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Nanotechnology Applications In The Energy Sector

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Abstract- The report on "Nanotechnology helps solve the world's Energy problems" is addressed to a general audience. The aim is to explain how nanotechnology can help address present and future sustainable energy needs. We start with a short explanation of nanotechnology, focusing on why it is relevant for addressing the world's future energy needs. The rest of the report takes the angle of the main fields of sustainable energy policies and research: renewable, conventional energy, more energy efficiency in industrial production, and energy saving. In each chapter, we start by sketching the present situation and needs for more sustainable (technical) solutions, and existing scenarios. The relevant technologies and applications include: solar cells, hydrogen and fuel cells, batteries, improvement of light bulbs, fossil fuel etc with nanostructure materials and nanopowders, isolation materials, membranes and catalysts, etc. The report ends with a short conclusion and contains an extensive list of literature and internet resources for further reading.

I. INTRODUCTION

Nanotechnology, a new field in science, is any technology that contains components smaller than 100 nanometres. For scale, a single virus particle is about 100 nanometres in width.

An important subfield of nanotechnology related to energy is nanofabrication. Nanofabrication is the process of designing and creating devices on the nanoscale.

Creating devices smaller than 100 nanometres opens many doors for the development of new ways to capture, store, and transfer energy. The inherent level of control that nanofabrication could give scientists and engineers would be critical in providing the capability of solving many of the problems that the world is facing today related to the current generation of energy technologies.

II. NEED

To secure global power supply in the long run, it is important not only to develop existing energy sources as efficiently and environmental friendly as possible, but also to minimize energy losses arising during transport from source to end user, to provide and distribute energy for the respective application purpose as flexibly and efficiently as possible and to reduce energy demand in industry and private households.

Nanotechnology provides the potential to enhance energy efficiency across all branches of industry to economically leverage renewable energy production through new technological solutions and optimize the production technologies

III. LITERATURE SURVEY

Nanotechnology has shown the possibility of fulfilling everyone's dream of getting cheap and clean energy through its strategic applications. Its intersection with energy is going to change the way energy was hitherto being generated, stored, transmitted, distributed and managed. Nanotechnology impacts each part of the value-added chain in the Energy Sector. Here, nanotechnological innovations are brought to bear on each part of value added chain in energy sector.
Energy Supply Chain includes:-

A. Energy Supply Chain:-

a) Energy Sources
b) Energy Conversion
c) Energy Distribution
d) Energy Storage
e) Energy Usage

a) Energy Sources:-

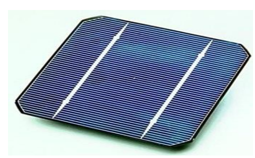

Fig. 1. Silicon-based solar cell Fig.2 Dye-sensitized solarcell

Today's word energy demands are satisfied via the combustion of fossils fuels of the 210 million barrels of oil equivalent per day is used worldwide, about 85 million barrels come from oil and rest of come from coal (23%), gas (17%), biomass (17%), some fission (5%) and little hydroelectric (6%) almost none from renewable sources.

It is estimated that by 2050 we will need twice the amount if energy that we are burning or consuming today (14 TW).

In such a case due to heavy combustion of fossil fuels causes to CO2 that are accumulated in atmosphere. Therefore there is urgent need for energy resources alternative to fossil fuels .for ex. solar, wind, geothermal, hydro etc. Most efficient and economical one is solar energy as every day earth is heat by 165.000TW o solar power

It holds great potential among all the renewable sources. Main problem with this is not its supply but development of devices that will allow for its efficient and cost effective conversion into electric current. Presently solar energy conversion is done by using solar photovoltaic cell (PV).

The main two problems of current PV are efficiency and cost. Efficiency of PV depends on type of semiconductor it is made of, and in its adsorbing capacity. All semiconductors adsorb only a piece of energy window (the 'band gap') which is just a fraction of entire solar energy available. And with crystalline silicon get excellent efficiency but it is expensive one.

