Enhancing data robustness at global level

Workshop synthesis brief

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MinFuture partner institutions

CSIRO	Commonwealth Scientific and Industrial Research Organization
CUNI	Univerzita Karlova v Praze
DELOITTE	BIO Intelligence Service
ECOLOGIC	Ecologic Institute
IFEU	Institut für Energie und Umweltforschung Heidelberg
IGSMIE PAN	Polska Akademia Nauk Instytut Gospodarki Surowcami Mineralnymi i Energia
MinPol	Guenter Tiess - Agency for International Minerals Policy
MIT	Massachusetts Institute of Technology MIT Corporation
NERC	Natural Environment Research Council – British Geological Survey
NGU	Geological Survey of Norway
NTNU	Norges teknisk-naturvitenskapelige universitet
RU	The Ritsumeikan trust academic juridical person
SDU	Syddansk Universitet
TU Wien	Technische Universitaet Wien
UAB	Universitat Autònoma de Barcelona
UCAM	The Chancellor, Masters, and Scholars of the University of Cambridge

1 Introduction to the MinFuture Workshop #2 - Enhancing data robustness at global level

1.1 Main objective and purpose of this workshop

In order to develop strategies as well as to define and reach goals concerning raw materials management, maps are needed to help navigate existing knowledge and data. However, there appears to be a lack of such maps in relation to material flows as material flows tend to be monitored for isolated materials thus generating individual point measurements, but leading to fragmentation of knowledge. For getting a more complete, comprehensive and realistic picture of material flows, developing a systemic mapping and system's monitoring appears promising because this can help putting statistical data into (its respective system) context.

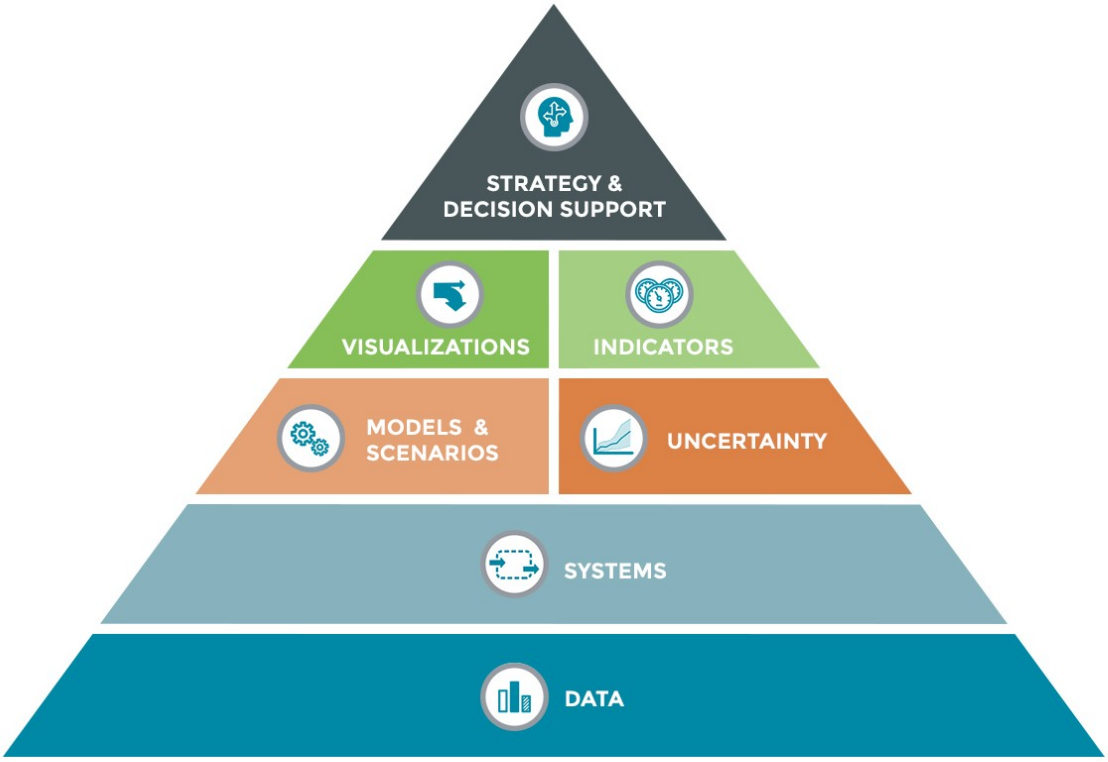
Against this background, the MinFuture project (www.minfuture.eu) wants to develop a 'proof of concept' for a kind of google maps of the global physical economy, allowing us to zoom in and out on different materials, while taking into consideration

- International trade
- As well as linkages and layers between different materials
- And how this is evolving over time (the so-called MinFuture dimensions (1) Stages, (2) Trade, (3) Linkages, (4) Time; please see http://minfuture.eu/theme/dimensions).

