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Advances in Nanotechnology can Provide Clean Energy Resources and Sustainable Developement

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The greatest threat and the biggest technical challenge facing the world in this century is how to provide clean, affordable energy supply, which is sustainable and universally available. The rate of growth in global energy demand runs the risk of outpacing affordable, stable supplies unless we can achieve breakthroughs not only in conservation and evolutionary improvements in terms of efficiency of existing resources, but also revolutionary new breakthroughs. Energy resources are vital to sustaining worldwide economic growth, progress, peace and global security in the 21st century. There is an urgent need for new technologies that can facilitate the development of cheaper, more efficient, and environmentally sound energy supplies.

By the middle of this century, global energy production will, at least, need to be doubled from its current level if we are to meet the demand of economic development. Without a major technological breakthrough, well over 1 billion people will still be without modern electricity in 2030. CO2 emission will also continue to increase by 14% for the next two decades unless the international agreements to cut the emission are implemented.

So the question is: can we achieve carbon-free energy supplies by the middle of the century that can meet our needs? This is an open question, but there are three potential ways to meet the 2050 carbon-free energy conditions: large-scale carbon sequestration, a broader use of nuclear power or the deployment of large scale renewable energy resources. Considering the carbon sequestration option, two thirds of the energy produced from fossil fuels worldwide will need to be sequestrated or 10,000 nuclear power plants will have to be built in order to meet our energy demand.

We have to think defiantly, deep and hard, invest in science and technology and remove all the barriers like politics and special interest groups, which prevent the application of and the investment into new technologies. Even though some of the energy increase will come from renewable energy resources that can play a major role in energy independence, nevertheless, this contribution might be insufficiently small to meet the production magnitude needed for ten billion people that will inhabit the planet in the next four decades. In other words small, incremental changes will not be sufficient to satisfy the world's future energy needs. What we need is a technological breakthrough. Nanotechnology is the breakthrough that can bring orders of magnitude improvements. Nanotechnology has the greatest potential impact in the energy field. It offers some unprecedented opportunities in the creation of sustainable energy forms and greatly increasing the efficiency of transmission and generation of power. It offers new methods for extracting energy from different resources that are inexpensive and environmentally friendly. All current technologies that are used to extract energy are energy wasters, because most of the energy is used as heat. Two-thirds of gas in an automobile’s tank, for example, goes right out the radiator. Even the most efficient heat engines waste at least half the applied energy. Conventional batteries have low energy density and long recharge times.

Investment in nanotechnology should concentrate on new materials that can have profound and ramifying effects on energy efficiency, such as catalysts for energy generation or emissions scrubbing, membranes for fuel cells or huge storage capacitors, or new materials for strong, lightweight transmission lines and new kinds of lighting. Nanotechnology such as nanotubes, nanowires, and nanocomposites for batteries, will bring orders of magnitude improvements. Nanostructured membranes, nanohorn electrodes, and nanocatalysts will make fuel cells smaller and more affordable.

The impact of nanotechnology on the energy sector seems to be so large and diverse that most of it cannot be precisely described right now since nanotechnology is in the primary stage of development. But, from what we already know, it has the potential to revolutionize and transform the whole energy sector.

We know that in spite of great technological strides in the last three decades in the field of renewable energy, especially in solar energy, there are still serious obstacles to overcome before energy can be produced on a large scale from this source. That, of course, is due mainly to the problems of storage, production cost and efficiency.

Advances in nanotechnology can remove these obstacles and provide efficient, cost effective and scalable renewable energy resources. Experimental research has already shown that quantum dots (tiny nanoparticles only a few nanometers in size) are three times more efficient for solar energy conversion than the best material currently used for solar cells. And nanofoams showed to be very effective and improved isolation materials for energy saving.

As already mentioned above, one of the basic drawbacks with renewable energy, like solar energy, is that there is no effective storage devices that can store sufficient power usable at a later point in time, in addition of course to the high cost of the present storage systems.

Thus, an effective and reliable storage system is needed and it must have high power and high density to enable the devices to hold a large amount of energy, be able to deliver that energy at high power, and at the same time recharge rapidly.

Battery technology can be improved with nanotechnology (increasing output and decreasing size). There is already real progress with rechargeable batteries, both dry and wet that use nanostructured materials. Wet batteries use basically the same materials as for hydrogen storage, and are based on metal hydrides, where hydrogen is the chemical energy carrier, or carbon nanotubes. Different research groups have already demonstrated that those nanotech batteries can store energy several times more efficiently than conventional batteries. Nevertheless, there are still a few technical issues that have to be solved before perfect nanotech batteries can be made.

The benefits of nanotechnology for the development of an efficient energy storage system can be extended to hydrogen storage devices that will become increasingly important as several countries around the world are hoping to move towards a real application of the hydrogen economy in the coming years. The research in hydrogen storage technology has started in the 1960s and went through several trends. Since the 1990s most of the studies and researches are focusing mainly on nanostructured hydrides like carbon nanotubes, metal hydride-carbon nanocomposites…etc

However, one has to keep in mind that the transformation from one generation of energy technology to the next is a slow and gradual process. Nanotechnology will not be any different, therefore, the wise investment in the early stage of application of nanotechnology must be directed at making the existing resources, especially fossil fuels, more efficient rather than at the creation of entirely new supplies from solar and hydrogen based technologies.

According to certain studies the use of nanomaterials in energy saving technologies is expected to witness faster growth, around 80% of the market until the middle of the next decade, where the majority of the application will be in the transportation sector.

