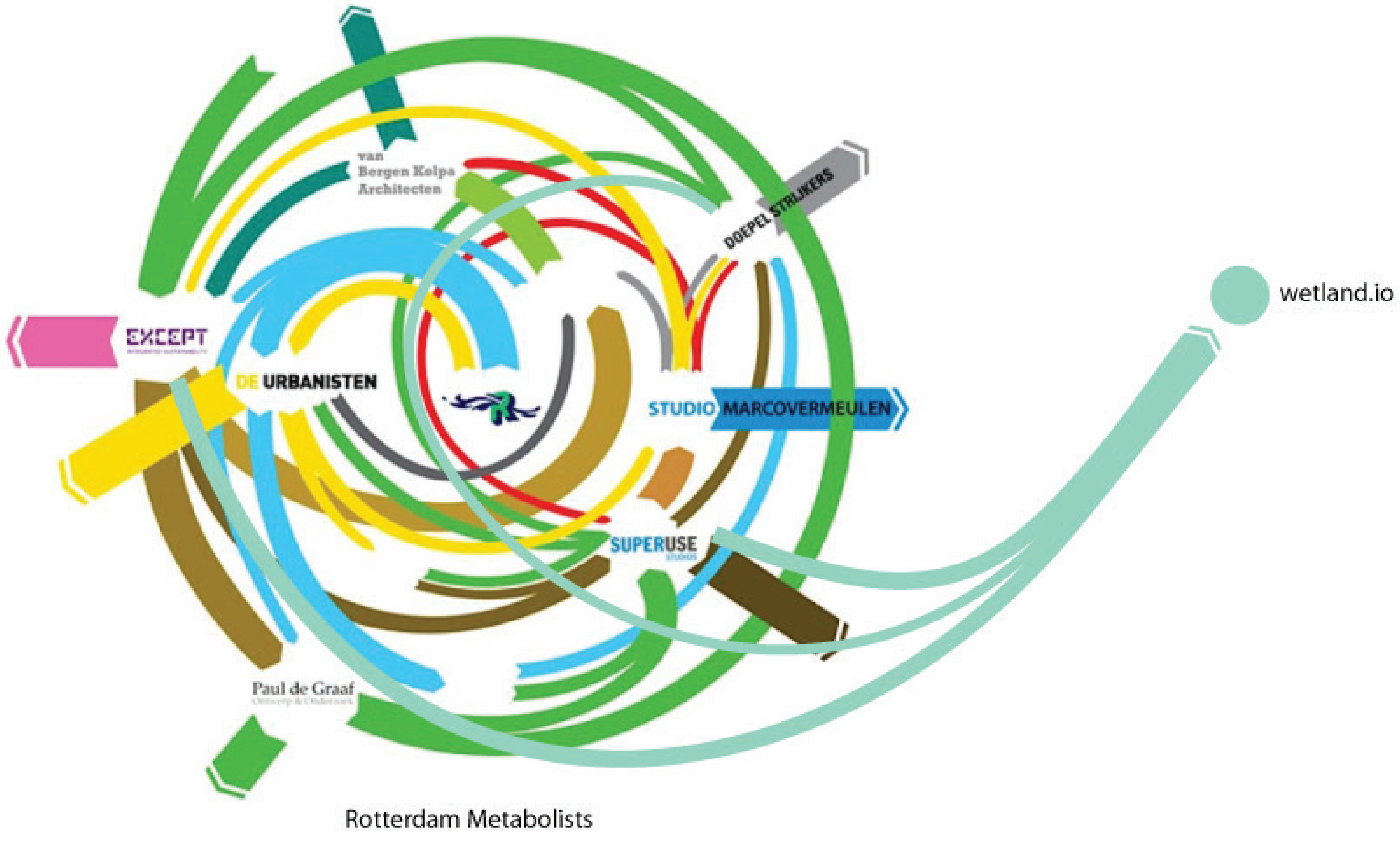
Smart City Systems

wetland.io/SmartCitySystems



Why Smart City Systems

Applying Industrial Ecology

Industrial Ecology finds symbiotic relationships between industrial actors, typically within eco-industrial parks, wherein one actor's waste will act as a feedstock for another actor's process.

Within several other disciplines, including product design, architecture, urbanism, planning, and governance, the principles of Industrial Ecology can be applied.

Applying Industrial Ecology in the built environment can create a post-LEED urban ecology with sustainable abundance of resources by considering buildings and other actors within a wider context.

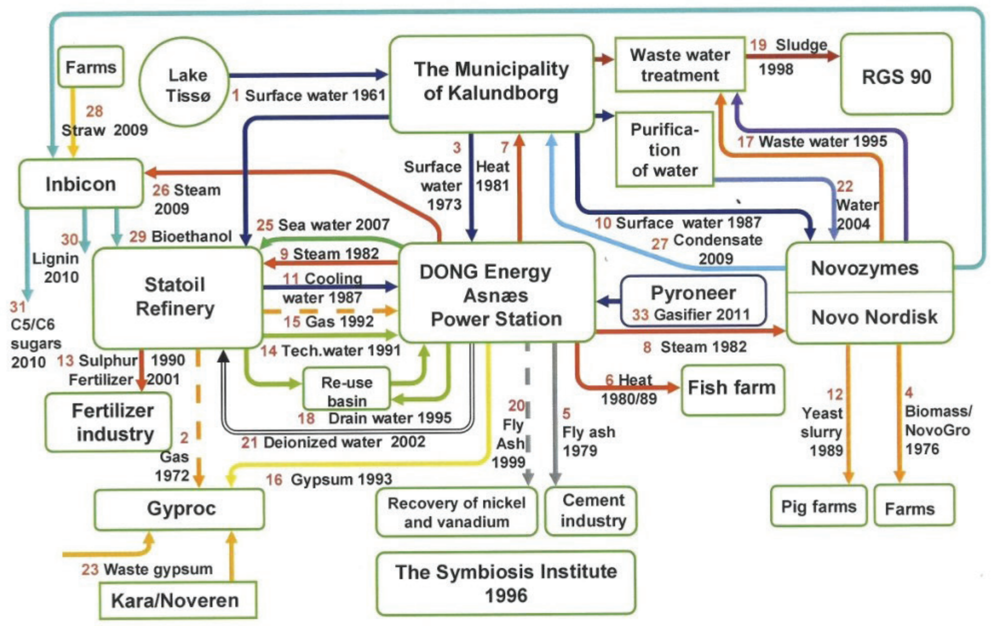
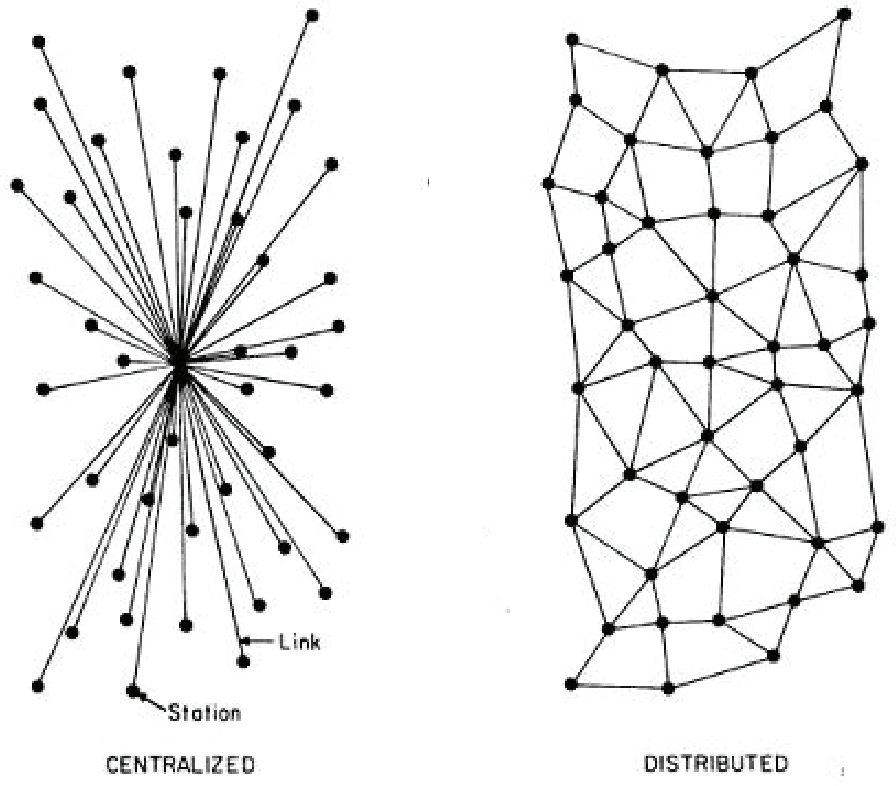


