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THE REALIZATION OPPORTUNITY OF IDEAL ENERGY SYSTEM USING NANOTECHNOLOGY BASED RESEARCH AND INNOVATIONS

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Abstract:

An energy system is primarily designed to produce or convert and deliver energy for useful work. It supports the dynamic functions of the people both for their basic needs and luxurious wants. Out of many energy sources used in practice, renewable energy sources are finding importance due to their inherent ability to support a sustainable world. The challenges of developing such an efficient system can be handled effectively by considering the model and the characteristics of the ideal energy system. In our previous paper, we have developed a model and identified about 34 characteristics of an ideal energy system as a predictive hypothetical system and discussed the possibility of developing at least optimum energy system using suitable technology. In this paper, we made an attempt to use nanotechnology, one of the two universal technologies of the 21st century to realize many characteristics of an ideal energy system. We also proposed and analysed the possibility of using some nonlinear Dye Sensitized Nanocomposite doped Polymer Films in the process of designing highly efficient, low cost solar energy to electric energy converters.This predictive analysis opens up various research possibilities of nanomaterials usage in developing optimum energy systems towards the objective of achieving ideal energy systems.

Key Words: Energy, System, Ideal Energy System, Renewable Energy Systems & Nanotechnology

1. Introduction:

Energy systems research is an important area of research in the entire world due to the fact that energy in various forms is essential for doing work both internally and externally to living beings. The law of conservation of energy, tells that energy cannot be created nor destroyed but can be converted from one form to another. So, any energy system which produces energy can only convert some input thing (matter/wave) to output energy instead of producing new energy from the system. It is known that all bodies can possess the energy of two types as kinetic energy and potential energy. The output energy of any system or energy source may be usually of electrical energy, chemical energy, mechanical energy, gravitational energy, nuclear energy, ionization energy, sound energy, thermal energy, or light energy.

These different forms of energies can be converted from one form to another but at different efficiencies using a system called transducer. It is also known that any matter can be converted into energy using Einstein's relation $E = mc^2$. Energy is an essential ingredient for every activity in the universe. Research in energy sector mainly focussed on improving the effectiveness of production, processing, conversion, manipulation, and detection of energy as well as generating it from renewable sources. In this paper, we are exploring the possibility of identifying a technology which can be close to ideal technology [1] in order to improve many characteristics of ideal energy system defined in our previous paper "The Concept & Characteristics of Ideal Energy System and its Realization Constraints" [2]. The avenue of the possibility of realization of such an optimum energy system using nanotechnology is discussed. We also proposed and analysed the possibility of using some nonlinear Dye-Sensitized Nanocomposite doped Polymer Films in the process of highly efficient low-cost solar energy to electric energy converters.

2. Objectives of the Study:

This paper is conceptual in nature and uses predictive analysis methodology to build a model and analyse it. The objectives of the paper are as follows:

- To review the characteristics of the ideal energy system.
- To identify and analyse a suitable technology to be used for the possibility of realising such an ideal energy system in practice.
- To investigate the possibility of realising ideal energy system using a universal technology called nanotechnology.
- To compare the ideal energy system characteristics with predicted nanotechnology-based energy systems.
- To analyse the possibility of using some photo-sensitive dyes sensitised nanocomposite doped polymer films to achieve the expected solutions.

3. Review of Ideal Energy System & Characteristics:

Predicting and developing ideal system model and its characteristics in terms of its input, output, processes, and environment and comparing it with practical systems of similar objectives is considered as a new research method to improve current systems [3]. In the history, many literatures are available on variety of ideal systems and their characteristics which include, ideal gas system with ideal properties [4], ideal amplifier system with infinite amplification ability [5], ideal engine system with 100% efficiency [6], ideal technology system with ideal characteristics [1, 7], ideal water purifier system with infinite water purifying ability [8], ideal drug system with ability to cure any disease [9], ideal business system with ubiquitous business potential [10-11], ideal education system for everybody [12-13], ideal banking system with ubiquitous banking opportunities [14-16], ideal electrical energy system with ideal generation, transportation, and distribution abilities [17], ideal software system with self-modifying ability [18], ideal computing system with ubiquitous and infinite computing ability [19], ideal library system for everyone [20] and ideal strategy concept with ability to win in any competition [21]. As we know every ideal system are predicted hypothetical systems with an objective to find out the characteristics of the system which are ideal in nature. Even though ideal systems cannot be realized in practice, the ideal characteristics of the system can be can be used to improve the characteristics of practical systems by redefining the research objectives continuously until the efficiency of the system improves towards 100 percent [3].

