Introduction to SUSTAINABLE ENGINEERING

BE 103

Module IV

- **Basic concepts of sustainable habitat**
  - **Green buildings**
    - **Green materials for building construction**
    - **Material selection for sustainable design**
    - **Green building certification**
    - **Methods for increasing energy efficiency of buildings**
  - **Sustainable cities**
  - **Sustainable transport**

Module IV (Contd.)

- **Projects**
  - **Consider the design aspects of a sustainable building for your campus**
  - **Explore the different methods that can be adopted for maintaining a sustainable transport system in your city**

SUSTAINABLE CITIES

- Also called as ecocity
- Term "ecocity" first coined by
  - Richard Register
  - In his book, Ecocity Berkeley: Building Cities for a Healthy Future (1987)

- Definition
  - A city designed with consideration of environmental impact, inhabited by people dedicated to minimization of required inputs of energy, water and food, and waste output of heat, air pollution, CO_2, methane, and water pollution
  - A city which should meet their inhabitants' development needs without imposing unsustainable demands on local or global natural resources and systems

Pillars of a sustainable city

Sustainable Cities

Social Development

* Education and Health
* Food & Nutrition
* Green Buildings
* Water & Sanittation
* Green public transport
* Green energy access
* Recreation areas

Economic Development

* Green Productive growth
* Creation of decent employment
* Technology & innovation (R & D)
* Production & Distribution of renewable energy

Environmental Management

* Waste recycling
* Energy efficiency
* Water management
* Air quality management
* Forest management
* Soil management
* Adaptation and mitigation of climate change

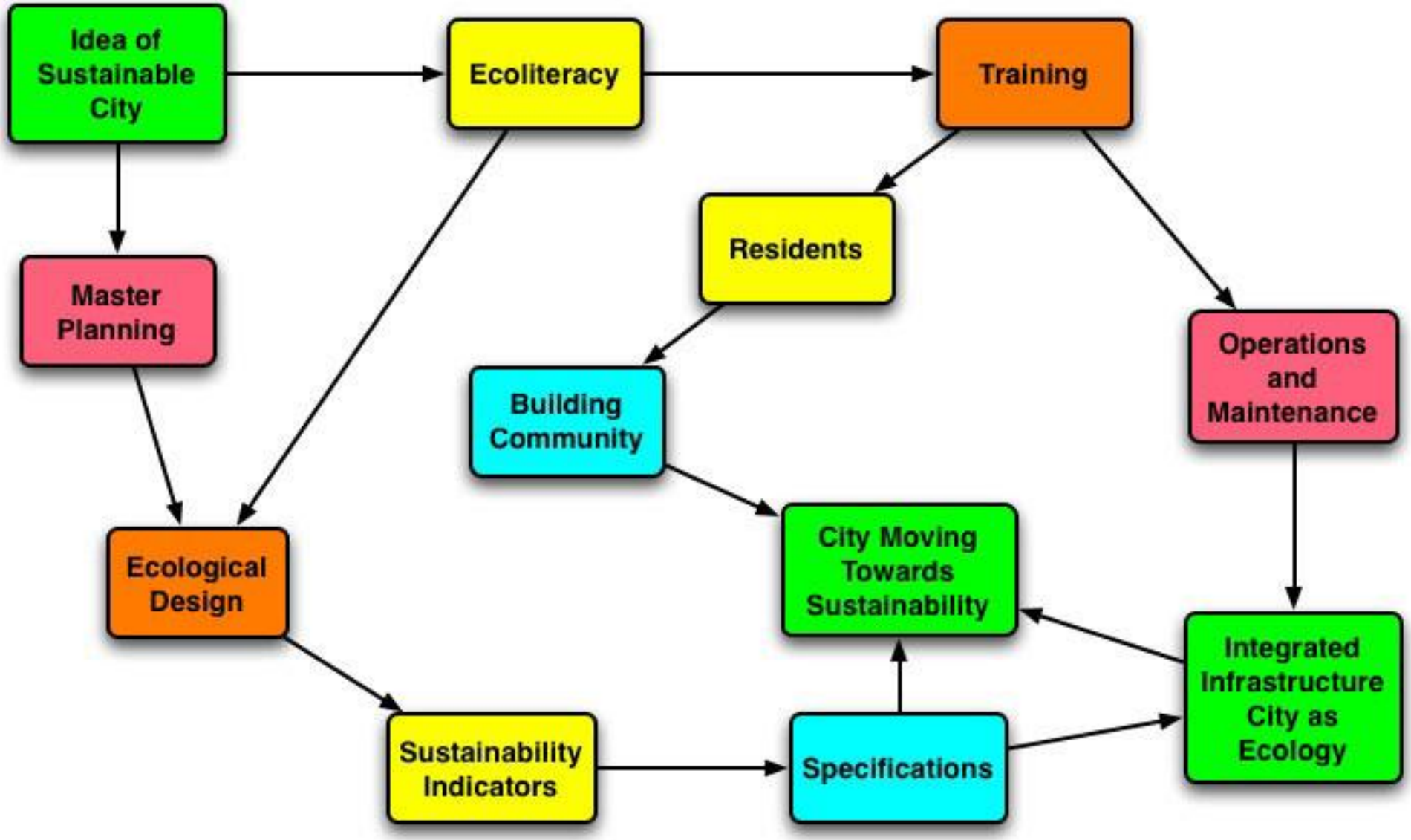
Urban governance

* Planning and decentralisation
* Reduction of inequities
* Strengthening of civil and political rights
* Support of local National, regional and global links

