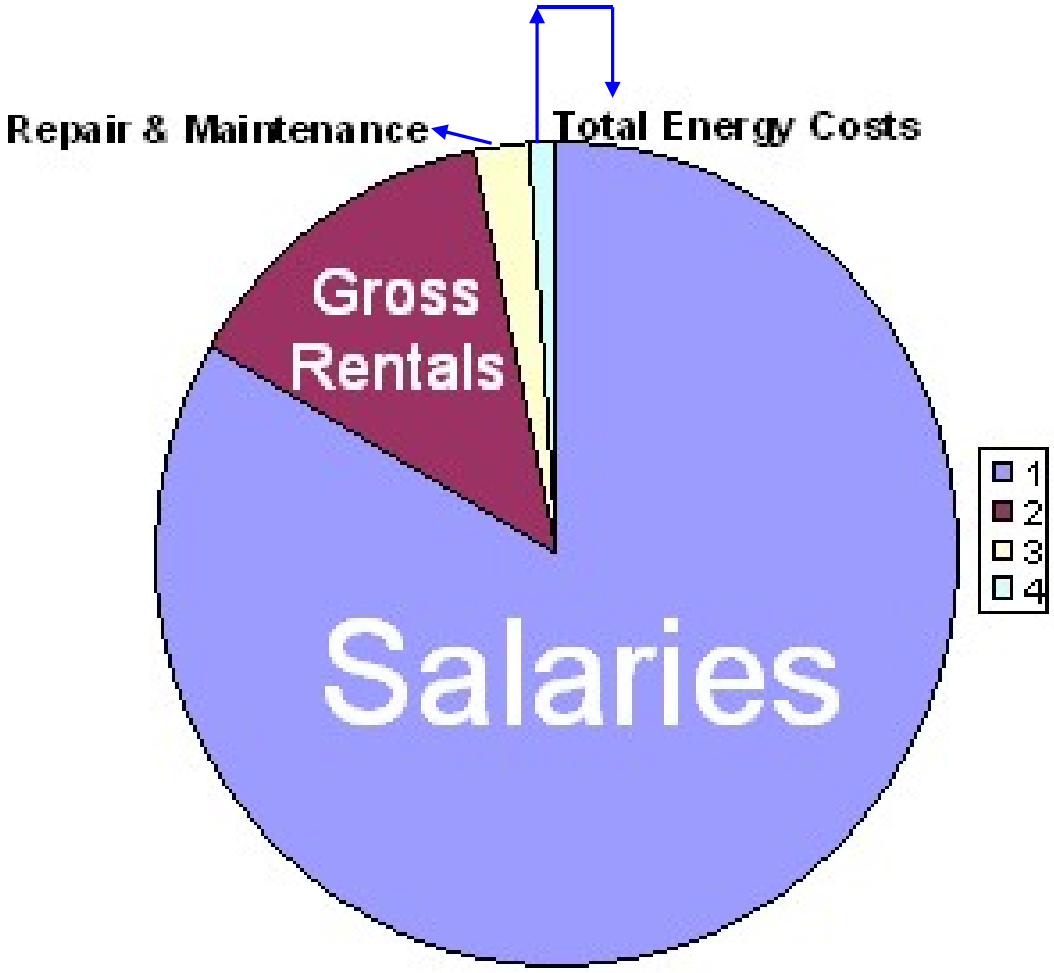
Influences on the design process: (b) costs

- Costs
  - Initial cost = first cost = maximum allowable construction cost
  - Life-cycle cost = initial + operation + maintenance + demolition
    - Often ignored by owners and designers
- Rule of thumb: 1:10:100



83.3%	$130.00	Salaries
13.5%	$ 21.00	Gross Office Rent
2.1%	$ 3.20	Repair and Maintenance
1.2%	$ 1.80	Total Energy Costs
100.0%	$156.00	Typ. Office Bldg. Operating Costs/SF/Yr.

http://www.automatedbuildings.com/

Influences on the design process: (c) passive and active approaches

- Passive, active, and hybrid approaches

TABLE 1.3 Defining the Characteristics of Passive and Active Systems

Characteristic	Passive System	Active System
Energy source	Uses no purchased energy (no electricity, natural gas, fuel oil, etc.); example: daylighting system	Uses primarily purchased (and nonrenewable) energy; example: electric lighting system
System components	Components play multiple roles in system and in the building as a whole; example: concrete floor slab that is structure, walking surface, and solar collector/storage	Components are commonly single-purpose elements; example: gas furnace
System integration	System is usually tightly integrated (often inseparably) with the overall building design; example: natural ventilation system using windows	System is usually not well integrated with the overall building design, often seeming an add-on; example: window air-conditioning unit
Passive and active systems represent opposing philosophical concepts. Design is seldom so straightforward as to permit the exclusive use of one philosophy. Thus, the hybrid system Hybrid systems are a composite of active and passive approaches, typically leaning more toward the passive. For example, single-purpose, electricity-consuming (active) ceiling fans might be added to a natural ventilation (passive) cooling system to extend the performance of the system and thus reduce energy usage that would otherwise occur if a fully active air-conditioning system were turned on instead of the fans.		

