"Fundamentals of Industrial Ecology".

In Section 1 of this course you will cover these topics:

- Technology And Environment
- Industrial Design Of Processes And Products

Topic : Technology And Environment

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Technology
- Understand the Environmental Design

Definition/Overview:

Design for Environment (DfE) is a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service, where environmental impacts are considered across its life cycle.

Life cycle assessment (LCA) is employed to forecast the impacts of different (production) alternatives of the product in question, thus being able to choose the environmentally friendliest. Different software tools have been developed to assist designers in finding optimised products (or processes/services). Design for Environment includes several subsidiary approaches, such as Design for Disassembly (to facilitate recycling) and source reduction.

Key Points:

1. Technology

Technology is a broad concept that deals with an animal species' usage and knowledge of tools and crafts, and how it affects an animal species' ability to control and adapt to its environment. Technology is a term with origins in the Greek "technologia", "τεχνολογία" "techne", "τέχνη" ("craft") and "logia", "λογία" ("saying"). However, a strict definition is elusive; "technology" can refer to material objects of use to humanity, such as machines, hardware or utensils, but can also encompass broader themes, including systems, methods of organization, and techniques. The term can either be applied generally or to specific areas: examples include "construction technology", "medical technology", or "state-of-the-art technology". The human race's use of technology began with the conversion of natural resources into simple tools. The prehistorical discovery of the ability to control fire increased the available sources of food and the invention of the wheel helped humans in travelling in and controlling their environment. Recent technological developments, including the printing press, the telephone, and the Internet, have lessened physical barriers to communication and allowed humans to interact on a global scale. However, not all technology has been used for peaceful purposes; the development of weapons of ever-increasing destructive power has progressed throughout history, from clubs to nuclear weapons. Technology has affected society and its surroundings in a number of ways. In many societies, technology has helped develop more advanced economies (including today's global economy) and has allowed the rise of a leisure class. Many technological processes produce unwanted by-products, known as pollution, and deplete natural resources, to the detriment of the Earth and its environment. Various implementations of technology influence the values of a society and new technology often raises new ethical questions. Examples include the rise of the notion of efficiency in terms of human productivity, a term originally applied only to machines, and the challenge of traditional norms.

Philosophical debates have arisen over the present and future use of technology in society, with disagreements over whether technology improves the human condition or worsens it. Neo-Luddism, anarcho-primitivism, and similar movements criticize the pervasiveness of technology in the modern world, claiming that it harms the environment and alienates people; proponents of ideologies such as transhumanism and techno-progressivism view continued technological progress as beneficial to society and the human condition. Indeed, until recently, it was believed that the development of technology was restricted only to human beings, but recent scientific studies indicate that other primates and certain dolphin communities have developed simple tools and learned to pass their knowledge to other generations.

In general technology is the relationship that society has with its tools and crafts, and to what extent society can control its environment. The Merriam-Webster dictionary offers a definition of the term: "the practical application of knowledge especially in a particular area" and "a capability given by the practical application of knowledge". Ursula Franklin, in her 1989 "Real World of Technology" lecture, gave another definition of the concept; it is "practice, the way we do things around here". The term is often used to imply a specific field of technology, or to refer to high technology or just consumer electronics, rather than technology as a whole. Bernard Stiegler, in Technics and Time, 1, defines technology in two ways: as "the pursuit of life by means other than life", and as "organized inorganic matter." Technology can be most broadly defined as the entities, both material and immaterial, created by the application of mental and physical effort in order to achieve some value. In this usage, technology refers to tools and machines that may be used to solve real-world problems. It is a far-reaching term that may include simple tools, such as a crowbar or wooden spoon, or more complex machines, such as a space station or particle accelerator. Tools and machines need not be material; virtual technology, such as computer software and business methods, falls under this definition of technology.

The word "technology" can also be used to refer to a collection of techniques. In this context, it is the current state of humanity's knowledge of how to combine resources to produce desired products, to solve problems, fulfill needs, or satisfies wants; it includes technical methods, skills, processes, techniques, tools and raw materials. When combined with another term, such as "medical technology" or "space technology", it refers to the state of the respective field's knowledge and tools. "State-of-the-art technology" refers to the high technology available to humanity in any field. Technology can be viewed as an activity that forms or changes culture. Additionally, technology is the application of math, science, and the arts for the benefit of life as it is known. A modern example is the rise of communication technology, which has lessened barriers to human interaction and, as a result, has helped spawn new subcultures; the rise of cyberculture has, at its basis, the development of the Internet and the computer. Not all technology enhances culture in a creative way; technology can also help facilitate political oppression and war via tools such as guns. As a cultural activity, technology predates both science and engineering, each of which formalizes some aspects of technological endeavor.

2. Environmental Design

Environmental design is the process of addressing environmental parameters when devising plans, programs, policies, buildings, or products. Classical prudent design may have always considered environmental factors; however, the environmental movement beginning in the 1960s has made the concept more explicit. Environmental Design has been defined: "We live in the world by design. Creating the everyday environment in which we live involves complex systems of cultural meaning, visual communication and the use of tools, technology and materials. As a field of study, Environmental Design encompasses the built, natural, and human environments and focuses on fashioning physical and social interventions informed by human behaviour and environmental processes. Design asks us to find answers to the most fundamental of human questions: how should we live in the world and what should inform our actions? This complex endeavour requires an interdisciplinary approach." Environmental design in the old-fashioned sense develops physical environments, both interior and exterior, to meet one or more aesthetic or day-to-day functional needs, or to create a specific sort of experience the focus being the human-designed environment. Environmental design includes such specialities as architects, acoustical scientists, engineers, environmental scientists, landscape architects, urban planning, interior designers, lighting designers, and exhibition designers. In many situations, historic preservation can be added to this list. Another recent addition to this general area might be "disability access". In terms of a larger scope, environmental design has implications for the industrial design of products: innovative automobiles, wind-electricity generators, solar-electric equipment, and other kinds of equipment could serve as examples.

Topic : Industrial Design Of Processes And Products

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Industrial Ecology
- Understand the History
- Learn about the Principles

Definition/Overview:

Industrial Ecology (IE) is an interdisciplinary field that focuses on the sustainable combination of environment, economy and technology.

Sustainable design (also referred to as "green design", "eco-design", or "design for environment") is the art of designing physical objects and the built environment to comply with the principles of economic, social, and ecological sustainability. It ranges from the microcosm of designing small objects for everyday use, through to the macrocosm of designing buildings, cities, and the earth's physical surface. It is a growing trend within the fields of architecture, landscape architecture, urban design, urban planning, engineering, graphic design, industrial design, interior design and fashion design.

