Relevant energy saving technologies for urban and rural areas in Vietnam

TECHNISCHE UNIVERSITÄT DARMSTADT

Presentation at German Vietnamese Science Day, April 26th 2023

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IWAR

VGU Vietnamese-German University

University of Civil Engineering Hanoi

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General Overview Water Cycle Energy Consumption

Energy consumption in the water cycle

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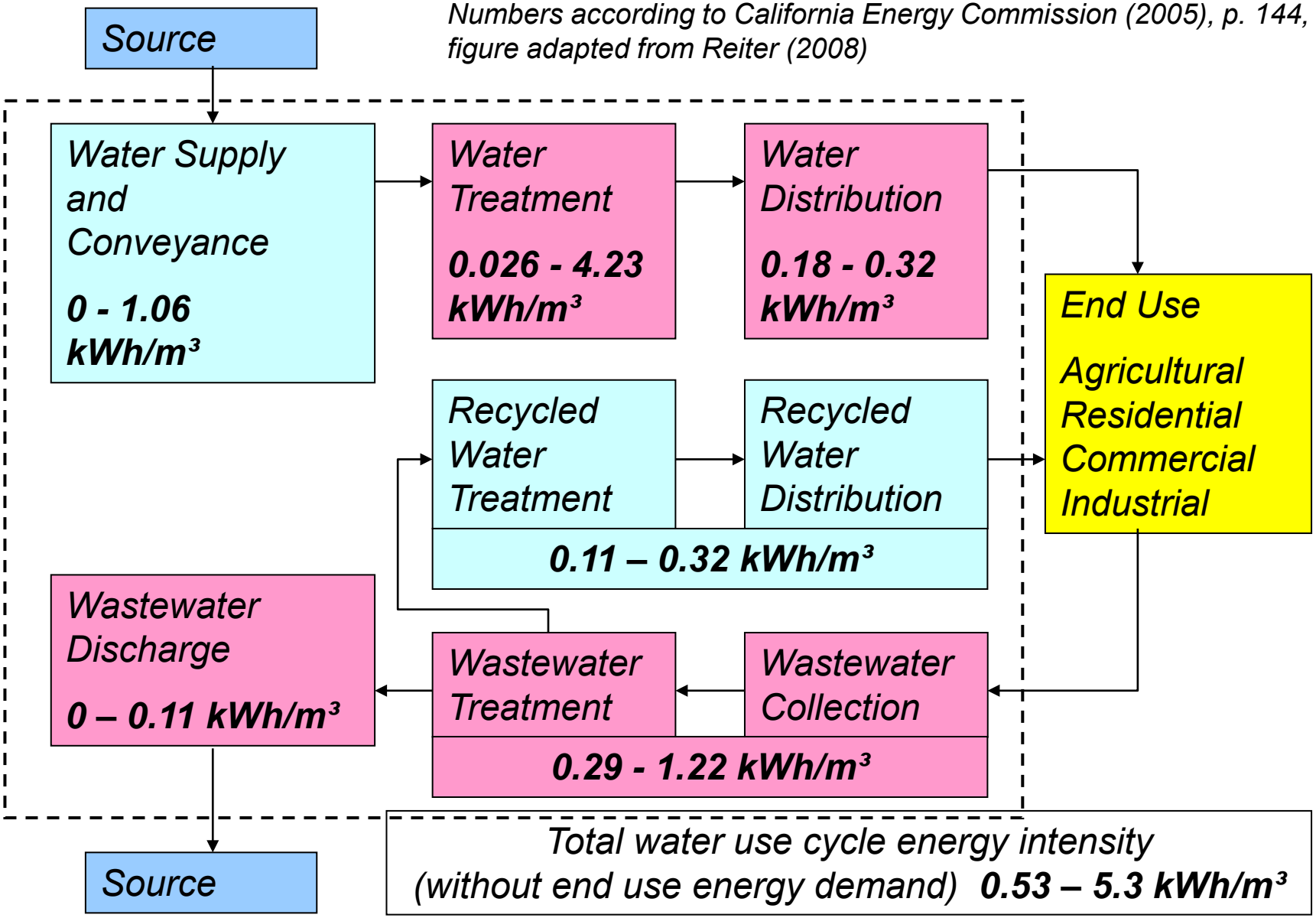
- **Supply, distribution (energy for pumping)**
  - Depending on **geographical situation** [CEC, 2005] (depth of the groundwater, length of pressure pipes, etc.) — 0.03 - 2.6 kWh/m³
- **Water treatment (water influent quality)**
  - **Treatment for groundwater/surface water** [Olsson, 2012] — 0.01 - 0.7 kWh/m³
  - Surface water/**salt water**, treatment by desalination [Olsson, 2012] — 3 - 5 kWh/m³
- **Wastewater collection and treatment (water effluent quality)**
  - Activated sludge process [MUNLV, 1998; ICF, 2008] — 0.2 - 1.2 kWh/m³
  - Non-aerated facultative lagoon [ICF, 2008] — 0.08 - 0.4 kWh/m³
- **To consider: Local conditions, plant size, age of the equipment, …**

Water Use Cycle and energy intensities for California.
Numbers according to California Energy Commission (2005), p. 144, figure adapted from Reiter (2008)



Wastewater Systems in Urban Areas

Examples for wastewater treatment systems: Activated Sludge Process

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- WWTP Schwerte (Germany, Ruhrverband)

Ruhrverband

Trickling filter

Examples for wastewater treatment systems: Membrane Bio-Reactors

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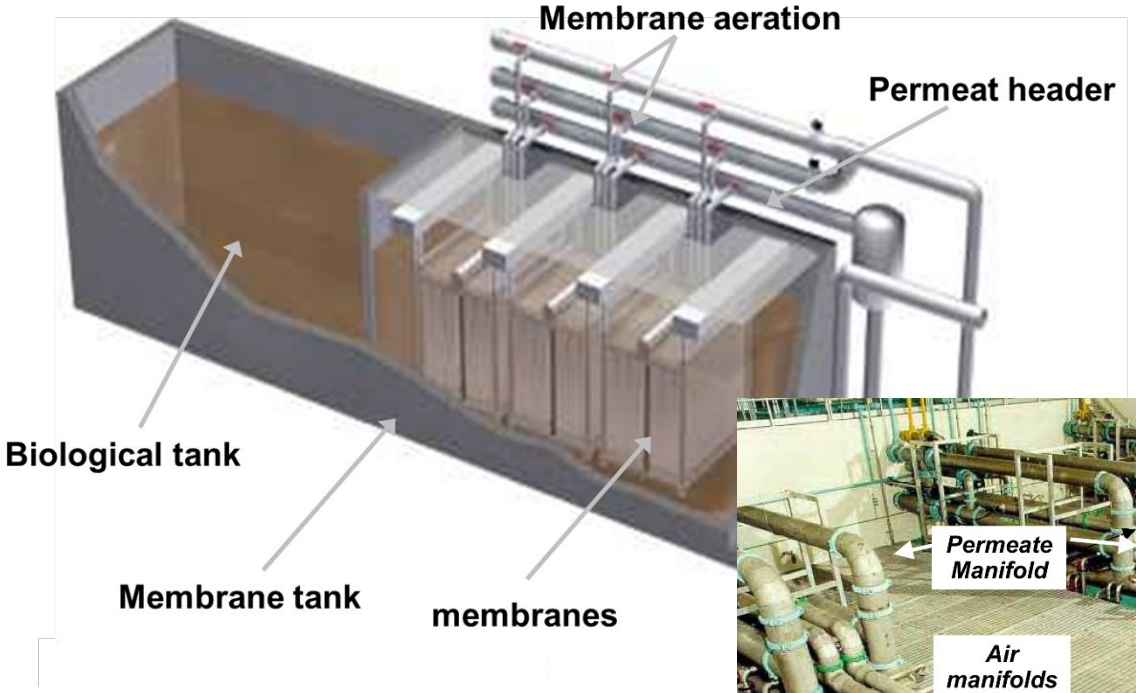