Another TiO2, which is cheaper one but having poor efficiency. Both can be achieved by using nanotechnology which produces cell with tailored adsorption char., also reduces cost with high conversion efficiency. For ex crystalline solids

Another way to use multi junction solar cell i.e. stack of thin film semiconductor with band gaps of different energies.

b)Energy Conversion:-

i)Pyroelectric Nanogenerator for Harvesting Thermoelectric Energy:-

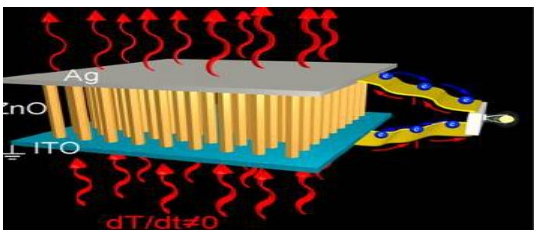

Fig. 3 Energy conversion principle

Harvesting thermoelectric energy mainly relies on the See back effect that utilizes a temperature difference between two ends of the device for driving the diffusion of charge carriers. However, in an environment that the temperature is spatially uniform without a gradient, the pyroelectric effect has to be the choice, which is based on the spontaneous polarization in certain anisotropic solids due to a time-dependent temperature variation. Using this effect, we experimentally demonstrate the first application of pyroelectric ZnO nanowire arrays for converting heat energy into electricity.

The coupling of the Pyroelectric and semiconducting properties in ZnO create a polarization electric field and charge separation along the ZnO nanowire as a result of the time-dependent change in temperature. The fabricated nanogenerator has a good stability, and the characteristic coefficient of heat flow conversion into electricity is estimated to be 0.05–0.08 Vm2/W. Our study has the potential of using pyroelectric nanowires to convert wasted energy into electricity for powering nanodevices.

ii) Fuel Cell:-

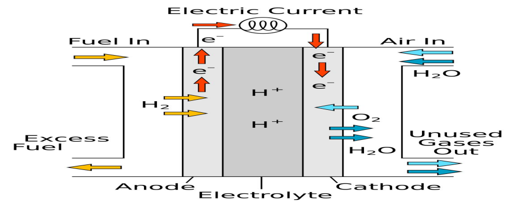

Fig. 4 Hydrogen Cell

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reactionwith oxygen or another oxidizing agent.

Hydrogen is the most common fuel, but hydrocarbons such as natural gas and alcohols like methanol are sometimes used. Fuel cells are different from batteries in that they require a constant source of fuel and oxygen to run, but they can produce electricity continually for as long as these inputs are supplied.

Fuel cells come in a variety of sizes. Individual fuel cells produce relatively small electrical potentials, about 0.7 volts, so cells are "stacked", or placed in series, to increase the voltage and meet an application's requirements. In addition to electricity, fuel cells produce water, heat and, depending on the fuel source, very small amounts of nitrogen dioxide and other emissions. The energy efficiency of a fuel cell is generally between 40-60%, or up to 85% efficient if waste heat is captured for use.

c) Energy Distribution:-

Wires and Cables:-

Replacing current wires with nanoscale transmission wires, called quantum wires (QWs) or armchair QWs, could revolutionize the electrical grid. The electrical conductivity of QW is higher than that of copper at one-sixth the weight, and QW is twice as strong as steel. A grid made up of such transmission wires would have no line losses or resistance, because the electrons would be forced lengthwise through the tube and could not escape out at other angles.

Grid properties would be resistant to temperature changes and would have minimal or no sag.

Long-distance transmission of electrical current entails significant losses (about 20%) due to electrical resistance. Superconductors transmit electricity with a small fraction of the losses from conventional conductors; thereby enabling power transmission at higher power densities. Such efficiencies may relieve transmission congestion and lessen the need for transmission equipment. High-temperature superconductors (HTS) (i.e., substances that become superconducting near liquid nitrogen temperatures [about 77 Kelvin (K)] rather than near liquid helium temperatures[about4 K]).

d) Energy Storage:-

i) Ultra capacitors:-

A capacitor is a device that is made of a pair of electrodes separated by an insulator that each stores an

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opposite charge. Using nanotechnology, researchers developed what they call "ultra capacitors." An ultra capacitor is a general term that describes a capacitor that contains nanocomponents. Ultra capacitors are being researched heavily because of their high density interior, compact size, reliability, and high capacitance. This decrease in size makes it increasingly possible to develop much smaller circuits and computers. Ultra capacitors also have the capability to supplement batteries in hybrid vehicles by providing a large amount of energy during peak acceleration and allowing the battery to supply energy over longer periods of time, such as during a constant driving speed. This could decrease the size and weight of the large batteries needed in hybrid vehicles as well as take additional stress off the battery.

