



INTRODUCTION TO CIVIL ENGINEERING

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Syllabus

Sustainable Development and Smart Infrastructure in Civil Engineering

- Sustainable materials and green construction: Green Building rating systems (LEED, IGBC, GRIHA), Energy efficient designs and materials, rainwater harvesting, green roofs. Use of sensors and smart systems in green buildings.
- Built-environment: Embodied energy, temperature and sound control in buildings, Security systems. Recycling. Environment: Water Supply and Sanitary systems, urban air pollution management, Solid waste management, identification of Land fill sites, urban flood control.

Introduction to Sustainability

- Sustainability has emerged as one of the most important guiding principles in engineering, planning, and design over the past few decades.
- The Brundtland Report (1987) defined **sustainable development** as meeting the needs of the present without compromising the ability of future generations to meet their own needs.



Sustainable Environment

Sustainable design and construction practices in the built environment –**GRIHA** and **LEED** rating system

- Green Building Rating Systems are comprehensive tools used in engineering practice to **quantify, measure, and validate** the sustainability performance of buildings throughout their life cycle.
- By setting specific benchmarks, they guide the design, construction, and operation of structures to reduce environmental impact and enhance human health.
- The two prominent examples discussed here are **GRIHA** (India's national system) and **LEED** (the globally dominant system).

Sustainable Environment

The Role of Green Building Rating Systems

- Green Building Rating Systems (GBRS) serve as quantifiable frameworks that assess the **environmental, social, and economic performance of buildings**. They move sustainable design from abstract principles to measurable engineering standards, ensuring resource efficiency, occupant health, and minimized environmental impact across a building's entire lifecycle.

Common Objectives of GBRS:

- **Reduce Resource Consumption:** Minimize energy, water, and material use.
- **Improve Health:** Enhance Indoor Environmental Quality (IEQ) for occupants.
- **Minimize Ecological Damage:** Promote sustainable site planning and protect biodiversity.

Sustainable Environment

GRIHA

(Green Rating for Integrated Habitat Assessment)

- GRIHA is **India's national green building rating system** developed by TERI (The Energy and Resources Institute) and endorsed by the Ministry of New and Renewable Energy (MNRE), Government of India.
- GRIHA, meaning "Abode" in Sanskrit, is India's national rating system, developed by TERI and endorsed by the Government of India. It is specifically designed to address the socio-economic and climatic conditions unique to the Indian subcontinent.

Sustainable Environment

GRIHA

- **Indian Ethos:** GRIHA prioritizes indigenous materials, passive solar techniques, and site-specific resource management, aligning with India's diverse climatic zones (composite, hot-dry, warm-humid, cold).
- **Mandatory Criteria:** GRIHA has several mandatory requirements that must be met to even qualify for certification, ensuring a baseline of sustainability.
- **Life Cycle Assessment (LCA):** The system deeply integrates LCA principles, particularly in its focus on the embodied energy and Global Warming Potential (GWP) of building materials.

GRIHA: Max 100 Points

Category (Points)	Key Sustainable Design Practices and Requirements
I. Sustainable Site Planning (8 points)	<ul style="list-style-type: none">• Low Impact Design (LID): Minimizing impervious surfaces and maximizing green infrastructure.• UHIE Mitigation: Using high-reflectance materials (SRI values) on roofs and paved surfaces.
II. Construction Management (9 points)	<ul style="list-style-type: none">• Pollution Control: Implementation of stringent measures for air and soil pollution control on site.• Topsoil Preservation: Protecting and reusing excavated topsoil.• Worker Welfare: Mandatory safety, sanitation, and dedicated facilities for construction labor.
III. Energy Efficiency (20 points)	<ul style="list-style-type: none">• Energy Optimization: Optimizing the building envelope (walls, roof, windows) for maximum thermal comfort and minimum mechanical heating/cooling demand (passive design).• Renewable Energy (RE): Utilization of on-site solar, wind, or other renewable energy to offset building load.

Category (Points)	Key Sustainable Design Practices and Requirements
IV. Occupant Comfort (12 points)	<ul style="list-style-type: none"> • Thermal & Visual Comfort: Use of daylight and ensuring prescribed air changes per hour (ACH). • Indoor Air Quality: Use of low-VOC (Volatile Organic Compound) paints, sealants, and adhesives in interiors.
V. Water Management (17 points)	<ul style="list-style-type: none"> • Demand Reduction: Installing low-flow plumbing fixtures (toilets, faucets) to conserve potable water. • Wastewater Treatment: Mandatory on-site treatment (e.g., Sewage Treatment Plants - STP) and reuse of treated water for flushing, irrigation, and cooling towers.
VI. Sustainable Materials (14 points)	<ul style="list-style-type: none"> • Alternative Materials: Using materials with high recycled content (e.g., fly ash bricks) and those utilizing local/regional resources. • Embodied Energy Reduction: Mandatory requirement to reduce GWP/Embodied Energy of structural materials through LCA.
VII. Monitoring & Validation (7 points)	<ul style="list-style-type: none"> • Smart Metering: Mandatory installation of smart meters for continuous monitoring of energy and water consumption post-occupancy to ensure performance gaps are minimized.

Sustainable Environment

GRIHA

A. Core Focus and Goals

- **Contextual Relevance:** GRIHA is tailored to India's diverse climate zones, resources, and construction practices, aiming to minimize a building's ecological impact within **nationally acceptable benchmarks**.
- **Life Cycle Approach:** It evaluates the environmental performance of a building **holistically over its entire life cycle**, from construction to demolition.
- **Quantification:** It quantifies aspects like energy consumption, waste generation, and renewable energy adoption to ensure that "what gets measured, gets managed".

Sustainable Environment

GRIHA

B. Key Rating Categories (Criteria)

- GRIHA assesses projects based on criteria divided into several categories, generally totaling **100 points** across criteria and 4 additional points for innovation.
- **Sustainable Site Planning:** Includes low-impact design, site selection, and measures to mitigate the Urban Heat Island Effect (UHIE).
- **Construction Management:** Focuses on air and soil pollution control, preservation of topsoil/landscape, and worker safety/sanitation.

Sustainable Environment

GRIHA

B. Key Rating Categories (Criteria)

- **Energy Efficiency:** Optimizing building design to reduce conventional energy demand and utilizing **Renewable Energy (RE)** sources.
- **Water Management:** Reduction in water demand, wastewater treatment, rainwater management, and water quality.
- **Sustainable Building Materials:** Promoting the use of alternative materials (e.g., waste materials like fly ash), and reducing the **Global Warming Potential (GWP)** and **Embodied Energy** through Life Cycle Assessment (LCA).

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GRIHA

B. Key Rating Categories (Criteria)

- **Occupant Comfort and Well-being:** Ensuring good Indoor Air Quality (IAQ), visual, thermal, and acoustic comfort.
- **Performance Monitoring:** Includes commissioning and smart metering/monitoring for ongoing performance validation.

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GRIHA

C. GRIHA Certification Levels

- GRIHA uses a **Star Rating system** based on the percentage of total points achieved.

Rating	Points Achieved
1 Star	25-40 points
2 Stars	41-55 points
3 Stars	56-70 points
4 Stars	71-85 points
5 Stars	86 or more points

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LEED

(Leadership in Energy and Environmental Design)

- LEED is an **internationally recognized** green building certification system developed by the **U.S. Green Building Council (USGBC)**. It provides a comprehensive framework for designing, constructing, and operating high-performance green buildings



Sustainable Environment

LEED

- **Global Benchmarks:** LEED relies on established **international standards** to set quantifiable benchmarks for building performance.
- **Market Transformation:** By creating **demand for green materials** and professional services, it has successfully driven the entire construction industry toward sustainable practices.
- **Performance-Based:** Certification is awarded based on the **total number of points achieved**, offering flexibility in which credits a project pursues.

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LEED:

LEED uses a **100-base point system** with additional points available for Innovation and Regional Priority (up to 110 total points).

Category (Potential Points)	Key Sustainable Design Practices and Requirements
Integrative Process (1 point)	<ul style="list-style-type: none">• Conducting early-stage energy and water modeling/analysis to inform design decisions and set performance targets.
Location and Transportation (16 points)	<ul style="list-style-type: none">• Connectivity: Selecting sites near diverse uses, public transit, and community resources.• Vehicle Use Reduction: Providing preferred parking for carpools, electric vehicles, and ample bicycle storage.
Sustainable Sites (11 points)	<ul style="list-style-type: none">• Site Development: Protecting existing natural habitat and restoring degraded areas.• Stormwater Management: Implementing green infrastructure like bioswales and pervious pavement to manage runoff.

Category (Potential Points)	Key Sustainable Design Practices and Requirements
Water Efficiency (11 points)	<ul style="list-style-type: none"> • Water Use Reduction: Mandatory prerequisites for reduction. Credits for reducing potable water consumption through efficient irrigation, non-potable sources, and efficient indoor fixtures.
Energy and Atmosphere (33 points)	<ul style="list-style-type: none"> • Energy Performance: The largest category. Credits awarded for exceeding energy efficiency standards through design and systems optimization (HVAC, lighting, plug loads). • On-site RE: Points for generating renewable power. Commissioning: Mandatory process to verify systems operate as intended.
Materials and Resources (13 points)	<ul style="list-style-type: none"> • Waste Management: Diverting construction and demolition waste from landfills. Sourcing: Using materials with Environmental Product Declarations (EPDs), certified sustainable wood (FSC), or low embodied energy.
Indoor Environmental Quality (16 points)	<ul style="list-style-type: none"> • Acoustics & Lighting: Controlling noise levels and maximizing daylight/views. • IAQ: Mechanical ventilation monitoring and use of low-emitting (low-VOC) interior materials.
Innovation & Regional Priority (10 points)	<ul style="list-style-type: none"> • Recognizing exemplary performance in existing credits or innovative strategies not covered elsewhere.

