The civilisation biorefinery – A networking approach for efficient utilisation of residual bioresources

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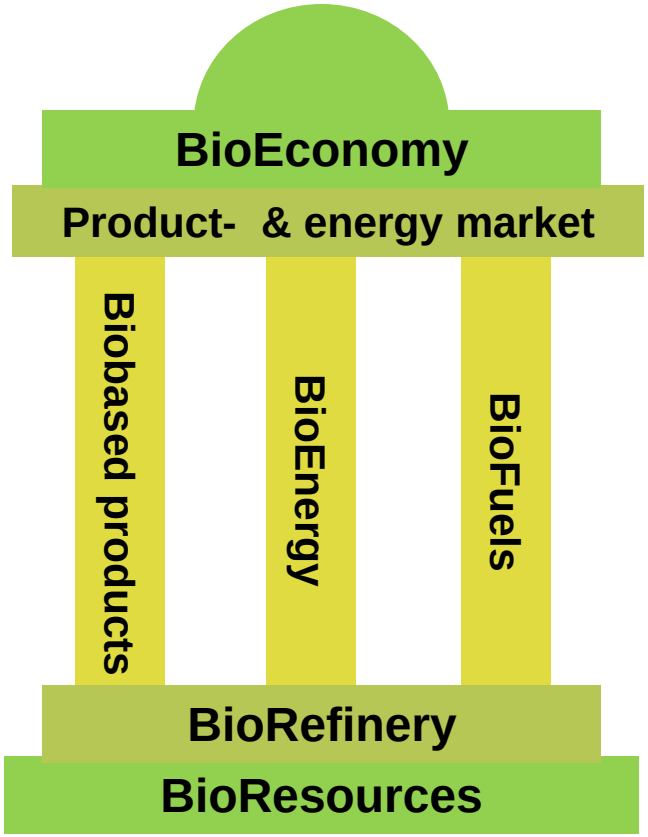
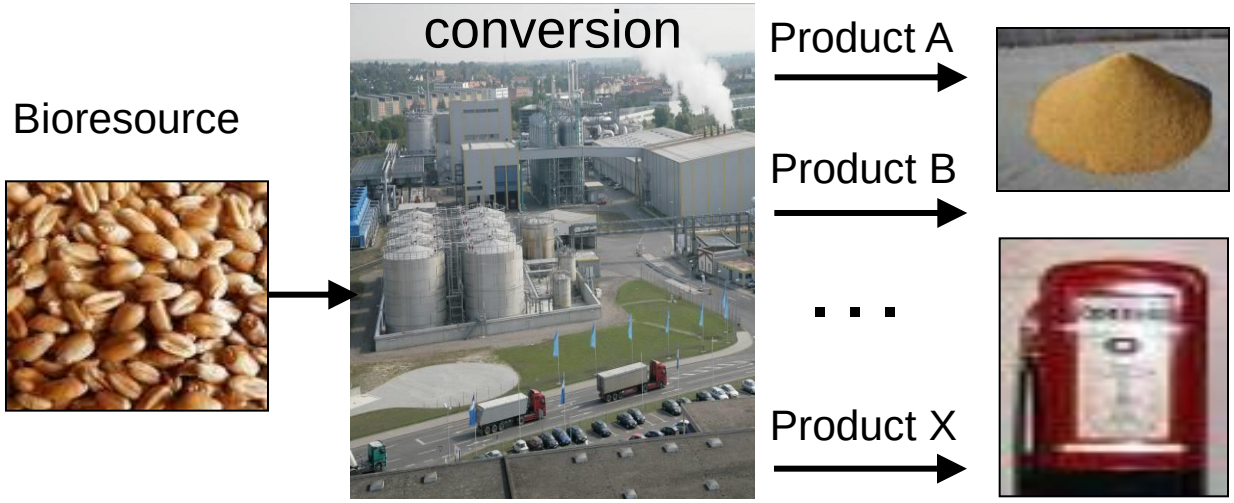
Bio-based economy



Source: modified after B. Kamm (BIOPOS)



A biorefinery is a **complex and integrated system of processes and plants** in which **bioresources** are converted into a **multitude of products** in the form of materials or energy.* It is characterised by a **complete and efficient** material utilisation as possible.

*) after Kamm et al., 2000

Bioresources

are biogenic substances

which can be used by humans for multiple purposes to produce:

- food
- substantial products
- energy carriers

They can be categorised:

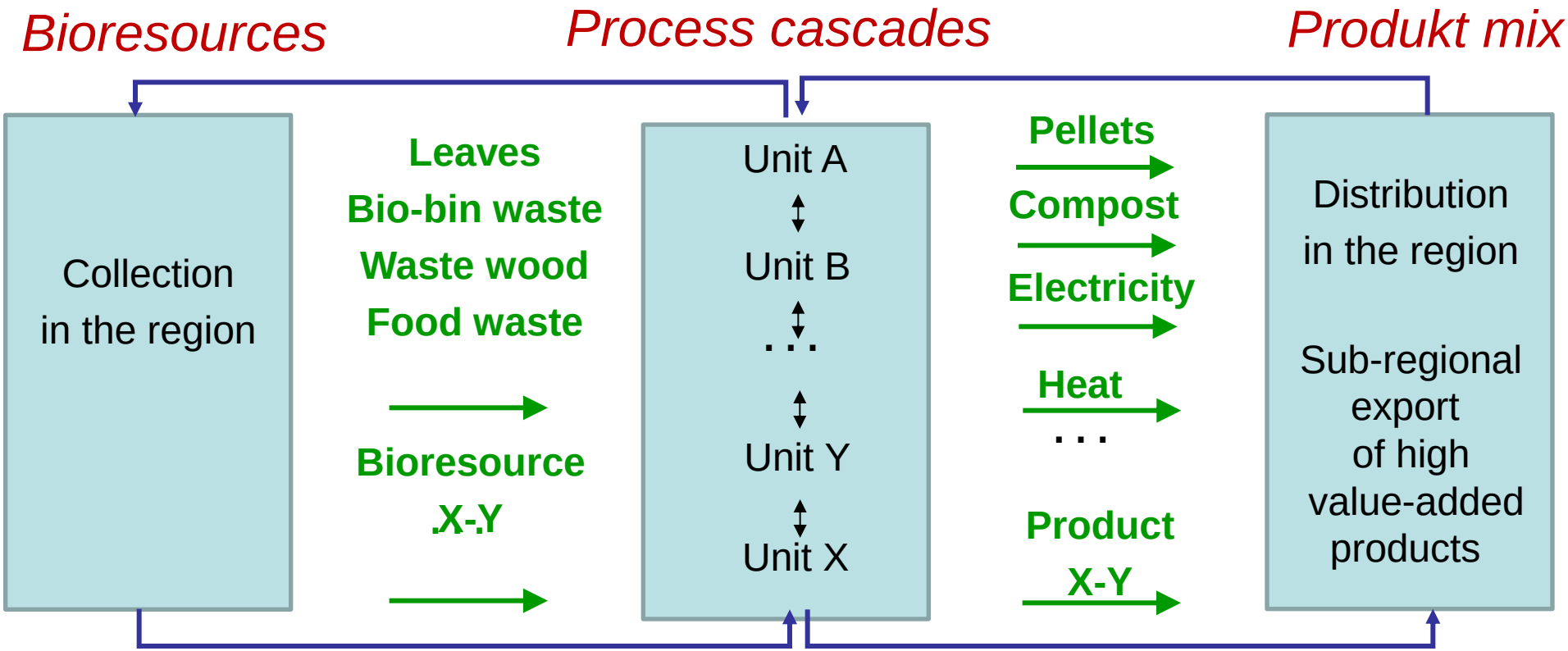
Primary, secondary, tertiary, quaternary bioresources

Structure

1. Civilisation biorefinery
2. Urban residual bioresources
3. Steps towards implementation
4. Examples
5. Outlook

The civilisation biorefinery is still a vision today!

