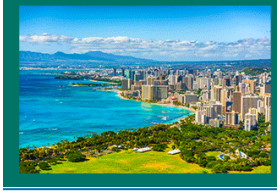
Paths Towards Energy Efficient Buildings Using Nano Architecture



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Paths Towards Energy Efficient Buildings Using Nano Architecture

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Abstract. Nanotechnology has been in a massive use in the last two decades in many fields specially the architecture and construction field. Applying nano technology in architecture is taking place and has become the biggest challenge in our time. The challenge of nano architecture is to improve the material properties, adding new properties or production new materials which used in architecture design of the building or in construction phase. The study aims to reduce the energy usage of the building by using nano architecture and to achieve one of the environmental sustainability factors.The research adopts the descriptive theoretical approach of nano technology and nano material in field of architecture and its impact on the energy use of the building. This followed by the second analytical part which examines the nano materials and nano devices through examples of global sustainable projects and nano architecture applications which leads us to a huge difference in the architecture design and reduces the total energy usage of the building. In conclusion, the research shows the effect of using nano material and devices on the building energy use which can help to save the environment by reducing the energy consumption.

Keywords: Nano architecture – Nano material – energy efficient building – environmental sustainability

1. Introduction

Nanotechnology is one of the new emerging technologies ofthe contemporary time, as a result of the international focus onnano sciences. Such technology has made it possible tomanipulate the matter on an atomic basis; this is expected totransform and revolutionizes the way of live. The nano world isa convergence of a real mix of scientific and technologicaldomains which once were separate.The Applications of nanotechnology include almost all aspects of our life, in medicine, industry, communications,transportation, and building façades. The application ofnanotechnology in architecture is wide and varies from theearly stages of sketching up to the final touches of finishing,especially in materials selection.

Nano architecture is the integration of nanotechnology in architecture, by using nano-products, nano-materials, nanotelecommunication, or even nano-shapes. In introducing nanotechnology to architecture, one should examine the benefits it can bring, such as additional functionality, value added, and market demand with regard to product development. Good design is based on demand, and the contributions to the evolution of both nanomaterial and the resulting nano-product in the long term.

1.1Problem Definition

The energy consumption is one of the largest sectors seen negatively on the environment. so consideringbuilding efficiency and recycling to preserve the environment one of the most important principles of sustainable architecture, and the methods usedSo far, there's a great need for a Re-studyProperties of materials based on modern technologies like nanotechnology to identify new possibilities of these materials reduce the negative returns are in construction and sustainability.

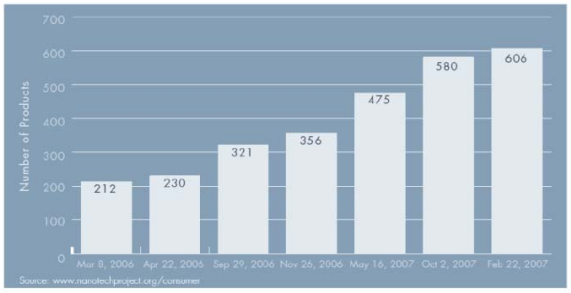
1.2 Aim and Objectives

This study aims to try using nano technology to achieve the principles of sustainability and reducing energy consumption of buildings by:

1. Monitoring and documenting the role of nano technology in achieving the principles of building sustainability.
2. Examine the application of nanotechnology in architecture to minimize the energy used in any building.
3. Clarification of nanotechnology techniques for achieving an appropriate living environment.

1.3 Nano Technology and Nano Sclae

Nanotechnology is the manipulation of matter at the scale of individual atoms and molecules. It includes processes for making materials, systems and structures. Some types of nano-materials exist in nature, but nanotechnology, the deliberate engineering of nanostructures and materials, largely began in the 1980s with the invention of new, more powerful types of microscopes. “Nanotechnology is an enabling technology that allows us to develop materials with improved or totally new properties**. (Figure 1) Development of nano products**



(Figure 1) development of total products listed for nanotechnology Source (1)

Nanoscale science, engineering, and technology are fields of research in which scientists and engineers manipulate matter at the atomic and molecular level in order to obtain materials and systems with significantly improved properties. Nanomaterials are usually defined as materials that have at least one dimension smaller than 100 nanometers. A nanometer is approximately 1/80,000th the width of a human hair or 1/7,000th the size of a single red blood cell. Materials at the nanoscale often exhibit physical, chemical and biological properties that are very different from those of their normal-sized counterparts.