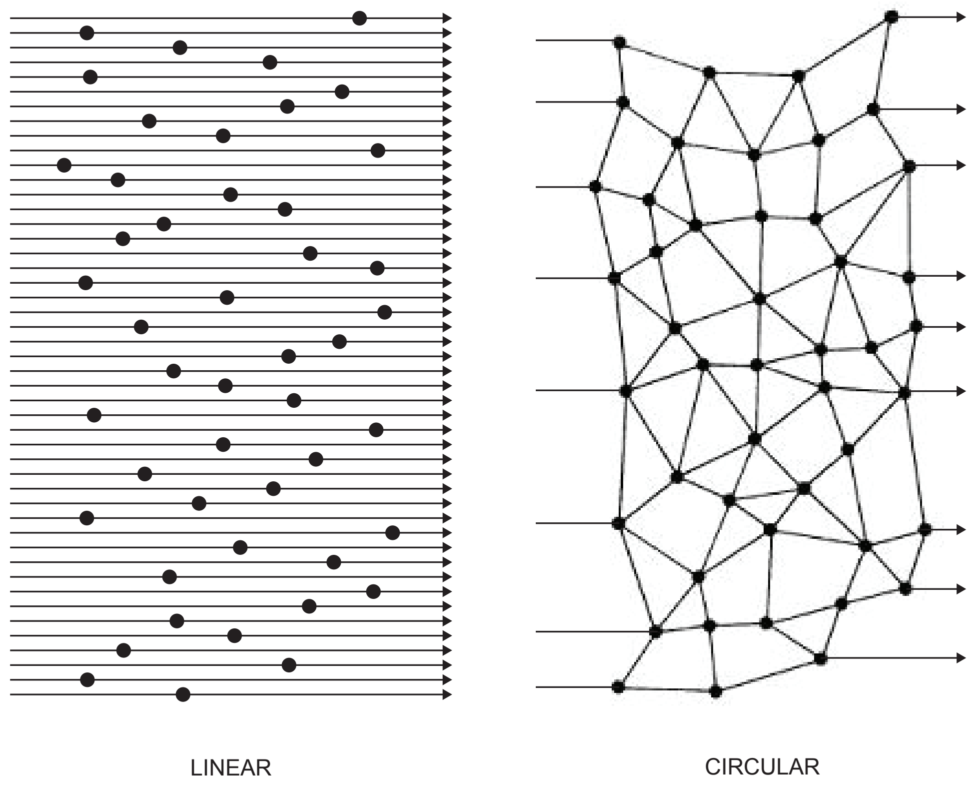
Image: Kalundborg Symbiosis

Improving urban metabolism through connectivity

Network type



Metabolism type



Capturing work value

Exergy

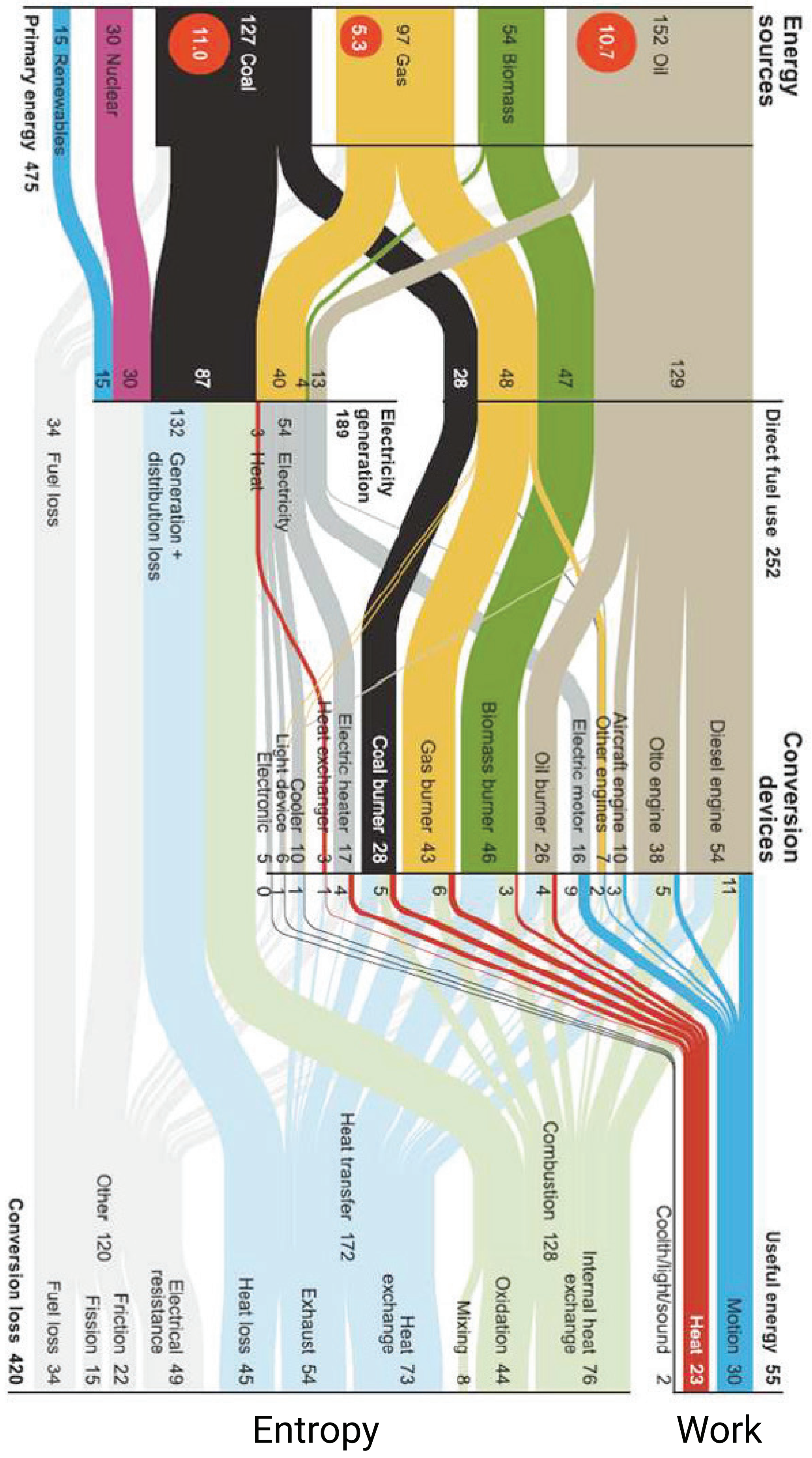


Image: JM Cullen and JM Allwood, 2009

Creating a Circular Economy

Circular Economies are regenerative and waste-free by design. In a Circular Economy, materials are indefinitely cycled at high quality, all energy is derived from renewable or otherwise sustainable sources, and natural and human capital are structurally supported rather than degraded through economic activities.

Achieving a Circular Economy requires systemic redesign of our modern industrial system with a great deal of focus on how it relates to both ecological and human systems.