In order to achieve this, we need to continuously involve governments and industry.

The conceptual framework of MinFuture forms a pyramid (see Figure 1; see also www.minfuture.eu/themes) of different components, where every layer is the foundation of the layer above. For instance, we need data and a good understanding of the system before we can develop meaningful models and scenarios. That means that we have to build up the MFA infrastructure from the bottom.

Figure 1: Conceptual Framework of MinFuture – the 'MinFuture pyramid'



Source: MinFuture consortium

In this context, the objective and purpose of the second MinFuture Workshop ('Enhancing data robustness workshop') – which took place in Nottingham on 30 November, 2017 – was to

1. Develop a common language (a 'google translate') for supporting the communication and allowing a translation between different cultures, e.g. between data providers and data users, MFA experts and geological surveys, etc.; and
2. Foster exchange between these stakeholders towards forming a joint system understanding
3. In order to overcome the current fragmentation of information and to improve communication between different professionals.

1.2 Structure of this workshop

Working towards this objective, the workshop featured two main sessions, following an introduction on the issue by the MinFuture project coordinator:

1. Highlighting the relevance of information and data flows for MFA by
   a) Presenting principles for designing information flows (MinFuture design principles – put on website!!!);
   b) Demonstrating the need for improved information flows for the case of Aluminium data;

c) Discussing options for improving information and data flows for the cases of Cobalt and construction minerals/aggregate with the external workshop stakeholders; and

d) Jointly elaborating potential

i. benefits of,

ii. barriers/threats in relation to, and

iii. use cases for illustrating benefits of and need for

placing statistical data into their proper system context, i.e. storing data with "coordinates".

2 Stressing the relevance and role of indicators in MFA

a) using the cases of the EC Circular Economy Indicators and of indicators used for Phosphorus management in Austria; and

b) for policy making by discussing the need for clearly defining the system and choosing meaningful indicators.

Workshop presentations are available from:

http://minfuture.eu/minfuture-workshop-enhancing-data-robustness-global-level

2 Workshop sessions and main discussions

2.1 Relevance of information and data flows for MFA

2.1.1 Need for improved information flows – the case of Aluminium

Aluminium case study, Billy Romain (NTNU)

http://minfuture.eu/sites/default/files/Romain_Liu_Information_flows_Aluminium.pdf

In relation to the 4 dimensions put forward by the MinFuture project (stages, trade, linkages and time), early models on Aluminium flows focused only on individual dimensions. The GARC model (2009) included only "stages" but no "linkages" and hence only took into account mass flows but not Aluminium content. A model by Gang Liu et al. (2013) went further by adding the "trade" and "linkages" dimensions thus refining the system representation in the model.

Building refined models needs large amounts of data as well as to reconcile between monetary and physical units. Inconsistencies in trade statistics (as the Aluminium content in goods is hard to estimate) further complicating the model building.

As challenges with data collection remain or grow in refined models, using an alternative MFA approach could be considered, in which data are contextualised within their system. This will produce refined maps, in which data gaps and uncertainties are made explicit. This is a more complex alternative, but also more robust.

Developing simple models into more complex models takes a long time and many iterative steps so that the model can get more robust. This included close collaboration with Aluminium industry, which helped improving the Aluminium system. But the Aluminium model, although refined, is not there yet and one of the aims of the MinFuture project is to refine the model further so that it can be used by the different experts without the MFA analysts having to be involved. If we have the coordinates of every measured statistical point, then we could just compile the information by machines; and you do not need an MFA specialist anymore once it is understood what the data stands for. But that needs to be done together with industry and government specialists that understand the system.

The data in the Aluminium model are individual country data, but aggregated to regional level. As the data is based on country-by-country level there are some 70 million data points.

