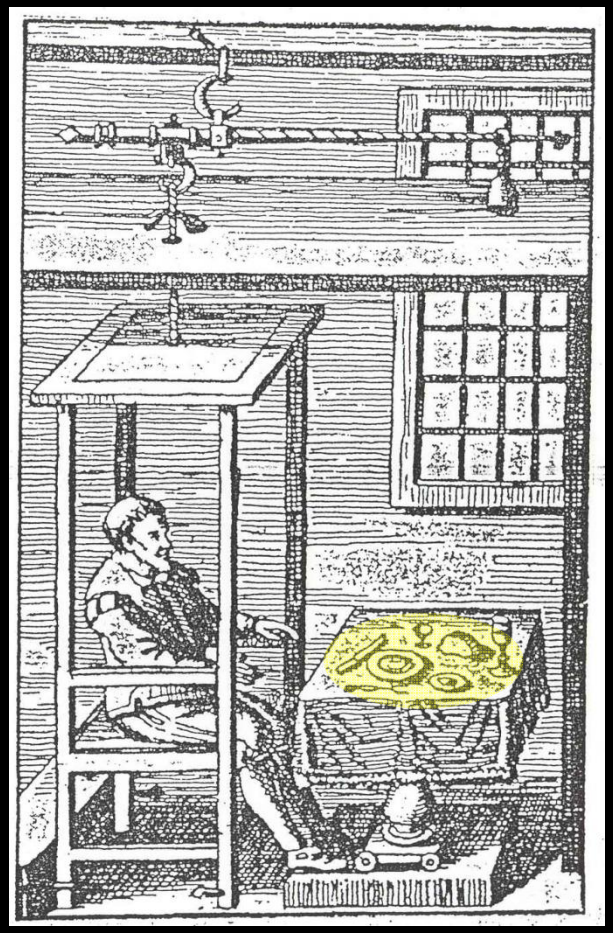
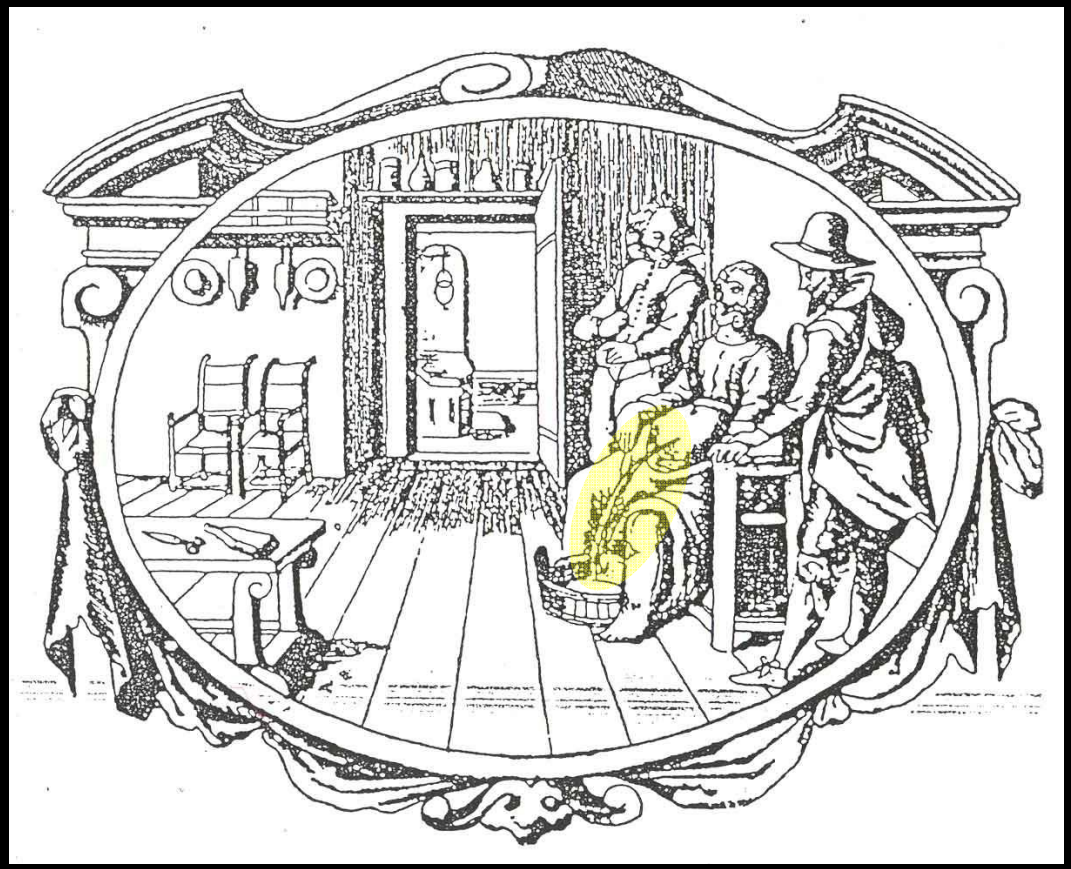
The application of MFA/SFA for decision making in resource and waste management

