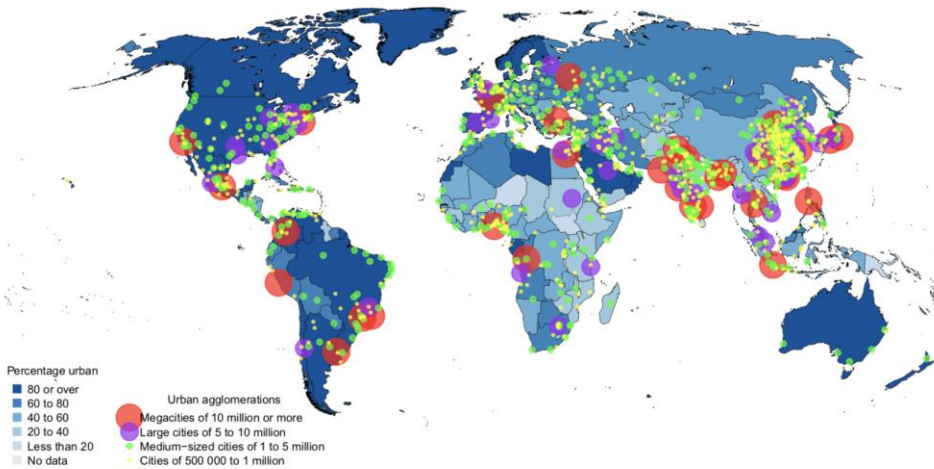


# WtE in South Mediterranean Regions: how to reduce the gap while increasing the sustainability through the Industrial Symbiosis

**G. Mancini, L. Lombardi, A. Luciano, D. Bolzonella, D. Fino**  
[giuseppe.mancini@unict.it](mailto:giuseppe.mancini@unict.it); [lidia.lombardi@unicusano.it](mailto:lidia.lombardi@unicusano.it)

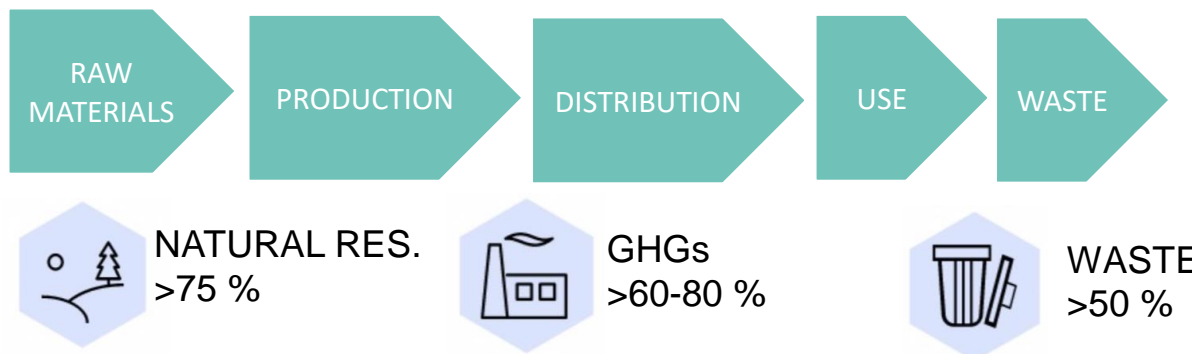
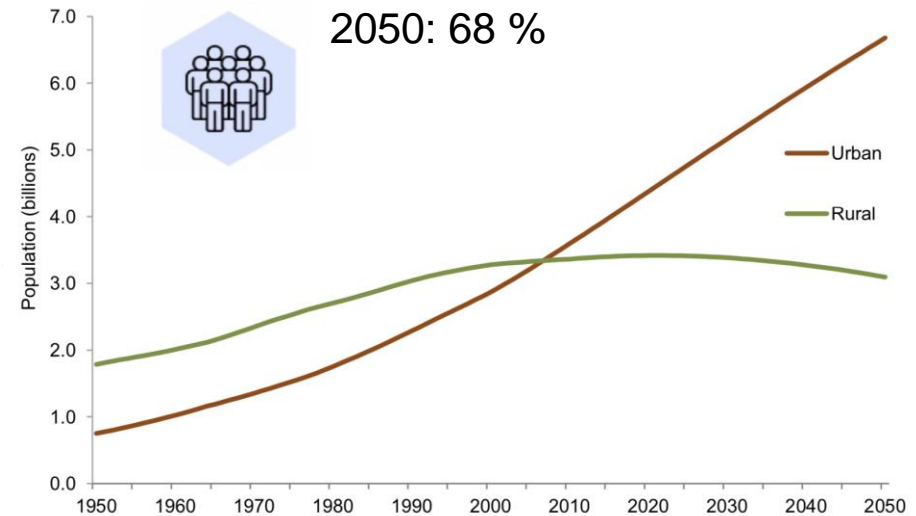
# Issues and Perspective

Percentage urban and urban agglomerations with 500,000 inhabitants or more, 2018



Data source: United Nations, Department of Economic and Social Affairs, Population Division (2018a).

Urban and rural populations of the world, 1950-2050



Data source: Ellen MacArthur Foundation. (2019). Circular economy in cities: project guide.