The civilisation biorefinery



Goal: Most complete & efficient utilization of urban bioresources.

Approach: Holistic and integrative.

The city: A Bioresource consument

Primary energy demand: 229 Mrd. MJ / a
with: 6 Mrd. MJ / a from urban bioresources
(sewage treatment biogas; waste)

Energy carriers

Food

Availability:
26 Mio. MJ / a

Material products

Paper demand: 0.4 Mio. Mg/a (6 Mrd. MJ / a)
Additional: e.g.. Construction materials,
wood material products

Data for Hamburg

becomes a bioresource producent.

Calculated wit data from: Umweltbundesamt,FAO,klima.hamburg;fao; nabu

Waste and wastewater collection

Avoiding Pollutions →

- hygienic
- ecologic
- aesthetic
- low odour

Collection →

- area wide
- reliable
- user-friendly
- cost efficient & -covering

Advanced →

- Getting bioresources & other resources for utilization

Bioresource transformation in a network

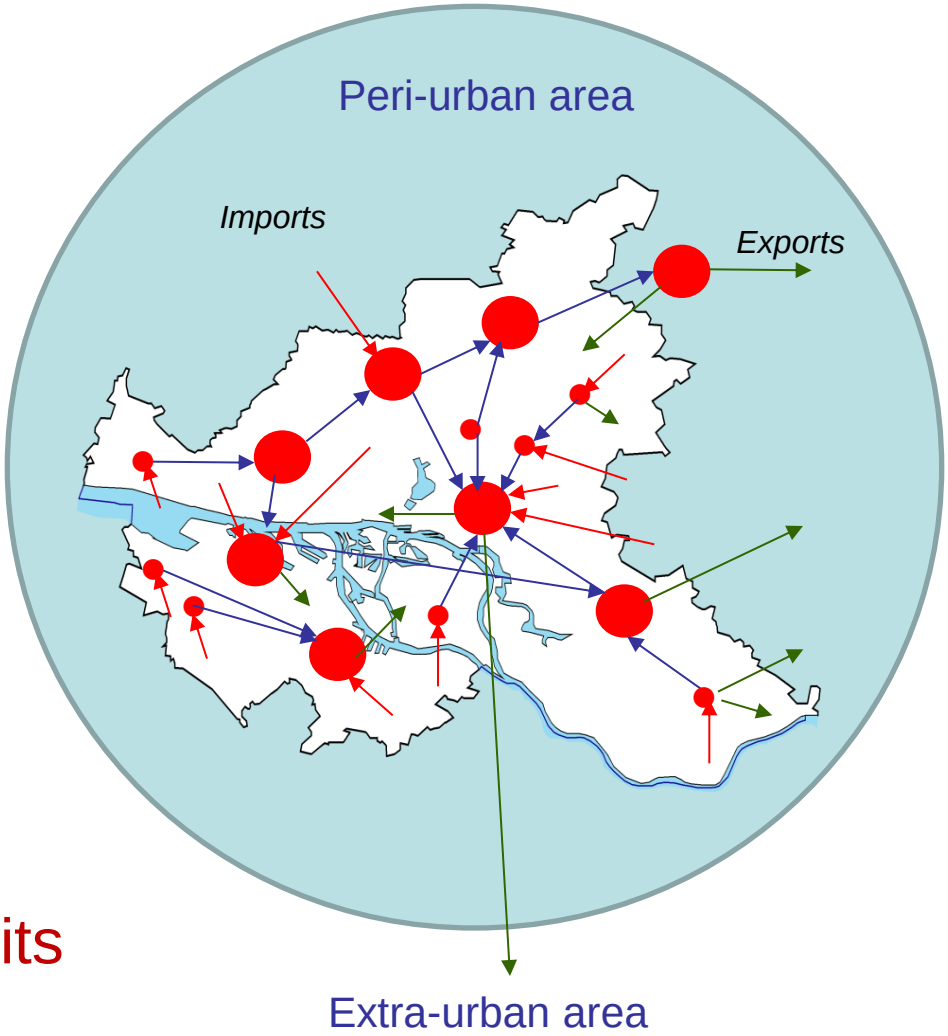
Larger, centralized complexes

Smaller, decentralized units

Delivery of urban bioresources

Exchange of intermediates

Delivery of products



Centralized & decentralized units work together in symbiosis.

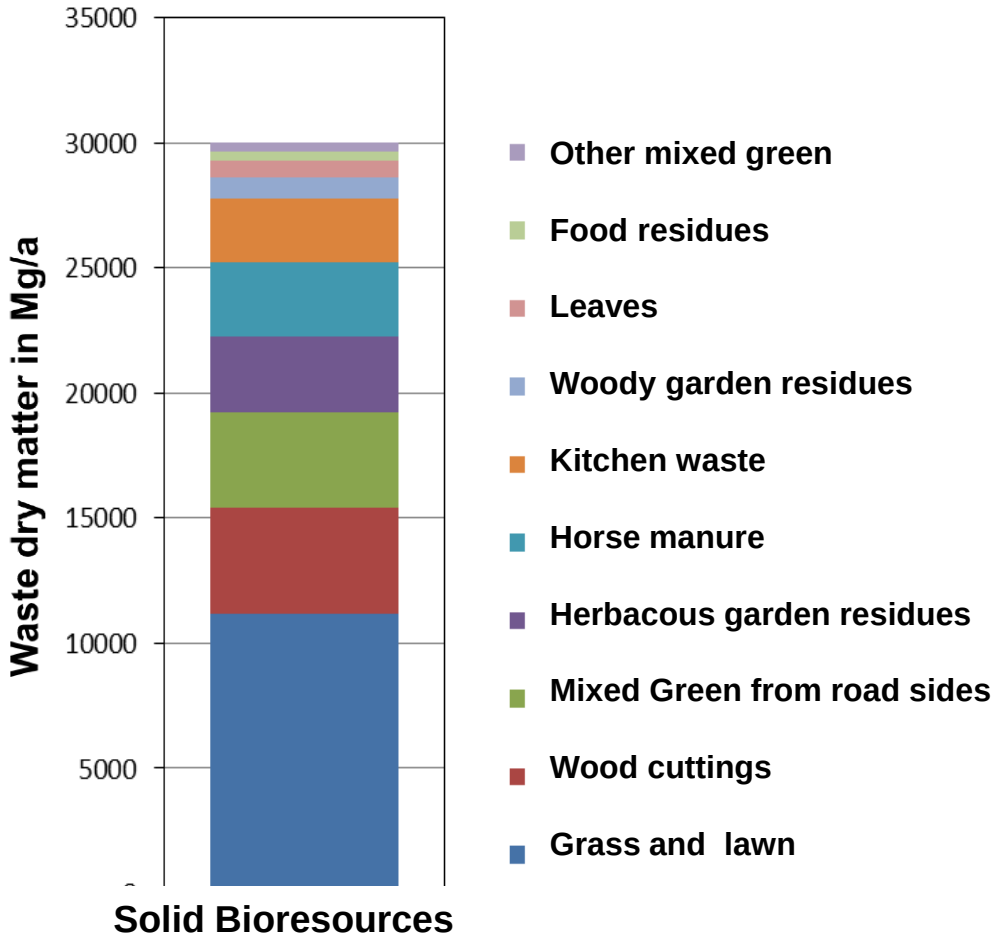
Urban bioresource categories

Primary bioresources **from primary production**	**Secondary bioresources** **from various sectors**
✖	 
for primary use food, high value bio-based products	**for multichain use** high and medium value bio-based products, energy
Lawn cuttings from privat gardens *Kitchen and restaurant food wastes*	*Fruit residues from industrial procesing* *Fresh lawn cuttings from large public areas* *Grease trap residues* *Blackwater from vacuum toilets*
for multichain use medium and low value bio-based products, energy	**for cascade use** medium and low value bio-based products, energy
 	 
