



Green Building & Sustainable Construction (TCM 5330)

Energy and Atmosphere



Dr. Tommy Tafazzoli

Where does the electricity we use at home come from?

- The electricity used in homes is typically generated from a variety of **renewable** and **non-renewable** energy sources.
- These can include fossil fuels like coal, natural gas, and oil; nuclear power; and renewable sources such as solar, wind, hydroelectric, and geothermal energy.
- The mix of these sources can vary significantly depending on **geographic location**, **availability** of resources, and **energy policy**.
- After generation, electricity is transmitted over long distances through high-voltage power lines and then distributed to individual homes via local power grids.



Watch the video

How do we get Electricity in our Home? Easiest Explanation | The Electrical Guy

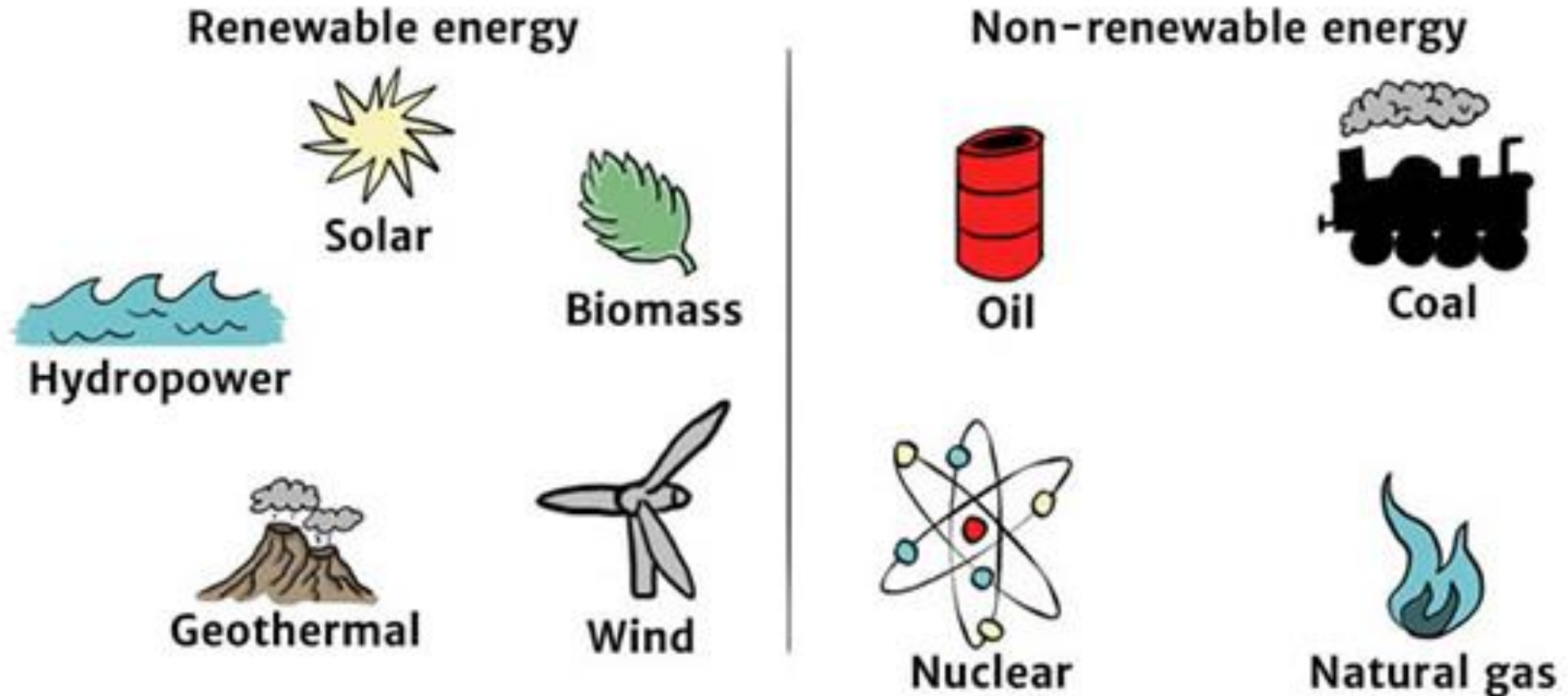
- Link:

https://www.youtube.com/watch?v=nBM1kd_ECog&ab_channel=GauravJ-TheElectricalGuy

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Renewable and non-renewable energy sources



