Journal of Fundamentals of Renewable Energy and Applications

Echiegu, J Fundam Renewable Energy Appl 2016, 6:6
DOI: 10.4172/2090-4541.1000e113

Editorial OMICS International

Nanotechnology as a Tool for Enhanced Renewable Energy Application in Developing Countries

Emmanuel A. Echiegu*

Department of Agricultural and Bioresources Engineering, University of Nigeria, Nsukka, Nigeria

***Corresponding author:** Emmanuel A. Echiegu, Senior Lecturer, Department of Agricultural and Bioresources Engineering, Faculty of Engineering, University of Nigeria, Nsukka, Nigeria, Tel: +234 803 677 9169; E-mail: emmanuel.echiegu@unn.edu.ng

Received date: Oct 28, 2016; **Accepted date:** Oct 30, 2016; **Published date:** Nov 02, 2016

Editorial

Energy plays a key role in the socio-economic, technological and political development of any nation. Inadequate supply of energy restricts socio-economic activity, limits technological and hence economic growth and adversely affects the quality of life. In fact, it is widely accepted that there is a strong correlation between socio-economic development and energy availability of a given nation.

Most developing countries are faced with acute energy problems; yet many have vast renewable and non-renewable energy potentials. In particular, energy supply in form of electricity is so poor in many of these countries that industrial and economic activities are seriously retarded. For example, Nigeria, which is a typical example of a developing country, has a total of 14 power plants, consisting of hydro and thermal power stations with an installed capacity of 7,876 MW. The country generates less than 4,000 MW to feed a population of nearly 180 million. This is grossly inadequate and results in massive load shedding which cannot be relied upon for meaningful industrial development expected of a country with such human and materials resources. To ameliorate this problem, industries and household tremendously engage in using generating set to offset this short fall in power supply. Among other problems, this form of energy supply is not reliable for robust industrial and economic activities. It also results in the emission of GHG which helps to worsen the global warming problem. In addition to the inadequate and epileptic power generation, there is also the problem of antiquated transmission lines and poor transmission coverage in the country. This scenario is typical of many developing countries.

As pointed out in an earlier editorial, renewable energy, defined as energy that comes from resources which is naturally replenished on a human timescale, is vital to the much needed socio-economic development of the developing countries. Nanotechnology has the potential to provide cleaner, more affordable, more efficient and more reliable ways to harness renewable energy resources. This can help developing countries to overcome their energy supply challenges and move towards energy self-sufficiency while simultaneously reducing dependence on non-renewable, contaminating energy sources.

Nanotechnology is the study, design, creation, synthesis, manipulation, and application of functional materials, devices, and systems through control of matter at the scale of 1-100 nm as well as the exploitation of novel phenomena and properties of matter which are known to arise at that scale including physical, chemical, electrical, mechanical, optical and magnetic properties. It is employed to improve the efficiency of energy generation, particularly in form of photovoltaic (PV) cells or to develop new methods to generate energy. It is also utilized for improved wind and geothermal power generation, energy storage, lighting and hydrogen fuel cells among others renewable energy applications.

In the area of energy generation, the greatest application of nanotechnology seems to be in the area of efficiently harnessing solar energy using PV cells. Efficient PV system has a lot of potentials for overcoming the energy supply challenges in developing countries. It is very convenient for powering street lights and for charging inverters which are becoming a very good alternative to the usual fossil fuel-powered electric generators predominantly used presently to augment the epileptic power supply in developing countries.

PV cells are made out of semi-conducting materials such as crystalline silicon which is presently considered the most efficient material. When light of the right band gap energy hits the cells, they absorb solar radiation in form of photon which knocks out electrons in the silicon. Addition of different impurities in the silicon such as phosphorus or boron, results in the creation of electric fields which acts as diodes by allowing electrons to flow in one direction resulting in electrical energy generation. The current drawback in the use of solar cells are the high cost of manufacturing which reflects in the present high cost of conventional PV cells. The efficiency of solar energy absorption is also currently very poor (less than 40%) with only a fraction of the absorbed energy converted into electrical energy. Alternative material such as TiO2 which results in cheaper PV cells has even lower conversion efficiency. Nanotechnology can be used to introduce alternative materials and fabrication methods to produce cost effective PV cells with acceptable if not higher energy conversion efficiency.

Classic nanostructures such as carbon nanotubes (CNT), fullerenes and quantum dots are being used to make solar cells lighter, cheaper and more efficient. The increased surface area to volume ratio of nanoparticles enhances solar radiation collection by exposing more conducting surfaces to solar radiation. Also the use of nanomaterials such as lead selenide results in more electrons (and therefore more electricity) to be released when hit by a photon of light. Structural properties of PV cells are additionally being modified using nanotechnology.

Nanotechnology is also used in improving the efficiency of windmills. An epoxy-containing carbon nanotubes is now used to make stronger and lighter windmill blades resulting longer blades which increase the amount of electricity generated by such windmills. The wind turbine life span can also be increased by using nano paints.

