Research & Reviews

ISSN: 2319-9873

Research and Reviews: Journal of Engineering and Technology

Energy and Nanotechnology- Advanced Strategy for the Future

Sunil R Kewate[1]*, Swapnil S Thorat[1], Akash D Kewate[2], and Rakesh S Ambade[2]

[1]Mechanical Engineering Dept. Govt. College of Engg. & Research, Ambegaon, Pune, Maharashtra, India.
[2]Mechanical Engineering Dept. JDIET, Yavatmal, Maharashtra, India.

Article

Received: 11/02/2013
Revised: 25/02/2013
Accepted: 27/02/2013

***For Correspondence**

Mechanical Engineering Dept. Govt. College of Engg. & Research, Ambegaon, Pune, Maharashtra, India.

Keywords: Energy, renewable, depletion, nanotechnologies, industries, conventional energy, nano-engineered materials, alternative energy.

ABSTRACT

Nanotechnology is fundamental over the next 50 years to providing sufficient energy for a growing world and to protecting the environment in which we live. Renewable energy resources are needed to maintain the world's energy supply to slow the depletion of fossil reserves and reduce global carbon emissions. Apart from the increasing needs for improving sustainability and efficiency of conventional energy usage, alternative energy sources like solar energy and hydrogen energy are also growing at a steady pace. Nanotechnology offers the ability to enhance many key properties of energy technologies to achieve sustainability and secure our future energy supplies. In this review research paper, it is explained and analyzed that the improvement of efficiency in current technologies rather than providing new energy sources and stronger influence of nanotechnology on promoting the use of revolutionary new energy sources such as hydrogen and solar conversions by improving the processes or providing nano-engineered materials for their energy storage and release.

INTRODUCTION

Nanotechnology is fundamental over the next 50 years to providing sufficient energy for a growing world and to protecting the environment in which we live. There are an energy/environmental storm gathering and we must pay attention. Our children's' and our grandchildren's' lives are at stake if we mess up the energy/environment issue. Under all practical solutions nanotechnology will play a critical role in any successful outcome. Just as we claim that nanotechnology will change our entire economic structure and our lives over the next decades, so will world energy demand and supply. The two are intimately intertwined. Detailed energy data, options, nanotechnology involvement and intelligent discussion are appearing regularly from responsible institutions. Some of the best energy information has just been mounted on the web. If you haven't considered investing in promising nanotech energy applications up to now, the following may change your mind. [4]

Forecast of Energy Demand

Nanotechnologies will have a major impact in making better use of existing resources rather than producing new energy sources.Figure.1 shows the growth rate of energy demand.

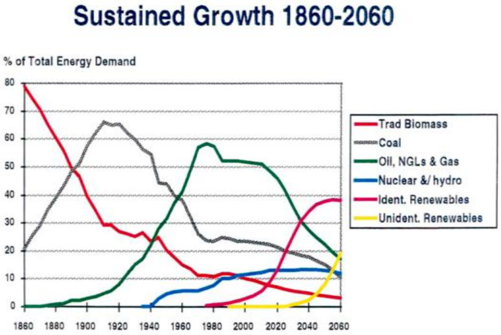

Figure1: Growth of energy demand

ISSN: 2319-9873

In 2010, Energy consumption for the transportation sector alone will be roughly 32.5Vquadrillion Btu, while the residential and commercial sector will be roughly 20 quadrillion Btu as shown in figure. 2 the energy consumption sector wise. Portable electronic energy consumption will be 0.31 trillion Btu.V. Although the latter accounts for only small portion of total consumption, it has shown an increase of 300% in ten years (2000 - 2010). Apart from the increasing needs for improving sustainability and efficiency of conventional energy usage, alternative energy sources like solar energy and hydrogen energy are also growing at a steady pace. Today the speed of progress in photovoltaics (PV) energy has increased dramatically. Flexible thin film solar panels are about to hit the market and are predicted to have a dramatic impact on the energy market within the next ten years. Advances in photovoltaics (PV) have driven forward other areas of energy technology and an increasing number of energy-based applications using nanotechnology have been released onto the market. Super efficient batteries, ultra-capacitors and fuel cells of a variety of sizes are becoming increasingly common in developed nations. There are still problems with long-term storage of energy from some renewable sources (i.e. safety issues with hydrogen), but further progress is expected in the energy sector with a high number of scientific papers on energy developments published recently. Nanotechnology offers the ability to enhance many key properties of energy technologies to achieve sustainability and secure our future energy supplies. [5, 6, 7]

