directions of nanotechnologies that are in developing stage and which are already exist in modern time.

Nanoelectronics

Nanoelectronics refer to the use of nanotechnology on electronic components, especially transistors. Nanoelectronics often refer to transistor devices that are so small that inter-atomic interactions and quantum mechanical properties need to be studied extensively. As a result, present transistors do not fall under this category, even though these devices are manufactured under 45 nm or 32 nm technology.

Nanoelectronics are sometimes considered as disruptive technology because present candidates are significantly different from traditional transistors. Some of these candidates include: hybrid molecular/ semiconductor electronics, one dimensional nanotubes/nanowires, or advanced molecular electronics.

The volume of an object decreases as the third power of its linear dimensions, but the surface area only decreases as its second power. This somewhat subtle and unavoidable principle has huge ramifications. For example the power of a drill (or any other machine) is proportional to the volume, while the friction of the drill's bearings and gears is proportional to their surface area. For a normal-sized drill, the power of the device is enough to handily overcome any friction. However, scaling its length down by a factor of 1000, for example, decreases its power by 10003 (a factor of a billion) while reducing the friction by only 10002 (a factor of "only" a million). Proportionally it has 1000 times less power per unit friction than the original drill. If the original friction-to-power ratio was, say, 1%, that implies the smaller drill will have 10 times as much friction as power. The drill is useless.

For this reason, while super-miniature electronic integrated circuits are fully functional, the same technology cannot be used to make working mechanical devices beyond the scales where frictional forces start to exceed the available power. So even though you may see microphotographs of delicately etched silicon gears, such devices are currently little more than curiosities with limited real world applications, for example, in moving mirrors and shutters. Surface tension increases in much the same way, thus magnifying the tendency for very small objects to stick together. This could possibly make any kind of "micro factory" impractical: even if robotic arms and hands could be scaled down, anything they pick up will tend to be impossible to put down. The above being said, molecular evolution has resulted in working cilia, flagella, muscle fibers and rotary motors in aqueous environments, all on the nanoscale. These machines exploit the increased frictional forces found at the micro or nanoscale. Unlike a paddle or a propeller which depends on normal frictional forces (the frictional forces perpendicular to the surface) to achieve propulsion, cilia develop motion from the exaggerated drag or laminar forces (frictional forces parallel to the surface) present at micro and nano dimensions. To build meaningful "machines" at the nanoscale, the relevant forces need to be considered. We are faced with the development and design of intrinsically pertinent machines rather than the simple reproductions of macroscopic ones.

Research is ongoing to use nanowires and other nanostructured materials with the hope to create cheaper and more efficient solar cells than are possible with conventional planar silicon solar cells. It is believed that the invention of more efficient solar energy would have a great effect on satisfying global energy needs.

Much of the research done on bio-nano generators is still experimental, with Panasonic's Nanotechnology Research Laboratory among those at the forefront.

Nanoengineering

Nanoengineering is the practice of engineering on the nanoscale. It is largely a synonym for nanotechnology, but emphasizes the engineering rather than the pure science aspects of the field.

The first nanoengineering program in the world was started at the University of Toronto within the Engineering Science program as one of the Options of study in the final years. In 2003, the Lund Institute of Technology started a program in Nanoengineering. In 2005, the University of Waterloo established a unique program which offers a full degree in Nanotechnology Engineering. The University of California, San Diego followed shortly thereafter in 2007 with its own department of Nanoengineering.

There are some techniques of nanoengineering shown below:

- Photolithography - Using light to produce patterns in chemicals, and then etching to expose the surface.
- Electron beam lithography - Similar to photolithography, but using electron beams instead of light.
- Scanning tunneling microscope (STM) - Can be used to both image, and to manipulate structures as small as a single atom.
- Molecular self-assembly - Arbitrary sequences of DNA can now be synthesized cheaply in bulk, and used to create custom proteins or regular patterns of amino acids. Similarly, DNA strands can bind to other DNA strands, allowing simple structures to be created.

Impact of Nanotechnology to Medicine

The ageing population, the high expectations for better quality of life and the changing lifestyle of European society call for improved, more efficient and affordable health care.

Nanotechnology can offer impressive resolutions, when applied to medical challenges like cancer, diabetes, Parkinson's or Alzheimer's disease, cardiovascular problems, inflammatory or infectious diseases.
Experts of the highest level from industry, research centers and academia convened to prepare the present vision regarding future research priorities in NanoMedicine. A key conclusion was the recommendation to set up a European Technology Platform on NanoMedicine designed to strengthen Europe's competitive position and improve the quality of life and health care of its citizens. This article has been extracted from the vision paper “European Technology Platform on NanoMedicine - Nanotechnology for Health” produced by the European Commission.
NanoMedicine is not only important to Europe from the social and welfare aspects, but also for its economic potential. It includes all products that can be defined as ‘systems and technologies for healthcare, aimed at prevention, diagnosis or therapy’. Little market data is published specifically about NanoMedicine at present. However, an analysis of the market segments for medical devices and drugs & pharmaceuticals gives an idea about the leverage of NanoMedicine on the markets. These two market segments represented in 2003 an end-user value of 535 billion Euros, of which the drugs segment is the most important, with a value of 390 billion Euros. Globally this market has been growing at a 7 to 9% annual rate, with variations according to country, technologies and market segments.
The medical devices market is expected to grow in value by about 9% annually at present. The introduction of novel nanotechnologies can be expected to give rise to a much higher rate, by providing innovative solutions and more precise care and new information for preventive medicine. The market can be further segmented into areas where NanoMedicine might have the highest potential of penetration, such as in-vitro diagnostic products, patient monitoring systems, imaging systems or imaging contrast agents.
In a medical devices market of 145 billion Euros in 2003, in-vitro diagnostic systems represented 18 billion Euros, or 13% of the total. It can be

expected that nanotechnology will have an impact on this expanding market in the coming years, as it offers the potential of faster and more accurate analyses of smaller and smaller samples.

