Towards a roadmap for monitoring the Physical Economy

Workshop synthesis brief No. 3

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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 #3 - Towards a roadmap for monitoring the Physical Economy

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 the four dimensions of MinFuture, please see http://minfuture.eu/theme/dimensions)

- Stages
- Trade
- Layers/Linkages
- Time

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 7 components of Material Flow Analysis, in which the robustness of components on the higher level, depends on the robustness of the components on the lower levels. 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 conduct MFAs from the bottom of the pyramid starting with the system.

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

Source: MinFuture consortium

Against this background, the purpose of the third MinFuture workshop ("Towards a roadmap for monitoring the Physical Economy"; held in Brussels on 7 June 2018) was to further develop the roadmap for monitoring the physical economy. During Spring 2018, the MinFuture project has held several commodity specific workshops to test the developed framework and to identify commodity specific trends, opportunities and challenges that can inform the MinFuture roadmap. Workshops has been held on aluminium, cobalt, neodymium, platinum, phosphorus and construction aggregates, and stakeholders from different parts of the supply chain has contributed to these workshops.

Against this background, the 3rd MinFuture workshop aimed at discussing with organisations involved in data reporting, material flow analysis as well as decision makers in Europe and elsewhere and jointly shaping a 'common framework to monitoring the physical economy', as currently being developed in the MinFuture project.

1.2 Structure of the workshop

Working towards this objective, in this 3rd MinFuture workshop, we presented the outcomes from the commodity specific workshops and took a further look at the opportunities and barriers to monitoring the physical economy from a decision-making and policy perspective. The results of the workshop will be used to further inform our work towards a better understanding and mapping of the physical economy and will be incorporated in the roadmap.

Therefore, the workshop featured three main sessions, following an introduction on the issue by the MinFuture project coordinator:

1. The need for a roadmap for monitoring the physical Economy
   a) Aiming towards a basis for the roadmap process
   b) Application of the framework – findings from case studies on Aggregates, Aluminum, Cobalt, Neodymium, Phosphorous and Platinum
2. Designing a framework for monitoring the physical economy
   a) Key principles for Systems and Data
   b) Key principles for Models, Scenarios and Uncertainty
   c) Key principles for Indicators, Visualizations, and Strategy & Decision support
3. Recommendations towards setting up a framework and a roadmap process
   a) Reporting data within a system context
   b) Facilitating data sharing
   c) Develop platform(s) for monitoring the physical economy

2 Workshop sessions and main discussions

Workshop presentations are available from:

https://minfuture.eu/developing-roadmap-monitoring-physical-economy

2.1 The need for a roadmap for monitoring the physical Economy

The need for a roadmap for monitoring the physical Economy, Daniel Müller (NTNU)

https://minfuture.eu/sites/default/files/Mueller_Introduction_MinFutureWS3.pdf

In order to ensure access to raw materials as well as to support efforts towards reaching the SDGs and realising a Circular Economy we must improve our understanding of global material cycles. Currently, this understanding is limited by fragmented and insufficient data and information.

Against this background, MinFuture aims to provide a proof of concept of a "Google maps" for the global physical economy in four dimensions (stages, international trade, layers and time). To do so, MinFuture will develop a framework that enables the monitoring of the physical economy.

The MinFuture pyramid represents part of such a framework. It comprises 7 components that are hierarchically ordered. These included systems; data; models & scenarios; uncertainty; indicators; visualisation; and strategy and decision support. The hierarchic order of the components is of great importance as the robustness of any component depends on the robustness of components on the lower levels. The framework aims to assess the state of the art for all the components.

