Metals-as-a-Service: From Challenge to Design

Closed-Door Strategy Workshop

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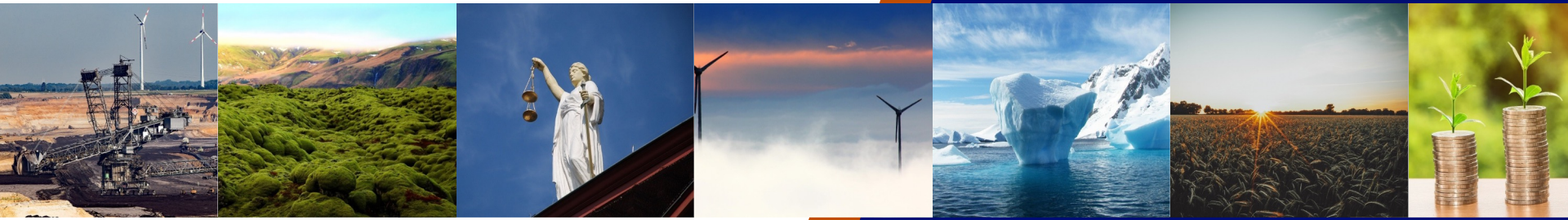


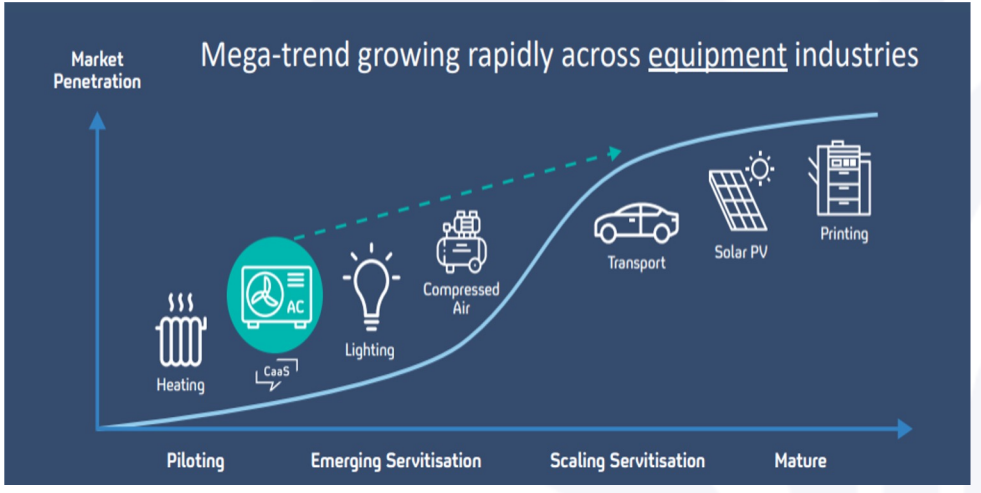
July 15, 2025

Background materials on ‘as a service’ business models

Option reading

Exhibit 1a: Servitization has taken off in capital intensive sectors

- Transformation of a traditional product-based business model into one that delivers service outcomes.
- Functionality or utility as a service, rather than through product ownership.
- Provider retains ownership of the physical asset or material, and the customers pay to access its use, performance or results over time.
- Use of leasing, subscription or pay-per-use arrangements.



Servitization phases: piloting, emerging, scaling, and maturing. Mature industries like transport, solar PV and printing have achieved full market adoption. Other equipment industries (e.g., cooling) are advancing fast

Other examples include ICT software, mobile phones, data centres.

Source: Market Transformation:Servitization of Cooling Industry

Exhibit 1b: Takeaways from other sectors

	Success	Challenge
Software-as-a-Service	• Higher affordability for the user • Reduced maintenance and in-house technical skill needed • Increased ease and agility to switch technology as it evolves	• Less customer flexibility to adapt s/w • Long term costs can offset short term savings
Cooling-as-a-Service	• Move from CAPEX to OPEX pay-as-you-use • Performance-based-contracts so financial incentive for supplier to deliver performance improvement • Well-designed equipment for modularity and second-life use	• Providers' higher upfront costs for more efficient equipment • Perceived increased commercial risk (e.g., new financing models, service lock-ins) • Measurement and verification standards needed for payment mechanisms
Battery-as-a-Service	• Lower EV costs by decoupling battery cost from the car • Customizable depending on driving needs • Minimize degradation through constant upgrades • Potential increase in EVs resale value	• Need initial CAPEX for constructing battery swap stations • Compatibility issues (e.g., swappable battery formats) • Logistics issues (e.g., recovered batteries' diagnosis, cooling, recharging)