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LEED

A. Core Focus and Goals

- **Global Standard:** LEED is the most widely used system globally, adopted in over 160 countries.
- **Holistic Approach:** It aims to produce buildings that are healthy, highly efficient, and save carbon and money.
- **Impact Areas:** LEED-certified buildings have been shown to reduce CO₂ emissions by an average of 34% and energy consumption by 25% compared to standard buildings.

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LEED

B. Key Credit Categories: LEED uses a **point-based system** where projects earn credits across several categories to reach certification.

- **Integrative Process (IP):** Encourages early collaboration among project teams to optimize energy and water systems.
- **Location and Transportation (LT):** Promotes site selection near existing infrastructure, access to public transit, and reduced vehicle reliance.
- **Sustainable Sites (SS):** Focuses on minimizing impact on ecosystems, reducing stormwater runoff, and controlling light pollution.

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LEED

B. Key Credit Categories

- **Water Efficiency (WE):** Optimizing indoor and outdoor water use through efficient fixtures, use of recycled water, and smart landscaping.
- **Energy and Atmosphere (EA):** The most heavily weighted category, emphasizing energy performance, commissioning, and use of renewable energy.
- **Materials and Resources (MR):** Encourages the use of sustainable, healthy, and regional materials, and the reduction of construction waste. points).

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LEED

B. Key Credit Categories

- **Indoor Environmental Quality (IEQ):** Prioritizes thermal comfort, daylighting, access to views, and good Indoor Air Quality (IAQ) via ventilation and low-emitting materials.
- **Innovation (IN):** Awards points for strategies not covered by existing credits.
- **Regional Priority (RP):** Addresses environmental issues specific to the project's geographic area.

Sustainable Environment

LEED

C. LEED Certification Levels

- LEED awards four ascending levels of certification based on the total points earned (out of a possible 110 points).

Certification Level	Points Achieved
Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above

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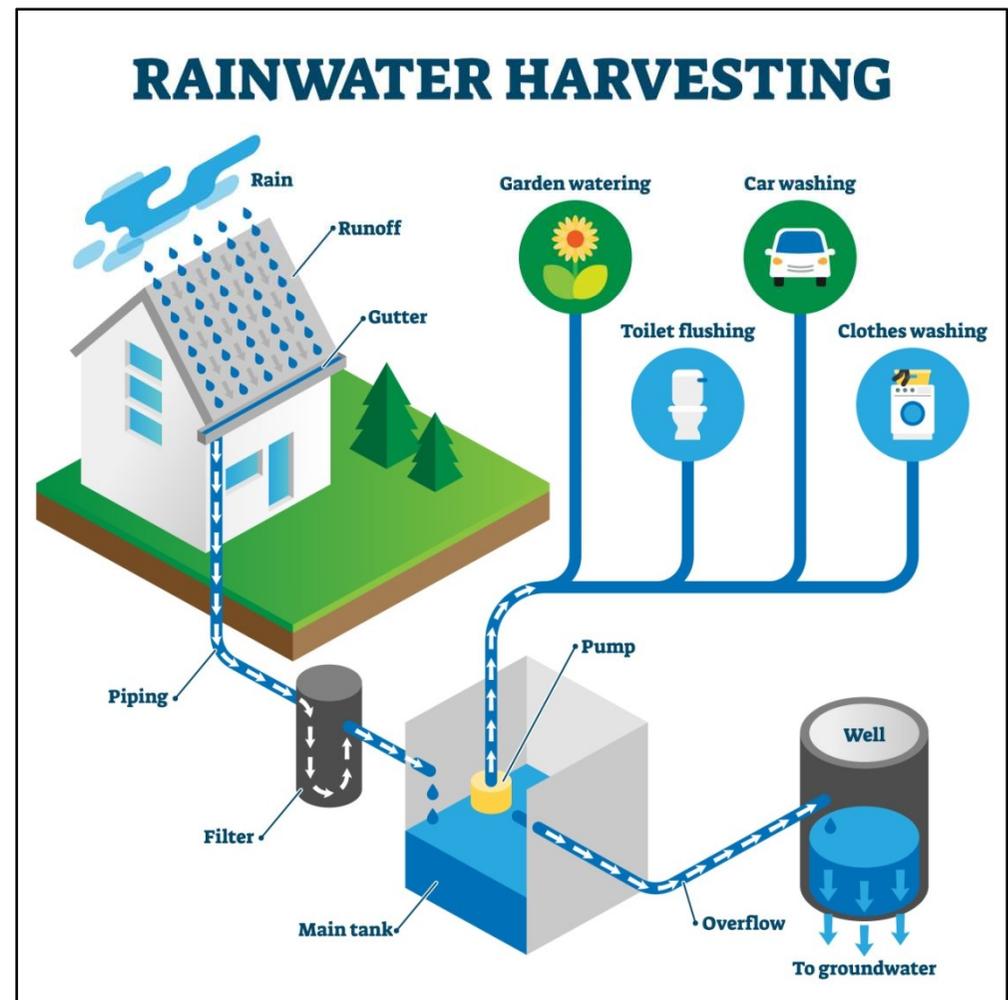
Feature	GRIHA (Green Rating for Integrated Habitat Assessment)	LEED (Leadership in Energy and Environmental Design)
Origin / Development	India's national rating system, developed by TERI and endorsed by MNRE.	International rating system, developed by the U.S. Green Building Council (USGBC).
Context	Climate and resource-specific to India, addressing regional ecology and natural resources.	Global standard, with "Regional Priority" credits to address local issues.
Emphasis	More comprehensive and focuses heavily on site-specific issues, use of passive solar techniques, and cultural/social aspects.	Stronger focus on energy efficiency and water conservation through prescriptive measures and high-performance technologies.
Certification Levels	Star Rating (1-5 Stars).	Tiered Levels (Certified, Silver, Gold, Platinum).
Post-Construction	Requires ongoing reporting of performance factors (energy, water, waste) to maintain certification.	Focuses more on design and construction, though separate ratings exist for existing buildings (O+M).

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Sustainable design and construction practices

I. Fundamental Principles of Sustainable Design

- Sustainable design aims to drastically reduce the negative environmental impact of buildings by addressing five core areas:



Sustainable Environment

I. Fundamental Principles of Sustainable Design

I. Resource Efficiency

- **Energy:** Minimizing the demand for conventional energy through **Passive Design** (e.g., maximizing daylight, optimizing orientation) and maximizing the use of **Renewable Energy** (e.g., solar panels). This includes reducing both **operational energy** (used during the building's life) and **embodied energy** (used to manufacture materials).
- **Water:** Reducing potable water consumption through efficient fixtures, **rainwater harvesting**, and treating/reusing gray and black water on-site

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I. Fundamental Principles of Sustainable Design

2. Sustainable Materials Selection

- Prioritizing materials that have **low embodied energy**, high **recycled content**, are **locally sourced** (to reduce transportation impact), and are **rapidly renewable** (e.g., bamboo, straw) .
- Avoiding materials with **Volatile Organic Compounds (VOCs)** or other toxins to ensure better indoor air quality (IAQ).

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I. Fundamental Principles of Sustainable Design

3. Site and Ecosystem Management

- **Site Selection:** Choosing sites near existing infrastructure and transit to reduce vehicle use.
- **Minimizing Disturbance:** Protecting existing green spaces, topsoil, and natural habitats during construction.
- **Stormwater Management:** Using **green infrastructure** (e.g., bioswales, rain gardens, permeable paving) to manage runoff and reduce pollution.

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I. Fundamental Principles of Sustainable Design

