Fair Soldering Tin: Recycling, Supply Chain Interventions, or Material Alternatives?

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This article explores sustainability issues concerning tin, one of the crucial soldering materials in the global IT industry. In addition to the potential negative social and environmental impacts of tin production, this article assesses initiatives that have emerged as a response to growing pressures on mining companies and producers to address these issues. In the following analysis, issues pertaining to demand and supply are illustrated using two country examples: Indonesia as the largest global producer of tin and Germany as the fourth largest tin consumer. Furthermore, an initiative active in the field of soldering tin in Germany (www.fairloetet.de) is portrayed and its experiences in developing a marketable product of fair and recycled soldering tin are analysed.

1 Introduction

Demand for natural resources is on the rise globally. Between 1970 and 2010, global material use has tripled, with annual extraction rates growing from 22 billion tonnes to 70 billion tonnes [1]. This has fuelled exploitation and production of raw materials in remote, ecologically sensitive and politically unstable regions, where environmental and social standards are either lacking or poorly implemented. Indeed, this is problematic, as the environmental and social impacts caused by the exploration, extraction, smelting, and transport of minerals are considerable.

The direct impacts of mining include land, water, and energy use, and the release of emissions that often cause environmental degradation and negatively impact upon the health of workers and local populations. The failure to dispose of mining residues in a sufficiently safe manner and to redevelop mining sites are additional issues that often have particularly far-ranging environmental impacts. Even decades after the closure of a mine, residues and hazardous waste materials from mining can negatively impact humans and the neighbouring environment alike.

Alongside the direct impacts of mining, secondary effects also adversely impact people and the environment. For example, in remote areas, new mining sites often incur large influxes of workers and lead to the new construction or extension of settlements and infrastructure.

The informal, artisanal and small-scale mining sector often induces particularly large social and environmental consequences. There is generally little or no thought given to responsible mining and mine site closure. Environmental standards and regulations are often overlooked and mining and processing practices are poor, leading to severe environmental impacts and serious health and safety consequences for workers and local communities [2].

In emerging and developing countries, where governance problems serve as an additional contributor to the myriad of challenges associated with resource extraction and production, mining constitutes a double-edged sword: whilst negative impacts are often high, the extractives sector also plays an important role in economic development. The employment it generates can help to alleviate poverty, and mining companies are attractive taxpayers and pose lucrative investment opportunities, as operations hold the promise of quick returns on investment. In particular, small-scale and artisanal mining can provide work and an important source of income for large population groups in mining regions. However, in order to have positive effects, operations have to be guided by a strong commitment to international performance standards and overseen by a robust regulatory environment. Lack of compliance to performance standards and environmental regulations, and uncontrolled operations, can easily deplete a country's natural resources to the advantage of a mere few – and, as many examples illustrate, at the expense of a nation's long-term development.

Tin is an important raw material for the IT industry. In combination with lead it has long been one of the industry's most important solders. Its relatively low melting temperature, electrical conductivity, and other favourable characteristics make it an ideal material to permanently link components like capacitors or resistors with other workpieces, for example on printed circuit boards (PCBs). Furthermore, tin is used in the plating and coating process of PCBs as a resist for removing the residual underlying copper. Nearly half of mined tin is used in soldering alloys for the IT industry [3].

Environmental and social impacts of tin mining differ depending on the mineral deposit and the specific mining methods: 56% of tin is found in hard rock deposits, which are most commonly industrially mined; 44% is found as alluvial deposits, which can be mined manually and with minimal or no mechanization. Therefore, artisanal and small-scale mining (ASM) makes up 38% of all tin-mining activities, making it a

source of income for many people in developing countries [4,5].

2 Country example Indonesia: Supply-side Issues in the Tin Sector

In 2012, global tin production from mining reached 281,862 tonnes, the majority of which was extracted in developing countries and emerging economies [6]. Indonesia is the main producer of tin by absolute volume and plays a central role in the production of tin bars and soldering tin [4]. Most of its tin production (65%) takes place in small-scale and artisanal mining sites [7,8]. This is problematic as controls and preventive measures to mitigate negative environmental and social impacts throughout the mining process are generally lacking. Notably, 90% of Indonesia's tin is produced on the islands of Bangka and Belitung that, together, account for the majority of the country's reserves [9]. Generating 21.3% of the region's GDP in 2006, tin mining is the primary income source for the province [10].

The tin-mining industry's governance and structures on the two islands are complex (see Rüttinger et al. 2014). It is difficult to separate illegal and informal activity from legally operating and registered mining sites. Small-scale mining produces around two thirds of primary tin, while the rest is produced by PT Timah, a large state-owned company that plays an important role in the tin-mining sector of the islands [6]. The number of mining sites is estimated at a total of 10,000 on Bangka alone and the number of workers at approximately 50,000 to 100,000 [10, 11].

Due to lacking controls and weakly enforced regulations, tin-mining has had devastating impacts on the islands' natural environment. Deforestation, high land use, and polluted soils and waterways have caused particular damage to ecosystems. Measures to recultivate and restore closed mining sites and to remove contaminants and hazardous waste after the closure of the mining sites are largely absent. In addition, there are notorious conflicts of interest, as well as cases of land use right violations, which are fuelling conflicts between small-scale miners and local and indigenous communities [12]. Furthermore, the health and lives of miners are often threatened, due to the lack of, or poor, health and safety standards. Many of the abandoned mining pits fill with water and are ideal breeding grounds for mosquitos, creating health problems, especially malaria, for miners and the local population. Furthermore, offshore tin-mining, which is of growing importance, has led to negative impacts on the flora and fauna of the ocean, in particular on coral reefs.

3 Emerging Interventions and Initiatives

The social and environmental impacts of mining have attracted increasing attention from the public, policy makers, and the private sector. As a response, due diligence in supply chains and responsible sourcing have emerged as central sustainability topics. In particular the introduction of the Dodd-Frank Act in the US, interventions in Europe to establish similar legislation, and the OECD's development of a due diligence guidance for supply chains of minerals from conflict-affected and high risk areas have created significant momentum in the sector. Collectively, these efforts aim at enforcing due diligence along mineral supply chains in conflict-affected and high risk countries and regions, predominantly to prevent the financing of non-state armed groups through mining and trade of so-called conflict minerals.

These developments have given rise to multiple initiatives that support companies in fulfilling due diligence requirements and responsible sourcing in their supply chain, e.g. through certification schemes. The Tin Supply Chain Initiative (iTSCi), which is led by the International Tin Research Institute (ITRI), is among the tin sector's most prominent programmes. Focusing on upstream supply chains (from mine to smelter) in conflict-affected and high-risk areas, it establishes the traceability of minerals to prevent conflict financing. Minerals are bagged and tagged with a barcode that allows for the identification of the packaged products when reaching intermediaries and smelters. iTSCi assists companies in complying with the provisions of the Dodd-Frank Act. Its 250 members from 35 countries undergo constant monitoring and are subject to independent audits at around 1000 mining sites across Burundi, Rwanda, and the DRC, where approximately 80,000 miners work [13]. (ITRI 2016).

While these developments are positive and have increased the pressure on companies to address environmental and social challenges, it is important to note that this is just the beginning of a longer process - major obstacles and challenges remain:

First, standards schemes and initiatives such as iTSCi often try to fill the gap of missing or weak governance in many producing countries or try to implement higher standards than legally required. In doing so they face many challenges, in particular when it comes to implementation. For example, to certify a mining site or individual products, regular audits are essential. Their success – namely, to guarantee certain standards are fulfilled as intended – requires high levels of transparency throughout the process and experi-

enced auditors with expertise and experience with local conditions. Often, auditors are external, as the local population lacks necessary skills or companies prefer auditors they already have experience with. This makes audits, and the effective control of standards, expensive and challenging to implement.

Second, the globalized nature of the mining industry and raw material trade means that higher standards can lead to the relocation of production. Companies might try to circumvent higher standards by moving to lesser-regulated environments. However, higher standards can also lead to the relocation from lesser to more developed countries. In the past, such effects could be observed in the forestry sector with the widespread implementation of certification schemes. This is a particular challenge for small-scale and artisanal mining that often provides income and livelihoods to relatively large numbers of people in developing countries (compared, for example, to large-scale mining). One solution is to accompany higher standards with measures to support implementation of those standards in developing countries.

Third, many standards initiatives that focus on due diligence and responsible sourcing primarily address the prevention of conflict financing and do not include other social or environmental risks. It is important to widen the narrow focus beyond conflict minerals, above all to include other minerals, environmental risks, and conflict risks of mining activities beyond financing of non-state armed groups. The due diligence approach is flexible and open enough to allow including such additional risks. In general, broad standard initiatives like e.g. the Initiative on Responsible Mining Assurance (IRMA) or Towards Sustainable Mining (TSM), that are geared towards sustainability as a whole should be further encouraged and supported. These standard initiatives comprehensively tackle the challenges and risks posed by the extraction and production of raw materials.

In addition to these approaches and initiatives, there is a potential for direct industry partnerships between producers and processing companies that has hardly been explored. This sort of cooperation can make use of short and closed supply chains to lower costs and increase transparency, and direct contact between actors can open up new opportunities and create more sustainable resource markets. This creates a win-win-situation for producers and consumers: Improved environmental and social conditions and more sustainable economic development on the production side, and enhanced product responsibility, an improved public image, and ensured access to fair resources on the side of industrial users. Such an integrated approach promises, first and foremost, huge potential for small and medium-sized enterprises, since it increases their otherwise minimal ability to influence the supply chain. It makes possible a direct and uncomplicated transfer of know-how. Furthermore, it offers the opportunity to close gaps in financing through mutual financial support.

Another option to improve the sustainability of the sector is increasing the recycling rate of tin. ITRI estimates the global tin recycling rate to measure around 8%. As tin is also used in alloys, the reuse rate for tin could be higher when considering the reuse rates of brass and bronze (ca. 20%) and solder alloys (ca. 30-40%). For 2010, secondary tin production reached more than 60,000 tonnes, with China providing a major share of recycled tin [14].

4 Case Example Germany – Demand-side Issues in the Tin Sector

Germany has gained international recognition for its early introduction of environmental policies and regulatory regimes. As a frontrunner in green technologies and sustainable management approaches, this has built an important knowledge base. Given its ranking as the fourth largest consumer of tin globally, Germany has the ability to considerably influence the trajectory of tin mining and production practices.

In fact, there is mounting pressure on German metal-processing companies, as the impacts of their operations are increasingly placed under the spotlight. Indeed, large companies have begun to demand that their suppliers ensure sustainability is increased along their supply chains. However, as illustrated above, putting these required measures into practice is often challenging. To overcome these challenges, there needs to be an analysis of resource flows, including a focus on the facilitators and barriers to sustainable supply chains. Furthermore, systemic interventions along the value chains of companies, e.g., resource efficiency, can build the necessary momentum for improving sustainability in the sector. Possibilities for a more sustainable resource sector exist all along a sustainable and integrated supply chain: both innovations for increasing resource productivity and efficiency, and substitutes for resources that cannot be responsibly extracted play a crucial role. For example, 3D-printed electronics and gluing technologies can reduce demand for metals, including soldering tin, especially in the IT sector. However, whilst basic research exists, research in close cooperation with enterprises on alternative materials and resource efficiency for metal-processing companies is often lacking.

Recycling exists as an additional option to improve the social and environmental sustainability of tin

products, as it can help to negate the negative social and environmental impacts, especially if stringent environmental and labour regulations are implemented. In general, the recycling of tin requires less energy than primary sourcing. Furthermore, it does not require the movement of rock, sediments and soil or other ecosystem-relevant interventions, and minimises potential water and soil pollution. Studies show that energy requirement for primary tin production of 100,000 tonnes is 1820 terajoule (TJ), whereas the energy requirement of the secondary production of the same amount of tin is 20 TJ. The carbon footprint of primary production is 218 kilotonnes of CO2, whereas secondary production is 2.4 kilotonnes of CO2 [15].

In 2003, Germany had a tin recycling rate of 9-10% [16]. In the US, around 22% of tin consumed is recycled [17]. The discrepancy between the US and Germany is due to the differing amount of tin consumption from soldering - this is higher in Germany than in the US. The sources of recycling include production waste containing tin, as well as the recovery of tin from end-of-life products [17].

Yet, tin recycling in Germany is costly and the quality of recycled tin is often-debated. Whilst initiatives like Fairlötet argue that recycled tin does not come with decreased quality, companies using solder are not easily convinced. It is therefore necessary to use material testing to clearly establish the case for recycled tin having the same properties as primary tin.

As highlighted above, soldering tin is an everyday part of all electrical and electronic products and is, therefore, found in great quantities in these products [18]. However, the recovery rate of tin from electrical and electronic products is still low. Considering that this segment accounts for the largest share of tin use, there is still significant potential for improvement. This means that such products can currently be considered a sink of tin. Yet even if the potential for tin recycling from electrical and electronic wastes is fully realized, this amount is not expected to be enough to cover industrial demand for tin [17]. Other important sources for the recovery of tin are tinplate cans, bearing metals and products made of bronze. Tinplate is a sheet of steel or iron that is thinly coated with tin. Through the process of tin-plating, ferrous and non-ferrous surfaces can be protected, e.g. from rust. Given that tin is a non-toxic and corrosion-resistant material, tin plates are particularly useful in the food processing industry. Today, tin plates are used for instance for the production of (beverage) cans. Further research is required regarding the potential of tin recycling from tinplate. If the effective recycling of tin from this material stream is not economically feasible, current consumption rates of tinplate should be reconsidered [18].

Tin is also found in landfills. It is estimated that in Germany, 50% of tin in copper alloys and 9% of tin in tinplate goes to landfills. This is a significant amount that is lost for secondary tin production and taken out of the tin recovery cycle. Furthermore, before the introduction of the law on electrical and electronic products in 2003, more than 40% of such products were landfilled and have remained there. However, estimates on quantities of tin in landfills do not exist [18].

In Germany, the initiative “FairLötet” has promoted recycling and the use of recycled tin. FairLötet is a non-profit organization mainly involved in education and development cooperation, where it focuses on social issues in the globalized production of electronics. Together with the company Stannol, a German producer of solder wire, it has recently launched the fairly produced, tin-based solder wire HS10. This product is designed to be an alternative to the primary material tin. A share of the profit earned from sales is used, among other things, to raise more awareness on working conditions in the supply chain of IT products, and to finance the initiative.

Drawing more attention to the topic of “fair electronics” through a concrete product was the starting point for Fairlötet. The idea of HS10 followed the discovery that solder wire was the only single component in the supply chain for the “fair computer mouse” produced by Nager IT (a German Startup) for which no socially and environmentally responsible alternative existed. To assess the market potential for its idea, FairLötet conducted a survey that revealed that the vast majority of the approximately 300 hobbyists interviewed would be willing to buy the fair solder tin and pay up to 20-25 % more than for conventional options. The collaboration with Stannol followed FairLötet publishing an article illustrating its idea. FairLötet contributes to the solder wire with its expertise on working conditions; Stannol mostly provides know-how and resources for manufacturing the solder wire. The requirements of material sourcing (e.g., environmental standards) and producing the wire, which make HS10 fairer than competitors’ products, are summarized in a white paper written by FairLötet.

5 Conclusion

This article serves to illustrate the complexity and numerous challenges associated with the production and consumption of raw materials, using the example of tin in electronics and electrical products. As shown, there have been many developments in both the primary and secondary production of raw materials. A full transition to secondary production will not be achieved in the foreseeable future and, ultimately, would induce considerable negative social and eco-

nomic impacts on countries and population groups that are dependent on the primary production of raw materials. It is therefore important to increase both the sustainability of primary production and promote secondary production at the same time. Improving the sustainability of material production and consumption necessitates an integrated approach, analysing and improving both the supply chain and the life cycle of raw material-based products as a whole.

6 Literature

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