Paul H. Brunner
Vienna University of Technology

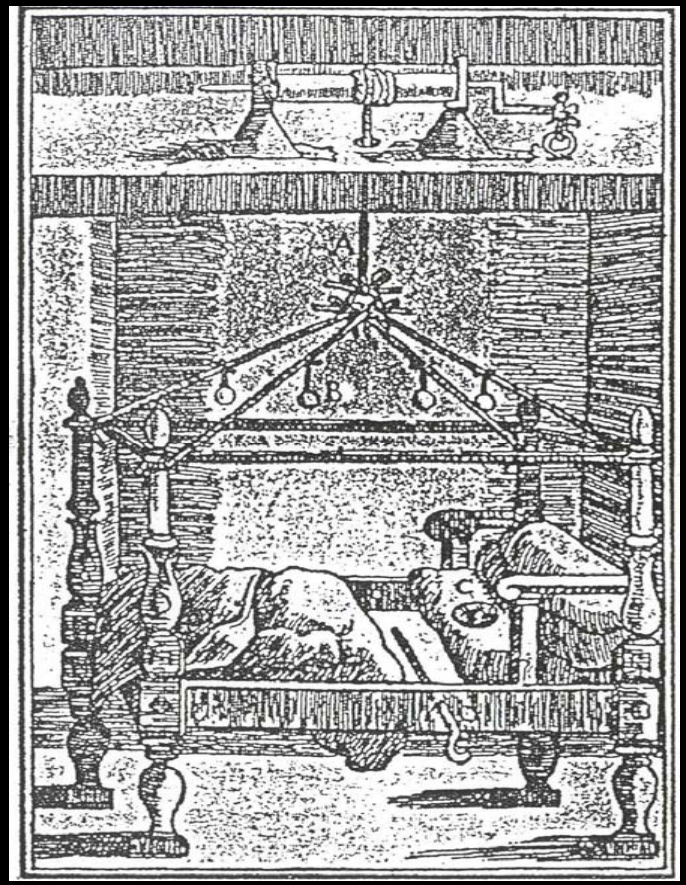
First MFA by Santorio 16th century: "human metabolism"





input = output?

The balance does not close - what happens at night?



Typical lessons learned from Santorio and early MFA:

1. How to measure?

   -> MFA and balance principle

2. Balance does not close!

   -> uncertainty treatment

   -> systems understanding

3. What do the results serve for?

   -> “cure the patient”

   -> MFA requires a goal!

Following generations of MFA (1950-1990)

- Regional and national MFA

  -> Metabolism of cities (Duvigneaud et al, 1977)

  -> National TMR-MFA (Wuppertal Institute a.o.)

Mainly descriptive, not on an operational level yet

From MFA to SFA (1980-2000)

- Substance level

  -> crucial for resources and environment
- Regional SFA

  -> Ayres, Stigliani, Baccini, and others
- MFA/SFA on all scales:

  -> molecular to global

  -> static to dynamic *(cf. ES&T Müller et al, 2014)*
- Software STAN, SIMBOX, and others

MFA/SFA today

- Exploration phase completed!
- MFA/SFA a tool for:
  - -> problem solving
  - -> decision making
- MFA/SFA applied for:
  - -> Resource management
  - -> Waste management
  - -> Environmental management
- MFA/SFA requires assessment methods like LCA!

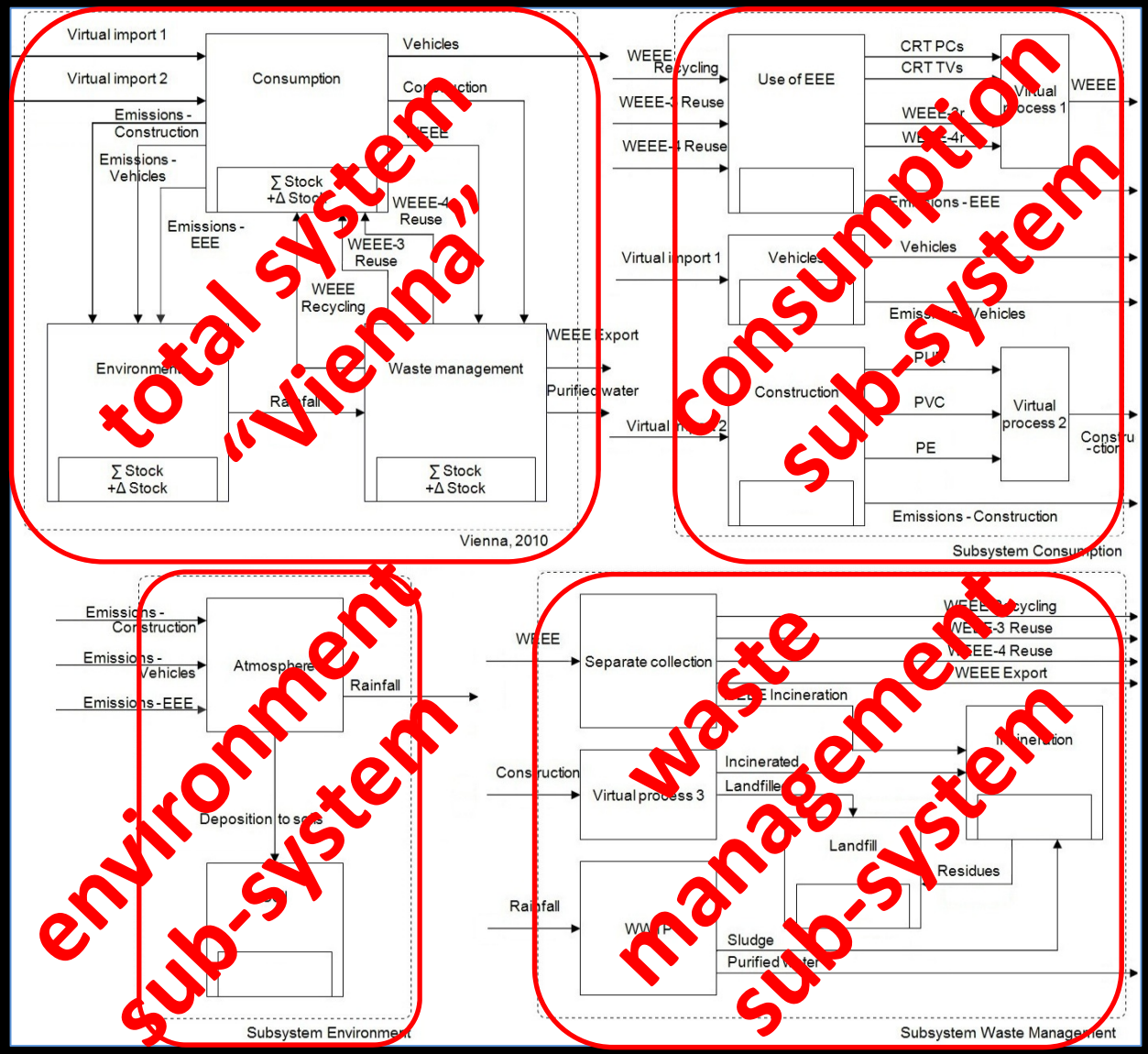
Example 1: Decision making for plastic recycling