Based on the findings of the ideal energy system model, it has about 34 characteristics under four headings as input characteristics, output characteristics, system/processes characteristics, and environmental characteristics. The box representation of such an ideal energy system model is shown in Figure 1. The identified characteristics of ideal energy system under the above four categories are listed below [2]:

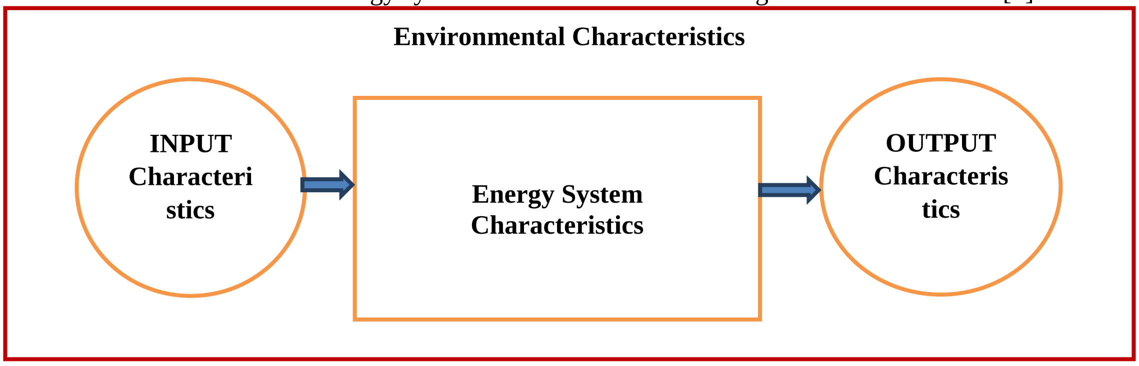

Figure 1: Box representation of Ideal Energy System model in terms of its characteristics [2]

(a) Input Characteristics:

- Zero input or (b) input should be abundant and freely available everywhere (if the law of conservation of energy is applicable to the ideal system).
- Self reliable system with no external stimulation or bias is needed.
- Affordable system in terms of cost, in terms of design, in terms of fabrication, and in terms of maintenance.
- Ubiquitous system with output energy of any quantity, any amount of time, anywhere, in any form of output energy, without any input.
- Takes any type of input which is abundant and in any format.

(b) System Characteristics:

- Instantaneous so that there is no time gap between input and output.
- Scalable so that it can general any amount of energy as per user requirement.
- No investment and no maintenance cost.
- Portable system with same the amount of output in any place with the same efficiency.
- Sustainable and renewable source of energy.
- No effect on the environment and hence no environmental pollution.
- Use safe processes so that no risk or threat to the sustainability of living systems in the universe.
- Simple system with easy design and low cost in terms of using various resources to build and maintain.
- Huge energy storage/delivery capacity depending on the external requirement.
- The system should not be poisonous so that it can produce clean and green energy at every time and at any amount of input and output load.
- Provide a great amount of energy per unit mass or volume.
- Low cost processes to increase or decrease the output energy whenever required.

(c) Output Characteristics:

- Free energy for any application.

- Infinite output energy as per ideal energy system definition.
- Output energy may be in any form as per external requirement & applications.
- Output energy is clean & green for environmental sustainability.
- Output is instantaneous and hence there is no time difference between input and output.
- Output is scalable to any amount between zero to infinity.
- Output should be continuous throughout the required time interval.
- Ubiquitous in the sense anywhere, anytime, and any duration of time.
- Output energy is safe due to its clean and green characteristics.
- Inexhaustible with time and amount.

(d) Environmental Characteristics:

- Green energy to provide environmental sustainability.
- No environmental degradation.
- Renewable energy so that output is inexhaustible.
- Pure energy and hence no harmful effects to living beings.
- No environmental pollution.
- Location independent so that portable system.
- No leakage of energy to the environment & rise of entropy.

