Principles of Sustainable Design

2nd Lecture

Everybody loves the sunshine

My life, my life, my life, my life
In the sunshine...

Everybody loves the sunshine, sunshine
Everybody loves the sunshine, sunshine
Folk's get down in the sunshine, sunshine
Folk's get brown in the sunshine

Just bee's and thangs and flowers
Just bee's and thangs and flowers
Just bee's and thangs and flowers
Just bee's and thangs and flowers

My life, my life, my life, my life
In the sunshine...

Everybody loves the sunshine, sunshine
Everybody loves the sunshine, sunshine
Folks get down in the sunshine, sunshine
Folks get brown in the sunshine

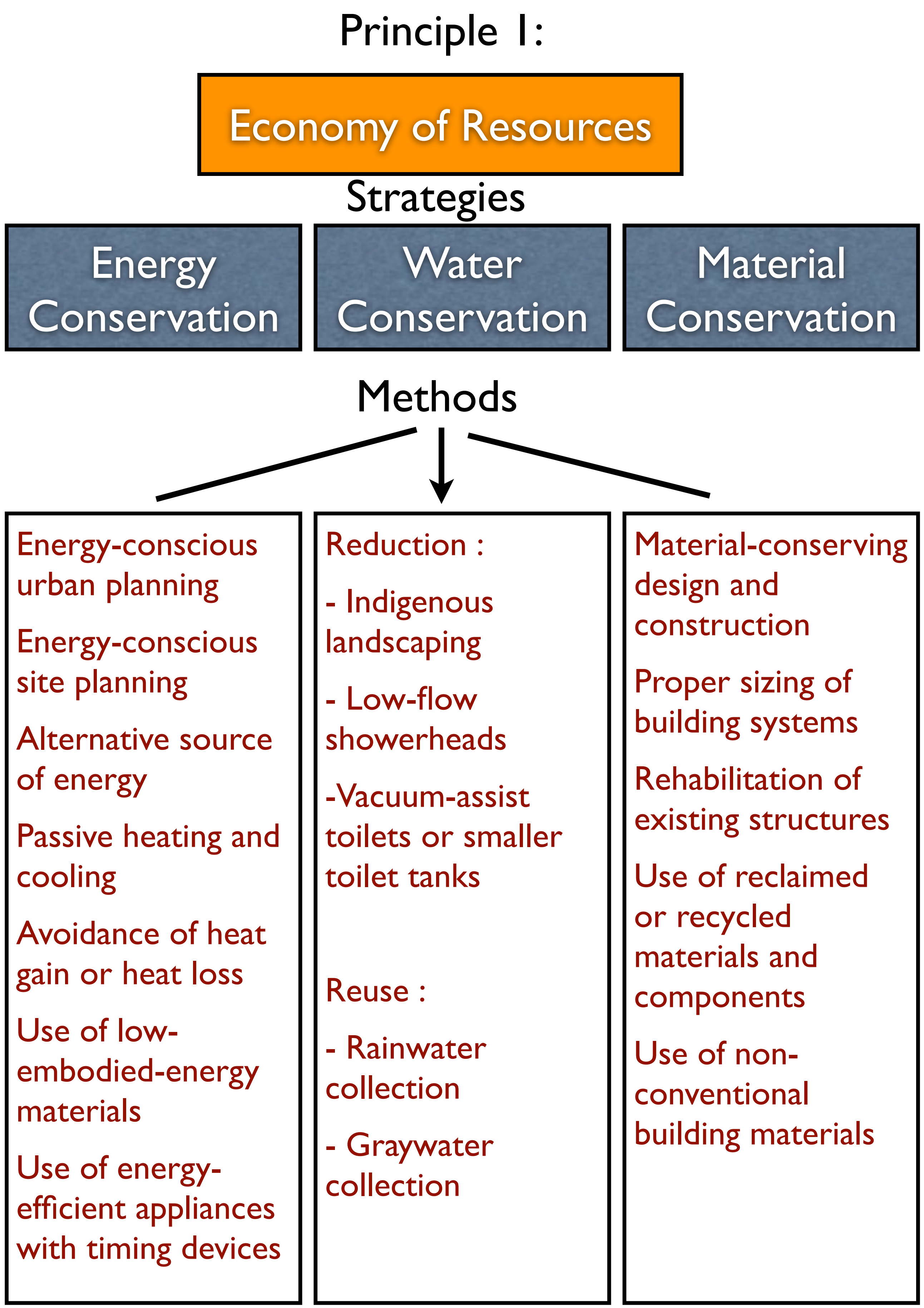
Feel what I feel, what I feel, what I feel what I'm feelin
In the sunshine
Feel what I feel, what I feel, what I feel, what I'm feelin
In the sunshine
Do what I do what I do what I do what I'm doing
In the sunshine
Do what I do what I do what I do what I'm doing
In the sunshine

Everybody loves the sunshine
Sunshine...

Roy Ayers

Methods for Achieving Sustainable Design

Economy of Resources
Life Cycle Design
Humane Design



Economy of Resources methods of application

Economy of Resources

Conserving energy, water, and materials can yield specific design methods that will improve the sustainability of architecture. These methods can be classified as two types.

1) **Input-reduction methods** reduce the flow of nonrenewable resources input to buildings. A building's resource demands are directly related its efficiency in utilizing resources.

2) **Output-management methods** reduce environmental pollution by requiring a low level of waste and proper waste management.

Economy of Resources

Principle 1:

Economy of Resources

Strategies

Energy Conservation

Methods

- Energy-conscious urban planning
- Energy-conscious site planning
- Alternative source of energy
- Passive heating and cooling
- Avoidance of heat gain or heat loss
- Use of low-embodied-energy materials
- Use of energy-efficient appliances with timing devices

Economy of Resources methods of application

Economy of Resources

Principle 1:

Economy of Resources

Strategies

Water Conservation

Methods

Reduction :

- Indigenous landscaping
- Low-flow showerheads
- Vacuum-assist toilets or smaller toilet tanks

Reuse :

- Rainwater collection
- Graywater collection

Economy of Resources methods of application

Economy of Resources

Principle 1:

Economy of Resources

Strategies

Material Conservation

Methods

- Material-conserving design and construction
- Proper sizing of building systems
- Rehabilitation of existing structures
- Use of reclaimed or recycled materials and components
- Use of non-conventional building materials

Economy of Resources methods of application

Economy of Resources

Energy Conservation

Energy-Conscious Urban Planning

Cities and neighborhoods that are energy-conscious are not planned around the automobile, but around **public transportation** **and** **pedestrian walkways**.

These cities have zoning laws favorable to **mixed-use developments**, allowing people to live near their workplaces.

Urban sprawl is avoided by **encouraging** **redevelopment of existing sites** **and the adaptive** **reuse of old buildings**.

Climatic conditions determine orientation and clustering.

For example, a very cold or very hot and dry climate might require buildings sharing walls to reduce exposed surface area; a hot, humid climate would require widely spaced structures to maximize natural ventilation.