Passive (자연적 조절) vs. Active (설비적 조절)

- About 50% of building energy can be saved by efficient design and operation (Baird et al, Energy Performance of Buildings, CRC press, 1984)
- Approach I: Passive control
  - use of architectural elements (orientation, form, U-values of envelopes, insulation) for indoor environmental control (thermal, visual, air quality) and energy
- Approach II: Active control
  - use of mechanical systems for indoor environmental control and energy
- Passive first, active next

Example

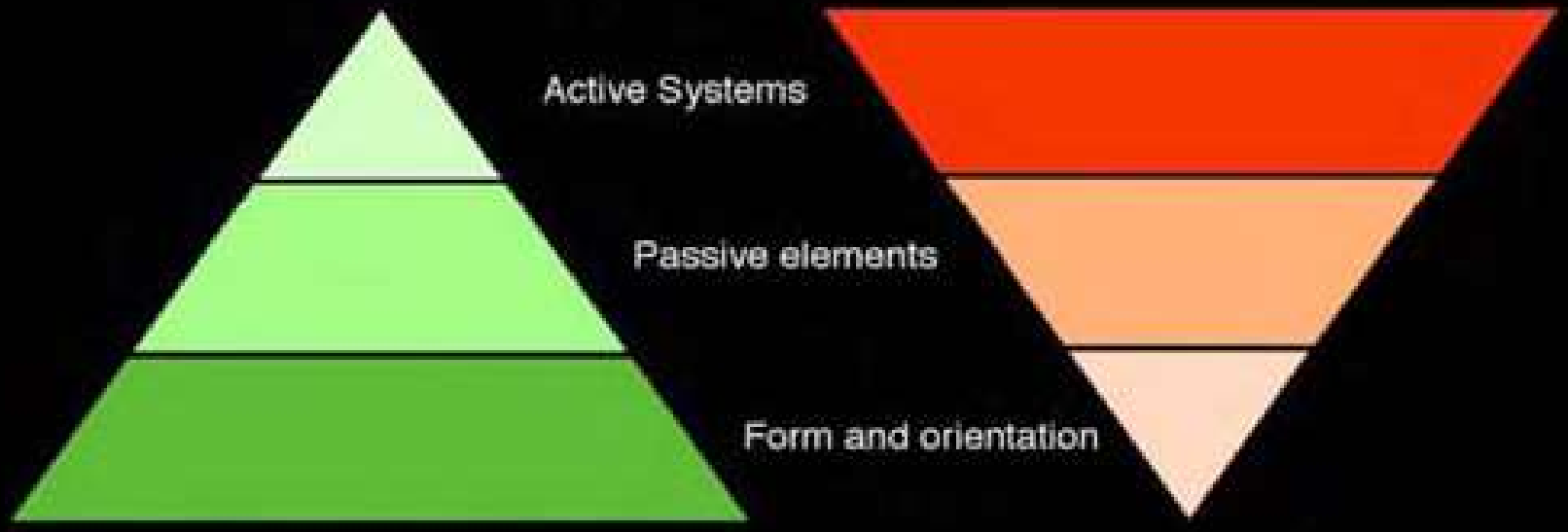
Designed by Skidmore, Owings & Merrill LLP (SOM)

	Oil(kg/m2.yr)	Elec.(kWh/m2.yr)
대한생명	26.3	254.4
LG Twin Tower	7.7	185.4

Year: 1991

Hopkins Architects

What makes a building "green"?