In relation to the framework, MinFuture will suggest steps for developing a roadmap towards monitoring the physical economy. This roadmap shall encompass

- Motivation and purpose (criticality of supply and beyond)
- Map: Framework of MFA
  - 4D, pyramid
  - Design principles for pyramid components
  - Current position on the landscape for selected materials (material-specific workshops)
- Goals and alternative roads:
  - Challenges and questions
  - Recommendations & questions, such as (i) Policy, regulation, finance; and (2) Roles and cooperation

The roadmap could pursue three goals

4. Report data with system context
   - Facilitating data harmonization
   - Monitoring of systems, not isolated flows
5. Develop a common ontology
   - Metadata to describe the system context
   - Enable data sharing
6. Facilitate data sharing
   - between industry, public authorities, International Government Organisations
   - Challenges with the ownership of data

Application of the framework – findings from case studies on Aggregates, Aluminum, Cobalt, Neodymium, Phosphorous and Platinum, Gang Liu (SDU)

https://minfuture.eu/sites/default/files/Liu_DemonstratingMinFuture%20Framework_MinFutureWS3.pdf

Six material specific workshops were held between April and May in London, Odense, Oslo and Trondheim, bringing together MinFuture and industry partners to discuss both state of the art and need for improving monitoring on Aggregates, Aluminium, Cobalt, Neodymium, Phosphorous and Platinum.

The following common challenges were identified across the six workshops:

- System definition is still not adapted to answer some challenges, because of the lack of resolution, linkages with other materials and understanding of End-of-Life routes.
- Spatial resolution is usually missing or incomplete

- Data gaps: in output/shipment, market share and material contents of products. Additionally, there are inconsistencies in the reporting and the current trade codes does not necessary reflect what we aim to monitor due to the fact that several stages in the value chain are combined in a single trade code for instance.
- Demand-supply forecasting models have to be improved: need for inclusion of dynamics and feedbacks in the system, increased technological and spatial resolution, increased understanding of the development of reserves.
- More work is needed on uncertainties and how uncertainty in systems, models and data can be communicated in a better way.

2.2 Designing a framework for monitoring the physical economy

To support the development of individual components, design principles are developed. These aim to enhance system understanding and clarify how data are linked to systems and/or are embedded in a systems context.

Framework for monitoring the physical economy – Design principles for Systems and Data, Maren Lundhaug (NTNU)

https://minfuture.eu/sites/default/files/Lundhaug_Design%20Principles_Systems%20and%20Data_MinFutureWS3.pdf

The goal of these design principles is to show examples on how differences and inconsistencies in data collection and reporting can arise, and to provide a way for companies to report their data in a system context, with explicit points of measurement defined. A common language should facilitate integration and comparisons between different data sources and providers.

- Production vs. shipment: reported numbers can be different depending if they are counted right after the production or only when shipped, the inventory between these two can make a diffrence.
- Finished products: this could have a different meaning for different companies, depending on where they are situated in the value chain and can further lead to double counting issues.
- Ore: different grades and definition can be in use in different countries.
- Incomplete reporting: not everything is reported
- Markets and international trade: the system is much more complex than using only imports and exports. One of the main reasons for this is that different delays can occur in the process: inventories, national stockpiles, customs, etc.

Furthermore, uncertainties in trade codes and the concentration in raw materials in products are also an important source of errors. This holds, too, for the fact that different countries or international bodies likely also use different reporting systems for trade. Monetary values are usually tracked more precisely, since this has implications for taxes.

Framework for monitoring the physical economy – Design principles for Models, Scenarios and Uncertainty, Astrid Allesch (TU Vienna)

https://minfuture.eu/sites/default/files/Allesch_Design%20Uncertainty_Model_MinFuture WS3.pdf

Figure 2: Impression from the presentation on Models, Scenarios and Uncertainty

Source: MinFuture consortium

Although studies of material flow systems can provide information, they also depend on information in their production process, and a lack of useful information can be a limiting factor to the level of detail provided in an analysis. More than that, the results are typically inherently limited in terms of accuracy and, thus, in their reliability in subsequent decision-making processes. Communicating and visualising uncertainty in a user-friendly way is more important from a scientific point of view and much harder to communicate to policy makers. The question is also how to convince data providers to include uncertainties in their publications. Incorporating uncertainties in industry usually leads to more complexity and work.

For the MinFuture pyramid context, uncertainties are present at every level. In MFA, the consideration of uncertainty should enable the use of all available information about the system, reflecting the purpose of the MFA and the data quality. The first step for handling uncertainty in MFA is to define the elements of the system and the mathematical relationships between them in consideration of the mass balance principle.

There are a handful of partly simple approaches to include data uncertainty in MFA. However, uncertainty is often characterised without the use of formal procedures, which impairs statements about the reliability of the MFA results. Therefore, consistent and transparent procedures for uncertainty characterization are imperative for uncertainty analysis in MFA.