4. Occupant Health and Well-being (IEQ)

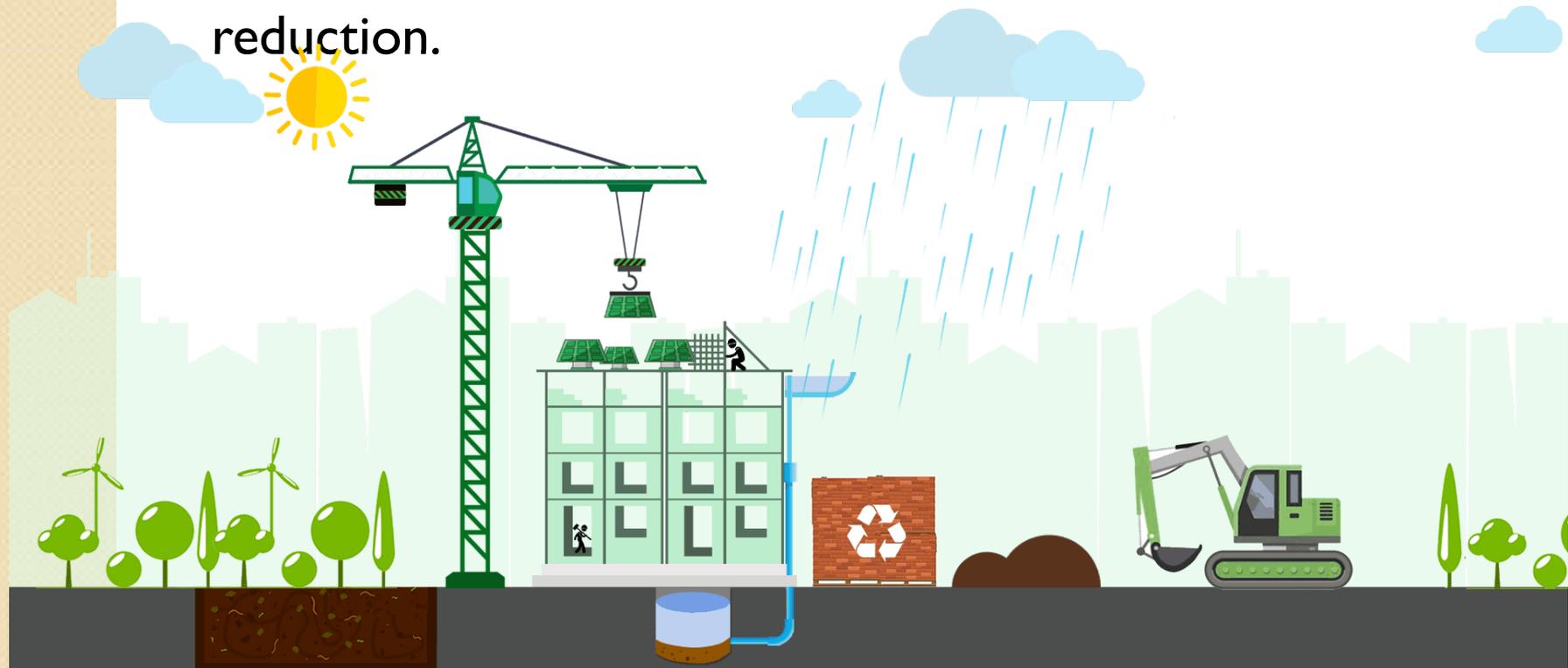
- **Indoor Air Quality (IAQ):** Ensuring proper ventilation, filtration, and using low-emitting materials.
- **Daylighting and Views:** Maximizing natural light and providing occupants with views of the outdoors to improve productivity and well-being.
- **Thermal Comfort:** Designing for consistent and comfortable indoor temperatures with minimal mechanical intervention.

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Sustainable design and construction practices

II. Key Sustainable Construction Practices

- Sustainable practices extend the design principles into the construction phase itself, focusing on efficiency and waste reduction.



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II. Key Sustainable Construction Practices

I. Construction Waste Management

- Implementing a plan to reduce, reuse, and recycle construction and demolition (C&D) waste, aiming to divert a high percentage of waste from landfills.
- **Deconstruction** (carefully taking a building apart to reuse components) rather than demolition.

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II. Key Sustainable Construction Practices

2. Erosion and Sediment Control

- Implementing strict measures (e.g., silt fences, sediment traps) to prevent soil erosion and control runoff, protecting nearby waterways and ecosystems during the construction period.

3. Integrated Project Delivery (IPD)

- Promoting early and close collaboration among all project stakeholders (architects, engineers, contractors, owners) to optimize the design from the start, avoiding costly changes and ensuring sustainable goals are met efficiently.

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Sustainable design and construction practices

III. Validation Through Green Building Rating Systems

A. GRIHA (Green Rating for Integrated Habitat Assessment)

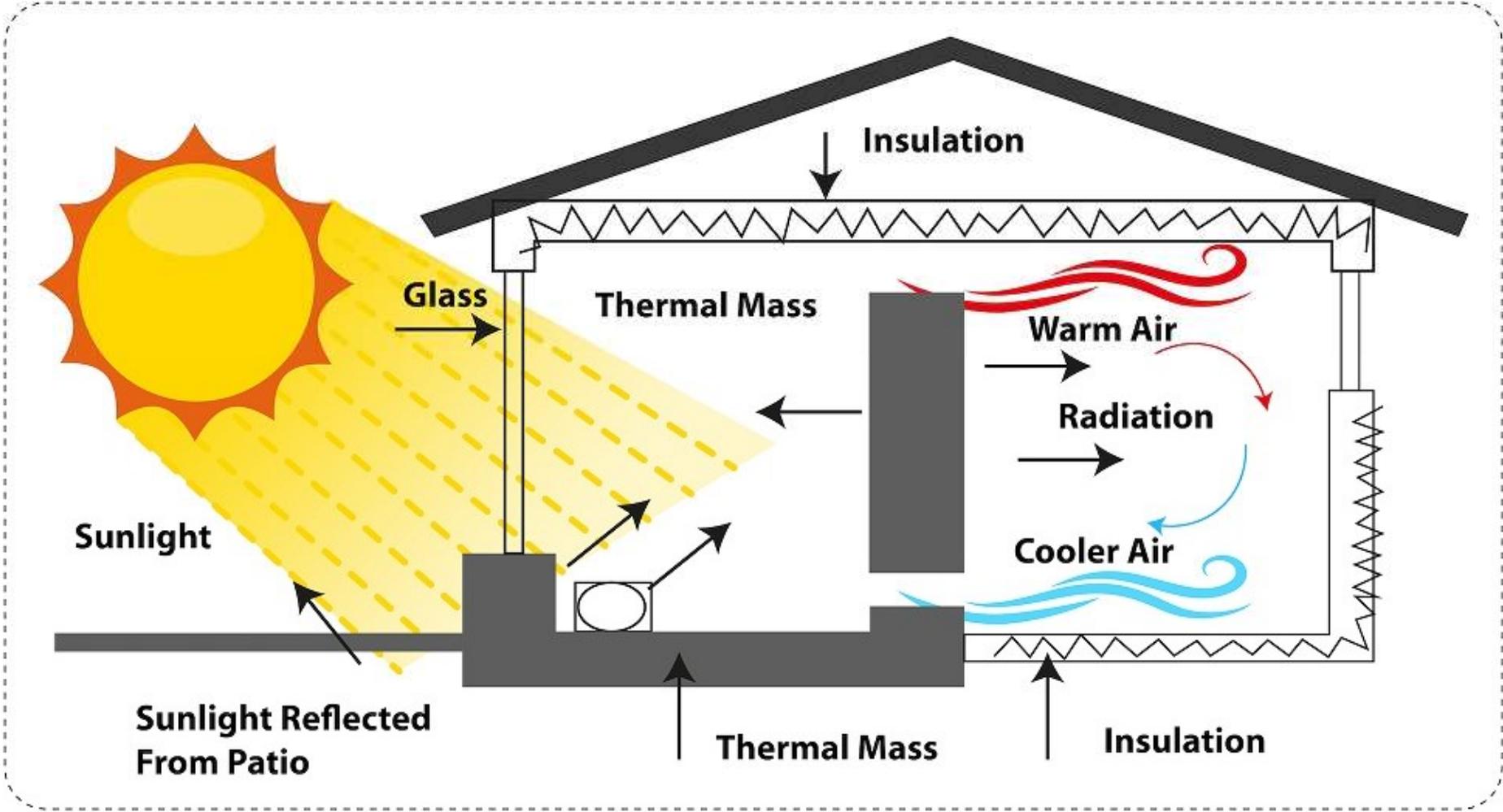
B. LEED (Leadership in Energy and Environmental Design)

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IGBC (Indian Green Building Council)

- The Indian Green Building Council operates under the Confederation of Indian Industry and has developed rating systems suited to Indian climate, codes, and market conditions. IGBC offers separate rating variants for new buildings, existing buildings, homes, factories, schools, townships, and more.
- IGBC rating categories typically cover site selection and planning, water conservation, energy efficiency, materials and resources, and indoor environmental quality, along with innovation and design process.

ENERGY-EFFICIENT DESIGNS AND MATERIALS





ENERGY-EFFICIENT DESIGNS AND MATERIALS

- Energy efficiency in buildings means designing and operating buildings so that they use the minimum possible energy to provide the same level of comfort, functionality, and services, mainly by eliminating energy waste rather than simply restricting use.
- It focuses on reducing energy demand for heating, cooling, lighting, and equipment while maintaining thermal comfort and indoor environmental quality through both design and technology.



ENERGY-EFFICIENT DESIGNS AND MATERIALS

Energy efficiency in buildings

- Energy efficiency in buildings is the extent to which a building uses **less energy per unit floor area** than typical or benchmark buildings of the same type and under similar climatic conditions, without compromising comfort, health, or functionality.
- In practice, this means that the energy consumption per square metre of floor area is equal to or better than established benchmarks for that building category, indicating reduced wastage and better performance.

ENERGY-EFFICIENT DESIGNS AND MATERIALS

Need for energy efficiency in buildings

- Energy efficiency is needed because buildings today consume more energy than either the transport or industrial sectors in many countries, mainly for space conditioning, lighting, and appliances.
- Cutting this demand is essential to address climate change, as it directly reduces greenhouse gas emissions from power plants that supply electricity and fuel for buildings.



ENERGY-EFFICIENT DESIGNS AND MATERIALS

Need for energy efficiency in buildings

- **Environmental benefits:** Using less energy reduces the amount of fuel burned in power stations, which lowers emissions of carbon dioxide and other pollutants, improving air quality and slowing global warming.



ENERGY-EFFICIENT DESIGNS AND MATERIALS

Need for energy efficiency in buildings

- **Economic benefits:** Energy-efficient buildings reduce operating costs, with many studies showing 20–30 percent savings in energy bills for homeowners and businesses when efficiency measures are properly implemented.