Carbon nanotubes (CNT) are another possible material for use in an ultra capacitor. Carbon nanotubes are created by vaporizing carbon and allowing it to condense on a surface. When the carbon condenses, it forms a nanosized tube composed of carbon atoms. This tube has a high surface area, which increases the amount of charge that can be stored. The low reliability and high cost of using carbon nanotubes for ultra capacitors is currently an issue of research.

ii)Hydrogen Storage:-

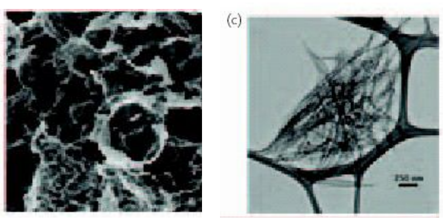

Fig. 5 Catalytic nanostructure hydrogen storage materials

One of the most obstacles in developing the hydrogen technology is its transport and storage**.**

Problem is easily seen by comparing the energy to volume ratio of gaseous hydrogen and that of conventional gasoline. This means that energy stored by hydrogen is ten times lower than that of conventional gasoline. This obviously represents the problem storing hydrogen gas in vehicle. As it requires a big and heavy volume of tank to store ant transport required amount of hydrogen gas.

Some possible solutions are to use liquid hydrogen, to compressed hydrogen, or to store hydrogen in solid metallic support such as metal complexes (hydrides). Solid metallic support is most viable option for hydrogen storageIn this approach hydrogen is loaded to a solid support and extracted from it when needed.

The main challenges are the material support. Nanotechnology can contribute in this field by developing new hydride molecule that allows high hydrogen loading capacity and acceptable regeneration kinetics. Nonmaterial such as carbon nanotubes are also currently investigated as support for hydrogen storage. Once again is the ability of manipulating matter at the atomic-scale–level together with the high surface volume that characterizes nonmaterial's, that makes nanotechnology so promising in this field.

III SYSTEM OVERVIEW

3.1 General Energy Applications:-

Nanotechnology is being used or considered for use in many applications targeted to provide cleaner, more efficient energy supplies and uses. While many of these applications may not affect energy transmission directly, each has the potential to reduce the need for the electricity, petroleum distillate fuel, or natural gas that would otherwise be moved through energy transmission ROWs. More efficient energy generation and use (and the consequent reduced need to transmit energy over long distances) may decrease the amount of construction, maintenance, repair, and decommissioning activities along the ROWs that would otherwise be needed to meet increased energy demands. Energy-related technologies in which nanotechnology may play a role include:

• Lighting,
• Heating,
• Transportation,
• Renewable energy,
• Energy storage,
• Fuel cells,
• Hydrogen generation and storage.

Examples of how nanotechnology may be integrated into each of these technologies areas are highlighted in the following sections.

i) Heating:-

Nanotechnology may help accelerate the development of energy-efficient central heating.

When added to water, CNTs disperse to form nanofluids. Researchers have developed nanofluids whose rates of forced convective heat transfer are four times better than the norm by using CNTs. When added to a home's commercial water boiler, such nanofluids could make the central heating device 10% more efficient.

ii) Transportation:-

Nanotechnology may enable more efficient transportation via catalysts in fuels; lighter, stronger materials; and more efficient batteries

Stronger materials: - More energy-efficient transportation resulting from the use of high-strength, low-weight materials developed with nanotechnology may reduce the need for transportation fuels that would be

Shipped via pipeline along a ROW. Nan particle-reinforced materials that are as strong as or stronger than today's materials but weigh less will help provide better fuel economy. By using high-strength

Nonmaterial's, parts for automobiles and other modes of transportation could be more than 50% lighter than conventional alternatives. The reduction in weight could cut fuel requirements, thereby potentially reducing the demand for

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petroleum fuel (and its attendant pipeline transportation in ROWs). Similarly, new materials developed through nanotechnology will permit the miniaturization of systems and equipment, which may further improve fuel economy

Batteries and capacitors: - More efficient batteries developed by using better electrolytes (composed of nonmaterial) may also reduce the need for transportation fuels. Nanotechnology is being used in lithium-ion and other batteries that are expected to increase the efficiencies of hybrid and electric vehicles. Nanoscale capacitors made from multiwall CNTs dramatically boost the amount of surface area, and thus the electrical charge, that each metal electrode in the capacitor can possess.