2. Nano Technology and Architecture

The applications of nano technology depends on the potential inherent within the materials that have been examined to produce different materials with new properties and capabilities, in addition to the new technology of devices that have been rapidly produced that have a marked difference with many changes in the way of thinking in architecture and to lead us to a new architecture forms which helps us improve our indoor and outdoor environment.[1]**Figure**

2. Applications of Nano Technology in Architecture

2.1 Nano Material in Architecture

Nano technology enables us to work within the small particles of the material to improve its properties to give more different potentials which can make the architect face more challenges and have a lot of solutions for the design and construction problems.[2] Nano material can be classified as follows:

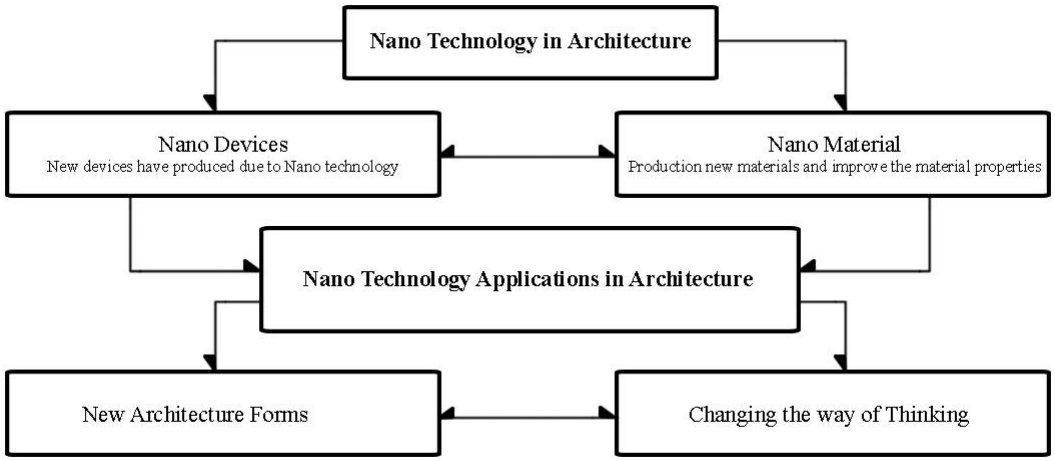


Figure 2.Applications of Nano Technology in Architecture (Source (1) editdede by the researcher)

- **Structure Material**

Nano technology in construction field can develop and improve the main structure material like concrete, steel by producing a new structure materials like Nano Carboon tubes.Structure material can do a lot like: Instead of cement in concrete mixture, Adding 3% increases pressure strength and bending from concrete mortar, Reduces CO2 emissions. **Table [1]**

- **Non – Structure Material**

Nano technology can help the non-structure material used in any building to be more effective by increasing the material's properties efficiency like Glass, wood and dry walls. They have a lot of benefits by adding SOI2 to the glass became a Fireproof glass**. Table[2]**

- **Insulation Material**

The progress has been made by nano technology in the insulation materials have made a huge difference in the lightness, firmness and flexibility of this materials like: Lumira, solar absorbing windows and thin-film insulation used in the indoor materials.There is a lot of technologies approved that insulation material have a very good effect on

energy building consuming it helps transmission of light and CO2 emissions, reducing heat gain and noise**. Table[3]**

- **Nano Coating Material**

Coating takes a big place in nano technology field of research to achieve a huge possibility in the material properties to be more effective coating materials like: self-cleaning, easy to clean and anti-finger print coating.Coating materials and its benefits like:[1]Self-Cleaning (Photo Catalytic) & Easy To Clean it is Non-sticking impurities on paint, easy to clean and reducing maintenance costs, expelling oil and water coatings (ETC) and there is a lot of other coatings like Anti-Finger Print, Anti -Graffiti, Anti - Scratching, Anti Reflection and Bacteria they have a lot of benefits like:

Anti-finger print on the outside coating, easy to clean by water, graffiti and paint resistant adhesion, adding (TIO2) it makes coating more anti bacteria and germs, improve light permeability to glass by 98% and plastic by 99%, improve lighting efficiency by 15% and reduce the reflected lights from 1% to 8%. Ultra Violet Protection have another different benefit to the indoor environment by adding (TIO2) (ZNO) (CEO) to the coating it helps to absorb the harmful rays without blocking good light**.**

2.2 Nano Devices

The revolution of nano technology in the improvement of nano devices and its applications in lighting, air and water filtration and in energy storage has become more effective to our environment.**Table[4]**It had a lot of development across the twenty past years because the new technologies and it begins to be used a lot by all the means in any field of work and study.