Watch the video

Difference between Renewable and Nonrenewable Resources

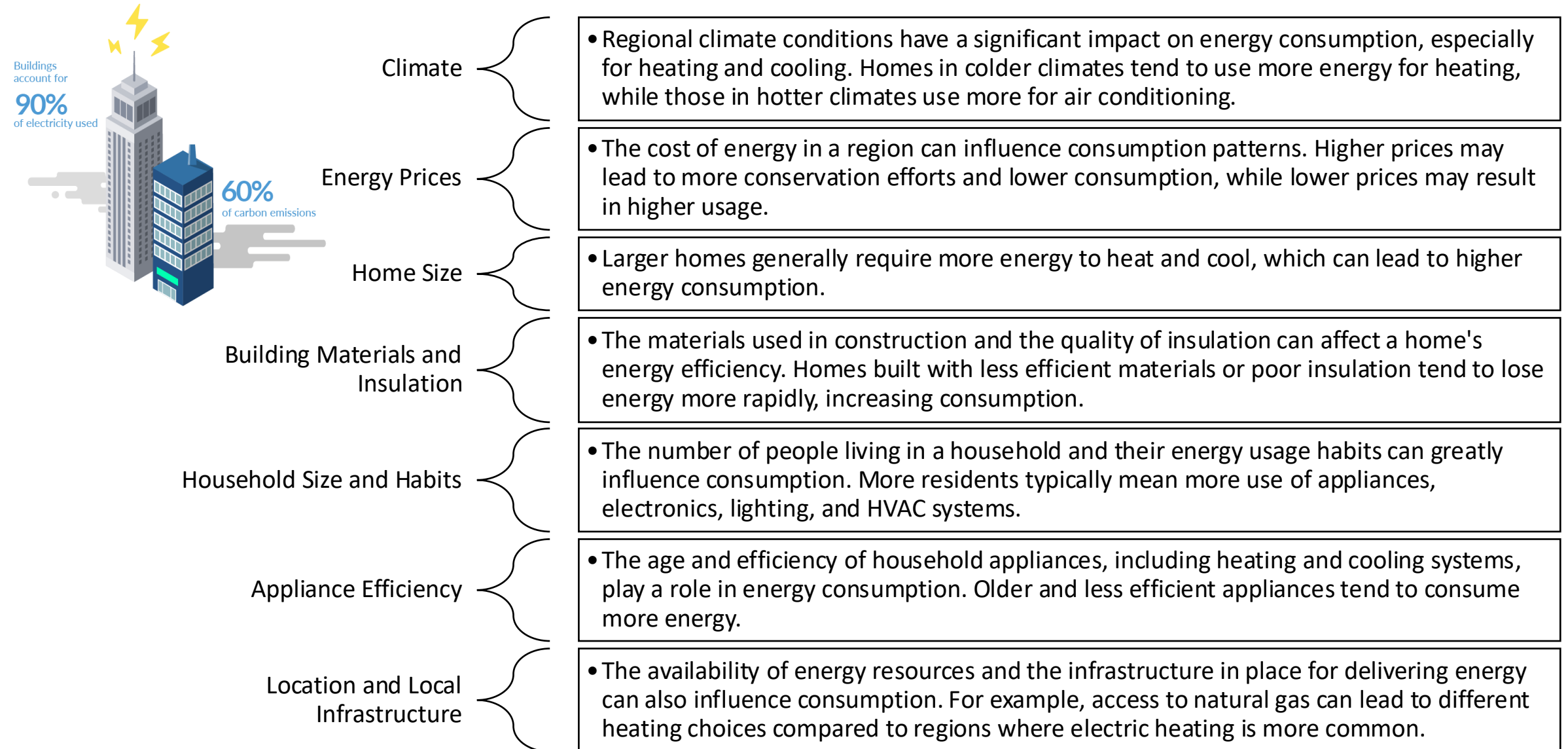
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https://www.youtube.com/watch?v=PLBK1ux5b7U&ab_channel=MoMooMathandScience

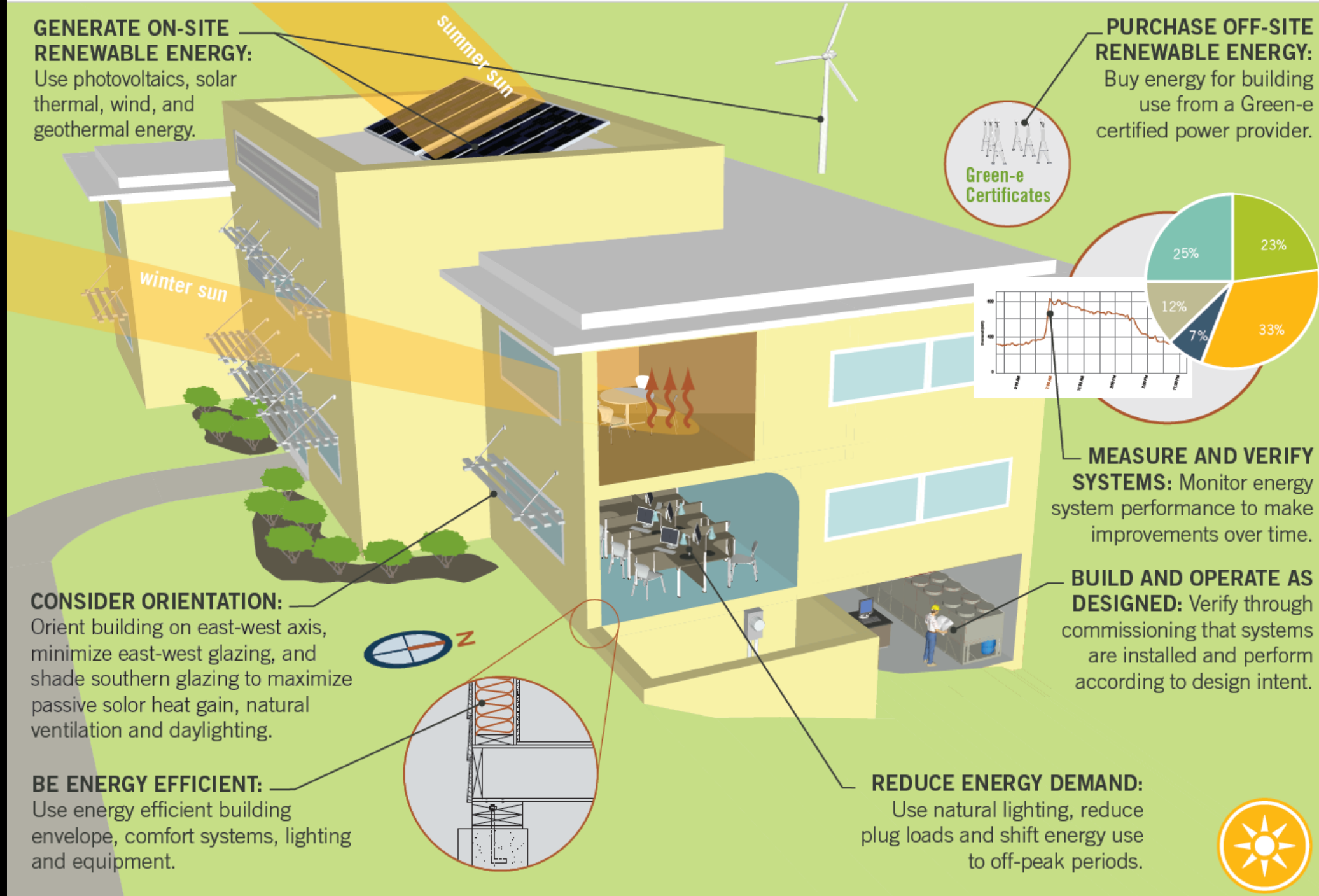
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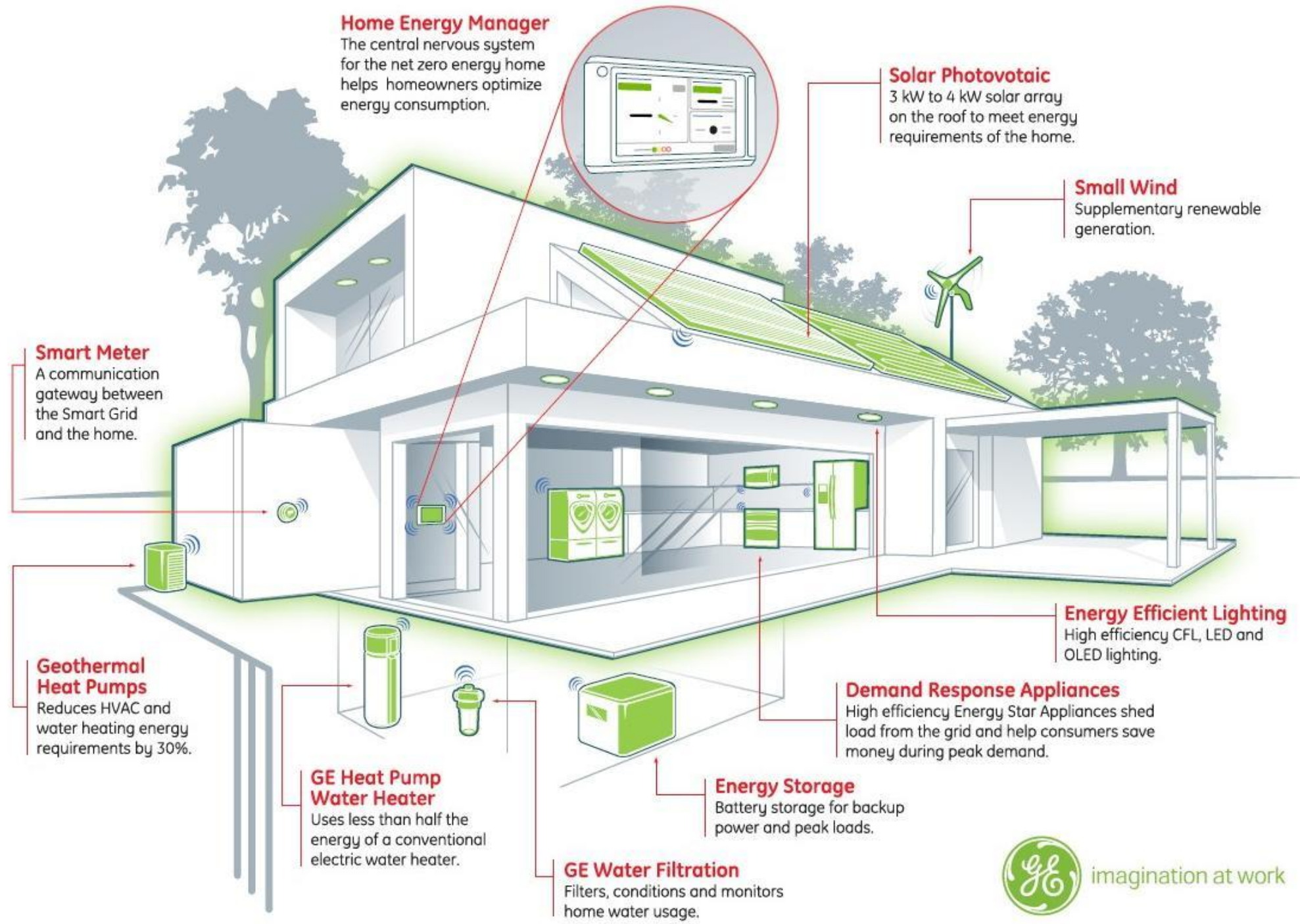
What factors contribute to the variation in energy consumption between different households?