PBDE/BFRs in video tapes (5/5) (Hirai et al, BFR 2007.)

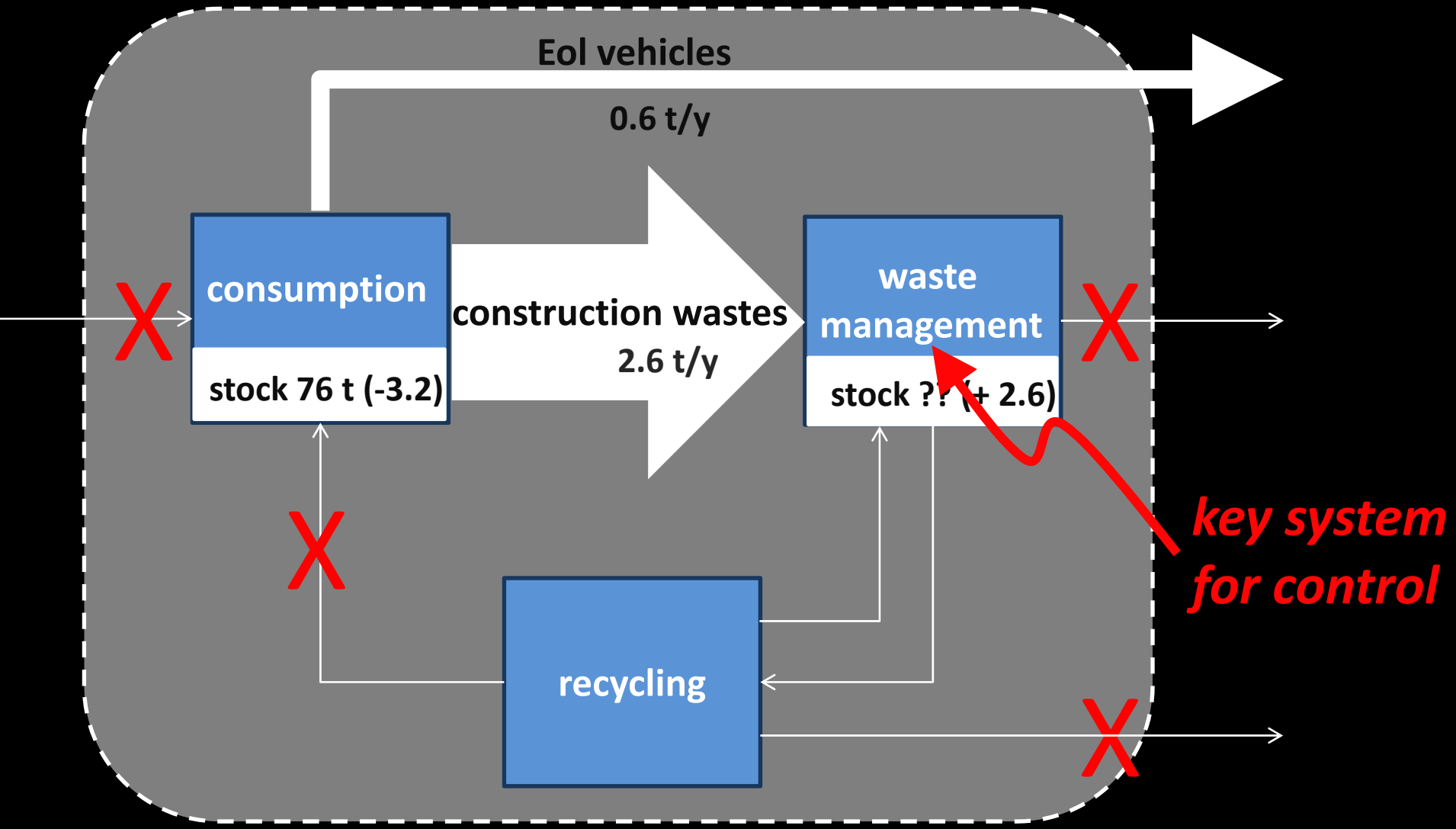
PBDE in children toys (Chen et al, ES&T, 2009)