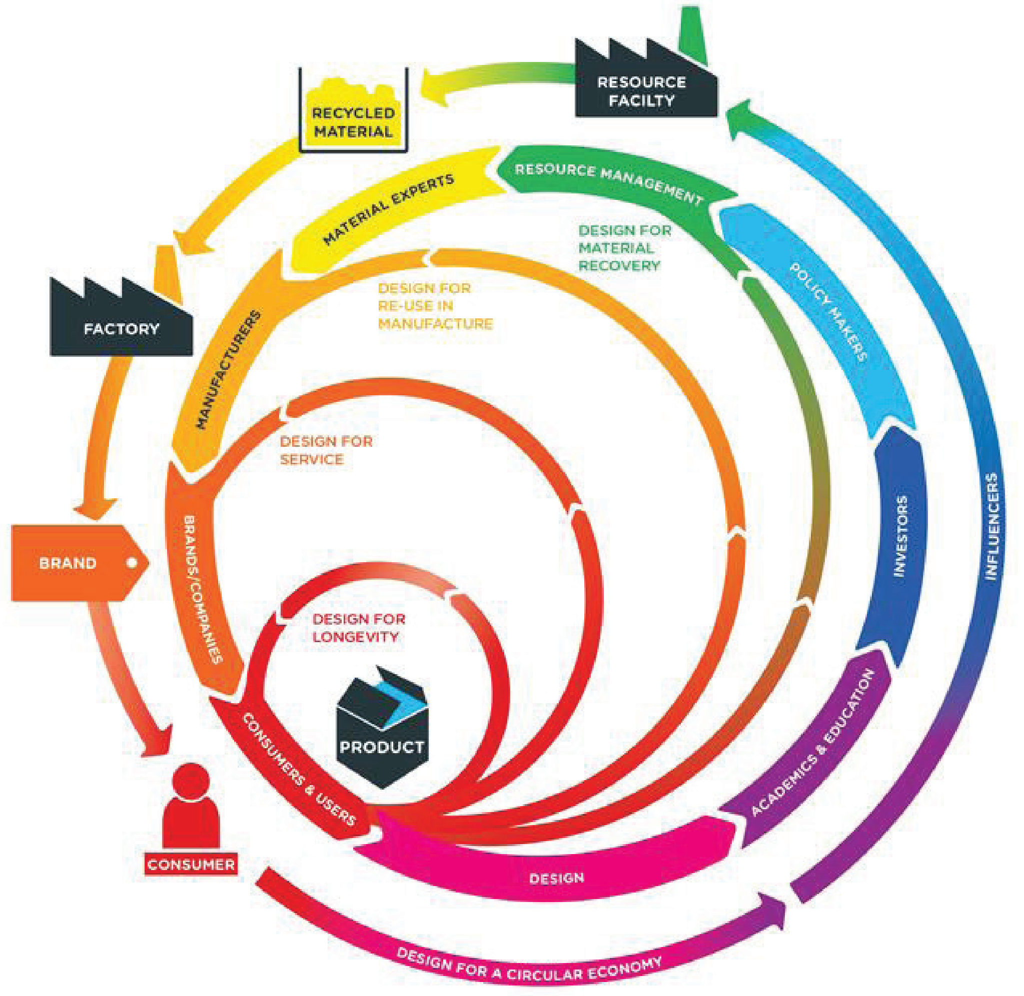


Image: The Ellen MacArthur Foundation

Smart City Systems Methodology

1. Define and map system

2. Vision and ambition

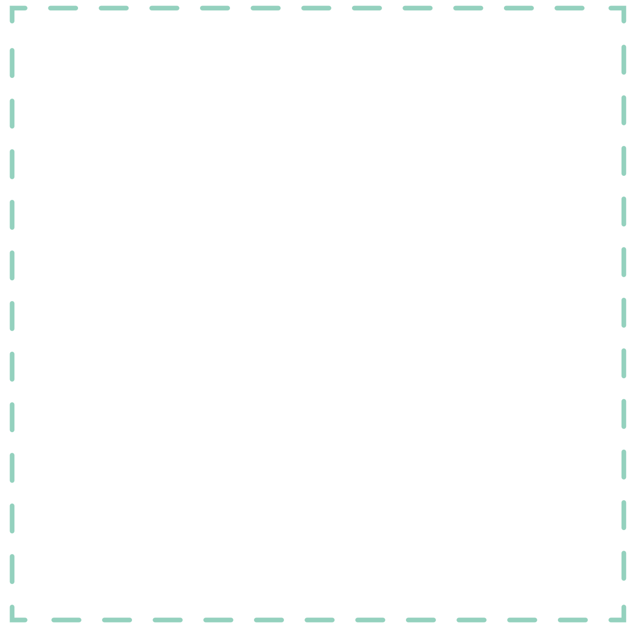
3. Urban input/output analysis

4. Action plan

Smart City Systems Methodology
1. Define and map system

A. Boundary

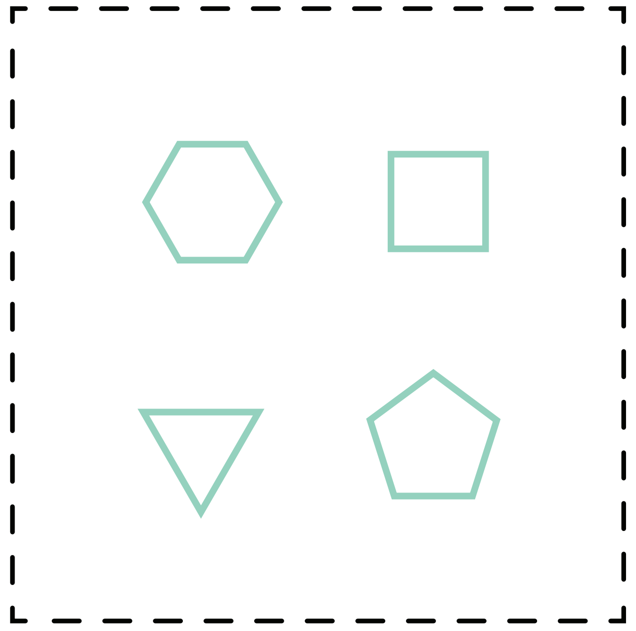
Delineate the system, such as the project area. Typical scales are building, neighborhood, and region, but the same analysis could be done for an engine or app. Include both the spatial and temporal boundaries.



System name, time period

B. Stakeholders and actors

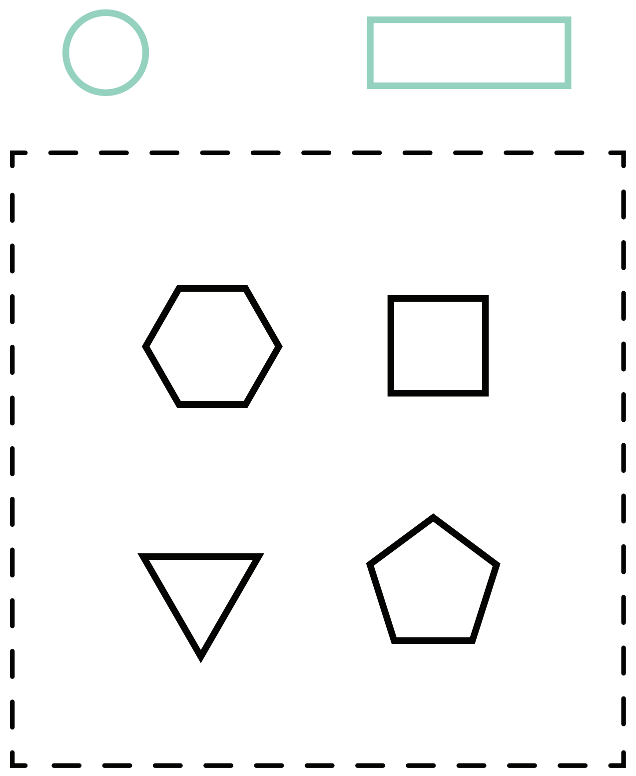
Map the actors within your system. An actor is anything that could change the vector of a flow, such as a building, a filter, an event, or a policy. The actors can be existing or planned.



System name, time period

C. Context

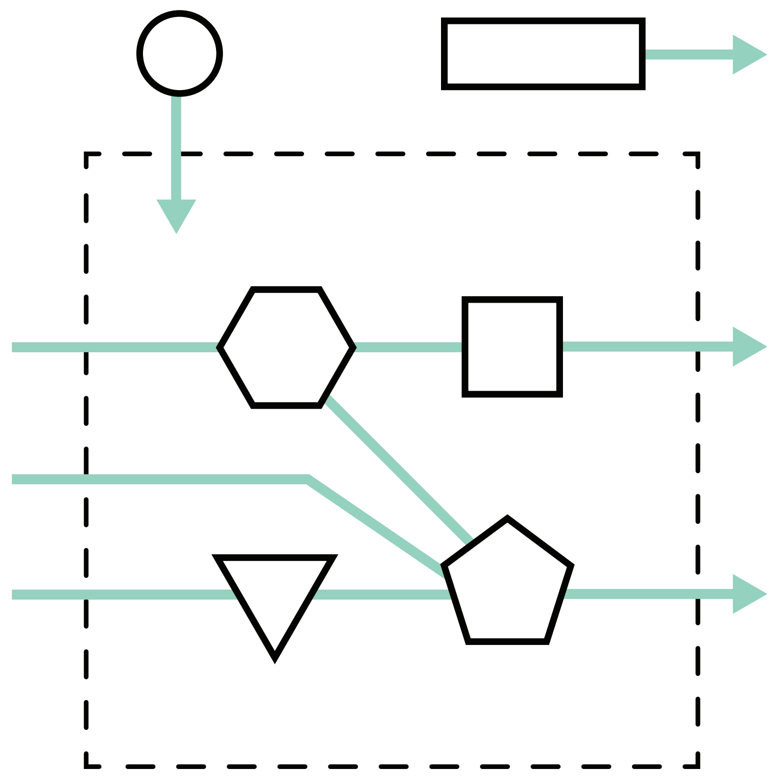
Map and analyze the environment around the system. Consider the natural flows, such as sun, wind and rain, as well as anthropogenic flows, such as power plants, waste heat, and traffic.