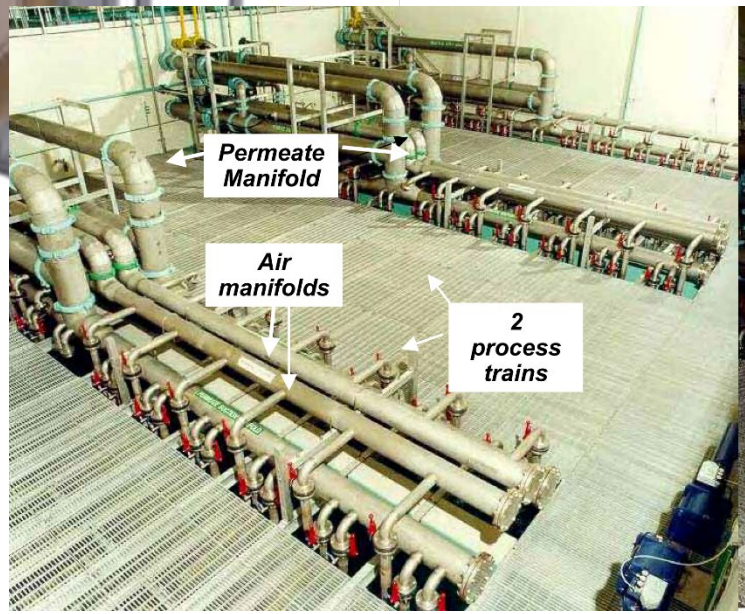

Veolia Water Technologies

Wastewater Systems in Rural Areas

Examples for wastewater treatment systems: Sewage ponds

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- Less technical solution for wastewater treatment

ISMA, 2019

Sewage ponds

Image source

Image source

Examples for wastewater treatment systems: Sewage ponds

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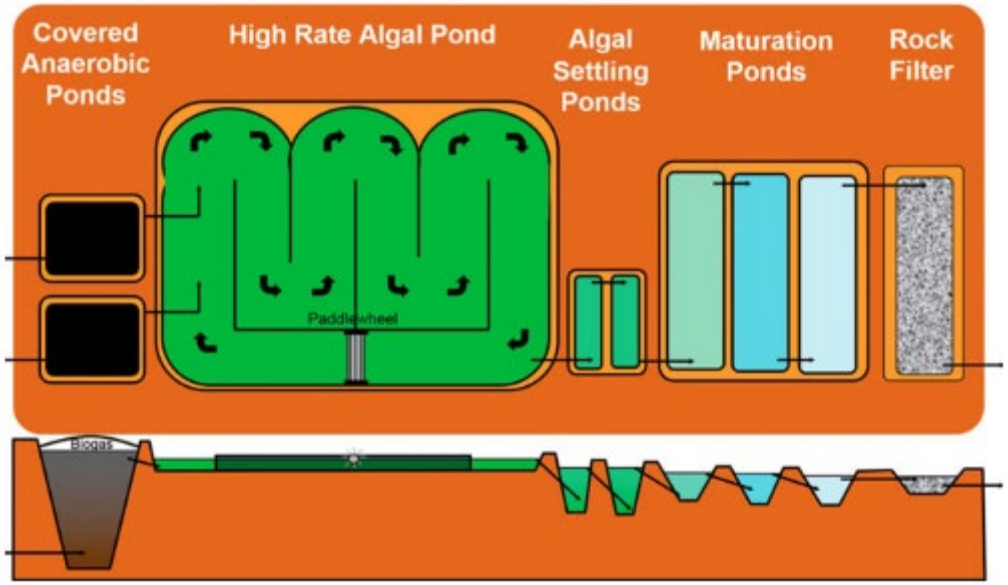

- Combination of different ponds and post-treatment
- Operation of sewage ponds heavily depends on the climate

Fotos by: R Craggs, J Park, S Heubeck & D Sutherland (2014) High rate algal pondsystems for low-energy wastewater treatment, nutrient recovery and energy production, NewZealand Journal of Botany, 52:1, 60-73, DOI: 10.1080/0028825X.2013.861855

Specific energy demand: different treatment technologies

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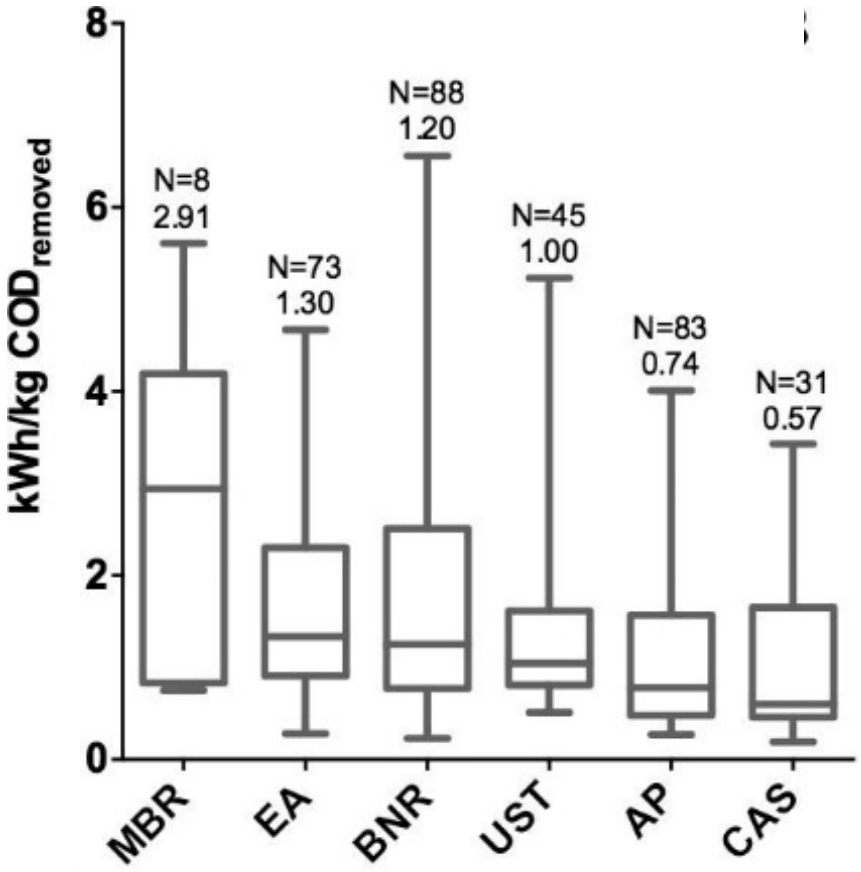
- Highest specific energy demand for MBR due to cross-flow and backflush of membranes
- Advantage of MBRs: filtrated effluent



