CHAPTER 3

IDEAL TECHNOLOGY & ITS REALIZATION OPPORTUNITY

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ABSTRACT :
This Chapter contains the concept of ideal technology and its realization opportunity using nanotechnology, opportunities & challenges for green technology in 21st century, concept of ideal water purifier system to produce potable water and its realization opportunities using nanotechnology, and nanotechnological innovations & business environment for automobile sector : a futuristic approach, nanotechnology innovations & business opportunities in renewable energy sector, concept & characteristics of ideal energy system and its realization constraints, realization opportunity of ideal energy system using nanotechnology based research and innovations and the concept of ideal drug &its realization opportunity using present pharmaceutical sciences scenario.

3.1 INTRODUCTION :

Technology is defined as a set of processes for making, modifying, using, and knowing of tools, machines, techniques, crafts, systems, and methods of organizing them in order to solving a problem, improving a pre-existing solution to a problem, achieving a goal, handling an applied input/output relation or perform a specific function. Technologies considerably affect human beings and other animal species' ability to control and adapt to their natural environments. Technology has affected society and its surroundings in many ways has helped to develop more advanced economies (including today's global economy) and has supported the rise of a leisure class people even with laziness & lethargy. Science has contributed many technologies to the society which include Aircraft technology, Automobile technology, Bio-technology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. have changed the lifestyle of the people and provided comfortability. In order to sustain this comfortness of people in the society, they have to vary about sustainability of the surrounding environment. Technology is the branch of scientific knowledge that deals with the creation, application and use of technical means and their interrelation with human life, society, and the environment, drawing upon such subjects as engineering, applied science, pure science and industrial arts. Many technological processes generate unwanted by-products, which give rise to pollution, and deplete natural resources, to the detriment of Earth's

environment. Implementations of new technology influence the culture and values of a society and often raises new ethical questions. To improve any present systems in the society, it is normal practice that such systems have to be compared with a hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect [1].

The concept of ideal gas, ideal engine, ideal switch, ideal fuel, ideal semiconductor devices like ideal diodes, ideal transistors, ideal amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical device or systems in mind, researchers have continuously improved the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal properties of a device or a system can be used to upgrade or improve its properties towards reaching 100% efficiency. By comparing the properties/characteristics of a practical device/system with its ideal counterpart, one can find out the possible modifications in that device /system towards reaching the objective of achieving such an ideal device [2-3].

An ideal gas is a hypothetical theoretical gas composed of many randomly moving particles that do not interact each other except when they collide each other elastically. The ideal gas concept is important and useful because it obeys the ideal gas law, a simplified equation of state, and is amenable to analysis under statistical mechanics. (1) The molecules of an ideal gas do not attract one another. (2) The molecules of an ideal gas repel one another. (3) The volume of the ideal gas molecules is negligible compared to the volume of the container [4-5].

The Characteristics of an ideal fuel are (1) The fuel should have high calorific value, (2) The fuel should have proper ignition temperature. (3) The rate of combustion should be balanced and moderate. (4) The content of non-volatile substances should be as low as possible. (5) There should be no poisonous or residue by-products on combustion. (6) The fuel should be easily available in plenty. (7) The fuel should be available at a low cost. (8) There should be convenience in transporting the fuel and should be easily storable [6].

An ideal operational amplifier has properties like (1) Infinite input resistance, (2) Zero output resistance, (3) Zero offset voltage, (4) Infinite bandwidth, (5) Infinite common-mode rejection, (6) Infinite open-loop voltage gain, and (7) Infinite Slew rate so that the output voltage changes occur simultaneously with the input voltage change [7]. The characteristics of an ideal heat engine are : (1) It should have a source of infinite thermal capacity, (2) It should have a sink of infinite thermal capacity, (3) The efficiency such heat engine during the conversion process of

heat into work and conversely is 100% [8]. Similarly, ideal fabric is the fabric which satisfies the three conditions, good hand, good appearance of suit, and mechanical comfort for wear.

In this chapter, some of the ideal systems like ideal technology, ideal water purifier system, ideal transportation system, ideal energy source, and ideal drug system are proposed along with detailed discussion of their characteristics. The chapter also contains the possible use of the nanotechnology as universal technology to realize various characteristics of such ideal systems.

3.1.1 Introduction to Ideal Technology :

The ideal technology model is essential to plan the improvement in the performance of any practical technology. The concept of ideal technology can be predicted as a technology which can solve all basic needs of human beings and provide luxurious comfortable life without affecting the society and environment. Ideal technology should have characteristics in order to elevate the quality of life to unique level with perfect equality so that every human being in this universe should lead happy and comfortable life and realize the so-called concept of heaven on earth. Based on various factors which decide the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements [2]. The input properties are (1) Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind. (2) In-expensive &self-reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations. (3) Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users. (4) Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost. The Output properties are (1) Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment. (2) Provide comfort life to the users by providing solutions to their desires. (3) Equality ; ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin. (4) Automation; ideal technology automate all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming. (5) Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span. The System Requirement Properties are (1) General purpose technology to support all fields and problems of human & living beings on the earth. (2) Self-directed &self-controlled & self-regulated so that the technology can control itself in order to achieve its goal. (3) Easy, simple, quick & user friendly to solve all type of problems and to

provide quick ideal solution. (4) Scalable so that it is used for solving small and simple problem to large and complex problems of life. (5) Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God. (6) Exploring new opportunities to improve and explore comfortability and further leisure in life of people. (7) Infinite potential for further development of life in the universe. The Environment/external Properties are (1) Maintain clean environment through its processes and avoids foot print of processes while achieving specific function. (2) Infinite business opportunities by creating new products / services with ideal characteristics. (3) Adaptive to any situations to achieve stated goal. (4) No side effects so that it should be safe for users, and environment. Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties [9]. One of the properties of ideal technology is sustainability and zero green gas emission to environment i.e., ideal technology is green technology and the chapter contains the proposal on how the technologies can be made sustainable by adding green component so that they can avoid environmental degradation and converted into green technologies to provide clean environment for future generations [10].

The chapter also discusses the opportunities and challenges for green technology for agriculture, green technology for potable water, green technology for renewable energy, green technology for buildings, green technology for aircraft and space exploration, green technology for industrial automation, green technology for computers and communication, green technology for education, green technology for food & processing, and green technology for health and medicine in 21st century.

3.1.2 Introduction to Ideal Drinking Water System :

For more than two million years, human beings are struggling and searching to get Nutritious food, clean drinking water, energy in different form, and comfortable health. In the twentieth century, Abraham Maslow (1943) proposed Hierarchy of Needs Theory [11] based on his assumption of five different needs which are defined as Physiological need, Safety needs, Social needs, Esteem needs, and Self-actualization needs. Out of these five needs, the physiological need is the basic need also called the basic problems of human beings including food, water, energy, and health. Other four needs are together categorized as comfortability of human beings. As the civilization is developed with time, the scientific thinking among the human beings is started and science had helped to solve many of these basic problems to a certain extent. After industrialization, the availability of drinking water in many countries is

becoming scared and there is a cry on future challenges in earning potable water for many regions on earth. It is reported that between 1990 and 2015, the world population using an improved potable water source has increased from 76 % to 91 %. It is estimated that more than 40 % of global population is affected by water scarcity and is proposed to increase further. In the global scenario, over 1.7 billion people are presently living in river basins where water use exceeds recharge. Similarly, over 2.4 billion people have no access to basic sanitation facilities. It is reported that each day, nearly 1,000 children die due to preventable water and sanitation-related diarrhoeal diseases. It is a challenge for the society to achieve universal and equitable access to safe and affordable drinking water for all. It is a challenge for decreasing substantially the proportion of untreated wastewater by increasing recycling and safe reuse globally. It is also a challenge to enhance the efficiency of use of water across all sectors by producing pure water at low cost and ensure a sustainable supply of potable water to manage water scarcity and hence to decrease the number of people affected from scarcity of potable water. Table 3.1 lists the causes of water pollution and its types [12].

Table 3.1 : Causes of water pollution & Types

S. No.	Type of water pollution	Reason	Solution
1	Undissolved impurities	Mix of various undissolved impurities in both surface and groundwater	Filtering
2	Chemical water pollution or oxygen depletion	Natural organic matter (NOM) found in all surface, ground, and soil waters	Most of the NOM can be removed by coagulation, although, the hydrophobic fraction and high molar mass compounds of NOM are removed more efficiently
3	Infected water with microbial	Bacterial cell components and viruses as microbial pollution	Antimicrobial nanomaterials for water disinfection and microbial control
4	Chemical toxin pollution	Various inorganic and organic chemicals	Use of CNTs as adsorbent media to concentrate and remove pathogens, NOM, and cyanobacterial toxins from water systems.
5	Calcium ions dissolved in water	Dissolved metal ions	Nanophotonics
6	Desalination of seawater	Dissolved NaCl	Nanomembranes
7	Treatment of sewerage Water	Inorganic and organic pollutants	Chlorine Dioxide

One of the research methodologies to improve the systems in the nature and society is identifying the characteristics of an existing system where improvements are required in terms of quality, cost, and easiness of using the system, and comparing such real system with an anticipated hypothetical predicted system and its characteristics. Based on such comparison,

the possibilities and challenges of improvement of present system can be identified. This chapter also contains the proposal and detailed discussion on an ideal water purifier system in terms of its input, internal processes, output, and environmental characteristics [13].

3.1.3 Introduction to Ideal Transportation System :

The Indian auto industry is one of the largest in the world growing very fast with an annual production of 23.37 million vehicles during 2014-15, with the annual growth of 8.68 per cent. It accounts for 7.1 per cent of the country's gross domestic product (GDP). As per Automotive Component Manufacturers Association of India (ACMA) the turnover of the auto component industry is INR 2340 billion (USD38.5 billion) during 2014-15, registering a growth of 11 per cent over the previous year and a Compounded Annual Growth Rate (CAGR) of 11 per cent over the last six years. The auto component industry in India is expected to scale up to Rs. 6347 billion in turnover by 2020 with exports to grow the in range of Rs, 2200-2550 billion. Indian Government is encouraging R&D in automobile industry for technological innovations by giving a 15 per cent reduction of rate of income tax on royalty and fees for technical services. To support sustainable technology development further to provide an industry perspective on emerging affordable and accessible technologies, ACMA has taken initiative to give priorities on light weighting, electrification of powertrains, improving the safety and fuel efficiency, and electronics of vehicles. In addition, Global automotive Original Equipment Manufacturers (OEMs) and suppliers identified India as a key market working on various technologies such as light weighting, electrification of power trains and safety features. Several initiatives by the Government of India and the major automobile players in the Indian market are expected to make India a leader in the world by 2020. Some of the major investments and developments in the automobile sector in India are as follows [14]:

- Global auto major Ford plans to manufacture in India two families of engines by 2017, a 2.2 litre diesel engine codenamed Panther, and a 1.2 litre petrol engine codenamed Dragon, which are expected to power 2,70,000 Ford vehicles globally.
- The world’s largest air bag suppliers Autoliv Inc, Takata Corp, TRW Automotive Inc and Toyoda Gosei Co are setting up plants and increasing capacity in India.
- General Motors plans to invest US$ 1 billion in India by 2020, mainly to increase the capacity at the Talegaon plant in Maharashtra from 130,000 units a year to 220,000 by 2025.
- US-based car maker Chrysler has planned to invest Rs 3,500 crore (US$ 525 million) in Maharashtra, to manufacture Jeep Grand Cherokee model.

- Mercedes Benz has decided to manufacture the GLA entry SUV in India. The company has doubled its India assembly capacity to 20,000 units per annum.
- Germany-based luxury car maker Bayerische Motoren Werke AG's (BMW) local unit has announced to procure components from seven India-based auto parts makers.
- Mahindra Two Wheelers Limited (MTWL) acquired 51 per cent shares in France-based Peugeot Motorcycles (PMTC).

The Government of India encourages foreign investment in the automobile sector and allows 100 per cent FDI under the automatic route. Some of the major initiatives taken by the Government of India are [14-15] :

- Encouraging automobiles manufacturers to become driver of 'Make in India' initiative, as it expects passenger vehicles market to triple to 9.4 million units by 2026, as highlighted in the Auto Mission Plan (AMP) 2016-26.
- In the Union budget of 2016-17 the Government has announced to provide credit of Rs 850,000 crore (US$ 127.5 billion) to farmers, which is expected to boost the tractors segment sales.
- The Government plans to promote eco-friendly cars in the country i.e. CNG based vehicle, hybrid vehicle, and electric vehicle and also made mandatory of 5 per cent ethanol blending in petrol.
- The government has formulated a Scheme for Faster Adoption and Manufacturing of Electric and Hybrid Vehicles in India, under the National Electric Mobility Mission 2020 to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles, aims at creating a vehicle base of ~7 million electric cars by 2020 in the country by providing incentives to buyers as well as suppliers and for undertaking R&D initiatives, to create public charging infrastructure, to encourage retro-fitment of vehicles.
- The Automobile Mission Plan (AMP) for the period 2006–2016, designed by the government is aimed at accelerating and sustaining growth in this sector. Also, the well-established Regulatory Framework under the Ministry of Shipping, Road Transport and Highways, plays a part in providing a boost to this sector.
- The National Electric Mobility Mission Plan 2020 and policy of Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India aims at creating a vehicle base of ~7 million electric cars by 2020. National Automotive Board (NAB) under the supervision of the department of heavy industries has been constituted for implementation of the plan.

- The government of India has extended support to the industry by increasing customs duty on CBUs of commercial vehicles from 10 percent to 40 percent, reduction in duty on chassis for ambulance manufacturing from 24 percent to 12.5 percent, extension in concession on select parts used in the manufacture of electric & hybrid vehicles and weighted deduction up to 200 percent of expenditure on R&D for computation of expenses under Corporate Tax.

India's automotive industry is one of the most competitive in the world. The Indian automotive sector has the potential to cover 100 per cent of technology or components required and to generate up to US$ 300 billion in annual revenue by 2026, create 65 million additional jobs and contribute over 12 per cent to India's Gross Domestic Product, as per the Automotive Mission Plan 2016-26 prepared jointly by the Society of Indian Automobile Manufacturers (SIAM) and government [16]. Some of the challenges identified in Indian automobile sector to reach its goal as per Automotive Mission Plan 2016-26, are:

- Challenge to attract capital investments required to implement roadmap developed by AMP 2016-26.
- Challenge to fulfil global emission standards and safety norms to erase the environmental footprint.
- Challenge to adopt new breakthrough technologies to make automobiles ideal for use.
- Challenge of lack of infrastructure, urban congestion, integration of smart concepts, meeting efficiency needs.
- Challenge to safeguarding intellectual property rights developed by R & D institutions.
- Other challenges like (a) Customs duty and transfer pricing issues plaguing the industry, (b) Planning and implementing simpler tax structures, (3) Policy of withdrawal for old vehicles. (c) Lack of growth opportunities for auto industry companies may attract them to invest in other sectors etc.

While the Indian government is making serious efforts on policy implementation, automobile industry is trying to make a breakthrough in improving the efficiency, durability and cost of vehicles using nanotechnology solutions [16-19] along with decreasing the pollution by using hydrogen fuel or electric engines. The chapter also contain the proposal of ideal automobile system to solve transportation problems of the country [20].

3.1.4 Introduction to Ideal Energy Source :

According to ideal energy system model ideal energy source is a system which produces energy with ideal characteristics which are divided into input characteristics, system characteristics, output characteristics, and environmental characteristics. Based on the Google search

information [21], an ideal source of energy should possess the following characteristics. (a) It should be capable of giving an adequate amount of useful energy. (b) It should be convenient to transport, store and use. (c) It should be economical, (d) It should be capable of supplying the desired quantity energy at a study rate over a long period of time. But when we study the broad picture of ideal energy system, we have considered many more characteristics like, availability, power output, volume, mass, cost, renewability, user safetyness, Maintenance, etc. Accordingly, a systematic study of ideal energy system is required and study will help the new researchers in energy system research to re-define their objectives [22].

3.1.5 Introduction to Ideal Drug System :

The objective of drug research is continuous improvements of existing drugs in terms of their curing ability and to discover new drugs which have substantial improved abilities to cure many existing and new diseases and the final goal of drug research is directed to identifying one drug which has the ability to cure all diseases. All research work in pharmaceutics is directed towards improving drug properties including their effectiveness, safety, selectivity, no side effects, cost, accessibility, time of cure, etc. The ideal drug is a material which shows ideal characteristics. According to ideal drug model it is a system which operates on other systems based on its own properties and these properties are divided into input characteristics, operational characteristics, output characteristics, and environmental characteristics. Based on various factors which decide the ideal drug system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements is proposed [23].

3.1.6 Introduction to Nanotechnology as Enabling Technology :

Technological innovations have changed the lifestyle of human beings since many years and solved their basic problems and provided happy & comfort life. Many killer technologies have been invented in the history which has become essential to lead life of common man. Killer technologies are those technologies invented in the society and penetrated common man's lifestyle in such a way that without them the life of human being is going to be miserable. For example, invention of wheel, mechanical engine, electricity, automobile, telephone, radio, television, computer, mobile phone, windows operating system, android based smart phones etc. are examples for killer application technologies. Many of the killer application technologies became general purpose technologies and spread their arms to all areas of the organizations and the society. For example, computer technology, information and

communication technologies transformed themselves into general purpose technologies and became essential in the progress of all other fields and became part and parcel of human life. Recently, during last 20 years, nanotechnology is growing as killer application technology and due to its importance and potential advantages, growing as another general purpose technology and expected to change the society substantially. Nanotechnology deals with the manipulation of matter at near atomic level to produce new materials, structures, devices and systems that exhibit properties and phenomenon that are unique at these scales. Nanotechnology is not only general purpose technology –it is also technology that enables the creation of new devices and new ways to improve the quality of life. Nanotechnology used in existing industries and new research areas are developed within existing areas, transforming them from microelectronics to nano-electronics, from photonics to nano-photonics, from biotechnology to nano-bio-technology, and from energy to nano energy. Business firms are exploring new ways to address consumer needs, new business models based on the changes nanotechnologies could enable in existing industries. Huge amount of investments in nanotechnology to support scientific and technological researches, the creation of technological and industrial platforms and infrastructures have led to more than two million articles related to nanotechnologies being published, and over one million application patents were lodged by the year 2015 [24]. To realize the ideal technology [9] in practice, we need to identify a general-purpose technology that should manipulate the fundamental nature of matter. The technology should be microscopic and able to provide solutions to the problems and challenges of fundamental needs of human beings and also support the processes required to enhance the comfort ability of the people. The products/services developed through such technology should have properties, at least close to Ideal technology properties. The presently developed technologies like agricultural technology, space technology, computer technology, electronics & communication technology, Automobile technology, bio-technology, and laser technology are unable to show all the characteristics which are close to ideal technology characteristics mentioned above. But it is expected that using the innovations in nanotechnology can solve the basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space travel and expanded life-span and so on [20]. Nanotechnology is considered as one of the anticipated breakthrough technologies of 21st century along with supporting some other interrelated Killer application technologies like Optical Computation, Embedded Intelligence, Chameleon Chips, Flying cars, Immortality through nano-bio-technology, and Space travel [24]. Nanotechnology will play major role in

solving all the problems of humans like food, drinking water, energy, health, environment, and many other areas including life span expansion. Some of the Application areas of Nanotechnology are [25-27] :

Agriculture & Food: This include contamination sensor, antimicrobial packaging, enhanced nutrient delivery, green packaging, pesticide reduction, tracking & brand protection, texture, food flavor, bacteria and virus identification & elimination, etc.

Potable Water: This include water cleaning nanotechnology devices, nanotubes as the pores in reverse osmosis membranes, and nanotech based water purifiers for polluted water, sewage water and even sea water in large scale.

Cleaner Air& Environment: This includes pollution control, nanotech windmill blades, nanostructure membranes, nanoparticle catalysts, removal of carbon dioxide from industrial smoke stacks.

Renewable Energy: This includes inexpensive solar cells, devices for capturing, storage, &use of energy optimally [28].

Electronics: This includes development of nanotransistors, nanogates, nanodevice based integrated circuits, nanoemmissive display panels, nanomemories, nanowires, nanophotonic devices, Nano-optical computers etc.

Batteries & Fuel Cells: This include nanostructure fuel cells, hydrogen nanofuel cells, nanotech alternative fuel cells, long life high storage capacity fast rechargeable nanotech batteries etc.

Health & Medicine: This include drug delivery, therapy techniques, diagnostic techniques, antimicrobial techniques, cell repair, cancer detection & curing, gene therapy, nanotech in regenerative medicine & tissue engineering, life span extension etc.

Automobile: This includes nanomaterial-based automobile parts to increase working life of the automobiles, to decrease running cost and maintenance cost, and to decrease the environmental degradation to zero level [20].

Sensors & Detectors: This includes chemical sensors, MEMS based sensors, nano-hydrogen sensors, Nanocantilevers etc.

Consumer Products: Devices like sporting goods, fabrics & textiles, cosmetics, skin care products, sunscreens, flame retardants, nanocleaning products, nanopaints, and any other products based on nanotechnology.

Defense: This include concepts like nano for the soldier, nano for defense vehicles, nano for aeronautics, nano for naval vessels, nanotechnology for weapon systems, nano for satellites,

nano for logistics, nano for security, nano for military operations at land, nano for military operations in the air, nano for military operations at sea, nanotechnology for urban operations etc.

Civil & Mechanical Engineering Manufacturing: This includes nano-material technology, nano-processing technology, nano-assembly technology, nano-coating technology, and nano-measurement technology in mechanical manufacturing. This also include nanorobotics, Micro-Electro Mechanical Systems (MEMS) for accelerometer chips, inkjet nozzles, pressure sensors, microphones, RF switches, gyroscope, oscillators etc.

Building Materials: This includes various future building materials like aerogels, nanotube mixed concrete, nanopaints, building integrated photovoltaics, nanophotonic materials as building cooler. Nanotechnology on construction, and fire protection etc.

Pharmaceutical Industry: The major goal of the nanotechnology is to improve the present way to drugs administration for efficient way of recovery of the patient. This include the creation of new drugs with a specific function till the fabrication of new drug delivery systems for the movement of different barriers in the human body with special care of increase the efficiency of drugs in terms of solubility [23]. Nano-drugs can cure dreadful diseases like AIDS, cancer, tuberculosis, diabetes, malaria, prion disease, etc.

Aircraft, Rocket and Space Technology: This includes low cost, less weight, high strength space elevators, weight reduction in spaceships and spacesuits, solar power satellites, bio-nano-machines for space applications, new breed of robots to explore the planets etc.

Lifespan Expansion: The two possible ways to extend the lifespan of human being are either by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. Techniques for building nano-robots are being developed that should make the repair of our cells possible [29].

3.2 IDEAL TECHNOLOGY CONCEPT & ITS REALIZATION OPPORTUNITY

3.2.1. Ideal Technology :

Technology is the branch of scientific knowledge that deals with the creation, application and use of technical means and their interrelation with human life, society, and the environment, drawing upon such subjects as engineering, applied science, pure science and industrial arts. Many technological processes generate unwanted by-products, which give rise to pollution, and deplete natural resources, to the detriment of Earth's environment. Implementations of new technology influence the culture and values of a society and often raises new ethical questions.

For example, the rise of the notion of efficiency and effectiveness in terms of human productivity, a term originally applied only to machines is now became common traditional norms [30].

To improve any present systems in the society, it is normal practice that such systems have to be compared with a hypothetical, predicted system of that kind called "Ideal system". The word 'Ideal system' refers to the system which has ideal characteristics i.e., perfect in every way. It is what the mind pictures as being perfect. The concept of ideal engine, ideal switch, ideal voltage source, ideal current source, ideal semiconductor devices like ideal diodes, ideal transistors, amplifiers etc. have been defined and taken as standards to improve the quality and performance of such practical devices or systems. It is found that, by keeping such hypothetical devices or systems in mind, researchers have continuously been improving the characteristics/properties of practical devices / systems to upgrade their performances. Hence ideal technology model is essential to plan the improvement in the performance of any practical technology. In this chapter, an attempt is made to develop a conceptual ideal technology model by considering it as a system and identifying various characteristics of the system. Similarly, the concept of ideal technology can be predicted as a technology which can solve all basic needs of human beings and provide luxurious comfortable life without affecting the society and environment. Ideal technology should have characteristics in order to elevate the quality of life to unique level with perfect equality so that every human being in this universe should lead happy and comfortable life and realize the so-called concept of heaven on earth.

3.2.2. Ideal Technology Model :

An ideal technology system should have characteristics to fulfill its objectives to solve all problems of human beings including both basic needs and advanced gadgets to support comfort living to realize their dreams. Based on various factors which decides the ideal technology system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument namely focus group method [31-33]. The block diagram of such a system is shown in Figure 3.1.

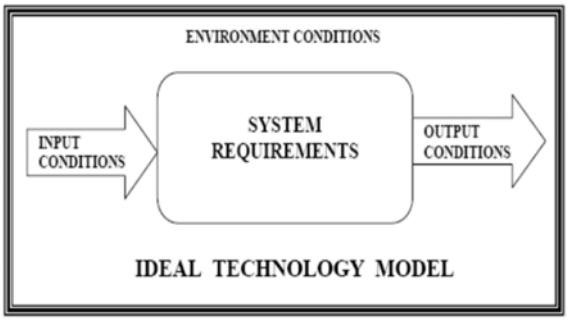

Fig. 3.1: System model of classifications of Ideal Technology characteristics.

3.2.2.1 Input Conditions

1. Manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind.

2. In-expensive &self-reliable in terms of resources to make it attractive to be used by people/countries of varied economical situations.

3. Ubiquitous so that the technology provides solutions and services at anytime, anywhere, any amount of time to the users.

4. Affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

3.2.2.2 Output Conditions

1. Solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment.

2. Provide comfort life to the users by providing solutions to their desires.

3. Equality : Ideal technology provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin.

4. Automation: Ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming.

5. Immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

3.2.2.3 System Requirement

1. General purpose technology to support all fields and problems of human & living beings on the earth.

2. Self-directed & self controlled & self regulated so that the technology can control itself in order to achieve its goal.

3. Easy, simple, quick & user friendly to solve all type of problems and to provide quick ideal solution.

4. Scalable so that it is used for solving small and simple problem to large and complex problems of life.

5. Omni-potent to identify and solve problems and provide comfortability to human being and feeling him like God.

6. Exploring new opportunities to improve and explore comfortability and further leisure in life of people.

7. Infinite potential for further development of life in the universe.

3.2.2.4 Environment Conditions

1. Maintain clean environment through its processes and avoids foot print of processes while achieving specific function.