Example of an energy-efficient building

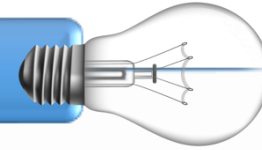


Example of an energy-efficient building



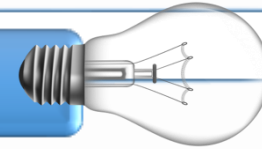
What are the impacts of energy production on environment, economy, and community?

Environment



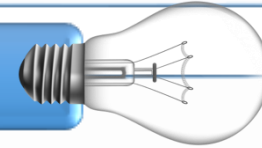
- Energy production causes emissions that contribute to climate change, smog, and reduced air quality on a global scale. With the enormous amount of energy that is used within buildings comes an opportunity to reduce these environmental impacts.

Economy



- Energy costs represent a significant percentage of buildings' operating expenses. Reductions in energy use, and therefore energy costs, can benefit the economy, allowing businesses to expand and/or invest in further building improvements.

Community



- Efficient buildings within a city or region can serve as a catalyst for community engagement and foster a sense of civic pride. A community that, as a whole, significantly reduces its energy use can benefit from both the direct savings (from lower energy use), thereby increasing the availability of funds for local investment, as well as the potential savings due to the lessened need for additional energy-generation infrastructure.

What aspects of building performance have a direct impact on energy use?

Water use

- Water use can directly affect energy use because it typically takes gas or electricity to heat the water and to move the water to and from the building.

Interior color

- Interior color schemes can significantly influence energy use. Light-color surfaces reflect more light than dark surfaces and can reduce the total amount of lighting power necessary to maintain the intended light levels.

Ventilation

- Increased ventilation strategies, while helpful for increasing the overall quality of indoor air, typically require a corresponding increase in HVAC energy use.

Lighting

- Lighting to meet the needs and preferences of building occupants should be a main consideration of project teams to ensure that the use of the space requires minimal energy. Enabling occupants to turn off their lights when not in use can net significant lighting energy savings.