Mapping Aluminium trade in Three Dimensions: Challenges, Monika Dittrich IFEU

http://minfuture.eu/sites/default/files/Dittrich_Ewers_Mapping_Aluminium_Trade_flows.pdf

Mapping the trade of Aluminium are faced by various challenges:

- Trade codes are not specific enough, so the Aluminium content of ores is unknown
- Coupled metal ores are unknown, which makes it harder to track by-products (e.g. Gallium or Vanadium for Aluminium)
- For intermediate products, we have from 35 to 100 trade codes of aluminium products depending on the database, but the Aluminium content is not specified.
- In end of life, there is no distinction between production and end of life scrap, alloys and other metals in waste flows are not considered
- Only waste with a commercial value is considered; waste statistics by definition are not trade as official trade statistics (COMTRADE) are in value and there is no value assigned to waste and scrap;
- Trade codes have been evolving over time, so for longer time series it is necessary to use outdated classifications with less detail to ensure consistency (Challenges with the time layer). The more recent the classification the more comprehensive the statistics are. Trade codes are usually updated every 5 years, so models need constant adjustments.

Further challenges relate to missing physical and monetary values and asymmetries between imports and exports. In addition, different price reporting (e.g. CIF vs. FOB prices; CIF – buyer is paying insurance and trade; FOB – free on board, i.e. the seller is paying) may require price adjustments. These inconsistencies make the conversion from monetary to physical units more challenging.

In an ideal situation trade data would have no outliers and no missing information; it would have information on primary and secondary metal(s) content in each of the statistics categories; it would provide more differentiation for some products (e.g. electric vs. conventional cars). Therefore, we should develop common guidelines and create lists of materials for traded products.

2.1.2 Options for improving information and data flows

Information flows, Maren Lundhaug NTNU & Tom Heldal NGU

http://minfuture.eu/sites/default/files/MarenLundhaug_TomHeldal_Information%20Flows.pdf

Information flows are essential to understand

- the primary scope of data,
- how the data is gathered
- where in the system the measurement is taken.

Furthermore, information flows are also important to get an overview of what we don't know.

A map of information flows enables to represent how a given company reports its production and emissions to different national, European or global institutions.

Providing the case of mining reporting in Norway exemplifies potential problems with information flows. When less than three companies operate in the country for a given material, the information reported is not made public because of confidentiality issues. A mining company in Norway has to report to different institutions (e.g. on production to the directorate of mining, on emissions to the directorate of environment), which makes the consolidation of information difficult as the different directorates may not have routines for exchange of such data. If you are building a tunnel in Norway, you produce a lot of material from excavation – much of which is sold as construction material; if you build an industrial area and need to remove a hill for that purpose, the quarrying activities of removing the hill does not count under the mining act. Hence, both excavation activities are not reported at all under the Mining act, so almost one quarter of masses are not reported at all under the Mining act. And finally, in Norway there is no general obligation for companies to report reserves.

This shows that it can be very difficult to get an overview as a lot of available information can be lost.

2.1.3 Design principles

MinFuture design principles for placing data into a proper system context, Daniel Müller NTNU

http://minfuture.eu/sites/default/files/DanielMueller_MinFuture_Design_Principles.pdf

Often, data are published without system context, so that any user of this data needs to make interpretations of what data means. A poor understanding of the data's system context leads to systematic errors in MFA.

In this context, MinFuture aims to develop design principles for placing data into system context and – in the long run – develop guidelines for geological surveys, statistical offices and MFA experts.

2.2 Parallel session on information flows and data for Cobalt and Construction Minerals

2.2.1 Parallel session on information flows and data on Cobalt

Discussion and suggestions

- Change from "resource" to "deposit-types"
- Differentiate classification into the following groups

Table 1: Example Table

Classification	Groups
onshore	1. Magmatic - high temperature processes -> copper and nickel 2. Hydrothermal - 3. Lateritic (nickel & cobalt)
offshore	4. Sea floor deposit - manganese products 5. Crust maganese cobalt
Tailings and slags	Tailings and slags

- Currently, the classification is based on geological genesis. As the nature of ores dictate how they are processed this has impacts on emissions, waste generation etc.
- Make explicit whether it is a by-product etc.
- Big uncertainty related to resources - no numbers are available.
- For mine production figures there is a certain amount of interpretation whether it is economically viable.
- First go into details for cobalt and later discuss meaningful ways how to aggregate, as the aim is to make an overview which makes sense to geologists, companies etc.
- Each commodity is different - so it is important to differentiate between commodities. Later, generic lessons can be drawn. System definition is individual for every metal, while generic lessons will be on the level of the design principles, for example.
- Very challenging to put numbers on everything; as examples there is one code for "metals and intermediates", misclassifications, mixed classifications, codes are suppressed, illegal mining.
- There is no robust number, but it is best to use CI numbers. It is important to note that Company numbers are not country numbers.
- Carbides are missing (Manufacturing)
- Intermediates are missing (dotted line)