Medical imaging systems represent 14.5 billion Euros, or 8% of the total devices market. Imaging tools and imaging agents (including contrast media and radiopharmaceuticals) represent 4 billion Euros, or 3%. These segments will benefit from the application of techniques developed from an understanding both of materials and cellular activities at the nanoscale. Already the sale of tools dedicated to molecular clinical and preclinical imaging represents 0.8 billion Euros out of the 14.5 billion Euros total, and the patient monitoring market represents 1.5 billion Euros.

NanoMedicine can also potentially affect aspects of all medical devices, for example new materials for surgical implants, nanometric systems for monitoring cardiac activities or minimally invasive surgery sensors.

The worldwide market for pharmaceutical drugs has been growing at a rate of 7% in 2004. The drug market can be segmented, with the global market for advanced drug delivery systems accounting for 42.9 billion Euros or 11% of the total. Approximately half of this market is in controlled release systems, with needle-less injection, injectable/implantable polymer systems, transmucosal, rectal, liposomal drug delivery and cell/gene therapy responsible for the rest and is estimated to reach 75 billion Euros in 2005.

Developments in this market are rapid; especially in the sector of alternatives to injected macromolecules, as drug formulations seek to cash in on the 6.2 billion Euros worldwide markets for engineered protein and peptide drugs and other biological therapeutics.

When reviewing the economic potential of NanoMedicine, all the biotech companies must be considered as they are directly involved in the development of new molecules, and also in the development of new tools for accelerating the discovery of appropriate molecules. Today half of the new molecules discovered worldwide come from biotech companies.

There are more than 4,000 worldwide, with over 300 companies in the US actively working on developing drug-delivery platforms, including therapies targeted to the site of the disease, as well as drug-containing implants, patches and gels.

Europe has acknowledged strengths particularly in medical devices development and in drug delivery research, and these are clearly areas where the establishment of a European NanoMedicine Platform would contribute to maintaining and improving European competitiveness.

Impact of Nanotechnology to Energy industry

Over the past few decades, the fields of science and engineering have been seeking to develop new and improved types of energy technologies that have the capability of improving life all over the world. In order to make the next leap forward from the current generation of technology, scientists and engineers have been developing Energy Applications of Nanotechnology.

An important subfield of nanotechnology related to energy is nanofabrication. Nanofabrication is the process of designing and creating devices on the nanoscale. Creating devices smaller than 100 nanometers opens many doors for the development of new ways to capture, store, and transfer energy. The inherent level of control that nanofabrication could give scientists and engineers would be critical in providing the capability of solving many of the problems that the world is facing today related to the current generation of energy technologies.

People in the fields of science and engineering have already begun developing ways of utilizing nanotechnology for the development of consumer products. Benefits already observed from the design of these products are an increased efficiency of lighting and heating, increased electrical storage capacity, and a decrease in the amount of pollution from the use of energy. Benefits such as these make the investment of capital in the research and development of nanotechnology a top priority.

Recently, previously established and entirely new companies are focusing on nanomaterials as a way to develop and improve upon older methods for the capture, transfer, and storage of energy for the development of consumer products.

ConsERV, a product developed by the Dais Analytic Corporation, uses nanoscale polymer membranes to increase the efficiency of heating and cooling systems and has already proven to be a lucrative design. The polymer membrane was specifically configured for this application by selectively engineering the size of the pores in the membrane to prevent air from passing, while allowing moisture to pass through the membrane. Polymer membranes can be designed to selectively allow particles of one size and shape to pass through while preventing others of different dimensions. This makes for a powerful tool that can be used in consumer products from biological weapons protection to industrial chemical separations.

A New York based company called Applied NanoWorks, Inc. has been developing a consumer product that utilizes LED technology to generate light. Light-emitting diodes or LEDs, use only about 10% of the energy that a typical incandescent or fluorescent light bulb use and typically lasts much longer, which makes them a viable alternative to traditional light bulbs. While LEDs have been around for decades, this company and others like it have been developing a special variant of LED called the white LED. White LEDs consist of semi-conducting organic layers that are only about 100 nanometers in distance from each other and are placed between two electrodes, which create an anode, and a cathode. When voltage is applied to the system, light is generated when electricity passes through the two organic layers. This is called electroluminescence. The semiconductor properties of the organic layers are what allow for the minimal amount of energy necessary to generate light. In traditional light bulbs, a metal filament is used to generate light when electricity is run through the filament. Using metal generates a great deal of heat and therefore lowers efficiency.

Research for longer lasting batteries has been an ongoing process for years. Researchers have now begun to utilize nanotechnology for battery technology. mPhase Technologies in conglomeration with Rutgers University and Bell Laboratories have utilized nanomaterials to alter the wetting behavior of the surface where the liquid in the battery lies to spread the liquid droplets over a greater area on the surface and therefore have greater control over the movement of the droplets. This gives more control to the designer of the battery. This control prevents reactions in the battery by separating the electrolytic liquid from the anode and the cathode when the battery is not in use and joining them when the battery is in need of use.

Thermal applications also are a future applications of nanothechonlogy creating low cost system of heating, ventilation, and air conditioning, changing molecular structure for better management of temperature.

The relatively recent shift toward using nanotechnology with respect to the capture, transfer, and storage of energy has and will continue to have many positive economic impacts on society. The control of materials that nanotechnology offers to scientists and engineers of consumer products is one of the most important aspects of nanotechnology. This allows for an improved efficiency of products across the board.

A major issue with current energy generation is the loss of efficiency from the generation of heat as a by-product of the process. A common example of this is the heat generated by the internal combustion engine. The internal combustion engine loses about 64% of the energy from gasoline as heat and an improvement of this alone could have a significant economic impact. However, improving the internal combustion engine in this respect has proven to be extremely difficult without sacrificing performance. Improving the efficiency of fuel cells through the use of nanotechnology appears to be more plausible by using molecularly tailored catalysts, polymer membranes, and improved fuel storage.

