Putting micropollutants, energy, nutrients and GHG emissions on an equal basis: An LCA approach

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Putting micropollutants, energy, nutrients and GHG emissions on an equal basis

A life cycle assessment (LCA) approach

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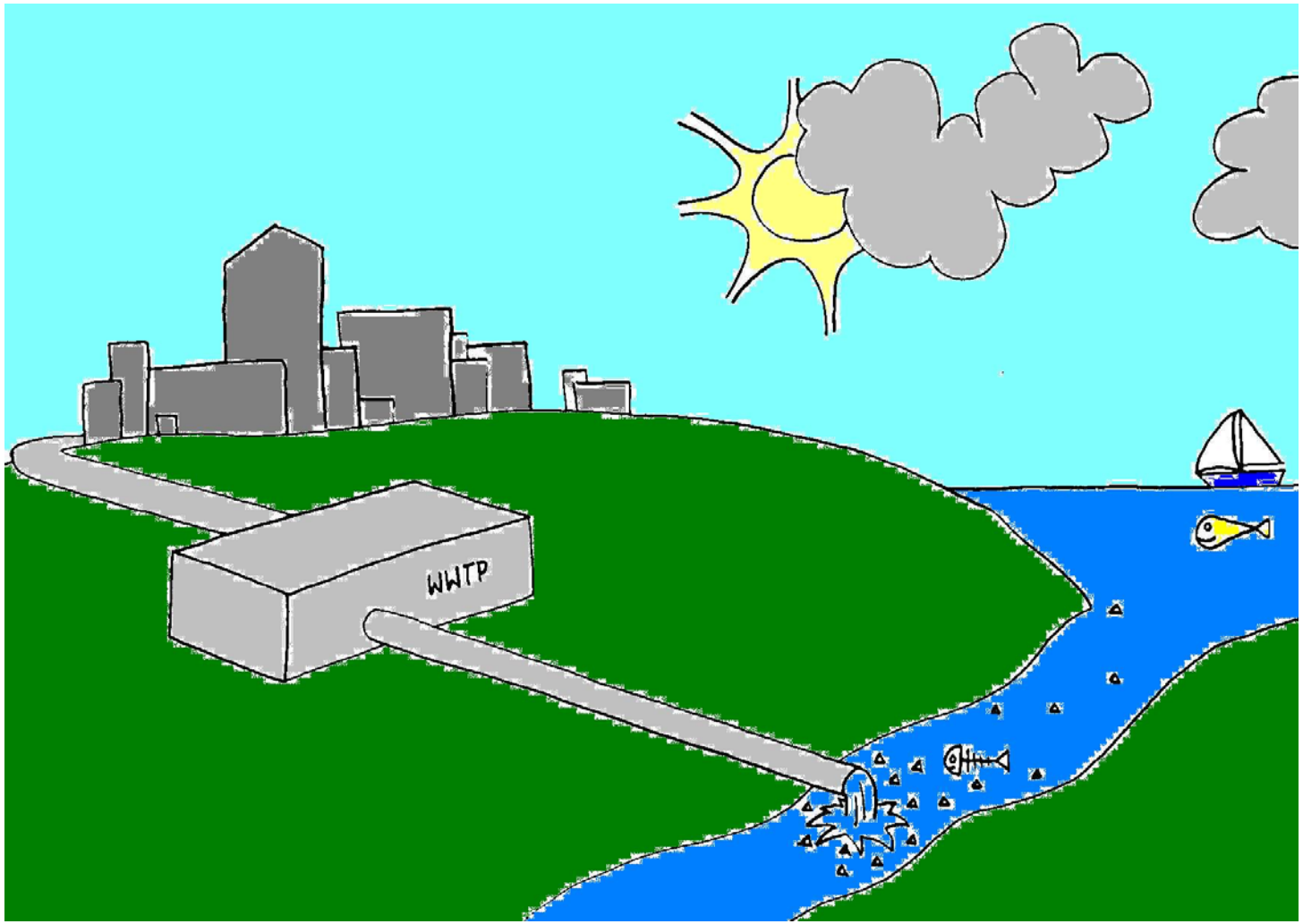
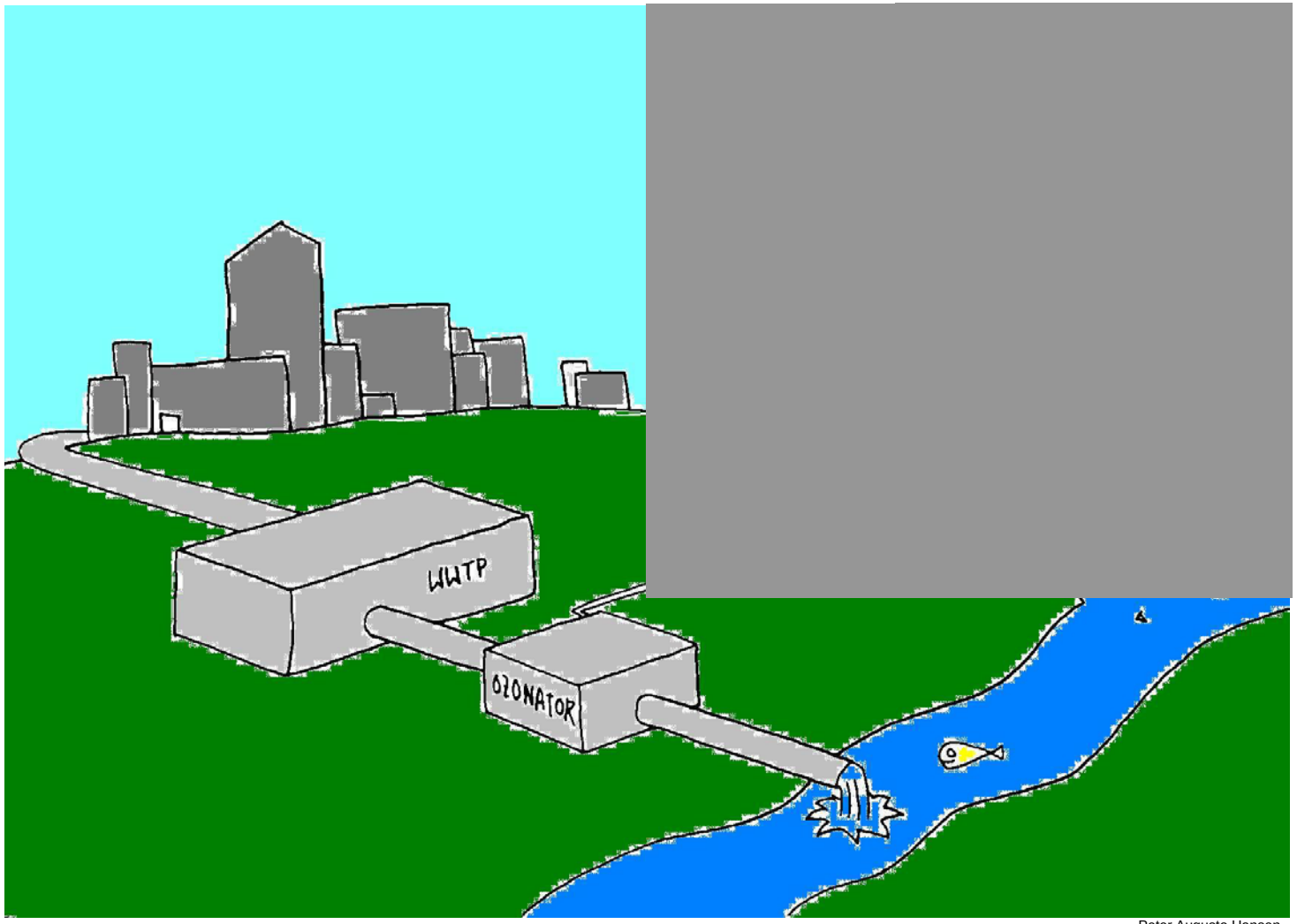
Problem