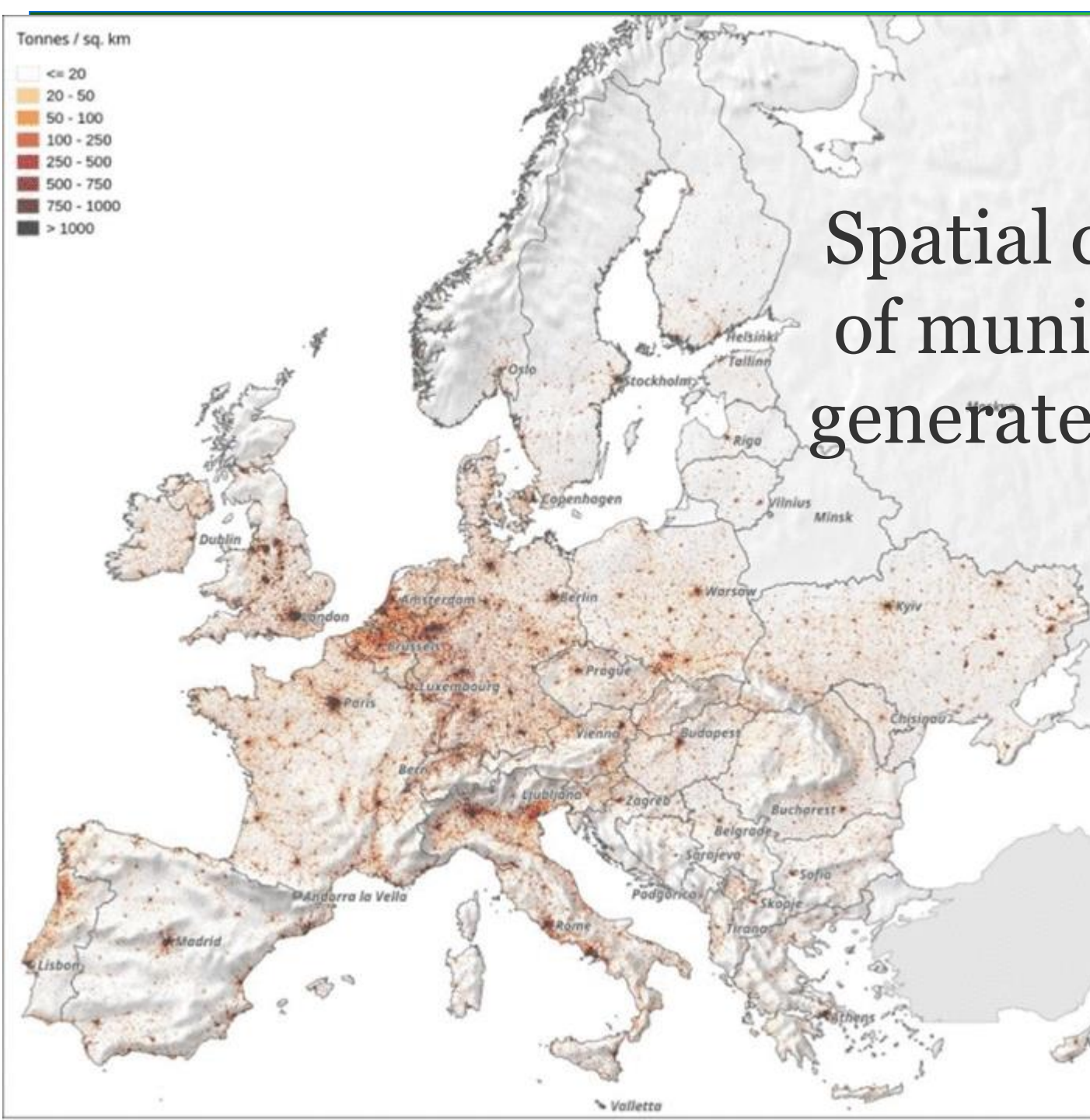


# Refusal of Waste treatment Plants (any)



**NO ALL'IMPIANTO A GIUGLIANO**





# Spatial distribution of municipal waste generated in Europe

**Scarlat et al.  
2019 Status and Opportunities for Energy Recovery from Municipal Solid Waste in Europe**

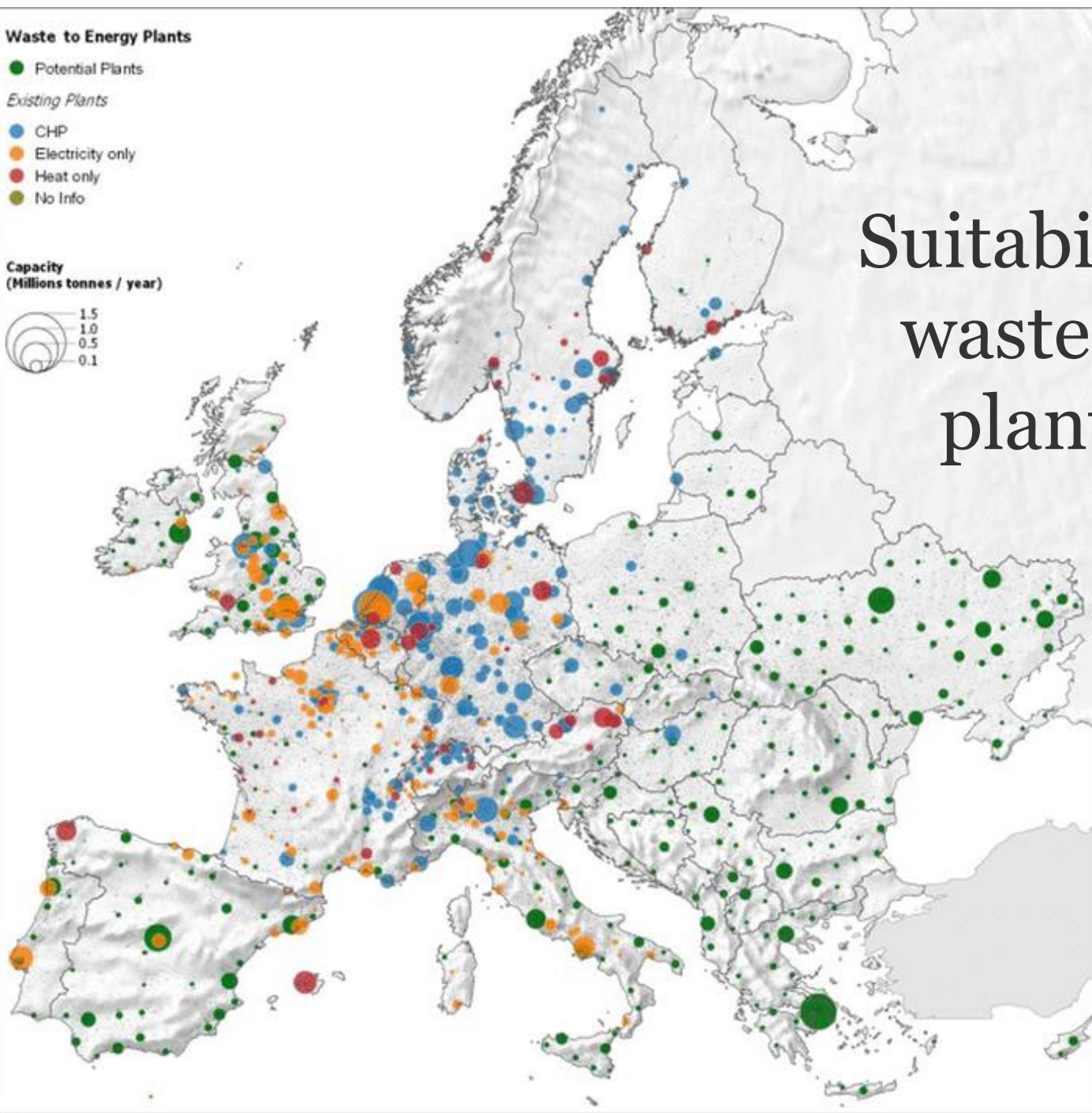
**Waste to Energy Plants**

● Potential Plants

*Existing Plants*

- CHP
- Electricity only
- Heat only
- No Info

**Capacity  
(Millions tonnes / year)**



# Suitability map for waste-to-energy plant location

**Scarlat et al.  
2019 Status and  
Opportunities  
for Energy  
Recovery from  
Municipal Solid  
Waste in Europe**

# Issue: the diffusion of ZERO-waste (uncompromising) approach



Zero Waste Athens



Giusepp

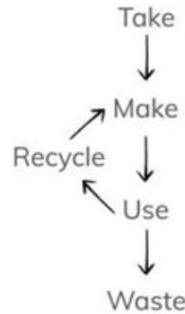
Segui Condividi Salva

## Foto

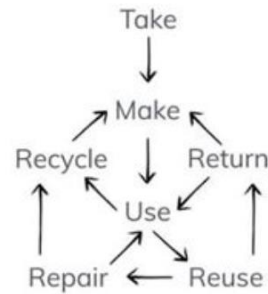
### LINEAR ECONOMY



### RECYCLING ECONOMY



### CIRCULAR ECONOMY



Mostra tutto

## Post



Zero Waste Athens

@zerowasteathens

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Informazioni

Foto

Post

Community

Crea una Pagina



# Circular economy is a fundamental part of the solution in waste management but.....



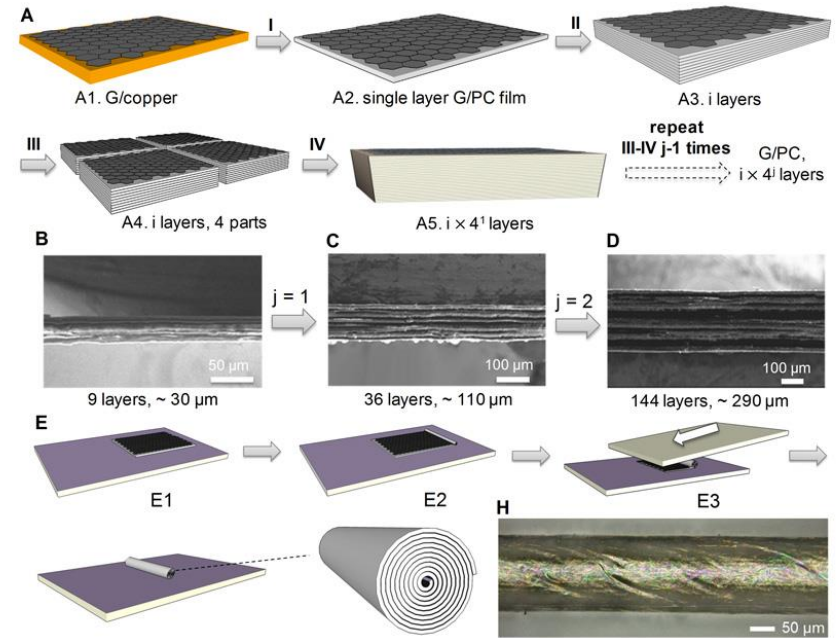
**SUSTAINABLE**  
**Circular**  
**ECONOMY**

# Really sustainable





# Issue: innovation in new composite materials versus recycling rate



**Ratna Chatterjee**  
Chief Consultant

**AUTOMOTIVE R&D MANAGEMENT CONSULTING**



# Issue: how many cycles – some scientific and public (???) concern



Home is where the toxins are - the hidden poisons we live with

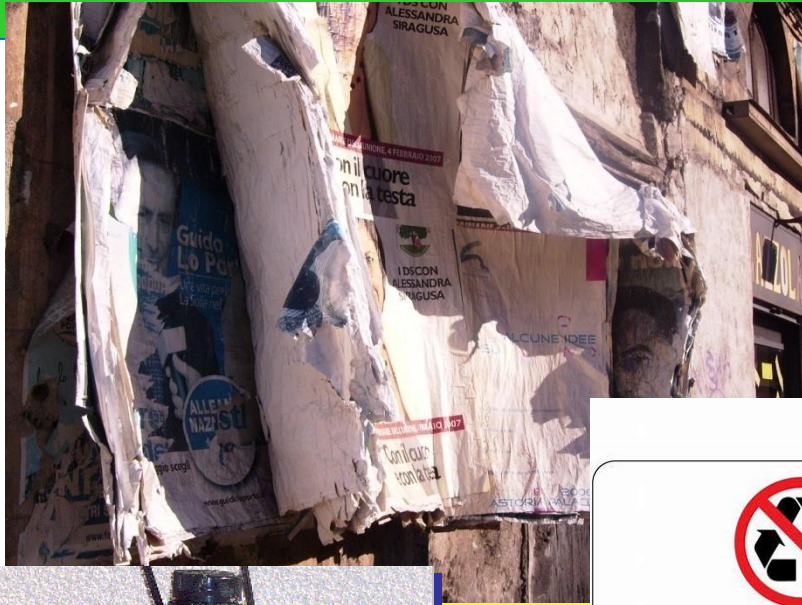
Some houses can be susceptible to a buildup of formaldehyde created by cleaning products. Which other everyday items can leave a harmful chemical trail?

Is There **POISON** in your **PLASTIC?**

4 Ways to Avoid BPA

The diagram illustrates a solenoid coil with a magnetic field  $B$  pointing to the right. An electron, labeled  $-e$ , is shown moving with a velocity vector  $v_{\parallel}$  parallel to the magnetic field and a velocity vector  $v_{\perp}$  perpendicular to it, causing it to spiral around the coil.

