“Nano Technology” New Age Energy Source

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Abstract:

We have gone through the Stone Age, Bronze Age, Iron Age and the Silicon Age. What next….? We are already into the nanotech age where materials are getting smart day by day. In not distant future the machines would work at clockwork precision and deliver desired results with least human intervention. All things would work in perfect synchronization, but still remain invisible to human eye. Nanotechnology operates at such a fundamental level that there is very little of a technological nature that it will not impact. Thus its effects on energy generation, transmission, storage and consumption are numerous and diverse. Some will be incremental and some quite possibly revolutionary. This field is a result of a search for alternative materials, devices and applications of electronics. The nanoparticle technology, relating to the preparation, characterization, processing, and applications of nano-sized particles, plays an increasingly important role in the emerging technology. Although the nanoparticles have many unique functional properties superior to the coarser particles, they also suffer from dispersion and stability problems because of their strong cohesiveness and high specific surface areas.

This paper aims at introducing different mechanisms and technologies present in nanotechnology which can be used for energy generation ranging from small batteries to non conventional energy generation mechanisms like solar and wind power generation sources.

1)Introduction: The nanotechnology has drawn much attention since the beginning of this century as the critical technology to advance industrial outputs and to extend human life in the 21st century.

Developing Commercial applications of nanotechnology, the nano-sized particles play a significant role because of their unique functional properties.

The definition of nanoparticles depends on their applications. In general, nanoparticle refers to the particle having a size smaller than 100 nm. However, it could be, in the narrow sense, less than around 10 nm as its physical properties, such as melting point, differ from those of the bulk solids. On the other hand, particles ranging from nm to one μm could also be called “nanoparticles” in the broader sense. In this paper, the particles less than the shortest wavelength of visible light (around 400 nm) are called “nanoparticles”, which are finer than the so-called “submicron particles”.

In fact, nano-sized particles, such as ink, pigment, carbon black, fine silica etc., are not new to some industries and have been used as additives to improve product structure and qualities. The nanoparticle technology is to bridge the new nanotechnology applications and the traditional power technology. Rather than trying to sketch the whole landscape, a few examples will hopefully illustrate the variety . The ordinary end of the scale you have anti-fouling paints for wave or tidal power, or materials with a higher tolerance for radiation in nuclear reactors.

In wind power, the potentially enormous improvements in strength-to-weight ratio of composite materials used in blades could pay back surprisingly well because the relationship of blade length to efficiency is not linear but follows a power law -- though there is much argument about how this pans out in the real world.

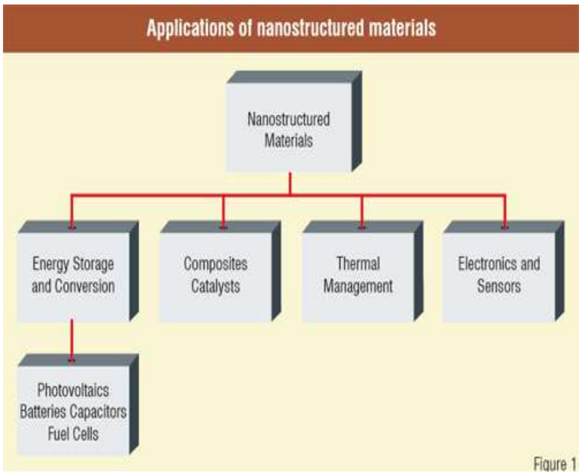
At the other extreme of nanotech impact, you have solar energy. We are children in this area, and the playground is built on the nanoscale. Almost any development is going to involve nanotech -- an intriguing recent exception being the use of lenses to focus light on old-fashioned silicon photovoltaics, thus demanding less of this expensive material.

But what makes for a revolution in energy generation? Two things: availability and economics. The fact that solar energy is so bountiful -- enough hits the Earth in a minute to meet our global requirements for at least a week -- makes it potentially revolutionary; it's just the cost of capturing that energy that has been standing in the way. Reduce that enough, or increase the cost of the alternatives, and you has a winning scenario.

