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Life Cycle Assessment



Materials Science & Technology

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# LCA of the Swiss e-waste recycling systems

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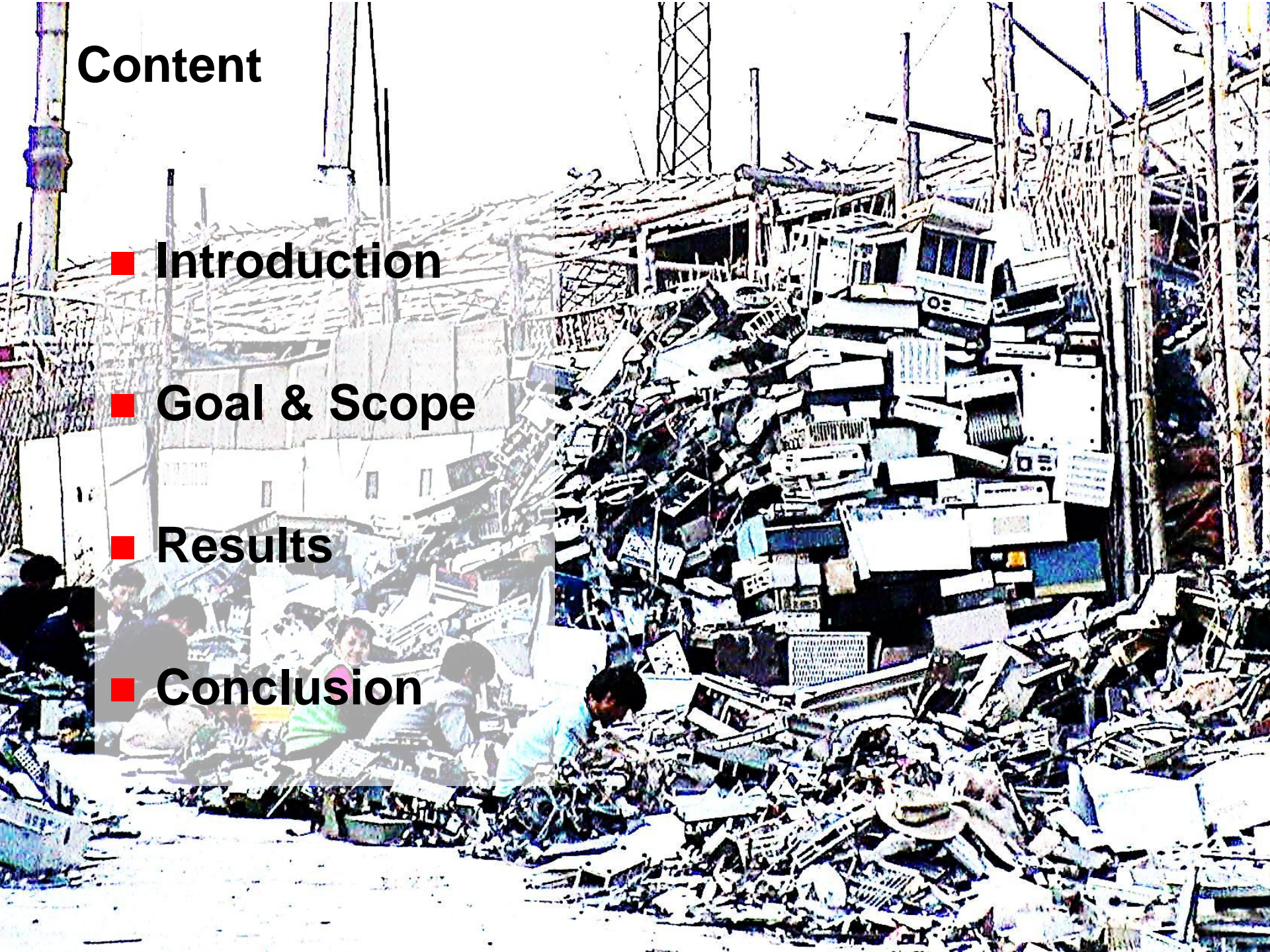
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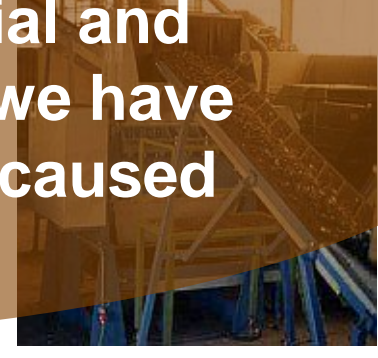
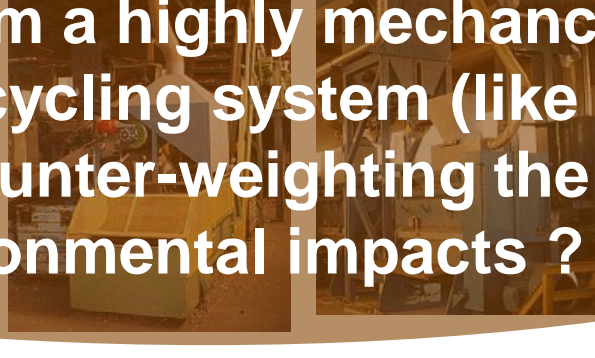




# Problem setting



Are the (secondary) resources, resulting from a highly mechanical and automated recycling system (like we have in Europe) counter-weighting the caused environmental impacts ?



# WEEE Recycling in Switzerland

## A long, successful story ...

- <1990 Individual strategies of certain manufacturers/distributors
- 1991 SENS introduces a recycling scheme for **refrigerators & similar** using a vignette.
- 1994 SWICO introduces a recycling scheme for **IT and office electronics** using an advance recycling fee.
- 1996 Introduction of **collection points for all e-waste** (paid via vignette, advance recycling fee or cash/bill).
- 1998 The “Ordinance on the return, the taking back and the disposal of electrical and electronic appliances” **ORDEA** becomes effective, defined and controlled by SAEFL.
- 1999 **Mobile phones** added to SWICO
- 2000 **Graphics industry** joins SWICO
- 2001 **Telecommunications equipment** added to SWICO
- 2002 **Entertainment & consumer electronics and photography** sector added to SWICO
- 2003 Prepaid Recycling Fee with SENS. **Most electric and electronic devices** can be returned free of charge and nationwide.
- 2005 ORDEA adds **Tools, Gardening and Hobby, Lighting Products, Recreational Equipment** and others as of 1. January 2005



# WEEE Recycling in Switzerland

## ... with impressive numbers !

Year	Number of SENS-licensed businesses	Large electrical appliances	Refrigeration, deep-freeze and air-conditioning appliances	Small electrical appliances	Electronic equipment	Lighting equipment	Fractions from appliances from external sources	Non-ORAREEA appliances	Total in tonnes p.a.
2001	20	9600	6700	Overall 17500			4300		38100
2002	18	5600	6400	Overall 22300			1) <sup>1)</sup>	300	34600
2003	27	14600	11600	5400	30200		9000	800	71600
2004	28	18100	13100	7500	33700		3600	1800	77800
2005	33	19100	11400	9300	37200	420 <sup>2)</sup>	3200	1900	82500
2006	34	23400	15300 <sup>3)</sup>	10700	41800	1100	3500	4200	100000 <sup>3)</sup>
2007	34	26100	14500	12300	42500	1110	8100	2900	107500
2008	21	26800	15100	13800	45000	1130	3600	2300	107700
2009	21	30700	15300	14600	46100	1120	3700	1200	112700
2010	20	30700	15800	15400	50700	1120	3200	3500	120400

... more than **17 kg** in 2010 per inhabitant !  
(while WEEE is asking 4 kg per inhabitant and year)



# WEEE Recycling in Switzerland

## Mobile Recycling

Fonda: mobile refrigerator and white good recycling

## Electronic Waste

IMMARK: full processing line, focus: electronic waste

## Electric Waste

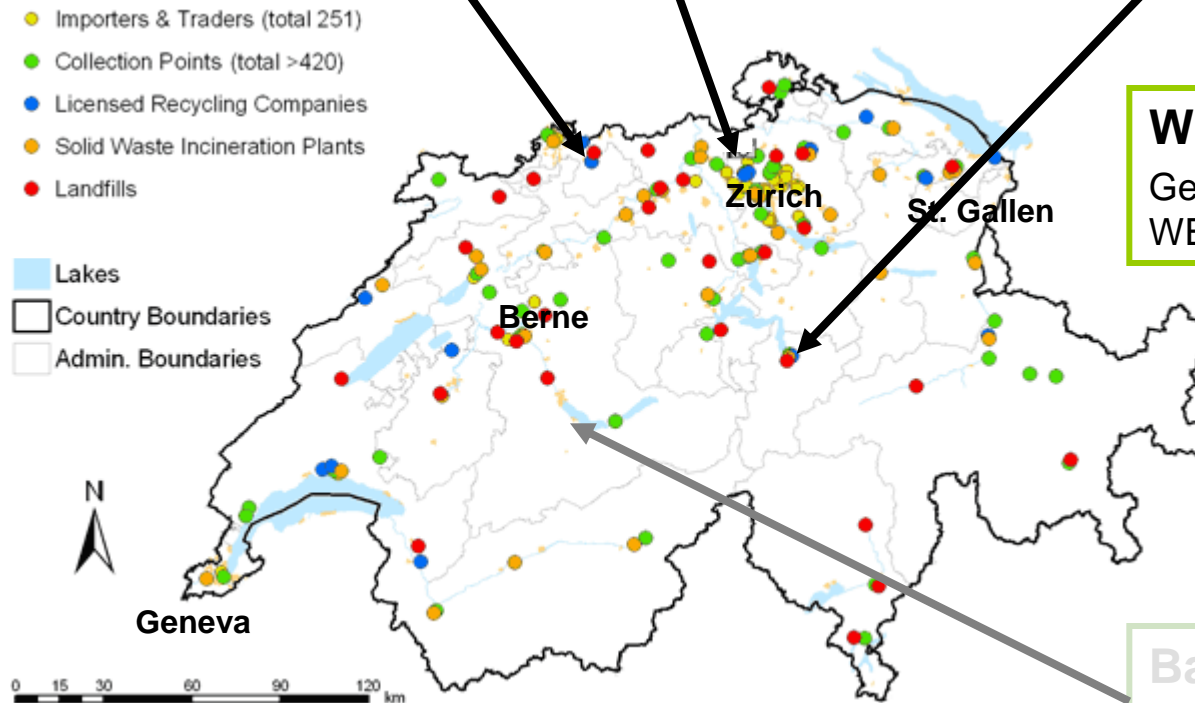
RUAG: full processing line, focus: all types e-waste

## WEEE Recycling

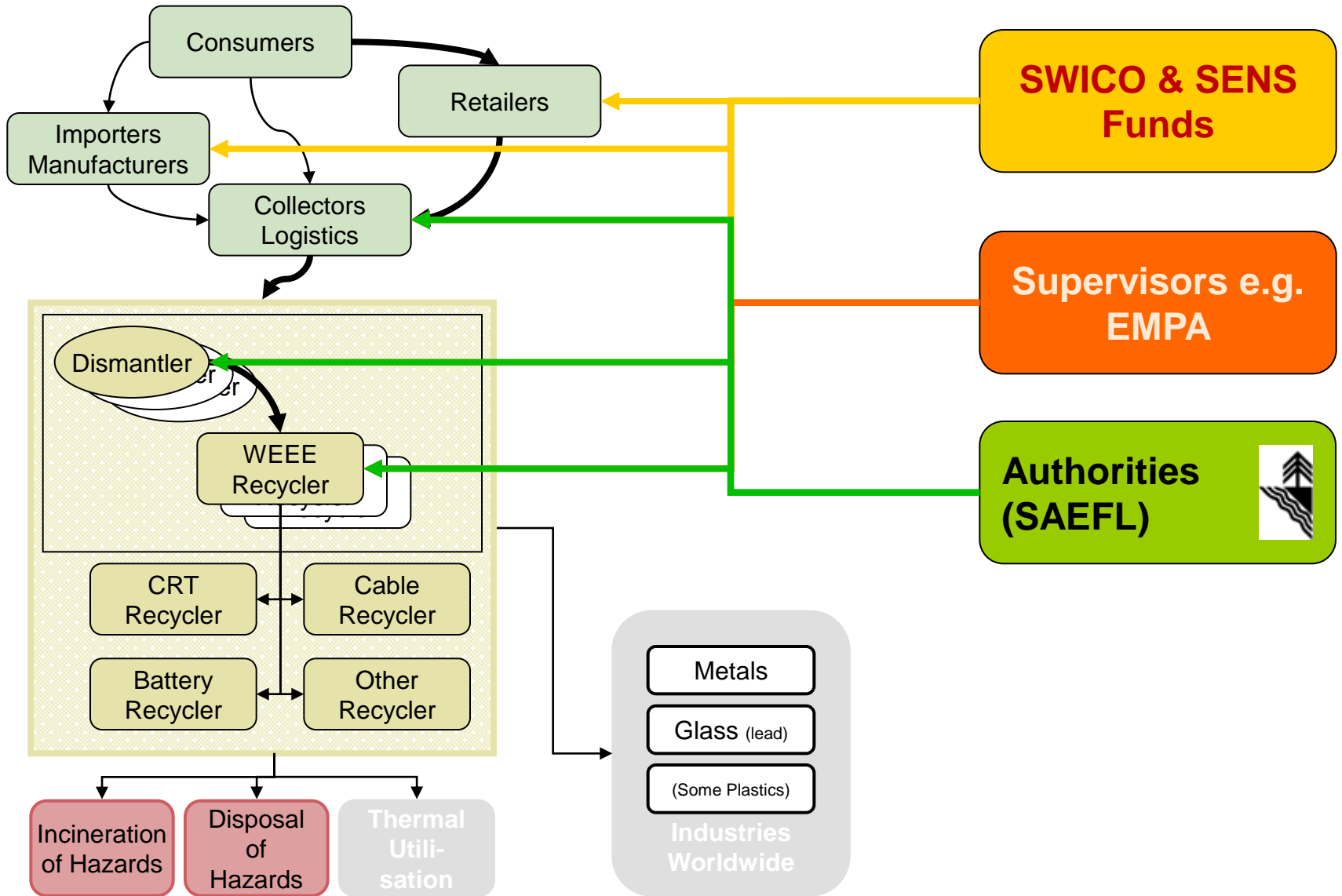
Generic Recycling Process of WEEE in Switzerland

## Batteries

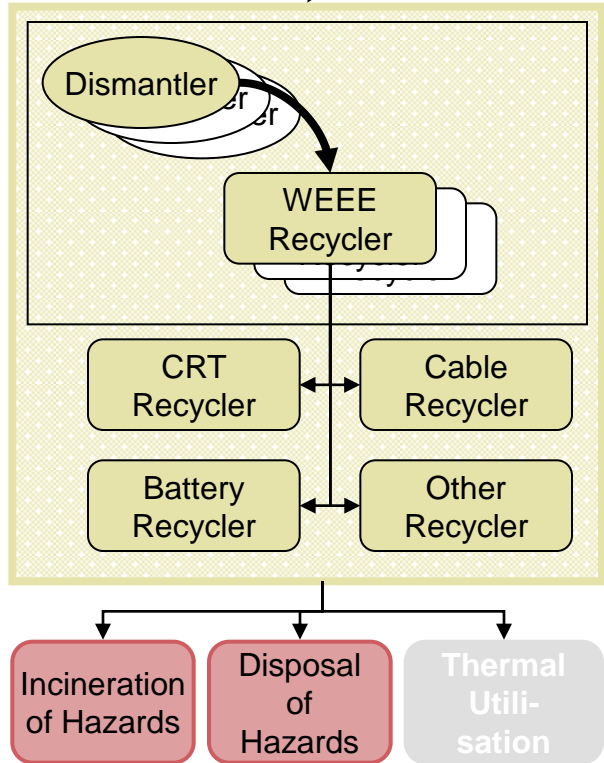
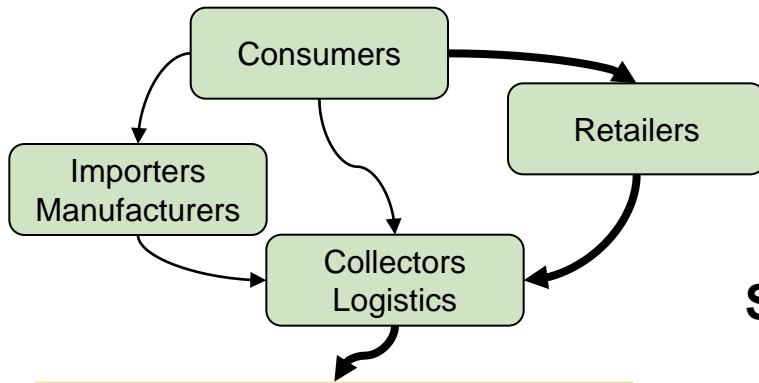
BATREC: full processing line for battery recycling



# WEEE Recycling in Switzerland



# Secondary Raw Materials



## Switzerland

Secondary Raw Materials

Traders of Secondary Raw Materials

- Steel Industry
- Metallurgic Industry
- Ceramics Industry
- Plastics Industry

## Europe

- Steel Industry
- Metallurgic Industry
- Ceramics Industry
- Plastics Industry

## Global: Focus on Asia/China

- Steel Industry
- Metallurgic Industry
- Ceramics Industry
- Plastics Industry

**Recyclers sell their secondary raw materials – depending on price and quantity – through:**

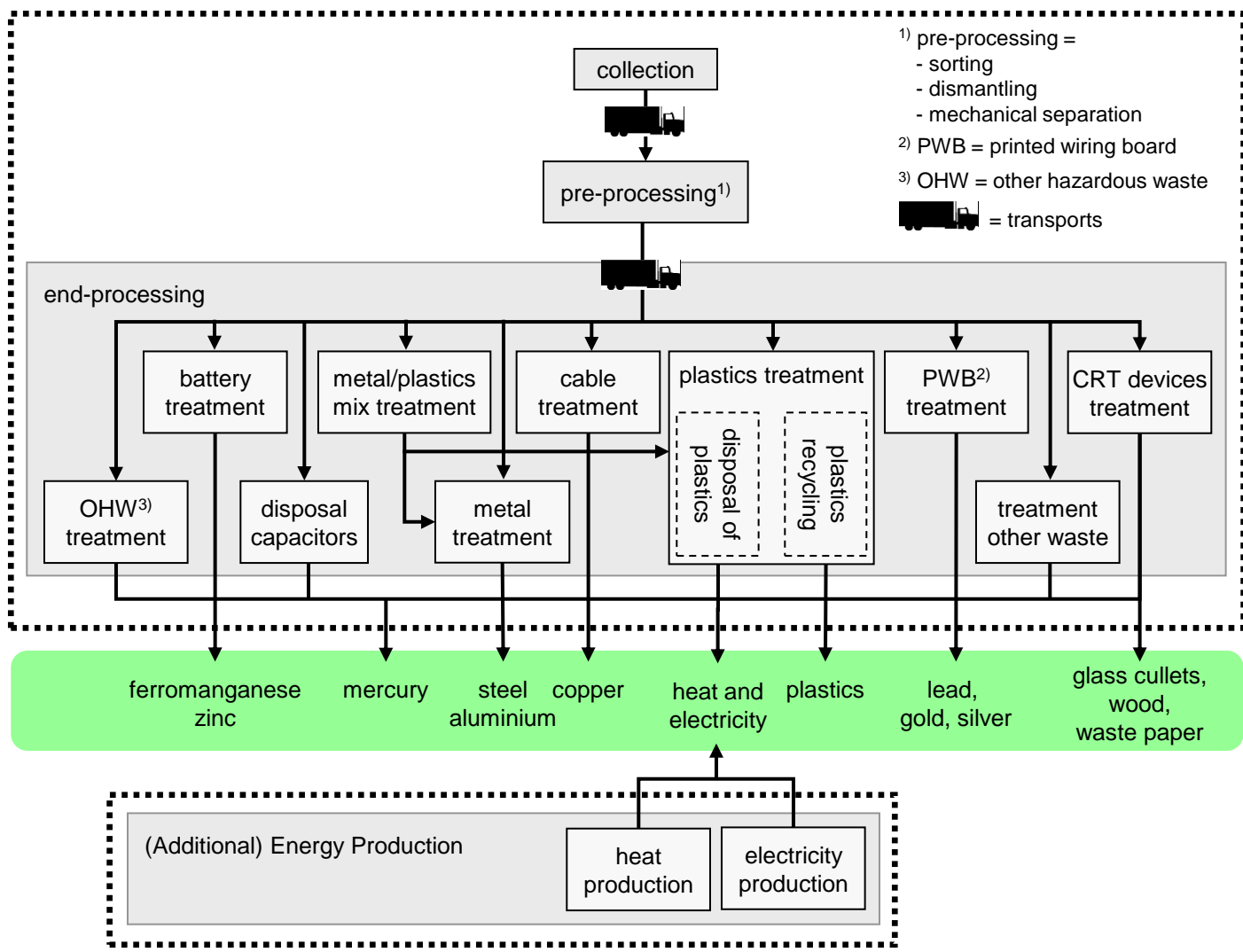
- Traders
- Directly to the industry
- Both, traders and directly



# Goal & Scope of the study

- Does the WEEE recycling – as it happens in Switzerland – make sense from an environmental perspective?
- Combined Material Flow Analysis (MFA) and Life Cycle Assessment (LCA) study ...
  - ... using latest material flow statistics from Swiss WEEE systems;
  - ... in combination with a stepwise LCA model covering the complete WEEE treatment chain (collection -> secondary resource/final disposal)
  - ... using ecoinvent v2 as background LCI database
- Functional unit:
  - Treatment of annual WEEE amount, collected in 2009 in Switzerland
  - ... using a «common basket of products»

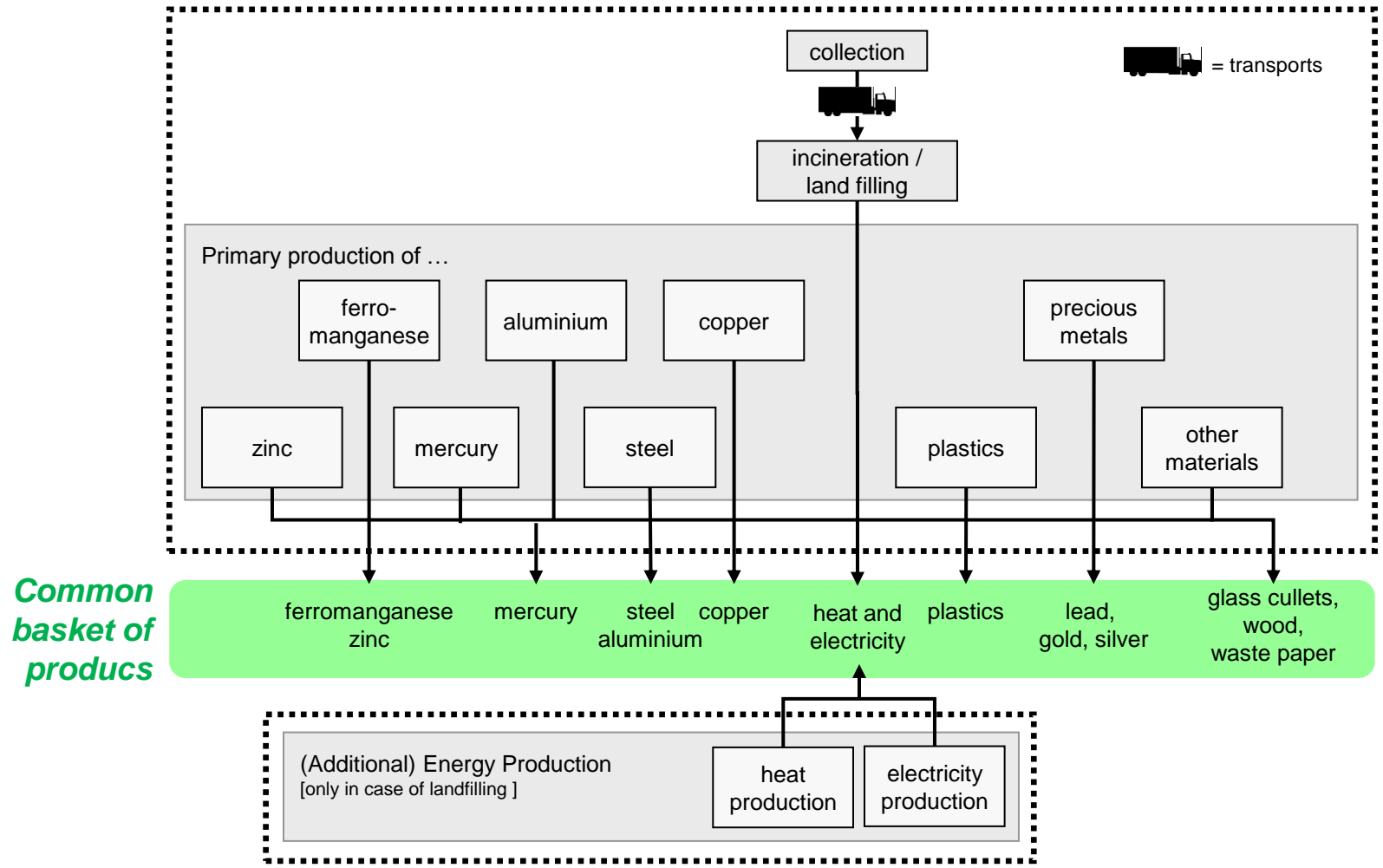
# System Boundaries WEEE treatment model



**Common basket of products**

# System Boundaries

## Base Case Modelling





# Material Flow Data SWICO/SENS

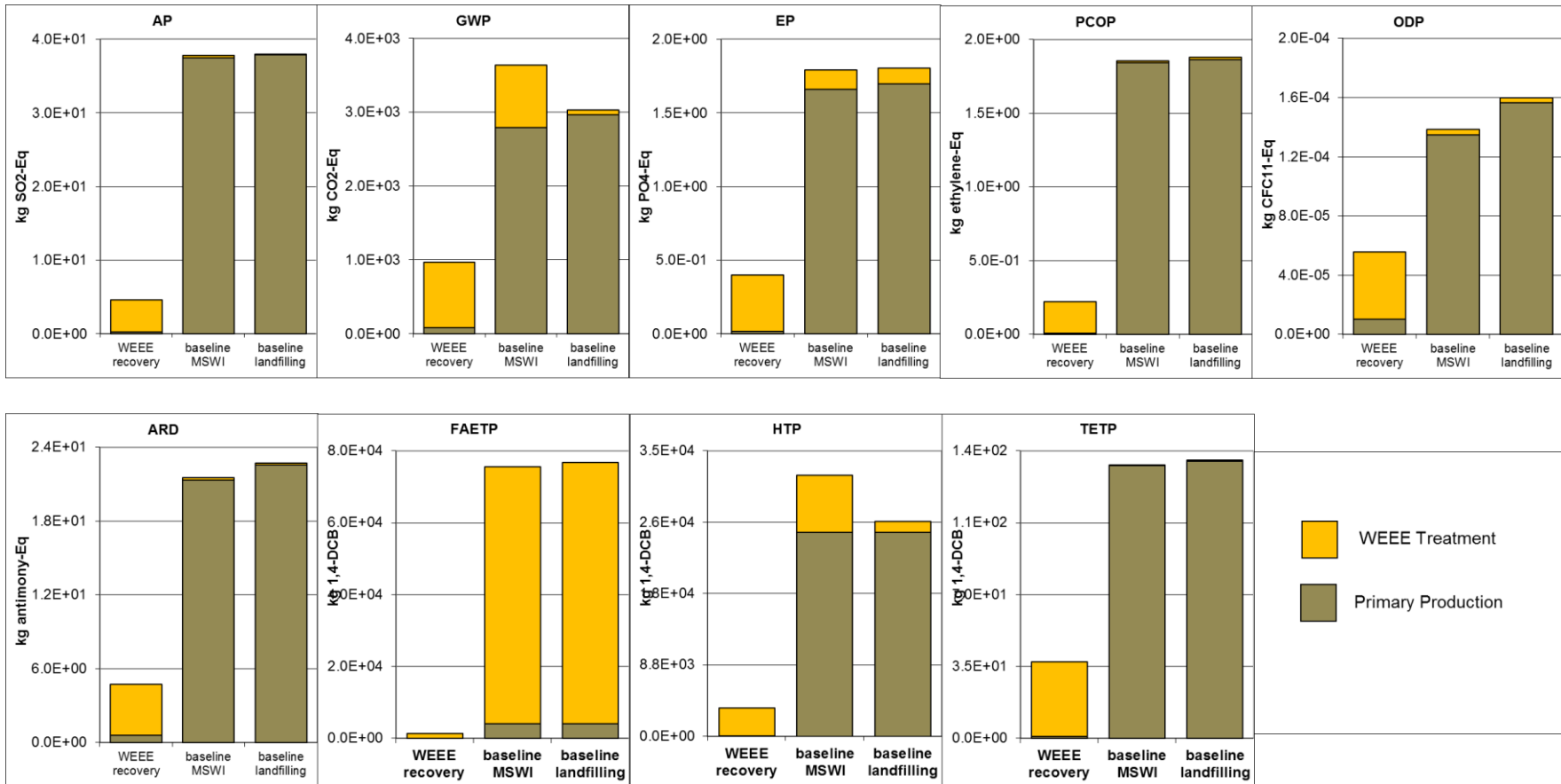
	2004		2009	
	Amount in t	in %	Amount in t	in %
<b><i>Hazardous fractions</i></b>				
<b>Batteries</b>	204	0.3	360	0.3
<b>Capacitors</b>	120	0.2	161	0.2
<b>Other hazardous fractions <sup>1)</sup></b>	233	0.3	639	0.6
<b><i>Valuable fractions</i></b>				
<b>Metals</b>	45'869	61.2	61'595	56.2
<b>Metals-plastics mixture</b>	8776	11.7	6'232	5.7
<b>Plastics</b>	9133	12.2	20'206	18.4
<b>CRT Glass</b>	6862	9.2	10'194	9.3
<b>Cables</b>	1105	1.5	1'563	1.4
<b>Printed wiring boards (PWB)</b>	1204	1.6	973	0.9
<b>Other valuable fractions <sup>2)</sup></b>	1450	1.9	7'700	7.0
<b><i>Sum of all fractions</i></b>	<b>74'957</b>	<b>100</b>	<b>109'623</b>	<b>100</b>

<sup>1)</sup> consisting of cooling substances, fluorescent layer from cathode ray tube (CRT) screens, mercury, selenium drums

<sup>2)</sup> consisting of glass, liquid crystal displays (LCDs), paper/board, toner modules, wood.

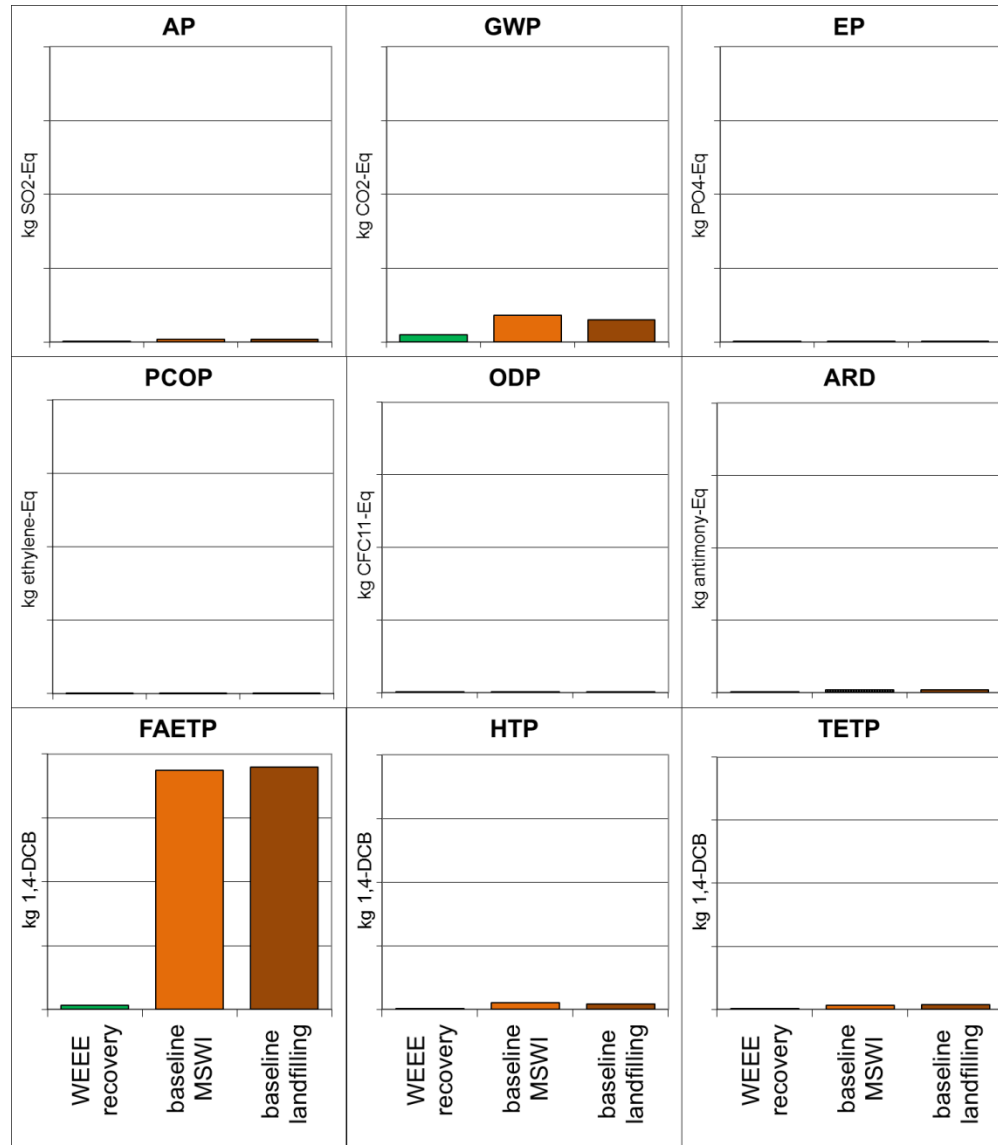
# Results

## Overall Impact of the various Models



# Results

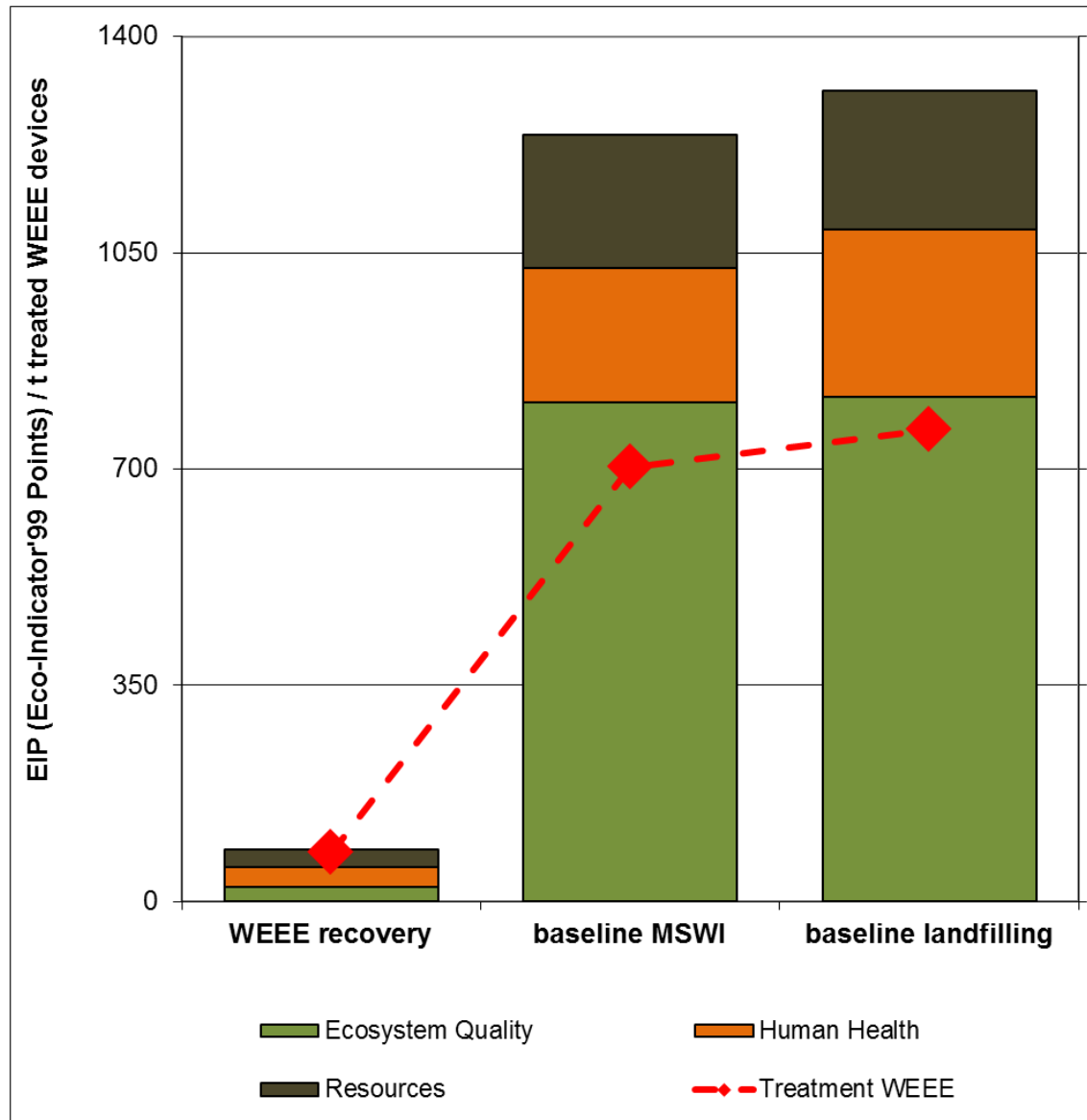
## Overall Impact of the various Models





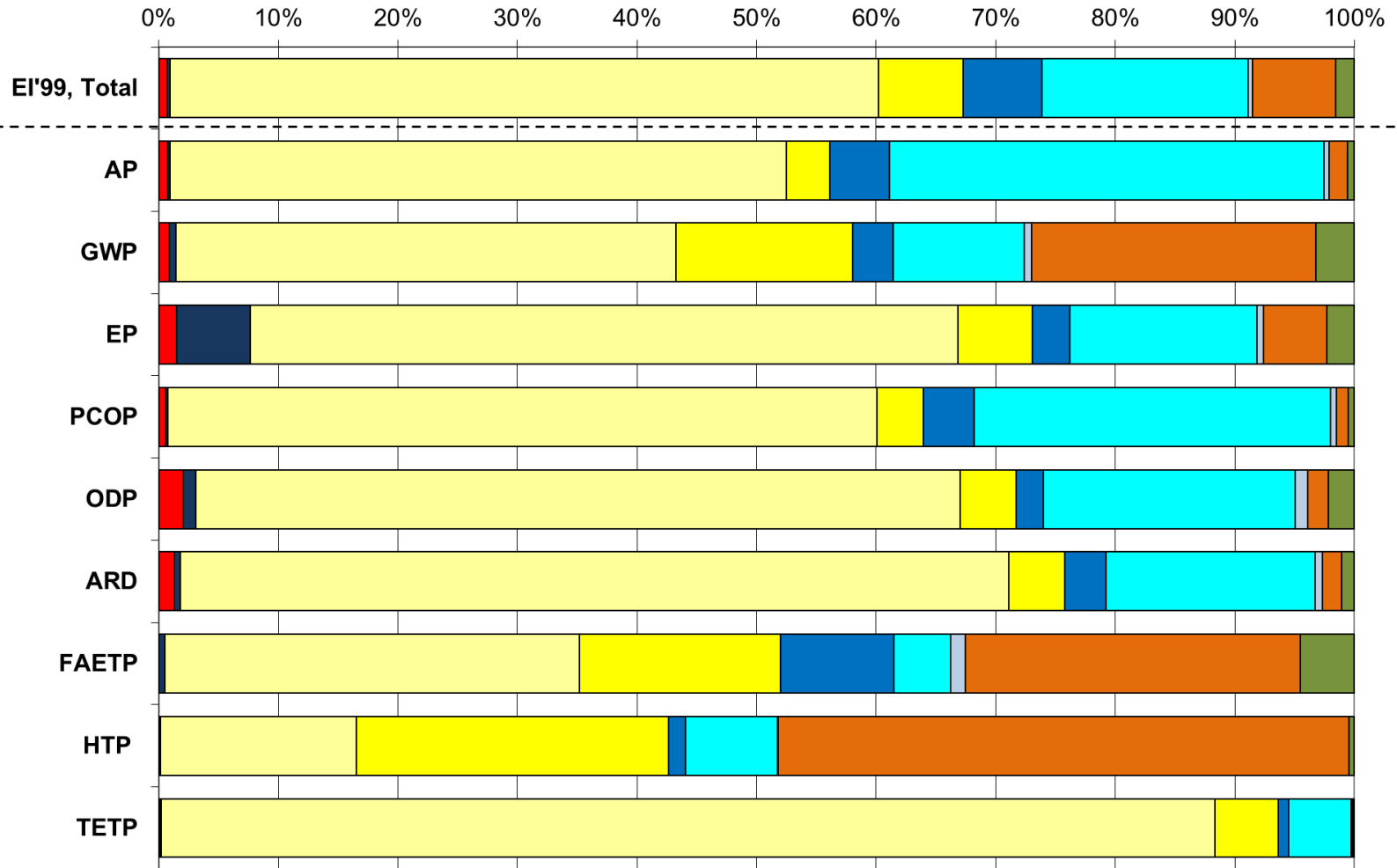
# Results

## Overall Impact of the various Models



# Results

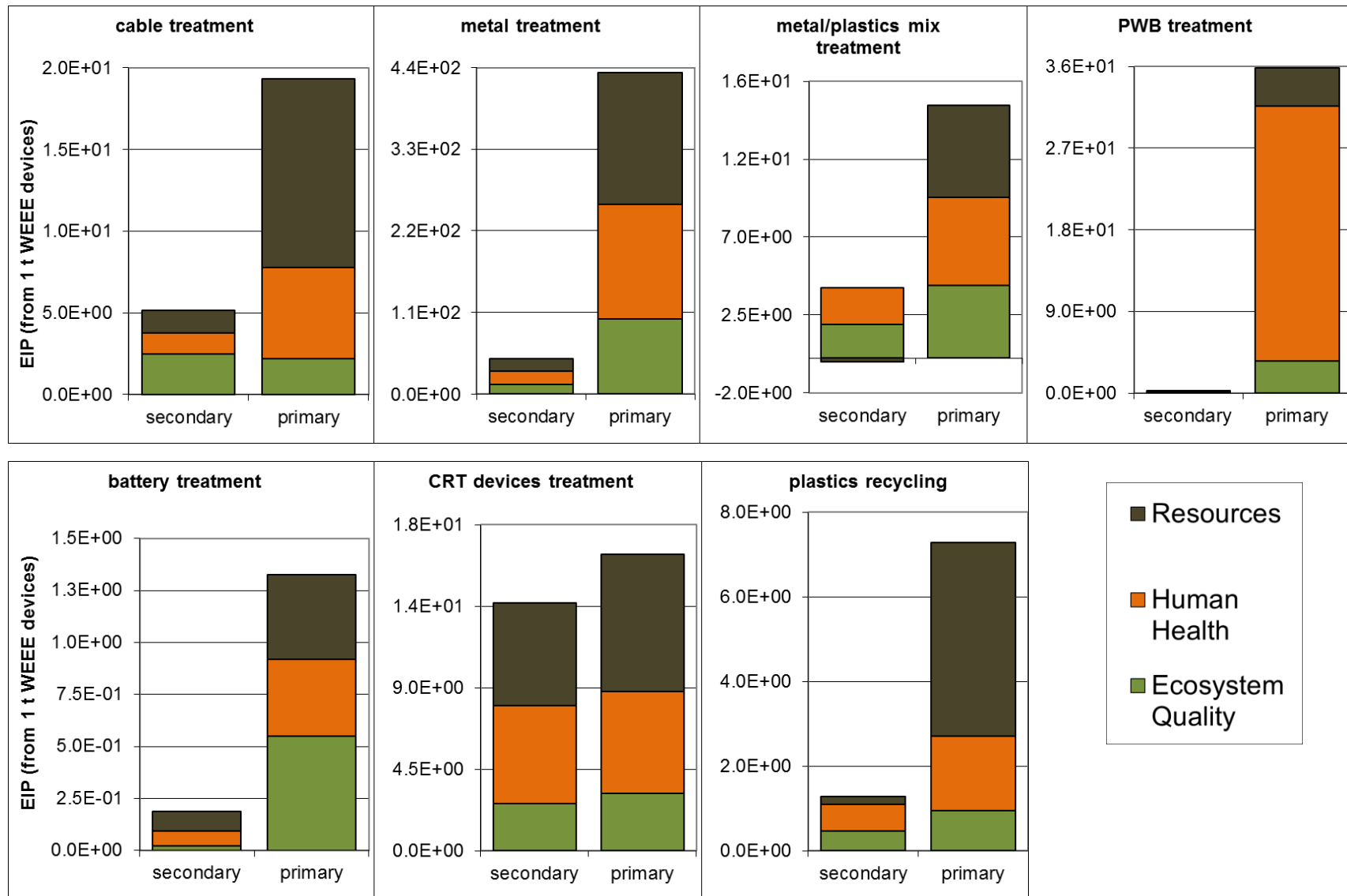
## The WEEE treatment model – step by step



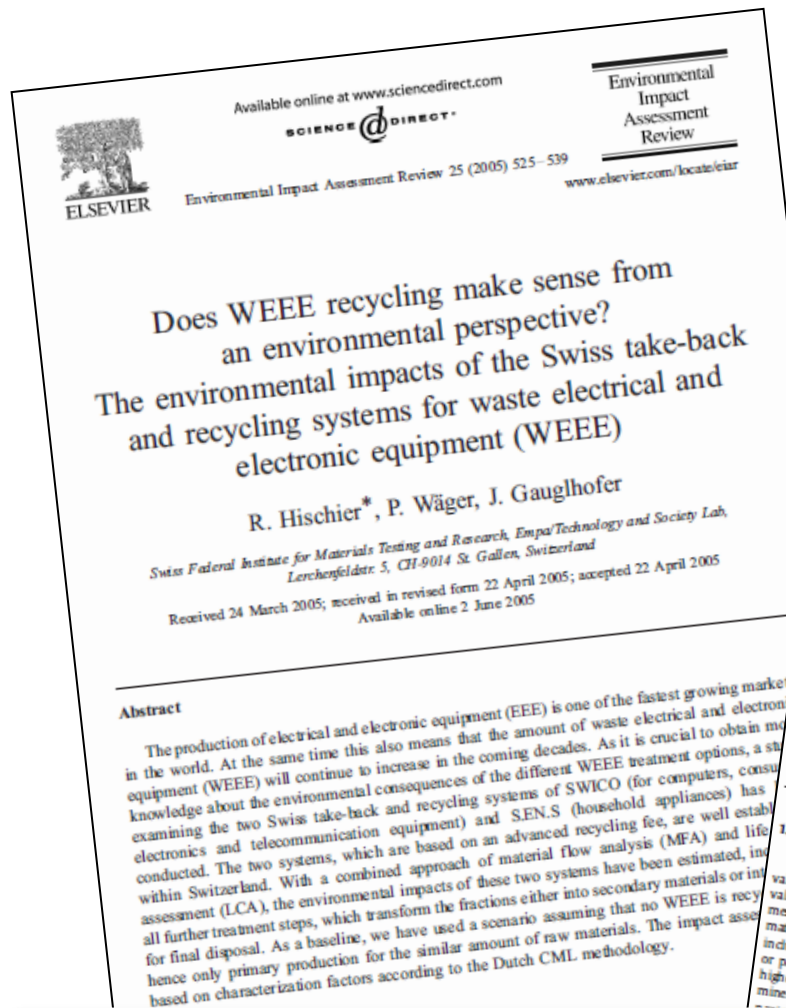
- collection & pre-processing
- metal/plastics mix treatment
- PWB treatment
- battery treatment
- cable treatment
- plastics treatment
- metal treatment
- CRT devices treatment
- treatment other waste & OHW

# Results

## Primary vs secondary production processes







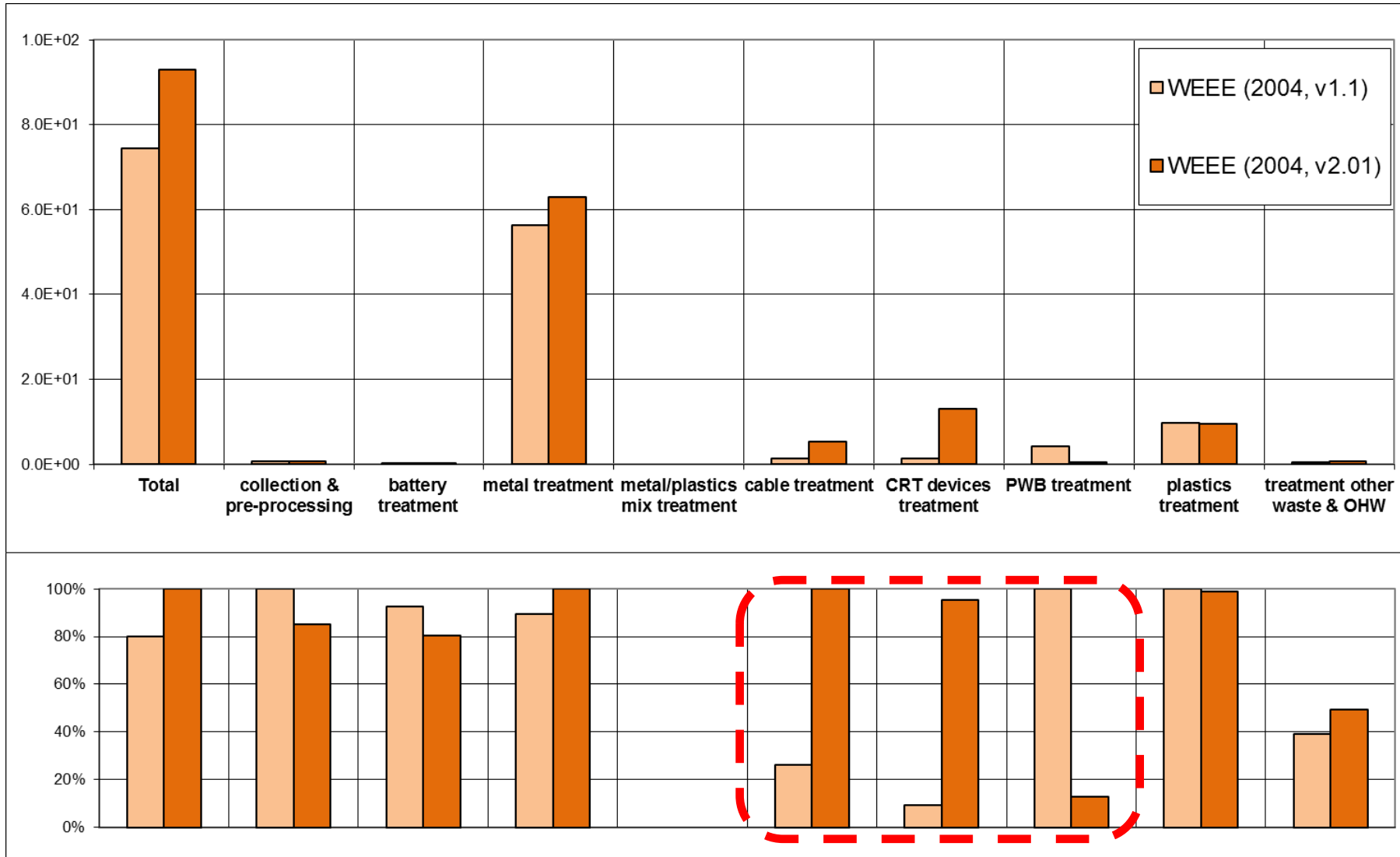
What is the influence on the result ...

(a) from development of LCI data (ecoinvent v1 -> v2)

(b) From the developments of the Swiss WEEE system (2004 -> 2009)

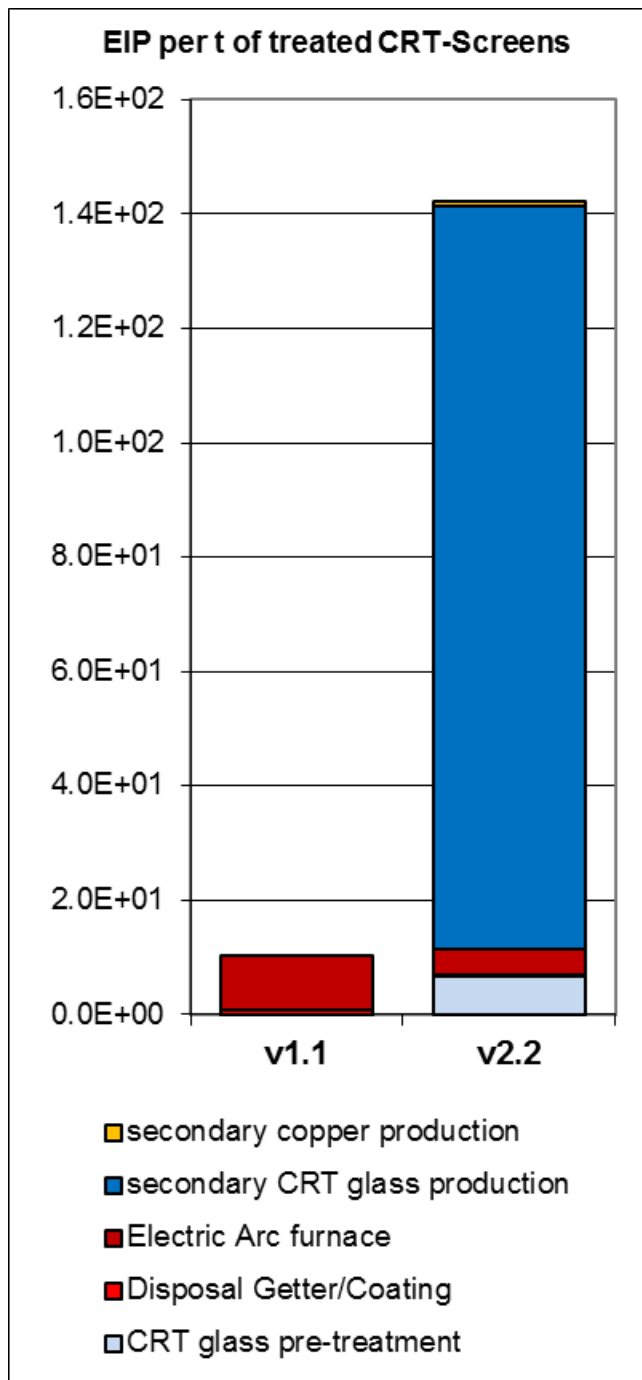
# Results

## Development in LCI data (ecoinvent v1 -> v2)

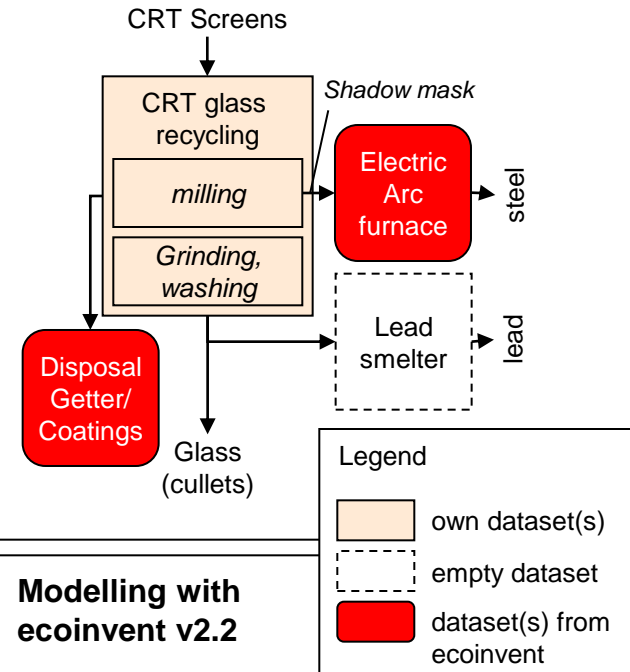


# Results

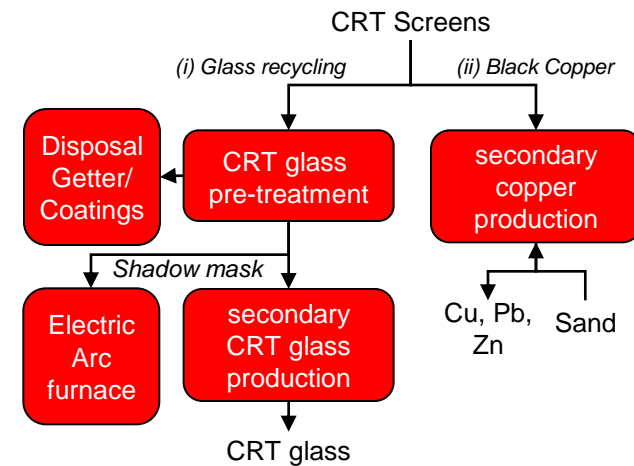
## New Modelling of CRT treatment



### Modelling with ecoinvent v1.1

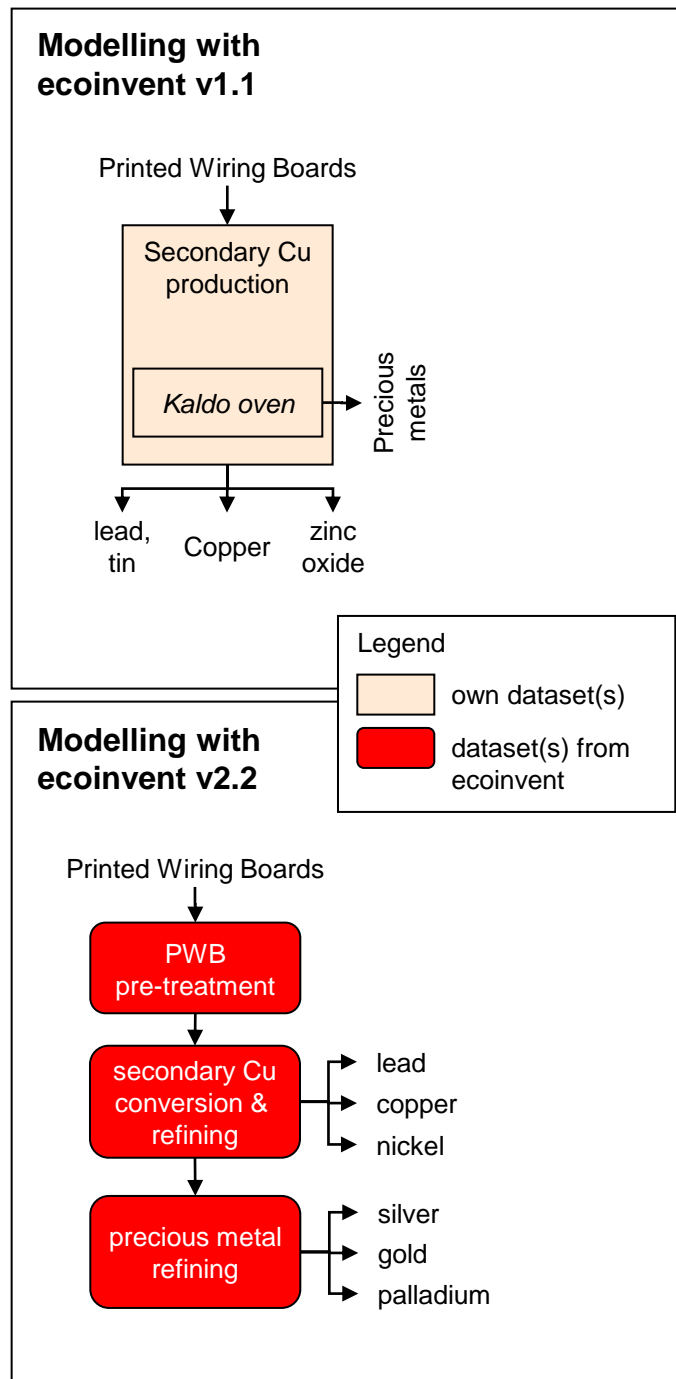
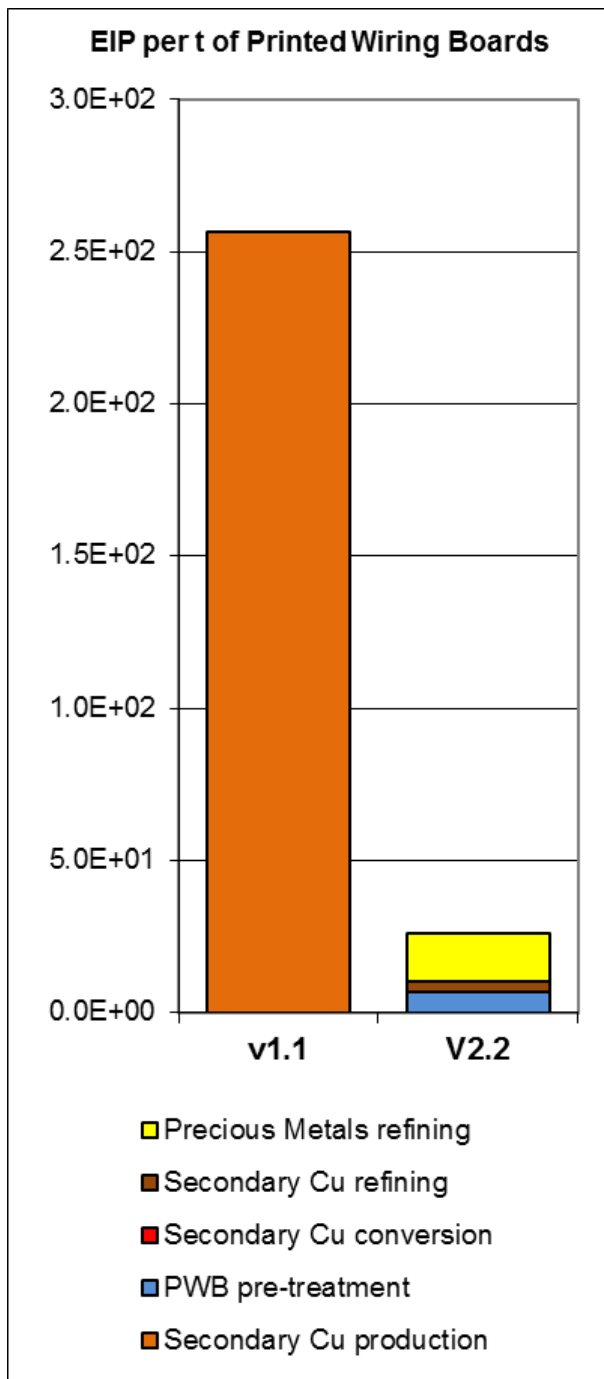


### Modelling with ecoinvent v2.2



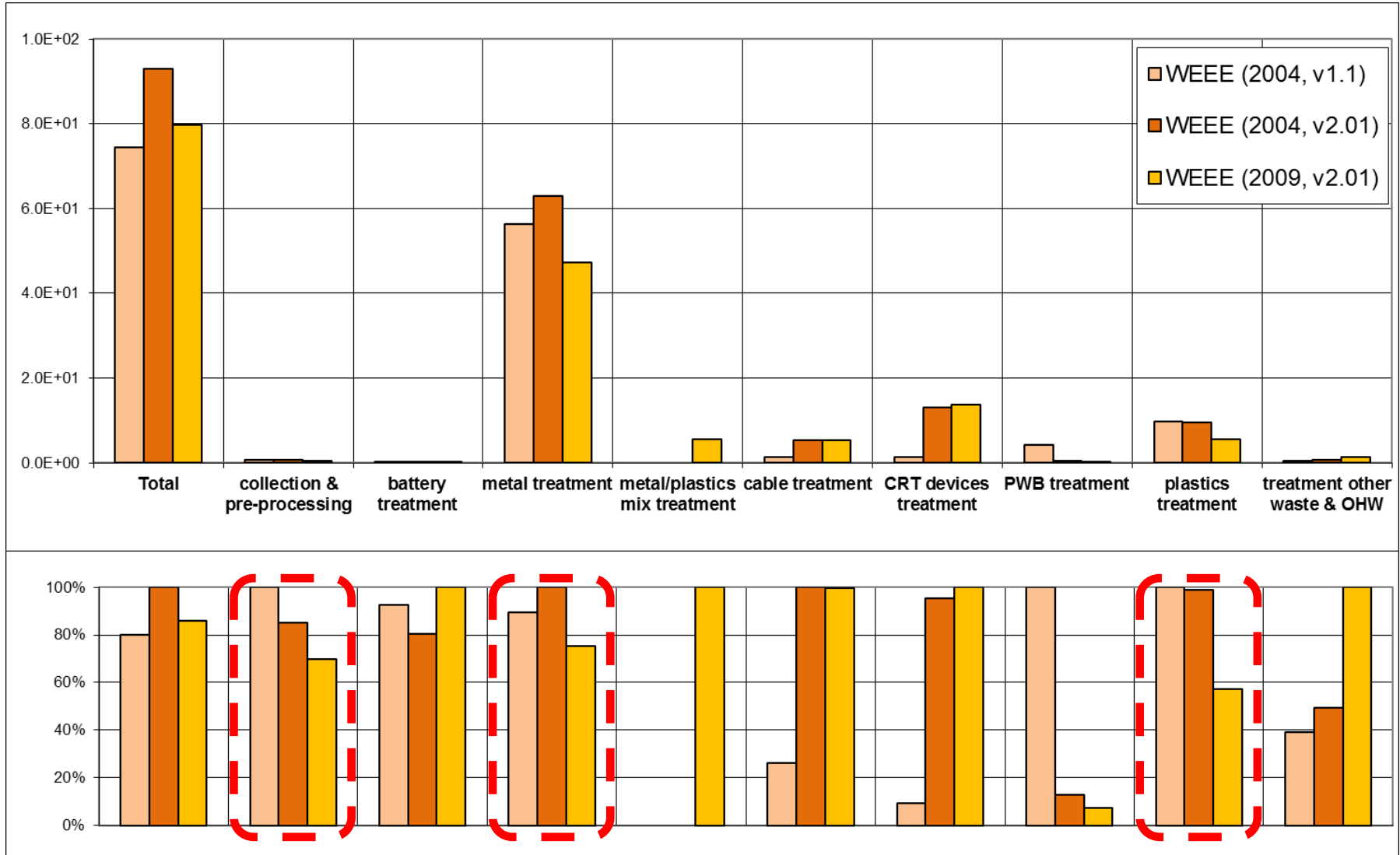
# Results

## New Modelling of CRT treatment



# Results

Development 2004 - 2009 (in WEEE tretment / in LCI data)





# Conclusion(s)

- A WEEE recycling & recovery system results in **clearly lower environmental impacts** than the baseline models (incineration / landfilling)
  - Collection and pre-processing contribute only marginally to environmental impacts;
  - main contribution comes from metals treatment, CRT devices treatment and plastics treatment;
  - greatest savings in can be achieved with secondary production from battery, metals, cables, and PWB treatment;
  
- Utilisation of non-adequate LCI data could influence in details the results considerably (in both directions) – but only minor influence on the overall picture

# Thank you!

## Environmental impacts of the Swiss collection and recovery systems for Waste Electrical and Electronic Equipment (WEEE): A follow-up

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### ABSTRACT

While Waste Electrical and Electronic Equipment (WEEE) collection and recovery have significantly gained in importance all over Europe in the last 15 years, comprehensive studies assessing the environmental loads and benefits of these systems still are not common. In this paper we present the results of a combined material flow analysis and life cycle assessment study, which aimed to calculate the overall environmental impacts of collection, pre-processing and end-processing for the existing Swiss WEEE collection and recovery systems, as well as of incineration and landfilling scenarios, in which the same amount of WEEE is either incinerated in a MSWI plant or landfilled. According to the calculations based on the material flow data for the year 2009 and a new version of the ecoinvent life cycle inventory database (ecoinvent v2.0i), collection, recovery and disposal result in significantly lower environmental impacts per t of WEEE than incineration. This is due to global warming or ozone depletion and the endpoint indicator Eco-Indicator 99 points. A comparison between the environmental impacts of the WEEE recovery scenarios 2009 and 2004, both calculated with ecoinvent v2.0i data, shows that the impacts per t of WEEE in 2009 were slightly lower. This appears to be mainly due to the changes in the treatment of plastics (more recycling, less incineration). Compared to the overall environmental impacts of the recovery scenarios 2004 obtained with an old version of ecoinvent (ecoinvent v1.1), the calculation with ecoinvent v2.0i results in an increase of the impacts by about 20%, which is primarily the consequence of a more adequate modeling of several WEEE fractions (e.g. metals, cables or CRT devices). In view of a further increase of the environmental benefits associated with the Swiss WEEE collection and recovery system, the recovery of geochemically scarce metals should be further investigated, in particular.

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