- Muddling of many things in "manufacturing" and "use"
- Need to prioritize for quantification
- secondary scrap vs primary scrap – from which part of the system is the scrap generated
- Nickel processes – look into similar materials to see if there are possibilities of extracting cobalt related data from this.
- Differentiate between "industrial use" and "consumer use"

In order to clarify where we can meaningfully group things and where we can't we should contact companies; e.g. CDI could advise on the missing intermediates.

Useful Books and presentations to consider in refining the Cobalt information flows are

1. Gus Gunn (ed). Critical Metals Handbook. (Gus will provide the cobalt chapter on pdf)
2. Crundwell, Moats, Venkoba, Ramachandran, Robinson & Davenport: "Extractive Metallurgy of Nickel, Cobalt and Platinum Group metals".
3. CDI: Presentation by Chinese representatives.
4. Cobalt factsheet
5. Commodity fact sheet: Al Barazi et al.: Cobalt from the Dr Congo - potential, risks and significance for the global cobalt market.

2.2.2 Parallel session on information flows and data on Construction minerals

Introduction, Mark Simoni NGU

http://minfuture.eu/sites/default/files/Simoni_Introduction_Aggregates_workinggroup.pdf

Trade data for aggregates, Monika Dittrich IFEU

http://minfuture.eu/sites/default/files/MonikaDittrich_Trade%20in%20aggregates.pdf

Discussion and suggestions

- German companies report based on tax payments – the logistic sector does not have to pay a lot of taxes, nor to report on masses, whereas the waste sector has to report => so logistics is outside the system and hence the masses of overburden, quarrying transported by the logistics sector are not reported
- mining companies do report only on some aspects, e.g. not the construction of houses nor for tunneling as this links to logistics
- in Austria tunneling materials are to be reported through the waste sector

- in Germany, recycling reporting is different from product use and this does not enter National Accounts or is aggregated in a different way/in different statistics => this leads to fragmentation of statistical reports
- unreported masses are a big unknown and might skew sustainability indicator reporting
- in the UK, if a site is not deemed a quarry, i.e. a construction site, then there is no reporting on it
- where are the actual measurements reported? what about different prices? resolution of data on national level has some uncertainty
- for the connection of the flows you have to take a systems approach
- add process for fine in quarry diagram
- add new reporting points for water emissions from processes 12 and 18 in quarry diagram.
- there should be a common market for all by-products
- difficult to get data on demolition waste because a large fraction is reused on site and never reported.
- by-products are not always reported, because only companies with mining concession licenses are reporting. If by-products are used by other companies without a concession, this is not reported.
- main products from industrial processes should be reported as this is an important flow, which is also used for taxes calculation.
- In the UK, double counting issues arise when quarries have agreements between each other: it is not always easy to know who first extracted the material from the ground.
- quarries measure internal numbers for intermediate products in crushing and screening stages, but this is not reported.
- inconsistency in reporting of waste: Only sellers report, not buyers.
- a common map could be built by comparing reporting schemes from 2-3 countries and find the highest common resolution.
- Deconstruction should be in a separate process from deconstruction to better track waste flows.

2.3 Discussion of Potential benefits of, barriers/threats in relation to, and use cases for placing statistical data into their proper system context

Discussion Questions:

1. Within your institution, what could be the **long-term benefits** of placing statistical data into their proper system context (storing data with "coordinates")?
2. What are **barriers or threats** for such implementation?

3 Do you know **cases**

a. for which we could illustrate the use/benefit of this system approach?

b. for challenging data issues that may benefit from a system approach, e.g. lacking design principles?