Progress in the area of nanoscience and nanotechnology has pervaded almost all areas of science and technology. Over last couple of decades the ability to manipulate and control materials at an atomic and molecular level (nanometer range) and subsequent understanding of the fundamental processes at nanoscale have led to new avenues. The knowledge thus acquired can be translated into innovative processes, leading to design or fabrication of better products. More importantly, new scientific phenomenon and processes have emerged that could provide either revolutionary or novel solutions to the energy, environmental, and sustainable mobility challenges that will face humanity in the 21st century.

With demand for clean and sustainable energy sources increasing at an exponential rate, new material technologies are being explored that could provide cost-effective and environmentally clean solutions to the world's energy problems. Developments in the areas of alternative fuels or energy storage technologies like advanced batteries, fuel cells, ultra capacitors and biofuels are emerging as strong contenders to petroleum-based sources.

Energy derivable from clean and renewable sources like solar and wind power have tremendous potential, but the practical use of these sources of energy requires efficient electrical energy storage (EES) technologies that can provide uninterrupted power on demand. In all of these new technologies, nanomaterials are increasingly playing an active role by either increasing the efficiency of the energy storage and conversion processes or by improving device design and performance. Figure 1 shows some of the applications which are using nanostructured materials as the "building block" for the next generation of technologies. In most cases, however, the use of nanoscale materials is a logical extension of the current technology.



The primary components of EES systems constitute chemical (batteries) and capacitive storage. Although electrochemistry is the main guiding principle behind both the technologies, there exists one basic fundamental difference. In the case of chemical storage, the reactants are stored in the cell to produce electricity whereas in capacitive storage, it is charge that is stored across the double layer.

2) Energy Generation Systems Of the Future To Be Backed By Nanotechnology

2.1) Energy Storage

The ability to store energy locally can reduce the amount of electricity that needs to be transmitted over power lines to meet peak demands. Energy storage could allow downsizing of baseload capacity and is a prerequisite for increasing the penetration of renewable and distributed generation, technologies such as wind turbines at reasonable economic and environmental costs. Suitable energy storage is critical to the increased use of renewable energies, particularly solar and wind, because these are inconsistent resources.

Nanotechnology may play a role in distributed generation through the development of cost-effective energy storage in batteries, capacitors, and fuel cells. The next generation of storage devices may be optimized by nano engineered advances and the use of nanoscale catalyst particles

2.2) Theory of capacitance

Understanding the concept of capacitance can be helpful in understanding why nanotechnology is such a powerful tool for the design of higher energy storing capacitors. A capacitor's capacitance (C) or amount of energy stored is equal to the amount of charge (Q) stored on each plate divided by the voltage (V) between the plates. Another representation of capacitance is that capacitance (C) is approximately equal to the permittivity (ε) of the dielectric times the area (A) of the plates divided by the distance (d) between them. Therefore, capacitance is proportional to the surface area of the conducting plate and inversely proportional to the distance between the plates.

Using carbon nanotubes as an example, a property of carbon nanotubes is that they have a very high surface area to store a charge. Using the above proportionality that capacitance (C) is proportional to the surface area (A) of the conducting plate; it becomes obvious that using nanoscaled materials with high surface area would be great for increasing capacitance. The other proportionality described above is that capacitance (C) is inversely proportional to the distance (d) between the plates. Using nanoscaled plates such as carbon nanotubes with nanofabrication techniques, gives the capability of decreasing the space between plates which again increases capacitance.

2.3) Fuel Cells

A fuel cell is a device used for electricity generation that is composed of electrodes that convert the energy of a chemical reaction directly into electrical energy, heat, and water. It is similar to a battery, except that it is designed for continuous replenishment of the reactants that become consumed, thereby requiring no recharging. It produces electricity from an external supply of fuel and oxygen, rather than the limited internal energy storage capacity of the battery.

2.4) Power Chips

Numerous nanotechnology applications will likely be developed within the next 20 years, but one example serves to illustrate the potential impact that nanotechnology may have on energy generation, and, in turn, on the reduced need for energy ROWs in the future. "Power Chips" are nanotechnology devices that use thermionics2 to convert heat directly into electricity.