Framework for monitoring the physical economy – Design principles for Indicators, Visualizations & Strategy support, Astrid Allesch (TU Vienna)

Indicators are extremely important, but their scope and availability is or can be limited. Indicators have to answer a question, not solve a problem and stand for quantitative measures that aim to reflect the status of complex systems. Indicators are very often dependent on the system and question asked. Different data users or practitioners from different fields would have different needs in terms of indicators (e.g. input/output vs. MFA). Indicators need to be based on a system: To create an indicator you need to have a good system (feedback loops).

Policy and decision makers need to have an understanding of the system in focus. While indicators should not be too simple and reflect the complexity of the system to be meaningful, you also need to clarify the goal of the indicators, which often seems to be overlooked in discussions. As indicators often are not developed with a system context in mind, focus should be put on developing a set of indicators, which represent the system as a whole. This way the focus will not be put on a single indicator, and the relationships between the indicators would be taken into consideration. Hence, a set of indicators is needed – do not rely on one indicator.

2.3 Recommendations towards setting up a framework and a roadmap process

2.3.1 Reporting data with system context

Table 1: Challenges, recommendations and key stakeholders in relation to "Reporting data with system context"

Aspects	Challenges	Recommendations	Key stakeholders
Technical	Convince statisticians that this is important Train/educate statistical offices Major data gaps (Geological, secondary, production etc.) Sufficient knowledge about how system works (not always sufficient data how does it actually works might not be available) Systems are missing for many of the commodities Systems should be flexible and able to aggregate or expand according to the objectives Necessity of a system accepted by all stakeholders Focus on common standards, without it there will not be progress at scale. This is why UNFC is important. multiple terminologies and systems Metadata availability and quality (may be non-existing or ambiguous/unclear)	Data infrastructure "market place" for mining and quarry waste (stocks and streams) Data reporting should use primary data as much as possible i.e. company data. for mine/smelter/refinery this is possible, all data should have date and location Development of systems for many commodities Scalable/zoomable Sankey diagrams linked to national databases data template for individual materials develop and provide and easy-to-use mini-guidance on how to report that can be adapted to many contexts Specify systems individually (replace those which are outdated/not fit for purpose) Level of detail (common understanding) Learn from CRIRSCO and UN experience of developing translation	Statistical offices OECD UN Stat Eurostat JRC USGS International study groups in Lisbon (Lead and Zink, Co, Ni) Researchers (international collaboration needed) Geological surveys Industry federations Working groups on specific commodities to develop systems that consists of researchers, industry, trade associations, government and public authorities. Cross-disciplinary consortiums are key to this.

Aspects	Challenges	Recommendations	Key stakeholders
	Determination of "elements of system context" (or classification) Reported data is not stored in databases designed to convey system context Need for criteria and guidance on how to report in system context	tables for resources/reserves. How did they overcome some of the challenges?	
Legal	Sometimes national law (within the EU) rely too much on the EU law and sometimes national law contradicts EU law Fragmented responsibilities and legislation on data reporting and collection not sufficient legal framework Data ownership and confidentiality authorities may have non-physical priorities	Go to national level, understand the structure of the industry, national law vs. European law, historical development By-product level (niche markets) have IPR issues and business-case protection data (confidentiality issues?) Inspire directive for the physical economy (stocks and flows)	Ministry of Industry/Trade/Economics European Commission
Financial	Costly at the beginning, saving in the long term Reporting data with system context may need additional synthesizing data and time consuming which require additional resources financial or others Changes to official reporting is slow and resource intensive? Understanding system to understand business case of data reporting	Be prepared to take on a very long-term effort to effect change Funding is key to facilitate this change. Public authorities at national level will need to change the way they work, which has financial implications. (Who is to fund such activities?) Who pays for the extra effort of reporting systems context? Should government provide platform and then	Resource taxes pay for reporting costs? Supports dematerialization, improve resource efficiency and Circular economy Consumption tax should pay for it? Open national markets to more diverse investors, establish more competitive national industry to remove confidentiality constraints.