Implementing the sustainable concept

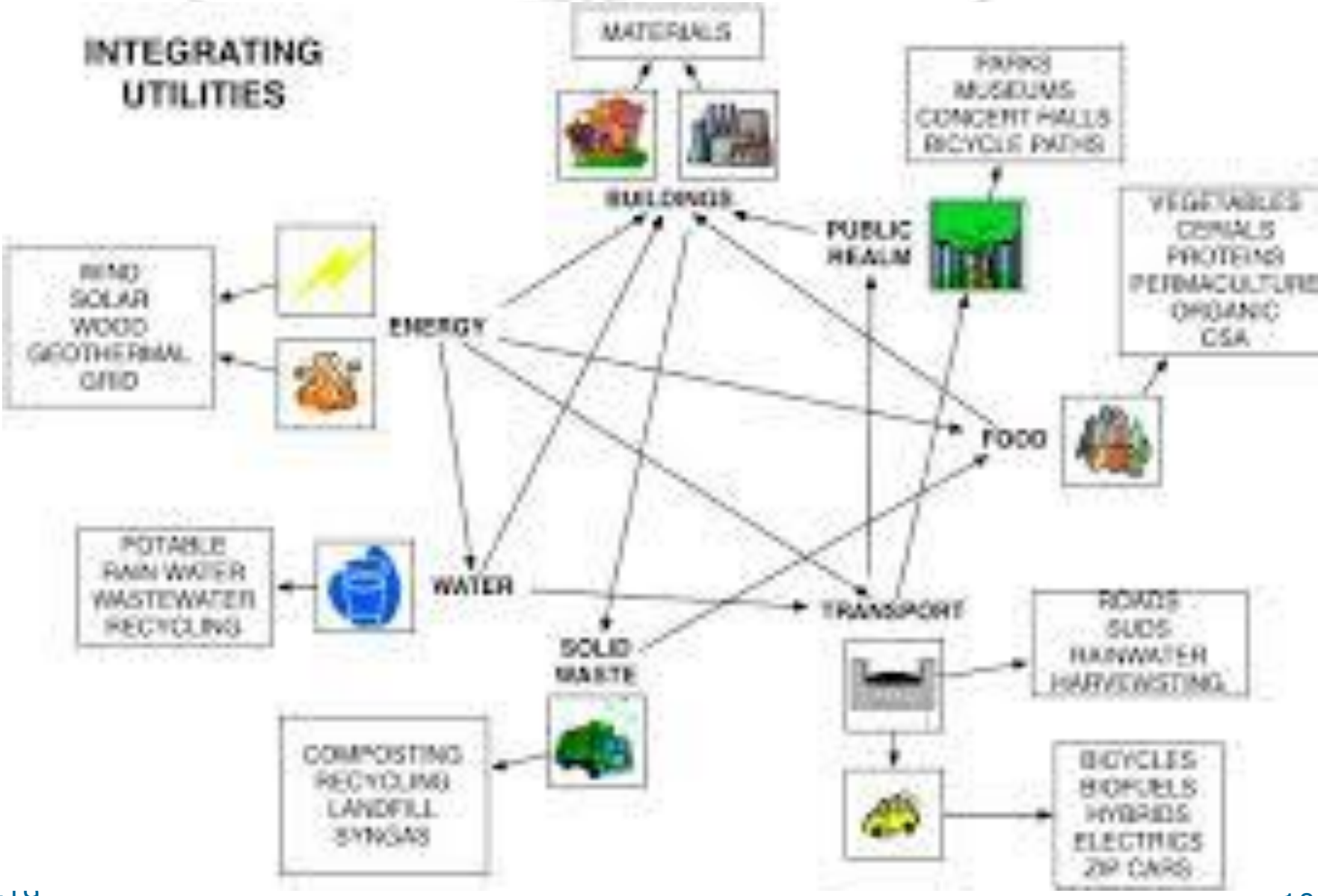
MOVING TOWARDS THE SUSTAINABLE CITY

Satisfies its needs, without diminishing the ability of future generations to meet their needs.