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Source:
- Software-as-a-Service https://www.saasmetrix.io/understanding-the-pros-and-cons-of-saas/?utm_source
- Cooling-as-a-Service https://www.caas-initiative.org/wp-content/uploads/2022/05/Cooling-as-a-Service-White-Paper-1.pdf
  - Practical example in Kaer https://www.kaer.com/
- Battery-as-a-Service https://www.catl.com/en/news/856.html (CATL) / https://www.nio.com/news/nio-launches-battery-service (NIO)

Exhibit 1c: Takeaways from other sectors

	Success	Challenge
Chemicals-as-a-Service	• Performance-based payment, promoting efficient chemical use, reducing environmental impact • Facilitates knowledge transfer on proper usage, unlike outsourcing • Lower upfront cost makes it especially attractive for SMEs and developing countries	• Technical and operational complexity in defining performance KPIs • Highly dependent on trust-based contract between provider and customer • Standardized process across customers • Reliable and independent performance monitoring system required
Facade as-a-Service	• Lower upfront costs and improved energy efficiency, ventilation, etc. • Incentivized to build durable, upgradeable, and energy-efficient systems to minimize lifecycle costs • Easier to update facades as technology evolves	• Need for standardized modular components • Weak second-hand market, weak predictable residual value and limited historical resale data • Facade cannot serve as a strong collateral
Precious metals leasing	• Generates in kind interest-like returns on idle physical assets when leased • Provides flexibility with working capital/ just in time supply for the buyer while returning to owner equivalent weight • Hedging strategies to minimize the exposure to the market	• Delivery, purity assurance, and return management complexity • Tracking, storing, and transporting high-value metals is costly and security-sensitive.

Source:
- Chemical-as-a-Service https://www.unido.org/sites/default/files/2013-10/Chemical_Leasing_0.pdf (UNIDO) / https://www.execon-partners.com/chemicals-as-a-service/(execon partners)
- Facade-as-a-Service https://www.circularbuildingscoalition.org/blueprint-projects/gearcraft
- Precious Metals Leasing https://coinweek.com/what-is-precious-metals-leasing-and-why-is-it-done / https://www.monetary-metals.com/insights/articles/leasing-vs-leasing-gold-for-a-return

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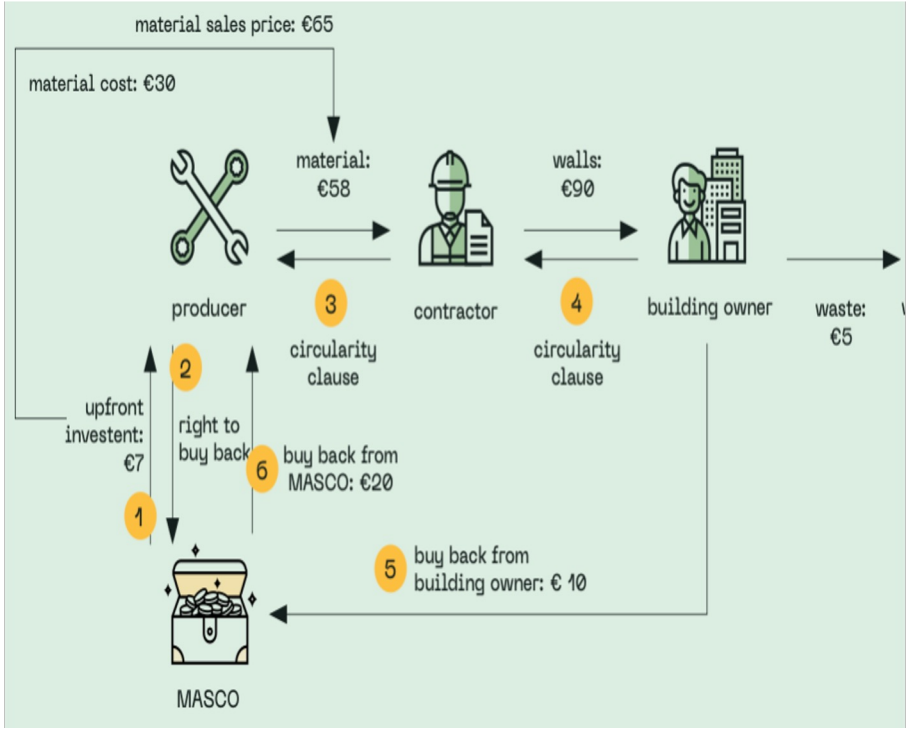
Exhibit 2a: An example of a 'material as a service company' (MASCO) to remove the capex risk for the producer



- **Buyback Agreements(⑤):**
  - MASCO includes a **contractual "circularity clause"** - the right to buy back the products at EOL from building owners
    - This buyback price helps **offset the owner's deconstruction and return logistics costs**, creating a **financial incentive** to return rather than discard

- **Circular Discount:**
  - The building owner receives a **discount($90)**, funded by the MASCO's investment
  - Producers can buy back materials **below the cost of producing new ones(<$30)**, reducing material input costs.
  - In non buy-back; owners are required to **repay the discount plus interest**, creating a **disincentive to discard** the product.

