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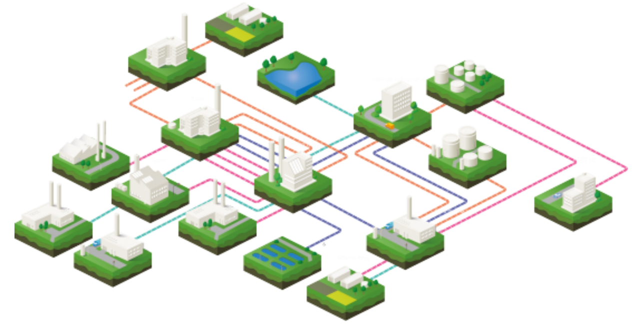
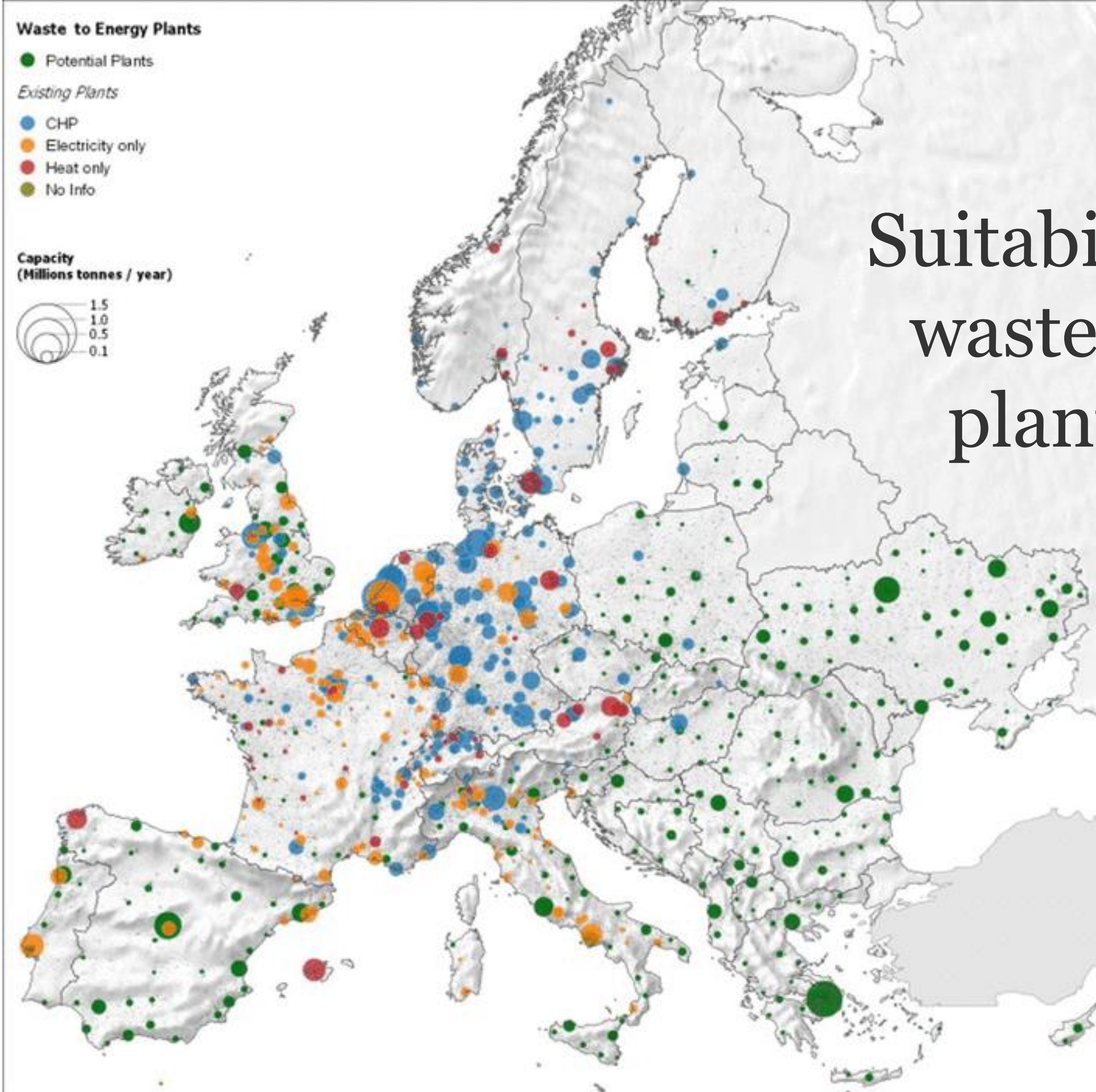


Waste-Water-Energy nexus: a feasible, sustainable approach in climate-change affected Mediterranean regions

Giuseppe Mancini
giuseppe.mancini@unict.it;

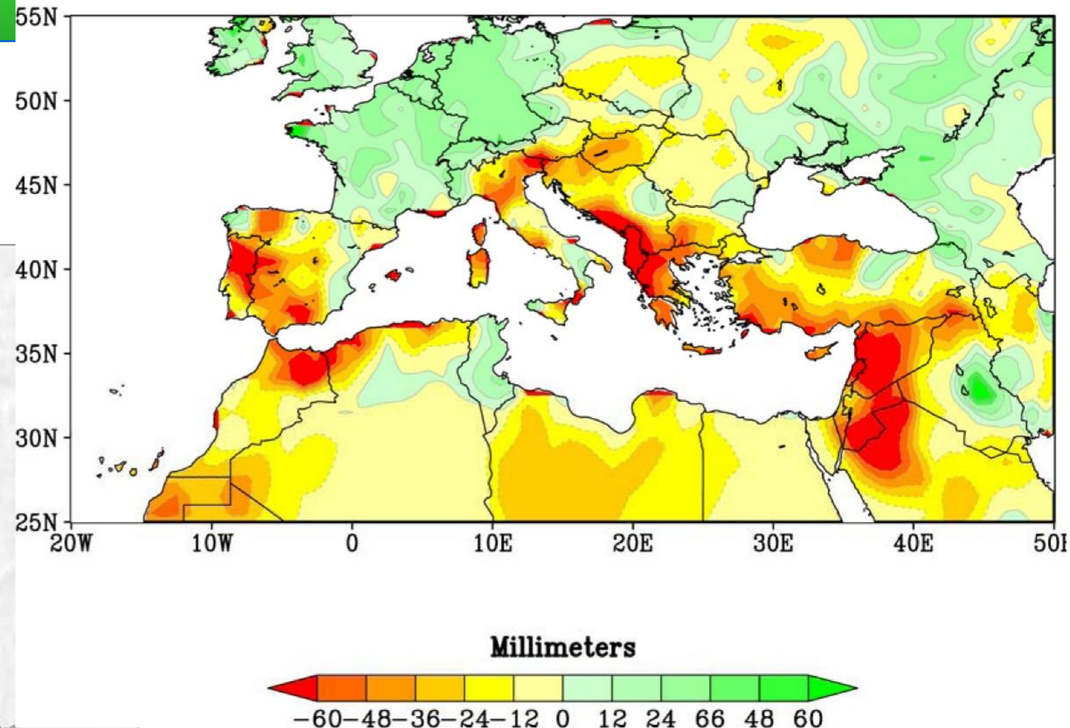
June 22h 2023

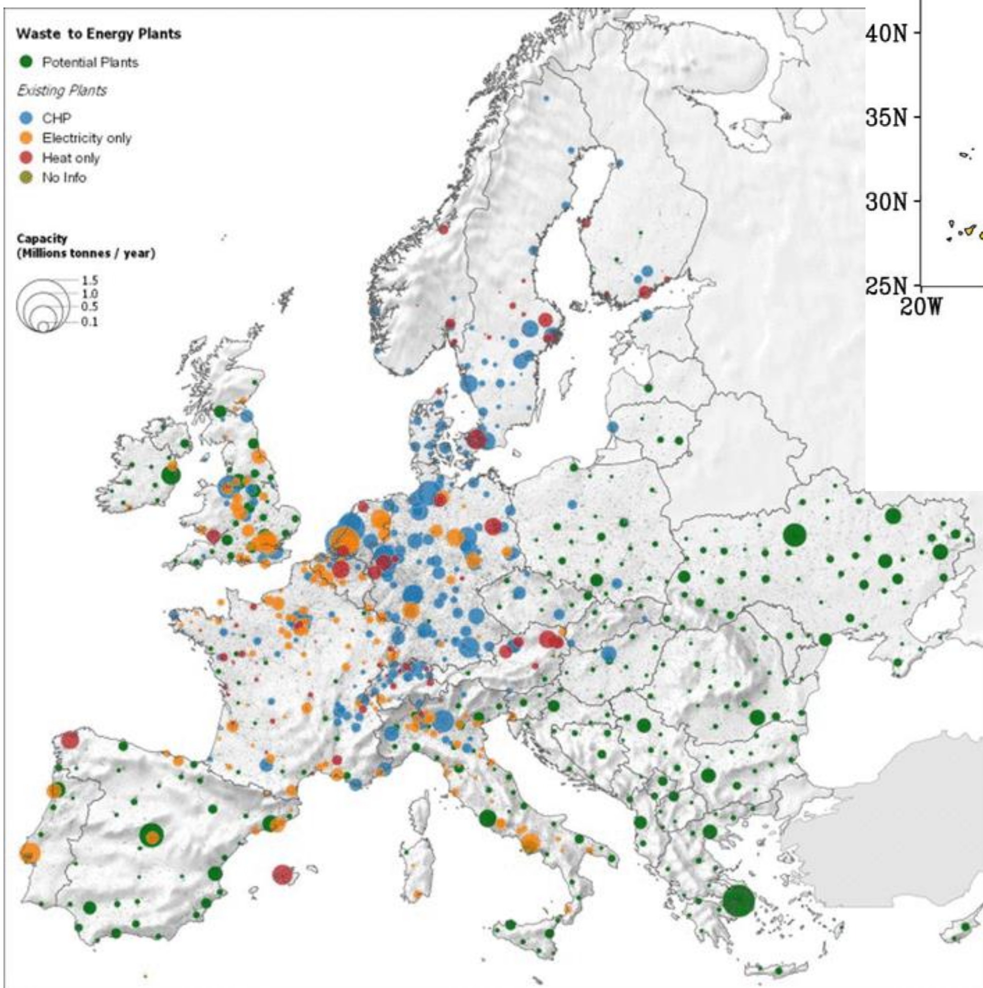
Suitability map for waste-to-energy plant location



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

Mediterranean Drought conditions areas



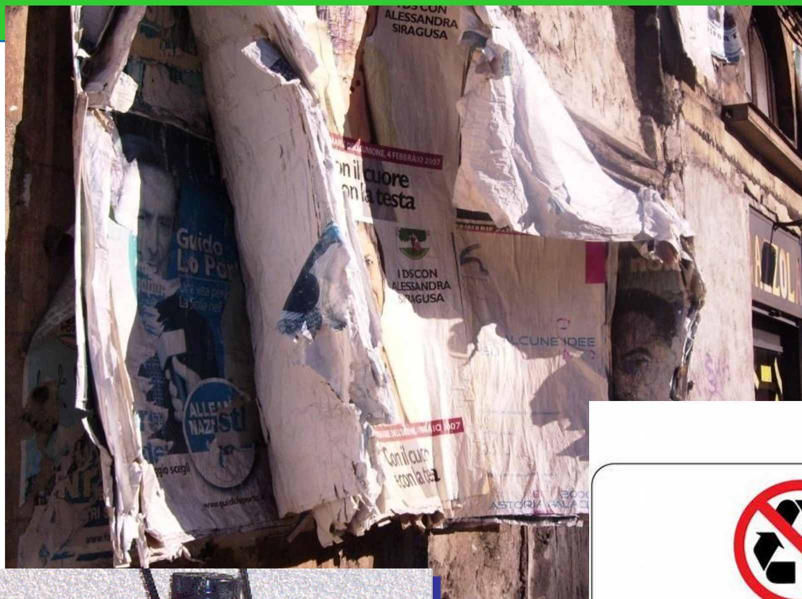


Issue: the diffusion of <u>uncompromising</u> approach

Was does not exist, you can recycle everything, if not it is a design mistake and you must correct it

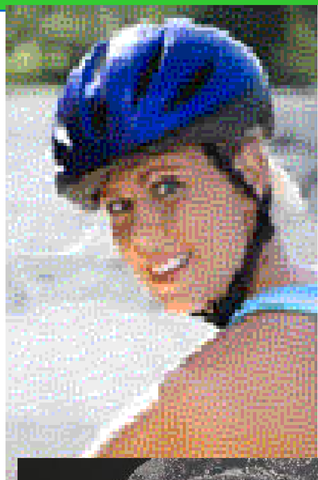
Refusal of any Waste treatment Plants (but WtE is first in line)

Issue: Non Recyclabe waste



Issue: Non Recyclabe waste

Issue: Non Recyclabe waste



Issue: how many cycles – some scientific and public (???) concern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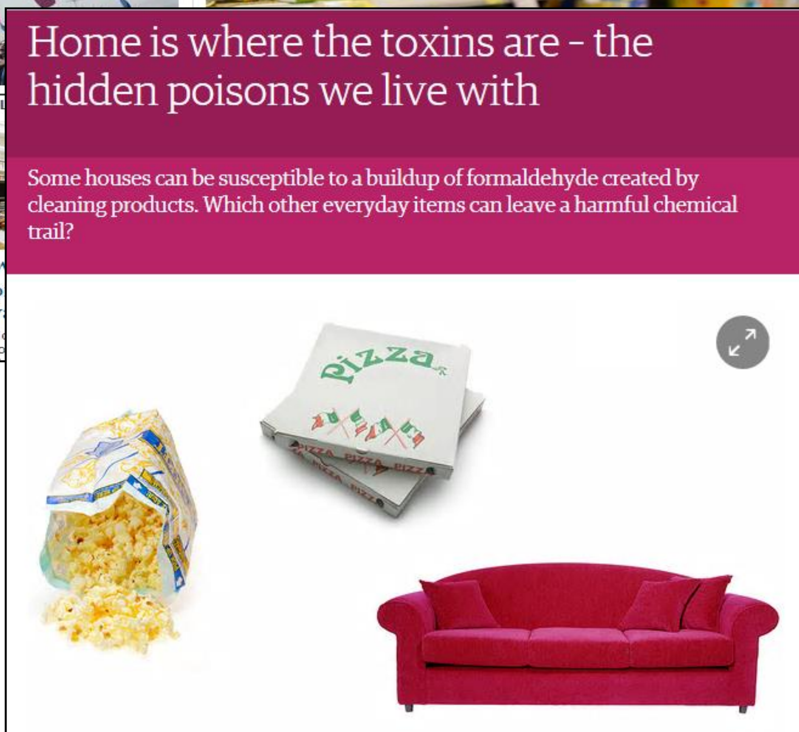
Life > Health & Families > Health News

Health fears over recycled food packaging

BY JEREMY LAURANCE , HEALTH EDITOR   WEDNESDAY 09 MARCH 2011


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?