Economy of Resources

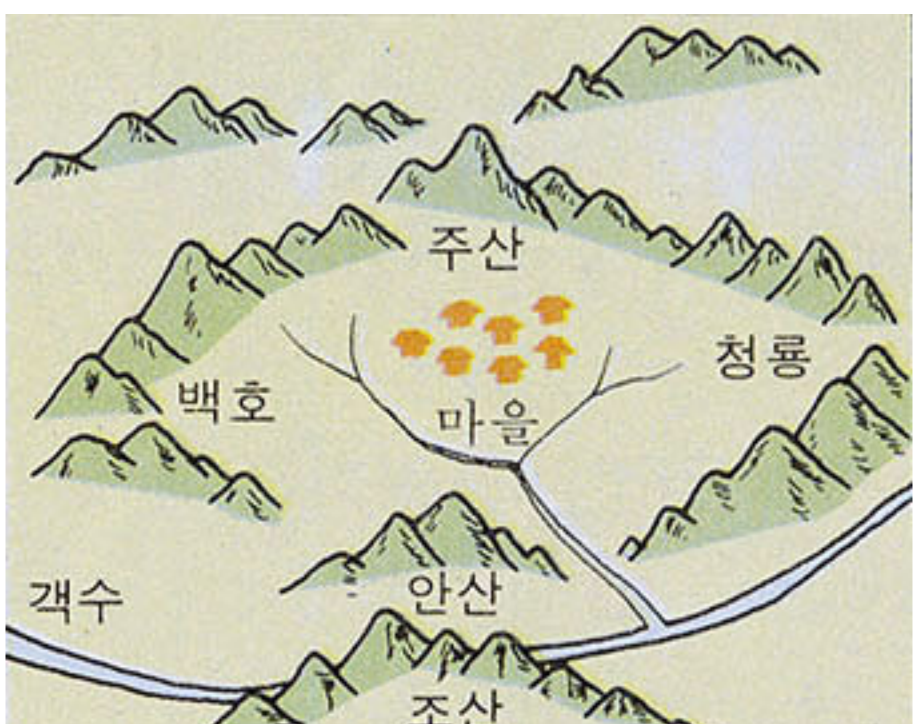
Energy Conservation

Energy-Conscious Site Planning

Such planning allows the designer to <u>maximize the use of natural resources on the site</u>. In temperate climates, open southern exposure will encourage passive solar heating; deciduous trees provide shade in summer and solar heat gain in winter. Evergreens planted on the north of a building will protect it from winter winds, improving its energy efficiency.

Buildings can be located relative to water onsite to provide natural cooling in summer.

장풍득수
藏風得水



배산임수背山臨水

- 일조와 이사취득 용이
- 계절풍에 유리-밤에 저지대에 형성되는 냉기층과 산정부근의 바람으로부터격리
- **삼대**가 적선을 해야 **남향집**에 산다.

Climate기후 - 오랜기간의 평균 기상

Weather기상- **기상이란 대기의 다양한 상태를 말함.**

- **Weather** is the state of the atmosphere, to the degree that it is hot or cold, wet or dry, calm or stormy, clear or cloudy.

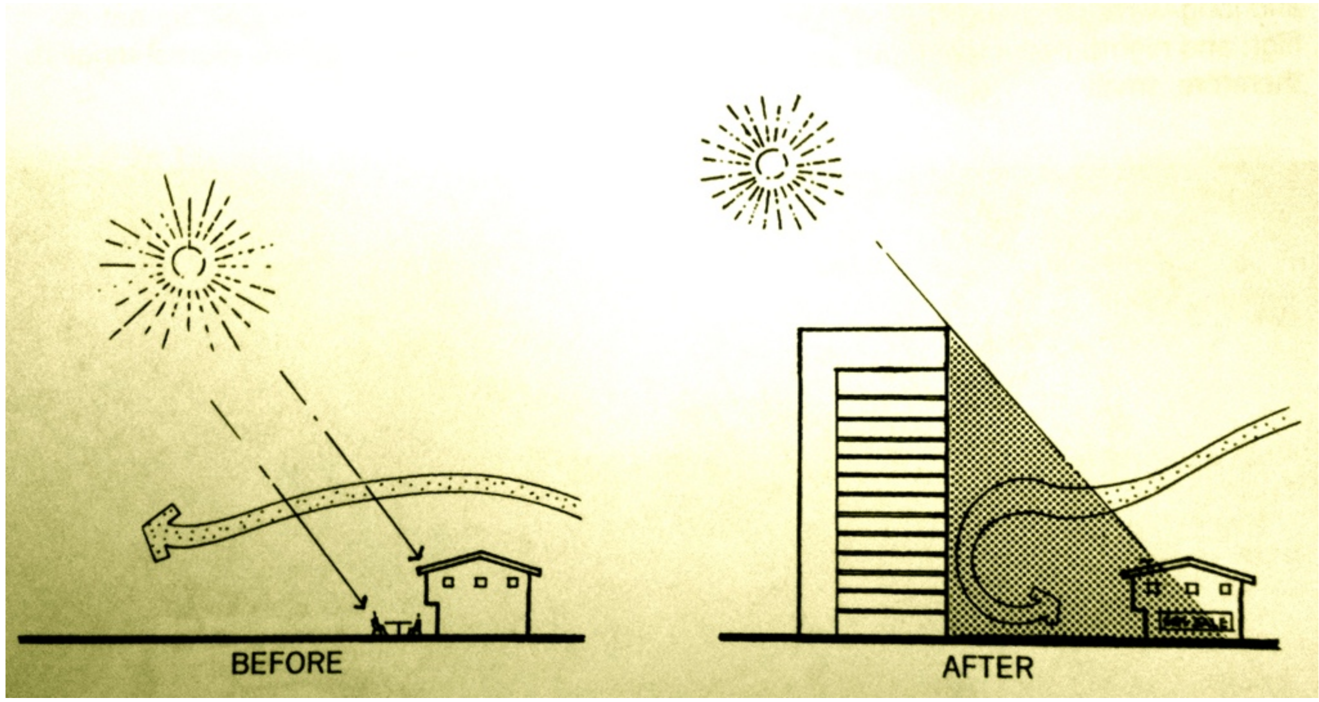
Micro Climate미기후-대기의 물리적 상태로, 건물, 실개천, 빗물 침투시설 및 숲의 존재 등에 영향을 받아 생활주변에서 나타나는 아주 작은 지역기후특성을 말함.(친환경 주택의 건설기준 및 성능)

- A **microclimate** is a local atmospheric zone where the climate differs from the surrounding area. 대지 및 주변

Macro Climate지역기후

- 건물 주변

기후
Climate



Microclimate

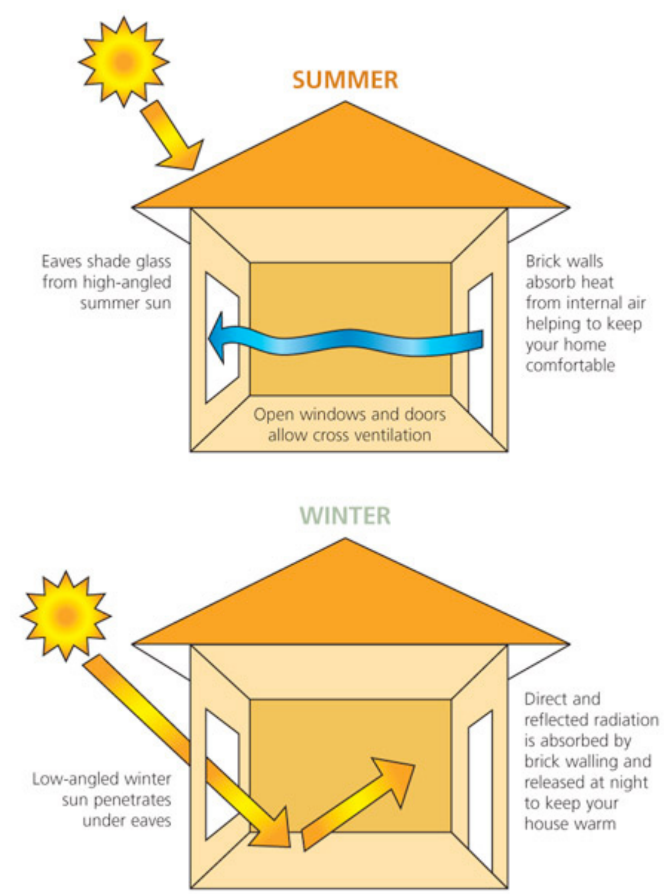
Economy of Resources

Energy Conservation

Passive Heating and Cooling

Solar radiation incident on building surfaces is the most significant energy input to buildings. It provides heat, light, and ultraviolet radiation necessary for photosynthesis. Historically, architects have devised building forms that provide shading in summer and retain heat in winter. This basic requirement is often overlooked in modern building design. Passive solar architecture offers design schemes to control the flow of solar radiation using building structure, so that it may be utilized at a more desirable time of day.