PBDEs in coffee cup (J. Samsonek & F. Puype, FAC, 2013)

Identifying the problem by MFA/SFA of cPentaBDE



PBDE in plastics - clean cycles and safe final sinks?



Vienna city limits, 2012

Vyzinkarova et al, 2013

Ex. 2: From single processes to complex systems

Decision making in waste management - How to find the "best" waste management system?

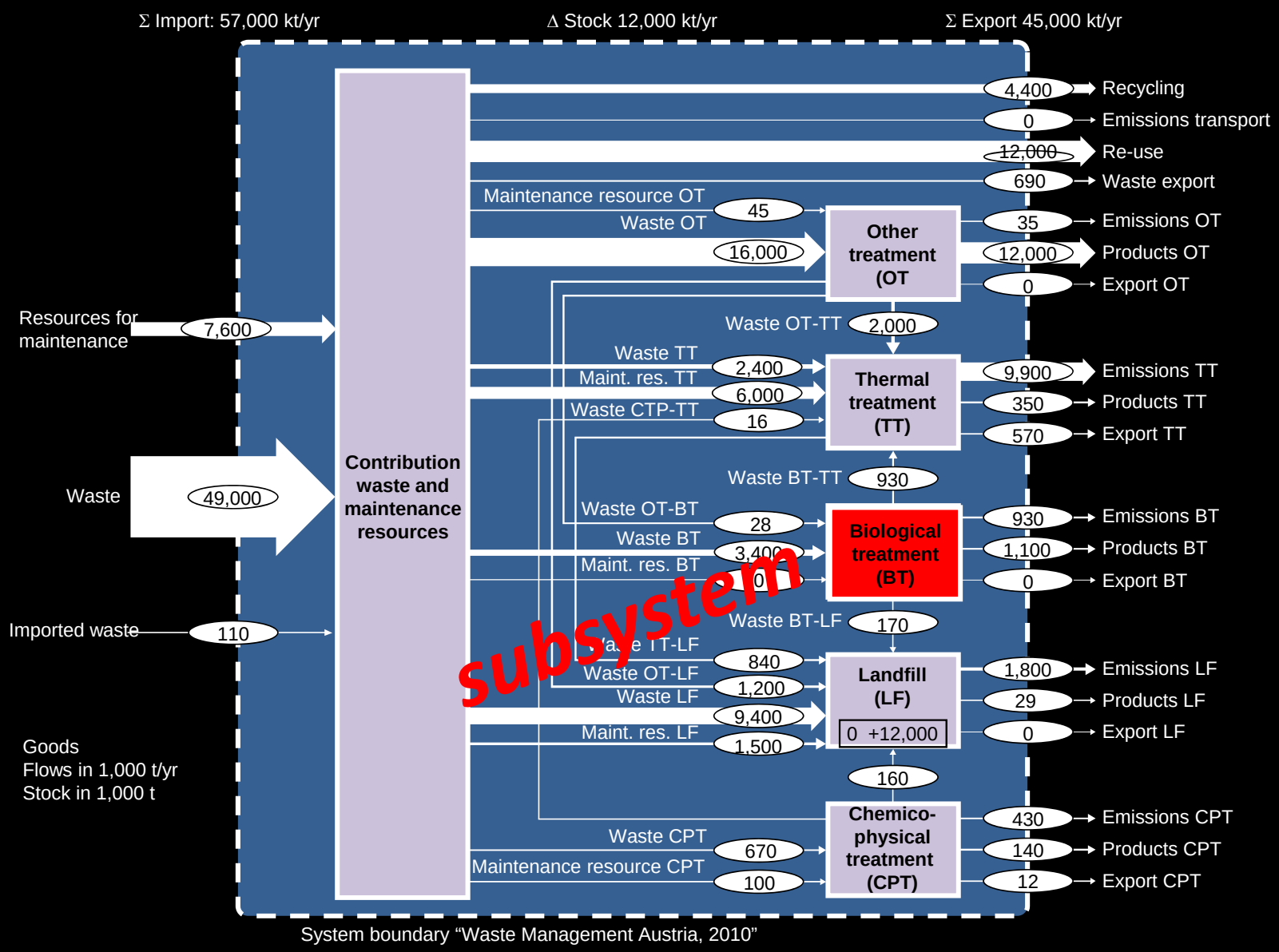
- Define goals
- Select indicators and criteria *(resources & emissions)*
- Comprehensive MFA/SFA model *(flows and stocks -> resources & emissions)*
- Evaluation of results *(LCA, SCE, and others)*
- Scenario analysis