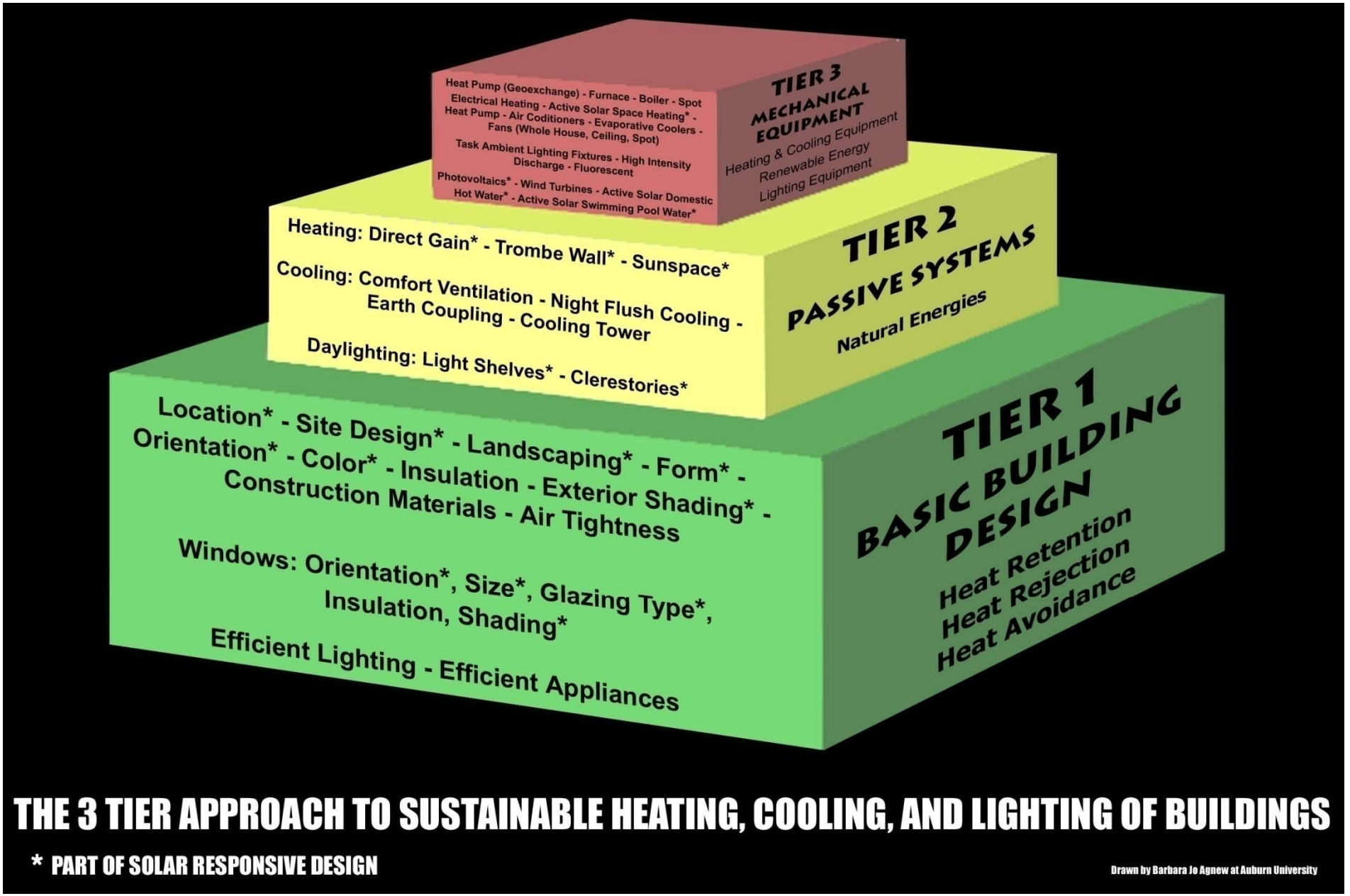


Image source: Norbert Lechner's lecture note

Pick the low-hanging fruit first!