Peter Augusto Hansen

Putting micropollutants, energy, nutrients and GHG emissions….(Larsen HF)

Sustainable solution or sub-optimisation?



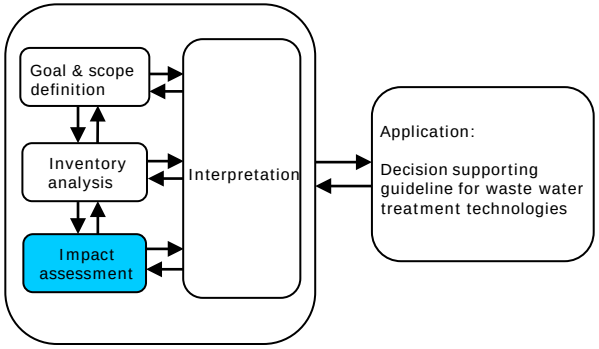
Peter Augusto Hansen

Putting micropollutants, energy, nutrients and GHG emissions….(Larsen HF)

Characteristics of LCA

- A decision supporting tool
- Focus on services typically represented by a product (the “functional unit”, fu). In this case: Treatment of one cubic meter waste water (all impacts related to this unit)
- Comparative (relative statements). In this case: Comparing induced impacts with avoided impacts regarding e.g. ozonation and PAC addition
- Holistic perspective
  - life cycle from cradle to grave
  - all relevant environmental impacts or damages to ‘areas of protection’. In this case:
    - Global warming
    - Nutrient enrichment (eutrofication)
    - Acidification
    - Ecotoxicity
    - ……..
- Aggregation over time and space
  - life cycle is global
  - life cycle may span over decades or even centuries

Life cycle impact assessment (LCIA)



Classification: "What does this emission contribute to?"