Key Points:

1. Industrial Ecology

Industrial Ecology is an interdisciplinary field that focuses on the sustainable combination of environment, economy and technology. The central idea is the analogy between natural and socio-technical systems. The word 'industrial' does not only refer to industrial complexes but more generally to how humans use natural resources in the production of goods and services. Ecology refers to the concept that our industrial systems should incorporate principles exhibited within natural ecosystems. Industrial ecology is the shifting of industrial process from linear (open loop) systems, in which resource and capital investments move through the system to become waste, to a closed loop system where wastes become inputs for new processes. Industrial ecology proposes not to see industrial systems (for example a factory, an ecoregion, or national or global economy) as being separate from the biosphere, but to consider it as a particular case of an ecosystem - but based on infrastructural capital rather than on natural capital. It is the idea that as natural systems do not have waste in them, we should model our systems after natural ones if we want them to be sustainable. Along with more general energy conservation and material conservation goals, and redefining commodity markets and product stewardship relations strictly as a service economy, industrial ecology is one of the four objectives of Natural Capitalism. This strategy discourages forms of amoral purchasing arising from ignorance of what goes on at a distance and implies a political economy that values natural capital highly and relies on more instructional capital to design and maintain each unique industrial ecology.

The needed aim of sustainable design is to produce places, products and services in a way that reduces use of non-renewable resources, minimizes environmental impact, and relates people with the natural environment. Sustainable design is often viewed as a necessary tool for achieving sustainability. It is related to the more heavy-industry-focused fields of industrial ecology and green chemistry, sharing tools such as life cycle assessment and life cycle energy analysis to judge the environmental impact or "greenness" of various design choices. Sustainable design is general reaction to the global "environmental crisis", i.e., rapid growth of economic activity and human population, depletion of natural resources, damage to ecosystems and loss of biodiversity. The appearance is that our growing use of the earth has exceeded the sustainable limits of the earth importantly because of continually increasing investment in diminishing resources. Proponents of sustainable design generally believe the crisis may be resolved by using innovative design and industrial practices which reduce the environmental impacts associated with goods and services. Green design is considered a means of doing that while maintaining quality of life by using clever design to substitute less harmful products and processes for conventional ones.

The limits of green design in reducing whole earth impacts are beginning to be considered because growth in goods and services is consistently outpacing gains in efficiency. As a result the net effect of sustainable design to date has been to simply improve the efficiency of rapidly increasing impacts. The present approach, which focuses on the efficiency of delivering individual goods and services, does not solve this problem. The basic dilemmas not yet well addressed include: the increasing complexity of efficiency improvements, the difficulty of implementing new technologies in societies built around old ones, that physical impacts of delivering goods and services are not localized but distributed throughout the economies, and that the scale of resource uses is growing and not stabilizing. 'Transformative' technologies are hoped for, but workable options are not yet evident. Only if the scale of resource uses stabilizes will the efficiency of how they are each delivered result in reducing total impacts. The motivation for sustainable design was articulated famously in E. F. Schumacher's 1973 book Small is Beautiful. Finally, green design is not the attachment or supplement of architectural design, but an integrated design process within architectural design.

2. History

Industrial ecology was popularized in 1989 in a Scientific American article by Robert Frosch and Nicholas E. Gallopoulos. Frosch and Gallopoulos' vision was "why would not our industrial system behave like an ecosystem, where the wastes of a species may be resource to another species? Why would not the outputs of an industry be the inputs of another, thus reducing use of raw materials, pollution, and saving on waste treatment?" A notable example resides in a Danish industrial park in the city of Kalundborg. Here several linkages of byproducts and waste heat can be found between numerous entities such as a large power plant, an oil refinery, a pharmaceutical plant, a plasterboard factory, an enzyme manufacturer, a waste company and the city itself.

The scientific field Industrial Ecology has grown fast in recent years. The Journal of Industrial Ecology (since 1997), the International Society for Industrial Ecology (since 2001), and the journal Progress in Industrial Ecology (since 2004) give Industrial Ecology a strong and dynamic position in the international scientific community. Industrial Ecology principles are also emerging in various policy realms such as the concept of the Circular Economy that is being promoted in China. Although the definition of the Circular Economy has yet to be formalized, generally the focus is on strategies such as creating a circular flow of materials, and cascading energy flows. An example of this would be using waste heat from one process to run another process that requires a lower temperature. This maximizes the efficiency of energy use. The hope is that strategy such as this will create a more efficient economy with fewer pollutants and other unwanted by products.

3. Principles

One of the central principles of Industrial Ecology is the view that societal and technological systems are bounded within the biosphere, and do not exist outside of it. Ecology is used as a metaphor due to the observation that natural systems reuse materials and have a largely closed loop cycling of nutrients. Industrial Ecology approaches problems with the hypothesis that by using similar principles as natural systems, industrial systems can be improved to reduce their impact on the natural environment as well. The Kalundborg industrial park is located in Denmark. This industrial park is special because companies reuse each others' waste (which then becomes by-products). For example, the Energy E2 Asns Power Station produces gypsum as a by product of the electricity generation process; this gypsum becomes a resource for the BPB Gyproc A/S which produces plasterboards. This is one example of a system inspired by the biosphere-technosphere metaphor: in ecosystems, the waste from one organism is used as inputs to other organisms; in industrial systems, waste from a company is used as a resource by others. IE examines societal issues and their relationship with both technical systems and the environment. Through this holistic view, IE recognizes that solving problems must involve understanding the connections that exist between these systems, various aspects cannot be viewed in isolation. Often changes in one part of the overall system can propagate and cause changes in another part. Thus, you can only understand a problem if you look at its parts in relation to the whole. Based on this framework, IE looks at environmental issues with a systems thinking approach.

Take a city for instance. A city can be divided into commercial areas, residential areas, offices, services, infrastructures, etc. These are all sub-systems of the 'big city system. Problems can emerge in one sub-system, but the solution has to be global. Lets say the price of housing is rising dramatically because there is too high a demand for housing. One solution would be to build new houses, but this will lead to more people living in the city, leading to the need of more infrastructure like roads, schools, more supermarkets, etc. This system is a simplified interpretation of reality whose behaviors can be predicted. In many cases, the systems IE deals with are complex systems. Complexity makes it difficult to understand the behavior of the system and may lead to rebound effects. Due to unforeseen behavioral change of users or consumers, a measure taken to improve environmental performance does not lead to any improvement or may even worsen the situation. For instance, in big cities, traffic can become problematic. Finally, the other days, both cars are allowed on the roads. The first effect could be that people buy a second car, with a specific demand for license plate numbers, so they can drive every day. The rebound effect is that, the days when all cars are allowed to drive, some inhabitants now use both cars (whereas they only had one car to use before the policy). The policy did obviously not lead to environmental improvement but even made air pollution worse.