MBR: Membrane bioreactor
EA: Extended aeration
BNR: Biological nutrient removal
UST: Unspecified secondary treatment
AP: Aerated ponds
CAS: Conventional activated sludge

Longo et al., 2016

Energy Production in sewers and WWTPs

Energy content and utilization

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Potential energy

Cornelsen, 2004

Due to height differences (e.g. topography)

1.2 kWh/(C·a)

Water wheel, turbine

Thermal energy

www.ipp.mpg.de

Results mainly from hot water generation

750 kWh/(C·a)

Heat exchanger

Chemically bound energy

Schaum, 2010

From the carbon content, estimated by COD

150 kWh/(C·a)

Digester gas/CHP
Incineration/turbine

Chemically bound energy
- simplified COD balance of a WWTP

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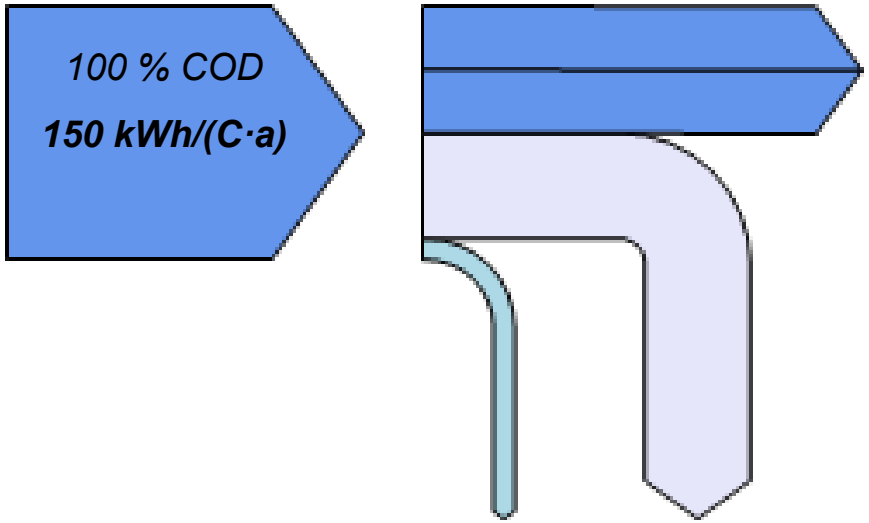
- **Municipal WWTP** (preliminary sedimentation, nitrification/ denitrification)

influent ***wastewater treatment***



sewage sludge
54 % COD
81 kWh/(C·a)

Effluent
8 % COD
12 kWh/(C·a)

Respired
38 % COD
57 kWh/(C·a)

Chemically bound energy
- simplified COD balance of a WWTP

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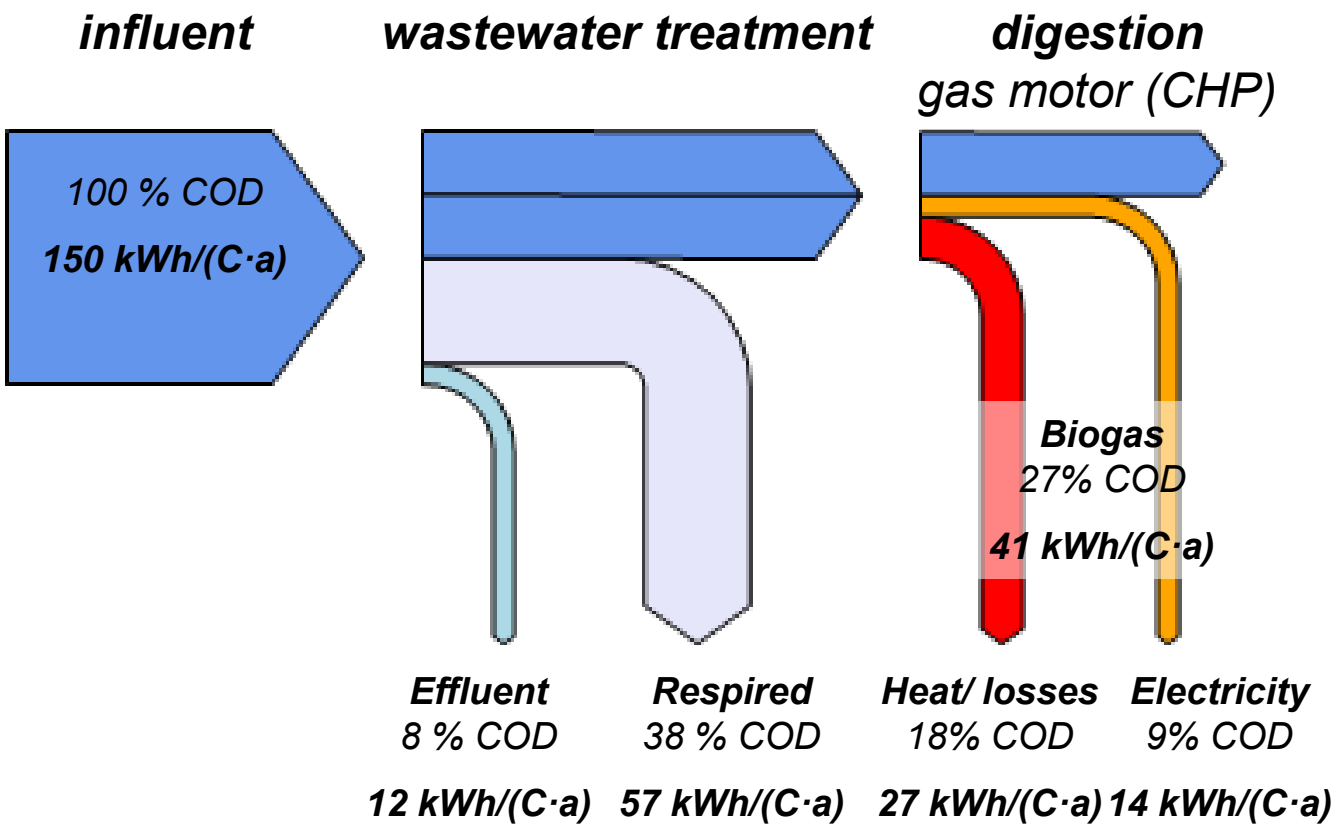
- … and anaerobic digestion