Implementing the sustainable concept

Planning a sustainable city

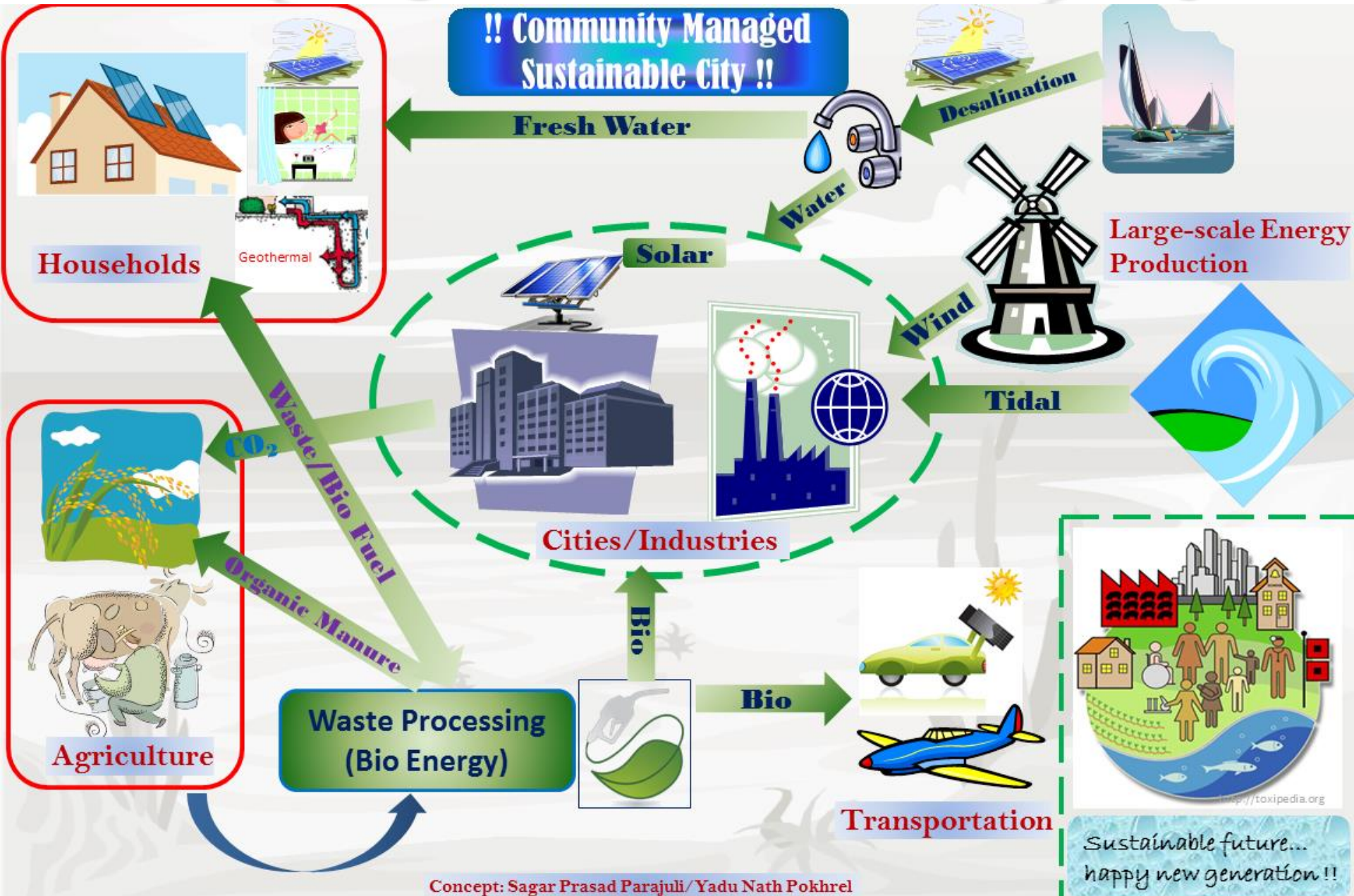


Elements of a sustainable city

Elements of a sustainable city

Artist's drawing of the Family Village concept at Hillcrest

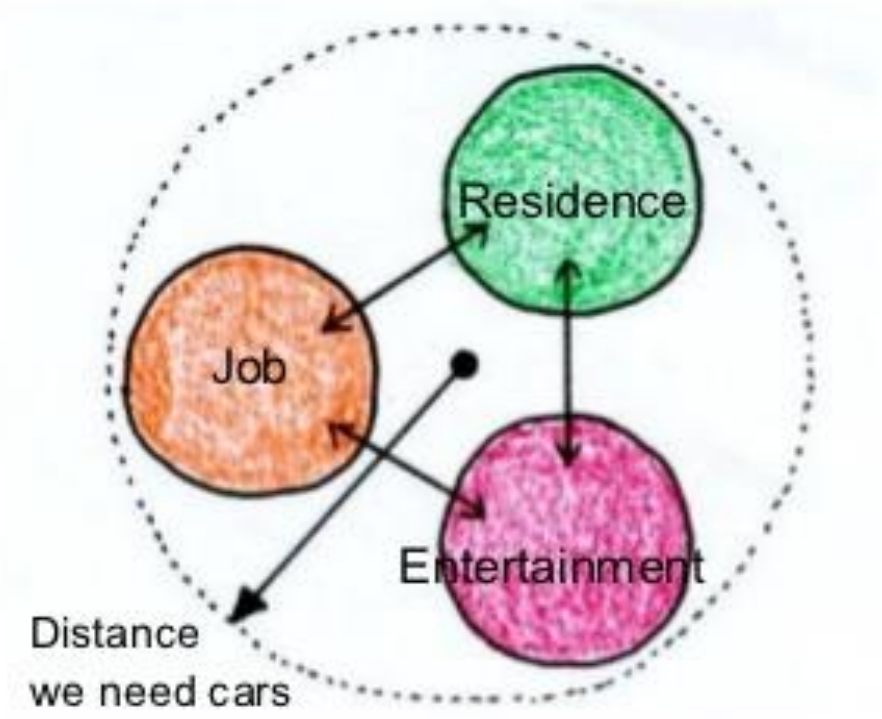
Working of a sustainable city



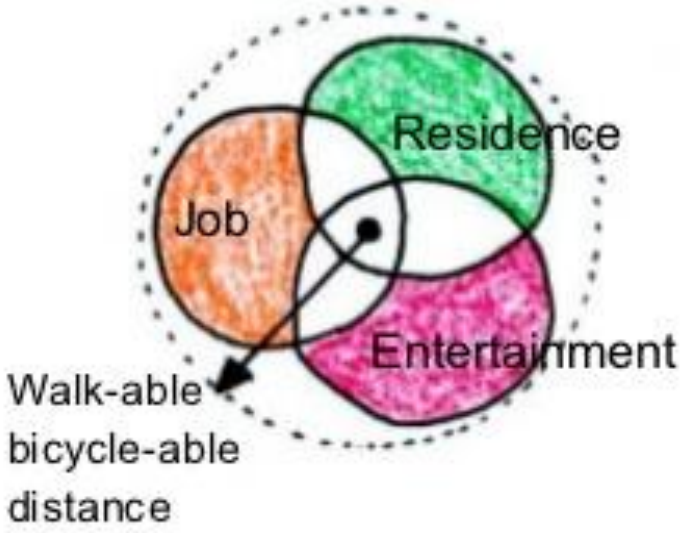
Compact City

Compact and mix-used city reduces transportation.

- Zoning of functions makes people depend their transportation on private



- Compact nodes can reduce car uses and people can walk or use bicycles in the community.



Rogers, Richard, and Philip Gumuchdjian. Cities for a Small Planet (In Japanese). Tokyo: Kashima Shuppankai, 2002 (1996). p39. Translated by Yashiro, Tomoya, Wada, Atsushi, and Takaharu, Tezuka.


Energy generation and management
Water generation and management
Waste management