Watch the video

How do buildings affect the environment

- Link:

https://www.youtube.com/watch?v=ap65Hnddfv4&ab_channel=MultiComfortUK

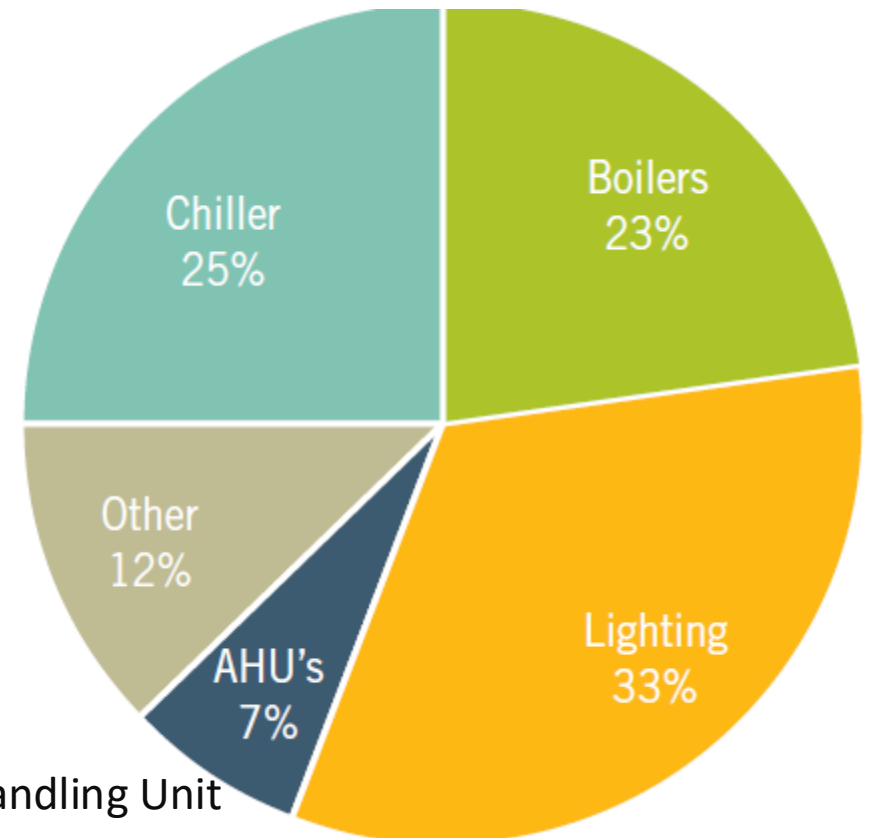
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What percentage of total produced energy & electricity in the U.S is consumed in buildings?

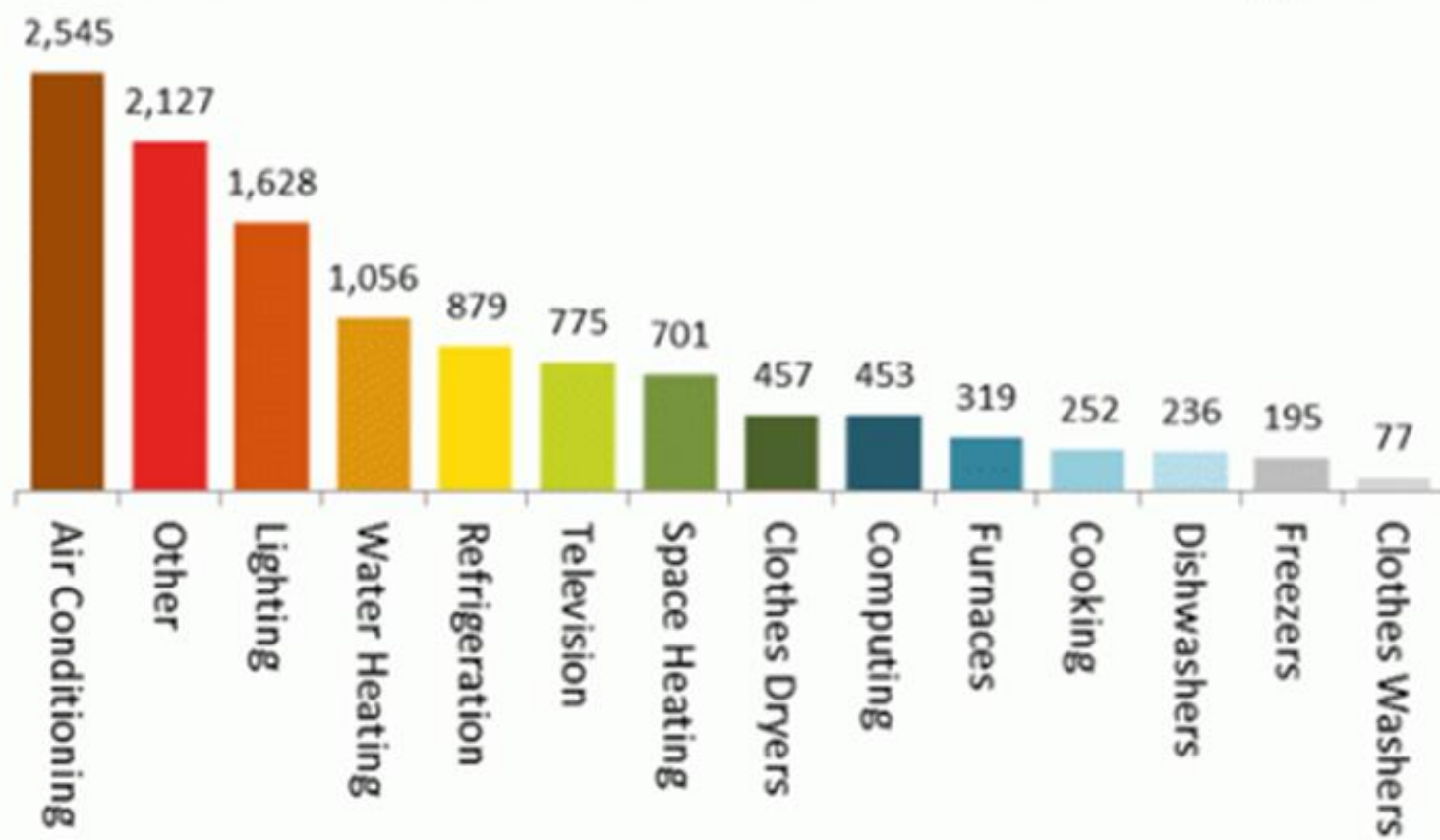
- Buildings consume approximately 39% of the energy and 74% of the electricity produced annually by the United States, according to the Department of Energy.

How does the energy use breakdown in buildings look like?



AHU: Air Handling Unit

Electricity Consumption in US Homes: kWh/year



Why are standard compact fluorescent lamps highly preferred to conventional incandescent lamps?

- Conventional incandescent lamps use approximately four times the energy to create the same light output as standard compact fluorescent lamps.
- The wasted energy is converted into heat and, in many buildings, creates an additional burden on the air-conditioning system.