In Section 2 of this course you will cover these topics:

- Designing For Energy And Efficiency
- Industrial Process Residues: Composition And Minimization

Topic : Designing For Energy And Efficiency

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Energy
- Understand the Energy Efficiency
- Learn about the Transportation
- Understand the Residential Sector, Commercial Sector and Industrial Sector

Definition/Overview:

Energy: In physics, energy is a scalar physical quantity that describes the amount of work that can be performed by a force. Energy is an attribute of objects and systems that is subject to a conservation law.

Key Points:

1. Energy Efficiency Trends in United States

The United States is currently the largest single consumer of energy. The U.S. Department of Energy categorizes national energy use in four broad sectors: transportation, residential, commercial, and industrial.

1. Transportation

The transportation includes all vehicles used for personal or freight transportation. Of the energy used in this sector, approximately 65% is consumed by gasoline-powered vehicles, primarily personally owned. Diesel-powered transport (trains, merchant ships, heavy trucks, etc.) consumes about 20%, and air traffic consumes most of the remaining 15%. The oil supply crises of the 1970s spurred the creation, in 1975, of the federal Corporate Average Fuel Economy (CAFE) program, which required auto manufacturers to meet progressively higher fleet fuel economy targets. The next decade saw dramatic improvements in fuel economy, mostly the result of reductions in vehicle size and weight which originated in the late 1970s, along with the transition to front wheel drive. These gains eroded somewhat after 1990 due to the growing popularity of sport utility vehicles, pickup trucks and minivans, which fall under the more lenient "light truck" CAFE standard. In addition to the CAFE program, the U.S. government has tried to encourage better vehicle efficiency through tax policy. Since 2002, taxpayers have been eligible for income tax credits for gas/electric hybrid vehicles. A "gas-guzzler" tax has been assessed on manufacturers since 1978 for cars with exceptionally poor fuel economy. While this tax remains in effect, it currently generates very little revenue as overall fuel economy has improved. The gas-guzzler tax ended the reign of large cubic-inched engines from the musclecar era. Another focus in gasoline conservation is reducing the number of miles driven. An estimated 40% of American automobile use is associated with daily commuting. Many urban areas offer subsidized public transportation to reduce commuting traffic, and encourage carpooling by providing designated high-occupancy vehicle lanes and lower tolls for cars with multiple riders. In recent years telecommuting has also become a viable alternative to commuting for some jobs, but as of 2003 only 3.5% of workers were telecommuters. Ironically, hundreds of thousands of American and European workers have been replaced by workers in Asia who telecommute from thousands of miles away. A vehicle's gas mileage normally decreases rapidly at speeds above 55 miles per hour. A car or truck moving at 55 miles (89 km) an hour can get about 15 percent better fuel economy than the same car going 65 mph (105 km/h). According to the U.S. Department of Energy (DOE), as a rule of thumb, each 5 mph (8.0 km/h) you drive over 60 mph (97 km/h) is similar to paying an additional $0.21 per gallon for gas (not true for all vehicles, some may attain maximum fuel efficiency at a higher speed than 60 mph (97 km/h)

2. Residential Sector

The residential sector refers to all private residences, including single-family homes, apartments, manufactured homes and dormitories. Energy use in this sector varies significantly across the country, due to regional climate differences and different regulation. On average, about half of the energy used in U.S. homes is expended on space conditioning (i.e. heating and cooling). The efficiency of furnaces and air conditioners has increased steadily since the energy crises of the 1970s. The 1987 National Appliance Energy Conservation Act authorized the Department of Energy to set minimum efficiency standards for space conditioning equipment and other appliances each year, based on what is "technologically feasible and economically justified". Beyond these minimum standards, the Environmental Protection Agency awards the Energy Star designation to appliances that exceed industry efficiency averages by an EPA-specified percentage. Despite technological improvements, many American lifestyle changes have put higher demands on heating and cooling resources. The average size of homes built in the United States has increased significantly, from 1,500 sq ft (140 m) in 1970 to 2,300 sq ft (210 m) in 2005. The single-person household has become more common, as has central air conditioning: 23% of households had central air conditioning in 1978, that figure rose to 55% by 2001. As furnace efficiency gets higher, there is limited room for improvement efficiencies above 85% are now common. However, improving the building envelope through better or more insulation, advanced windows, etc., can allow larger improvements. The passive house approach produces superinsulated buildings that approach zero net energy consumption. Improving the building envelope can also be cheaper than replacing a furnace or air conditioner.

Even lower cost improvements include weatherization, which is frequently subsidized by utilities or state/federal tax credits, as are programmable thermostats. Consumers have also been urged to adopt a wider indoor temperature range (e.g. 65 F (18 C) in the winter, 80 F (27 C) in the summer). One underutilized, but potentially very powerful means to reduce household energy consumption is to provide real-time feedback to homeowners so they can effectively alter their energy using behavior. Recently, low cost energy feedback displays, such as The Energy Detective or wattson have become available. A study of a similar device deployed in 500 Ontario homes by Hydro One showed an average 6.5% drop in total electricity use when compared with a similarly sized control group. Standby power used by consumer electronics and appliances while they are turned off accounts for an estimated 5 to 10% of household electricity consumption, adding an estimated $3 billion to annual energy costs in the USA. "In the average home, 75% of the electricity used to power home electronics is consumed while the products are turned off."

3. Home Energy Consumption Averages:

- Space conditioning, 44%
- Water heating, 13%
- Lighting, 12%

- Refrigeration, 8%
- Home electronics, 6%
- Laundry appliances, 5%
- Kitchen appliances, 4%
- Other uses, 8%

Energy usage in some homes may vary widely from these averages. For example, milder regions such as the southern U.S. and Pacific coast of the USA need far less energy for space conditioning than New York City or Chicago. On the other hand, air conditioning energy use can be quite high in hot-arid regions (Southwest) and hot-humid zones (Southeast) In milder climates such as San Diego, lighting energy may easily consume up to 40% of total energy. Certain appliances such as a waterbed, hot tub, or pre-1990 refrigerator use significant amounts of electricity. However, recent trends in home entertainment equipment can make a large difference in household energy use. For instance a 50" LCD television (average on-time= 6 hours a day) may draw 300 Watts less than a similarly sized plasma system. In most residences no single appliance dominates, and any conservation efforts must be directed to numerous areas in order to achieve substantial energy savings. However, Ground and Water Source Heat Pump systems are the more energy efficient, environmentally clean, and cost-effective space conditioning systems available (Environmental Protection Agency), and can achieve reductions in energy consumptions of up to 69%.