-> Optimized wm system

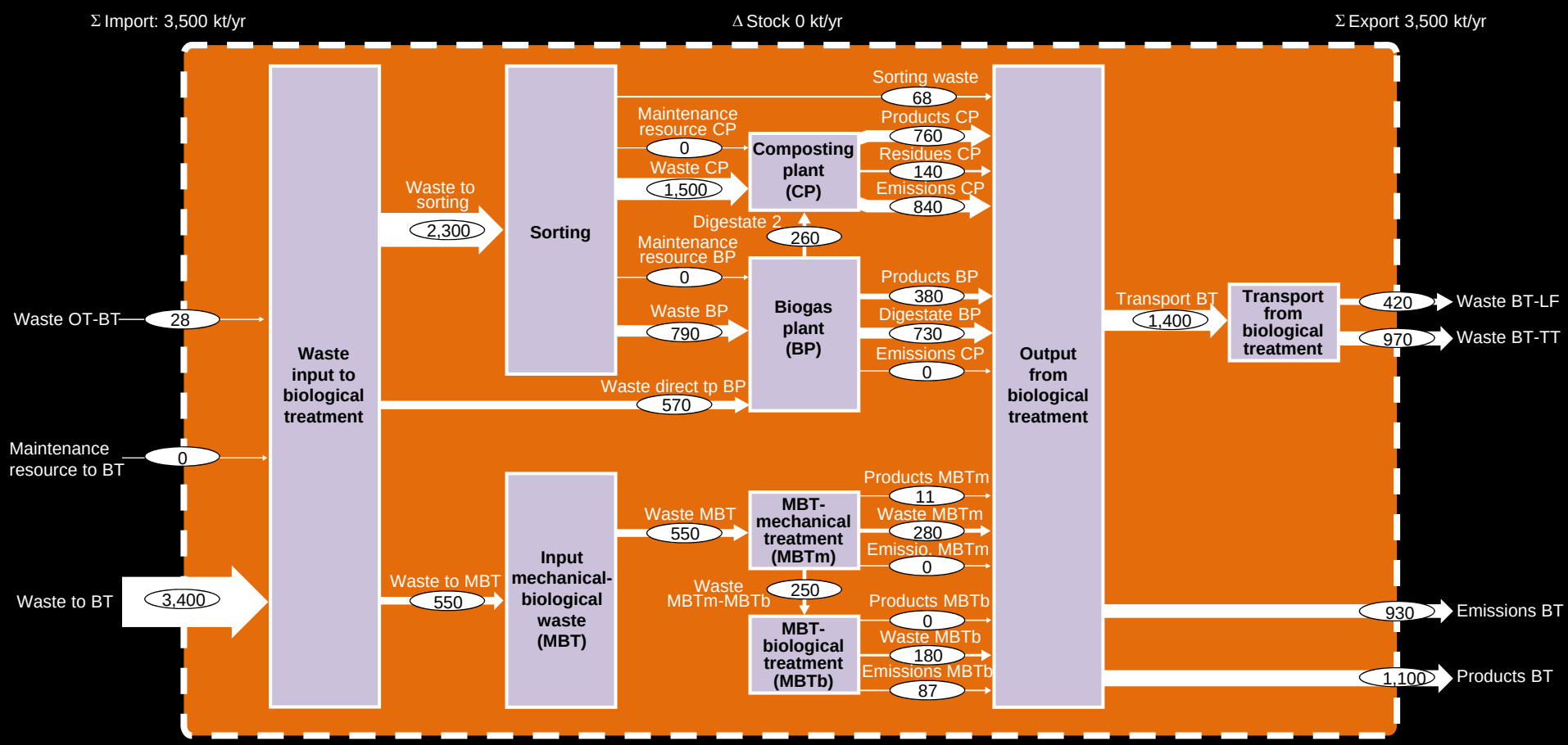
-> transparent and reproducible process

-> acceptance of stakeholders

MFA / SFA for decision making in waste management I



MFA / SFA for decision making in waste management II



Goods
Flows in 1,000 t/yr
Stock in 1,000 t

Subsystem Biological treatment, 2010

MFA / SFA tomorrow

- MFA/SFA for optimizing the “Metabolism of the Anthroposphere”
  - -> the activity concept using MFA/SFA
  - -> more service and less material turnover
- Linking MFA and economics
  - -> using MFA/SFA to optimize industrial processes

