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DEUTSCHE ZUSAMMENARBEIT

The Urban NEXUS

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

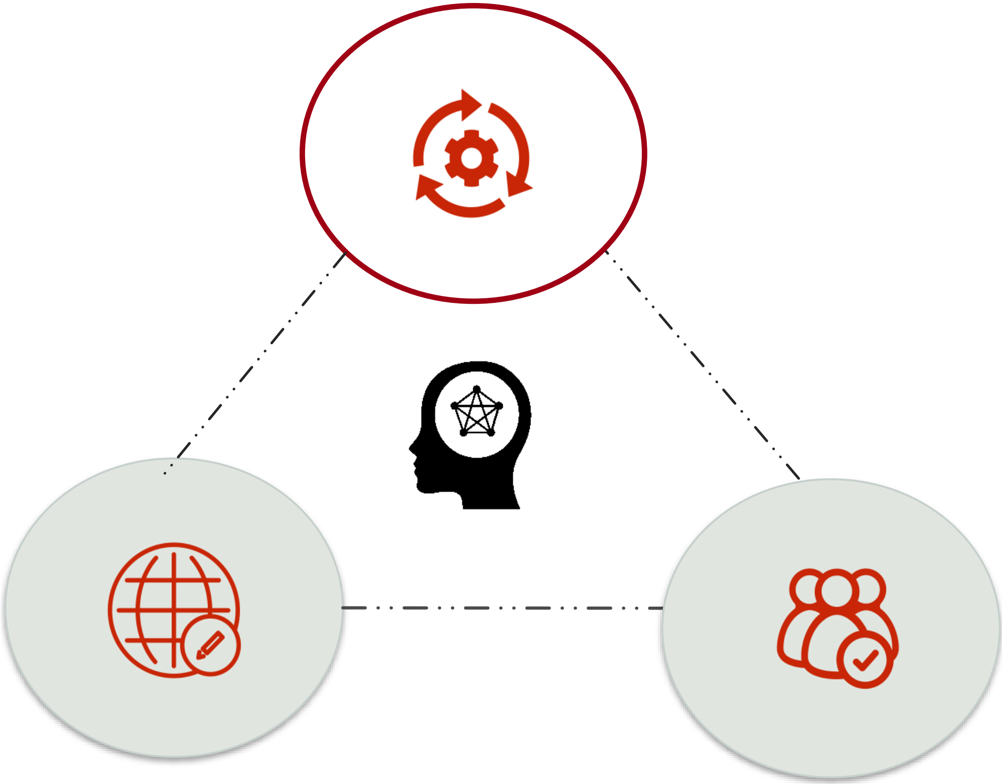
Module 2

Innovative engineering solutions for key Nexus sectors

The Urban Nexus Guide

The Urban Nexus Guide

Module 2:
Planning and implementing
the Urban Nexus



Module 1:
Linking Global Agendas
and the Urban Nexus
approach

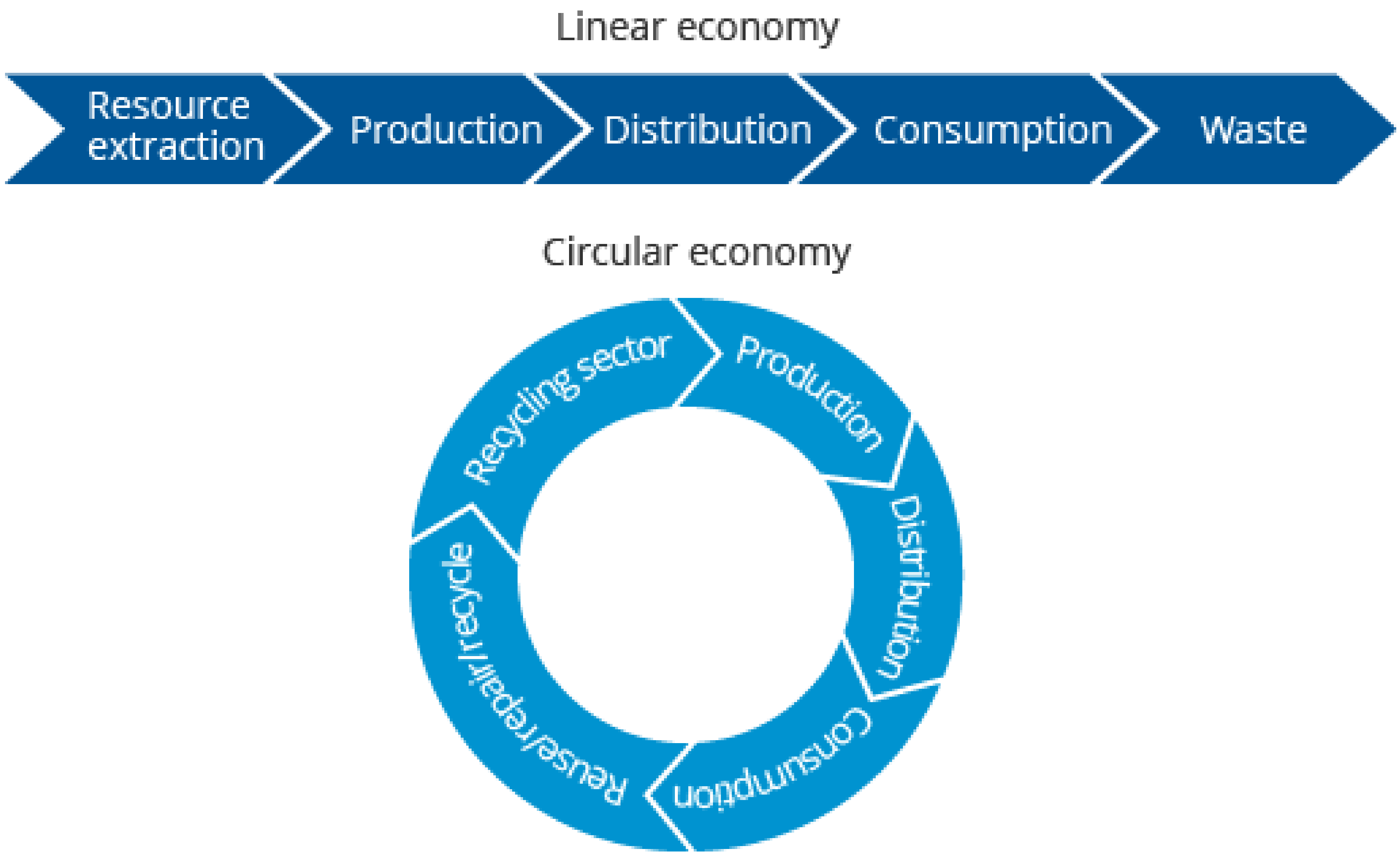
Module 3:
Governing the
Urban Nexus

Learning Goals Module 2: Innovative Engineering Approaches

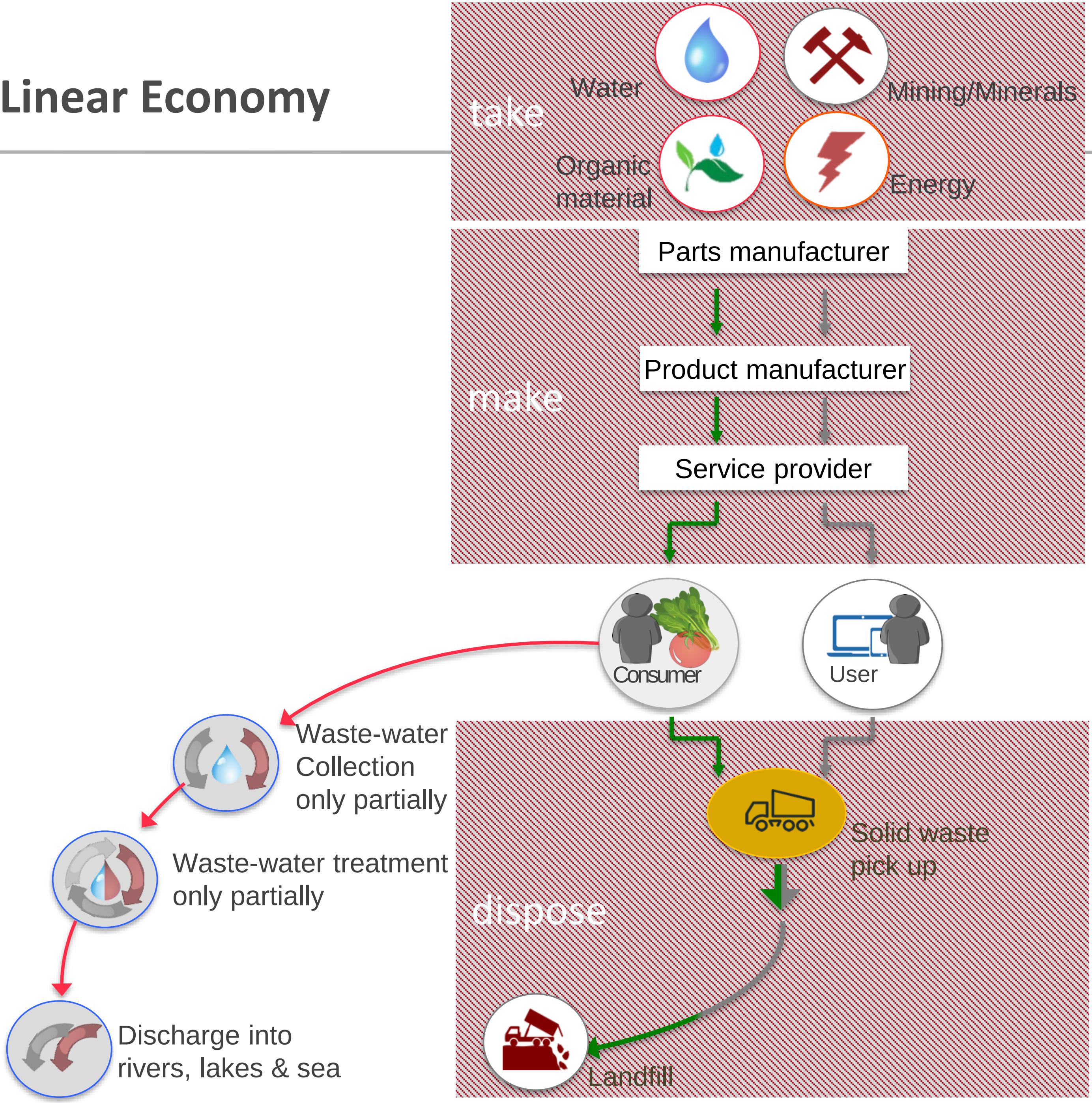
1. Understanding the concepts of “circular economy” and “close the loop”
2. Increased knowledge of innovative engineering solutions to address the nexus across water, energy and solid waste
3. General understanding of approaches and technologies for
   - Integrated wastewater management and reuse
   - Energy efficiency in buildings
   - Integrated solid waste management