Shading in summer, by plants or overhangs, prevents summer heat gain and the accompanying costs of air-conditioning. The wind, or the flow of air, provides two major benefits: cooling and hygienic effects. Prevailing winds have long been a major factor in urban design. For instance, proposals for Roman city layouts were primarily based on the direction of prevailing winds.



Economy of Resources

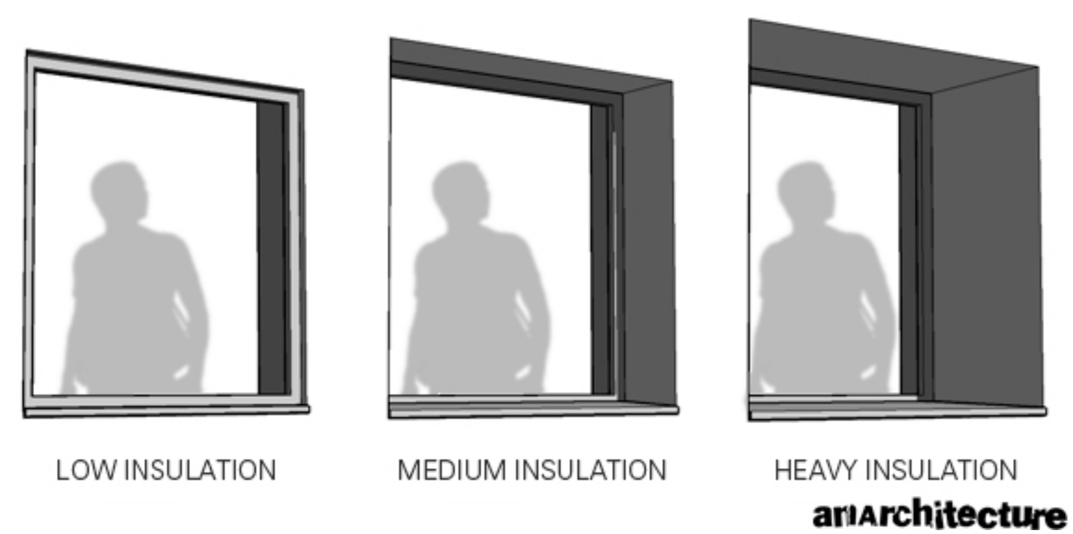
Energy Conservation

Insulation

High-performance windows and wall insulation prevent both heat gain and loss. Reducing such heat transfer reduces the building's heating and cooling loads and thus its energy consumption. Reduced heating and cooling loads require smaller HVAC equipment, and the initial investment need for the equipment will be smaller.

Aside from these tangible benefits, high-performance windows and wall insulation create more comfortable thermal environments.

Due to the insulating properties of the materials, the surface temperatures of windows and walls will be higher in the winter and lower in the summer. The installation of smaller HVAC equipment reduces mechanical noise and increases sonic quality of the indoor space.

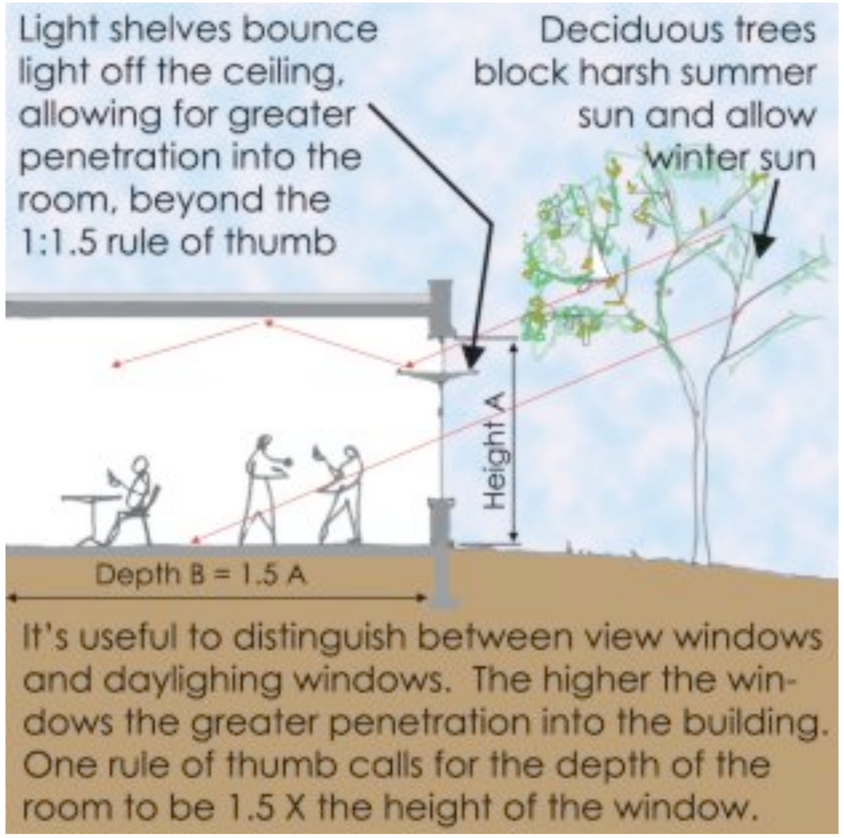


Economy of Resources

Energy Conservation

Alternate Sources of Energy

Solar, wind, water, and geothermal energy systems are all commercially available to reduce or eliminate the need for external energy sources. Electrical and heating requirements can be met by these systems, or combination of systems, in all climates.



Economy of Resources

Energy Conservation

Daylighting

Building and window design that utilizes natural light will lead to conserving electrical lighting energy, shaving peak electric loads, and reducing cooling energy consumptions. At the same time, daylighting increases the luminous quality of indoor environments, **enhancing the psychological wellbeing and productivity of indoor occupants**. These qualitative benefits of daylighting can be far more significant than its energy-savings potential.

Economy of Resources

Energy Conservation

Energy-Efficient Equipment & Appliances

After construction costs, a building's greatest expense is the cost of operation. Operation costs can even exceed construction costs over a building's lifetime. Careful selection of high efficiency heating, cooling, and ventilation systems becomes critical. The initial price of this equipment may be higher than that of less efficient equipment, but this will be offset by future savings.

Appliances, from refrigerators to computers, not only consume energy, they also give off heat as a result of the inefficient use of electricity. More efficient appliances reduce the costs of electricity and air-conditioning. The **U. S. Environmental Protection Agency** has developed the "**Energy Star**" program to assist consumers in identifying energy efficient electronic equipment.