2. Infinite business opportunities by creating new products / services with ideal characteristics.

3. Adaptive to any situations to achieve stated goal.

4. No side effects so that it should be safe for users, and environment.

Any technology which has the above properties/characteristics is considered as ideal technology and the conventional technologies have serious drawbacks/limitations in terms of the above properties.

3.2.3. Analysis of Ideal Technology Characteristics :

Ideal Technology characteristics can be explained based on their effectiveness in improving the qualities and comfortability of human life in the society. The characteristics mentioned in ideal technology model are depicted in figures 3.2 –3.5 and further discussed below :

3.2.3.1 Input Conditions :

1. Manipulate the fundamental nature of matter :

Ideal technology manipulated fundamental nature of matter. This includes four Interactive Forces manipulation, and Unified Field manipulation. The ideal technology is able to control the four interactive forces of Strong Force, Weak Force, Electromagnetism, and Gravity all in one. Ideal technology allows user to control four fundamental forces of the universe, reaching nearly any effect they desire. As a result, the user can rearrange matter to create other configurations and can even transmute elements and manipulate space-time to a degree by using gravity to distort them. Hence, ideal technology helps to manipulate the fundamental nature of matter to provide solutions to basic and advanced problems of mankind.

2. In-expensive &self-reliable in terms of resources :

Any technology should be cheap, simple, universal, self reliable in terms of resources so that can be used by anybody, anywhere with available basic resources. One of the examples of such technology is Appropriate technology which is an ideological movement (and its manifestations). Though the nuances of appropriate technology vary between fields and applications, it is generally recognized as encompassing technological choice and application that is small-scale, decentralized, labor-intensive, energy-efficient, environmentally sound, and locally controlled [34]. Schumacher and many modern-day proponents of appropriate technology also emphasize the technology as people-centered [34].

Appropriate technology is most commonly discussed in its relationship to economic development and as an alternative to transfers of capital-intensive technology from industrialized nations to developing countries [35-36]. Today appropriate technology is often developed using open source principles, which have led to open-source appropriate technology (OSAT) and OSAT has been proposed as a new model of enabling innovation for sustainable development [37]. Such property of technology makes it attractive to be used by people/countries of varied economical situations.

3. Ubiquitous :

Ubiquitous, means being present everywhere simultaneously or existing everywhere at the same time. The very concept behind this kind of technology being everywhere and still being virtually inexistent or invisible. This technology is sometimes also referred to as pervasive computing - things that think, or calm technology. The aim of such technology is to establish an environment where people can always be on-the-go, and still carry information and power to solve their problems at their inconvenience, without being bound by the location of any particular technological device. The main underlying principle or rather thought behind Ubiquitous technology is to turn the virtual reality inside out [38-39]. Virtual reality always attracts a common user into a technical system and makes him/her a part of a world, which is beyond mediation. On the other hand, this technology makes systems live and work in a world with people. Thus, Ubiquitous technology provides solutions and services at anytime, anywhere, any amount of time to the users.

4. Affordable to everybody :

Ideal technology should be so smart, so simple and so powerful it works for everybody. Development and maintenance of such technology should be simple, cost effective with fewer constraints for implementation. Innovative technology like smart phones and tablets are becoming more accessible as new models are being brought out at cheaper prices. For example,

advent of technology made healthcare services more affordable than ever before. Hence ideal technology is affordable to everybody so that it uses common materials available in nature and manipulate effectively to the need of human being at affordable cost.

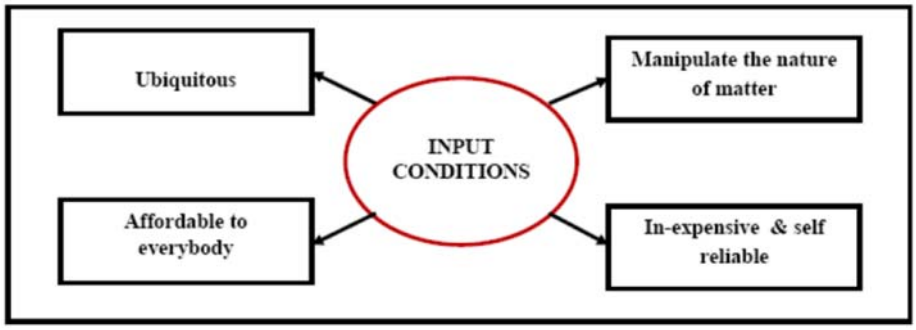

Fig. 3.2 : Input condition characteristics of Ideal technology

3.2.3.2 Output Conditions

1. Solve basic needs :

Science and technology are essential means of meeting society's needs for food, water, energy, health care, shelter, safety and alleviation of poverty. Technology is produced through the existence of the "scientific establishment", formed by the group of institutions, persons and resources directly involved in the production of new knowledge accordingly to certain "internal" rules and procedures. Basic human needs to lead comfortable life constitute a major worldwide shameful problem in the twenty first century. In contrast to the dazzling scientific advancement in fundamental and biomedical science there exists at the other end of the spectrum a formidable picture of unmet basic needs leading to serious health problems. Currently people in underdeveloped and developing countries are suffering from poor quality of life because of (1) Food shortage and malnutrition. (2) Unsafe drinking water. (3) Improper or absent sanitation system. (4) Poor or absent Health Care. (5) Overcrowding or shelter deprivation. (6) Primitive in effective education. (7) Weak or absent social security. Those problems are localized in underdeveloped and developing countries in contrast to being nearly unknown in developed ones. The gap between people who enjoy such services and the people who are not is astronomically widening. Lack of scientific social and technologic development is recognized as the root causes of that disparity in the quality of life and living conditions. Hence ideal technology should have capability to solve basic needs like food, drinking water, renewable energy, clothing, shelter, health and clean environment.

2. Provide comfort :

Technological development offers new possibilities to make people's daily lives more healthy, safe, understandable, independent, fun and comfortable. New technologies provide us, for instance, with energy-friendly and sustainable solutions to improve the environment in which we live as well as tools for elderly people to live longer on their own. Furthermore, new technologies provided us with new means of communication and entertainment. Examples are smartphones, ambient intelligence and smart homes, online shopping and communities, 3D television and renewable energy technologies like hydrogen technology and biomass. In the historical accounts of engineers, comfort is generally presumed to be a definable human condition or attribute, with each new innovation bringing society closer to the achievement of ideal indoor conditions. Starting from a different set of assumptions, social historians take comfort to be a malleable construct and social achievement. Ideal technology through its ingredients provide comfort life to the users by providing solutions to their desires.

3. Equality :

Technology provides equal opportunity to everybody in terms of identifying and en-cashing opportunities throughout the world. Thus, ideal technology also should provide equal opportunity and similar solutions to every user irrespective of their gender, religion, background, education, economic status, and country of origin.

4. Automation :

Automation or automatic control, consists of using various control systems for operating equipment such as machinery in industries, boilers and heat-treating ovens, processes in factories, switching in telephone networks, steering and stabilization of ships, controlling aircraft and other applications with minimal or reduced human intervention. Ideal technology automates all processes in every type of industries to avoid human interference in work/control in order to provide expected output based on programming.

5. Immortality :

Immortality is eternal life or the ability to live forever. Biological life has inherent limitations which medical interventions or engineering may or may not be able to overcome. Nature in its natural selection has developed potential biological immortality in some living species like jellyfish. Certain scientists, futurists, and philosophers, have theorized about the immortality of the human body, and advocate that human immortality is achievable in the first few decades of the 21st century, while other believes that life extension is a more achievable goal in the short term, with immortality awaiting further research breakthroughs into an indefinite future. It is predicted that newly developing technologies may be used to induce biological immortality

in human beings. Human embryonic stem cells research created considerable excitement for the development of mass-producing replacement cells for the treatment of degenerative diseases involving the loss or dysfunction of cells, including those in osteoarthritis, macular degeneration, heart failure, diabetes, Parkinson's disease, and several other disorders. The preliminary report of the isolation of these cells marked the birth of the new area of research called regenerative medicine. This technology offers the theoretical potential of rejuvenating an entire human body back to a youthful state. Hence immortality is the ultimate goal of ideal technology so that it can create an avenue for deathless situation or enhancement of human life span.

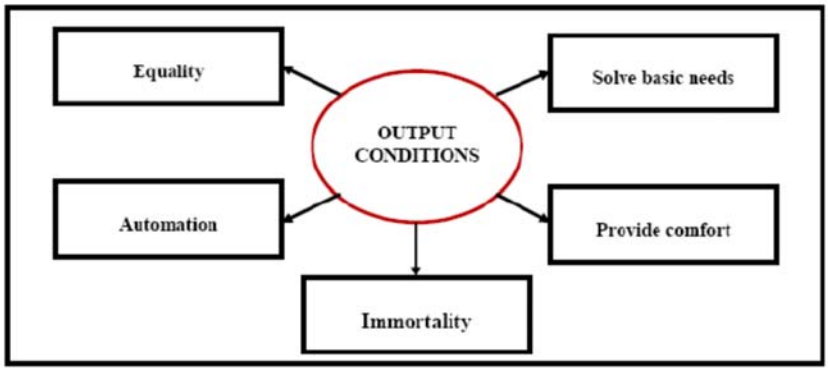

Fig. 3.3 : Output condition characteristics of Ideal technology

3.2.3.3 System Requirement :

1. General Purpose Technology :

General-purpose technologies (GPT) are technologies that can affect an entire economy of the world. GPTs have the potential to drastically alter societies through their impact on pre-existing economic and social structures. Steam engine, railroad, interchangeable parts, electricity, electronics, material handling, mechanization, automation, the automobile, the computer, the Internet and the mobile phone are few examples for GPT. Thus, as GPT's spread throughout the economy, bringing about generalized productivity gains. Ideal technology should be general purpose technology in order to support all fields and problems of human & living beings on the earth.

2. Self-directed & self controlled & self regulated :

Ideal technology is expected to be self-directed, self-controlled and self-regulated so that the technology can control itself in order to achieve its goal. Changes in any parameters due to internal or environmental variations should be re-adjusted through feedbacks and automatic controls.

3. Easy, simple, quick & user friendly :

User-friendly describes a hardware device or software interface that is easy to handle. It is "friendly" to the user, meaning it is not difficult to learn or understand by an ordinary person. The common attributes of such user-friendly technology are (a) simple, a user-friendly interface is not overly complex, but instead is straight forward, providing quick access to common features or commands. (b) clean, a good user interface is well-organized, making it easy to locate different tools and options. (c) intuitive, in order to be user-friendly, an interface must be making sense to the average user and should require minimal explanation for how to use it. (d) reliable, an unreliable product is not user friendly, since it will cause undue frustration for the user. A user-friendly product is reliable and does not malfunction or crash. These features allow to solve all type of problems and to provide quick ideal solution.

4. Scalable :

Scalability is the ability of a system, network, or process to manage a growing amount of work in a capable manner or its enlarged ability to accommodate such growth. For example, it can refer to a systems capacity to increase its total output under an increased load when resources are added. It also refers to anything whose size can be increased. For example, a font is said to be scalable if it can be represented in different sizes. Scalability is the ability of a system based on technology it uses so that it is used for solving small and simple problem to large and complex problems in society.

5. Omni-potent :

The noun omnipotence describes having an enormous amount of power, or even an infinite amount of power. Omnipotent technology has an ability to solve problems of many and multiple areas. Hence it can identify and solve problems and provide comfortability to human being and feeling him like God.

6. Exploring new opportunities :

The technological opportunity discovery (TOD) can be divided into two types: anticipating new technology and applying existing technology to solve basic and advanced problems. Ideal technology should focus on exploring new opportunities to improve and explore comfortability and further leisure in life of people.

7. Infinite potential for further development :

An ideal technology has ability to expand to all realm of the society and all branches of science. It should show its existence in solving problems of physical, chemical and biological areas. Through its innovative ability of improving quality of human life, it has infinite potential for further development of life in the universe.

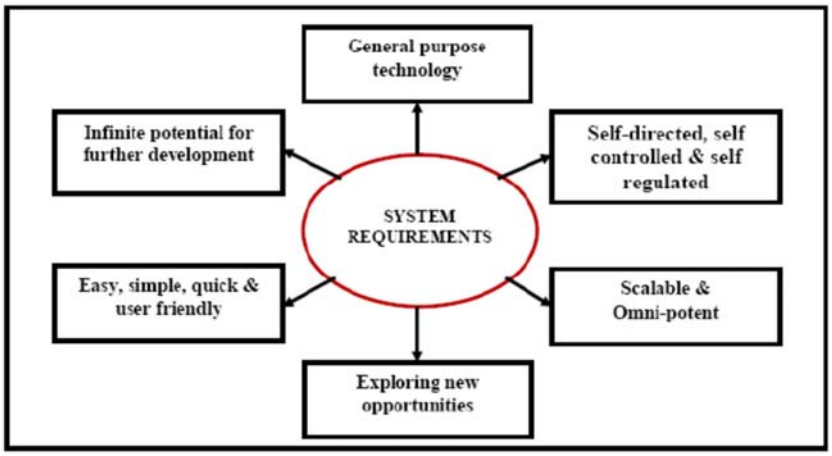

Fig. 3.4 : System requirement characteristics of Ideal technology

3.2.3. 4 Environmental Conditions

1. Maintain clean environment :

Environmental technology or clean technology is the application of one or more processes of environmental science, green chemistry, model and conserve the natural environment and resources, environmental monitoring and electronic devices to monitor, and to curb the negative impacts of human involvement in environmental pollution. Clean technology includes recycling, renewable energy, green transportation, electric motors, lighting, grey water, information technology, and many other appliances that are now more energy efficient. It is a procedure to create energy in the form of electricity and fuels, with lower environmental footprint and minimise pollution. Thus, ideal technology maintains clean environment through its processes and avoids foot print of processes while achieving specific function.

2. Infinite business opportunities :

New technology creates new business opportunities in many areas depending upon its ability to solve problems provide innovative solutions in different areas in the society. When considering the characteristics of ideal technology, it should offer infinite business opportunities without any boundaries and constraints by creating new products / services with ideal characteristics.

3. Adaptive :

Another aim of this technology is to make the devices so advanced that they can sense the changes in the surrounding and environments and change themselves accordingly. This way, they become adaptive enough to function as per the necessary changes and preferences.

4. No side effects :

In addition to its intended benefits, every design is likely to have unintended side effects in its production and application. On the one hand, there may be unexpected benefits. For example, working conditions of the workers may become safer when materials are moulded rather than stamped, and materials designed & developed for space vehicles may become useful in consumer products. On the other hand, substances or processes involved in production work may harm production workers or the public in general giving rise to side effects; for example, sitting in front of a computer for long period may strain the eyes and lead to isolation from other employees. There may be enhanced opportunity and increased employment for the people involved in the new technology, which in turn decreases employment for others involved in the old technology. This may change the nature of the work people must do in their jobs. But ideal technology should be free from all such kind of side effects so that it should be safe for users, and environment.

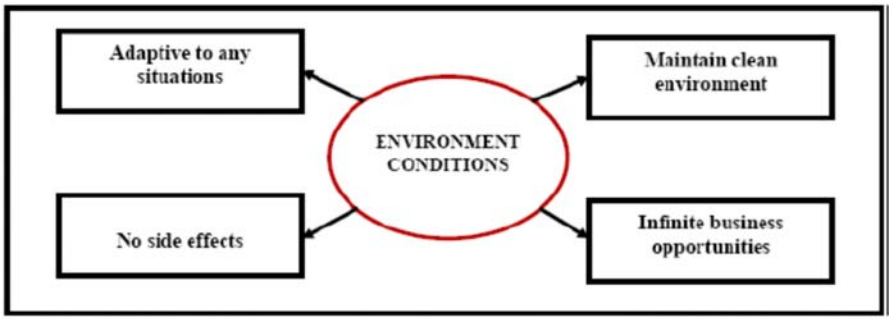

Fig. 3.5 : Environment characteristics of Ideal technology

3.2.4. Challenges to Achieve Ideal Technology :

To realize the Ideal Technology in practice, we need to identify a general purpose technology which should manipulate the fundamental nature of matter. The technology should be microscopic and able to provide solutions to the problems and challenges of fundamental needs of human beings and also support the processes requited to enhance the comfortability of the people. The products/services developed through such technology should have properties, at least close to ideal technology properties. The presently developed technologies like agricultural technology, space technology, computer technology, electronics & communication technology, automobile technology, bio-technology, and laser technology are unable to show all the characteristics which are close to ideal technology characteristics mentioned above.

3.2.5. Nanotechnology as Ideal Technology :

The emerging nanotechnology is expected to solve both basic needs and comfort needs of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort needs are realizing the automation in every field, space

travel and expanded life-span and so on. Nanotechnology is the manipulation of matter on an atomic, molecular, and supra-molecular scale. The earliest, widespread description of nanotechnology [40-41], referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macro scale products, also now referred to as molecular nanotechnology. Some of the applications of nanotechnology initially thought are :

• Clean, secure, affordable energy;

• Stronger, lighter, more durable materials;

• Low-cost filters to provide clean drinking water;

• Medical devices and drugs to detect and treat diseases more effectively with fewer side effects;

• Lighting that uses a fraction of the energy associated with conventional systems;

• Sensors to detect and identify harmful chemical and biological agents; and

• Techniques to clean up harmful chemicals in the environment.

Nanotechnology is sometimes referred to as a general-purpose technology. That's because in its advanced form it will have significant impact on almost all industries and all areas of society. It will offer better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general [39].

(1) Food : Nanotechnology innovations in agriculture is expected to solve the problems in food sector and maximizes productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition, while world grain harvest has fallen short for the last four years. Biodiversity is being destroyed worldwide with 9.4 hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. The world population is currently at 6.4 billion and is estimated to swell to 8.9 billion by the year 2050. It is anticipated that 98% of this growth will be in poorer countries. It is also predicted that there will be 5 billion city dwellers by 2030 which will place heavy demands on the growth and distribution of food. Nanotechnology will provide solutions through precision farming using nanosensors, nano-pesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water.

(2) Drinking Water : Nanotechnology has potential to provide efficient, cost effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low cost water

purification is expected to solve drinking water problem of the world. Water is one of the Earth's most precious natural resources. Most of it is saltwater. Fresh usable water is only 3% of the world's supply and two-thirds of that is frozen in glaciers, ice caps and icebergs. The remaining 1% is available for human consumption. Today 1.1 billion people don't have access to safe water and 2.4 billion lack sanitation facilities.80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, in 1998 of water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering the current rates of consumption, population and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology will provide solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps conversion of sea water into drinking water at very low cost.

(3) Renewable Energy : Nanotechnology innovations in renewable energy solves entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing humankind's need for energy with the environmental cost to our planet is a major challenge. Demand for energy on earth is forecasted as increasing 50% by the year 2025 with most of these being fossil fuels. Currently over 1.6 billion humans have no access to electricity and2.4 billion rely on plant material, vegetation, or agricultural waste as an energy and heating source. Our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, theCO_2 concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest of record, 2001 came in the second warmest and 2004 was the fourth warmest [42]. Nanotechnology will help to solve our need for energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid.

(4) Clothing : Nanotechnology based cloths are presently available in market. Making composite fabric with nanosized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques. It supports creating fabrics that do not wrinkle, stain, or allow the growth of bacteria. Anti-microbial socks, underwear, and sporting apparel; wind and water proof jackets; wrinkle and stain resistant suits and casual wear; and swimsuits that protect

against UVA and UVB rays are all products that are treated with nanocoatings or use nanotechnology in the manufacturing process. The advantages of nanotech fabrics are water and stain resistant, insulates against heat or chill, dirt rinses off in rain similar to property of the lotus plant, reduces odours and bad smell [43].

(5) Shelter : Nanotechnology offers interesting new opportunities in the construction sector through the development of energy efficient, ultra-high strength, extra durable, extremely lightweight construction materials. Preceded by the IT and software revolution, Nanotechnology and Science are expected to usher a new paradigm shift in all spheres of technology including infrastructure and construction. In a nutshell, Nanotechnology is today recognised as a revolutionary technology that can help address key needs relating to energy, environment, health, shelter and agriculture in developing countries. It has been estimated that $ 1 trillion worth of products worldwide will incorporate nanotechnology in key functional components by the year 2015. To achieve this goal, the Govt. of India has launched an ambitious mission mode programme with a budgetary allocation of Rs. 1000 crore under which several major research initiatives have been initiated. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nano-meter scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nano particles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. Nanotechnology may have its biggest impact on the medical industry. Patients will drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nanosurgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that conventional surgery does. Additionally, nanorobots could change your physical appearance. They could be programmed to perform cosmetic surgery, rearranging the atoms of human body to change his ears, nose, eye colour or any other physical feature he wishes to alter.

(6) Human health : The important and major area of nanotechnology research is in human health. Humans are living longer lives. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be

significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola and the Avian Flu. HIV/AIDS, the most critical threat, has killed 22 million and infected 42 million. In 2003 roughly 5 million people became infected worldwide. AIDS according to a United Nations study is increasingly becoming global as it spreads rapidly to Eastern Europe and Asia. Cancer kills over 500,000 people and 1.5 million are diagnosed annually in the United States.

According to the World Cancer Report, there could be a 50% increase to 15 million new cases in the year 2020 primarily attributed to an aging population worldwide. Recent nanotechnology research is making tremendous progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. In the Expert Opinion essays, longer-term applications of advanced nanotechnology to health and longevity are explored [44].

(7) Environment & Climate : There is an ever-increasing demand for natural resources and living space for humans, while toxics continue to build up in our water and soil. Biodiversity is being destroyed worldwide with 7 million hectares of forest being lost annually. Half of our world's forests and a quarter of our coral reefs are gone. Biodiversity decreases each year, with increasing threats especially to the oceans. Damage to the atmosphere's ozone layer has slowed but a hole still remains. Many believe that man-made greenhouse gases are causing disruption to the planet's climate, a process popularly termed 'global warming.' Proposals to correct this are expensive and unlikely to be followed by developing nations who see economic advance as more urgent. Nanotechnology will provide solutions through precision pollution monitoring using nanosensors, lower energy needs due to lightweight strong materials, and reducing the use of harsh cleansers through the applications of nanocoatings to surfaces. A more advanced nanotechnology solution will be building our products with molecular-level precision through the use of productive nanosystems, resulting in virtually no chemical waste.

Table 3.2: Comparison of nanotechnology with ideal technology model.

S. No.	Major Problems of human beings in the Society	Ideal technology solution	Nanotechnology solution
1	Nutritious food for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology in agriculture.

2	Clean drinking water for everybody	Basic feature of Ideal technology	Possible to solve using nanotechnology filters
3	Renewable energy at affordable cost	Basic feature of Ideal technology	Possible through nanotech solar cells & battery technology
4	Quality and long lasting cloth	Basic feature of Ideal technology	Possible to solve using nanotechnology in fabrics.
5	Affordable Shelter to every body	Essential feature of Ideal technology	Possible to solve using nanotechnology in construction.
6	Health care	Basic feature of Ideal technology	Possible to solve using nanotechnology in medicine.
7	Environment & climate	Essential feature of Ideal technology	Possible to solve using nanotechnology as clean technology.
8	Sustainable technology for every body	Essential feature of Ideal technology	Due to its fundamental nature, nanotechnology is sustainable for everybody and everywhere.
9	Comfort life	Luxurious feature of Ideal technology	Possible to solve using nanotechnology in customer products & ability to upgrade all other technologies.
10	Space travel	Luxurious feature of Ideal technology	Nanotechnology supports low cost & efficient space travel.
11	Life span expansion	Desirable feature of Ideal technology	Bio-medical applications of nanotechnology supports life span expansion.

(8) Sustainable transportation, & information communication technology for everybody : Nanotechnology will become a key enabling platform technology for next generation transportation systems to develop more efficient and lighter materials for automotive and aircraft systems, High performance tyres for automobiles, efficient and non-platinum based catalytic converters. Novel and more efficient fuel and power sources etc. There are currently many people who lack widespread access to communications, information, basic technology services, and tech resources. This lack of access creates insurmountable barriers to education, democratization, and economic growth. The use of nanotechnology applications will drastically reduce the cost and increase the performance of memory, displays, processors, solar powered components, and embedded intelligence systems. It will also enable networks to be

self-configuring. These improvements would create a pervasive computing environment that would promote greater global communication, cross-cultural understanding and cooperation [45-46].

(9) Nano-factories : Nanofactories-manufacturing systems that work on the atomic & molecular scale-are gradually moving from science fiction to science fact and one day could be used to build all types of items such as drugs, semiconductor chips and even cell-sized robots that patrol the human body. The first step would be to develop nanoscopic machines, called assemblers, that scientists can program to manipulate atoms and molecules at their will. In order to make molecular manufacturing to be reality, one would need trillions of assemblers working together simultaneously. It is predicted that assemblers could first replicate themselves, and then build other assemblers. Each generation would build another, resulting in exponential growth until there are enough assemblers to produce objects. Trillions of assemblers and replicators could fill an area smaller than a cubic millimeter and could still be too small for us to see with the naked eye. Assemblers and replicators could work together to automatically construct products and could eventually replace all traditional labour methods and create a method of three-dimensional material/device printer. This could vastly decrease manufacturing costs, thereby making consumer goods plentiful, cheaper and stronger. Eventually, such 3D printers allow us to replicate anything, including diamonds, water and food. Famine could be eradicated by machines that fabricate foods to feed the hungry [47-48].

Table 3.3 : Comparison of ideal technology and Nanotechnology in terms of their characteristics.