Watch the video

Traditional light bulbs VS CFL (Compact Fluorescent Lamps)

- Link:

https://www.youtube.com/watch?v=DIB6_2g0WW0&ab_channel=DanskSocialArbejde

(you may also click on the YouTube Logo below)



What are the four main factors to reduce the impacts of energy use by buildings?

Energy demand

Energy efficiency

Renewable energy

Ongoing energy performance

Factors to reduce the impacts of energy use by buildings

Factor 1. Energy Demand



What do we mean by "energy demand" in a building?



- The first step a project team should consider when trying to save energy is to reduce energy demand.
- "Energy demand" in a building refers to the amount of energy required to maintain comfortable living or working conditions within that structure.
- This encompasses the energy needed for heating, cooling, lighting, operating appliances, and powering systems that provide for the functional and operational needs of the building's occupants.
- Energy demand is the total energy consumption necessary for a building to function effectively and comfortably, often measured over a specific time period, such as daily or annually.

What factors can influence the energy demand of a building?

Local weather conditions and microclimate.

Heat from direct and reflected sunlight.

Temperatures of surrounding buildings and the ground.

Heat exchange between neighboring buildings.

Heat transfer due to wind.

Urban heat island effects.

Building design and materials.

Insulation and energy efficiency measures.

Building usage and occupancy patterns.

Efficiency of appliances and systems within the building.



Strategies to lower the energy demand

1. Establish design and energy goals.

- This approach involves setting specific targets and strategies early in the design process to ensure energy efficiency and sustainability are integral components of the building's design, construction, and operation.

Prioritize energy-efficient design and equipment.

Employ an integrated design process, facilitating collaboration among architects, engineers, and stakeholders to optimize energy performance.

Incorporate renewable energy sources, such as solar and wind power, to meet the building's energy needs and reduce reliance on fossil fuels.

Utilize passive design strategies that leverage natural resources for heating, cooling, and lighting to minimize mechanical system use.

Select high-performance materials and technologies, like triple-glazed windows and LED lighting, to enhance the building's energy efficiency.

Apply energy modeling and simulation tools during the design process to evaluate and optimize the building's energy performance.

Align the project with energy performance standards and certifications, such as LEED or BREEAM, to ensure compliance with established benchmarks.

Conduct lifecycle cost analysis to consider the building's total cost over its lifespan, highlighting the long-term savings from energy efficiency.

Design buildings to be adaptable to climate change, ensuring they remain energy-efficient and resilient in the face of changing environmental conditions.

Influence occupant behavior by designing spaces that encourage energy awareness and promote energy-saving practices.

Strategies to lower the energy demand

2. Size the building appropriately.

- Sizing the building appropriately has the following advantages:

Reduces heating and cooling loads by optimizing the building's surface area to volume ratio.

Limits excessive solar gain in summer, reducing the need for air conditioning.

Enhances the effectiveness of insulation by minimizing exposed exterior surfaces.

Supports passive solar heating in winter, reducing the need for artificial heating.

Encourages the use of natural ventilation, reducing dependence on mechanical ventilation systems.

Allows for more efficient use of space heating and cooling technologies.

Improves building envelope performance, leading to lower energy loss.

Optimizes daylighting, reducing the need for artificial lighting.

Facilitates the integration of renewable energy systems by aligning size with energy generation capacity.

Encourages sustainable design practices, leading to a holistic reduction in energy demand.

Strategies to lower the energy demand

3. Use free energy.

- Using free energy includes the following :



Incorporates solar panels for electricity generation

Utilizes passive design to allow the building to be warm in the winter, stay cool in the summer, and capture daylight

Employs wind turbines for on-site power generation

Implements geothermal systems for heating and cooling

Utilizes rainwater harvesting for landscaping and toilet flushing

Incorporates daylighting techniques to reduce artificial lighting needs

Installs energy-efficient windows to maximize natural heating and minimize heat loss

Uses natural ventilation strategies to reduce the need for air conditioning

Employs green roofs to insulate and reduce heat island effect

Integrates smart energy management systems to optimize energy use

Strategies to lower the energy demand

4. Insulate.

- Here is how insulating can influence a building



Reduces heat loss
in winter

Lowers heat gain
in summer

Decreases the
need for heating
and cooling
systems

Maintains a more
consistent indoor
temperature

Reduces energy
consumption for
heating and
cooling

Improves occupant
comfort

Decreases
greenhouse gas
emissions from
energy use

Strategies to lower the energy demand

5. Monitor consumption.

- The following shows how monitoring consumption can lower the energy demand in a building:

Encourages energy-efficient behavior among occupants

Identifies inefficient appliances or systems for upgrade or replacement

Enables targeted energy-saving measures based on consumption patterns

Supports the implementation of energy-efficient scheduling for building operations

Facilitates the detection and correction of energy leaks or wastage

Enhances the effectiveness of energy management systems

Promotes the adoption of renewable energy sources by highlighting potential savings

Improves the allocation of energy resources within the building

Encourages participation in demand response programs to reduce peak load demand

Increases awareness and accountability regarding energy use among all building users



