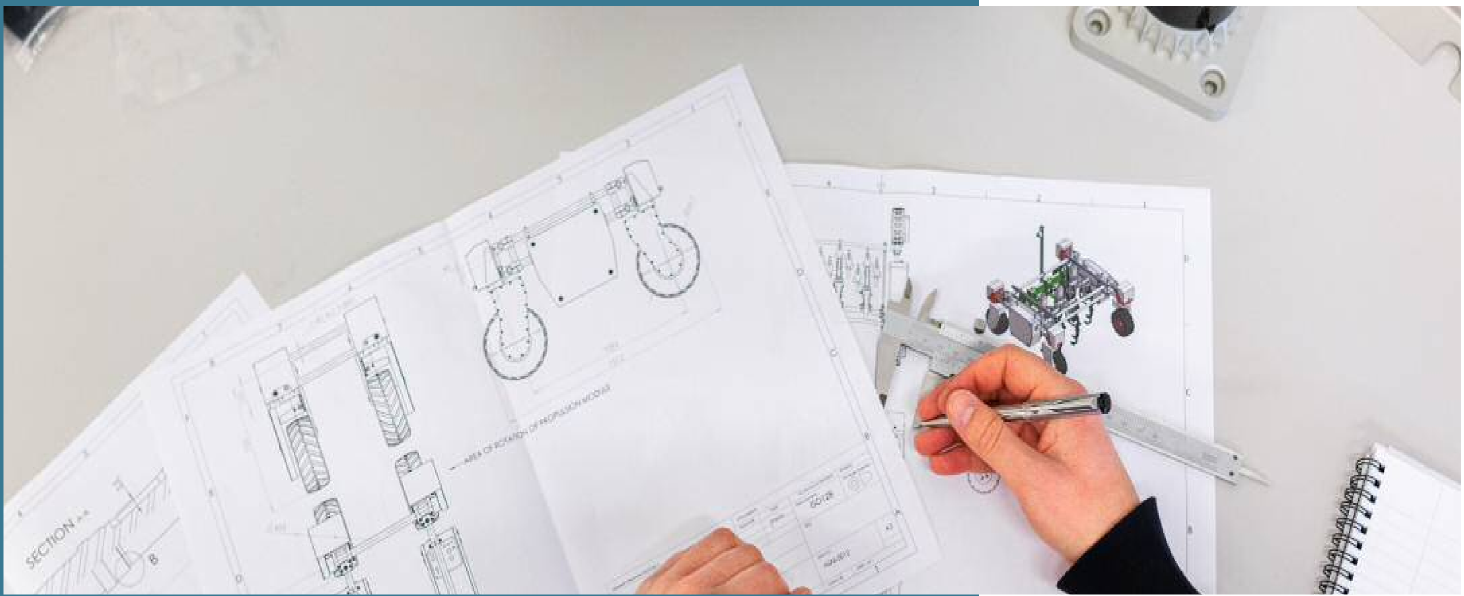
re-sourcing



RE-SOURCING
Briefing document No 10
March 2022
Author: Prof. Dr.-Ing Jan Rosen-kranz
Affiliation: Luleå University of Technology

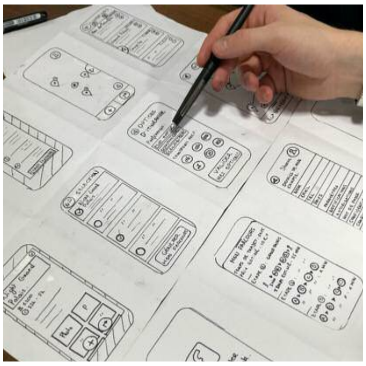
Designing for Responsible Sourcing - An Engineering Perspective

Abstract:

Responsible sourcing (RS) refers to the sourcing and procurement of raw materials, products and services in an ethical, sustainable and socially conscious way. While most of the RS discourse focuses on guidelines, reporting standards & tools as well as certification, the decision of which raw materials are used, whether these raw material can be potentially sourced while fulfilling RS criteria, and how sustainable the supply chain for a product will be, is to a large extent already defined at the time of the design and development stage of a new product. As engineers largely develop the technical solution, generating the bill of materials and thus selecting materials and production processes, their impact on RS should not be underestimated. This briefing document discusses the engineering perspective and role of engineers in the RS of minerals and metals for manufacturing consumer goods and industrial products.

The **RE-SOURCING Project** aims to build a global stakeholder platform for responsible sourcing. The project addresses the challenges facing businesses, NGOs, and policymakers in a rapidly evolving ecological, social, business and regulatory world; through a collective, consultative, and industry & civil society driven approach. RE-SOURCING is funded by the European Commission's Horizon 2020 programme and runs from 1 November 2019 to 31 October 2023.

1. Introduction



The work of engineers encompasses the design and development of infrastructure, machines, and vehicles as well as the equipment required for their manufacturing (including parts and goods) and the production of raw materials. This work includes identifying the minerals and metals required to manufacture these products. In today's technology-driven world, engineers bear a particular responsibility for the impacts of these products and production processes, which are reflected in professional standards and principles of ethical conduct.

These standards and codes of conduct require engineers to be dedicated to safety, health, environmental protection, have the required competences and virtues, and be committed to quality. Optimally, engineers need to be able to see the "big picture" as well as the details of smaller domains. Moreover, they need to identify actual or potential conflicts of interest in the engineering design process and be able to handle these in a responsible manner.

Design for X

Designing a complex product and developing it to the stage where it is ready for manufacturing, requires different engineering disciplines to work together through the design process, either in a sequential approach or iteratively, as nowadays, in concurrent engineering. Systems engineering provides solutions for integrating and managing this process. Different aspects of product design are introduced as design guidelines that, for instance, ensure that all parts of the product can be realistically made with materials and processes that are relatively common and mature (Design for Manufacturing – DfM), that the product can be easily assembled (Design for Assembly – DfA), or that recycling of the end-of-life product is facilitated (Design for Recycling – DfR).

More recently, this family of Design for X techniques (DfX or Design for Excellence) has been extended by including guidelines that are less related to function and technical design (see Figure 1). Instead, these refer to more comprehensive terms such as Design for Logistics (aiming at reducing logistics cost), Design for Supply Chain (to align the product design with infrastructure and supply chain capabilities) or even Design for Sustainability (to design products with least environmental and social impact - even though the considerations for social dimensions are often limited as it is more difficult to capture).

When it comes to sourcing of raw materials and semi-fabricates, the focus is usually on reducing the risks from single-source procurement with regard to costs and loosing flexibility (the "monopoly trap"). A comprehensive design framework that includes different aspects of responsible sourcing (RS), i.e. sourcing and procurement of raw materials, products and services in an ethical, sustainable and socially conscious way, is still to be developed.

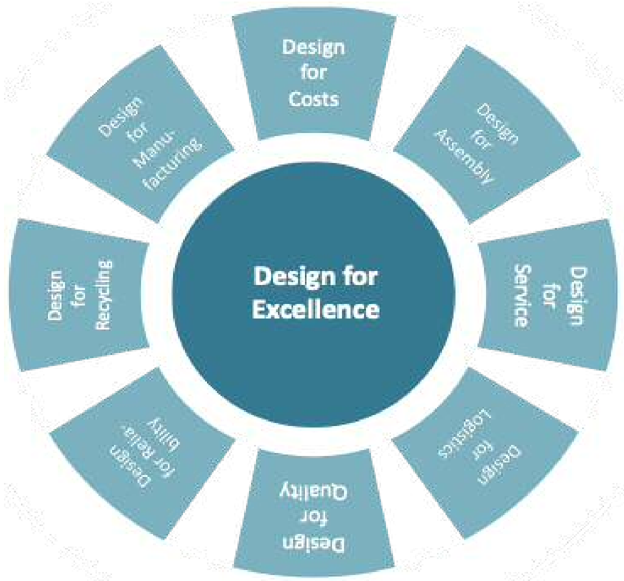


Figure 1: Design for X - Examples of DfX Types

2. Product development and responsible sourcing

The current discussion of RS in the minerals value chain focuses very much on guidelines, reporting standards & tools as well as certification of supply chains, to fulfill due diligence requirements driven by legislation, consumer and investor demand[1]. With regard to minerals and metals included in a product, the supply chain part upstream to the manufacturing is in the center, i.e. the extraction and processing.

These extraction and processing activities often involve human health and environmental issues, problematic labor conditions, child labor, human rights violation etc. – depending on the commodity, the location of the deposits and production sites[2]. Examples of global supply chains that are critical to RS refer to electronics and communication equipment (requiring the 3TG – tin, tungsten, tantalum, gold, known as conflict minerals), batteries for electrical cars that shall enable green transition in mobility (using lithium, cobalt, nickel, graphite), or wind turbines (involving rare-earth elements (REE) for magnets) and solar panels (indium) for low carbon energy production[3].

What does RS involve in the context of design engineering and product development? Answering this question requires a closer look at the development process for a new product (see Figure 2). The development is initiated by multiple and diverse drivers that relate to a firm's internal as well as external stakeholders (like customers, investors, legislators). For instance, the development of electric cars in Europe is driven by the European Union decision to achieve a Green Transition in the mobility sector.

This policy is supported by national governments through providing tax incentives for

1 See: State-of-play: The International Responsible Sourcing Agenda (2020) for more details
2 See: State-of-play & Roadmap Concepts: The Renewable Energy Sector (2021) for more details
3 For more details, see the Sectors webpage from the RE-SOURCING Project.

the purchase of electric cars. This in turn provides opportunities for car manufacturers to launch new electric car models improving their profitability, product mix and branding. Development of new battery technology for electrical cars is driven by the need to become more efficient; performance in these emerging mobile solutions; adding large capacity batteries and powerful electrical engines is driven by end consumer and/or sales and marketing requests for cars with long driving range and high performance.

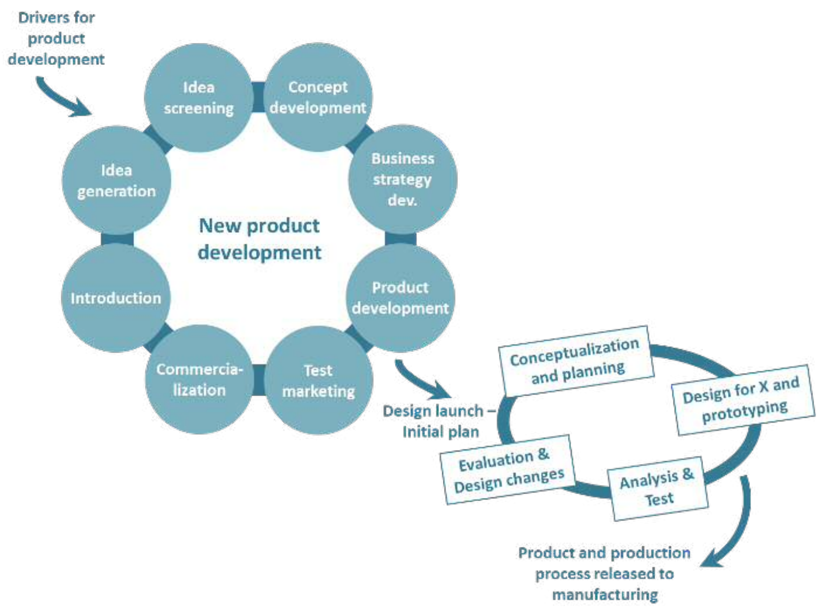


Figure 2: Product development process

The new product development process starts with idea generation, concept and strategy development before moving to the design and engineering stage. Concurrent engineering is the methodology that considers the different design aspects along the product's life cycle concurrently. Development is conducted in an iterative way, commonly in a PDCA ("Plan-Do-Check-Act") cycle. Within this cycle, several DfX techniques are simultaneously applied to consider the different aspects of the product, thus providing a set of multiple criteria and targets to the design process. The integration of the techniques in one holistic design approach leads to a complex decision-making situtation that requires trade-offs between conflicting criteria while meeting the particular product design specifications.

Trade-offs between different design criteria

While several guidelines or design rules aim at excluding non-feasible solutions or reducing the overall costs in manufacturing, other DfX techniques address less commercial aspects as well. In the Design for Environment (DfE) approach, the aim is to reduce the human health and overall environmental impact of a product over its life cycle. Besides design for reuse or recycling, the production processes (including raw material extraction and processing) and materials are analyzed.

Such an eco-design can be rule-based (for example use materials that can be easily recycled; use natural materials; use renewable energy sources; use processes that do not produce toxic materials) but also be based on quantitative criteria (for example results from a life-cycle assessment) for the identification of the most environmentally friendly alternative. Considering environmental, economic, and quality criteria usually leads to trade-offs between these dimensions as well as within each dimension, for example material selection may require a trade-off between cost, quality (performance, durability, etc.) and environmental impact (toxicity, recyclability, resource-efficiency, use of recycled material, etc.).

In a Design for Sustainability approach, the social impacts of product and production (health and safety, non-discrimination, job creation, etc.) are included as an additional dimension. In a framework for the simultaneous consideration of multiple and often competing criteria, the criteria first need to be identified, classified according to priorities (shall have and should have criteria), quantified (physical parameters, identification of indicators) and explored (e.g. by a Pareto analysis) in order to investigate trade-offs and derive preferences for decision-making.

Trade-offs between different parts of the value chain

When looking at design engineering, several of the above-mentioned trade-offs can relate to different phases of the product's life-cycle (i.e. design-manufacturing-assembly-usage-service-disassembly-recycling) but also to different parts of the whole value chain including their actors (comprising primary raw material extraction – mineral and metallurgical processing – manufacturing of components, parts and products – recycling of end-of-life products for secondary raw materials)[4].

While the manufacturer aims at the best product in terms of design, function, performance and cost, the recyclability of a product benefits from the correct selection of materials, reduced variety of materials, avoidance of compounds, modular design, easy assembling and disassembling, etc. For instance, recycling of mobile phones is hampered by the high number of different materials and designs that are more detrimental to mechanized disassemblage and recycling.

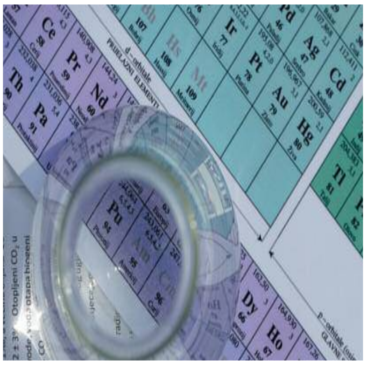
Similarly, a trade-off can be necessary within the value chain, for example between the manufacturing of the product and the extraction and processing of the required raw materials. If the aim of the manufacturer is to produce the best quality product as well as to require compliance with high environmental standards for the extraction of the required raw material, the upstream part of the value chain may have contrary effects on the downstream parts. For instance, for an improved product design the required raw materials can only be sourced from a world region where there is low compliance with environmental standards or extraction is carried out under poor working conditions.

In other cases, while extraction may be technically possible it generates a large environmental impact as well as conflicts with other human needs (such as as drinking water or agriculture) etc. In contrast to the manufacturer, a mining company is more limited in the operating parameters it faces. Exploration, permitting and commissioning of a mine take a long time (10 to 15 years) and requires large capital investments over the long-term.

4 For a discussion on RS requirements across the value chain see Road for Responsible Sourcing of Raw Materials until 2050 (2021).

While refineries or smelter have more flexibility in replacing raw material sources or move operations, a mine cannot be moved or changed. Therefore, in designing a product, the trade-off between the upstream and downstream parts of the value chain needs to be considered.

3. Design Considerations for Responsible Sourcing



What solutions can be considered to include RS in product development? Substitution of certain raw materials is an option, aiming to avoid specific commodities with potentially problematic RS issues, while accepting that the substitute may not provide the best or most advanced product. Replacement of certain sources in the supply chain would be another approach. While changing sources may not result in the lowest procurement costs to the manufacturer, it can ensure the most sustainably extracted and processed raw materials are used in the product.

Finally, re-use and recycling of materials could partly replace primary raw materials in a responsible way – as long as the secondary materials' origin can be traced. In all these cases, a comprehensive framework Design for Responsible Sourcing (DfRS) needs to be developed, that establishes RS practices in the product development process and is treated coequally with other DfX techniques (see Figure 3).

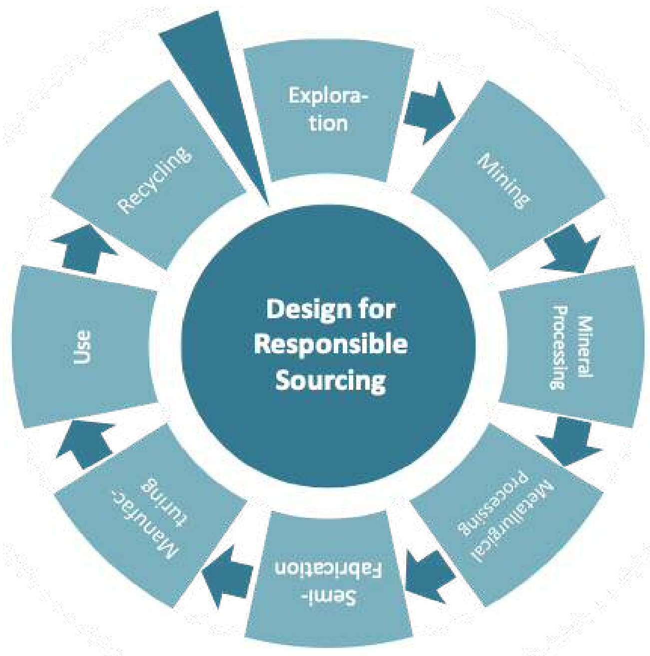


Figure 3: Design for X - Examples of DfX Types

Challenges for defining and implementing such a design framework include:

- The framework has to consider all parts of the value chain including primary and secondary raw materials. For each part, RS goals and relevant sustainability indicators need to be identified and quantified.

- For the selection of responsibly extracted primary raw materials, transparency is required. Potential suppliers need to disclose their sources and production methods and have their due diligence systems and processes certified.

- To identify responsible secondary raw material sources, traceability of recycled material is required. Smelters need to provide proof of origin of not only the primary material but also the processed secondary material.

- Internal organization and processes have to be aligned with RS principles. For instance, procurement professionals should already be involved during the design phase of a new product. Developing the future supply chain for a certain product, based on RS standards, can then be used as a boundary condition for the engineering design.

- The right metrics for RS need to be identified, e.g. by aligning RS goals and internal procurement metrics. Environmental impact assessments during procurement can lead to an increased use of recycled material or reused components.

In the end, the Design for Responsible Sourcing framework needs to be integrated into the overall decision-making during the product development stage. This involves the trade-off between multiple criteria and of course the economic valuation of the design. Sustainable supply alternatives are usually more expensive. Due diligence monitoring adds extra costs. However, increasing awareness of the importance of sustainable raw material supply by customers, shareholders and investors is starting to shift preferences of manufacturers towards the added value from responsible sourcing.

Photo credits:

- P.1 Photo by ThisisEngineering RAEng on Unsplash
- P.2 Photo by Ameie Mourichon on Unsplash
- P.3 Photo by PixaBay on Pexels
- P.5 Photo by Vedrana Filipovic on Unsplash
- P.7 Photo by ThisIsEngineering on Pexels

Key take-aways

- Engineers play an important role in the definition of supply chains for a product.
- The engineering of a new product involves several design frameworks combined in a multi-criteria approach.
- Technical and non-technical aspects of the design involve trade-offs between multiple and often competing criteria.
- A product design framework that includes responsible sourcing and procurement of raw materials, products and services is still to be developed.

Subscribe to the RE-SOURCING Stakeholder Network

Subscribe

Visit the RE-SOURCING website

https://re-sourcing.eu/