In order for a fuel cell to operate, particularly of the hydrogen variant, a noble-metal catalyst (usually platinum, which is very expensive) is needed

to separate the electrons from the protons of the hydrogen atoms. However, catalysts of this type are extremely sensitive to carbon monoxide reactions. In order to combat this, alcohols or hydrocarbons compounds are used to lower the carbon monoxide concentration in the system. This adds an additional cost to the device. Using nanotechnology, catalysts can be designed through nanofabrication that are much more resistant to carbon monoxide reactions, which improves the efficiency of the process and may be designed with cheaper materials to additionally lower costs. Fuel cells that are currently designed for transportation need rapid start-up periods for the practicality of consumer use. This process puts a lot of strain on the traditional polymer
electrolyte membranes, which decreases the life of the membrane requiring frequent replacement. Using nanotechnology, engineers have the ability to create a much more durable polymer membrane, which addresses this problem. Nanoscale polymer membranes are also much more efficient in ionic conductivity. This improves the efficiency of the system and decreases the time between replacements, which lowers costs.
Another problem with contemporary fuel cells is the storage of the fuel. In the case of hydrogen fuel cells, storing the hydrogen in gaseous rather than liquid form improves the efficiency by 5%. However, the materials that we currently have available to us significantly limit fuel storage due to low stress tolerance and costs. Scientists have come up with an answer to this by using a nanoporous styrene material (which is a relatively inexpensive material) that when super-cooled to around -196^{o}C, naturally holds on to hydrogen atoms and when heated again releases the hydrogen for use.

Capacitors: then and now

For decades, scientists and engineers have been attempting to make computers smaller and more efficient. Crucial components of computers are capacitors. A capacitor is a device that is made of a pair of electrodes separated by an insulator that each stores an opposite charge. A capacitor stores a charge when it is removed from the circuit that it is connected to;

the charge is released when it is replaced back into the circuit. Capacitors have an advantage over batteries in that they release their charge much more quickly than a battery.

Traditional or foil capacitors are composed of thin metal conducting plates separated by an electrical insulator, which are then stacked or rolled and placed in a casing. The problem with a traditional capacitor such as this is that they limit how small an engineer can design a computer. Scientists and engineers have since turned to nanotechnology for a solution to the problem.

Using nanotechnology, researchers developed what they call “ultracapacitors.” An ultracapacitor is a general term that describes a capacitor that contains nanocomponents. Ultracapacitors are being researched heavily because of their high density interior, compact size, reliability, and high capacitance. This decrease in size makes it increasingly possible to develop much smaller circuits and computers. Ultracapacitors also have the capability to supplement batteries in hybrid vehicles by providing a large amount of energy during peak acceleration and allowing the battery to supply energy over longer periods of time, such as during a constant driving speed. This could decrease the size and weight of the large batteries needed in hybrid vehicles as well as take additional stress off the battery. However, as of now, the combination of ultracapacitors and a battery is not cost effective due to the need of additional DC/DC electronics to coordinate the two.

Nanoporous carbon aerogel is one type of material that is being utilized for the design of ultracapacitors. These aerogels have a very large interior surface area and can have its properties altered by changing the pore diameter and distribution along with adding nanosized alkali metals to alter its conductivity.

Carbon nanotubes are another possible material for use in an ultracapacitor. Carbon nanotubes are created by vaporizing carbon and allowing it to condense on a surface. When the carbon condenses, it forms a nanosized tube composed of carbon atoms. This tube has a high surface area, which increases the amount of charge that can be stored. The low reliability and high cost of using carbon nanotubes for ultracapacitors is currently an issue of research.

In a study concerning ultracapacitors or supercapacitors, researchers at the Sungkyunkwan University in the Republic of Korea explored the possibility of increasing the capacitance of electrodes through the addition of fluorine atoms to the walls of carbon nanotubes. As briefly mentioned before, carbon nanotubes are an increasing form of capacitors due to their superb chemical stability, high conductivity, light mass, and their large surface area. These researchers have fluorinated single-walled carbon nanotubes (SWCNTs) at high temperatures to bind fluorine atoms to the walls. The attached fluorine atoms changed the non-polar nanotubes to become polar molecules. This can be attributed to the charge transfer from the fluorine. This created dipole-dipole layers along the carbon nanotube walls. Testing of these fluorinated SWCNTs against normal state SWCNTs showed a difference in capacitance. It was determined that the fluorinated SWCNTs are advantageous in fabricating electrodes for capacitors and improve the wettability with aqueous electrolytes, which promotes the overall performance of supercapacitors. While this study brought to knowledge a more efficient example of capacitors, little is known about this new supercapacitor, large scale synthesis is lacking and is necessary for any massive production, and preparation conditions are quite tedious in achieving the final product.

Current Researches

Governments are spending huge money to researches of this new science. And main research subjects are:

Nanomaterials: This includes subfields which develop or study materials having unique properties arising from their nanoscale dimensions.

- Interface and colloid science has given rise to many materials which may be useful in nanotechnology, such as carbon nanotubes and other fullerenes, and various nanoparticles and nanorods.
- Nanoscale materials can also be used for bulk applications; most present commercial applications of nanotechnology are of this flavor.
- Progress has been made in using these materials for medical applications; see Nanomedicine.
- Nanoscale materials are sometimes used in solar cells which combats the cost of traditional Silicon solar cells
- Development of applications incorporating semiconductor nanoparticles to be used in the next generation of products, such as display technology, lighting, solar cells and biological imaging; see quantum dots.

Top-down and **bottom-up** are two approaches for the manufacture of products. These terms were first applied to the field of nanotechnology by the Foresight Institute in 1989 in order to distinguish between molecular manufacturing (to mass-produce large atomically precise objects) and conventional manufacturing (which can mass-produce large objects that are not atomically precise). Bottom-up approaches seek to have smaller (usually molecular) components built up into more complex assemblies, while top-down approaches seek to create nanoscale devices by using larger, externally-controlled ones to direct their assembly.

Bottom-up approaches: These seek to arrange smaller components into more complex assemblies.

- DNA nanotechnology utilizes the specificity of Watson–Crick basepairing to construct well-defined structures out of DNA and other nucleic acids.
- Approaches from the field of "classical" chemical synthesis also aim at designing molecules with well-defined shape (e.g. bis-peptides).