4. Best Building Practices

Current best practices in building design and construction result in homes that are profoundly more energy conserving than average new homes.
Smart ways to construct homes such that minimal resources are used to cooling and heating the house in summer and winter respectively can significantly reduce energy costs.

5. Commercial Sector

The commercial sector consists of retail stores, offices (business and government), restaurants, schools and other workplaces. Energy in this sector has the same basic end uses as the residential sector, in slightly different proportions. Space conditioning is again the single biggest consumption area, but it represents only about 30% of the energy use of commercial buildings. Lighting, at 25%, plays a much larger role than it does in the residential sector. Lighting is also generally the most wasteful component of commercial use. A number of case studies indicate that more efficient lighting and elimination of over-illumination can reduce lighting energy by approximately fifty percent in many commercial buildings. Commercial buildings can greatly increase energy efficiency by thoughtful design, with today's building stock being very poor examples of the potential of systematic (not expensive) energy efficient design. Commercial buildings often have professional management, allowing centralized control and coordination of energy conservation efforts. As a result, fluorescent lighting (about four times as efficient as incandescent) is the standard for most commercial space, although it may produce certain adverse health effects. Potential health concerns can be mitigated by using newer fixtures with electronic ballasts rather than older magenetic ballasts. As most buildings have consistent hours of operation, programmed thermostats and lighting controls are common. However, too many companies believe that merely having a computer controlled Building automation system guarantees energy efficiency. As an example one large company in Northern California boasted that it was confident its state of the art system had optimized space heating. A more careful analysis by Lumina Technologies showed the system had been given programming instructions to maintain constant 24 hour temperatures in the entire building complex. This instruction caused the injection of nighttime heat into vacant buildings when the daytime summer temperatures would often exceed 90 F (32 C). This mis-programming was costing the company over $130,000 per year in wasted energy. Many corporations and governments also require the Energy Star rating for any new equipment purchased for their buildings. Solar heat loading through standard window designs usually leads to high demand for air conditioning in summer months. An example of building design overcoming this excessive heat loading is the Dakin Building in Brisbane, California, where fenestration was designed to achieve an angle with respect to sun incidence to allow maximum reflection of solar heat; this design also assisted in reducing interior over-illumination to enhance worker efficiency and comfort. Recent advances include use of occupancy sensors to turn off lights when spaces are unoccupied, and photosensors to dim or turn off electric lighting when natural light is available. In air conditioning systems, overall equipment efficiencies have increased as energy codes and consumer information have begun to emphasise year round performance rather than just efficiency ratings at maximum output. Controllers that automatically vary the speeds of fans, pumps, and compressors have radically improved part-load performance of those devices. For space or water heating, electric heat pumps consume roughly half the energy required by electric resistance heaters. Natural gas heating efficiencies have improved through use of condensing furnaces and boilers, in which the water vapor in the flue gas is cooled to liquid form before it is discharged, allowing the heat of condensation to be used. In buildings where high levels of outside air are required, heat exchangers can capture heat from the exhaust air to preheat incoming supply air.

6. Industrial Sector

The industrial sector represents all production and processing of goods, including manufacturing, construction, farming, water management and mining. Increasing costs have forced energy-intensive industries to make substantial efficiency improvements in the past 30 years. For example, the energy used to produce steel and paper products has been cut 40% in that time frame, while petroleum/aluminum refining and cement production have reduced their usage by about 25%. These reductions are largely the result of recycling waste material and the use of cogeneration equipment for electricity and heating. The energy required for delivery and treatment of fresh water often constitutes a significant percentage of a region's electricity and natural gas usage (an estimated 20% of California's total energy use is water-related.) In light of this, some local governments have worked toward a more integrated approach to energy and water conservation efforts. Unlike the other sectors, total energy use in the industrial sector has declined in the last decade. While this is partly due to conservation efforts, it's also a reflection of the growing trend for U.S. companies to move manufacturing operations overseas.

Topic : Industrial Process Residues: Composition And Minimization

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Industrial Waste
- Understand the Extended Producer Responsibility
- Learn about the Hazardous Waste

Definition/Overview:

Industrial waste: Industrial waste is a type of waste produced by industrial activity, such as that of factories, mills and mines. It has existed since the outset of the industrial revolution.

Extended producer responsibility: Extended Producer Responsibility (EPR) is a strategy designed to promote the integration of all costs associated with products throughout their life cycle (including end-of-life disposal costs) into the market price of the product.

Key Points:

1. Industrial Waste

Industrial waste is a type of waste produced by industrial activity, such as that of factories, mills and mines. It has existed since the outset of the industrial revolution. Much industrial waste is not hazardous or toxic, such as waste fiber produced by agriculture and logging. Toxic waste and chemical waste are two designations of industrial waste. Sewage treatment can be used to clean water tainted with industrial waste. There are a number of concepts about waste management which vary in their usage between countries or regions. Some of the most general, widely-used concepts include: Waste hierarchy the waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The waste hierarchy remains the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste.

2. Extended Producer Responsibility

Extended Producer Responsibility (EPR) is a strategy designed to promote the integration of all costs associated with products throughout their life cycle (including end-of-life disposal costs) into the market price of the product. Extended producer responsibility is meant to impose accountability over the entire lifecycle of products and packaging introduced to the market. This means that firms which manufacture, import and/or sell products are required to be responsible for the products after their useful life as well as during manufacture. Polluter pays principle the Polluter Pays Principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the waste.

3. Hazardous Waste

The term "hazardous waste" comprises all toxic chemicals, radioactive materials, and biologic or infectious waste. These materials threaten workers through occupational exposure and the general public in their homes, communities, and general environment. Exposure to these materials can occur near the site of generation, along the path of its transportation, and near their ultimate disposal sites. Most hazardous waste results from industrial processes that yield unwanted byproducts, defective products, and spilled materials. The generation and disposal of hazardous wastes is controlled through a variety of international and national regulations. Hazardous waste was formerly known as 'special' waste.