Forbes

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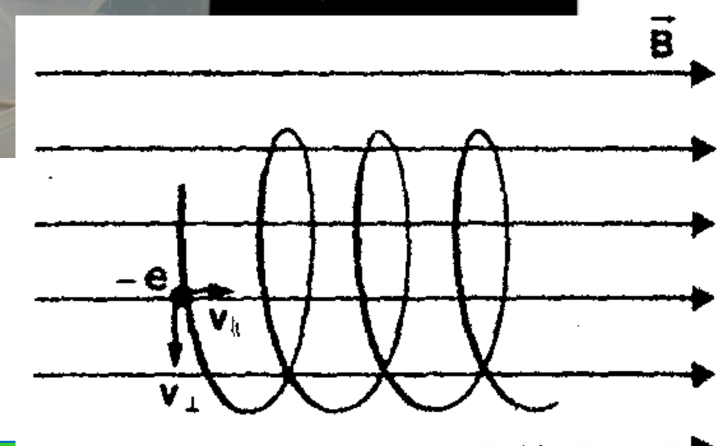
Amy Westervelt, Contributor

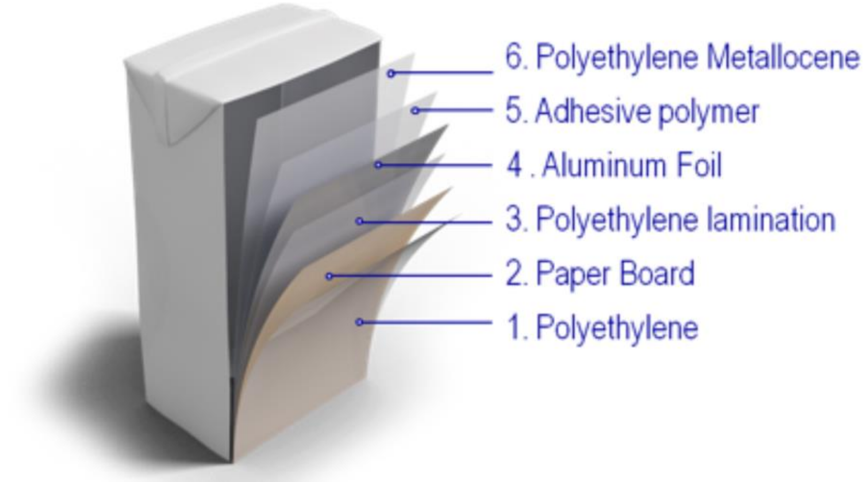
Innovation at the intersection of health and the environment

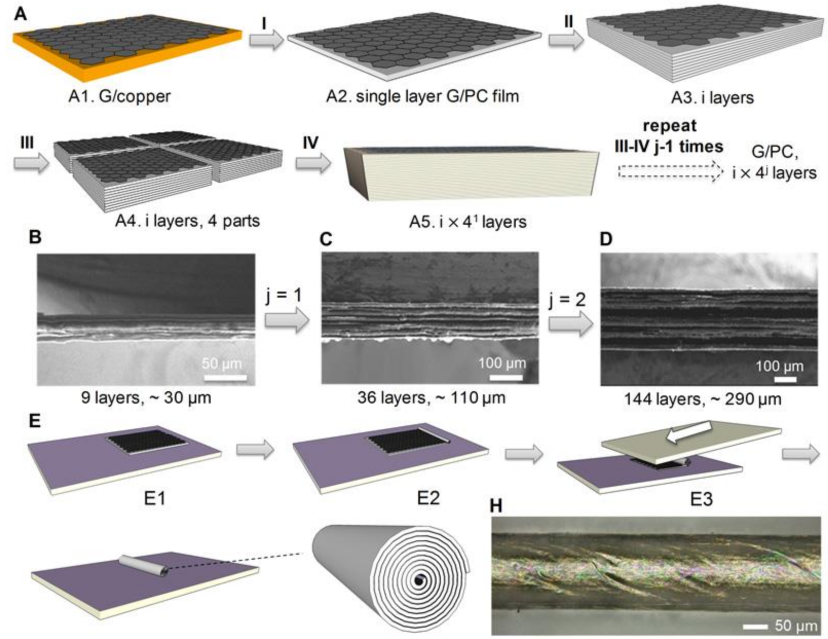
GREEN TECH | 8/27/2012 @ 11:51AM | 2,161 views

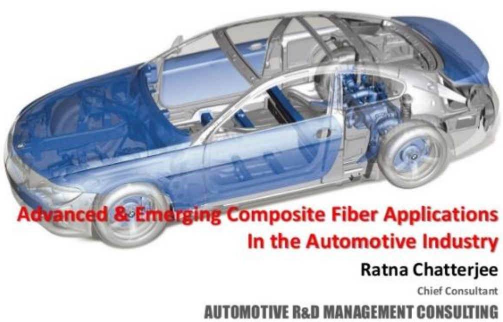
Report Finds Toxic Levels of Phthalates Lurking in Popular Back-to-School Items



Issue: innovation in new composite materials versus potential recycling rate



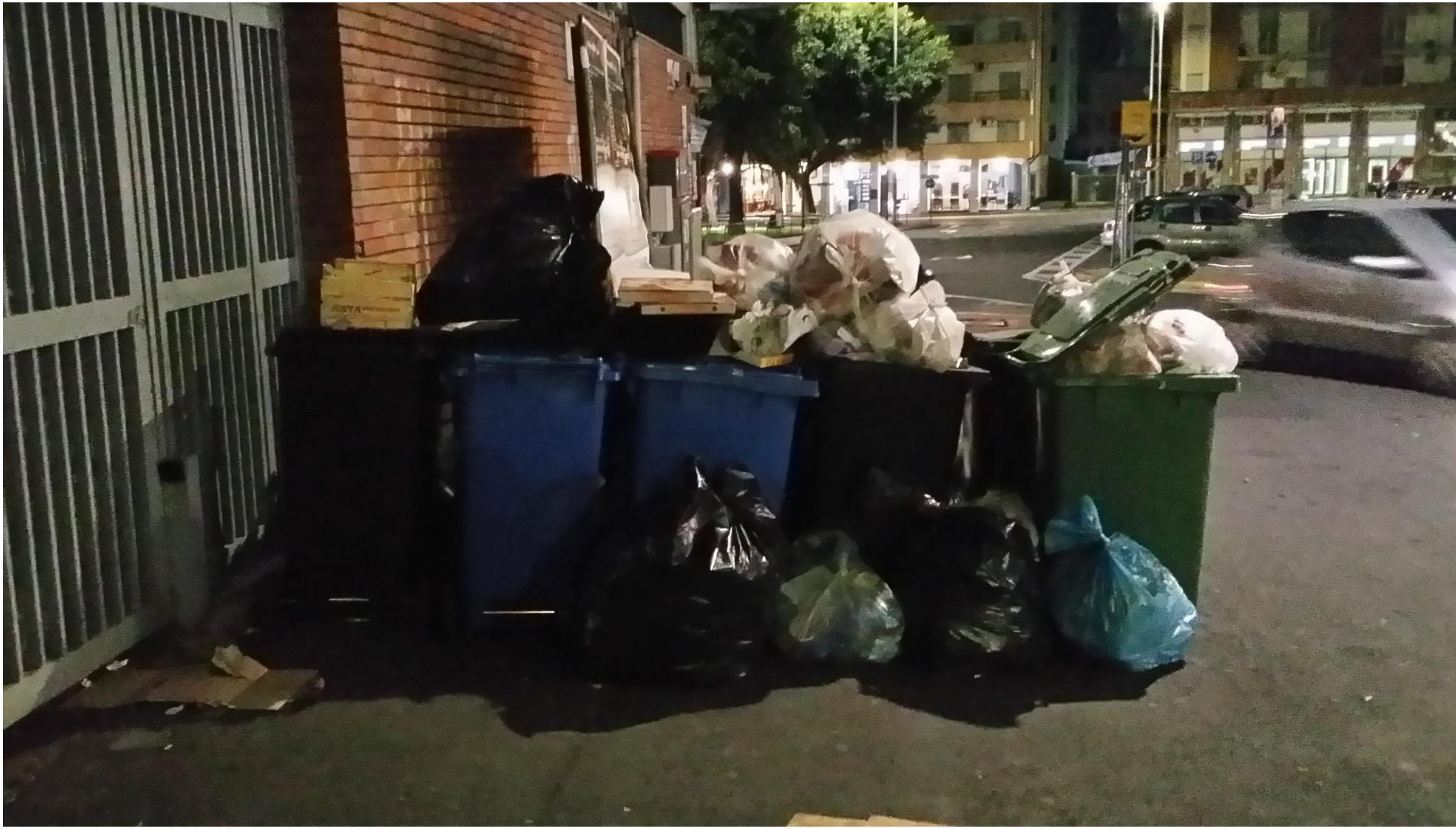




Issue: ‘Social behaviour’




Door to door collection (consierge+internal space)



Door to door
(consierge+internal space)

Issue: scraps from plastic waste selection

Scraps from composting

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

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

SUSTAINABLE
Circular
ECONOMY

Once we made the perfect door to door separate waste collection….

How far from the goal are we yet?

Two simple calculations: %
Separate collection VS Recycling

SC 75-80%

(when???)

60-65% recycling

+

12-13%
(Scraps)

32-38%

20-25%
(unsorted)

Two simple calculations: %
Separate collection VS Recycling

SC 65-70%

(soon???)

50-60% recycling

+

40-48%

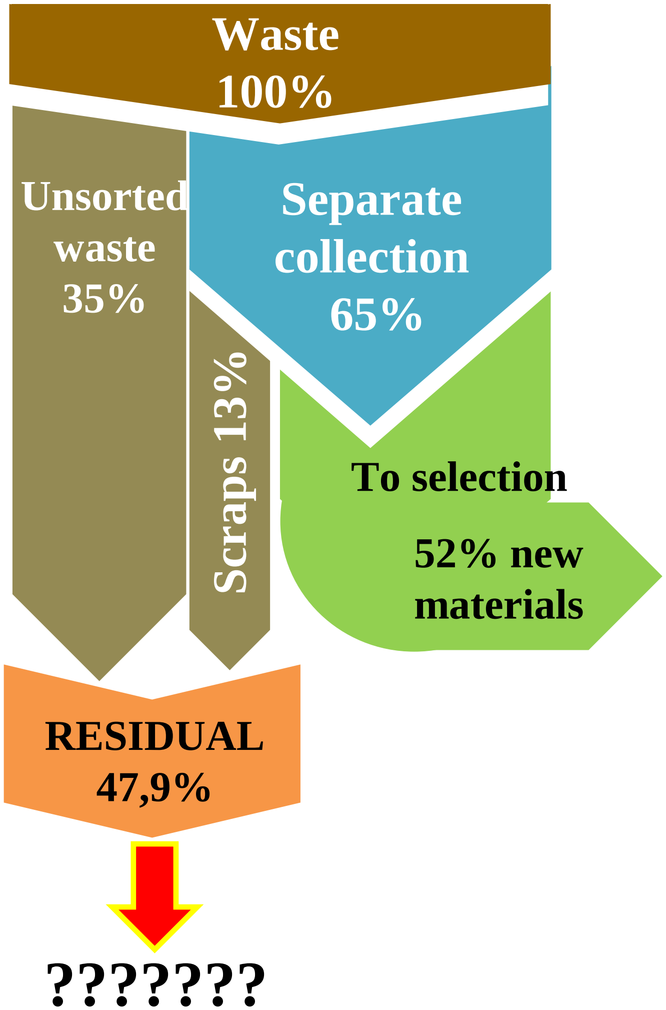
30-35%

(unsorted)

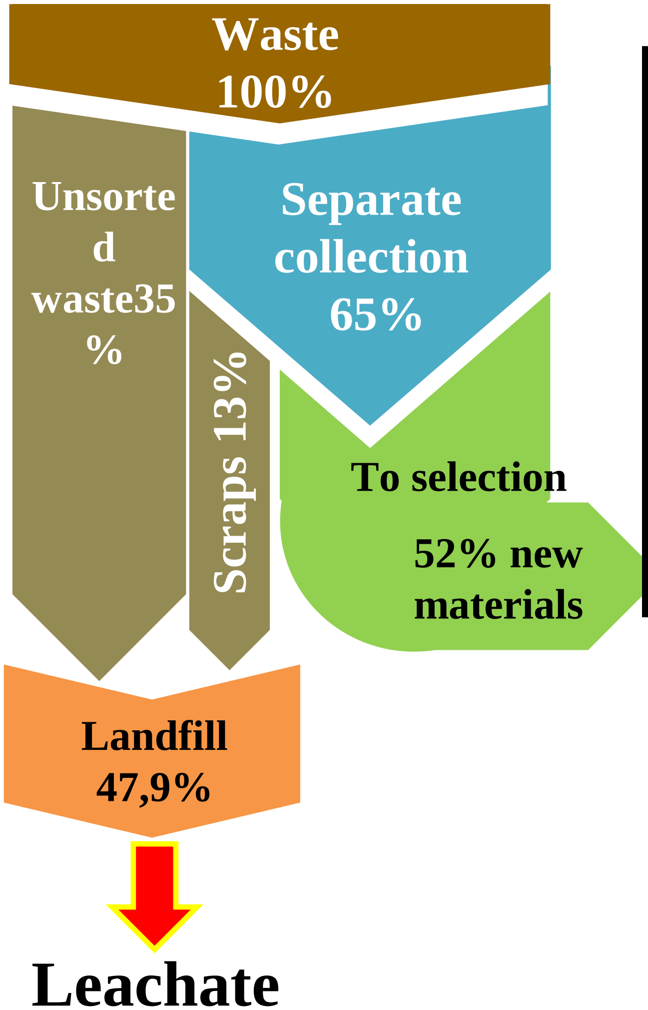
10-13%

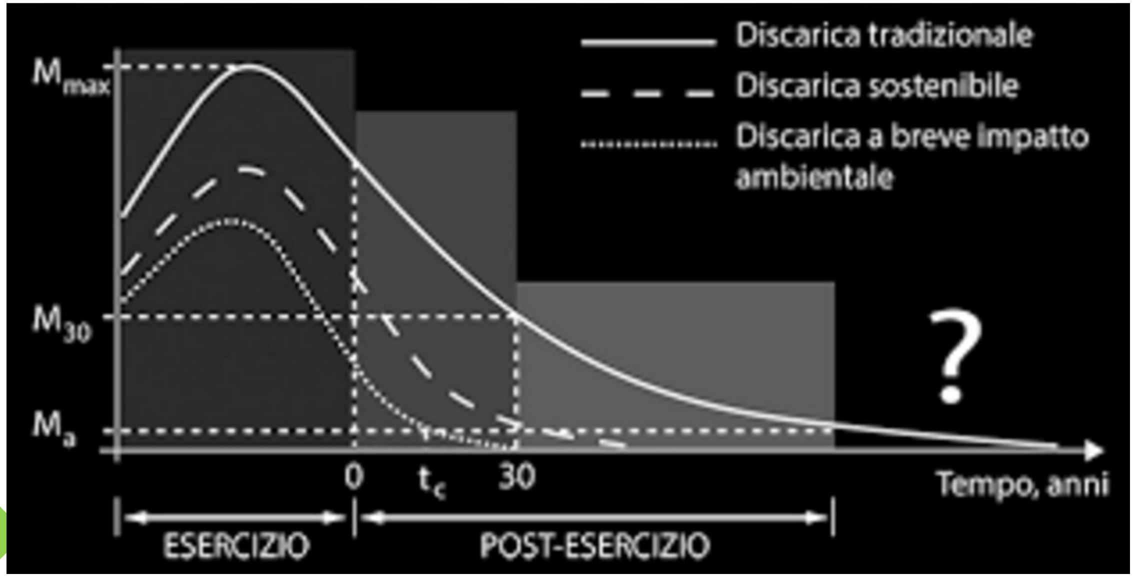
(Scraps)

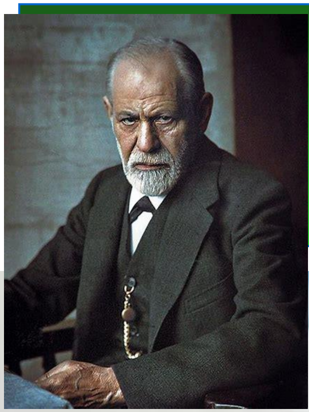
How to manage Residual waste (unsorted + scraps)???? The first fork..