ENERGY-EFFICIENT DESIGNS AND MATERIALS

GLOBAL IMPACT



Climate Change & Pollution



Resource Depletion



Unsustainable

ECONOMIC BURDEN



High Operating Costs



Rising Utility Bills
Reduced Property Value



Costly

HUMAN WELL-BEING



Discomfort & Health Issues



Stress & Financial Strain
Poor Indoor Air Quality



Unhealthy

ENERGY-EFFICIENT DESIGNS AND MATERIALS

DESIGN PRINCIPLES TO ACHIEVE ENERGY EFFICIENCY



SITE SELECTION
AND PLANNING



LOCAL WEATHER
AND MICROCLIMATE



SITE LAYOUT, BUILT
FORM, AND
SURFACE-TO-VOLUME RATIO



ORIENTATION OF BUILDING
AND OPENINGS



LOCATION OF
WATER BODIES
AND LANDSCAPE
FEATURES



OPTIMIZED
DESIGN FOR
SUSTAINABILITY





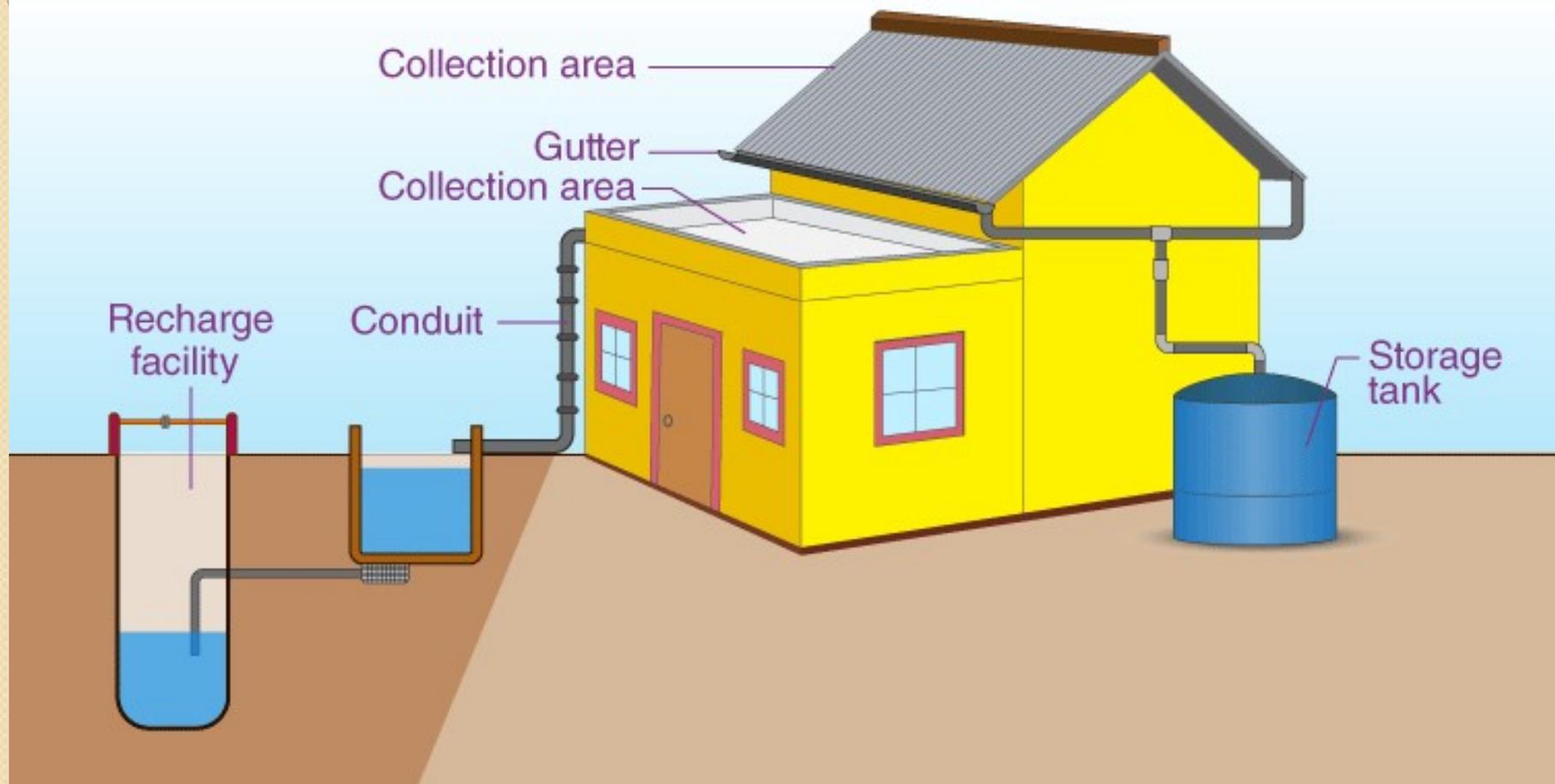
ENERGY-EFFICIENT DESIGNS AND MATERIALS

Design principles to achieve energy efficiency

The most important design elements that directly or indirectly affect thermal comfort and energy use in buildings include:

- Site selection and planning
- Local weather and microclimate
- Site layout, built form, and surface-to-volume ratio
- Orientation of building and openings
- Location of water bodies and landscape features

RAINWATER HARVESTING SYSTEMS



RAINWATER HARVESTING SYSTEMS

Purpose and benefits

- Rainwater harvesting systems collect clean rooftop rainwater for non-potable uses like toilet flushing, landscape irrigation, and vehicle washing, potentially offsetting 30-50% of municipal demand in medium-rainfall areas.
- They mitigate urban flooding by reducing peak runoff, improve groundwater levels through recharge, and support green building certifications by meeting criteria for 20-100% rainwater management depending on rating level.

RAINWATER HARVESTING SYSTEMS

Key system components:



CATCHMENT AREA



COARSE MESH AND GUTTERS



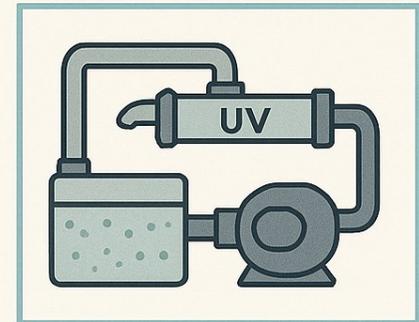
FIRST-FLUSH DIVERTER



PRE-FILTERS AND SEDIMENTATION



STORAGE TANKS



TREATMENT AND DISTRIBUTION

RAINWATER HARVESTING SYSTEMS

Key system components: A complete rainwater harvesting system follows a logical sequence from collection to use:

- **Catchment area:** Primarily rooftops (RCC, GI sheets, or tiles) that directly receive rainfall; unpaved surfaces like lawns can supplement but require more filtration.
- **Coarse mesh and gutters:** Roof-level screens block leaves/debris; gutters (PVC, galvanized steel, or semi-circular channels) sized 10-15% oversize for peak storm flows transport water to downspouts.

RAINWATER HARVESTING SYSTEMS

Key system components:

- **First-flush diverter:** Discards initial 10-20 gallons (40-80L) of dirty "first flush" containing pollutants accumulated on roofs; simple PVC pipe or automatic diverters divert clean subsequent flow.
- **Pre-filters and sedimentation:** Leaf screens, sand/charcoal filters, or vortex filters remove finer particles before storage; multi-chamber filters (sand-aggregate-pebbles) handle large roofs.

RAINWATER HARVESTING SYSTEMS

Key system components:

- **Storage tanks:** Underground or elevated polyethylene/ferrocement tanks with floating intake for clean water extraction, overflow to recharge, and UV-resistant covers; sized based on rainfall, roof area, and demand.
- **Treatment and distribution:** Final filtration (microfiltration, UV, chlorination for potable use), pumps (if needed), and piping to end-uses; gravity-fed systems preferred for low energy.

RAINWATER HARVESTING SYSTEMS



RAINWATER HARVESTING SYSTEMS

Groundwater recharge methods

- Excess or untreated water recharges aquifers via

Method	Description	Suitability
Recharge pits/trenches	Gravel-filled pits (1-2m deep) or trenches allow percolation	Shallow aquifers, sandy soils
Percolation wells/shafts	Bored wells (3-5m deep) with filter media	Deeper aquifers, low-permeability soils
Permeable pavements	Porous pavers direct runoff underground	Urban sites, parking areas

Green roofs



Green roofs

- Green roofs are layered systems covering roofs with vegetation, growing media, and drainage over waterproofing membranes to mimic natural landscapes while supporting building functions.
- They reduce urban heat islands by 2-5°C, retain 50-90% stormwater, and cut roof heat flux by 70-90% through insulation and evapotranspiration.

Green roofs

1. Extensive Green Roof

Lightweight (50-150 kgm²)
5-15cm Soil Depth
Sedums/Sedges

Low Maintenance
Ecology/Energy Savings



2. Intensive Green Roof

Heaver
(300-100 kgm²)
Shrubs/Trees/Recreation

15-60+ Soil Depth
Shrubs/Trees/Recreation
High Structural Demands

Superior
Substantial
Stormwater Retention



Green roofs

- 1. Extensive green roofs:** Lightweight (50-150 kg/m² saturated), 5-15cm soil depth, droughttolerant sedums/sedges; low maintenance, minimal structural load (add ~100mm dead load); focus on ecology/energy savings.
- 2. Intensive green roofs:** Heavier (300-1000 kg/m²), 15-60cm+ soil, shrubs/trees for recreation; higher structural demands but amenity value like rooftop parks; superior storm water retention (up to 75% volume).