Circular Economy

Closing the Loop – From Linear to Circular Economy

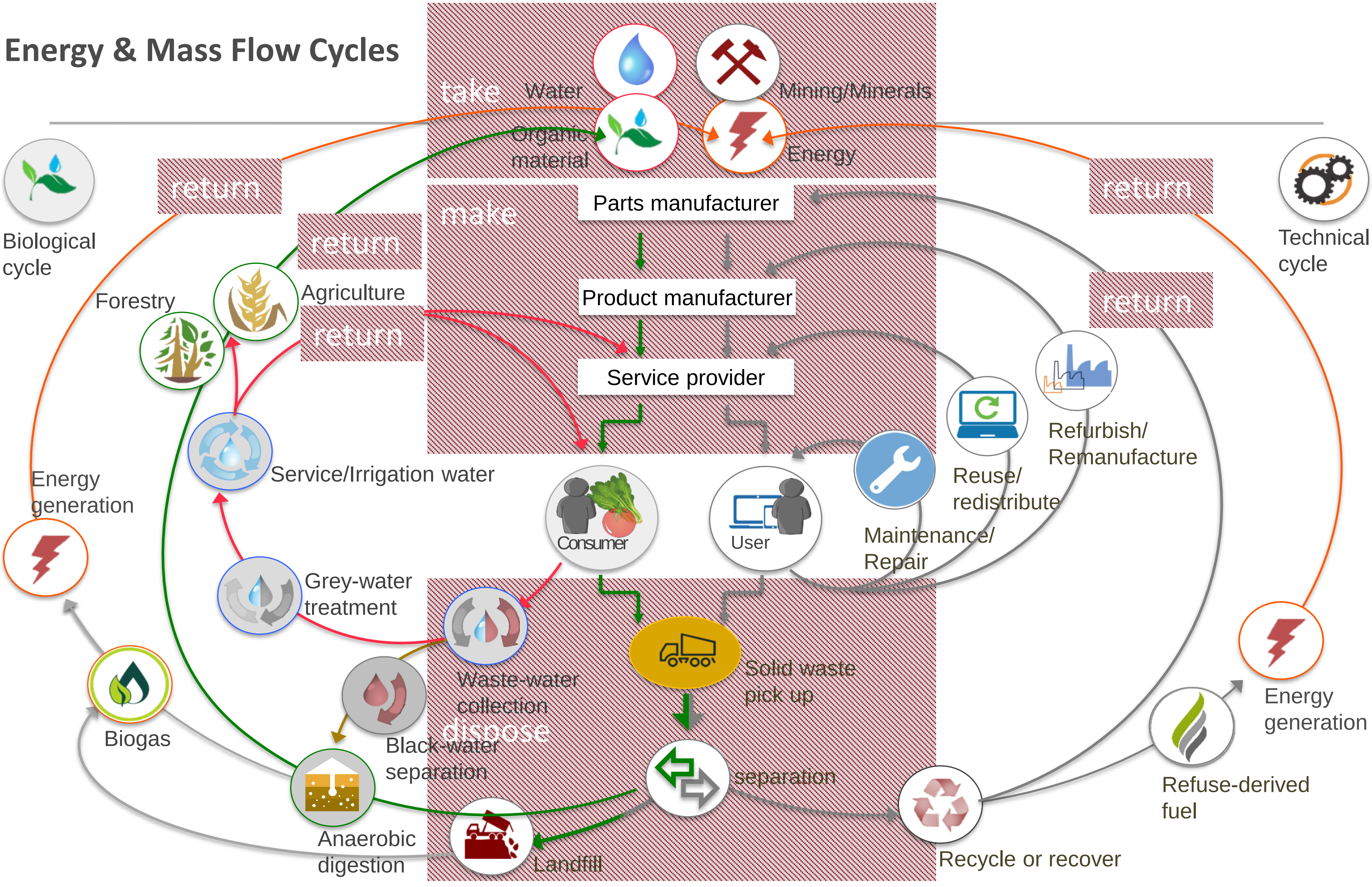


Linear Economy



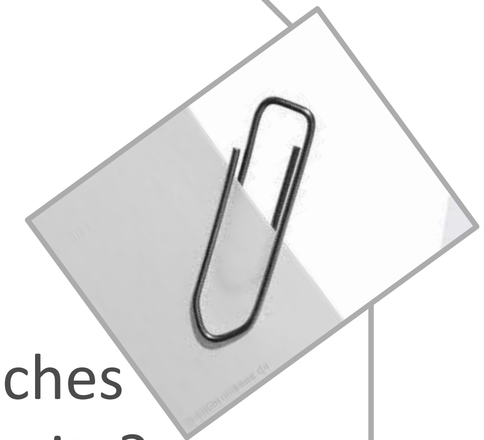
Source: adapted from GIZ

Energy & Mass Flow Cycles



Source: adapted from GIZ

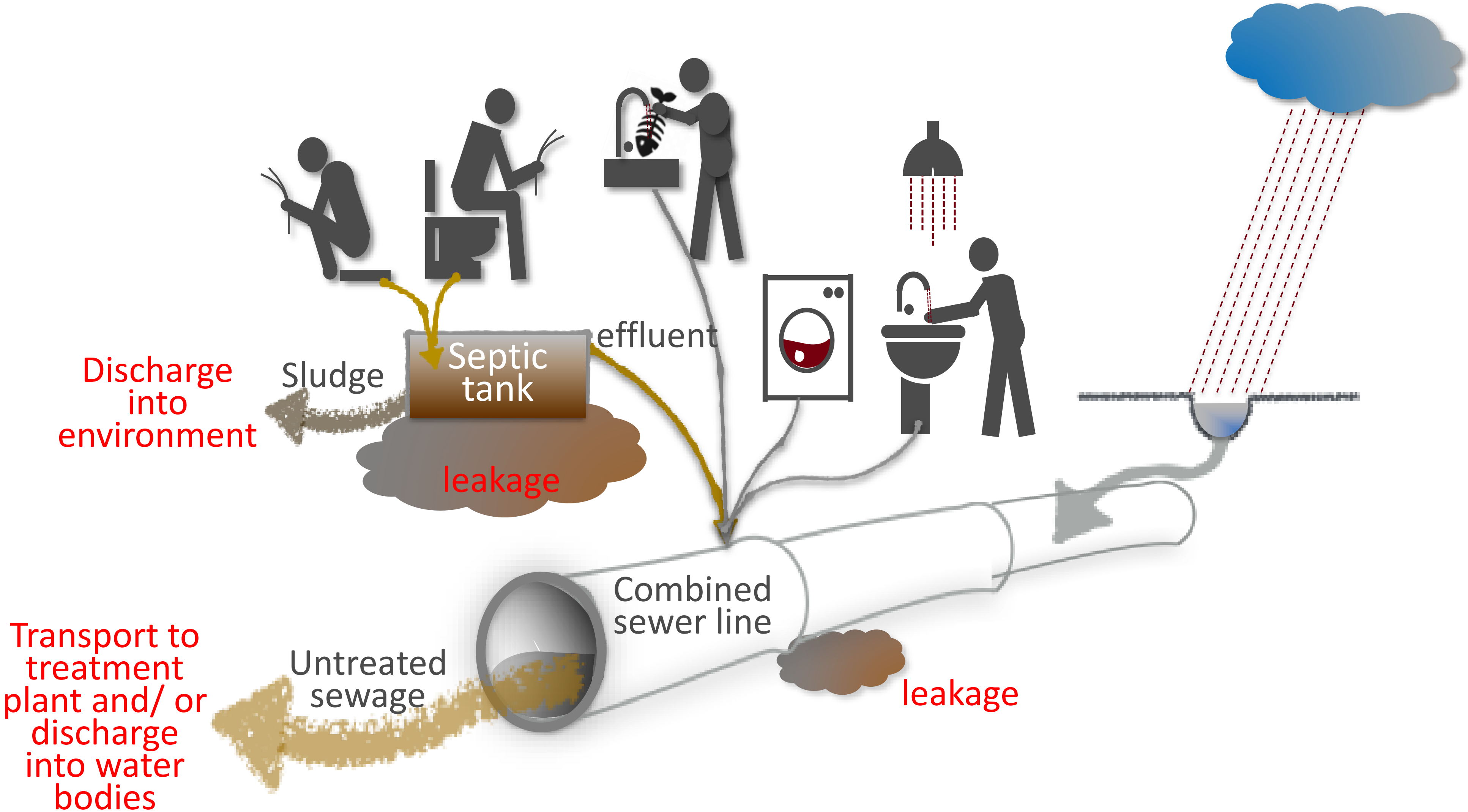
Your experiences?



Do you know of any examples of circular approaches to water, waste, and energy management in your city?

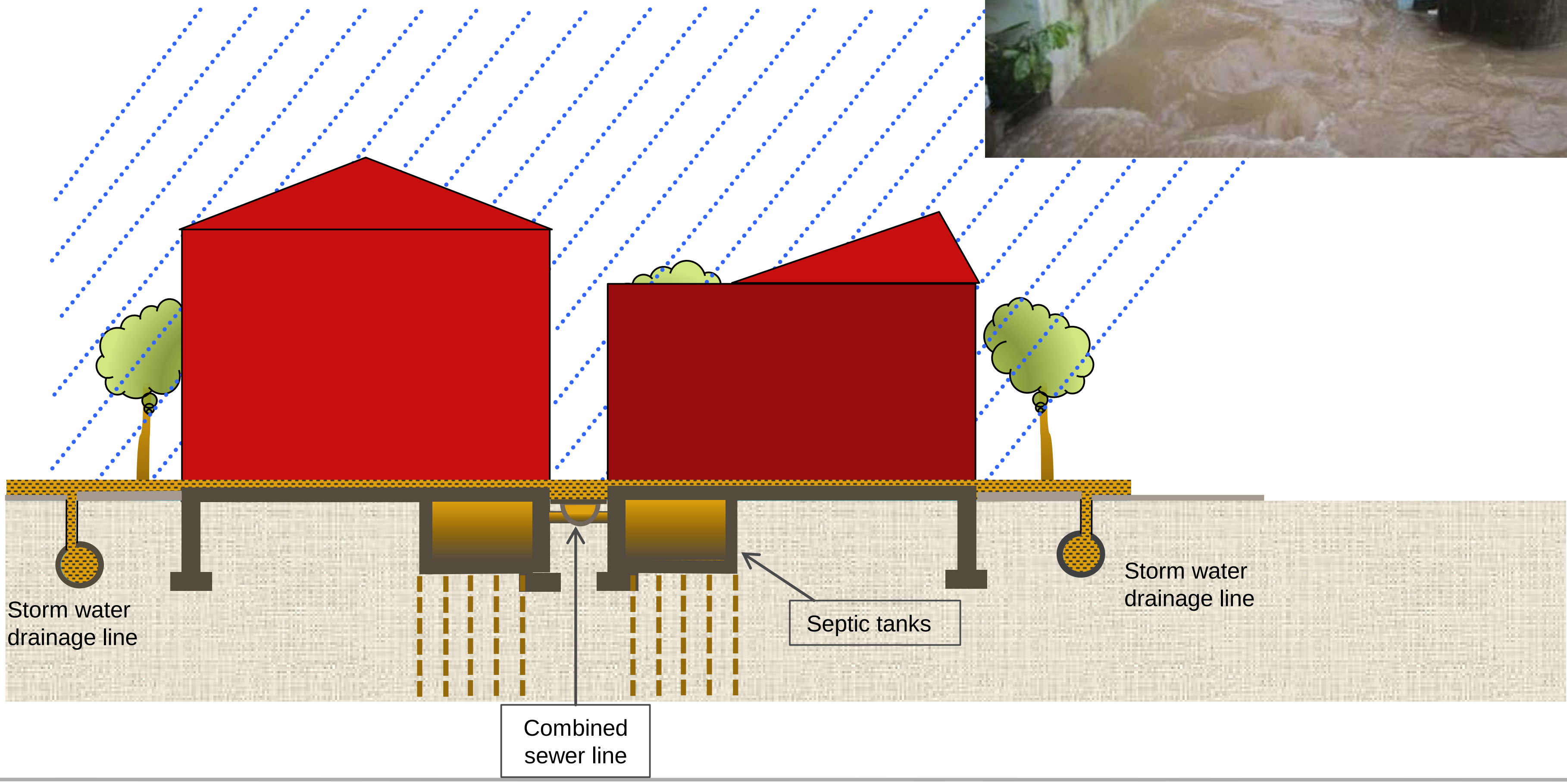
Integrated Wastewater Management and Reuse

Risks Related to the Common Sanitation System in most Asian Cities



Source: adapted from GIZ