Factors to reduce the impacts of energy use by buildings

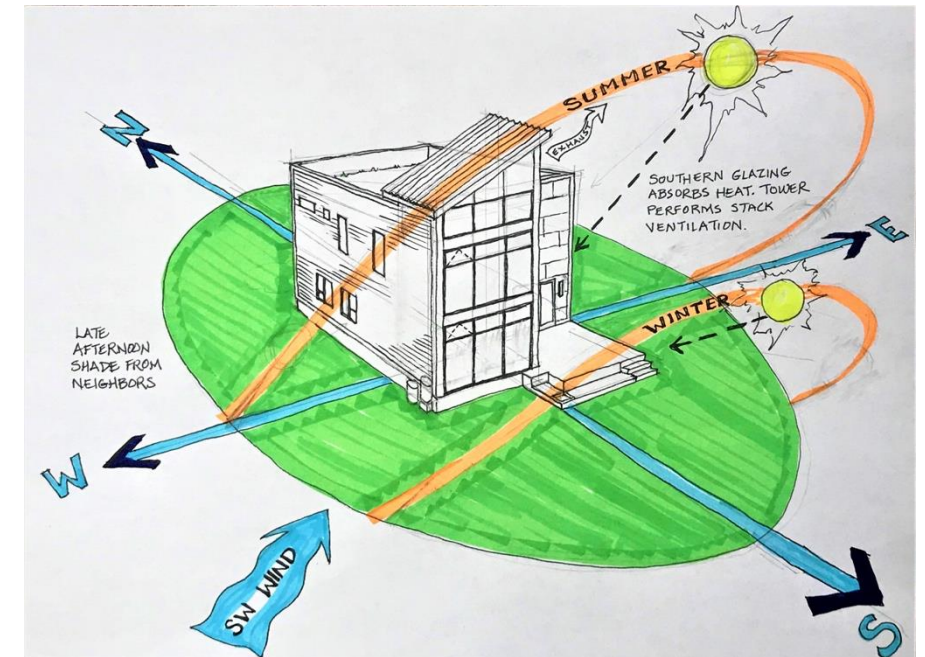
Factor 2. Energy efficiency



Strategies to increase the energy efficiency

1. Identify passive design opportunities.

- This means recognizing and leveraging the natural resources and conditions surrounding the building to minimize energy consumption for heating, cooling, lighting, and ventilation.
- This approach focuses on the building's design and orientation, materials, and construction techniques to reduce reliance on mechanical systems and artificial energy sources.



What are the key components of passive design to increase the energy efficiency of the building?

Orientation and Layout

- Optimizing the building's orientation and layout to take advantage of solar gain in winter and minimize heat gain in summer, thus reducing the need for heating and cooling.

Insulation and Thermal Mass

- Utilizing materials with high thermal mass and effective insulation to stabilize indoor temperatures, keeping the building warm in winter and cool in summer without extensive mechanical heating or cooling.

Natural Ventilation

- Designing windows, vents, and openings to encourage cross-ventilation and exploit natural breezes for cooling, reducing the need for air conditioning.

Daylighting

- Maximizing natural light penetration into the building to reduce the need for artificial lighting, while controlling glare and excessive heat gain.

Shading and Glazing

- Implementing shading devices, such as overhangs, louvers, and trees, along with selecting appropriate glazing types to control solar radiation and heat transfer.

Landscaping and Site Planning

- Using landscaping strategically for shading, wind protection, and to enhance the microclimate around the building.

Roof Design

- Employing cool roofs or green roofs to reflect more sunlight and absorb less heat or provide additional insulation and reduce heat island effect.

Strategies to increase the energy efficiency

2. Address the building envelope.

- What are some examples of addressing the building envelope to increase the energy efficiency?

Enhancing insulation in walls, roofs, and floors to reduce heat loss or gain.

Installing high-performance windows and glazing to minimize energy loss.

Implementing air sealing techniques to prevent drafts and air leakage.

Using thermal mass materials to regulate indoor temperatures naturally.

Applying cool roofing materials to reflect more sunlight and absorb less heat.

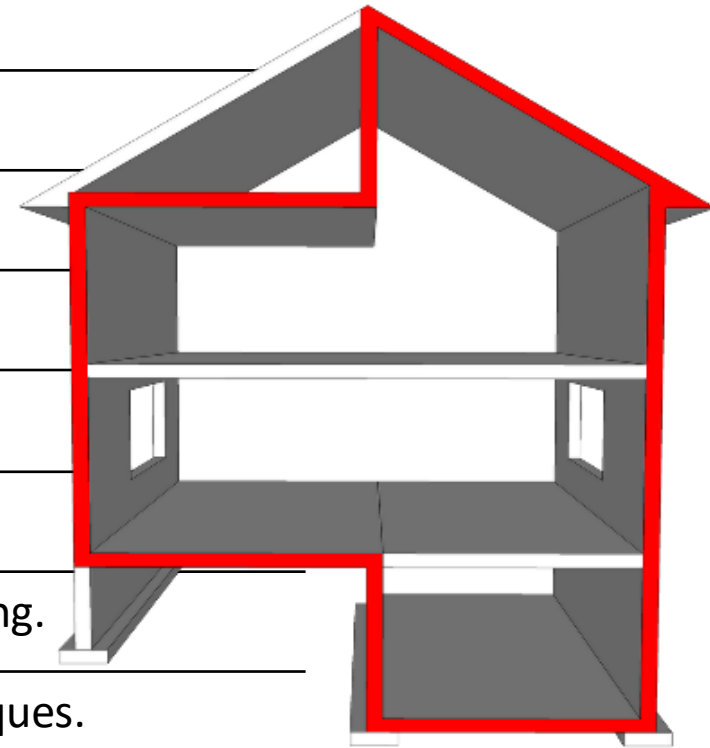
Incorporating shading devices (e.g., overhangs, louvers) to reduce cooling loads.

Upgrading doors and windows with weather stripping and caulking for better sealing.

Utilizing energy-efficient exterior wall systems, including advanced framing techniques.

Incorporating green roofs or roof gardens to improve insulation and reduce heat island effect.

Implementing passive solar design principles to maximize natural heating, cooling, and daylighting.



Strategies to increase the energy efficiency

3. Install high-performance mechanical systems.

- Installing high-performance mechanical systems can increase the energy efficiency in a building through various means, including:

Enhanced HVAC efficiency

Improved air quality and ventilation

Automated energy management

Variable speed drives

High-efficiency boilers and chillers

Demand-controlled ventilation

Heat recovery systems

Enhanced insulation and sealing

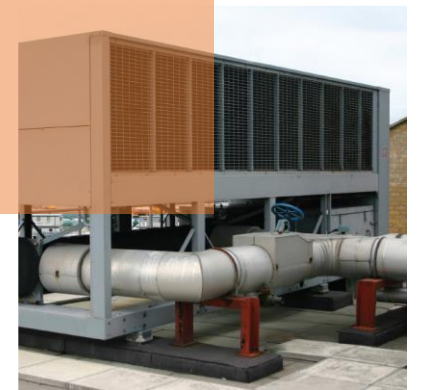
Use of renewable energy sources

Smart meters and sub-metering

High-performing systems often carry a cost premium but use less energy than conventional systems. Investments in premium systems often pay for themselves many times over during the equipment's lifetime.