- **Ownership Transition:**
  - "Producer → building owner → MASCO → producer".
  - This loop keeps materials circulating in the economy and **prevents waste by incentivizing returns**.

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Source: https://cdn.prod.website-files.com/6540cf880126ab97b2f349fc/65d3cbe6c7970d4fe3f3334d_20240215-Whitepaper_CVI.pdf

Exhibit 2b: Value creation of MASCO in the Model

- **Central knowledge hub:** MASCOs serve as hubs for expertise in circularity, handling contracts, analytics, financing structures, and helping standardize circular business practices.
- **Encourages return of products:** MASCOs create incentives (e.g., buyback schemes) for building owners to return products after their use period, keeping materials in the loop.
- **Diversified risk:** By aggregating multiple producers and materials, MASCOs reduce investment risk through diversification.
- **Access to green financing:** MASCOs can unlock funding for circular materials, making them more bankable and attractive to impact investors, private equity, and green funds.
- **Circular discount mechanism:** MASCOs offer an upfront discount to building owners, reducing initial CAPEX and improving the affordability of circular materials.
- **Attractive ROI:** Products with high **Circular Value Index (CVI > 3)** present strong business cases for MASCO-backed investment, enabling profitable reuse and resale cycles.

Producers

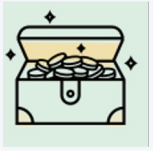
- More opportunities to accelerate business growth due to the lower material cost with circular discount

Contractors

- Enable quick installation of materials due to their high circular value

Building Owners

- Lower upfront cost
- Incentivize the return of product
- The buyback price should cover the demounting and transportation costs that owners are responsible for



Financial Sector

- Open feasible investment opportunities
- The **Circular Value Index** can be an objective way of measuring the viability of the model

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Source: https://cdn.prod.website-files.com/6540cf880126ab97b2f349fc/65d3cbe6c7970d4fe3f3334d_20240215-Whitepaper_CVI.pdf

Exhibit 2c: The Circular Value Index(CVI)

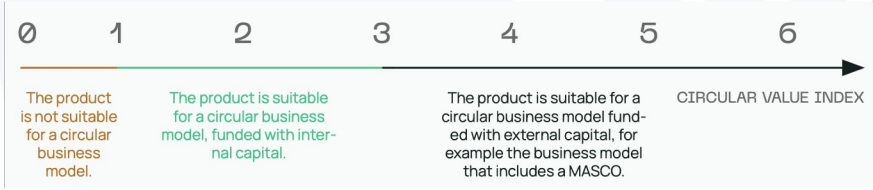
CVI: a financial metric to evaluate the economic viability of reusing materials in a circular business model

$$\text{Circular Value Index} = \frac{\text{residual value}}{\text{cost of reuse}} \times \text{risk}$$

- **Residual Value**: Potential worth after use [= max(second-hand price, buyback price, resource price) - material losses during recovery]
- **Cost of Reuse**: Incurred expenses during recovery [= sum(Demounting, repair, quality assurance, transport, storage, etc.)]
- **Risk Factor**(≤1): Adjusts for regulation, demand, toxicity, technological obsolescence

Takeaway;

- Generally, a > 1 CVI convincing business model
- **With MASCO model**, required to ensure that the sale and repurchase of high-circular-value products generate sufficient returns, **CVI of more than 3** will be ideal
- If the cost for demounting and quality checks surpasses the second-hand value of the product, resulting in less than 1 CVI and commercially unviable model



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Source: https://cdn.prod.website-files.com/6540cf880126ab97b2f349fc/65d3cbe6c7970d4fe3f3334d_20240215-Whitepaper_CVI.pdf

Exhibit 3a: Some potential MaaS archetypes

	Metal + Service Bundles	Performance-based contracting + function deployment	Metal leasing with take-back scheme	Closed-loop MaaS: ownership + performance-based?
	Provide metals with fabrication, delivery, maintenance, or processing	Fee on metal's performance not the quantity (e.g., durability, corrosion). Deploy structural function to meet specific needs. Combined with IoT / digital twins to monitor metal in use.	Pay to use model. Metals recovered at EOL. Down cycling risk not monitored	Lease metals *coupled with services of performance-based contracting*. Retrieve and reuse these metals for new customers without down cycling (closed loops)
Ownership	Transferred	Transferred	Typically retained	Retained
Service Focus	High	High	Low	High
Circularity Focus	Low	High (if combined with function deployment)	High	High
Financial Viability	High	Intermediate	Low	High
Product Fungibility*	Low	Low	High	High
Traceability Need	Low	High	Low/ Intermediate	High
Contract Complexity	Low	High	Intermediate	High

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* Of a product or commodity that has been contracted for: that can be replaced by another identical item without breaking the terms of the contract. More generally: interchangeable, replaceable(*Oxford English Dictionary*).