The activity concept using MFA

Material turnover in European private households to satisfy basic human needs

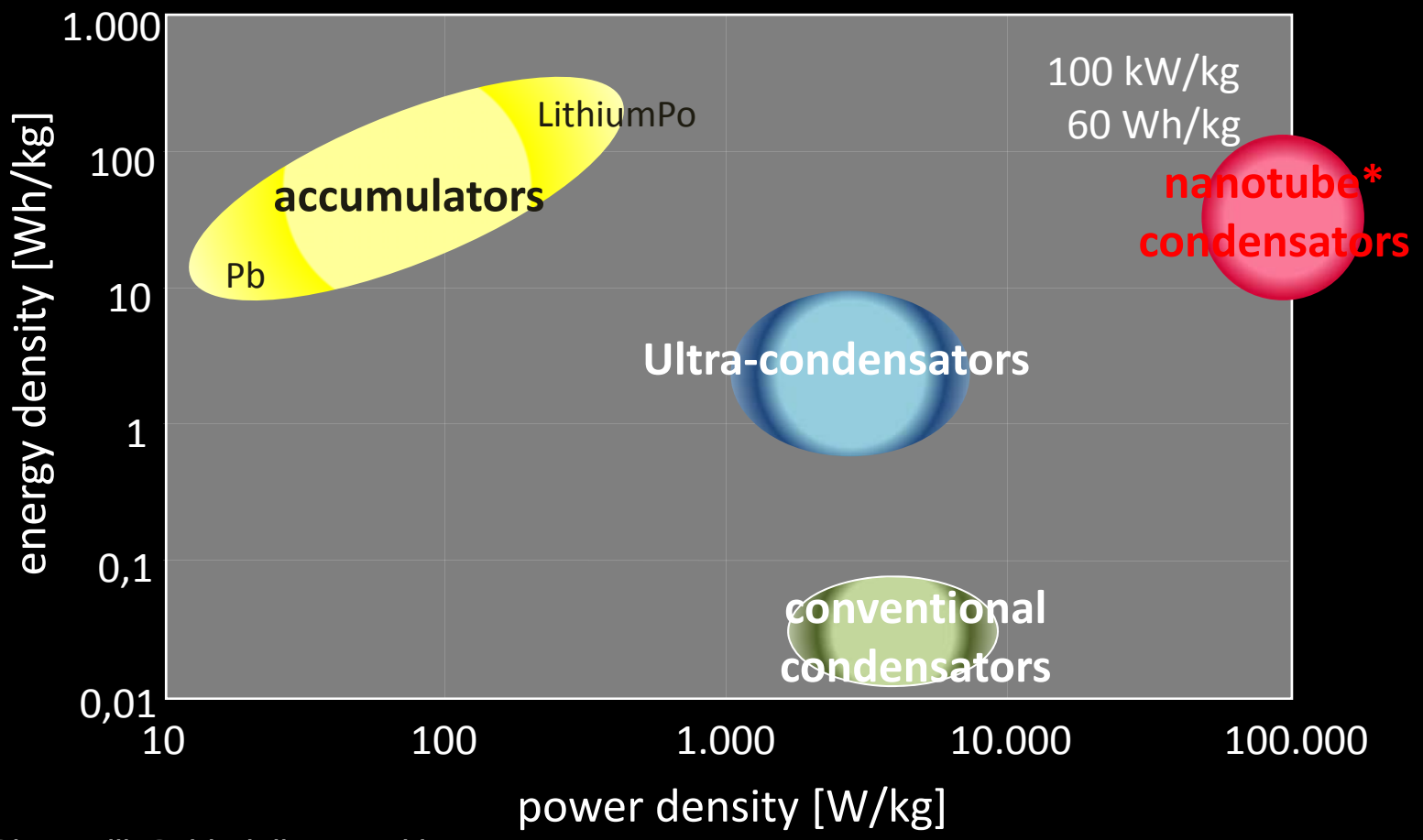
activity	input	output			stock
	[t/c.y]	sewage	off gas *[t/c.y]*	solid residues	*[t/c]*
to nourish	5,7	0,9	4,7	0,1	< 0,1
to clean	60	60	0	0,02	0,1
to reside	10	0	7,6	1	100 + 1
to transport	10	0	6	1,6	160 + 2
Total turnover	86	61	19	2,7	260 + 3

Activity concept

- How to satisfy basic human needs in view of changing technology and economy?
- Example “ to transport”

Activity concept

How to satisfy the need for transportation in view of limited resources of Lithium?



*Signorelli, Schindall, Kassakian

MFA / SFA tomorrow

Optimizing the “Metabolism of the Anthroposphere”