4. Possibility of Realization of Ideal Energy System Using Nanotechnology:

4.1 Nanotechnology as Universal Technology: Nanotechnology is a field of study, design, preparation, modifications, manipulation, application, and use of various functional materials, components, and systems through use of matter of low dimensions typically 1 to 100 nanometers to exploit novel characteristics of mater at that dimension including, physical characteristics, chemical characteristics, electrical characteristics, optical characteristics, magnetic characteristics and mechanical characteristics. These modified characteristics at nanoscale range made these materials to be unique and potential to many navel devices with optimal properties including solar photovoltaic cells for highly efficient renewable electric energy generation. Nanotechnology is considered as universal technology and created hope for scientists and engineers to be a potential candidate in solving both types of problems in the society related to fundamental needs and advanced wants of human beings. By proper applications of nanotechnology techniques, many basic problems in the primary industrial sectors like agriculture, food, drinking water, shelters, renewable energy, and healthcare can be solved optimally [7, 22]. Nanotechnology is also expected to contribute advanced applications in many industry sectors like automobiles, aircraft, space vehicles, artificial intelligence and robotics, optical computing, ubiquitous communication, entertainment, organ replacement, environmental purification, lifespan expansion, singularity, and even, immortality [23]. Based on such possible wide applications of nanotechnology in many industry sectors it is recently classified as one among two universal technologies (along with information communication and computation technology (ICCT)) for 21st century [24]. It is also estimated that nanotechnology, due to its special ability of support practical systems close to ideal systems is considered as 21st century technology [1, 3] and is expected to do many breakthroughs in this century [25-28].

4.2 Nanotechnology Based Energy Systems: Nanomaterials are used to improve the efficiency of energy storage devices. Nanomaterials, being light in weight and strong in strength, are also used in turbine manufacturing in the wind and geothermal based power generation. By identifying or developing suitable novel nonmaterial or their mixtures through continuous research, one can develop an optimum device based on nanotechnology to realize many properties ideal energy system. It is proved that nanomaterials can be used for improving efficiency and hence productivity of renewable energy systems. Currently, solar cells are made up of semiconductor materials which have low efficient in energy conversion and costly in such a way that a common man in a developing country cannot afford to use such systems. On the other hand, nanomaterials used for solar cells manufacturing are cheap and through intensive research, novel nanomaterils developed can be used to manufacture new solar cells or coatings to improve efficiency. Thus, there is a hope that nanomaterials based photovoltaic cells are potential candidates to develop energy system mimic to ideal energy system [2]. The conceptual model ofenergy system using solar panels and storage systems fabricated based on nanotechnology is shown in figure 2. There are different principles and methods to improve the efficiency of solar cells using nanotechnology which include:

- Improving the efficiency of solar cells using nanomaterial coatings on conventional semiconductor solar cells.
- Developing new solar cells using nanomaterials
- Developing efficient solar cells using nanocomposite materials
- Fabricating solar cells using nano charge sensitive materials doped polymer films for enhanced efficiency.
- Developing new kind of nano-paints to be pasted on roof-structures or vehicle bodies for effective utilization of solar energy anywhere round the clock.

- To improve the battery life using efficient, tailored hybrid nanostructures.
- Improving the efficiency of any other energy system using nanotechnology principles.
- Improving the durability of such systems using nanomaterials and nanosystems.
- Developing methods and designs to combine elements to produce nano-compounds of binary, ternary, and quaternary systems have created much more interest in terms of improving the energy conversion efficiency.
- Devices based on new principles like Antenna-rectifier system for exploiting the wave nature of sunlight into electrical energy. Using nanomaterials one can design and fabricate of antennas with a typical dimension of ~100–1000 nm and can reach the efficiency up to 95% is possible theoretically.

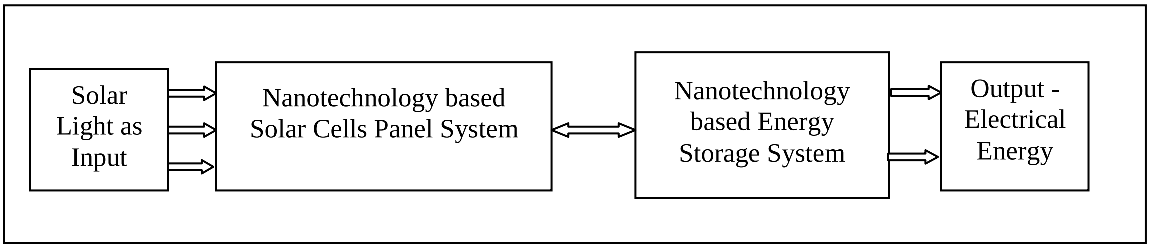

Figure 2: Conceptual model of Energy system using various processes based on nanotechnology