Exhibit 3b: The function and performance MaaS business model archetype: beyond retained ownership

Function + **Performance**

- Deploying *function* (e.g. beams a specific size, structural nodes) rather than tons of metal tackles waste during on-site fabrication and logistics.
- This model aligns supply with actual structural demand, reducing transport of excess material and costly on-site cutting.
- Deploying only needed materials avoids waste, lowering CO2 and recycling burdens. Up to 50% of CO2 could be avoided by better material use combined with recycling strategies.

- Adding a *performance* fee aligns incentives by linking fees to structural effectiveness—e.g., strength, uptime, utilization rate—rather than metal tonnage that encourages over-purchase and off-cut waste.
- This shifts risk to the provider, who now has motivation to minimize material waste along the fabrication chain and optimize designs to deliver precise function and performance.
- Providers tend to remain deeply involved—tracking usage, optimizing performance, and refurbishing or recycling parts to maximize asset life.

Source: https://www.weforum.org/stories/2024/04/why-recycling-metal-is-an-opportunity-too-good-to-waste
https://learningloop.io/plays/business-model/performance-based-contracting

Exhibit 3c: Could MaaS transform a resource company to become a tech company with added market value?

- Move away from a business model supplying mass/feedstock to one delivering optimized outcomes across the life of the product. Make use of tech-based solution (e.g., structural function, longevity, IoT).
- By managing product performance through using digital models and IoT monitoring, businesses accumulate valuable data to improve future product design. Create tech-driven products as well as raw material commodities.
- Could providing tech services unlock additional market value?
  - Why? Market values of as a service models significantly higher than commodity-based business models.

Feature	Traditional Steel Seller	Performance-Driven Service Model
Pricing	$/ton, incentivizes volume	$/structure or $/performance unit; links fee to outcome
Waste	Off-cut scrap, site inefficiencies	Minimized through off-site precision manufacturing off-site, take-back, and high-level design data
Revenue Type	Transactional, one-off	Recurring and long-term, performance-based
Data/IP	Minimal	Builds proprietary analytics, digital twin capabilities
Valuation Multiple (roughly)	~0.2–0.5× revenue	~6–8× revenue (as circular tech analogs)

Source: https://www.bain.com/insights/machinery-and-equipment-the-circular-path-to-value-global-machinery-and-equipment-report-2024
https://reports.weforum.org/docs/WEF_Circular_Transformation_of_Industries_2025.pdf
https://www.weforum.org/stories/2022/01/5-circular-economy-business-models-competitive-advantage

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Exhibit 4a: MaaS as a strategic hypothesis for systems change

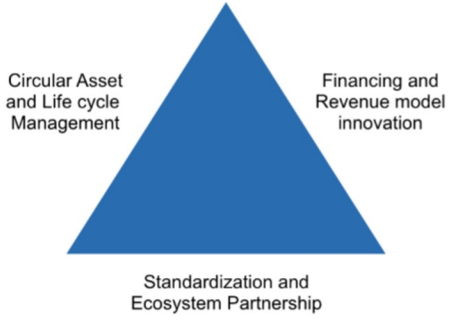
Theory of Change - MaaS

Retention of ownership by the producer will empower them to maintain their strategic advantage and challenge the resource curse. Requisites to return the metal upon the end of term will propel circularity of metals, delivering shared value across the value chain.

Inputs and Activities

- Working capital financing
- Liability management
- Improved tracking systems
- Material flow analysis
- Metal recovery and inspection

Key Strategic Areas



Core Assumptions

1. Metals maintain value over time
2. Ownership enables better long term resource control
3. Consumers will be willing to change CapEx to OpEx
4. Materials will be be tracked and recovered
5. Regulatory and ESG trends will support MaaS

Outcomes

Short Term

- Predictable revenue for producers
- Hedge against price fluctuations
- CapEx relief for Consumers

Medium Term

- Scalable recyling solutions
- Supply chain certainty
- Optimized usage, minimized waste

Long Term

- Regenerative material flows
- Balanced stakeholder benefits
- Closed Loop value creation

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Exhibit 4b: stakeholder business drivers: benefits and risks