This tables shows the new materials and technologies started from beginning till now. they have a new technology in nano technology and new devices for energy in lighting in heating using them to consume the energy used in the public buildings or in the small residential apartments. Starting with table one till table four.

Table[1]. Structure Materials(Source By Researcher)

Nano Materials	Nano Applications	Descriptions
Concrete	Nano Silica (NS)	Instead of cement in concrete mixture, Adding 3% increases pressure strength and bending from concrete mortar, Reduces CO2 emissions.
	Nano Titanium Dioxide (TIO2)	Adding from 5% to 10% from (TIO2) increases concrete strength by 26% to 35%, self cleaning concrete.
Steel	Nano Fillers	Adding nano fillers to concrete mixture increase bending strength from 15% to 20%
Carbon Tubes	Nano Carbon Tubes	Stronger than steel more than 100 times and more lighter, flame resistance by adding nano tubes to the glass, frost resistance increased from 150 to 400 degrees Fahrenheit 46%

Table[2]. Non – Structure Materials (Source By Researcher)

Glass	Nano Titanium Dioxide (TIO2)	Blocks ultra violet rays, expel water and anti reflection by adding zinc oxide ZNO + TIO2 and self cleaning glass plus controls the air pollution.
	Silicon Dioxide (SIO2)	By adding SOI2 to the glass became a Fireproof glass
Dry walls	Dehydrated Calcium Sulfate	Light interior walls and ceilings, water and mildew resistant, less energy consumption in construction
Wood	Nano Wood	Water and oil expelling and easy to clean, wood doesn't change its color and protect it from temperature changes

Table[3]. Insulation Materials (Source By Researcher)

Dry Silica	Lumira (Aerogel)	Helps transmission of light, less consumption of energy and CO2 emissions, reducing heat gain and noise
Thin – Film Insulation	Thin – Film Insulation Sheets	Low room temperature from 2-3C, reducing electricity cost for air conditioning, blocking sunlight if needed
Solar Absorbing Windows	Solar Absorbing Nano Material	Heat gain coefficient is 0.55, visible light permeability up to 70% and less outside noises

Table[4]. Nano Devices (Source By Researcher)

Lighting	Nano LED	More energy efficient and smaller than normal lamps up to 93%, economically good for the long term use , long life more than 50.000 hours, have more speed of light
	Organic Light Emitting Diodes (OLED) – Quantum Dot Lighting (QLED)	(OLED) Reducing energy efficient usage from 2 to 10 Volt and (QLED) is more energy efficient than the OLED from 30% to 40%, reducing energy

Filtration	Indoor Air and Water Filtration	Eliminate pollutants such as viruses and bacteria without releasing oxidation in the air, detoxification of the groundwater by adding nano particles, elimination of industrial pesticides in water.

3. Environmental Sustainability

As a general term refers to the capacity to endure. Sustainable development is the development thatmeets the present needs without compromising the ability of future generations to meet their own needs [5].Currently it is considered as an infinite process through the ecosystem, a dynamic Evolutionary way towards theimprovement of management of human and natural resources. In the construction field, sustainability is a matter ofgrave importance. In architecture sustainability describes environmentally conscious design techniques, minimizingnegative environmental impact and enhancing efficiency in the use of materials, energy and space.

The principles for sustainable environmental design include:

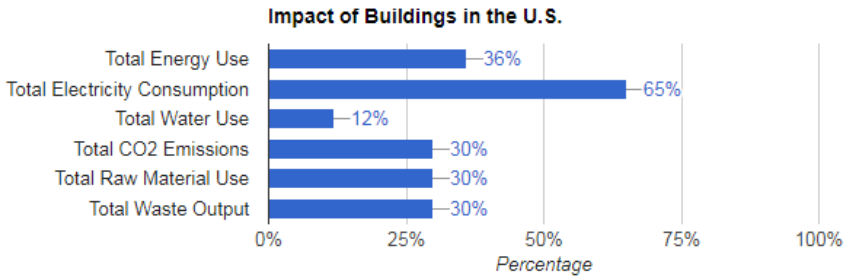
- Low-impact materials (non-toxic, sustainably produced or recycled)
- Energy efficiency (less energy in manufacturing and production)
- Quality, durability,
- Reusability and Recyclability [6]