Residual waste to landfill (less than 10% al 2035)

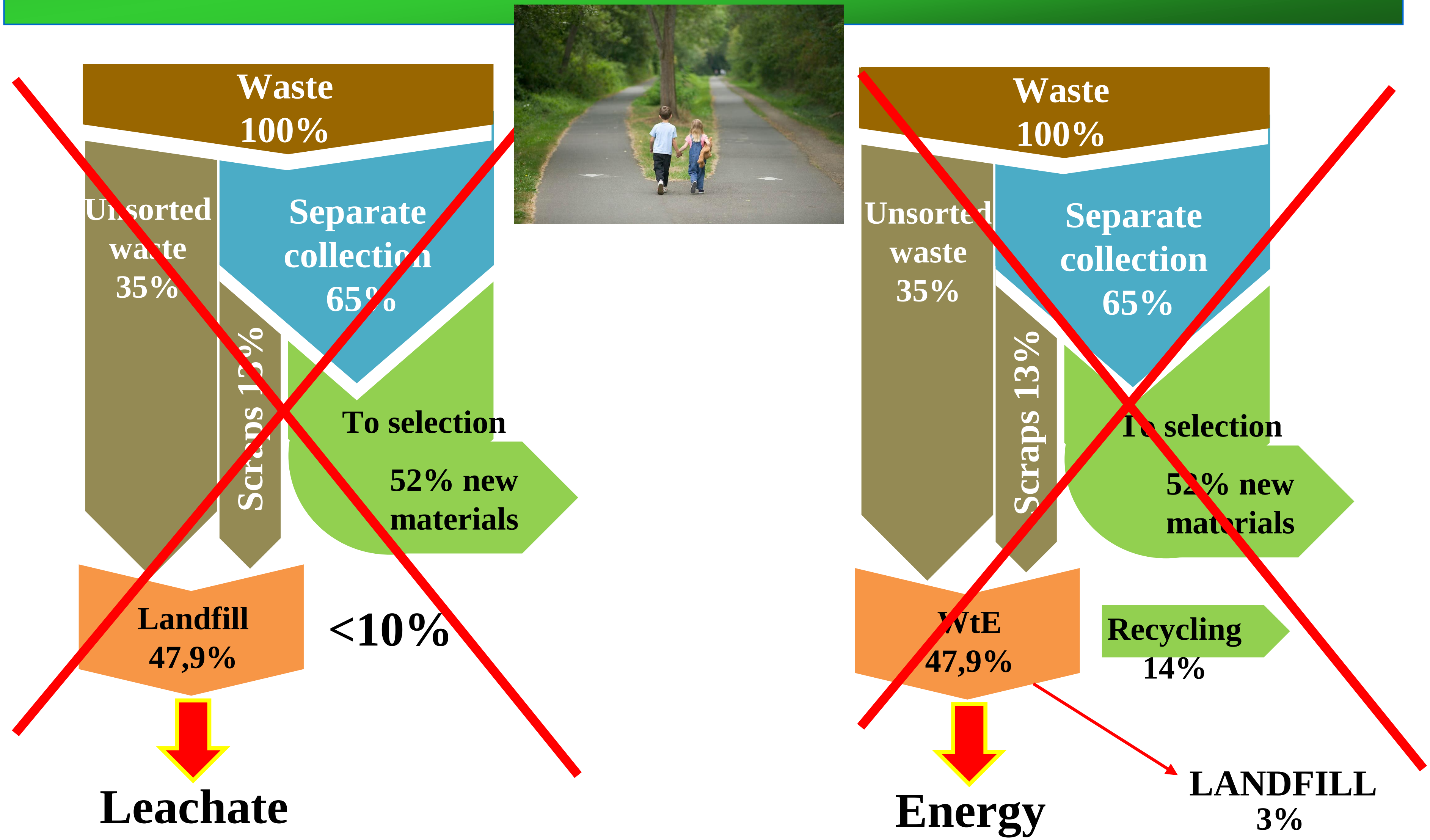






Accepting it…. really the first step

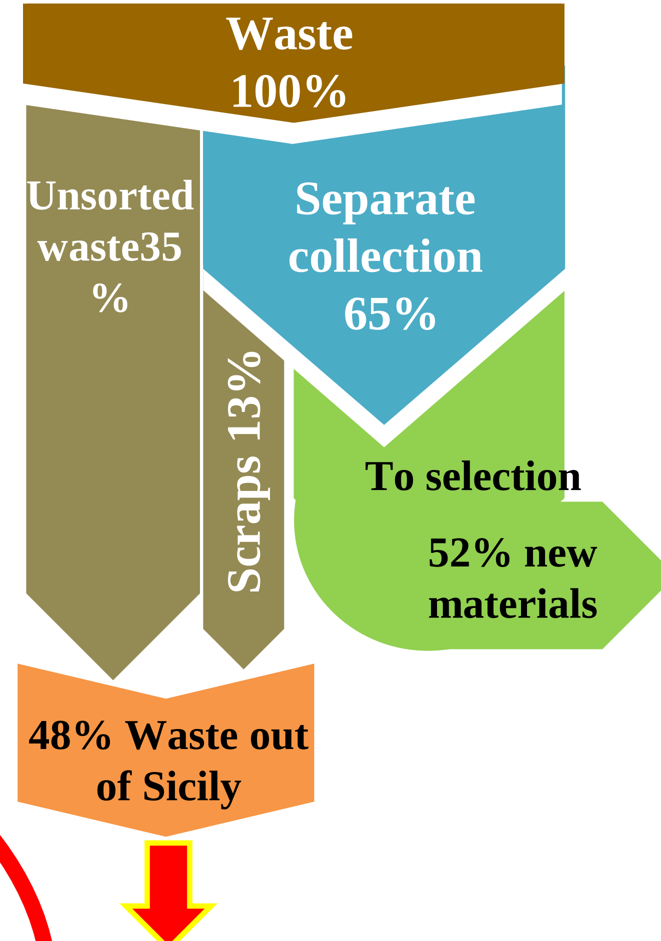
Management Alternatives



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



Economic losses… and RESILIENCE losses

The risks of the waste global market

How China's foreign waste ban has spurred the recycling industry

Fires at waste management plants in Italy

CORRIERE DELLA SERA

BRESCIA / CRONACA

AMBIENTE

Rifiuti, in Lombardia un incendio al mese: «Inquinare è un business, ora la terra dei fuochi è qui»

Quattro roghi su 10 si verificano al Nord, nell'ultimo anno in Lombardia è divampato un incendio al mese. Milano, Brescia e Pavia le province più colpite

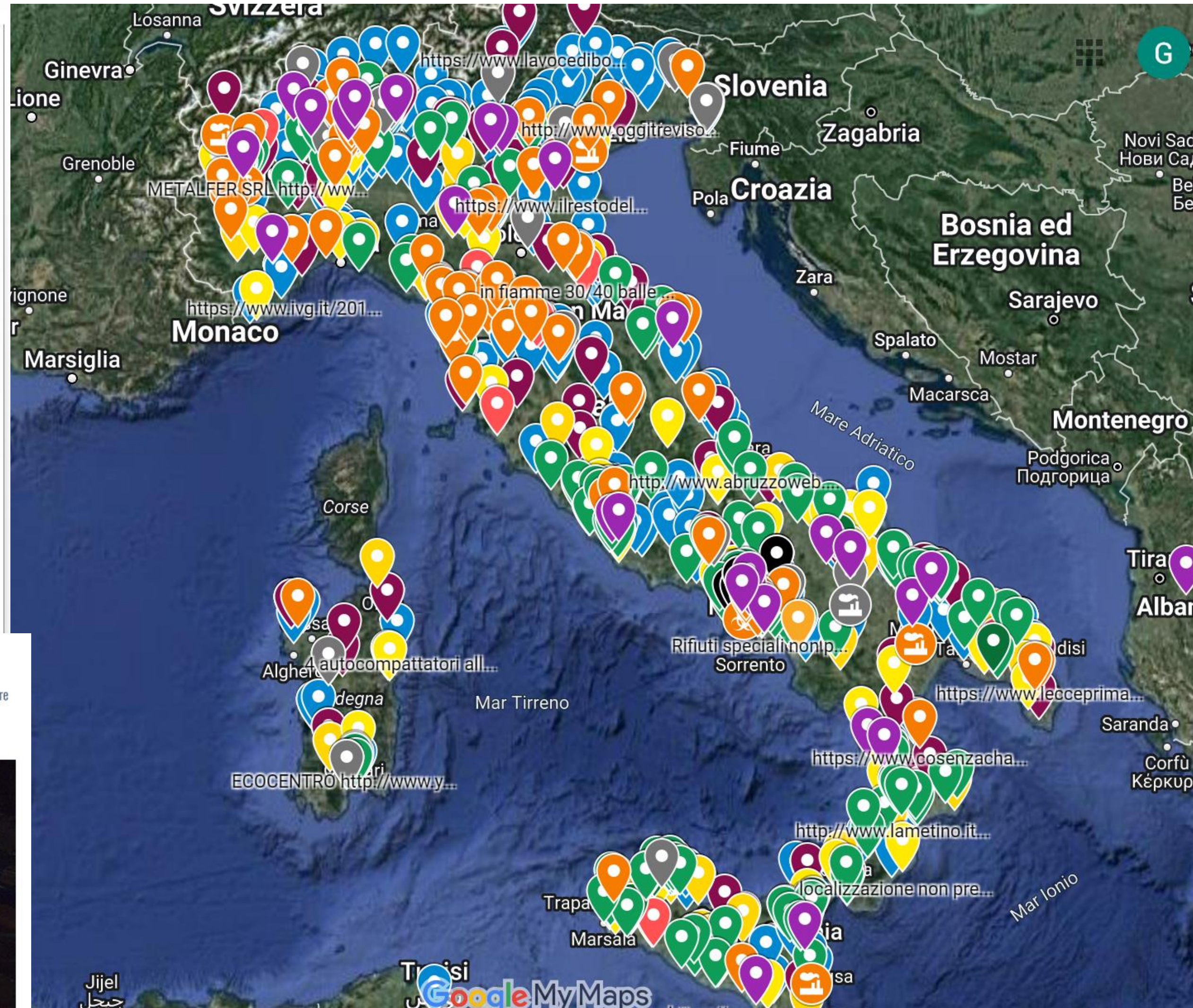
di Luca Rinaldi

522

Incendi e spazzatura, tutta l'Italia è come la Terra dei fuochi

Negli ultimi tre anni si contano 260 incendi in impianti di stoccaggio e recupero dei rifiuti. La maggior parte di origine dolosa. "Il rifiuto meno lo tratti e più guadagni", si sente in una intercettazione. Le anticipazioni della relazione della Commissione parlamentare d'inchiesta sui rifiuti

di Lidia Baratta



Context and open issues: climate change and drought

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Italy drought: 11 regions poised for state of emergency

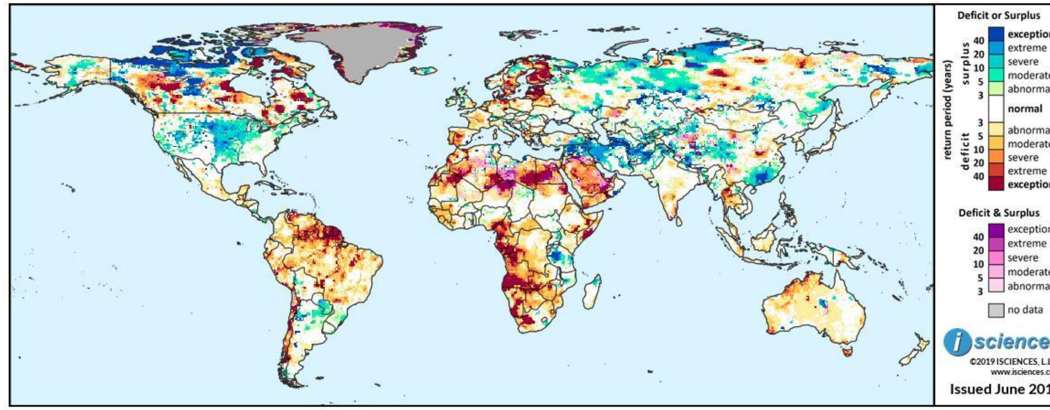
2 August 2017

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: High impacts from discharges and zero wastewater reuse

Context and open issues: sludge management

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

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

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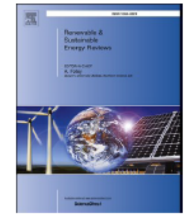

A water-waste-energy nexus approach to bridge the sustainability gap in landfill-based waste management regions

Published October 2020

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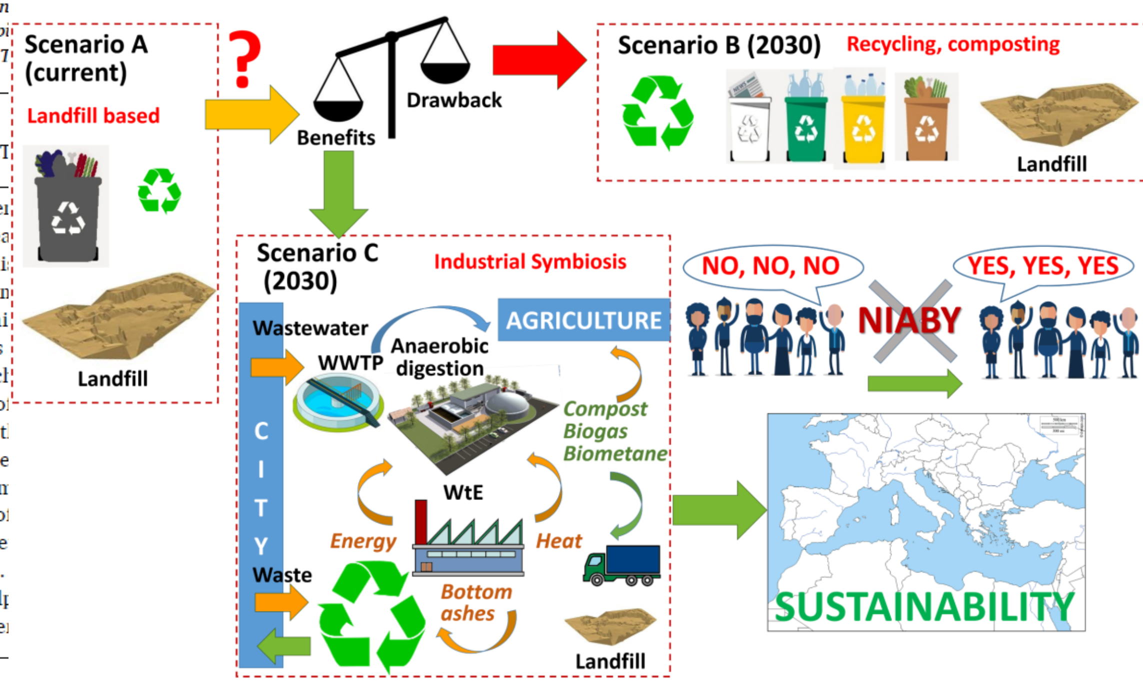
Circular economy
Green deal
Waste
Wastewater
Energy
Anaerobic digestion
Waste to energy
Nexus
Sustainability
Costs
Sludge
Biogas
Wastewater reuse
Landfill
Leachate

ABSTRACT

The present paper
evaluating the fea
are not fully utili
wastewater treatn
is able to maximi

The enormous
refinery approacl
allowing 100% o
reduced to less t
environmental be

Electricity fron
lower the costs o
water cost compe
fully sustainable.
dominant, to help
water manageme



2° review submitted TODAY

Energy

A reduction in global impacts through a waste-wastewater-energy nexus: a life cycle assessment

--Manuscript Draft--

Manuscript Number:	EGY-D-22-11037R2
Article Type:	VSI: Waste to energy in CE
Keywords:	waste, wastewater, Waste to Energy, Anaerobic Digestion, life cycle assessment, nexus
Corresponding Author:	Antonella Luciano, Ph.D ENEA National Agency for New Technologies Energy and Economic Sustainable Development Italy ITALY
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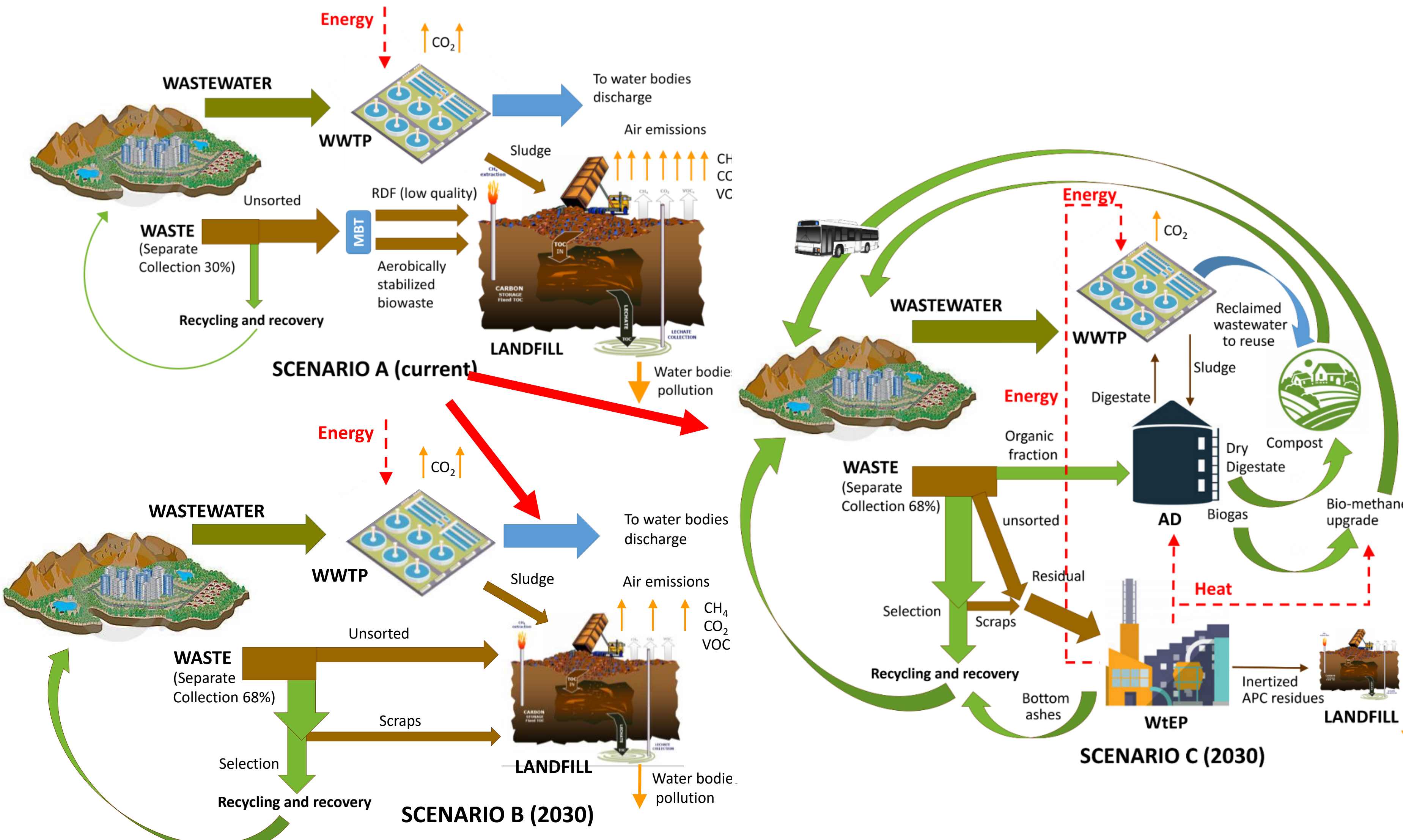
Order of Authors:	Giuseppe Mancini
	Lidia Lombardi
	Antonella Luciano, Ph.D
	David Bolzonella
	Paolo Viotti
	Debora Fino