Appliances & Electronics

- Buying Efficient Products
- Estimating Energy Use
- Turning Off Computers

Designing & Remodeling

- Passive Solar
- Whole-House Design
- Zero-Energy Homes
- Log Homes
- Manufactured Homes
- Earth-Sheltered Homes
- Financing an Efficient Home

Electricity

- Reducing Electricity Use
- Buying Clean Electricity
- Making Clean Electricity
- Reading Electric Meters

Heating & Cooling

- Selecting & Replacing Your System
- Cooling Systems
- Heating Systems
- Heat Pumps
- Thermostats, Ducts, & Meters

Insulation & Air Sealing

- Weatherstripping & Caulking
- Insulation
- Controlling Moisture
- Ventilation

Landscaping

- For Your Climate
- For Your Microclimate
- Shading
- Using Windbreaks
- Conserving Water & Xeriscaping

- Buying Clean Electricity
- Making Clean Electricity
- Reading Electric Meters

System
- Cooling Systems

에너지 절약

Insulation & Air Sealing →

- Weatherstripping & Caulking
- Insulation
- Controlling Moisture
- Ventilation

Landsc

- Conserving Water & Xeriscaping

Lighting & Daylighting →

- Artificial Lighting
- Types of Lighting
- Turning Off Lights
- Natural Lighting

Water Heating →

- Selecting a Water Heater
- Solar Water Heaters
- Demand (Tankless) Water Heaters
- Reducing Water Heating Bills
- Swimming Pool Heating

Windows, Doors & Skylights →

- Energy Performance Ratings
- Selecting Windows
- Selecting Exterior Doors
- Selecting Skylights

Connect with Energy Savers

- Energy Savers Blog
- Facebook

Economy of Resources

Energy Conservation

Choose Materials with Low Embodied Energy

Building materials vary with respect to how much energy is needed to produce them. The **embodied energy** of a material attempts to measure the energy that goes into the entire life cycle of building material. For instance, <u>aluminum has a very high embodied energy</u> because of the large amount of electricity that must be used to manufacture it from mined bauxite ore; recycled aluminum requires far less energy to refabricate. By choosing materials with low embodied energy, the overall environmental impact of a building is reduced.

Using local materials over imported materials of the same type will save transportation energy.

Bottle Water

Economy of Resources

Water Conservation

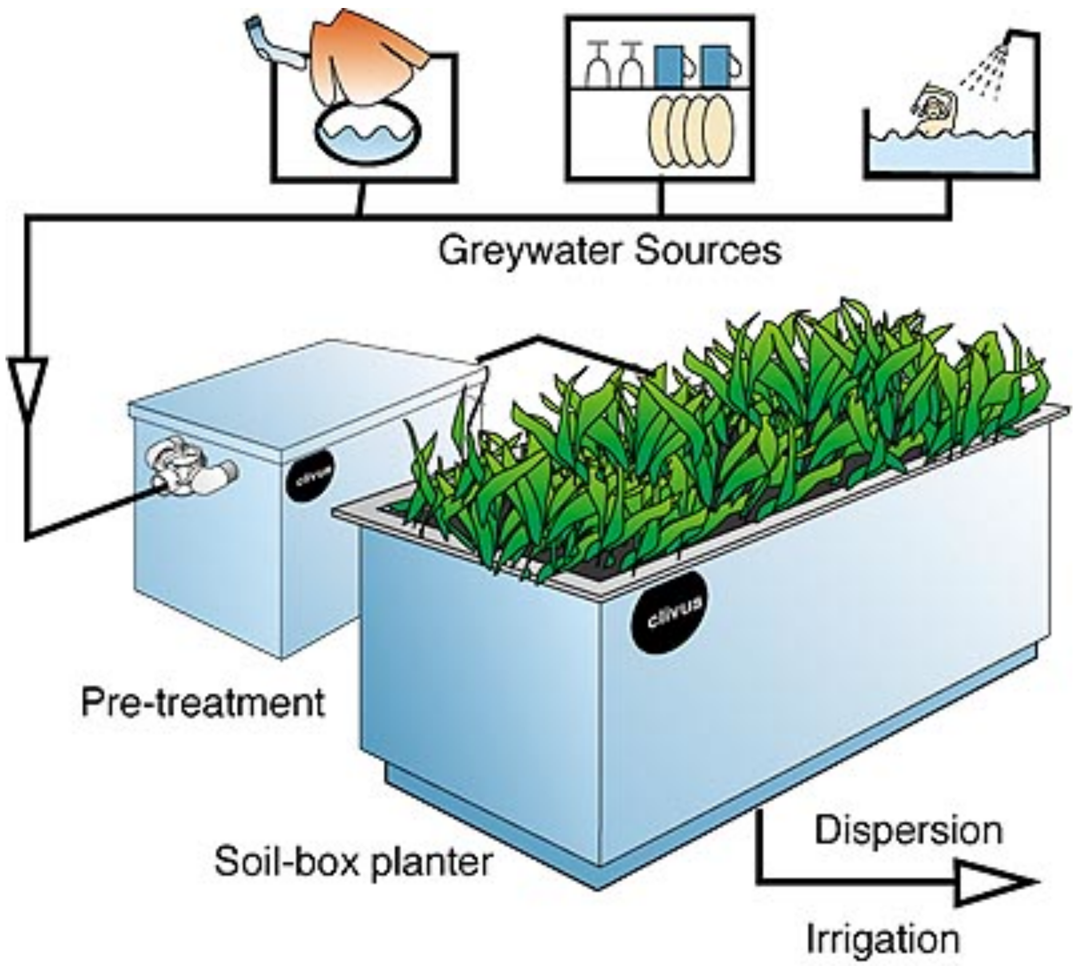
Reuse Water Onsite

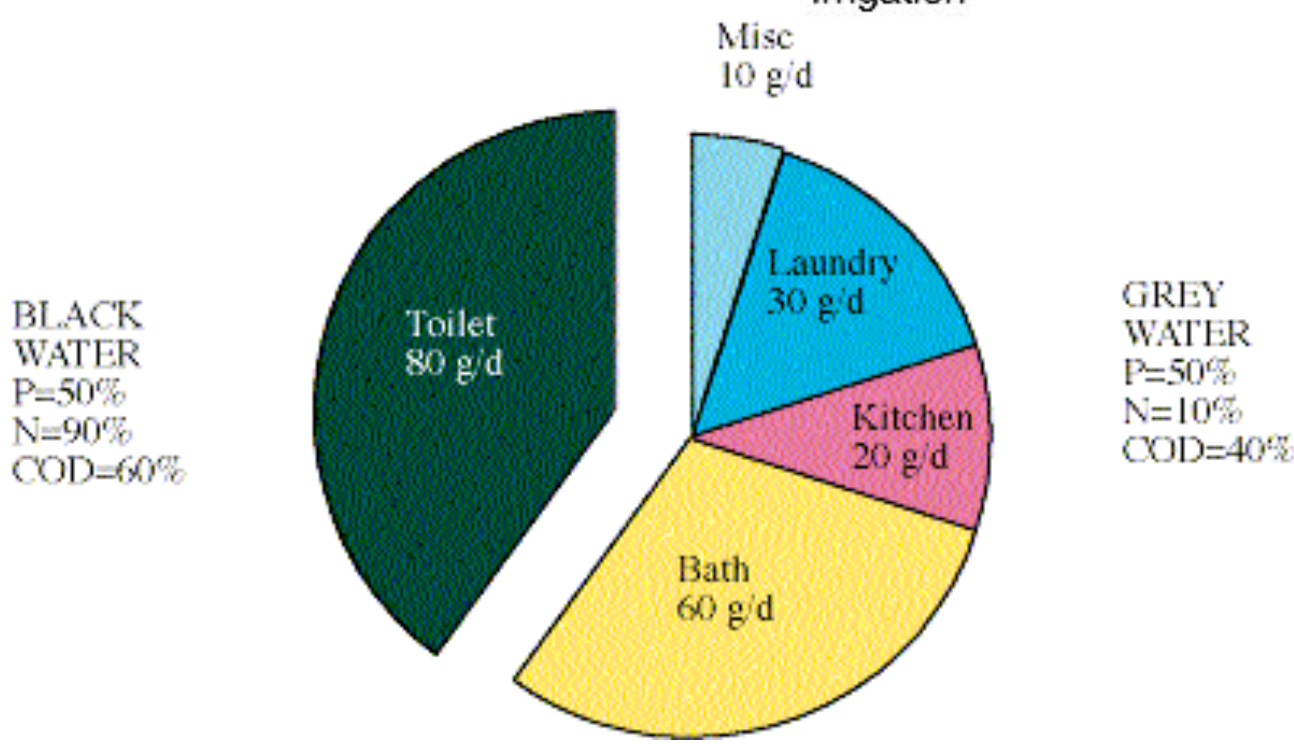
Water consumed in buildings can be classified as two types: graywater and sewage.