# Non Recyclable waste



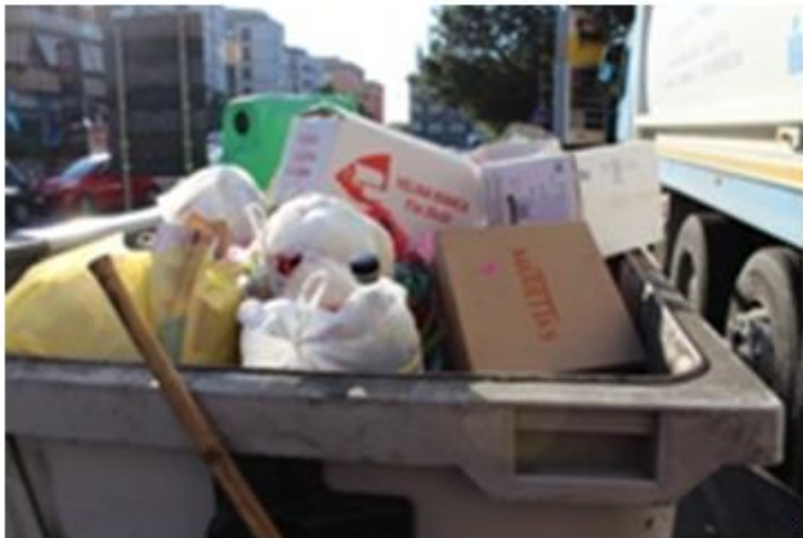
# Non Recyclable waste



# Non Recyclable waste



# Issue: 'Social behaviour'



# ‘Social behaviour’



# Door to door collection (consierge+internal space)





# Door to door 'Social behaviour'



# Door to door 'Social behaviour'



# Door to door (consierge+internal space)



# Issue: scraps from plastic waste selection

**up to 50%**



# Scraps (hidden) from composting



# Scraps from composting



# Issues : we still have the unsorted waste %? ('social behaviour')



# Two simple calculations: % Separate collection VS Recycling

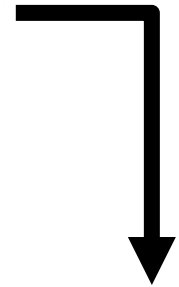
**RD 75-80%**

**(when???)**



**60-65% recycling**

**+**



**20-25%**  
**(unsorted)**

**32-38%**



**12-13%**  
**(Scraps)**





# Two simple calculations: % Separate collection VS Recycling

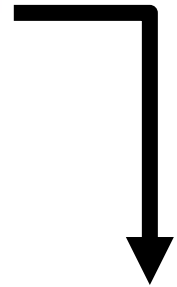
**RD 65-70%**

(soon???)

**50-60% recycling**



+



**30-35%**  
(unsorted)

**40-48%**

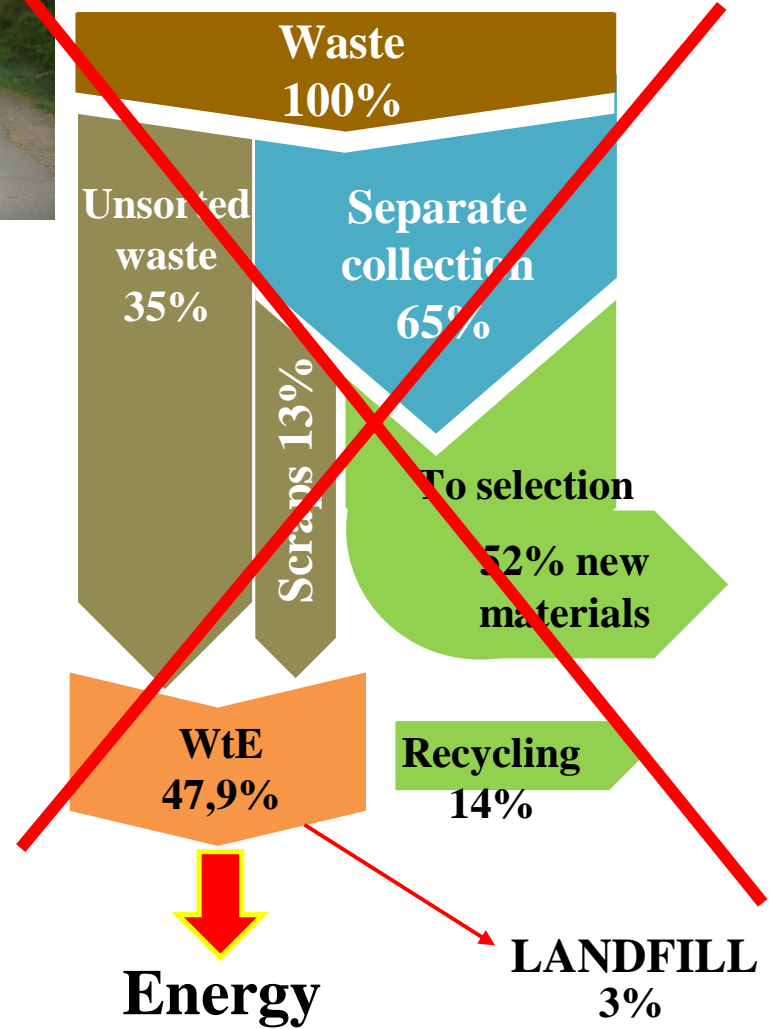
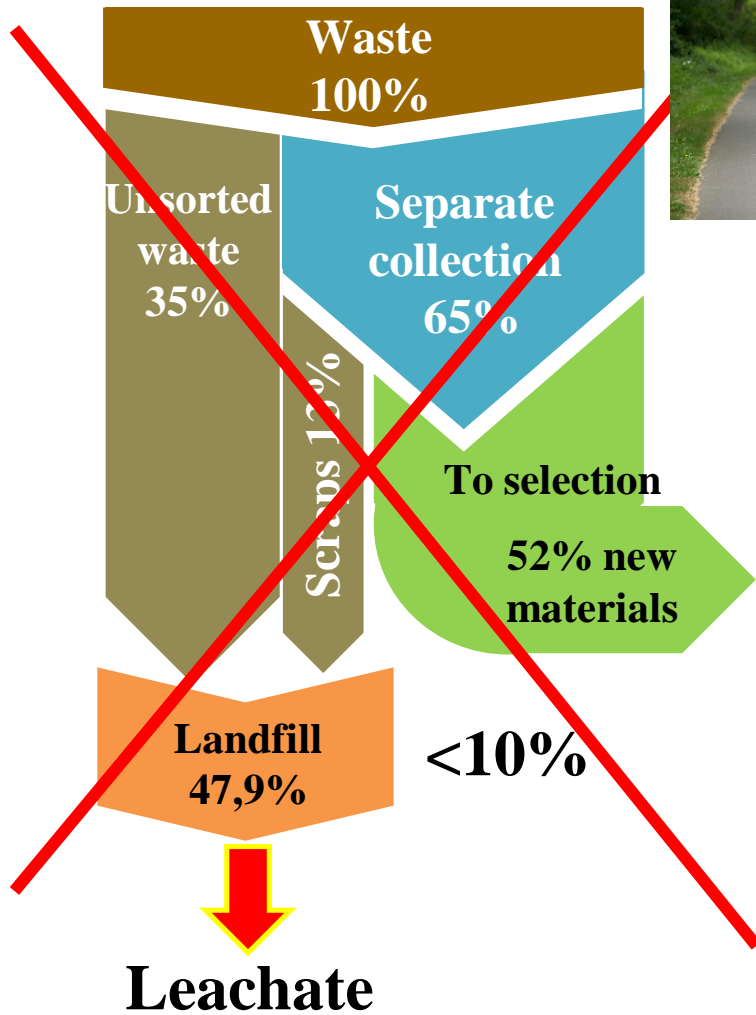


**10-13%**  
(Scraps)





# Management Alternatives



**NO WtE**

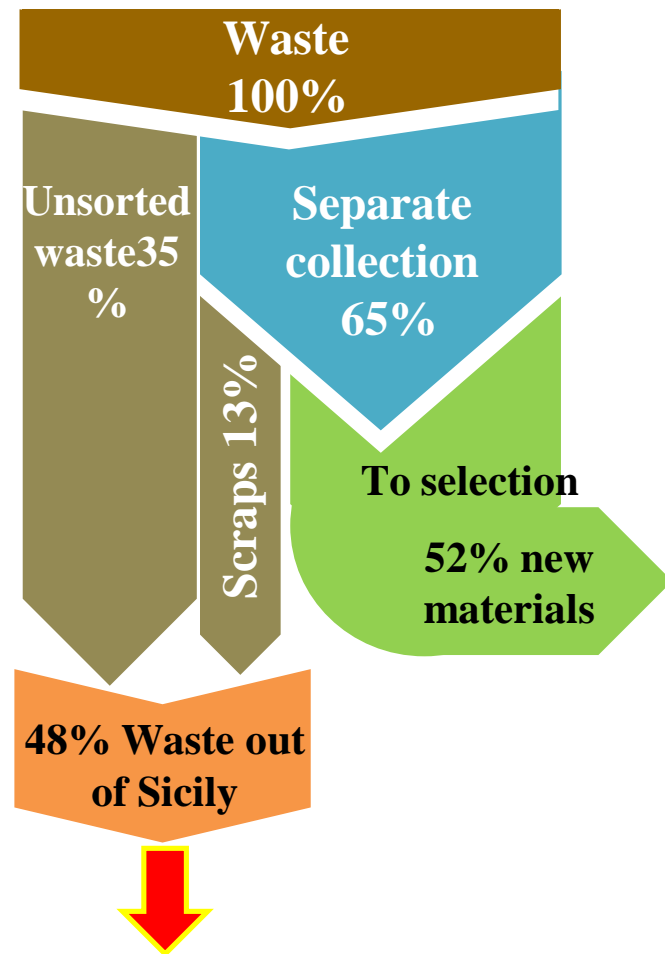
**NO Landfill ...is there any other way?**