2.3.1 Potential long-term benefits

Transparency/identification of gaps/better data

- Making data transparent eliminates/reduces misinterpretation
- Trace back data origin and assumption made
- Increased transparency and awareness of ‘issues’, ‘bottlenecks’ etc.
- Data = Resources -> Adding information to data = adding value to data = upgrading?
- Enable us to improve the consistency of the data we publish
- Better understanding, identifying data gaps and further research needs on data
- Better understanding of data meaning and relevance for different research purposes
- Reducing risks of using wrong data or ‘misusing’ data for own research
- Data inconsistencies are identified and resolved
- Making data gaps transparent, showing uncertainties of aggregated data reduces risks and costs / improves decision making
- Transparency
- Sound data base
- Improve our understanding of the data we collect
- Assist the data collection process and simplify the data dissemination/provision by making more explicit the meaning of the information collected.
- Identifying missing flows
- Reduce gaps in data when re-categorized
- Prevent data misuse (wrong conclusions)
- Harmonization of data input to MFAs
- Gain time for next updates (know precise source and context of use)

Better models, improved understanding of system, better research

- More realistic forecasting models -> better prediction of expected trends in future demand for RM
- Ability to track and trace construction trends and forecast life cycle of materials, reserves.

- Refining the understanding of the entire system
- Improved basis for commodity research, market research, market analysis, supply-demand forecast, circular economy etc. etc.
- Avoid repetition / time saving
- A REGIONAL methodology might yield more data by overriding the <3 company rule and thus allowing the publication of more detailed information.

Better communication among experts and with stakeholders

- Data are more 'useful' to more stakeholders
- Easy interpretation of data between regions/countries
- Transparency for (international) comparison
- The ability to collaborate with MFA specialists
- Better communication / raised awareness of all stakeholders on all aspects of material resource use.
- Clear communication
- Comparison across countries

Societal benefits (policymaking, planning, companies)

- More rational resource management
- Stronger competition based on commonly available information
- More economic "services" provided to the consumer
- Better land-use planning
- More sustainable society
- Support the companies in the planning of RMs cycles
- Identification of mitigation strategies/research priorities etc.
- Ability to ensure sufficient permitted resources for construction materials exist to satisfy demand (due to 5-10 year period it takes to open a new quarry)
- Decision-making based on a system taking the mass-balance into account
- Better monitoring of effectiveness of specific policy actions (e.g. 3 pillars of RMI)

2.3.2 Potential barriers & threats

Barriers

- data is often supplied to us without the "coordinates", so we don't have the context; we would have to guess in some cases

- it would take time to implement and we don't have the financial or staff resources to do it
- data providers would not see any benefit to them for implementing it and would therefore not do it
- data providers may not themselves know the coordinates of the data in a system context
- lack of trust to this kind of system context by stakeholders
- more data transparency may reveal unwanted hidden flows or not so good performance
- political requirement to report on certain data without system consideration: "why should I report in a system context then?"
- institutional resistance to change
- lacking understanding of data system context among data providers
- various approaches of different actors in raw materials sector
- lacking will of industry disclosure, e.g. confidentiality, competition
- data confidentiality
- confidentiality – no knowledge of data; complexity of systems
- poor quality
- not many data for many commodities, especially minor/by-product/critical metals
- lack of resources to implement
- too many data gaps
- data interpretation varies regionally, e.g. Aluminium consumption in Europe means primary + secondary; Aluminium consumption in the Americas includes downstream product use of tube and foil
- lack of law
- not willing to share data
- legislation
- poor cooperation between government agencies
- "it depends" issue(s) in real data collection
- data sharing/confidential data
- high complexity of systems requires experts to participate in system definition
- different materials have different systems
- data protection
- too much work load
- confidentiality (competition act)
- time consuming

- needs training
- resources and time required to map statistical data – who assumes this cost?
- a lack of understanding and resources by government statistics agencies to properly understand what points in the system statistical data represents
- data fragmentation and limited availability
- convince the policy makers that they could benefit from that (1st step)
- convince them that it makes sense to invest in such harmonization (2nd step)
- physical data storage requires standardization and harmonization, whereas MFA system definition requires flexibility
- resistance to loss of monopoly based on proprietary information
- fear of "taxation"
- lack of understanding of the value of information
- funding not provided to the activities of acquiring valuable information
- additional work load for data producers
- change of habits, tradition, etc.