Stakeholders	Benefits	Risks
Miners	- Recurring cash flow from leasing - Retained ownership of strategic materials - Improved ESG positioning	- Commodity price risk - Longer cash conversion cycle - Increased default risk
Metal Processors	- Reduced metal procure -ment and storage costs - Reduced market risk exposure - Supply chain certainty	- Loss of capital gains from refined metal products - Limited inventory manage -ment - Contract dependency
OEMs	- Reduced exposure to commodity price volatility - Lower upfront CapEx - Reliable, guaranteed supply of materials	- Increased liability and metals insurance expense - Must guarantee return of materials at EoL - Provision of collateral

Exhibit 4c: Stakeholder business drivers: benefits and risks

Stakeholders	Benefits	Risks
Recyclers	- Predictable revenue opportunities - Increased investments in process innovation - Higher profitability	- Increased materials handling liability - Contamination challenges - Transparency and traceability requirements
Traders	- Creation of new financial instruments - Arbitrage opportunities - Improved capitalization and liquidity	- No clarity on exposure to emerging risks - Lack of initial liquidity - Complexity of valuing leased assets over time
Financiers	- Access to new asset class - Multiple ways to hedge commodity portfolios - Long term strategic asset development	- Complexities assessing value chain risks - Liquidity challenges - Taxation and policy risk

Exhibit 5a: Scenario model run

Is Maas economically viable with volume based monthly lease payments?

Metal Selection and Focus

Copper, due to existing recyling infrastructure, demand, availability

Key Assumptions

- **10 years** — Pilot duration
- **8 tonnes** — Copper leased
- **EV Charging Station** — Downstream product
- **$9,702** — price per metric ton of copper (LME)
- **10.36%** — Interest rate for MaaS lease
  - **4.36%** Risk Free Rate
  - **2.00%** Inflation Premium
  - **1.00%** Default Risk Premium
  - **1.50%** Liquidity Premium
  - **1.50%** Maturity Premium

Stakeholder Roles

Producers - Lease metals to OEMs.

OEMs - Manufacture EV charging stations.

Financiers - Initial invested capital for leasing requirem -ents and capital risk coverage

Recyclers - EoL Metal recovery

Capital Structure and Risk

Total CapEx for Producer - $77,616 ($9,702/tonne x 8 tonnes)

Financing components - Green Bonds, Equity, Grants, etc.

Downstream repayment source - Electric Vehicle charging fees used to pay Copper leasing fees.

Risk mitigation - Hedging for price volatility, third party tracking and auditing, End of Life (EoL) tracking, Insurance, etc.

KPIs - NPV, Utilization rate, EoL Recovery rate, etc.

Timeline

1. **0-3 Months:** Metal sourcing
2. **4-12 Months:** Charger production
3. **2-9 years :** Operations
4. **10th year:** Metal recovery

Source: McKinsey, Can public EV fast-charging stations be profitable in the United States? International Copper Organization, Copper intensity in the electrification of transport and the integration of energy storage. Danlec UK, What is the lifespan of an EV charging station?

Exhibit 5b: Scenario model assumptions

Questions and Factors to Consider

With multiple outlooks towards how a MaaS model could work, a few questions to consider as food for thought:

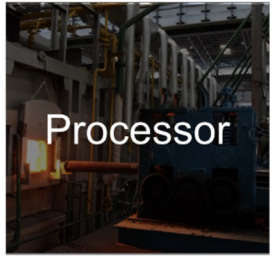
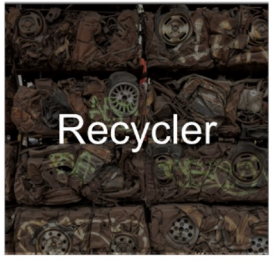
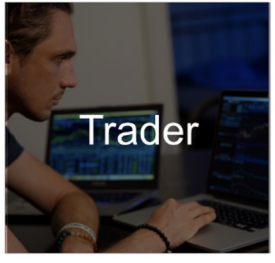
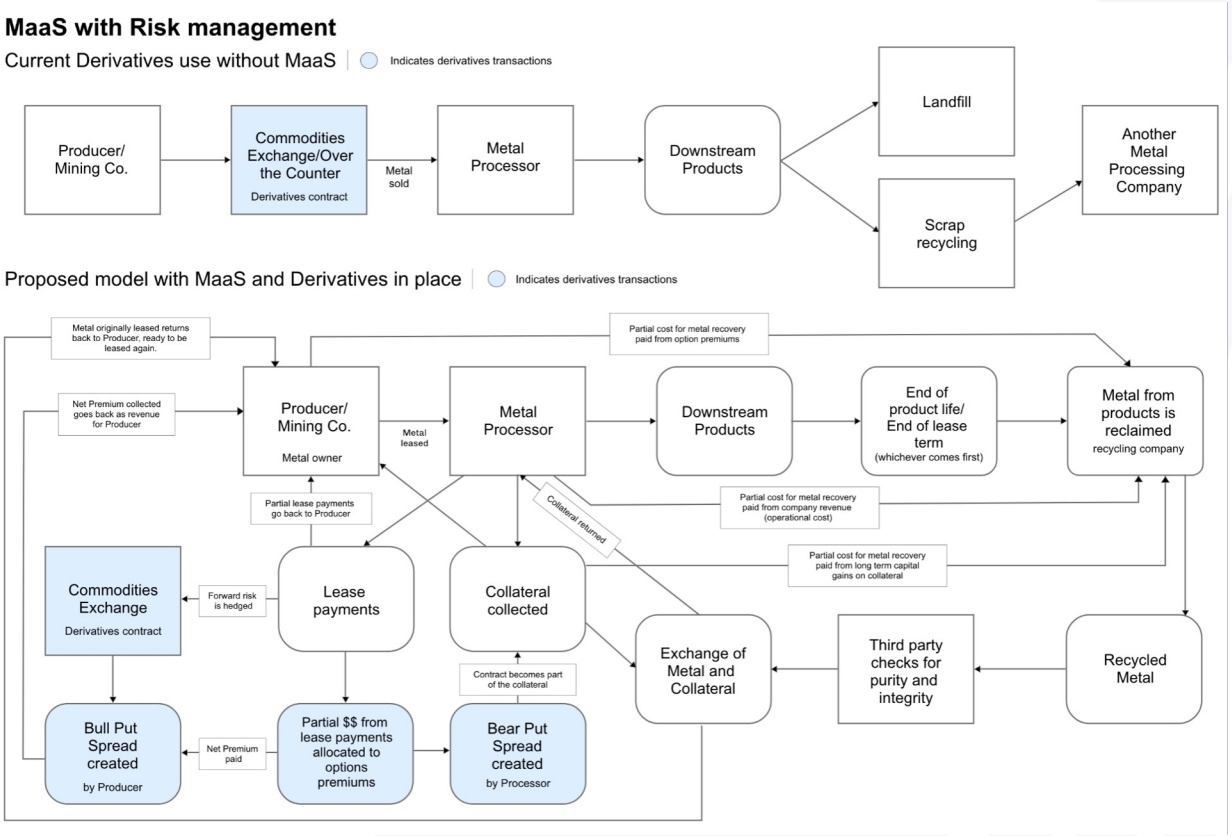
Miner	Processor	OEM	Recycler	Trader	Financier
					
How would MaaS impact capital expenditures and operational flexibility?	How would variability in metal quality and supply affect operating margins?	What are the financial impacts of leasing metals on product pricing and margins?	What tech advancements are needed to reduce the cost of metal recovery?	How would MaaS affect metal pricing, market efficiency, and volatility?	How does leasing affect return on capital employed and asset utilization for Producers?

Exhibit 5c: Use of a commodity option contract alongside MaaS for risk management

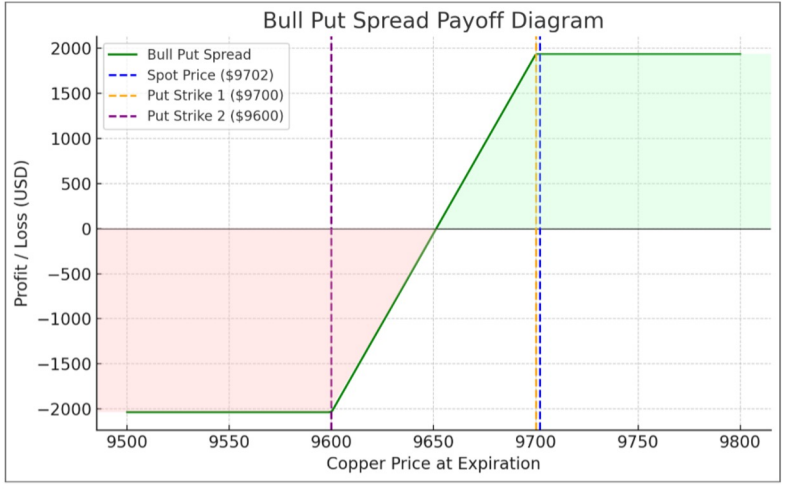
- The existing use of derivatives by Producers to gain a hedge against commodity price fluctuations and volatility can be easily incorporated into a MaaS framework.
- In the example shown, the producer hedges the forward risk (commodity price decrease) through a bull put spread, which is bought by the OEM (resulting in a bear put spread)
- The contracts bought by the OEM become a part of their collateral in the event of a default, further protecting the producer.