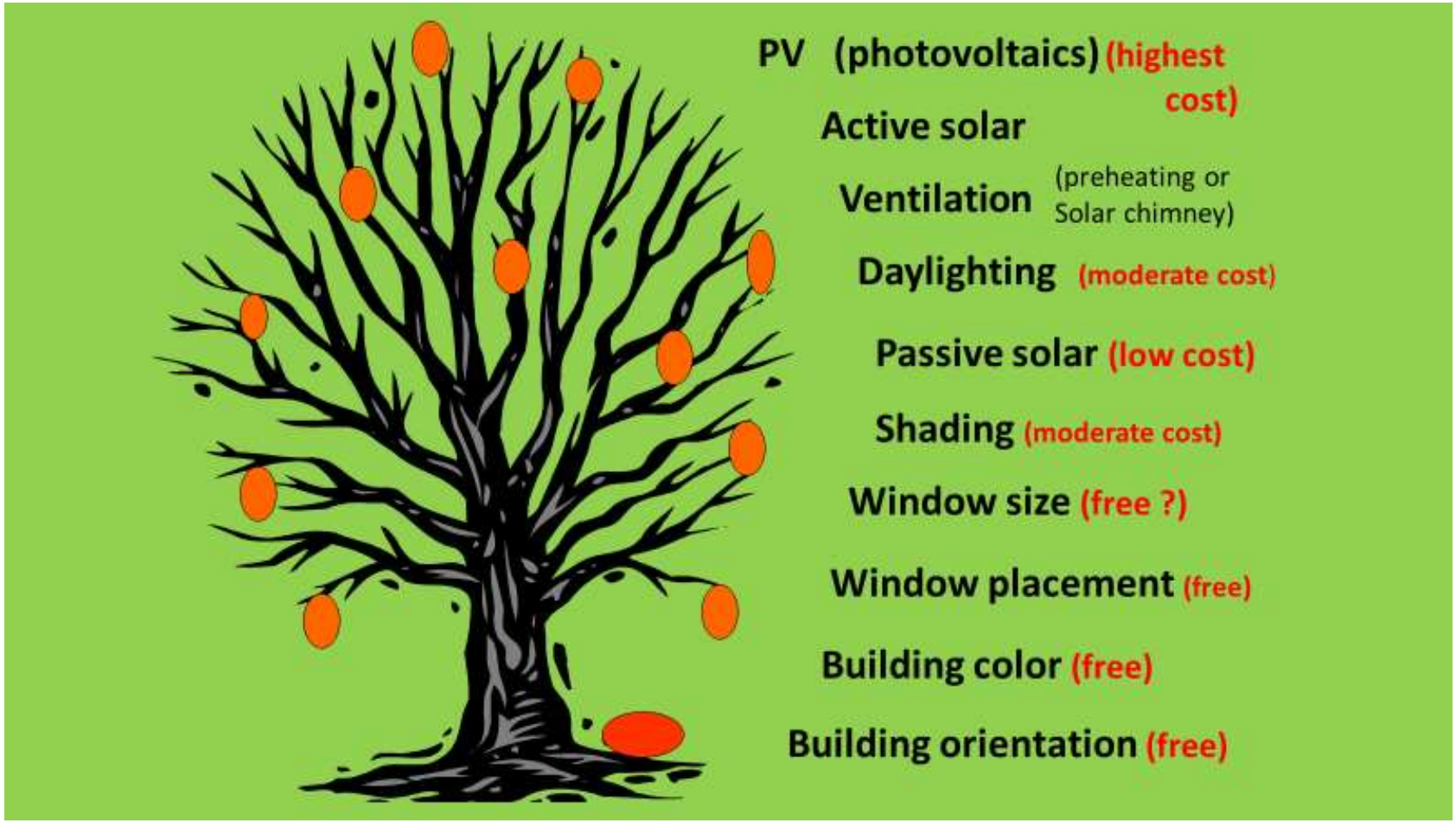


Image source: Norbert Lechner's lecture note

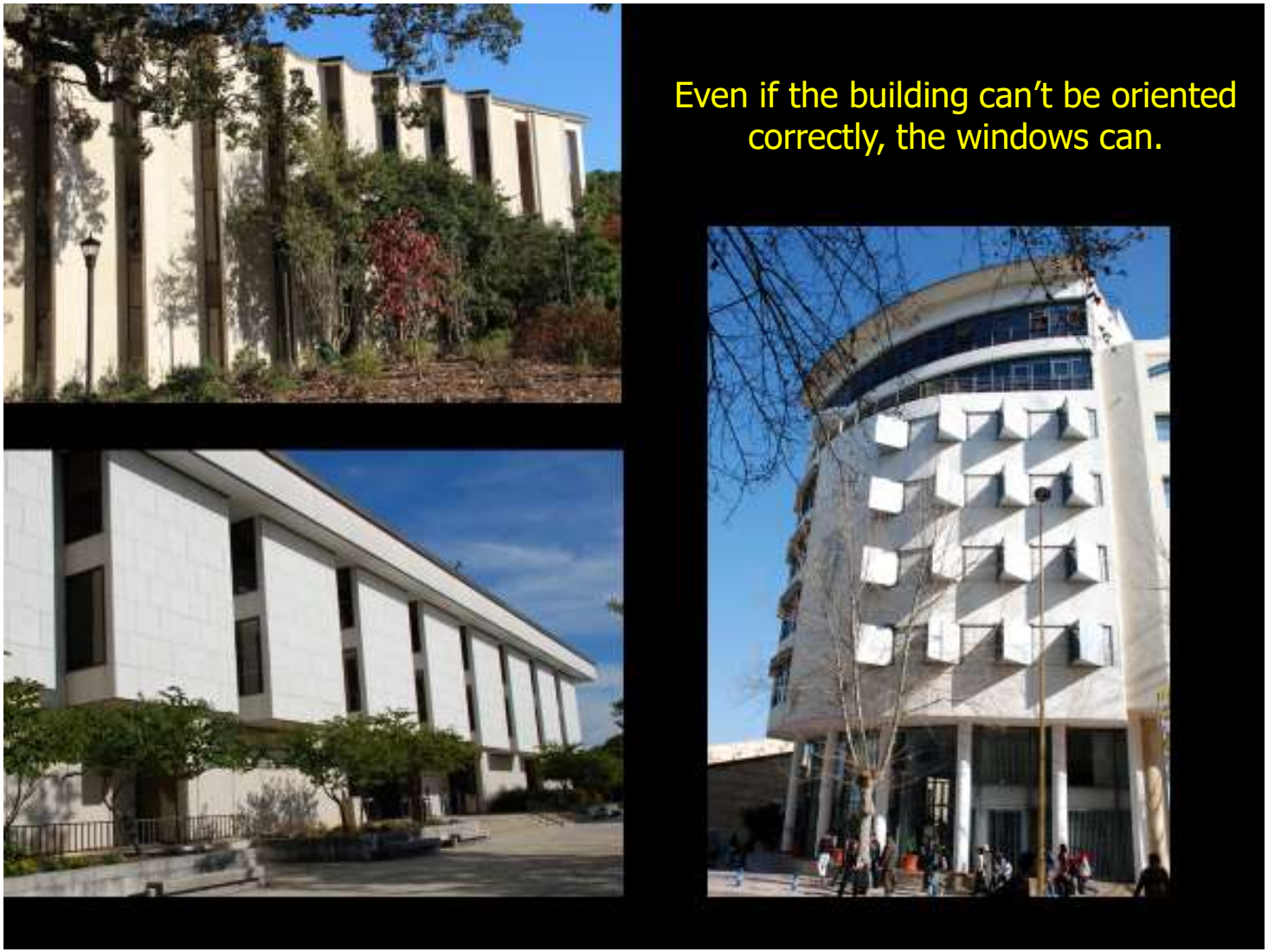


Image source: Norbert Lechner’s lecture note

Influences on the design process: (d) energy efficiency

- Energy efficiency: most commonly discussed performance aspect since the energy crisis of the 70s
- USA: ASHRAE/IENSA 90.1-2019 standards
  - Two options provided: prescriptive approach or performance-based approach
- On-site vs off-site: on-site energy usage focused (off-site energy consumption, e.g., energy transportation, or generation, is not addressed): This may skew thinking about energy efficiency design.

Influences on the design process: (e) Passive House performance

- A Passive House does not need to be a house; it may be an office, school, or other building type.
  - A Passive House (denoting annual energy performance) is not necessarily a house with passive heating/cooling/lighting systems.
- Passive House (with caps) is a building performance guideline with stringent energy benchmarks for both site (specifically space conditioning) and source energy
- Currently, the benchmark requirements for Passive House performance in the United States (PHIUS) are:
  - Heating energy: ≤ 4.75 kBtu/ft^2/yr (15 kWh/m^2/yr)
  - Cooling energy: ≤ 4.75 kBtu/ft^2/yr (15 kWh/m^2/yr)
  - Total source (primary) energy: ≤ 38.1 kBtu/ft^2/yr (120 kWh/m^2/yr)
    - Heating, cooling, lighting, domestic hot water, etc.