4. Hazardous Waste in United States

Many types of businesses generate hazardous waste. Some are small areas that may be located in a community. For example, dry cleaners, automobile repair shops, hospitals, exterminators, and photo processing centers all generate hazardous waste. Some hazardous waste generators are larger companies like chemical manufacturers, electroplating companies, and oil refineries. A US facility that treats, stores or disposes of hazardous waste must obtain a permit for doing so under the Resource Conservation and Recovery Act. Generators of and transporters of hazardous waste must meet specific requirements for handling, managing, and tracking waste. Through the RCRA, Congress directed the United States Environmental Protection Agency (EPA) to create regulations to manage hazardous waste. Under this mandate, the EPA developed strict requirements for all aspects of hazardous waste management including the treatment, storage, and disposal of hazardous waste. In addition to these federal requirements, states may develop more stringent requirements or requirements that are broader in scope than the federal regulations. In the United States, hazardous wastes generated by commercial or industrial activities may be classified as "listed" hazardous wastes or "characteristic" hazardous wastes by the EPA.

In Section 3 of this course you will cover these topics:

- Choosing Materials
- Product Delivery: Packing, Transport, And Installation

Topic : Choosing Materials

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Sustainable design
- Understand the Sustainable Planning and Technologies

Definition/Overview:

Sustainable architecture: Sustainable architecture is the design of sustainable buildings. Sustainable architecture attempts to reduce the collective environmental impacts during the production of building components, during the construction process, as well as during the lifecycle of the building (heating, electricity use, carpet cleaning etc).

Key Points:

1. Sustainable Design

Sustainable design (environmental design, environmentally sustainable design (ESD), environmentally-conscious design) is the philosophy of designing physical objects, the built environment and services to comply with the principles of economic, social, and ecological sustainability. The intention of sustainable design is to "eliminate negative environmental impact completely through skillful, sensitive design". Manifestations of sustainable designs require no non-renewable resources, impact on the environment minimally, and relate people with the natural environment. Applications of this philosophy range from the microcosm - small objects for everyday use, through to the macrocosm - buildings, cities, and the earth's physical surface. It is a philosophy that can be applied in the fields of architecture, landscape architecture, urban design, urban planning, engineering, graphic design, industrial design, interior design, and fashion design. Sustainable design is a general reaction to global environmental crises, the rapid growth of economic activity and human population, depletion of natural resources, damage to ecosystems and loss of biodiversity.

The limits of sustainable design in reducing whole earth impacts are beginning to be considered because growth in goods and services is consistently outpacing gains in efficiency. As a result, the net effect of sustainable design to date has been to simply improve the efficiency of rapidly increasing impacts. The present approach, which focuses on the efficiency of delivering individual goods and services, does not solve this problem. The basic dilemmas not yet well addressed include: the increasing complexity of efficiency improvements, the difficulty of implementing new technologies in societies built around old ones, that physical impacts of delivering goods and services are not localized but distributed throughout the economies, and that the scale of resource uses is growing and not stabilizing. 'Transformative' technologies are hoped for, but workable options are not yet evident. Only if the scale of resource uses stabilizes will the efficiency of how they are each delivered result in reducing total impacts. The motivation for sustainable design was articulated famously in E. F. Schumacher's 1973 book

Small Is Beautiful. In architecture, sustainable design is not the attachment or supplement of architectural design, but an integrated design process. This requires close cooperation of the design team, the architects, the engineers and the client at all project stages, from the site selection, scheme formation, material selection and procurement and project implementation.

2. Sustainable Planning

Urban planners that are interested in achieving sustainable development or sustainable cities use various design principles and techniques when designing cities and their infrastructure. These include Smart Growth theory, Transit-oriented development, sustainable urban infrastructure and New Urbanism. Smart Growth is an urban planning and transportation theory that concentrates growth in the center of a city to avoid urban sprawl; and advocates compact, transit-oriented development, walkable, bicycle-friendly land use, including mixed-use development with a range of housing choices. Transit-oriented development attempts to maximise access to public transport and thereby reduce the need for private vehicles. Public transport is considered a form of Sustainable urban infrastructure, which is a design approach which promotes protected areas, energy-efficient buildings, wildlife corridors and distributed, rather than centralised, power generation and wastewater treatment. New urbanism is more of a social and aesthetic urban design movement than a green one, but it does emphasize diversity of land use and population, as well as walkable communities which inherently reduce the need for automotive travel. Both urban and rural planning can benefit from including sustainability as a central criterion when laying out roads, streets, buildings and other components of the built environment. Conventional planning practice often ignores or discounts the natural configuration of the land during the planning stages, potentially causing ecological damage such as the stagnation of streams, mudslides, soil erosion, flooding and pollution. Applying methods such as scientific modelling to planned building projects can draw attention to problems before construction begins, helping to minimise damage to the natural environment. Cohousing is an approach to planning based on the idea of intentional communities. Such projects often prioritize common space over private space resulting in grouped structures that preserve more of the surrounding environment.

3. Sustainable Technologies

Sustainable technologies are technologies which use less energy, fewer limited resources, do not deplete natural resources, do not directly or indirectly pollute the environment, and can be reused or recycled at the end of their useful life. There is a significant overlap with appropriate technology, which emphasizes the suitability of technology to the context, in particular considering the needs of people in developing countries. However, the most appropriate technology may not be the most sustainable one; and a sustainable technology may have high cost or maintenance requirements that make it unsuitable as an "appropriate technology," as that term is commonly used.

Topic : Product Delivery: Packing, Transport, And Installation

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Environmental Impact of Buildings
- Understand the Green Building Practices
- Learn about the Green Building Material

Definition/Overview:

The topic provides a general overview of the environmental impacts of buildings, the topic also explains the green building practices used today and the material that is used in the Green Building.

Packing: Packing, also known as an O-ring or other type of Seal (mechanical), a term for a sealing material.

Key Points:

1. The Environmental Impact of Buildings

Buildings have a profound effect on the environment, which is why green building practices are so important to dramatically reduce those impacts. Buildings in the United States account for a large amount of land use, energy and water consumption, and air and atmosphere alteration. More specifically, in 2002, the amount of land developed was 107,300,000 acres (434,000 km) out of 1.983 billion acres of total land, excluding Hawaii and Alaska. This is a 24% increase in ten years. Since 2002, developed land has increased significantly. Out of all the total energy consumed by Americans in 2002, 39.4% was consumed by buildings. From that percentage, 54.6% was consumed by residential buildings and 45.4% by commercial buildings. As for electricity, in 2002 building used 67.9% of the total amount consumed in the United States. With 51.2% used by residential buildings and 48.8% by commercial buildings. 38.1% of the total amount of carbon dioxide in the United States can be attributed to buildings. 20.6% from homes and 17.5% from commercial uses. Part of this has to do with the location of homes and other buildings that people travel by automobile everyday. Buildings account for 12.2% of the total amount of water consumed per day in the United States. Given these statistics, reducing the amount of natural resources buildings consume and the amount of pollution given off is crucial for future sustainability. However, the environmental impact of buildings is often underestimated, while the perceived costs of building green are overestimated. A recent survey by the World Business Council for Sustainable Development finds that green costs are overestimated by 300%, as key players in real estate and construction estimate the additional cost at 17% above conventional construction, more than triple the true average cost difference of about 5%.