S. No.	Ideal technology Characteristics	Conventional Technology	Nanotechnology
1	General purpose technology	Special purpose technology	General purpose due to its ability to provide solutions in many fields.
2	Self-directed & self controlled & self regulated	External control by human being is required in many cases.	Can be Self-directed & self controlled & self regulated by molecular programmed nano-machines & nano-factories.
3	Easy, simple, quick & user friendly	Most of the conventional technologies are simple, easy & user friendly.	Possible to get easy, simple & quick solutions to many problems.
4	Scalable	Not all	Scalable depending on application.
5	Omni-potent	Not applicable except mobile technology	Partially applicable for some areas.
6	Exploring new opportunities	Limited opportunities	Unlimited opportunities.
7	Infinite potential for further development	Finite potential	Infinite potential due to its general purpose nature and

			ability to solve fundamental and other problems of society.
8	Maintain clean environment	Failed drastically	This is major advantage of nanotechnology.
9	Infinite business opportunities	Limited business opportunity	Infinite business opportunities due to multiple field applications.
10	Adaptive nature	Partially possible	More or less possible
11	Manipulate the fundamental nature of matter	No	Yes due to atomic level & molecular level manipulation.
12	In-expensive & self reliable in terms of resources	No	Yes due to its fundamental nature.
13	Ubiquitous	Only few like mobile computing technology	Yes due to its fundamental general purpose nature.
14	Affordable to everybody	No	Yes in most cases due to its fundamental nature.
15	Solve basic needs	No	Yes by using only one technology.
16	Provide comfort	Partially	Yes due to its potential to solve real world problems to provide luxury to human life.
17	Equality	Partially	Yes irrespective of various affecting factors.
18	Automation	Partially	Possible in almost all application fields.
19	Immortality	No	Yes in long time span.
20	No side effects	No	Yes based on careful handling.

(10) Space-travel : The challenges facing by humanity on the earth are the result of our heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology will create the ability for humans to operate in space more safely. Applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics and life support environments. These will be more efficient, stronger, self-healing and lighter than what is currently available.

(11) Extended life span : There are two ways in which nanotechnology may be able to extend our lives. One is by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level - a nano version of the fountain of youth. The most exciting possibility exists in the potential for repairing our bodies at the

cellular level. Techniques for building nanorobots are being developed that should make the repair of our cells possible. For example, as we age, DNA in our cells is damaged by radiation or chemicals in our bodies. Nanorobots would be able to repair the damaged DNA and allow our cells to function correctly. This ability to repair DNA and other defective components in our cells goes beyond keeping us healthy: it has the potential to restore our bodies to a more youthful condition. The extension of the human lifespan could be facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age related conditions. Aubrey de Grey et al. have proposed that soil bacterial enzymes might have the capacity for degrading lipofuscin. It is proposed that humans might live as long as1,000 years under the appropriate rejuvenative therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. And in 35 to 40 years, we literally will be immortal [49]. Table 3.3 compares the possible ideal technology solutions with nanotechnology solutions for solving major problems of human being in the society.

The system properties like - General purpose technology, Self-directed & self controlled & self regulated, easy, simple, quick & user friendly, Scalable, Omni-potent, exploring new opportunities, Infinite potential for further development, the environmental conditions like - Maintain clean environment, Infinite business opportunities, Adaptive nature, and no side effects nature of ideal technology are also can be realizable using nanotechnology for various products/services. The input properties like - Manipulate the fundamental nature of matter, In-expensive &self reliable in terms of resources, Ubiquitous, Affordable to everybody; the output conditions like – Solve basic needs, Provide comfort, Equality, Automation, Immortality of ideal technology model also realizable to certain extent using nanotechnology as shown in Table 3.3.

3.3 OPPORTUNITIES & CHALLENGES FOR GREEN TECHNOLOGY

A sustainable society is founded on equal access to nutritious food, clean drinking water, health care, smart shelter, education, energy, economic opportunities and employment. In this ideal society, humans live in harmony with their natural environment, conserving resources not only for their own generation, but also for their future generations. Each citizen enjoys a high quality

of life and there is social justice for all. Many technologies like nanotechnology, next generation nuclear power, bio-fuels, bio-plastics, smart monitoring & prediction analysis, tidal energy etc. are some of the possible sustainable technologies for future. Sustainable cities need sustainable technology for construction, maintenance and further growth. Sustainable construction means recycled construction materials, green roofs for storm water management, zero-energy buildings (those that generate at least as much renewable energy as they use), natural ventilation systems, etc., sustainable infrastructures like sustainable urban drainage systems, low-irrigation landscaping, renewable energy sources such as biogas created from sewage, etc., sustainable Transport Systems like public trains and buses that run on renewable fuels, coordinated bike paths and walkways, increased access to transport, tolls for private vehicle use, etc., and sustainable local resource production: like recycled rainwater for drinking and irrigation, farm scrapers, urban agricultural plots, farmers markets, etc. By means finding means to decrease the cost of production, maintenance, improving government policies to support research and adoption of such technologies, and educating people to promote and use such technologies in day-to-day life the sustainable technologies can be promoted.

3.3.1. Green Technologies

Green Technology (GT) is environmental healing technology that reduces environmental damages created by the products and technologies for peoples' conveniences. It is believed that GT promises to augment farm profitability while reducing environmental degradation and conserving natural resources Green technologies are sustainable technologies which will not create footprint when used for various processes/applications. Green technologies support the use of natural organic resources and avoid production of green gasses. They also consume less resource and do not support to increase the entropy of the universe. Green technologies do not support any kind of environmental degradation. They support automation of every process and hence avoid human intervention. Since they are do not support environmental degradation and contribute to creating the footprint, they are sustainable, improves the lifestyle of the people and contribute for human comfortability. The major technologies used in present day like Aircraft technology, Automobile technology, Biotechnology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. can be made green using the principle of green technology [50-58]. Such green technologies may contribute to solving problems of the society both basic and advanced kind of civilization. The objectives of green technologies in some of the basic and advanced fields of society are listed in table 3.4.

Table 3.4 : Objectives of green technologies in various areas of the society

S. No.	Area	Objectives of green technologies
1	Agriculture	To avoid environmental degradation in agricultural processes.
2	Food Processing	To eliminate poisonous contents in food and to avoid green gas emission and environmental degradation in all food packaging processes.
3	Potable water	To large scale filter used water and sea water through green processes without environmental degradation.
4	Sustainable Energy	To develop technologies for harvesting potential natural energy sources to generate required energy to human civilization without degrading environment.
5	Consumer products	To produce variety of new generation consumer products without side effects and without degrading environment in any production, packaging and in actual use by consumers.
6	Automobiles	To produce energy efficient, zero emission automobiles using renewable energy processes.
7	Construction	To build environmental friendly, energy efficient, smart buildings.
8	Industrial Automation	To develop industrial processes which are environmental friendly, no green gas emission, recyclable waste products using green energy.
9	Computer and Information Communication	To develop and utilize environmental friendly, recyclable electronic and computer components which uses renewable energy and efficient performance.
10	Education	Use of green technology in all education services.
11	Health	Use of green technology and green processes in all health and medical services.
12	Aircraft & Space Travel	Use of green energy and green materials and environmental friendly processes in air and space travel.

3.3.2. Nanotechnology as Green Technology :

The emerging nanotechnology is expected to solve both basic needs and comfort wants of human beings. The basic needs of human being are food, drinking water, energy, cloth, shelter, health and environment and the comfort wants are realizing the automation in every field, space

travel, expanded lifespan and so on. Nanotechnology is the manipulation of matter on an atomic, molecular, and supramolecular scale. The earliest, widespread description of nanotechnology, referred to the particular technological goal of precisely manipulating atoms and molecules for fabrication of macro scale products, also now referred to as molecular nanotechnology. Planned and controlled development in nanotechnology leads to environmental sustainability and hence can be used as green technology. Some of the applications of nanotechnology initially thought as green technology are :

• Clean, secure, affordable, renewable energy;
• Stronger, lighter, more durable recyclable materials;
• Low-cost filters to provide clean drinking water from seawater;
• Medical devices and drugs to detect and treat diseases more effectively with fewer or no side effects;
• Lighting that uses a fraction of the energy associated with conventional systems;
• Sensors to detect and identify harmful chemical and biological agents; and
• Techniques to clean up harmful chemicals in the environment.
• Green building and sustainable infrastructure.
• Modified production processes to minimize green gas emission.

The green Nanotechnology is going to be evolving as a general-purpose technology due to its applications in all areas of society. Hence in the advanced form, it will have a significant impact on almost all industries and all areas of society by offering better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for the industry in general. Thus, by controlled utilization of nanotechnology for environmental sustainability, it can be developed as green technology for sustainable society.

3.3.3. Green Technology for Agriculture and Food :

The green technology should be efficient, practical, cost effective and free from pollution. The sustainability factor should be looked at the ability of the agricultural land to maintain acceptable levels of production over a long period of time, without degrading the environment. Some define sustainability as the maintenance of productivity under stress conditions. Agricultural sustainability in this context should seek to maximize food production within constraints of profitability.

The specific challenges for green technology in agriculture are:

(1) Identifying appropriate technology suitable for income generation through sustainable agriculture i.e., ecological agriculture, rural renewable energy, etc;

(2) Examining the impact and implications of national policies for making recommendations for the extension of appropriate technology;

(3) Diagnosing policy-level impact of such green technology (GT) on rural income generation under the sustainable agriculture development framework;

(4) Reviewing the challenges and available policy options for the adoption of GT sustainable agriculture integrates three main goals-environmental health, economic profitability, and social and economic equity.

Some of the opportunities towards sustainable agriculture are:

(1) Integrated Pest Management (IPM), (2) Rotational Grazing, (3) Soil conservation, (4) Water quality/wetlands, (5) Cover crops, (6) Crop/ landscape diversity, (7) Nutrient management, (8) Agro-forestry, and (9) Marketing of green products.

The revolution in the challenge is to make applied technology competitive and sustainable nanotechnology innovations in agriculture are expected to solve the problems in the food sector and maximize productivity in agriculture. There is an ever-increasing demand for food and adequate nutrition and nanotechnology will provide solutions through precision farming using nanosensors, nano-pesticides, and inexpensive decentralized water purification. A more advanced nanotechnology solution will be plant gene therapy; creating pest resistant, high yield crops that require less water etc. which also supports a sustainable environment.

3.3.4. Green Technology for Potable Water :

Nanotechnology has the potential to provide efficient, cost-effective and environmentally sustainable solutions for supplying portable water for human use and clean water for agricultural and industrial uses. Nanotechnology innovations in low-cost water purification are expected to solve drinking water problem of the world by providing sustainable drinking water to everybody making it as green technology. Water is one of the Earth's most precious natural resources. Most of it is saltwater. Fresh usable water is only 3% of the world’s supply and two-thirds of that is frozen in glaciers, ice caps and icebergs. The remaining 1% is available for human consumption. Today 1.1 billion people don’t have access to safe water and 2.4 billion lack sanitation facilities. 80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, due to water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world’s water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering

the current rates of consumption, population, and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology as a green technology will provide a solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps to recycle rain water into clean drinking water, conversion of sea water into drinking water large scale at very low cost. Water purification plants functioning using green nanotechnology can produce a large amount of drinking water using renewable solar or wind energy so that the water purification plant can be sustainable with minimum maintenance cost.

3.3.5. Green Technology for Sustainable Energy :

Nanotechnology innovations in renewable energy solve entire energy requirement of human beings for their basic needs and for the comfortable life. Balancing human beings need for energy with the environmental cost to our planet is a major challenge. Demand for energy on earth is forecasted as increasing 50% by the year 2025 with most of these being fossil fuels. Currently over 1.4 billion humans have no access to electricity and 2.2 billion rely on plant material, vegetation, or agricultural waste as an energy and heating source. Our fossil fuel consumption is escalating and could become double by the year 2025. Meanwhile, Earth's glaciers are receding, the CO_2 concentrations in the atmosphere have nearly doubled, and world temperatures, recorded since 1861, were the hottest in three of the past five years. 1998 was the warmest on record, 2001 came in the second warmest and 2004 was the fourth warmest. Nanotechnology will help to solve our need for energy solutions through more efficient lighting, fuel cells, hydrogen storage, solar cells, locally distributed power generation, and decentralized generation and storage by reinventing the power grid. Nanotechnology as green technology supports large-scale renewable solar energy and wind energy production and distribution at low cost without any environmental degradation, contributing sustainable energy solution. Even though research in nanotechnology is progress towards developing highly efficient solar cells, the challenge is to achieve 100 % solar conversion efficiency.

3.3.6 Green Building Technologies :

Nanotechnology offers interesting new opportunities in the construction sector providing green solutions through the development of energy efficient, ultra high strength, extra durable, extremely lightweight construction materials. Preceded by the IT and software revolution, nanotechnology is expected to usher a new paradigm shift in all spheres of construction technology. Nanotechnology is recognised as a revolutionary green technology that can help

address key needs of green buildings relating to energy, environment, and health aspects. Nano-modification of cement is an emerging field. Synthesis and assembly of materials in the nanometer scale offers the possibility for the development of new cement additives such as novel super-plasticisers and nanoparticles. It is now possible to manipulate the fundamental structure of cement phases to control concrete properties, performance, and durability. Nano-modification also provides crucial information for predicting the service life of concrete more accurately and insights on improving it further. The challenges lie in how to improve energy efficiency and heat control of the buildings, how to improve the speed and durability of construction etc. using green nanotechnology.

3.3.7. Green Technology for Aircraft & Space Travel :

The challenges faced by humanity on the earth are the result of our ambition of flying everybody at low cost which created heavy demand on various resources and raw materials. Many of these materials can be found in space but the expense to extract them is a major barrier. In addition to cost, other obstacles to developing space are safety, reliability, and performance. According to the National Space Society, there are four reasons why we need to pursue space exploration and colonization. These reasons—survival, growth, prosperity, and curiosity—all point to the fact that we, as a species, want more room. Space exploration will give us a means to monitor the health of our planet, a source of resources and an outlet for our imagination. Nanotechnology as green technology will create the ability for humans to operate in space more safely. Potential applications where nanotechnology will impact space exploration are propulsion fuels, coatings, structural materials, smart uniforms, electronics, and life support environments. Green nanotechnology is expected to provide materials which will be more efficient, stronger, self-healing and lighter than what is currently available.

3.3.8. Green Technology for Education :

Green higher education is all about creating of knowledge, skills, attitudes and values related to the environment. It's more needed in higher education because of the dependence of environment with the economy. Higher education plays a pivotal role in creating and developing human capital. This resource that is created should not just look at the economic point of business but societal aspect as well. The demands for green jobs are on high. The solar energy and wind energy have to be still be utilized to reach out the masses in an efficient manner which calls for efficient green managers. From the construction industry to all management sector there is a need to create sustainable future which means that many green-oriented graduates are needed. The infrastructure has to be in such a way that buildings, energy

costs, reliability and performance which has a positive impact on the environment. The faculties will be promoting learning in a conducive environment where they will address local, regional and national development issues. The systems, processes, structures, procedures and devices to learn green are eco-friendly ways. Green can be used in a large way when it is open and distance learning. Continuous research on green jobs, green concepts, and promotion of it in operations management is needed. The college resources should be in a manner of commitment by top administrators, building facilities, faculties who believe in green ideology, a curriculum that supports philanthropic and interest amongst students. It is essential that sustainability is brought into the business model. The environment provides typical challenges to the current and future generation in terms of climate change, resources getting depleted, water issues, poverty, food and war issues, environment caused diseases and pollution. This is further accelerated in developing countries because of less economic development and high population explosion. Initiatives taken from the colleges and universities will help students develop knowledge, skills and attitudes to fighting with these issues. As a university, they have an important role in reviewing the various courses and degrees and address issues which address about sustainability. The teachers who are a crucial stake in this system have a great role to keep updated and informed and transfer knowledge an innovative way. The whole methodology of teaching should be learning oriented rather than teaching oriented. Pedagogy should include the real world learning experiences so that the learning is very fruitful. The subjects that can be added in this kind of systems are agriculture, organic farming, climate and atmosphere, green tourism, green medical services, green transportation etc. In this form people, planet, and profit will be achieved in all industries. Green education also includes enhancing student knowledge in using green technology. Computer and information technologies are already considered as green technologies due to their contribution to clean environment in many industrial automation processes. Green nanotechnology has been described as the development of clean technologies, to minimize potential environmental and human health risks associated with the manufacture and use of nanotechnology products, and to encourage replacement of existing products with new nanoproducts that are more environmentally friendly throughout their lifecycle. Green nanotechnology is the study of how nanotechnology can benefit the environment, such as by using less energy during the manufacturing process, the ability to recycle products after use, and using eco-friendly materials [59].

3.3.9. Green Technology for Health & Medicine

The important and major area of green nanotechnology research is in human health. Humans are living longer lives. In the previous centuries, men and women expected to live to 48 and 51 years respectively. But life expectancy is now 74 and 80 years and could be significantly longer with anti-aging advancements currently being developed. At the same time, 30 new highly infectious diseases have been discovered in the last 20 years. These diseases account for 30% of the deaths worldwide and include HIV/AIDS, Ebola, and the Avian Flu. HIV/AIDS. According to the World Cancer Report, there could be a 50% increase to 15 million new cases in the year 2020 primarily attributed to an aging population worldwide. Green nanotechnology research provides tremendous opportunity in making progress in the medical field. Some of the nanotechnology applications in the arena will be inexpensive and rapid diagnostics, new methods of drug delivery, and faster development of new drugs. Some longer-term and even more powerful nanotechnology solutions will repair DNA and cellular damage and customize drug therapy. The longer-term applications of advanced nanotechnology for sustainable health and longevity are explored. Developments are expected in pharmaceutics and green nanotechnology, which allows patients to drink fluids containing nanorobots programmed to attack and reconstruct the molecular structure of cancer cells and viruses. There's even speculation that nanorobots could slow or reverse the aging process, and life expectancy could increase significantly. Nanorobots could also be programmed to perform delicate surgeries such nano-surgeons could work at a level a thousand times more precise than the sharpest scalpel. By working on such a small scale, a nanorobot could operate without leaving the scars that conventional surgery does. Additionally, nanorobots could change our physical appearance. They could be programmed to perform cosmetic surgery, rearranging the atoms of the human body to change his ears, nose, eye colour or any other physical feature he wishes to alter [3].

The green nanotechnology may be able to extend our lives by helping to eradicate life-threatening diseases such as cancer, and the other is by repairing damage to our bodies at the cellular level--a nano version of the fountain of youth. The extension of the human lifespan could be also facilitated through the removal of a substance called lipofuscin from certain types of non-dividing cells, including the brain, heart, liver, kidneys and eyes. Lipofuscin is a metabolic end product that accumulates primarily within lysosomes (the garbage disposal organelles within cells). It's thought that when lipofuscin accumulates to certain levels, it begins to negatively impact cell function, which eventually manifests in many age-related conditions. It is proposed that humans might live as long as 1,000 years under the appropriate rejuvenation

therapies. In 30 or 40 years, we'll have microscopic machines travelling through our bodies, repairing damaged cells and organs, effectively wiping out diseases. The nanotechnology will also be used to back up our memories and personalities. And in 35 to 40 years, we literally will be immortal [29].

3.3.10. Green technology for food & processing

Food is an essential component of life and human existence. Since the beginning of time, humans have had to eat to survive. Finding a balance between food supply and demand in a manner that is sustainable and which ensures the long-term survival of the human species will be one of the most important challenges for humankind. Heavy population growth in the world during the last several centuries has made the need for sustainable food production and processing technologies even more important. Green technologies in food and food processing sector have challenges associated with the use of technologies to reduce the generation of process-induced toxins; social factors that influence consumer perceptions about some of the current and emerging agri-food technologies including nanotechnology, and the need and importance of biodiversity in maintaining sustainable diets of world populations [60]. Food processing is a diversified sector encompassing the use of various raw materials, processes, and end products and need special attention for maintaining quality, safety, and nutritional properties through green technology. Various technologies like Bio-preservation, Electromagnetic wave heating, Electric and magnetic fields, Nonthermal technologies etc. under the broad umbrella of biotechnology and nanotechnology have potential opportunities to reduce process-induced toxins in the food and environmental impact of food production and processing.

3.4 CONCEPT OF IDEAL WATER PURIFIER SYSTEM :

An ideal water purifying system removes both undissolved and dissolved impurities by removing all contamination of water using a filter which uses a fine physical barrier, a chemical process, optical process, or a biological process. It converts impure water of type and any quantity into 100% pure water. Filters cleanse water to different extents for various purposes and various purity levels which include the applications like supplying drinking water, providing water for agricultural irrigation, food processing, constructions, industrial processes, public and private aquaria, and the safe use of ponds, swimming pools, and other water-based utilities. Ideal Filters may use sieving, adsorption, ion exchanges, and other processes to remove unwanted substances from water. Unlike a sieve or screen, a filter can potentially remove particles much smaller than the holes through which its water passes. Types of water

filters include media filters, screen filters, disk filters, slow sand filter beds, rapid sand filters, cloth filters, and biological filters such as algae scrubbers. The schematic diagram of ideal water purifying system along with its internal components to convert any type of impure water to perfectly pure water is shown in figure 3.6. It takes impure water or sea water as an input, processes water for removing both dissolved and un-dissolved impurities and converts it into 100% pure water. For drinking purpose and agricultural purpose, a pre-determined amount of minerals can be added by using the mineral mixing system.

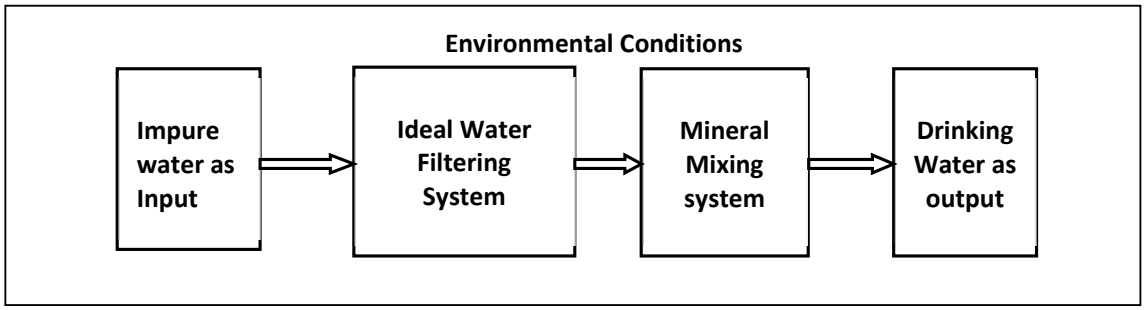

Fig. 3.6 : Block diagram of Ideal water purifier system

3.4.1. Characteristics of an Ideal Water Purifier System :

The system model of Ideal water purifier allows us to discuss its characteristics in terms of input conditions, Purifier Requirements, output conditions, and environmental conditions.

Input Conditions :

(1) Ideal water purifier takes any type of impure water for purification.

(2) Ideal water purifier takes any amount of input water at a time for purification.

(3) Scalable system to any level.

Purifier System Requirements :

(4) Ideal water purifier produces 100% pure water for any level for any type of input impurity.

(5) Ideal water purifier system removes both undissolved and dissolved impurities completely.

(6) Ideal water purifier filters water instantly and there is no time lag between input and output.

(7) Ideal water purifier does not consume any external power for filtering process – self reliable system.

(8) Ideal water purifier does not consume any resources for its operation. Hence it has zero operating cost.

(9) Zero investment & zero maintenance cost.

(10) Simple technology & easy to use.

(11) Long life & reliability.

(12) Self-directed & self-controlled & self-regulated system.

(13) Programmability to decide the output quality.

Output Requirements :

(14) Ideal water purifier produces 100% pure water

(15) Ideal water purifier produces zero wastage of water

(16) Separation of by-products for reuse.

(17) Provision to add minerals for specified applications

Environmental Conditions :

(18) No environmental degradation

(19) Safe to use.

(20) Location independency.

(21) Portability.

3.4.2 Analysis of Ideal Water Purifier Characteristics :

Ideal water purifier characteristics can be explained based on their effectiveness in improving the quality of water purification. The characteristics mentioned in the ideal water purifier model are depicted in figures 3.7–3.10 and further discussed below :

3.4.2.1 Input Conditions :

(1) Purifying any type of impure water : Ideal water purifier takes any type of impure water for purification. Impure water usually contains either suspended impurities or dissolved impurities or both. Suspended impurities are substances that are not completely soluble in water and are present as particles. These particles usually impart a visible turbidity to the water. Dissolved impurities may contain dissolved minerals like chlorides, sulphates, bicarbonates of sodium, magnesium, calcium, and iron. Wastewater contains both suspended impurities and dissolved impurities including substances such as human waste, food scraps, oils, soaps, and chemicals. Ideal water purifier should have the capability to treat and purify any type of impure water including, salty water, groundwater, wastewater, sewage, river water, etc. for both drinking and agricultural applications. It also allows recycling of water in industrial and household applications.

(2) Purifying any amount of water: Ideal water purifier takes any amount of input water between zero to infinity at a time for purification. This allows purification of water for small-scale (home) to large scale (industrial/agricultural) applications. The ideal water purifier can purify and desalinate sea water in any quantity as well as recycling of used water from any application.

(3) Scalability : Ideal water purifier is a scalable system to any level. It can be used in homes, offices, business units, industries, or irrigations and can take a small amount or a large amount of water at a time at input depending on output requirement.

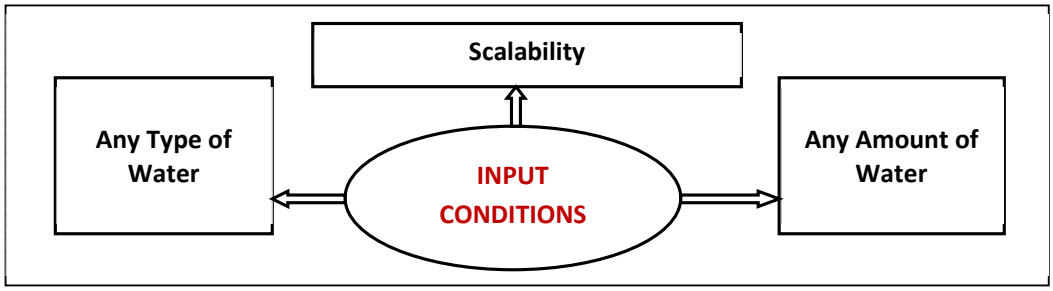

Fig. 3.7 : Input condition characteristics of Ideal Water Purifier

3.4.2.2 Purifier System Requirements :

(4) Production of Pure Water : Ideal water purifier produces 100% pure water for any input level and any type of input impurity. The system removes all undissolved and dissolved impurities including physical, chemical and biological impurities.

(5) Removes all impurities : Ideal water system removes both undissolved and dissolved impurities completely. The undissolved physical impurities like dust, fine sand, clay, rust, etc remain suspended in the water and cause muddy water or cloudiness in water. The amount of chemical impurities dissolved in the water and is usually expressed as 'parts per million' (ppm) or as 'milligrams per liter' (mg/L). The biological impurities like algae, bacteria, protozoa, pathogens, microbes, Viruses, Parasites and their eggs etc. collectively known as microorganisms or germs also contaminates the water and causes various diseases to human beings.