Actual Situation in most Asian Cities: *Risks of Contamination*



Source: GIZ

Some Facts about Human „Waste“

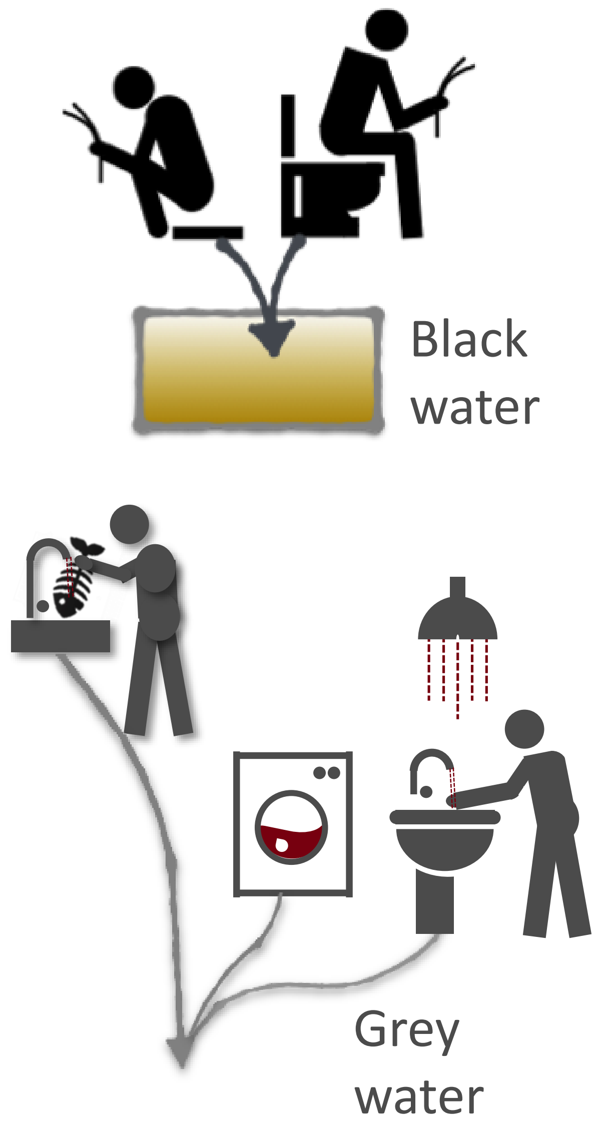
One person generates approx. **1.5 liters of "waste" per day** (urine, faeces):

- large proportion of **organic matter (energy)**, and
- **rich in nutrients** (high phosphate and nitrogen concentrations)

conventional water-based sanitation systems require approx. **25 to 50 liters flush water per person per day** to transport the "waste" :

- **dilution** effect through **flush water**
- **dilution** through **grey water** and
- **further dilution through rainwater** in combined sewer systems