Graywater is produced by activities such as handwashing. While it is not of drinking-water quality, it does not need to be treated as nearly as intensively as sewage. In fact, it can be recycled within a building, perhaps to irrigate ornamental plants or flush toilets. Well-planned plumbing systems facilitate such reuse.

In most parts of the world, rainwater falling on buildings has not been considered a useful resource. Buildings are typically designed to keep the rain from the occupants, and the idea of utilizing rain water falling on building surfaces has not been widely explored. Building envelopes, particularly roofs, can become rainwater collecting devices, in combination with cisterns to hold collected water. This water can be used for irrigation or toilet-flushing.

Greywater





http://www.greywater.com/

Economy of Resources

Water Conservation

Reduce Consumption

Water supply systems and fixtures can be selected to reduce consumption and waste. **Low-flow faucets** and **small toilet tanks** are now required by code in many areas of the country.

Vacuum-assisted and biocomposting toilets further reduce water consumption. **Biocomposting toilets**, available on both residential and commercial scales, treat sewage on site, eliminating the need for energy-intensive municipal treatment.

Indigenous landscaping — using plants native to the local ecosystem — will also reduce water consumption. These plants will have adapted to the local rainfall levels, eliminating the need for additional watering. Where watering is needed, the sprinkler heads should be carefully placed and adjusted to avoid watering the sidewalk and street.

Economy of Resources

Materials Conservation

Adapt Existing Buildings to New Uses

One of the most straightforward and effective methods for material conservation is to make use of the resources that already exist in the form of buildings. Most buildings outlive the purpose for which they were designed. Many, if not all, of these buildings can be converted to new uses at a lower cost than brand-new construction.

Incorporate Reclaimed or Recycled Materials

Buildings that have to be demolished should become the resources for new buildings. Many building materials, such as wood, steel, and glass, are easily recycled into new materials.

Some, like brick or windows, can be used whole in the new structure. Furnishing, particularly office partition systems, are also easily moved from one location to another.

王樹

Pritzker Architecture Prize

하얏트 재단이 "건축예술을 통해 재능과 비전, 책임의 뛰어난 결합을 보여주어 사람들과 건축 환경에 일관적이고 중요한 기여를 한 생존한 건축가" 에게 수여하는 상이다.
1979년 제이 프리츠커(Jay A. Pritzker)가 만들고 프리츠커 가문이 운영하는 이 상은, 현재 세계 최고의 건축상이다
프리츠커상은 때때로 "건축계의 노벨상"으로도 불린다

1979 / 필립 존슨 (1906–2005)/ 미국
1980 / 루이스 바라간 (1902–1988)/ 멕시코
1981 / 제임스 스털링 (1924–1992) / 영국
1982 / 케빈 로시 / 아일랜드 / 미국
1983 / 이오 밍 페이 / 미국
1984 / 리처드 마이어 / 미국
1985 / 한스 홀라인 / 오스트리아
1986 / 고트프리트 뵘 / 서독
1987 / 단게 겐조 (1913–2005) / 일본
1988 / 고든 번샤프트 (1909–1990)/ 미국
오스카르 니에메예르/ 브라질
1989 / 프랭크 게리 / 캐나다 / 미국
1990/ 알도 로시 (1931–1997) / 이탈리아
1991 / 로버트 벤투리 / 미국
1992 / 알바루 시자 비에이라 / 포르투갈
1993 / 마키 후미히코 / 일본
1994 / 크리스티앙 드 포잠박 / 프랑스
1995 / 안도 다다오 / 일본
1996 / 라파엘 모네오 / 스페인
1997 / 스베레 펜 / 노르웨이
1998 / 렌조 피아노 / 이탈리아
1999 / 노먼 포스터 / 영국
2000 / 렘 콜하스 / 네덜란드
2001 / 헤르초크 & 드 뫼롱 / 스위스
2002 / 글렌 머컷 / 오스트레일리아
2003 / 이외른 우촌 / 덴마크
2004 / 자하 하디드/ 이라크 / 영국
2005 / 톰 메인 / 미국
2006 / 파울루 멘데스 다 로샤 / 브라질
2007 / 리처드 로저스 / 영국
2008 / 장 누벨 / 프랑스
2009 / 페터 춤토르 / 스위스
2010 / 세지마 가즈요 / 니시자와 류에 / 일본
2011 / 에두아르두 소투 드 모라 / 포르투갈
2012 / 왕수 / 중국
2013 / 이토 도요 / 일본
2014 / 반 시게루 / 일본

Economy of Resources

Materials Conservation

Use Materials That Can Be Recycled

During the process of designing the building and selecting the building materials, look for ways to use materials that can themselves be recycled. This preserves the energy embodied in their manufacture.

Economy of Resources

Materials Conservation

Size Buildings and Systems Properly

A building that is oversized for its designed purpose, or has oversized systems, will excessively consume materials. When a building is too large or small for the number of people it must contain, its heating, cooling, and ventilation systems, typically sized by square footage, will be inadequate or inefficient.

This method relates directly to the programming and design phases of the architectural process. The client's present and future space needs must be carefully studied to ensure that the resulting building and systems are sized correctly.

Architects are encouraged to design around standardized building material sizes as much as possible. In the U. S., this standard is based on a **4'x8' sheet of plywood**. Excess trimming of materials to fit non-modular spaces generates more waste.