The Sustainable City
Planning, engineering and architecture
Sustainable building materials
Transportation planning and management


Green Urbanism
Energy and Materials
Renewable Energy
Local Materials
Zero Waste Concept
Local Food
Socio-Cultural Features
Special Strategies for Developing Cities
Liveability, Health and Mixed-use
Cultural Heritage
Governance and Leadership
Education and Research
Water and Biodiversity
Water Management
Landscape, Gardens, Biodiversity
Urban Planning and Transport
Green Buildings and Districts
Density and Retrofitting
Climate and Context
Transport and Public Space

!! Community Managed Sustainable City !!

Households

Fresh Water

Desalination

Water

Solar

Wind

Tidal

Waste/Bio Fuel

CO_2

Organic Manure

Agriculture

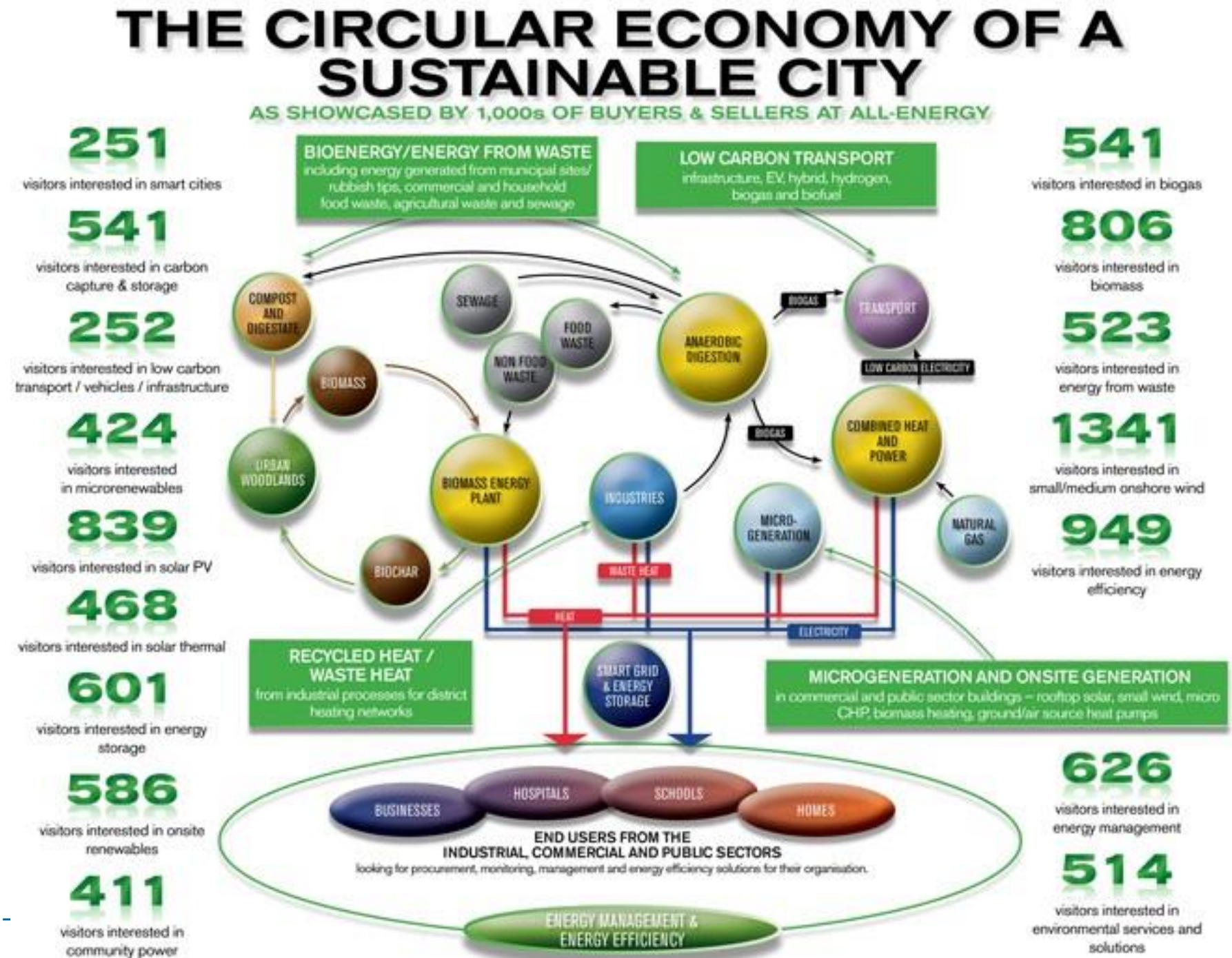
Cities/Industries

Bio

Waste Processing (Bio Energy)