If successful, these small solid-state devices could improve current power generation and waste heat recovery techniques. They are estimated to deliver up to 70 to 80% of the maximum (Carnot) theoretical efficiency for heat pumps (conventional power-generation equipment

Operates at up to 40% Carnot efficiency). Currently under development, Power Chips contain no moving parts or motors and can be either miniaturized or scaled to very large sizes for use in a variety of applications.

2.5) NANO TUBES, CNT ELECTRONICS.

Single-walled carbon nanotubes (SWNTs), which are graphite cylinders made of a hexagonal carbon-atom lattice, have drawn a great deal of interests due to their Fundamental research importance and tremendous potential technical applications. For Example, they might play important role in future molecular electronic devices, such as room-temperature single electron and field-effect transistors, and rectifiers. A SWNT can be either a semiconductor or a metal, depending on its helicity and diameter. The electronic properties of the SWNT have been the subject of an increasing number of experimental and theoretical studies since 1995.And it is expected that very soon SWNT will see its application in Nano electronics.

2.6)NANOWIRES

A nanowire is a wire of dimensions of the order of a nanometer. They are also called quantum wires because their properties are governed by quantum mechanics. They can be used to link or connect tiny component is nanocircuits. They are referred as 1 dimensional material (because their length to width ratio is very high). The electrons here are quantum confined and occupy different energy levels than those of bulk material. They will see their application in electronics, opto-electronics and Micro Electro mechanical systems. They will be seeing possible appellations in future molecular electronic devices, as resonant tunnelling diodes, single-electron transistors, and field effect structures and also in making logic gates.

2.7)QUANTUMDOT

It is the semiconductor nanostructure which exhibits the phenomenon of confining motions of electrons of conduction, valence or exactions in all three spatial directions. They have superior quantum and optical properties and are being researched for diode laser, amplifier, sensors, etc. They are also seeing application in Light Emitting Diodes (Quantum Dot Single Electron Device). The ability to control electron charging of a capacitive node by individual electron makes there devices suitable for memory application. A quantum well is a potential well that confines particles, which were originally free to move in three dimensions, to two dimensions, forcing them to occupy a planar region

2.8)MANUFACTURING CHALLENGES

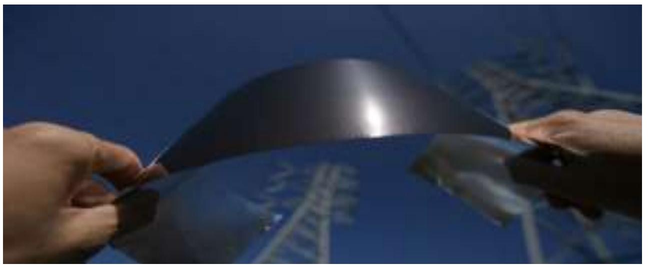
Nanofabrication is being developed to construct devices such as resonant tunnelling diodes and transistors and single electron transistors and carbon nanotubes transistors. The most common type of transistor being developed for use at the nanoscale is the field effect transistor. Economics issues are constraining nano-electronics to hit market. Two ways of manufacturing nano materials are:

1. Bottom up self assembly (wet chemistry) in this type of fabrication we start from atoms or molecules to get to the desired material.
2. Top down self assembly (Lithography and derivatives) in this type of fabrication the bulk material is broken down into smaller pieces.

Thought we have knowledge about many new materials and their physics at nanoscale but to get the technology economically available (cost effective) and to get the state of art levels of manufacturing nanomaterials is still under development.

2.9)Thin Film Solar Cells

Solar cells are currently made in an expensive, high purity process. Thin film solar cells generate electricity in a completely different manner, use a completely different manufacturing method and are based on cheap, abundant and common materials. These cells are not silicon based but use extremely thin layers of semiconducting plastic to absorb light and generate electricity. These thin semiconducting layers can be printed onto virtually any surface in a very low cost manner.