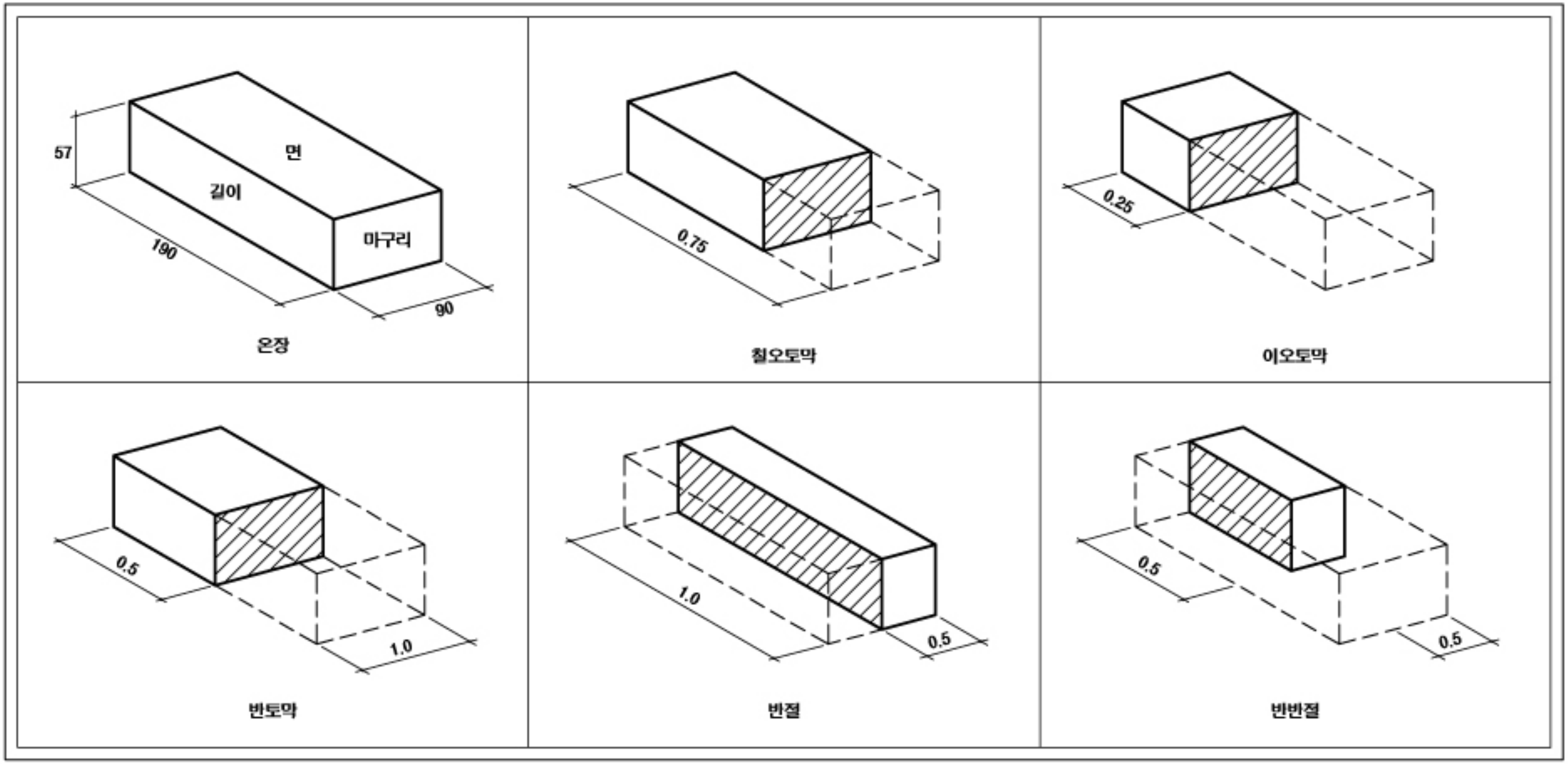
Economy of Resources

Materials Conservation

Reuse Non-Conventional Products as Building Materials

Building materials from unconventional sources, such as recycled tires, pop bottles, and agricultural waste, are readily available. These products reduce the need for new landfills and have a lower embodied energy that the

벽돌의 규격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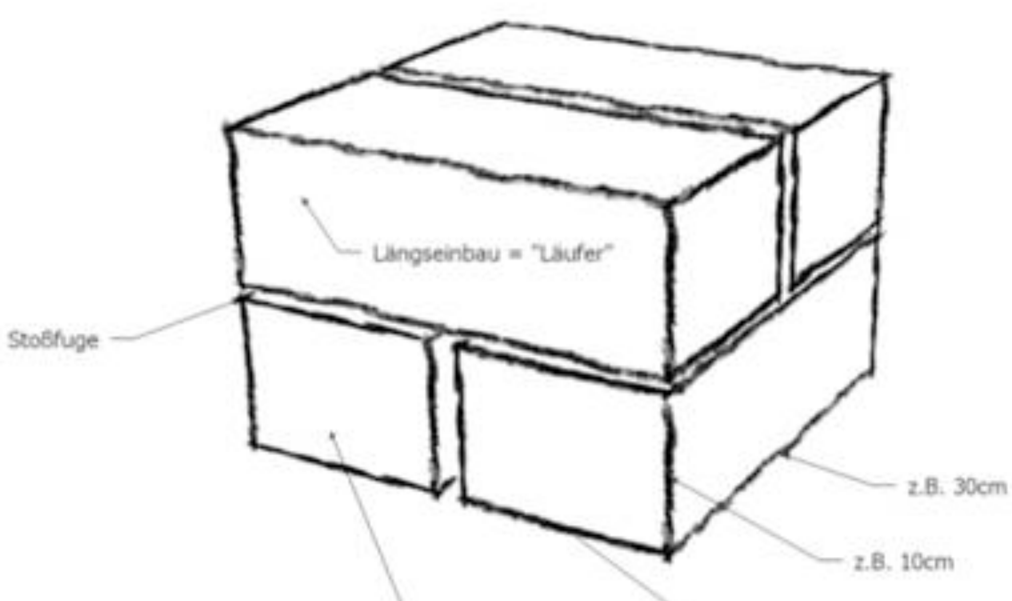
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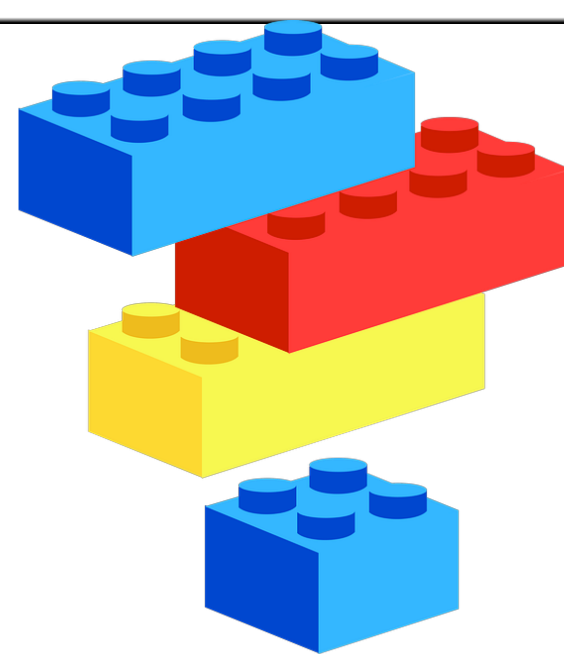