System name, time period

D. Flows

Quickly summarize and map all flows coming into and leaving from your system. Also, map all flows within your system between actors. Don't forget to also map flows from the environmental context, even though they might not enter your system currently.



System name, time period

Smart City Systems Methodology
2. Vision and ambition

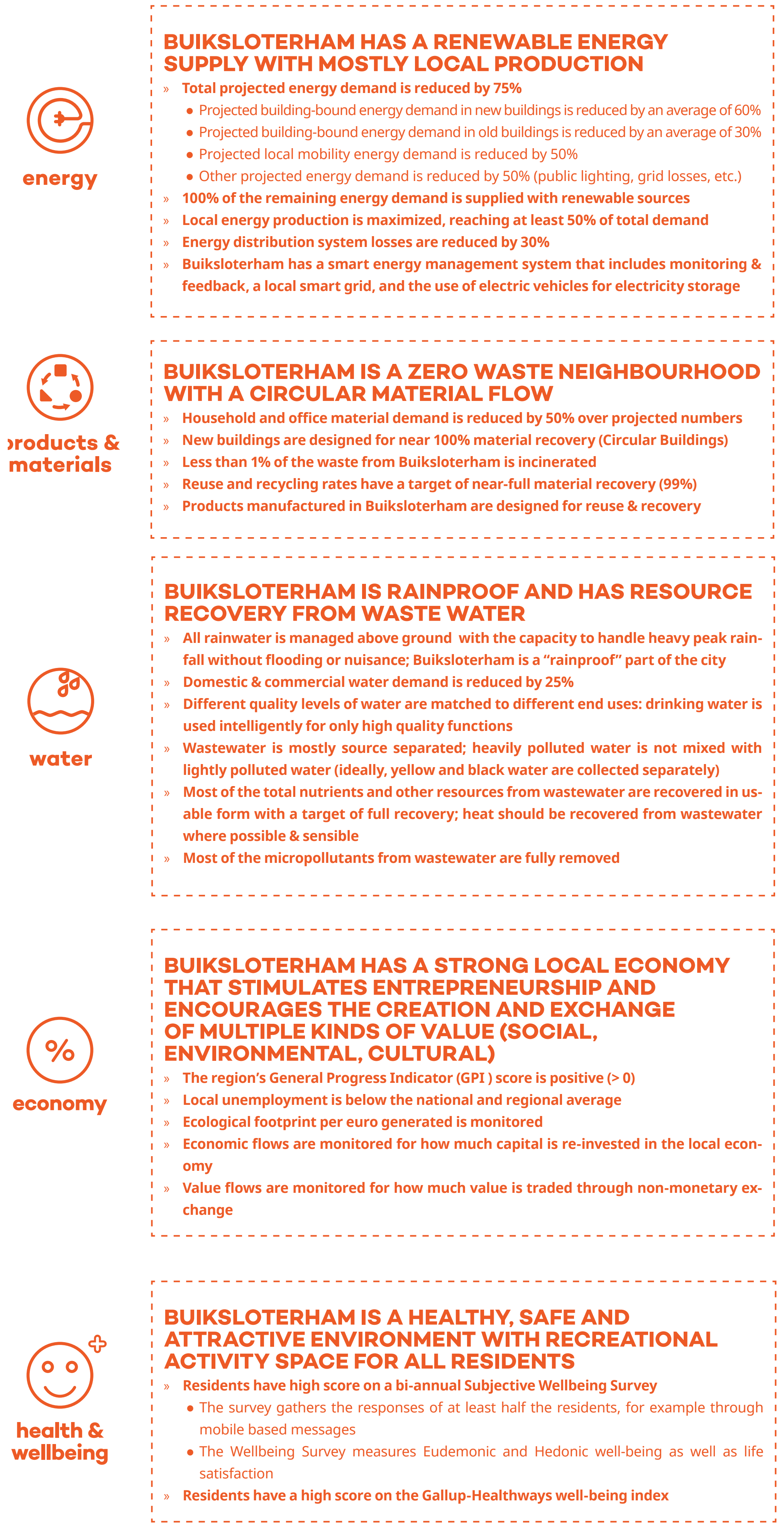
A. Establish performance targets

Establish targets for your system.

Some examples are:

- 100% renewable energy
- 100% circular material flow
- 100% resource recovery from wastewater
- Treatment of pollutants
- Zero emission mobility
- High quality, livable environment
- Local circulation of infrastructure capital

Additional examples are shown adjacent.



energy

BUIKSLOTERHAM HAS A RENEWABLE ENERGY SUPPLY WITH MOSTLY LOCAL PRODUCTION

» **Total projected energy demand is reduced by 75%**
- Projected building-bound energy demand in new buildings is reduced by an average of 60%
- Projected building-bound energy demand in old buildings is reduced by an average of 30%
- Projected local mobility energy demand is reduced by 50%
- Other projected energy demand is reduced by 50% (public lighting, grid losses, etc.)

» **100% of the remaining energy demand is supplied with renewable sources**

» **Local energy production is maximized, reaching at least 50% of total demand**

» **Energy distribution system losses are reduced by 30%**

» **Buiksloterham has a smart energy management system that includes monitoring & feedback, a local smart grid, and the use of electric vehicles for electricity storage**

products & materials

BUIKSLOTERHAM IS A ZERO WASTE NEIGHBOURHOOD WITH A CIRCULAR MATERIAL FLOW

» **Household and office material demand is reduced by 50% over projected numbers**

» **New buildings are designed for near 100% material recovery (Circular Buildings)**

» **Less than 1% of the waste from Buiksloterham is incinerated**

» **Reuse and recycling rates have a target of near-full material recovery (99%)**

» **Products manufactured in Buiksloterham are designed for reuse & recovery**

water

BUIKSLOTERHAM IS RAINPROOF AND HAS RESOURCE RECOVERY FROM WASTE WATER

» **All rainwater is managed above ground with the capacity to handle heavy peak rainfall without flooding or nuisance; Buiksloterham is a "rainproof" part of the city**

» **Domestic & commercial water demand is reduced by 25%**

» **Different quality levels of water are matched to different end uses: drinking water is used intelligently for only high quality functions**

» **Wastewater is mostly source separated; heavily polluted water is not mixed with lightly polluted water (ideally, yellow and black water are collected separately)**

» **Most of the total nutrients and other resources from wastewater are recovered in usable form with a target of full recovery; heat should be recovered from wastewater where possible & sensible**

» **Most of the micropollutants from wastewater are fully removed**

economy

BUIKSLOTERHAM HAS A STRONG LOCAL ECONOMY THAT STIMULATES ENTREPRENEURSHIP AND ENCOURAGES THE CREATION AND EXCHANGE OF MULTIPLE KINDS OF VALUE (SOCIAL, ENVIRONMENTAL, CULTURAL)

» **The region's General Progress Indicator (GPI) score is positive (> 0)**

» **Local unemployment is below the national and regional average**

» **Ecological footprint per euro generated is monitored**

» **Economic flows are monitored for how much capital is re-invested in the local economy**

» **Value flows are monitored for how much value is traded through non-monetary exchange**

health & wellbeing

BUIKSLOTERHAM IS A HEALTHY, SAFE AND ATTRACTIVE ENVIRONMENT WITH RECREATIONAL ACTIVITY SPACE FOR ALL RESIDENTS

» **Residents have high score on a bi-annual Subjective Wellbeing Survey**
- The survey gathers the responses of at least half the residents, for example through mobile based messages
- The Wellbeing Survey measures Eudemonic and Hedonic well-being as well as life satisfaction