Chemically bound energy - simplified COD balance of a WWTP

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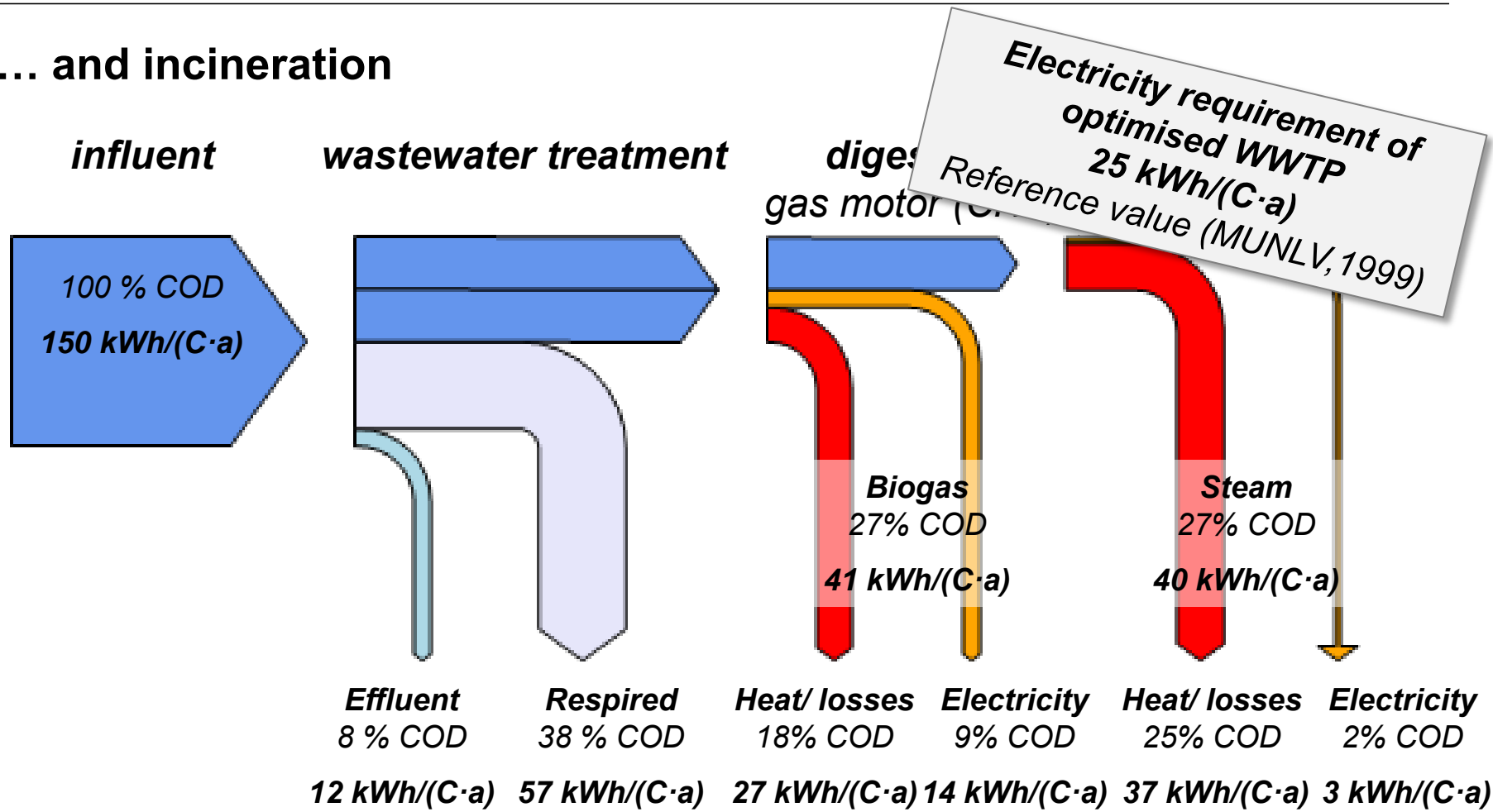
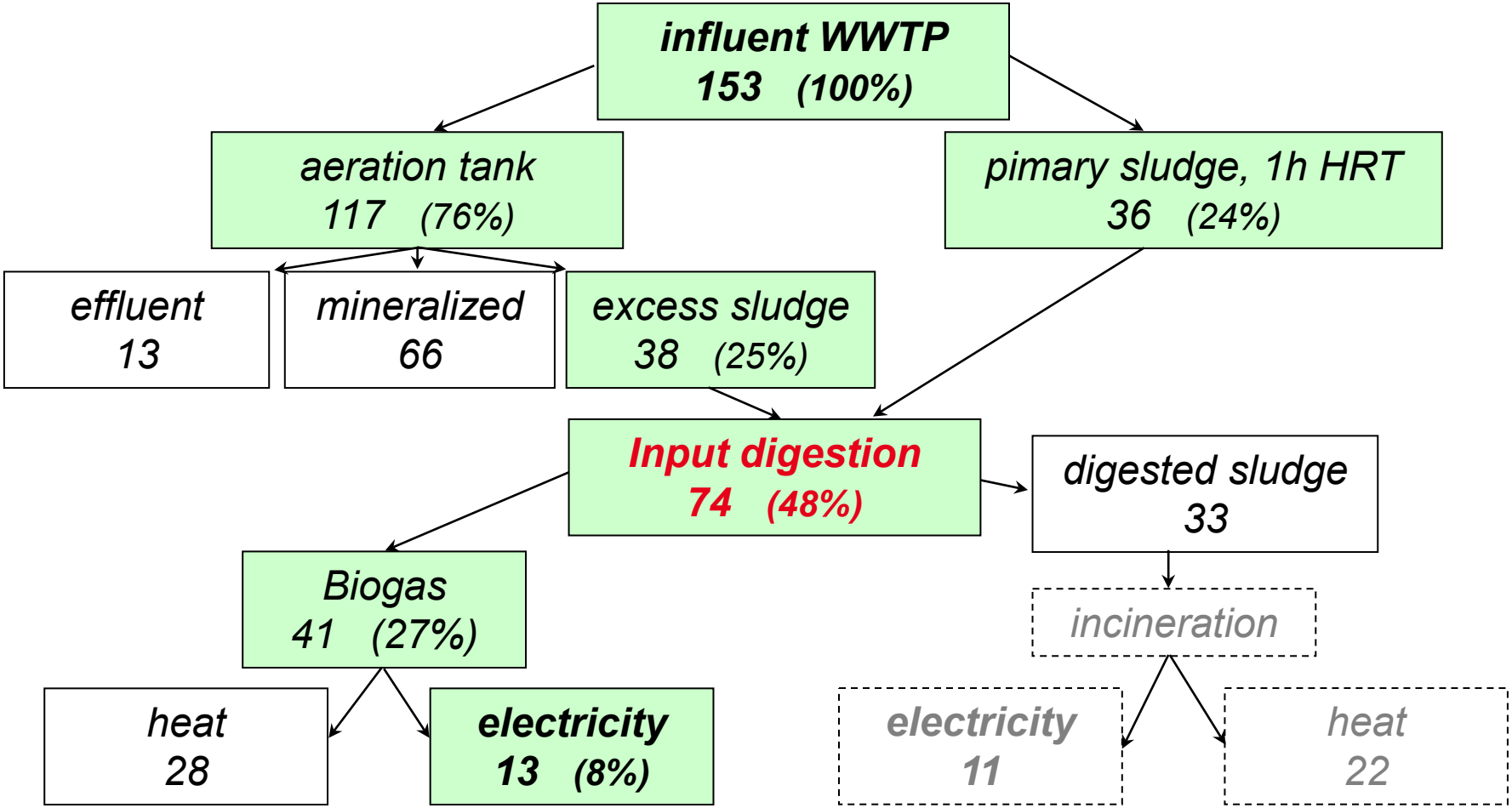
- … and incineration