Economy of Resources

Materials Conservation

Consumer Goods

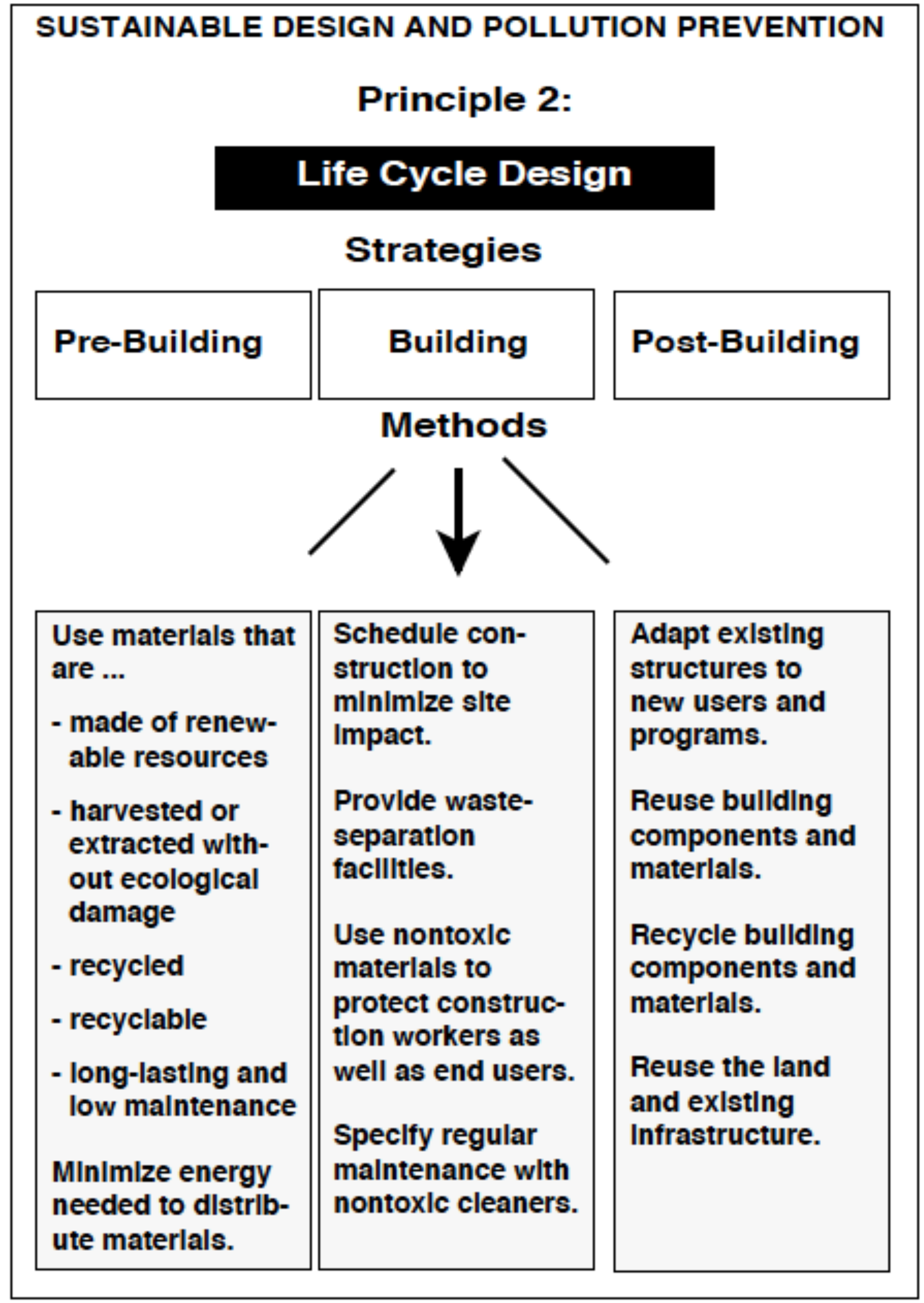
All consumer goods eventually lose their original usefulness.

The "useful life" quantifies the time of conversion from the useful stage to the loss of original usefulness stage. For instance, a daily newspaper is useful only for one day, a phone book is useful for one year, and a dictionary might be useful for 10 years. The shorter the useful life of consumer goods, the greater the volume of useless goods will result. Consequently, more architectural considerations will be required for the recycling of short-life consumer goods.

The conventional term for consumer goods that have lost their original usefulness is waste. But waste is or can be a resource for another use. Therefore, in lieu of waste, it is better to use the term "recyclable materials." One way buildings can encourage recycling is to incorporate facilities such as on-site sorting bins.

Life Cycle Design

These strategies, in turn, can yield specific design methods that will improve the sustainability of architecture.
Consuming fewer materials lessens the environmental impact of the associated manufacturing processes. This then reduces the eventual output of the building ecosystem.



Life Cycle Design methods of application

Life Cycle Design

Pre-Building

Use Materials Made From Renewable Resources

Renewable resources are those that can be grown or harvested at a rate that exceeds the rate of human consumption. Using these materials is, by definition, sustainable. Materials made from nonrenewable materials (petroleum, metals, etc.) are, ultimately, not sustainable, even if current supplies are adequate. Using renewable materials wherever possible reduces the need for nonrenewable materials.

Life Cycle Design

Pre-Building

Use Materials Harvested or Extracted Without Causing Ecological Damage

Of the renewable materials available, not all can be obtained without significant environmental effects. Therefore, the architect must be aware of how various raw materials are harvested and understand the local and global ramifications.

Life Cycle Design

Pre-Building

Use Recycled Materials

Using recycle materials reduces waste and saves scarce landfill space. Recycled materials also preserve the embodied energy of their original form, which would otherwise be wasted. This also reduces the consumption of materials made from virgin natural resources. Many building materials, particularly steel, are easily recycled, eliminating the need for more mining and milling operations.

Life Cycle Design

Pre-Building

Use Materials with Long Life and Low Maintenance

Durable materials last longer and require less maintenance with harsh cleansers. This reduces the consumption of raw materials needed to make replacements and the amount of landfill space taken by discarded products. It also means occupants receive less exposure to irritating chemicals used in the installation and maintenance of materials.

Life Cycle Design

Building

Minimize Site Impact

Careful planning can minimize invasion of heavy equipment and the accompanying ecosystem damage to the site. Excavations should not alter the flow of groundwater through the site. Finished structures should respect site topology and existing drainage. Trees and vegetation should only be removed when absolutely necessary for access. For sensitive sites, materials that can be hand-carried to the site reduce the need for excessive road-building and heavy trucks.

Life Cycle Design

Building

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Life Cycle Design

Building

Employ Nontoxic Materials

The use of nontoxic materials is vital to the health of the building's occupants, who typically spend more than threequarters of their time indoors. Adhesives used to make many common building materials can outgas — release volatile organic compounds into the air — for years after the original construction. Maintenance with nontoxic cleansers is also important, as the cleaners are often airborne and stay within a building's ventilation system for an extended period of time.

Life Cycle Design

Post-Building

Reuse the Building

The embodied energy of a building is considerable. It includes not only the sum of energy embodied in the materials, but also the energy that went into the building's construction. If the building can be adapted to new uses, this energy will be conserved. Where complete reuse of a building is not possible, individual components can be selected for reuse — windows, doors, bricks, and interior fixtures are all excellent candidates.

Life Cycle Design

Post-Building

Recycle Materials

Recycling materials from a building can often be difficult due to the difficulty in separating different substances from one another. Some materials, like glass and aluminum, must be scavenged from the building by hand. Steel can easily be separated from rubble by magnets. Concrete can be crushed and used as aggregate in new pours.

Life Cycle Design

Post-Building

Reuse Existing Buildings and Infrastructure

It has become common for new suburbs to move farther and farther from the core city as people search for "space" and "nature." Of course, the development of new suburbs from virgin woods or fertile agricultural fields destroys the very qualities these suburbanites are seeking. Moreover, in addition to the materials for new houses, new development requires massive investments in material for roads, sewers, and the businesses that inevitability follow. Meanwhile, vacant land and abandoned structures in the city, with its existing infrastructure, go unused, materials wasted.