(6) Instantaneous Process : Ideal water purifier converts impure water into pure water instantly and there is no time lag between input and output. This characteristic avoids any processing delay between input and output and hence ensures that all processes used for removal of dissolved and undissolved impurities are ideal processes. This characteristic nullifies the waiting time of the user.

(7) Self-Reliable System : Ideal water purifier does not consume any external power for filtering process. In that sense it is a self-reliable system. Either it produces its power requirement internally or its processes do not need any external power for filtering both tangible and intangible contaminations.

(8) Zero Operating Cost : Ideal water purifier does not consume any resources for its operation. Hence it has zero operating cost.

(9) Zero Investment : By definition, an ideal water purifier system requires zero investment and zero maintenance cost. There is no cost for fabrication of such system. Since it has no operating cost and repairing cost, its maintenance cost is also predicted as zero.

(10) Easy to Operate : Ideal water purifier must be simple for operation and must use simple technology. The simple technology of the system makes easy to operate so that non-technical people should also able to use the system.

(11) Long life &Reliability : Since the ideal water purifier does not need maintenance, it works comfortably for long time without any trouble. Hence such system is reliable and independent on internal failure and environmental catastrophe.

(12) Self-directed, self-controlled & self-regulated System : The ideal water purifier system is a hypothetical system completely independent on external control and external stimulation so that it is a self-regulated and self-directed system. Hence to control the system, human intervention is not required.

(13) Programmable : The ideal water purifier can be programmable to get different water quality at the output for different applications like pure water, drinking water, irrigation water etc. and to get output water for different time intervals.

3.4.2.3 Output Requirement :

(14) Pure water at Output : Ideal water purifier produces 100% pure water at output irrespective of the quality of input water. Such pure water is free from any type of minerals, germs, and any other dissolved & undissolved impurities. For potable purpose, additional minerals in pre-determined amount can be added using a mineral adding subsystem.

(15) Produces Zero Wastage of water : Ideal water purifier will not waste any water during the purifying process. All input water is processed in such a way that the impurities are separated in the form of their actual format and not in liquified format. This avoids wastage of water during impurity separation process.

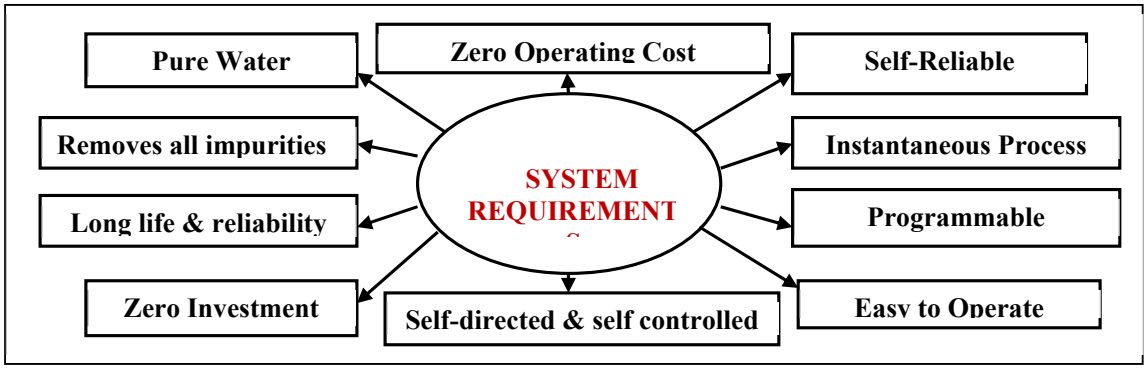

Fig. 3.8 : System Requirement characteristics of Ideal Water Purifier

(16) Separation of by-products for reuse : In ideal water purifier, the dissolved and undissolved impurities get separated in such a way that they can be reused in their original form either as fertilizers or minerals.

(17) Provision to add minerals : For specified applications like producing drinking water/water for irrigation, using additional subsystem, one can add required minerals at the output of ideal water purifier system.

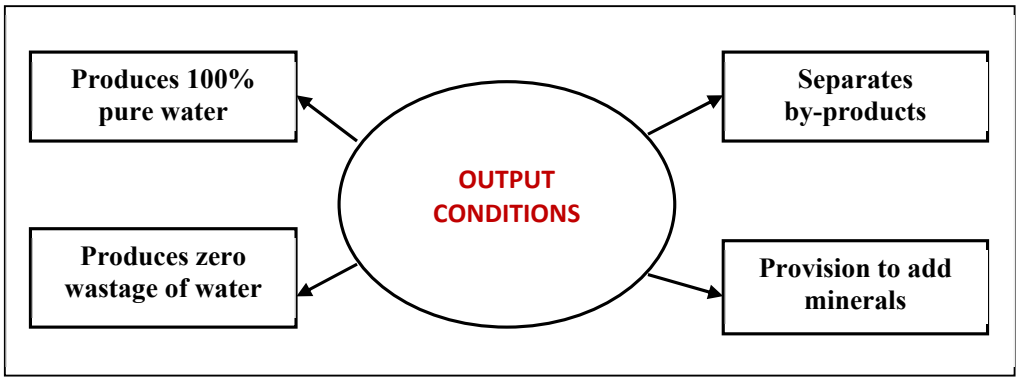

Fig. 3.9 : Output condition characteristics of Ideal Water Purifier

3.4.2.4 Environmental Conditions :

(18) No environmental degradation : In ideal water purifier, the purification process takes place internally without consuming any external resources. As a result, no emission of unwanted green house gases or poisonous by-products to the environment. Hence there is no environmental degradation/pollution occurs.

(19) Safe to use : Since ideal water purifier, is a self-controlled, self-regulated and self-directed system, without consuming any resources externally for its operation, it is safe to use and monitor while producing pure water at output.

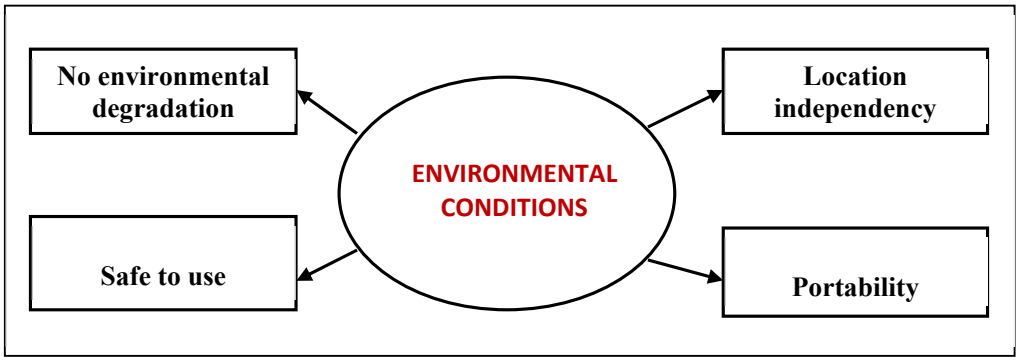

Fig. 3.10 : Environmental condition characteristics of Ideal Water Purifier

(20) Location independency : The performance of ideal water purifier is independent on the geographical region. It should give satisfactory performance at output for any quality of input water at any location in the whole universe.

(21) Portability : An ideal water purifier functions equally in any geographical location and hence portable to any place.

3.4.3. Challenges to Achieve Ideal Water Purifier :

Conventional water-treatment technologies include filtration, ultraviolet radiation, chemical treatment, and desalination. The general method uses five stages including coagulation, flocculation, sedimentation, filtration, and disinfection. Such conventional water treatment, include a pre-filter for filtrating sediment and removing debris from received water; an ionization and oxidation unit for sanitizing water received from the pre-filter; an ultraviolet (UV) light unit for sanitizing water received from the ionization and oxidation unit with ultraviolet (UV) light; a reverse osmosis (RO) unit including a series of membranes for removing impurities from water received from the ultraviolet (UV) light unit; a remineralization filter for reinfusing water received from the reverse osmosis (RO) unit with trace minerals and salts; and an alkalinization and ionization with integrated (UV) light filtration unit for performing an electrodialysis process on water received from the remineralization filter. But these systems cannot be scalable easily, high cost, and high energy consuming methods needs further improvement in performing in various stages of the purification process.

Another method frequently used to treat iron manganese, and traces of hydrogen sulphide in utility plants is called Manganese greensand filtration system. It is found that high levels of manganese and iron dissolved in water will damage plumbing fixtures, give water an unpleasant taste and colour and provide nutrients to certain strains of bacteria. The manganese greensand filtration system does not use coagulation and flocculation, but it typically uses aeration and chlorination (or any other type of oxidant addition) followed by pH adjustment of the water.

Most of the seawater desalination systems are energy intensive, which consume a large amount energy like gas, electricity, oil and fossil fuels. These processes lead to carbon footprints, which causes depletion of ozone layer as well as health hazards on mankind. The potential of harnessing solar energy is most efficient and effective for heat to heat conversion. The thermal desalination is a low temperature application processes with one-time investment for life time water production up to 10 to 15 years. There are a variety of solar thermal desalination methods

such as direct and indirect methods are being used. The indirect methods are preferable for medium and large-scale desalination systems, whereas the direct methods employing the solar stills are more suitable for small scale systems. The performance of the low cost solar stills can be improved with simple modification by using various locally available materials. These low-cost stills can be easily and economically fabricated for meeting the daily need of the fresh drinking water. These low cost solar stills are sufficient for the small households and communities living in islands, coastal areas. It can also be used for distillation of brackish water for the population residing near river banks. Such a system also suitable for the fluoride affected area to remove fluoride from the water. The low cost solar water purifier is sufficient for the removal of arsenic, mercury, cadmium, coliform, virus, and bacteria [61-62]. Various constraints and disadvantages associated with such system for scalability and to make location independence are discussed [62].

Thus achieving ideal characteristics like : any type of impure water for purification, any amount of input water at a time for purification, scalable system to any level, producing 100% pure water for any level for any type of input impurity, removing both undissolved and dissolved impurities completely, developing purifier which operates instantly with no time lag between input and output, system which does not consume any external power for filtering process – self reliable system, system which does not consume any resources for its operation and hence has zero operating cost, Zero investment & zero maintenance cost, Simple technology & easy to use, Long life & reliability, Self-directed & self-controlled & self-regulated, Programmability to decide the output quality, produces 100% pure water, system which produces zero wastage of water, Separation of by-products for reuse, Provision to add minerals for specified applications, No environmental degradation, Safe to use, Location independence, and Portability etc is difficult using conventional purifier methods and technology. Further, current technologies for purifying contaminated and impure waters are typically expensive and ion specific, and therefore a significant need for new technologies and approaches.

3.4.4. Possibility of Realization of Ideal Water Purifier Using Nanaotechnology :

Nanotechnology is emerging as multi-disciplinary new frontier of Science & Technology capturing the imagination of scientists and engineers worldwide due to its potential applications in solving many problems/needs/requirements of human beings. Nanotechnology has the ability to provide cost effective, efficient, and environmentally sustainable optimum solutions for supplying potable water for drinking and clean water for irrigation and industrial uses. Using nanotechnology innovation, one can develop low cost water purifiers to solve the

drinking water problem of the world. Water is one of the Earth's most precious natural resources. Most of the water available on the earth surface is saltwater. Only 3% of the world's supply is drinking/sweet water and two-thirds of it is frozen in glaciers, ice caps, and icebergs. The remaining 1% is available for human consumption. As per the reports, today 1.1 billion people don't have access to safe water and 2.4 billion lack sanitation facilities. 80% of developing world diseases are water-borne with an estimate of 3.4 million deaths, mostly children, in 1998 of water-related diseases. Demand for fresh water is increasing. Agriculture currently uses 70% of the world's water supply. To feed 2 billion more by the year 2030 there will be a 60% increase in demand on the water supply. Considering the current rates of consumption, population, and development, some two-thirds of the world population will be affected by droughts by the year 2050. Nanotechnology will provide a solution for this challenge through inexpensive decentralized water purification, detection on the molecular level of contaminants, and greatly improved filtration systems. This helps the conversion of seawater to drinking water at a very low cost [3]. The use of highly advanced nanotechnology ideas and concepts to traditional process engineering opens new opportunities in technological developments for advanced water and wastewater technology processes. The nano-enabled technologies include a variety of different types of membranes and filters based on carbon nanotubes, nanoporous ceramics, magnetic nanoparticles and other nanomaterials. Ref. [63] contains a comparison between conventional and nano-enabled technologies for water treatment.

Separation membranes with the structure at the nanoscale can also be used in low-cost methods to produce potable water. In a recent study in South Africa, several polymeric nanofiltrations and reverse osmosis membranes were tested for the treatment of brackish groundwater. The tests showed that nanofiltration membranes can produce potable water from the brackish groundwater. As expected, the reverse osmosis membranes removed about 99% of all the solutes, but the concentrations of essential nutrients, such as calcium and magnesium ions, were reduced to levels that were below the specifications of the World Health Organization standard for drinking water. The product water, therefore, had to be spiked with these nutrients to provide drinking water of the required quality.

Nano-enabled technologies for water treatment are already on the market — with nanofiltration currently seeming to be the most mature — and many more are on their way. Although the current generation of nanofilters may be relatively simple, many researchers believe that future generations of water-treatment devices will capitalize on the new

properties of nanoscale materials and may prove to be of interest in both developing and developed countries [64-76].

A huge amount of research results has been published since 1980 on the idea of the use of various nanomaterials and nanocomposites as water purification filters for both dissolved and undissolved impurities. Nanomembranes are very useful for treating and purify any type of impure water including, salty water, groundwater, wastewater, sewage, river water, etc. for both drinking and irrigation applications. Table 3.5 contains some of the published results of use of nanotechnology for different types of water purification processes.

Table 3.5 : Use of nanotechnology for different types of water purification processes

S.No.	Purification process	Nanomaterial/system used	Reference
1	Water desalination	Carbon nanotube membranes	Das, R., et al [77]
2	Removal of contaminants	Carbon nanotube technology	Upadhyayula, V. K., [78]
3	Removal of arsenic	Nanoparticles of hydrous iron oxide	Sylvester, P. et al [79]
4	Water disinfection and microbial control	Antimicrobial nanomaterials	Li, Q., et al [80]
5	Cleaner water	Bimetallic nanoparticle catalysts	Wong, M. S. et al [81]
6	Water disinfection and microbial control:	Antimicrobial nanomaterials	Mahendra, S. et al [82]
7	Ultrafast permeation of water	Protein-based nanomembranes	Peng, X. et al [83]
8	Heavy metal removal and disinfection control	Smart magnetic graphene	Gollavelli, G. et al [84]
9	Water decontamination	Novel magnetic nanoparticles	Zhang, X. et al [85]
10	Removal of arsenic	Nanocrystalline magnetite	Mayo, J. T. et al [86]
11	Virus inactivation for drinking water treatment	Silver doped titanium dioxide nanoparticles	Liga, M. V. et al [87]
12	Point-of-use drinking water disinfection	Silver nanoparticle-alginate composite beads	Lin, S. et al [88]
13	Nitrate removal from water	Nano-alumina	Bhatnagar, A. et al [89]
14	Complete removal of pathogenic bacteria from drinking water	Nano silver-coated cylindrical polypropylene filters	Heidarpour, F. et al [90]
15	Point-of-use water treatment	Bactericidal paper impregnated with silver nanoparticles	Dankovich, T. A. et al [91]
16	Providing Safe and Clean Water to Each Individual	Magnetic nanoparticles	Roy, E. et al [92]
17	Drinking Water Treatment	Hybrid Nanoadsorbents	Gupta, A. K. [93]
18	Drinking water purification	Nanocomposite filtration membranes	Anadão, P. [94]
19	Elimination of hazardous fluoride from drinking water	Th–Mn nanoadsorbent.	Tomar, V. [95]
20	Rapid water disinfection	Vertically aligned MoS_2 nanofilms and visible light.	Liu, C. [96]
21	Phosphate Removal from Wastewater.	Modification of Titanium Dioxide Nanoparticles	Antwi, D. M. B. [97]

22	Universal water purification	Amyloid–carbon hybrid membranes	Bolisetty, S. [98]
23	General water purification.	Magnetic graphene–carbon nanotube iron nanocomposites as adsorbents and antibacterial agents	Sharma, V. K. [99]
24	High efficiency water purification	$Fe(OH)_3$/g-C_3N_4 composite membrane	Wang, Y. et al [100]
25	Water desalination	Single-layer MoS_2 nanopore	Heiranian, M. et al [101]
26	Water desalination	Graphyne as the membrane	Kou, J. et al [102]
27	Antibacterial behaviour for water purification	Halloysite nanotubes decorated with copper nanoparticles in a novel mixed matrix membrane	Duan, L. et al [103]
28	Adsorption, photodegradation and antibacterial study of for multipurpose water purification application	Graphene–Fe_3O_4 nanocomposite	Santhosh, C. et al [104]
29	Fast water purifier	Cellulose nanofiber intermediary to fabricate highly-permeable ultrathin nanofiltration membranes	Soyekwo, F. et al [105]
30	Water purification for disinfection	Silver–magnetic nanocomposites	Surendhiran, D. et al [106]
31	Effective Water purification	Polymer nanocomposites	Pandey, N. et al [107]
32	Removal of inorganic pollutants, organic pollutants, and biological pollutants.	Inorganic, organic, and inorganic-organic hybrid nanoporous membranes.	Wang, Z. et al [108]
33	General water purification	Gelatin hydrogel nanocomposites	Thakur, S. et al [109]
34	Drinking Water Production	Chitosan-based Nanocomposite Beads	Masheane, M. L. et al [110]
35	Water purification and its applicability to volatile organic compounds	Zinc oxide nano-enabled microfluidic reactor	Azzouz, I. et al [111]
36	Antibacterial water treatment	Nanosized metal oxides (NMOs) and polyoxometalates (POMs)	Carraro, M. et al [112]
37	Removal from Wastewater	Titanium Dioxide Nanoparticles for Phosphate	Antwi, D. M. B. et al [113]

By cascading of different types of nanomembranes in a serial manner for removing all type of impurities leads to the production of pure water in any scale and can be called as universal nanotechnology water purifier as shown in figure 3.11. This leads to the development of universal water purifier at low cost and low energy consumption which is going to be a step towards achieving ideal water purifier.

Where
F1 = Physical Impurities Filter
F2 = Inorganic Impurities Filter
F3 = Organic Impurities Filter
F4 = Biological Impurities Filter

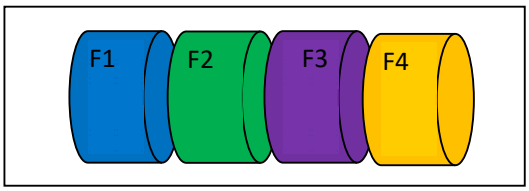

Fig. 3.11 : Block diagram of Cascaded universal water purifier using nanotechnology filters

3.4.5. Risk of nanotechnology in producing Drinking Water :

Though nanotechnology shows potential opportunities for developing devices for water-treatment, there is also a need to do further research to assess the possible human health and environmental risks. There are only a few studies have been carried out, and it is expected that the unique properties of nanomaterials (for example, size, shape, reactivity, conductivity) may convert water to be toxic [114]. Thus, it is imperative that information about possible risks and risk-management approaches should be developed and monitored systematically and need to be weighed up against the potential benefits [115-117].

3.4.6. ABCD Listing of Use of Nanotechnology Based Universal Water Purifier :

Many analysing frameworks are used to study any system or a model which include, SWOT [118], SWOC [119], PEST [120], ABCD [121-122], Competitive Force Model [123] etc. In this paper, for analysing a practical water purifier system using nanotechnology, we felt that ABCD qualitative analysing framework is found suitable. In ABCD qualitative analysing framework [124-133] lists the Advantages, Benefits, Constraints, and Disadvantages of realizing such a system from various stakeholder's point of view are discussed.

1. Advantages :

(1) Nanotechnology based filters are small in size and high mechanical strength.

(2) Nanotechnology based filters can be cascaded for filtering different types of impurities.

(3) Nanotechnology based filters can be fabricated to any structure so that it can be scaled to any extent.

(4) Filters any type of input impurity 100 %.

(5) Nanotechnology based filters remove both undissolved and dissolved impurities completely.

(6) Nanotechnology based membranes filter water instantly.

(7) Nanotechnology based filters do not consume any external power for filtering process – self reliable system.

(8) Nanotechnology based filters do not consume any resources for its operation.

(9) Nanotechnology based filters have very low investment cost/per filter for large scale production.

(10) The technology behind nanotechnology based universal filter is simple.

(11) Nanotechnology based universal water purifier has a long working life.

(12) Nanotechnology based universal water purifier can be programmable to decide the quality of output.

(13) Nanotechnology based water purifier is not producing any impure water outlet.

(14) Nanotechnology based universal water purifier separates by-products at individual filters.

(15) Nanotechnology based universal water purifier has provision to add minerals at output.

(16) It is assumed that nanotechnology based universal water purifier does not make environmental degradation.

(17) The performance of nanotechnology based universal water purifier is location independent.

2. Benefits :

(1) Nanotechnology based universal water purifier light in weight.

(2) Nanotechnology based universal water purifier filters all kind of impurities.

(3) Any amount of input water can be purified at a time.

(4) Purity of output water is 100 %.

(5) Nanotechnology based filters are useful for removal of both undissolved and dissolved impurities completely.

(6) The instantaneous filtering property gives the benefit of no time lag between input and output.

(7) Since there is no external power required for filtering process, nanotechnology based universal filter is a self-reliable system.

(8) Nanotechnology based filters has no operating cost.

(9) Nanotechnology based filters have low maintenance cost.

(10) Nanotechnology based filters are easy to use.

(11) Nanotechnology based universal water purifier is reliable for long duration.

(12) Nanotechnology based universal water purifier has facility to decide the output water quality.

(13) Nanotechnology based water purifier produces no wastage of water.

(14) Separated by-products can be used for respective applications.

(15) Mineral water can be also produced at the output of nanotechnology based universal water purifier.

(16) Safe to use provided the required precaution is taken.

(17) The location independence makes it portable.

3. Constraints :

(1) Technology development

(2) Water management

(3) Construction of mega plant for water purification

(4) Maintenance

(5) Creating awareness

4. Disadvantages :

(1) Predicted risk on human health

(2) Predicted Environmental risk

The characteristics of ideal water purifier can be comparable with the predicted characteristics of nanotechnology based universal water purifier and is listed in table 3.6. It is observed from table 3.6 that nanotechnology based universal water purifier is almost in par with the expected qualities of ideal water purifier for all practical purpose.

Table 3.6 : Comparison of ideal water purifier properties with nanotechnology based universal water purifier

S. No.	Water Purifier Characteristics	Ideal water purifier System	Nanotech based Universal water purifier system
1	Any kind of impure water	Can be purified 100 %	Can be purified to pure water level
2	Any amount of input water	Can be purified instantaneously	Can be purified to desired level
3	Scalable system to any level	Zero to Infinity	Small scale to large scale
4	Output water quality	Always 100% pure	Required purity level
5	Type of filtration	Removes both undissolved and dissolved impurities completely	Removes both undissolved and dissolved impurities to the required level
6	Time for filtration	Filtration of water instantly and there is no time lag between input and output	Filtration of water in real time and there is no considerable time gap between input and output
7	Power for filtering process	No consumption of any external power	Can use renewable power from Sun or Wind
8	Operating cost	Zero operating cost	Low operating cost
9	Investment	Zero investment	Low investment
10	Type of technology	Ideal technology	Nanotechnology
11	Life & Reliability	Infinite life and reliability	Long life and reliability

12	Programmability to decide the output quality	Yes	Yes, for a certain extent
13	Wastage of water	Zero	Minimum or zero
14	By-products	Automatically separable and reusable for their applications	Easily separable and reusable for their applications
15	Environmental degradation	Absolutely not	Yet to be decided
16	Portability	Yes	Possible
17	Safe to use for living beings	Yes	O.K. but questionable

3.5 NANOTECHNOLOGICAL INNOVATIONS & BUSINESS ENVIRONMENT FOR INDIAN AUTOMOBILE SECTOR :

3.5.1. Electric/ Hydrogen Fuel Technology for Pollution Free Automobiles:

Due to the reasons of global warming and the inevitable exhaustion of Earth's oil reserves, it has become highly desirable to find an alternative energy source for automobiles. Major challenge of Indian transport system is decreasing the automobile fuel cost and polluted gas emission. Making automobile sector free from fuel consumption, India can be made the land based, water based and air based automobiles. By means of renewable electric energy technology or hydrogen fuel technology, Indian automobile sector, can solve many of its problems and contribute heavily on development of the country by decreasing foreign payments. Generating renewable electric energy through different technologies and storing them for powering automobiles using electrical storage technology for long period is the major challenge of automobile sector. Generation of renewable electrical energy is possible by means of solar, wind, tidal, hydro or even nuclear energy, which can be made pollution free. By using new technology batteries and super capacitors, energy storage constraints can be minimized. Indian automobile sector should focus on developing low cost, light weight, durable, efficient automobile electrical engines and low cost, light weight, high storage batteries/ storage cell technologies during next decade. This solution in turn, minimizes green gas emission and hence automobile based pollution of the country. Alternately, hydrogen fuel technology also contributes to the green power requirement of automobile sector in the country. Hydrogen fuel cells are used extensively as green fuel in developed countries even though, the cost of such technology of manufacturing and storage of hydrogen gas in the form of condensed fuel cells for powering the automobile is high. By means of developing hydrogen fuel technology the automobile sector can be made pollution free. Hydrogen storage and refilling is found to be major technological barrier to the development of hydrogen fuel cell based automobiles. To overcome this barrier, solid fuel cells are recently adopted. Solid oxide fuel cells offer a clean, pollution-free technology to electrochemically generate electricity at high efficiencies. These

fuel cells provide many advantages over traditional energy conversion systems including high efficiency, reliability, modularity, fuel adaptability, and very low levels of NO*x* and SO*x* emissions. Based on present strategy of Indian government's investment for research and developments in nanotechnology through nanotechnology initiative programme, it is expected that the country can find optimum solution to its automobile sector problems/requirements to increase the quality, durability and performance, and decrease the cost of land based, water based and air based vehicles. This will also improve the efficiencies and controls the green gas emission and hence controls the pollution level in the country.