**Residual waste from  
65%separate collection  
48Kg over 100 kg  
can go to.....**



# The third way... abroad



Caos rifiuti, vertice alla Regione, ipotesi estero o Emilia Romagna per uscire dalla crisi

LA TERZA SOLUZIONE È L'AMPLIAMENTO DELLA DISCARICA DI LENTINI

**Economic losses... and RESILIENCE losses**

# Context and open issues: climate change and drought

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### Italy drought: 11 regions poised for state of emergency

© 2 August 2017

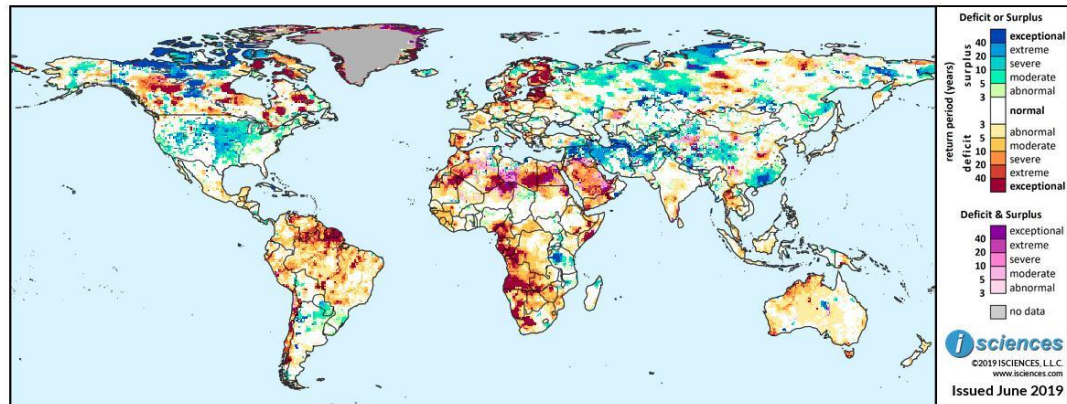
f     Share



The River Po at Linarolo in Lombardy has shrunk considerably

Eleven of Italy's 20 regions are set to ask for a state of emergency to be declared in order to help tackle the ongoing drought.

ISciences Water Anomalies Forecast: March 2019 - February 2020



# Context and open issues: zero wastewater reuse, High impacts from discharges

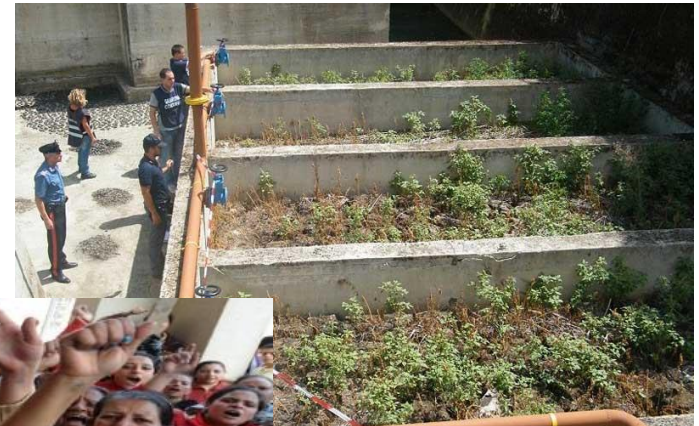


# Context and open issues: sludge management





# In summary, we have... so many issues



# HOW to change the waste/wastewater management paradigm in SouthEurope regions?



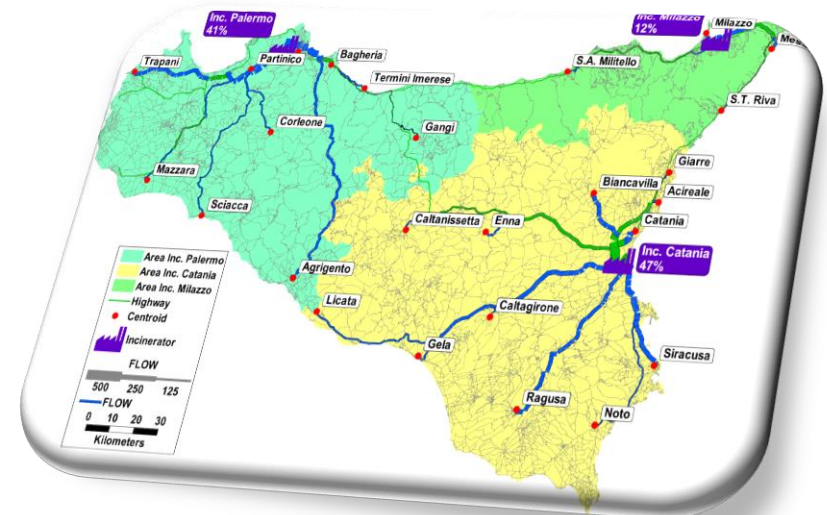
# Symbiosis....a lesson from the Nature....

The term '**symbiosis**' builds on the notion of mutualism in biological communities where **at least two otherwise unrelated species** exchange materials, energy, or information in a **mutually beneficial manner**



# CASE STUDY

- The “Symbiosis Approach” is evaluated on the Metropolitan Area of Catania plus the provinces of Enna, Siracusa and Ragusa
- It considers 2 million p.e. in terms of waste production and 545,000 p.e. in terms of the WWTP capacity

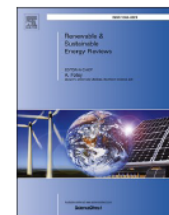




Contents lists available at ScienceDirect

# Renewable and Sustainable Energy Reviews

journal homepage: <http://www.elsevier.com/locate/rser>



## A water-waste-energy nexus approach to bridge the sustainability gap in landfill-based waste management regions

**Published  
October 2020**

G. Mancini<sup>a,\*</sup>, A. Luciano<sup>b</sup>, D. Bolzonella<sup>c</sup>, F. Fatone<sup>d</sup>, P. Viotti<sup>e</sup>, D. Fino<sup>f</sup>

<sup>a</sup> Department of Electrical Electronic and Computer Engineering, University of Catania, Viale Andrea Doria 6, 95125, Italy

<sup>b</sup> ENEA – Italian National Agency for the New Technologies, Energy and Sustainable Economic Development – Department for Sustainability, Casaccia Research Centre, Via Anguillarese 301, Rome, 00123, Italy

<sup>c</sup> Department of Biotechnology, University of Verona, Strada Le Grazie 15, Verona, 37134, Italy

<sup>d</sup> Department of Science and Engineering of Materials, Environment and City Plan

<sup>e</sup> Department of Civil, Construction and Environmental Engineering (DICEA), Sapienza University of Rome

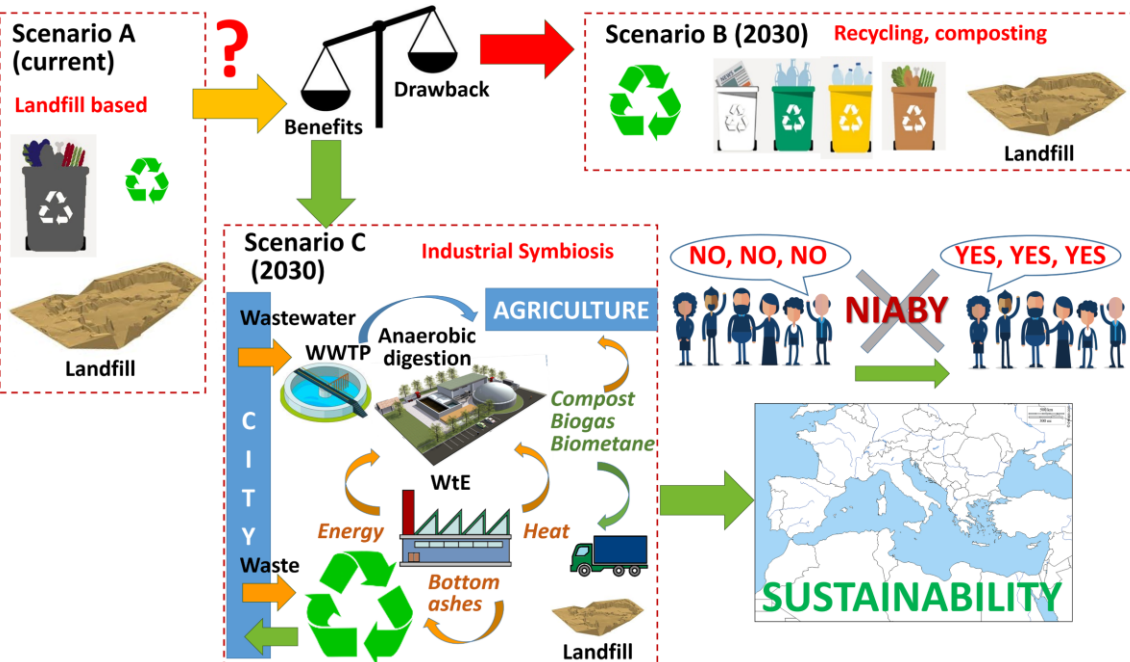
<sup>f</sup> Department of Applied Science and Technology (DISAT), Polytechnic of Turin, Italy