- Assignment of emissions to impact categories according to their potential effects
  - Global warming (e.g. CO2, CH4)
  - Acidification (e.g. NO2, SO3)
  - Ecotoxicity (e.g. pharmaceuticals, heavy metals)
  - Human toxicity (e.g. benzene, PAH's)
  - ……..

Characterisation: "How much may it contribute?"

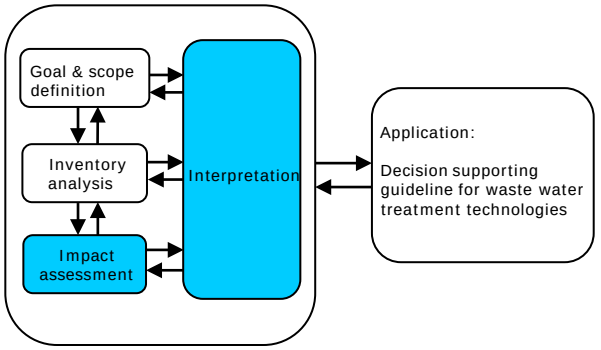
- Quantification of contributions to the different impact categories by estimating impact potentials, IPs (e.g. multiplying the characterisation factors (CFs) for each chemical by the emitted amount (Q) per functional unit (fu):

$$IP = Q*CF$$

- Example (GWP):

Substance	Q (g/fu)	CF (g CO_2-eq/g)	IP (g CO_2-eq/fu)
Carbon dioxid (CO_2)	250	1	250
Methane (CH_4)	10	25	250
Total			500

Life cycle impact assessment (LCIA) and interpretation



Normalisation: "Is that much?"

- Expression of the impact potentials relative to a reference situation (person-equivalence, PE), e.g. normalisation reference (NR) for GWP: 8,700 kg CO2-eq/pers/year. The normalised impact potential (nIP):

$$nIP = IP/NR$$

Impact category	NR (CO_2-eq/pers/year)	IP/fu (kg CO_2-eq/fu)	nIP (mPE/fu)
Global warming (GWP)	8700	0,5	0,057

Valuation: "Is it important?"

- Assignment of weights (weighting factors, WFs) to the different impact potentials (EDIP: political reduction targets), e.g. for global warming a targeted 10 years reduction of 20% => WF=1/(1-0.2) = 1.3. The weighted impact potential (wIP):

$$wIP = nIP*WF$$

Impact category	WF	nIP (mPE/fu)	wIP (mPET/fu)
Global warming (GWP)	1,3	0,057	0,074

Interpretation: "Which alternative is better and what determines it?"

- E.g. is ozonation worth it in an environmental sustainability context or should we avoid it?