4.3 Analysis of Use of Nanomaterials for Solar Cells: Due to peculiar surface, mechanical, structural and electrical properties of nanomaterials and further the possibility of tailoring such properties to optimum level, they are considered as potential candidates for solar cells as well as any other efficient energy system.Nanomaterials or nanostructures combined with other material systems have potential ability to improve the required properties of solar based electrical energy systems like solar cells or nanoantenna based rectifiers. The continuous improvement in such systems based on intensive research in nanotechnology, solar energy conversion efficiency of more than 95% can be achieved against the 20% conversion efficiency of presently used solar cells. The analysis of the use of nanomaterials for solar cells is carried out using qualitative ABCD listing [29-35].

Advantages of Using Nanomaterials for Solar Cells: It is expected and proved partially in many types of research that nanomaterials have many advantages in using in development of optimum energy systems [36]. Some of them are:

- Cost effective
- Improved manufacturing methods
- Reduced pollution
- Light weight systems
- Strong and durable
- Enhanced efficiency
- Easy handling
- Possibility of further innovations
- Changed principles of operation
- Superior technology
- Flexible usage form like full structured solar cells or Coatings for solar cells etc.
- Possibility of new breakthroughs like antenna-based rectifier systems using nanomaterials.
- Theoretical solar light conversion efficiency up to 95%.

Benefits of Using Nanomaterials for Solar Cells:

- Efficient energy systems
- Low cost, durable system for continued output energy
- Effective use of renewable energy
- Low atmospheric pollution
- Efficiency of conversion up to 95% in case of nanotechnology antenna-based rectification systems.
- Self sustainability in solar energy gives rise to economically independent countries which intern leads to enhanced growth.

Constraints of Using Nanomaterials for Solar Cells:

- Funding for research and innovation
- Continuous follow-up in research
- Accountability in many new researchers.
- Further research requirement.
- Developing a suitable product with all expected characteristics of ideal energy systems.

- Commercialization of technology challenges.

Disadvantages of Using Nanomaterials for Solar Cells:

- Anticipated side effects of nanomaterials.
- Nanotechnology is yet to reach its matured level due to comparatively less research personnel and facilities.
- Realization of theoretical findings and expectations in practice is found to be difficult and is considered as a hindrance in further progress.
- Anticipated ecological effects and genetic effects on nature hinders the public funding on nanotechnology research.
- Device manufacturing difficulty due to nanoscale processes.

5. Comparison of Ideal Energy System Charactristics with Nanotechnology Based Energy System:

The use of nanotechnology in developing electrical energy systems which mimic many characteristics of ideal energy system is possible. Many nanotechnology based structures and systems are used to improve the characteristics of solar cells towards ideal model. The different characteristics of Nanotechnology based systems are compared with conventional solar panels and is depicted in table 1.

Table 1: Comparison ofNanotechnology based systems with conventional solar panels

S.No	Ideal Energy System Characteristics	Semiconductor Technology Based Systems Using Silicon	Nanotechnology Based Systems
(A) Input Characteristics:			
1	Input should be abundant and freely available everywhere	Yes, Solar energy	Yes, Solar energy
2	Self reliable system	Possible some extent	Possible more extent
3	Affordable system	Not affordable for developing countries	Affordable for every countries and people at matured stage
4	Ubiquitous system	No.	Possible through advanced storage techniques
5	Takes any type of input which is renewable	Yes. Solar energy in IR spectrum	Yes. Solar energy in broad spectrum
(B) System Characteristics:			
6	Instantaneous	Yes	Yes
7	Scalable	Yes. But low efficiency	Yes. High efficiency and hence flexible output range
8	No investment and no maintenance cost	High investment and low maintenance cost	Low investment and low maintenance cost
9	Portable system	Not for large energy systems	Possible due to small size
10	Sustainable and renewable source of energy	Yes. Lower efficiency	Yes. Higher efficiency
11	No effect on environment	Low	Low
12	Use Safe processes	Yes	Yes
13	Simple system	Yes	Yes
14	Huge energy storage/delivery capacity	No	Possible
15	The system should not be poisonous	Not poisonous	Not poisonous
16	Provide a great amount of energy per unit mass or volume	No	Possible
17	Low cost processes	No	Possible
(C) Output Characteristics:			
18	Free energy	Low cost	Very low cost
19	Infinite output energy	No	High output
20	Output energy may be in any form	Electric form but possible to convert to other forms	Electric form but possible to convert to other forms
21	Output energy is clean & green	Yes	Yes
22	Output is instantaneous	Yes	Yes
23	Output is scalable to any amount	No. Low range scalability	Comparatively better