Energy flows in a typical large scale aerobic WWTP (ASP), values in kWh/(C·a)



Energy flows in a typical large scale aerobic WWTP (ASP), values in kWh/(C·a)

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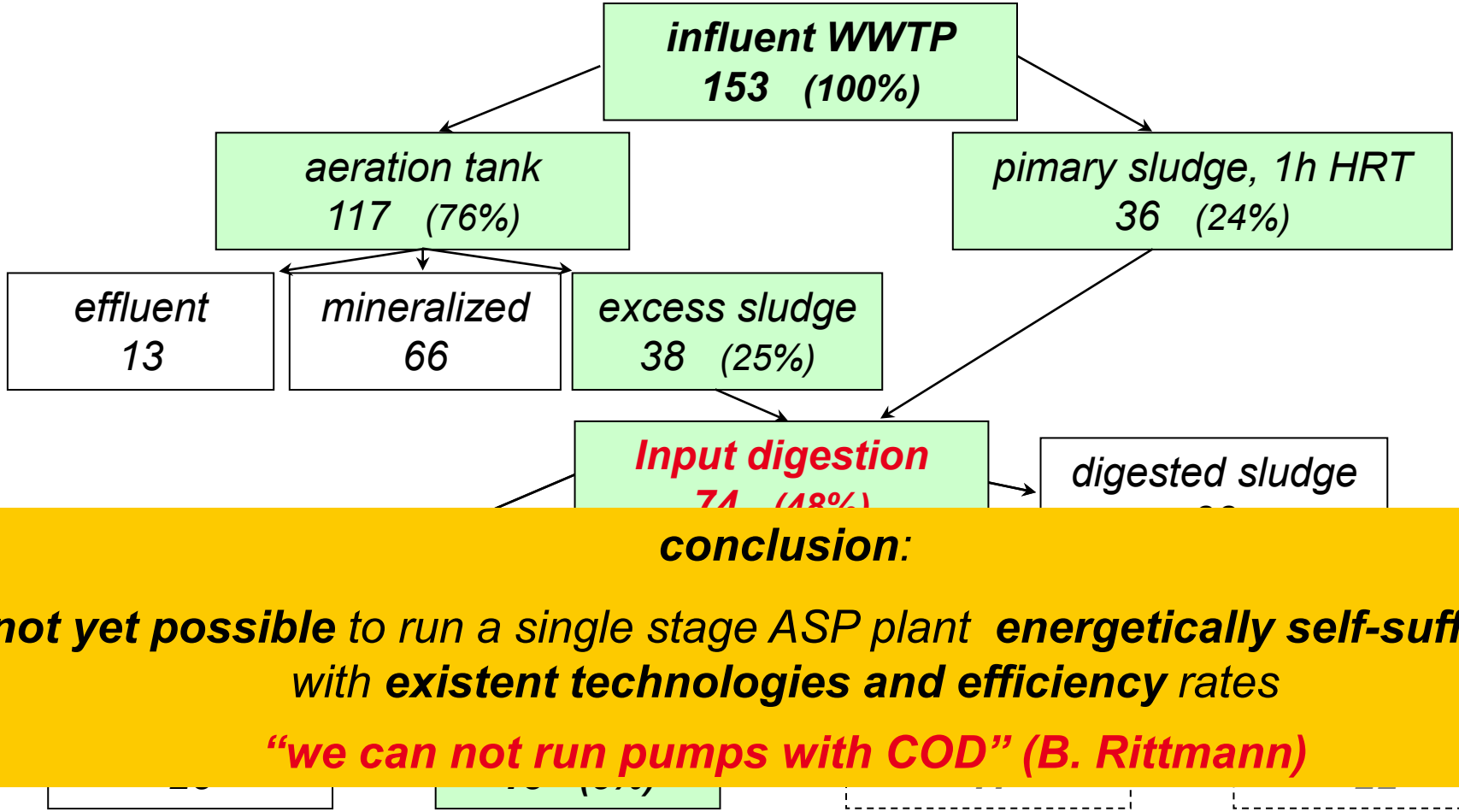


conclusion:

not yet possible *to run a single stage ASP plant* ***energetically self-sufficient*** *with* ***existent technologies and efficiency*** *rates*

"we can not run pumps with COD" (B. Rittmann)