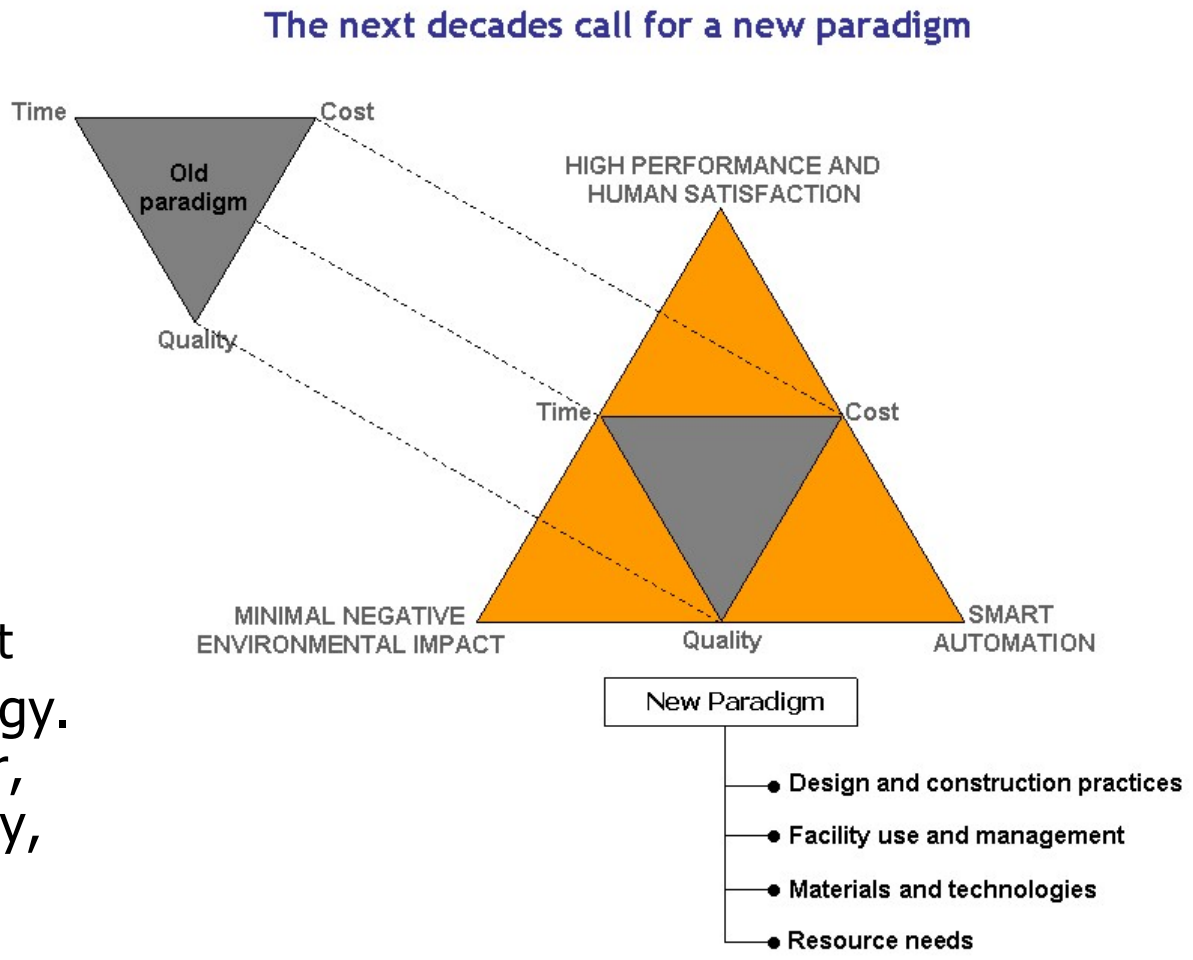
Influences on the design process: (f) net-zero energy

- By definition (National Renewable Energy Laboratory, NREL), a net-zero energy building will—on an annual basis—produce as much energy from renewable resources (e.g. solar and wind) as it consumes.
- "net-zero energy" as opposed to "zero-energy" (which would essentially mean an unused building).
- Boundaries: temporal, spatial
  - The common perception is 'net-zero operational energy' measured at the site boundary.
  - Temporal: design, construction, operation
  - Spatial: on-site vs. off-site

	Building A	Building B	Building C
On-site energy (kwh/m2.yr)	100 (best)	120	300
Off-site energy (kwh/m2.yr)	300	240 (best)	900
Produced energy from renewable sources (kwh/m2.yr)	0	0	250
Net energy use (system boundary = on-site)	100	120	50 (best)
Net energy use (system boundary = off-site)	300	240	150 (best)

Influences on the design process: (g) green building design strategies

- Green building design strategies
  - Not an 'option' but a 'must' in near future
  - GSA declares all newly constructed federal buildings should be…
- 'Green' is understood
  - concern for health and well-being
  - respect for environment
- Green goes beyond energy. It includes energy, water, materials. Energy is a key, but not sole element in green design.
- What is the LEED system?