### ARTICLE INFO

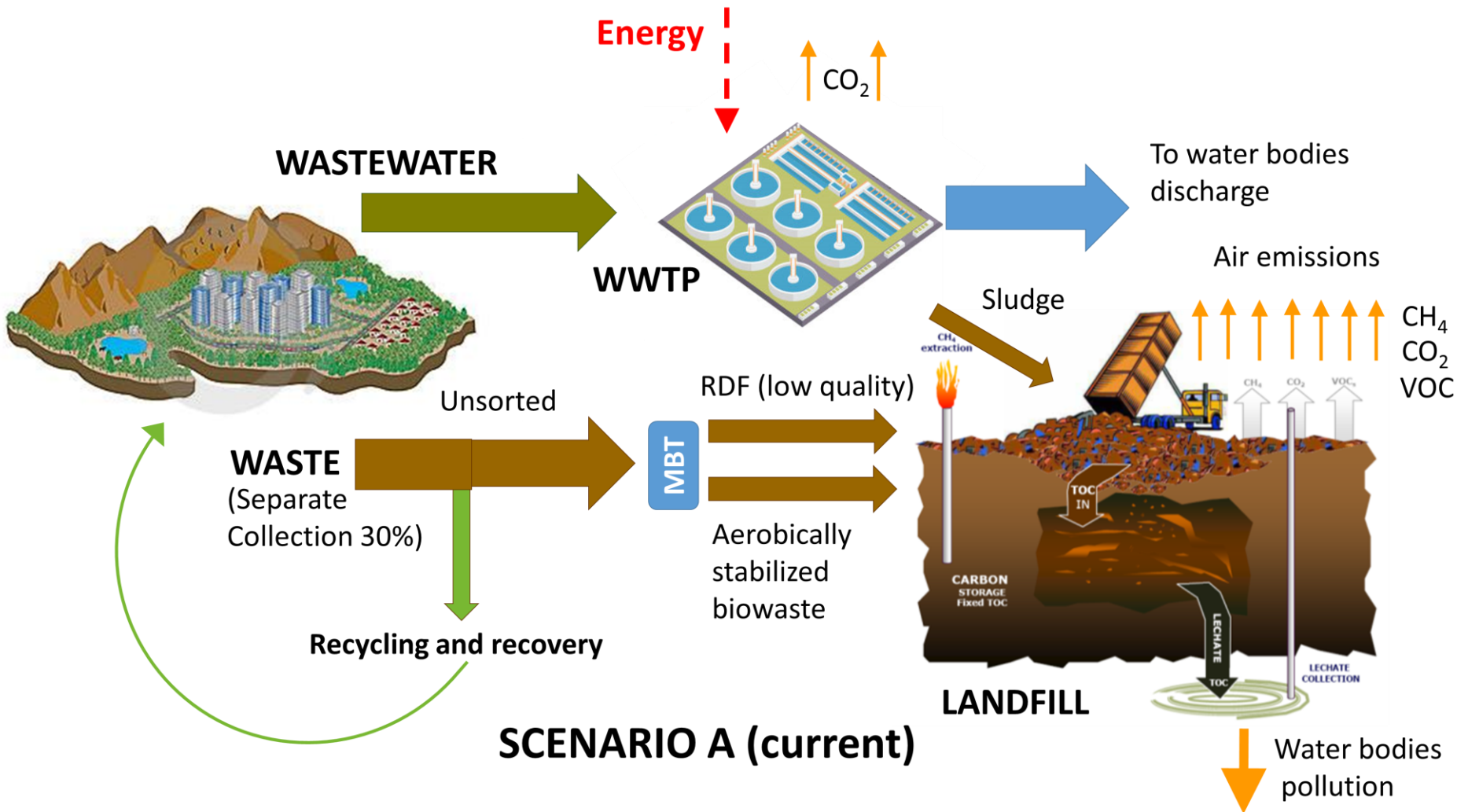
**Keywords:**  
 Industrial symbiosis  
 Circular economy  
 Green deal  
 Waste  
 Wastewater  
 Energy  
 Anaerobic digestion  
 Waste to energy  
 Nexus  
 Sustainability  
 Costs  
 Sludge  
 Biogas  
 Wastewater reuse  
 Landfill  
 Leachate

### ABSTRACT

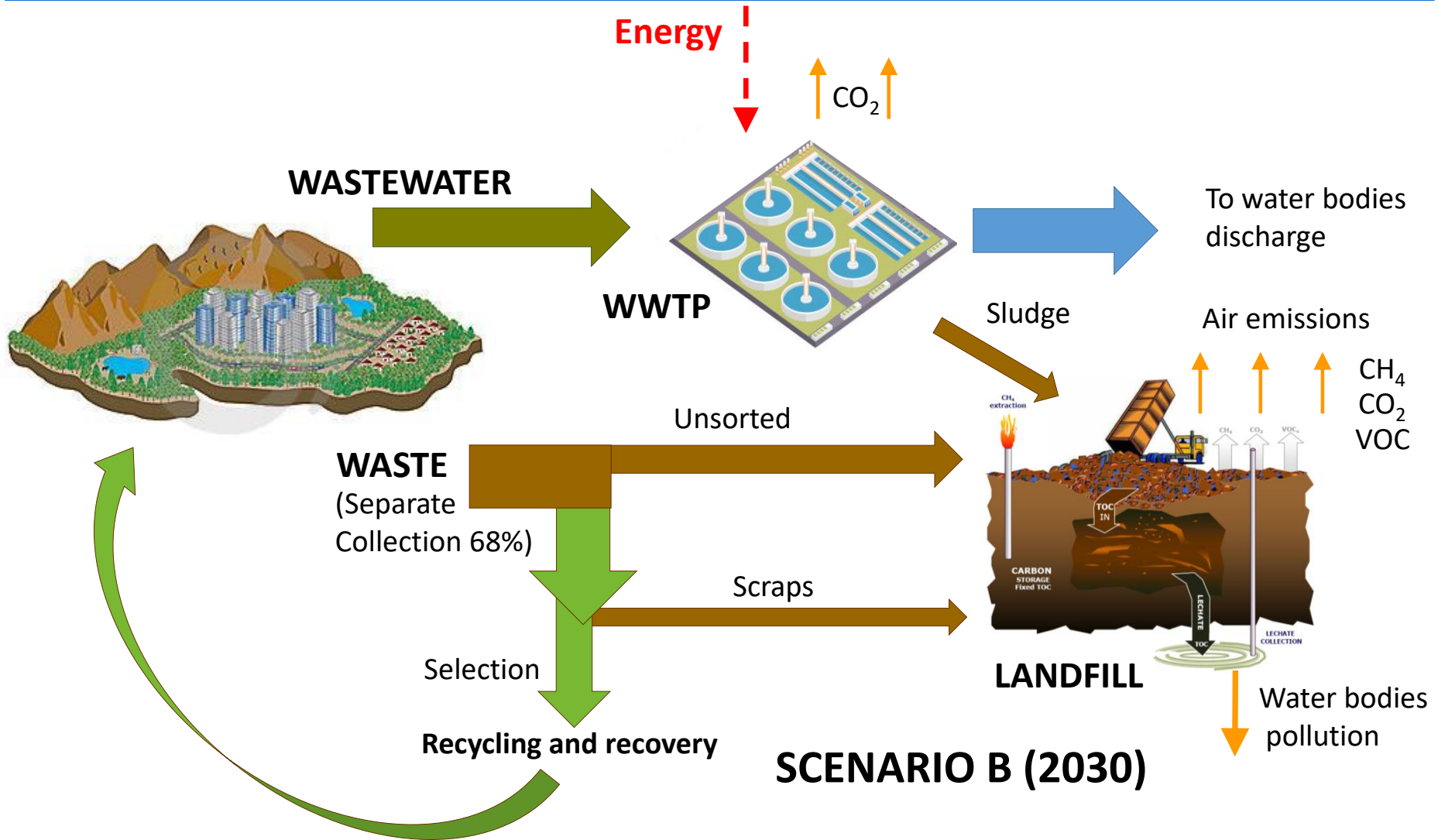
The present paper, evaluating the feasibility of the proposed approach, are not fully utilized, wastewater treatment is able to maximize the energy recovery. The enormous refinery approach, allowing 100% of reduced to less than 10% environmental benefits. Electricity from lower the costs of water cost completely sustainable. dominant, to help water management.