Aspects	Challenges	Recommendations	Key stakeholders
	National/regional statistical offices (who pays for that?) Limited motivation of industry stakeholders to store knowledge on e.g. niche markets	require reporting? If we want the data to be freely available to all, support for reporting in system context must be publically funded.	
Roles and responsibilities	Require more active involvement or inputs from industry Getting support from industry (despite broad societal benefit) Who coordinates data reporting (who reviews data to ensure quality? Who defines the system? Data providers, data users, policy makers? The intergovernmental organizations (OECD, UN) and the EU are big voices but they might not reach challenges at a national level.	Should ideally be easier and more appealing than other reporting templates/schemas (incl. voluntary ones) Continuity is important i.e. an organization which has done the same work repeatedly will do a better job. For reporting of freely available public data, governments should take the lead. Define targets for GRPS for dissemination Improving Improving geological IP (geological surveys)	Government: monitor societal costs of missing/inefficient physical economy Industry: Sustainable value generation that minimise societal costs Industry Government should take initiative to reform reporting GeoERA Intergovernmental agencies to coordinate (an IPCC for the physical economy mapping) Stakeholder analysis required for each material, as roles/responsibilities differ from material system to material system.

A key question is who will pay in the longer-term. For long-term public funding, it is necessary to show how stakeholders will benefit from it. As the goal of such funding is to understand the complete metabolism of the physical economy, which is both of public and business interest, but it will benefit the public first, it should receive public funding.

2.3.2 Facilitating data sharing

Table 2: Challenges, recommendations and key stakeholders in relation to "Facilitating data sharing"

Aspects	Challenges	Recommendations	Key stakeholders
Technical	Variations of data reporting -> lack of harmonisation Who owes the data? (IPR) Develop data exchange platform Storage capacity -> large data sets Meta data Translation of data	How to use systems? Stop using Excel Block chain Centralized system versus Peer -to-Peer Data protection should not be an obstacle for reporting, but for publishing only -> neutral "clearance" needed Harmonization of data formatting and structuring Anonymous data security and simultaneously ensuring data sharing quality	Eurostat National States Offices JRC OECD Industrial and trade associations Market segment insiders to assess correction of data/statistics
Legal	Limitations on micro-data sharing and publishing at EU and Global level Geopolitical issues = international cooperation Confidentiality -> suppression of data to protect companies Data protection Competitive advantage Who is the data owner? Under which country/law the data would be stored	Open data Initiatives Review of statistics and legislations Confidentiality (e.g., food industry has to report all ingredients of products) Industry cooperation on data sharing MFA data/metadata -> standards that facilitates automatic data harvesting (INSPIRE) More open data sharing under legal	Government Industry Industry Federations

Aspects	Challenges	Recommendations	Key stakeholders
	and shared? Distinguish between data existence and sharing and priories the former	support Joint policy target across the globe/Europe	
Financial	Sharing precise data means really disclosing what you do, not everyone wants this Who pays to facilitate data sharing? Prisoners' dilemma? Fear of losing out on competition when sharing data?	User pays/government pays? Incentive to data sharing along value chains Incentive to balance out potential economic disadvantages from data sharing Reporting efforts need to provide clear benefits for providers (owners)	World Bank Funding from governments
Roles and responsibilities	Need for frontrunners to start data sharing Industry could "own" and control system understanding US could own and control system understanding = Questions of Power	From a global perspective, should it go through the UN? From which participant (industry, data user) to start the initiative? Explanation of data Public authorities need to take a lead; balance between sharing and confident An international protocol for implementation, e.g. GHGs, CFCs	Industry Associations Intergovernmental organisations Governments Wikipedia type of addition of data

In order to facilitate data sharing, a standardised nomenclature and terminology is needed.

Block chain allows for protection of data so that this may facilitate the sharing of data across different users. Block chain allows for sharing of data while ensuring that it is not modified (data integrity), but it does not help with confidentiality.

A new system must be easier to use for industries and provide better value than existing time-consuming reporting schemes. This could be done if one service is centralising all data exchanges from a company and forwards data to the different government agencies that require reporting. Here, the system component is the missing link, the system needs to satisfy the industry and the government.