- More generally, molecular self-assembly seeks to use concepts of supramolecular chemistry, and molecular recognition in particular, to cause single-molecule components to automatically arrange themselves into some useful conformation.

Top-down approaches: These seek to create smaller devices by using larger ones to direct their assembly.

- Many technologies that descended from conventional solid-state silicon methods for fabricating microprocessors are now capable of creating features smaller than 100 nm, falling under the definition of nanotechnology. Giant magnetoresistance-based hard drives already on the market fit this description, as do atomic layer deposition (ALD) techniques. Peter Grunberg and Albert Fert received the Nobel Prize in Physics for their discovery of Giant magnetoresistance and contributions to the field of spintronics in 2007.
- Solid-state techniques can also be used to create devices known as nanoelectromechanical systems or NEMS, which are related to microelectromechanical systems or MEMS.
- Atomic force microscope tips can be used as a nanoscale "write head" to deposit a chemical upon a surface in a desired pattern in a process called dip pen nanolithography. This fits into the larger subfield of nanolithography.
- Focused ion beams can directly remove material, or even deposit material when suitable pre-cursor gasses are applied at the same time. For example, this technique is used routinely to create sub-100 nm sections of material for analysis in Transmission electron microscopy.

Functional approaches: These seek to develop components of a desired functionality without regard to how they might be assembled.

- Molecular electronics seeks to develop molecules with useful electronic properties. These could then be used as single-molecule

components in a nanoelectronic device. For an example see rotaxane.
- Synthetic chemical methods can also be used to create synthetic molecular motors, such as in a so-called nanocar.

Speculative: These subfields seek to anticipate what inventions nanotechnology might yield, or attempt to propose an agenda along which inquiry might progress. These often take a big-picture view of nanotechnology, with more emphasis on its societal implications than the details of how such inventions could actually be created.

- Molecular nanotechnology is a proposed approach which involves manipulating single molecules in finely controlled, deterministic ways. This is more theoretical than the other subfields and is beyond current capabilities.
- Nanorobotics centers on self-sufficient machines of some functionality operating at the nanoscale. There are hopes for applying nanorobots in medicine, but it may not be easy to do such a thing because of several drawbacks of such devices. Nevertheless, progress on innovative materials and methodologies has been demonstrated with some patents granted about new nanomanufacturing devices for future commercial applications, which also progressively helps in the development towards nanorobots with the use of embedded nanobioelectronics concepts.
- Programmable matter based on artificial atoms seeks to design materials whose properties can be easily, reversibly and externally controlled.
- Due to the popularity and media exposure of the term nanotechnology, the words picotechnology and femtotechnology have been coined in analogy to it, although these are only used rarely and informally.

Nanostructure modeling software

There is shown a list of computer programs that are used for modeling of nanostructures at classical and quantum levels.

- Ascalaph Designer
- Atomistix ToolKit and Virtual NanoLab
- CST STUDIO SUITE(TM)
- CoNTub
- Nanohub allows simulating geometry, electronic properties and electrical transport phenomena in various nanostructures
- Nanorex
- NEMO 3-D enables multi-million atom electronic structure simulations in empirical tight binding. It is open source. An educational version is on nanoHUB as well as Quantum Dot Lab
- Nanotube Modeller
- Materials Studio
- MD-kMC
- TubeASP
- Tubegen
- Wrapping

These types of software are also called Molecular Design Software that is software for molecular modeling, distinctive property of which is the presence of the special support for developing the molecular models.
In contrast to the usual molecular modeling programs such as the molecular dynamics and quantum chemistry programs, such software directly supports the aspects related to the construction of molecular models that are molecular graphics, interactive molecular drawing and conformational editing, building of polymeric molecules, crystals and solvated systems, partial charges development, geometry optimization, support for the different aspects of Force Field development and etc.

2.2 Implications of Nanotechnology

The implications of nanotechnology extend human affairs from the medical, ethical, mental, legal and environmental, to fields such as engineering, biology, chemistry, computing, materials science, military applications, and communications.

Benefits of nanotechnology include improved manufacturing methods, water purification systems, energy systems, physical enhancement, nanomedicine, better food production methods and nutrition and large scale infrastructure auto-fabrication. Products made with nanotechnology may require little labor, land, or maintenance, be highly productive, low in cost, and have modest requirements for materials and energy.

There are possible risks that arise with the development of nanotechnology. In the US the Center for Responsible Nanotechnology suggests that new developments could result, among other things, in untraceable weapons of mass destruction, networked cameras for use by the government, and weapons developments fast enough to destabilize arms races.

Benefits of nanotechnology such as:

- Environmentally useful material abundance for all by providing universal clean water supplies
- Atomically engineered food and crops resulting in greater agricultural productivity with fewer labor requirements
- Nutritionally enhanced interactive ‘smart’ foods
- Cheap and powerful energy generation
- Clean and highly efficient manufacturing
- Radically improved formulation of drugs, diagnostics and organ replacement
- Much greater information storage and communication capacities
- Interactive ‘smart’ appliances and increased human performance through convergent technologies

Reduction of Transport Emissions

The traditional automotive industry rule of thumb is that a 10% reduction in weight gives a 5% increase in fuel efficiency, but the adoption of composites across the vehicle, from engine parts to body panels has increased this saving. According to the US Transportation Research Board, the relationship between fuel consumption and vehicle weight is now linear. Thus, if we assume that a manufacturer reduces the weight of a vehicle by 10%, a corresponding fuel consumption reduction of 10% will occur.

The use of fuel borne catalysts is expected to further increase efficiency, and despite the recent troubles of market leader Oxonica, we have assumed increasing numbers of market entrants giving a mean fuel saving of 7% (manufacturers estimates range from 5-15%).