# Scenario A (current)



# Scenario B (2030)



# The Waste-Wastewater-Energy Nexus through Industria Symbiosis

Holistic approach





# Mass Balance – Scenario A

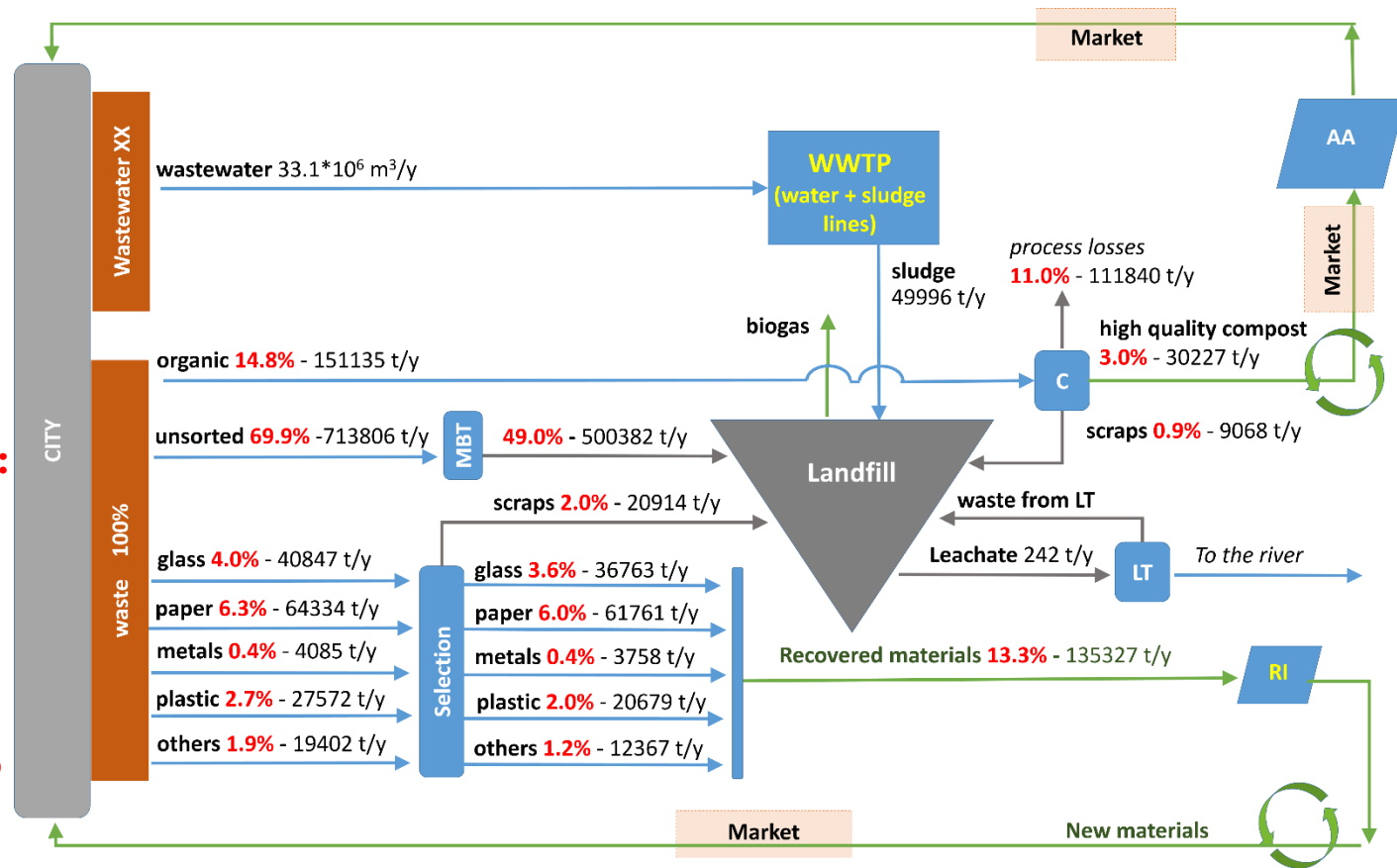
**To landfilling:  
Unsorted + scraps:  
530 364 t y<sup>-1</sup> (52%)**

**Sludge: 49 996 t y<sup>-1</sup>**

**To recovery from selection:  
135 327 t y<sup>-1</sup> (13%)**

**Compost:  
30 227 t y<sup>-1</sup> (3%)**

**Biogas: 10701 Nm<sup>3</sup>/giorno**



# Mass Balance– Scenario B

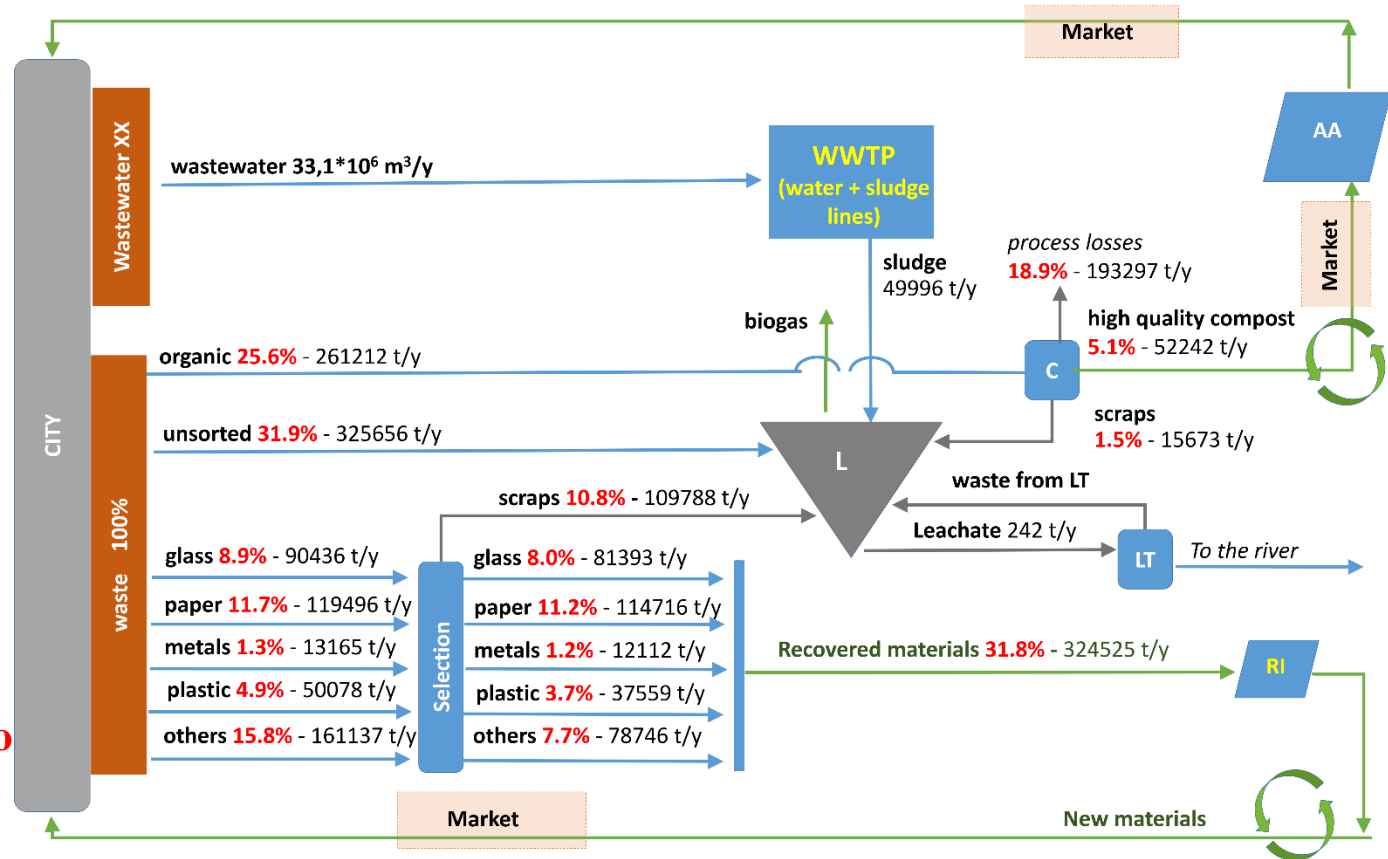
**To landfill:**  
**Unsorted + scraps:**  
**451 119 t y<sup>-1</sup> (44%)**

**Sludge 49 996 t y<sup>-1</sup>**

**To recovery from selection:**  
**324 525 t y<sup>-1</sup> (32%)**

**Compost:**  
**52 242 t y<sup>-1</sup> (5%)**

**Biogas: 10701 Nm<sup>3</sup>/giorno**



# Mass Balance – scenario C

To landfill:  
 Scarps to WtE  
 10 200 t y<sup>-1</sup> (2,2%)

Recovery from selection:  
 324 525 t y<sup>-1</sup> (32%)