Digester

Image source

Digester

Digester as design element at WWTP Bottrop, Germany

Image source

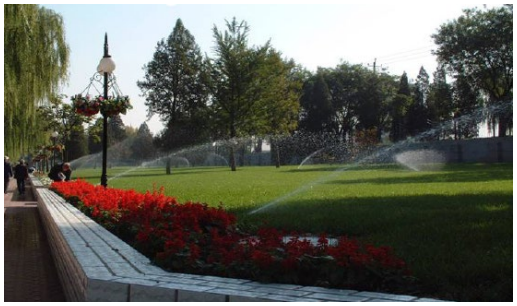
Water reuse save energy

Wastewater treatment for reuse purposes: Reuse applications

Agricultural irrigation

Cooling water

Toilet flushing



Park irrigation

Firefighting

Street cleaning

Wastewater treatment for reuse purposes: Energy demand

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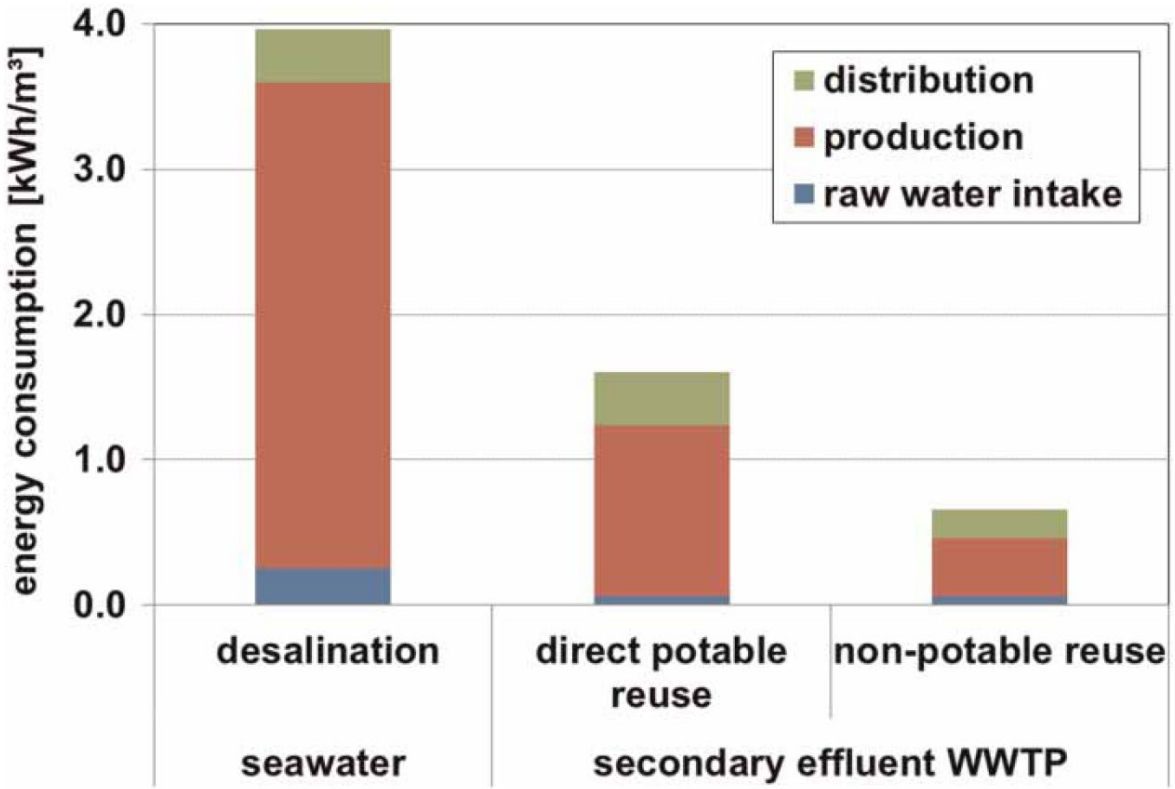
- Lower energy demand of WWTP effluent compared to seawater desalination



Data: ATSE, 2013

New requirements for WWTP effluents

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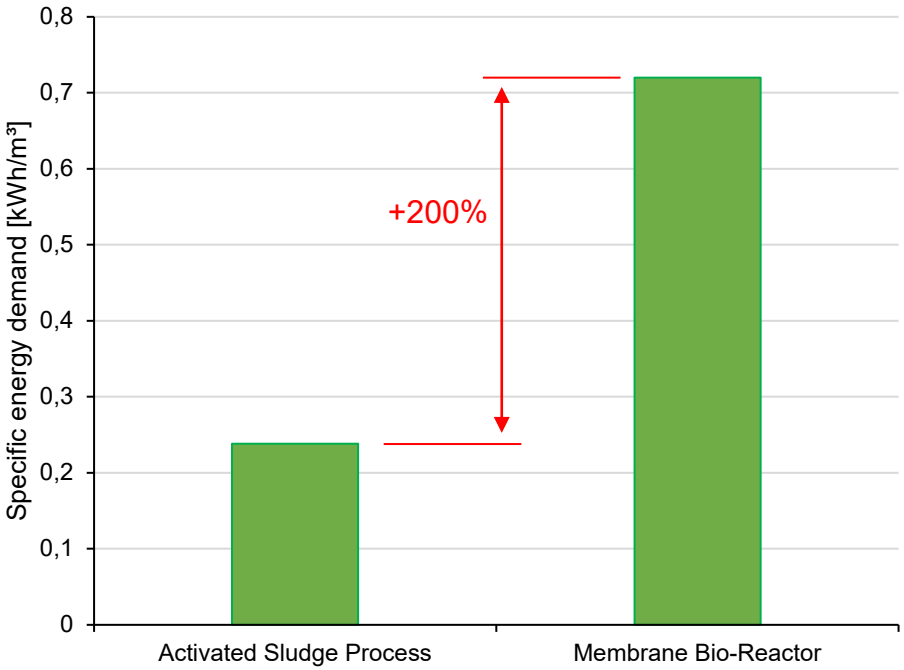
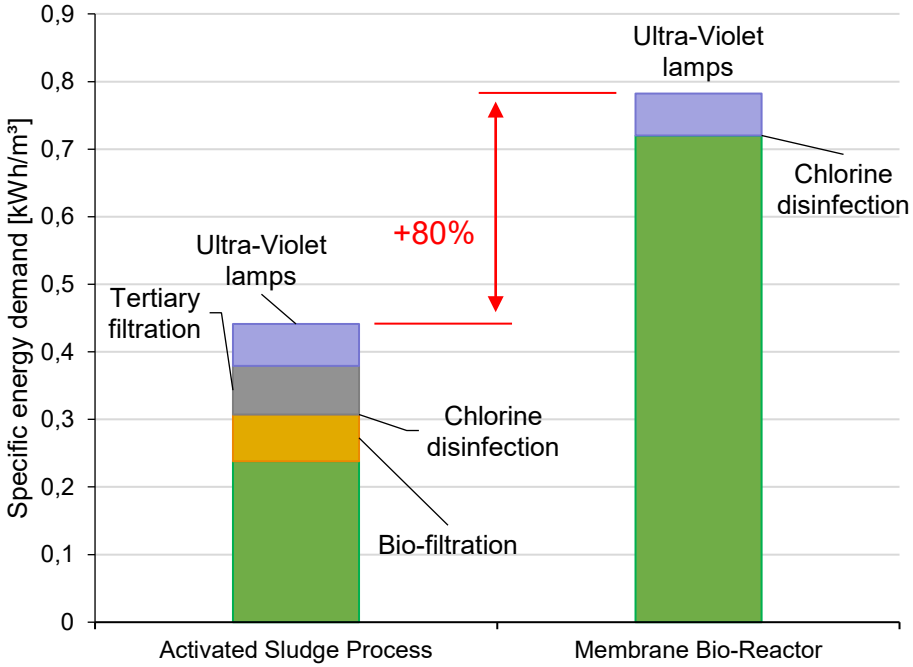
- To fulfill new requirements, additional process engineering is necessary
- Comparison of Activated Sludge Process and Membrane Bio-Reactor:





- MBR-Systems become more interesing for wastewater treatment!