Bio

Transportation


THE CIRCULAR ECONOMY OF A SUSTAINABLE CITY
AS SHOWCASED BY 1,000s OF BUYERS & SELLERS AT ALL-ENERGY
251
visitors interested in smart cities
541
visitors interested in carbon capture & storage
252
visitors interested in low carbon transport / vehicles / infrastructure
424
visitors interested in microrenewables
839
visitors interested in solar PV
468
visitors interested in solar thermal
601
visitors interested in energy storage
586
visitors interested in onsite renewables
411
visitors interested in community power
BIOENERGY/ENERGY FROM WASTE
including energy generated from municipal sites/ rubbish tips, commercial and household food waste, agricultural waste and sewage
LOW CARBON TRANSPORT
infrastructure, EV, hybrid, hydrogen, biogas and biofuel
541
visitors interested in biogas
806
visitors interested in biomass
523
visitors interested in energy from waste
1341
visitors interested in small/medium onshore wind
949
visitors interested in energy efficiency
COMPOST AND DIGESTATE
SEWAGE
FOOD WASTE
NON FOOD WASTE
ANAEROBIC DIGESTION
BIOGAS
TRANSPORT
LOW CARBON ELECTRICITY
BIOMASS
URBAN WOODLANDS
BIOMASS ENERGY PLANT
INDUSTRIES
COMBINED HEAT AND POWER
BIOGAS
MICRO-GENERATION
NATURAL GAS
BIOCHAR
WASTE HEAT
HEAT
ELECTRICITY
RECYCLED HEAT / WASTE HEAT
from industrial processes for district heating networks
SMART GRID & ENERGY STORAGE
MICROGENERATION AND ONSITE GENERATION
in commercial and public sector buildings – rooftop solar, small wind, micro CHP, biomass heating, ground/air source heat pumps
626
visitors interested in energy management
514
visitors interested in environmental services and solutions
BUSINESSES
HOSPITALS
SCHOOLS
HOMES
END USERS FROM THE INDUSTRIAL, COMMERCIAL AND PUBLIC SECTORS
looking for procurement, monitoring, management and energy efficiency solutions for their organisation.
ENERGY MANAGEMENT & ENERGY EFFICIENCY

INTEGRATING UTILITIES

MATERIALS

BUILDINGS

PARKS
MUSEUMS
CONCERT HALLS
BICYCLE PATHS

PUBLIC REALM

VEGETABLES
CERIALS
PROTEINS
PERMACULTURE
ORGANIC
CSA

WIND
SOLAR
WOOD
GEOTHERMAL
GRID

ENERGY

FOOD

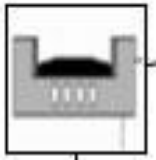
POTABLE
RAIN WATER
WASTEWATER
RECYCLING

WATER

TRANSPORT

SOLID WASTE

ROADS
SUDS
RAINWATER
HARVEWSTING

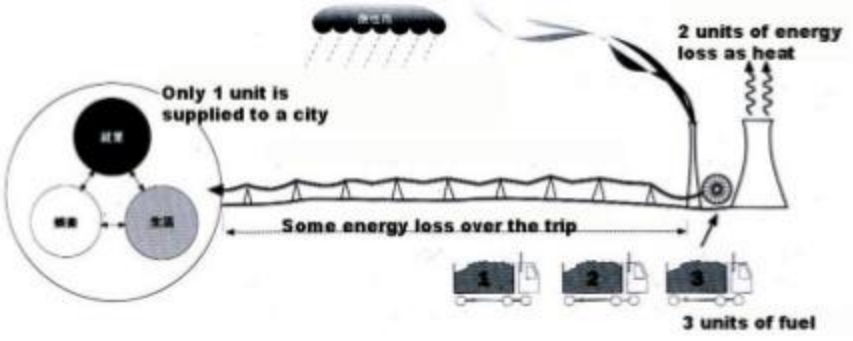


COMPOSTING
RECYCLING
LANDFILL
SYNGAS

BICYCLES
BIOFUELS
HYBRIDS
ELECTRICS
ZIP CARS

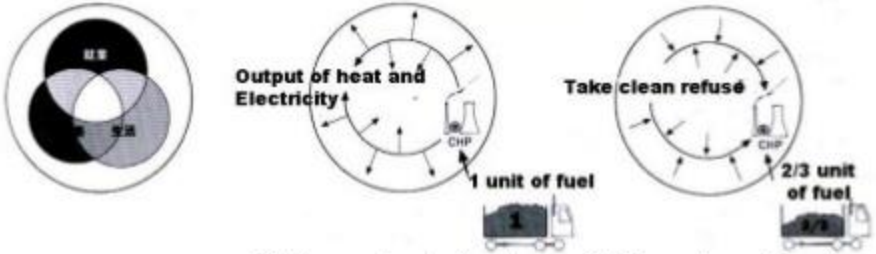
Energy Reduce

Compact city also can reduce energy consumption.