» **Residents have a high score on the Gallup-Healthways well-being index**

Transitioning Amsterdam to a Circular City, 2015

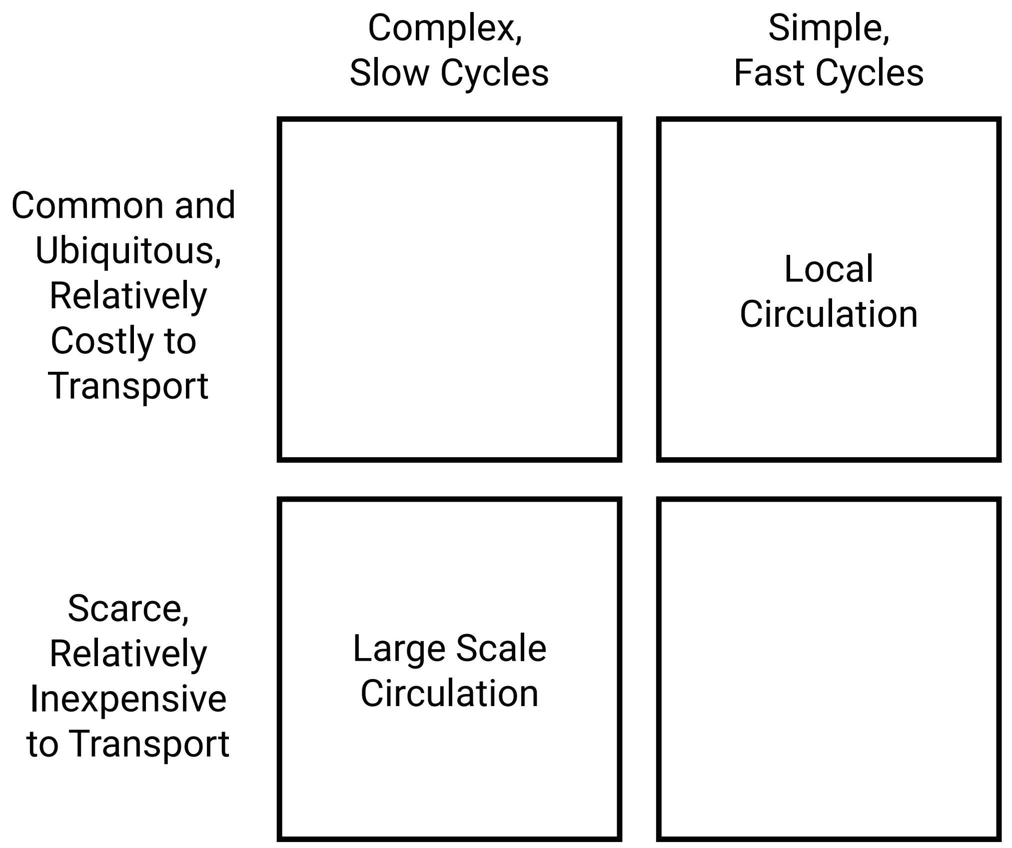
B. Identify target cycles

Within the large set of flows within the system and the performance targets, cycles are targeted for deeper analysis, and actions.

In prioritizing flows or cycles for improvement, decisions can be based on the scale at which the flows should be closed. The scale of a cycle can be determined by density of resource demand versus density of availability. For that reason, energy and water are often two top priorities for local flow closure or supply.

Fast cycling and high volume material streams like food waste and other local organic wastes from which nutrients can be recovered are also likely targets. The more complex or scarce a material, the less of a priority there is on closing that material cycle locally.

The more costly it is to transport (by pipe, cable, or road) a flow, and the more spatially ubiquitous that flow is (for example, energy and water in the form of sunlight and rain), the higher the priority for closing that flow locally.



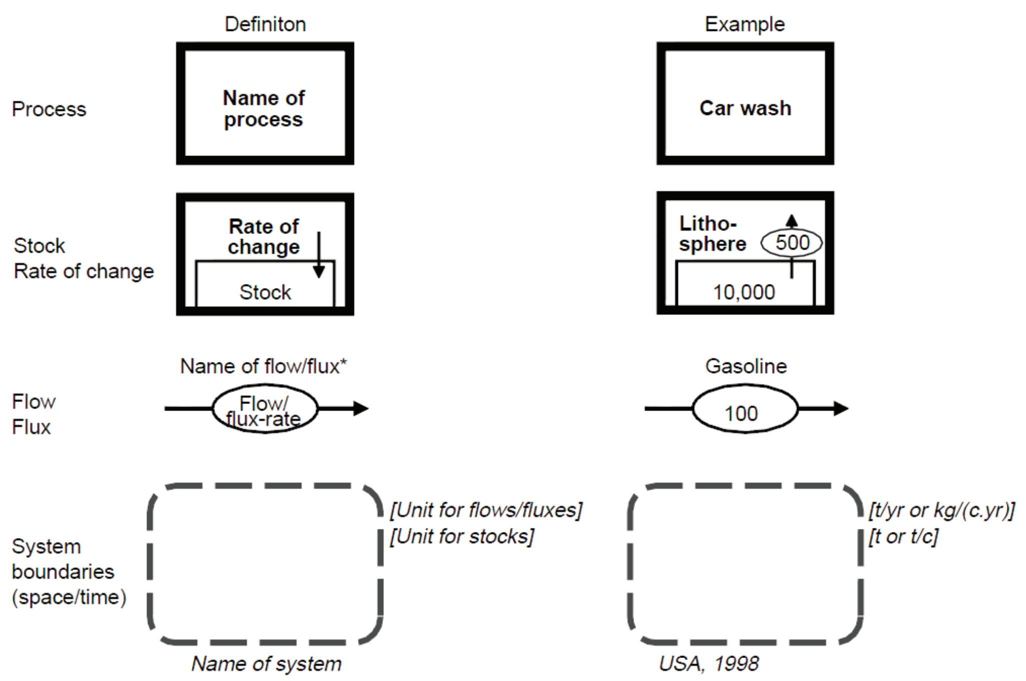
Smart City Systems Methodology
3. Urban input/output analysis

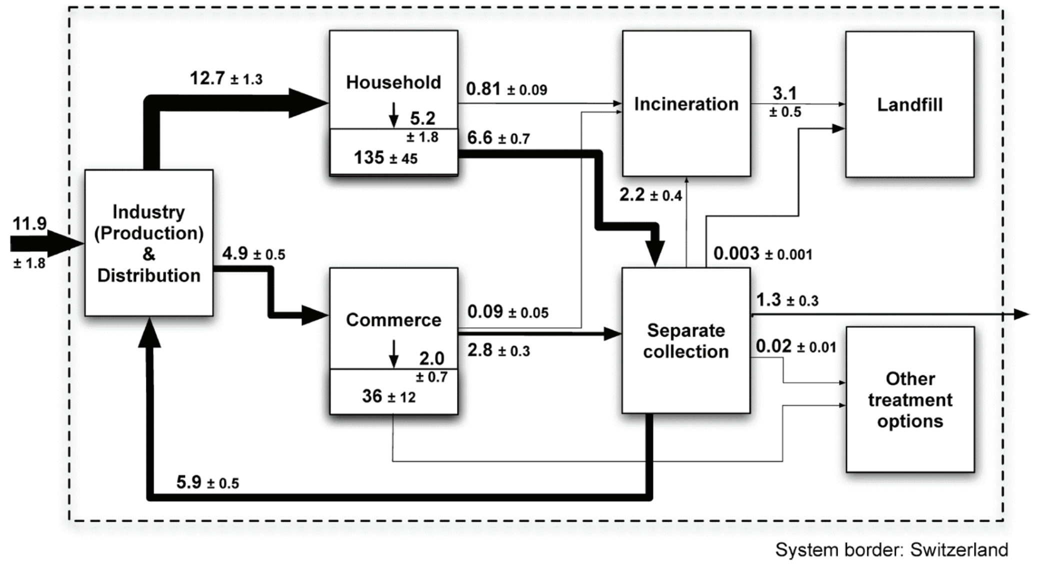
A. Material and energy flow accounting of target cycle flows