3.5.2. Nanotechnology Based Opportunities:

In addition to contributing to building and maintaining lighter, smarter, more efficient, and "greener" vehicles, aircraft, and ships, nanotechnology offers various means to improve the transportation infrastructure:

- Nano-engineering of steel, concrete, asphalt, and other cementitious materials, and their recycled forms, offers great promise in terms of improving the performance, resiliency, and longevity of highway and transportation infrastructure components while reducing their cost. New systems may incorporate innovative capabilities into traditional infrastructure materials, such as the ability to generate or transmit energy.
- Nanoscale sensors and devices may provide cost-effective continuous structural monitoring of the condition and performance of bridges, tunnels, rails, parking structures and pavements over time. Nanoscale sensors and devices may also support an enhanced transportation infrastructure that can communicate with vehicle-based systems to help drivers maintain lane position, avoid collisions, adjust travel routes to circumnavigate congestion, and other such activities.
- The use of nanofluids as coolants in automobile engines would support to decrease the use of fluids and hence the small size of the radiators. This will also shrink the size of coolant pump and the automobile engines can be operated at higher temperatures to improve the efficiency. This is due to their higher conductivity and better heat transfer properties. Hence nanofluids have higher potential to improve automobile engine cooling rates by increasing the efficiency, lowering the weight and decreasing the complexity of convective heat transfer performance. It is already reported that use of nanofluids showed about 20% increase in frictional pressure drop and 40% increase in pumping power compared with water [134].

- Nanotechnology based coatings and paints are highly scratch resistant, self-healing and dirt repellant. Such coatings and paints developed for automobile bodies last for the lifetime of the vehicle without aging, and require cleaning much less often. Paints manufactured using nanotechnology can alter their heat-reflecting properties depending on the intensity of the incident sunlight and also reflect different colours depending on surrounding temperature [135]. As a result, the colour of the vehicle changes with time. The nanotechnology based paints also helps to regulate the inside temperature using air-conditioner thereby saving fuel. Nano coatings outside the glass creates hydrophobic (water-resistant) surface thereby eliminates the requirement of wipers on vehicle glass. Similar approach of use nano-coating inside the glass prevents water vapour condensing on the glass in humid conditions.

3.5.3. Nanotechnology Based Solutions:

(a) Nanotechnology Based Auto-Components: Nanotechnology can be used to make wide range of automotive components for making new models of automobiles, making it possible to build them with extensive service life; lower component failure rate and smart materials for repairing. Automobiles developed with nanomaterials have advantageous in terms of durability, strength, efficiency and cost [136]. Nanotechnology based global automotive markets expect exponential positive returns, but hurdled by high initial investments and limited research and development. Although nanotechnology applications in automotive industry are manifold, many of the solutions are still untapped. Many features like sustainability, safety, comfortability, and eco-friendliness, leads to CO_2- free engines, safe driving, quiet cars, self-cleaning body, and windscreens etc. are expected to be real [137]. Nanotechnology is not only finding its way into every corner of automobiles, but is also bringing great benefits in several domains like frames and body parts, engines, paints and coatings, suspension and breaking systems, lubrication, tires, exhaust systems, etc. Certain nano-materials like carbon nanotubes and carbon black produced in India have enhanced mechanical, physical, and processing properties will render new functionalities. In addition, they may improve manufacturing speed and enhance environmental, thermal, and mechanical stability [138]. This means automobile bodies will undergo less wear, better gliding, thinner coating, fewer lubrication, longer service intervals, and weight reduction. Lighter vehicle bodies will use less material, without compromising the stiffness and crash resistance and will indirectly save fuel.

Nanotechnology based auto-components include nanomaterial based automobile parts, components of space elevators, components for weight reduction in spaceships and spacesuits,

components of solar power satellites, bio-nano-machines for space applications, components of new breed of robots to explore the planets etc. Automotive industry will see nanotechnology benefits from advanced power train designs, lighter weight, stronger materials, sensing technology, and higher efficiency. Since almost all automobile components can be improved through nanotechnology, innovations and new markets are practically guaranteed, assuming that manufacturing costs can be kept down. In all areas like, body style, brakes, acceleration, and safety will depend mostly on the ability of the company to develop and include nanomaterials. Future applications are likely to see energy-harvesting bodywork, self-healing paint, shape-shifting skin, and improved fuel cell performance of future electric and hydrogen-powered cars- all the next wave of innovation in the automobile sector.

(b) Nanotechnology Based Auto-Engines: Auto engines working on oil/gas based combustion as well as based on electric energy will get benefit due to inventions and innovations in nanotechnology. Nanotech additives act like minuscule ball bearings to lubricate moving metal surfaces that come into contact inside engines, reduce friction in automobile engines and machines, and hence improves fuel efficiency. By apply nanostructure coatings to automobile engines one can make heat transfer far more efficient. Use of nanofluids as coolants in automobile engines would contributes to increase thermal conductivity by minimizing heat build-up which increases fuel efficiency and reduces wear. Due to less energy wasted through friction, which boosts instantaneous power and torque in the engine. Thus, auto engines will consume less power, reduce exhaust gas and particle emission, becomes eco-friendly. Further, engine parts made by nanoparticle enforced steel will increase the durability of the engine due to decreased wear and tear. Nanotechnology supports to increase the strength of engine parts but reduces the engine weight and fuel consumption. Long term research in nanotechnology may lead to automobile engines with 100 % efficiency as in case of ideal engines.

(c) Nanotechnology Based Auto-Tyres: One of the dreams of automobile industry is innovation to give long life to auto-tyres in such a way that if auto-tyres last long for 10 – 50 years, then the maintenance cost as well as recycling them to reduce environmental pollution will be reduced. It is found that use of nano-material additive for the rubber mixture of the tyre tread significantly cuts wear in automobile tyres. As a result, the tyre will give longer service life. It is also found that use of such nano-material additives to enhance wear resistance does not effect on rolling resistance or wet grip of the tyre. By using such nano-materials as additive at tyre manufacturing stage, Indian auto-tyre manufacturers can add values to automobiles and expand their market share. Use of nano-materials like carbon black, silica, and nano-clays are

found to be promising candidates to green tyre industry. Adding such materials have the potential to decrease tyre rolling resistance, which improve the fuel consumption and decreases the CO_2 emissions, and lower wear resistance which increases tyre lifetime while maintaining wet road grip and existing safety levels [139]. Thus, nanotechnology bridges the gap between the characteristics of ideal tyres and practical tyres.

(d) Nanotechnology Based Auto-Electronics: This includes Electronic control units/ Vehicle controls, Sensors, Smart functions through artificial intelligence, Telematics/vehicle communication etc. The technology of thermal interface materials (TIMs) based electronic control unit (ECU). The TIM assembly is playing a key role in achieving good heat conductions within and from a package to heat sinking device. Emerging nanotechnology in TIMs shows that carbon nanotubes (CNTs) and carbon nanofibres (CNFs) when used as the structure of TIM or TIM filler could improve the overall thermal and mechanical properties of TIMs. Automotive manufacturer has initiated research and development for connected vehicle systems, vehicle connectivity can prevent crashes, optimize travel routes, issue road condition warnings, and generate environmental benefits by taking advantage of continuous, real-time connectivity to vehicles, infrastructure, and wireless devices.

Electronic display units with improved performance and unique features are possible by nanotechnology. Light emitting devices, such as LEDs, OLEDs (Organic Light Emitting Diode), fluorescent or field-emissive displays, electro-luminescent and perhaps lasers, are utilizing nano-phosphors and nanolayers to improve their performance. Lower cost laser light emission sources are possible to improved performance, longer life, higher energy efficiency, unique presentation features, reduced package size become the value proposition for adopting such new technology. An electronic display based on carbon nanotube technology (CNT) is being explored for low voltage field-emission displays which are potentially very efficient and long-lasting emitters in applications like nano-electronics. Using nano-photonics technology, many new devices like optical thin films, non-linear holographic reflectors, micro-lenses, and light conversion films are being developed to modulate or redirect electromagnetic radiation [140]. Electronic systems can be miniaturized using nanotechnology which can also have cumulative effect in miniaturization of electronic components in automobile industry. The future automobiles based on nanotechnology will be lighter, stronger, faster, safer, and more intelligent than the driver by using nano-electronic and eco friendly components.

(e) Nanotechnology Based Auto-Seat Materials: Textiles are used extensively in cars - from seat coverings and seatbelts to air filters and tyre cord. There is a general trend in automotive

design towards replacing more and more hard surfaces inside the vehicle with fabrics, as they are an easy way to reduce weight, and improve overall recyclability. Conventional fabrics are highly susceptible to wear and tear, collection of dust and dirt, and can be a fire hazard if untreated. A wide array of nanotechnologies can be applied to textiles to improve their performance and lifetime. Nanofibre based auto interior provides safety, good looking, and comfort including good management of heat and water vapour transfer; moisture wicking, self-cleaning, anti-stain/easy to clean characteristics; antimicrobial/antibacterial properties; anti-allergic trimming; Flame resistance; antistatic properties; tear and wear resistance, UV resistance, noise reduction, and improved acoustic performance. A product already available in the market called NANOMAN is a Spray which protects automotive fabrics and textiles from water, dirt, contaminant and stains, without affecting the fabric's appearance, colour, or feel and is easy to use, whilst remaining totally invisible. Even water, coffee and liquids are repelled from NANOMAN treated textiles and hence provide ideal protection for automobile seats and convertible roofs. The look, breakability and feel of the fabric remain unchanged. Auto seats with integrally knitted nanotechnology sensors, warn drivers when they start to fall asleep at the wheel, are also under development. Thermo-electric fabrics made by nanotechnology generate electricity by absorbing passengers/drivers body heat. The fabric made up of tiny carbon nanotubes locked up in flexible plastic fibers and made to feel like fabric that uses temperature differences to create a charge. Hence use of nanotechnology in automobile cloths and fabrics fills the gap between conventional cloths properties and ideal cloths properties.

(f) Nanotechnology Based Auto-Bodies: The main objectives of nanotechnology usage in automobiles are weight reduction and increasing the strength of the body. This will increase the fuel efficiency and the durability of the vehicle. It is found that nanoengineered thermoplastic materials allow a weight reduction of up to 40% compared to traditional steel chassis parts. Embedded nano-particles of metallic carbon nitride can increase the permanent strength of steel to use as chassis. By means of further processes, it can be made corrosion free. This will improve the life of the automobile to greater extent. The outer metal bodies are also can be replaced by nanoplastic/polymer sheet bodies which will further reduce the weight and strength of the vehicle. Nanocomposite glasses used in windows also contribute for weight reduction and body strength. This will also support recycling of materials and avoids environmental foot print. Thus, nanotechnology supported innovations in automobile bodies decreases the body weight to the large extent without compromising in strength and durability.

The countries like India which are not independent in crude oil production will get substantial benefit to become self-reliant. Thus, the automotive industry in India will see nanotechnology benefits in all areas of automobile production including power train designs, lighter weight, stronger materials, sensing technology, and higher efficiency to become world leader in exporting automobiles and components.

(g) Nanotechnology Based Aeroplanes: Nanomaterials with their exceptional multifunctional properties may transform the aviation industry dramatically. There are many benefits to improve aeroplane performance using nanotechnology. Some of them are:

- Use of nanotechnology to store hydrogen in solid state so that hydrogen can be used as a clean alternative to hydrocarbon based fuels in aeroplanes.
- Nanotube coating on plane outer surface would absorb radar beam making it undetectable to enemies.
- Ultrathin nanofilm coating on outer surface of aeroplane aimed at decreasing the drag and improving the fuel efficiency.
- Nanotechnology based products may help to keep the aeroplane dry and self-cleaning.
- Nanotechnology based innovations are capable to develop aircraft wings, propellers, and transport vehicles that can literally change shape to improve performance and efficiency.
- Aircraft wings with smart materials make them more aerodynamic and easier to control. Such a craft would sense conditions while in flight. Sensors in the wings will measure the pressure on each wing's surface. Using actuators, the wing can respond, even changing shape, just as a bird's wing responds to air pressure or weather.
- Lighter and stronger materials will be of immense use to aircraft manufacturers, leading to increased performance.
- Nanotech is lowering the mass of supercapacitors that will increasingly be used to give power to assist electrical motors for launching hang gliders off flatland to thermal-chasing altitudes.
- Continuous innovation in aircraft design has led to fuel savings, noise reductions and lower fares for passengers by making flights more efficient.
- Nanomaterials can fulfil the requirement of aerospace industry to improve the properties like Light Weight High Strength High Toughness Corrosion Resistance Easy Reparability & Reusability Less Maintenance & Durability of aeroplanes.

- The nanocomposite coatings are used for low friction and wear resistant applications of aircraft.
- Nano Electro Mechanical Systems offer the possibility of developing a standard fuel management unit which controls the fuel control in aero-engines.
- Nanostructured metals used in aircrafts primarily yield strength, tensile strength and corrosion resistance, coupled with low density which helps keep the total weight of the aircraft down.

(h) Nanotechnology Based Spacecrafts:

- With stated benefits of weight reduction, enhanced strength, enhance corrosion resistance, allows countries to produce low cost, high quality, smaller weight spacecrafts so that countries like India can also provide space travel opportunities to its citizens.
- Radiation shielder : certain kind of nano coating in spacecrafts can act as safe space radiation shielder for astronauts to protect them from harmful high frequency space radiations.
- Satellite protection from enemies: Nanotechnology can be used to improve the design of satellites to mitigate the threats posed by ground-based directed energy weapons and high-powered microwaves.
- Space elevator: Space elevator based on carbon nanotube cable provides a strong cable between space stations to earth surface thereby providing an easy access to space travel.

(i) Nanotechnology Based Rockets: Innovations in rockets technology using nanotechnology has following advantages:

- Enhancement of thrust of rockets using nanotechnology: Nanoparticle Field Extraction Thruster (nanoFET) is a device based on nanotechnology in which nanoparticles are charged by losing electrons when they touch an electrode at a positive voltage. After the nanoparticles are charged, an electric field can accelerate them, providing thrust to the spacecraft.
- Nanotechnology based rocket fuels: By adding certain metallic nanopowder with solid or liquid propellant of rocket, the efficiency of acceleration can be increased.
- Based on above discussions, one can realize the challenges of automobile sector in India and the opportunities to handle such challenges using next generation nanotechnology. The table 3.7 contains the applications & benefits of NT in Automobile sector:

Table 3.7: Applications & benefits of NT in Automobile sector

S. No	Applications	Business Benefits
1	Nano-clearcoats with high scratch and wear resistance	Improve scratch resistance
2	Nano-coatings with anti-corrosion performance for car bodies	Protect metal body of the vehicle against corrosive materials.
3	Smart nano-scale container anticorrosive coating	Self-repairing coatings are further enhance anticorrosive properties of metal substrates
4	Weathering resistant automotive coatings	Protecting the car body against environmental conditions and imparting desirable aesthetic appearance
5	Spark plugs	Quick start & durability
6	Smart windows based on electrochromism	Controlling all types of energy like sound, light and heat which enter the car body
7	High-strength steels for vehicle bodies	Enhance protection of vehicles and passengers safety at crashes
8	Nanostructured rubber tyres	Significantly enhance tyres durability as well as higher fuel efficiency.
9	Nanotechnology based seat fabrics	Novel anti-microbial textiles to avoid micro-organisms growth especially at proper humidity and temperature in contact to human body.
10	Nono-tech super hydrophobic surfaces	To create self-cleaning surface on seat & interior fabrics as well as wiper free self cleaning front glasses.
11	Nano-coatings for engine application	Act as improved Lubricator reduce load, Thermal insulator to reduce heat losses and frictional losses to improve fuel efficiency
12	Nanotube composites in the braking systems	Nanotube composites in the braking systems results in effective braking performance, and is also likely to reduce brake system weight while increasing acceleration.
13	Nano super capacitors & Nano tech solar cells	Alternative fuel for vehicles

3.5.3 Impact of Nanotechnology on Indian Automobile Sector:

The expected inventions and innovations in automobile sector based on nanotechnology opportunities are going to do many changes in production, usage and even export of automobiles in the country. The possible impacts of these innovations on economical, political and renewable energy sector of the country are listed below:

- **Impact on Economical Environment:**

Based on possible decrease in cost, size, weight, environmental degradation of automobiles and increase in efficiency, durability, comfortability, demand, nanotechnology innovated automobiles are going to be very attractive in the country. By using renewable energy and enhanced vehicle lifespan there will be enhanced demand for vehicles. Due to innovations, the production cost of the vehicles is going to be very nominal and the maintenance cost is going to be zero. If India is the first innovator in this area, it can get the economical advantage by producing and exporting such automobiles to other countries. Additionally, India can get benefit of saving its foreign exchange cost on oil import which is going to give big economical advantage to the country. Thus, anticipated nanotechnological breakthrough in automobile sector will give huge economical advantage to the country both for development and for citizens' comfortability. The nanotechnology based innovations in automobile sector creates new business opportunities for which organizations have to be prepared. Organizations should plan for financial investment strategy for nanotechnology infrastructure development, investment through Research & Development and product commercialization to encash opportunities and for long term profit. The economy of the country will also get benefit through such technological innovations. The impact of such developments will be affecting on automobile garages, used vehicle sales, and also on Insurance companies to re-think their business model.

- **Impact on Political Environment:**

When the economy of the country is improved through technological breakthroughs, the political environment is also get affected. Changes in the structure of international business and the improvements in quality of life in the society, the political decisions on budget investment and the road map on Country development plans should be redesigned. Since nanotechnology is general purpose technology and is expected to impact on all areas in the society, the poverty level in the country is going to be re-defined. New issues like environmental safety will become political debatable issues.

- **Impact on Renewable Energy Sector:**

Use of nanotechnology based solar cells with 100 % conversion efficiency will solve energy problems in all households, factories, and for automobiles. Smart homes, smart factories, and smart automobiles with zero maintenance cost are going to be common after the year 2050 with energy independency. Low cost air travel and space travel are going to be common and is going to be affordable to the common people of the country.

- **Impact on Public Life: (Comfortness & Luxury)**

Innovations in automobile sector and its effect on road transportation, sea transportation and air transportation in terms of cost, affordability, efficiency and availability to everyone, the quality of human life is going to be moderate in future days. In India, according to the World Bank estimate during 2015, about 17.2 crores people are below poverty line. This is about 12.4 % of the total population. If Government and private organizations invest on research and development of nanotechnology based automobile sector innovation, the poverty of the country can be reduced to zero. Alternately all the people of the country can lead comfort luxurious life in future days. In countries like India where the population of poor and the corruption in the society are considerably high, only technological solutions can be effective in solving the problems and gives hope for future generations. Low cost air travel and space travel are going to be common and is going to be affordable to the common people of the country.

- **Impact on Public Perception:**

Ever increasing oil prices, uncontrollable cost of vehicle maintenance, sky shooting vehicle prices, Short life of automobile vehicles due to tight emission norms, continuous degradation of environment and rise of temperature due to green gas emission, are decreasing the hope and confidence of publics on better future. Social problems like poverty, corruption, and struggle for basic needs like food, clean drinking water, low cost renewable energy, low cost affordable shelter and comfortable health are major challenge & threats in the society for human prosperity. In such bad time for the people of developing country like India got hope on future due to expected and projected breakthroughs of nanotechnology. If nanotechnology innovations are able to reach the expectations of publics unlike science fiction, the human life is going to be happy and prosperous in future generations and the dream and hope of human beings growth and perception are going to be true.

3.6 NANOTECHNOLOGY INNOVATIONS & BUSINESS OPPORTUNITIES IN RENEWABLE ENERGY SECTOR :

3.6.1. Possible Impact of Nanotechnology on Energy Sector:

Out of basic needs of human which include food, drinking water, energy, cloth, shelter, health and clean environment, perhaps, solving energy problem by providing a way to generating, storing, and converting it to required form at any time and any amount of time called ‘ubiquitous energy’ is the opportunity and the challenge for scientific world and for human prosperity. The potential of nanotechnology in energy sector involves generation of different form of energy, transition of generated energy from one place to another, storage of energy in

different form to minimize the loss, and usage of stored or instantaneous produced energy for useful work using nanotechnology principles. While analysing any system, it is customary to compare it with ideal system of that kind [9, 141-144]. As per the definition of ideal energy system, it should provide infinite amount of energy to the user continuously and it should able to convert one form of energy into another form without any internal loss i.e., ideal energy system has 100% efficiency. Nanotechnology is also expected to play a major role in the process of conversion of energy from one form to another with up to 100% efficiency. Such invention leads to easy accessibility of energy for individuals, homes, offices, companies, and industries at almost zero cost, ubiquitously and makes major impact on economy of every country.

(1) Energy Sources: The possible impact of nanotechnology on energy generation is multi-fold. Nanotechnology supports efficient generation of electrical energy by converting other form of energy in nature. This includes conversion of light/electromagnetic energy into electrical energy by means of photo-electric converters, conversion of wind energy into electrical energy by means of wind turbines optimized using nanotechnology, conversion of mechanical energy of motion into electrical energy efficiently using hydro-electric turbines optimized using nanotechnology, conversion of gravitational energy into electrical energy, or conversion of nuclear energy into electrical energy using steam based turbines optimized their efficiency using nanotechnology etc. Out of different types of energies, electrical energy is most convenient energy to be used for useful work and to be stored by means of existing technologies. Progress in nanotechnology research focus on how all other forms of energies can be converted in to electrical form for easy transmission, utilization and storage. Nanotechnology provides easy way to convert heat energy into electrical energy, light energy into electrical energy, sound energy into electrical energy, mechanical energy into electrical energy, Wind energy into electrical energy, Geothermal energy into electrical energy, Atomic and nuclear energy into electrical energy at optimum cost & efficiency, leading to a concept of "unification of energy".

(2) Energy Transmission: The possible impact of nanotechnology on energy transmission is improving the efficiency by minimizing the loss. Nanotechnology based transmission cables are already proven their enhanced efficiency and leading towards zero transmission loss. Nanotechnology based transmission cables are also expected to reduce the cost, increase the durability, and to be environmental friendly. Research is also progressing on developing wireless energy transmission systems for transmission of electrical energy with minimum loss

between distant points on the surface of earth as well as between space and earth surface and will get boost and viability through nanotechnology. Once we reach such stage of wireless transmission of energy between distant points, huge amount of solar energy can be taped by sending large number of solar space stations sent very near to sun and convert into electrical energy and transmitted to earth to solve the energy crunch of civilized society.

(3) Energy Storage: The possible impact of nanotechnology on energy storage is development of batteries and fuel cells with small size, low weight, low cost, huge storage capacity, and long durability. Nanotechnology supports to develop and maintain ideal batteries to store huge amount of electricity in a small battery. Fuel cells generate electricity instantaneously depending on requirement and nanotechnology supports developments of fuel cells having ideal characteristics. The nanotechnology based batteries and fuel cells are going to make revolution in automobiles, electronic communication, industrial production, aircraft technology, and space technology leading to new industrial revolution.

(4) Energy Utilization: The possible impact of nanotechnology on energy utilization is improvement in systems performance due to improved efficiency of the systems. Since the nanotechnology based systems are expected to be very close to ideal systems with ideal characteristics, their performance efficiency is always close to 100%. Hence, they need very low energy for their functions. In such scenario of both the energy supply and the energy utilizing system shows optimum performance with least energy usage. Thus, nanotechnology based energy sources and systems are going to be best systems in the nature to keep the entropy of the universe at lowest level.

3.6.2 Seven areas of Nanotechnology Impact on Energy Sector:

The nanotechnology impact on seven areas of energy sector including solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system (figure 3.7) and are reviewed as given below. Ubiquitous energy system is a concept of integrated energy system provides energy to everybody, anywhere, anytime, and any amount of time like ubiquitous banking in banking system [145-146].

(1) Solar Energy: Advances in nanotechnology based solar cells can lead to higher efficiencies and lower costs. Nanotechnology can increase the efficiency problem, by tinkering with solar power cells at a fundamental level to boost their ability to convert sunlight into power, and by providing the industry to use less expensive materials. One of the methods used in nanotechnology is to reduce the amount of light reflected back from solar cell surface by

increasing the absorption at the outer surface. Other methods are using organic solar cells with quantum dot sensitized, and dye sensitized solar cells with various permutations and combinations to increase the efficiency with low cost and long durability. Research in solar collecting paint based on nanotechnology is also under progress which uses a stable, electricity-conducting liquid filled with solar-collecting nanocrystals, which can be painted or printed like an ink onto surfaces such as window glass or plastic roof panels, leads to smart houses with self-sustainable electrical systems. Table 3.8 contains the summery of review on nanomaterial usage and their advantages in solar cells research.

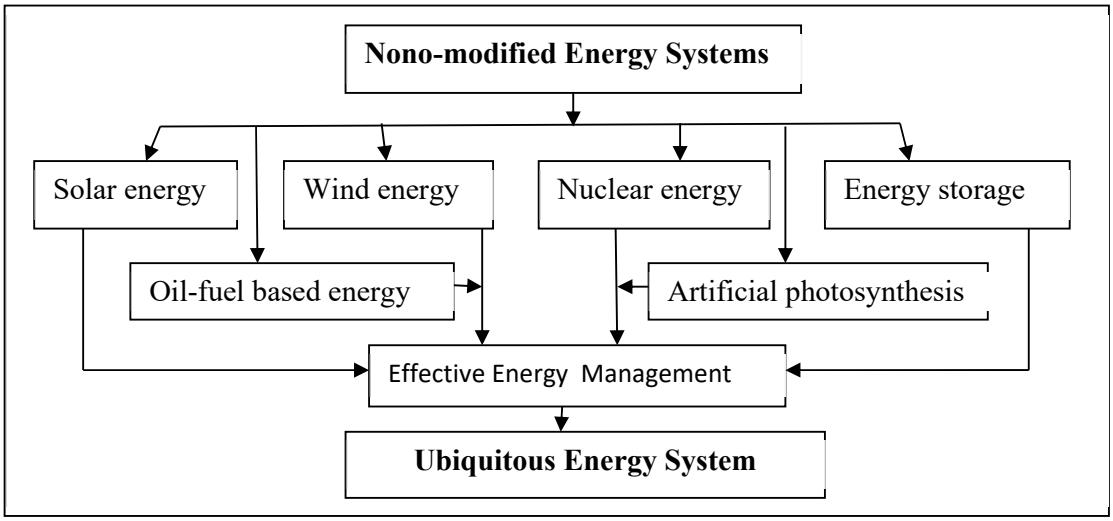

Fig. 3.12 : Concept of Ubiquitous Energy System effective management of Nano-modified energy systems.