Comparison of three scenarious

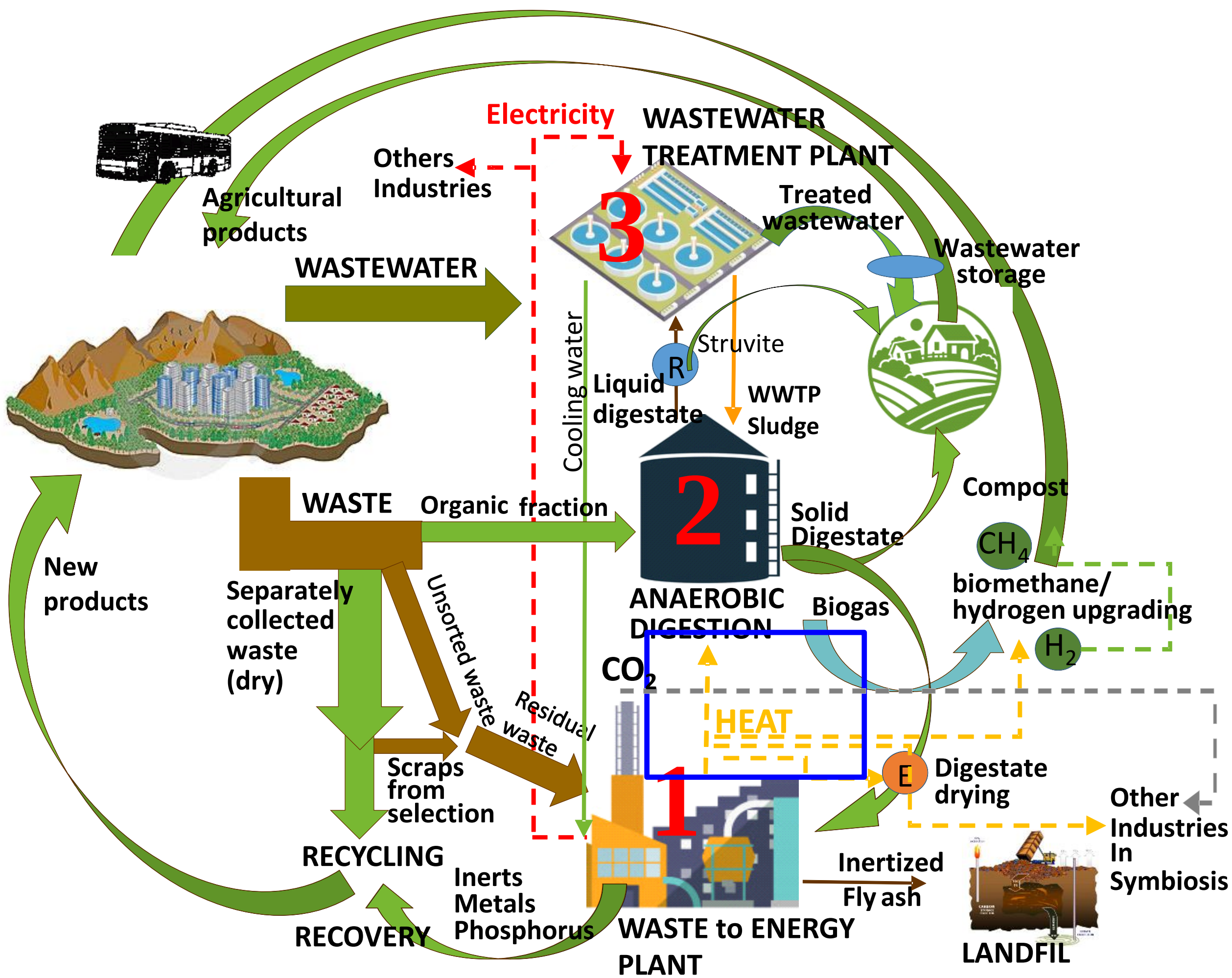


Industrial Symbiosis scenario

Symbiotic exchanges

1. Part of the **heat generated by waste-to-energy**, suitably commensurate through a well-dimensioned management of steam spills, can be used, also in **semi arid climate regions to carry out the AD in the thermophilic phase** reducing digestion times and volumes, increasing the biogas production yield with an advantage that also affects the **greater efficiency of sludge digestion compared to more traditional mesophilic processes.**

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

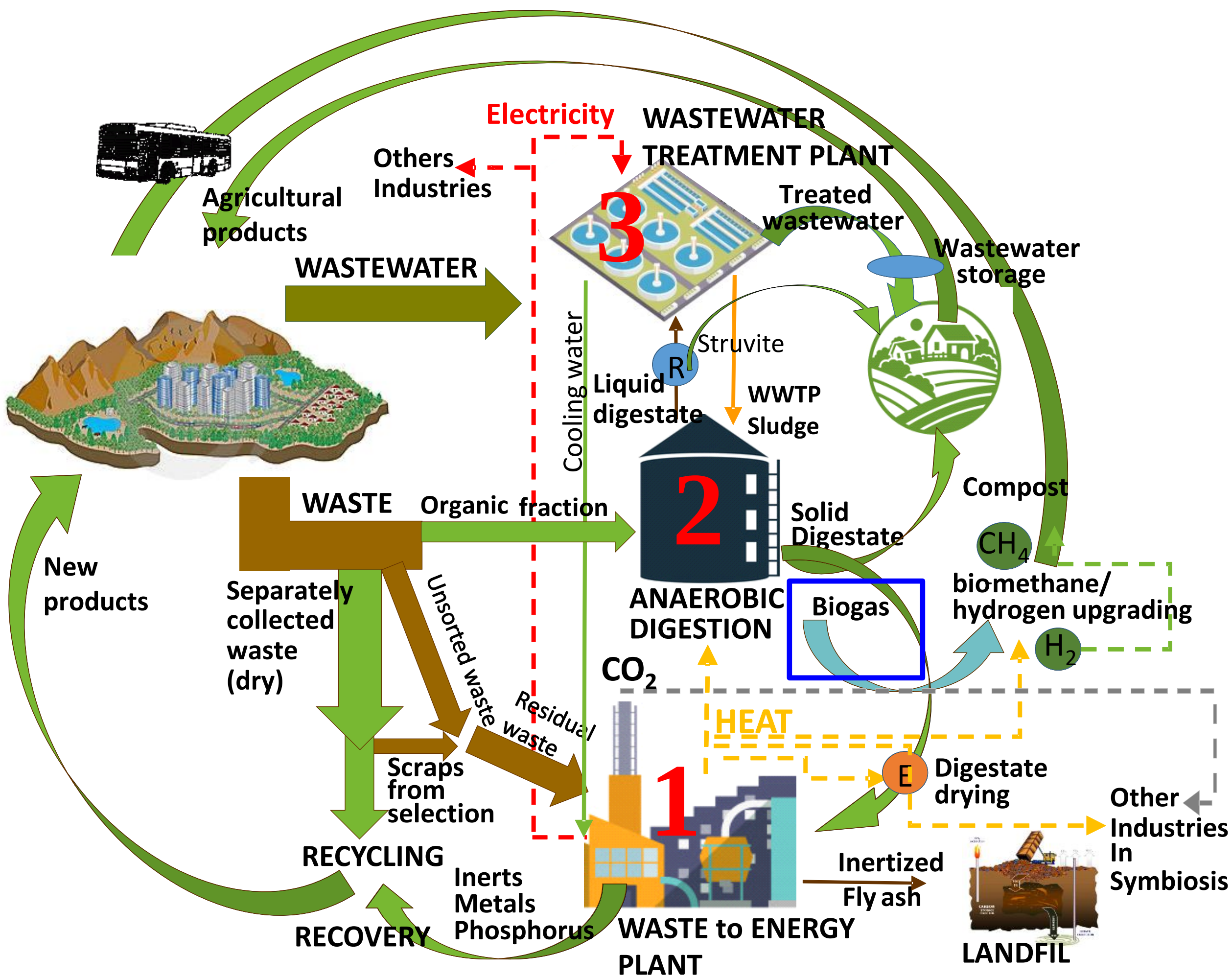


Industrial Symbiosis scenario

Symbiotic exchanges

2. **Also the recovery of the energy content of OFMSW is maximized** as it is no longer necessary to burn, in the boiler, part of the biogas produced by the same process. **The heat is now supplied by** the treatment of the residual fraction of MSW in the WtE plant. **The biogas produced can be totally converted into biomethane** thus maximizing any **economic incentives**.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

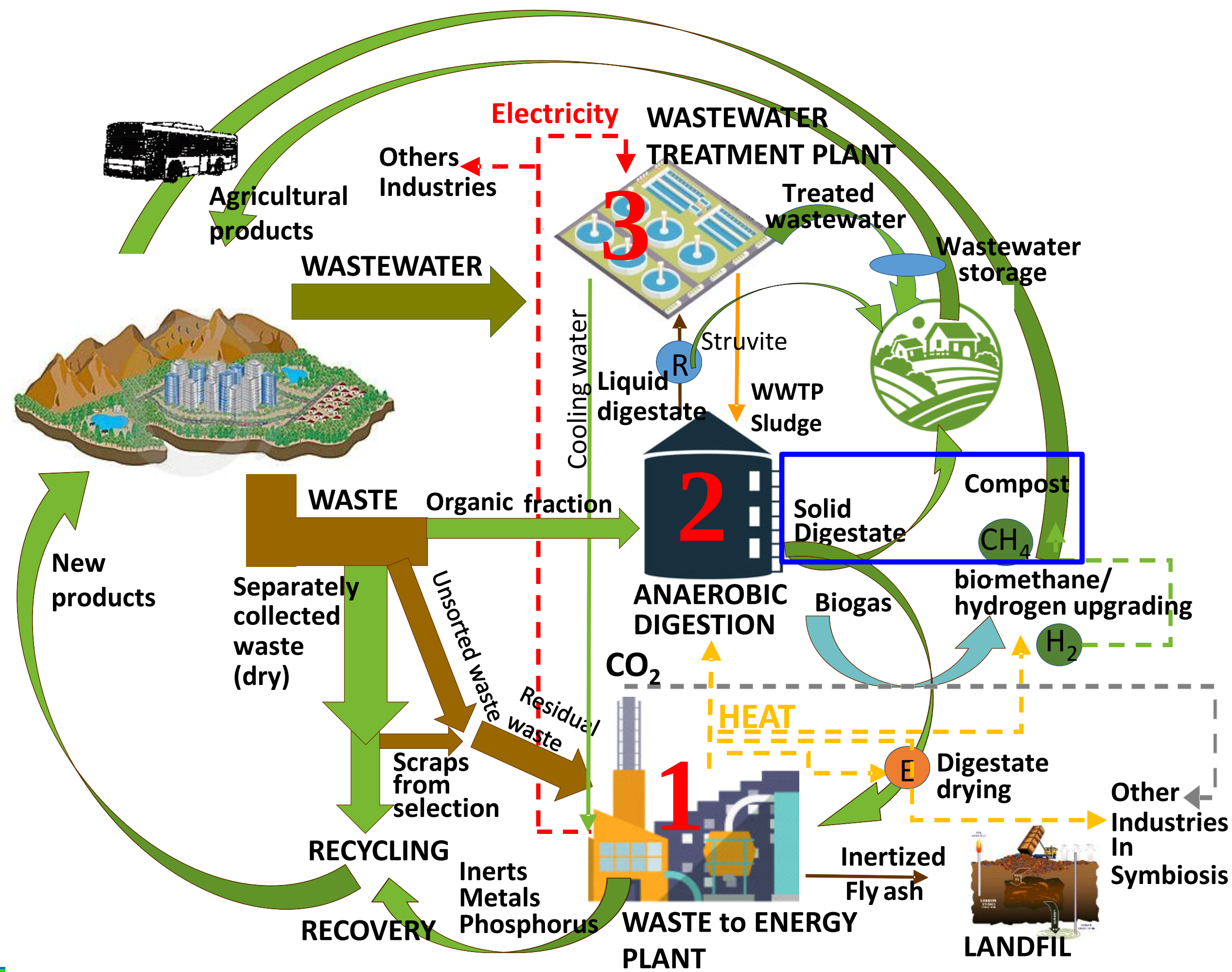


Industrial Symbiosis scenario

Symbiotic exchanges

3. **Energy demand for the treatment of OF waste is severely reduced,** leaving only the minimum residual **maturation phase** to the much more expensive energy-consuming **composting** with an **advantage in terms of direct and indirect CO_2 emissions** (for energy production) while still producing quality compost.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

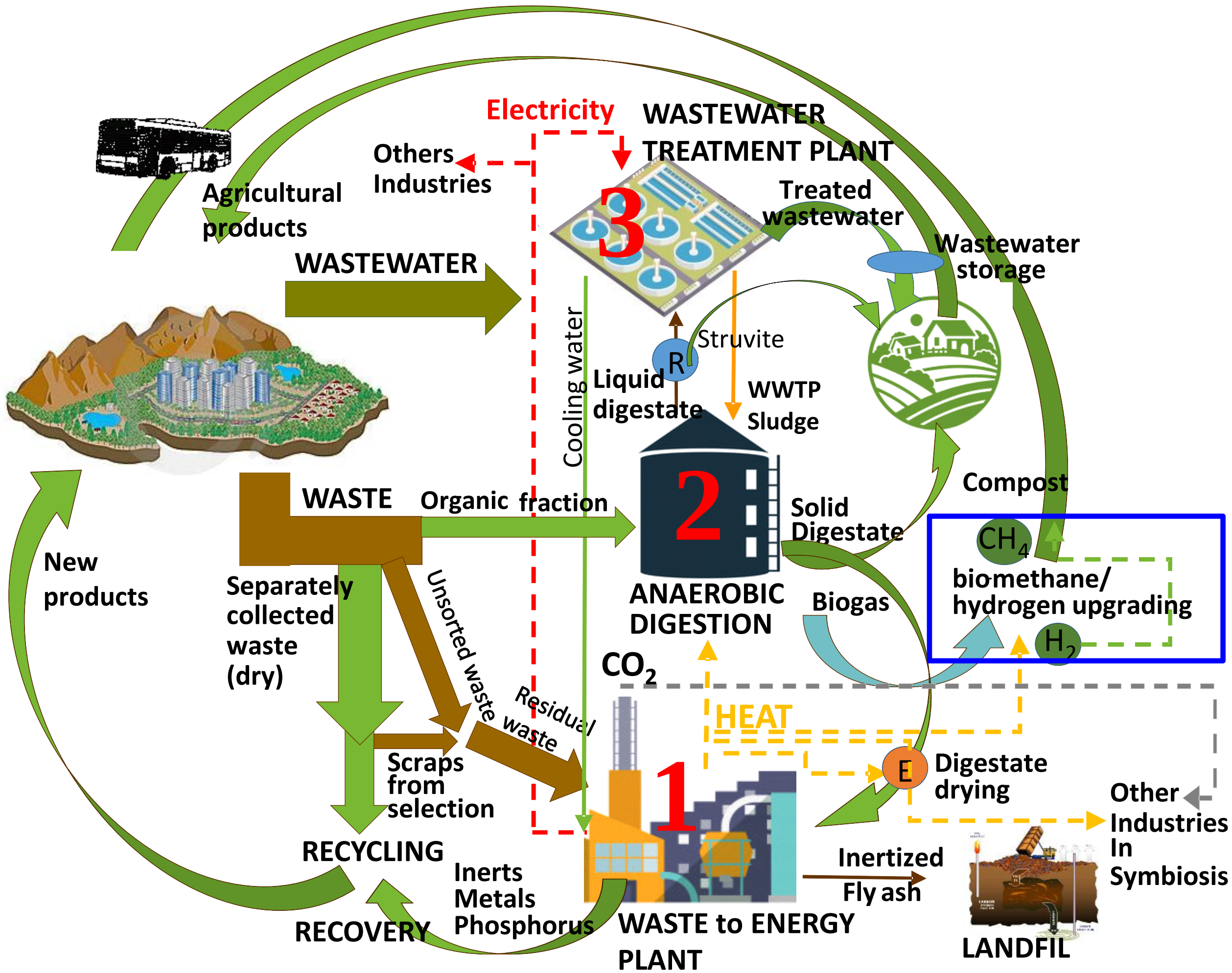


Industrial Symbiosis scenario

Symbiotic exchanges

4. Part of the **heat from waste-to-energy** could also be used in the process of **converting biogas into biomethane**, **reducing the costs for its use** in public transportation and waste collection trucks, **increasing the benefits of circularity for the territory** and further reducing GHG emissions;