Smaller and more powerful capacitors may facilitate the development of microchips having greatly increased circuit density. Such Nanoscale capacitors may also impact the development of compact and cost-effective super capacitors, which could help reduce the amount of weight in hybrid-electric vehicles, thus improving fuel consumption

iii) Renewable Energy:-

Nanotechnologies may also facilitate the generation of electricity directly from solar, wind, and geothermal sources. Using such energy at or near the source could enable distributed energy production of electricity, thereby minimizing transmission losses and reducing the need for ROW-based transmission of electricity, oil, and gas. Practical energy collectors that are simple and automated may result from cheap nanofabrication

Solar photovoltaic technology, which at present relies on crystalline-silicon wafers that are costly to produce, is deployed economically only in limited settings. Less costly quantum dot (nanocrystal) technologies could make important contributions to improving the efficiency of solar energy systems

Examples of some of these potential nanotechnology-enabled improvements are highlighted below:

High-performance semiconductor nanocrystals (nanodots) that are active over the entire visible spectrum and into the near-infrared have been combined with conductive polymers to create ultrahigh-performance solar cells.

The solar cells have improved efficiencies because the nanocrystals harvest a greater portion of the energy spectrum.

Solar roofing tiles using quantum dots that are based on metal nanoparticles are expected to be commercialized within the next several years.

Highly ordered nanotube arrays have demonstrated remarkable properties when used in solar cells.

Researchers explain that the nanotube arrays provide excellent pathways for electron percolation, acting as “electron highways” for directing the photo-generated electrons to locations where they can do useful.

iv) 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 base load 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.

v) Batteries:-

CNTs have extraordinarily high surface areas and good electrical conductivity, and their linear geometry makes their surface areas highly accessible to a battery’s electrolyte.

These properties could enable CNT-based electrodes in batteries to generate increased electricity output as compared to traditional electrodes. This ability to increase the energy output from a given amount of material means not only that batteries could become more powerful, but also that smaller and lighter batteries could be developed for a wider range of applications.

Commercial firms are actually developing such next-generation batteries today

The battery technology utilizes 25-nm nanostructures lithium titanate spine (a hard, glassy mineral) as the electrode material in the anode of a rechargeable lithium-ion battery, replacing the graphite electrode typically used in such batteries and contributing to performance and safety issues. The new battery offers vastly faster discharge and charge rates, meaning that the time to recharge the battery can be measured in minutes rather than in hours. The nanostructures materials also increase the useful lifetime of the battery by 10 to 20 times over current lithium batteries and provide battery performance over a broader range of temperatures than currently achievable; over 75% of normal power would be available at temperatures between −40°F and +152°F. These types of batteries may enable the U.S. auto industry to “leapfrog” the next generation of hybrid-electric vehicles, thereby accelerating the reduction of the need for petroleum (and for the pipeline transmission of petroleum).

Other commercial applications for these batteries are for uninterruptible power supplies (UPSs) and emergency backup power (EBP). Present-day UPS and EBP systems typically use lead-acid batteries because of their reliability and low initial cost. However, lead-acid batteries must be replaced every 2 to 3 years, and hazardous materials issues surround their manufacture, handling, and maintenance.

vi) Capacitors:-

While batteries, which derive electrical energy from chemical reactions, are effective in storing large amounts of energy, they must be discarded after many charges and discharges. Capacitors, however, store electricity between a pair of metal electrodes. They charge faster and longer than normal batteries, but because their storage capacity is proportional to the surface area of their electrodes, even today's most powerful capacitors hold 25 times less energy than similarly sized chemical batteries. Researchers, however, have covered capacitor electrodes with millions of nanotubes to increase electrode surface area and thus the amount of energy that they can hold. The researchers claim that the new technology "combines the strength of today's batteries with the longevity and speed of capacitors and has broad practical possibilities, affecting any device that requires a battery"

vii) 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.

Fuel cells come in various sizes and provide useful power in remote locations such as spacecraft and weather stations.

Fuel cells are often considered in the context of hydrogen, because they change hydrogen and oxygen into water, producing electricity and heat in the process but no other by-products.

A fuel-cell system running on hydrogen has no major moving parts and can be compact and lightweight. Many believe that in the future, fuel cells will be used to power everything from handheld electronic devices to cars, buildings, and utility power plants. IBM projects that fuel cells in cars will be a "daily fact of life"

General Motors estimates that it will have a million fuel-cell cars in production by then (IBM 2004). Such technologies may supply much of the power that would otherwise need to be transported via ROWs (although pipelines may still be needed to transport the natural gas or hydrogen that feeds the fuel cells).