Threats:

- ensure the coordinates are the cornerstones, if not
- time, resource consuming for 1st iteration, but gain for the following
- data collected under confidentiality agreement must be aggregated
- misunderstanding the data we are using
- double-counting
- Governments are reducing the amount of data they report (e.g. Canada); unlikely that this trend will be reversed
- asking for more detailed information makes it more likely that the < 3 company rule will be invoked and data suppressed
- misunderstanding by data providers may make the position worse caused by language issues, terminology, lack of understanding of what we are asking (them to do)
- my institution would lose a large part of its work
- if we ask data providers for "system context" – then they may stop providing data altogether
- Big companies often report regional or global data – no country breakdown
- data for China is often unavailable or misleading or late

2.3.3 Potential use cases for illustrating the approach of placing data in a system context

- Update of EC studies on MFA, RMIS, inventory, CRM fact sheets
- Good practice that can be a basis for the material company reporting.
- Cyclical material use indicator (Circular economy monitoring framework)
- T.I.C statistics for Ta & Nb see: www.tanb.org/images/bulleting_164_find.pdf
- Misconceptions about "peak material" and concerns regarding running out of resources
- The managed aggregate supply system (mass) – one for the mechanisms for planning for aggregates in the UK.
- Construction material planning
- EC material system analysis (MSA) criticality
- The REEs (eg. Nd) case
- Data quality from different sources
- Illustrate the benefits for some of the major metals where data is available
- All minor metals, data are quite opaque and having a system understanding could benefit end enhance our knowledge
- Some agencies report data in a format that is fundamentally different from standard definitions.
- Find a case where multiple commodities are produced and where waste streams from one or more value chain(s) are the resource base for others – demonstrating the added value of processing complexity.
- Estimation of illegal trade (and production)
- Brazil aluminum (lots of data published by ABAL, the description of each data point are not always clear.
- Waste management system in Austria
- Phosphorus-budget of Austria for detection of systematic data errors
- Cyclical material use indicator (Circular economy monitoring framework)

2.4 Relevance and role of indicators in MFA

2.4.1 EC Circular Economy Indicators

Challenges related to monitoring the circular economy – Lie Heymans, DG GROW

There are two key initiatives at EU level:

1. The raw material scoreboard:

- An initiative of the EIP on Raw Materials and developed with the support of the JRC

- Objectives: it should contain relevant data, be credible and accepted by all stakeholders and needs to be accessible and reach the right audience
- Based on 24 indicators: the overall number of indicators is limited to improve readability; a new indicator will be added on construction materials in the next version, but challenges remain with data quality: data collection on construction waste should be improved.

2 The circular economy monitoring framework:

- part of the Circular Economy Action Plan, will be published in January 2018.
- Objective: to assess progress towards a more circular economy and the effectiveness of actions
- 10 indicators grouped in 4 thematic clusters: Production and consumption, Waste management, Secondary raw materials and Competitiveness, innovation, economics
- Challenges:
    - capturing systemic change
    - data availability
    - lack of harmonisation for certain indicators

2.4.2 Indicators used for Phosphorus management in Austria

How we come from data to sound strategies – Helmut Rechberger, TU Vienna

http://minfuture.eu/sites/default/files/HelmutRechberger_AustrianPhosphorusBudget.pdf

Applying MinFuture's pyramid to the Austrian phosphorus budget:

- **Data layer**: Many data from different sources that are not interconnected. However, data collection for phosphorus is overall very good because of mandatory reporting for main emitters.
- **Systems layer**: 56 processes, 8 stocks and 122 flows. It is drawn with a software and contains subsystems to improve readability. The system has been updated for every year (amounts to about 50% of project time)
- **Uncertainty layer**: 3 steps: assign uncertainty, analyze propagation of uncertainty and reconcile conflicting data. Putting data into context (system) helps identifying systematic errors. System understanding is improved when the system is quantified for several years.
- **Models and scenarios layer**: 15 actions were considered for scenario analysis, with the definition of optimum (target) values for some parameters.
- **Indicators and visualisation layer**; 3 indicators:
    - Import dependency
    - mineral fertilizers concentrations

    - emissions to water bodies
- They enable to follow the impact of different scenarios.
- **Strategy and decision support layer**: the different actions are ranked according to their efficiency, which can give us understanding of where in the system it would be best to intervene. However, decision support requires taking into account the interaction with other resources (energy, costs…).

2.4.3 Indicators in Policy making – system definition and choosing meaningful indicators.

Material Flow Analysis and Indicators for Raw materials – Gara Villalba, UAB

http://minfuture.eu/sites/default/files/GaraVillalbe_Indicators_raw_materials.pdf

- Why?: to transform the socio-economic metabolism in a desired direction
    - complex
    - poorly understood
    - indicators overly simplify
    - direction not clearly defined
    - diverging interests
- Indicators: Answer policy-relevant questions that address the systemic nature of material cycles, including their linkages with other materials, with energy use and with emissions.