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

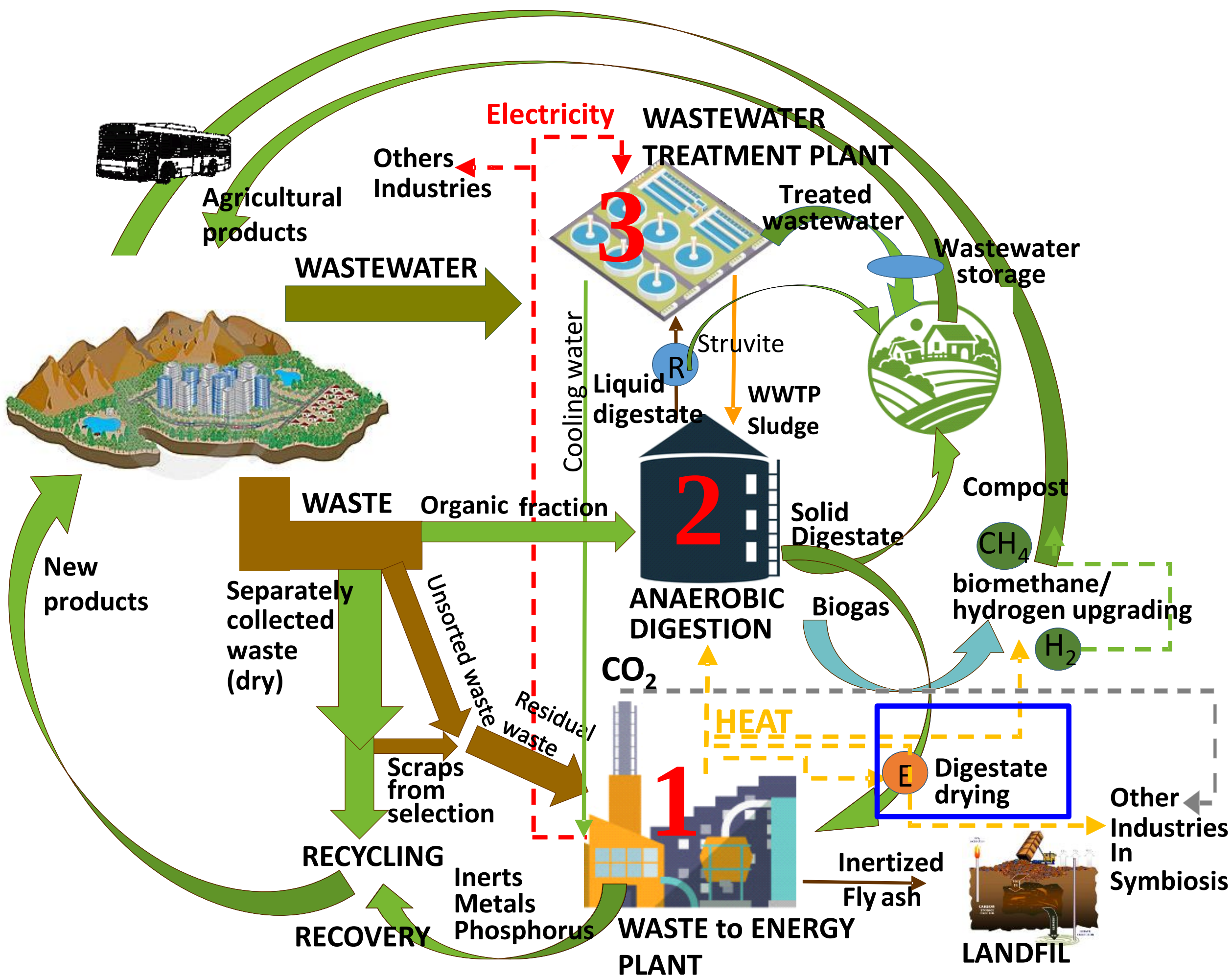


Industrial Symbiosis scenario

Symbiotic exchanges

5. Part of the **heat from waste-to-energy** can be used to **<u>pre-drying</u> the dewatered digestates (sludge of even both)** with a view to their **energy recovery,** in a dedicated line of the waste-to-energy plant, which also collects **contributions from other smaller nearby plants**, to ensure **recovery of phosphorus from the ashes** and **eliminate the problem of final disposal (ZERO DISCHARGE)**.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

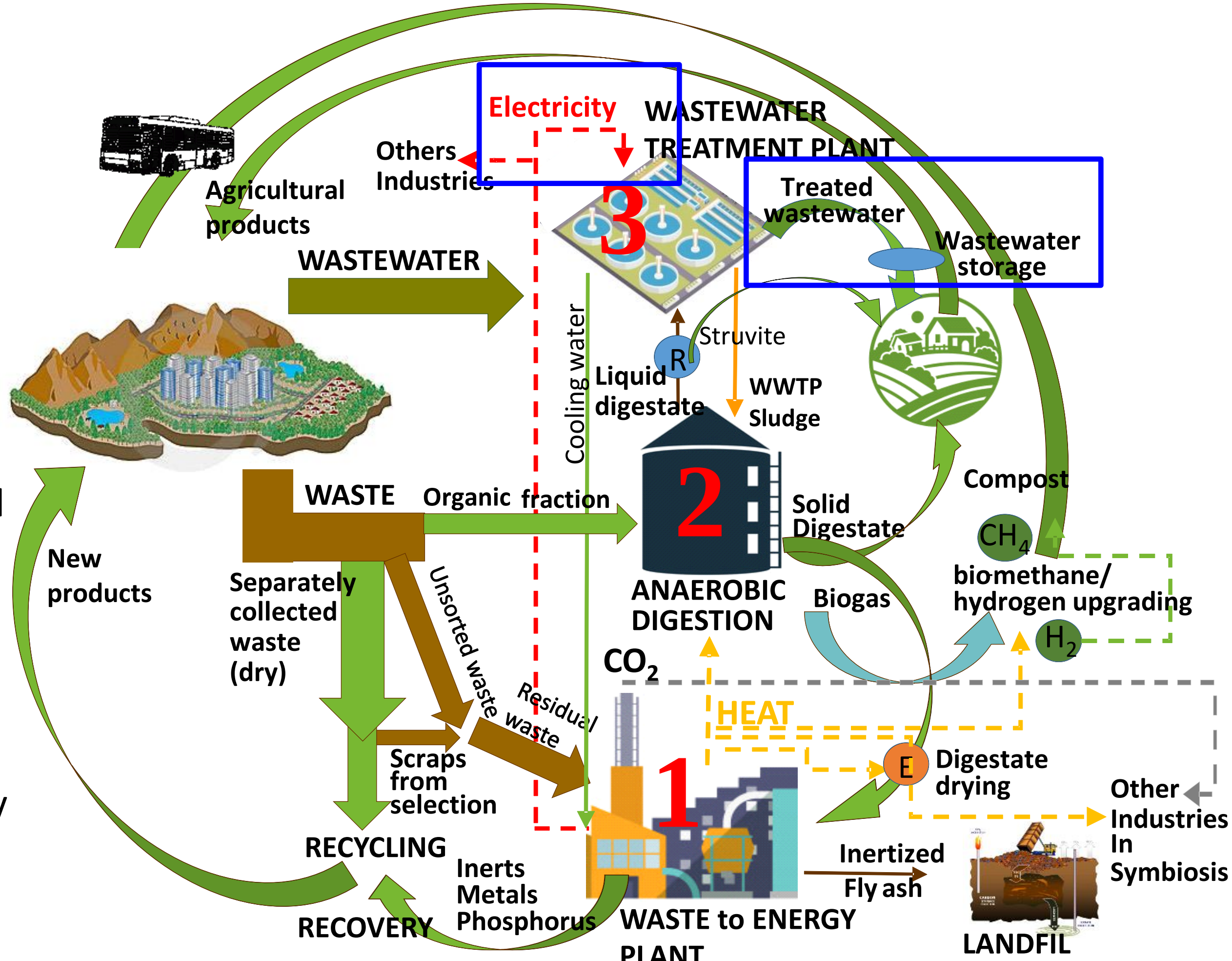


Industrial Symbiosis scenario

Symbiotic exchanges

6. The **electricity produced by the WtE plant** can be partially used (a few percentage units) to **support the tertiary treatment** phase **and pumping of the treated wastewater to the agricultural areas** in order to make the **cost of the treatec wastewater competitive**, guaranteeing its **full reuse avoiding** that the **concentrated load** is discharged into water bodies with the **related impacts**, especially in islands and coastal areas **(ZERO DISCHARGE GOAL)**. The huge amount of remaining electricity can go to the market.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis



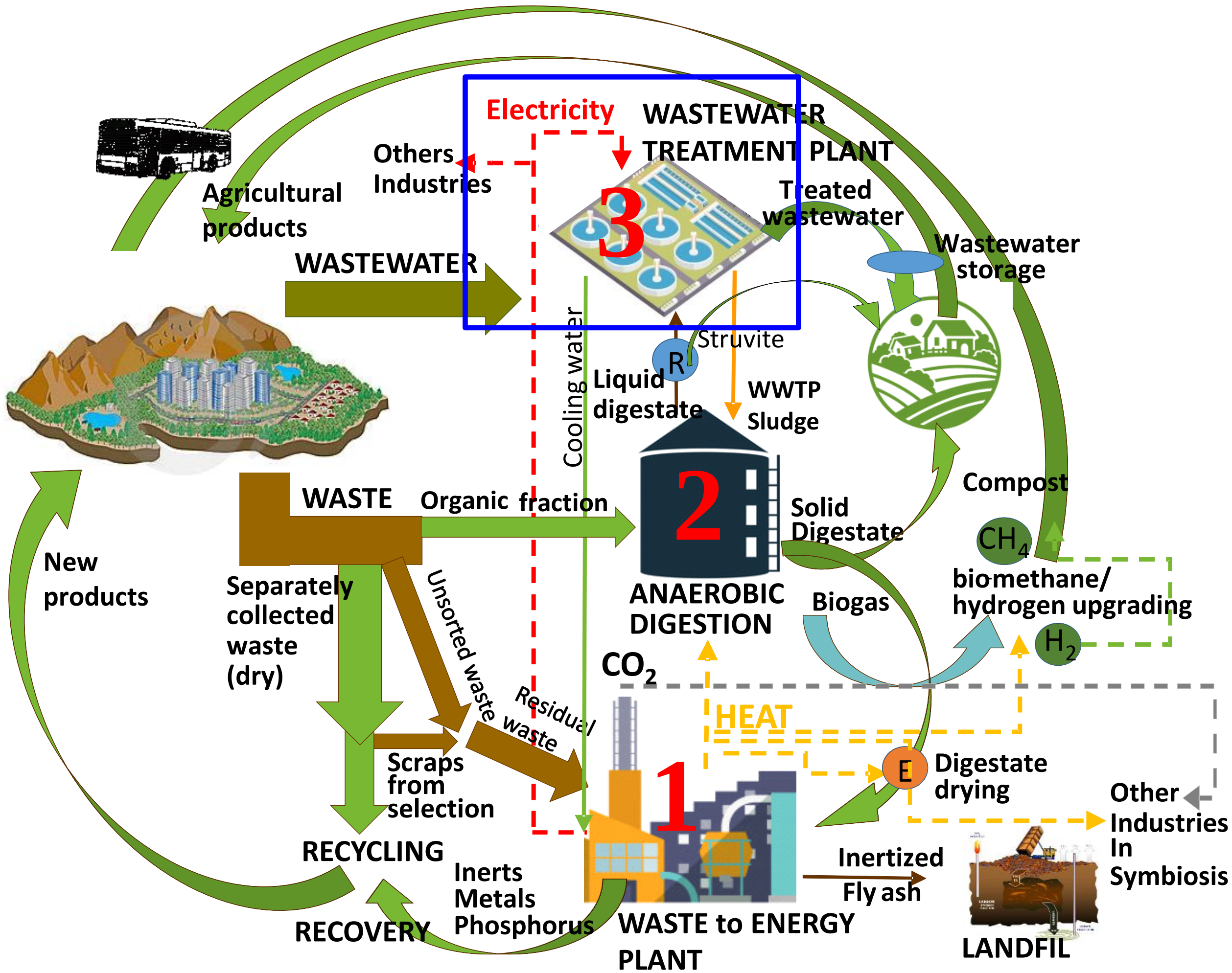
Industrial Symbiosis scenario

Symbiotic exchanges

7. A further part of the **electricity produced by the WtE** plant could be used **to support the entire wastewater treatment process** in full view of industrial symbiosis (**Almost ZERO CO_2 Emissions Goal**).

- The oxidation phase in the water line should in any case be conducted as a classic scheme with a high load to minimize energy consumption, taking into account subsequent reuse also through a **limitation of denitrification**.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

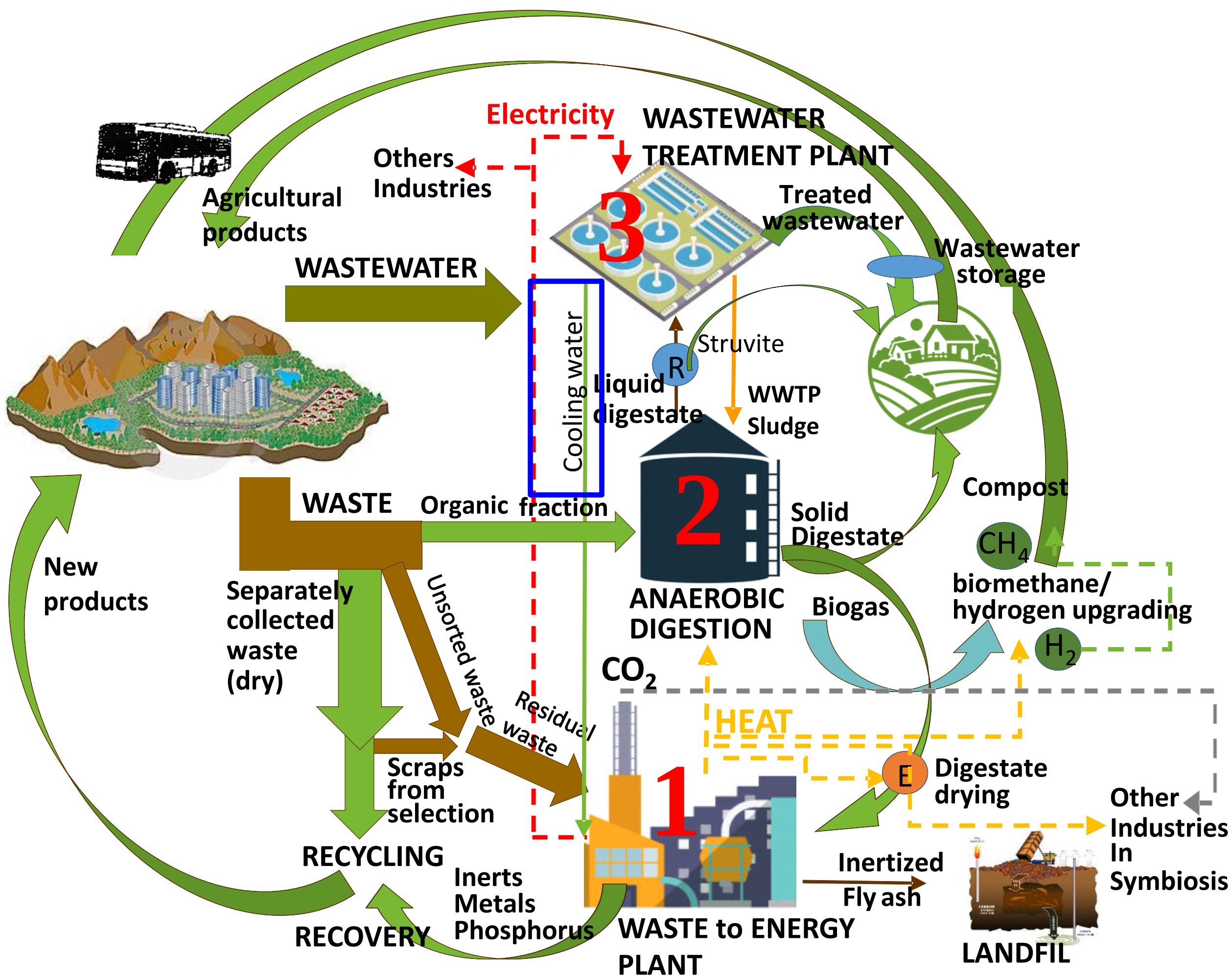


Industrial Symbiosis scenario

Symbiotic exchanges

8. Part of the purified effluent can be used as **cooling water for the waste-to-energy plant**, saving a precious resource for other uses and **increasing** the overall **circularity** of the proposed system.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis

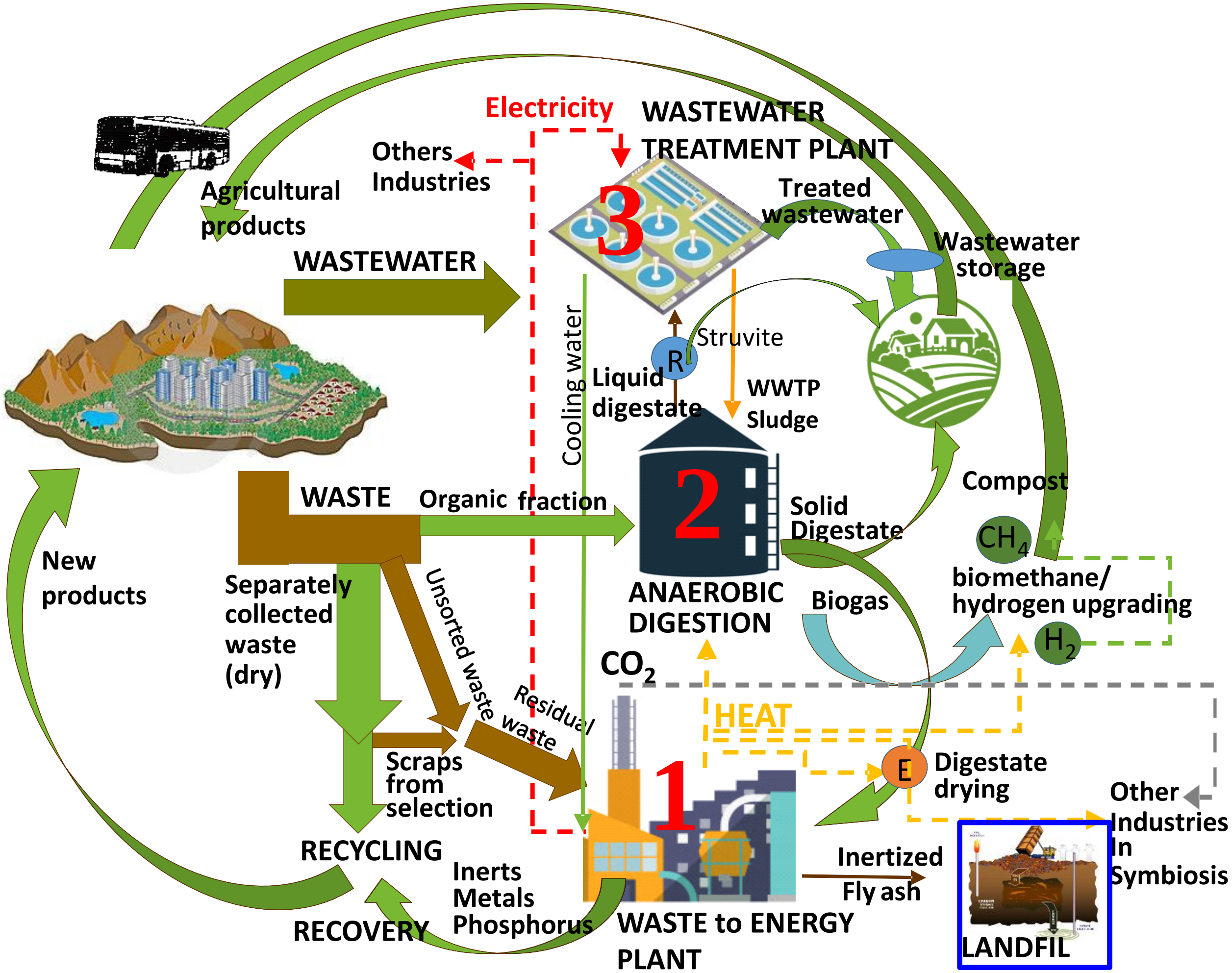


Industrial Symbiosis scenario

Symbiotic exchanges

9. The **residual fraction and non-recyclable waste are reduced in volume** (about 10%) by reducing the landfill requirement and the consequent impacts.

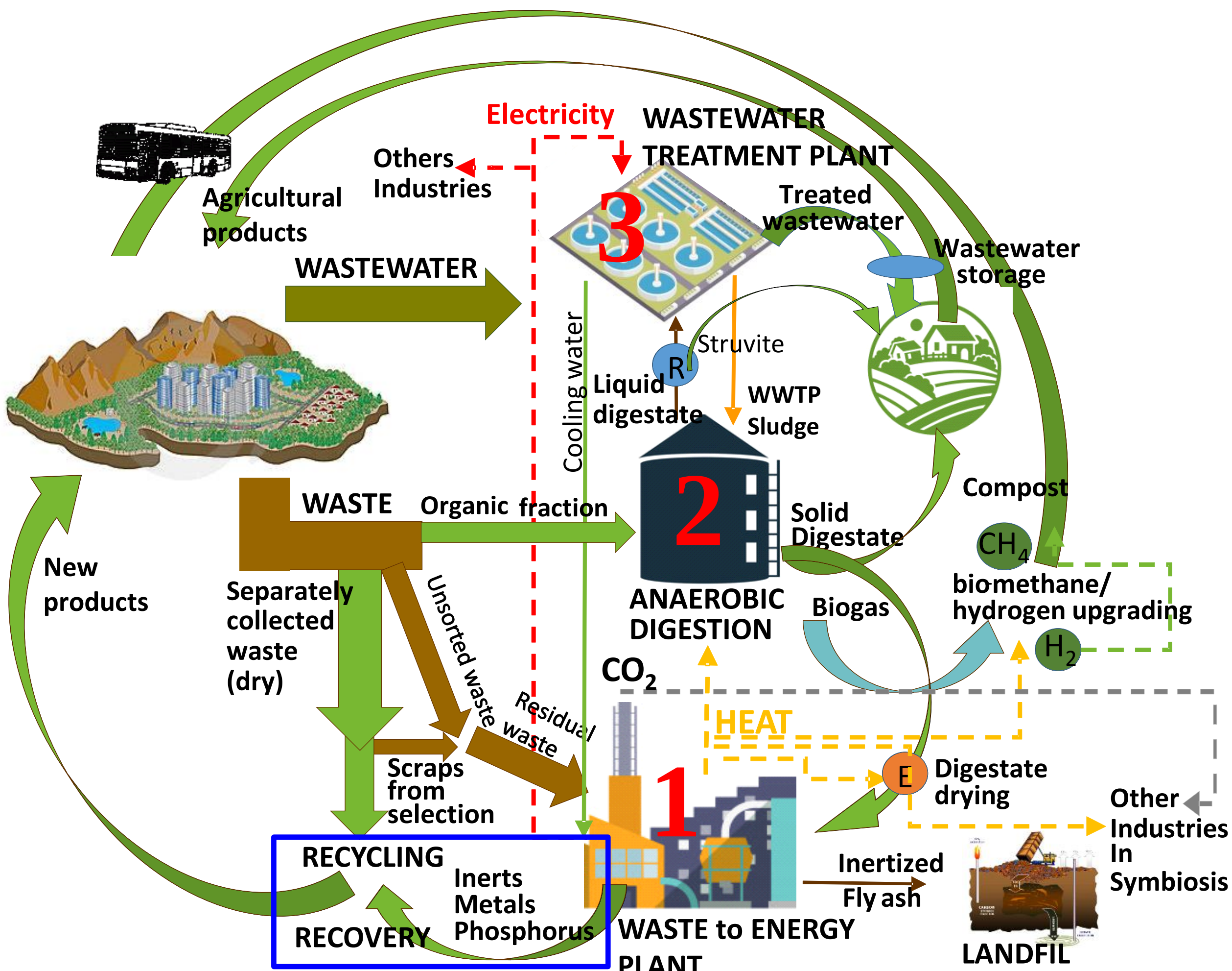
The Waste-Wastewater-Energy Nexus through Industria Symbiosis



Industrial Symbiosis scenario

Symbiotic exchanges

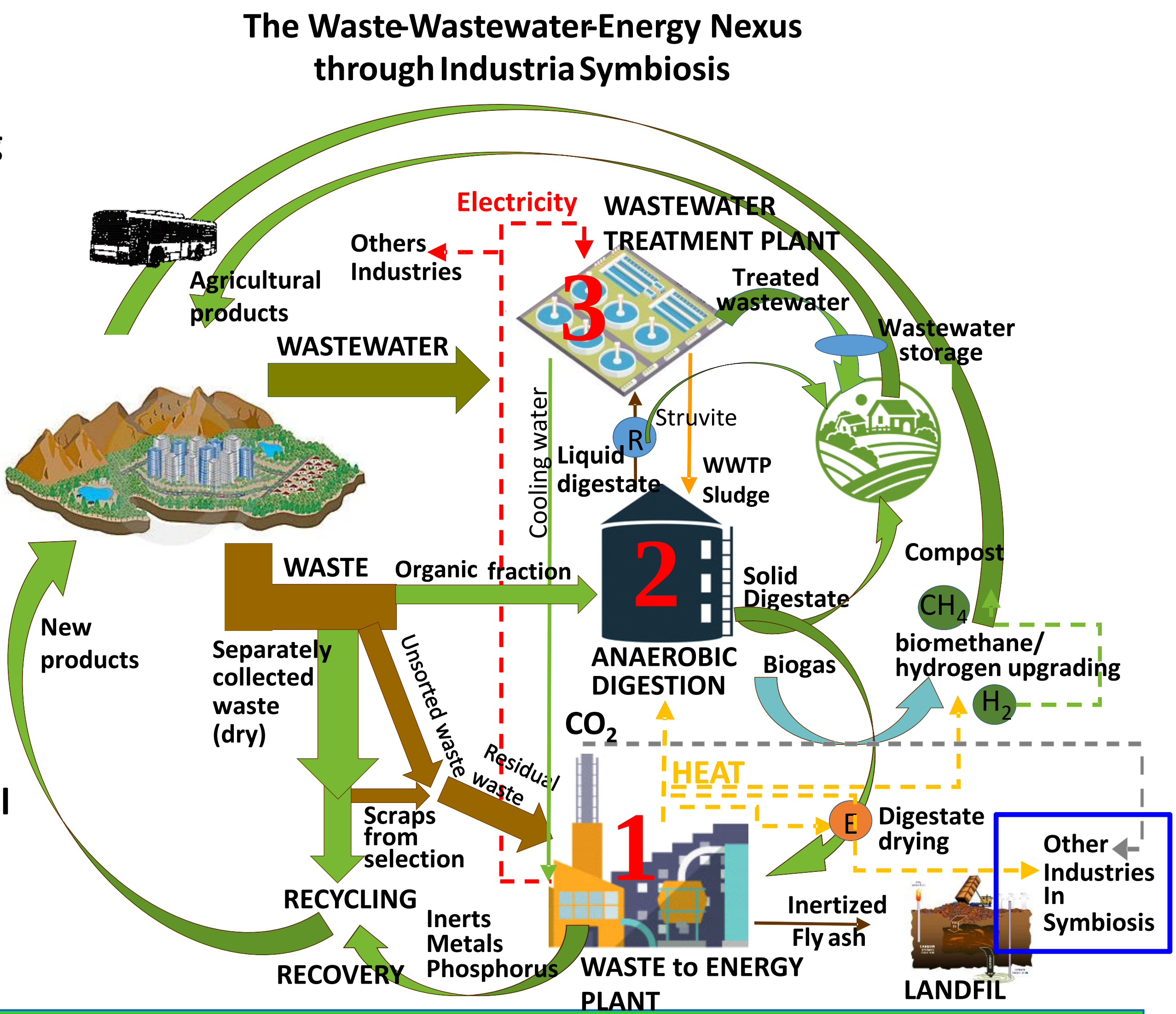
10. Thanks to the **recovery of bottom ashes** in construction materials, the **reduction of waste to be disposed of in landfills could be further limited to only inertized fly ash** (approximately 2-4% of the total waste, in full **compliance** with the **European directives (**which set the limit of 10% by **2035**). This allows to **increase the overall recycling of materials** (+5-10%) of the total waste depending on the residual portion) - significantly increasing the circularity of the entire system **helping to respect Recycling EU Directives**.



Industrial Symbiosis scenario

Symbiotic exchanges

11. Part of the **heat from WtE** can be used to support **surrounding industries** (existing or wishing to enter the industrial district) by **exploiting the residual heat at advantageous conditions for their processes** (e.g. agri-food process industry), in addition to any **heating and cooling needs**, in full view of industrial symbiosis with a consequent reduction of their CO_2 emissions.
12. Part of the **heat from WtE** can also be used to **pre-drying biomasses from the agricultural sector** before their energy recovery in the same waste-to-energy plant, reducing disposal problems;

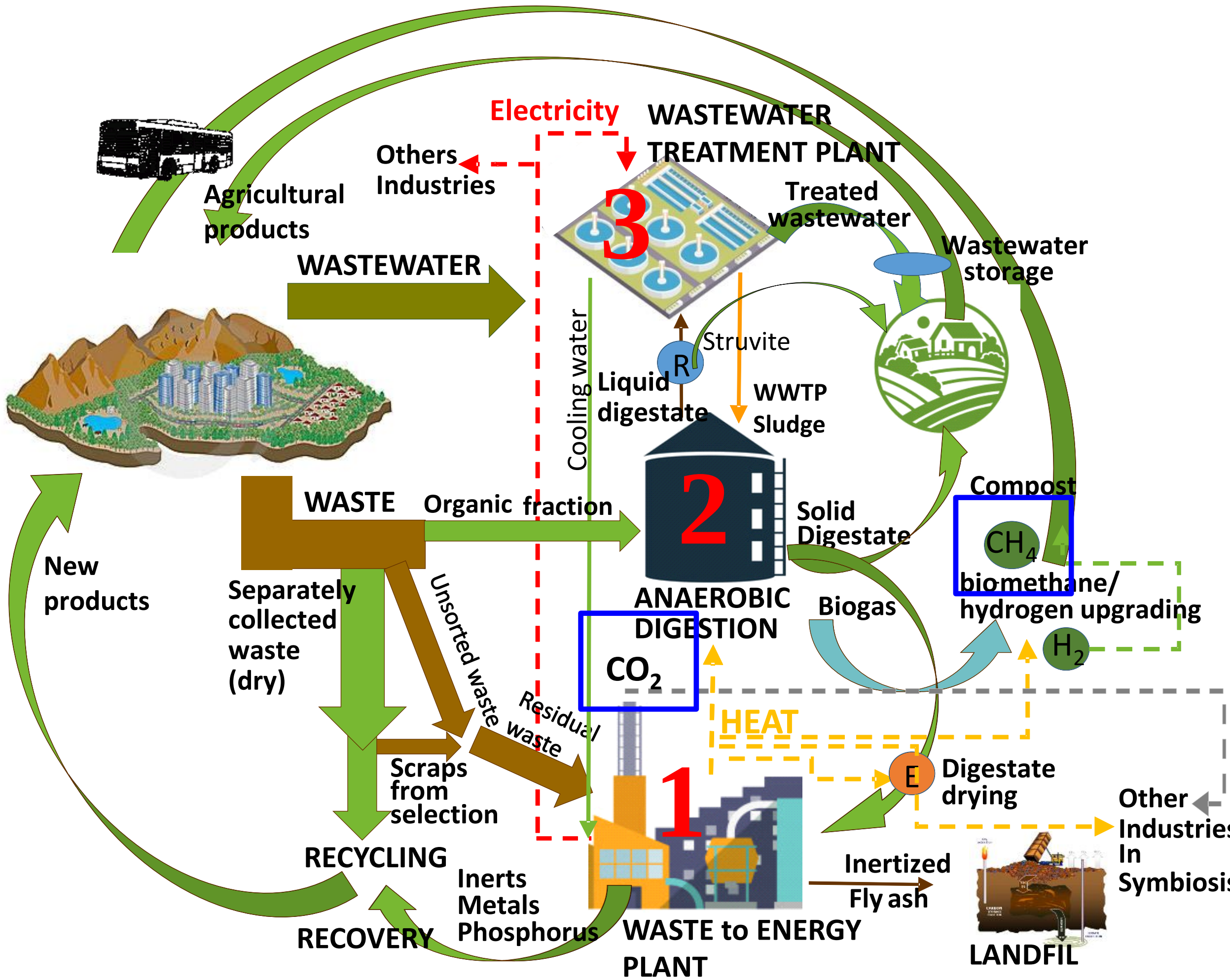


Industrial Symbiosis scenario

Symbiotic exchanges

13. A part of the **CO_2 produced by the conversion process into biomethane** and/or contained in the fumes of the waste-to-energy plant **could be recovered (e.g. converted into algal biomass** to be used for **high added value products).**

