NANOTECHNOLOGY AND RENEWABLE ENERGY

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Innovation has always been an important driver of change and its pace is accelerating. Applications of nanotechnology in renewable energy (R.E.) are set to trigger new opportunities for efficiency improvements in a wide range of R.E. technologies. Here in a nutshell, is a summary of the latest developments in this little known area.

Nanotechnology offers some hope to increase the effectiveness, economics, viability and supply of renewable energy sources. The main areas where promising innovations are expected are electricity generation, biomass technologies, hydrogen technologies and energy storage. The attempt is to impact certain thermochemical, electrochemical, and other phenomena that can only occur at a nanometre scale. In the area of electricity generation, photovoltaic (PV) cell technology will be significantly impacted by nanotechnology. New manufacturing techniques, new methods of generating high surface area structures, the ability to optimise photosensitive bandgaps, and increasing spectral absorbency, are some of the several improvements possible through the adoption of nanotechnology in photovoltaics, thereby increasing solar efficiency. For biomass technologies, the boon may come in the areas of production of biofuels and generation of hydrogen. Nanotechnology in biomass will come in the form of nanoscale catalysts and nanoporous membranes. These catalysts enable reactions to reach their thermodynamic equilibrium faster and, hence, can allow processes to occur under normally unfavourable conditions. Electricity generation from fuel cells and hydrogen storage techniques also utilise the high surface area characteristics of the nanoscale; in addition, they utilise nanocatalytic properties. Described below is a brief, sector-wise exposition of the probable improvements in renewable energy technologies through the infusion of nanotechnology.

SOLAR ENERGY

Photovoltaic Cells: Photovoltaic cells were first developed by Bell Labs in 1954, with an efficiency of 6%. Since then, solar cells have benefited from nanoscale feature size development. Conventional photovoltaic devices use the photoelectric effect, wherein incident light or photons excite an electron of the valence band in the semiconductor (silicon) and move that electron into an excited state called the conduction band. The correct bandgap must be chosen for the appropriate wavelength of the light harvested. Larger bandgaps absorb less light and the combination of multiple semiconductor materials with differing bandgaps can absorb multiple wavelengths with high efficiency.

Different morphologies of solar cells viz. crystalline silicon, amorphous silicon, thin film and multi-junction photovoltaic cells are impacted by nanotechnology. In crystalline silicon, one novel silicon pressing technique textures the silicon surface, creating randomly distributed hemispherical pits of submicron range upto 5 microns in diameter. This texturisation method has the advantage of increasing the spectral absorbency and decreasing the reflectivity, which corresponds to an increase in the overall efficiency of the solar cell. In the case of amorphous silicon cells, varying the hydrogen content can modify its bandgap. However, amorphous silicon cells have the problem of photo-instability which can result in it losing over 50% of output. Nanotechnology helps to finetune amorphous silicon's bandgap and crystalline structure, thereby increasing its photo-stability and resultant efficiency.

Thin film photovoltaic cells are made using Copper Indium Gallium Selenide (CIGS), Copper Indium Sulphide (CIS), and Cadmium Telluride (CdTe). Here, nanotechnology helps in reducing fabrication costs through the introduction of novel nano-fabrication methods, and by altering the absorbing layer's composition to increase its efficiency. So nanotechnology helps to improve control over material fabrication, composition and structure, thereby providing decreased cost and increased efficiency. In the case of multi-junction solar cells, micro and nanofabrication methods recently developed are used to produce solar cells with multiple layers. Multi-junction cells are made using different semiconductor materials viz. single crystal, multicrystal, or amorphous silicon. In all these semiconductor types, the stacking of materials with different bandgaps increases efficiency by taking advantage of the full solar spectrum. A precise tuning of the nanoscale, precise bandgap selection, and high crystal quality will help to achieve precise