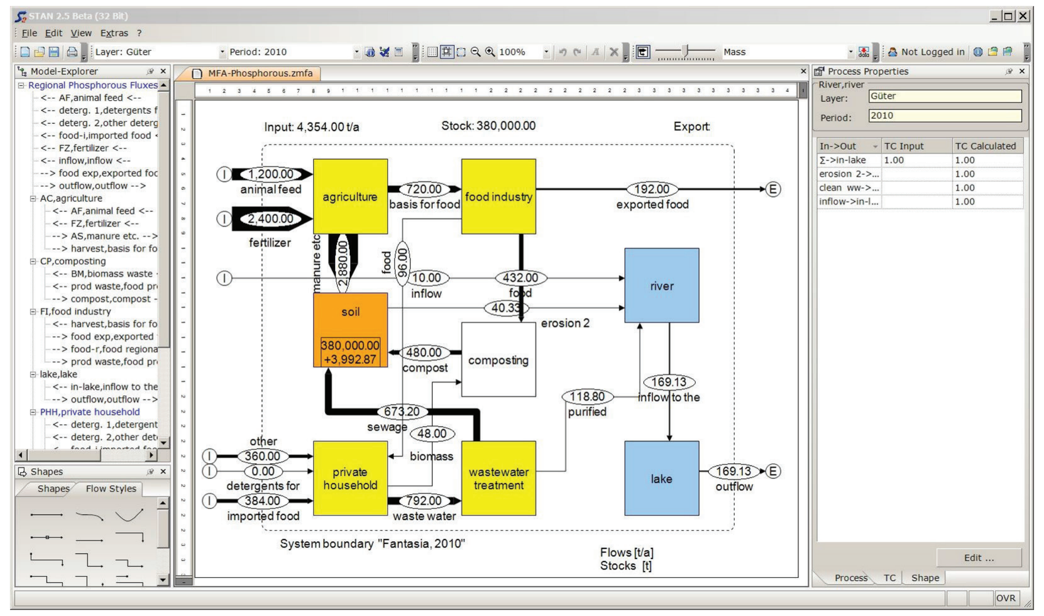
With the delineated system, analyze material flows and stocks in well-defined, uniform terms. By assessing the relevant flows and stocks in quantitative terms, mass and energy balance principles will reveal and help solve sensitivities and uncertainties.

Flow accounting will reduce the complexity of the system and providing a basis for sound decision making. The results are reproducible, understandable, and transparent.

An open source software, STAN, has been developed for flow accounting.



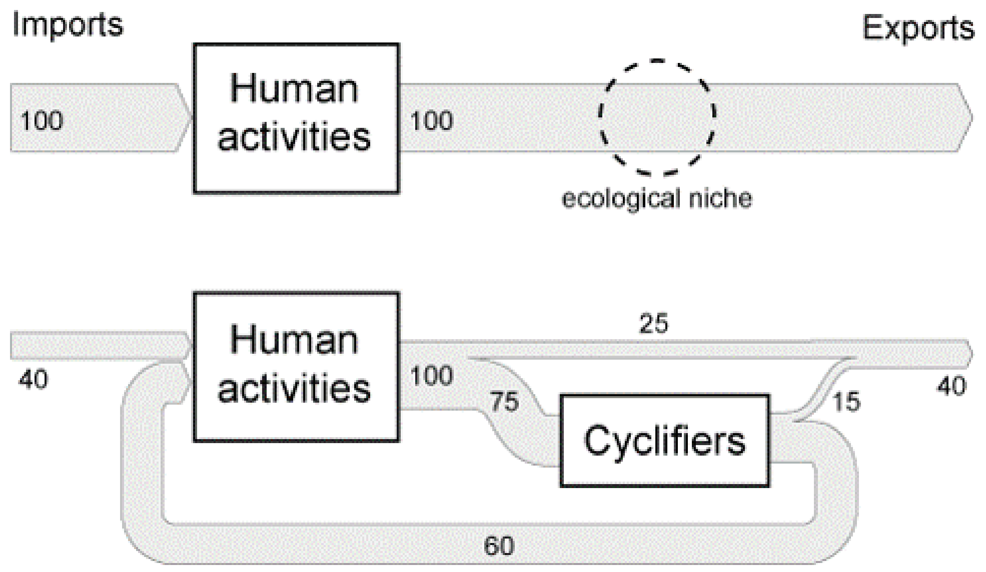




Top images: Paul H. Brunner and Helmut Rechberger, 2004. *Practical Handbook of Material Flow Analysis*
Bottom image: STAN2.0 screenshot

B. Identify opportunities

Within the results of the flow analysis, locate work value that can be valorized by connecting actors within the system or by introducing novel program into the system to create productive use of the ecological niche. The opportunities identified are leverage points for social, economic, technological, environmental efficiency improvements within the system that symbiotically connect actors.



Smart City Systems Methodology
4. Action plan

A. Systemic actions

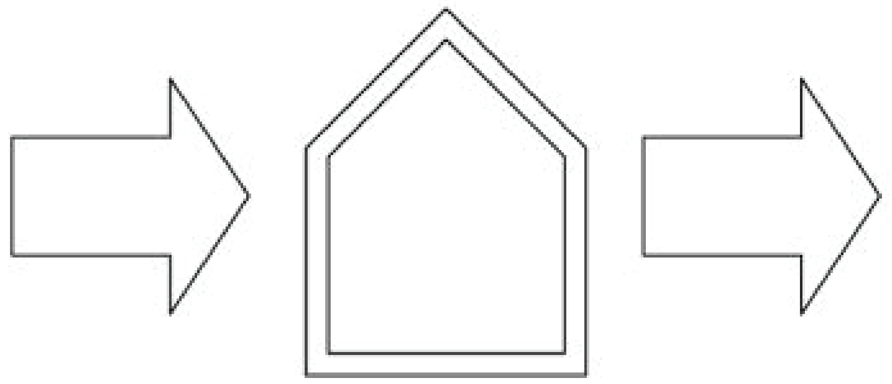
Create plans and policies that influence the future development of the system, such as remote sensing, data reporting, and enforcement of key performance indicators.

B. Technical interventions

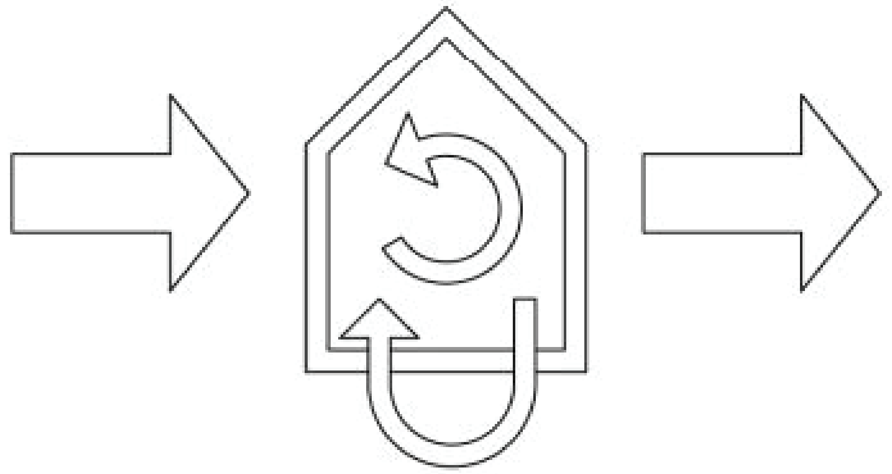
Plan for methods of altering the flows between actors such that there is an overall increase in system efficiency.

Additional priorities for targeting cycles:

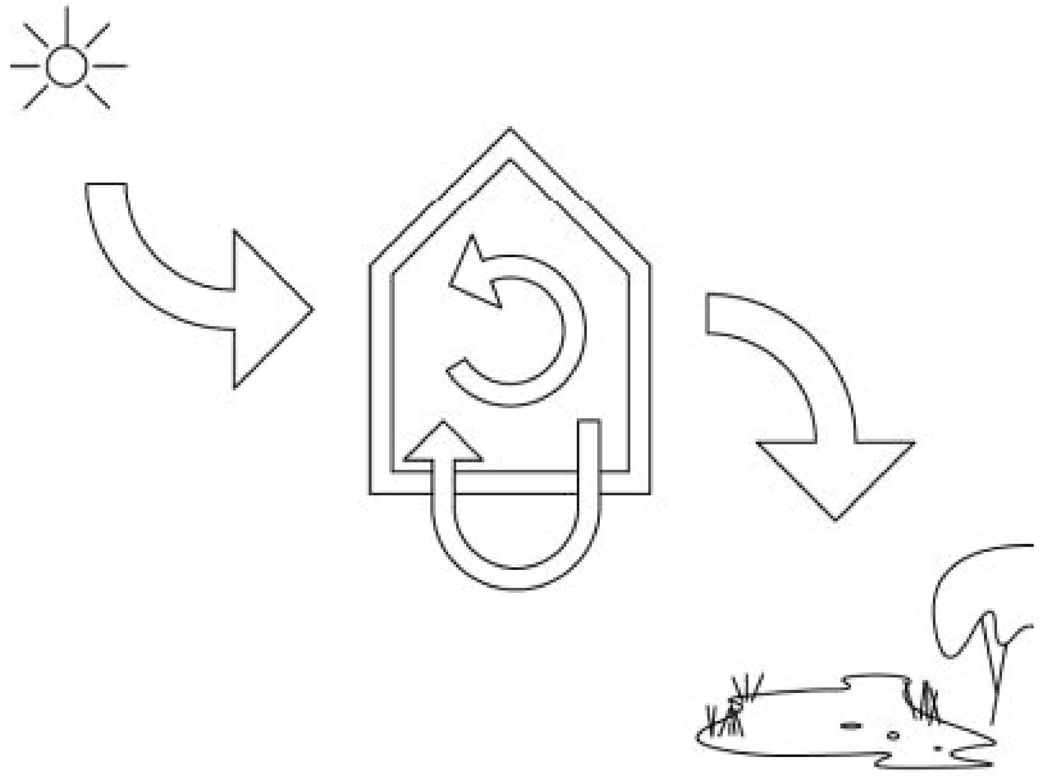
1. Reduce volume of local flows (demand-side management)