Nano engineered materials may help improve fuel cells' efficiency in several ways; some examples are highlighted below:

Fuel cells operate by catalyzing the conversion of hydrogen into energy as the hydrogen passes through a catalytic medium. Advanced designs for next generation fuel cells involve the use of a polymer membrane as the structure through which the hydrogen passes and on which the catalysis occurs. The use of nano engineered membrane materials may increase the volume of hydrogen conversion and thus result in more energy.

Precious metal nanoparticles of various compositions have been optimized to act as effective electro-catalysts in polymer electrolyte fuel cells and direct methanol fuel cells at both the anode and the cathode sides.

A materials design concept used to control and manipulate the structure of a new material on the nanoscale could lead to more powerful fuel cells than currently available and to devices that enable more efficient energy extraction from fossil fuels and carbon-neutral fuels. The new electrode material allows more efficient direct utilization of natural gas or biogas (produced from waste) in fuel cells.

CNTs' high strength and toughness-to-weight characteristics may be important for composite components in fuel cells that are deployed in transport applications where durability is important

viii) Hydrogen Generation and Storage:-

The hydrogen economy is a hypothetical future economy in which hydrogen is the primary form of stored energy for mobile applications and load balancing. It is typically discussed as an alternative to today's fossil-fuel economy. Many barriers need to be overcome for the hydrogen economy to become a reality. These include producing the hydrogen (for which adequate sources of electricity are needed), transporting it (including the possible need for additional ROWs), and storing it. Nanotechnology may play a role in helping to meet these challenges.

Highlighted below are ways in which nanotechnology may help addressing hydrogen storage problems:-

Because hydrogen is the smallest element, it can escape from tanks and pipes more easily than conventional fuels.

There are two ways to store hydrogen in materials.

One way involves absorption of the hydrogen within the material, and the other is to store the hydrogen in a container.

The challenge for absorption is to control the diameter of the nanotubes so that the absorption energy of hydrogen on the outside and inside of the tube is high enough to provide the desired storage capacity at an acceptable pressure.

If the absorption behaviour of the optimized tube acceptable, the challenge then is to develop a process capable of producing the material at a reasonable cost.

Single-walled CNTs are a leading candidate for solving the storage problem for hydrogen-fuelled cars and trucks.

However, if this approach cannot be carried out, CNTs could still facilitate storage in a container.

Small hydrogen-fuelled vehicles would have a pressurized tank, and large hydrogen-fuelled vehicles, ships, and planes would have a cryogenic liquid hydrogen tank.

In this case, CNTs may be used in super-strong composites in the bodies of the vehicles to make them lighter.

IV SYSTEM ANALYSIS

Nanotechnology applications having particular relevance to Energy transmission technologies:-

Numerous nonmaterial and other nano-related applications relevant to electricity transmission and petroleum distillate fuel and gas pipeline transport are in various stages of research, development, and deployment. These applications have the potential to directly or indirectly reduce the

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environmental impact associated with the construction, operation, and dismantlement of energy transmission technologies. The remainder of this section highlights examples of nanotechnology applications relevant to transmission of electricity via cables and of fossil fuels (i.e., petroleum distillate fuel and natural gas) through pipelines. Potential pitfalls and timeframes have been identified in the literature. In general, however, the potential for practical scale-up of most of the techniques in use today for nanoparticle production is limited by high capital costs, low production rates, the need for exotic and expensive precursor materials, and limited control over nanoparticle physical and chemical homogeneity. Breakthroughs in nanotechnology research may accelerate the development and implementation of these technologies