Conventional System

Power is generated far to a city



CHPs supplies heat and electricity to the region. (heat will not be wasted)

CHPs can turn refuse to energy.

Compact System

Power is generated in the district, so heat of secondary product can also be used.

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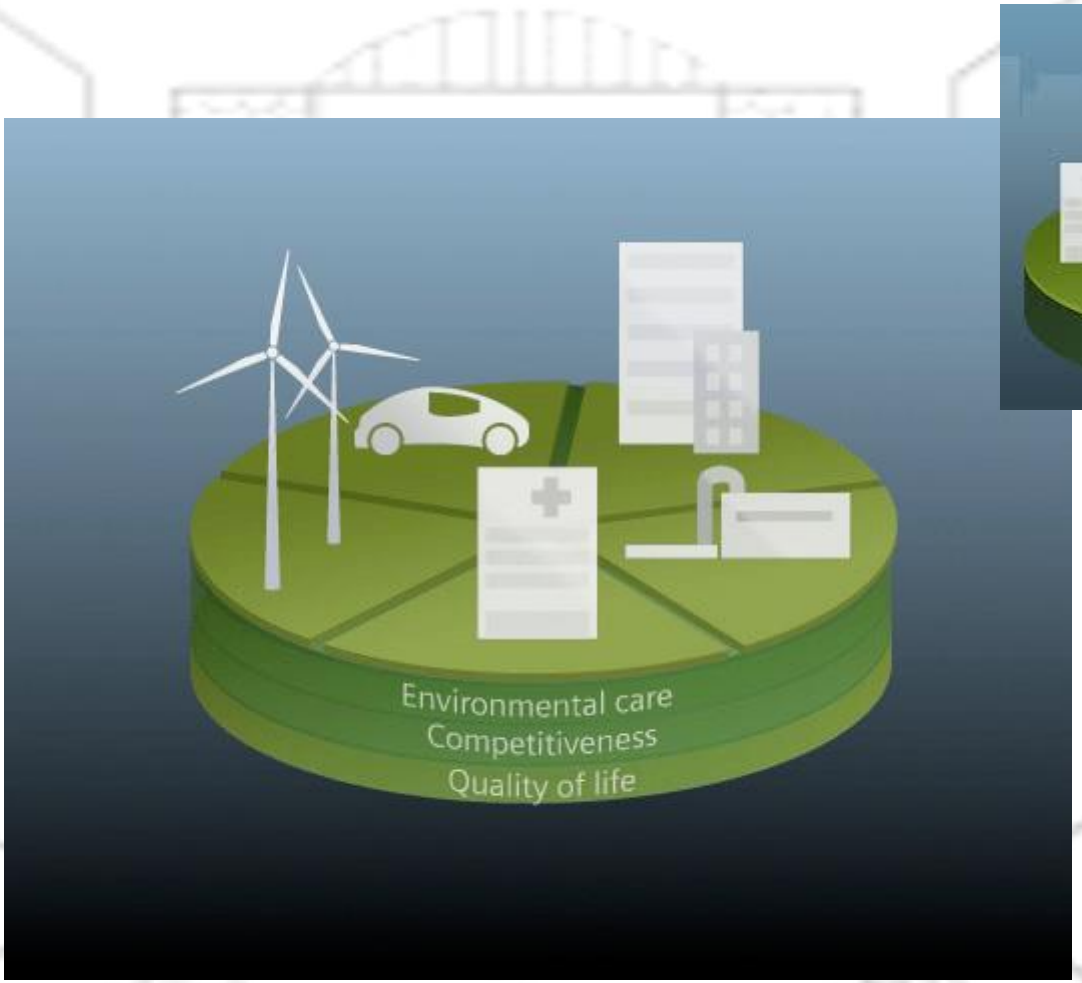
Water Management


Environmental care
Competitiveness
Quality of life


Sustainable Cities


Social Performance
Transport
Waste
MUtopia Integrated Modelling
Energy
Economics
Water

Measures to be taken for the city to move towards sustainability

- Monitoring and improving air quality in built environment and cities
  - (e.g., healthy built environment and proper air quality management)
- Maximise the waste recycling in cities
  - reduce waste, reuse and recycle materials
- Energy efficient, low, zero carbon buildings communities such holistic approaches in the construction sector makes cities to reduce carbon emissions
- Smart energy generation such as tapping the maximum amount of renewable energy sources and putting a control over the utilization of fossil fuels
- Proper urban design planning, regulations, legislation, policy, social, health and environmental impact related to sustainable and future cities

Measures to be taken for the city to move towards sustainability (Contd.)

- **City transport**
  - e.g., innovative and smart transport methods; public transportation
- **Water harvesting and management**
  - Development of appliances designed to minimize water use, water recycling and solar-powered systems, water treatment

SUSTAINABLE TRANSPORT

- **Any means of transport with low impact on the environment**
- **Goal**
  - **To ensure that environment, social and economic considerations are factored into decisions affecting transportation activity**

Economic	Social	Environmental
Traffic congestion	Inequity of impacts	Air and water pollution
Mobility barriers	Mobility disadvantaged	Habitat loss
Accident damages	Human health impacts	Hydrologic impacts
Facility costs	Community interaction	DNRR
Consumer costs	Community liveability	-
DNRR	Aesthetics	-

DNRR: Depletion of non-renewable resources.