The primary factors to consider in selecting the HVAC systems for the tenant space are

1. Expected life
2. Energy performance



Strategies to increase the energy efficiency

4. Use high-efficiency appliances.

- Look for the star! ENERGY STAR equipment uses less energy than conventional appliances. The following are the benefits of using high efficiency appliances:

Reduce energy consumption by using less electricity or gas

Lower utility bills due to reduced energy use

Decrease greenhouse gas emissions and carbon footprint

Enhance performance and reliability compared to older, less efficient models

Enable smart energy management through integrated technologies

Increase property value and marketability

Comply with energy efficiency standards and regulations

Extend appliance lifespan through advanced technologies and materials

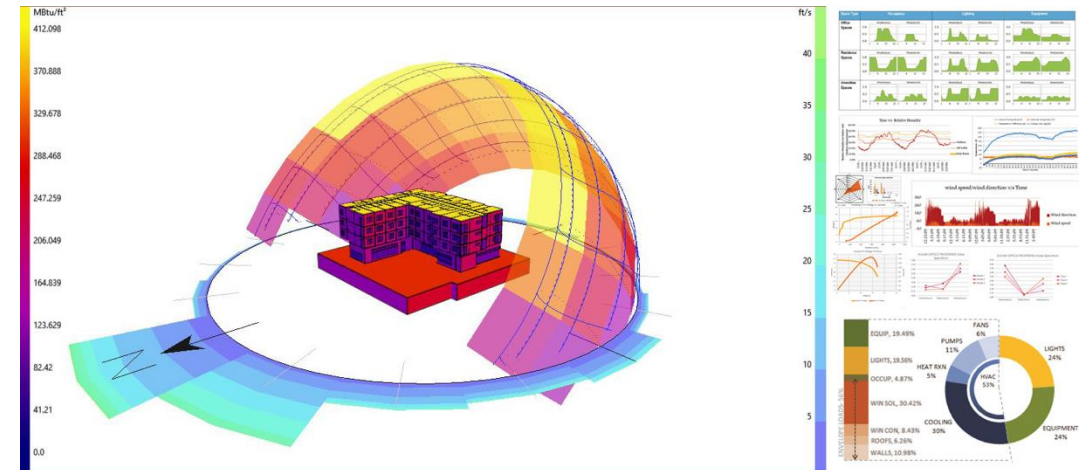
Optimize energy use during off-peak hours to save costs

Support renewable energy integration by reducing overall energy demand

Strategies to increase the energy efficiency

5. Use energy simulation models.

- Building performance can be predicted before the building is even constructed, and design options can be evaluated to determine which one offers the greatest energy benefit.
- Energy simulation or energy modeling allows the team to look at the different energy efficiency measures to see how they work together and which offer the greatest benefit.



Strategies to increase the energy efficiency

6. Use high-efficiency infrastructure.

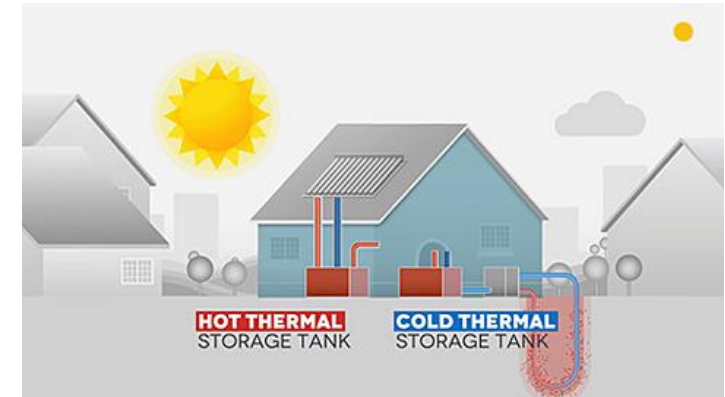
- High-efficiency infrastructure in buildings encompasses a range of technologies and systems designed to minimize energy use, reduce environmental impact, and enhance occupant comfort.
- Some examples include:

LED Lighting	High-Efficiency HVAC Systems	Energy-Efficient Windows	Solar Panels	Smart Thermostats	Energy Recovery Ventilators (ERV)
Green Roofs	Water-Efficient Fixtures	Insulation and Air Sealing	Demand-Controlled Ventilation (DCV)	Building Automation Systems (BAS)	Energy Management Systems (EMS)
		Geothermal Heat Pumps	On-site Renewable Energy Generation		

Strategies to increase the energy efficiency

7. Use thermal energy storage.

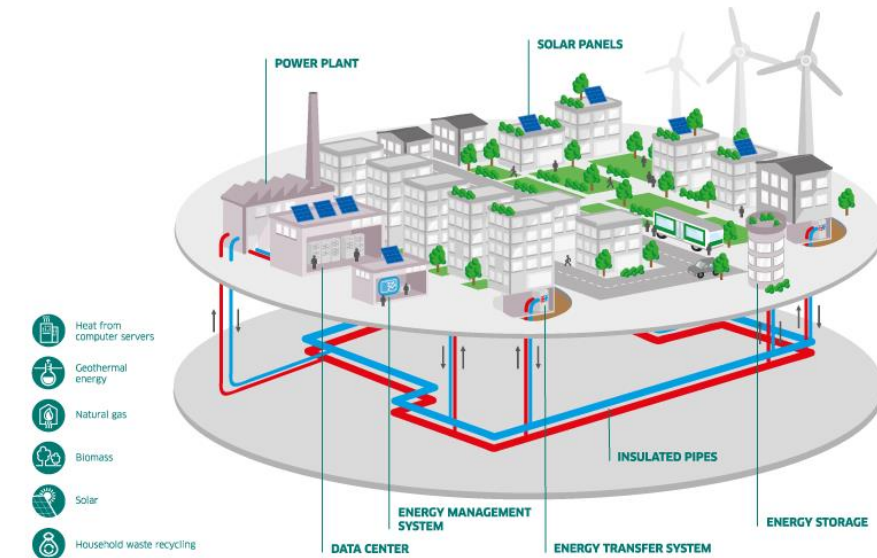
- Thermal Energy Storage (TES) in buildings is a technology that stores thermal energy for later use, offering a way to balance energy demand and supply, improve energy efficiency, and reduce operational costs.
- Because of the day/night cycle and corresponding temperature fluctuations, it is possible to capture heat during the day for use at night, and reject heat at night to provide cooling during the day



Strategies to increase the energy efficiency

8. Capture efficiencies of scale.

- District heating and cooling systems provide a centralized solution for the thermal conditioning of multiple buildings within a defined area, such as a university campus, a hospital complex, or a downtown district.
- These systems offer significant advantages over individual heating and cooling systems installed in each building due to their scale and efficiency.