Table 3.8 : Review on Nanomaterial usage in solar cells research

S. No.	Nanomaterial Usage	Advantage	References
1	Quantum Dot Solar Cells based on these Zn–Cu–In–Se QDs	An average PCE of 11.66% and a certified PCE of 11.61% have been demonstrated	[147]
2	Silicon nanowire-based solar cells on silicon wafers	From a partially illuminated area of 0.6 cm^2 open-circuit voltages in the range of 230–280 mV and a short-circuit current density of 2 mA cm^{-2} were obtained.	[148]
3	Nano-structured ZnO	dye-sensitized solar cells with enhanced efficiency	[149]

4	Quantum dot-sensitized solar cells	Efficiency is further boosted to as high as 5.38%.	[150]
5	Dye Sensitized Solar Cell (DSSC)	It was observed that incorporating graphene sheets of various sizes in the photo anode helped to improve the efficiency of DSSC significantly, giving a maximum efficiency of 6.62%. In case of novel dyes used in the DSSC fabrication the D-A-pi-A indoline dyes showed a great enhancement in the cell efficiency, with efficiency of up to 6.9%. Incorporation of Pt in counter electrodes and 3D-CE also showed notably good efficiency in DSSC, the efficiency improving up to 8.8%.	[151]
6	Quantum Dot Sensitized Solar Cells	Amorphous TiO_2 Buffer Layer Boosts Efficiency of Quantum Dot Sensitized Solar Cells to over 9%	[152]
7	Plasmon enhanced absorption in dye sensitized solar cells (DSSC) over a broad wavelength range.	45% enhancement in the power conversion efficiency is observed with the inclusion of plasmonic gold nanoparticles (NPs).	[153]
8	Graphene in perovskite solar cells	Achieved 7.8 percent conversion of sunlight to electricity.	[154]
9	Discovered radical new properties in a nano-metamaterial which opens new possibilities for highly efficient thermophotovoltaic cells,	This nano-metamaterial harvest heat in the dark and turn it into electricity.	[155] & [156]
10	CdS/CdSe quantum dot sensitized solar cells with a ZnSe passivation layer	Doubling the power conversion efficiency	[157] [158]

(2) Wind Energy: The global wind turbine manufacturing industry growing industry and there is increasing interest in manufacturing new types of turbine blades with enhanced properties. It is essential to design and produce blades with good fatigue resistance and good stiffness properties to ensure operational longevity. Nanotech polymer matrix composites dominate the wind turbine blade market because of their low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries. Wind turbine blade manufacturers are faced with the challenge of constructing technologically increasingly robust, more sophisticated, larger wind turbines with the total production cost per turbine as low as possible. Nano-particle lubricant additives for wind

turbine gearbox will increase the power generation by decreasing rotation resistance for the turbines. Table 3.9 contains a review on various nanomaterials used in wind mills research.

Table 3.9 : Review on Nanomaterial usage in wind mills research

S. No.	Nanomaterial Usage	Advantage	References
1	Reinforcing wind turbine blades with carbon nanofibers	Larger, more resilient wind energy conversion (WEC) systems	[159]
2	Boron based surface treatment and nano-particle lubricant additives for wind turbine gearbox applications.	*Nano*-particle lubricant additives for *wind turbine* gearbox decreases Friction and wear.	[160]
3	Multifunctional carbon nanofiber (CNF) paper-based nanocomposite coating was developed for wind turbine blades.	Shows great promise for usage with wind turbine blades, owing to its excellent damping properties, great friction resistance, and super hydrophobicity.	[161]
4	Carbon nanotubes / polymer nanocomposites used in wind turbine blade	Good fatigue resistance and good stiffness properties to ensure operational longevity	[162]
5	Carbon nanotubes, are a potential candidate to be incorporated into marine current turbines.	Structural reinforcement, fouling release coating, structural health monitoring, high performance wires/cables and lubrication.	[163]

(3) Nuclear Energy: Nuclear energy generated using nanotechnology can be more efficient, safer and generate less radioactive waste than current technologies. Nanomaterials and nanotechnologies are useful for advanced nuclear fuel fabrication, spent nuclear fuel reprocessing, nuclear waste disposal and nuclear environmental remediation. Table 3.10 contains a review on various nanomaterials used in nuclear reactors research.

Table 3.10 : Review on Nanomaterial usage in nuclear reactors research

S. No.	Nanomaterials Used	Advantage	References
1	Nanostructured sorption materials (carbon materials included)	Purification of radioactive waste.	[164]
2	Alumina nanoparticles	Maximizing heat transfer efficiency in nuclear reactors	[165]

3	Zero-valent iron nanoparticle and its graphene composite	Efficient removal of uranium from aqueous solution in Nuclear power plant waste	[166]
4	Nanopowder of dysprosium hafnate changing instead of using boron carbide.	Control-rod modernization in nuclear reactors	[167]
5	Nanocrystalline uranium dioxide fuels	Grain boundaries absorb defects, lengthen life of nuclear fuel	[166]
6	Carbon nanotubes	Water-cooled reactor designs featuring enhanced safety	[168]

(4) Oil –Fuel Based Energy: Nanotechnology has the potential to introduce revolutionary changes in several areas of the oil and gas industry, such as exploration, drilling, production, enhanced oil recovery, refining and distribution. Nano-sensors have been developed rapidly to enhance the resolution of the subsurface imaging leading to advanced field characterization techniques. Nanotechnology also strikes the stage of production enormously to enhance the oil recovery via molecular modification and manipulate the interfacial characteristics. Some of the nanomaterials which have potential advantage in such applications with more efficient, less expensive, and more environmentally sound, are listed in table 3.11.

Table 3.11: Review on Nanomaterial usage in crude oil purification research

S. No.	Nanomaterial Used	Advantage	References
1	Magnetic shell cross-linked knedel-like nanoparticles (MSCKs) using iron oxide	Crude oil purification by successful removal of the hydrophobic contaminants	[169] & [170]
2	Nanocatalysts portray unique catalytic and sorption properties due to their exceptionally high surface area-to-volume ratio and active surface sites.	In-situ heavy oil upgrading and recovery enhancement.	[171]
3	Polydimethylsiloxane (PDMS)–graphene sponge	Exhibited high adsorption performance for the removal of petroleum products, organic solvents and emulsified oil–water mixtures.	[172]
4	Carbon nanotube sponges	Oil spill cleanup from sea water	[173]
5	Carbon nanomaterials such as mesoporous carbon (CMK-3), sulfur-	Improved performances in detection, assessment as well as	[174]

	or nitrogen-doped porous carbon and carbon black	purification of oil and natural gas are studied and demonstrated.	

(5) Energy Storage: Materials store and deliver energy in the forms of batteries, super capacitors, or fuel cells. High performance nanomaterials for storing hydrogen would enable more energy efficient vehicles and off–grid operation. Nanotechnology improves battery technology by increasing the available power from a battery, decreasing the time required to recharge a battery, reducing the possibility of catching fire, and increases the shelf life of a battery by separating liquids from the solid electrodes with the help of nanomaterials when there is no power draw on the battery. Some of the nonmaterial used in Battery and Fuel cell research are listed in table 3.12.

Table 3.12: Review on Nanomaterial usage in Battery and Fuel cell research

S. No.	Nanomaterial Used	Advantage	References
1	Three-dimensional hierarchical Co_3O_4/CuO nanowire heterostructure arrays on nickel foam for high-performance lithium ion batteries.	The superior electrochemical performances of electrodes composed of hierarchical Co_3O_4/CuO NW arrays connected directly on nickel foam make them potential anode materials for high performance LIBs.	[175]
2	TiO_2 nanotubes.	Provide an open-circuit voltage of 3.39 V and a short-circuit current density of 1.01 mA/cm^2. Such an integrated power pack could serve as a power source for mobile electronics.	[176]
3	Activated carbon nanotubes.	Improved electrochemical properties of batteries.	[177]
4	Nanostructured $FePO_4$ for sodium-based batteries.	Improved capacity and power performance.	[178]
5	Nano-Sn electrode with high-quality nano-SEI formation for lithium ion battery.	Improved stability.	[179]

(6) Artificial Photosynthesis: As an alternative to fossil fuels, technology can lead to some of the most efficient energy supply methods possible for future. By attempting to directly harness the power of the sun as bacteria, algae, and plants do through natural photosynthesis, scientists are seeking to produce viable renewable energy resources. Artificial photosynthesis is a

chemical process that replicates the natural process of photosynthesis, a process that converts sunlight, water, and carbon dioxide into carbohydrates and oxygen. This leads to artificial food production. The recent breakthroughs in nanotechnology have led to a more bottom up approach more similar to natural photosynthesis, where engineered nanostructures are used for the capture and conversion of light into usable energy. In artificial photosynthesis, scientists are trying to mimic the core processes in natural photosynthesis like light gathering, charge separation, and recombination with the aim to create efficient synthetic nanostructures that can function as antennae and reaction centers. Table 3.13 contains a summery on review on nanomaterial used in artificial photosynthesis.

Table 3.13: Review on Nanomaterials usage in Artificial Photosynthesis.

S. No.	Nanomaterial Used	Advantage	References
1	Artificial Photosynthesis systems contain a chromophore, such as a porphyrin, covalently linked to one or more electron acceptors, such as fullerenes or quinones, and secondary electron donors.	This system uses sunlight to split water to oxygen and hydrogen fuel, but efficiencies are low and an external electrical potential is required.	[180]
2	Nanoparticle made of four zinc tetraarylporphyrin molecules, $(P_{ZP})_3$-P_{ZC}, a free-base porphyrin, and a fullerene molecule, P-C_{60}.	Efficient synthetic nanostructures that can function as antennae and reaction centers for artificial photosynthesis.	[181]
3	Highly efficient photosynthetic energy and electron transfers were realized at gold and indium–tin oxide (ITO) electrodes modified with self-assembled monolayers of porphyrin–fullerene-linked systems.	Porphyrin-modified gold nanoclusters were found to have potential as artificial photosynthetic materials and photonic molecular devices.	[182]
4	Rational Design and Engineering of Quantum-Dot-Sensitized TiO2 Nanotube Arrays for Artificial Photosynthesis.	Nanotubular morphology and hybridization of TiO_2 with CdS enables highly efficient photoregeneration of cofactors by ensuring better diffusion of reaction species and rapid charge separation.	[183]
5	Clusters of nano-sized cobalt-oxide molecules (CoO) acts as catalyst for artificial photosynthesis.	Found to be stable and highly efficient triggering agent in an artificial photosynthesis system.	[184]

6	A team of scientists at MIT, used a man-made virus to serve as a scaffold that attracts molecules of the catalyst iridium oxide and a biological pigment (zinc porphyrins).	The viruses then become "wire-like" and are able to split the water molecules into hydrogen and oxygen by having just the right spacing to induce the reaction.	[185]

(7) Effective Energy Management: Renewable energy can be generated using nanotechnology materials and components in efficient manner at low cost by means of proper planning using nano-modified solar cells or by means of artificial photosynthesis and generated electrical energy has to be distributed by means of nanotechnology based transmission system and stored by means of nanotechnology batteries so that one can decrease the loss of energy during distribution as well as storage of energy. By means of properly planned energy management system, the loss of energy can be minimized. By means of properly arranged solar cells and battery system can provide continuous electrical energy for the concept of ubiquitous energy (any time, any amount and any amount of time).

3.6.3. Innovations and Business Opportunities for Nano-Modified Solar Cells:

Nano-modified solar cells and solar paints are potential products for future business both in developed countries and developing countries due to their enhanced conversion efficiency, low cost, and durability. The improved characteristics of such solar panels increase the demand in the market so that the business firms which involve in nano-modified solar panel business have huge business opportunities for long period of time.

Business of Smart House: The planning and construction of smart house and smart office using nanotechnology is going to be major business in 21st century. In smart house and smart office, the green electricity is generated for keeping the night warm, running the electrical appliances including air conditioners and all other requirements using the nano modified solar paint pasted on both roof, walls, and windows. All houses and buildings are going to be independent and self sustainable in electrical energy usage.

Business of Solar Energy: Generating solar electricity in large volume either planning big solar parks or generating electricity near sun using space stations and transmitting the electrical energy to earth stations by wireless electricity transmission systems is a new challenge for 21st century.

Solar Automobiles: Improved battery storage and solar cell technology using nanotechnology, solar automobiles can be developed which can use renewable energy without environmental pollution and improves the efficiency in terms of mileage. By developing efficient battery

storage technology and manufacturing of automobile body by solar panels or solar paint, the automobile companies have huge business potential for long period.

Solar Industries: The heavy industries also have opportunity to make use of renewable energy either using nanotech solar park, or nanotech wind park or nano-modified nuclear reactors to improve the efficiency and to lower operational cost.

3.6.4. Innovations and Business Opportunities in Nano-Influenced Batteries & Fuel Storage Cells:

Fuel cells are electrochemical devices that convert chemical energy to electricity and thermal energy. Fuel cell systems are used for applications ranging from portable electronics, automobiles, computers, space vehicles, in Electronic entertainment Devices & Security Devices, and to utility power plants. Many types of fuel cells are already in market. Nanotechnology increases the efficiency and decreases the size and weight of the fuel cells so that they can last longer period with required energy output. Fuel cells can offer a higher energy storage density and more convenience than conventional battery systems. Fuel cells are also environmentally friendly due to their low emission nature. Nanostructured fuel cells find business opportunities in many areas in the society which include:

Fuel Cell Automobiles: Fuel cell vehicles powered by hydrogen, or ethanol or gasoline with nano-material as catalyst lead higher efficiency and low cost and hence have potential business opportunities.

Fuel Cells in Computers: Business opportunity is also open for fuel cells with nanocomposites as catalyst to provide continuous electrical energy to maintain as server for providing undisturbed support to the entire world.

Fuel Cells in Space Vehicles: A fuel cell combines a fuel (hydrogen or hydrogen source) with an oxidizer (oxygen or air) to produce electrical power. Business opportunities are open to the organizations to develop fuel cells to provide auxiliary equipment power to commercial aircraft, for reusable launch vehicles, for Mars airplane, and for Space Shuttle upgrade, as well as for systems to produce electricity and store energy on the Moon, Mars or any other planet.

Fuel Cells in Electronic entertainment Devices & Security Devices: Nanotechnology offers business opportunity to develop micro fuel cells to use with devices such as digital cameras, portable radios, and notebook computers. A micro fuel cell is a power source for electronic devices that converts chemical energy into electrical energy mostly uses methanol or solid oxides instead of hydrogen.

Fuel Cells for Electrical and Thermal Power to Buildings: Nanotechnology supported stationary fuel cells are ideal for power generation, either connected to the electricity grid to provide supplemental power and backup for critical areas, or installed as a grid independent generator for on-site services The advantages are operate virtually silently, reduce noise pollution as well as air pollution, the waste heat from a fuel cell can be used to provide hot water or room heating, and are highly efficient and have relatively low maintenance requirements.

Nanotech Batteries: Nanotechnology allows to increase the available power from a battery and decreasing the time required to recharge a battery. This is possible by coating the surface of an electrode with nanoparticles to increases the surface area of the electrode thereby allowing more current to flow between the electrode and the chemicals inside the battery. Nanotechnology also increases the shelf life of a battery and eliminates the possibility of batteries catching fire. As a result, huge business potential exists for organizations due to the advantages of nanotech batteries compared to presently using metal-acid or lithium-ion batteries.

3.6.5 ABCD Analysis of Nanotechnology Business Opportunities in Energy Sector:

ABCD listing and ABCD framework are two models of qualitative [126-133] and quantitative ABCD analysis [121-122, 186-190] respectively. In this section, we have used ABCD analysis for qualitative listing of advantages, benefits, constraints and disadvantages from business service providers and customer's point of view.

Advantages:

- Nanotechnology solar cells are expected to be highly efficient in conversion of light into electricity, easy to large scale fabrication and maintenance for business service providers.
- Nano-solar cells and panels are efficient, durable and cost-effective for the customer point of view.
- Nano-solar cells are expected to solve the world energy problem by effective use of solar energy and contribute to the development of civilian society.
- Nanotech polymer matrix composites dominate the wind turbine blade market because of their low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries.

- Nanomaterials and nanotechnologies have the advantage in nuclear fuel fabrication, spent nuclear fuel reprocessing, nuclear waste disposal and nuclear environmental remediation.
- Battery - Nanotechnology decreases the time required to recharge a battery, reducing the possibility of catching fire, and increases the shelf life of a battery by separating liquids from the solid electrodes with the help of nanomaterials when there is no power draw on the battery.
- Nanotechnology has advantage in crude oil exploration, oil well drilling,
- Oil production from the wells, enhanced oil recovery, improved refining and distribution. Nanotechnology is used in detection, assessment as well as purification of oil and natural gas.
- High performance nanomaterials for storing hydrogen in fuel cells enable more energy efficient vehicles and off–grid operation.
- Nanotechnology helps artificial Photosynthesis systems to use sunlight as the renewable energy source to produce carbohydrates and oxygen.
- In the case of solar cells, much higher output power can be expected from nanosized structures compared to their bulk forms.
- Opportunity for developing ubiquitous energy system.

Benefits:

- Due to higher absorption coefficient, nano-solar cells are highly efficient in conversion of light into electricity. The organic nano-solar cells are easy to fabricate and cost effective to both business service providers and the customers.
- Nano-metamaterial used in nano-solar cells harvest heat in the dark and turn it into electricity.
- Due to low-cost, lower weight-to-power ratios, superior fatigue characteristics, high specific strength and modulus, and ability to make complex geometries, nanotech polymer matrix composites, decreases the weight and strength of wind turbine blades.
- Environmental sustainability due to reduced.
- Nanotechnology improves battery technology by increasing the available power from a battery, increases the durability, and recharge cycles, and decreases the recharge time, size, and weight of the battery.
- Nanotechnology improves electrochemical properties of batteries.
- Increased efficiency in crude oil purification.

- Nanotechnology improves the performances in detection, assessment as well as purification of oil and natural gas.
- Nanotechnology-supported artificial photosynthesis system produces artificial food to the society.
- The benefit of using energy anytime, anywhere, and any amount of time through Ubiquitous energy system.

Constraints:

- Educating the people to shift from conventional energy sources to renewable energy sources.
- Higher initial cost for commercialization of new technology.
- Achieving higher efficiency in artificial photosynthesis using suitable nanostructures to convert sunlight, water, and carbon dioxide into carbohydrates and oxygen.
- The problem of complexity is the major constraints. The more advanced systems have huge numbers of parts, and their design and manufacturing involve a series of projects impressive in their complexity.

Disadvantages:

- Nanoparticles as though they are hazardous materials and take measures to ensure they are contained during manufacture and disposal.
- Presently artificial photosynthesis is costly process compared to natural food production.
- Deliberate abuse of the technology by hostile entities ranging from governments to terrorists, could be used for weapons of mass destruction.

3.6.6. Molecular Nanotechnology: A Futuristic Possibility to Solve Ever Demanding Energy Crisis:

Advanced research in nanotechnology is expected to produce some molecular machine systems which have the ability to self-replicate to make copies of themselves. Constructing an artificial self-replicating system at the molecular level will be difficult, but once made, it could make many copies of similar system and perhaps too many copies lead to over replicated machines as virus do. A molecular machine can be defined as an assembly of a discrete number of molecular components – that is, a supramolecular system – in which the component parts can display changes in their relative positions as a result of some external stimulus. Molecular machines and motors are of interest not only for basic research, but also for the growth of

nanoscience and the subsequent development of nanotechnology to make further impact on solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system.

3.7 CONCEPT OF IDEAL ENERGY SOURCE AND ITS REALIZATION OPPORTUNITY USING NANOTECHNOLOGY :

3.7.1 Introduction to Energy Source :

Energy research is one of the primary areas of research due to the objective of providing renewable, cheap, and safe energy to every user including industry, home, and individual human beings throughout the world. The major research areas in the energy sector include Renewable energy, Fossil and nuclear energy, Energy storage and grid modernization, Energy policy and economics, Energy end-use efficiency, and Energy environmental impacts. Out of these areas, the effective use of renewable energy sources and the impact of energy sourcing and utilization on the environment are getting priority and are able to attract huge funding from both developed and developing countries. Renewable energy research area has various alternative fields like bioenergy field, photovoltaics field, wind energy field, solar thermal field, and renewable fuels field. Many environmental effects like greenhouse effect, degraded air and water quality, climate change, and their consequences on a sustainable environment. Renewable energy is an energy produced from such energy systems which are based on renewable resources, usually naturally replenished with time, such as sunlight, rain, tides, wind, waves, geothermal heat etc. An energy system is a system which produces or converts and delivers energy for useful work. An energy system is primarily designed to supply energy to various processes in the dynamic world and to provide both basic needs and luxurious services to end-users. There are many energy sources of different types used in practice. The sustainability model of the universe suggests the use of renewable energy sources for harvesting energy for practical use. Renewable energy research is finding importance due to its priority of maintaining environmental sustainability. The objective and direction of renewable energy research can be properly guided by considering the properties of Ideal energy source.

3.7.2. Concept of Ideal Energy Systems :

Predicting the ideal system model in terms of its ideal characteristics to study any practical system with an objective to improve it is a new research method recently introduced.Ideal systems are hypothetical systems predicted to find out their ideal characteristics. Such ideal characteristics of a given system can be used to improve the characteristics of the

corresponding practical systems with an objective to continuous improvement towards 100 percent efficiency. By comparing the characteristics of a practical device/system with its ideal system counterpart, it is possible to modify the device /system towards reaching the objective of achieving such an ideal device.

The concept of ideal voltage source and current source are already defined in many electrical and electronics textbooks and their characteristics are compared with the practical voltage source and current source. In this section, we are proposing the concept of ideal energy system in a systematic manner using system model. In system model of any concept, the characteristics of a system are divided in terms under input characteristics, system characteristics, output characteristics, and external characteristics. Based on the Google search information [191], an ideal source of energy should possess the following characteristics. (a) It should be capable of giving an adequate amount of useful energy. (b) It should be convenient to transport, store and use. (c) It should be economical, (d) It should be capable of supplying the desired quantity energy at a study rate over a long period of time. But when we study the broad picture of ideal energy system, we have considered many more characteristics like, availability, power output, volume, mass, cost, renewability, user safetyness, Maintenance, etc. Accordingly, a systematic study of ideal energy system is required and study will help the new researchers in energy system research to re-define their objectives.

3.7.3. System Model of Ideal Energy System :

According to ideal energy system model it is a system which produces energy with ideal characteristics which are divided into input characteristics, system characteristics, output characteristics, and environmental characteristics. Based on various factors which decide the ideal energy system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument called focus group method mentioned earlier part of this chapter [31-33]. The box representation of such ideal energy system is shown in Figure 3.13. The expected characteristics of ideal energy system under these categories are listed below :

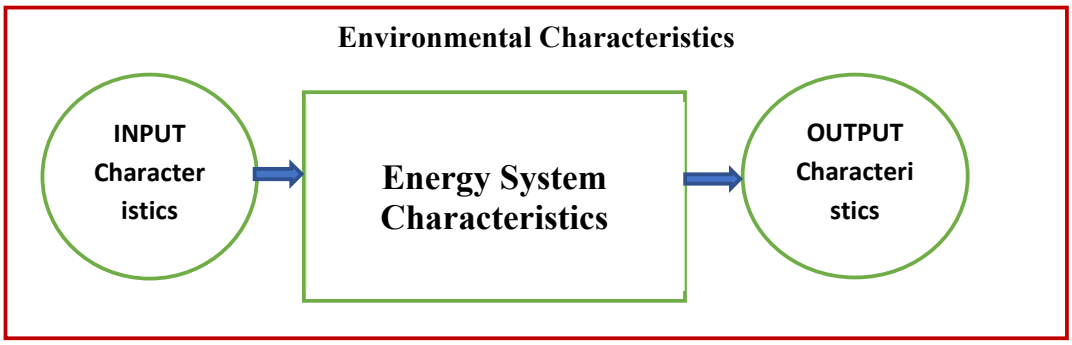

Fig. 3.13 : Box representation of Ideal Energy System model in terms of its characteristics

(a) Input Characteristics :

(1) Zero input or input should be abundant and freely available everywhere

(2) Self reliable system

(3) Affordable system

(4) Ubiquitous system

(5) Takes any type of input

(b) System Characteristics :

(1) Instantaneous

(2) Scalable

(3) No investment and no maintenance cost

(4) Portable system

(5) Sustainable and renewable source of energy

(6) No effect on environment

(7) Use Safe processes

(8) Simple system

(9) Huge energy storage/delivery capacity

(10) The system should not be poisonous.

(11) Provide great amount of energy per unit mass or volume.

(12) Low cost processes

(c) Output Characteristics :

(1) Free energy

(2) Infinite output energy

(3) Output energy may be in any form

(4) Output energy is clean & green

(5) Output is instantaneous

(6) Output is scalable to any amount

(7) Output should be continuous

(8) Ubiquitous

(9) Output energy is safe

(10) Inexhaustible

(d) Environmental Characteristics :

(1) Green energy

(2) No environmental degradation

(3) Renewable energy

(4) Pure energy

(5) No environmental pollution

(6) Location independent

(7) No leakage of energy to the environment & rise of entropy.

3.7.4. Analysis of Ideal Energy System Characteristics :

(a) Input Characteristics :

*(1) Zero input or input should be abundant and freely available everywhere :*The ideal energy system

Ideal energy source gives output continuously, of any amount, without any material input.

(2) Self reliable system :

An ideal energy system is expected to be self reliable. It does not need any stimulation or bias from an external energy source.

(3) Affordable system :

Since an ideal energy system is independent on any material input and external bias or stimulation, it gives output energy continuously without any input and hence such systems are affordable to everybody in terms of cost, in terms of design, in terms of fabrication, and in terms of maintenance.

(4) Ubiquitous system :

An ideal energy system is ubiquitous in the sense that it can give an output of any quantity, any amount of time, anywhere, in any form of output energy, without any input.

(5) Takes any type of input :

In case if ideal energy system which works on abundant and freely available input everywhere then it should capable to take any material in any format.

(b) System Characteristics :

(1) Instantaneous :

An ideal system generates its output instantaneously, whenever required. There is no time gap between input and output.

(2) Scalable :

An ideal system is scalable. i.e., it can be used for generating any amount of energy as per user requirement. As the external demand increases the system has the capacity to increase the output proportionately. The relation between energy demand and output demand is linear at any point.

(3) No investment and no maintenance cost :

An ideal energy system is a simple system in such a way that it should be fabricated using the materials freely available in environment or earth surface. Thus, ideal systems do not need huge investment in terms of various resources. Further, ideal energy system does not take any input or it takes only the input which is abundantly available in nature so that such systems are self sustainable and hence have no maintenance cost.