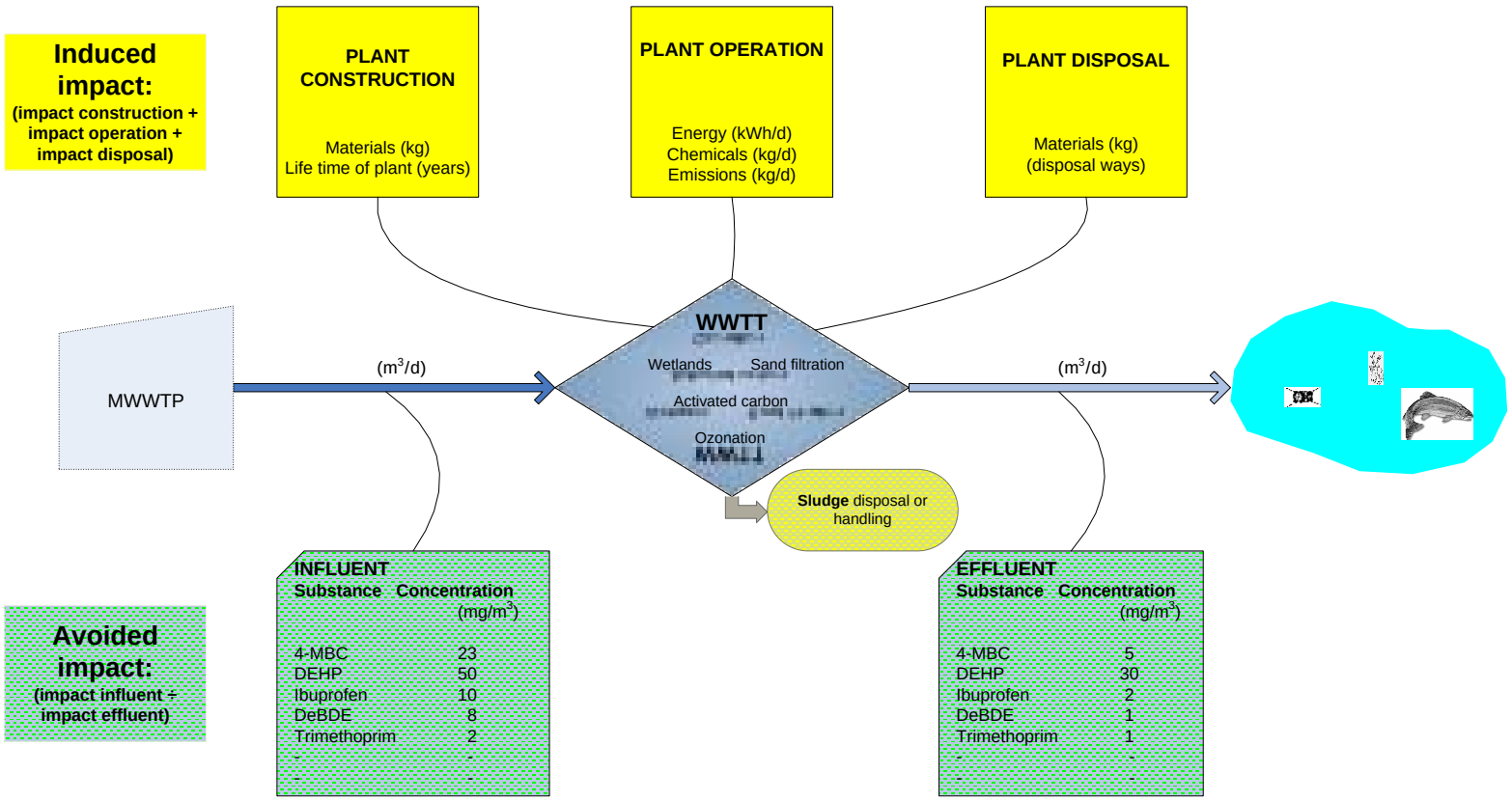
Normalisation references (NRs) and weighting factors (WFs) for the LCA method EDIP97

Impact category	Unit for impact	Normalisation reference (NR, 1994) *1 PE*	Region	Weighting factor (WF, 2004) *1 PET*
Ecotoxicity water	Cubic meter water	352.000 m^3/capita/year	EU-15	1,18
Ecotoxicity soil	Cubic meter soil	964.000 m^3/capita/year	EU-15	1
Human toxicity water	Cubic meter water	52.200 m^3/capita/year	EU-15	1,3
Human toxicity soil	Cubic meter soil	127 m^3/capita/year	EU-15	1,23
Photochemical oxidation	Kg C_2H_4-eq	25 kg/capita/year	EU-15	1,33
Nutrient enrichment	Kg NO_3^--eq	119 kg/capita/year	EU-15	1,22
Acidification	Kg SO_2-eq	74 kg/capita/year	EU-15	1,27
Global warming	Kg CO_2-eq	8.700 kg/capita/year	Global	1,12