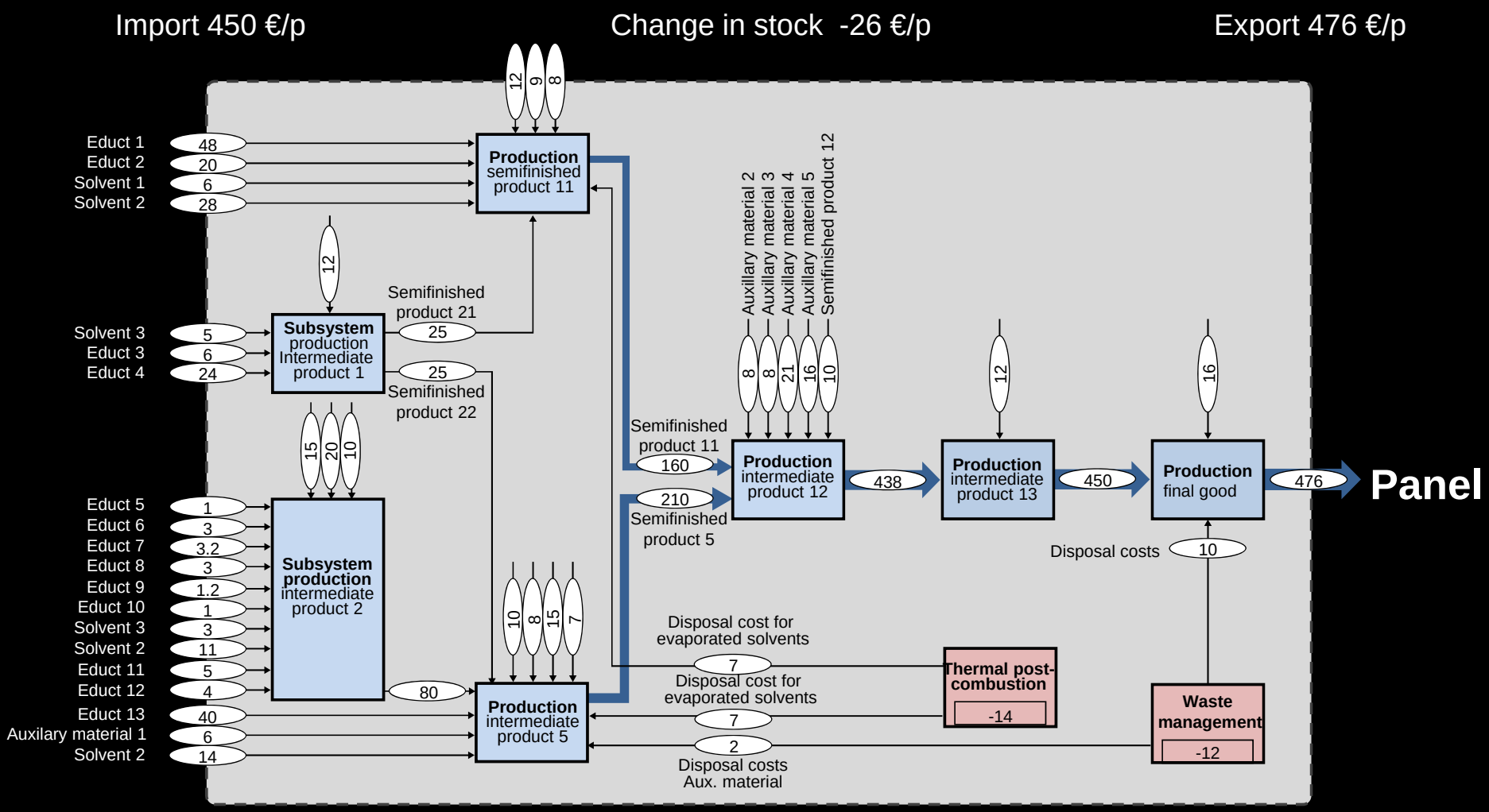
-> the activity concept using MFA/SFA

-> more service and less material turnover

Linking MFA and economics

-> using MFA/SFA to optimize industrial processes

Linking material flows and cost-flows



Flows [€/unit of good]

System boundary "production of panels, 2011"

Conclusions

- Input equals output – transparent and rigid methodology
- Substance level decisive
- All scales from household to planet
- Future indispensable tool for :

  -> early recognition

  -> assessing and solving metabolic problems

  -> designing new strategies and concepts

  -> new knowledge base about metabolism

  -> governance!