Tertiary bioresources **from various sectors**	**Quaternary bioresources** **from used products**

Wet & Solid urban bioresources

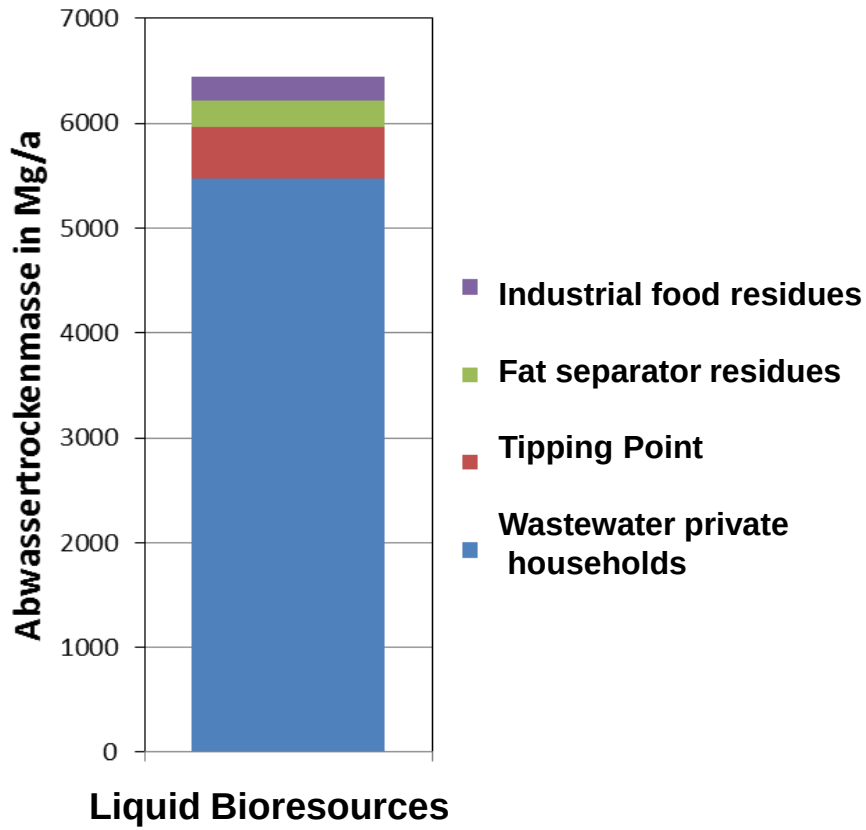
Inventory results for the district Bergedorf

84.000 Mg/a wet mass



0,7 Mg wet mass / inhabitant & a

560.000 m³/a wastewater volume

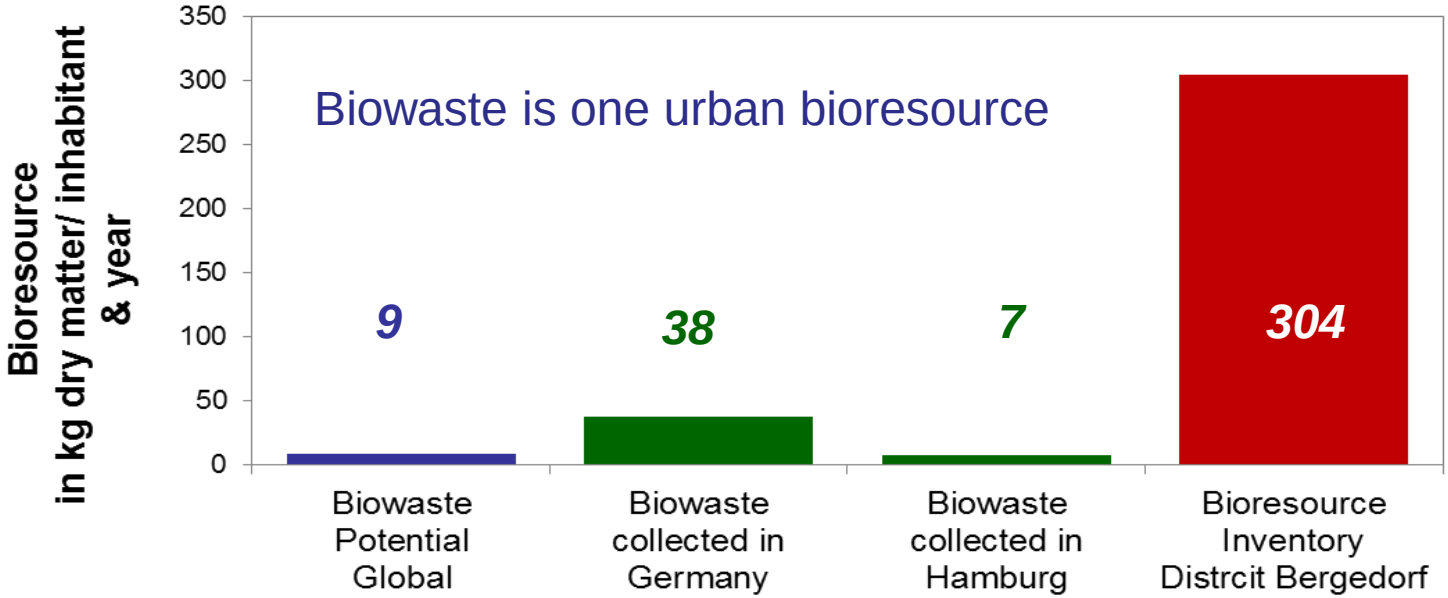


46 m³ Wastewater/ inhabitant & a

Bioresource inventories

Various methods, definitions, time frames, assumptions are used for bioresource inventories and are therefor difficult to compare.

We have more urban bioresources as commonly thought.



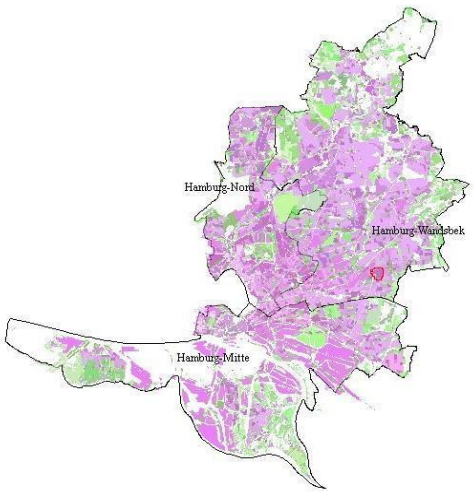
Based on data from: Thrän 2011, destatis, 2010; statistik-nord, 2010; BERBION 2009

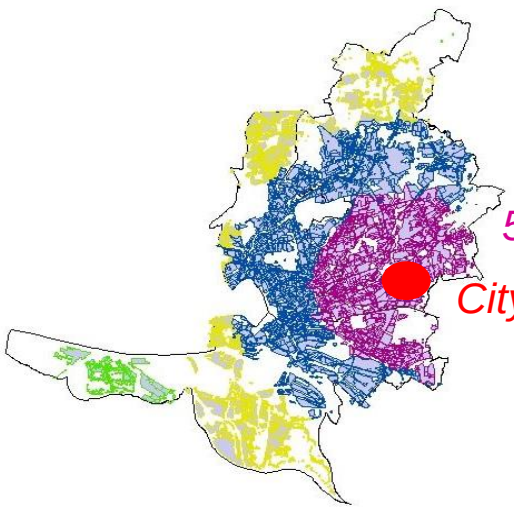
Steps towards civilisation biorefineries:
Methodologic bioresource inventories

Example for GIS based inventory of lawn cuttings in Hamburgs district Wandsbek

Data from biotope cadaster:

- Public and private buildings
- Public green areas: Sports facilities/leisure facilities/parks/cemetry…
- Private green areas: orchard/garden plots…
- Under nature protection: Fens…





5-km-radius

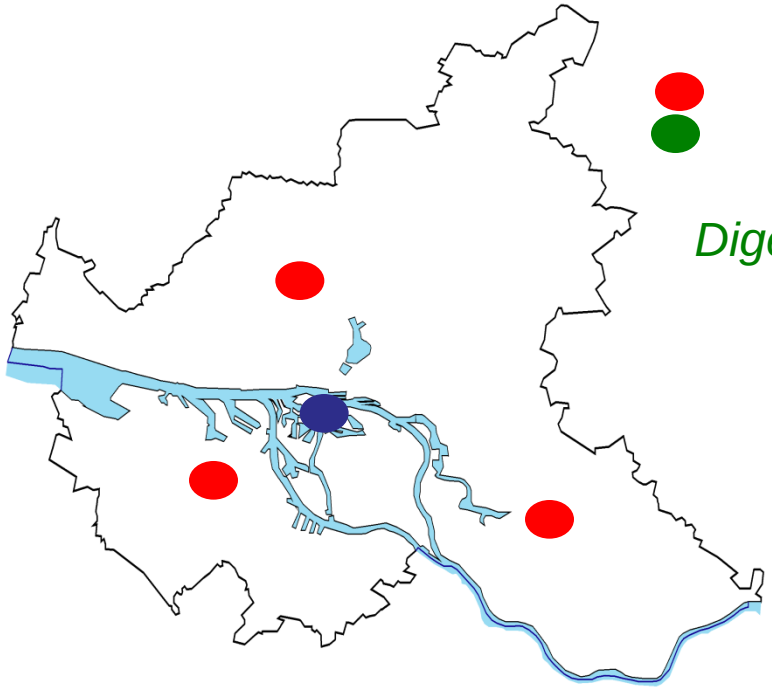
City quarter Jenfelder Au

Public green area:	1.299 ha
Fresh matter:	21.315 Mg/a
Biogas:	**3.711.534 m³/a**

Source: Flerlage, 2013

Steps towards civilisation biorefineries:
Facility inventories

WASTEWATER & SEWAGE SLUDGE
Treatment complex



LEAVES
Pelletizing

BIOWASTE
Digestion & Composting

FOOD WASTE
Digestion

WASTE WOOD
Incineration

RESIDUAL WASTE
Incineration

Steps towards civilisation biorefineries:
Flow inventories

Data 2009 for main Waste & Wastewater flows in Hamburg

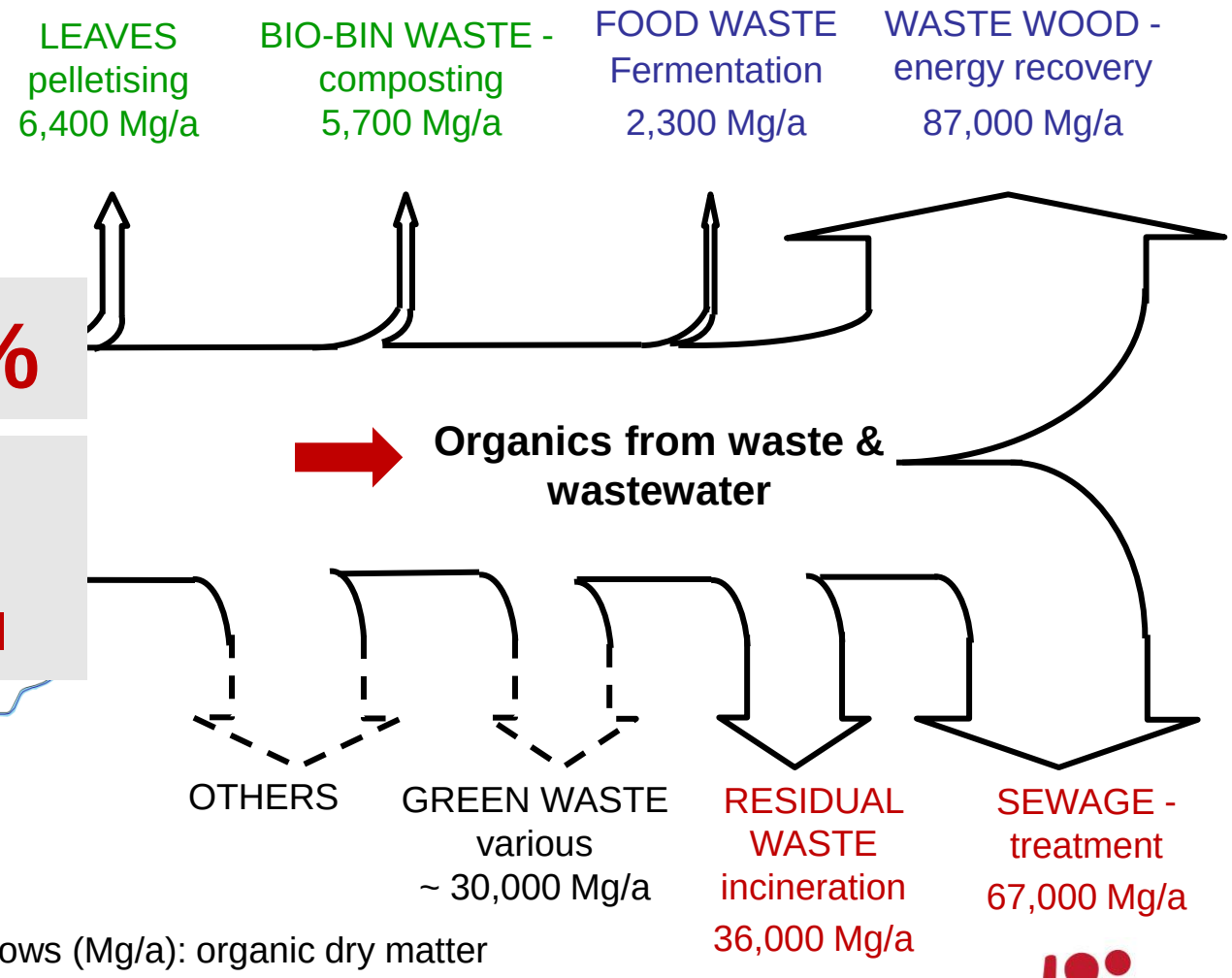
Processes:

6% : 43%: 51%

Material recovery :