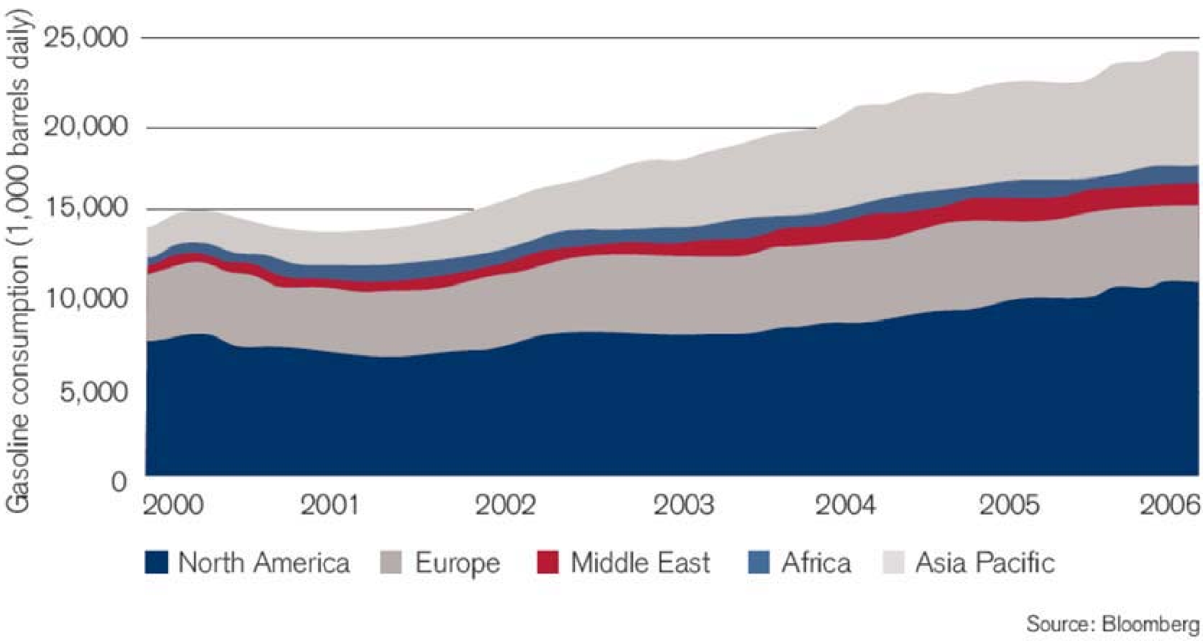

Figure 6: Global Gasoline Consumption

Unlike nanocomposite materials, the use of fuel borne catalysts is not limited to newly built vehicles and the potential market is correspondingly larger. As a result of its use, and using a conservative version of manufacturers estimates of the market size, we estimate a reduction in CO_2emissions of 2,600 tons in 2010 rising to 153,000 tons by 2015.

Health implications of nanotechnology

The health implications of nanotechnology are the possible effects that the use of nanotechnological materials and devices will have on human health. As nanotechnology is an emerging field, there is great debate regarding to what extent nanotechnology will benefit or pose risks for human health. Nanotechnology's health implications can be split into two aspects: the potential for nanotechnological innovations to have medical applications to cure disease, and the potential health hazards posed by exposure to nanomaterials.

The extremely small size of nanomaterials also means that they are much more readily taken up by the human body than larger sized particles. How these nanoparticles behave inside the body is one of the issues that needs to be resolved. The behavior of nanoparticles is a function of their size, shape and surface reactivity with the surrounding tissue. They could cause overload on phagocytes, cells that ingest and destroy foreign matter, thereby triggering stress reactions that lead to inflammation and weaken the body’s defense against other pathogens. Apart from what happens if non-degradable or slowly degradable nanoparticles accumulate in organs, another concern is their potential interaction with biological processes inside the body: because of their large surface, nanoparticles on exposure to tissue and fluids will immediately adsorb onto their surface some of the macromolecules they encounter. This may, for instance, effect the regulatory mechanisms of enzymes and other proteins.

Other properties of nanomaterials that influence toxicity include: chemical composition, shape, surface structure, surface charge, aggregation and solubility and the presence or absence of functional groups of other chemicals. The large number of variables influencing toxicity means that it is difficult to generalize about health risks associated with exposure to nanomaterials – each new nanomaterial must be assessed individually and all material properties must be taken into account.

Environmental issues

On the other hand, some possible future applications of nanotechnology have the potential to benefit the environment. Nanofiltration, based on the use of membranes with extremely small pores smaller than 10 nm (perhaps composed of nanotubes) is suitable for a mechanical filtration for the removal of ions or the separation of different fluids. Furthermore, magnetic nanoparticles offer an effective and reliable method to remove heavy metal contaminants from waste water. Using nanoscale particles increases the efficiency to absorb the contaminants and is comparatively inexpensive compared to traditional precipitation and filtration methods.
Furthermore, nanotechnology could potentially have a great impact on clean energy production. Research is underway to use nanomaterials for purposes including more efficient solar cells, practical fuel cells, and environmentally-friendly batteries.

Societal implications

Beyond the toxicity risks to human health and the environment which are associated with first-generation nanomaterials, nanotechnology has broader societal implications and poses broader social challenges. Social scientists have suggested that nanotechnology's social issues should be understood and assessed not simply as "downstream" risks or impacts. Rather, the challenges should be factored into "upstream" research and decision making in order to ensure technology development that meets social objectives
Many social scientists and organizations in civil society suggest that technology assessment and governance should also involve public participation

A need for regulation

There is significant debate related to the question of whether nanotechnology or nanotechnology-based products merit special government regulation. This debate is related to the circumstances in which it is necessary and appropriate to assess new substances prior to their release into the market, community and environment.

Potential benefits and risks for developing countries

Nanotechnologies may provide new solutions for the millions of people in developing countries who lack access to basic services, such as safe water, reliable energy, health care, and education. The United Nations has set Millennium Development Goals for meeting these needs. The 2004 UN Task Force on Science, Technology and Innovation noted that some of the advantages of nanotechnology include production using little labor, land, or maintenance, high productivity, low cost, and modest requirements for materials and energy.