2.10) Aerogels

Aerogels are very low density solid-state solids created by producing a gel and replacing the liquid part of the gel with air. The result is a material with only about twice the density of air. Mostly made from silica based materials they can be used as excellent thermal insulators for building materials or for insulating liquefied fuels. Aerogels are transparent and can also replace window glass to make buildings more energy efficient.

2.11) Piezoelectric power.

Piezoelectric substances develop an electric potential along particular crystal axes when deformed; or alternatively, deform mechanically when an electric field is applied. Thus they potentially provide a way to transform mechanical work into electricity without macroscopic moving parts such as turbines.

Piezoelectric materials are widely used at present for oscillators and sensors, most notably for nanoscale science in scanning-probe microscopes (SPMs). One study has shown that the maximum efficiency of electricity production with conventional packages of PZT (lead zirconate titanate, $Pb(Zr,Ti)O_3$, another perovskite), a commercially available piezoelectric material, is only ~10%. According to this analysis, a great deal of energy is stored temporarily as strain without causing electrical generation.

This energy is simply returned mechanically to the environment. Quite apart from the potential of developing and fabricating new piezoelectric materials,
nanofabrication would help make even the present low-efficiency materials more practical for power generation. Power generation would requires nanostructuring on a large scale, not only for the sheer volume of material required, but because building up significant voltages requires nanolayered structures, in which thin layers of piezoelectric material are interlayered with electrodes of alternating polarity connected in series.

2.12)Nanomaterials for batteries:In order to meet the need for vehicles with improved fuel economy, many automotive companies now offer gas-electric hybrids (HEVs) that utilise large batteries (> 1kWh) to store energy recovered from braking events. There is also much interest in the development of plug-in-hybrids (PHEVs), which have large batteries (> 5kWh) that can be recharged from the power grid. Although current HEVs use batteries based on nickel-metal hydride (NiMH) chemistry, there is much interest in replacing them with lithium-ion batteries because of their larger gravimetric and volumetric energy density. Realizing the potential of this technology in making PHEVs and HEVs a reality, there has been tremendous efforts in industry, governmental agencies, and academia to accelerate the development of lithium-ion battery. The offices of the Freedom Car of the DOE in association with United States Automotive Battery Consortium (USABC) have mandated specifications and requirements, both in terms of performance and cost for lithium-ion cell technology.

The increased surface area allows the electrolyte to surround individual particles for better accessibility of the electro-active material. It is worth mentioning that the increase in surface area however, could be a potential impediment for the cell performance and life as it could accelerate unwanted reduction-oxidation chemistry that occurs on the electrode material surface. Interestingly, to alleviate this problem researchers have found another nanotechnology-based solution that involves chemically coating the particle surface with a few-nanometer-thick layer of amorphous carbon or other suitable inorganic material. The presence of such a film avoids the surface chemistry as well as increases the intrinsic conductivity of the particle without affecting the transport of lithium-ions into and out of the core of the particle. Therefore, it is becoming increasingly evident that at a materials level going over to the nanometer-sized particle is particularly advantageous.

3) Nanotechnology Applications Relevant to Electricity Transmission

3.1) Wires and Cables

Nanotechnology may help improve the efficiency of electricity transmission wires.
Today, aluminium conductor steel reinforced (ACSR) wire is the standard overhead conductor against which alternatives are compared. The development of new overhead conductors is expected to increase the capacity of existing ROWs by five times that of ACSR wire at current costs. The 3M Corporation has developed a nanomaterials-based metal-matrix overhead conductor known as the aluminium conductor composite reinforced (ACCR) wire, which is designed to resist heat sag and provide more than

twice the transmission capacity of conventional conductors of similar size.

This ACCR wire is currently in use, or has been selected for use, by six major utilities across the country. According to 3M "Aluminium has been a key ingredient in bare overhead conductors for decades. The difference is that ACCR wire is based on the use of aluminium processed in new ways to create high-performance and reliable overhead conductors that retain strength at high temperatures and are not adversely affected by environmental conditions." The ACCR wire's strength and durability derive from its nanocrystalline aluminium oxide fibers, which are embedded in the high-purity 3M aluminium matrix core wires using a patented process. The constituent materials are chemically inert with respect to each other and can withstand extreme temperatures without chemical reactions or any appreciable loss in strength. The material used in the core of the cable replaces the steel used in conventional cables.