(4) Portable system :

An ideal energy system is portable in the sense that it can be used anywhere in the world or in the universe with any kind of environment. Portable energy system provides same the amount of output in any place with the same efficiency.

(5) Sustainable and renewable source of energy :

An ideal energy source is always sustainable in such a way that it is able to meet the external growing demand without compromising the future requirement. As demand changes the output energy also changes. Sustainable energy source has two inherent properties including continuous renewability and constant efficiency.

(6) No effect on the environment :

An ideal energy source does not produce a negative effect or degrade the environment. Since an ideal energy source is renewable, it produces green energy and is not involved in polluting the environment.

(7) Use Safe processes :

An ideal energy system does not use any process which affects the normal life of living beings. There will be no by-products which are poisonous or degrade the environment. Such systems will not pose any risk or threat to the sustainability of living systems in the universe.

(8) Simple system :

An ideal energy system is a simple system in which there are no complex interconnections between various subsystems and maintaining such systems are easy and low cost in terms of using various resources to build and maintain.

(9) Huge energy storage/delivery capacity :

An ideal energy system produces any amount of energy depending on the external requirement. An ideal energy system which takes the external material as input is capable to store huge amount of energy in order to deliver any amount of energy requirement at the output.

(10) The system should not be poisonous :

An ideal energy system produces clean and green energy at every time and at any amount of input and output load. The system does not leave any poisonous by-products while providing energy as output.

(11) Provide a great amount of energy per unit mass or volume :

In an ideal energy system, the energy density is infinite so that it can give any amount of energy at a given time as output energy. Energy density is the amount of energy stored in a given system or in a given space per unit volume.

(12) Low cost processes :

As mentioned earlier, an ideal energy system contains simple processes internally to increase or decrease the output energy whenever required at low production and maintenance cost. Every ideal system of any type, as per their definition, consumes less or zero resources so that they are always low cost or zero cost natural systems.

(c) Output Characteristics :

(1) Free energy :

In the first model of ideal energy source, it gives output energy in any form without any input. Thus here, the output energy is available in any amount without any input so that output energy is freely available to the users.

In the second model of ideal energy source, it gives output energy by consuming freely available resources in nature. As a result, the output energy is also freely available in this type of ideal energy system.

(2) Infinite output energy :

As per the definition of the ideal energy source, the output energy can be varied between zero to infinity. Even though it cannot be achieved in practice, an ideal energy source should able to supply energy levels required for any type of practical applications.

(3) Output energy may be in any form :

The output energy for ideal energy source may be in any form including mechanical energy, electrical energy, magnetic energy, gravitational energy, chemical energy, ionization energy, nuclear energy, chromodynamic energy, elastic energy, sound energy, thermal energy, rest energy, and radiant (electromagnetic or light) energy.

(4) Output energy is clean &green :

Since an ideal energy system is sustainable and renewable, it provides renewable clean and green energy ubiquitously to its users.

(5) Output is instantaneous :

The output of the ideal energy system is instantaneous. There is no time lag between input and output.

(6) Output is scalable to any amount :

Scalability is the capability of a system to vary the output to the desired level. In case of an Ideal energy system, the output can be varied to any extent even between zero to infinity. Ideal energy system should be scalable to any level depending on the application of energy usage.

(7) Output should be continuous :

Ideal energy system provides output continuously at any output level during the entire period of observation. The user will not find irregularity or discontinuity in such systems while collecting the energy for useful work.

(8) Ubiquitous :

As per the definition, an Ideal energy system can give any amount of energy output in any form (including mechanical energy, electrical energy, magnetic energy, gravitational energy, chemical energy, ionization energy, nuclear energy, chromodynamic energy, elastic energy, sound energy, thermal energy, rest energy, or radiant energy) anywhere, anytime, with any environment, and any amount of time continuously. Such property of ideal system makes it as a ubiquitous energy source.

(9) Output energy is safe :

Another important property of energy source is the safety of the energy system and the output energy it delivers as output. In case of ideal energy source, it gives clean, green, and safe energy as output for any and every application. Ideal systems will not give any by-products which are poisonous or degrading the environment.

(10) Inexhaustible :

An ideal energy system can give output energy any amount between zero to infinity. Hence the system can take any load at a given time and for any amount of time without a decrease in output energy. Hence an ideal energy system is inexhaustible.

(d) Environmental Characteristics :

(1) Green energy :

Green energy is the energy obtained from natural sources like sunlight, wind, water, rain, tides, plants, algae and geothermal heat. These sources produce energy without any contribution to global warming and climate change.

(2) No environmental degradation :

Since the energy produced from the ideal energy source is green energy which does not contribute to global warming, climate change, and poisonous to living beings. Hence the ideal energy system will not contribute to environmental degradation which is a challenge for the sustainability of the earth and other planets.

(3) Renewable energy :

Renewable energy is the energy in any form, produced by renewable energy resources. Such sources are naturally replenished in a short duration of time so that the replenishment is faster than consumption. The sources of such energy are sun, wind, rain, tides, and geothermal heat etc. In case of ideal energy source, it does not take any energy or material as input to provide energy as output or it takes only natural resources which are available plenty. Thus, the output energy of the ideal energy source is renewable.

(4) Pure energy :

Since the ideal energy source produces green, clean, renewable and energy in a useful form at the output without any side effects or environmental degradable items, it is considered as pure energy. Such pure energy will not contribute to an increase in entropy of the universe.

(5) No environmental pollution :

An ideal energy system will not contribute to the production of green gases and other contaminants which are dangerous for human and animal life on the earth. The pollutants are a threat to the sustainability of the earth and hence human life.

(6) Location independent :

As per the performance of the ideal energy system is concerned, its output does not depend on its environmental factors like variation in temperature, variation in pressure, energy type to be obtained at output etc. Moreover, the performance of the energy source shows ubiquitous so

that it is not location dependent. Thus, the performance and the efficiency of the ideal energy system is independent of its location as well as its surrounding environment.

(7) No leakage of energy to the environment & rise of entropy :

An ideal energy source is a fool proof system where the energy output can vary to any level whenever required. During the non-operational time, the ideal energy source is perfectly insulated from the environment. There is no leakage of energy in the form of heat or pressure or in any other format to its surrounding environment. i.e., in an ideal energy source, the aging of the system will not affect the output performance of the system. Moreover, due to no leakage of energy in any form to the environment, the entropy of the environment is not affected by such a system.

3.7.5. Constraints in Achieving Ideal Energy Source in Practice :

As discussed in the above sections it is not possible to realize an ideal energy system in practice but many characteristics of the ideal system can be achievable to a certain extent using renewable energy sources and by adopting the suitable technology. Table 3.14 shows the comparison of the properties of ideal energy system with practical renewable energy system using suitable technology. Based on table 3.14, one can hope that by identifying suitable technology and improving it through research and innovations, many of ideal energy system characteristics can be practically realizable for at least renewable source based electrical energy system.

Table 3.14 : Comparison of ideal energy system properties with practical energy (Electrical) system

S. No.	Ideal System Characteristics	Achievable Characteristics of a Practical Energy system
(a) Input Characteristics		
1	Zero input or input should be abundant and freely available everywhere	Input should be abundant and freely available everywhere
2	Self reliable system	Self reliable system as a renewable energy source
3	Affordable system	Can be an affordable system based on technology used
4	Ubiquitous system	Ubiquity can be achievable to some extent based on design & technology used
5	Takes any type of input	Uses renewable energy sources as input
(b) System Characteristics :		
6	Instantaneous	Instantaneous electrical energy is possible
7	Scalable	Scalable to some extent based on design & technology used
8	No investment and no maintenance cost	Low investment and low maintenance cost is possible depending on the type of renewable energy used and type of technology adopted
9	Portable system	Portability is possible for a small system for home applications which further depend on the type of renewable source and type of technology used

10	Sustainable and renewable source of energy	Sustainable and renewable source of energy is possible
11	No effect on environment	Very low effect on the environment for renewable solar systems with proper technology
12	Use Safe processes	Use Safe processes is possible for solar energy using proper technology
13	Simple system	Simple system is possible for a system based on optimum technology
14	Huge energy storage/delivery capacity	Limited energy storage/delivery capacity
15	The system should not be poisonous	The 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 suitable technology
17	Low cost processes	Low cost processes are possible for simple systems based on the renewable energy of right technology
(c) Output Characteristics :		
18	Free energy	Low cost energy for renewable energy system using optimum technology
19	Infinite output energy	Finite amount of output energy is possible and the efficiency depends on the technology used
20	Output energy may be in any form	Output energy may be in electrical energy form for many renewable energy systems
21	Output energy is clean & green	Output energy is clean & green for renewable energy systems
22	Output is instantaneous	Instantaneous output is possible which is depending on the type of the technology
23	Output is scalable to any amount	Output is scalable to some amount and is depends on technology and input material used
24	Output should be continuous	Output is continuous only for certain level of output and is further depends on technology
25	Ubiquitous	Presently not Ubiquitous but can be improved depending on the technology
26	Output energy is safe	For renewable energy system, the output energy is safe for all stakeholders
27	Inexhaustible	Renewable energy sources are inexhaustible to a certain level of output
(d) Environmental Characteristics		
29	Green energy	Renewable energy systems provide green energy which further depends on technology
30	No environmental degradation	Renewable energy systems are not creating environmental degradation which further depends on technology
31	Renewable energy	Renewable energy based systems produce renewable energy
32	Pure energy	Renewable energy systems are producing pure energy which further depends on technology
33	No environmental pollution	Renewable energy systems are not contributing to environmental pollution
34	Location independent	Difficult but depends on the technology used
35	No leakage of energy to the environment & rise of entropy	Possible using suitable technology for renewable energy systems

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

3.7.6. 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 [192-193]. 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 [194]. 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 [195]. 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 and is expected to do many breakthroughs in this century [196-199].

3.7.6.2 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 [200]. The conceptual model of energy system using solar panels and storage systems fabricated based on nanotechnology is shown in figure 3.14. There are different principles and methods to improve the efficiency of solar cells using nanotechnology which include :

(1) Improving the efficiency of solar cells using nanomaterial coatings on conventional semiconductor solar cells.

(2) Developing new solar cells using nanomaterials

(3) Developing efficient solar cells using nanocomposite materials

(4) Fabricating solar cells using nano charge sensitive materials doped polymer films for enhanced efficiency.

(5) 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.

(6) To improve the battery life using efficient, tailored hybrid nanostructures.

(7) Improving the efficiency of any other energy system using nanotechnology principles.

(8) Improving the durability of such systems using nanomaterials and nanosystems.

(9) 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.

(10) 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.

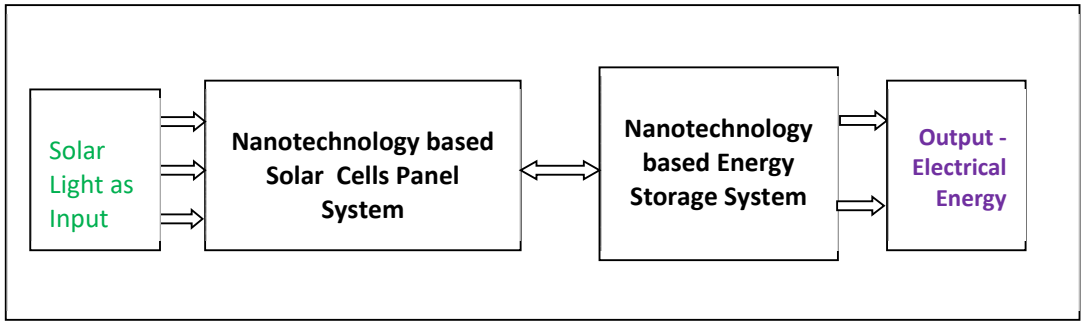

Fig. 3.14 : Conceptual model of Energy system using various processes based on nanotechnology

3.7.6.3 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 [201].

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. Some of them are :

(1) Cost effective

(2) Improved manufacturing methods

(3) Reduced pollution

(4) Light weight systems

(5) Strong and durable

(6) Enhanced efficiency

(7) Easy handling

(8) Possibility of further innovations

(9) Changed principles of operation

(10) Superior technology

(11) Flexible usage form like full structured solar cells or Coatings for solar cells etc.

(12) Possibility of new breakthroughs like antenna-based rectifier systems using nanomaterials.

(13) Theoretical solar light conversion efficiency up to 95%.

Benefits of using nanomaterials for solar cells :

(1) Efficient energy systems

(2) Low cost, durable system for continued output energy

(3) Effective use of renewable energy

(4) Low atmospheric pollution

(5) Efficiency of conversion up to 95% in case of nanotechnology antenna-based rectification systems.

(6) Self sustainability in solar energy gives rise to economically independent countries which intern leads to enhanced growth.

Constraints of using nanomaterials for solar cells :

(1) Funding for research and innovation

(2) Continuous follow-up in research

(3) Accountability in many new researchers.

(4) Further research requirement.

(5) Developing a suitable product with all expected characteristics of ideal energy systems.

(6) Commercialization of technology challenges.

Disadvantages of using nanomaterials for solar cells :

(1) Anticipated side effects of nanomaterials.

(2) Nanotechnology is yet to reach its matured level due to comparatively less research personnel and facilities.

(3) Realization of theoretical findings and expectations in practice is found to be difficult and is considered as a hindrance in further progress.

(4) Anticipated ecological effects and genetic effects on nature hinders the public funding on nanotechnology research.

(5) Device manufacturing difficulty due to nanoscale processes.

3.7.7. Comparison of Ideal Energy System Characteristics 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 3.15.

Table 3.15 : Comparison of Nanotechnology 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

3.7.8. Dye Sensitized Nanocomposite Doped Polymer Films as Solar cells :

3.7.8.1 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 nanocomposites. 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 nanocomposites are the main criteria that determine the suitability of the material for solar energy application. Table 3.16 identifies some of the research results carried out by various research teams during last few years.

Table 3.16 : 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) [202]
2	Poly (3-hexylthiophene): TiO_2 nanocomposites	Kwong, C. Y., et al (2004) [203]
3	Hybrid organic/inorganic nanocomposites	Liu, R. (2014) [204]
4	$CH_3 NH_3 SnI_3$ /TiO_2 nanocomposites	Grätzel, M. (2014) [205]
5	ZnO–SnO_2 nanocomposite	Song, J., (2016) [206]
6	Graphene oxide/mesoporous TiO_2 nanocomposite	Han, G. S., (2015) [207]
7	Yb_2O_3/Au upconversion nanocomposites	Liu, T., et al (2014) [208]
8	CdTe–ZnO nanocomposites	Huang, W. J., (2015) [209]
9	Polymer/copper indium sulfide nanocomposites	Rath, T., et. al (2011) [210]
10	TiO_2/$CuInS_2$ nanocomposites	O'Hayre, R. et al (2006) [211]
11	$CuInS_2$–Poly (3-(ethyl-4-butanoate) thiophene) nanocomposite	Maier, E., et al (2011) [212]
12	Polythiophene and ZnO nanoparticles	Beek, W. J., et al (2006) [213]
13	Molybdenum disulphide/titanium dioxide nanocomposite-poly 3-hexylthiophene bulk heterojunction	Shanmugam, M., et. al (2012) [214]
14	TiO_2/CdS nanocomposite	Zhao, D., et al (2016) [215]

3.7.8.2 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. Some of the published results of dye sensitized nanocomposite solar cells research are summarized in table 3.17.

Table 3.17 : 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) [216]
2	Dye-sensitized solar cells based on nanocomposite of polyaniline/graphene quantum dots	Dinari, M., (2016) [217]
3	Graphene-based dye-sensitized solar cells	Singh, E., et al (2015) [218]
4	Dye-sensitized carbon nanotube aerogel–Pt nanocomposites	Chen, H., et al (2016) [219]
5	Dye-sensitized nanocomposite Semi-Solid Redox Ionic Liquid Electrolytes	Rutkowska, I. A., et al (2015) [220]
6	Dye-sensitized TiO_2–Au Nanocomposite	Pandikumar, A., et al (2015) [221]
7	Dye-sensitized solar cells employing polymers	Yun, S. et al (2016) [222]
8	Dye-sensitized solar cells with tetra alkyl ammonium cation-based ionic liquid functionalized graphene oxide	Kowsari, E. et al (2017) [223]
9	Nano-structured TiO_2/ZnO nanocomposite for dye-sensitized solar cells	Boro, B. et al (2017) [224]
10	Dye sensitized solar cells: From genesis to recent drifts	Sharma, S. et al (2017) [225]
11	Ionic nanocomposite gel electrolytes	Usui, H. et al (2004) [226]
12	Dye-sensitized Nanowire-based composites	Baxter, J. B. et al (2005) [227]
13	Dye-sensitized anatase TiO_2 hollow spheres/carbon nanotube composites	Yu, J. et al (2011) [228]
14	TiO_2–Au plasmonic nanocompositeTiO_2–Au plasmonic nanocomposite	Muduli, S. et al (2012) [229]
15	Dye-sensitized solar cells based on Titania nanotube array electrodes	Paulose, M. et al (2006) [230]
16	Dye-sensitized ZnO–TiO_2 nanocomposite films for high light harvesting efficiency	Manthina, V. et al (2012) [231]
17	Dye-sensitized solar cells using 2-(hexylthio) thiophene conjugated bipyridine	Cao, Y. et al (2009) [232]

18	Dye-sensitized photoelectrochemical solar cells based on nanocomposite organic–inorganic materials	Stathatos, E. et al (2005) [233]
19	Poly (ethylene oxide)/Poly (vinylidene fluoride)/TiO_2 Nanoparticle composites	Han, H. W. et al (2005) [234]
20	Dye-sensitized tin sulfide nanoparticles with reduced graphene oxide	Yang, B. et al (2015) [235]

3.7.9 Predictive Analysis of Dye Sensitized Nanocomposite doped Polymer Films :

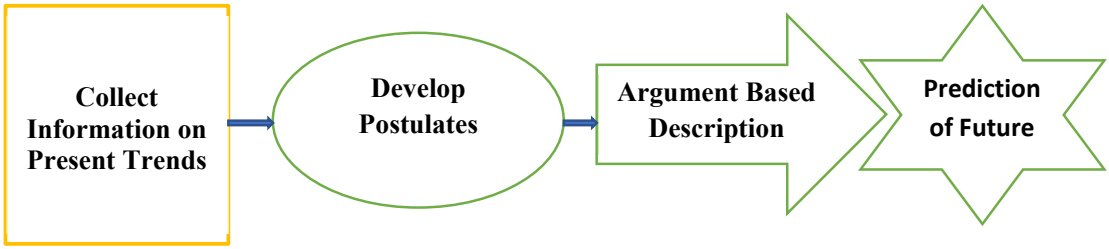

Fig. 3.15 : Predictive Analysis Model to predict future

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 3.15. 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 :

(1) Nanocomposites are potential candidates for efficient solar cell structure

(2) Dye-sensitized nanocomposite solar cells are to be researched to enhance the conversion efficiency.

(3) Nonlinear organic dyes are better candidates as sensitizers for charge transfer and hence to enhance the conversion efficiency [236-243].

(4) 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.

(5) 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) [244-253].

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 :

(1) 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.

(2) The dye material should possess comparatively high transmission at the lower intensity incident light beam to increase the efficiency at low light intensity.

(3) The spectral response of dye material should be wide to cover the substantial amount of the light in the visible region.

(4) 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 [254-255]. 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 [256-261]. 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 [255]. 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 [262]. 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.

3.7.10. 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 [263-267]. 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. Table 3.18 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 3.18 : 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 output of 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.

3.8 CONCEPT OF IDEAL DRUG & ITS REALIZATION OPPORTUNITY USING NANOPHARMACEUTICAL RESEARCH SCENARIO :

3.8.1. Introduction to Drug :

A drug is a chemical material made up of various molecules obtained naturally or synthetically that affects the physiological functions of human beings/animals. Drug is used to diagnose, cure, treat, prevent, or relief some kind of discomfort in many types of diseases and the curing process is called drug therapy. The field pharmacology is focussed on the continual advancement of drugs and the field pharmacy is focussed on appropriate management of drugs. Every drug interacts with the human body or any living systems (or vice-versa) through chemical processes and can be triggered through two major mechanisms which include activating or inhibiting normal body processes, and binding to regulatory molecules. The drug molecules usually different chemical reactions by disrupting some negative process occurring in the patient called *Therapeutic Effects*. It also causes Toxic effects, as used by parasites on their host. Thus, any drug can act like an **agonist** or an **antagonist**. An *agonist* drug acts as an activator or promotes the activity of a specific regulatory system or body process. An *antagonist* drug acts as an inhibitor, having the opposite effect to the agonist. The three general characteristics of *an effective pharmacological drug* are listed below [268-269] :

- The drug should have specific molecular size, shape, and charge to interact with the receptor.
- The drug molecule should able to travel to its site of action from its location of administration.
- The drug must be easily excreted from the body once it completes its action.

Apart from the above general physical properties of a drug, it should some additional desired characteristics like effectiveness in response, safety for the living body, and selectivity in action. If the drug is not effective in response, it should not be used. There is no such drug as a safe drug to the living body. All drugs will cause harm either directly or indirectly. There is no drug presently available in practice which is completely selective because all drugs can cause side effects. Thus effectiveness, safety, and selectivity of drug action are the challenges of drug research. Drug research is considered as a very important research area and probably found more investments of resources and time during the last few centuries [270]. Drug research also contributed to the progress of medical sciences substantially and improving characteristics of drugs in terms of various predicted properties is continued as a challenge and agenda of these researches. Focus on new drug discovery which has better properties towards achieving improvements in effectiveness, safety, and selectivity is the drug research agenda of many pharmaceutics research laboratories around the world. In order to further intensify the objectives of drug research, in this paper, we have predicted the characteristics expected in a hypothetical drug called ideal drug and also discussed the possibility of realizing such ideal drug in practice. The objectives of the study are as follows :

- To formulate a method to improve the performance of drugs by knowing the objectives of drug research.
- To study the characteristics of the ideal drug by considering it as an ideal system.
- To discuss the characteristics of the ideal drug in detail using ideal system model.
- To analyse the possibility of realising ideal drug in practice.
- To investigate the possibility of realising ideal drug using nanotechnology &nano-biotechnology.
- To compare the ideal drug characteristics with predicted nanotechnology-based drugs.
- To predict a timeline to achieve the expected solutions.

3.8. 3. Ideal Drug System Model :

The objective of drug research is continuous improvements of existing drugs in terms of their curing ability and to discover new drugs which have substantial improved abilities to cure many existing and new diseases and the final goal of drug research is directed to identifying one drug which has the ability to cure all diseases. All research work in pharmaceutics is directed towards improving drug properties including their effectiveness, safety, selectivity, no side effects, cost, accessibility, time of cure, etc. The ideal drug is a material which shows ideal characteristics. According to ideal drug model it is a system which operates on other systems

based on its own properties and these properties are divided into input characteristics, operational characteristics, output characteristics, and environmental characteristics. Based on various factors which decides the ideal drug system characteristics, a model consisting of input conditions, output conditions, environmental conditions and system requirements are derived by a qualitative data collection instrument namely focus group method. The block diagram of such ideal drug system is shown in Figure 3.16. The expected characteristics of ideal drug under these categories are listed below :

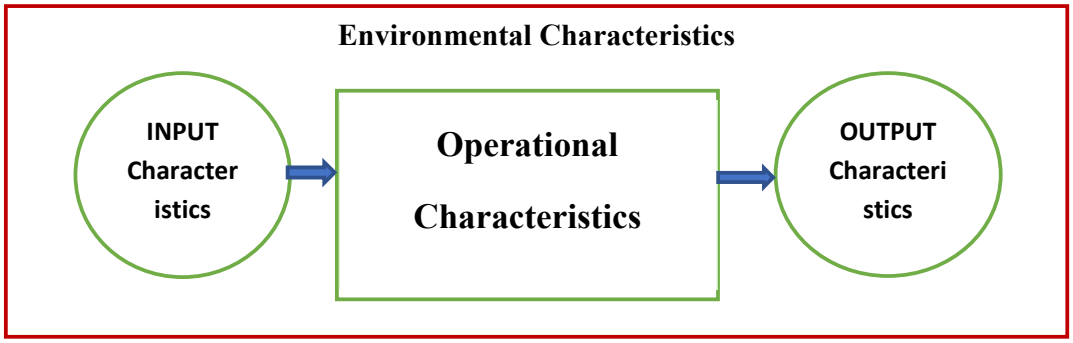

Fig. 3.16 : System model representation of Ideal drug in terms of its characteristics

(a) Input Characteristics :

(1) Ideal drug can have any type of physical state.

(2) Ideal drug independent on dosage.

(3) Ideal drug is a scalable system.

(4) Ideal drug is affordability for patients in terms of material usage.

(5) Ingredients used in ideal drug are abundant and freely available to everybody.

(b) System/Process Characteristics :

(1) Ideal drug should be non-toxic, biocompatible, and biodegradable.

(2) Ideal drug has no side effects.

(3) Ideal drug shows the selectivity in its action.

(4) Rate of ideal drug release is instantaneous and controllable.

(5) In ideal drug, the drug release has no relationship with the drug action.

(6) Ideal drug release is as per required therapeutic amount.

(7) No carrier is required to take ideal drug to reaction site.

(8) The delivery system for ideal drug should be easy, simple, and cost effective.

(9) The ideal drug should be easily eliminated from the body by simple metabolic processes after its action.

(10) The ideal drug will not get accumulated in any part of the body causing inflammation.

(11) Ideal drug is 100 % effective in curing the disease.

(12) Ideal drug is100 % safe for the living body.

(13) Ideal drug shows broad spectrum of efficacy.

(c) Output Characteristics :

(1) Ideal drug cures the disease completely.

(2) Ideal dug cures diseases immediately.

(3) Ideal drug produces no by-products.

(4) No repetition of same disease again.

(5) No therapies and rest required after recovery.

(d) Environmental Characteristics :

(1) No side effects so that it should be safe for users, and environment.

(2) No environmental harm and degradation.

(3) Location independence.

(4) Solutions to all types of health problems.

Ideal drug cures every disease of every living human beings & animals and hence decreases mortality. The ideal drug also helps to regenerate human organs where ever necessary. Hence it is expected that this hypothetical drug solves all health problems in the society.