2. Green Building Practices

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other techniques, such as using packed gravel for parking lots instead of concrete or asphalt to enhance replenishment of ground water, are used as well. Effective green buildings are more than just a random collection of environmental friendly technologies, however. They require careful, systemic attention to the full life cycle impacts of the resources embodied in the building and to the resource consumption and pollution emissions over the building's complete life cycle. On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

3. Green Building Materials

Building materials typically considered to be 'green' include rapidly renewable plant materials like bamboo and straw, lumber from forests certified to be sustainably managed, dimension stone, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable, and/or recyclable (e.g. Trass, Linoleum, sheep wool, panels made from paper flakes, baked earth, rammed earth, clay, vermiculite, flax linen, sisal, seagrass, cork, expanded clay grains, coconut, wood fibre plates, calcium sand stone...). Building materials should be extracted and manufactured locally to the building site to minimize the energy embedded in their transportation.

4. Reduced Energy Use

Green buildings often include measures to reduce energy use. To increase the efficiency of the building envelope, (the barrier between conditioned and unconditioned space), they may use high-efficiency windows and insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement (daylighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy loads. After heating and cooling loads are reduced, high efficiency cooling, heating, and water heating equipment, along with insulated hot water pipes and properly sealed and insulated ducts increase whole house efficiency. Higher efficiency appliances and other electric devices not only lowers direct energy use, but also lowers cooling loads in the summer by producing less waste heat. Similarly, fluorescent lighting, which uses one-fourth to one-fifth less energy than conventional incandescent bulbs lowers direct electricity use and cooling loads. Other improvements include adding thermal mass to stabilize daily temperature variations, absorption chillers, optimizing houses for natural ventilation, cool roofs in warm climates, heat recovery ventilation and hot water heat recycling. Finally, onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.

5. Reduced Waste

Green architecture also seeks to reduce waste of energy, water and materials. During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills. To reduce the impact on wells or water treatment plants, several options exist. "Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars. Rainwater collectors are used for similar purposes. Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission. Producing artificial fertilizer is also more costly in energy than this process.

In Section 4 of this course you will cover these topics:

- Environmental Interactions During Product Use
- Design For Recycling

Topic : Environmental Interactions During Product Use

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Product
- Understand the Equivalent or Interchangeable Product

Definition/Overview:

Environmental policy: Environmental policy is any (course of) action deliberately taken (or not taken) to manage human activities with a view to prevent, reduce or mitigate harmful effects on nature and natural resources, and ensuring that man-made changes to the environment do not have harmful effects on humans.

Key Points:

1. Product

In marketing, a product is anything that can be offered to a market that might satisfy a want or need. In retailing, products are called merchandise. In manufacturing, products are purchased as raw materials and sold as finished goods. Commodities are usually raw materials such as metals and agricultural products, but a commodity can also be anything widely available in the open market. The verb produce (prə doos' or -dyoos') is from the Latin prōdūce(re), (to) lead or bring forth. The noun product (prod'əkt or-ukt) is "a thing produced by labor or effort". Since 1575, the word "product" has referred to anything produced. Since 1695, the word has referred to "thing or things produced". The economic or commercial meaning of product was first used by political economist Adam Smith. In general usage, product may refer to a single item or unit, a group of equivalent products, a grouping of goods or services, or an industrial classification for the goods or services.

2. Equivalent or interchangeable product

The specific meaning of generic product names varies over time and location. Some products such as bread, milk, and salt have been bartered or sold for centuries, but the meaning of "bread" or "milk" as a product varies. The technologies were not available for pasteurization and homogenization of milk until the 20th century, and these food processing technologies are not used worldwide. Bread varies by type of grain, specific recipe, and size of loaf. In 1924, Morton Salt introduced iodized table salt, a product previously unavailable. Since 1961, pork bellies have traded on the Chicago Mercantile Exchange, but due to selective breeding and changes in hog feed, today's pork belly is not exactly equivalent to a 1960s pork belly. Certain products may be considered equivalent or interchangeable for the purposes of trade, record-keeping, and reporting, despite gradual changes in the product or variations among geographical locations.

The distinction between a new product and a minor modification to an existing product is not always clear. Certain products have a product life cycle in which the supply and demand for the product increases then decreases over time. The demand for certain food products such as bread will tend to increase with population, but the supply and demand for a specific brand of bread may decline over time. In the United States, a patent for a product is recognition that the product is new in a legal sense. "Utility patents may be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof; design patents may be granted to anyone who invents a new, original, and ornamental design for an article of manufacture; and, plant patents may be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant." In business an equivalent, interchangeable or fungible product is defined by a company and its customers. A company's inventory is a set of physical products, or goods, that are usually recorded as counts of equivalent unique products, such as 50 8-oz cans of salsa. The equivalent unique products may be assigned a product code or item code, such that "50 8-oz cans of salsa" is recorded as "50 17766443" on the company's records. If the company carries two brands of 8-oz salsa, it may assign separate item codes to the brands, or it may use a single item code for both brands.

Topic : Design For Recycling

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Recycling
- Understand the Supply and Collection

Definition/Overview:

Recycling: Recycling is the reprocessing of old materials into new products, with the aims of preventing the waste of potentially useful materials, reducing the consumption of fresh raw materials, reducing energy usage, reducing air (from incineration) and water (from landfilling) pollution by reducing the need for "conventional" waste disposal, and lowering greenhouse gas emissions as compared to virgin production. Recycling is a key concept of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy, though colloquial usage of "recycling" can also include "reuse".