All energy sources can be improved and revolutionized with the application of this emerging technology, whether they be renewable or conventional sources. In other words, this new technology can reduce the waste, the cost, increases the efficiency of conventional energy sources by having better extracting methods and also save for both people and the environment. For instance, in the field of nuclear energy (nuclear fission) nanotechnology can help by improving the radiation resistance of materials. Primary energy sources that need to be transformed into heat, mechanical power or electricity can benefit from the application of nanotechnology because at present, there is no effective solution for the transformation of these energies. Fuel cells that transform hydrogen or other gases into electricity is well known, example. But there are other nanotechnology devices like catalysts and membranes for separating different types of gases. These can be used in fuel cells or other energy transforming technologies.

More importantly, however, I believe that new materials can be made that can allow the extraction of nuclear energy at low cost, low temperature and without the danger of radioactive waste. Nanotechnology is the right path for the realization of nuclear fusion. Proper nanostructured material is the vital ingredient in making the suitable nuclear fuel that will lead to the production of fusion energy at practical and much lower temperatures than fusion energy from ″thermonuclear reaction″, the illusionary dream that we have been chasing for 6 decades with no end in sight.

In spite of these great potentials and advantages for this emerging technology, it is not without its opponents, who are similar to the opponents of nuclear energy with their legitimate concerns about the radioactive waste, safety of nuclear reactors and nuclear proliferation. But in the case of nanotechnology most of the arguments of its critics who demand the suspension of its development are based on science fiction and pure speculations. Those people are mainly politicians and specialized researchers with a limited knowledge in a certain field of nanotechnology. In their debates they mainly use the issue of toxicology of nanoparticles.

Some types of nanoparticles have shown to be toxic in certain environments and this should not come as great surprise. We are in the initial stage of studying the characteristics of nanoparticles.

Toxicology is an important issue and it must be given the priority in any application of nanotechnology, but at the same time it must not be used as an excuse to delay the development of nanotechnology.

There are a few important things which the opponents of nanotechnology must understand. For a start, natural nanoparticles have always existed in nature. An interesting recent article in Nature magazine ″ nanoparticles everywhere″ explains this natural phenomenon: http://www.softmachines.org/wordpress/?p=31 And in ancient times nanoparticles have already been used: ″Gold nanoparticles in ancient and contemporary ruby glass″. See Science Direct.

It is true we still do not have a clear understanding of the behaviors of some nanoparticles especially when they interact with biological cells or when some nanoparticles with specific sizes interact with certain materials. Therefore, research in the toxicology of nanoparticles is crucial and will lead to both clear and conclusive evidence about the harmful effects of types of nanoparticles and at the same time to the solution to these harmful effects based on a deeper understanding of the physical and chemical properties of those particles.

In his article "Nanotechnology - Good and Bad” Mr. Karl Schwarz advised toxicology researchers to focus on the true effects of what current pollution has done to the environment and its toxicology on all life forms on this planet. ″That is a far bigger threat to mankind than nanotechnology. Unlike our current technology, nanotechnology can be applied to reverse much of the harmful effects that the industrial and IT revolutions have left behind.″

The opponents of nanotechnology would be more justified in their criticism to point out the danger of nanotech weapons on earth and in space. Nanotechnology has the potentials for creating the most evil and most destructive weapons imaginable. This technology has the potential to make all weapons of mass destruction more deadly. New generations of nuclear, chemical and biological weapons can be developed that are compact, undetectable and much more destructive.

Since the beginning of the 20th century and especially in the second half, we had so many scientific breakthroughs and inventions. Those technological breakthroughs and inventions have their technical drawbacks. Mainly the efficiency of engines and the energy conversion methods compare to projected capabilities of nanotechnology. But, even with that technology our world would have been a better place today, if the advanced nations of the world cooperated with each other and established a civilized economic order based on modern scientific tools and principles, humanitarianism and above all ecological considerations. That could have resulted in less people living in developing countries today and without those conflicts that are raging right now. Very few countries with small percentage of their population fully benefited from those scientific inventions, while most of them were exploited for military applications anyway, like uranium based weapons. Those few nations had to go to two devastating major wars in order to maintain their privileges. If that was not enough we just have to look to the stockpiles of nuclear, chemical and biological weapons that we have right now. Even small nations are now in a race against time to develop these weapons. It is only a matter of time before these weapons will be used, particularly if we consider the deteriorating economic environment and the rising geopolitical

tensions over fossil fuel resources. We are living in an increasingly dangerous world not only because of these weapons but also because of increasing environmental deterioration. There are no words that can precisely describe the impact of pollutions in the atmosphere, on land or in the oceans that was caused mainly because of our economic and social backwardness rather than the backwardness of our technology. These are obvious facts to everybody and they show that any technological development is insufficient and in fact can be very dangerous without economic and social progress. Therefore, the real issue is not whether nanotechnology is good or bad but whether it is rationally used, serving social needs rather than corporate needs.

From a technical point view nanotechnology can provide clean energy resources and sustainable development. It has great potentials for transforming the technology of our present energy resources and creating new ones that are cleaner and saver. In a technical review paper I am currently writing - Green Energy Resources in the Age of Nanotechnology - those great potentials are explained in detail.

By taking a quick glance at our scientific and technological progress just over the last century, it is quite obvious the progress is moving with incredible speed. Our knowledge about life in general and the structure of matter in the universe is increasing every passing day. What is abundantly clear, however, from the analysis of our experiences and knowledge is that the whole nature of the universe and its fabrics is operating on the principle of good versus evil and as we move on and continue to discover these fabrics and engineer them in laboratory or try to form new materials from these fabrics, the decision to use these discoveries for evil purposes like making destructive weapons or good purposes like trying to achieve deeper understanding of life and our place in the universe will always be in our hands. That decision will be influenced by our educational level, social and economic development.

Therefore, scientific advances like nanotechnology cannot guarantee a bright future for mankind without deep social and economic reforms of our society.