Dilution complicates recovery of energy and nutrients

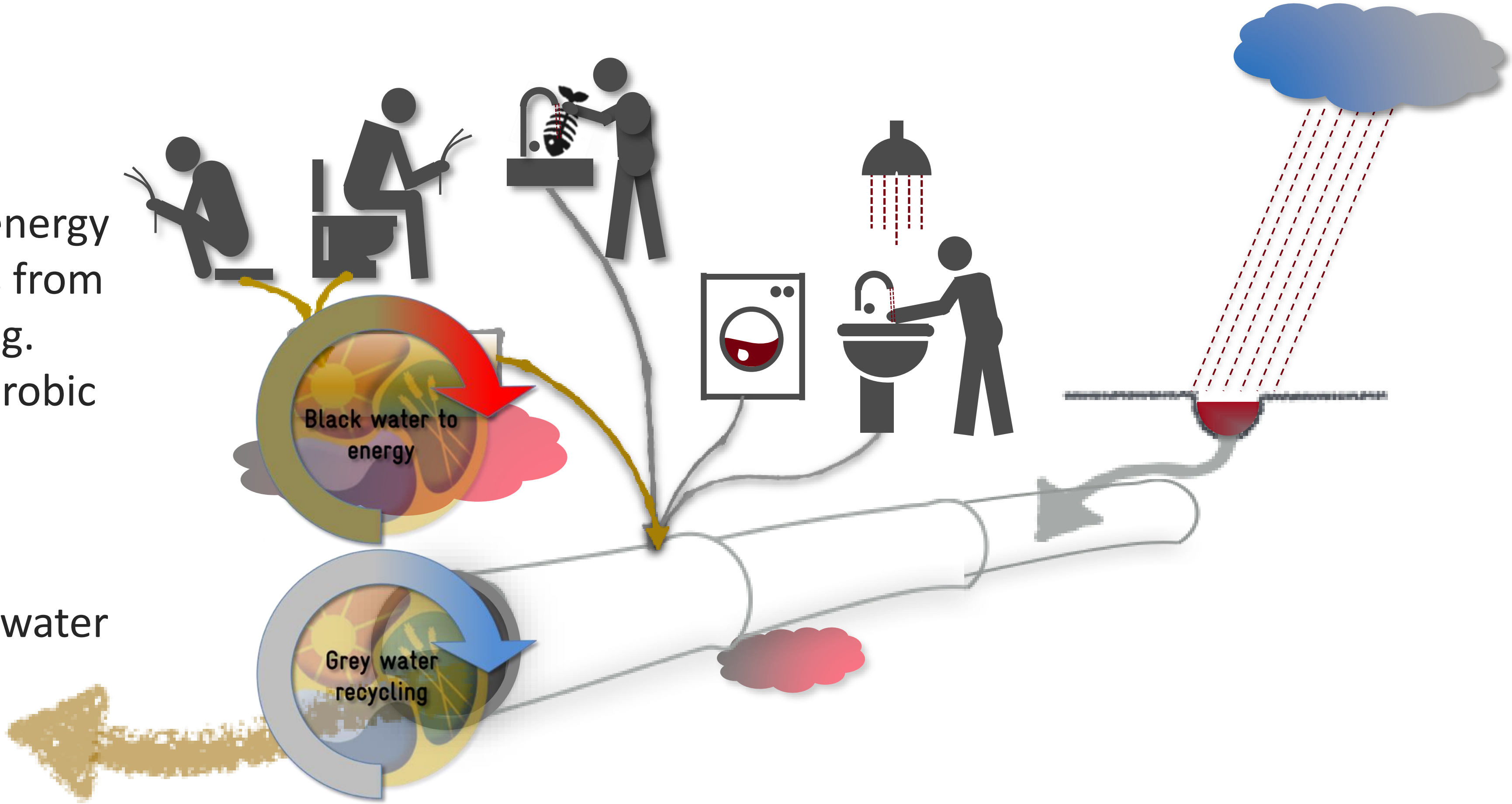


Source: GIZ

Closing the Energy & Mass Flow-cycles from Black & Grey Water: *Basics*

Separating black from grey and storm water allows:

- Recovery of energy and nutrients from blackwater e.g. through anaerobic digestion
- Reuse of grey water after minor treatment

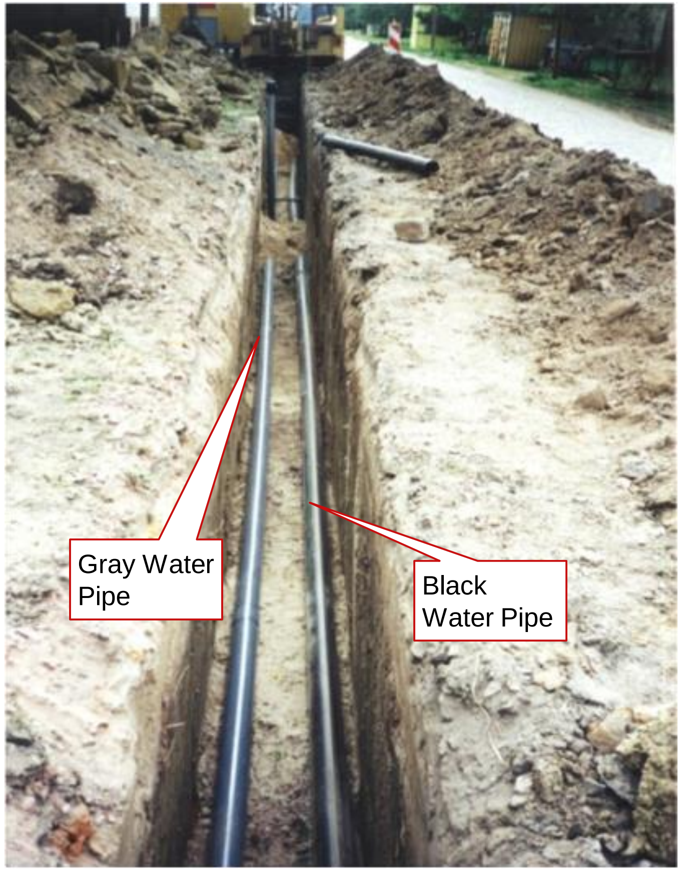


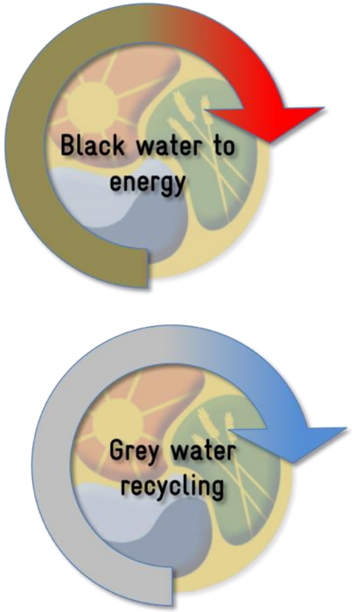
Source: GIZ

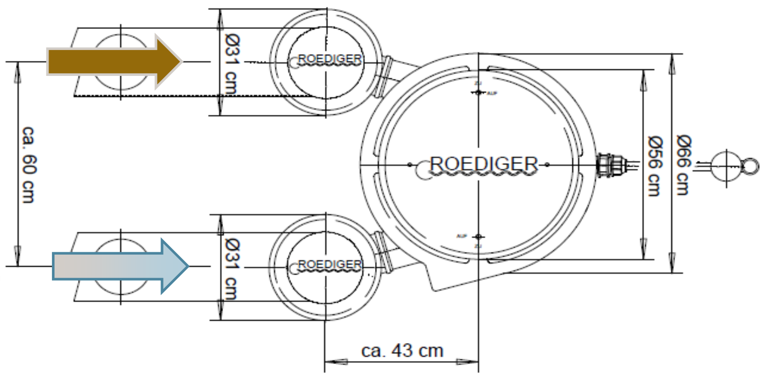
Vacuum Collection of Sewerage with Source Separation

Separated Vacuum Sewerage Collection for Black & Grey Water

Vacuum sewerage collection requires **less water** to transport waste and allows transportation of concentrated black water.