SENSORS AND SMART SYSTEMS

USE OF SENSORS AND SMART SYSTEMS IN GREEN BUILDINGS

- Sensors and smart systems in green buildings use IoT devices, wireless sensors, and building management systems (BMS) to monitor real-time data on energy use, occupancy, environmental conditions, and equipment performance, enabling automated adjustments that cut energy waste by 20-55% while maintaining occupant comfort.



Key sensor types and functions:

ENVIRONMENTAL SENSORS



- Temperature, Humidity, CO₂ Levels
- Air Quality (PM2.5, VOCs)
- Light Intensity

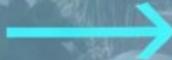


- Demand-Controlled HVAC Setpoints,
- Daylight-Linked Lighting

OCCUPANCY/MOTION SENSORS

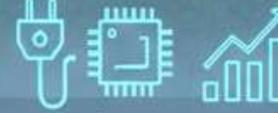


- PIR, Ultrasonic Radar Technology.
- Detects Presence.



- Activate/Deactivate Lights, HVAC Zones, Plugs be up to up to 90%

ENERGY METERS & SUB-METERS



- Track Real-time Consumption Panel, Circuit, HVAC Zones, Levels.
- Reduce Lighting by kWh for HVAC, Lighting



- Identify Inefficiencies, Support Load Shifting

EQUIPMENT SENSORS



- Vibration, Flow, Pressure, Temperature
- Pumps, Chillers, Fans



- Predictive 10-30% Energy Loss Loss from Faults

SENSORS AND SMART SYSTEMS

Key sensor types and functions: Sensors form the foundation of smart green buildings by providing continuous data for optimization across systems.

- 1. Environmental sensors:** Measure temperature, humidity, CO₂ levels, air quality (PM2.5, VOCs), and light intensity to enable demand-controlled ventilation, precise HVAC setpoints, and daylight-linked lighting controls.
- 2. Occupancy/motion sensors:** Detect presence via PIR, ultrasonic, or radar technology to activate/deactivate lights, HVAC zones, and plugs only when spaces are occupied, reducing lighting energy by up to 90% in low-use areas.

SENSORS AND SMART SYSTEMS

Key sensor types and functions:

- 3. Energy meters and sub-meters:** Track real-time consumption at panel, circuit, or appliance level (e.g., kWh for HVAC, lighting) to identify inefficiencies and support load shifting.
- 4. Equipment sensors:** Monitor vibration, flow, pressure, and temperature in pumps, chillers, and fans for predictive maintenance, preventing 10-30% energy losses from faults.

SMART BUILDINGS



SMART BUILDINGS

- Smart buildings, also known as **intelligent buildings** or **connected buildings**, are structures that **utilize advanced technologies and automation to enhance their functionality, efficiency, and occupant comfort.**
- These buildings integrate various systems and components, such as lighting, HVAC (Heating, Ventilation, and Air Conditioning), security, energy management, and communication systems, to create a more optimized and sustainable environment.

AUTOMATION & CONTROL



- Centralized Control Systems, Systems Regulate Functions
- Adjust Lighting, Temp & Temp Auditor, Manage, Manage Security

ENERGY EFFICIENCY



- Reduce Energy Consumption
- Sensors, Data & Machine Learning HVAC Zones,
- Identify Efficiency Usage Improvements
- Cost Savings & Reduced Footprint

CONNECTIVITY SUB-METERS



- Intereccepted Ecosystem
- Devices, Sensors, HVAC Zones, Over s Network
- Real-time Decision-Making Load Shifting

EQUIPMENT SENSORS



- Enhance Well-being Comfort & EXPERIENCE
- Adjust Wbat/Temp/ Indoor Airq/Temp Indoor Air Quality Personalized Services Personalized Room Booking, Wayfinding

SMART BUILDINGS

Here are some key features and aspects of smart buildings:

- 1. Automation and Control:** Smart buildings employ centralized control systems that automate and regulate various building functions. These systems can adjust lighting levels, optimize temperature settings, monitor energy usage, and manage security systems based on predefined parameters or real-time conditions.
- 2. Energy Efficiency:** One of the primary goals of smart buildings is to reduce energy consumption and improve sustainability. Energy management systems in these buildings utilize sensors, data analytics, and machine learning algorithms to optimize energy usage, monitor power consumption, and identify areas for efficiency improvements. This can lead to substantial cost savings and a reduced environmental footprint.

SMART BUILDINGS

Here are some key features and aspects of smart buildings:

- 3. Connectivity and Internet of Things (IoT):** Smart buildings are interconnected ecosystems where various devices, sensors, and systems communicate with each other over a network. This enables the collection and analysis of data, facilitating real-time decision-making and providing valuable insights for building management.
- 4. Occupant Comfort and Experience:** Smart buildings focus on enhancing the comfort and well-being of their occupants. They can adjust lighting and temperature settings based on occupancy and personal preferences, provide indoor air quality monitoring and control, and offer personalized services such as room booking systems or way finding apps.

EMBODIED ENERGY

THE HIDDEN COST OF EVERYTHING



EMBODIED ENERGY

- Embodied energy represents the total energy required to produce a building material.
- Including extraction of raw resources, manufacturing, transportation, installation, and end-of-life processes like demolition or recycling
- Typically quantified in megajoules per kilogram (MJ/kg) or megajoules per square meter (MJ/m²).

EMBODIED ENERGY

- Embodied energy accounts for both **direct energy** (e.g., fuel for machinery) and **indirect energy** embedded in supply chains (e.g., electricity for steel production),. Distinguishing it from operational energy used during a building's occupancy.
- It typically constitutes **10-50% of a building's lifetime** energy footprint, with higher proportions in low-energy designs where operational demands are minimized through insulation or renewables.
- Unlike operational energy, embodied energy occurs upfront and cannot be "turned off," making material choices during design critical for sustainability.

EMBODIED ENERGY

- Total embodied energy = Initial + Recurrent + Demolition,
- calculated as MJ/m² of floor area for whole buildings.

Initial Embodied Energy



Recurrent Embodied Energy



Demolition Energy



Total Embodied Energy



Total Embodied Energy

Initial + Recurrent + Demolition

MJ/m² of floor area
for whole buildings

EMBODIED ENERGY

Components across building life cycle

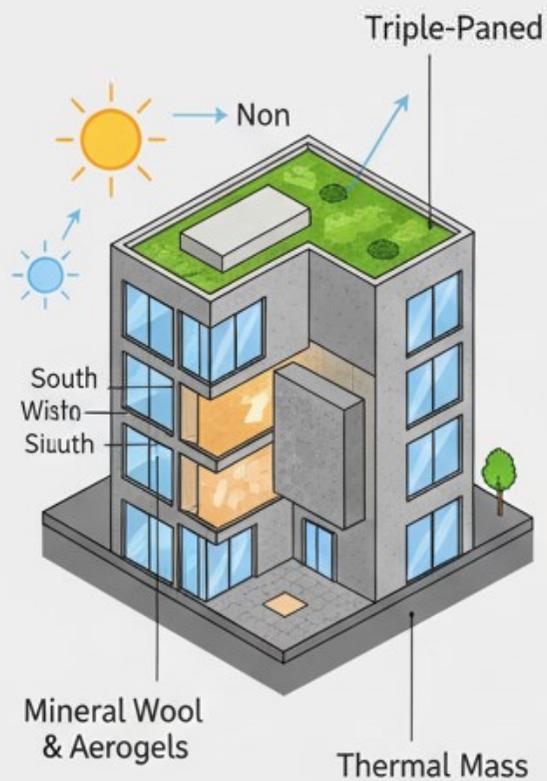
Embodied energy divides into three main phases, analysed using life-cycle assessment (LCA) tools like SimaPro or ICE Database:

- **Initial embodied energy:** Energy for raw material extraction, processing, manufacturing, transport to site, and on-site construction (largest component, often 70-90% of total).
- **Recurrent embodied energy:** Energy for maintenance, repairs, painting, and replacements over 30-50 years (e.g., repainting every 10 years or roof replacement).
- **Demolition/disposal energy:** Energy to deconstruct, transport waste, and recycle/reuse materials (5-15% of total, reduced by design for disassembly).

Temperature Control in Buildings

Effective temperature control (climate control) balances occupant comfort with energy efficiency, primarily through passive design strategies and active mechanical systems.