Data: Longo et al., 2016

Semizentral – A new infrastructure concept with water reuse

Projects in Hanoi and Qingdao

SEMIZENTRAL: Integrated treatment on district level

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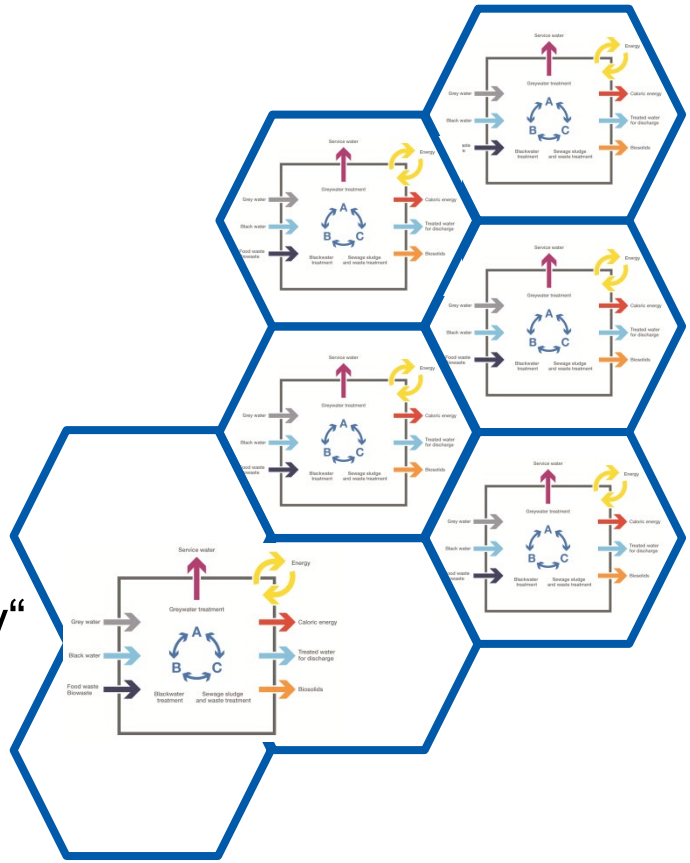
- Adaptable to growth rate
- Flexible
- Adjusted
- Integrated
  (wastewater, waste, water, energy)