Stranddorf et al. 2005

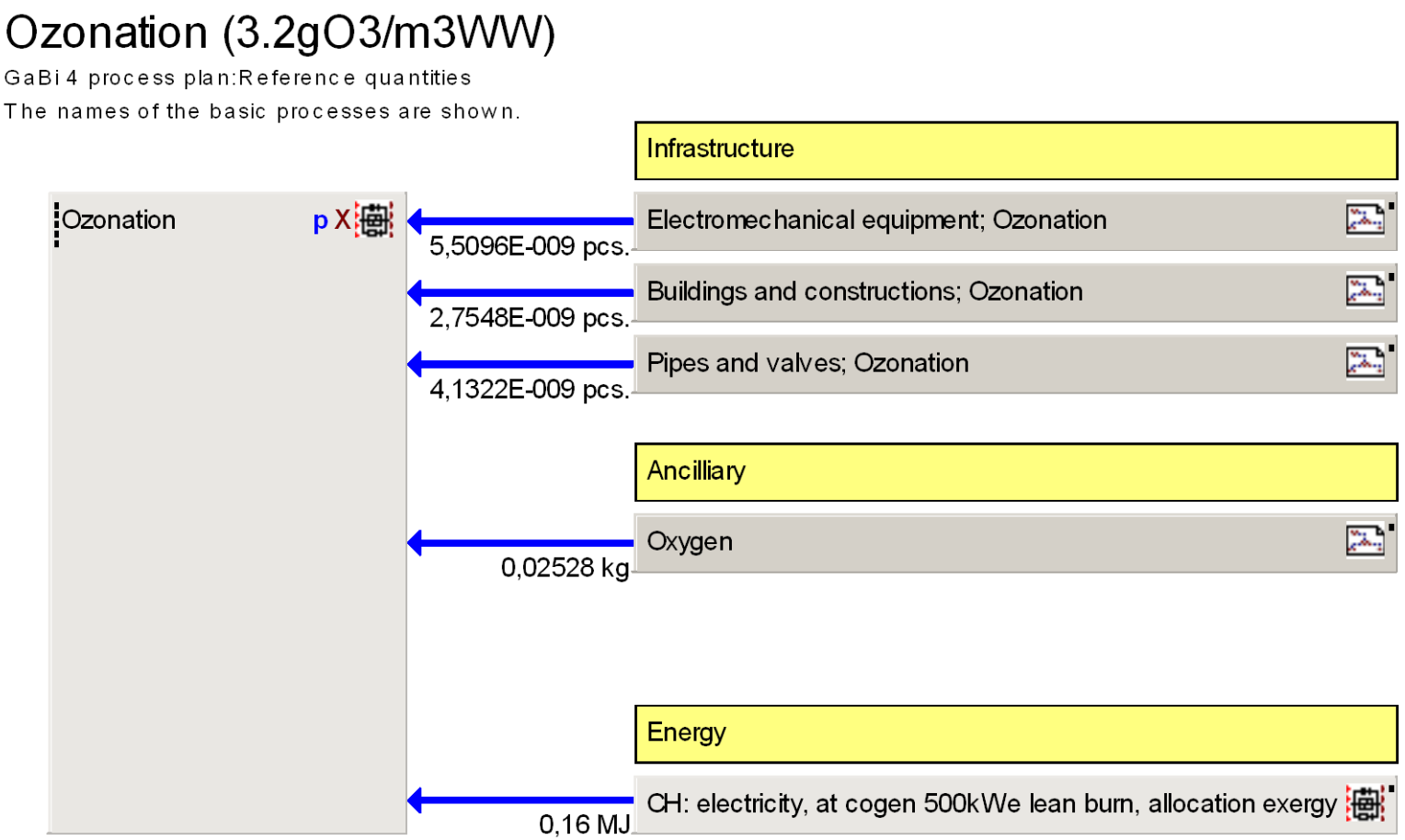
LCA approach used in the EU project Neptune for environmental sustainability assessments of WWTTs