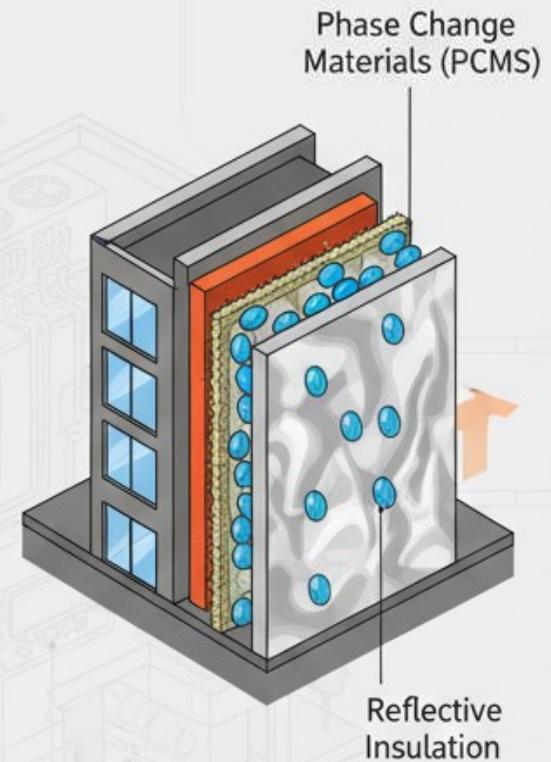
1. Passive Design



2. Active Systems



3. Innovative Materials





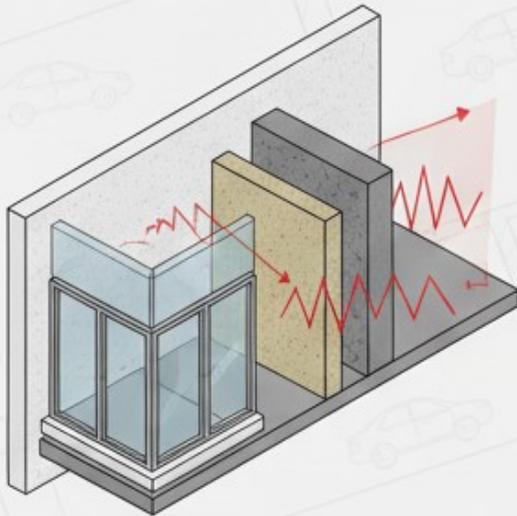
Temperature Control in Buildings

1. **Passive Design:** This involves building orientation to maximize or minimize solar exposure, using high-performance insulation (like mineral wool or aerogels) in walls, roofs, and windows, and leveraging the thermal mass of materials (e.g., concrete) to stabilize indoor temperatures.
2. **Active Systems:** These include HVAC (Heating, Ventilation, and Air Conditioning) systems, ground source heat pumps, and smart thermostats that optimize energy use by adjusting heating and cooling based on real-time data and occupancy.
3. **Innovative Materials:** Advanced solutions like phase change materials (PCMs) and reflective insulation help manage heat transfer through the building envelope.

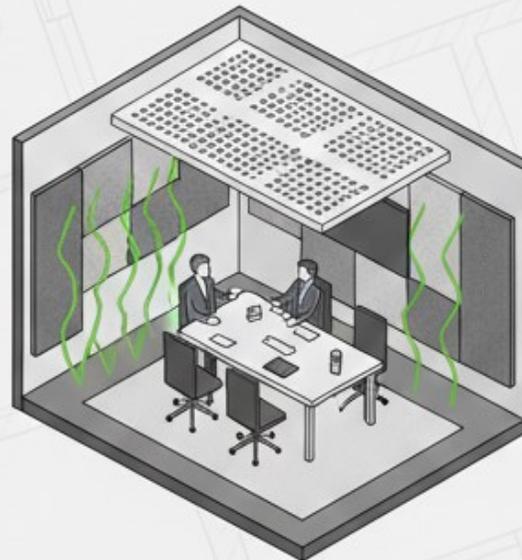
Sound Control in Buildings

Sound control involves managing noise levels to ensure acoustic comfort and productivity, using a combination of sound isolation and sound absorption techniques.

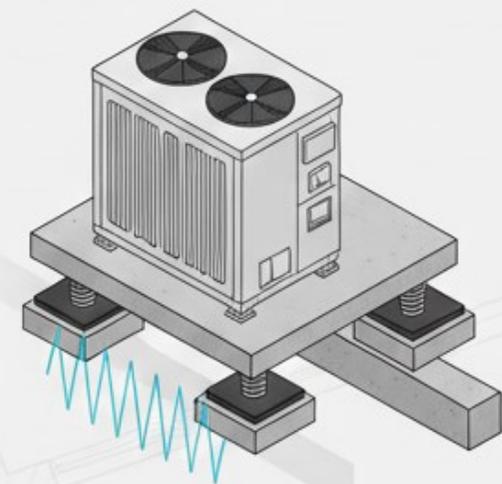
1. Sound Insulation/ Isolation



2. Sound Absorption



3. Vibration Control





Sound Control in Buildings

- 1. Sound Insulation/Isolation:** This focuses on blocking sound transmission between spaces (e.g., between apartments or from outside traffic). Methods include using dense materials (concrete), multiple layers in walls and floors, air cavities, and specialized acoustic doors and windows with proper sealing.
- 2. Sound Absorption:** This aims to reduce sound reflections (echo and reverberation) within a room to improve speech clarity. Materials such as acoustic panels, ceiling tiles, and soft furnishings are used for this purpose.
- 3. Vibration Control:** For noise generated by mechanical equipment (HVAC units, pumps), vibration isolation pads and mounts are used to prevent the sound from traveling through the building structure.

RECYCLING



RECYCLING

Recycling is the process of converting **waste materials** into **reusable materials**, thus diverting them from disposal and reducing the demand for raw resources. It is an important practice that helps **conserve natural resources**, **reduce energy consumption**, **minimize pollution**, and **mitigate the environmental impacts** associated with resource extraction and waste disposal



RECYCLING

Here are some key aspects of recycling:

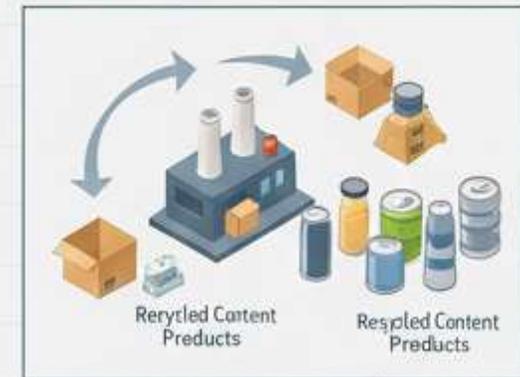
1. Collection & Sorting



2. Processing & Conversion



3. New Product Manufacturing



4. Market Demand & Use



5. Benefits of Recycling



6. Challenges & Solutions



RECYCLING

Here are some key aspects of recycling:

- **Types of Materials:** Recycling can involve a wide range of materials, including paper, cardboard, glass, metal (such as aluminium and steel), plastics, textiles, electronic waste, and organic waste (such as food scraps and yard waste). Each material requires specific recycling processes to transform it into reusable materials.
- **Collection and Sorting:** Recycling begins with the collection of recyclable materials from households, businesses, and public spaces. These materials are then sorted to separate different types of recyclables, often through manual or automated processes. Sorting is crucial to ensure that the materials are appropriately processed.

RECYCLING

Here are some key aspects of recycling:

- **Processing and Conversion:** After sorting, recyclable materials undergo various processing techniques to prepare them for reuse. For example, paper and cardboard may be shredded, pulped, and turned into new paper products. Plastics can be melted and moulded into new plastic products, while metals are melted and shaped into new metal items.
- **Market Demand and Recycling Infrastructure:** Recycling is influenced by market demand for recycled materials. The availability of buyers for recycled products plays a significant role in the success of recycling programs. It is essential to have a well-established recycling infrastructure that includes collection systems, sorting facilities, processing plants, and markets for recycled materials.

RECYCLING

Here are some key aspects of recycling:

- **Benefits of Recycling:** Recycling offers numerous environmental, economic, and social benefits. By recycling, we conserve natural resources, such as timber, minerals, and water, reducing the need for extraction and minimizing environmental degradation. Recycling also saves energy compared to producing goods from virgin materials, as recycling often requires less energy-intensive processes. Furthermore, recycling helps reduce the amount of waste sent to landfills and incinerators, mitigating pollution and greenhouse gas emissions.

RECYCLING

Here are some key aspects of recycling:

- **Challenges and Considerations:** While recycling is a valuable practice, it is not without challenges. Some common challenges include contamination of recyclables, limited infrastructure in certain regions, fluctuating market demand for recycled materials, and the need for consumer education and awareness. It is crucial for individuals, businesses, and governments to support recycling efforts and address these challenges through improved waste management practices and policies..

RECYCLING

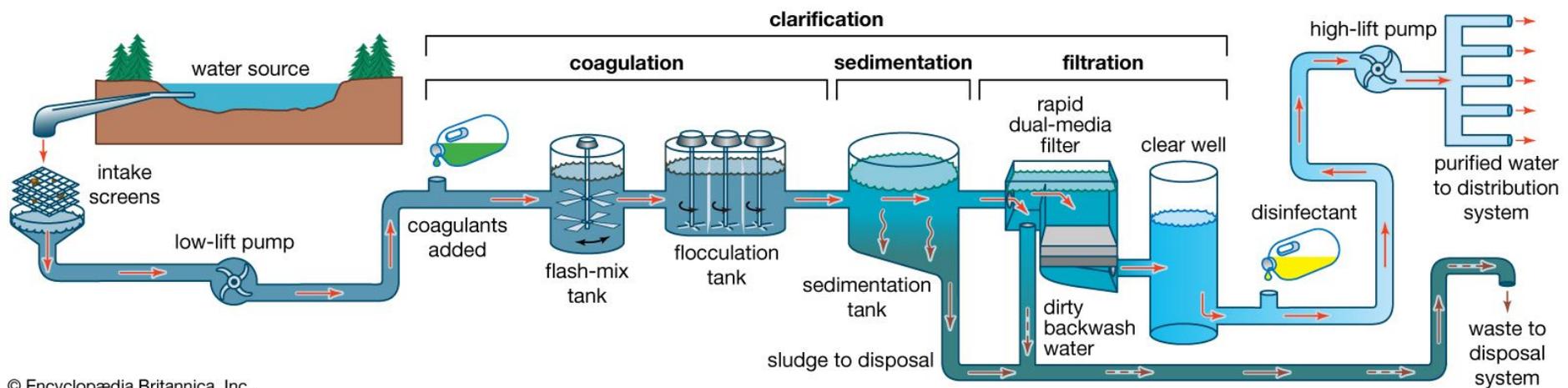
Here are some key aspects of recycling:

- **Circular Economy:** Recycling is an integral part of the broader concept of a circular economy. A circular economy aims to minimize waste and maximize the use of resources by promoting a system where materials are reused, recycled, or regenerated at the end of their life cycle.