The Waste-Wastewater-Energy Nexus through Industria Symbiosis



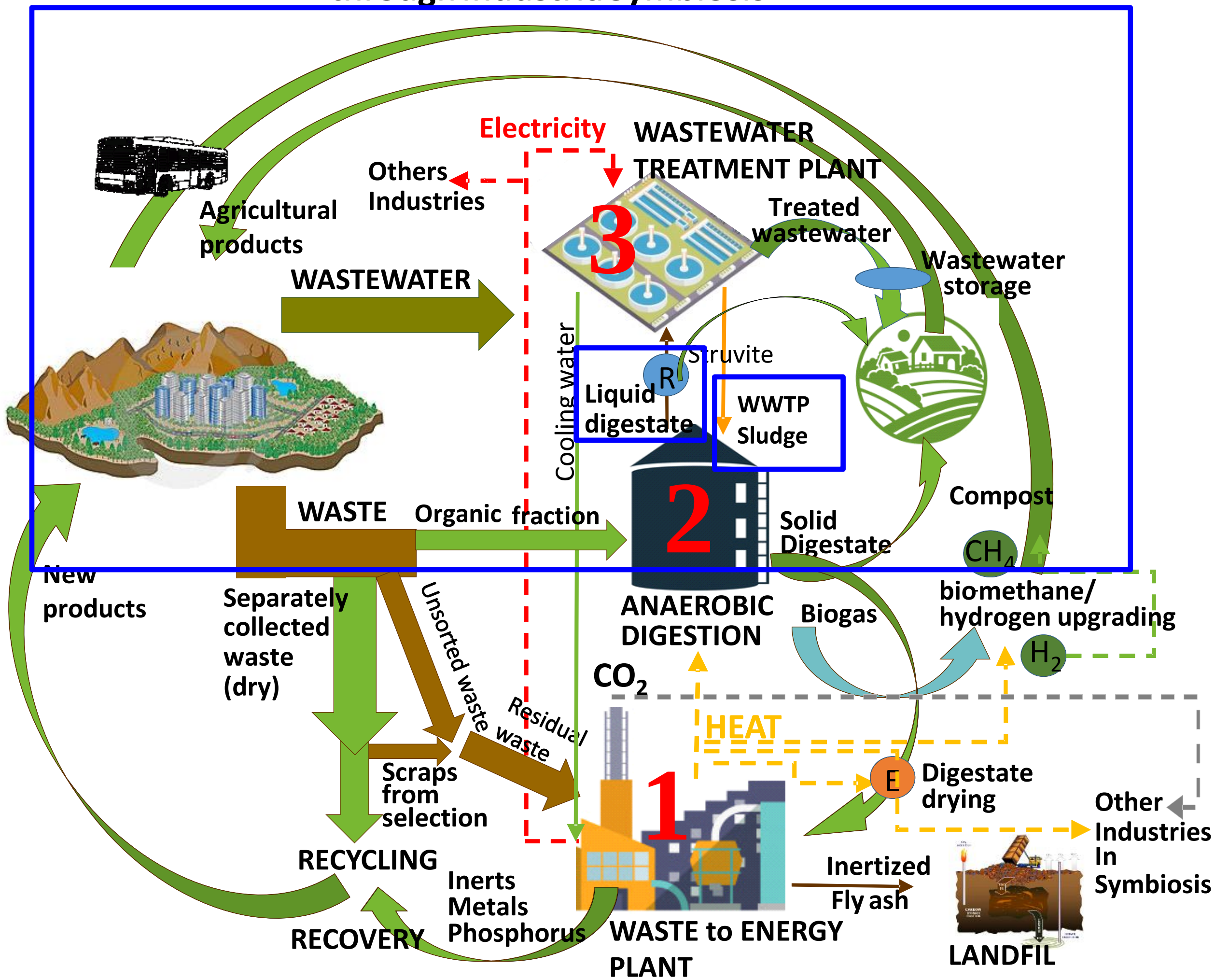
Industrial Symbiosis scenario

Symbiotic exchanges

14. The liquid fraction of the digestate can be recirculated to the WWTP as effluent, greatly reducing management costs (with direct/indirect recovery of nutrients)

15. The composted digestate and the wastewater contribute to increasing the agricultural yield by favoring a closure of the organic cycle.

The Waste-Wastewater-Energy Nexus through Industria Symbiosis



A rough energy balance

Energy required for the WWTP (year) 9,9 GWh
Energy required for tertiay treatment +pumping (year) 20,2 GWh

Heat requirement for sludge digestion (year) 14,2 GWh

Heat requirement for sludge drying (year) 29 GWh

WtE Electricity production (year) 452,6 GWh

Wastewater

Waster Organic fraction + sludge

Residual waste+scraps

62

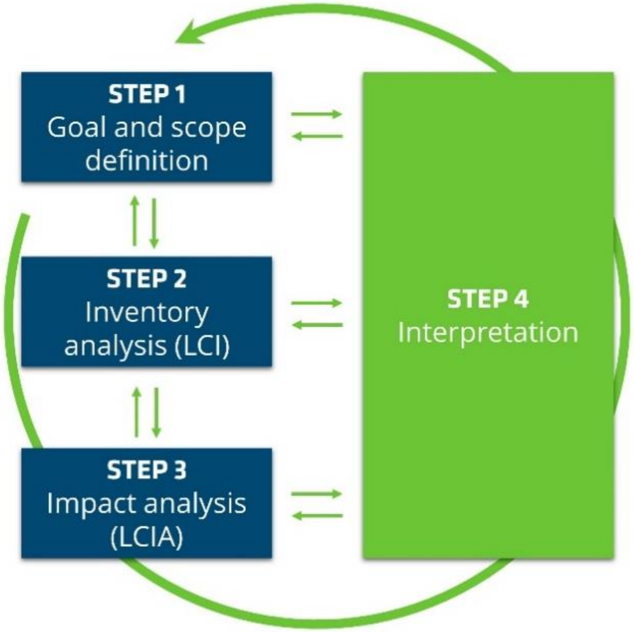
Heat requirement for OF digestion (year) 19,4 GWh

Heat requirement for digestate drying (year) 112 GWh
(

WtE Heat production (year) 726,1 GWh

Other Companies
(district heating and cooling)

Life Cycle Assessment



Life-cycle thinking

SUSTAINABLE CIRCULAR ECONOMY

- Impact assessment method Product Environmental Footprint (PEF) → **climate change**
- software SimaPro 9.1.0.7
- database Ecoinvent 3

LCA – Goal and scope definition

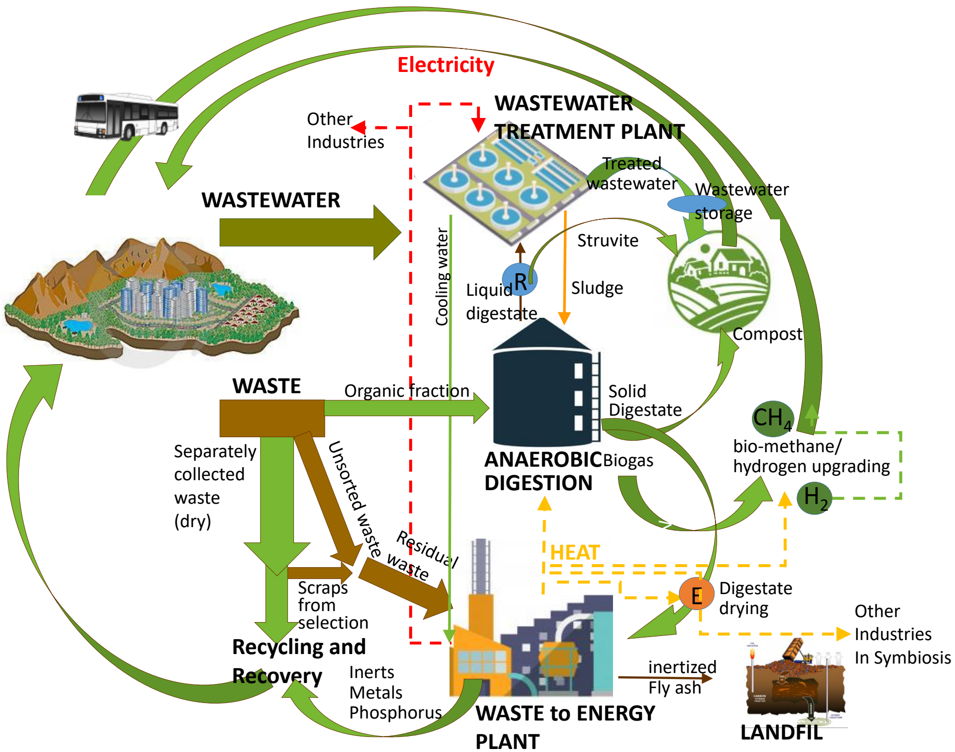
GOAL:

Comparison of three scenarios:

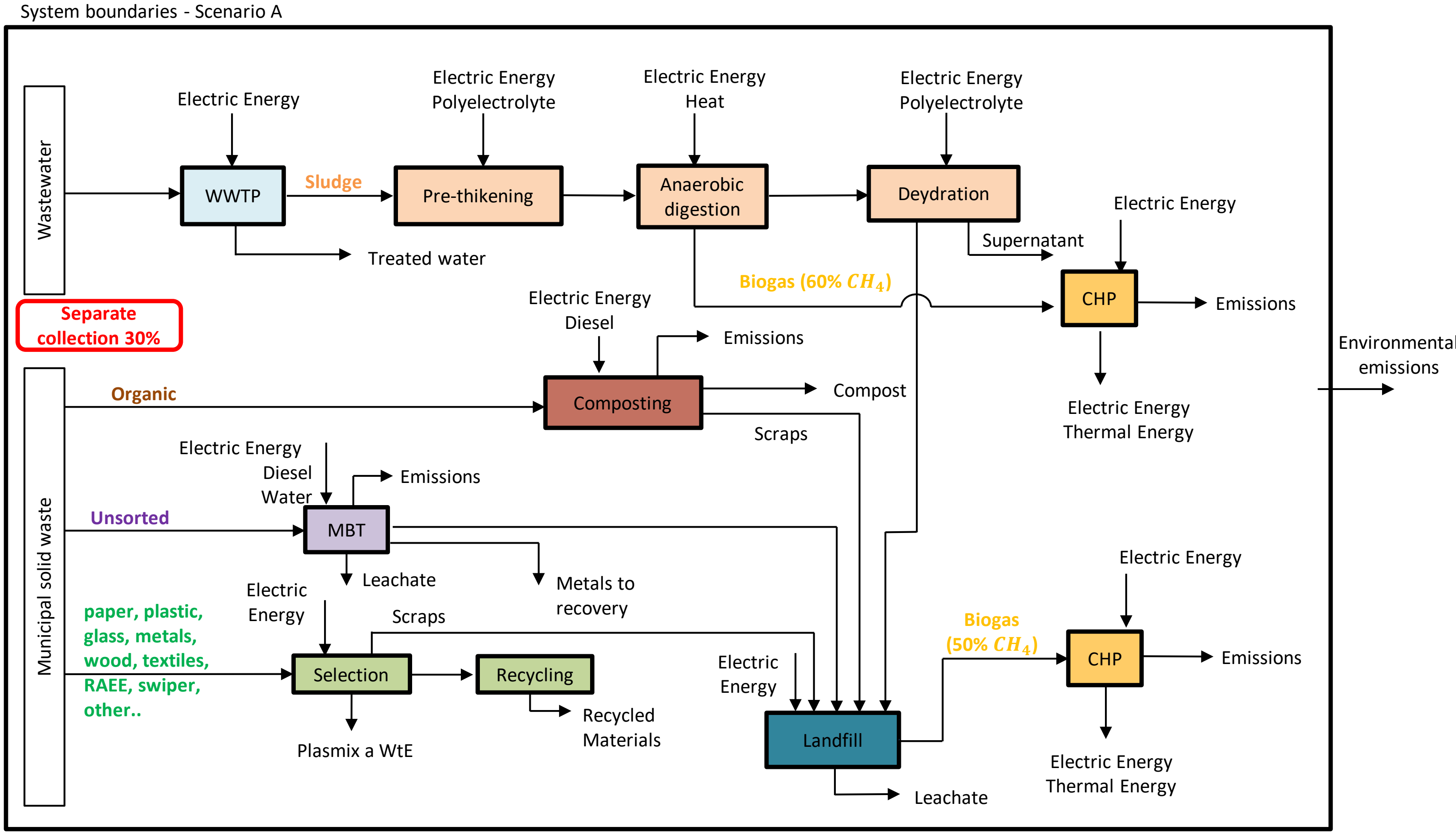
- current scenario (A)
- future scenario (B)
- **Improved future scenario by symbiosis (C): holistic approach fully exploiting the water-waste-energy nexus**

FUNCTIONAL UNIT:

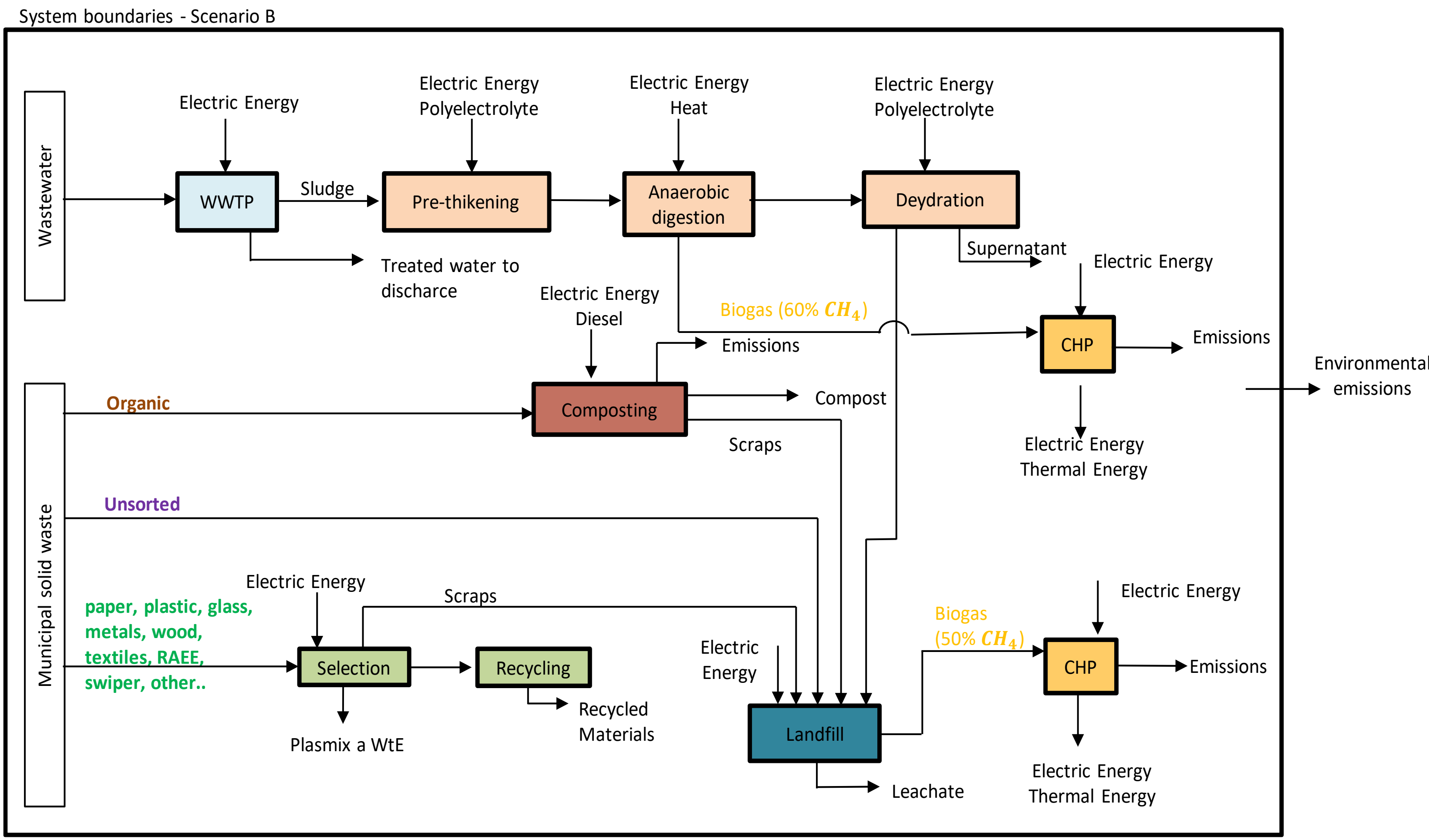
- Annual production of MSW in the reference metropolitan area
- Annual production of urban wastewater in the reference metropolitan area