Avoided against induced impacts



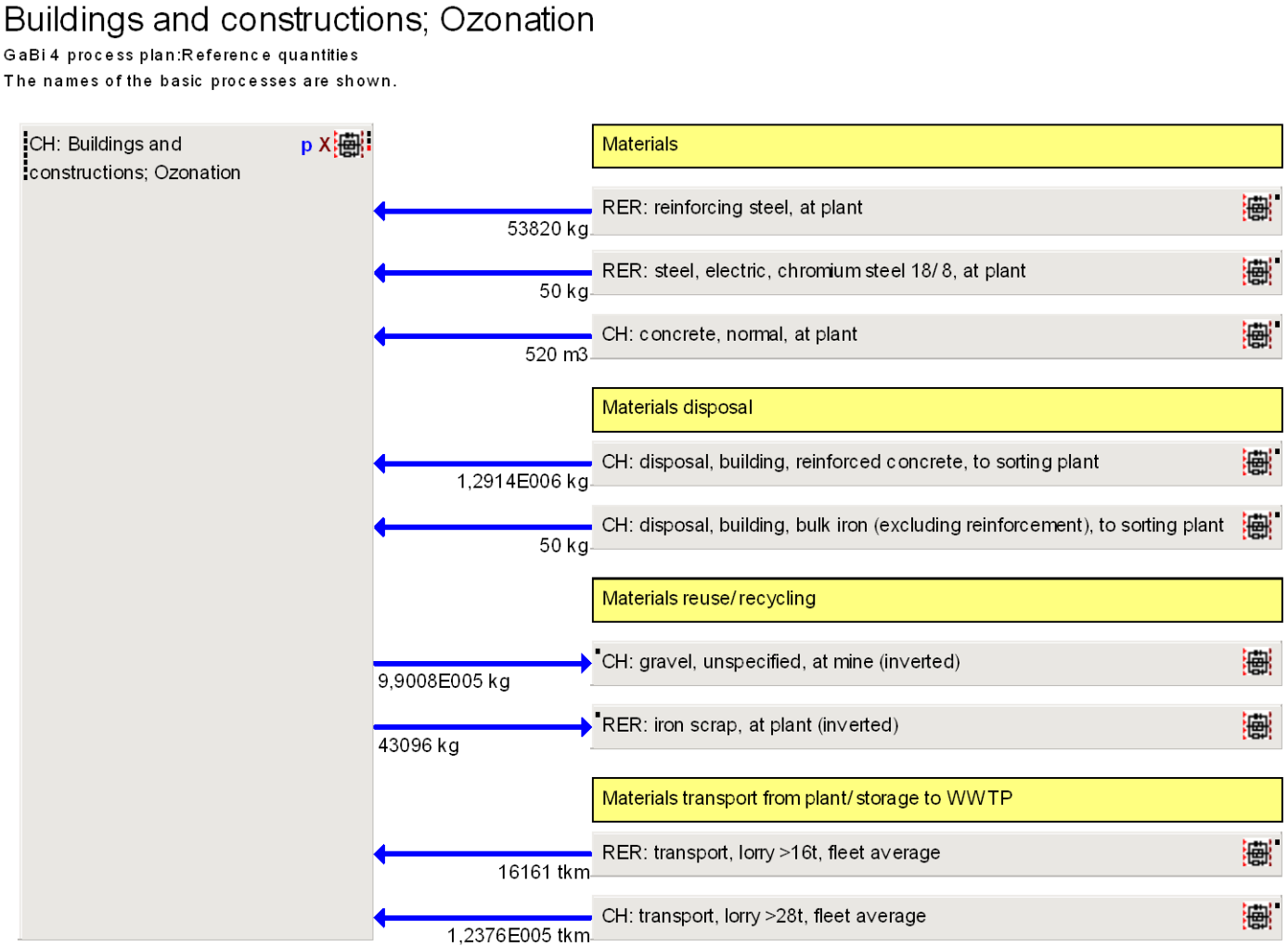
Modelling LCA on ozonation; Main plan

(physical inventory)



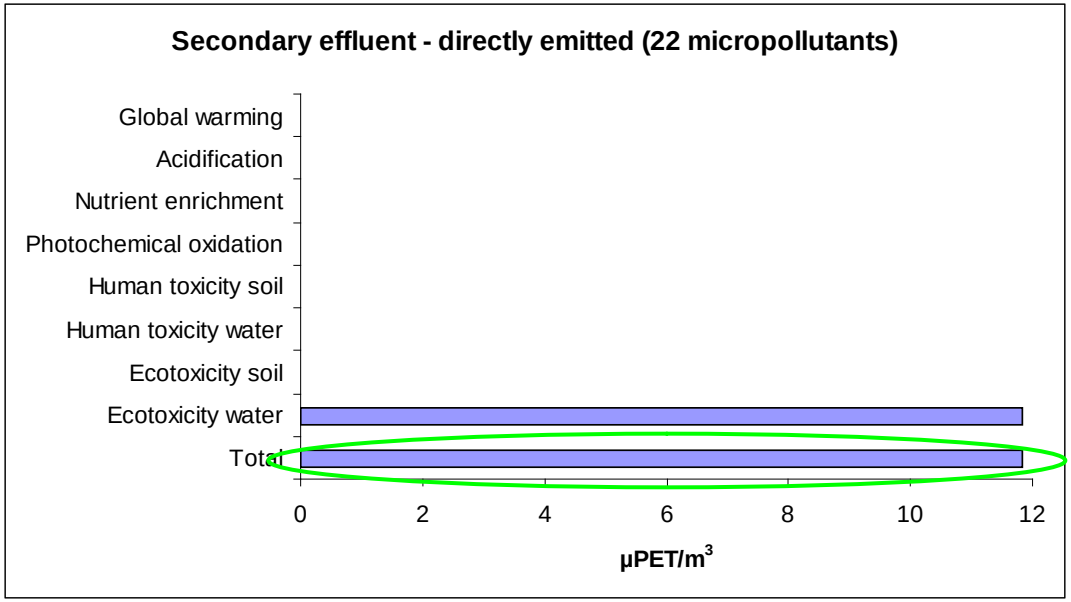
Modelling LCA on ozonation; Sub-plan

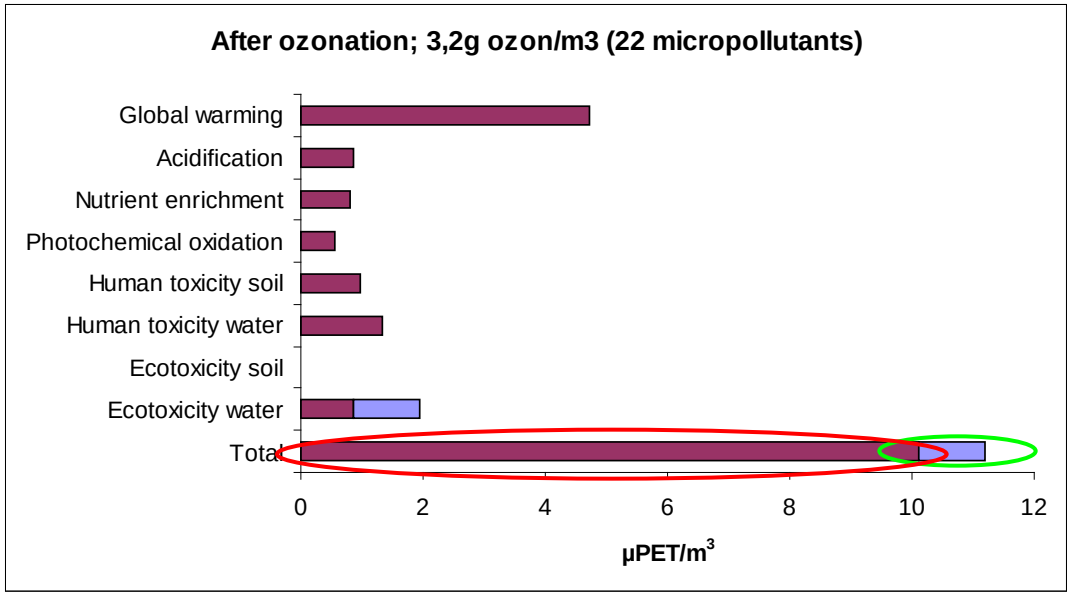
(physical inventory)