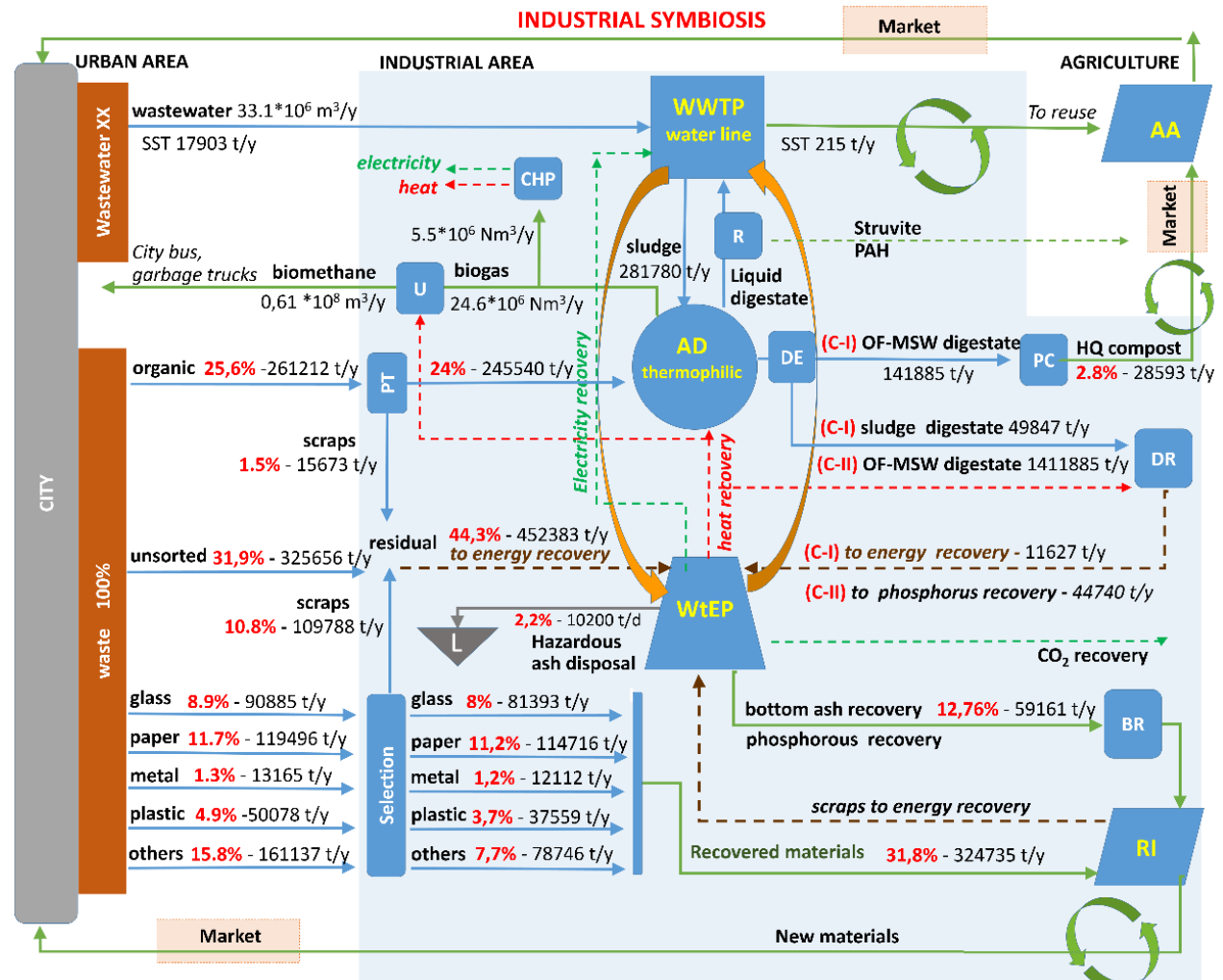
Compost:  
 28 593 t y<sup>-1</sup> (2,8%)