3.1 Building sustainability with Nanotechnology

Nanotechnology is an enabling technology that is opening a new world of materials functionalities, and performances. Therefore, it is opening also new possibilities in construction sustainability. It could lead to a better use of natural resources, obtaining a specific characteristic or property with minor material use. It can (also) help to solve some problems related to energy issues in building (consumption and generation), or improve internal environmental conditions to mention only a few matters. [7]

3.2 Energy Efficient Buildings with Nano Architecture Application

The use of nanotechnology in architecture is strongly linked to sustainability, to improve energy efficiency and reducegreenhouse gases. Architects are to find innovative solutionsfor climate changes, by combining ambitious architecture withenergy efficiency. The use of materials and surfaceproperties that have now become possible throughnanotechnology offer architecture, interior architecture and related disciplines a mean of achieving greater energy efficiency and sustainable architectural design through innovations.



Source: EPA, USGBC

3.3 Efficient Use of Energy

Another key aspect of sustainability is the efficient use of energy. The most advanced nanotechnology projects related to energy are: storage, conversion, manufacturing improvements by reducing materials and process rates, energy saving by better thermal insulation for example, and enhanced renewable energy sources like solar cells. Efficient use of energy in building can be achieved through the following aspects:

3.3.1 Reduction of Energy Consumption

- **Insulation:**

In the EU, over 40% of total energy produced is consumed by buildings. Insulation is an obvious solution to reduce some of this energy use; however, limited space for installation is a major problem for building renovation. As a possible remedy, work by Aspen Aerogels has produced an ultra-thin wall insulation which uses a nano porous aerogel structure which is hydrophobic and repels water so it is mould free. Another intriguing application of aerogels is silica-based products for transparent insulation, which leads to the possibility of super-insulating windows. [4]**Figure.3 OLED Structure and Nanogel Aerogel System**

- **Lighting:**

Nanotechnological approaches like light-emitting diodes (LEDs) or quantum caged atoms (QCAs) could lead to a strong reduction of energy consumption for illumination. Reducing energy use of lighting can be the most essential field of research can be made nowadays. [15]

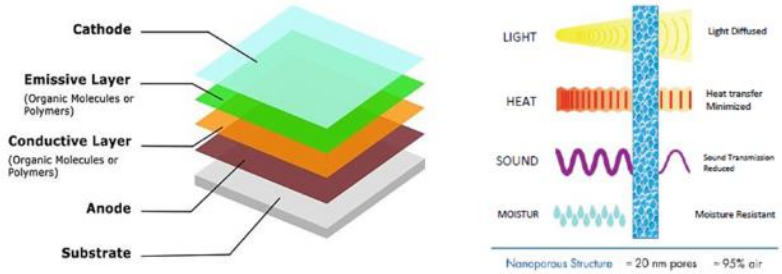


Figure.3 OLED Structure and Nanogel Aerogel System

3.3.2 Close Definition of OLED Lighting Structure Material:

An OLED (organic light-emitting diode) is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. OLEDs are used to create digital displays in devices such as television screens, computer monitors, portable systems such as mobile phones, handheld game consoles and PDAs. A major area of research is the development of white OLED devices for use in solid-state lighting applications.

An OLED is a solid-state device consisting of a thin, carbon-based semiconductor layer that emits light when electricity is applied by adjacent electrodes. In order for light to escape from the device, at least one of the electrodes must be transparent. The intensity of the light emitted is controlled by the amount of electric current applied by the electrodes, and the light's color is determined by the type of emissive material used.

4. Analytical Nano Technology Studies

There is an opportunity for OLED Nano lighting to have a significant impact in short term. A combination of Recent

LED and OLED lighting will enable the greatest energy and cost savings. What is required is collaboration. OLED panel performance has been demonstrated, but the high cost of panels is slowing the market development of OLED lighting. By thinking creatively and collaborating together, the industry can come up with lower-cost solutions. Dealing with nano technology and all of its new terms can make the future more advanced and glorious. By mixing insulation and lighting.

4.1 Example 1.

Sports hall, Carquefou, ZAC du Souchais, France	
Architecture Agency	MA, Murail Architectures, Nantes,France
Client	City of Carquefou
Manufacture	Multi-wall panels with nano Aerogel filling
Opened	2006
Area	3,360 m² with Surface l,450 m²
CO2 Emissions	Greenhouse gases reduction by energy saving and natural lighting

Figure 4 Sports hall, Carquefou, ZAC du Souchais, France (internal and external view)

4.1.1 Description:

All elevations of this sports complex have been clad withaerogel-filledmulti-wall polycarbonate panels. With thisconstruction the architects voluntarily comply with theguidelines set down by the French "green" environmentalinitiative Haute QualityEnvironmental (HQE).