Geothermal energy generation is also enhanced by nanotechnology. In conventional geothermal energy production, cold fluids are injected into naturally heated hot rocks usually found over 1500m below the earth surface. The heated fluid is then extracted and used to generate

electricity. Nanotechnology is now helping to make geothermal energy more practical by allowing efficient energy production closer to the surface and at lower temperatures. The heat-retaining properties of the fluid are also being enhanced with nanoparticles.

Still on energy generation, it has been demonstrated that sunlight, concentrated on nanoparticles, can produce steam with high energy efficiency. The stem can be used to run power plants in developing countries. Sheets of nanotubes have also been used to build "thermocells" that generate electricity when the sides of the cell are at different temperatures. By wrapping these nanotube sheets around hot pipes such as the exhaust pipe of cars, electricity can be generated from heat that is usually wasted.

Also piezoelectric nanofibers that are flexible enough to be woven into clothing have been developed. The fibers can turn normal motion into electricity to power such items as cell phone and other mobile electronic devices. This technology will be very useful in a developing country like Nigeria which, with 167,371,945 mobile lines as at 2014, is the 7th largest user of mobile phones in the world.

Even in the area of non-renewable energy generation, nanotechnology is equally very useful. By making the production of fuel from low grade raw material economical, the technology can address the shortage of fossil fuels, such as diesel and gasoline. It can also be used to make the production of fuels from normal raw materials more efficient. And by reducing friction using lubricants fortified with nanoparticles, energy consumption from conventional engines can be significantly reduced leading to increased service life of engines.

In the area of energy storage, some of the most important energy storage systems are batteries and capacitors. Carbon nanotubes (CNT) are now being used to replace conventional graphite electrodes in batteries. These nanomaterials have extraordinary high surface area, good electrical conductivity and linear geometry which make their surface areas highly accessible to battery electrolyte resulting in increased electricity output. The conductivity of electrolytes is also increased by introducing nanoparticle into it and this equally leads to increased energy output. The increase in output from a given amount of material results in more powerful, smaller and lighter batteries which can be used for a wide range of applications. Also nanobatteries which can recharge at about 60 times faster than conventional batteries have been developed. Some of these can operate over a broader range of temperature than is currently achievable. Again batteries which prevent electrodes contact prior to activation have also been developed using nanotechnology and this gives limitless shelf life and longer active life to such batteries. In the case of capacitors, millions of nanotubes are used to increase the electrode surface area and thus the amount of energy that can be held since the storage capacity of capacitors are proportional to the surface area of the electrode.

Storage of solar thermal energy can also be enhanced by using storage mediums enriched with nanoparticles.

In terms of electrical energy transmission, the drawbacks to the use of the conventional aluminium conductor steel reinforced transmission wires currently available are the fact that due to relatively higher resistance, a lot of the transmitted energy is lost in form of heat. The increased temperature of the wires also leads to sagging necessitating the reduction in the spacing of transmission poles or stanchions with the resultant increase in the transmission cost. Wires containing carbon nanotubes that have significantly higher electrical conductivity than the wires currently used in the electric transmission grid have been developed. These wires possess the properties of flexibility, elasticity and high tensile strength. They can resist heat sag and provide more transmission capacity than conventional conductors of similar size.

In transformers, fluid containing nanoparticles could be a more efficient coolant. This could improve the performance of transformers and possibly lead to use of decreased number of transformers. Nanosensors can also be used to remotely monitor transmission infrastructure and possibly place trouble calls to technicians whenever problems are detected.

High efficiency light bulbs have also been developed using nanotechnology. Such bulbs can be made using plasmonic cavities, a nano-sized structures or a nano-engineered polymer matrix. The later has the advantage of being shatter-proof with twice the efficiency of compact fluorescent light bulbs. Solid state light devices in form of light emitting diodes (LED) are also being developed. Another idea under development is to update incandescent light bulbs by surrounding the conventional filament with crystalline material that converts some of the waste infrared radiation into visible light. The introduction of these efficient light bulbs in developing countries can help in reducing the energy consumption and hence energy bills.

In the area of biomass production, nanotechnology can be used to enhance bio-availability of plant nutrient and to detect and treat diseases efficiently and effectively using smart sensors. It can also be used to increase the efficiency of herbicides and pesticides thereby allowing for the use of smaller doses. All these leads to reduced cost of production and increased biomass yield. The biomass can be in form of fuel wood which can be harvested and used for cooking. It can also be in form of algae or crops such as oilseeds which can be used for the production of biofuels. A method of extracting oil from algae without destroying the plants is also being developed. Nanoparticles with many pores are used to soak up the oil like sponge and this oil can be processed into biodiesel.

Other applications of nanotechnology include the reduction in the cost of catalyst used in fuel cells and the improvement of the efficiency of membranes used to separate hydrogen ions from other gases, such as oxygen. It is also used to increase the binding energy of hydrogen to the graphene surface in a fuel tank, resulting in a higher amount of hydrogen storage and therefore a lighter weight fuel tank.

In conclusion, nanotechnology can play a key role in enhancing the use of renewable and other energy sources in developing countries. It can be employed to improve energy generation especially using PV cells. It can also be used to improve energy storage and electrical energy transmission among other things. Developing countries need to increase their effort by investing on nanotechnology research as this could help them to overcome their energy challenges.