GSA

- The U.S. General Services Administration (GSA) procurement power influences AEC markets.
  - Over the last decade, 253 million square feet of buildings were constructed for GSA, representing more than $11 billion in value.
- The U.S. federal government takes the lead on low embodied carbon buildings. GSA recently shifted its procurement policy toward low embodied carbon building materials and approaches.
- GSA's two recommended approaches
  - A material approach for all projects, requiring environmental product declarations for 75% of materials used (by cost or weight), and that their emissions fall in the best performing 80% of global warming potential among functionally equivalent products.
  - A whole building life cycle assessment approach for larger projects (over $3 million), requiring that buildings be designed in such a way that life-cycle carbon assessment shows that the selected design results in a 20% carbon reduction.

https://www.gsa.gov/governmentwide-initiatives/federal-highperformance-buildings/policy/green-building-advisory-committee
SBSE Newsletter, Spring 2021, page 3

LEED: Leadership in Energy and Environmental Design

- a voluntary, consensus-based market-driven building rating system based on existing proven technology that evaluates environmental performance from a 'whole building' perspective over the building service life
- Developed by U.S. Green Building Council (www.usgbc.org)
- They claim that it is close to performance-based standards (vs. prescriptive)
- LEED rates the environmental aspects of a building and the behavior of its occupants to arrive at a final score that results in a platinum (highest level), gold, silver, or bronze plaque being awarded
- LEED-NC, LEED-EB

Why was LEED developed ?

- Use as a design guideline for a sustainability indicator
- Stimulate “green” competition
- Transform market space

LEED certification process

A three-step process:

- Step 1: Project registration
  - Welcome packet and on-line project listing
- Step 2: Technical support
  - Reference package
  - Credit rulings
- Step 3: Building certification
  - Upon documentation submittal and USGBC review

LEED-certified

(a) (b)

Fig. 1.12 *(a) The Jean Vollum Natural Capital Center, Portland, Oregon. A warehouse from the industrial era was rehabilitated by Ecotrust to serve as a center for the conservation era. (b) LEED plaque on the front façade of the Vollum Center. The plaque announces the success of the design team (and owner) in achieving a key element of their design intent. (© Alison Kwok; all rights reserved.)*

Questions

- LEED score is an aggregated indicator to account for sites, water, energy, IEQ, materials, etc. Is there any proportionality between weights of each item and its amount of impact on environment? If not, what advantages can we take out of LEED scoring?
  - 3 apples + 2 oranges = 4 bananas + 1 strawberries
- Can we make any single aggregated indicator representing a car's characteristics and performance such as fuel efficiency, engine power, NO_x emission, design, etc.?

Korean green building certification

- http://www.greenbuilding.or.kr/

Influences on building design: (h) carbon-neutral design

- Carbon dioxide (CO_2) is a major greenhouse gas; methane is another.
- Design to reduce carbon emissions is becoming an issue on many building projects. The term carbon-neutral design is generally used to express this concern.
- The focus is the operational energy and operational carbon.