Sustainability transport indicators

- **To facilitate sustainable transportation the following rule of thumb can be practiced for the given factors:**
  - **Transportation fossil fuel consumption and CO_2 emissions: Less is better**
  - **Use of renewable fuel sources in transportation sector: More is better**
  - **Noise pollution: less is better**
  - **Vehicle pollution emissions: Less is better**

Sustainability transport indicators (Contd.)

- **Per capita motor vehicle mileage: Less is better**
- **Transport mode split: More is better**
  - **Walking, cycling, rideshare, public transport**
- **Traffic crash injuries and deaths: Less is better**
  - **More safety**
- **Transport land consumption: Less is better**
- **Roadway aesthetic conditions**
  - **People tend to be more inclined to care for environment that they consider beautiful and meaningful**

Sustainability transport indicators (Contd.)

- **The most sustainable model of transport for urban areas**
  - **Passenger rail transit systems**
  - **Electric vehicles**
    - **Depend on how electricity is produced**

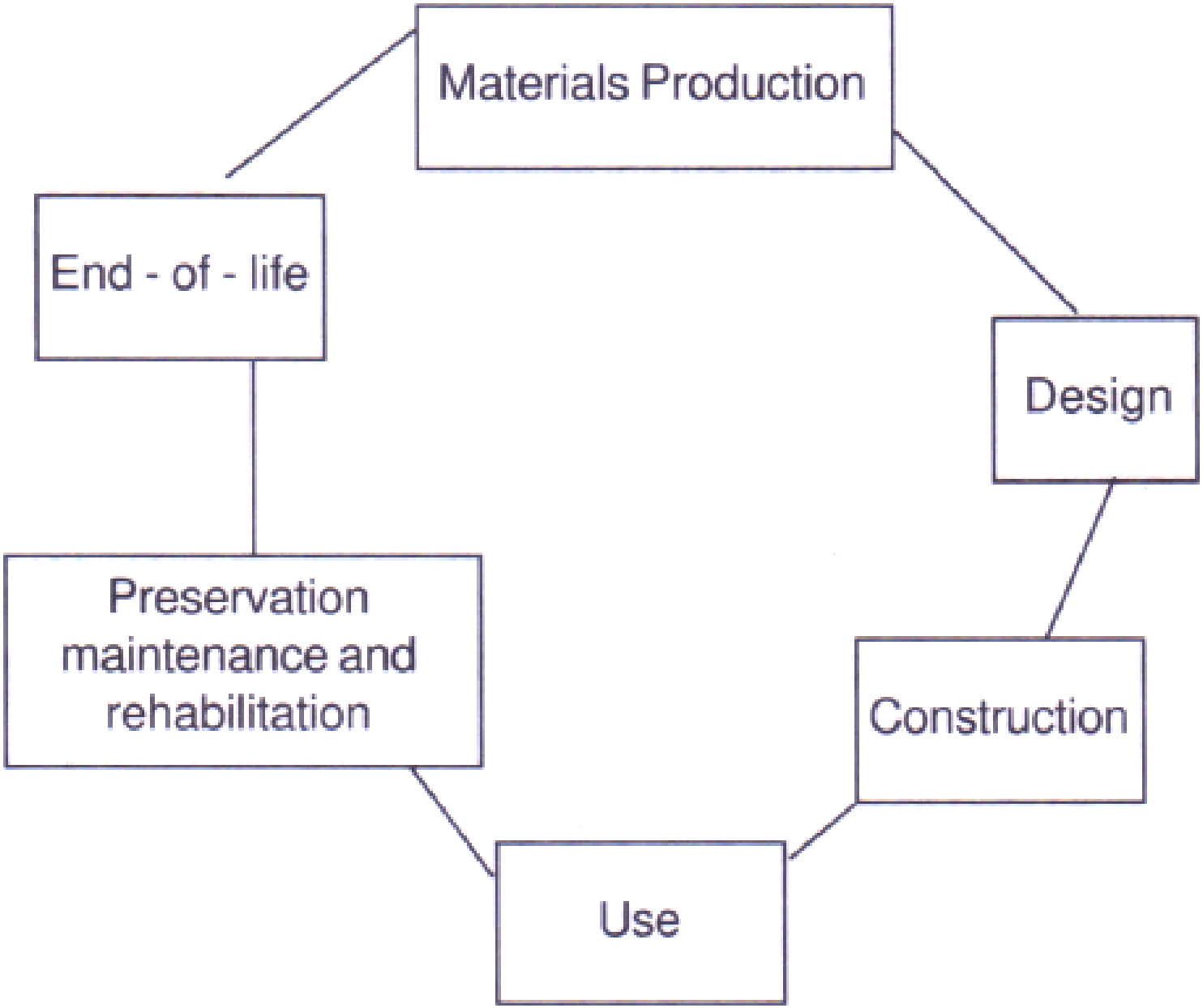
SUSTAINABLE PAVEMENTS

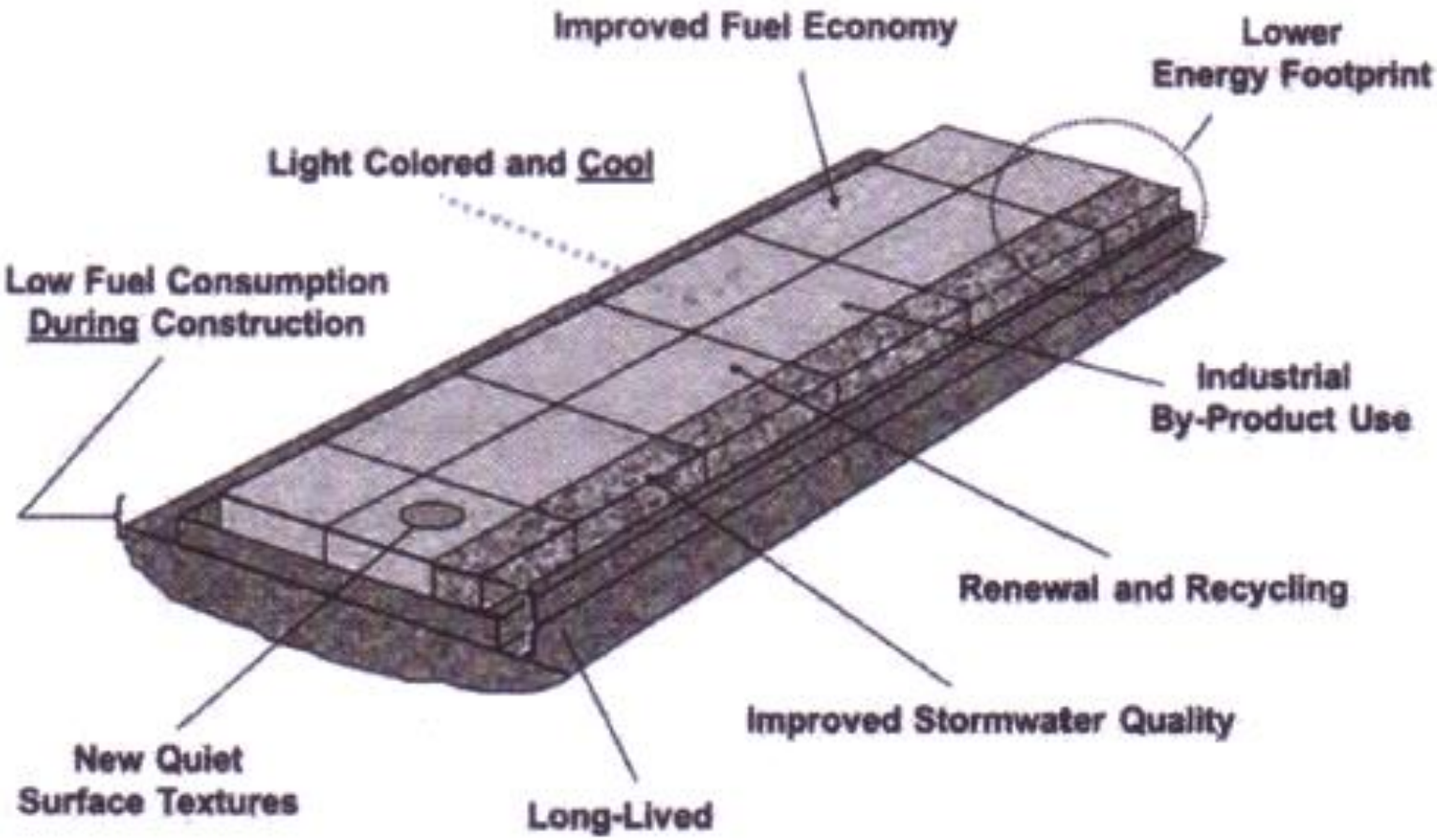
- **A sustainable pavement is one that achieves its specific engineering goals, while, on a broader scale it:**
  - **Meets basic human needs**
  - **Uses resources effectively**
  - **Preserves/restores surrounding ecosystems**
- **Sustainable pavements should be safe, efficient and should limit the impact on the environment**