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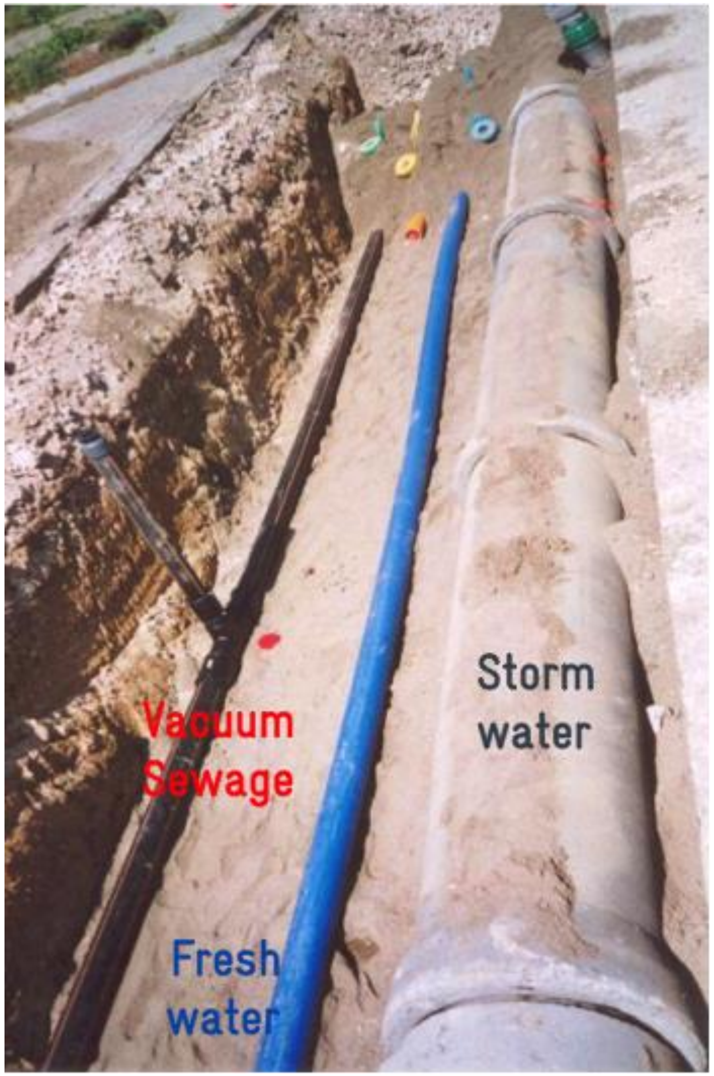
Vacuum Sewer System

- Allows conveyance in **flat terrain and areas with shallow groundwater tables**
- **Easier and cheaper** to build than gravity systems, small diameter pipelines laid in shallow and narrow trenches;, flexible pipeline construction, easy to lay pipelines around obstacles
- Closed system with **no leakage or smell.** Sewers and water supply pipes can thus be laid in a common trench; system is **flood proof**
- **No manholes** along the vacuum sewers
- One central vacuum station can replace several pumping stations – **energy savings**



Vaccum Sewer System: Potential Applications

A vacuum sewer system can also be used to collect sewerage from houses built on stilts in the water.

This could be the implemented e.g. in Tanjungpinang/ Senggarang, Indonesia

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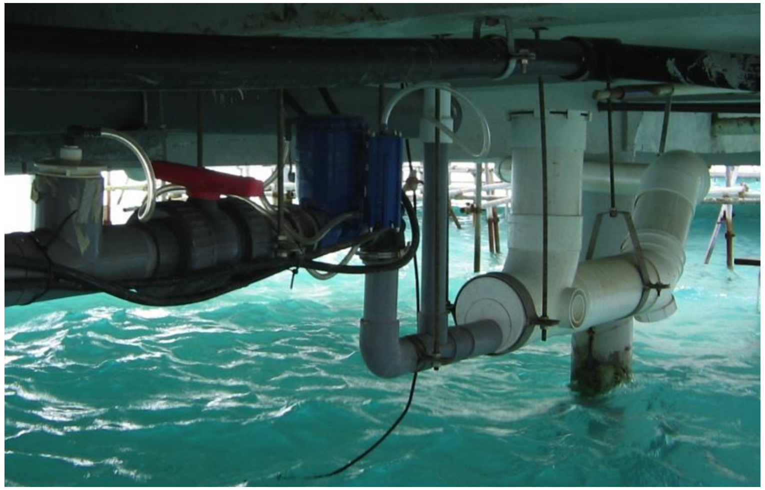
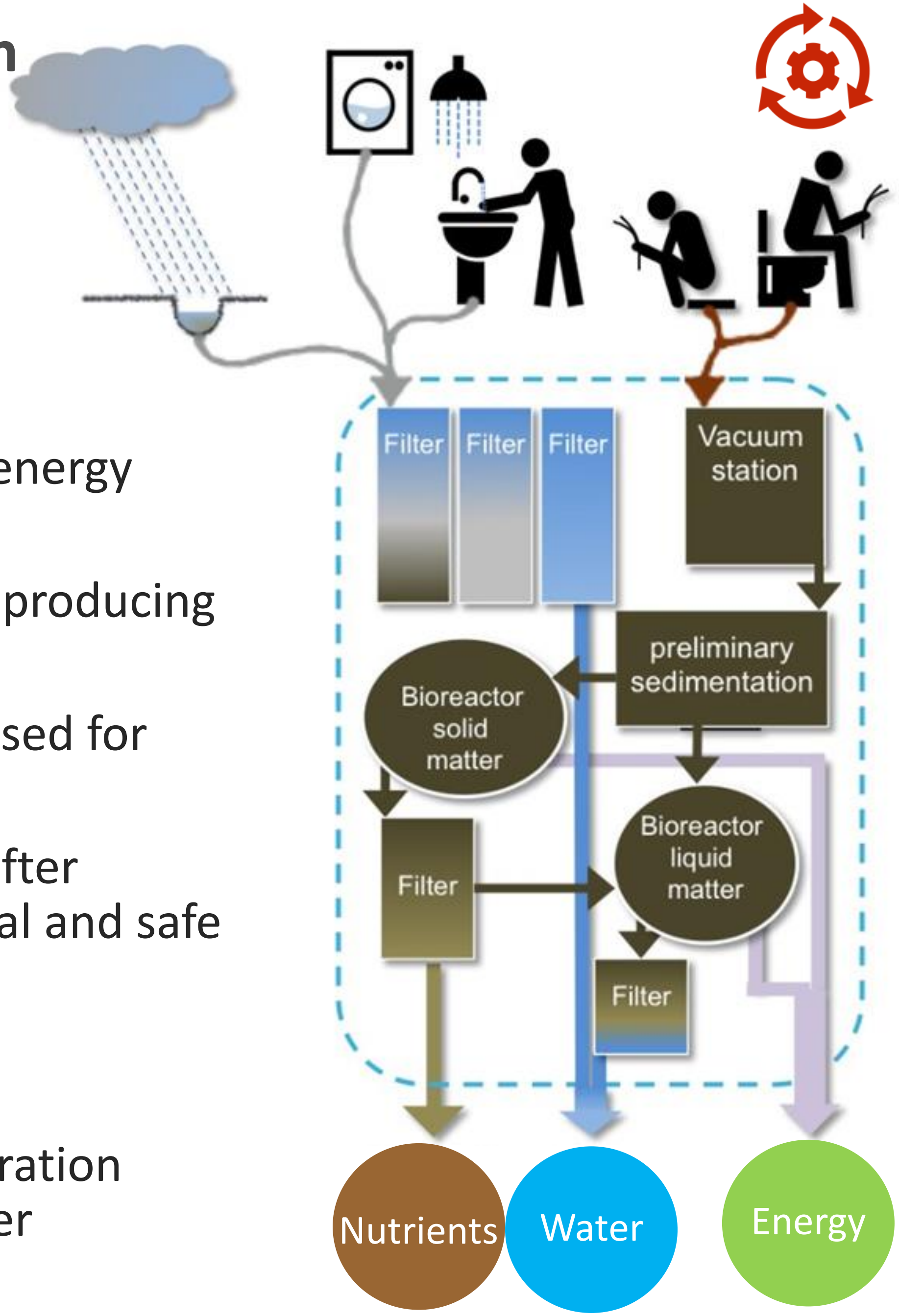


Closing the Energy and Mass Cycle through Integrated Wastewater Management



Example of a semi-decentralised system

Black water treatment

- Preliminary sedimentation for more profitable energy recovery
- Treatment in anaerobic digesters (bioreactors), producing biogas (energy recovery)
- Remaining solids (sludge) can be further processed for reuse as fertilisers (nutrient recovery)
- Remaining water (if produced) may be reused after treatment – caution regarding pathogen removal and safe handling required

Grey water treatment

- Separate treatment e.g. through membrane filtration removing pathogens but nutrients remain (water recovery)

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Closing the energy and mass cycle through integrated wastewater management

Energy

Biogas can be used as:

- Fuel for generators (electricity)
- Fuel for cars and trucks
- Fuel for cooking and heating

Nutrients

Sludge/digestat from anarobic treatment can be used

- as fertiliser on agricultural fields (disinfection might be neccessary)
- Further pocessed and de-watered to be used as soil enrichment

Water

Treated grey-water can be used:

- As nutrient-rich irrigation water
- Other urban uses (street cleaning etc.)