Potential opportunities of nanotechnologies to help address critical international development priorities include improved water purification systems, energy systems, medicine and pharmaceuticals, food production and nutrition, and information and communications technologies. Nanotechnologies are already incorporated in products that are on the market. Other nanotechnologies are still in the research phase, while others are concepts that are years or decades away from development. Protection of the environment, human health and worker safety in developing countries often suffers from a combination of factors that can include but are not limited to lack of robust environmental, human health, and worker safety regulations; poorly or unenforced regulation which is linked to a lack of physical (e.g., equipment) and human capacity (i.e., properly trained regulatory staff). Often, these nations require assistance, particularly financial assistance, to develop the scientific and institutional capacity to adequately assess and manage risks, including the necessary infrastructure such as laboratories and technology for detection.

However, concerns are frequently raised that the claimed benefits of nanotechnology will not be evenly distributed, and that any benefits (including technical and/or economic) associated with nanotechnology will only reach affluent nations. The majority of nanotechnology research and development - and patents for nanomaterials and products - is concentrated in developed countries (including the United States, Japan, Germany, Canada and France). In addition, most patents related to nanotechnology are concentrated amongst few multinational corporations, including IBM, Micron Technologies, Advanced Micro Devices and Intel. This has led to fears that it will be unlikely that developing countries will have access to the infrastructure, funding and human resources required to support nanotechnology research and development, and that this is likely to exacerbate such inequalities.

Producers in developing countries could also be disadvantaged by the replacement of natural products (including rubber, cotton, coffee and tea) by developments in nanotechnology. These natural products are important export crops for developing countries, and many farmers' livelihoods depend on them. It has been argued that their substitution with industrial nano-products could negatively impact the economies of developing countries, that have traditionally relied on these export crops.

According to the Center for Responsible Nanotechnology:

Molecular manufacturing allows the cheap creation of incredibly powerful devices and products. How many of these products will we want? What environmental damage will they do? The range of possible damage is vast, from personal low-flying supersonic aircraft injuring large numbers of animals to collection of solar energy on a sufficiently large scale to modify the planet's albedo and directly affect the environment. Stronger materials will allow the creation of much larger machines, capable of excavating or otherwise destroying large areas of the planet at a greatly accelerated pace.

It is too early to tell whether there will be economic incentive to do this. However, given the large number of activities and purposes that would damage the environment if taken to extremes, and the ease of taking them to extremes with molecular manufacturing, it seems likely that this problem is worth worrying about. Some forms of damage can result from an

aggregate of individual actions, each almost harmless by itself. Such damage is quite hard to prevent by persuasion, and laws frequently don't work either; centralized restriction on the technology itself may be a necessary part of the solution.
Finally, the extreme compactness of nanomanufactured machinery will tempt the use of very small products, which can easily turn into nano-litter that will be hard to clean up and may cause health problems. The site list numerous other risks and benefits.

Studies on the implications of nanotechnology

The first major attempt to assess the societal implications of nanotechnology was a workshop held at the National Science Foundation (NSF), September 28-29, 2000. A second extensive follow-on workshop was held at NSF December 2-3, 2003. Societal Implications of Nanoscience and Nanotechnology, Nanotechnology: Societal Implications - Maximizing Benefits for Humanity, and Nanotechnology: Societal Implications - Individual Perspectives.

2.3 Nanotechnology in Azerbaijan

Although the nanoscience and nanotechnology is very new for Azerbaijan, for the last years Azerbaijan government involved universities, government organizations and ministries in working intensive scientific and practical aimed researches for improvement of this technology. Special courses and programs operate for increasing specialist with the abilities to use nanotechnologies for scientific researches. Nanotechnology Development Program of Azerbaijan Republic (NDPAR or NDP) first established by the Baku State Universities related areas scientist with the aim of initiating and developing the nanotechnology in the country. The main purpose of the scientific program of nanomaterials and nanotechnology in the Republic of Azerbaijan is to prepare base level for the education and technology. Program should provide integration of nanotechnology to the world's developed countries and develop it in Azerbaijan. The main goals of NDP are:

- Nanotechnology in the field of human potential development.
- Organization and preparation nanotechnology and nanoscience R&D works for raising these field’s R&D to the level of world standards.
- Development and improvement of competitive nanotechnology product section in world markets.
- By improving nanotechnology in the field of military equipment and special material supply issues.
- Establishment of new medical methods of diagnostics and preparation of pharmaceutical items based on application of nanomaterials in various diseases prevention, diagnostics and treatment of the development of bases.
- Application of nanotechnology in environmental safety and environmental problems.
- Application of scientific bases for the development of technology for the oil nanomaterials.
- Preparation of integrated circuits and discrete semiconductor devices on the basis of Nanostructures.

- Application of nanotechnology-based products in the solution of problems of operations against the terrorist actions.

Government budget, external financial budget and international joint grant projects are main financial sources in realization of NDP. Program was prepared by Ministry of Education, Baku State University (BSU) and Azerbaijan National Academy of Sciences (ANAS). Program has 3 period:

I period – period to 2010
II period – period between 2010 and 2012
III period – period between 2012 and 2015

In higher educational institutions, institutes of Azerbaijan National Academy of Sciences (ANAS), the branch research institutes receive, investigate and apply nanomaterials for various applications. In the country, new faculties, research laboratories, nano-research centers dealing with these important areas. Sectoral companies, universities, SOCAR (State Oil Company of Azerbaijan Republic), Institute of National Academy of Sciences, Azerbaijan National Academy of Aviation are main institutions existing in this industries and researches.