3.8. 4. Descriptions of Ideal Drug Model :

New drugs are designed and discovered by many scientists belonging to the subject called pharmaceutics. Pharmaceutics is the subject of pharmacy that deals with the process of discovering a new drug or old drugs into a new drug used by patients for curing their disease safely and effectively. The listed characteristics of ideal drug are further described below :

(a) Input Characteristics :

(1) Ideal drug can have any type of physical state :

The physical state of an ideal drug can be solid, liquid, or gases and the physical state of the drug is not a constraint for feeding it to the living body as medicine.

(2) Ideal drug independent on dosage :

The action and effect of the ideal drug are independent on the dosage. Whatever the quantity of drug is fed to the body will able to selectively cure the disease. In practice dosage increases with an increase in drug quantity and an optimum dosage is required to cure a particular disease of particular gravity.

(3) Scalable system :

Ideal drug is a scalable system and can be used for zero to infinite number of dosages to any number of patients. Practical drug systems have limited capacity in terms of dosage and scalability.

(4) Affordability in terms of material usage for Ideal Drug :

The materials used for the preparation of an ideal drug should be freely available in nature. The cost of an ideal drug should be zero so that everybody can afford for it.

(5) Ingredients used are abundant and freely available to everybody :

The ingredients used for the preparation of ideal drug are freely and abundantly available in all parts of the universe so that every living being has equal access to such ingredients to prepare the drug irrespective of their physical location.

(b) System/Process Characteristics :

(1) Ideal drug should be non-toxic, biocompatible, and biodegradable :

It is believed that all practical drugs are toxic for one or other organs of the living body. Drug reactions are of two types as allergic and toxic. Allergic drug reactions are independent on the dose of medication and are unpredictable. Toxic reactions occur in the body when there is an accumulated of too much drug in the bloodstream which leads to adverse effects on the body. Ideal drug by its definition does not be toxic to the body due to its nature of biocompatible and biodegradable. Biodegradation refers to the process by which the drug delivery system is broken down inside the body.

(2) Ideal drug has no side effects :

All practical drugs come with side effects. Some side effects are just an inconvenience, some are minor, a few are serious, and a few are just plain strange. Many drugs produce an allergic reaction which can range from itching and rash to even a life-threatening anaphylactic reaction. But as per the definition, the hypothetical ideal drug is free from all kinds of side effects.

(3) Ideal drug shows the selectivity in its action :

Restrict drug distribution to target cells or tissues or organs only and should have uniform capillary distribution. The ideal drug is highly specific in activity in identifying and curing the diseases. It also works with only diseased cells or organs and acts on it to cure the disease completely.

(4) Rate of ideal drug release is instantaneous and controllable :

Drug release is an important property of a therapeutic system, constituting a prerequisite to absorption of the therapeutic agent and one that contributes to the rate and extent of active availability to the body. When placed in a release medium, the agent that has to diffuse to the

surface of the membrane for release immediately. In the case of an ideal drug, it is assumed that drug release is instantaneous and controllable, biodegradation occurs immediately through diffusion or dissolution.

(5) In ideal drug, the drug release has no relationship with the drug action :

In pharmacology, the drug action refers to the biochemical interaction with the specific molecular targets to which the drug binds, such as an enzyme or receptor. Drug release is an important property of a therapeutic system, constituting a prerequisite to absorption of the therapeutic agent and one that contributes to the rate and extent of active availability to the body. In case of an ideal drug, the drug release is instantaneous and has no relationship with the drug action.

(6) Ideal drug release is as per required therapeutic amount :

Since drug release is an important property of a therapeutic system in curing the diseases, it should be instantaneous and as per the requirement of the therapeutic amount in the releasing region. In case of practical drug release, there is no perfect equilibrium between optimum drug requirement in curing region and the drug release. But as per definition, in case of an ideal drug, the drug release amount is as per therapeutic requirement.

(7) No carrier is required to take an ideal drug to reaction site :

Ideal drug identifies its destination itself, i.e., its reaction site automatically and hence no carrier is required. Drug carrier is a material used along with the drug and is works to manage the drug release in a systematic circulation so that the selectivity, safety, and effectiveness of the drug can be improved. In case of an ideal drug, the drug itself identifies its destination so that no separate carrier is required.

(8) The delivery system for the ideal drug should be easy, simple, and cost effective :

Drug delivery is the method of administering a drug to achieve a therapeutic effect in a systematic manner. In practical drug delivery systems many concepts, methods, and techniques are used and together have been named as controlled release technology. Examples of controlled release technologies are transdermal and transmucosal controlled-release delivery systems, drug-impregnated lozenges, ml6 nasal and buccal aerosol sprays, encapsulated cells, iontophoretic devices to administer drugs through the skin, oral soft gels, and a variety of programmable, implanted drug-delivery devices [271]. These technologies are technically complex and expensive for the common man. As per the definition of the ideal drug, the delivery system for the ideal drug should be easy, simple, and cost effective.

(9) An ideal drug should be easily eliminated from the body by simple metabolic processes after its action :

Once the drug reaction is complete, the excess drug should be eliminated by a simple metabolic process so that there will be no side effects on any other cells or organs of the body. This is possible only in hypothetical ideal drug whereas, in conventional drugs, the side effect is due to the action of the drug with other regions/body parts which is unacceptable.

(10) The ideal drug will not get accumulated in any part of the body causing inflammation :

Inflammation is a self defense mechanism of the human body to heal any damaged cells, irritants, and pathogens. It is a part of every body's immune response. Usually, during medication, the part of the drug leftover or access in the body may cause inflammation which is unnecessary. But in the case of an ideal drug, since there is no accumulation of drug in any part of the body, there is no possibility of causing inflammation.

(11) Ideal drug is 100 % effective in curing the disease :

All drugs are not equally effective in curing diseases. But as per the definition, an ideal drug cures a disease completely and is 100 % effective.

(12) Ideal drug is100 % safe for the living body :

Since the ideal drug is not showing any side effect due to its peculiar property of selectivity and noninflammability, it is completely safe to the living body.

(13) Ideal drug shows a broad spectrum of efficacy :

Efficacy means the ability to produce a desired or intended result. Broad spectrum of efficacy means the ideal drug can fight against both Gram-positive and Gram-negative bacteria or virus to cure the diseases.

(c) Output Characteristics :

(1) Ideal drug cures the disease completely :

An ideal drug defined here has the property to cure a given disease completely. An ideal disease can cure one or more disease completely. As per the definition, an ideal drug should cure all the diseases completely in every living being.

(2) Ideal dug cures diseases immediately :

The ideal drug defined here has property to cure a given disease instantaneously and completely. In case of the practical drugs, some of them may cure the diseases by killing or halting the spread of bacteria or viruses, some drugs may identify and kill cancerous cells in the body and some other drugs may replace missing substances or hormones or vitamins.

(3) Ideal drug produces no by-products :

Ideal drug is a hypothetical entity which does not produce any harmful by-products during the curing process. But the conventional drugs may produce adverse drug reactions in some living bodies due to the interaction of drug and its by-products with body cells.

(4) No repetition of the same disease again :

As per our assumption, when the ideal drug is inhaled, it has the ability to cure the diseases instantaneously and the drug cures the disease in such a way that it will never appear again in that living being, i. e., no repetition of the same disease again.

(5) No therapies and rest required after recovery :

Usually in practical drugs based curing, once the disease is cured the therapy should continue for some time for complete curing and during such time the patient is advised to take rest by the doctors. On the other hand, in the case of ideal drugs, no rest to the patient is required due to the fact that the disease completely cures instantaneously.

(d) Environmental Characteristics :

(1) No side effects so that it should be safe for users, and environment :

The ideal drug acts only on diseased cells and does not produce any harmful chemical during its action so that it has no side effect and hence is assumed to be safe to the users and environment.

(2) No environmental degradation :

Since the ideal drug is not producing any harmful chemical as the by-product, there is no excretion of harmful chemicals occurs from the body to the environment. As a result, the environment is not affected by the excreted drug discharge.

(3) Location independency :

Ideal drug yields same result of complete curing of diseases in any location around the world and in any time after the disease is started. The geographical factors and physical factors like temperature and pressure will not affect the expected performance of the ideal drug.

(4) Solutions to all health problems :

As per the definition of the ideal drug, it is always effective and gives quick solutions to any kind of diseases from a headache to cancer and hence solves all the health problems of living beings.

3.8. 5. Challenges & Opportunities in Achieving Ideal Drug System :

As mentioned earlier, the concept of the ideal drug is purely hypothetical and looks strange but it gives appropriate direction for future research. This model gives the idea of the required quality improvement of various properties of the drug in order to cure the diseases and the

opportunities and challenges in future research. The ideal drug model sets the goal of every researcher to decide their objectives while choosing the research topic related to drug discovery.

(1) Opportunities :

Ideal drug concept and characteristics based on the system model provides the following opportunities to drug researchers and drug manufacturers :

- Improve the quality of the drug by setting new objectives.
- Setting the target for the researchers to improve input, process, output, and environmental characteristics of the drugs.
- Continuous improvement opportunity by planning and researching in an identified characteristic.
- Focused research on issues related to the effectiveness of the drug, safety to patients, selectivity in drug action, decreased side effects, low cost, wide accessibility, less time for the cure, etc.
- To think on the realization of an Ideal drug with input characteristics like having any type of physical state, independent on dosage, scalability, affordability in terms of material usage for patients, and abundant and freely available ingredients usage.
- To also think and use the system process characteristics mentioned above while planning the drug discovery process.
- Drug manufacturing companies get new opportunity to use this model to re-define their objectives and enhance their R & D activity along with R & D budget.
- The consumers/patients also get the opportunity to have access to improved drugs to cure their diseases.

(2) Challenges :

Apart from opportunities, the ideal drug concept imposes many challenges for drug researchers, drug manufacturers, patients, health industry and even for the entire society. The individual characteristics under different headings like input, process, output, and environmental sections of the ideal drug system are really posing challenges for conventional thinkers and for the entire health industry. Converting these challenges into an opportunity to realize ideal characteristics of the drug at least individually if not altogether is the new goal of the health science research. The following are some of the challenges for drug researchers and drug manufacturers :

- The researchers face new challenges in their attempt to realize the ideal drug characteristics.

- The challenge of developing a material to be used as an ingredient to realize ideal drug.
- Manufacturing the drug using such ingredients which can possess ideal drug characteristics.
- The challenge of convincing the drug manufacturing companies to invest in attempting to realize the ideal drugs.
- Challenge on handling heavy resistance to be observed from the health science & pharmacy community as they see it as a threat for their profession.

3.8. 6. Nanotechnology as Universal Technology :

Nanotechnology is expected as a technology of the 21st century to solve many problems of society both at primary and secondary level [25-29]. Nanotechnology allows many fields of science and technologies to converge to single integrated technology and offers a new way to solve problems of society both at fundamental and applied levels. Such convergence ability of nanotechnology from many fields to single field leads to an increase in *interdisciplinary* research at the nanoscale. Many nanotechnology interdisciplinary groups for interdisciplinary research are formed in this century all over the world during recent years to accelerate the research and development in nanotechnology and related areas. Nanotechnology has solutions of many problems of agriculture to get nutritious food to every living being of the world, potable water for drinking and irrigation, renewable energy for essential human activities, many new and essential consumer durable systems, and better healthcare facilities. Nanotechnology is expected to change the definition and principle of functioning of many products and services provided by various industries to their customers as general purpose technology [195]. It is expected that the effect of Nanotechnology (NT) along with another already matured technology called Information Communication and Computation Technology (ICCT) is enormous in future days in the society on lifestyle of human beings and these two technologies are expected to solve many problems and requirements of the society and hence named them as Universal Technologies [195]. Being one of the Universal technologies, nanotechnology has huge hope in solving all the problems of living beings related to health sciences. Many problems in medical sciences have already anticipated solutions at least at conceptual level using nanotechnology and ICCT. In the next section, we have discussed the anticipated breakthroughs of nanotechnology solutions in health and medical science problems and hence the possibility of realizing the ideal drug characteristics using nanobiotechnology in future years.

3.8. 7. Possibility of realizing Ideal Drug using Nanotechnology :

Nanotechnology being a general-purpose technology of 21st century and growing as universal technology has solution in the process of developing ideal solutions to health and medical sciences problems. Nanotechnology is evolving as a new hope to create and utilization of materials and tools at nanometer scale and influencing number of industries in health and medical sciences including in particularly pharmaceutical industry. Nanotechnology tools and techniques developed for different industry sectors along with biotechnology ideas have potential opportunities in achieving ideal drug characteristics in pharmaceutical industry. It is also believed that nanotechnological tools suitable for improving the characteristics of drugs towards ideal drug are exotic, disruptive, and futuristic so that may take long time in terms of several hundred years for commercialization. Currently nanoparticles and nanodevices such as nanobiosensors and nanobiochips, are used to discover new drugs or to improve the characteristics of existing drug in pharmaceutical research industry. This include :

- Some nanosubstances like fullerenes are considered as potential drugs for the future healthcare industry.
- The nanoparticle based drug delivery systems allows to target drugs to specific areas of the body [272].
- The medical imaging technique is expected to utilize drug delivery systems to illuminate to any cellular functions including tumors, or the brain in the body [273].
- The nano scale drug particles can reach inaccessible areas in the body such as inflamed tissues due to their improved permeability and retention effect.
- New nano-scale drug carriers are developed using dendrimers, to increase the possibility of increasing therapeutic index of drug molecules [274].
- The nanotechnology based long acting injectable therapies for HIV treatment [275].
- The nanomaterial based systems are used as carriers of antibiotics for infectious diseases [276].
- Various nanoparticles, and nanofibers and nanoporous scaffolds are used in the fabrication scaffolds for nanoengineering scaffolds to replaced and re-grow damaged tissues and organs [277].
- Silica based mesoporous nanomaterials with surface reactive functionalities are used for bone tissue engineering [278].
- Use of nanomedicine for managing diabetics [279].

Based on such many possibilities discovered till now, there is a hope that many more diseases may find optimal curing solutions in future days using nanotechnology based techniques.

3.8.8. Current Research Agendas in Nanotechnology based Drug Research :

Nanotechnology is a useful tool to improve the selective delivery of drug to the specific site of action. Recent developments in nanotechnology to engineer nanoparticles with desired physicochemical properties have been projected as a new line of defense against many diseases. Table 3.19 summarizes some of the current research agendas in nanotechnology based drug research.

Table 3.19: Some of the current research agendas in Nanotechnology based Drug research

S. No.	Type of disease	Nanotechnology based solution	Reference
1	Bone related disease	Development of nanomaterials for bone-targeted drug delivery	Cheng, H. et al. (2017) [280]
2	Tissue regeneration, drug delivery and pharmaceuticals	Electrosprayed nanoparticles and electrospun nanofibers based on natural materials	Sridhar, R., et al (2015) [281]
3	Oncologic Disease	Nanomedicine	Brown, P. D., et al. (2015) [282]
4	Cancer therapy	Nanotechnology-based chemotherapy	Coccia, M. et al. (2015) [283] Singh, D. et al (2017) [284]
5	Neural regeneration	Nanotechnology-based approaches for guiding neural regeneration	Shah, S. et al (2015) [285]
6	Liver tissue engineering	Primary liver cells cultured on carbon nanotube substrates	Che Abdullah et al (2014) [286]
7	Treatment of melanoma	Nanoparticle-mediated drug delivery	Mundra, V. et al (2015) [287]
8	Drug delivery	Synthetic micro/nanomotors	Gao, W. et al (2014) [288]
9	Treatment and eradication of HIV/AIDS	Nanodrug formulations to enhance HIV drug exposure in lymphoid tissues and cells	Shao, J. et al (2016) [289]
10	Delivery of peptide nucleic acids (PNAs).	Nanotechnology based solutions	Gupta, A. et al (2016) [290]
11	Controlled drug release	Pharmaceutical nanocarriers	Lee, J. H. et al (2015) [291]
12	Smart drug delivery in cancer therapy	Ph-sensitive polymeric nanoparticles	Lim, E. K., et al (2018) [292]
13	Alzheimer's disease therapy	Nanotechnology approach	Ansari, S. A. et al (2017) [293]
14	Parkinson's disease	Nanotechnology-mediated nose to brain drug delivery	Kulkarni, A. D., et al (2015) [294]
15	Tuberculosis treatment	Nanotechnology-Based approach in tuberculosis treatment	Nasiruddin, M., et al (2017) [295]

16	Drug delivery platform	Biofunctionalized nanoparticles-based drug delivery platform	Bose, R. J. et al (2016) [296]
17	Preclinical imaging & drug delivery	DNA nanomaterials	Jiang, D. et al (2016) [297]
18	Cancer metastasis treatment	Nanotechnology-based intelligent drug design	Gao, Y. et al (2014) [298]
19	HIV AIDS treatment	Nanotechnology: a magic bullet	Kumar, L. et al (2015) [299]
20	Antibacterial Agents	Silver Nanoparticles	Franci, G. et al (2015) [300]
21	New method for potent drug development	Biological nanomotors	Pi, F. et al (2016) [301]
22	Broad-spectrum treatment of viral infections	Nanomedicine for infectious disease applications	Jackman, J. et al (2016) [302]
23	Eradicating HIV reservoirs	Nanotechnology approach	Cao, S. et al (2018) [303]
24	Ocular surface diseases	Role of nanotechnology in control of human diseases	Rai, M. et al (2016) [304]
25	Coronary artery disease	Nanotechnology in diagnosis and treatment	Karimi, M. et al (2016) [305]
26	Treatment of tuberculosis	Nanotechnology as a delivery platform	Choudhary, S. et al (2015) [306]
27	Brain cancer and Alzheimer's disease	Nano-enabled drug delivery systems	Ma, J. et al (2015) [307]

3.8.9. ABCD Listing of Nanotechnology in Drug Discovery :

(1) Advantages :

- Nanotechnology has given rise to promising new therapies and diagnostic tools for a wide range of diseases, especially cancer.
- The most important advantage offered by nanotechnology is the ability to specifically target organs, tissues, and individual cells.
- Nanotechnology-based drug delivery systems improve delivery of photosensitizers which are poorly water-soluble and facilitates them to reach intracellular sites of action.
- Nanotechnology systems can be designed and developed for the sustained release of drugs from the matrix and drug delivery to a specific target.
- Nanotechnology based drugs increase absorption, bioavailability, and controlled release of the drug at the site of administration.
- Provides faster, smaller, and highly sensitive diagnostic tools & techniques.

(2) Benefits :

- Nanotechnology in oncology offers selectively killing the tumor cells without harming healthy cells.
- The ability of nanotechnology to specifically target organs, tissues, and individual cells, ultimately leads to decrease the systemic side effects and hence improves the therapeutic index of drug molecules.
- The sustainable drug release properties of the nanotechnology systems enable the improvement of the bioavailability of drugs, can reduce the dosage and frequency of administration, and may solve the problem of non-adherence to prescribed therapy.
- Increased effectiveness of the drug, safety to patients, and selectivity in drug action,
- Nanotechnology based drugs provide decreased side effects, low cost, wide accessibility, less time for the cure, etc.
- Help to solve many unsolved health problems.

(3) Constraints :

- The process of detection, quantification, and removal of toxin part from nanoformulations while using them as drugs or carriers of drugs.
- It is predicted that nanomaterials used as the drug may give damage to lungs or any other organs in the body.
- Large-scale manufacturing and costs of nanomedicines are also important issues to be addressed.
- The research on drugs based on nanotechnology is under planning and development stage so that awareness about the consequence is yet to be created.

(4) Disadvantages :

- The safety issues of nanomaterial based drugs are not clear and yet to be convinced to the society.
- The cost associated with nanotechnology based research is presently high so that the cost of nanomedicines are accordingly high.
- Superspeciality research in nanotechnology based drug development is rare due to less number of experts in the field.

Table 3.20 : Comparison of Conventional drug and Nanotechnology based drug in terms of Ideal System Characteristics.

S. No.	Ideal Drug Characteristics	Conventional Drug	NT based Drug
1	Any type of physical state	Yes	Yes
2	Independent on dosage		

3	Scalable system	No	Yes
4	Affordability for patients in terms of material usage	No	Yes
5	Ingredients used are abundant and freely available	No	Possible
6	Non-toxic, biocompatible, and biodegradable	No	Possible
7	No side effects	No	Possible
8	Selectivity in its action	No	Possible
9	Rate of release is instantaneous and controllable	No	Possible
10	Drug release has no relationship with the drug action	No	Possible
11	Drug release is as per required therapeutic amount	No	Yes
12	No carrier is required to take drug to reaction site	No	Yes
13	Delivery system should be easy, simple, and cost effective	No	Possible
14	Drug should be easily eliminated from the body by simple metabolic processes after its action	No	Possible
15	Drug will not get accumulated in any part of the body causing inflammation	No	Possible
16	100 % effective in curing the disease	No	Possible
17	100 % safe for the living body	No	Possible
18	Shows broad spectrum of efficacy	No	Possible
19	Cures the disease completely	Possible	Possible
20	Cures diseases immediately	No	Possible
21	Produces no by-products	No	Possible
22	No repetition of same disease again	No	Possible
23	No therapies and rest required after recovery	No	Possible
24	No side effects	No	Possible
25	No environmental harm and degradation	No	Possible
26	Location independence	Possible	Yes
27	Solutions to all types of health problems	No	Possible

3.9 CONCLUSION :

The various properties of Ideal technology are identified, classified and analysed in the form of a model. A suitable possible practical technology is identified to realize most of the properties of Ideal technology. The characteristics and opportunities of nanotechnology are identified and analysed and the possibility of realization of Ideal technology using nanotechnology. It is found that nanotechnology being a general purpose technology can provide solutions almost all basic and high level problems like hypothetical Ideal technology. Hence nanotechnology is future technology expected to solve all problems of human beings

and elevate the human life to such a comfortable level towards ubiquitous and omnipotent like God.

Technology has affected the society and its surroundings in many ways and helped to develop more advanced economies including today's global economy. Science has contributed many technologies to the society which include Aircraft technology, Automobile technology, Biotechnology, Computer technology, Telecommunication technology, Internet technology, Renewable energy technology, Atomic & Nuclear technology, Nanotechnology, Space technology etc. have changed the lifestyle of the people and provided comfortability. In order to sustain this comfortness of people in the society, they have to worry about the sustainability of the surrounding environment. In this paper, we propose how the technologies can be made sustainable by adding green component so that they can avoid environmental degradation and converted into green technologies to provide a clean environment for future generations. The paper also discusses the opportunities and challenges for green technology for agriculture, green technology for potable water, green technology for renewable energy, green technology for buildings, green technology for aircraft and space exploration, green technology for education, green technology for food & processing, and green technology for health and medicine in 21st century.

Developing capability of producing an abundant amount of potable water is one of the basic requirements of civilized society and can be addressed using nanotechnology. In this paper, we have used a method of research where the ideal system is predicted by means of its various characteristics and analysed the possibility of improving the real systems towards ideal systems using suitable technology. Accordingly, the ideal water purifier system is proposed based on its anticipated input, system, output, and environmental characteristics and discussed how these characteristics can be achieved using a practical system developed using nanotechnology. The advantages, benefits, constraints, and disadvantages of such nanotechnology-based system are analysed from the user point of view using the ABCD listing framework. Based on the analysis, it is found that a practical water purifier system using nanotechnology-based filters are capable to improve the performance towards ideal water purifier performance.

The effect of nanotechnology innovations on Indian automobile sector in order to solve the problems in automobile efficiency, durability, cost, and environmental pollution are discussed. Nanotechnology based solutions for Auto-Components, Auto-Engines, Auto-Tyres, Auto-Electronics, Auto-Seat Materials, Auto-Bodies, Aeroplanes, Space Crafts, and Rockets are analysed. Based on applications and benefits of nanotechnology in different areas of

automobile industry, the opportunities to realize the vision and roadmap of the country and possible impact of these innovations on economical, political and renewable energy sector in India are discussed.

The nanotechnology supported energy sources, distribution lines, energy storage systems, and energy utilising systems are becoming important and popular among the customers due to potential advantages of nanotechnology in electrical energy generation and storage. The clean energy without environmental degradation, at almost zero cost, is expected to solve energy problem of the world through the concept called ubiquitous energy. The impact of nanotechnology on seven energy sectors including solar energy, wind energy, nuclear energy, oil-fuel based energy, artificial photosynthesis, energy storage and effective energy management to promote nanotechnology based energy as ubiquitous energy system along with possible business opportunities are discussed and reviewed. Finally, the advantages, benefits, constraints and disadvantages of nanotechnology in the energy sector from business service providers and customers point of view are identified and listed.

The concept of ideal energy source using system model is developed in order to study the ultimate objectives of the energy system research and development. Based on system model, the input characteristics, system/process characteristics, output characteristics, and environmental characteristics of ideal energy system are predicted, listed, and discussed. The 35 identified characteristics are analysed and compared with renewable practical electrical energy systems and possibility of developing optimum energy system close to ideal system in terms many characteristics using suitable technology are discussed. The concept and characteristics of such predicted hypothetical ideal energy system allows researchers to think innovatively to improve the practical energy systems by identifying suitable technology and design. Though the ideal energy system is a hypothetical model, it gives ideas and sets challenges to realize it through innovative research. In this chapter, we have also 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. A comparison of the properties of the ideal energy system with nanotechnology based electrical energy system is made and is based on the predictive analysis of the possible features of nanotechnology and its various anticipated processes.

Similarly, the ultimate objective of health science is precaution and prevention of all types of diseases of living animals including human beings. Both prevention and curing of diseases need suitable drug/medicine system. The drugs presently used for different diseases have many limitations and need to be improved in terms of their ability to cure the disease completely. In this paper, we have defined a so-called ideal drug system which can help the researchers and decision makers in the drug industry to redefine their objective in research and development in the pharmaceutical industry. The drug system which can cure any diseases instantaneously is called ideal drug or ideal medicine. Based on the exact expectations of the properties from a drug system as a medicine to cure all diseases, we tried to identify the characteristics of an ideal drug which can cure all diseases in the universe. Further, we also discussed the challenges and opportunities to realize such an ideal drug which can cure all the diseases. Further, we also analysed the possibility of using nanotechnology which is emerging as universal technology to realize the possibility of developing ideal drug and in this context, on some of the research agendas focussed on solving various diseases using nanotechnology are analysed. The advantages, benefits, constraints, and disadvantages of using nanotechnology in drug research with the goal of improving them towards an ideal drug system are also listed. Finally, the comparison is made between conventional drugs and nanotechnology based drugs in terms of Ideal System Characteristics. This paper is on futuristic research along with new knowledge creation and analysis based new interpretation of nanotechnology in medicinal drugs [308-316].

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