4)Other Electrical Transmission Infrastructure

Nanotechnology applications may help improve other components of the electric transmission infrastructure, thereby potentially reducing environmental impacts. The examples below pertain to transformers, substations, and sensors.

4.1) Transformers.
Fluids containing nanomaterials could provide more efficient coolants in transformers, possibly reducing the footprints, or even the number, of transformers. As noted nanoparticles increase heat transfer, and solid nanoparticles conduct heat better than liquid. Nanoparticles stay suspended in liquids longer than larger particles, and they have a much greater surface area, which is where heat transfer takes place.

Using nanoparticles in the development of HTS transformers could result in compact units with no flammable liquids, which could help increase siting flexibility.

4.2)Substations. Substation batteries are important for load-leveling peak shaving, providing uninterruptible supplies of electricity to power substation switchgear, and for starting backup power systems. Smaller, more efficient batteries could reduce the footprints of substations and possibly the number of substations within a ROW.

4.3)Sensors. Nanoelectronics have the potential to revolutionize sensors and power-control devices. Nanotechnology-enabled sensors would be self-calibrating and self-diagnosing. They could place trouble calls to technicians whenever problems were predicted or encountered. Such sensors could also allow for the remote monitoring of infrastructure on a real-time basis. Miniature sensors deployed throughout an entire transmission network could provide access to data and information previously unavailable. The real-time energized status of distribution feeders would speed outage restoration, and phase balancing and line loss would be easier to manage, helping to improve the overall operation of the distribution feeder network.

5) Example of Nanotechnology Affecting Energy Technology

5.1)Solar Technology:
Nanosolar a leader in the drive to make solar affordable - Nanosolar has developed proprietary technology that makes it possible to simply roll-print solar cells with performance and durability similar to silicon-wafer cells, while cutting the costs, making solar affordable. The long-term limitation will be the growing scarcity of Indium.

5.1.1)Solar / Thermal Electric Advanced Diamond Solutions amorphous nanostructures - Semiconductor Industry Company serendipitously developed thermionic solar cells using amorphous diamond nanostructures that offer potential efficiencies of 50% at half the cost of silicon solar cells. Also has good promise as a thermal electric generator

5.1.2)Carbon nanotubes offer new way to produce electricity - MIT scientists have discovered that moving pulse of heat travelling along the miniscule wires known as carbon nanotubes can cause powerful waves of energy. These "thermo power waves" can drive electrons along like a collection of flotsam propelled along the surface of ocean waves, creating an electrical current. The previously unknown phenomenon opens up a new area of energy research.

5.1.3)Scientists turn light into electrical current using a golden nanoscale system - Material scientists at the University of Pennsylvania have demonstrated the transduction of optical radiation to electrical current in a molecular circuit. The system, an array of nano-sized molecules of gold, respond to electromagnetic waves by creating surface Plasmon's that induce and project electrical current across molecules, similar to that of photovoltaic solar cells.

Researchers from Tel Aviv University have discovered a new nanomaterial that can repel dust and water and could provide a self-cleaning coating for windows or solar panels. The new material is made up of molecules of peptides that "grow" to resemble small forests of grass. The coating also acts as a super-capacitor, thereby possibly providing an energy boost to batteries.

5.1.4)Nanopillar Solar May Cost 10x Less Than Silicon - A team of researchers from the University of California, Berkeley, have developed a new kind of flexible solar cell that consist of an array of 500-nanometer-high cadmium sulfide pillars printed on top of an aluminium foil... If this could be done on a roll-to-roll process, the cost could be 10x less than crystalline silicon panels.

5.1.5)A Hybrid Nano-Energy Harvester - Researchers have combined a nanogenerator with a solar cell to create an integrated mechanical- and solar-energy-harvesting device. This hybrid generator might be used, e.g., to power airplane sensors by capturing sunlight as well as engine vibrations.