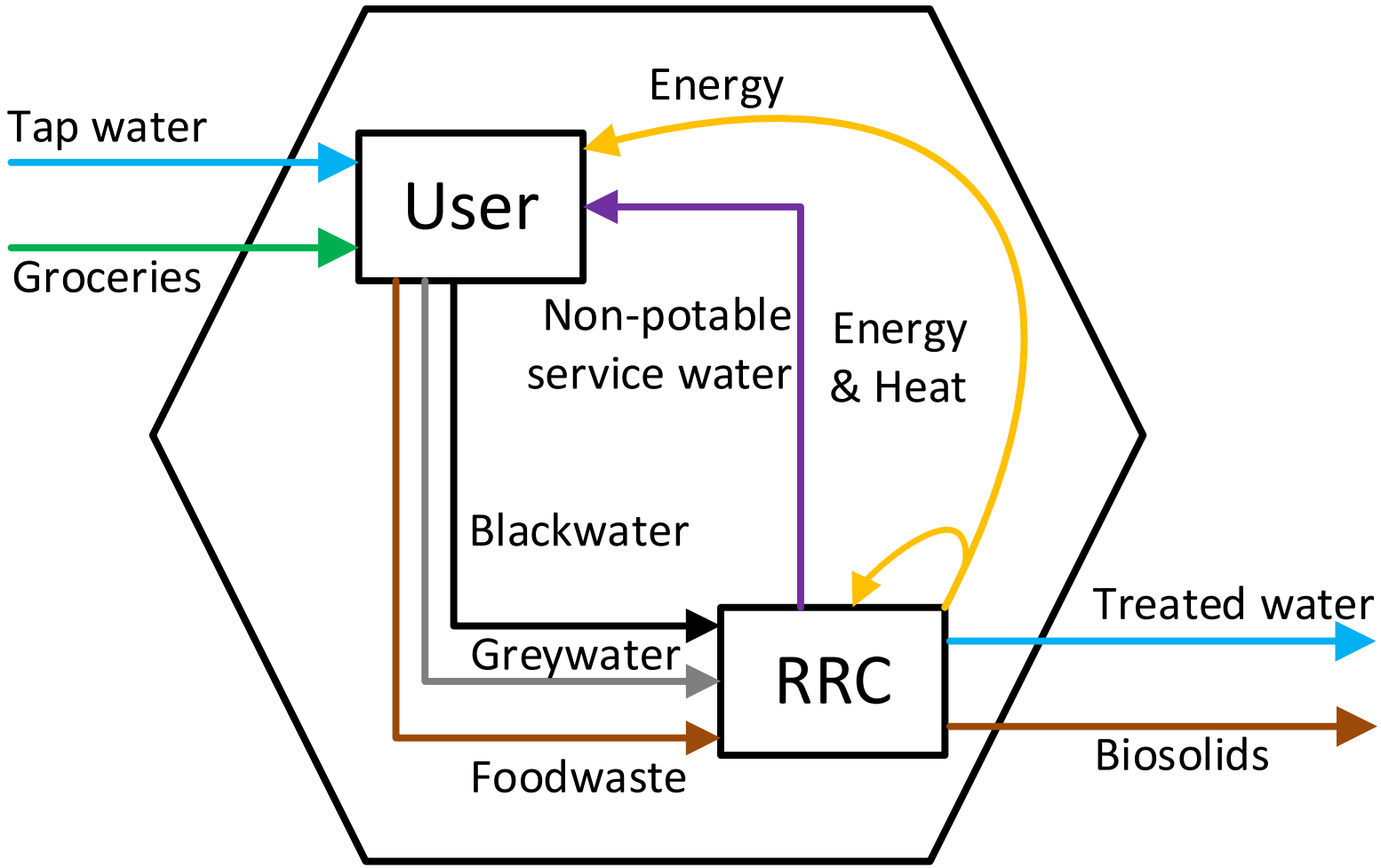
- Enclosed construction → low-emission

- „As small as possible, as large as necessary“

- **Infrastructure on demand**



SEMIZENTRAL: Integrated treatment on district level



The 'Semicentralized Approach'
Specific research issue for Hanoi, Vietnam

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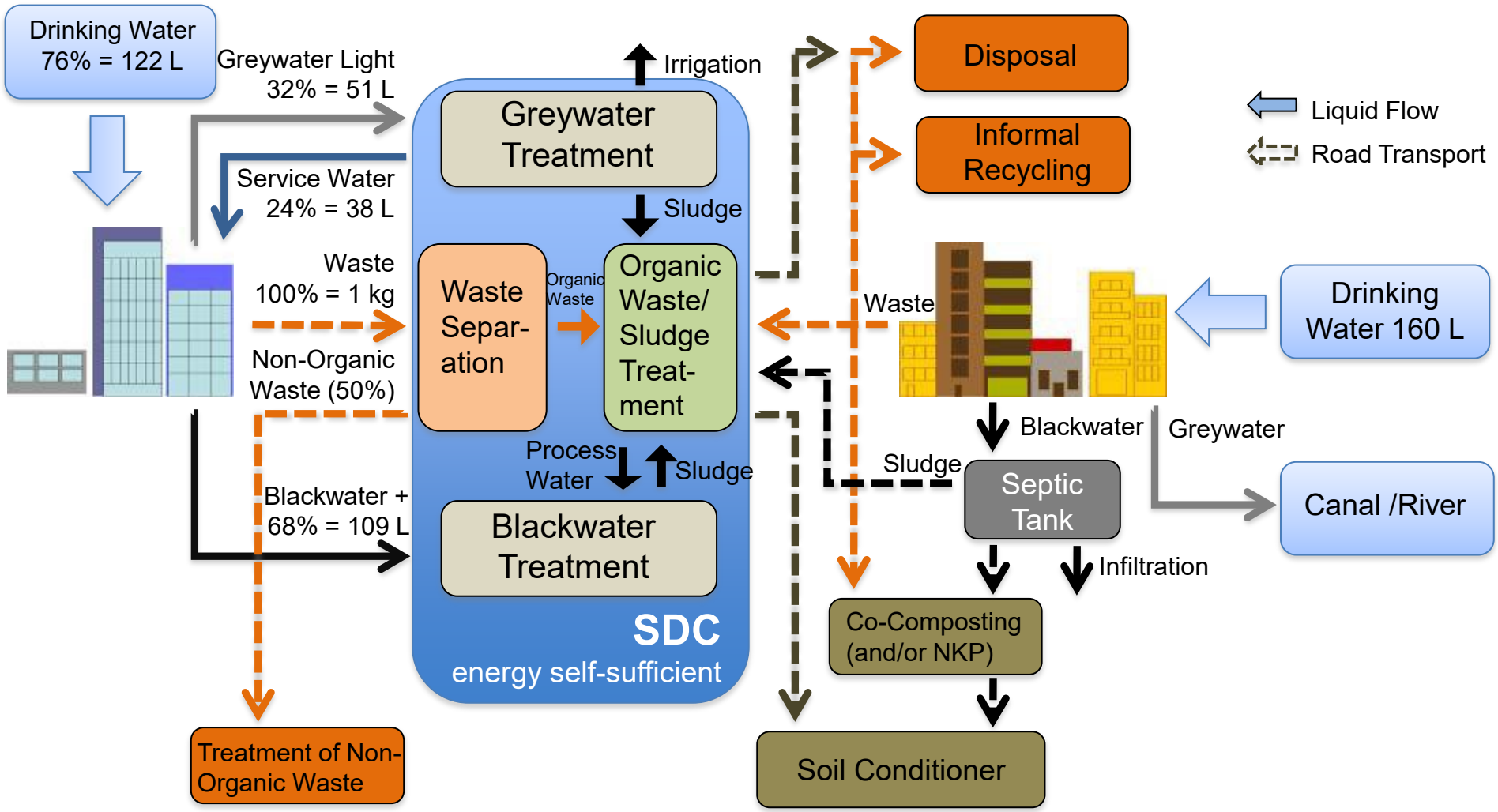
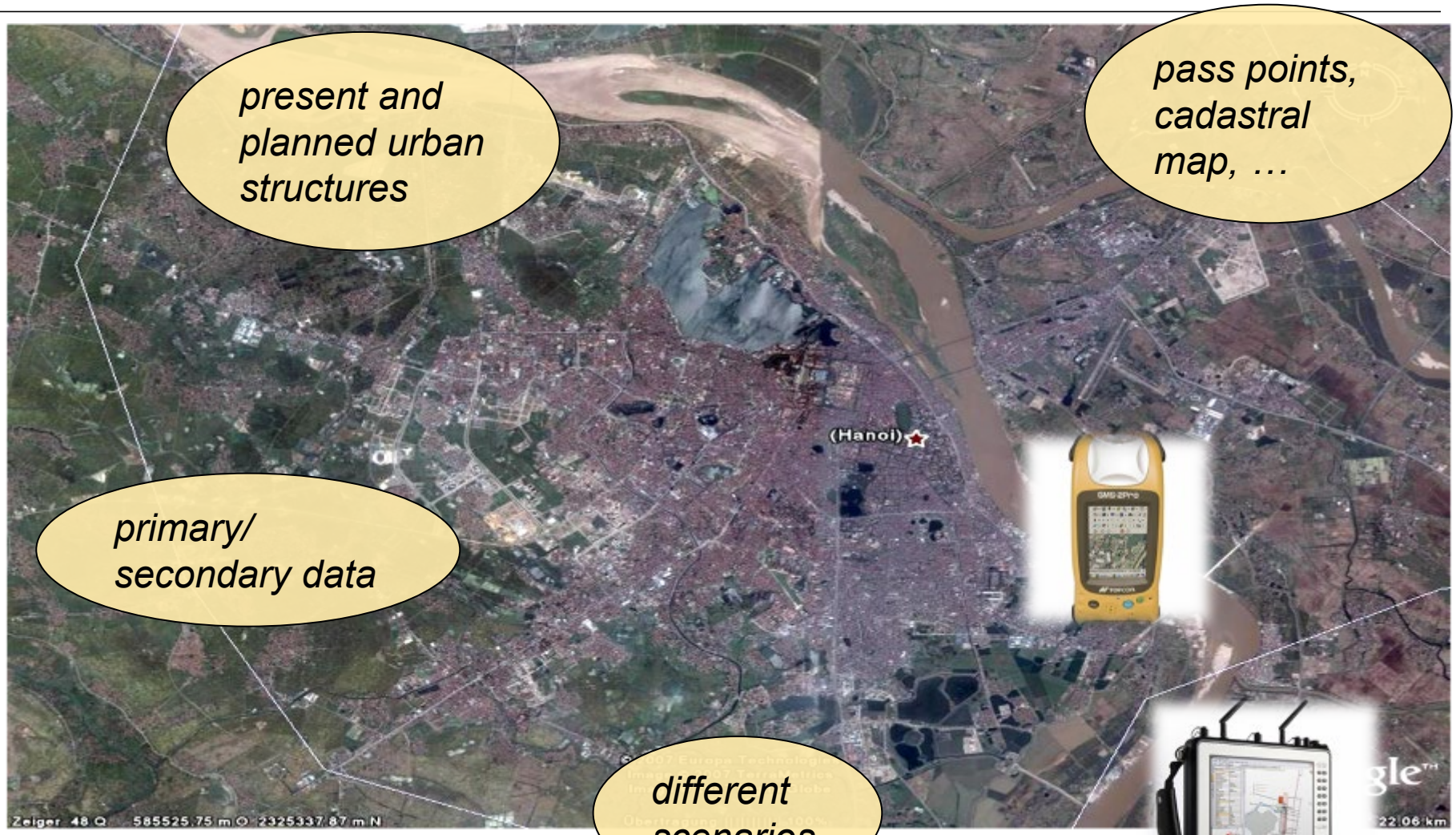


Data collection area



German pilot plant
→ pretreatment (biowaste)

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Pilot plant, TU Darmstadt






Resource Recovery Center Qingdao Shiyuan

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- **Implementation during the 2014 World Horticultural Exposition**

- **Catchment area with 12.000 EW_{CSB}**
  - 2 Housing areas 2
  - 2 Hotels + guest houses 2
  - Offices and a cantina

RRC in Qingdao ShiYuan

RRC Qingdao
Water reuse for irrigation

RRC Qingdao
Treated grey water

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