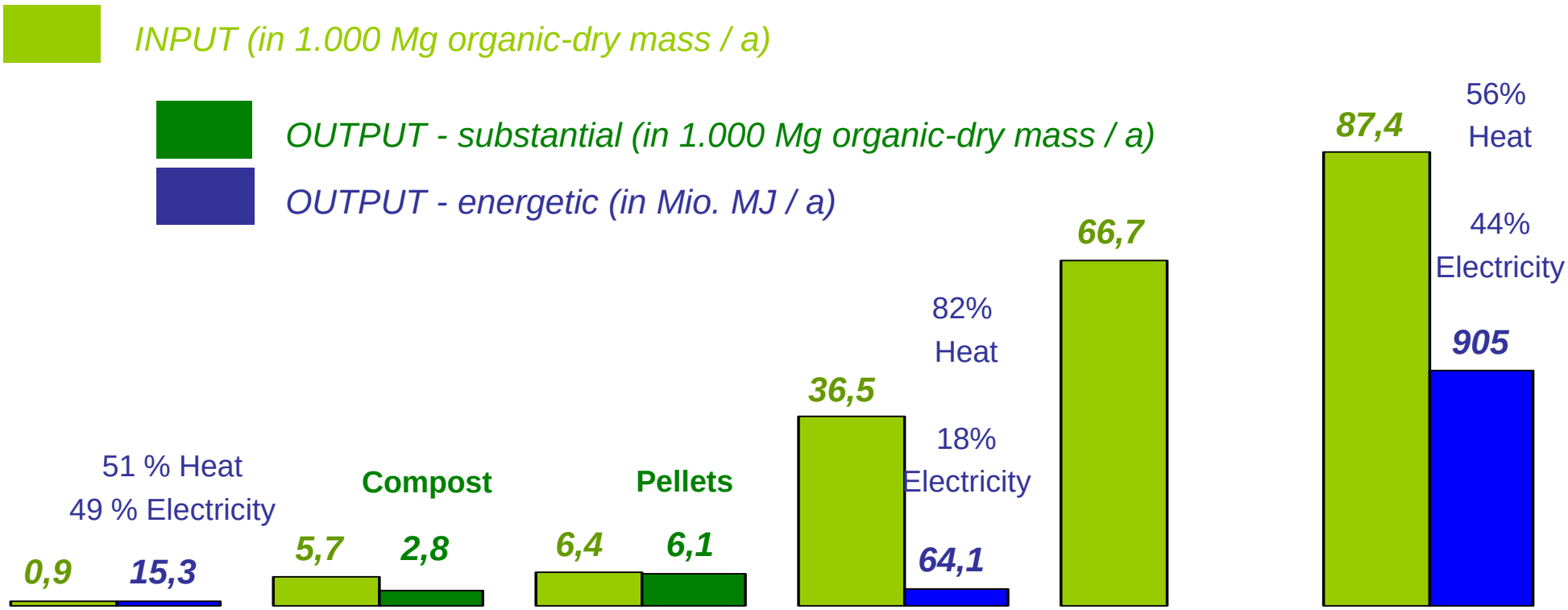
Energy recovery :

disposal



all mass flows (Mg/a): organic dry matter

Steps towards civilisation biorefineries:
Process evaluations



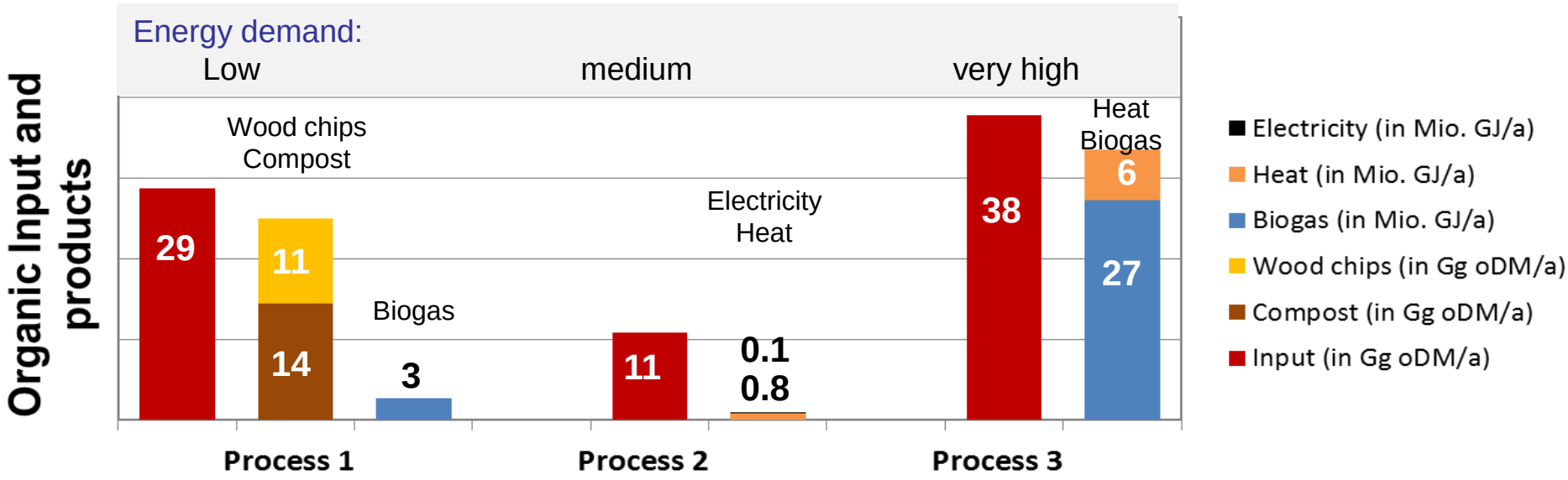
5% of the organic is included in the compost resp. in the pellets.

24% of the organic is transformed into heat and electricity.

71% of the organic is unutilized lost mainly as carbon dioxide.

Steps towards civilisation biorefineries: Process inventories

Hamburg 2013: Input vs. material & energy products

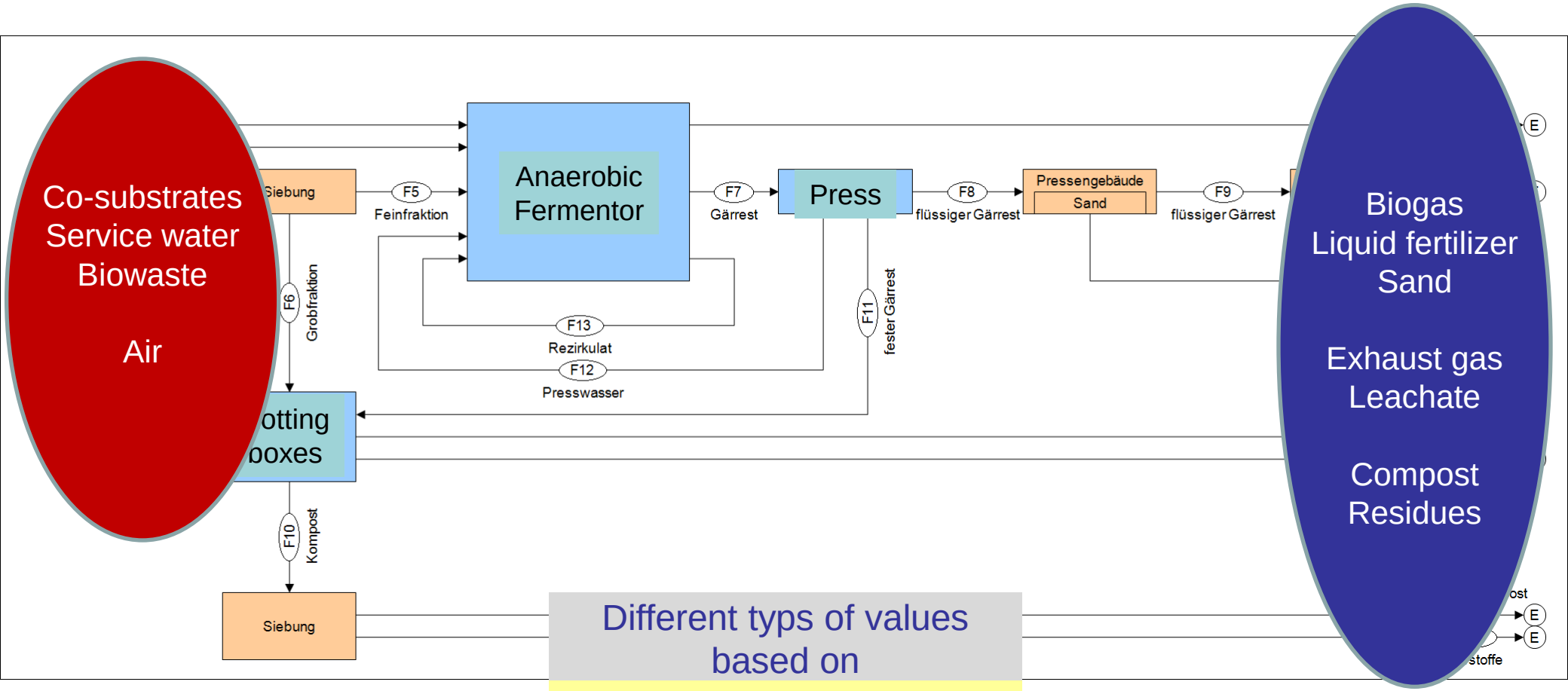


Biowaste & green waste:
Anaerobic digestion combined with composting

Kitchen waste fraction in residual waste:
Four residual waste incineration facilities together