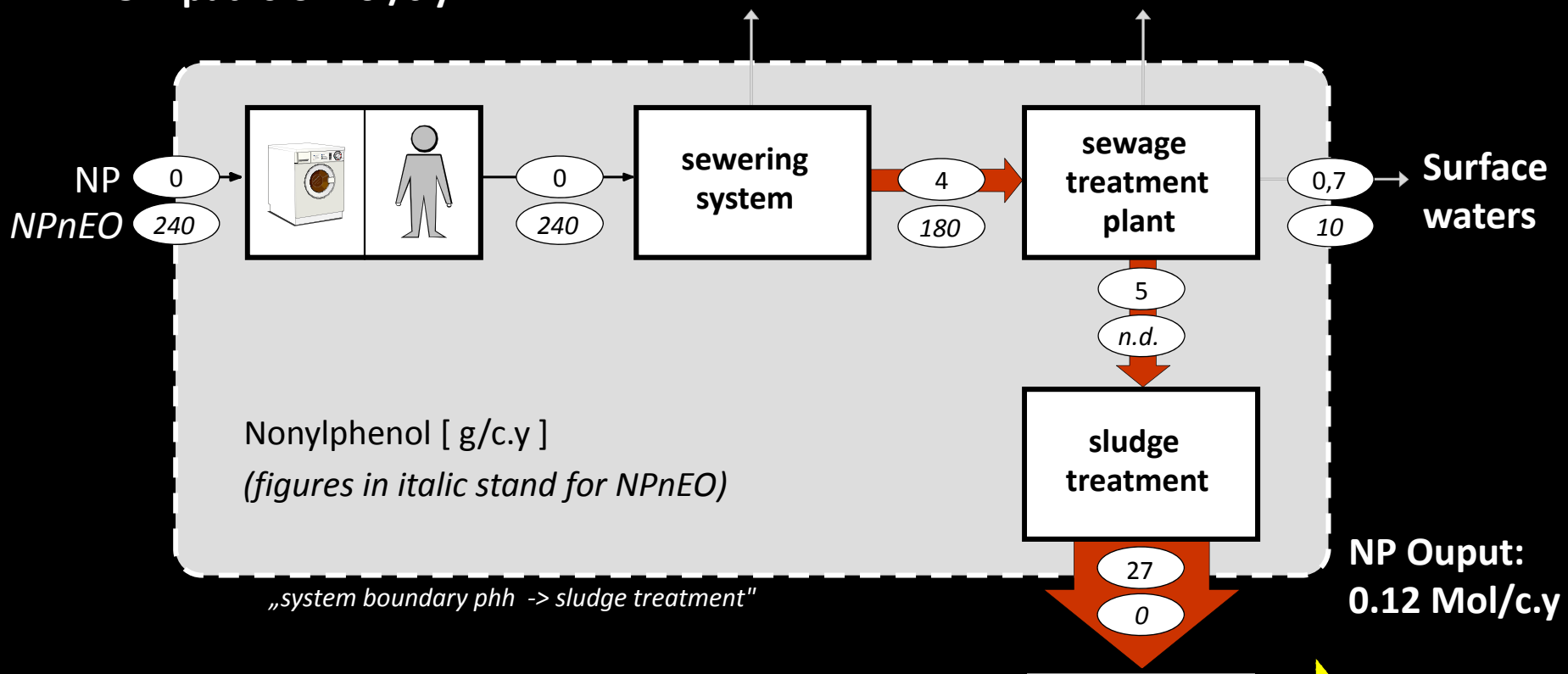
Recycling is not

The End

is the final sink

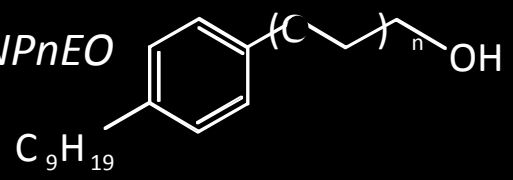
Activity “to clean” – which substances are appropriate?

NPnEO Input: 0.3 Mol/c.y



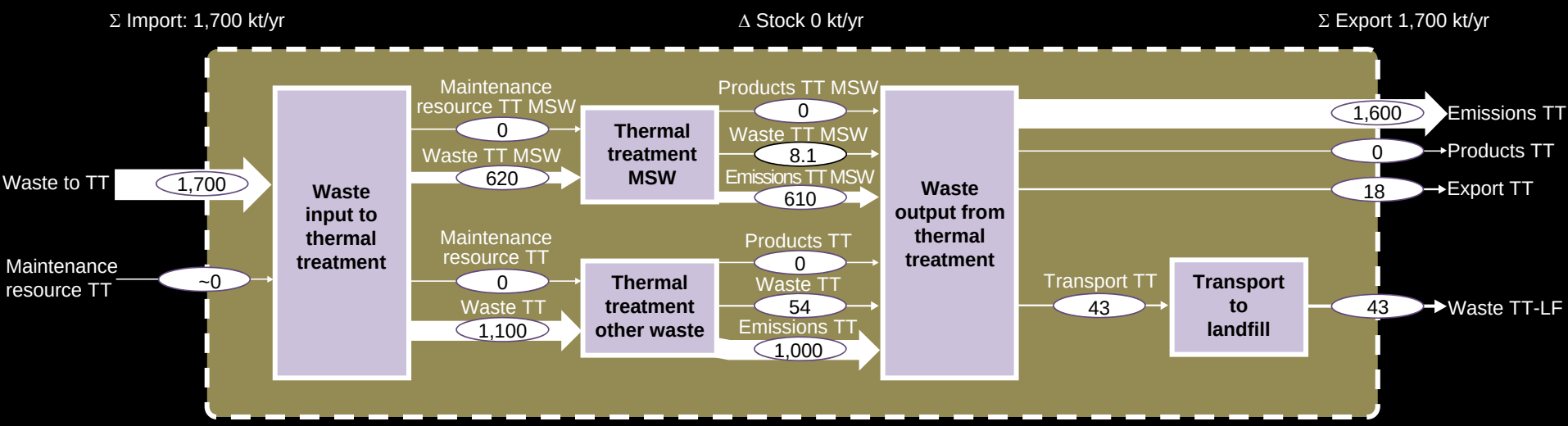
NP Ouput: 0.12 Mol/c.y

Nonylphenolpolyethoxylat NPnEO



MFA / SFA for decision making in waste management III

From MFA to SFA: carbon flows from thermal waste treatment



System boundary "Thermal treatment Austria, 2010"

Carbon
Flows in 1,000 t/yr
Stock in 1,000 t

The application of MFA for decision making in resource and waste management
Analysis, evaluation, design (examples for all three)

Goal oriented, the phase of methodological development is over: there must be a problem stated in order to solve it with MFA
Which problems can be solved: all problems, but for which MFA is effective???

1. The law on conservation of matter: input equals output
2. What is MFA: goods and substances
3. All scales from person to planet
4. For waste management
5. For regional materials management
6. Environmental management
7. Resource management
8. For governance (V.EFB)

_____-
Mention the surprise about nutrients (MFA of private hh)
Mention the surprise of stocks (Lohm) when there were deltas in MFA between I/O