2. Find local supply synergies (heat cascades, material cascades, novel program)



3. Supply local flows in a renewable fashion

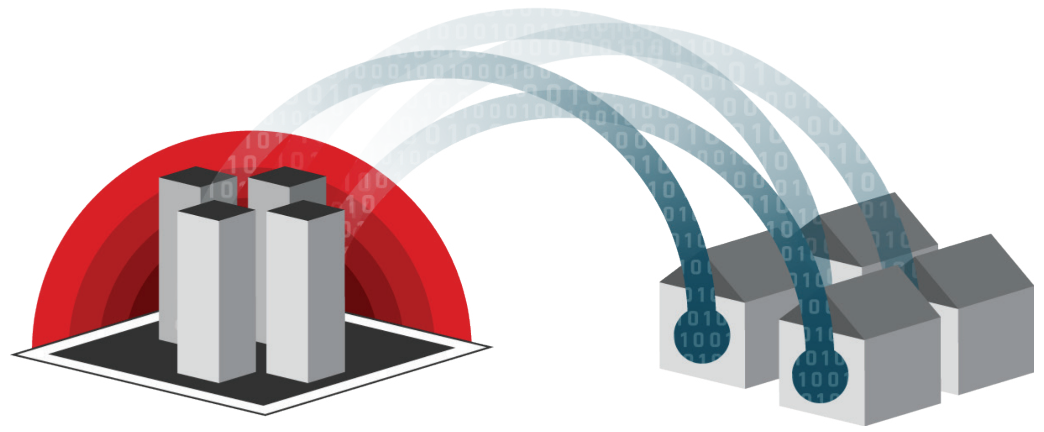


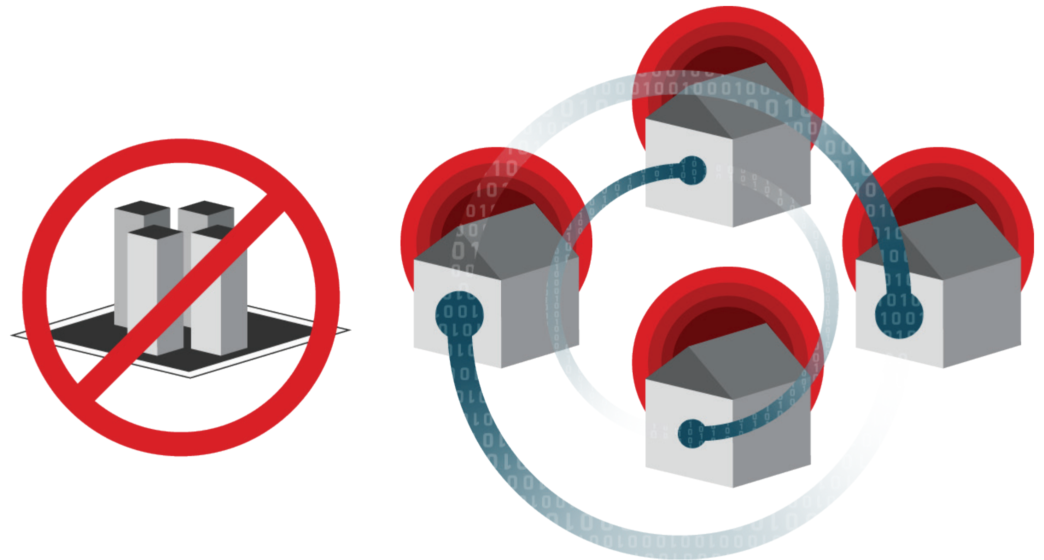
Images: Rotterdam Energy Approach

Clever examples of Smart City Systems

Appliance: Project Exergy

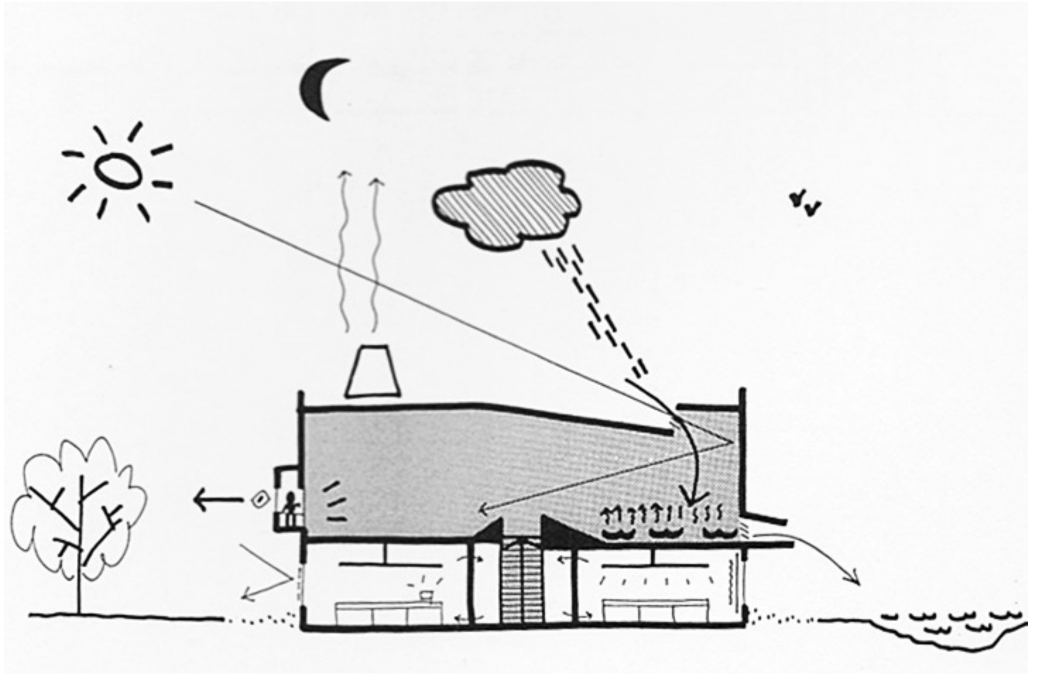
Using cloud computing to heat homes

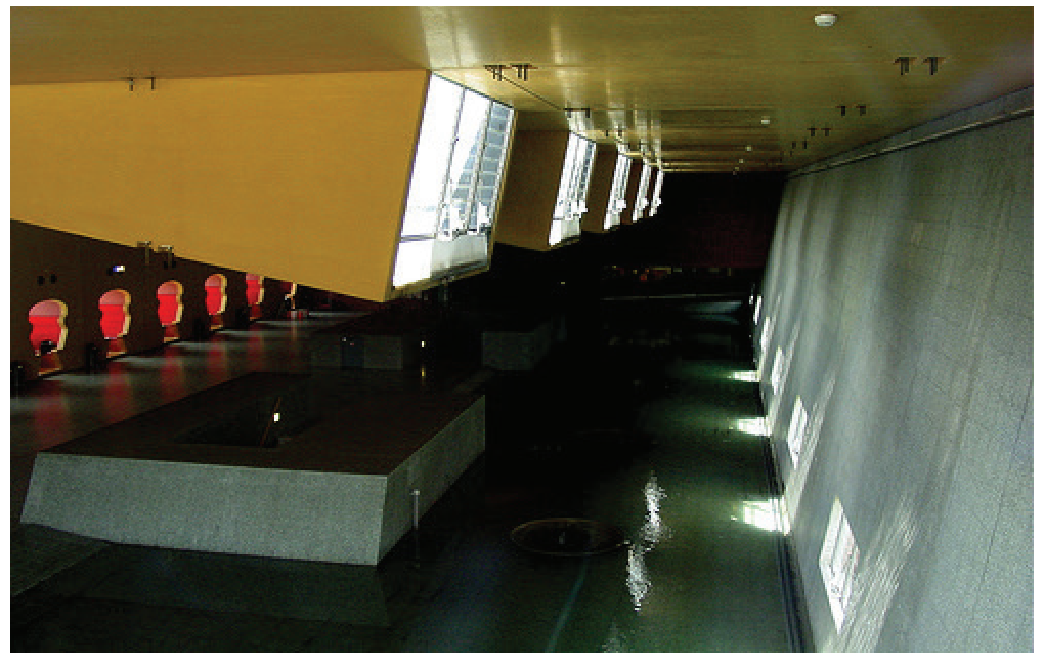