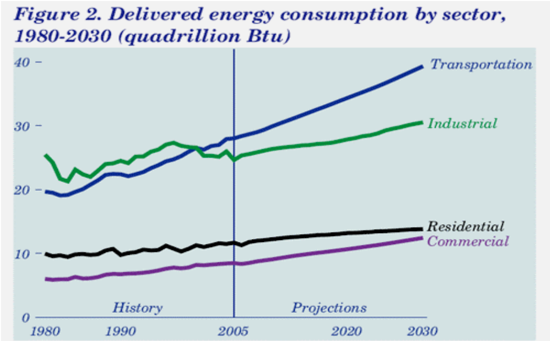

Figure 2: Energy consumption sector wise

Renewable Energy

In 2000, all renewable contributed only 13.8% of the world's energy supply. This includes 2.3% hydro energy, 11% combustible renewable and waste, and 0.5% other, including geothermal, solar, wind, heat etc. The outlook for 2010 is a reduction in all renewable to 12.9% and for 2020 to 12.3% of total energy supply, in the reference scenario, assuming no new measures is taken. (IEA, world energy statistics 2002). Figure 3.shows diagram sources of renewable energy.

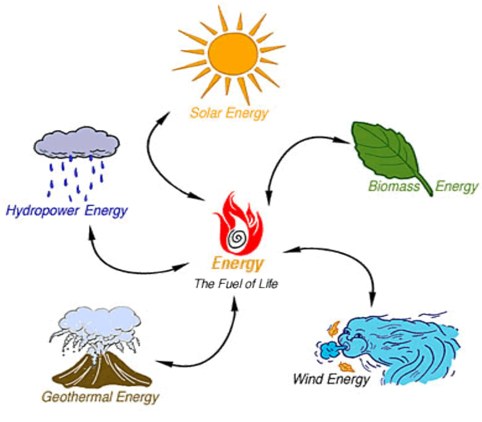

Figure 3: Renewable energy

Total energy consumption is forecast to grow by 20% by 2020. CO_2 production will grow by 14% unless new policy measures are implemented. Due to the Kyoto agreement the EU needs to reduce CO_2 production by 8% compared to 1990. They are committed to increasing the share of renewable in total energy supply from 6-12% and to improve energy efficiency. Energy security is also a reason for some governments to invest in alternative energy sources. Energy security means that governments want to reduce the dependence on one energy source, such as oil, the supply of which can be threatened by conflicts in strategic regions such as the Middle East. If all measures governments consider at the moment are implemented, IEA expects renewable to take a larger share of

ISSN: 2319-9873
energy supply. IEA does not appear to directly consider technological innovation as a driver of the uptake of renewable energy sources, even though they do include forecasts of cost reductions in some renewable energy technologies. [5, 6, 7]

Gratzel Cells

The organic Gratzel solar cell consists of a 10µm thin layer of Titanium Dioxide TiO_2 particles, which are 20 nm in diameter as shown in figure. 4 working of gratzel cell. Organic dye molecules are adsorbed in the pores between the TiO_2 particles, surrounded by an electrolyte fluid. The cell is completed by two transparent electricity conducting electrodes, and a catalyst. The efficiency of Gratzel cells is much lower than of commercial crystalline silicon (around 7-8% instead of around 15%). Therefore they are not competitive in the main market for Solar PV. The EU Nanomax project aims to improve this performance to 15%. This solar powered clock can work indoors without a battery. It can work indoor, because the organic dye sensitive solar cells can convert low light intensities in electricity. Nanotechnology is not really difficult, as this example shows: Even a child can make organic solar cells including nano-structured material. The company Mansolar in the Netherlands manufactures and sells educational kits for school children to make their own organic solar cell, using blackcurrant juice or hibiscus tea as the dye. [1, 2, 3]