Watch the video

An Introduction to District Heating Systems

- Link:

https://www.youtube.com/watch?v=a8Khzns0KIk&ab_channel=CityBeautifull

(you may also click on the YouTube Logo below)



Factors to reduce the impacts of energy use by buildings

Factor 3. Renewable energy



Strategies to use renewable energy

1. Generate on-site renewable energy.



- Generating on-site renewable energy by buildings involves installing renewable energy systems directly on the premises to produce electricity or thermal energy from sustainable sources. This approach reduces reliance on the grid and decreases carbon emissions. Common methods include:

Solar Panels (Photovoltaics):	Convert sunlight into electricity to power building operations.
Solar Thermal Systems	Capture sunlight to heat water or air for domestic use or space heating.
Wind Turbines:	Small-scale turbines can generate electricity from wind, suitable for buildings with enough space and in windy locations.
Geothermal Heat Pumps	Use the stable temperature of the earth to provide heating, cooling, and hot water efficiently.
Biomass Systems	Use organic materials, such as wood pellets, for heating or generating electricity.

Strategies to use renewable energy

2. Purchase off-site renewable energy.

- Purchasing off-site renewable energy allows buildings to invest in or buy renewable energy from sources located elsewhere, rather than generating it on-site.
- This approach enables buildings to offset their energy consumption with clean energy, contributing to sustainability goals without the need for installing renewable energy systems like solar panels or wind turbines directly on their premises.



Factors to reduce the impacts of energy use by buildings

Factor 4. Ongoing energy performance



Strategies to improve ongoing energy performance

1. Adhere to owner's project requirements.

- The owner's project requirements (OPR) are determined at the beginning of design and establish the building's functional requirements.
- During design, and throughout construction and operation, the OPR should be used as a benchmark for achievement when evaluating design options and functionally testing the systems once constructed.



Strategies to improve ongoing energy performance

2. Provide staff/occupant training.



- Informed building occupants are better able to use the systems as they are intended.
- Staff training resources ensure that building operators understand how to maintain and operate complex systems. It has the following advantages:

Enhances understanding of energy-efficient features and systems

Promotes energy-conscious behaviors and practices

Encourages participation in energy-saving initiatives

Improves the use of programmable thermostats and other energy management tools

Increases compliance with energy-efficient operating procedures

Facilitates feedback on energy use and conservation opportunities

Reduces wasteful energy habits

Empowers occupants to make informed decisions about energy use

Identifies and corrects inefficient energy use patterns

Supports the maintenance of energy-efficient equipment and systems

Strategies to improve ongoing energy performance

3. Conduct preventive maintenance.

Periodic maintenance helps ensure that systems stay in peak operating condition.

This has the following advantages:

Ensures equipment
operates at peak
efficiency

Reduces
unexpected
downtime due to
equipment failure

Extends the
lifespan of building
systems and
equipment

Minimizes energy
waste from
inefficient
operation

Keeps HVAC
systems running
efficiently

Reduces the need
for emergency
repairs and
associated costs

Identifies potential
issues before they
become major
problems

Ensures optimal
performance of
insulation and
building envelope

Maintains efficient
lighting systems

Optimizes water
heating system
performance

Supports
consistent indoor
air quality and
comfort

Enhances the
reliability of
renewable energy
systems



Strategies to improve ongoing energy performance

4. Create incentives for occupants and tenants.

- Motivated building users can be an ally in reducing energy use.
- The use of incentives and the direct transfer of energy costs can help encourage occupants to turn off lights and equipment when they are not in use.



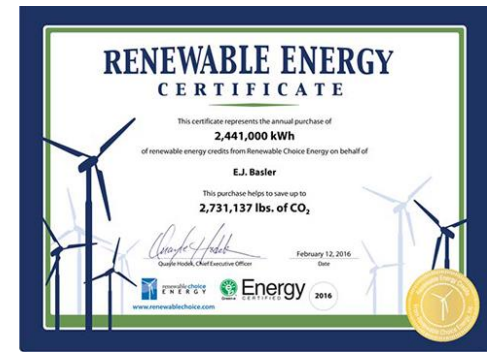
Strategies to improve ongoing energy performance

5. Commission building systems.



- One of the most cost-effective ways to ensure optimal ongoing energy performance is to commission building systems.
- Commissioning building systems involves a quality assurance process that ensures these systems are designed, installed, tested, operated, and maintained according to the operational requirements of the building owner.
- This process helps in identifying and fixing problems early, ensuring that the building's mechanical, electrical, and plumbing systems, as well as its building envelope, are functioning as efficiently as possible.

Renewable Energy Certificates (RECs)



- RECs represent proof that electricity has been generated from renewable energy sources and fed into the grid.
- Each certificate corresponds to a certain amount of renewable electricity generated and delivered to the power grid.
- By purchasing RECs, an entity can claim to have supported the production of renewable energy, even if the physical electricity consumed comes from a different, potentially non-renewable, source.
- This mechanism allows for the support and expansion of renewable energy projects and gives flexibility in meeting renewable energy goals or requirements without the need for direct on-site renewable installations.
- RECs play a critical role in tracking and verifying the green attributes of electricity, enabling businesses and individuals to reduce their environmental footprint by supporting renewable energy development.

What are refrigerants in buildings and what is their negative environmental impact?

- Refrigerants in buildings are substances used in air conditioning and refrigeration systems to absorb heat from the environment and release it elsewhere, allowing for cooling. These substances transition between liquid and gas phases within the refrigeration cycle, effectively removing heat from indoor spaces to provide a comfortable environment or to preserve perishable goods.
- The negative environmental impact of certain refrigerants stems primarily from two major issues:
 1. Global warming potential
 2. Ozone depletion potential



Process energy

- Process energy refers to the energy used for activities that are specific to the particular processes of a building's function, such as cooking in kitchens, running office equipment, and operating escalators.
- This contrasts with "regulated energy," which is used for more general building operations such as heating, cooling, lighting, and water heating.
- Process energy accounts for a variable portion of a building's total energy consumption, depending on its use and the efficiency of the equipment involved.