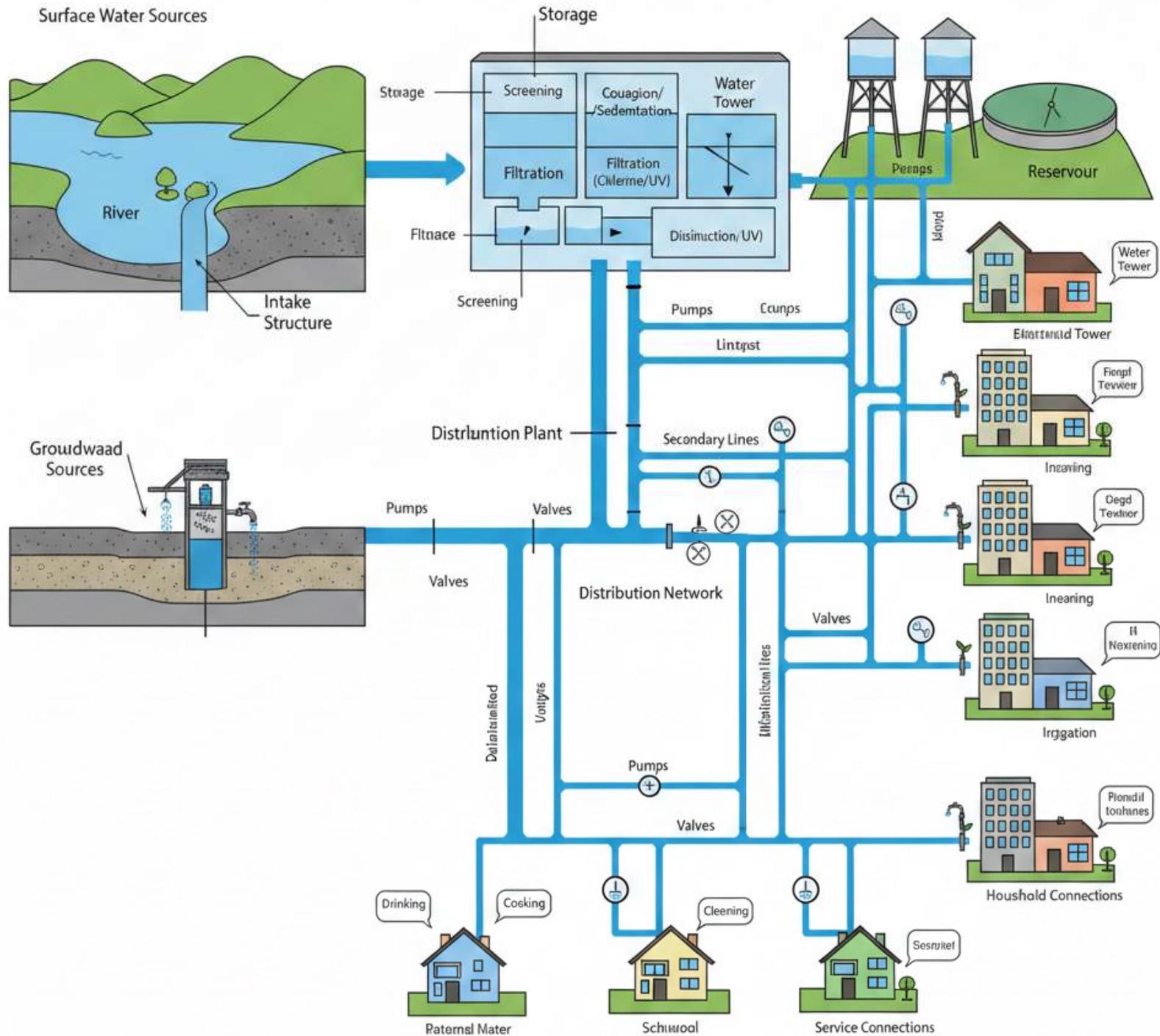
Recycling plays a vital role in closing the loop and creating a more sustainable and resource efficient society. Recycling is a proactive approach to waste management and resource conservation.

WATER SUPPLY AND SANITARY SYSTEMS

Water supply and sanitary systems are essential infrastructure components that provide clean and safe water for domestic, commercial, and industrial use, as well as proper management of wastewater and sewage. These systems play a crucial role in maintaining public health and ensuring a hygienic living environment.



WATER SUPPLY SYSTEMS:



WATER SUPPLY AND SANITARY SYSTEMS

WATER SUPPLY SYSTEMS:

Water supply systems are designed to extract water from various sources, treat it to remove impurities, and distribute it to consumers. Here are the key components of a typical water supply system:

- **Water Sources:** Common sources include surface water (rivers, lakes, and reservoirs) and groundwater (wells and aquifers).
- **Intake and Treatment:** Water is extracted from the sources through intake structures and undergoes treatment processes such as screening, coagulation, sedimentation, filtration, disinfection (usually with chlorine or ultraviolet light), and sometimes fluoridation.



WATER SUPPLY AND SANITARY SYSTEMS

WATER SUPPLY SYSTEMS:

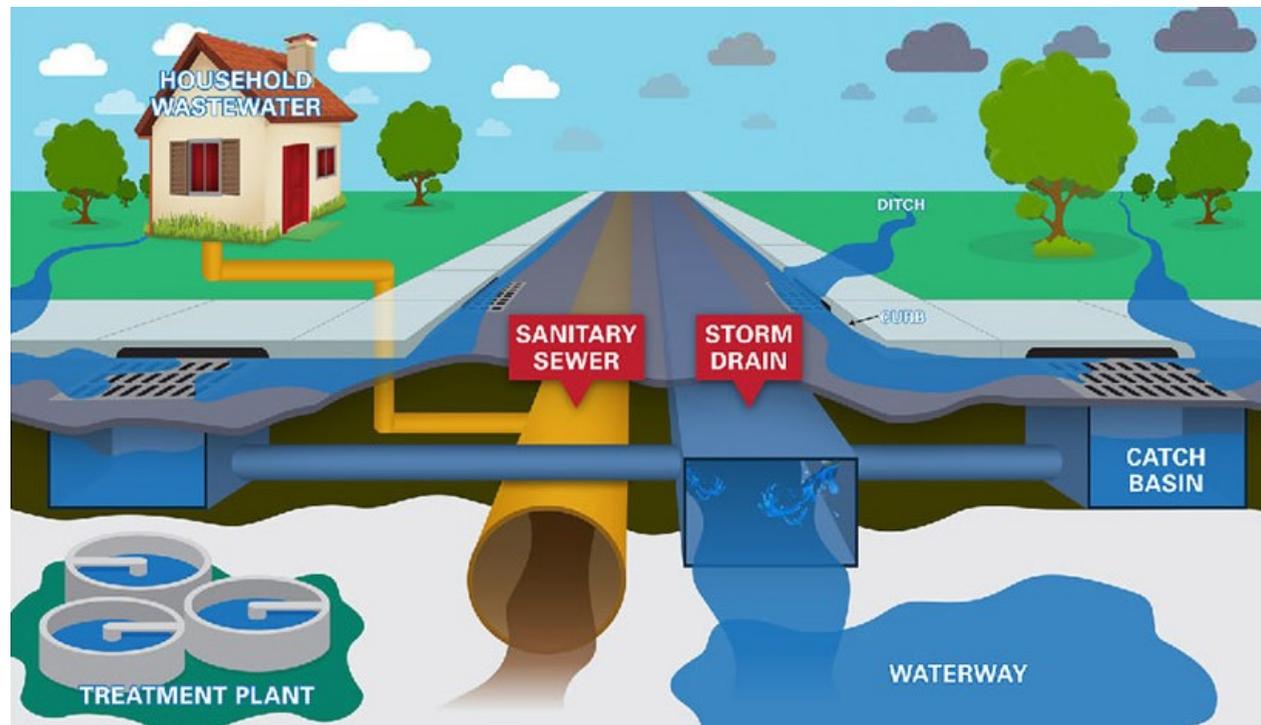
Here are the key components of a typical water supply system:

- **Storage:** Treated water is stored in reservoirs or water towers to meet peak demand and provide a reserve during emergencies.
- **Distribution Network:** Pipes, valves, and pumps are used to transport water from storage facilities to consumers. The network includes main distribution lines, secondary lines, and service connections to individual buildings.
- **Household Connections:** Water meters and service lines deliver water to individual buildings or properties, allowing consumers to access water for various purposes like drinking, cooking, cleaning, and irrigation.