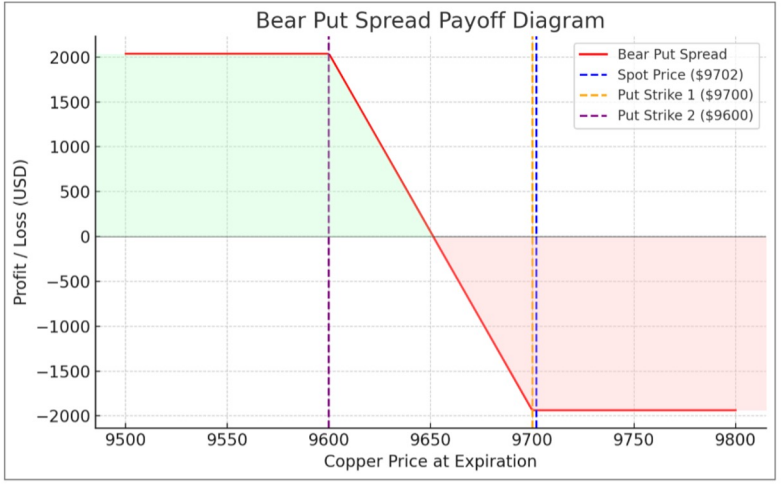


Sources: 1. FCX Form 10-K ending 31st December 2024
2. Mitsubishi Materials Integrated Report 2024

Exhibit 5d: Use of Commodity Option Contract alongside MaaS For Risk Management - Payoff structures

MaaS with Risk management - Payoff structures





Producer Side Payoff Calculations with LME Copper

If $S \leq K1$: Payoff = $-(K2 - K1) + P_{net}$ If $K1 < S < K2$: Payoff = $S - K2 + P_{net}$

If $S \geq K2$: Payoff = P_{net}

OEM side Payoff Calculations with LME Copper

If $S \leq K2$: $Payoff = (K1 - K2) - P_{net}$ If $K2 < S < K1$: $Payoff = (K1 - S) - P_{net}$

If $S \geq K1$: $Payoff = -P_{net}$

Abbreviations: S - Spot Price K1 - Higher Strike K2 - Lower Strike P_{net} - Net Premium Paid = $P(K1) - P(K2)$

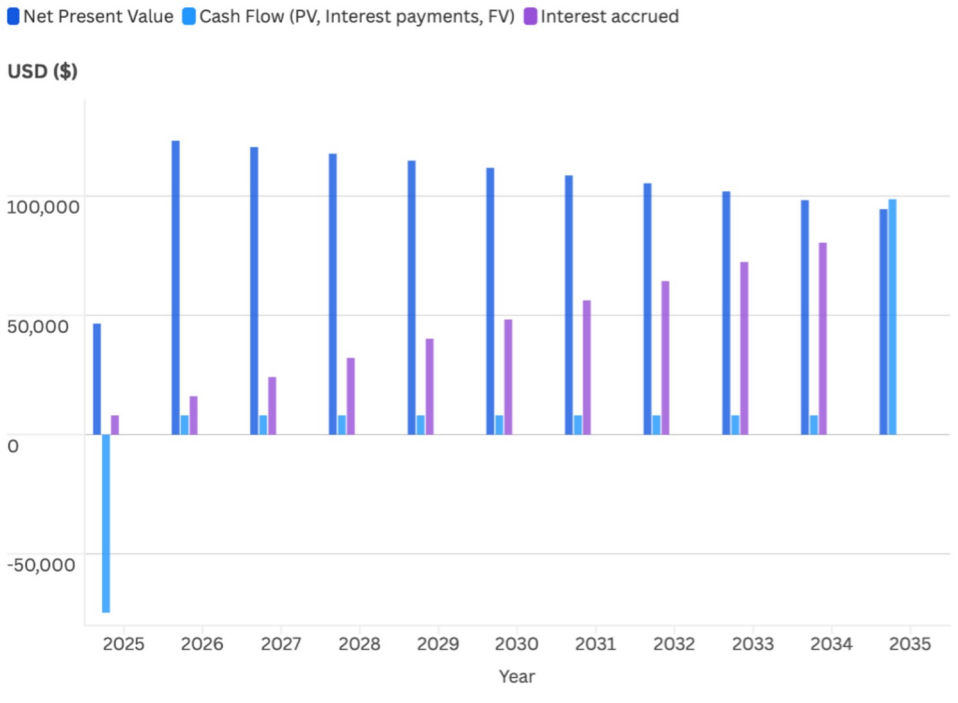
- The payoff for the Bull Put Spread is the inverse of that of a Bear Put Spread. In both cases, the upside and downside risks are limited, protecting the Producer and Miner from drastic fluctuations in the underlying assets.