Urban agriculture in Da Nang, Vietnam, Source: GIZ

Case Study Da Nang - Existing Sanitation and Sewerage System

- Only grey water from kitchens and bathrooms are collected by sewer lines
- **Toilets often not at all connected to sewer system** or only the effluent of septic tanks, septic tanks not emptied
- **River and ground water contaminated** (faecal bacteria)
- Waste water treatment plants do only receive diluted waste water, black water is not properly managed – **no potential to recover energy and nutrients**
- **Open sewers in walkways**: unhygienic, odors, attract rats & cockroaches

Source: adapted from GIZ

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Case Study Da Nang – Vacuum vs. Gravity Sewer System

	Vacuum sewer system	Gravity sewer system
Investment cost		
• Connection pipe from house (110)		3.311.634.370 VND
• Construction cost of system network		5.644.105.921 VND
• Equipment cost		3.714.688.000 VND
Total investment		**12.670.428.291 VND**
Per household		**115.185.711 VND**
Operation & Maintenance cost		519.148.216 VND/year

Addtional benefits:

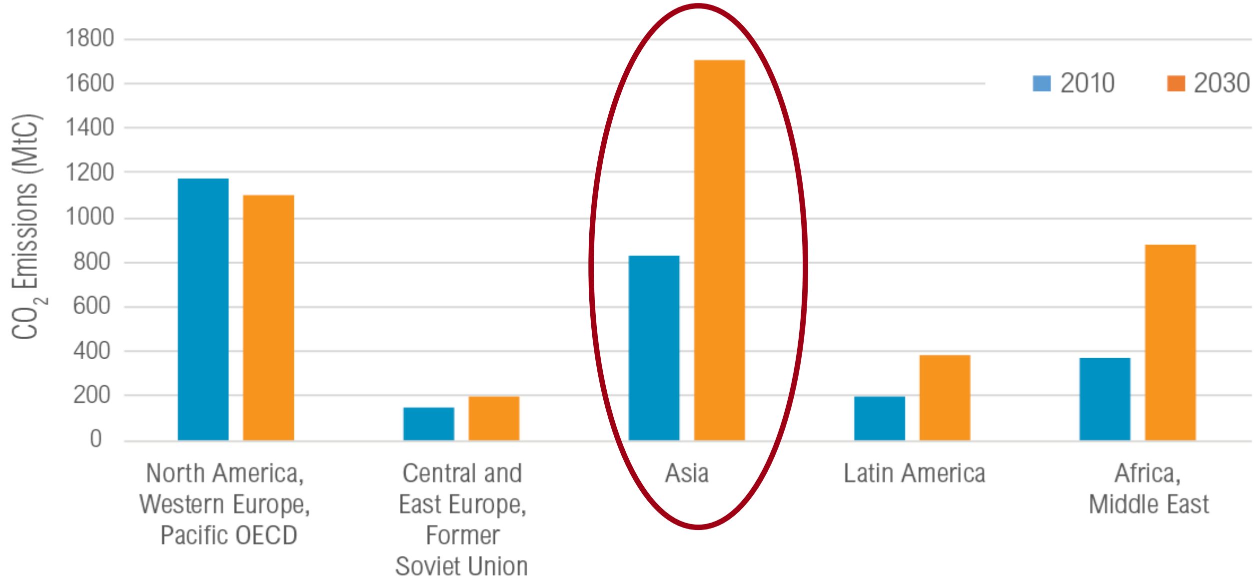
- Vacuum sewer lines can be laid in backyard walkways
- No major construction work inside the house necessary
- With closed sewer systems (no odors, rats) backyards may become pleasant places

Energy Efficiency in Buildings

Energy Efficiency in Buildings

- Globally, buildings account for **32% of energy consumption and 25% of CO_2 emissions**
- **Urbanization and economic growth** will set off a **"building explosion"**
- Without changes in construction practice, related emissions are also expected to skyrocket

Building Sector Emissions by World Region, 2010 and 2030 Projections



Source: World Resources Institute

➢ Heating and cooling, ventilation, lighting, preparation of hot sanitary water require approx. 75% of a residential building‘s energy demand

➢ More efficient buildings can generate **economic benefits, reduce environmental impacts and improve people's quality of life**

Energy Efficiency in Buildings

Successful implementation of energy efficiency measures in buildings is based on:

- Increasing the **thermal protection** of existing and new buildings → in moderate climates reducing the air leakage through the building envelope, in hot and humid claimes allowing air flow for ventilation
- Increasing the **efficiency of heating, cooling and ventilation** → passive solar building design, effective window placement, solar water heating
- Onsite **generation of renewable energy** → solar power, wind power, hydro power, biomass
- Increasing the **efficiency of lighting systems and energy appliances**

➢ Most rigorous standard: **Energy Plus Houses**

© Dpt of Energy Solar Decathlon 2013 / Flickr

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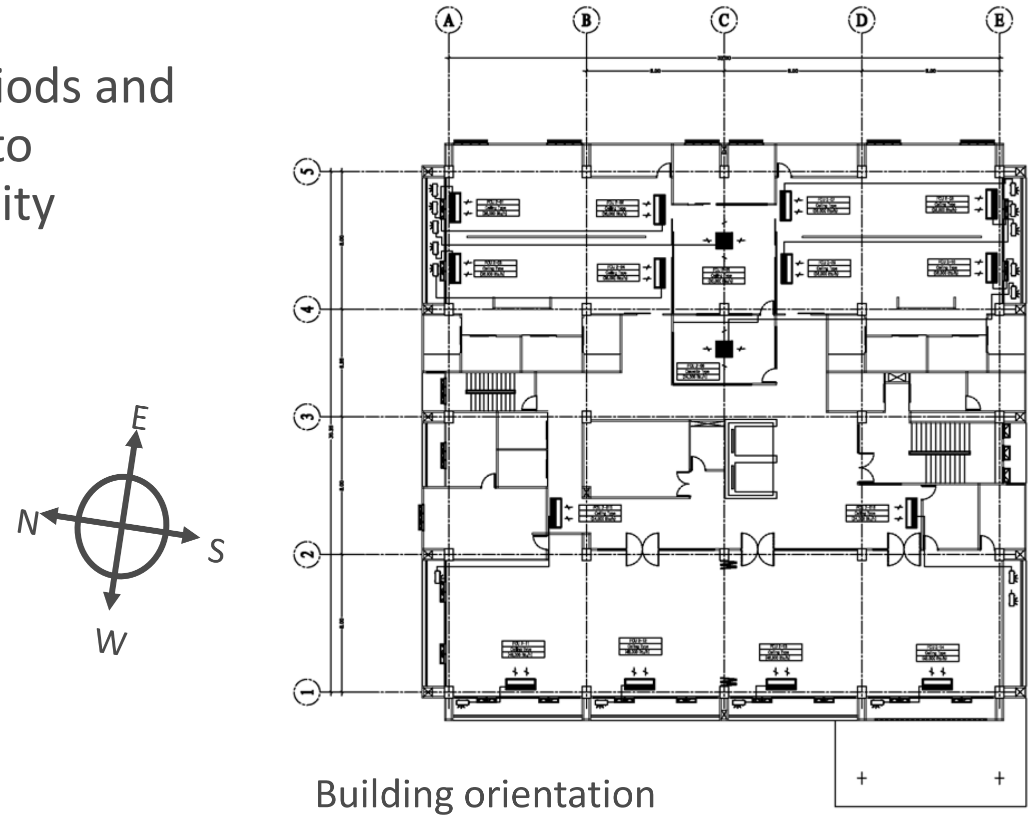
Closing the Loop: Chiang Mai Healthcare Center

- Energy efficiency study on new building project for a Health Care Center in Chiang Mai, Thailand
- Project owner is the Chiang Mai municipality
- The property of the building site is currently unbuilt and used as a parking space
- All buildings in the close vicinity are not more than two floor levels and do not cast shadows on the site
- The current design foresees about 2.670 m^2 of total usable floor area, distributed over three floor levels

Closing the Loop: Chiang Mai Healthcare Center

- Review of existing building design for planned Chiang Mai Health Care Center to improve its anticipated energy performance
- Suggestion of probable energy efficiency measures and simulation of the current design's baseline performance
- Projection of anticipated life-cycle periods and calculated payback periods identified to compare their specific economic viability

South West Façade



Building orientation

Closing the Loop in Residential Areas: Chiang Mai Healthcare Center

Combination of two measures are suggested for implementation:

Option 1

LED

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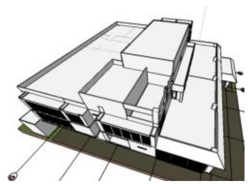
Roof Insulation



= **Best Economical Option**

Option 2

LED

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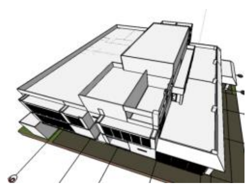
Roof Insulation