Nanotechnology Applications Relevant to Electricity Transmission:-

Nanotechnology may help improve the efficiency of electricity transmission wires. Today, aluminum conductor steel reinforced (ACSR) wire is the standard overhead conductor against which alternatives are compared. Another example, mentioned in Section 2.2 and still in the research phase, is the use of armchair CNTs – a special kind of single-walled CNT that exhibits extremely high electrical conductivity (more than 10 times greater than copper). Also possessing flexibility, elasticity, and tremendous tensile strength, CNTs have the potential, when woven into wires and cables, to provide electricity transmission lines with substantially improved performance over current power lines. Replacing current wires with nanoscale transmission wires, called quantum wires (QWs) or armchair QWs, could revolutionize the electrical grid. The electrical conductivity of QW is higher than that of copper at one-sixth the weight, and QW is twice as strong as steel. A grid made up of such transmission wires would have no line losses or resistance, because the electrons would be forced lengthwise through the tube and could not escape out at other angles .Grid properties would be resistant to temperature changes and would have minimal or no sag. (Reduced sag would allow towers to be placed farther apart, reducing footprint and attendant construction and maintenance impacts.) QW, if spun into noncorrosive polypropylene-like rope, could conceivably be buried "forever" with no fear of corrosion and "no need for shielding of any kind" Such a grid could have a million times greater capacity than what exists today (assuming the 1-centimeter-diameter aluminum cable carrying about 1,000 to 2,000 amps); even if the capacity were increased by only 0.1%, the amount of enhanced capacity would still be impressive. The realization of such conducting possibilities depends on developing processes for producing high-quality CNTs in industrial quantities and at reasonable cost, finding ways to manipulate and orient nanotubes into regular arrays, and developing robust testing methods. Today, QWs made from metallic CNTs are very short – no longer than several centimetres – and are manufactured only in limited quantities. When nanotubes are synthesized, a variety of different configurations appears. Currently, only 2% of all nanotubes can be used as QWs, and sorting the armchair nanotubes from the rest is nearly impossible. Current processing technologies are not capable of producing nanotubes with controlled and desirable production properties consistently. Until a good solution for separating the "good one from the many other unfavorable configurations is reached for large-volume manufacturing, the impact of nanotubes on power line usage is hypothetical". Long-distance transmission of electrical current entails significant losses (about 20%) due to electrical resistance. Superconductors transmit electricity with a small fraction of the losses from conventional conductors, thereby enabling power transmission at higher power densities. Such efficiencies may relieve transmission congestion and lessen the need for transmission equipment. High-temperature superconductors (i.e., substances that become superconducting near liquid nitrogen temperatures [about 77 Kelvin (K)] rather than near liquid helium temperatures [about 4 K]) were discovered in the late 1980s. Noting that transmission constraints have contributed to higher electricity prices and reduced reliability, the 2001 National Energy Policy Report (National Energy Policy Development Group 2001) recommended expanded research and development on transmission reliability and superconductivity.

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.

Transformers: Fluids containing nonmaterial could provide more efficient coolants in transformers, possibly reducing the footprints, or even the number, of transformers. 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 sitting flexibility.

Substations: Substation batteries are important for load-levelling peak shaving, providing uninterruptible supplies of electricity to power substation switchgear, and for starting backup power systems. Smaller, more efficient batteries (see Section 3.1.5) could reduce the footprints of substations and possibly the number of substations within a ROW.

Sensors: Nan electronics 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.

Nanotechnology applications relevant to pipeline transmission of petroleum distillate fuel and natural gas:

Today, most of the identified nanotechnology applications for pipelines involve material coatings (insulation, corrosion, and multipurpose). Other potential applications include nanosensors, which have the potential to minimize environmental damage by identifying potential leaks before they spread, and oil spill remediation with nonmaterial, which may minimize damage should a leak occur. Because the current and expected future applications of nanotechnology for petroleum distillate fuel pipelines are basically the same as those for natural gas pipelines, this section cites examples of general nanotechnology applications for pipelines.

Materials:

Advanced materials using nanotechnology may extend service life, reduce failure rates, and limit the potential for environmental damage. Nanocoating metallic surfaces can help achieve super hardening, low friction, and enhanced corrosion protection. Stronger materials may reduce wear, corrosion, and the chances of puncturing associated with third-party damage. Also, because nonmaterial can be stronger per unit volume than conventional materials, the use of pipe materials that contain or are coated with nonmaterial may mean fewer disturbances to the environment during installation, maintenance, and dismantlement.

Examples of nonmaterial with applicability to pipelines include:

Corrosion inhibitors: Corrosion under insulation (CUI) is a costly problem that is difficult to detect in pipelines. According to a study by CC Technologies in cooperation with NACE International, the costs associated with direct corrosion on gas and liquid transmission pipelines are $7 billion per year. Corrosion was the major cause reoreportable incidents in North America requiring more than $1 billion in repairs to one pipeline alone. Nansulate™ is a high-performance thermal insulator that prevents CUI. The translucent characteristic of the coating allows for visual inspection of the substrate without having to remove the coating, making it well-suited for use in gas and liquid transmission pipelines. The coatings utilize nanotechnology to prevent CUI, whereas many of the insulations currently in use actually cause the problem of CUI.