Key Points:

1. Recycling

Recycling is the reprocessing of old materials into new products, with the aims of preventing the waste of potentially useful materials, reducing the consumption of fresh raw materials, reducing energy usage, reducing air (from incineration) and water (from landfilling) pollution by reducing the need for "conventional" waste disposal, and lowering greenhouse gas emissions as compared to virgin production. Recycling is a key concept of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy, though colloquial usage of "recycling" can also include "reuse". "Recyclable materials" or "recyclables", may originate from home, business or industry. They include glass, paper, metal, textiles and plastics. Though analogus, the composting of biodegradable waste such as food or garden waste is not typically considered recycling. These materials are either brought to a collection centre or picked-up from the curbside; and sorted, cleaned and reprocessed into new products bound for manufacturing. To judge the environmental benefits of recycling, the cost of this entire process must be compared to the cost of virgin extraction. In order for recycling to be economically viable, there usually must be a steady supply of recyclates and constant demand for the reprocessed goods; both of which can be stimulated through government legislation. Meanwhile, critics claim that government mandated recycling wastes more resources than it saves. These critics claim that free market prices, and not politicians, are the most accurate way to determine whether or not any particular type of garbage should be recycled. According to these critics, whenever recycling truly does save resources, the private sector will voluntarily offer people money for their garbage. Much of the difficulty inherent in recycling comes from the fact that most products are not designed with recycling in mind. The concept of sustainable design aims to solve this problem, and was first laid out in the book "Cradle to Cradle: Remaking the Way We Make Things" by architect William McDonough and chemist Michael Braungart. They suggest that every product (and all packaging they require) should have a complete "closed-loop" cycle mapped out for each component a way in which every component will either return to the natural ecosystem through biodegradation or be recycled indefinitely. As with environmental economics, care much be taken to ensure a complete view of the costs an benefits involved. For example, cardboard packaging for food products is more easily recycled than plastic, but is heavier to ship and may result more waste from spoilage.

2. Supply

In order for a recycling program to work, having a large, stable supply of recyclable material is crucial. Three legislative options have been used to create such a supply: mandatory recycling collection, container deposit legislation, and refuse bans. Mandatory collection laws set recycling targets for cities to aim for, usually in the form that a certain percentage of a material must be diverted from the city's waste stream by a target date. The city is then responsible for working to meet this target. Container deposit legislation involves offering a refund for the return of certain containers, typically glass, plastic, and metal. When a product in such a container is purchased, a small surcharge is added to the price. This surcharge can be reclaimed by the consumer if the container is returned to a collection point. These programs have been very successful, often resulting in an 80% recycling rate. Despite such good results, the shift in collection costs from local government to industry and consumers has created strong opposition to the creation of such programs in some areas. A third method of increase supply of recyclates is to ban the disposal of certain materials as waste, often including used oil, old batteries, tires and garden waste. One aim of this method is to create a viable economy for proper disposal of banned products. Care must be taken that enough of these recycling services exist, or such bans simply lead to increased illegal dumping.

3. Collection

A number of different systems have been implemented to collect recyclates from the general waste stream. These systems tend to lie along the spectrum of trade-off between public convenience and government ease and expense. The three main categories of collection are "drop-off centres", "buy-back centres" and "curbside collection". Drop-off centres require the waste producer to carry the recyclates to a central location, either an installed or mobile collection station or the reprocessing plant itself. They are the easiest type of collection to establish, but suffer from low and unpredictable throughput. Buy-back centres differ in that the cleaned recyclates are purchased, thus providing a clear incentive for use and creating a stable supply. The post-processed material can then be sold on, hopefully creating a profit. Unfortunately government subsidies are necessary to make buy-back centres a viable enterprise, as according to the United States Nation Solid Wastes Management Association it costs on average US$50 to process a ton of material, which can only be resold for US$30.

In Section 5 of this course you will cover these topics:

- Dfe Assessments Of Products And Processes
- Implementing Dfe In The Corporation

Topic : Dfe Assessments Of Products And Processes

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Design for Environment
- Understand the Simple Online Calculators
- Learn about the Economic Impact Models

Definition/Overview:

The topic tends to explain the concept of the design for environment, the simple online calculators and the economic impact models.

Product Assessment: Product Assessment is verification and validation of the specified functionality and, if applicable, development cycle.

Key Points:

1. Design for Environment

Design for Environment (DfE) is a general concept that refers to a variety of design approaches that attempt to reduce the overall environmental impact of a product, process or service, where environmental impacts are considered across its life cycle. Life cycle assessment (LCA) is employed to forecast the impacts of different (production) alternatives of the product in question, thus being able to choose the environmentally friendliest. Different software tools have been developed to assist designers in finding optimized products (or processes/services). Design for Environment includes several subsidiary approaches, such as Design for Disassembly (to facilitate recycling) and source reduction.

2. Simple Online Calculators

The Energy Star building energy calculator & targeting tool based on the US IEA and CBECS data from long term US nationwide energy use surveys. This is the estimator that projects use to qualify for a Green Globes rating. It is solid and simple but tells you less about your particular choices - Easy carbon footprint tools, are the simplest of the tools that estimate the total by adding up the easily visible parts.

3. Economic Impact Models

The "$Shadow" impact estimation method starts simple to get the correct scale of total impacts. It uses the long range trends in US DOE and EU IEA data, 8000btu/$ and .57kiloCO2/$ (in 2007 for 1995$), as global standard measures for the total energy used worldwide to deliver a unit of GDP, and then adjusting for local circumstances. Approached this way it appears that our choices are responsible for 10 or more times the impacts visible from the methods that just add up the visible and accountable parts.

4. Advanced Impact and Energy analysis Tools

US DOE list of "building energy tools" This is a huge list and is probably quite incomplete, but has good concise software reviews. All the design and engineering software packages are also starting to build in energy impact tools and climate modeling, etc. Many of them rely on the move to BIM whole building design data models that allow many consultants to work on the same building or urban design scheme at once. The "Greenhouse Gas Protocol" is an intergovernmental data service used by the major international bodies for organizing the greenhouse gas data and reporting requirements. It's organized primarily by industry. "Athena Eco-Calculator" is an advanced and thorough Life-Cycle impact assessment tool for buildings. You might look it up on the DOE list above for their review. "EcoFootprinting" provides a way to measure your total use of productive land, or 'ecological footprint'. Its figures are based on studies showing that our burden on renewable resources is significantly greater than the earth's regenerative capacities, and still increasing. The results may not measure uncertainty, but would probably be comparable to each other.

Topic : Implementing Dfe In The Corporation

Topic Objective:

At the end of this topic student would be able to:

- Learn about the Sustainable Planning
- Understand the Sustainable Architecture
- Understand the Sustainable Landscape
- Understand the Sustainable Product Design
- Understand the Agriculture
- Understand the Domestic Machinery

Definition/Overview:

Sustainable architecture: Sustainable architecture is the design of sustainable buildings.

Corporation: A corporation is a legal entity separate from the persons that form it. It is a legal entity owned by individual stockholders.