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Inverter

= **Highest Energy Savings**

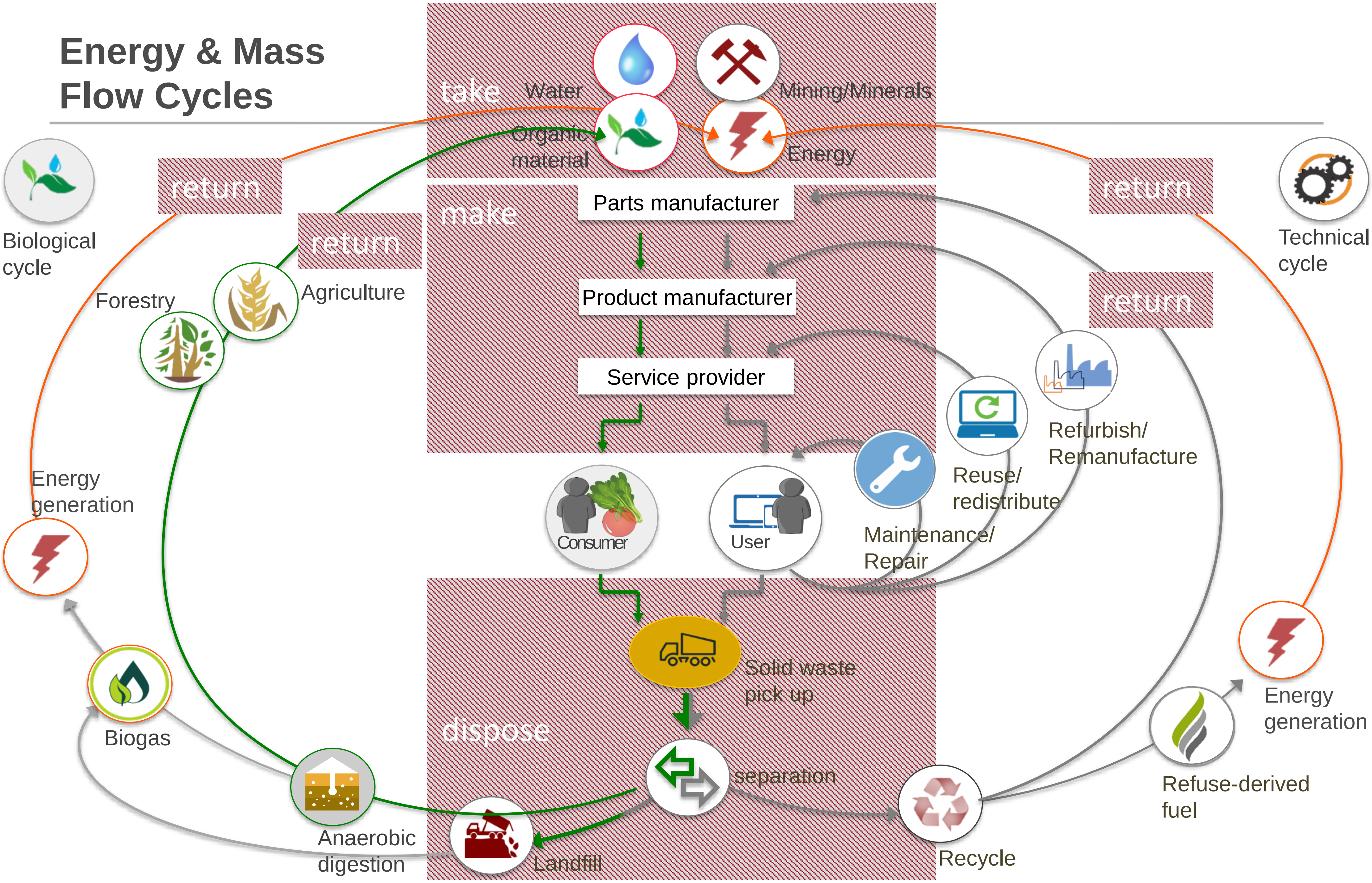
Closing the Loop in Residential Areas: Chiang Mai Healthcare Center

Additional recommendations:

- Recalculation of the cooling load to reduce investment costs for air-conditioning system
- Improvement of visual comfort and well-being, especially of the nursery wards :
    - Provision of windows for visual contact to the exterior
    - Integration of green zones in interior spaces and exterior balconies

Solid Waste Management

Energy & Mass Flow Cycles



Source: adapted from GIZ

Composition of Municipal Solid Waste

Type of waste	Typical sources
Organic	food scraps, yard waste (leaves, grass, brush), wood
Paper	newspapers, cardboard, packaging, paper bags
Plastic	bottles, plastic bags, plastic containers, foils, packaging
Glass	bottles, jars, broken glassware
Metal	cans, tins, aluminum foils, pots, appliances, bicycles,
Electronic waste	electric appliances, cables, screens
Inert materials	ashes, construction and demolition waste, dirt, rocks,
Other	textiles, rubber, leather, batteries, multi-laminates

The composition of municipal solid waste varies greatly, depending on the level of econmic development, energy sources, cultural norms as well as the existing mechanisms for recycling.

Some Facts about Waste in Asian Cities

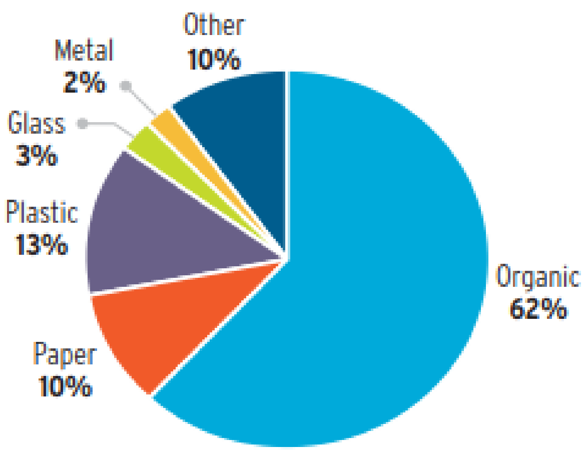
Waste composition

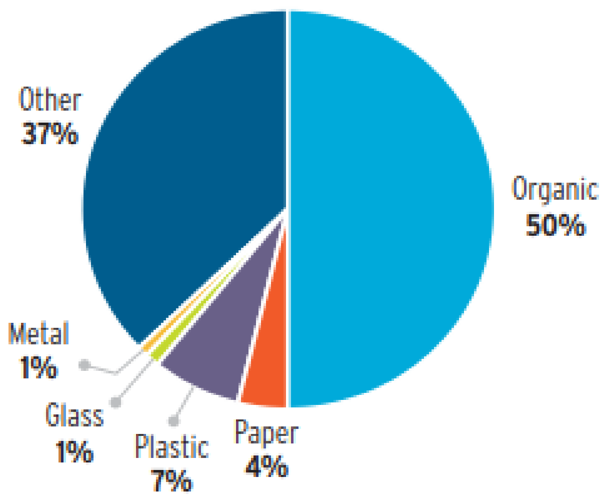
- **High organic fraction: about 50-65%** of solid waste generated is organic (incl. food scraps and garden waste)
- **Recyclable inorganic materials: about 26-33%** (such as paper, plastic, metal, and glass)

Opportunities

→ can be turned into compost (nutrients) or transformed into biogas (energy)

→ can be recycled and returned into manufacturing processes





Waste composition in East Asia and Pacific and South Asia

Source: WB 2012

Existing Practice – Different Types of Land Disposal Facilites

Criteria	Open Dump	Controlled Dump	Sanitary Landfill
Siting of facility			
Cell planning			
Leachate management			
Gas management			
Application of soil cover			
Compaction of waste			