Energy: 452,6 GWh y<sup>-1</sup>

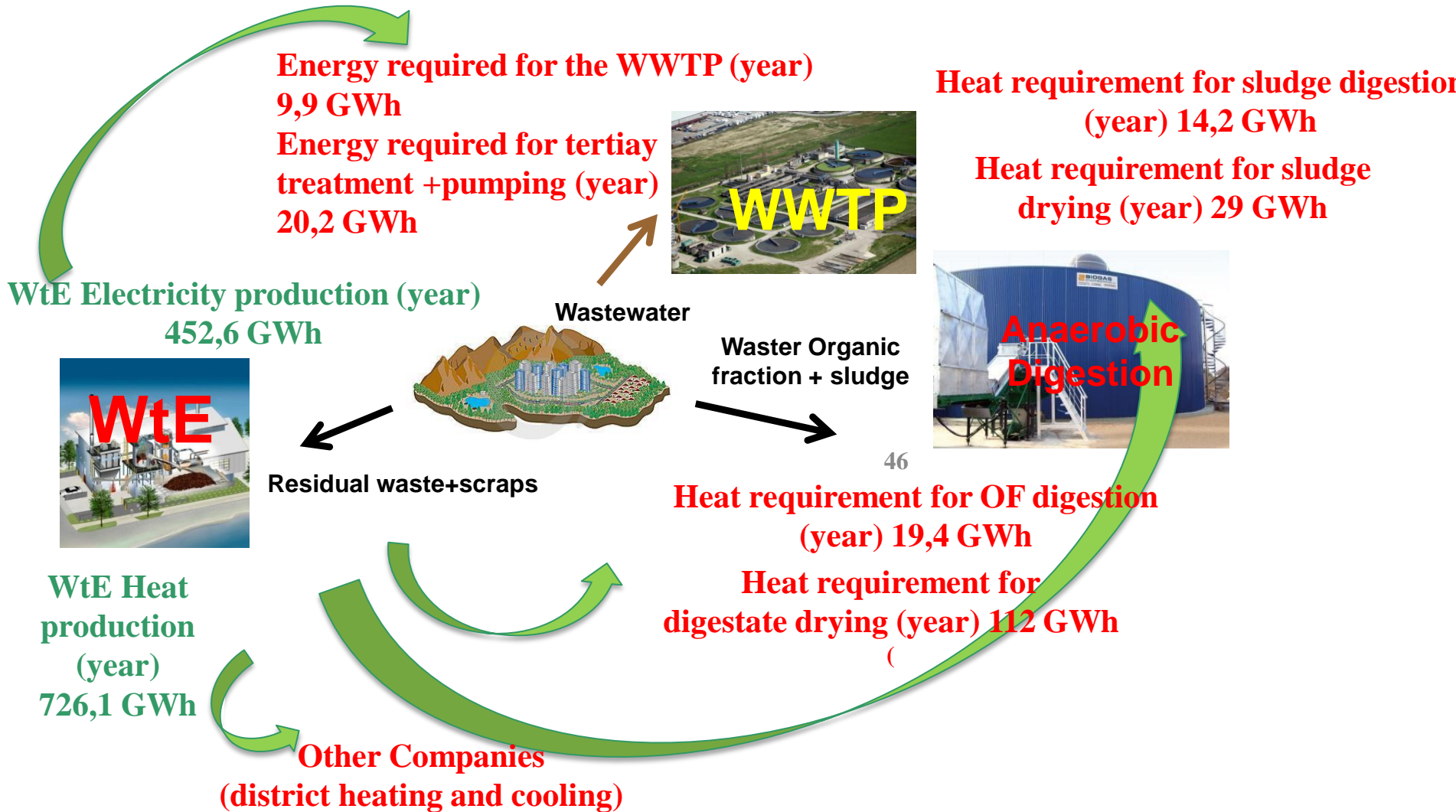
Heat: 726,1 GWh y<sup>-1</sup>

Biogas: 82287 Nm<sup>3</sup>/giorno

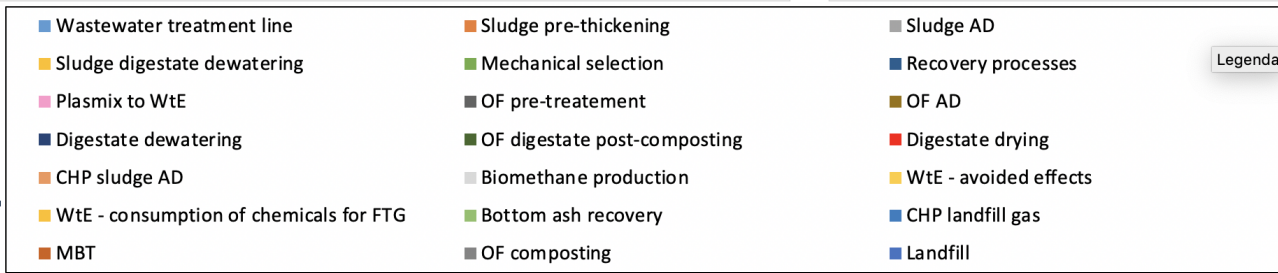
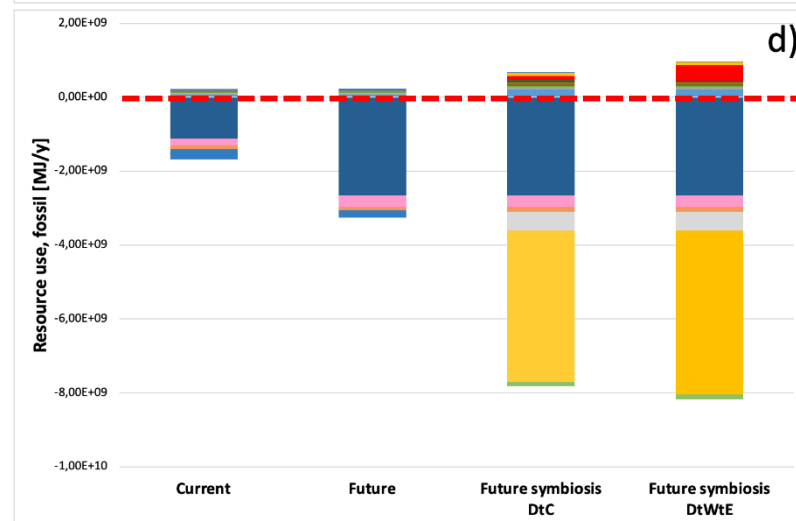
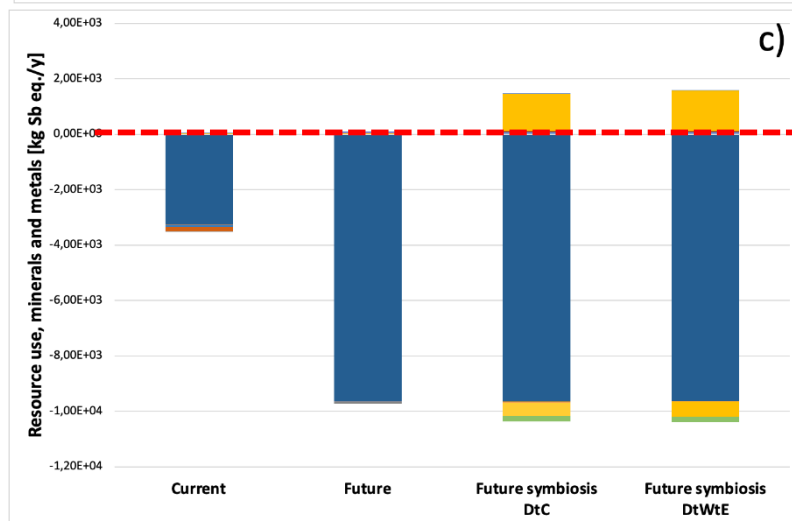
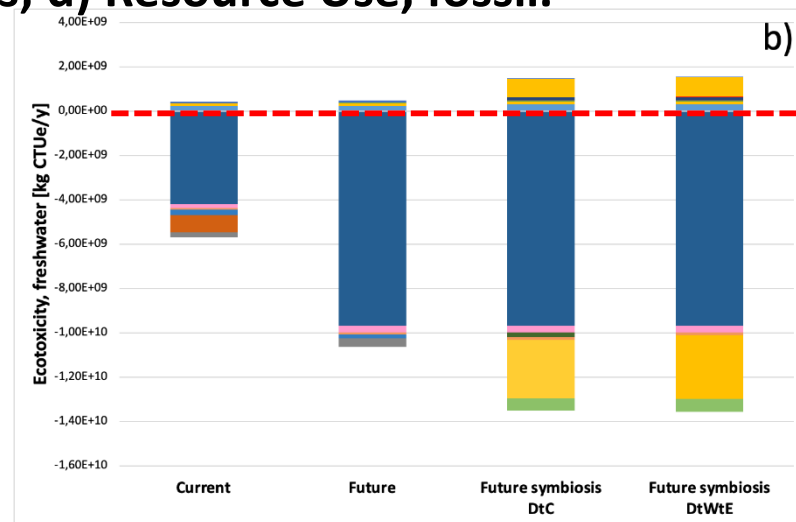
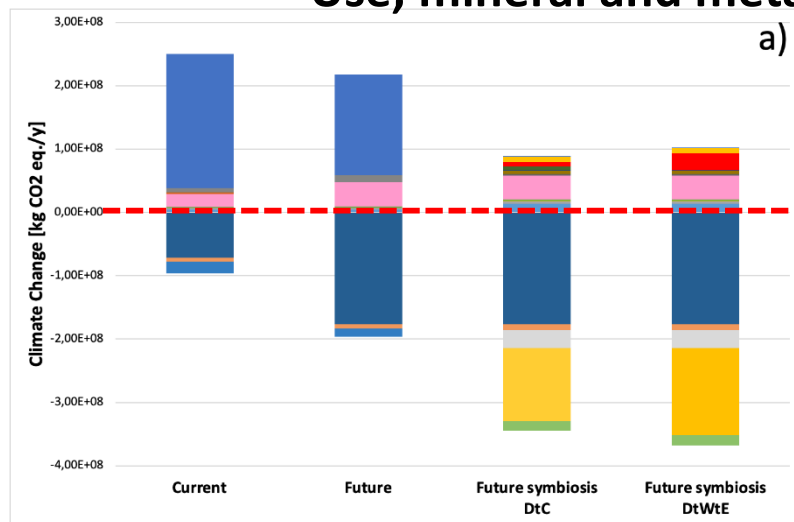
Recovery Phosphorous  
 Recovery slag  
 Wastewater reuse



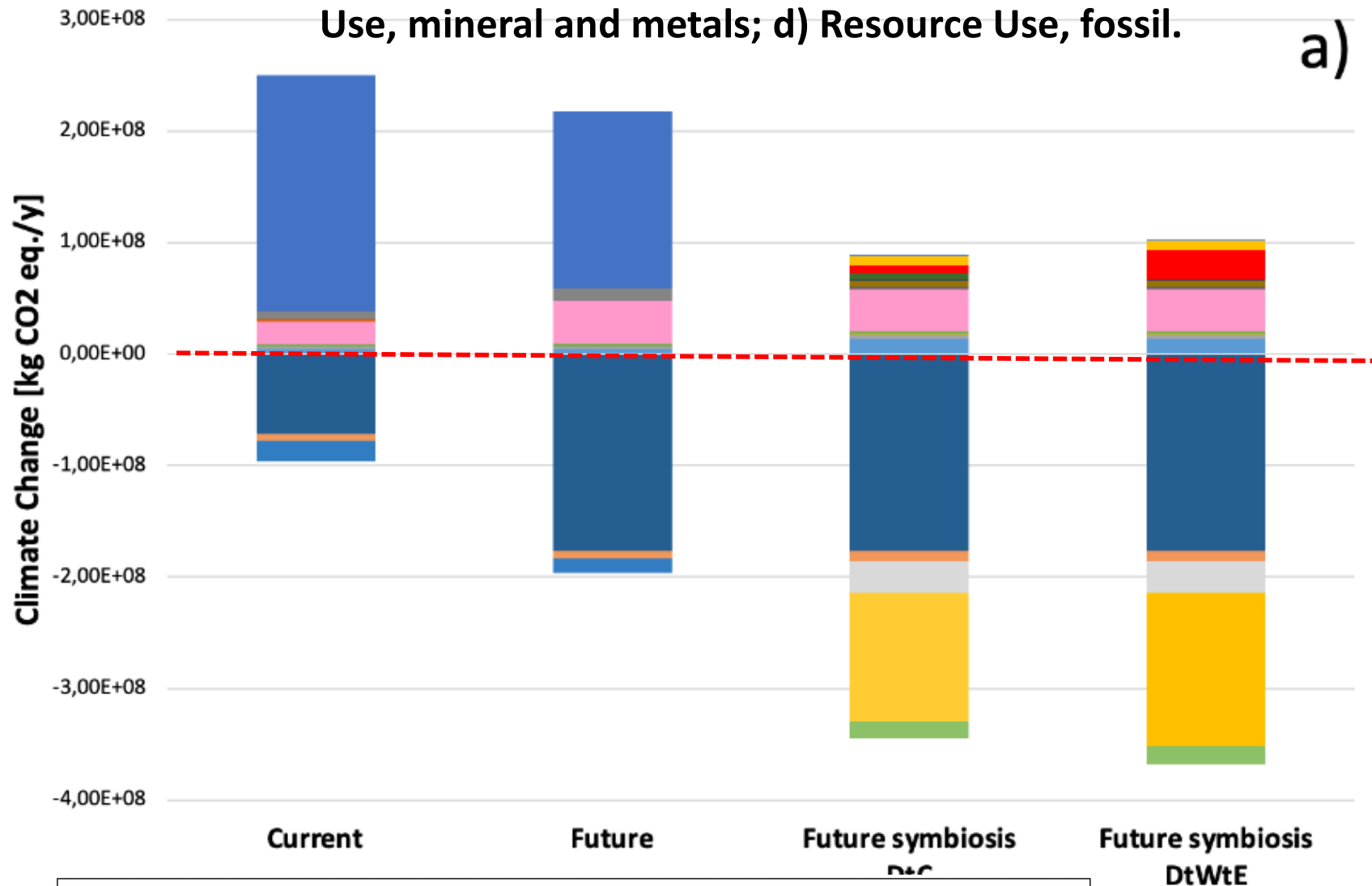
# A rough energy balance



# Contribution analysis: a) Climate Change; b) Ecotoxicity freshwater; c) Resource Use, mineral and metals; d) Resource Use, fossil.



# Contribution analysis: a) Climate Change; b) Ecotoxicity freshwater; c) Resource Use, mineral and metals; d) Resource Use, fossil.



- Wastewater treatment line
- Sludge digestate dewatering
- Plasmix to WtE
- Digestate dewatering
- CHP sludge AD
- WtE - consumption of chemicals for FTG
- MBT
- Sludge pre-thickening
- Mechanical selection
- OF pre-treatment
- OF digestate post-composting
- Biomethane production
- Bottom ash recovery
- OF composting
- Sludge AD
- Recovery processes
- OF AD
- Digestate drying
- WtE - avoided effects
- CHP landfill gas
- Landfill

Legenda

# Recycling versus WtE



**Landfill**



# Recycling and WtE complementary to divert waste from landfill





# Recycling, Recovery and (wastewater) Reuse