Key Points:

1. Sustainable Planning

Urban planners that are interested in achieving sustainable development or sustainable cities use various design principles and techniques when designing cities and their infrastructure. These include Smart Growth theory, Transit-oriented development, sustainable urban infrastructure and New Urbanism. Smart Growth is an urban planning and transportation theory that concentrates growth in the center of a city to avoid urban sprawl; and advocates compact, transit-oriented development, walkable, bicycle-friendly land use, including mixed-use development with a range of housing choices. Transit-oriented development attempts to maximise access to public transport and thereby reduce the need for private vehicles. Public transport is considered a form of Sustainable urban infrastructure, which is a design approach which promotes protected areas, energy-efficient buildings, wildlife corridors and distributed, rather than centralised, power generation and wastewater treatment. New urbanism is more of a social and aesthetic urban design movement than a green one, but it does emphasize diversity of land use and population, as well as walkable communities which inherently reduce the need for automotive travel. Both urban and rural planning can benefit from including sustainability as a central criterion when laying out roads, streets, buildings and other components of the built environment. Conventional planning practice often ignores or discounts the natural configuration of the land during the planning stages, potentially causing ecological damage such as the stagnation of streams, mudslides, soil erosion, flooding and pollution. Applying methods such as scientific modelling to planned building projects can draw attention to problems before construction begins, helping to minimise damage to the natural environment. Cohousing is an approach to planning based on the idea of intentional communities. Such projects often prioritize common space over private space resulting in grouped structures that preserve more of the surrounding environment.

2. Sustainable Architecture

Sustainable architecture attempts to reduce the collective environmental impacts during the production of building components, during the construction process, as well as during the lifecycle of the building (heating, electricity use, carpet cleaning etc) This design practice emphasizes efficiency of heating and cooling systems, alternative energy sources such as passive solar, appropriate building siting, reused or recycled building materials, on-site power generation (solar technology, ground source heat pumps, wind power), rainwater harvesting for gardening and washing, and on-site waste management such as green roofs that filter and control stormwater runoff. Sustainable architects design with sustainable living in mind.

3. Sustainable Landscape Architecture

Sustainable landscape architecture is a category of sustainable design concerned with the planning and design of outdoor space. Design techniques planting trees to shade buildings from the sun or protect them from wind, using local materials, on-site composting and chipping to reduce greenwaste hauling, and also may involve using drought-resistant plantings in arid areas (xeriscaping) and buying stock from local growers to avoid energy use in transportation.

4. Sustainable Product Design

Sustainable graphic design considers the environmental impacts of graphic design products (such as packaging, printed materials, publications, etc.) throughout a life cycle that includes: raw material; transformation; manufacturing; transportation; use; and disposal. Techniques for sustainable graphic design include: reducing the amount of materials required for production; using paper and materials made with recycled, post-consumer waste; printing with low-VOC inks; and using production and distribution methods that require the least amount of transport.

5. Agriculture

There are strenuous discussions - among others by the agricultural sector and authorities - if existing pesticide protocols and methods of soil conservation adequately protect topsoil and wildlife. Doubt has risen if these are sustainable, and if agrarian reforms would permit an efficient agriculture with fewer pesticides, therefore reducing the damage to the ecosystem.

6. Domestic Machinery

Automobiles and appliances can be designed for repair and disassembly (for recycling), and constructed from recyclable materials such as steel, aluminum and glass, and renewable materials, such as Zelfo, wood and plastics from natural feedstocks. Careful selection of materials and manufacturing processes can often create products comparable in price and performance to non-sustainable products. Even mild design efforts can greatly increase the sustainable content of manufactured items.

7. Disposable Products

Detergents, newspapers and other disposable items can be designed to decompose, in the presence of air, water and common soil organisms. The current challenge in this area is to design such items in attractive colors, at costs as low as competing items. Since most such items end up in landfills, protected from air and water, the utility of such disposable products is debated.

8. Sustainable Technologies

Sustainable technologies are technologies which use less energy, fewer limited resources, do not deplete natural resources, do not directly or indirectly pollute the environment, and can be reused or recycled at the end of their useful life. There is a significant overlap with appropriate technology, which emphasizes the suitability of technology to the context, in particular considering the needs of people in developing countries. However, the most appropriate technology may not be the most sustainable one; and a sustainable technology may have high cost or maintenance requirements that make it unsuitable as an "appropriate technology," as that term is commonly used.

9. Encouraging Sustainability

The use of sustainable technologies may be encouraged through means such as reducing the capacity of the electrical cable supplying a home, such as Australia's Crystal Waters Village. In some cases the electricity supplier charges a higher rate for the energy used when the capacity of the supply is increased (for example, in Indonesia). The Ecosa Institute began offering total immersion programs in sustainable design in 2000. Open to designers and non-designers alike, these semester programs were founded on the idea that interdisciplinary learning and real-world projects were critical ingredients in a sustainable education. Currently, one of the first sustainable low- and mid-income family housing projects in the country is on its way to construction in the Mission Lane neighborhood of Phoenix, Arizona, designed by Ecosa Institute students. In recent years, there has been an increase in the number of certificate and degree programs offered with a concentration in sustainable design. Carnegie Mellon University's Master of Science in Sustainable Design degree program provides an integrated education that strives to prepare its graduates for careers that will reshape the built environment in a sustainable fashion. This challenging program is intended for recent graduates and practicing professionals with degrees related to the built environment including architecture, landscape architecture, ecology, engineering, construction, interior architecture/ design, facilities management and others. Carnegie Mellon School of Architecture was recently ranked No. 1 in sustainable design in the United States by Design Intelligence.

Boston Architectural College offers both a certificate in sustainable design, as well as a bachelor of design studies degree with a concentration in sustainable design. Additionally, the University of Texas main campus in Austin offers a masters degree in architecture with emphasis on sustainable design. Western Washington University in Bellingham, WA has a growing sustainable design program as a cooperation between the Industrial Design major the and Huxley

College of the Environment. With an increased focus on the importance of sustainable design globally, there is likely to be higher demand for professionals educated specifically in this discipline. In 2007, Philadelphia University began offering a Master of Science in Sustainable Design degree. This program seeks a horizontal acquisition of knowledge and skills based on collaborative and interdisciplinary work.

Minneapolis College of Art and Design's ground breaking Sustainable Design Certificate Program is the first ever accredited online certificate program not exclusive to architecture, focusing on sustainability ideas that can be applied to any effort. The program was developed, and is taught, by long-standing eco-practitioners and advocates for sustainable design, including members of: Worldchanging, Biomimicry Guild, The Natural Step, Sustainable Packaging Coalition, and the Permaculture Guild, with the core group coming from the o2 Global Network. As an all online program, students come from all industries, cultures, and career stages to share ideas and insights while learning how to apply systems thinking to their own work. Not limited to designers, business and government decision makers find they not only learn how to apply sustainability systems thinking, but learn creative out-of-the-box thinking as well.