LCA impact profiles

(weighting factor = 1 for all impact categories)
(22 micropollutants)



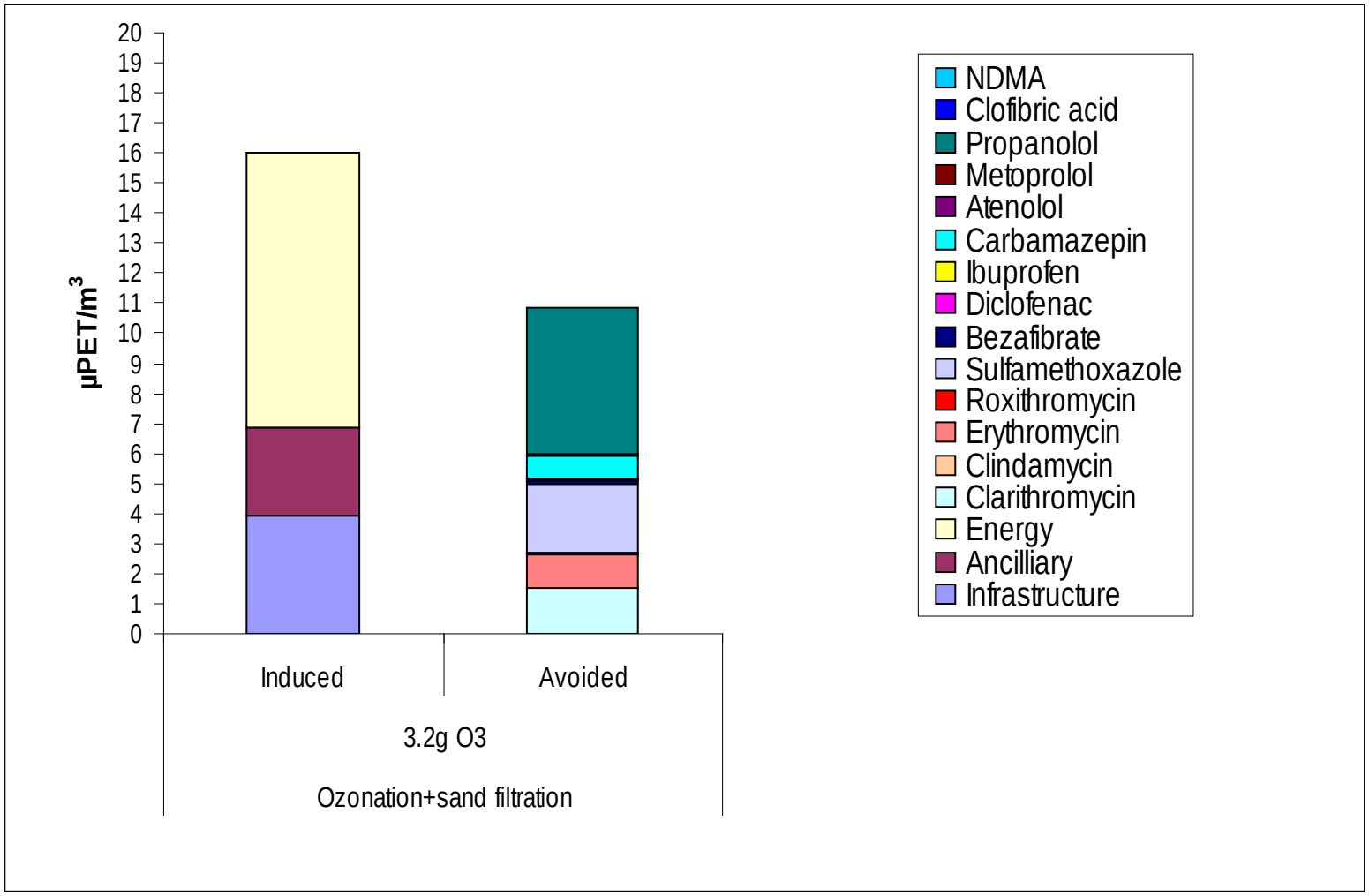


Avoided: 10,7 µPET/m3

Induced: 10,1 µPET/m3

Environmental sustainability profile; ozonation + sand filtration

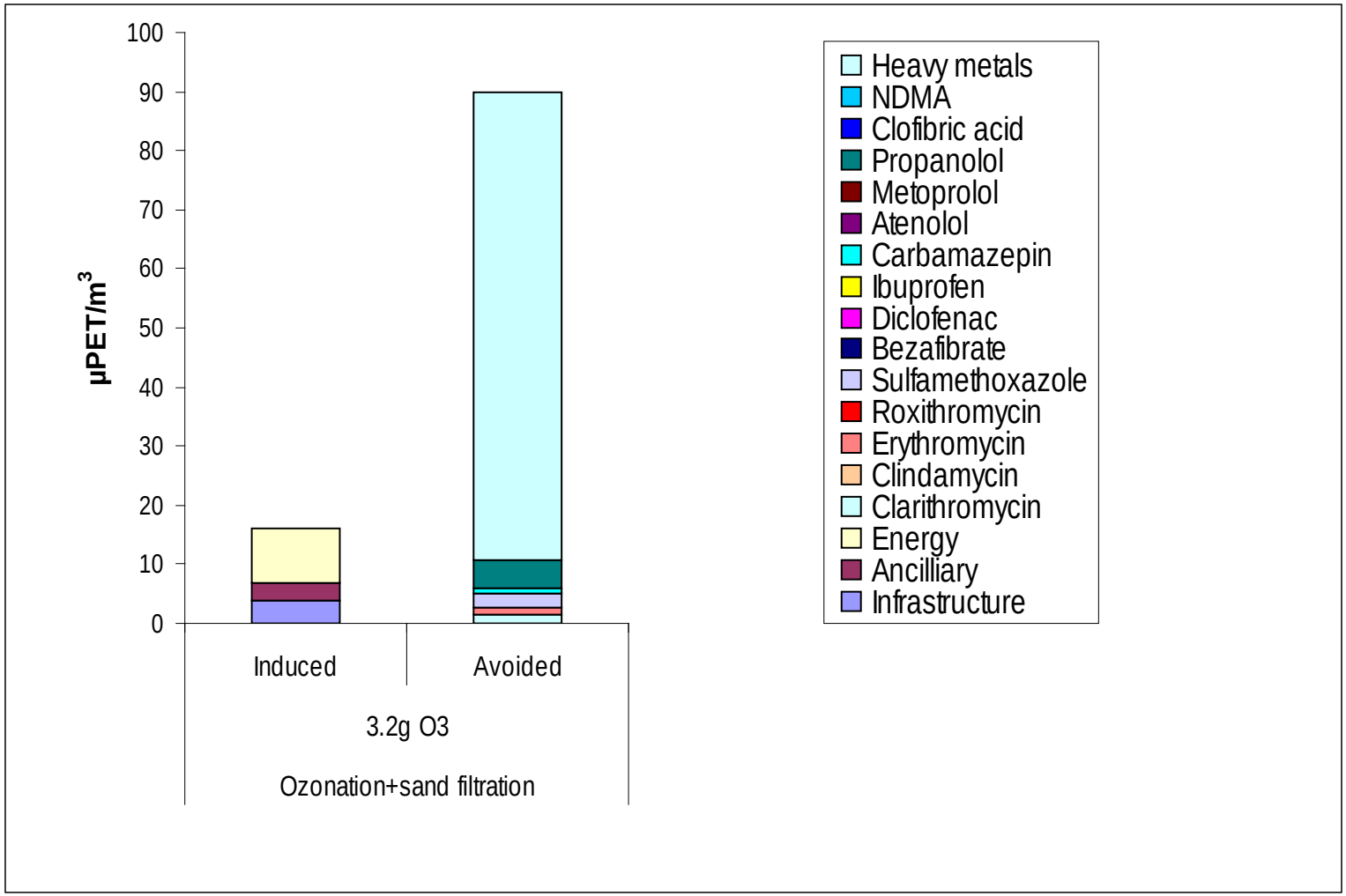
(22 micropollutants, only significant ones shown)
(weighting factor = 1 for all impact categories)



Environmental sustainability profile; ozonation + sand filtration

(Including removal of metals in sand filter)

(**31** micropollutants (only significant ones shown); weighting factor = 1 for all impact categories)



Environmental sustainability profile; ozonation + sand filtration

(including both metal and phosphorus removal)

(**31** micropollutants **+ P** (only significant ones shown); weighting factor = 1 for all impact categories)