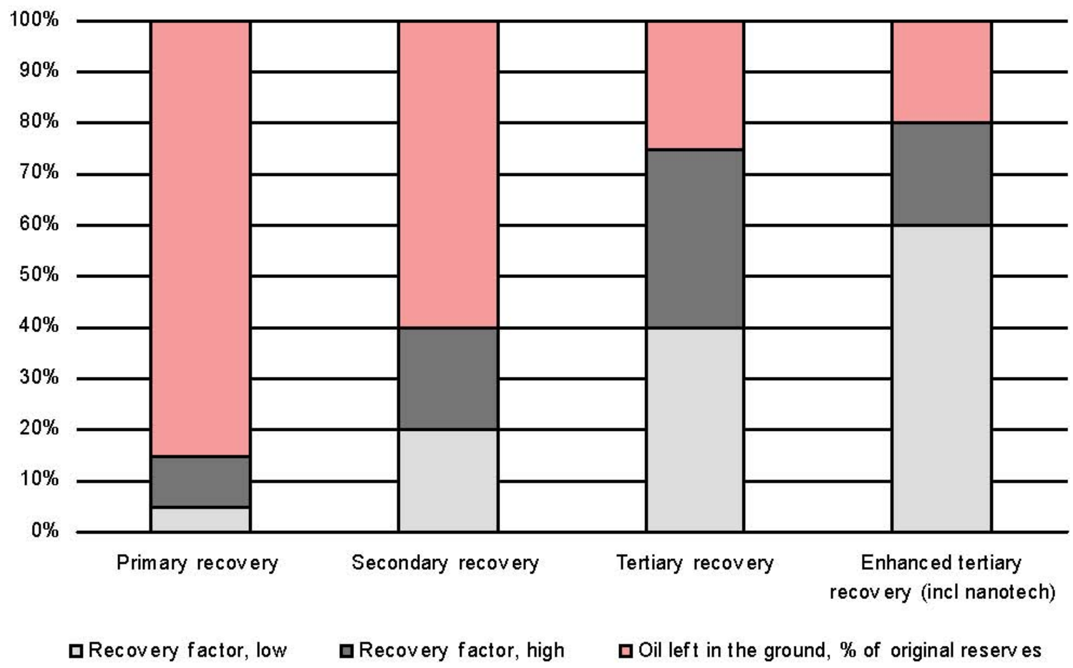

Figure 7: NEW TECH COULD SEE BASE RECOVERY FACTOR RISING TO 60-80%

World oil producers currently leave an average of up to 70% of discovered oil in the ground. This is because current output stimulation processes cannot overcome the forces binding the oil to the micro-cavities that contain it. A key production asset performance indicator used throughout the industry is the oil recovery factor (ORF), which is the ratio of oil extracted from the ground versus the original estimates of the original oil in place (OOIP, often calculated by simple volumetric methods). As oil production technology has advanced, the oil recovery factor has grown from an average of 5%-15% for primary recovery methods, such as gravity drive and artificial lift, to nearly 40% for secondary recovery methods, which includewater flooding (particularly if implemented immediately at the start of the production cycle). The process has been taken a step further with technologies such as gas-water drive and polymer additives, coupled with directional drilling and fraccing, which combined arecalled tertiary oil production or enhanced oil recovery (EOR) methods. They also include thermal and chemical processes, coupled with the injection of foams, liquids or gaseous mixtures with properties different from the simple water-based artificial drive methods. These methodscan raise the ORF up to 75%, depending on the deposit’s initial properties. New technology hasalso made unconventional reserves (including bitumen and extra-heavy oil) accessible, raising their ORF by several times; Canada rose to top the list of the world’s oil-rich countries with the application of such technology
The State Oil Company of the Azerbaijan Republic (SOCAR) reported the successful application of water-cut reducing nanotechnology in 2004, with a 20% reduction of water flooding and equal-sized energy savings at its mature fields in Azerbaijan.

Azerbaijan Technical University

Nanotechnology recently began to apply oil production in Azerbaijan. The main benefit of nanotechnology is considered that nanomatters can increase by themselves. Scientists found that nanotechnology can increase production of oil. The mass of oil can be increased 2-2.5 times by influencing crude oil with those nanomatters. This result shows a huge improvement in oil sector. Laboratory research samples were taken from Bibiheybat oil fields. Based on prof. Kamal Huseinov (chief of nanotechnology research center in ATU) statements the result seems positive. This researches and research laboratories are financed by State Oil Company of Azerbaijan Republic (SOCAR). By using this technology SOCAR can increase company’s oil production and revenue.

Baku State University “Nanotechnology Center”

One of the institutions did lots of work in this new emerging science in Azerbaijan, is Baku State University. The department “Chemical Physics of Nanomaterials” BSU has been established on the basis of the order of Council of Ministers of the Azerbaijan Republic from November, 15, 1971 the decision of Board of the Ministry of Education from May, 12, 1972. In the beginning it has received the name of Department “Quantum mechanics of atoms and molecules” then “Chemical physics of Nanomaterials”. Taking into account the scientific and technical importance of research nanomaterials, the purpose deeper studying of this area, the organization of educational process, formation a direction of scientifically methodical development by the order of rector BSU from 21.01.06. on the basis of the decision of the Academic council from 06.01.2006 Department it is renamed on into Department “Chemical Physics of Nanomaterials ”. During the long period on department the competent scientific faculties for republic have been prepared.

At Department there is an Educational laboratory. On department 8 employees work, in that 3 the Professor assistant lecturer Ph.D., 2 Senior teachers Ph.D., 1 biologist Ph.D.(biologist), 1 head of laboratory Ph.D. and 1 senior laboratory scientist. Now 2 aspirants and 2 dissertators conduct research work. Long time supervised Department (1972-1993) Doctor, professor I. I. Guseinov at present works at university in Turkey and supports constant scientific communication with employees of Department. Received the international popularity the scientific works on physics of atoms and molecules.

I.I.Guseinov has played the big role in creation and development of department. From 1993-2005 head of department was Doctor, professor T. M. Mursalov. For this time employees of department carried out works on a problem «Development quantum mechanical methods of calculation in multielectronic problems». Scientific directions of department of chemical physics nanomaterials are processes of burning and explosion. Now employees of department carry out lecture and seminar employment at physical and chemical faculties BSU, carry out a management of final works of bachelors and magistrers dissertations. On department are prepared 2 doctor's, 20 master's theses are successfully protected. Scientific works of employees are published in authoritative international and republican scientific magazines reported on various symposiums and scientific conferences.

In 2003-2009 3 educational books, 4 educational manuals, 125 articles(in republic 57, in foreign 68), 117 theses (in republic 75, in foreign 42) were is issued and received 4 patents.The Department of Chemical Physics Nanomaterials BSU cooperates and supports scientific communications with a number of research establishments and universities of countries CIS and the foreign states.