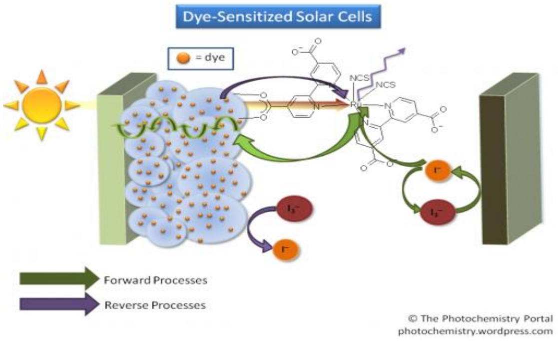

Figure 4: Working of gratzel cell

Super Capacitor Energy Storage (SCES)

Supercapacitor is a double layer capacitor; the energy is stored by charge transfer at the boundary between electrode and electrolyte. The amount of stored energy is function of the available electrode and electrolyte surface, the size of the ions, and the level of the electrolyte decomposition voltage.

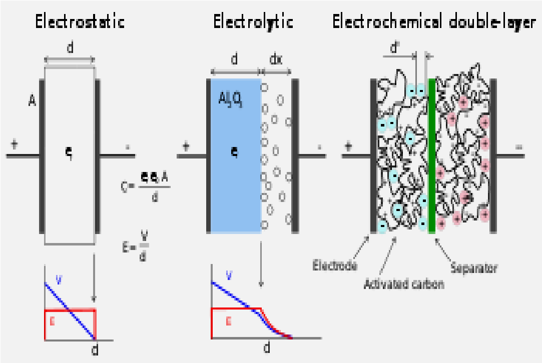

Figure 5: Super Capacitors

Super capacitors are constituted of two electrodes, a separator and an electrolyte. The two electrodes, made of activated carbon provide a high surface area part, defining so energy density of the component as shown in figure5. On the electrodes, current collectors with a high conducting part assure the interface between the electrodes and the connections of the supercapacitor. The two electrodes are separated by a membrane, which allows the mobility of charged ions and forbids no electronic contact. The electrolyte supplies and conducts the ions from one electrode to the other. Usually super capacitors are divided into two types: double-layer capacitors and electrochemical capacitors. The former depends on the mechanism of double layers, which is result of the separation of charges at interface between the electrode surface of active carbon or carbon fiber and electrolytic solution. Its capacitance is proportional to the specific surface areas of electrode material. The latter depends on fast faraday redox reaction. The electrochemical capacitors include metal oxide super capacitors and conductive polymer super capacitors. They all make use of the high reversible redox reaction occurring on electrodes surface or inside them to produce the capacitance concerning with electrode potential.

Capacitance of them depends mainly on the utilization of active material of electrode. The working voltage of electrochemical capacitor is usually lower than 3 V. Based on high working voltage of electrolytic capacitor, the hybrid super-capacitor combines the anode of electrolytic capacitor with the cathode of electrochemical capacitor, so it has the best features with the high specific capacitance and high energy density of electrochemical capacitor. The capacitors can work at high voltage without connecting many cells in series. The most important parameters of a super capacitor include the capacitance(C), ESR and EPR (which is also called leakage resistance). [8, 15, 16, 17]

Hydrogen

There is a lot of discussion at the moment about the Hydrogen Economy, where hydrogen will be the dominant fuel, converted into electricity in fuel cells, leaving only water as waste product. The hydrogen is not freely available in nature in large quantities, so it must be produced by conversion of other energy sources, including fossil fuels and renewable. Only renewable based hydrogen production can contribute to CO_2 emission reduction. Current renewable production methods of hydrogen include H2 production from biomass, from water by electrolysis (where the electricity has been produced by wind, solar or hydroenergy), and the Millennium Cell alternative, Hydrogen on Demand. a process in which a catalysed reaction between water and sodium borohydrate produce hydrogen for applications in cars. The advantage is that the storage of the sodium borohydrate is inherently safe. It is a derivative of borax, which is a natural raw material with substantial natural reserves. [12, 13, 14]