5.1.6)Harvesting the sun's energy with antennas - Nanoantennas absorb energy in the infrared part of the spectrum and can take in energy from both sunlight and the earth's heat, with higher efficiency than conventional solar cells. Individual nanoantennas can absorb close to 80 percent of the available energy.

5.1.7)Cheap, Efficient Thermoelectrics via Nanomaterials - Researchers at MIT and Boston College have developed an inexpensive, simple technique for achieving a 40 percent increase in the efficiency of a common thermoelectric material, bringing the technology closer to becoming economically feasible for a wide range of waste heat recovery.

5.1.8) Solar Hairy Solar Panels From Nanowire - Researchers have grown light-absorbing nanowires on carbon-nanotube fabric, made from exotic materials that can absorb more energy from the sun than silicon. The aim is to produce flexible, affordable solar cells that will achieve efficiency of 20% within five years, and 40% longer term

5.1.9) Thin Film Solar / Thermal Electric New nanostructured thin film shows promise for efficient solar energy conversion - Researchers at Berkeley have demonstrated highly efficient thermoelectric behavior from arrays of silicon nanowires grown onto a silicon wafer. The technology is compatible with fabrication processes used in the large-scale silicon processing industry. A low-cost thermoelectric system could be used to generate electricity from heat lost from fossil-fuel based energy generation.

5.1.10) Thermal Electric Nansulate Paint May Soon Generate Electricity from Thermal Differences - With the application of a paint coating, the thermal difference between inside and outside temperatures could be used to generate electricity, in addition to saving energy through its insulating properties.

5.1.11) Nanotechnology and Photovoltaics - Solar power for less than $1. Nanosys Inc. combines their nanocomposite photovoltaic technology with precisely engineered inorganic semiconductor nanocrystals, yielding light-weight, flexible host-matrix.

5.1.12) Inexpensive, Easy To Produce Solar Panels - Researchers at NJIT have developed an inexpensive solar cell that can be painted or printed on flexible plastic sheets. The process uses tiny carbon Buckyballs to trap electrons, combined with carbon nanotubes, which conduct current better than any conventional electric wire.

5.2)Battery Technologies

5.2.1)Nanotube Super Capacitor Battery - MIT researchers are developing a battery based on capacitors that utilize nanotubes for high surface area, enabling near instantaneous charging and no degradation. Estimating ~5 years to commercialization.

5.2.2) Batteries Nanowire Battery Holds 10 Times The Charge - Stanford researchers have found a way to use silicon nanowires to reinvent the rechargeable lithium-ion batteries that power laptops, iPods, video cameras, cell phones, and countless other devices. Could also be applied to electric vehicles.

5.2.3) Piezoelectric Nanowire Extracts Energy from Motion - Researchers at the University of Illinois are working on making a nanogenerator out of barium titanate, which exhibits a greater piezoelectric effect than zinc-oxide, to convert miniscule mechanical energy into electricity for biosensors and tiny portable devices.

5.2.4) Batteries Weaving Batteries into Clothes - A novel machine that makes nanostructured fibers could be the key to a new generation of military uniforms that take on active functions such as generating (e.g. solar) and storing energy.

5.2.5) Nanogenerator Provides Continuous Direct Current - Researchers have demonstrated a prototype nanometer-scale generator that produces continuous direct-current electricity by harvesting mechanical energy from such environmental sources as ultrasonic waves, mechanical vibration or blood flow.

6) Future Research and Development

6.1) Nanotech/Batteries Carbon Nanotube Batteries Pack More Punch –

Carbon nanotubes are attractive materials for battery-making because of their high surface area, which can accept more positive ions and potentially last longer than conventional batteries. Instead of this design, researchers at MIT have introduced something new — using chemically modified carbon nanotubes as the positive ion source themselves.

6.2)Batteries Made from Regular Paper - A group of Stanford University researchers have shown that ordinary paper can be turned into a battery electrode simply by dipping it into carbon-nanotube inks. The resulting electrodes, which are strong, flexible, and highly conductive, might be used to make cheap energy storage devices to power portable electronics.