Additionalsolar protection is unnecessary, allowing a clean and unifiedappearance uninterrupted by brise-soleils or louvers. Naturaldaylight provides an even and glare-free illumination of theindoor space and additional indoor lighting is not necessaryduring the day. There are no cast shadows that could bedistracting for certain sports. The thermal insulating effect ofthe aerogel panels also reduces the heat demand: a 25 mm thickpanel has a U-value of 0.89 W/ m² K and is available in 1.05 m
wide panels of up to 6 m in length**.**

4.2.2 Close Definition of Aerogel Insulation Material:

Aerogel currently holds the record as the lightest known solid material and was developed back in 1931. It is relatively banal: it is simply ultra-light aerated foam that consists almost 100% of air. The remaining foam material is a glass-like material, and silica. The nanodimension is of vital importance for the pore interstices of the foam: the air molecules trapped within the minute nanopores –each with a mean size of just 20nm – are unable to move, lending the aerogel its excellent thermal insulation properties. **The Nanogel makes up a translucent panel, which achieves**

a remarkable level of energy saving while providing indoor spaces with natural light.

4.2 Example 2.

LightHouse Tower Project	
Architecture Agency	Mikou Design studio
Client	Brazilian city of Rio de Janeiro NanoLED
Manufacture	2011
Opened	paths and public venues
Type	Illuminated with bright light with little emission heat -save energy
CO2 Emissions	

4.2.1Description: Infusing new life to conventional lighthouses, installed to mark dangerous coastlines, hazardous shoals and reefs in and around the sea, Mikou Design Studio has planned a tower to build in the Brazilian city of Rio de Janeiro. Entitled the "Lighthouse Tower," the mammoth structure is rooted on the island of Cotunduba and makes an arched gateway to the capital city. Accessed through a large gate from the sea, the modern lighthouse provides enough space for a number of observation points, an auditorium, skywalk, bungee jump platform and climbing tower, together with a gyro drop, cafeteria, souvenir store, urban balconies and multi-usage space.

Figure 5 multi-usage space in lighthouse tower

Illuminated with bright (possibly Nano LED) lights, the tower does not only look good at night but also provides a mesmerizing view of the "samba" city. Nano LED Makes the building More energy efficient and it's smaller than normal lamps up to 93%, economically good for thelong-termuse, long life more than 50.000 hours, have more speed of light.

4.2.2 Examples Conclusion

Nanomaterialsand nanotechnologies are expected to contribute to greatly improve different environments.

- Nanotechnology give great facilitates to better use of natural resources.
- Nanotechnology not only resolves many problems associated with various construction materials, but it also reduces the impact of the construction industry on the environment and improves sustainability.
- Nanotechnology offers low cost solutions for demanding problems such as energy consumption in buildings.

5. Conclusion and Recommendation

Potentiality - benefits and risks

A central aim of nanotechnology is to consistently use the minimum amount of raw material and energy: from an ecological point of view "nano" is a winning factor. From the point of view of the client or the user, the most realistic and sensible application of nanotechnology focuses on aspects of functionalityand sustainability. The use of nanotechnologies in the design and construction disciplines usually involves the optimization of existing products or common materials. Nanotechnology brings us a step closer towards customized materials with specific individual properties and represents a shift away from the catalogue of standard materials. Similarly to Le Corbusier, who once quoted that “a house is a machine to live in”; we are able now to describe ahouse as a living machine or even a living organism. There are nevertheless two important challenges for future research: achieve to combine properties in real life and manage to produce large scale structures within viable cost limits.

The importance of taking into consideration what Nanotechnology has to offer concerning energy consumption in buildings and its sustainability.

- To Keep with and share experiences with all nations that have started to interact with these technologies in different fields by establishing nanotechnology research centers.

- Nanotechnologies may be directly used for new forms of architectural art, and architectural urban design, but it will be an effective tool to give many functional alternatives in design process.
- The Nanotechnology has possibilities to help many developing countries solve problems. It also present an opportunities to bridge the gap between the east and west.

- Egypt has a very big market for Nano products in order to help solve many of our urban architectural problems.

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