TRACEMET

TraceMet Report:

Outlook

TraceMet – Traceability for sustainable metals and minerals
Project time: December 2019 to January 2021

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• Svemin, the industry organization for mines, mineral and metal producers in Sweden, is TraceMet's project owner and initiator.

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Report on WP2 TraceMet

Report on Outlook TraceMet
Work Package 2

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Abbreviation	Full
CAPEX	Capital Expenditure
CoC	Chain of Custody
DD	Due Diligence
E.g.	For example
EnvDD	Environmental Due Diligence
HRA	Human Rights Abuses
HuRiDD	Human Rights Due Diligence
MB	Mass Balance
OPEX	Operational Expenditure
SMI	Swedish Mining Innovation
WEF	World Economic Forum

Preface

This document was compiled throughout 2020 within the TraceMet project. It contains the Market Outlook to TraceMet as the final deliverable for work package 2 (WP2). The TraceMet project was initiated and owned by Svemin, the Swedish Industry Association of Mines, Mineral and Metal Producers, and was funded by the strategic innovation program Swedish Mining Innovation (SMI). SMI is a joint investment of Vinnova, Formas and the Swedish Energy Agency.

Assignment WP2

This report summarizes the results from WP2 – Market Outlook. It builds on the outlook that was conducted in 2019 by RISE during the pre-study/feasibility study for the TraceMet project. This report adds new developments in Chain of Custody (CoC) and blockchain. It identifies, assesses and evaluates currently best available and to some extent future (pipeline) technologies and solutions against applicability to mass-balance in metal value chains to provide recommendations to the TraceMet partners when developing the blockchain (functionalities) as one part of the mass balance CoC-system.

From the RISE pre-study report

The overarching aim of the pre-study report was to make sustainability a competitive advantage for actors in metal and mineral value chains. The project was more specifically limited to evaluate whether a solution built on blockchain combined with a novel approach to CoC may offer buyers of metals and minerals an option to choose a certain "sustainability level". Further, the pre-study was limited to the value chain of copper, i.e. the questions raised were *(i)* which CoC model is suitable for the copper value chain and *(ii)* is blockchain a good solution to create traceability in this case?

Based on the state-of-the art and the market analysis carried out as part of this study the CoC model "mass balance" (MB) was recommended to use for the copper value chain. The **main reason** is that the production logic for copper is to mix input materials, like copper scrap and copper concentrate, from different origins.

The pre-study concluded that a blockchain solution would give the suggested labelling system a robust, secure and trustworthy infrastructure. A third-party audit would always be necessary to verify the input claims entering the blockchain.

Besides desktop research during the market analysis, a so-called townhall meeting was organised upon strong wish of the TraceMet steering committee to *i)* catch the «market voice» on latest developments within the TraceMet project, and *ii)* «test the water» for a possible continuation of TraceMet. The townhall meeting and its result are not within scope of this report.

Report on market situation

To be successful in the marketplace, various supply chain actors collect, analyse, and willingly (or not) share and report substantial amounts of complex data to various stakeholders. The faster it's received and the more accurate and credible the data are, the better. As such, sound data management practices are a key enabler for effective oversight across all stages of the prod-

uct's lifecycle stages in the supply chain. Well-managed data helps the supply chain actors to e.g. follow legal and market regulations, prioritize preferred mining initiatives/partners e.g. with sustainability criteria and maximize transparency.

When taking the bird's eye perspective, we can identify two relevant traceability tracks in supply chain (data) management trying to meet different expectations. At this point, we note that identified voluntary market activities seem to have a tension to respond to market expectations (e.g. increase sales through transparency and credibility on premium product claims), whereas policy makers increasingly interfere in the marketplace by enforcing legal compliance on human rights and environmental law via due diligence requirements. The role of the state as both a policy maker and enforcer/protector is indirectly considered when discussing legal compliance in this report but providing recommendations on its ability to define and shape markets with e.g. regulatory and fiscal frameworks (e.g. carbon boarder taxes) is kept out of scope. In addition, when the report mentions eligible and non-eligible materials, eligible is understood as meeting compliance requirements; here for carbon footprint, and not conflict/HRA.

Desktop research confirms that global interest in traceability in the mineral and material value chains is steadily growing. Besides many new voluntary initiatives that recently started and were not considered in the pre-study – incl. WEF Battery Alliance's interest in CoC and blockchain[i] for copper, steel and cobalt - it was also noted that e.g. the Nordic Council of Ministers are discussing an initiative on traceability/CoC and the European Union Horizon 2020 research fund finances a project "Responsible sourcing" with the aim to implement best practices on sustainability use of materials in the supply chain.

Drivers for increased traceability

Downstream expectations (brand owners, and the end-user) for traceability are the main drivers to achieve greater transparency in the minerals and metals supply chains. Human rights abuse cases are predominating the calls for more transparency and remedial action, but industry is also gaining an interest in the carbon issue. These expectations are mainly driven by:

- Legal compliance. Buyers of minerals and metals are subject to a number of laws in various countries that require them to conduct increased due diligence around the provenance of the raw materials they source. Legislation includes CO2 regulations, the Dodd Frank Act Section 1502 in the United States (for 3TG), the EU Conflict Minerals Legislation (for importers of 3TG), the French corporate vigilance law, and the Modern Slavery Act in the United Kingdom. For the copper and steel supply chains in the EU the EU green deal outlining of a plan to raise carbon dioxide emission prices is a threat and an opportunity.[ii]
- Public scrutiny in international news media, NGOs and CSOs are raising the public's awareness of responsible sourcing issues in metals and minerals.
- Investor expectations increases pressure from financial institutions on ESG-issues (Environment, Social and Governance) and good practice risk management of companies.

All three drivers are increasing the public pressure on companies to identify and manage risks especially regarding human rights in their supply chains, and to exercise appropriate leverage to remediate them. To manage these supply chain risks, companies are currently focusing primarily on acquiring the following information with regards to the minerals and metals they source:

- Provenance: I.e. in which mines and by whom are the minerals and metals produced that are contained in end products?
- Production methods: I.e. with which methods and under what circumstances are these minerals and metals produced? Are they produced responsibly?

Corporations attempts to achieve greater traceability through application of a CoC system appears here to be the logical consequence to meet these downstream demands.

In addition, in Europe, global supply chain **security** gained more attention and traction because of the COVID-crisis that revealed unfavourable dependencies due to:

- "hidden" single sourcing cases due to supply chain non-transparency. Multiple broken supply chains made down-stream corporations quickly and painfully realise that despite of having contracted several intermediaries (multiple sourcing strategy) for critical product supply, that these intermediates eventually sourced from the same identical mine, smelter a.s.o.
- Complex, anonymous supply chains that are easily disrupted because of crises and can easily externalise environmental and social cost because of considerably differing environmental and social standards in various countries of sourcing.
- Nations with reserves/deposits use these as political instruments to manipulate the trading prices on the commodity markets. As a counter reaction, countries without reserves invest in recycling infrastructure and stockpiling to limit dependencies.
- New foreign (direct) investments in new mines in USA, Australia, Africa and Europe.

The attention to these issues is supposed to increase even more due to the extreme climate events. It is hence an increased pressure on actions that can reduce these risks which include the development om new IT-solutions such as cloud computing and blockchains.

Market analysis on due diligence and voluntary initiatives

An external analysis of predominately due diligence initiatives that relate to responsible sourcing was conducted. The information was summarized in an excel file under 4 main headings: *i) Identification, ii) Challenges addressed, iii) Power balance* and *iv) Details standard and Model Support* and complemented with subheadings such as the *addressed metal of the initiative,* what *reference* and the *title of the initiative*. Furthermore, information of the characterization as *management system* or *data/Identification* and the *tool used (business strategy, due diligence (guideline), or audits)* was integrated and lastly, if the outcome is a *certificate (org. or product)* or a *standardized report*.

Example excel sheet
Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas under OECD concerns multi metals, is a due diligence standard that is used as a tool whereas a certificate (org) is the outcome.

Challenges addressed were examined by investigating the standards' focus areas and objectives. The focus areas were divided into financial/risk/ESG, environment, social or sustainability. The power balance was studied by examining if the initiatives scope of application is upstream, downstream, mid-stream or consists of a value chain. Furthermore, the initiatives application area is considered (Mining - artisanal, small or industrial, large -, processing, manufacturing or second life). Finally, an initiative can be governed via either multi-stakeholder engagement, industry associations, legal compliance (policy makers) or NGO/CSOs working in a

regional, national, continental or global dispersion. Where appropriate, the scope can be further narrowed down to a specific nation. Please note that *legal compliance* is arguing from a mandatory, legal perspective, whereas NGO and industry driven initiatives should be classified as voluntary market regulation.

Details of the standard and the model support was investigated by identifying if there is a CoC and what model is used (identity preservation, segregation, mass-balance, certificate trading or all of them). The performance level as well as the assurance level (first party/self-declared, second party/label, third party/independent) and the key focus area was investigated. Second-party/label is derived from the general practice in e.g. type I ecolabels (ISO14024) where a label/standard owner conducts the verification against the standard. In third party verification the verification task is conducted by a party that is independent from the organization under verification *and* the standard owner.

Identified key initiatives

A mapping of current initiatives and activities that can become of relevance for actors in the ferrous and non-ferrous metals market (a.k.a. can be of importance to TraceMet and its partners) was conducted. During the analysis we also briefly checked the broader scope - i.e. CoC – to check for "possible" surprises in e.g. OECD and other "fundamental" pieces of work. During this assessment, we were able to identify four initiatives that are of particular interest to the ferrous and non-ferrous metal sector (and TraceMet).

Responsible Sourcing Blockchain Network by RCS Global Group and IBM

Responsible Sourcing Blockchain Network is an initiative aligned with OECD and RMI with participation from LG Chem, Volkswagen AG, Ford Motor Company, Fiat Chrysler Automobiles, Volvo Cars, a.o. Representatives from industries are members in the governance board of the initiative. The initiative centers on human rights and environmental protection in mineral SCs. It is a mine-to end manufacturer distributed ledger platform and the scope of application is small scale and artisanal mining and metals relevant to batteries as Co, Ni and 3TGs. Audits are implemented and certificates certifies that the product complies with a responsible production[iii]. It is based upon and contributing to Hyperledger Fabric, which is a competitor to TraceMet's blockchain technology Ethereum[iv]. To improve trust amongst users the initiative includes IoT technology and crypto anchors.

WEF Blockchain Consortium

In December 2020[v],[vi] the WEF's Mining and Metals Blockchain Initiative (MMBI) informed that it signed a contract with the Dutch Blockchain provider Kryha using Parity Substrate blockchain technology to trace carbon emissions in the copper supply chain and track GHG emissions mine-to-smelter, and finally to the original equipment manufacturers. The Carbon Tracing Platform «COT platform» is supposed to have created a blueprint to track all essential metals from mine to market and back via recycling. With a focus on end-to-end traceability, the COT platform uses distributed ledger technology to track CO2 emissions.

Besides this newly launched «COT platform», the WEF provides a modular toolkit[vii]. Supported and backed by multiple corporate user cases. The toolkit consists of 14 modules in which all relevant distributed ledger technologies feel represented. It covers modules dealing with operational integrity, regulatory compliance, interoperability, security, scalability, and formal governance and industry collaboration, information sharing, a.s.o. and aims to enable cooperation

among actors globally. It is a toolkit based on business strategies developed to help organisations implement the blockchain system and an "end-to-end supply chain integration"[viii]. More than 100 enterprises are participating in the consortium globally.[ix] The WEF argues that especially medium sized or small businesses benefit from participating in and using the toolkit since implementation of blockchain systems can be expensive[x].

Aluminium Stewardship Initiative (ASI) standard

For aluminium there is the Aluminium Stewardship Initiative (ASI), including a performance standard and a CoC standard according to which a third-party certification is conducted. The goal is to ensure that sustainability and human rights principles are met in the production, use, and recycling of aluminium. ASI is a member of the International Social and Environmental Accreditation and Labelling (ISEAL) Alliance. The ISEAL Alliance is an association for sustainability standards, assessing them according to Code of Good Practice and supporting the development of credible standards that address the most pressing social and environmental issues the world faces today.

The standard aims to promote responsibility in all stages of production chain of Aluminum, with focus on environment, social and governance sustainability. The certification level is third party certifications where certified auditors assure the implementation of the standard. There are two standards under the initiative, the ASI Performance Standard and the ASI Chain of Custody Standard which is voluntary for members. Members must have at least one facility registered against the standard[xi]. An update is in progress according plan (2020-2022), i.e. the review process is ongoing, and we can expect an update of the standard. The ASI Chain of Custody Standard sets out the framework for implementing a CoC for Aluminum in downstream sectors. It is one of very few using Mass Balance and/or Market Credits CoC systems in metals[xii]. In January 2021 the initiative had 150+ members[xiii] and 100+ certifications. Most certifications are against the ASI Performance Standard but roughly a 1/4 is against the ASI Chain of Custody Standard[xiv].

RCA Copper Mark

RCA Copper Mark is a social and environmental assurance process for copper production and fabrication[xv]. Copper Mark has a board of directors and a council with multi-stakeholders. The International Copper Association (ICA) provide funding as well as fees paid by members[xvi]. RCS Global Group is one of many RCA Copper Mark assessor[xvii]. The SDGs, and especially nr 12, is the inspiration behind the work toward a responsible production of copper within aspects of environmental, social and governance. The Responsible Minerals Initiative has developed the Risk Readiness Assessment (RRA) which complies criteria that must be fulfilled in order to get the Copper mark and fulfill the SDG nr 12[xviii]

Together with the International Lead Association (ILA), the International Zinc Association (IZA) and the Nickel Institute signed an agreement to develop a joint Due Diligence Standard for the London Metal Exchange (LMA) who makes OECD DD compulsory from 2023. The standard cover copper, nickel, lead and zinc. The work is divided into four phases finishing in early 2022[xix]. Further Copper mark is planning on a CoC standard[xx]. Based on earlier research that was conducted by Tillväxtanalys in 2019and within TraceMet when e.g. cross-checking the Copper Mark's "Criteria Guide for the Risk Readiness Assessment" (Copper Mark, 2020) for IRMA adoption and alignment, we feel safe to say that the Copper Mark is more or less ICCM and IRMA compliant.

ResponsibleSteel Initiative

ResponsibleSteel is an international certification scheme covering the entire supply chain of steel. Apart from mining, every stage is covered by their own guidelines and for the extraction sector they cooperate with existing standards such as IRMA and TSM. The reason for the development of this standard was the widespread use of steel. It is the most widely used material in the world and is essential for many industries, including the energy sector. Steel production has a major impact on the environment, partly because of its high energy consumption, as well as social and economic impacts. However, through responsible action by all parties involved, these impacts can also be positive. The aim is to reduce GHG emissions, create jobs, promote local development and support the achievement of SDG12 "Responsible Consumption and Production". The standard is based on 12 principles covering environmental, social and governance issues. After September-/October 2021, we can expect the publication of further requirements under the ResponsibleSteel Initiative for:

- responsible sourcing of input materials, and
- greenhouse gas (GHG) emissions[xxi.]

Traceability

In the context of value chains, traceability is the ability to track products through a CoC. More precise, the key function of a traceability system is to collect and maintain data on product characteristics and trace data along value chains. In principle, traceability systems range from supply chain mapping, a validated material/ product reporting, to a traceability scheme/ system. These systems have various levels of digital sophistication and follow different needs. E.g. the German start-up sustainabill uses traceability when digitally mapping whole supply chains and their material flows to conduct plausibility checks on claims.[xxii]

Value chains see both legal and physical ownership of products that are being transferred between miners, smelters, traders, manufacturers, retailers and end-users. The fundamental differences between the today's four practiced CoC models (coming with adaptations) are in the handling or tracking of a physical product and the handling or tracking of associated data. Depending on the applied CoC model, it will specify how a product shall be managed throughout the value chain. E.g. is mixing between certified and non-certified material accepted or not, and if so where and under what conditions can this occur? As that, the CoC system is the "complete set of documents and mechanisms used to verify the traceability between the verified unit of production and the claim about the final product." (ISEAL 2016, p.2). Consider it the detailed application of the CoC model that also should combine a standard with a monitoring mechanism that again can be associated with a reporting system.

The success of sustainability pursuits rests in considerable part in a sector's/value chain's ability to valorise sustainability practices. Transparency is considered to play a critical role in the verification, tracking and rewarding of sustainable practices. It should not surprise that transparency is considered a key element in the competitiveness of sustainable mining and processing activities. The key question is – how to create trust regarding these sustainability claims. The answer to this question is dependent on the trust of the sustainability information and the trust to the traceability system securing that supply chain actors do not manipulate the information. This include the trust of the applied Chain of Custody model. Hence, one relevant question for TraceMet is whether the mass-balance approach is enough trustworthy in relation to claims related to emission of greenhouse gases and recycled content.

Chain of Custody

It is widely argued that the decision on which type of CoC system shall be implemented should predominantly rely upon the organization and structure of the supply chain; i.e. technical, business, governance and process considerations should prevail. For example, can/should smelter facilities allow for segregation and/or can we support mass balance batch, site or group level reporting? Other frequently noted factors are the ability to establish an inclusive, by the market accepted CoC system, as well as cost (initial and maintenance) and ease of implementation. No doubt, these factors are rather relevant for the success or failure of the efforts, but we need to point out that not only the *how*, but also the *why* needs a thorough consideration.

Please consider that the "objective of the CoC System is to validate claims made about the product, process, business or service covered by the sustainability standard. This is achieved by defining a set of requirements and measures that provide the necessary controls on the movement of material or products, and associated sustainability data, from approved or certified businesses through each stage of the supply chain. Many standard systems set a CoC standard for this purpose, in addition to their production or management standard.[xxiii]" (ISEAL 2016).

The CoC choice should depend on the dilemma resp. the claim that is to be solved. When you shall provide proof that your metal is socially and/or environmentally "good enough", you need identity preservation or segregation to make the respective claims. However, if the aim is to create a premium product track and trace system, the mass-balance and book and claim models can also be a feasible option. Please note that most initiatives presented in chapter 1ff. are targeting requirements to meet the "good enough" claim.

Table 1. CoC models with claims

CoC model	Claim
(Identity) Preservation	Full provenance integrity from **one** source to product.
Segregation	All products can be traced to responsibly sourced material from various sources, but of which all are attested responsible.
Mass balance	A percentage of material in the product is responsibly sourced. *Tracing via the volumes of the materials that are measured*
Book and Claim (Certificate trading)	A percentage of purchased material is responsibly sourced. *No tracing bc. buyers buy a 'credit' of responsibly sourced material and claim responsible sourcing on this basis)*

You have strong drivers for "good enough" traceability. One conclusion from Tillväxtanalys (PM 2020:17) is that traceability systems are most developed in situations where you have regulations (legal compliance) forcing brand firms to monitor specific sustainability risk in the supply chain. One example is the 3TG regulation of metals. But there are others, most often related to social risks. As a follow up to the EU Green Deal, the EU commission also introduced a legislative initiative on mandatory human rights and environmental corporate governance due diligence[xxiv] (see also chapter: "Blockchain in Due Diligence"). Public legislation and private initiatives are many times based on the OECD due diligence guidance for responsible supply chains of minerals from conflict-affected and high-risk areas. This means that many chain-of-custody models are based on identity preservation or segregation (Tillväxtanalys, PM 2019:01).

In a mass balance and book and claim model on the other hand, production is certified, and certificates are generated for a quantity of certified material (audited at source). Certificates are then disconnected from the physical product due to the mixing of various sources of origin; in a book and claim model the certificates can be sold via an exchange (market) that lacks any connection between products sold and the sustainability claim. E.g. Vattenfall sells certificates of origin for renewable energy produced in Sweden to a purchaser in the USA (grids disconnected). In consequence, certificate owners in book and claim and mass balance models (*in case MB is not limited to e.g. on-site, single company, cannot purchase/sell more MB certified products as actually purchased/sold)* cannot guarantee that the physical material purchased contains the certified material. Instead, the purchase of certificates rewards certified producers. Certificate trading finds acceptance in markets where track and trace is coming at a (too) high cost and incentivization of markets to move to e.g. a circular economy is the main driver. The risk that these initiatives face greenwashing accusations is real, as the societal unease in e.g. The Netherlands regarding "real" renewable energy[xxv][xxvi] or Nestle's zero carbon claim that is challenged[xxvii] showcase.

Market premium for sustainably produced steel and copper

The claim that follows the selected CoC system is critical when communicating to stakeholders. Esp. the book and claim and mass balance models call for caution, because the physical and fungible properties of the bought/consumed goods only indirectly relate to the sustainability claim. Disconnecting the claim from the physical product is an acceptable choice, but you will need to be hyper-transparent about it when communicating consistently on the things that matter, and with proof. To avoid being challenged with "show me the numbers" as in L'Oréal's case[xxviii]. Whereas consumer facing industries such as the fashion and food can capture a premium on sustainable products, the same cannot yet be observed in the metals industry. Though, forerunners such as e.g. Fairphone[xxix] with claims on the metals used in their mobile phones (Cobalt, REE, a.s.o.) or SSAB, LKAB and Vattenfall's fossil-free «HYBRIT»[xxxxxxi] steel pilot plant in Luleå have strong credibility because of the implemented CoC models. Northvolt[xxxii], Volkswagen[xxxiii] and other car manufacturers' bold sustainability commitments[xxxiv] are also an indicator that the sector will increasingly adopt similar product related claims to utilize the market premium. With corresponding greater market awareness, it is thinkable that a price premium model could one day be adopted based on a sustainability claim.

How successful manufacturers will be in their transitions to sustainable, CO2 free corporations offering zero carbon products (at premium) depends on various factors. A McKinsey study (2020) pointed out that for the steel industry the availability of renewable energy, green hydrogen, raw materials production technologies and supportive regulatory frameworks will be decisive.[xxxv] Regarding the famous carrot and stick principle, its estimated that CO2 (emission) prices per ton emitted will increase until 2050. McKinsey argues in their report that carbon pricing will be one of the most powerful political instruments in every EU country forcing native and foreign manufacturers to offer low(er)-carbon products for continued access to and competitiveness in the respective EU markets. At the end of 2019, the average price of CO2 in Europe was 25 EUR per ton. In Germany politicians want CO2 prices in the range of 55 to 65 EUR per ton after 2026 and, by 2050, CO2 prices in the range of 100 to 150 EUR per ton for Europe are not unimaginable (McKinsey 2020).

Proof of origin/provenance

One issue missing in most mining standards is the 'proof of origin'. This is usually included in standards relating to conflict minerals (identity preservation or segregation). For example, the ARM or the Fairmined Standard respectively, provide traceability back to the ASM operation for their traded gold. However, this type of traceability scheme requires inspectors to be located directly at the operation in order to be able to approve the certification of the raw material. The same applies to the traceability of raw materials along the supply chain when using blockchain. There must be a supervisor at the mine assessing the production processes, certifying the materials according to a specific scheme, and registering it in the system – a real proof of origin is missing. An example for such a system based on a paper trail CoC system is the International Tin Supply Chain initiative (ITSCI) which is also based on the OECD Mineral Guidance. Relevant data associated with the minerals shipped from a mining site is documented by an on-site government agent who tags each bag of material. Their responsibility is the assurance of the origin of the tagged material. This process continues at the processing plant and the exporter. All data is transferred to the ITSCI data center where it is checked for anomalies.[xxxvi]

However, according to our expert consultations some work has been conducted in this field since the publication of a cited BGR study[xxxvii]. IRMA is in the process of publishing a CoC Standard. This standard was developed to provide the base-level requirements for traceability for any mined material from the mine through the downstream CoC to the end consumer. The IRMA CoC Standard will, as needed, be supplemented by Annexes specifying additional guidance for specific mineral supply chains. In addition, this standard has been developed to work in concert with existing and emerging traceability services and technologies (e.g., blockchain, mineral ID scanning, testing, etc.). It also can be used to help validate key systems and documentation through on-site audits that are associated with secure ledgers and testing results. It is also intended to be compatible with other standards and programmes forwarding responsible sourcing of mined materials (e.g. ResponsibleSteel, Responsible Jewelry Council). IRMA will work to adapt expectations when coordinated with other systems working to common purpose to convey value for responsible practices at the mine level down the chain to consumer-facing products (Result of expert consultations, IRMA)[xxxviii.]

In other industrial sectors mass-balance is already successfully (i.e. accepted)introduced to the market. E.g. for timber the Forest Stewardship Council (FSC) aims to have all forest products sourced from certified forests. The council allows a MB model for a set of certified products (identified or segregated) to contain a mixture of FSC-certified and non-FSC certified material (CoC-standard, Controlled Wood and Forest Management certificates)[xxxix]. To sell FSC products on a larger scale. UTZ Certified offers the MB system in their cocoa supply chain to push for sustainable production at less cost, allowing more farmers to benefit from the UTZ Certified label and as such offer the market a financial incentive.

But whether this incentive is supporting "good enough" claims in the eyes of the end-consumers remains open, because most are in essence nothing more than premium product pricing models. Premium product pricing models only work as long as the target market remains a niche, here with controlled volumes and the promise to sell a "better" product meeting specific criteria. Once the volumes saturate the niche market, to expand the scheme it will have to start competing on price in the commodity market. Something we see happing e.g. with the Fairtrade[xl] brand (e.g. Fairtrade Cotton) failing to facilitate the market change. The Better Cotton Initiative (BCI) takes another route and e.g. does neither have a formal product labelling system

nor provides premium prices for better grown cotton to the growers; they lobby for market transformation top-down and bottom-up.

Comment
When taking in the discussion between the TraceMet partners, we foresee the possibility that a similar scenario kicks in for carbon-neutral steel or copper markets as feasible, because it was argued to be in a niche market selling at a premium price. But, following the economic model - *when successful* - at a given point starting to compete with the traditional commodity markets on price would become unavoidable.

For the better product to survive, an entire industry sector's business model will need to transform, when following the economics behind the up-scaling argument brought into the game by a.o. mass-balance and book and claim supporters. Diluting sustainability claims to allow for up-scaling is a commonly applied marketing strategy and is valid as long as it serves its objective. And yes, mass balancing is practiced in numerous sectors such as food, chemical, biofuels, a.s.o. (ISO22095, RED Cert2[xli], BASF[xliixliii)] with all having their own adaptations and modifications, but stakeholders do not (want to) see these distinctions and tend to generalise. E.g. the fact that BASF' promoted biomass-balancing approach is *site-level* specific and comes with several additional limitations is unknown to most of its critics but makes a huge difference when applying allocation rules in lifecycle assessment compared to other MB approaches. Here ,the ISO 22095 'Chain of Custody – General Terminology and Models provides a generic framework and a shared language that also applies for MB approaches. This ISO standard should pave the way to get the clarity for various CoC-models and allowed claims when discussing the set of specified product characteristics.

Blockchain

Technology update

Blockchains are data systems of increasing sophistication that can contain tons and tons of data/information. That's it; no? Well, they are new types of data systems that differ from traditional centralised databases as they are not controlled by any trusted third party (distributed ledger technology) and should increase digitalised collaboration throughout value chains. The novelty is that they enable peer to peer interaction over the internet. For that, they remove intermediaries and replace them with a decentralised network that maintains a secured registry that consists of immutable records.

Industry 3.0 and 4.0 technologies integration (IoT)

With the arrival of Industry 4.0 the market does not only see exploding transaction volumes in SCs, it can also support organisations to meet market and regulators' needs for data provision and application e.g. in:

- Smart, efficient and real-time (specific) data collection and preparation
- Smart contracts (set of rules that can be stored in the blockchain) can support in carbon data verification and reporting
- harmonised data structure for digital data connections in value chains

The industry in general is changing from a physical to digital market environment, demand and supply will increasingly be linked by adopting artificial intelligence in digital services. Data and information need to be digitised and available for digital solutions that will interconnect whole value chains and industries to drive full automation (the so-called information industry).[xliv]

Example
Aragon's Technological Institute (ITAINNOVA) will be looking into implementing a blockchain platform in the mining sector as part of an EU's Horizon 2020 program The Dig_IT project entitled: "A human-focused platform for the Internet of Things for the sustainable digital mine of the future".

Results from a deep-dive session in the TraceMet project indicate that in the mining sector measuring and reporting material flows for standard products in shorter intervals with support of industry 3.0 and 4.0 technologies (e.g. IoT supported sensorics) is starting to pick-up. It can rightly be argued that the primary driver is better process control to increase quality and efficiency, but it is also an excellent opportunity to drive the necessary data transparency increase for evaluation/comparison of premium carbon free product claims on product and project level by the product end-user (e.g. architects, a.s.o.). In addition, a shift focus from currently aggregated product categories at site level towards more discrete product/batch measuring across functions for premium (carbon) products was noted. These trends support the expected growth in transaction volumes and call for efficient and digital solutions to manage these volumes.

A report published in 2018 by Provenance and Tillväxtanalys[xlv], argues that blockchain can guarantee and incentivise sustainable practices across economies. They argue that in the Swedish REE market it could be a market solution capable of ensuring security and trust as well as providing significant infrastructural and operational cost reduction benefits. In the report it is further argued that "in the short-term this may involve the incentivisation and mechanism for allocating sustainability premiums, stimulating the flow of money towards sustainable practices. In the long-term this may include the achievement of physical traceability and full value-chain transparency in the sector". This is an interesting observation, since the Swedish REE market has so far not managed to adopt a blockchain, presumably because of lacking financial incentives and technical issues (small quantities, non-transparent and complex SCs, a.s.o.).

Technology platforms

Today, most blockchain deployments focus of the financial sector (its origin) and carry names like *Stellar, Bigchain DB, CREDITS* a.s.o. and focus on financial transactions. But our literature review confirms the growing interest in several industries (e.g. minerals and metals, agriculture) testing and successfully deploying blockchain technology in their supply chains as part of their traceability efforts.

Ethereum is a community-run technology powering the cryptocurrency, ether (ETH) and thousands of decentralized applications. The community predominately positions itself as a "technology that's home to digital money, global payments, and applications"[xlvi]. February 4, 2021 the community counted 8493 active nodes, i.e. volunteers running the blockchain. Ethereum is generally not considered commercially feasible for large deployments outside the financial sector, because the technology is not supported by key system providers and integrators.

Please note that Ethereum was selected for TraceMet because RISE used the technology platform in another project financed by EIT RM (CERA) and was granted to re-use parts of the developments in the TraceMet project. CERA wants to develop a universal standard for ethics, sustainability and environmental impact. Its certification scheme is supposed to ensure a consistent standard of environmental, social and economic impact throughout the entire raw materials value chain.

Hyperledger is an open-source blockchain community focused on developing a suite of stable frameworks, tools and libraries for enterprise-grade blockchain deployments. It serves as a neutral home for various distributed ledger frameworks including Hyperledger *Fabric*, Sawtooth and Indy (decentralized identity). Originally developed by IBM, it is fully supported by Accenture, Consensys, Evernym, Orcale, SAP, a.s.o. In consequence, industry is more or less softly forced to use this technology platform, because the "*which platform do we use?*" decision was already made for them by their very own system providers (and integrators). In TraceMet most industrial partners run their systems on SAP.

The good news is that Hyperledger Fabric is an open source solution specifically developed for deployment in supply chains. It uses distributed ledger technology to provide a decentralized, single version of the truth with smart contacts that define the conditions for data transfers.

Open/unsolved issues around successful blockchain application

Data transparency (sharing of data)

The strength (and weakness) of a blockchain is that once it's on the chain, it's there forever or you need to destroy the key resp. agree to change the respective data on all the block's storage allocations. There is (still) no practical solution to alter the blocks. It's an incorruptible system that can perfectly deal with adding absolute facts (data), but has its limitations e.g. when dealing with audit reports that need room for interpretation, discussion and iteration, a/o once agreed upon may turn out to be faulty from a content perspective and as that need to be removed. We also found from analysing some best practice that the level of commercial confidence (little collected experience, high-risk CAPEX and OPEX) in investments in physical product tracking is currently low compared to book & claim, i.e. certificate trading. On the other hand, physical tracking of the material/product throughout the value chain with support of blockchain promises improved *tag, track and tracing* opportunities supporting sustainability claims on material/product level at all stages of the value chain, which again is relevant for the credibility of the information on the blockchain supporting the claim.

Data security

Security and trust in a blockchain system are largely based on cryptographic primitives. More complex cryptographic mechanisms can be used to achieve security goals such as confidentiality or anonymity. In a classical approach, sensitive data can go encrypted in the blockchain and only the software that has the key can open it (e.g. verifiers). Then, however, a corresponding key management for the encryption keys would have to be available, which is conceptually not part of a blockchain system. Problem here is that if an encryption algorithm becomes insecure/ keys are compromised the affected ciphertexts cannot easily be withdrawn or re-encrypted. Reason is that they are distributed throughout the whole network and are no longer under control. ONE cryptographic approach is to use zero-knowledge (ZK) protocols. However, this is according to the source consulted[xlvii] very complex and resource intensive.

A simple practical solution - with limitations! - to the deficiencies of confidentiality is not to store commercially and privacy (GDPR) sensitive data directly in the blockchain, but to use only references of the data (e.g. hash values). The data itself would then have to be stored and protected against unauthorised access in an external database. Problem is that only the existence and integrity of the data can be ensured by the blockchain. The availability for the execution of operations in e.g. smart contracts is not guaranteed.

Smart contracts are computerized transaction protocols that execute the terms of a contract. I.e. it's an executable program and was first widely introduced in the Ethereum blockchain. In Hyperledger Fabric, the smart contract is known as *chaincode* or *distributed applications (dAPPs)*. Different to Ethereum is that Hyperledger Fabric separates consensus from contract execution and validation. Both regarding the chronological order and the responsible nodes. This approach should lower redundancies and increase throughput because no longer all network nodes have to execute the contracts. The differences between existing smart contract systems are significant. When TraceMet wants to introduce such a solution the team a.o. needs to decide on the programming language, ordering and validation as well as the runtime environment, because all have a direct impact when choosing a suitable blockchain platform[xlviii].

Deployment cost

There is low financial incentive to track and trace steel and copper (in SE); the tempting sustainability premium is not a given. In addition, supply chain deployment cost is high for physical tracking of materials, because the supply chain needs to be equipped with physical tracking solutions. Deployment cost for a supply chain without tracking (book and claim) is lower, because the only physical system elements are the audits at the source. In certificate trading it's at the source where the audit to receive the certificate is decisive, whereas in (tag), track and trace the incentive to "add" non-certified materials to the supply chain is always present. Here, the challenge is not the blockchain with its immutable data blocks, but how susceptible the certified system as a whole is to alteration and manipulation (e.g. counterfeits) when the goods are moved around in the ecosystem. We cannot ignore the point that blockchain (technology) alone cannot replace the quality control system.

Blockchain implementation in the Traceability context

Blockchains are one out of many technological solutions for data storage and transfer. Our market review shows that finding the right fit for the TraceMet CoC model's use case and supporting technologies is important for its success. In an earlier chapter, we presented the three main drivers for traceability. We will now describe in some more detail the legislator's increasing focus on compliance via due diligence (public legislation, supply chain security, a.s.o.) making the identity preservation and segregation the dominating CoC models in the market. The market's need for additional transparency (meeting public scrutiny and investor expectations) when connecting premium product quality claims with "sustainably sourced from sustainable sources" claims closely follow due diligence requirements. Though, the use case for blockchain technology in combination with mass balance as the CoC-model supporting the environmental premium product claim is less developed. One reason is that the MB-method itself is still considered underdeveloped and needs further testing in combination with e.g. blockchain technology.

Due Diligence as driver for identity preservation and segregation CoC-models

Due Diligence (DD), has emerged as one of the primary tools for business enterprises, including financial institutions, to live up to their responsibilities towards people and planet. Generally, DD is understood as the means by which companies can efficiently identify, assess, prevent, mitigate/remediate and account for (incl. monitor) the impacts of their activities or those linked to their business relationships. BUT, a standard of diligence is rarely identified. Although some companies have adapted their business models to meet their commitments to sustainability, others continue to exclusively prioritise profits, growth, and the interests of their shareholders. Whereas due diligence on financial and environmental regulations (and impact) has already a

high maturity level and is part of various international and national "hard law", human rights due diligence is fairly new and, in many respects, "soft law".

HuRiDD

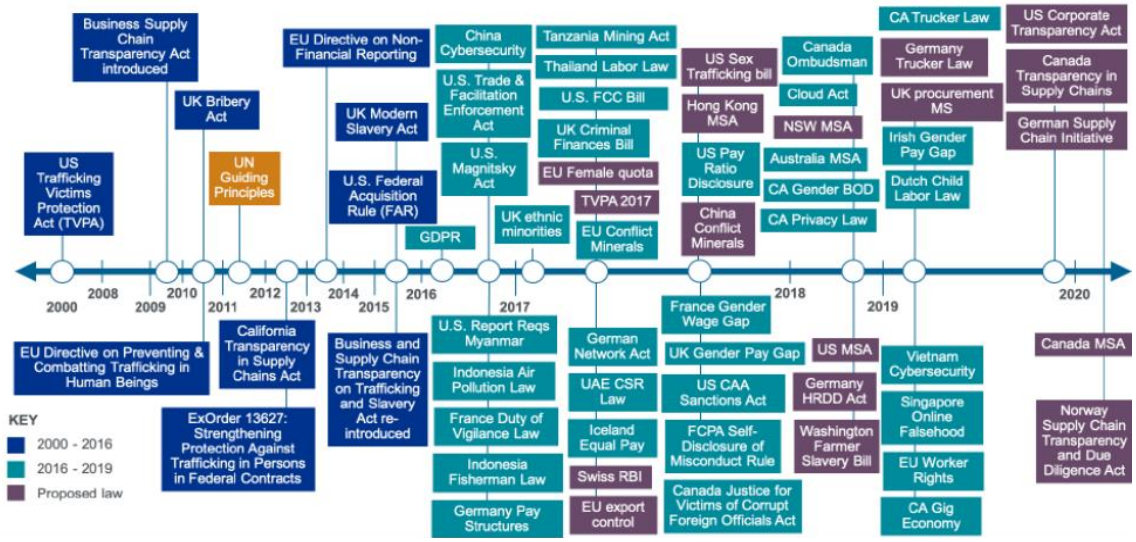
It's unmistakeable that organisations cannot longer 'benefit' from Human Rights (HuRi) abuses. The trend to include HuRiDD in hard law was initiated early 2010 by the BSCTA (see fig. 1) and now is coming to a first climax with a new EU Directive on DD that will put disobeying organisations' license-to-operate at stake. Globally, disclosure requirements (e.g. UK modern slavery act), mandatory due diligence (e.g. Dutch Child Labor Due Diligence Act) and even criminal liability and sanctions (US global Magnitsky act & the UK criminal finance act) have been introduced to the market. As that the move in DD requirements from voluntary market regulation to judicial/regulatory enforcement is a fact. To be effective legislation, it must impose robust obligations to market players and can e.g. include penalties for non-disclosure and non-remediation. Transparency is here also key.

Reversal of the burden of proof

Activists require from EU legislators that parent companies disprove its connection to the business entities involved in the harm and show what steps were integrated to manage HuRi and environmental standards in its operations to prevent the harm from occurring. As of today, claimants (victims of corporate abuse) still need to prove liability, causality and damages in courts. But this principle may change when consulting the various initiatives currently under debate (e.g. the Swiss "Konzernverantwortungsinitiative[xlix]").

Before summer 2019, the EU Commissioner for Justice, Didier Reynders, committed to a legislative initiative on due diligence today also better known as the *Directive of EU Parliament and the Council on Corporate Due Diligence and Corporate Accountability*, which originally was only about Human Rights, but now includes embodied carbon/climate change. This Directive will make HuRiDD and environmental DD mandatory by default. I.e. organisations will need to provide proof that they have the mechanisms and due diligence standards in place to map potential impacts, have the processes and systems to control and monitor its activities to avoid, mitigate and remediate negative impacts.

Figure 1. Business & human rights legislation: 2000 to now



Fields of application

In the TraceMet project a key finding from earlier research was reconfirmed that "mapping the material stream of copper is very difficult since the actors in the supply chain are unwilling to reveal who they buy from and sell to." But, a blockchain involves that this type of commercially sensitive information shall become available for e.g. verifiers but does not necessarily become visible to all participants/users (argument against blockchain solution not pointed out in the pre-study). It is crucial to accept that a blockchain is to increase transparency in the supply chain and can only enforce the rules that can be understood by a computer. I.e. a blockchain is very useful to enforce rules on information inside a system (prevent double spending, a.s.o.), but it cannot control *what* information enters the system. Latter is managed and agreed upon by its users.

SC application

The sustainability monitoring of supply chains is generally weak. Companies generally neither have detailed information about which firms they have in their supply chains (tier n+1) nor their locations for manufacturing/plants. Many large firms instead have requirements on direct suppliers (1st tier) that they shall have the same sustainability requirements imposed on their suppliers as opposed to them, and so forth (the so-called cascaded method). I.e. they push the sustainability responsibility into their supply chains (shared responsibility and burden) via SC-programmes like SEDEX[i] or Together for Sustainability[ii] and internal policies/codes, e.g. Supplier Codes of Conducts, to attempt to green the supply chain. However, in practice the cascading chain tactic many times already stops at the direct suppliers[iiiiiii,] so that it rightly can be argued that the effect of such initiatives is and remains limited.

Copper value chain

From the pre-study report

The analysis indicates mass-balance being the most suitable CoC model for **copper**. The main reason is that the production processes of copper products today mix materials from different sources to create the most suitable products regarding quality and economical aspects. Copper concentrates from different mines are mixed when producing copper cathodes, and copper cathodes from different smelters are mixed when producing copper wire.

To apply an identity preservation model, a smelter could use copper concentrate from only one mine at a time. This is not coherent with the production and the business logics of copper smelters. It would also be impossible to add copper scrap and still preserve the identity of the material. The segregation model is more flexible since the claim is in focus, not the origin. However, it could be difficult to find a suitable claim or sustainability criteria that would stand out in the industry, since all input material needs to meet the same claim. Segregation could be suitable for broad claims, for example if organization has a certified management system. The copper market is also mature to implement a MB approach since they already agreed on a highest quality grade of copper, so called grade A on LME, London Metal Exchange. The CoC system does not need to assure a certain physical quality performance, only the value of the sustainability impact in the production.

Mass balance cannot handle the challenges with conflict free minerals (HuRiDD) since customers will not accept even fractions of conflict materials and require fully guaranteed *conflict free* materials. Therefore, when the crucial factor is conflict free, another CoC model must comple-

ment the TraceMet mass balance approach. Evidence suggests that responsible sourcing practices are limited in electronics and electricity (important users of copper) with the exception of 3TG[liv].

Steel value chain

Several automotive brand companies (e.g. PSA, Toyota, Volkswagen and Volvo cars) work with LCA to identify "hot-spots" of greenhouse gas emissions in their supply chains. To reduce these emissions, they are demanding increased use of recycled materials (steel, aluminum and plastics) and renewable energy[lv] The use of more recycled materials is according the steel industry only "shifting the burden" since, in practice, all steel is already being recycled (Svemin, 2021). All to ultimately remove CO2 from their organizations and supply chains. Results from a deep-dive session in the TraceMet project confirm these findings and point to the stricter environmental regulations that will get in place with the European Green Deal. One financial instrument that is currently under debate is the Carbon Border Tax that - when developed and used as a penalty for carbon imports to the EU-market – has the potential to be a real market changer that will redefine the rules of the game for various energy intense industry sectors.

The building sector already works much more LCA based and in Sweden e.g. EPD are more and more common. This means that the actions to reduce emissions are not that specific as in automotive. The material choices are more technology neutral.

Certification (calculation rules LCA)

Accepting mass balancing in LCA-calculations is not a technical, but more a political decision. From a technically/methodological angle, it is currently fiercely debated whether mass balance can be used in LCAs that are conducted in conformance with the ISO 14040 series standards dealing with Lifecycle Assessment, or not? This is a clear indication that most mass balance methods for LCA are considered underdeveloped by the LCA community. The BASF model for biogenic material is a more mature model that e.g. uses mass balance on site level and follows other strict rules when e.g. preparing for an LCA, but still fights for its acceptance and recognition in the LCA community. Other common applications of mass balance in LCA is in biofuels (Swedish Preem), renewable energy and waste.

But the key decision should be about whether you want to incentivize and push industries into the circular economy by providing credits for the adoption of renewable sources (e.g. renewable energy, bio-based materials, a.s.o.) in their supply chains, or not? Many industries (incl. chemical) use mixing of material sources in their fundamental production methods and cannot keep the flows strictly separated. When the answer is yes, mass balance application has a valid point and should seek for further acceptance by maturing its method. Or, do you prefer to stay within the traditional LCA domain (attributional LCA), i.e. materials are allocated (coupled) to the product and coupled to the claim to support e.g. eco-efficiency increases?

Reporting carbon

When taking advantage of a privacy preserving CoC system, GHG emissions can be calculated in real time, in an automated way via smart contracts. This would work in the following way:

- The standard uploads its framework for GHG emissions (TraceMet SMAD) calculations as a smart contract running on the blockchain.
- The smart contract is connected to the CoC records from the different actors and takes the movement of goods as an input

- The sustainability standard accesses the smart contract and updates the standard values when and where necessary
- The GHG emissions data can now be shared with the supply chain

It's understood that the WEF MMBI is piloting such (similar) approaches to test carbon emissions and recycling reports as part of the blueprints accessible for the COT-platform members.

In TraceMet, the GHG calculations according the EU-ETS standard are kept outside the blockchain (no smart-contracts). For the calculations the participants comply with the developed product category rules and SMAD -document. Steel supply chain participants report their GHG calculations on an annual basis in a sequential manner (up-stream --> down-stream) to the blockchain. In a next step, an independent auditor audits the procedures, calculations and reports stored in the blockchain. In the copper value chain, carbon footprint calculations follow the same process, but the carbon is calculated per ton of ore or alt. per ton of copper content. Here, the participant can choose but needs to be consistent. The TraceMet blockchain cannot verify whether the actors have received, nor consumed the material with the CFP that is reported to the blockchain. It would need a third-party verification on the amounts producing a document of proof for both to be provided to the verifier/auditor for verification before the "verified stamp" is added to the block. A document of proof for both will need to be provided to the verifier/auditor for verification before the "verified stamp" is added to the block.

Reporting Recycled Materials

Boliden wants to report copper virgin and recycled in the order of magnitude of 80% primary and 20% secondary via mass balance (in batch) to ascertain a stable process, because its not designed to treat 100% scrap . The challenges from a credibility and efficiency perspective are that TraceMet does not handle the amounts of recycled material in an automated way and recycled content is not calculated on the blockchain. Scrap entering the products lifecycle throughout the supply chain is not being tracked. I.e. actors are allowed to define the percentage of recycled materials they want/agreed upon to receive in a contractual transaction. Today, TraceMet's blockchain is keeping record that Boliden is not selling more recycled materials than accessible via the total pool.

Integration and acceptance of blockchain technology

Blockchain projects like TraceMet (and almost any other deployed blockchain) involve cross-enterprise workflows (sharing of data). As that collaboration is a critical success factor that needs to be considered at proof-of-value (PoV) time. Failing on cross-enterprise cooperation and data exchange is the most common reason why fewest PoVs for blockchain solutions actually found deployment into production. In practical terms, blockchain pilots that ran at WEF members confirm what technology providers begun documenting. This documentation includes two generalised models for managing a blockchain ecosystem, i.e. the concept of a minimum viable ecosystem (MVE) and a prime tenant model. All models seem to share the "premise of starting out small with an ecosystem an organisation can control […] and then build from there" (WEF 2019, p. 22).

In general, from research it can be noticed that acceptance and implementation of new methods and technologies by an industry largely depends on its critical aspects and drivers. The automotive industry is largely driven by carbon neutrality, i.e. carbon placed in a life cycle approach

(not LCA) whereas the building sector is driven by building level LCA regulation. Both industries supply their copper and steel from similar/identical sources, but the usability of the accompanying claim rests in different needs.

Interoperability is the ability for computer systems to exchange and make use of information in a collaborative way. Not only the lack of reporting standard for carbon and recycled steel as well as standardisation in data collection, but also the distributed ledger technology can become challenging. It needs to be considered in large detail and with care for successful deployment. Being considerate of such compatibility issues will help future-proof the blockchain part of the CoC-system at the technical, business, governance and process levels.

Scalability of blockchains is limited to design decisions. I.e. scalability is not flexible, i.e. TraceMet will become obsolete someday. A disconnecting of current decentralised applications from their underlying blockchain protocols should be pursued. This should support any future migration to a new platform at least resources spent.

Recommendations

From the TraceMet Proposal
TraceMet will develop a system for following certified metals from mine to end usage. In the project, the criteria "carbon footprint" and "share recycled" will be used. The project studies two value chains for copper and steel production. The copper case concerns "from mine for use in high voltage lines", and the value chain for steel, "from mine to steel in trucks"

We conclude that premium claims on carbon footprint or recycled content of steel and copper could increase the international attractiveness of metals and minerals. This project has resulted in a pilot in this direction. Relating to the findings in this report with the original objective of the TraceMet project in mind, the team will now share important points for consideration and recommendations. We begin with the market development, with the main question – will there be a demand for TraceMet?

Points for consideration regarding the market development

Mass balance is a CoC model suitable for complex value chains and production processes with mixed commodities. The fundamental of the mass balance principle is that the volume of sustainable claimed material that enters the process is equivalent to the volume of claimed material leaving the process. This reflects the production logic for copper and steel. Copper concentrates from different mines are mixed when producing copper cathodes, and copper cathodes from different smelters are mixed when producing copper wire. To not rely on only one source is often also part of strategic risk management for stakeholders in the value chain. But as we argue, the MB has limitations/reservations regarding the credibility of a claim.

- According to EIT RM[lvi] plus forty different certification schemes exist for mining activity alone. Some certificates are specific to a single geography, process or humanitarian concern, and others to a single mineral. TraceMet is developed mainly in the interest of miners. The European mining sector is today mainly focusing on sustainability claims that increase the local acceptance of mines, which requires identity preservation or segregation due to the claim that needs to be traced back to a local circumstance/situation. TraceMet is focusing on claims that are related to premium products; i.e. OEMs try to maintain market shares or enter new markets.

- The claims on premium products is sector specific today, e.g. the approach is different in automotive compared to construction sector, which both use steel and copper in large quantities. A single blockchain solution targeting this aspect therefore should be adaptable to CoC approach (mass-balance or certificate) and input requirements. This implies that BOLIDEN, LKAB and SSAB would need to build the competence and capacity (incl. infrastructure) to deliver different types of input data. A more likely scenario is that several blockchains would be developed (made and fit for purpose).

To summarize, TraceMet is in our opinion - *in its current deployment stage* - suited for handing "premium product" environmental claims as demonstrated under TraceMet for the Swedish copper and steel value chain pilots with one miner/ smelter, manufacturer and down-stream actors.

TraceMet is in our opinion - *in its current deployment stage* - not suited for expanding to environmental and social "good enough" claims. A.o. the mass balance method will not meet the expected tag, track and trace requirements for local production method and provenance claims. In addition, the inclusion of additional market actors – and thereby letting go of the applied on-site, single company rule - will create challenges on the certification scheme. We also cannot recommend including other metals such as Cobalt (CoC follows other purpose and claim). Instead, the arguments for making the blockchain more specific and targeting a specific end-user sector seem to prevail. In other words, TraceMet is Sweden centric, but when becoming a global application, it will need to face different challenges (e.g. lack of HuRiDD) that were not addressed in the TraceMet pilot.

To conclude on a positive note, we are convinced by our market analysis that it was and still is a good choice for TraceMet to focus on "premium claims" for two reasons:

- many initiatives already target "good enough" claims;
- carbon footprint and recycled content claims will likely become important in the future as Rio Tinto is pointing out[lvii] and Swedish firms may bank on a first-to-market competitive advantage in steel and copper.

However, at the same time it's difficult to foresee *when* and *how* these "premium product claims" will prevail, which makes TraceMet a high-risk project for industry.

Points for consideration regarding the development of the blockchain

Most successful blockchains start out small and expand. Starting big has proven difficult and produced few successes. When up-scaling through internalisation and supply chain collaboration for sustainability is feasible, the value of adopting a blockchain technology may become apparent.

The current blockchain can arguably be challenged for being overengineered for its purpose, i.e. to avoid double counting, and simultaneously its lack of sophistication:

- scope limited to Swedish SC
- scope on carbon and recycling (HuRiDD is more pressing in political and public sphere);
- lacking automation, e.g. entry of new material flows (i.e. scrap) not possible;
- timeliness, annual reporting
- when on the same blockchain all shall follow the same standard - *SMAD & PCR*, but verification/auditing process is not developed to be waterproof.

It's fair to conclude that the current TraceMet blockchain is at a rather rudimentary development stage; it contains no smart contracts, does not deal with identity and privacy concerns and is exposed to little complexity in value chains. In theory, the blockchain could work for all MB approaches (horizontal and vertical supply chain expansion) because it only provides a repository for verified data, but the real pressing technical, governance and process challenges that were – *wisely* - left out of the pilot scope to provide the proof of concept will need to be tackled in its future development.

Four areas of importance for a development of the blockchain would be:

- In TraceMet, the blockchain was developed and tested to function as a data repository and for down-stream oriented data transfers. So far, the only calculation on the blockchain relates to data inventory management to make double spending of material impossible, which is critical to any CoC-model. Though, lacking dashboards make it difficult to e.g. view total carbon emissions as well as recycled materials. Users currently need to summarise from json file or MS Excel exports.
- Blockchains are predominantly collaboration tools. As that they are too cumbersome and costly to play a role in supply chain system scenarios that don't require collaboration. The current TraceMet blockchain's main objective is avoiding double spending. When all other remains the same, we consider this an expensive cooperation exercise.
- Consider switching to Hyperledger Fabric to benefit from its open source community support and integration options via system integrators a.s.o. The option for future merger with e.g. WEF and other large players in the market remains open.
- An independent organisation needs to own the Blockchain and linked accreditation scheme. This is important for the accreditation system's credibility, e.g. when verifying "approved" verifiers who need to verify the calculations (using PCR and SMAD) on the blockchain. E.g. in the current TraceMet set-up the reported **certified** (*by whom with what credentials?*) number needs to include an entry about which standards are used, but a separate audit (event) is not accounted for. A clear consequence of the decision that only verified data are shared on the blockchain.

Finally, it could also be worthy to investigate the possibility to collaborate with broad initiatives with CoC-models for "good-enough" claims such as IRMA.

A personal reflection

MB in combination with blockchain can be used as a powerful *politically motivated incentivisation system* for moving industries into a circular economy, not for e.g. pushing energy efficiency increases.

The copper and steel's current relatively low price coupled with the fairly large quantities that are handled supports feasibility of physically tracking the metals along existing value chains. The deployment cost for physical tracking solutions are considered high, but industry 4.0 technologies (e.g. IoT, sensors a.s.o.) have the potential to lower deployment cost, but also support organisations in e.g. quality management and continuous improvements. Track and trace certificates are digital goods and in consequence make them an ideal target for blockchains that excel when enforcing rules on digital assets, as recently seen in so called "smart contracts", but TraceMet is lacking this level of sophistication. Further, both metals fungibility (German: Potemkingut) i.e. one atom of copper is mutually interchangeable with any other, makes it difficult

to isolate a certified chain from an uncertified chain. This potential source of higher cost of physical tracking - given there is more room for stringent monitoring and enforcement efforts - would be required to ensure the integrity of certified products. A physical traceability system could work for Swedish copper and steel, but stringent requirements on track and trace will be hard to extend to other players worldwide.

Finally, in the light of increasing EU DD requirements on not only upstream suppliers but also regarding enforcing DD (EnvDD and HuRiDD) on downstream customers, an inclusive supply chain may seem an interesting approach when testing "good enough" claim CoC-models. Here, a pilot with the involvement of (EU/SE) policy developers working on downstream DD enforcement may result in a tremendous knowledge transfer and credibility building between SE industry and EU/SE policy makers, who's premium task is to develop new policy, and not on how to best deploy the new directives.

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