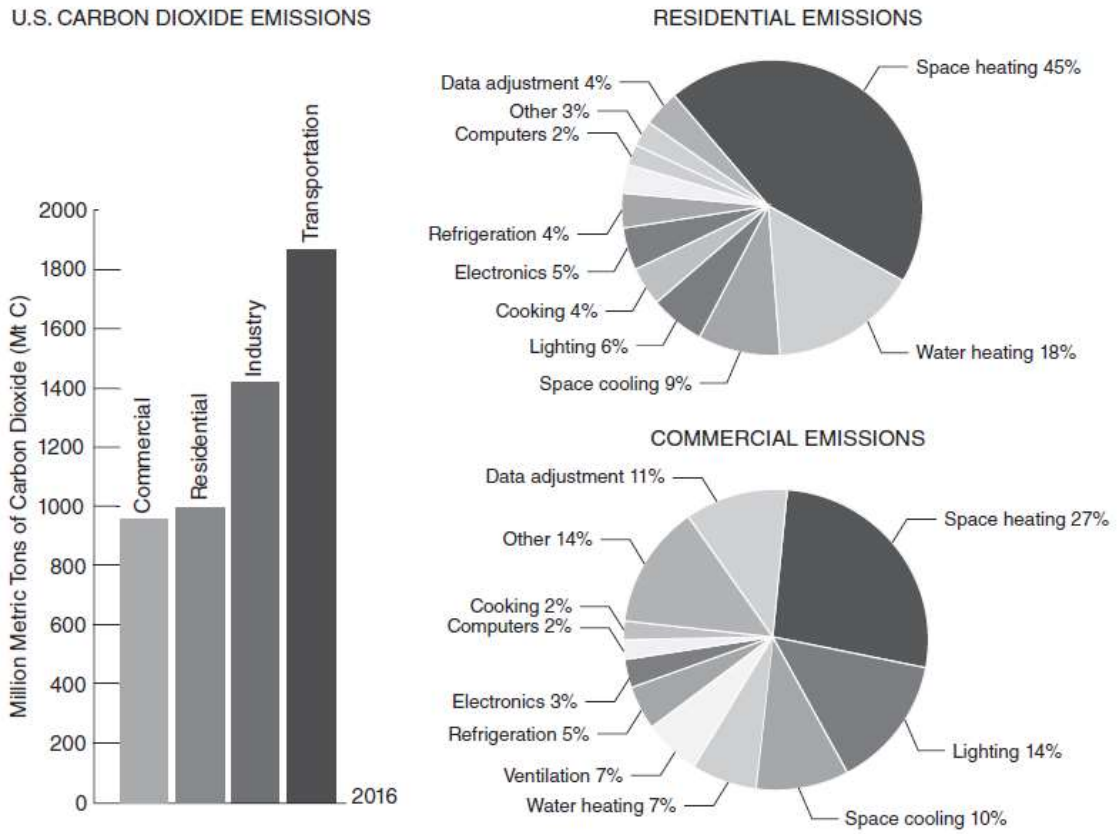


Fig. 1.13 Contribution of the buildings sector (commercial and residential) to U.S. carbon dioxide emissions (Mt C = million metric tons of carbon dioxide), and the relative impact of various use categories on commercial and residential carbon impacts. (Drawn by Sharon Alitema. Source: 2017 Buildings Energy Data Book, *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.)*

Influences on the design process: (h) carbon-neutral design

- carbon dioxide emissions in several distinct ways
  - fossil fuel energy consumed during the design process (computer use, printing, site visits, etc.)
  - fossil fuel energy consumed during the construction process (by equipment, worker commutes, site conditioning, etc.)
  - ongoing fossil fuel energy consumption for heating, cooling, lighting, and building support operations
- At this time, there is no code, standard, or guideline that defines "carbon neutral" and only limited formal design guidance to assist in reaching that goal. This situation should change as interest in and demand for carbon-neutral projects grow.

	Building A	Building B	Building C	Building D
On-site energy (kwh/m2.yr)	100 (best)	120	300	??
Off-site energy (kwh/m2.yr)	300	240 (best)	900	??
Produced energy from renewable sources (kwh/m2.yr)	0	0	250	??
Net energy use (system boundary = on-site)	100	120	50 (best)	??
Net energy use (system boundary = off-site)	300	240	150 (best)	??
CO2 emission (kg)	??	??	??	??

Influences on the design process: (i) embodied energy/embodied carbon

- In addition to the energy consumed in the day-to-day use of a building, however, energy is consumed to manufacture, transport, and install the materials that constitute a building. This energy is termed embodied energy.
- In addition to the carbon emitted in the day-to-day use of a building, carbon (specifically, carbon dioxide) is emitted as materials are manufactured, transported, and installed in a building. This carbon is termed embodied carbon.
- In typical, code-compliant buildings with a reasonable life span, embodied carbon (and energy) may be 10–15% of the total carbon attributable to a building during its life.
- The Embodied Carbon Network (2018) is an online repository of information.

Influences on the design process: (j) design strategies for sustainability

- Unlike green design, the meaning of "sustainability" has not been rationalized.
- Sustainability is defined as follows:
  - "Sustainability involves meeting the needs of the current generation without compromising the ability of future generations to meet their own needs. A sustainable society restores, preserves, and enhances nature and culture for the benefit of all life present and future; a diverse and healthy environment is intrinsically valuable and essential to a healthy society; today's society is seriously degrading the environment and is not sustainable." (The World Congress of Architects in Chicago, June, 1993)

"미래 세대가 그들의 필요를 충족시킬 능력을 저해하지 않으면서, 현재 세대의 필요를 충족시키는 발전"

Happy Holiday to all SBSE'rs (2008)

조상에게서 물려받은 유산이 아니라, 미래에 살게 될 아이들에게서 빌린 것입니다.

	Building A	Building B	Building C	Building D
On-site energy (kwh/m2.yr)	100 (best)	120	300	??
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Net energy use (system boundary = on-site)	100	120	50 (best)	??
Net energy use (system boundary = off-site)	300	240	150 (best)	??
CO2 emission (kg)	??	??	??	??
Sustainability (??)	??	??	??	??