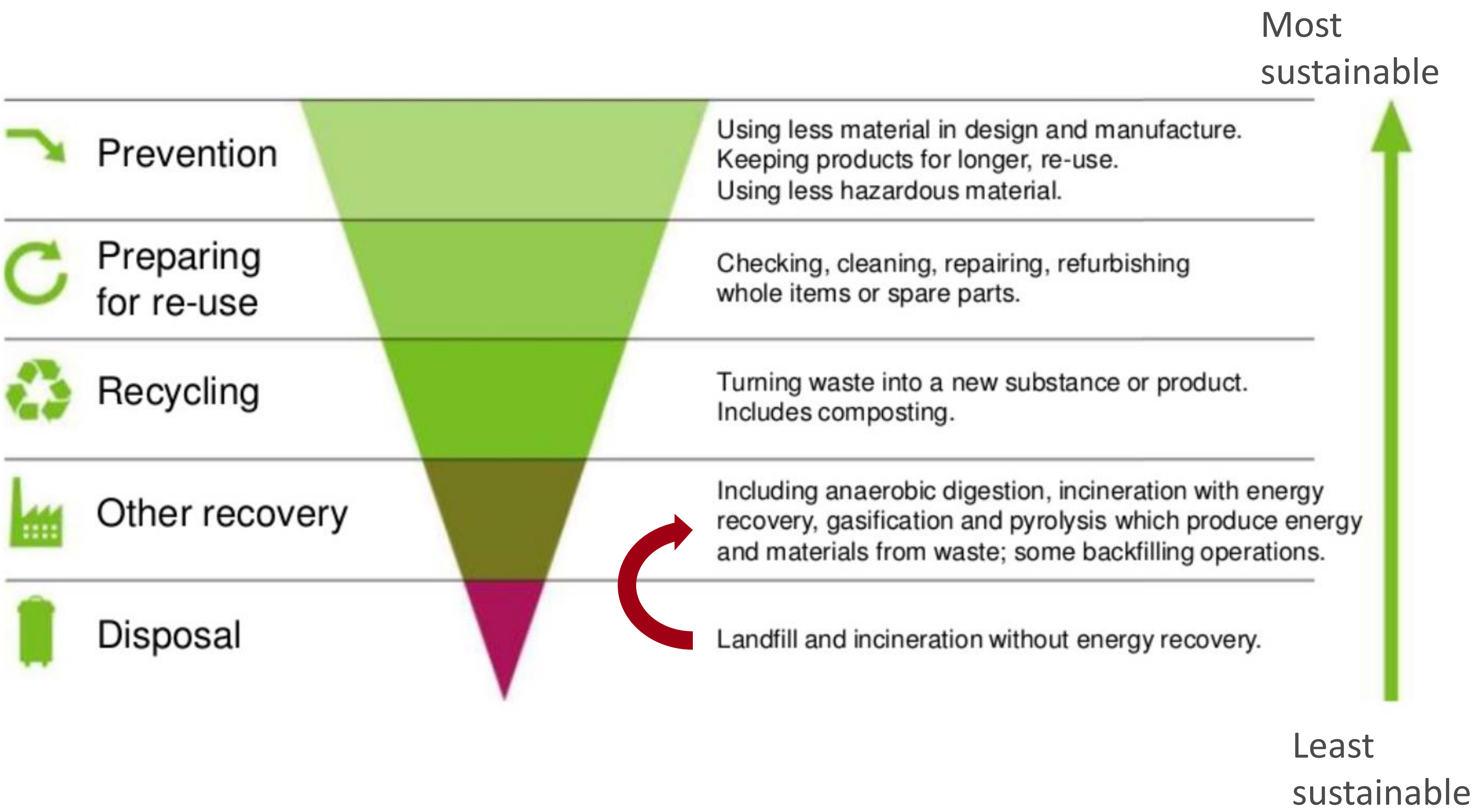
Source: UNEP 2005, GIZ

Existing Practice – Different Types of Land Disposal Facilites

Criteria	Open Dump	Controlled Dump	Sanitary Landfill
Waste picking	• Waste picking by scavengers	• Controlled waste picking and trading	
Closure	• No proper closure of site after cease of operations	• Closure activities limited to covering with loose or partially compacted soil	
Cost	• Low initial cost, high long term cost	• Low to moderate initial cost, high long term	
Environmental and health impacts	• High potential for fires and adverse environmental and health impacts	• Lesser risk of environmental and health impacts compared to an open dump site	

Source: UNEP 2005, GIZ

Integrated solid waste management - The waste hierarchy

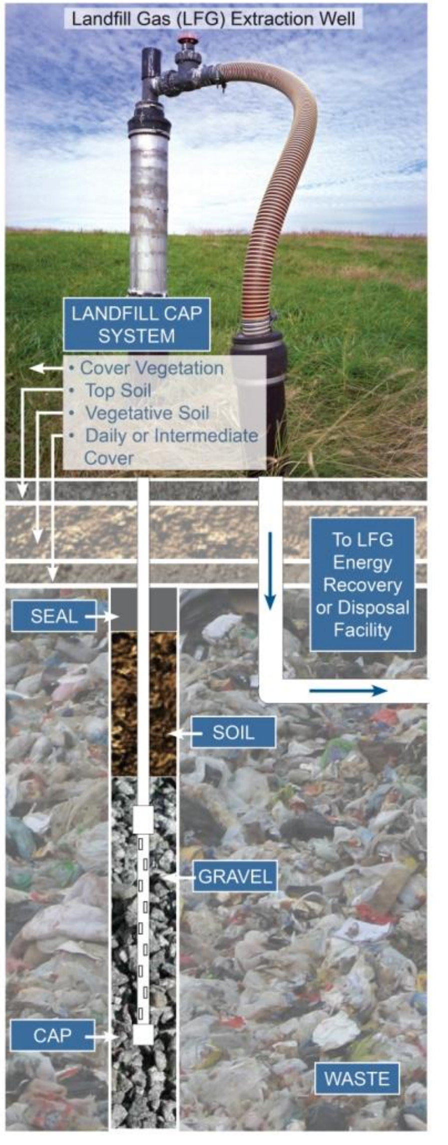


Closing the Loop from Waste to Energy – Capture of Landfill Gas

Landfill gas is produced in landfills through **anaerobic degradation** inside the "waste body"
(very complex, yet **partly unknown** processes)

Final product of the anaerobic degradation:
- **Digestion gas** (landfill gas),
  Methane (CH_4) and Carbon-dioxide (CO_2)

Opportunities for energy recovery: If captured, landfill gas can be used…
- to generate electricity, heat, or steam;
- as an alternative vehicle fuel;
- sold on the energy market as a renewable "green" power or gas.



Source: GIZ

Maximum Yield Technology

MYT®

Maximum Yield Technology

The other way of thinking -
Usage of waste as resource - Replacing "Sanitary Landfills"

MYT® breaks waste down into its four components,

- energy sources,
- metals,
- water
- minerals

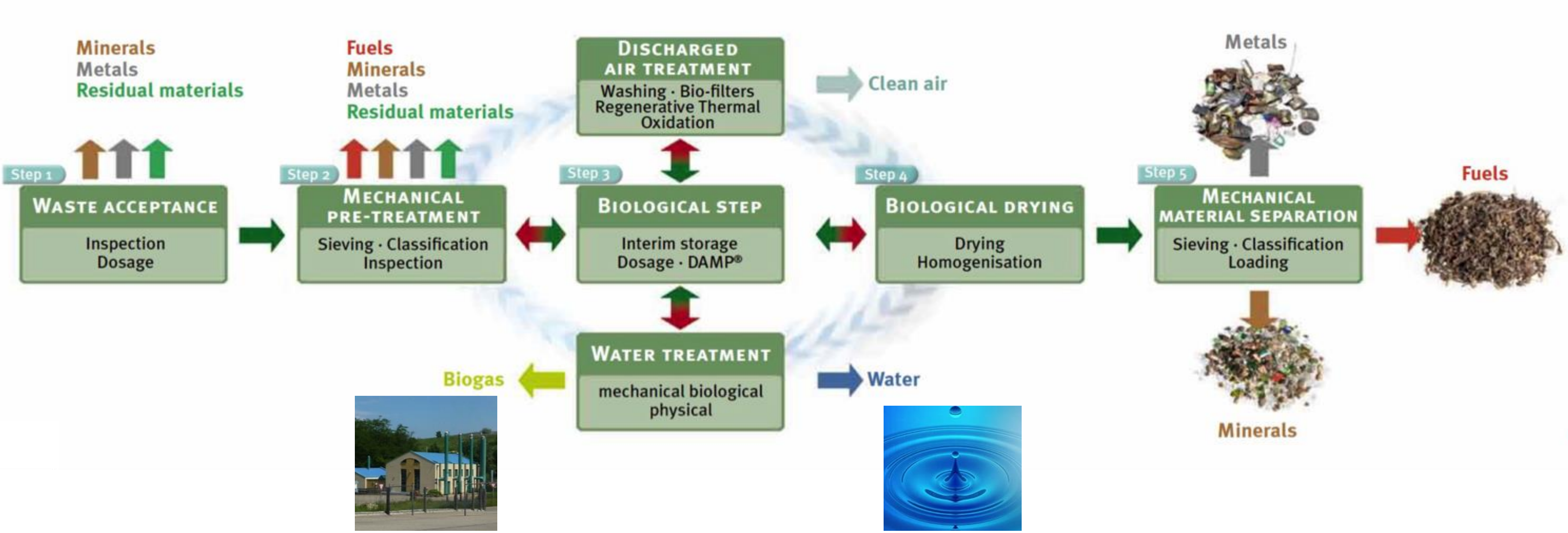
For optimum economic exploitation of waste in the form of raw materials, quality-assured fuels and energy-rich biogas.

Maximum Yield Technology

MYT®

Maximum yield technology

involves 5 completely modular steps:



Maximum Yield Technology

MYT® Maximum yield technology

MYT extracts the following components from residual household waste: