The ProSUM Project

"I am useful"

Producing best available data

18 September 2016
Information Network meeting
Patrick Wäger & Vera Susanne Rotter

Empa
Materials Science and Technology

berlin

ProSUM
Prospecting Secondary raw materials in the Urban mine and Mining wastes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641999.

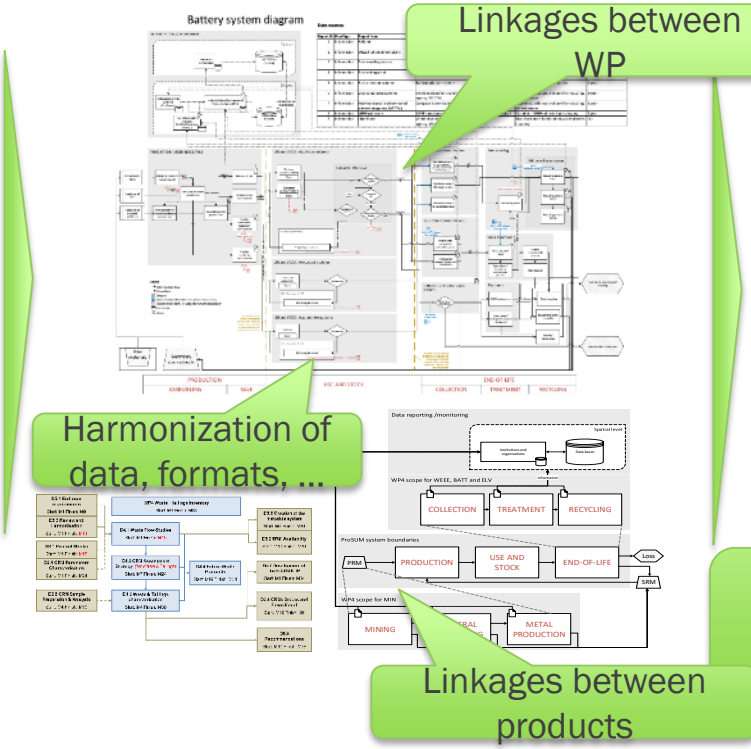
Content

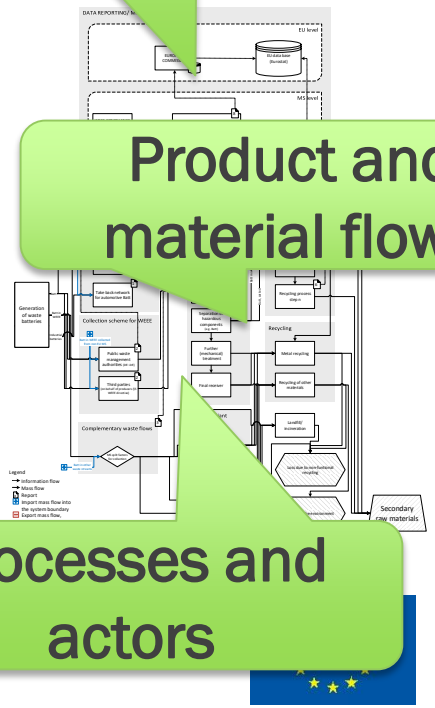
- Procedures
- Examples
  - Vehicles
  - Batteries
  - Electric and Electronic Equipment
  - Mining waste
- Conclusions

Step 1

Defining the systems

- Identification and visualization of stock and flows (WP2-4)
- Common terminology



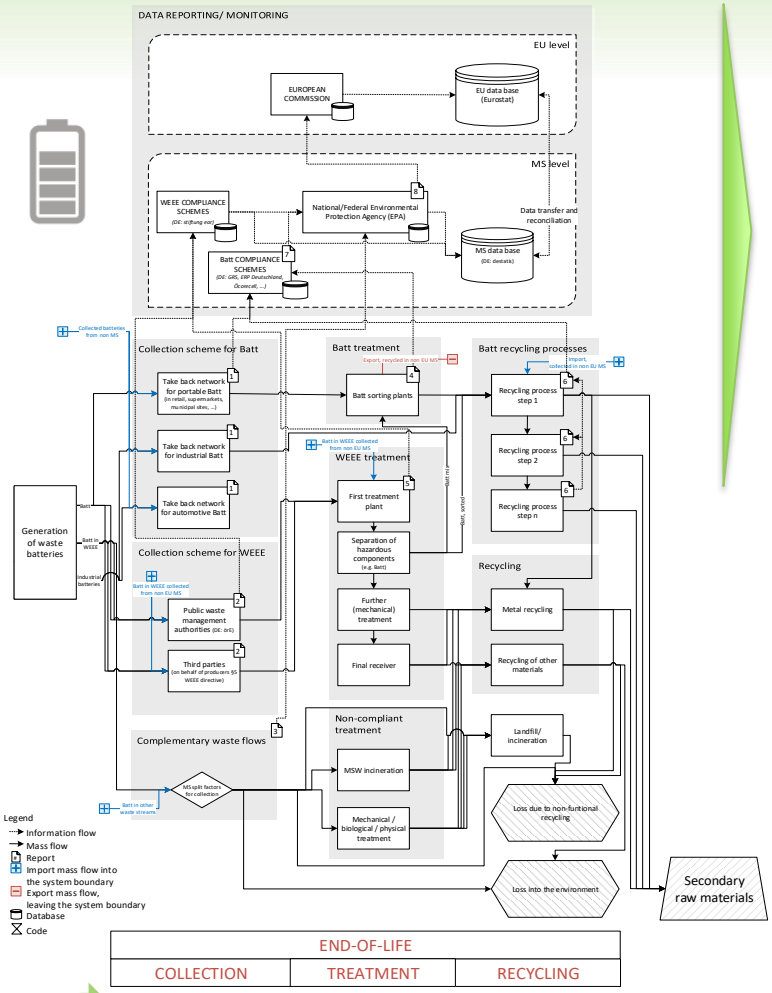


ProSUM

Step 2

Identification of data sources

Description of information types



Report	Report from	Report to	Obl…	…rmation content	Submission interval
1	Batt collection scheme	Batt compliance scheme	…66/EC	Quantities per battery chemistry	1-year
2	WEEE collection scheme	WEEE compliance scheme	…Directive 2012/19/EC	Quantities WEEE collected per category	1-year
3	Undefined	EPA	-	Mass fraction of Batt in other waste streams (studies)	n/a
4	Batt sorting plant	Batt compliance scheme	Directive 2006/66/EC	Sorting efficiency, composition of battery waste stream (level of detail undefined)	n/a
5	WEEE (first) treatment plant	WEEE compliance scheme	Directive 2012/19/EC	Quantities of WEEE per category according Directive	1-year
6	Batt recycling process	EPA	Directive 2006/66/EC	Recycling efficiency; treatment design; mass per year; share battery chemistries; recovery rate on elemental base	1-year
7	Batt compliance scheme	EPA	Directive 2006/66/EC	Quantities, collected and send for recycling; collection rate	1-year
8	EPA	EC	Directive 2006/66/EC	Quantities, collected and send for recycling, collection rate	1-year

Identification and description:

- Pan-European data sources
  (e.g. Eurostat, ProMine, …)
- Multinational data sources
  (e.g. Fennoscandian Ore Deposit Database, IMDS,..)
- National data sources
  (e.g. NSI, NGS, …)
- Other data sources

Step 3

Data collection

- Identification and collection of (unstructured) data sources in common EndNote bibliography with use of ProSUM meta data descriptors
- Data inventory tables representing the availability and accessibility of information
- Data inventories for all waste groups and all EU28+2 countries

Data sources identified

Expert groups

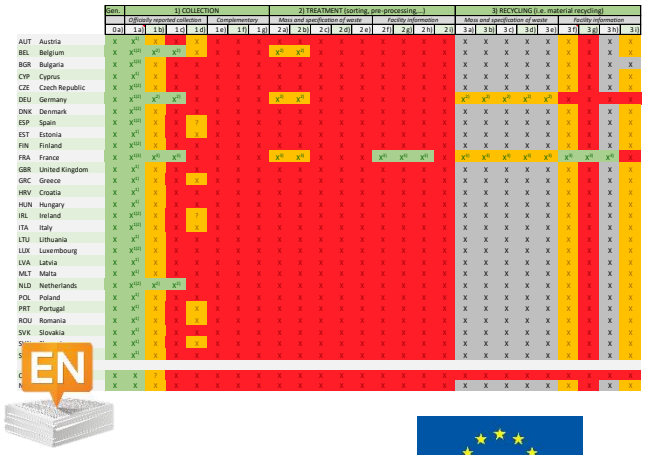
Structuring

Data sources organised (EndNote)

Questionnaires to ProSUM members and IN members

Evaluation

Data inventories



Step 3

Data collection

Data inventories on the example of batteries

Table 25: General data inventory: overview and evaluation of data availability for BATT EoL information for EU28+2, focus on portable batteries, but not exclusively. Status not completed (green – data available; yellow - data (partially) available, but not always publicly available; red - no data available; grey - data are (partially) available. Required since 2015 in context of reports about recycling efficiency; question marks – most likely)

		Gen.	1) COLLECTION							2) TREATMENT (sorting, pre-processing,...)									3) RECYCLING (i.e. material recycling)								
			Officially reported collection				*Complementary*			*Mass and specification of waste*					*Facility information*				*Mass and specification of waste*					*Facility information*			
		0a)	1a)	1b)	1c)	1d)	1e)	1f)	1g)	2a)	2b)	2c)	2d)	2e)	2f)	2g)	2h)	2i)	3a)	3b)	3c)	3d)	3e)	3f)	3g)	3h)	3i)
AUT	Austria	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BEL	Belgium	X	X[1)2)]	X[2)]	X[2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
BGR	Bulgaria	X	X[1)3)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CYP	Cyprus	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CZE	Czech Republic	X	X[1)2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DEU	Germany	X	X[1)2)]	X[2)]	X[2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
DNK	Denmark	X	X[1)2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ESP	Spain	X	X[1)2)]	X	X	?	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
EST	Estonia	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FIN	Finland	X	X[1)2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
FRA	France	X	X[1)3)]	X[3)]	X[3)]	X	X	X	X	X[3)]	X[3)]	X	X	X	X	X	X	X	X[3)]	X[3)]	X[3)]	X[3)]	X[3)]	X[3)]	X[3)]	X[3)]	X
GBR	United Kingdom	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GRC	Greece	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HRV	Croatia	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HUN	Hungary	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
IRL	Ireland	X	X[1)2)]	X	X	?	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ITA	Italy	X	X[1)2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LTU	Lithuania	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LUX	Luxembourg	X	X[1)2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
LVA	Latvia	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MLT	Malta	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NLD	Netherlands	X	X[1)2)]	X[2)]	X[2)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POL	Poland	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
PRT	Portugal	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ROU	Romania	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SVK	Slovakia	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SVN	Slovenia	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
SWE	Sweden	X	X[1)]	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CHE	Switzerland	X	X	?	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NOR	Norway	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

1) EPBA, 2) National compliance schemes, 3) National EPA

EoL steps

Data on waste composition e-p, e-c, c-p

Data collection ambitio

Data on flow p-f

Data achievable

X data available

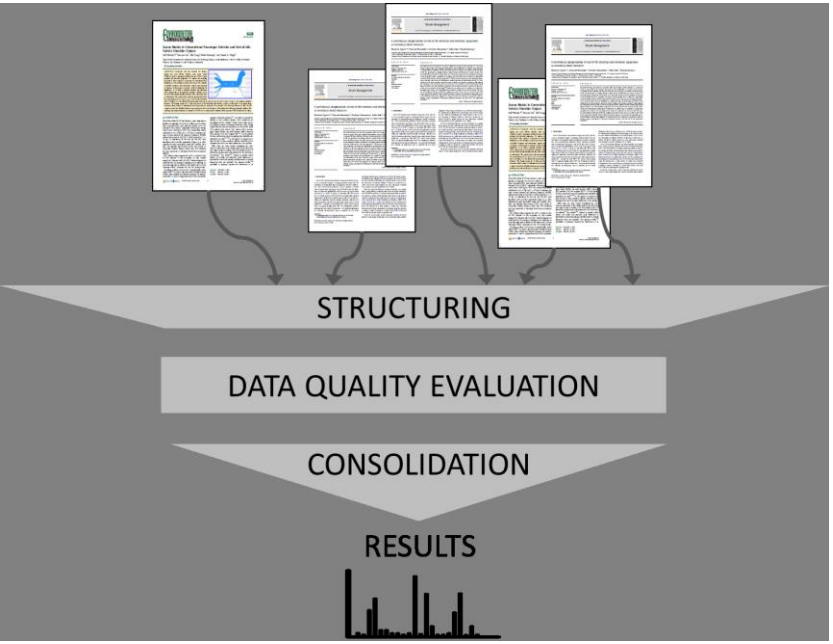
X partial data

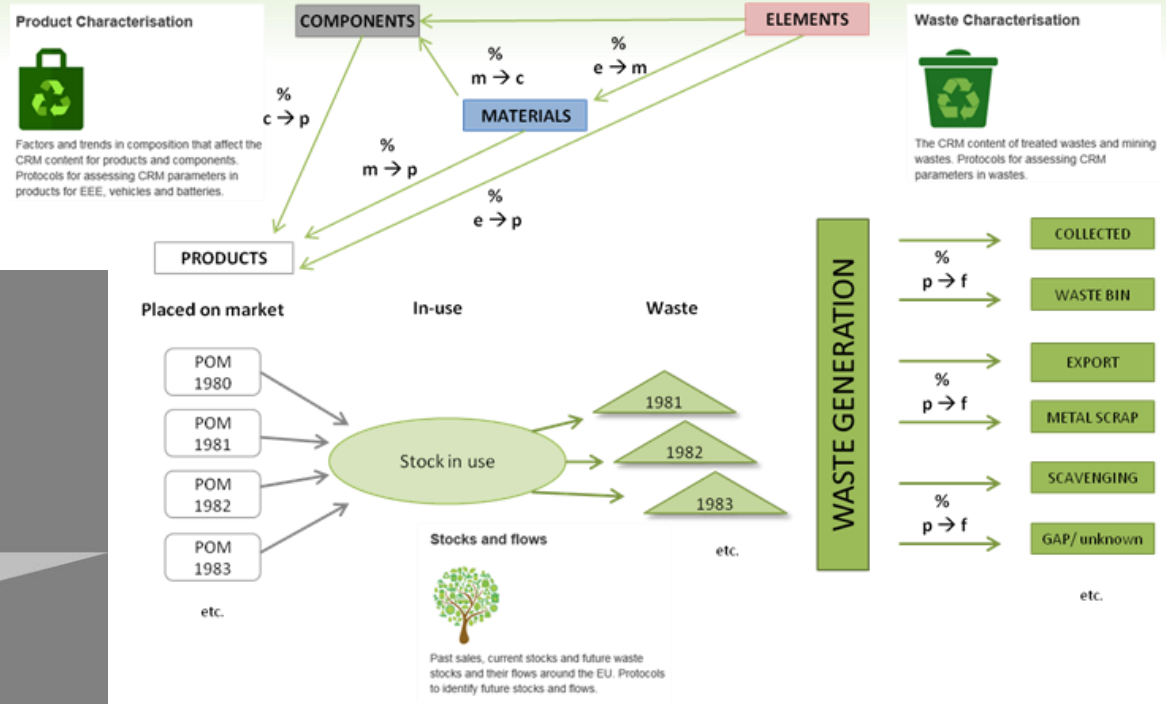
X no data

X Data reporting requirements from of 2015

Step 4

Data consolidation





Data set per product key

- Time resolution
- Country resolution

Working groups data processing

- UNU, WF, Empa, TUB, CBS

- TUB, Recharge, Eucobat

- Empa, Chalmers, TUB

- SGU, BRGM, GEUS, CGS, GeoZS, EGS

Case Vehicle

Maria Ljunggren Söderman

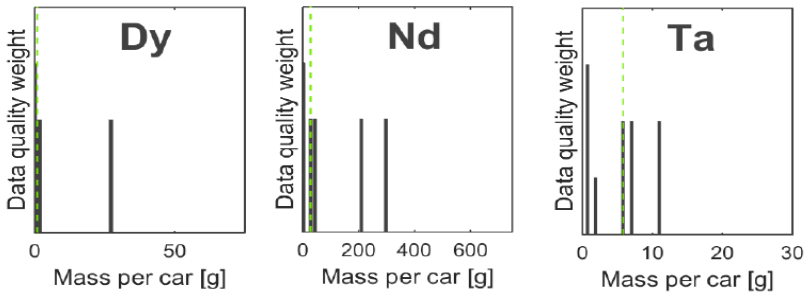
ProSUM

Vehicle, composition

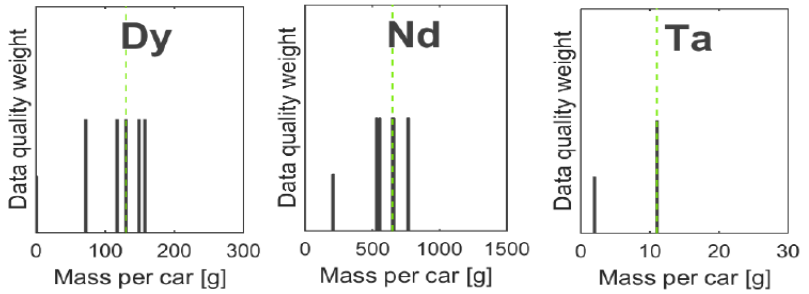
- Few studies
- For most elements only e-p data
- Some e-c data may become available, such as:
  - Battery
  - Catalytic converter
- e-p data for different motor energies:
  - Conventional (petrol and diesel)
  - HEV (hybrid electric vehicle)
  - PHEV (plug-in HEV)
  - BEV (battery electric vehicle)

Mass fraction of selected elements (e-p) in vehicles

Conventional vehicles



Electric and hybrid-electric vehicles

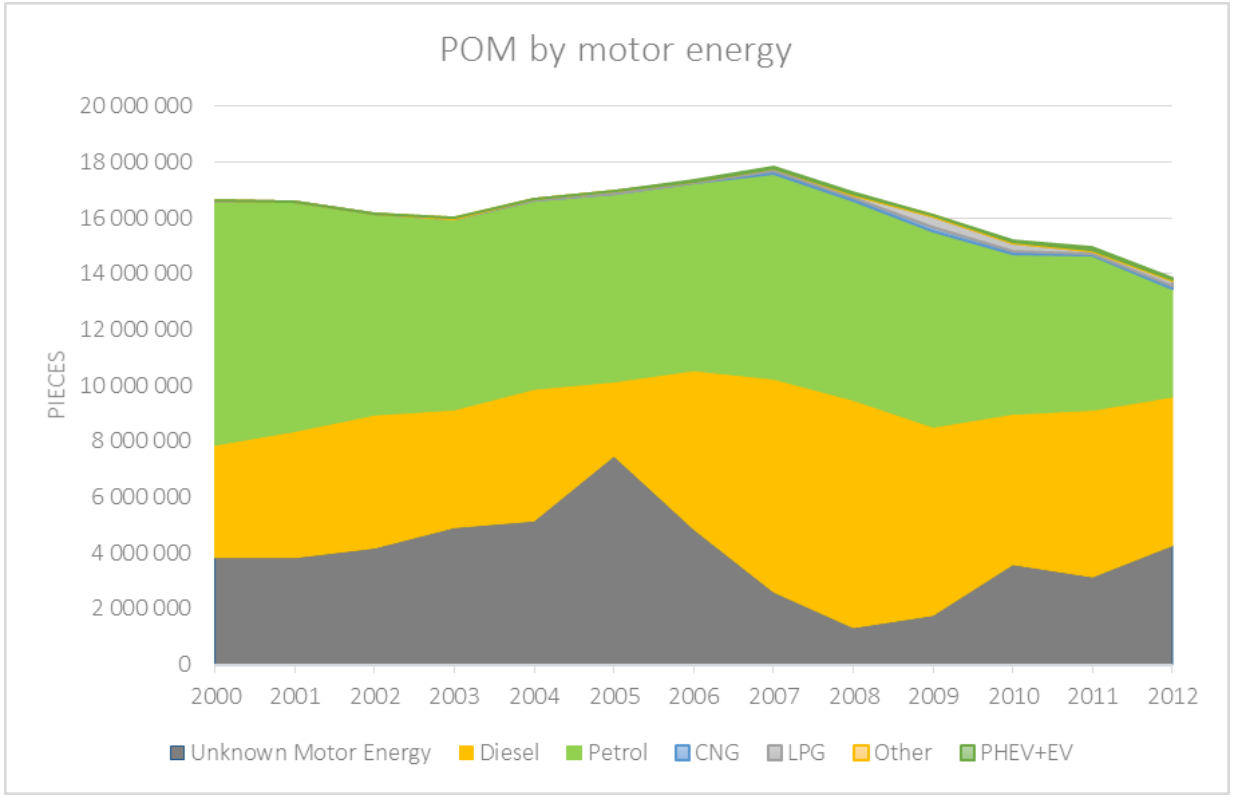


ProSUM

Vehicle, flow put on market

POM Vehicles, EU 28+2, by motor energy

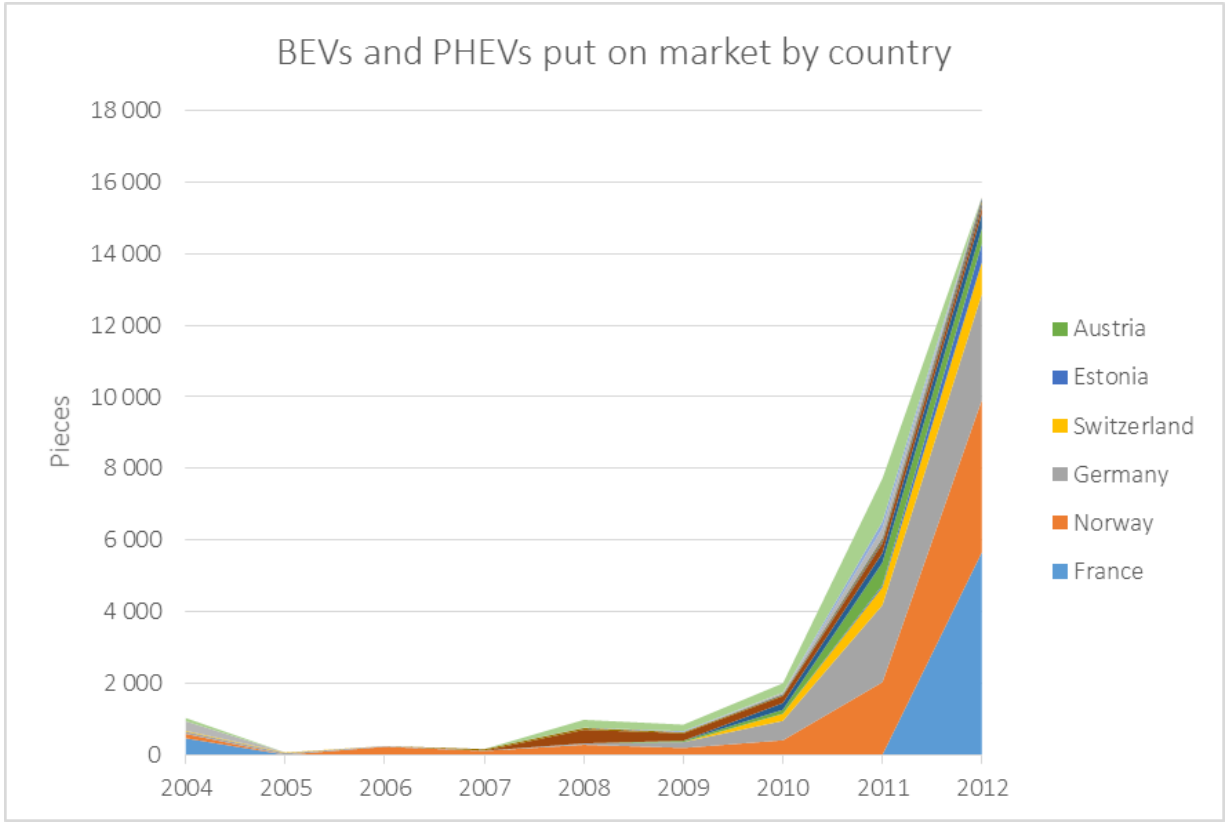
In contrast to data on CRM composition, vehicle fleet data is rich.



CNG = compressed natural gas (NG or biogas)
LPG =liquefied petroleum gas (mostly ethanol)
BEV = battery electric vehicle
PHEV = plug-in hybrid electric vehicle

Vehicle, flow put on market

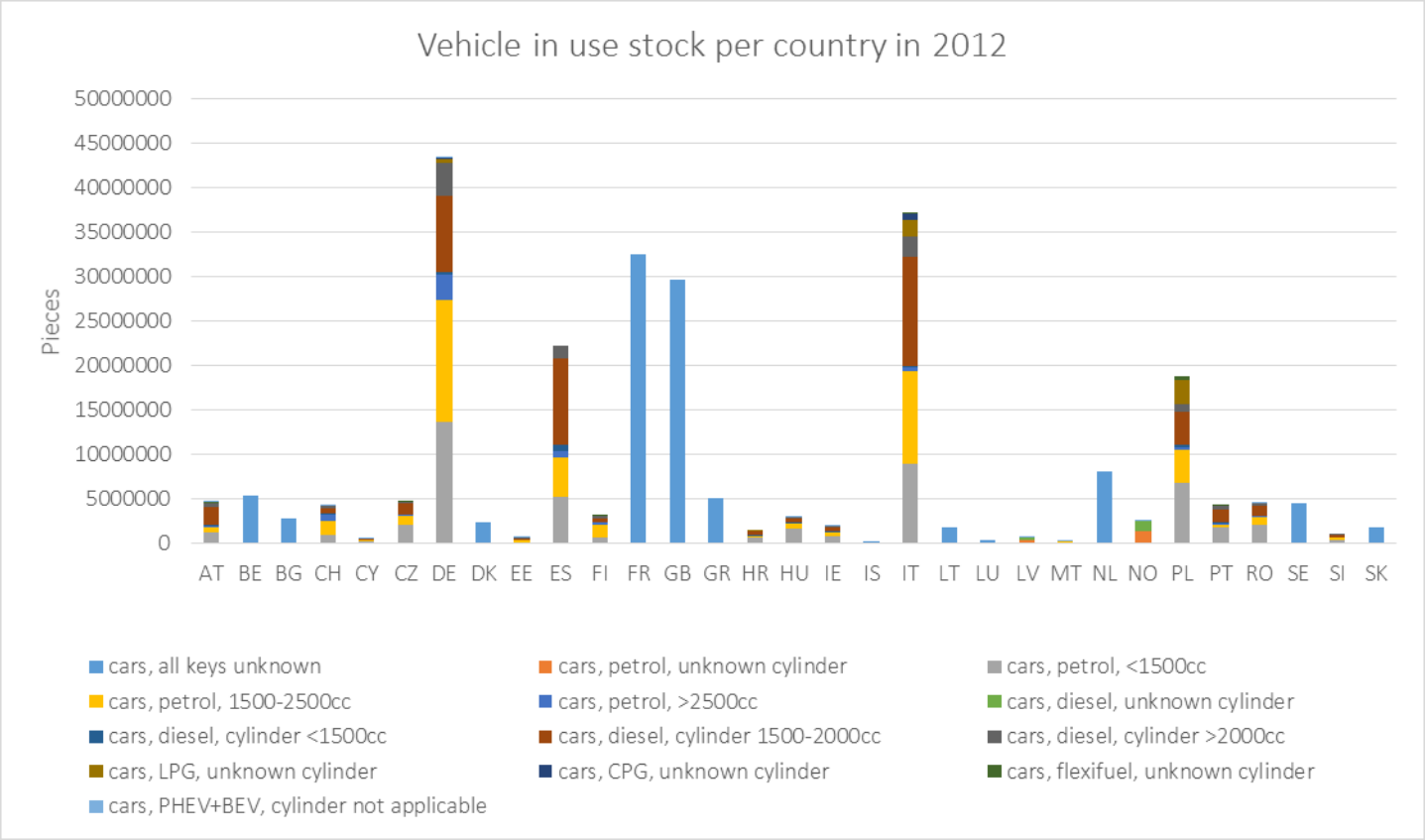
Example Vehicle, POM specific vehicle key (p-f)



BEV = battery electric vehicle
PHEV = plug-in hybrid electric vehicle

Vehicle, stocks

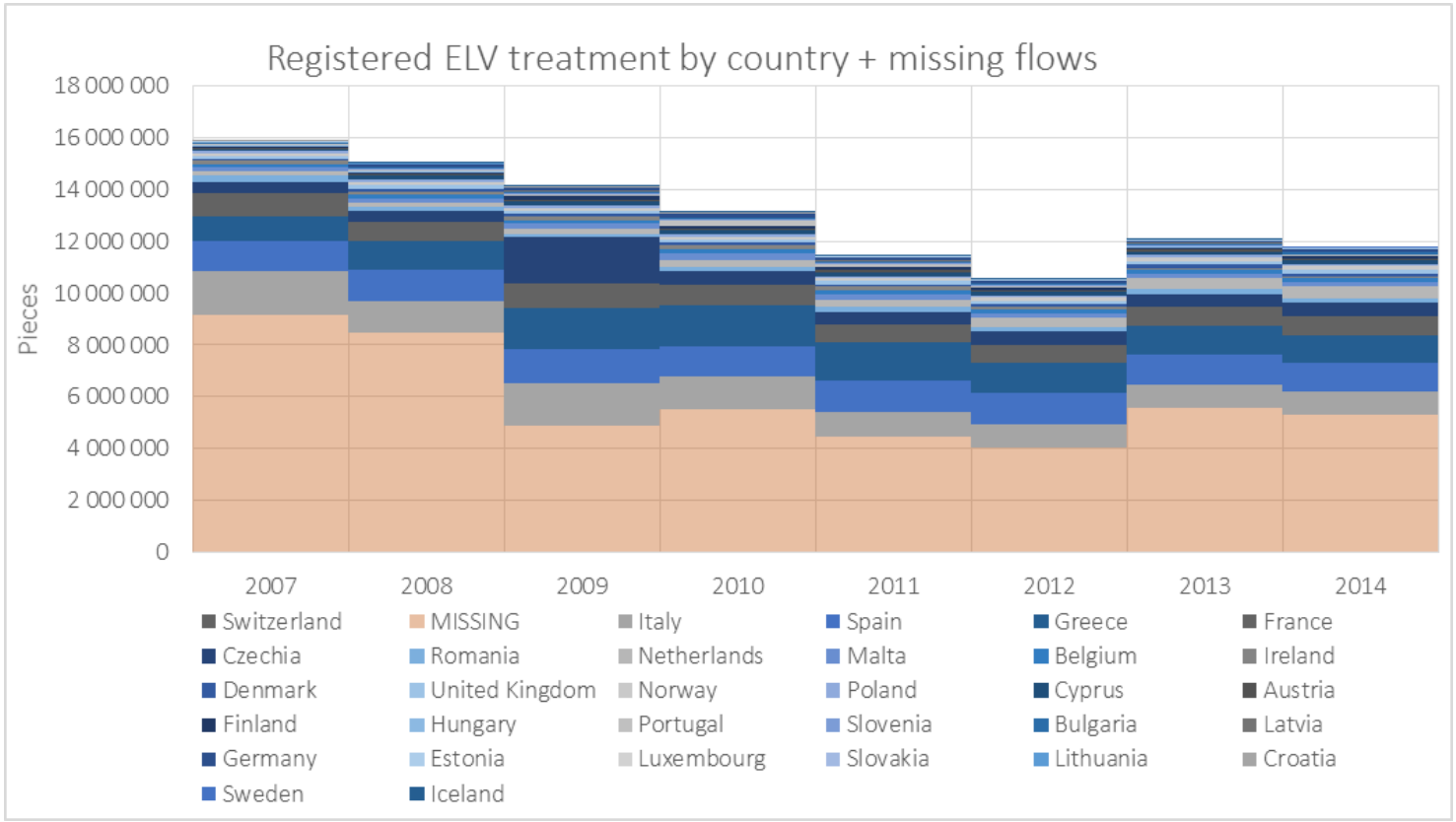
Example Vehicle stock, specific vehicle key (p-f) per country in 2012



LPG =liquefied petroleum gas (mostly ethanol)
BEV = battery electric vehicle
PHEV = plug-in hybrid electric vehicle

Vehicle, waste flow

Example ELV, collected per country (p-f) and year



CNG = compressed natural gas (NG or biogas)
LPG =liquefied petroleum gas (mostly ethanol)
BEV = battery electric vehicle
PHEV = plug-in hybrid electric vehicle

Vehicle temporal scope and data availability

What we (will) have	What is Missing	Comments
Vehicle Stock/Flow model with complete vehicle and age distributions from 2000-2020s		Can output as pieces or mass, with mass estimates for each vehicle key, as well as age distribution
Vehicle POM **products** data per EU 28+ETFA (2000-2014) per Vehicle Key, with age distribution	Data < 1995 and > 2015 for many categories, ELV pre 2005	Many missing data categories can be extrapolated/interpolated from model.
Vehicle IN USE STOCK **products** data per EU 28+ETFA (2000-2014) per Vehicle Key, with age distribution		Errors in the range of 3% on vehicle keys, 5-8% on mass based indicators
Vehicle **trade flows** 2000-2014, EU 28+ETFA per Vehicle Key, with age distribution	No explicit data for mass distribution, but this can be estimated to high degree of accuracy	
Vehicle **deregistration flows** 2000-2014, EU 28+ETFA per Vehicle Key, with age distribution		Capable of modeling into future due to stock residence time
Estimated **ELV flows** 2000-2020+, EU28+EFTA per Vehicle Key, with age distribution	Data <2005 can be inferred from national data sources on non-ELV scrapping	Can be checked against some national sources to tune model accuracy. Can be predicted into future by assuming that the trend of split ELV/dark flow from deregistration continues
Anticipated **'Dark' flows** 2000-2020+, EU28+EFTA per Vehicle key and with age/mass distribution	Still a large 'dark flow'	Dark flow is not easy to explain, limits the accuracy of ELV distribution over vehicle keys (assumes equal distribution of ELV and dark flow over keys)
Compositions mainly in 'e-p' format. POM and waste is assumed equal per vehicle key	Compositions data accounting for changes over time	Work in progress

Case Battery

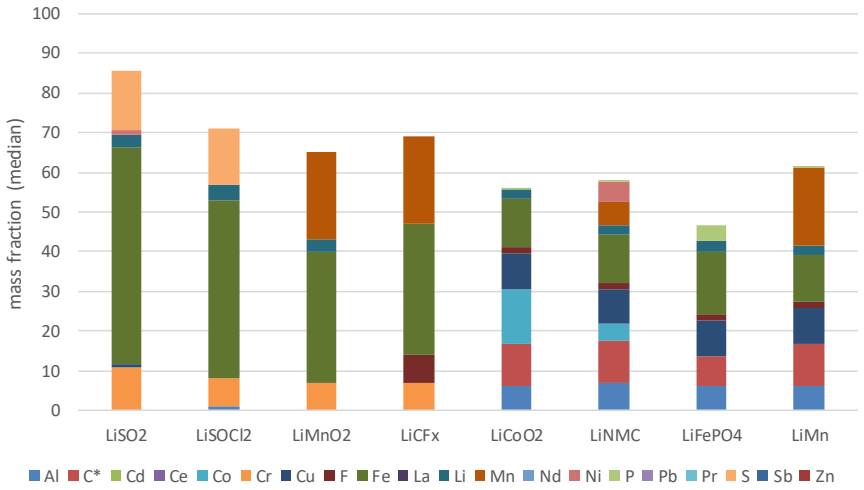
Vera Susanne Rotter

ProSUM

Battery, composition

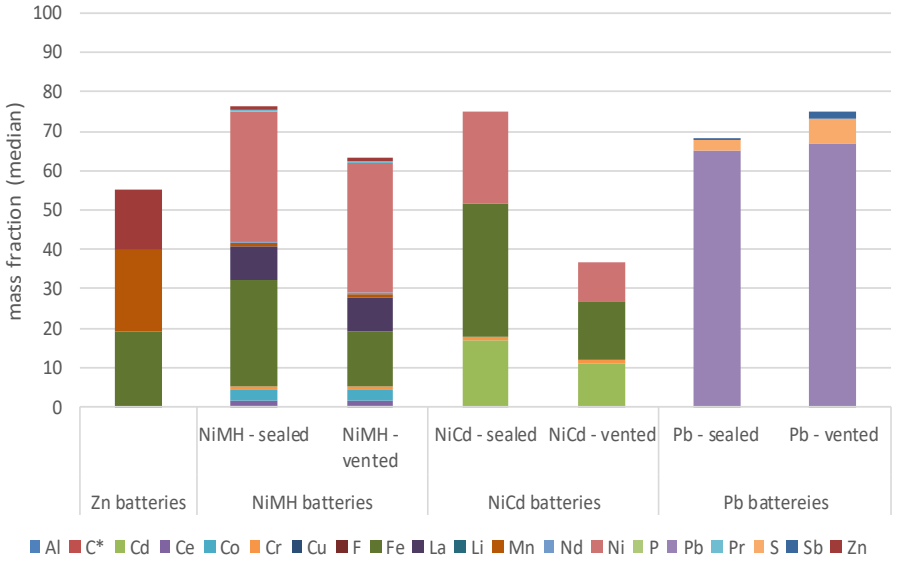
elements in products (e-p)

Elements in Lithium batteries



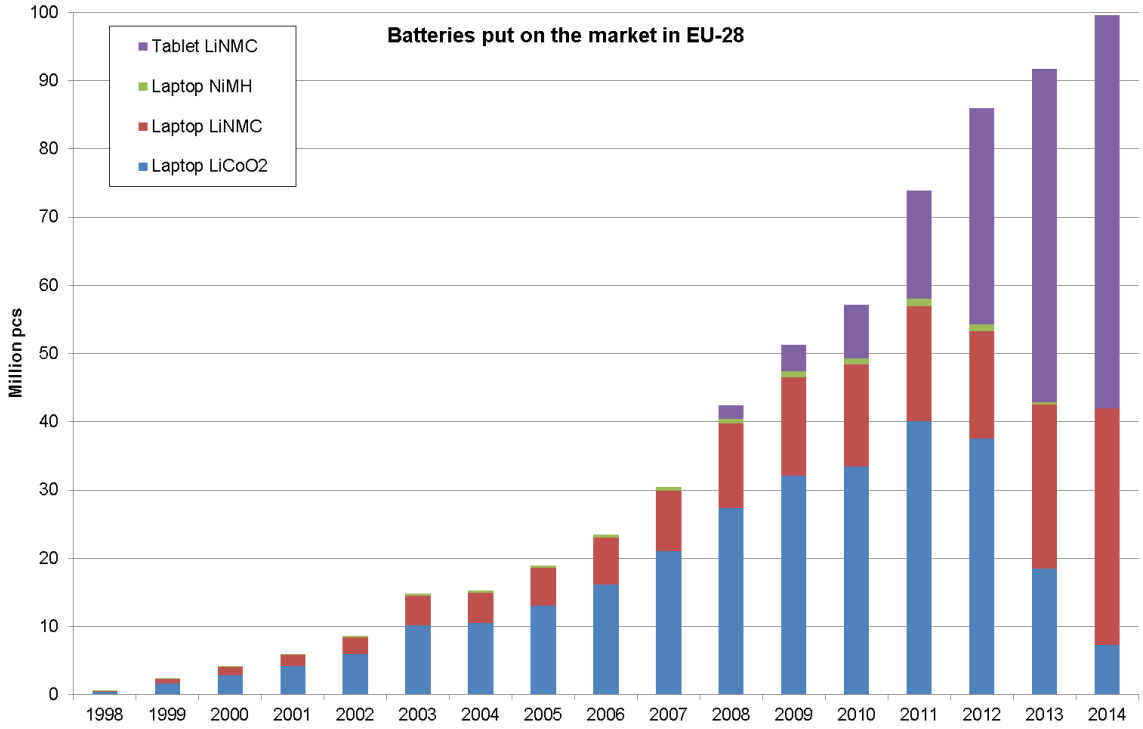
C* = graphite Carbon

Elements in Zn, NiMH, NiCd, Pb batteries



Battery, flow put on market

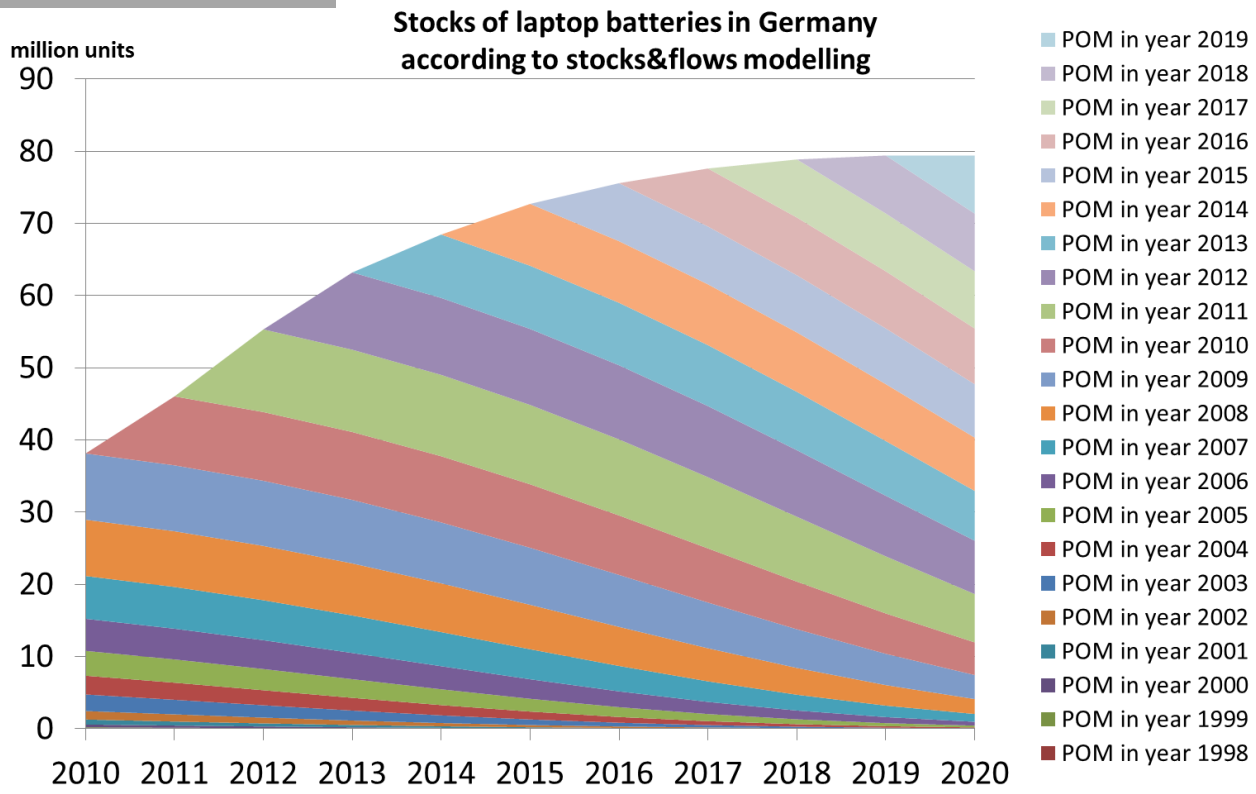
Example
BATT POM for 0303, EU28 (p-f)



Data source: Avicenne, extracted by RECHARGE

Battery, stocks

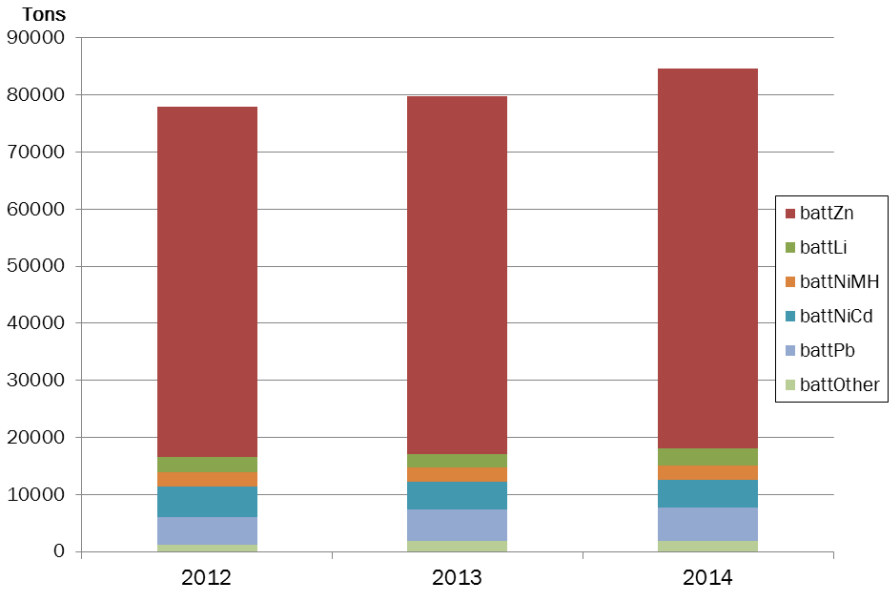
Example:
BATT Stock 0303, Country X (p-f)



Data sources for the modelling: POM: Avicenne, extracted by RECHARGE; residence times: Bebat

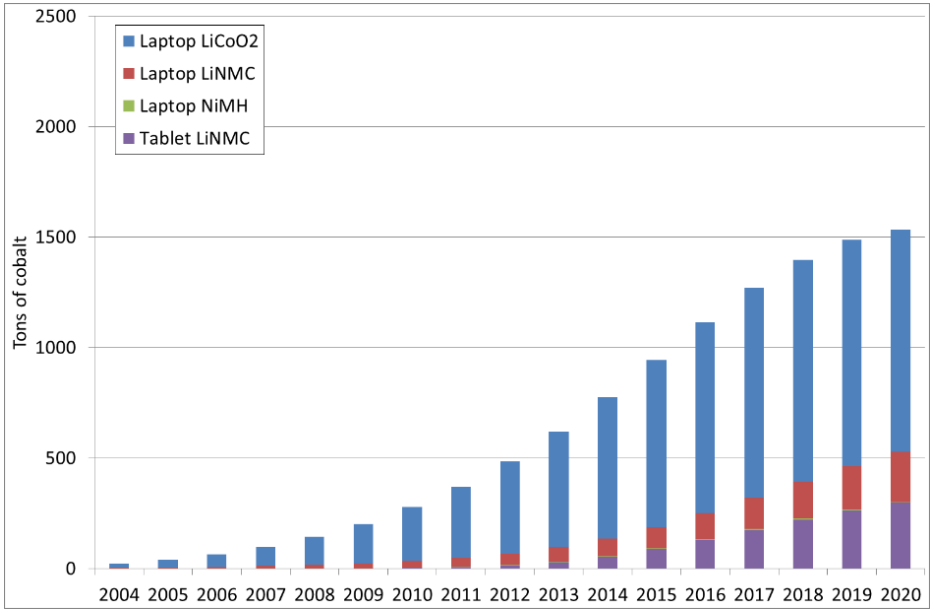
Battery, waste flow

Portable BATT Waste collected in EEA+Switerland (p-f)



Data sources: EPBA, Eucobat

Cobalt in BATT Waste 0303, EU-28 (e-f)



Data sources for the modelling: POM: Avicenne, extracted by RECHARGE; residence times: Bebat; Cobalt content in BATT: Sommer et al., 2015

BATT temporal scope and data availability

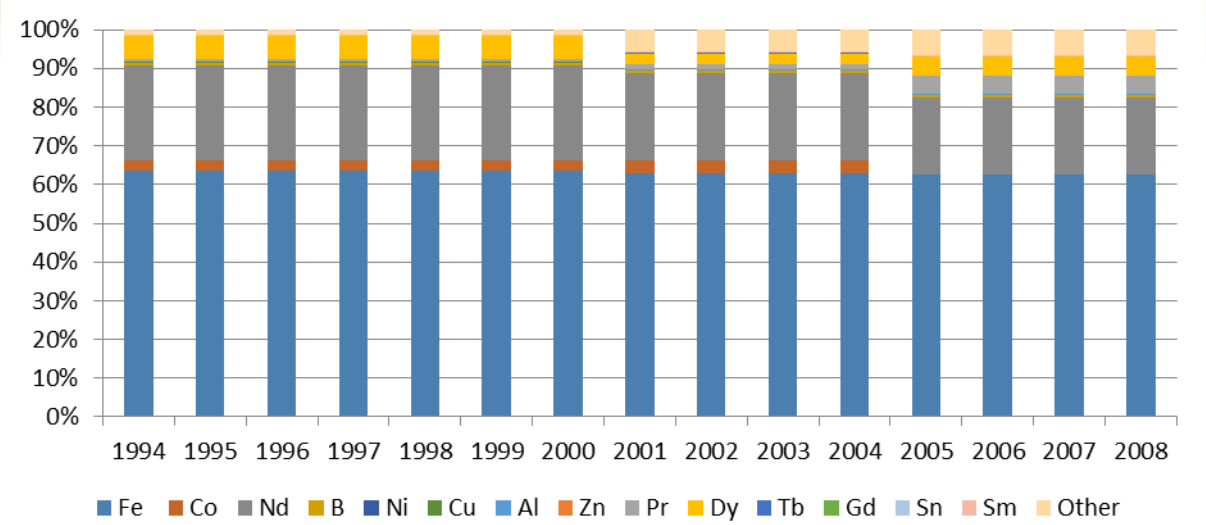
What we (will) have	What is Missing	Comments
POM **products** data per EU 28+2 (2000-2014) per BATT key and for some BATT subkeys	Data < 2000 and > 2015, for some countries large uncertainties	Pre-1995 can be extrapolated
POM **compositions** for all BATT subkeys, mainly in 'e-p' format	Reliable measurement of the variability of the composition of BATT	The decisive factors for the development of the material composition of batteries are not changes of the composition of batteries with a specific electrochemical system, but market shifts from an electrochemical system to another
Compositions of waste BATT is assumed to be the same as the compostions of POM batteries per BATT subkey		
Survey data on **stocks** of batteries for three countries	Data for most countries, granularity in terms of BATT keys and years	
Estimated **generation of waste batteries** (2000-2020) per BATT key or subkeys. Data > 2015 as coherent estimates	Data <2000 and data >2020	Before 2000 can be extrapolated. Data after 2015 as specific extrapolated POM trend per BATT key or subkey
Collected waste batteries (2000-2020) per BATT key	Data are not available or of low quality before 2010 in many countries	Lack of harmonisation of the data collection limits the data quality
Waste batteries in **municipal solid waste**	Data are not available for all countries, no differentiation of the BATT keys Data not available for most other complementary flows	

Case Electrical and Electronic Equipment

Jaco Huisman

ProSUM

EEE, composition

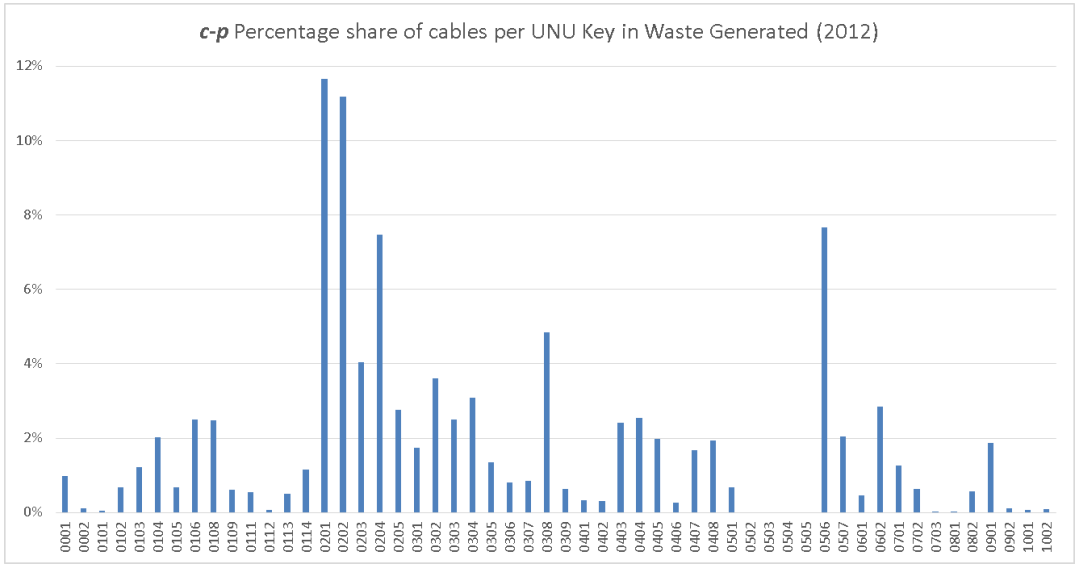


elements in components (e-c)

Example: mass fraction metals in HDD magnets for UNU key 0303 und 0302

components in products (c-p)

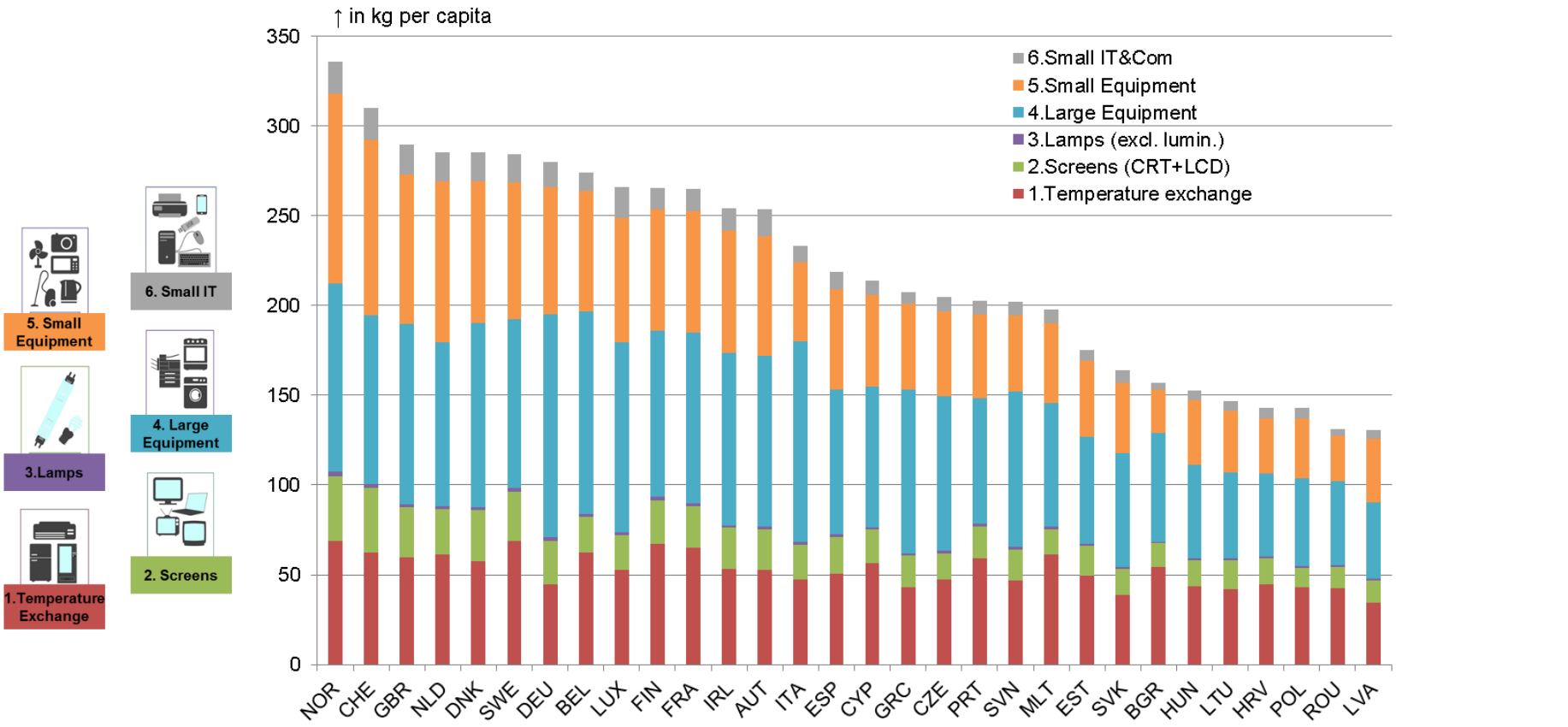
Example: % of cable per product per UNU key in WEEE (c-p)



ProSUM

EEE, stock

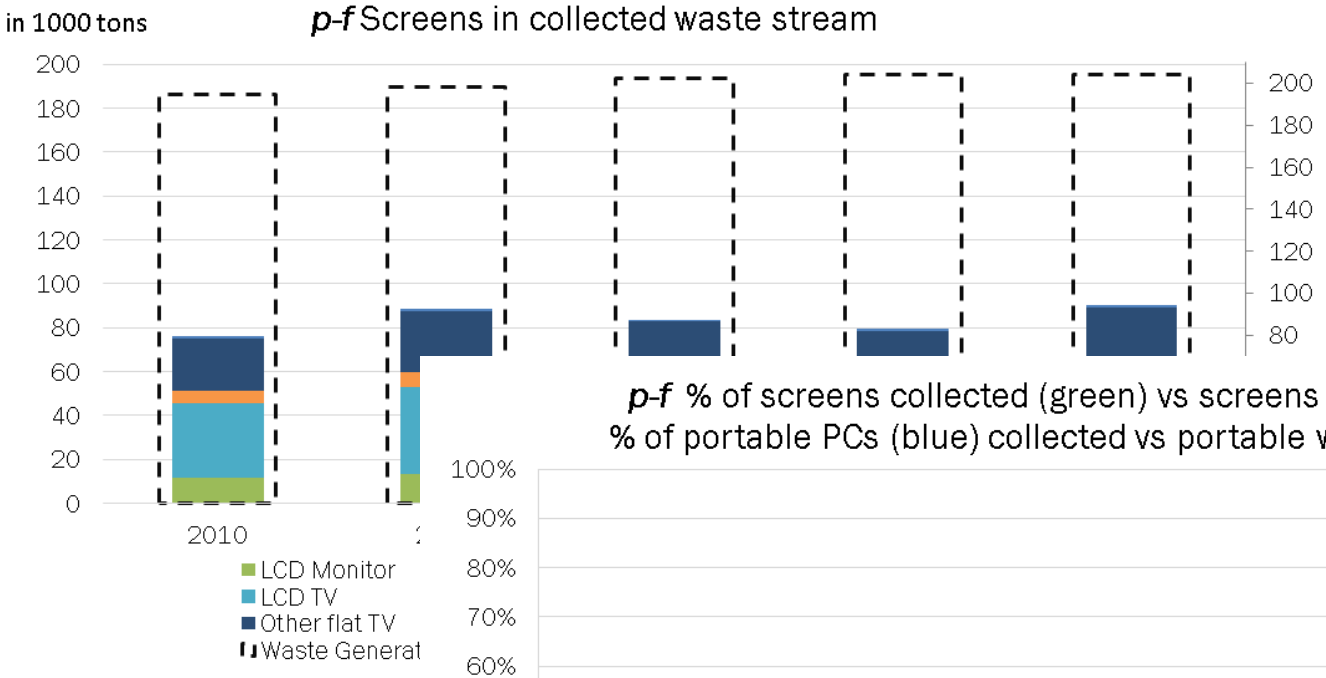
Example: EU 2014 EEE ‘Stock’ (s) per EU28+2

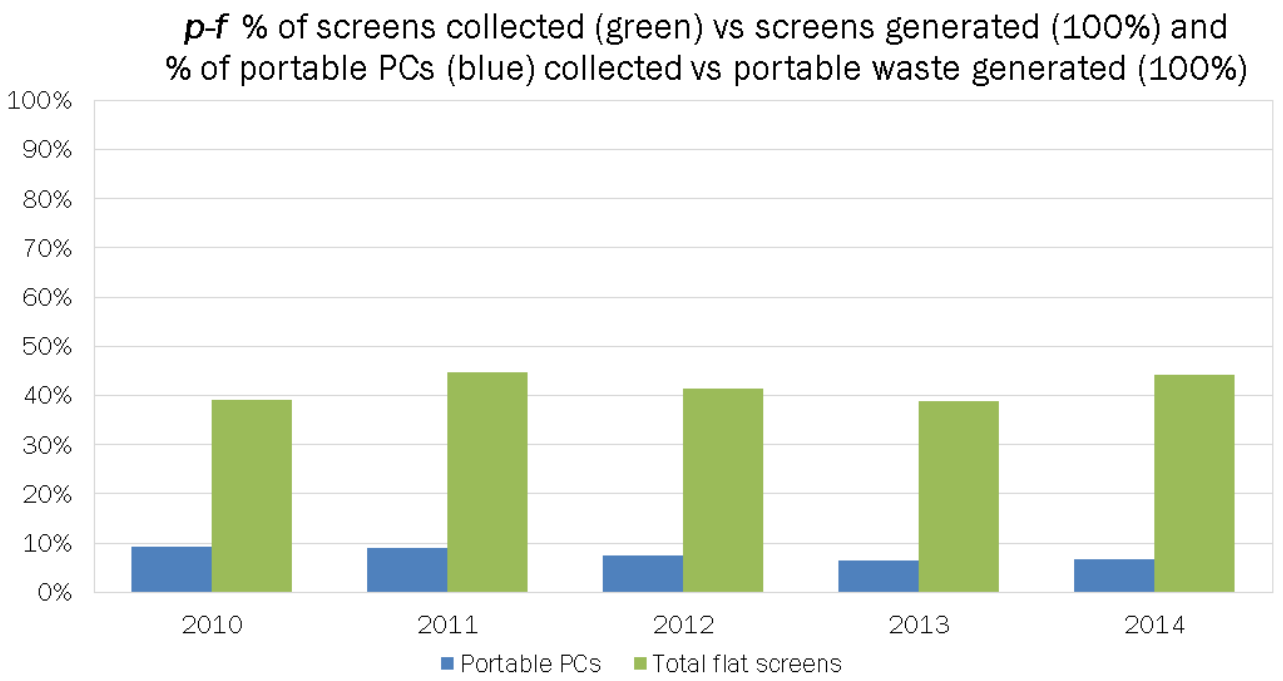


There is ≈ 123 million tonnes in the ‘Urban Mine’!
(EU28+2 Source UNU)

EEE, products in waste flow

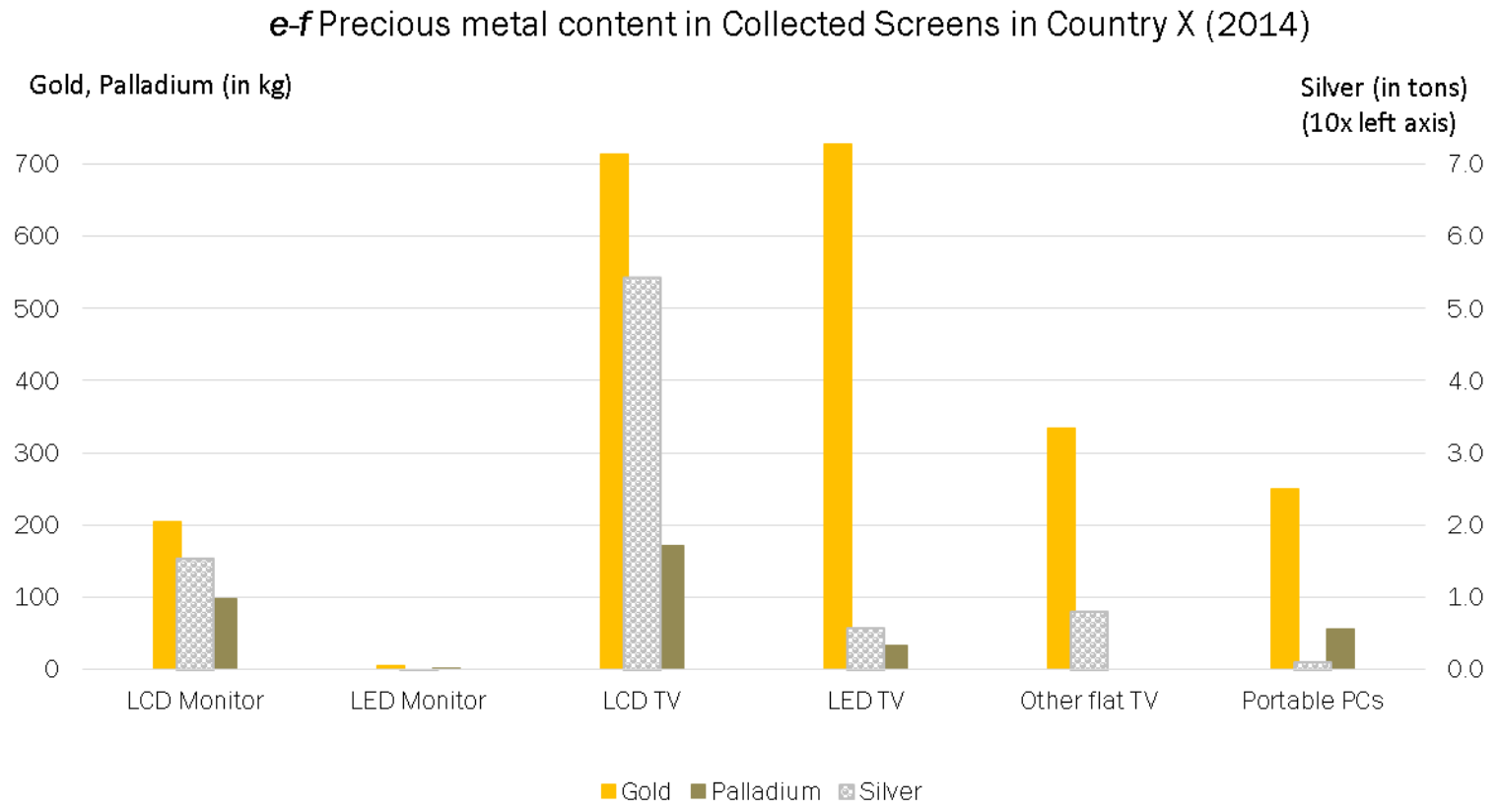
Example: Portable PCs and Screens collected against waste generated, (p-f)





EEE, elements in collection flow

Example: Country X 2014 Precious metals in Collected (e-f)



WEEE temporal scope and data availability

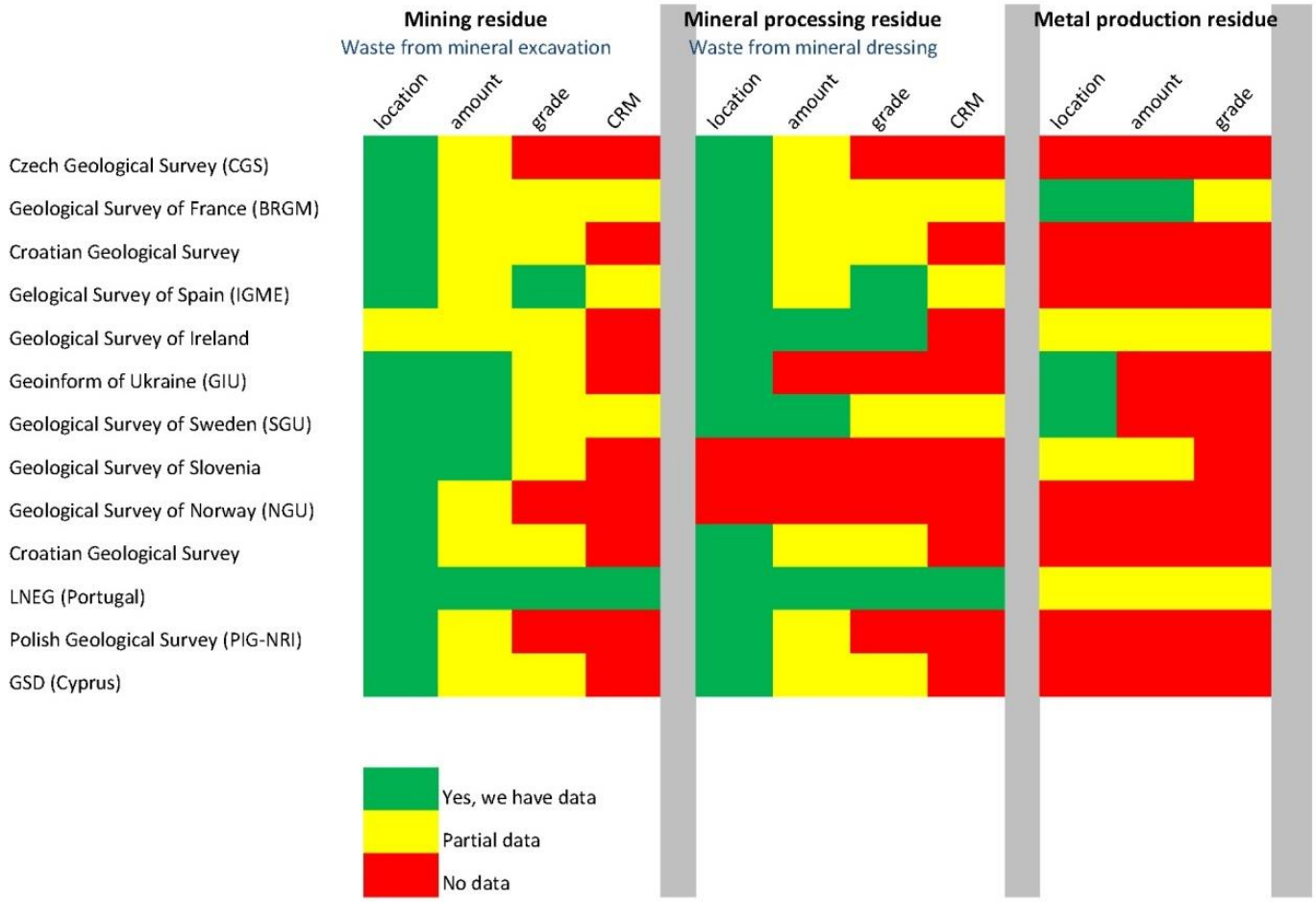
What we (will) have	What is Missing	Comments
POM **products** data per EU 28+2 (1995-2014) per UNU key	Data < 1995 and > 2015, CHE + NOR 2013/2014; PV data from delta in installed capacities.	Pre-1995 can be extrapolated to market introduction year
POM **compositions** (2005-2014) for al most all UNU keys, mainly in 'e-p' format	POM data > 2005 is rare for many UNU keys. Many UNU keys will not have detailed 'e-c-m-p' or 'e-c-p' data. Trends over time not always available for all main components.	Most data from sampling of collected products > 10 yrs old, age info not always available
WEEE **products** (2000-2020) per UNU key. Data > 2015 as coherent estimates, except for some short lived products.	Data <2000 and data >2020	Before 2000 can be extrapolated. Data after 2015 as specific extrapolated POM trend per UNU key
WEEE **compositions** (2000-2020) for the most relevant UNU keys, estimated compositions for other UNU keys	Data <2000 and >2020. Full time-series for each UNU key are N/A.	Trend in return stream composition not always available. Can be constructed based on hot-spot approach for relevant components.
WEEE **product flow** data EU 28+2 (2010-2014) in colcat 6	Data before 2010 and 2015, data N/A on UNU key level	'p-f' product count data not available for most flows, only for collected for few countries
WEEE **flow composition** data EU28+2 (2010-2014) in colcat 6, scavenging information for only few components	Data not per UNU key, scavenging information of all relevant components N/A.	Scavenging of both 'p' and 'c' affects the 'f' composition severely. Very different over time, country and recycler.

Case mining waste

Anders Hallberg

ProSUM

Mining Waste – best available data



Mining waste

”Sampling stations”

Previous databases
(Min4EU, ProMine, Mining waste directive etc.)

Mining statistics

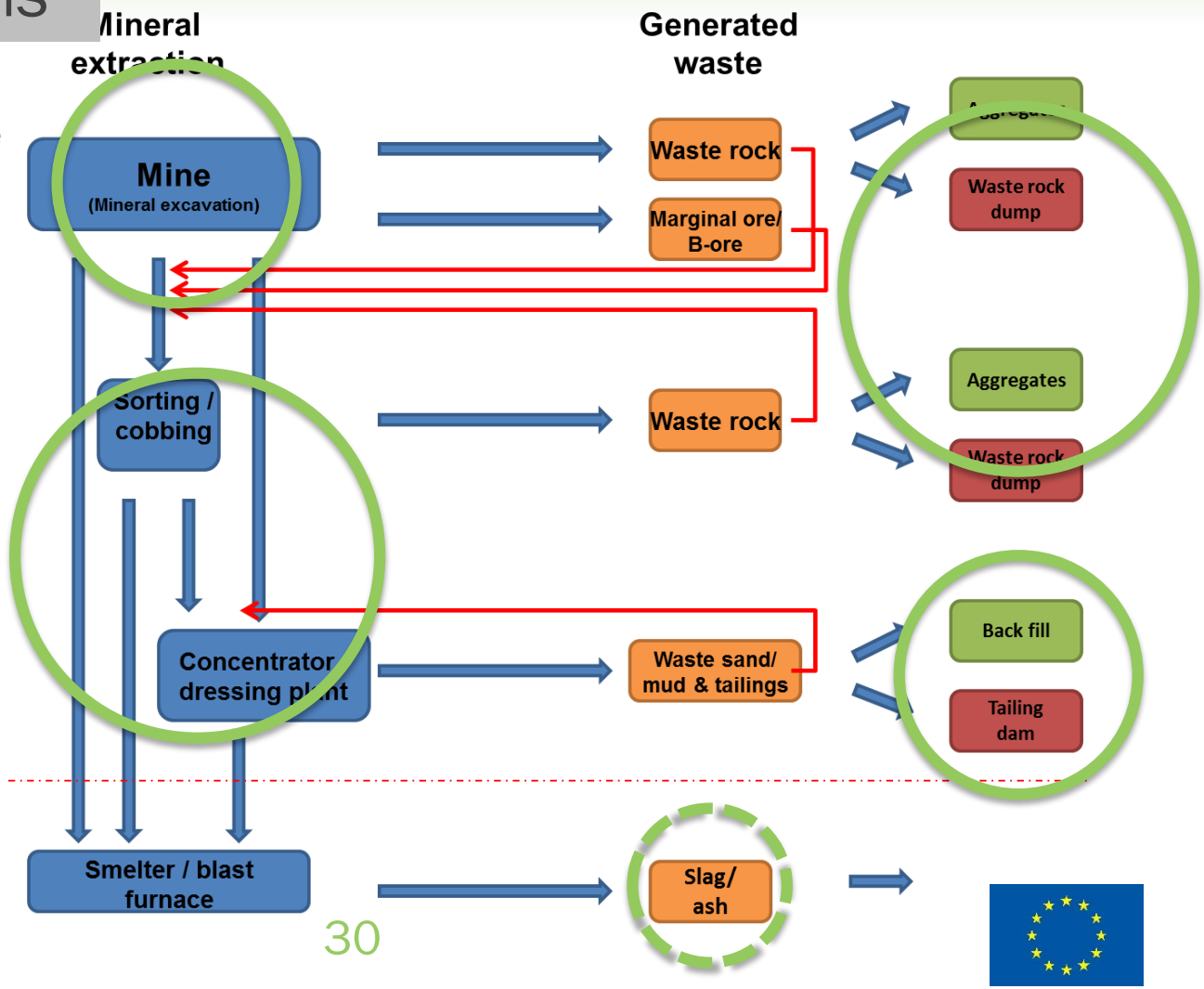
Environmental reports

Research reports

Company reports

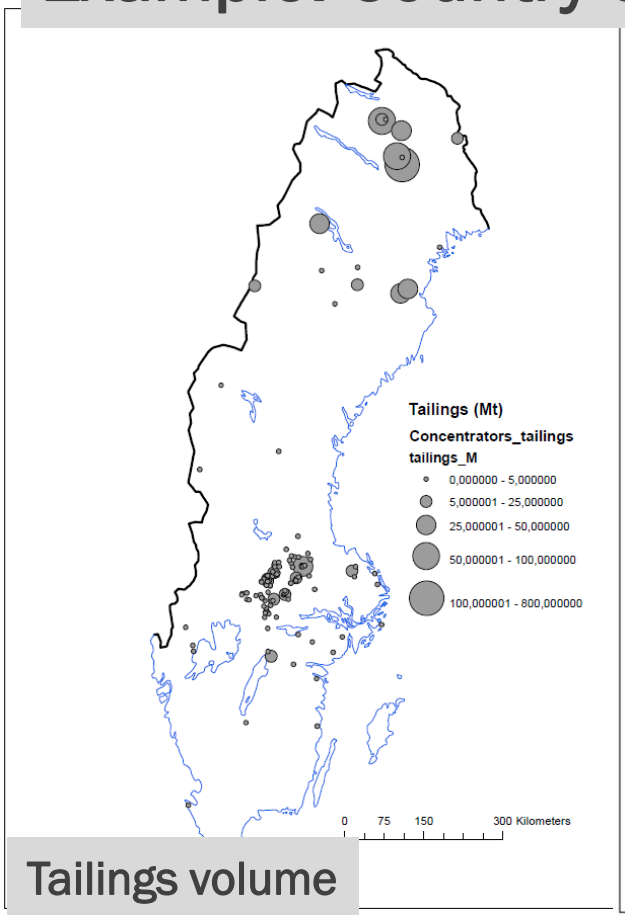
Remote sensing

Field work and sampling

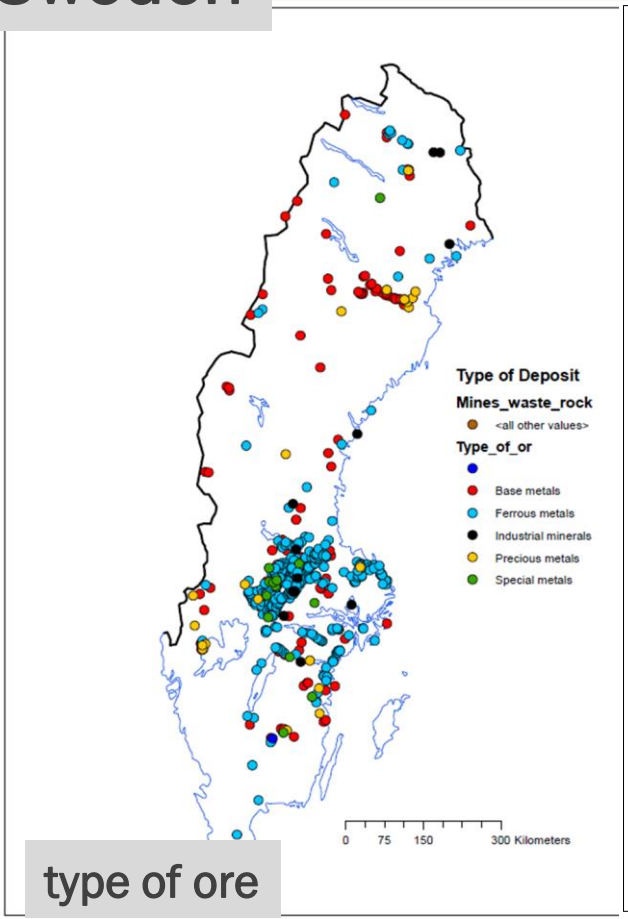


Mining Waste, stock

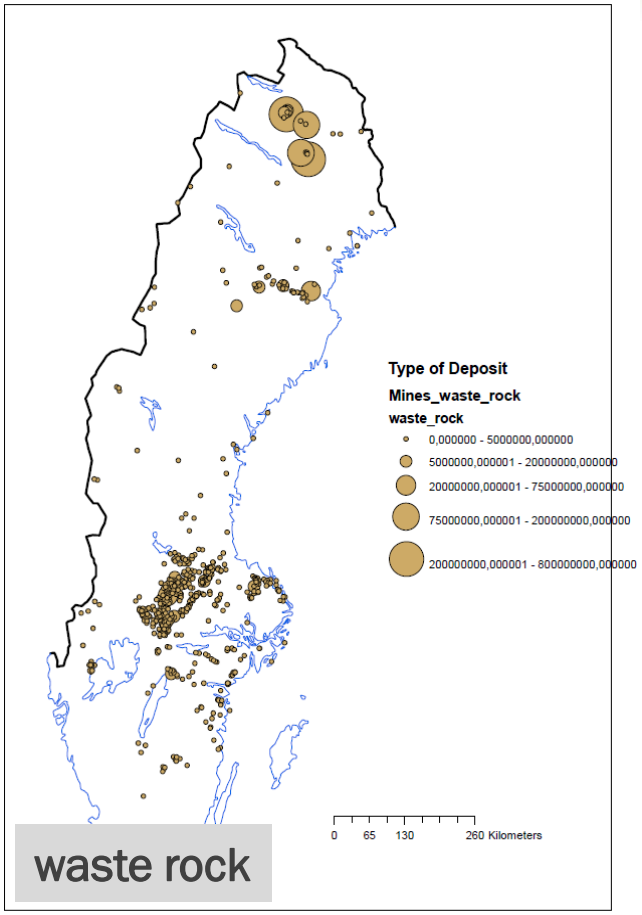
Example: Country Sweden



Tailings volume



type of ore



waste rock

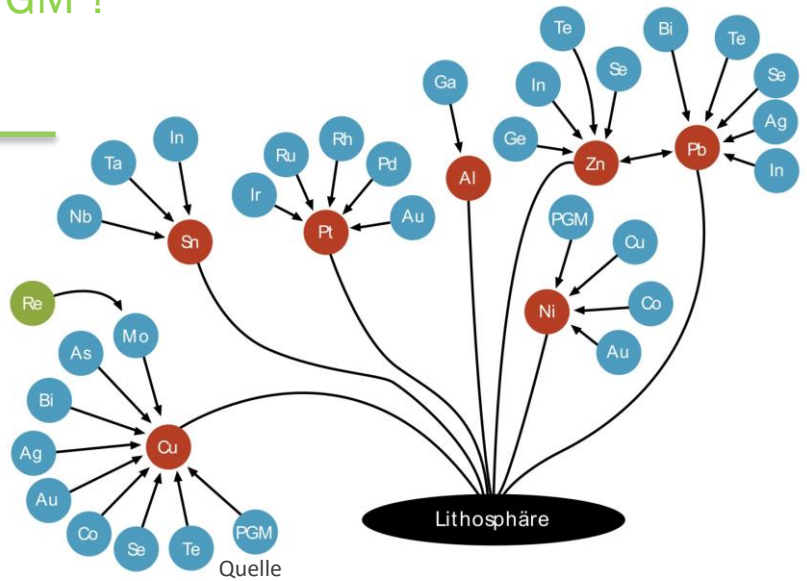
Mining Waste, composition

Example: Approximating composition data for mining waste

Iron ore	Fe	P, REE ?
Base metal ore	Cu, Zn, Pb	Sb, In ?
-"" –	Cu, Ni	Co, PGM ?
Bauxite ore	Al	Ga ?

Metal associations in primary resources

- Cu-Ni ore + Co, PGM
- Fe-apatite ore + P, REE
- Fe-skarn ore + REE
- Zn-Pb ore + In
- .....



Quelle
Hagelüken. C. and Meskers C. Complex Life Cycles of Precious and Special Metals In: From the Strüngmann Forum Report. Linkages of Sustainability Edited by Thomas E. Graedel and Ester van der Voet. 2010. © MIT Press

Conclusions

Information level	Product/waste type			
	Vehicle	Battery	EEE	Mining waste
Put on market product level	market information for Vehicles key available	market information for Batt Keys available	market information for EEE Keys available	n.a.
Stock	Good information on the fleet level	Only modeled from POM flow, waste flows do not specify Batt Keys	Modelled. Measured data only for 5 countries for some UNU keys	Only case studies, varies between countries
Waste flow	Reported flows, Key specification only model based, Gap of relevance	No Batt Key specification, only model-based information	For some flows per collection cat., significant gap remaining	NGS have data
Composition	Little data on CRM, design and time variation of high relevance	Good specifica-tion for battery types from POM	Wide variety of research data with little quality control	Mostly indirect information through ore type approx.

Vera.rotter@tu-berlin.de
Patrick.Waeger@empa.ch

Brussels
18/10/2016

ProSUM
Prospecting Secondary raw materials in the Urban mine and Mining wastes

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641999.