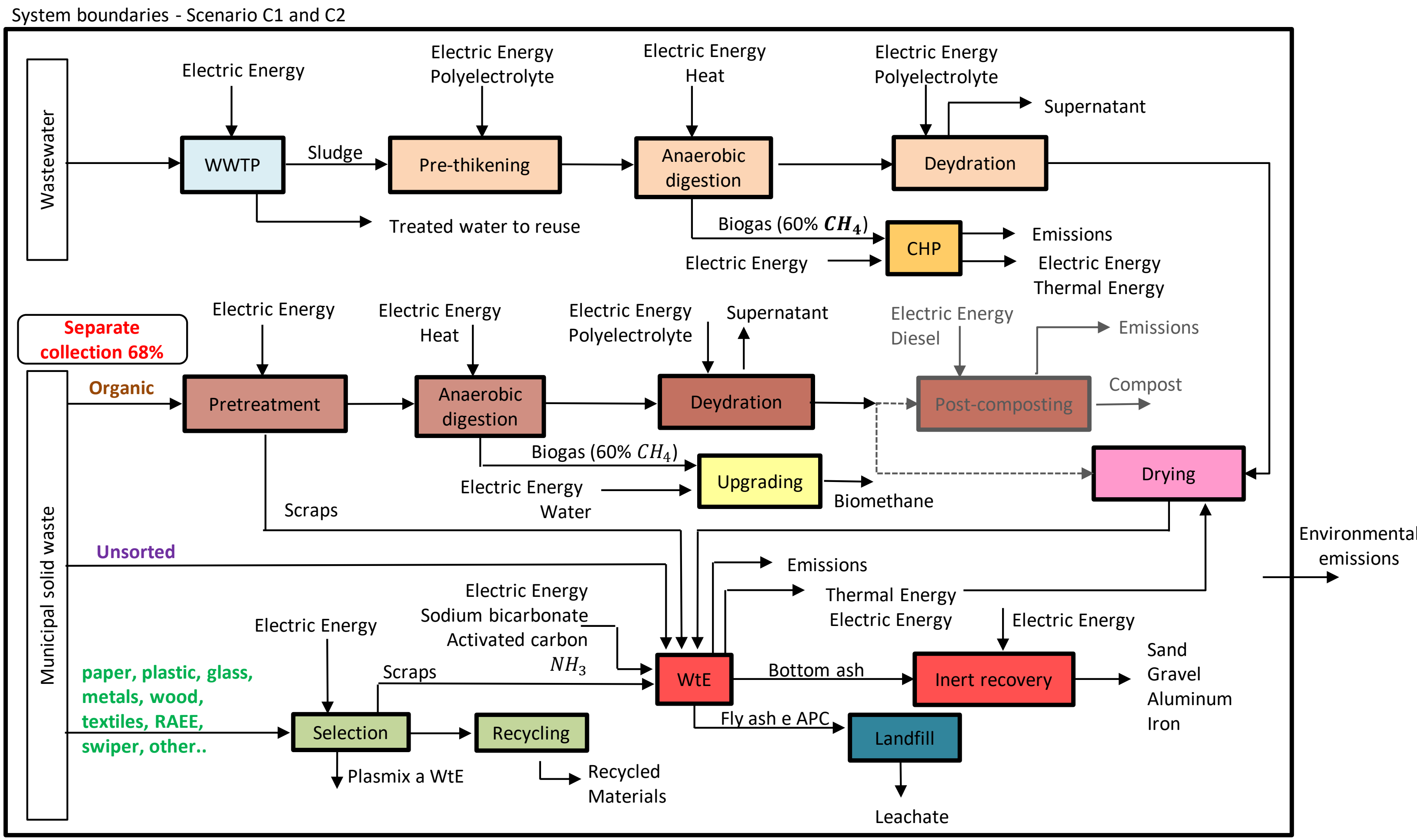
System boundaries of the future scenario A



System boundaries of the future scenario B

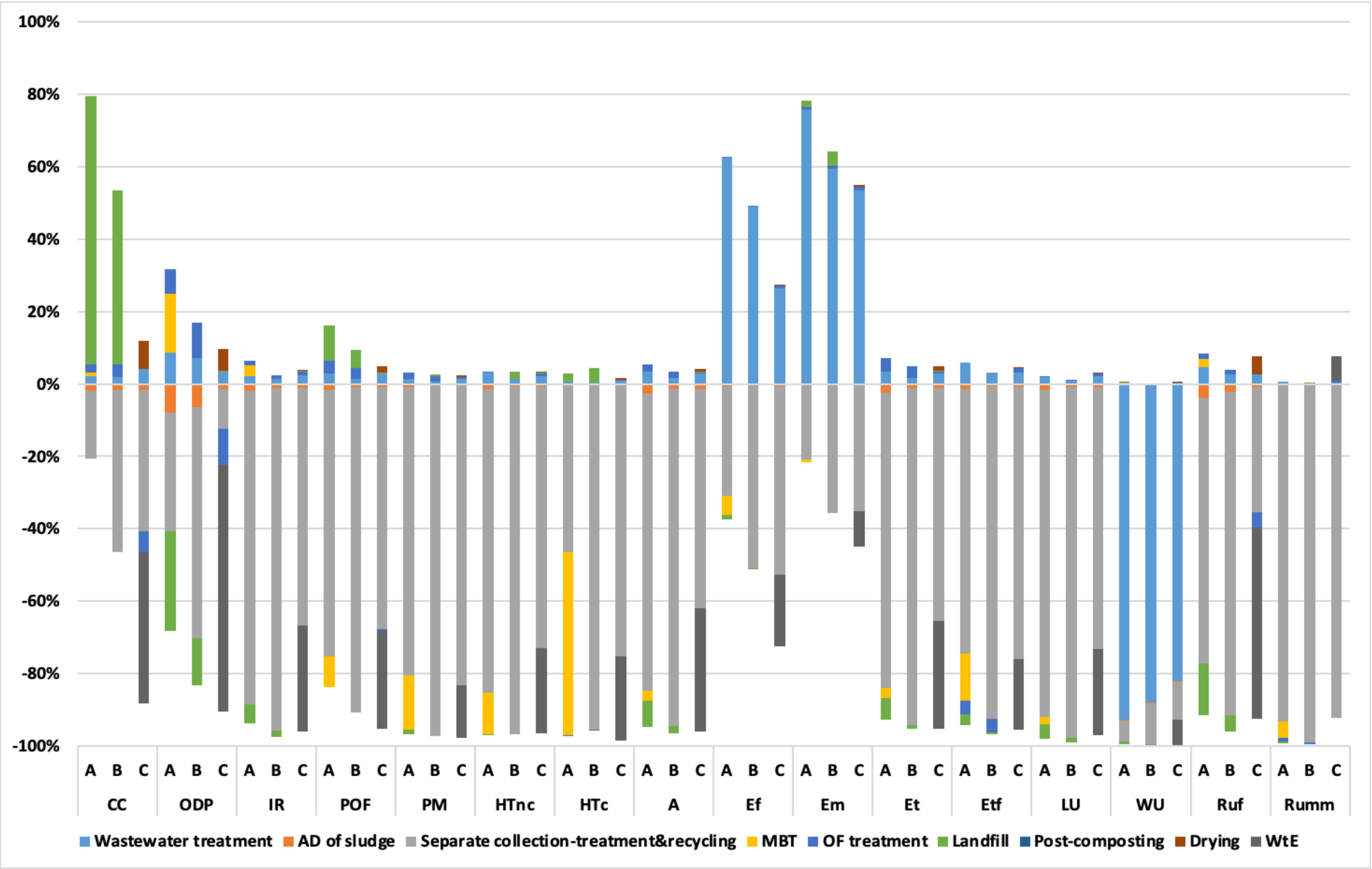


System boundaries of the future scenario c

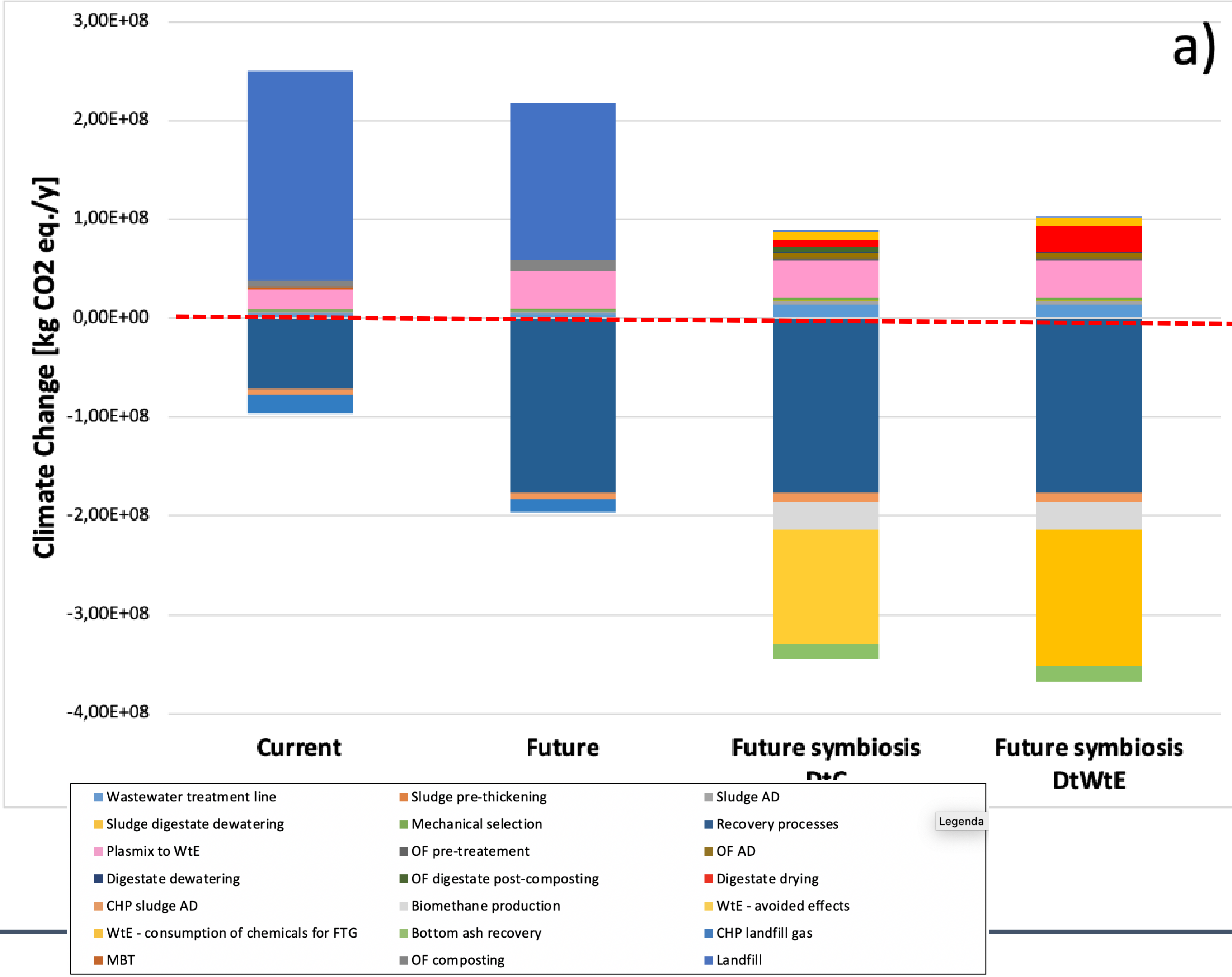


The dotted processes are alternative sub-scenarios;
C1: Digestate-to-Compost (DtC); C2: Digestate-to-WtE (DtWtE).

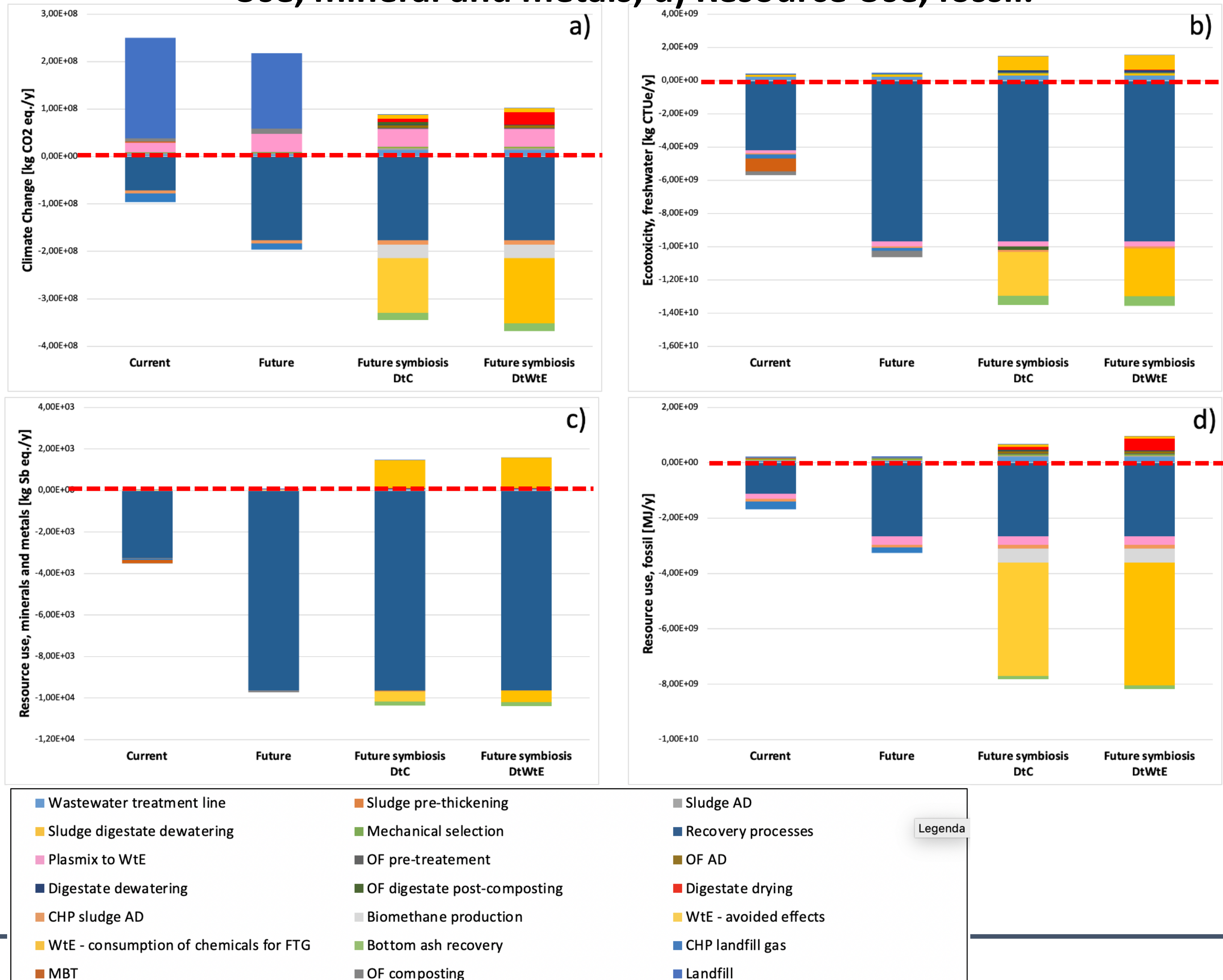
Contributions of the macro-processes to the total value of each indicator. (A, current scenario; B, future scenario; C, future symbiosis scenario in the DtWtE option).



Contribution analysis: a) Climate Change



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



Take Home (Chania) Message

Recycling and WtE are complementaty to divert waste from landfill