6.3) 3-D photovoltaic systems go where the sun don't shine - Researchers at Georgia Tech have developed a new type of three-dimensional PV system using optical fiber that promises solar generators that are foldable, concealed and mobile, meaning they could be hidden from view and leave rooftops panel-free. Sunlight entering the optical fiber passes into the nanowires, where it interacts with the dye molecules to produce electrical current.

6.4) Longer-Running Electric-Car Batteries - In an advance that could help electric vehicles run longer between charges, researchers at Stanford University and Hanyang University in Ansan, Korea, have shown that silicon nanotube electrodes can store 10 times more charge than the conventional graphite electrodes used in lithium-ion batteries.

6.5) Cheaper Geothermal - Researchers at Pacific Northwest National Laboratory in Richland, WA, say they've developed a superior type of heat-extracting fluid using nanomaterials that could dramatically improve the economics (of producing renewable power from low-temperature geothermal resources. The proprietary liquid can potentially boost the rate of heat capture by 20 to 30 percent.

6.6) Secrets Of Electricity-Producing Materials - A team of University of Houston scientists has set out to both amplify and provoke the potential in materials known as piezoelectrics, which naturally produce electricity when subjected to strain, such as mechanical movement or jostling. The objective is to create nanodevices that can power electronics, such as cell phones, MP3 players and even biomedical implants.

6.7) Project Sage: Bringing Solar Power to the Masses - Nano-scale research at the Univ. of Arizona could one day lead to photovoltaic materials thin enough, flexible enough and inexpensive enough to go not only on rooftops but in windows, outdoor awnings and even clothing. The goal for UA scientists is to understand and control the interfaces in these devices to enable the development of long-lived solar energy conversion devices on tough, flexible and extremely low-cost plastic substrates.

6.8) Printable batteries - For a long time, batteries were bulky and heavy. Now, a new cutting-edge battery by Fraunhofer ENAS is revolutionizing the field. It is thinner than a millimeter, lighter than a gram, and can be produced cost-effectively through a printing process.

6.9) Using nanoparticles to increase the effiiciency of thin film solar cells - Researchers at the Institute of Condensed Matter and Solid State Optics in Germany have found that using metallic nanodiscs distributed over the surface of a thin film solar cell increases absorption in the cell, improving its efficiency by up to 50 percent.

6.10) Tiny boats made of nanomaterials are powered directly by sunlight - Researchers at the University of California, Berkeley, are using carbon nanotubes to build small, simple waterborne machines propelled directly by sunlight. In theory, they say, these machines could be scaled up to make energy-generating pumps directly powered by the sun.

6.11) Print-on-Demand Power - Flexible carbon-nanotube supercapacitors could give more power to cell phones and other electronics. Researchers have made the first printable supercapacitor. This high-performance energy-storage device performs better than conventional supercapacitors currently on the market.

6.12) Nanotech Batteries For A New Energy Future - Researchers at the Maryland NanoCenter at the University of Maryland have developed new systems for storing electrical energy derived from alternative sources that are, in some cases, 10 times more efficient than what is commercially available

6.13)New Method Produces Longest Platinum Nanowires Yet; Implications for Increased Fuel Cell Longevity and Efficiency - The platinum nanowires are roughly ten nanometers in diameter and also centimeters in length — long enough to create the first self-supporting web of pure platinum that can serve as an electrode in a fuel cell. A report on the work is published in the

6.14)Sun-powered device converts CO2 into fuel - Powered only by natural sunlight, an array of nanotubes is able to convert a mixture of carbon dioxide and water vapour into natural gas at 20 times higher than with other nanotech methods.

6.15) Harnessing Hamster Power with a Nanogenerator - Researchers have demonstrated that a nanogenerator can be driven by irregular, low-energy biomotion, including the tapping of a human finger and a hamster's erratic running and scratching.