WATER SUPPLY AND SANITARY SYSTEMS

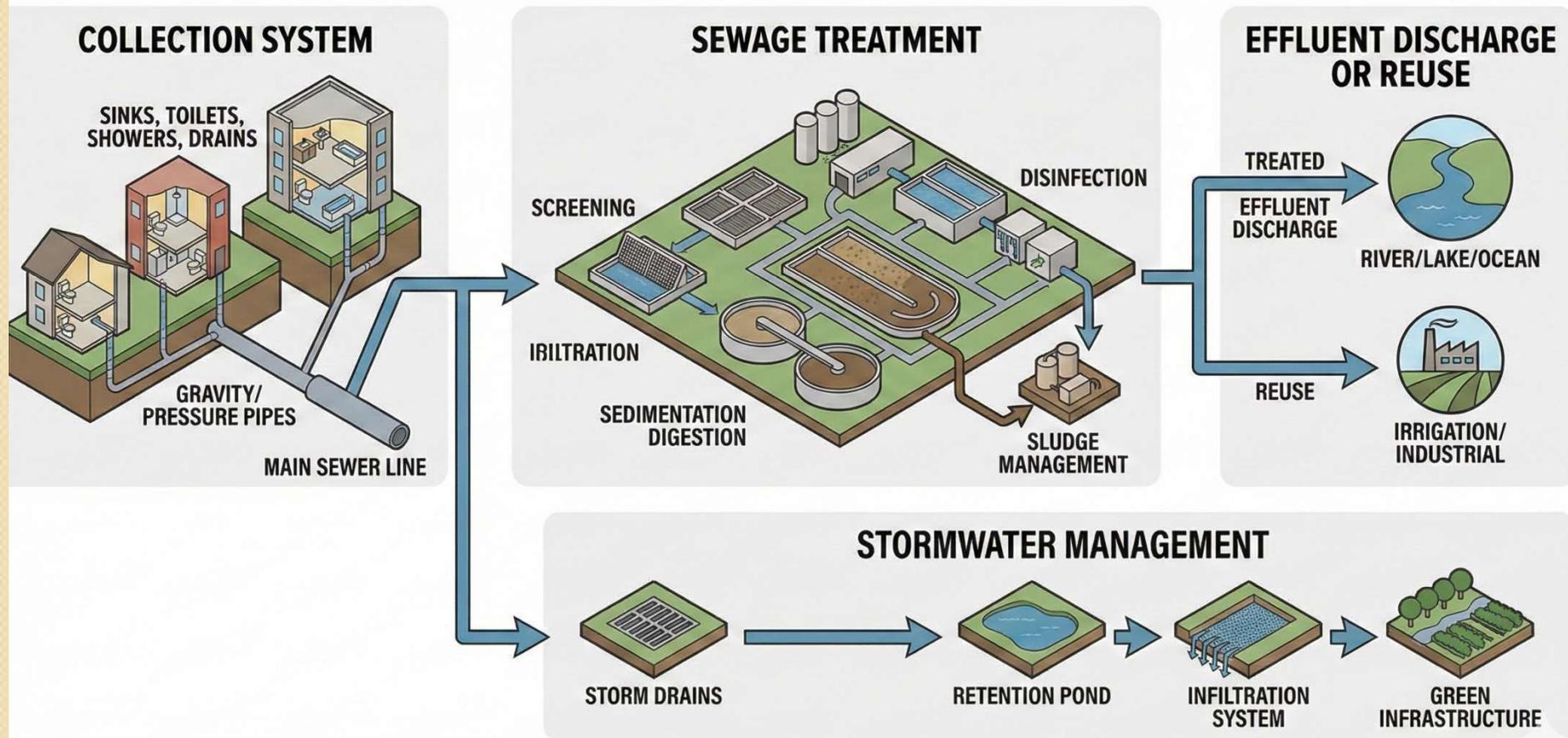
SANITARY SYSTEMS:

Sanitary systems are responsible for the safe disposal of wastewater and sewage. They help prevent the contamination of water sources and the spread of diseases.



WATER SUPPLY AND SANITARY SYSTEMS

SANITARY SYSTEMS:





WATER SUPPLY AND SANITARY SYSTEMS

SANITARY SYSTEMS:

Key components of a sanitary system include:

- **Collection System:** Gravity or pressure-based pipes collect wastewater from buildings, including water from sinks, toilets, showers, and drains. In some cases, separate systems are used for storm water and wastewater.
- **Sewage Treatment:** Wastewater is transported to treatment plants where physical, biological, and chemical processes are employed to remove contaminants and pollutants. Treatment may involve screening, sedimentation, biological digestion, filtration, disinfection, and sludge management.

WATER SUPPLY AND SANITARY SYSTEMS

SANITARY SYSTEMS:

Key components of a sanitary system include:

- **Effluent Discharge or Reuse:** Treated wastewater, known as effluent, is either discharged into bodies of water (rivers, lakes, or oceans) or reused for irrigation, industrial processes, or other non-potable purposes, depending on local regulations and treatment quality.
- **Storm water Management:** Storm water, which includes rainwater runoff, is managed separately to prevent flooding and reduce the burden on the sewage system. Techniques like retention ponds, infiltration systems, and green infrastructure are used to control storm water and promote natural absorption.

WATER SUPPLY AND SANITARY SYSTEMS

SANITARY SYSTEMS:

Key components of a sanitary system include:

- **Septic Systems:** In rural or decentralized areas without access to centralized sewer systems, septic systems are used. These individual on-site systems treat and dispose of wastewater from a single property using a septic tank and a drain field.

Effective water supply and sanitary systems require proper planning, design, construction, operation, and maintenance. They are typically managed by water utility companies, municipalities, or government agencies to ensure the provision of clean water and effective sanitation services to communities.

URBAN AIR POLLUTION MANAGEMENT

Air Pollution Control – Key Strategies

- **Emission Control:** Enforce emission standards, promote clean technologies, use renewable energy, and install emission-control devices.
- **Transport Management:** Improve public transport, reduce congestion, promote walking/cycling, and encourage electric vehicles.
- **Industrial Control:** Apply strict industrial emission norms, adopt cleaner production, ensure proper waste management, and conduct regular monitoring.

URBAN AIR POLLUTION MANAGEMENT

Air Pollution Control – Key Strategies

- **Urban Planning:** Design cities to reduce congestion, separate industrial/residential areas, and increase green spaces for natural air filtration.
- **Awareness & Education:** Inform public on health impacts, promote sustainable habits, reduce vehicle use, conserve energy, and encourage clean cooking/heating methods.
- **Monitoring & Data Analysis:** Deploy air quality monitoring networks; use real-time data to identify hotspots; share data for informed decisions.

URBAN AIR POLLUTION MANAGEMENT

Air Pollution Control – Key Strategies

- **International Cooperation:** Adopt global standards; share best practices; participate in global air quality initiatives and agreements.
- **Research & Innovation:** Develop cleaner energy technologies; improve emission control systems; enhance air quality modelling and forecasting.

SOLID WASTE MANAGEMENT

Solid Waste Management – Key Strategies

- **Waste Minimization & Segregation:** Reduce waste at source; promote reuse; separate recyclables, organics, and non-recyclables for efficient processing.
- **Collection & Transportation:** Maintain regular, efficient waste collection; provide proper collection points; use appropriate vehicles; ensure safe handling of hazardous waste.
- **Recycling & Resource Recovery:** Establish recycling facilities; recover materials like paper, plastic, metal, and glass; promote recycling awareness and incentives.

SOLID WASTE MANAGEMENT

Solid Waste Management – Key Strategies

- **Composting & Organic Waste Management:** Compost food and yard waste to produce soil nutrients; support household and community composting initiatives.
- **Waste Treatment & Disposal:** Use sanitary landfills with proper lining and monitoring; adopt waste-to-energy, anaerobic digestion, and thermal treatment to reduce volume and recover energy.
- **Public Awareness & Education:** Educate communities on segregation, recycling, and composting; involve schools, NGOs, and media to encourage behavioural change.

SOLID WASTE MANAGEMENT

Solid Waste Management – Key Strategies

- **Policy & Regulation:** Enforce waste management rules; set reduction targets; implement EPR (Extended Producer Responsibility); provide incentives for sustainable practices.
- **Research & Innovation:** Develop advanced waste treatment technologies; improve recycling efficiency; explore new uses for recovered materials.

IDENTIFICATION OF LANDFILL SITES:

Landfill Site Selection – Key Criteria

- **Environmental Impact Assessment:** Evaluate potential effects on air, water, soil, ecosystems, and cultural resources.
- **Hydrogeological Studies:** Analyze groundwater flow, aquifers, soil strata, and risk of contamination.
- **Land Use Compatibility:** Check proximity to residential, industrial, agricultural, and protected areas; ensure alignment with current and future land use plans.
- **Socioeconomic Factors:** Assess community impacts (odor, noise, traffic) and potential economic benefits or drawbacks.

IDENTIFICATION OF LANDFILL SITES:

Landfill Site Selection – Key Criteria

- **Engineering Feasibility:** Evaluate topography, soil stability, availability of cover material, leachate management, and gas control potential.
- **Legal & Regulatory Compliance:** Ensure site meets all regional/national rules for landfill siting, construction, operation, and closure.
- **Public Consultation:** Engage communities and stakeholders to gather feedback, address concerns, and improve transparency.
- **Comparative Analysis:** Compare shortlisted sites based on environmental, social, and technical criteria to select the most suitable location.