Group work

Questions for the group work:

1. What is the system definition that should be considered for this policy?
2. What indicators can we use to inform/monitor about these targets?
3. Do these indicators do a good job representing the system?
4. How would you design/improve indicators to better represent the entire system so we don´t have fragmented information?
5. What options do consumers have to reach policy targets?

Group 1 (presented by Helmut)

- The indicators chosen should be indicators for the goals and not for the means to achieve the goals.
- Goal: Environmental protection - Means to achieve: Recycling
- We should have indicators that represent both the goal and the means.

- Very unclear what the goals actually are, if the indicators should makes sense, the goals should be clear.

Group 2 (presented by Gang):

- All indicators can only be used when you have a goal: looking at one specific process and being explicit regarding what the indicator reflects. Recycling rate as a whole in a system in which recycling happens in several parts does not give a good indication of recycling. You would then need individual recycling rates.
- Should only quantitative indicators be used, or should price for instance be a part of this? Indicators needs better expressions in the form of systems.

Group 3 (presented by Mark):

- Defining system boundaries correctly,
- all should be able to understand the definition of the indicator. Loopholes must be closed, so that indicators should not me be miss-used. A set of different indicators for different purposes should be used together: environmental, financial, social indicators.
- Goals:
    - a service economy - when you do not look at the material, but the service the material provides. What is the service that people need to get where they need to go.
    - SDGs - Each with their own indicators - do they make sense for MinFuture.

Group 4 (presented by Tom):

- Indicators could focus on energy consumption (type of energy renewable/fossil has to be taken into account when making comparisons) and EOL recycling. CO_2 emissions could be way to have more meaningful indicators.

Group 5 (presented by Zhi):

- No consensus on system definition because recycling is not always good.
- You need to look at the entire system not only the individual parts. Not confusing the means with the end. Indicators are a necessary evil, but a part of the system will never represent the whole. Indicators should be considered very carefully.
- Single indicators could mask possible trade-offs: optimising a single indicator can lead to poorer performance in other areas. For this reason, a system understanding is key to reach the goals.

3 Summary

The MinFuture workshop 'Enhancing data robustness on global level' served to present and test the MinFuture approach of placing statistical data in a system context so that global information flows on mineral raw material become less fragmented and provide a more complete, comprehensive and realistic picture.

Workshop discussions highlighted that placing statistical data into a system context would

1. yield benefits, e.g. in terms of improving data transparency, identifying gaps, allowing to build better models and enhance system understanding, facilitating communication among experts and with other stakeholders, and providing societal benefits through improved policy-making and planning;
2. face barriers, such as need for additional time and financial or personal resources, data confidentiality issues, unavailable data or data of poor quality;
3. be able to build on relevant use cases, for instance for updating EC studies on MFA, RMIS, inventory, CRM fact sheets or for revisiting the Phosphorus-budget of Austria for detection of systematic data errors.

Furthermore, workshop discussions

- suggested adding relevant data sources and system boundary definitions to representing global flows of Cobalt and of Construction minerals
- highlighted that indicators are needed to represent both the goal (e.g. environmental protection) and the means to achieve the goals (e.g. recycling activities), and that any single indicator could mask possible trade-offs (e.g. optimising one indicator can lead to poorer performance in other areas).

Hence, the workshop showed that a system understanding is key to improve both information flows and communication between producers and users of data.

Annex: List of workshop participants

(*see list in Travel document from BGS and take from xls-list*):

Daniel Müller (NTNU), Mark Simoni (NGU), Gang Liu and Zhi Cao (SDU), Monika Dittrich (IFEU), Marzena Smol (Polish Academy of Science), Maren Lundhaug (NTNU), Romain Billy (NTNU), Sigurd Hejberg (Advisory Board), Blazena Hamadova (MinPol), Sarah Heidenreich (NTNU), Teresa Brown (BGS), Tom (BGS), MHG, Nedal Nassar (USGS), Gus Gunn (BGS), Gara Vilballa (UaB), Evi Petravatzi (BGS), Helmut Rechberger and Astrid Allesch (TU Vienna), Tom Heldal (NGU)

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