6.16) Carbon Aerogels and Ultracapacitors - This technology will improve ultracapacitors by swapping in carbon nanotubes. This greatly increase the surface area of the electrodes and the ability to store energy since the amount of energy ultracaps can hold is related to the surface area and conductivity of electrodes. So.. since they have a extremely high surface area, carbon aerogels are used to create ultracapacitors with values ranging up to thousands of farads.

6.17) True properties of carbon nanotubes measured - For more than 15 years, carbon nanotubes (CNTs) have been the flagship material of nanotechnology. Researchers have conceived applications for nanotubes ranging from microelectronic devices to cancer therapy. Their atomic structure should, in theory, give them mechanical and electrical properties far superior to most common materials.

7) Conclusion:

Great Things Come in Small Packages that's what nano technology mean. Intensive research in nano technology will help in unfolding numerous energy related problems faced by engineers currently.

Research and development in this field can unfold unknown secrets of the natures. Reliability and efficiency will drastically increase paying way to better technologies and better handling there by reducing the dependence on fossil fuels and the effects of global warming. Nano technology will and can change the way we think on power generation and utilisation extracting energy from simple actions done by mankind.

References

[1] P. Lim Et Al., "Design Of A Novel Highly Capacitive Mems-Based
Vibration To Electricity Energy Converter With Suspended In-Plane
Overlap Technology", Proc. Of Apcot'06, Singapore, 2006
[2] S. Roundy Et Al., "Micro-Electrostatic Vibration-To-Electricity
Converters", Proc. Of Imec'02, New Orleans, Usa, 2002
[3] P. Basset Et Al., "Chip-Size Antennas For Implantable Sensors And
Smart Dusts", Proc. Of Transducers'05, Seoul, Korea, 2005

[4]A Bulk Silicon-Based Vibration-To-Electric Energy Converter Using An In-Plane Overlap Plate (Ipop) Mechanism
Ayyaz M. Paracha1, Philippe Basset1*, Peter C. L. Lim2, Frédéric Marty1, Tarik Bourouina1

[5]Continuous Electricity Generation At High Voltages And Currents Using Stacked Microbial Fuel Cells
P E T E R A E L T E R M A N , K O R N E E L R A B A E Y ,
H A I T H E P H A M , N I C O B O O N , A N D W I L L Y V E R S T R A E T E *
Laboratory Of Microbial Ecology And

[6]Energy Harvesting Using Nanowires?**
By Marin Alexe,* Stephan Senz, Markus Andreas Schubert, Dietrich Hesse, And
Ulrich Go¨Sele

[7]Production Of Electricity During Wastewater Treatment Using A Single Chamber Microbial Fuel Cell
Hong L I U , †
R a m a n a t h a n r a m n a r a y a n a n , ‡ a n d
B r u c e e . L o g a n * , †

[8]Potential Impacts Of Nanotechnology On Energy Transmission Applications And Needs
Pan, Z. W.; Dai, Z. R.; Wang, Z. L. Science 2001, 291 (5510), 1947-
1949.
Gao, P. X.; Ding, Y.; Mai, W. J.; Hughes, W. L.; Lao, C. S.; Wang,
Z. L. Science 2005, 309 (5741), 1700-1704.
Wang, X. D.; Summers, C. J.; Wang, Z. L. Nano Lett. 2004, 4 (3),
423-426.
Gao, P. X.; Wang, Z. L. Appl. Phys. Lett. 2004, 84 (15), 2883-
2885.
Look, D. C.; Coskun, C.; Claflin, B.; Farlow, G. C. Physica B 2003,
340, 32-38.

[9]Piezoelectric And Semiconducting Coupled Power Generating Process Of A Single Zno Belt/Wire. A Technology For Harvesting Electricity From The Environment
Jinhui Song, Jun Zhou, And Zhong Lin Wang*
School Of Materials Science And Engineering, Georgia Institute Of Technology,
Atlanta, Georgia 30332-0245

[10]Modeling Nano Enabled Elements Of Solar And Fuel Cell
Rohit Pathak, Satyadhar Joshi, Pawan Kotak, Salman Ahmed, And Virendra Verma