Batteries

Batteries are needed to supply electrical energy when you can't get it from the electricity grid. This includes mobile applications such as mobile phones, walkmans, but also home or even village power supply in remote areas and in back up systems in case the grid goes down. In the future, rechargeable batteries will be even more needed in combination with renewable electricity production such as by solar photovoltaics. The sun does not shine when you need the light the most: at night. Even though at the moment both rechargeable and non-rechargeable batteries are available on the market, the trend is towards rechargeable. There are basically two types of rechargeable batteries where nano-structured materials are applied and the focus of research. The first and most advanced is Lithium based, for example Li-ion batteries. These are dry batteries. The other types are 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 nano-tubes. (Source Martin Ouwerkerk, Philips, Netherlands in Chemisch 2 Weekblad, pending publication.) The above mentioned Millenium cell system is also applied in batteries. [9, 10, 11]

Energy Saving

The most sustainable energy use is no energy use. Governments therefore also stimulate energy saving by consumers as well as industry. Some of these measures imply the use of new technologies, such as improved isolation materials. Nano-structured materials such as nano-foams may play a role here. The report gives a general overview.

CONCLUSION

Nanotechnology research can contribute to solving future needs for energy technologies, especially in new generations of solar photovoltaic's, the hydrogen economy, more efficient conventional energy production and energy saving for industry as well as consumers. Considering the substantial budgets for research dedicated to nano-research including for energy applications, much of this potential is likely to be realized in the coming decades. In further review research paper, the analysis and experimental and optimization of nan- research potential including energy applications will be the study work in future.

REFERENCES

1. BO'Regan, M Gratzel. A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films. Nature Intl Weekly J Sci. 1991; 353: 737.
2. M Gratzel. Conversion of sunlight to electric power by nanocrystalline dye-sensitized solar cells. J Photochem Photobiol A: Chem. 2004;164(1-3): 1-226.
3. JM Kroon. Progress in Photovoltaics. Res Appl. 2007; 15(1):15.
4. S Yanagida, CR Chim. Nanospheres with proper volume in the ZnO-based photoelectrod. J Nanotechnol. 2006; 9:597.
5. GS Beddard, G Porter. Concentration quenching in chlorophyll. Nature Intl Weekly J Sci. 1976; 260:366.
6. K Tennakone, PV Jayaweera, PKM Bandaranayake. Why Gratzels cell works so well. J Photochem Photobiol A: Chem. 2003; 158(2-3):125-130.

ISSN: 2319-9873

7. KP Bandaranayake. Dye-sensitized solar cells made from nanocrystalline TiO2 films coated with outer layers of different oxide materials. J Coordination Chem Rev. 2004:248:1277.
8. PV Jayaweera. 1/f noise and dye-sensitized solar cells. Semiconductor Sci Technol. 2005;20:L40–L42.
9. K Tennakone. Photovoltaics: Research and Applications. J App Phy. 2001;40:L732.
10. MB Weissman. Solar models, neutrino experiments, and helioseismology. Rev Modern Phy. 1988;60:537.
11. LKJ Vandamme. IEEE Trans. Electron Devices. J App Phy. 1994; 41:2176.
12. PJD Lindan, NM Harrison, MJ Gillan. Daresbury functional theory (DFT) techniques we use" Physical Reviews, Volume 80 The American Physical Society (1998) P.762
13. R Summitt, NF Borrelli. Simplest oxide semicon- ductor of noncubic symmetry. J Phy Chem Solids. 1965;26:921
14. C Kormann, DW Bahnemann, MR Hoffmann. Photolysis of chloroform storage in TiO2 (anatase) nanoparticles. J Phy Chem. 2003;42:3237.
15. Y Diamant. Preparation of Nb2O5 coated on the electronic properties of the electrode. Coord Chem Rev. 2004;248:1271-1276.
16. E Palomares. Slow in dye-sensitized solar cells (DSSC) using Al2O3 coated nanoporous TiO2 films. 1464-5. In Chemical communications (Cambridge, England) p.1464.
17. K Hara. Performance of the solar cell depended remarkably on the semiconductor materials. Solar En Mat Sol Cells. 2000;64: 115.