Wastewater & sludge treatment:
Complex containing nitrification, denitrification, anaerobic digestion, dewatering, drying & incineration facilities

Steps towards civilisation biorefineries:
Inventory of complete mass and energy flows



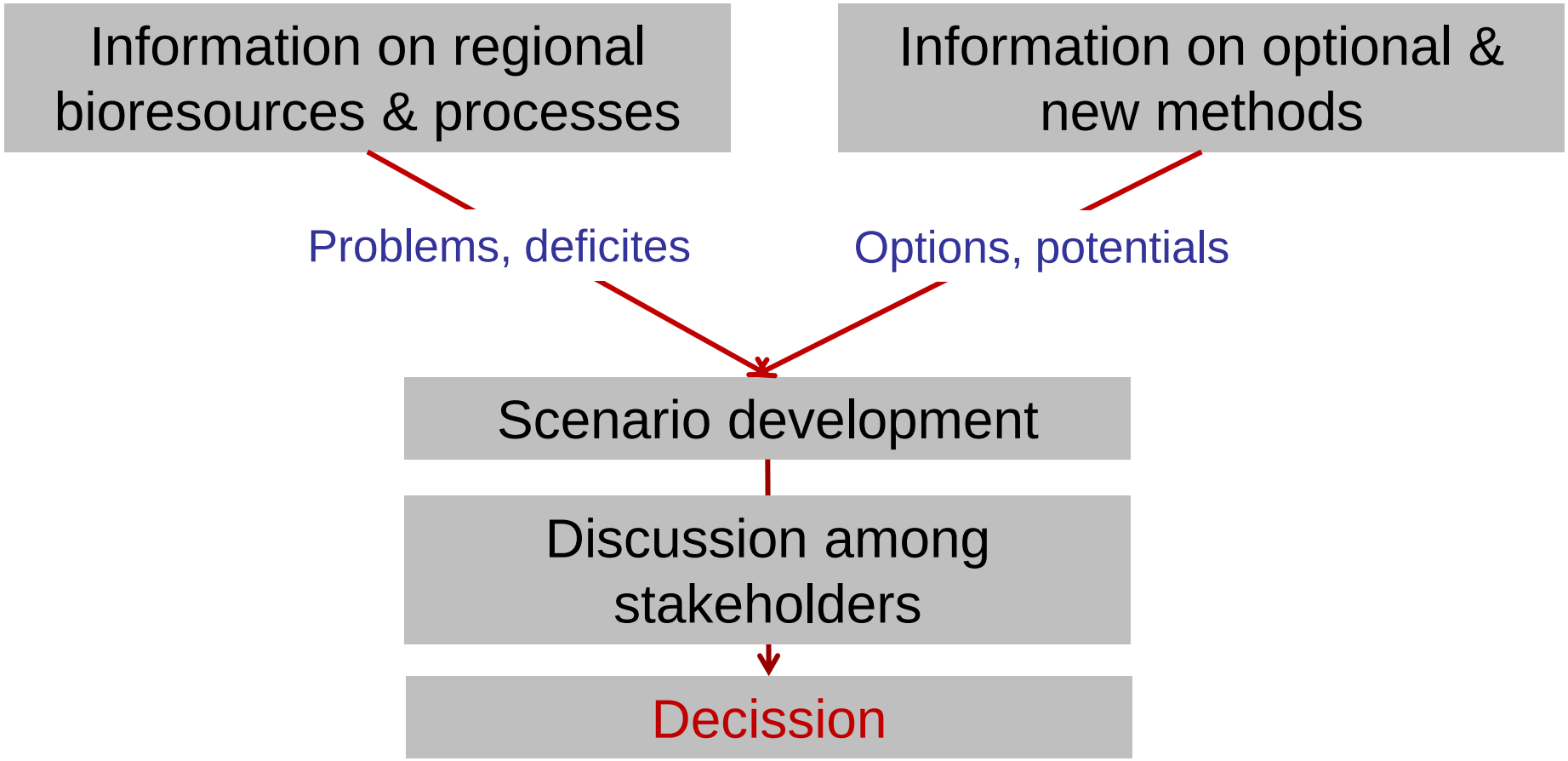
Different typs of values based on

Regular measured values
experimental values
estimations
calculations

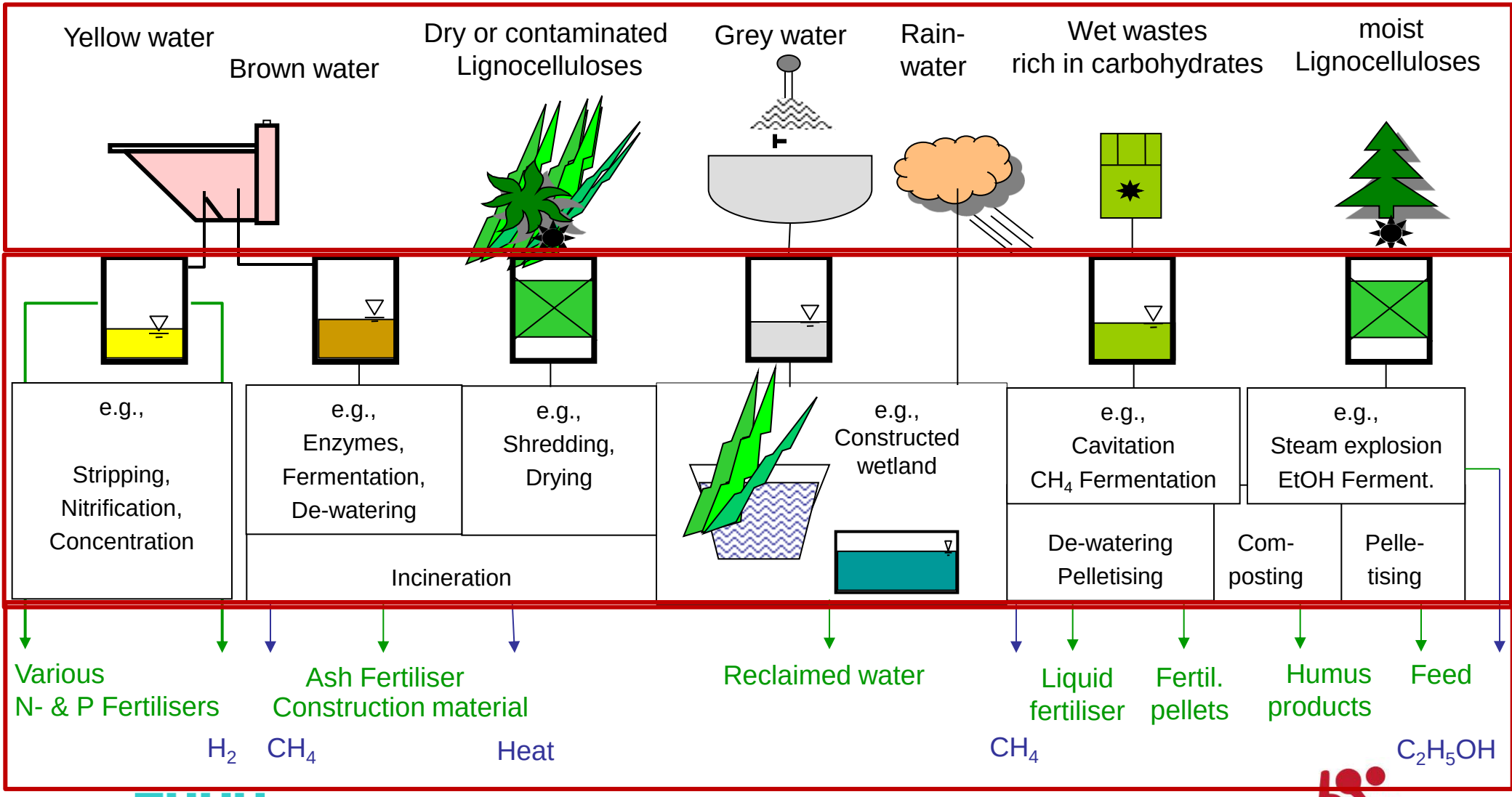
Flowsheet of the biogas & composting facility from BUHCK company, Trittau, Germany