Educational programs

1 Educational program of subject of bases nanotechnologies

2 Subjects and their programs educated in bachelor a stage

3 Subjects and their programs educated in magistracy a stage

4 Subjects and the programs educated in magistracy on a specialty physics nanoparticles

List of works done by BSU in the last decade:

1. Elaboration and investigation of new photo-electro thermoluminescent polymer nanocomposite materials.

2. Radio ecological survey of the soil of the territory of Baku city of Absheron peninsula
3. Application of nanotechnology in the prevention of suppurative inflammatory processes in postsurgical complications
4. The Project - The development program of Nanotechnology in Azerbaijan Republic
5. Azerbaijan and USA Joint Grant Program(JGP II) - 2007 ."Influence of Interphase Interactions on Physico-Chemical Properties of Polymeric Magnetic Nanocomposites" Azerbaijan head of grant project: Mahammadali Ramazanov, Institute of Physics of NAS Azerbaijan USA head of grant project: Mostafa El-Sayed, Georgia Institute of Technology USA
6 Interactions of nanoparticles with membrane systems of cells of higher water plants - towards mechanisms of nano-phytotoxicity.

The Educational Laboratory of Department of Chemical Physics of Nanomaterials BSU is created according to the order of the rector in 1996. Now in educational process of laboratory it is used:
Program NanoEducator (ZAO NT-MDT, 124460, Moscow, Zelenograd);
The computer programs working in operation sysem MS Windows and prepared in system Delphi Studio for calculations of electronic structure nanostructures by method Hartree -Fock - Roothaan and by semiempirical methods (Hukkel and Wolfsberg-Helmholts) in basis Slater Functions;

Two modern computers in BSU; In laboratories of Baku State University two Scanning Atomic Force Microscopies (Model SZMU-L5) and Fluorescence Spectrophotometer Cary Eclipse are being used in researches of new nanoproducts by scientists.

Picture 1: Scanning Atomic Force Microscope (Model SZMU-L5) & Fluorescence Spectrophotometer Cary Eclipse

Software

Here is the list of softwares uses in the laboratories of BSU. These softwares makes nanoparticles visible and creates it 3D view.

1. Program **NanoEducator** is working MS Windows for studying nanostructures in Scanning Probe Microscopes (Moscow, Zelenoqrad).

2. For studying electronic structures in nanostructures by the method **Hartree-Fock-Roothaan** in the base of Sleyter Type Function and semiempirical quantum-chemical methods (**Hukkel and Wolfsberg-Helmholts**) in the chair designed computer programs working in the system Delphi Studio MS Windows.

3. Microsoft Visual Studio 2005 and Delphi Studio

Conclusion

The commercialization of nanotechnology research in countries in many ways presents a depressingly familiar picture of excellent research that is not being translated to the country's commercial benefit to the same extent as it is in other competitor countries. The nanotechnology development programs of countries and the scientific community lacked the foresight and leadership to drive forward this advantage. A commercially valuable trick was missed. The benefits of nanotechnology were too uncertain and far off for industry to get involved without Government stimulation of interest and help with the provision of expensive facilities.

In Azerbaijan there is no special government or social nanoproduct implication control organization or agency that request all pollution related information and analyzes implications of these products.

The commercialization of nanotechnology research in countries in many ways presents a depressingly familiar picture of excellent research that is not being translated to the country's commercial benefit to the same extent as it is in other competitor countries. The nanotechnology development programs of countries and the scientific community lacked the foresight and leadership to drive forward this advantage. A commercially valuable trick was missed. The benefits of nanotechnology were too uncertain and far off for industry to get involved without Government stimulation of interest and help with the provision of expensive facilities.

Based on the research I've made we can say there is need for special government or social nanoproduct implication control organization or agency that request all pollution related information and analyzes implications of these products.

Using nanotechnology in extraction of oil government can benefit more by saving as nanotechnology increases production of oil. It is considered normal to extract 30-40% of all oil, because modern technologies in Azerbaijan can not go so deep to drill and absorb of more oil. The new chemical nanomatters are used to increase its production. These nanochemicals weight concentrations are 0.5-5% more. Thus increases production and also profit.

In these estimates, nanotools play the most prominent role on the world market, though with smallest growth rates. Nanodevices and nanomaterials start on a slightly lower level, but nanodevices increase with a much higher rate. Nanotechnology is only marginal, but increases substantially during the period of reference. Overall increases are at on average of 15 % annually, which does not yet reflect a real breakthrough. It is obvious to conclude that nanotechnology is not yet on the take off point of revolutionizing the world economy. Based on the calculations and predictions (regression analysis), a market share for nanotechnology products of 4% of general manufactured products in 2014, with 100% nanotech in PCs, 85% in consumer electronics, 23% in pharmaceuticals and 21% in automobiles. This would lead for nanotechnology to an overall share of 15 % of the global manufacturing output in 2014.

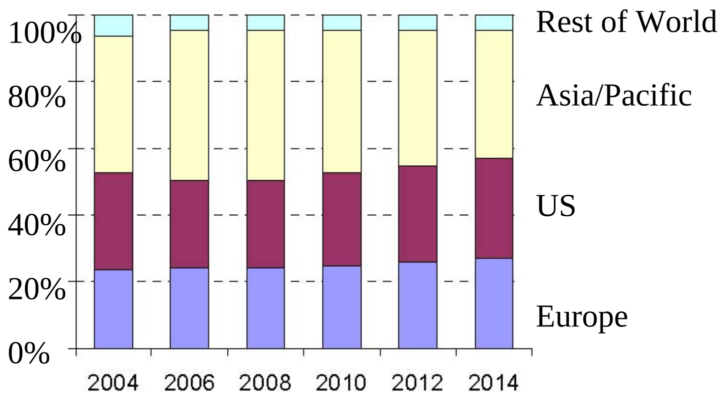

Figure 8: Global sales of nanoproducts

Figure 6 shows us global sales of nanoproducts incorporating emerging nanotechnology by region and forecasted in percentage. Scenarios and forecasts analyzed in this report, all are indicators of development of nanotechnology in the future.

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