2.3.3 Develop platform(s) for monitoring the physical economy

Table 3: Challenges, recommendations and key stakeholders in relation to "2.3.3 Develop platform(s) for monitoring the physical economy"

Aspects	Challenges	Recommendations	Key stakeholders
Technical	Find Common Methodology / language to link different platforms under one hub Tools, software, educating/educated people, …	Is there any 'successful' platform we could clone? Platform that shows the clear linkages between different sectors Need for technical guidance (UNFC-like) Different platforms for different stakeholders Modular approach needed Develop common ontology/database structure Non-structured 'data-lakes' vs. rigid storage format Open source/open data? A platform to monitor exchanges between companies together with info on cumulative environmental impact, basic data about the exchange and stock change Visualisation tools integrated in the	Host: JRC? UNSTATS? OECD? USGS/USEPA? Are we over focused on the "West" at the expense of the "East"? National EPAs or Ministries for the Environment report to the EU level Global Industry & Policy developers, UN Member States JRC could be the natural EU-hub/platform; it needs to be hosted by a "permanent" institution (beyond a project)

Aspects	Challenges	Recommendations	Key stakeholders
		platform, e.g. Eurostat ++?	
Legal	Confidentiality, data protection, ownership of data Who owns the platform and results/outcomes? How would the platform be legally established? Licensing? Open access for strategic information will only be possible at aggregated level => could be used for trade wars		Who has access rights for Uploading data? Downloading data?
Financial	Resources Who should support the platform? Who pays for maintaining the platform?	Discount for data providers Business model: free access? Subscription? Analysis required: who benefits from data refinement? Who has extra effort? => business model development Financed by income tax (<<0.1%) Could it be established under existing initiatives? Optimum to have a business case for the platform => eco-invent Education for providing data, especially for end-of-life	Industry Business associations Banks Investment funds Governments? Foundations UNECE OECD Consumers can benefit from platform (e.g., sell their second-hand products) Global business players
Roles and	Who leads the platform and maintains	Start with a small case	Cooperation with USGS, USEPA, UN-

Aspects	Challenges	Recommendations	Key stakeholders
responsibilities	the platform? Buy-in (sharing data) How to design a platform in order to fulfil needs of science, industry, policy?	Find an existing host institution Use or integrate available resources from industry data (such as world Aluminium (IAC) or etc.) Aim globally; look to International Energy Forum and their JODI database for oil and gas Learn from trade data harmonisation (WTO, UNSTATS) Multi-level platform? Global, country, region	FRR, OECD USGS is now main data source – Europe should develop cooperation with China => true knowledge gap Get OECD/IRP/UNEP/UNFC/UNSTATS to sign roadmap recommendations Permanent international body with clear remit & funding Eurostat, national statistical offices, public authorities, companies

A verification body is needed to maintain the data quality. This may speak in favour of a permanent governmental agency (e.g. IPPC for resources) to guarantee the international use of this platform on the long term.

3 Summary

- The representation of exploration in the system is still under discussion. This is a challenging question because of the dynamic nature of this process. It is also difficult to represent in an MFA, because even though it implies large monetary flows, this is not directly translated into the physical economy, and does not follow the mass balance principle. For some commodities, it might still be possible to infer the future increase in resources from the investments in exploration.
- Using Input-Output / bulk MFA data, such as EXIOBASE data, can help filling gaps in our systems. However, EXIOBASE data is not refined enough and not really mass balance consistent. Therefore, it is most likely to be the other way around, that MFA could complement EXIOBASE by improving their modelling of the physical economy. EXIOBASE is only based only on global monetary Input-Output data, which is not reliable enough and lead to mistakes when translating it to physical data. Therefore, we should make plans to further develop the Input-output approach and foster the will for harmonisation among the Input-output-community.
- Many projects have been unsuccessful in providing a clear roadmap. An idea is to cluster different projects working on this topic to fill the gaps, and working on a proposal for a second phase to collect more recent data. Platforms for data sharing already exist in other projects. The main contribution from the MinFuture project is the system understanding. This project should not only benefit the USGS – further development of data reporting in a systems context should be supported by the European Commission to avoid this situation.
- The benefits for the stakeholders should be communicated clearly to avoid the fear of change in the industry. It would be important to get business support.