			range scalability
24	Output should be continuous	No.	Yes. Using advanced high storage battery
25	Ubiquitous	No.	Possible through advanced storage techniques
26	Output energy is safe	Yes	Yes
27	Inexhaustible	Yes. Low efficiency	Yes. Improved efficiency
(D) Environmental Characteristics:			
28	Green energy	Yes	Yes
29	No environmental degradation	Low	Very low
30	Renewable energy	Yes	Yes
31	Pure energy	Yes	Yes
32	No environmental pollution	Low	Low
33	Location independent	No	No
34	No leakage of energy to the environment & rise of entropy	Yes	Yes

6. Dye Sensitized Nanocomposite Doped Polymer Films as Solar Cells:

6.1 Nanocomposite Solar Cells: Nanocomposites are the materials that incorporate nanosized particles into a matrix of standard material. Such addition of nanoparticles leads to drastic improvement in various properties including mechanical strength, toughness, electrical, optical, and thermal properties of the resultant nanocomposite.Nanocomposite solar cells promise significant advantages with respect to cost-efficient mass production since they do not require imprinted chemical potential gradients for charge separation. Organic and inorganic nanocomposites have been successfully used in the preparation of thin film organic solar cells with the view either to enhance the harvesting of solar energy or to assist in the charge transport processes. The optical absorption, electrical conductivity, and environmental stability of the nanocomposite are the main criteria that determine the suitability of the material for solar energy application. Table 2 identifies some of the research results carried out by various research teams during last few years.

Table 2: Some of the published results of nanocomposite solar cells research

S.No	Solar cells research using Nanocomposites	Reference
1	Graphene-based polymer composites	Das, T. K., &Prusty, S. (2013) [37]
2	Poly (3-hexylthiophene): TiO_2 nanocomposites	Kwong, C. Y., et al (2004) [38]
3	Hybrid organic/inorganic nanocomposites	Liu, R. (2014) [39]
4	CH_3 NH_3 SnI_3 /TiO_2 nanocomposites	Grätzel, M. (2014) [40]
5	ZnO–SnO_2 nanocomposite	Song, J., (2016) [41]
6	Graphene oxide/mesoporous TiO_2 nanocomposite	Han, G. S., (2015) [42]
7	Yb_2O_3/Au upconversion nanocomposites	Liu, T., et al (2014) [43]
8	CdTe–ZnO nanocomposites	Huang, W. J., (2015) [44]
9	Polymer/copper indium sulfide nanocomposites	Rath, T., et. al (2011) [45]
10	TiO_2/$CuInS_2$ nanocomposites	O'Hayre, R. et al (2006) [46]
11	$CuInS_2$–Poly (3-(ethyl-4-butanoate) thiophene) nanocomposite	Maier, E., et al (2011) [47]
12	Polythiophene and ZnO nanoparticles	Beek, W. J., et al (2006) [48]
13	Molybdenum disulphide/titanium dioxide nanocomposite-poly 3-hexylthiophene bulk heterojunction	Shanmugam, M., et. al (2012) [49]
14	TiO_2/CdS nanocomposite	Zhao, D., et al (2016) [50]

6.2 Dye Sensitized Nanocomposite Solar Cells: Among the renewable energy sources, solar energy is at the forefront with a clean and most abundant form of energy and affordable cost/efficiency performance of solar cells. From the various types of solar technologies, dye-sensitized solar cell (DSSC) technology is an inexpensive and environmentally friendly solution to meet today's increasing energy needs.In the conventional p–n junction solar cells, only the electrons and holes that can diffuse to the space charge region can be collected as a current. In order to get a long diffusion length, the purity of semiconductors should be increased and the defect concentration should be decreased, resulting in expensive solar cell materials. In a dye-sensitized solar cell, a photon absorbed by a dye molecule gives rise to electron injection into the conduction band of nanocrystalline oxide semiconductors such as TiO_2 or ZnO. Because of the high surface area, relatively high photocurrent can be obtained in spite of the simple process.Dye-sensitive solar cells are considered as inexpensive and environmentally friendly solar cell devices with good and acceptable power conversion efficiency.