Coatings: Nanostructure coatings have excellent toughness, wear, and adhesion properties. Nanostructure powders have grains less than 100 nm in size, which are agglomerated to form particles large enough to be sprayed using conventional thermal spray methods. These coatings may be used to repair component parts instead of replacing them, resulting in reduced maintenance costs and disturbance. Additionally, the nanostructure coatings may extend the service life of the components because of their improved properties over conventional coatings

Insulation: Aero gels are highly porous solids formed from a gel in which the liquid is replaced with a gas. Containing more than 95% air, they have been dubbed the world's lightest solids. While aero gels were first discovered in 1931, their insulating power was unusable because they were so brittle.

Nanosensors: Nanosensors, or sensors made of nonmaterial, can be extremely sensitive, selective, and responsive .As such, they could be smaller and cheaper, and consume less power than conventional sensors. Sensors and controls that are small in size; work safely in the presence of electromagnetic fields, high temperatures, and high pressures; and can be changed cost-effectively may provide the ability to monitor conditions in the infrastructure and monitor for pollutants (vapour or oil losses) continually. Researchers have recently developed sensors made from titanic nanotubes coated with a discontinuous layer of palladium. The photo catalytic properties of titanic nanotubes are so large – a factor of 100 times greater than any other form of titanic – that sensor contaminants are efficiently removed with exposure to ultraviolet light, so that the sensors effectively recover or retain their original sensitivity to hydrogen. Sensors in uncontrolled locations become contaminated by a variety of substances including volatile organic vapours, carbon soot, and oil vapours, as well as dust and pollen. A self-cleaning function capable of oxidizing contaminants would extend sensor lifetime and minimize sensor errors. Nanosensors may also be used to identify approaching vehicles or equipment that may otherwise lead to third-party damage; or, if the pipeline is damaged, provide an immediate indication (e.g., alarm or other notification) so that any potential environmental damage may be mitigated quickly.

Potential Environmental, Safety, and Health Risks:-

Due to their extremely small size and relatively large surface areas, nonmaterial may interact with the environment in ways that differ from more conventional materials.

Potentially harmful effects of nanotechnology could result from the nature of the nanoparticles themselves and from products made with them. Environmental, safety, and health (ES&H) risks could occur during research, development, production, use, and end-of-life processes. The 21st Century Nanotechnology Research and Development Act, signed into law in December 2003, calls for addressing potential environmental and societal concerns associated with nanotechnology. About 10% of the Federal nanotechnology budget is characterized as environmental, but much of this amount is for developing nanotechnologies to address existing environmental problems rather than for investigating potential ES&H effects. Some research has been conducted on the toxicology of nonmaterial, but research on the fate, transport, and transformation; risk characterization, mitigation, and communication; and exposure, bioaccumulation, and personal protection have yet to come. All of the departments and agencies with Federal funding from the National Nanotechnology Initiative have environmental research planned or underway, but industry, nongovernmental organizations, and others have questioned whether the amount of research on the potential ES&H impacts of nanotechnologies is sufficient, given the number of unknowns and the size of the potential nanotechnology market. There have been relatively few studies on the ES&H risks of engineered nanoparticles. There are also no regulatory requirements to conduct such studies, and little funding is allocated to them. The limited results to date are neither conclusive nor consistent. For example, evidence indicates that nanoparticles in the lungs may cause more severe damage than conventional toxic dusts, but few if any inhalation or exposure studies have been conducted. Nanotechnologies may speed cleanup of soil and water contamination, but in the process may harm local soil ecology. The impacts of large quantities of nonmaterial on the environment or human health have not been studied, and there are no studies on accumulation or other long-term impacts

V CONCLUSION

This study, which focussed on the similar issue, environmental implications of NT, with a research question "What are the environmental implications of Nanotechnology", carried out the study with a primary objective of studying the potential applications of NT and assessing their potential implications to the environment Nanotechnology can potentially contribute in delinking welfare from use of nature, a primary driver in global efforts to move towards sustainability. The study carried on the self-cleaning glass environmental implications, under life cycle use stage shows that due to surfaces being cleaned by nature, there is a less need of cleaning or they can be easily cleaned. This potentially reduces the need of resources in maintaining it.

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