SUSTAINABLE PAVEMENTS

- **Main criteria for a sustainable pavement**
  - Minimizing the use of natural resources
  - Reducing energy consumption
  - Reducing greenhouse gas (GHG) emissions
  - Limiting pollution
    - air, water, earth, noise, etc.
  - Improving health, safety and risk prevention
  - Ensuring a high level of user comfort and safety

The Pavement Life cycle




Improved Fuel Economy
Lower
Energy Footprint
Light Colored and Cool
Low Fuel Consumption
During Construction
Industrial
By-Product Use
Renewal and Recycling
Improved Stormwater Quality
New Quiet
Surface Textures
Long-Lived

Concrete pavements as a sustainable choice

- **Concrete**
  - **Economical**
  - **Cost-effective pavement solution**
  - **That consumes minimal materials, energy, and other resources for construction, maintenance, and rehabilitation activities over its life time.**

General attributes of concrete pavements that can make them a sustainable choice

- Long life
- Cost effective
- Minimal impact to the surrounding environment
- Light color and increased reflectivity improve night time visibility, reduce the amount of power needed to illuminate roads at night, and help mitigate urban heat and smog generation

General attributes of concrete pavements that can make them a sustainable choice (Contd.)

- Aesthetically pleasing
- Renewable and 100% recyclable
- Requires less sub base aggregate materials for structural support than asphalt pavements
- Exhibit a lower energy footprint