Input = Output

Steps towards civilisation biorefineries:
Concept development



Combination of process cascades to a civilsation biorefinery



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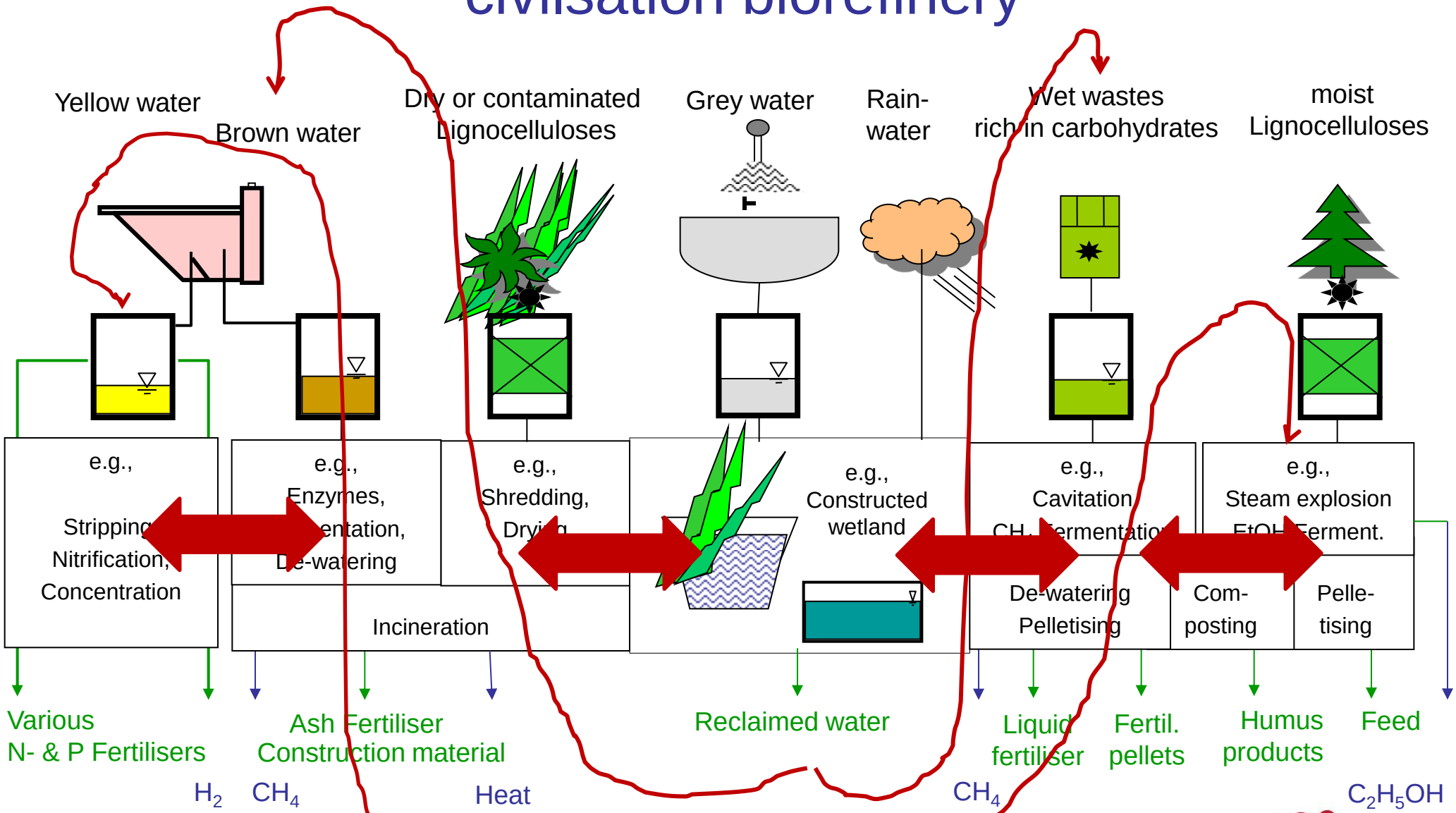


The Jenfelder Au project

- Realization of the HAMBURG WATER Cycle® -

+ grease trap residues
+ lawn cuttings

Quelle: HAMBURG WASSER

- ▶**Area: 3,5 km²**
- ▶**New appartments: 800**
- ▶**New inhabitants: 2 400**

Separate collection and treatment of the various fractions;
Utilization of the ingredients from blackwater & co-substrates
(electricity, heat, processed water, fertilizer)

New collection methods

Macerator in the kitchen

- Kitchen waste is hackled in the sink with water
- The mashed waste flows

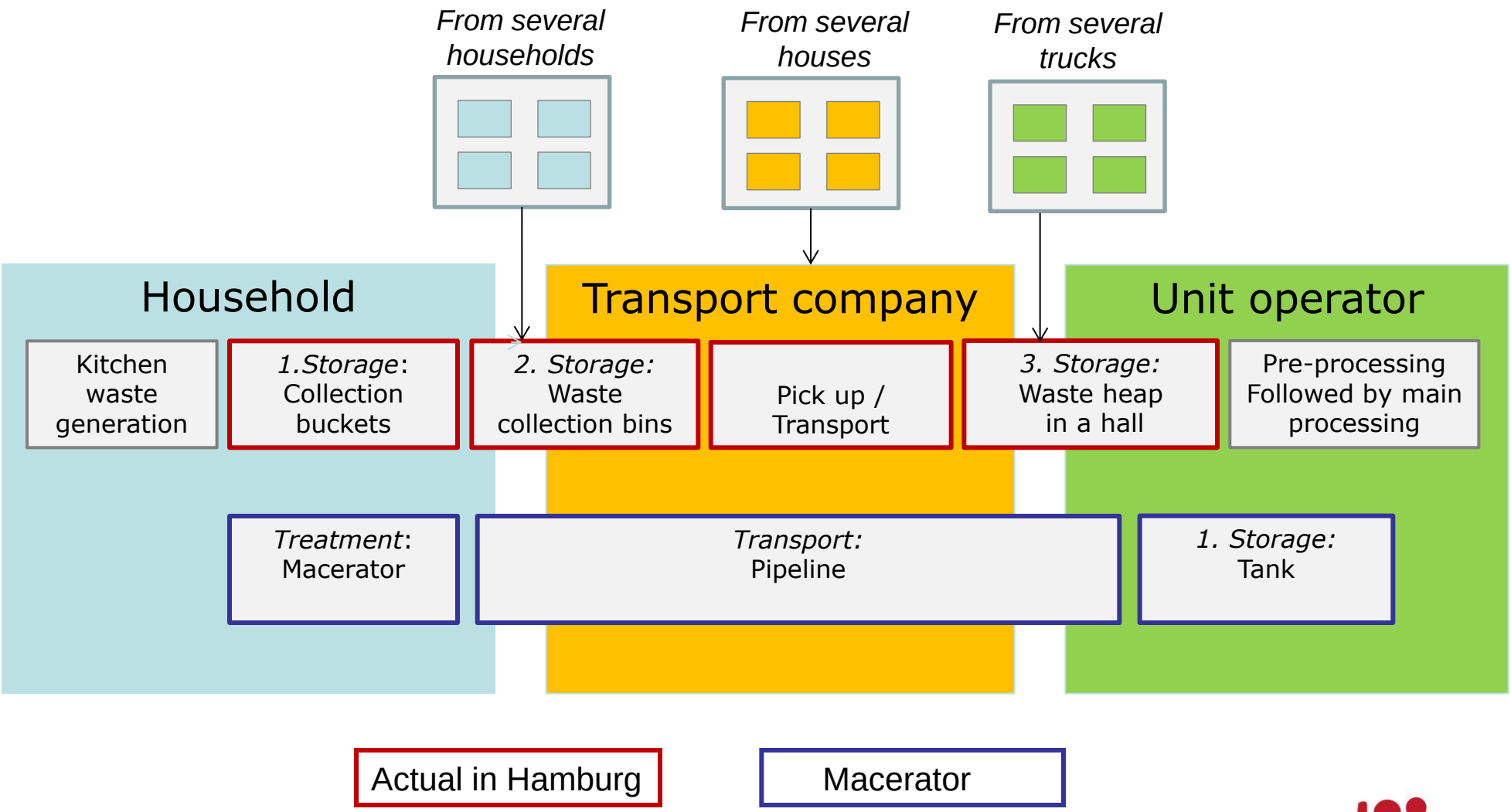
  into underfloor collection container, <u>or</u>