Building: Minnaert

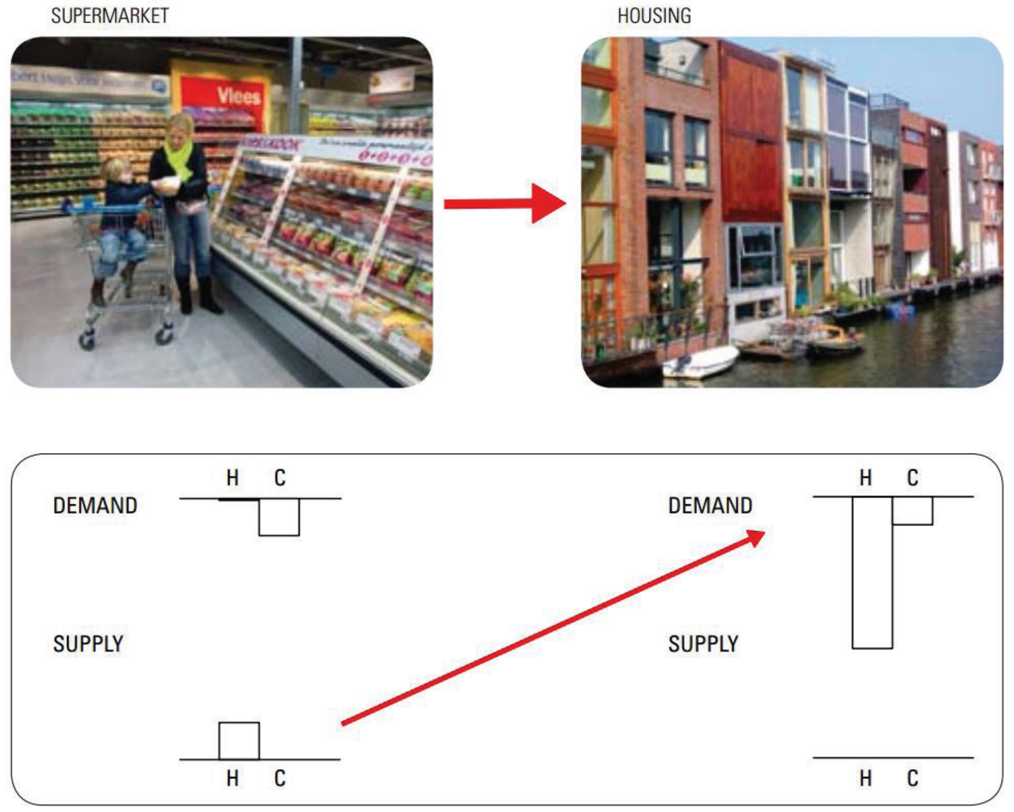
Rainwater is used for cooling an office building

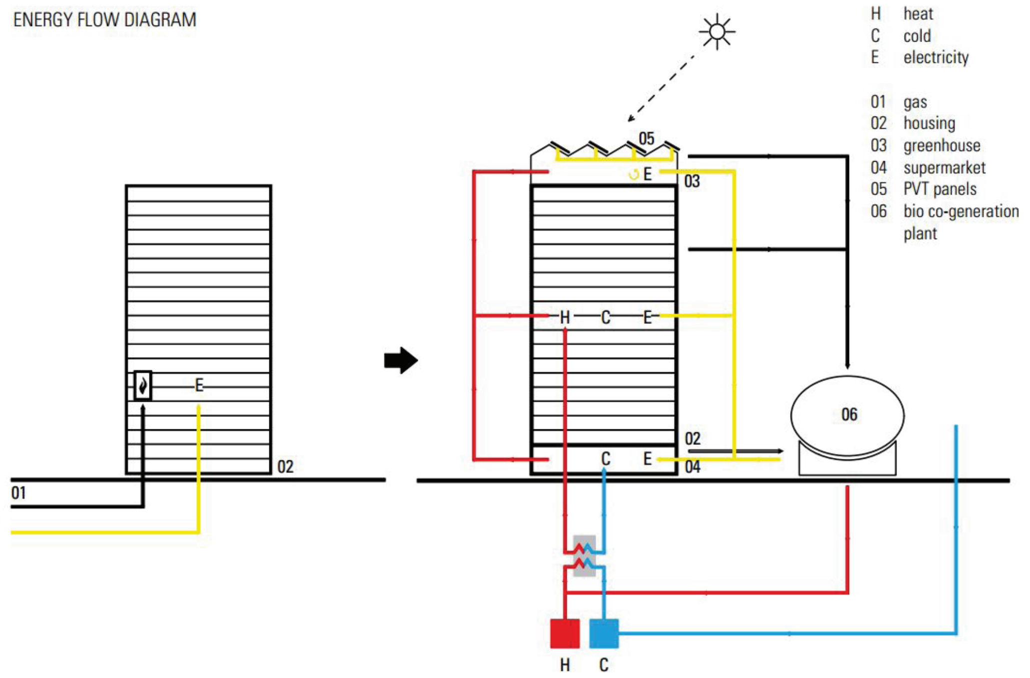




Block: Supermarket Heating

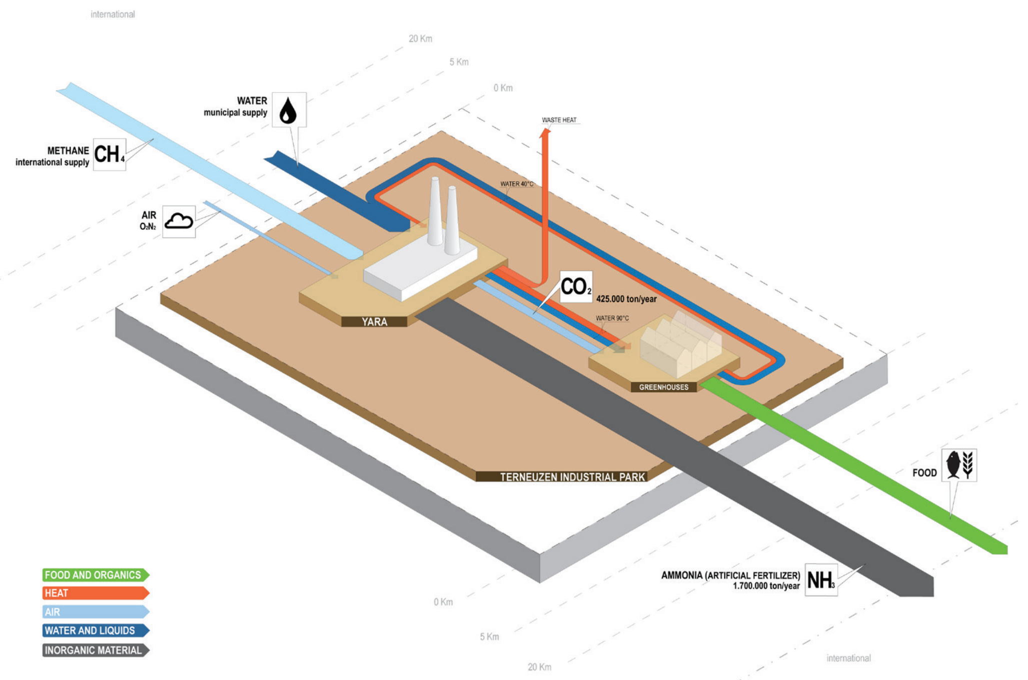
Waste heat from supermarket used in homes





Infrastructure: WarmCO_2

Heat and CO_2 from fertilizer production used in greenhouses



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