Table 3: Some of the published results of dye sensitized nanocomposite solar cells research

S.No	Solar cells research using dye sensitized Nanocomposites	Reference
1	Dye-sensitized nanocrystalline solar cells employing a polymer electrolyte.	Nogueira, A. F., (2001) [51]
2	Dye-sensitized solar cells based on nanocomposite of polyaniline/graphene quantum dots	Dinari, M., (2016) [52]
3	Graphene-based dye-sensitized solar cells	Singh, E., et al (2015) [53]
4	Dye-sensitized carbon nanotube aerogel–Pt nanocomposites	Chen, H., et al (2016) [54]
5	Dye-sensitized nanocomposite Semi-Solid Redox Ionic Liquid Electrolytes	Rutkowska, I. A., et al (2015) [55]
6	Dye-sensitized TiO_2–Au Nanocomposite	Pandikumar, A., et al (2015) [56]
7	Dye-sensitized solar cells employing polymers	Yun, S. et al (2016) [57]
8	Dye-sensitized solar cells with tetra alkyl ammonium cation-based ionic liquid functionalized graphene oxide	Kowsari, E. et al (2017) [58]
9	Nano-structured TiO_2/ZnO nanocomposite for dye-sensitized solar cells	Boro, B. et al (2017) [59]
10	Dye sensitized solar cells: From genesis to recent drifts	Sharma, S. et al (2017) [60]
11	Ionic nanocomposite gel electrolytes	Usui, H. et al (2004) [61]
12	Dye-sensitized Nanowire-based composites	Baxter, J. B. et al (2005) [62]
13	Dye-sensitized anatase TiO_2 hollow spheres/carbon nanotube composites	Yu, J. et al (2011) [63]
14	TiO_2–Au plasmonic nanocompositeTiO_2–Au plasmonic nanocomposite	Muduli, S. et al (2012) [64]
15	Dye-sensitized solar cells based on Titania nanotube array electrodes	Paulose, M. et al (2006) [65]
16	Dye-sensitized ZnO–TiO_2 nanocomposite films for high light harvesting efficiency	Manthina, V. et al (2012) [66]
17	Dye-sensitized solar cells using 2-(hexylthio) thiophene conjugated bipyridine	Cao, Y. et al (2009) [67]
18	Dye-sensitized photoelectrochemical solar cells based on nanocomposite organic–inorganic materials	Stathatos, E. et al (2005) [68]
19	Poly (ethylene oxide)/Poly (vinylidene fluoride)/TiO_2 Nanoparticle composites	Han, H. W. et al (2005) [69]
20	Dye-sensitized tin sulfide nanoparticles with reduced graphene oxide	Yang, B. et al (2015) [70]

7. Predictive Analysis of Dye Sensitized Nanocomposite Doped Polymer Films:

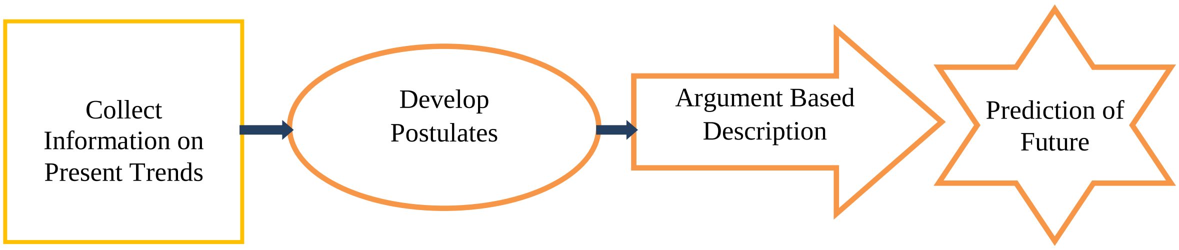

Figure 3: Predictive Analysis Model to predict future

Predictive analysis is a method consisting of several techniques to predict future possibilities using present trends. It is different from predictive analytics in such a way that it will support to predict future. On the other hand, predictive analytics is a method of generating information from historically available dataset to determine and predict future trends and outcomes. In this section, we have used predictive analysis qualitatively to predict future possibilities by studying present trends using self-developed predictive analysis model shown in figure 3. As per present trend, many research groups globally working in dye-sensitized metal nanoparticle doped solar cells. In this analysis, we suggest, a new combination of nanocomposites sensitized by nonlinear photosensitive dyes and doped in polymer film base called polymer matrix as proposed efficient, low weight, low cost, durable solar cells/panels.Accordingly, following postulates can be predicted:

Postulates:

- Nanocomposites are potential candidates for efficient solar cell structure
- Dye-sensitized nanocomposite solar cells are to be researched to enhance the conversion efficiency.
- Nonlinear organic dyes are better candidates as sensitizers for charge transfer and hence to enhance the conversion efficiency [71-79].
- Instead of using polymer-based nanocomposites, it can be argued that dye-sensitized nanocomposites doped in the polymer matrix as a film for solar cells show better conversion efficiency.
- Finally, Non-linear dye sensitized, nonlinear nanocomposites doped, polymer matrix in film form is predicted to be efficient solar cells with highest conversion efficiency.

Argument Based Description: There are many nonlinear dyes with high nonlinear susceptibility. Many azo dyes are widely identified as very attractive candidates for nonlinear optical properties due to their highly deformable & distributed π - electrons which give rise to high molecular level optical nonlinearities in the form of either Two-Photon Absorption (TPA) and/or Reverse Saturation Absorption (RSA) [80-88]. In the case of dye molecular medium with molecules of high RSA, when solar light passes through the medium, the number of the molecules in the excited state increases. Such an increase in the number of excited state molecules is proportional to the ground state cross section and the incident photon flux. The increase in excited state molecules in dye medium will give rise to more charge carriers and responsible for the increase in photo-electric current. To enhance the charge carrier generation, the conditions required are:

- The ratio of the excited state absorption cross-sections and ground state absorption cross-sections should be large so that the material will absorb incident light.
- The dye material should possess comparatively high transmission at the lower intensity incident light beam to increase the efficiency at low light intensity.
- The spectral response of dye material should be wide to cover the substantial amount of the light in the visible region.
- The dye material should have a fast response time for the incident light beam.

Most of the molecular design schemes underlying the design and the optimization of efficient molecules for nonlinearity are based on intramolecular charge transfer (ICT) processes from a donor species toward an acceptor moiety through a π-electron conjugated chain, such as in benzene, azobenzene, polyene, stilbene, or thiophene derivatives [89-90]. It is found that in the organic molecular systems the delocalized π-electrons that govern various macroscopic arrangements and thereby show characteristic nonlinear optical responses through intramolecular charge transfer.

For real applications, these dyes can be used to sensitize nanocomposites doped in thin films of the polymer substrate [91-96]. Molecules with high optical nonlinearity responses must possess small differences between the ground and low excited states, and there must be a large difference between the dipole moments of the ground and excited states [90]. These properties can be accomplished by compounds with a D-π-A structure, where an electron donor (D) group and an electron acceptor (A) group are placed away from each other in the molecule through a π-conjugated system, therefore creating a high asymmetry in the electronic density [97].Hence based on predictive analysis, such nonlinear dye sensitized nanocomposite doped polymer films may be potential candidates for enhanced conversion efficiency solar cells in near future.

8. Other Possibilities & Suggestions:

Nanoantenna based rectifiers are another type of devices which are considered as complementary to nanotechnology based solar cells due to their ability to absorb heat part (infrared part) of the solar light spectrum. Such nanotechnology-based antenna-coupled rectifiers are predicted as emerging systems that has the potential to provide ultra-high efficiency, low-cost solar energy conversion systems. Both antenna and rectifier made by nanomaterial/structure have the ability to convert up to 95% of IR energy part of solar light energy against 20 to 30% efficiency of solar cells. Such nanoantenna based rectifier systems if fabricated in the form of wide area large array kind system, are capable to act as highly efficient electrical energy systems. Such systems can also be used in any industrial processes and natural processes where heat is generated and wasted. Such excess heat can be absorbed through nanoantenna based rectifier arrays to convert them back into electrical energy [98-102]. If improved properly, such rectennas are expected to be future electrical energy sources close to ideal energy systems in terms of their characteristics and able to solve the energy problems of the world.

9. Conclusion:

Though the ideal energy system is a hypothetical model, it gives ideas and sets challenges to realize it through innovative research. In this paper, we have discussed the possibility of realizing various predicted properties of ideal energy system by segregating them as input properties, system requirements, output properties, and environmental expectations. The realization opportunity or to decrease the gap between present conventional energy system and ideal energy system are analysed using the most hopeful universal technology of 21st century called nanotechnology. A conceptual model ofan energy system using various processes based on nanotechnology is presented and the advantages, benefits, constraints, and disadvantages of using nanomaterials for solar cells in order to improve the conversion efficiency, decrease the cost, and increase the durability. It is also proposed and analysed the possibility of using some nonlinear dye-sensitized nanocomposite doped polymer films in the process of designing highly efficient, low cost solar energy to electric energy converters. This predictive analysis model opens up various research possibilities of nanomaterials usage in developing optimum energy systems towards the objective of achieving ideal energy systems. Table 4 depicts the comparison of the properties of the ideal energy system with nanotechnology based electrical energy system which is based on the predictive analysis of the possible features of nanotechnology and its various anticipated processes.

Table 4: Comparison of the properties of the ideal energy system with nanotechnology based electrical energy system

S.No	Ideal System Characteristics	Achievable Characteristics of a Nanotechnology based Electrical Energy system based on predictive analysis
(a) Input Characteristics		
1	Zero input or input should be abundant and freely available everywhere	Input solar light is abundant and freely available everywhere with varied intensity
2	Self reliable system	Self reliable system as a renewable energy source
3	Affordable system	Nanotechnology is expected to be low cost technology at its matured stage
4	Ubiquitous system	Ubiquity can be achievable to a greater extent in case of nanotechnology based solar cells or nanotechnology based antenna rectifiers
5	Takes any type of input	Uses renewable solar energy source as input
(b) System Characteristics:		
6	Instantaneous	Instantaneous electrical energy is possible
7	Scalable	Scalable to some extent based on design
8	No investment and no maintenance cost	Low investment and low maintenance cost for solar based electrical energy system
9	Portable system	Portability is possible for a small system for home applications as well as industrial applications
10	Sustainable and renewable source of energy	Nanotechnology used sustainable and renewable source of energy
11	No effect on environment	Very low effect on the environment for renewable solar systems using nanotechnology. Further nanotechnology can be used for environmental cleaning
12	Use Safe processes	Use Safe processes is possible for solar energy using proper technology
13	Simple system	Nanotechnology based energy system is expected to be simple system
14	Huge energy storage/delivery capacity	Nanotechnology based batteries are expected to store substantially high amount of electrical energy
15	The system should not be poisonous	The nanotechnology based renewable energy systems are green and clean
16	Provide a great amount of energy per unit mass or volume	Optimum systems can be developed to provide an optimum amount of energy per unit mass or volume using nanotechnology
17	Low cost processes	Low cost processes are possible for simple systems based on nanotechnology for electrical energy using renewable energy sources
(c) Output Characteristics:		
18	Free energy	Low cost energy for renewable energy system using nanotechnology is possible
19	Infinite output energy	Finite amount of output energy is possible with good conversion efficiency for nanotechnology based solar cells or nanotechnology supported antenna based rectifier systems
20	Output energy may be in any form	Output energy is in electrical energy form but can be further converted in to any form
21	Output energy is clean & green	For nanotechnology based renewable energy systems the output energy is clean & green

22	Output is instantaneous	Instantaneous output is possible in case of nanotechnology based energy systems
23	Output is scalable to any amount	Output is scalable to some extent for nanotechnology based electrical energy systems
24	Output should be continuous	Output of nanotechnology based energy systems is continuous for continuous input or through stored energy
25	Ubiquitous	Certain level of ubiquity is possible for nanotechnology based energy systems
26	Output energy is safe	For renewable energy system based on nanotechnology, the output energy is safe for all stakeholders
27	Inexhaustible	Renewable energy sources are inexhaustible to a certain extent hence the outputof nanotechnology based energy systems
(d) Environmental Characteristics:		
29	Green energy	Renewable energy systems provide green energy which is further assured by nanotechnology
30	No environmental degradation	Nanotechnology based renewable energy systems are not creating environmental degradation and can be made environmental friendly
31	Renewable energy	Nanotechnology supports optimum renewable energy electrical systems using solar cell model and solar antenna based rectifiers model
32	Pure energy	Nanotechnology based renewable energy systems are producing pure electrical energy
33	No environmental pollution	Nanotechnology based solar renewable energy electrical systems are not contributing to environmental pollution
34	Location independent	The performance of nanotechnology based electrical energy systems depending on solar light availability in IR spectrum region
35	No leakage of energy to the environment & rise of entropy	Nanotechnology based battery systems can be made leak proof.

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