  into vacuum-blackwater pipeline

The kitchen-waste based bioresource can be used for decentralized biogas generation.

Comparision of actual and new procedures

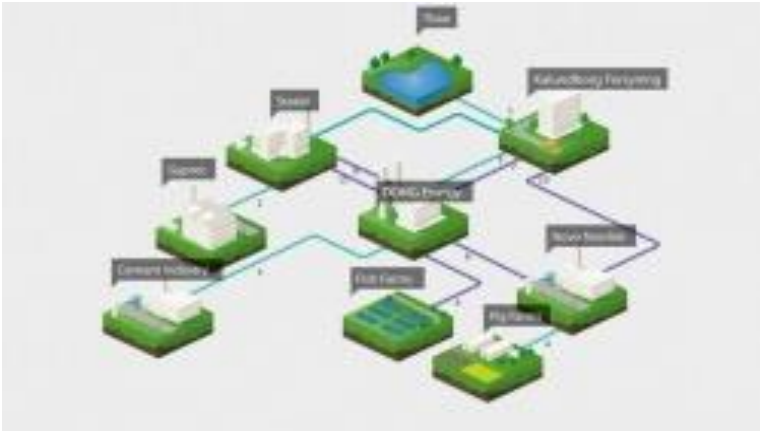
Collection methods kitchen waste



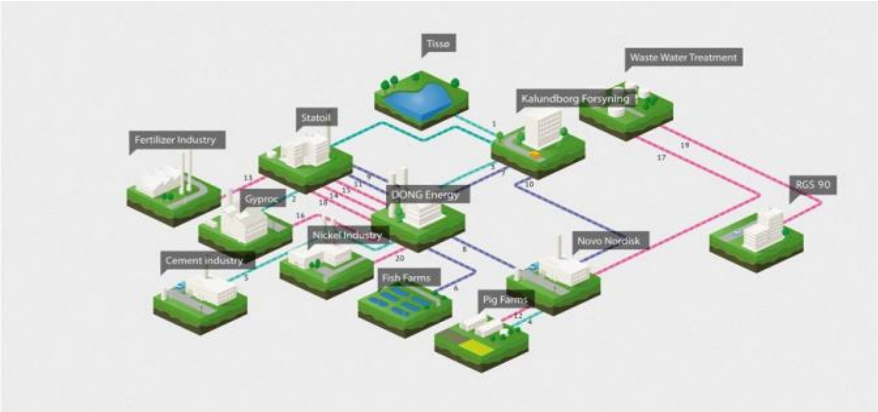
The Kalundborg symbiosis

1961-1979

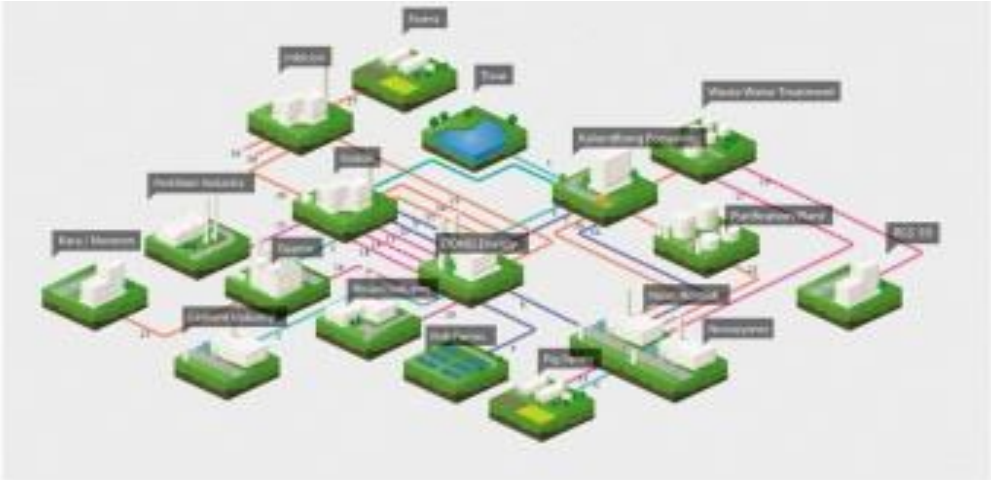
1980-1989



1990-1999



2000-2010



Exchanched resources in Kalundborg

8 Participants

surface water	1961, 1973
gas	1972
biomass	1976

9 Participants

heat	1980, 1981, 1989
steam	1982
surface water	1987
cooling water	1987
yeast slurry	1989

sulfur fertilizer	1990, 2001
technical water	1991
gas	1992
gypsum	1993
wastewater	1995
drain water	1995
sludge	1998
fly ash	1999

13 Participants

deionized water	2002
water	2004
waste	2004
sea water	2004
steam	2007
condensate	2009
straw	2009
bioethanol	2010
lignin	2010
C5/ C6 sugars	2010

18 Participants

Based on data from: www.symbiosis.dk

Possible products from civilisation biorefineries

	PRODUCT MIX		
	Energy carriers +	***Material products*** +	***Precusors***
Bulk products ***For regional application***	*Heat* *Biogas* *Wood chips* *Briquettes* *…*	*Liquid digestate products* *Solid digestate products* *Fresh and mature composts* *Mulch* *…*	Biochar …
Special products ***For subregional export***	*Wood pellets* *Biofuel* *Biodiesel* *Natural gas substitute* *…*	*Paper* Mineral fertilizers Organic fertilizer pellets Organic fertilizer granulates Terra-preta inspired composts …	Carbohydrates Lignin Pectins Proteins Fats …

The civilisation biorefinery is a communication challange

Politics

Industry & Commerce

Waste & Wastewater management

Energy management
Material management
Food production

Civilisation biorefinery

collection, conversion, utilization

City planning
Landscaping
Logistics

Science

Agriculture
Forestry
Water managment

Population

Further Reading

Elsevier, 2015
ISBN: 978-0-444-63453-5

Chapter 7: Ina Körner
Civilization Biorefineries: Efficient Utilization of Residue-Based Bioresources

Thematic areas:

- Quality fertilizers from residues
- Sustainable soils
- Advances in emission prevention
- The bioresource challenge
- Sustainable Regions

RAMIRAN 2015

16th International Conference

Rural- Urban Symbiosis

8-10 September 2015

Hamburg
Germany

www.ramiran2015.de