Catherine Mohr works on surgical robots and robotic surgical procedures, using robots to make surgery safer -- and to go places where human wrists and eyes simply can't.

Why you should listen to her:

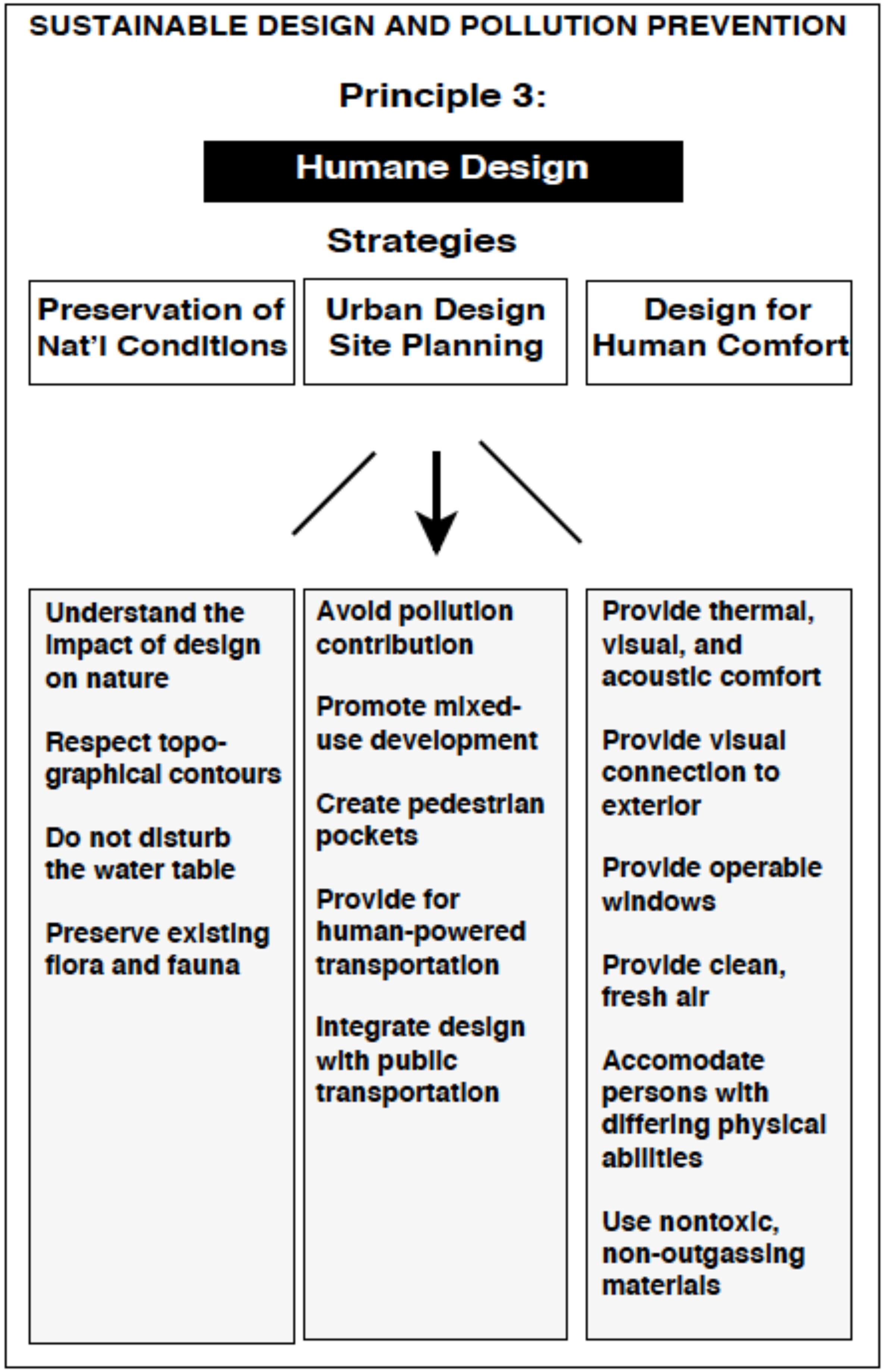
Catherine Mohr began her career as an engineer, working for many years with Paul MacCready at AeroVironment to develop alternative-energy vehicles and high-altitude aircraft.**Her midcareer break: medical school**, where she invented a brilliantly simple device, the LapCap, that makes laproscopic surgeries safer.

Mohr now oversees **the development of next-generation surgical robots and robotic procedures**, as the director of medical research at Intuitive Surgical Inc., where she's the clinical design leader for the DaVinci Surgical Robotic system. She also works at Stanford's School of Medicine, where she studies simulation-based teaching methods to teach clinical skills to budding doctors. And she's a senior scientific advisor to the GlobalSolver Foundation, an innovative funding and study group that looks at ways to match up scientists and money to help the world's oceans.

"They take away some of the impreciseness of the human hand."

Dr. Nikhil Shaw on CNN.com

Catherine Mohr builds green



Humane Design methods of application

Humane Design

As described in the introduction, this principle embodies three strategies: preservation of natural conditions, urban design and site planning, and design for human comfort.

These strategies, in turn, yield specific design methods that will improve the sustainability of architecture. Figure 11 shows how each method relates to the three strategies of Humane Design. These methods focus primarily on improving the quality of life for humans and other species.

Humane Design

Preservation of Coditions

Respect Topographical Contours

The existing contours of a site should be respected. Radical terraforming is not only expensive but devastating to the site's microclimate. Alteration of contours will affect how water drains and how wind moves through a site.

Do Not Disturb the Water Table

Select sites and building designs that do not require excavation below the local water table. Placing a large obstruction (the building) into the water table will disturb natural hydraulic process. If the water table is exposed during construction, it will also become more susceptible to contamination from polluted surface runoff.

Preserve Existing Flora and Fauna

Local wildlife and vegetation should be recognized as part of the building site. When treated as resources to be conserved rather than as obstacle to be overcome, native plants and animals will make the finished building a more enjoyable space for human habitation.

Humane Design

Urban Design and Site Planning

Integrate Design with Public Transportation

Sustainable architecture on an urban scale must be designed to promote public transportation. Thousands of individual vehicles moving in and out of area with the daily commute create smog, congest traffic, and require parking spaces.

Promote Mixed Use Development

Sustainable development encourages the mixing of residential, commercial, office and retail space. People then have the option of living near where they work and shop. This provides a greater sense of community than conventional suburbs.

The potential for 24-hour activity also makes an area safer.

Humane Design

Design for Human Comfort

Provide Visual Connection to Exterior

The light in the sky changes throughout the day, as the sun and clouds move across the sky. Humans all have an internal clock that is synchronized to the cycle of day and night.

From a psychological and physiological standpoint, windows and skylights are essential means of keeping the body clock working properly,

Provide Operable Windows

Operable windows are necessary so that building occupants can have some degree of control over the temperature and ventilation in their workspace.

Provide Fresh Clean Air

Fresh air through clean air ducts is vital to the well-being of building occupants. The benefits of fresh air go beyond the need for oxygen. Continuous recirculation of interior air exposes people to concentrated levels of bacteria and chemicals within the building.

Use Nontoxic, Non-Outgassing Materials

Long-term exposure to chemicals commonly used in building materials and cleaners can have a detrimental effect on health.

Accommodate Persons with Differing Physical Abilities

One aspect of sustainable design is its longevity. Buildings that are durable and adaptable are more sustainable than those that are not. This adaptability includes welcoming people of different ages and physical conditions. The more people that can use a building, the longer the building's useful life.