Source: LME Copper Options Contract Specifications

Exhibit 5e: Bringing all together: Economic benefits for the copper producers - Projections

MaaS Projections (NPV & Cashflow)

Net Present Value (NPV) and Cashflow projections for the producer incorporating the MaaS framework.



Abbreviations: PV - Present Value of Copper leased, FV - Future Value of Copper leased

Value of Copper Loaned	Total Interest Accrued	Recovery Cost
$77,616	$80,410	$29,394

Traditional Model

- One time sale of $77,616
- No upside metal appreciation captured
- All value received upfront, suceptible to inflationary risk
- No value captured from recycling or future use
- Risk management through derivatives is often a liability
- Dependency to exploit new mines, which has an extremely high CapEx

Opportunity Cost without MaaS

Future Value of Maas Contract	Net premium collected from option spread	Internal Rate of Return (%)
$139,657	$1,936	11.76%

Source: 1. U.S Federal Reserve, Market Yield on U.S Treasuries
2. LME Copper
3. Fortune, Copper is the New Oil
4. Reuters, China's copper smelters win better-than-expected $0 processing fee from Antofagasta

Exhibit 6a: Thoughts on policy and legal enablers

Legal ownership and use rights frameworks

- Clear rules for retained ownership of metals by producers and usage rights for different customers, across multiple life cycles.
- Adapt property law or leasing statutes to accommodate multi-life, circular assets

Evolution of Extended Producer Responsibility (EPR) frameworks

- Move beyond end-of-life obligations: adapt EPR frameworks to actively support producer ownership, material recovery, and circular service contracts.

Standards & certifications for quality and traceability

- Digital product passports and international standards (including contracts) to guarantee quality, track use history, and facilitate secondary markets for reused metal.
- Harmonization across borders to minimize regulatory conflict.

Contractual innovation

- Legal contracts suited for multi-party MaaS contracts (long value chains).
- Contracts for material flows designed by a neutral party (stocks or EPR schemes).

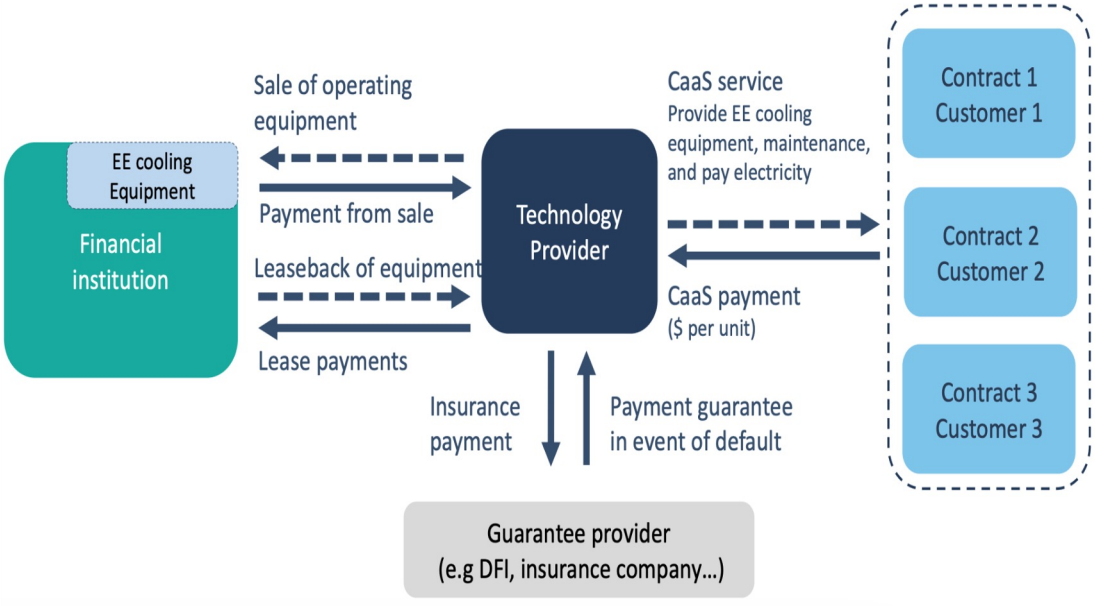
Fiscal regimes

- Create fiscal incentives for servitization (tax benefits for leasing models).

Industrial policy and public procurement

- Promote policies that prioritize durability, reusability, and lower total lifecycle costs in critical mineral value chains.
- Use government procurement to stimulate early MaaS markets.

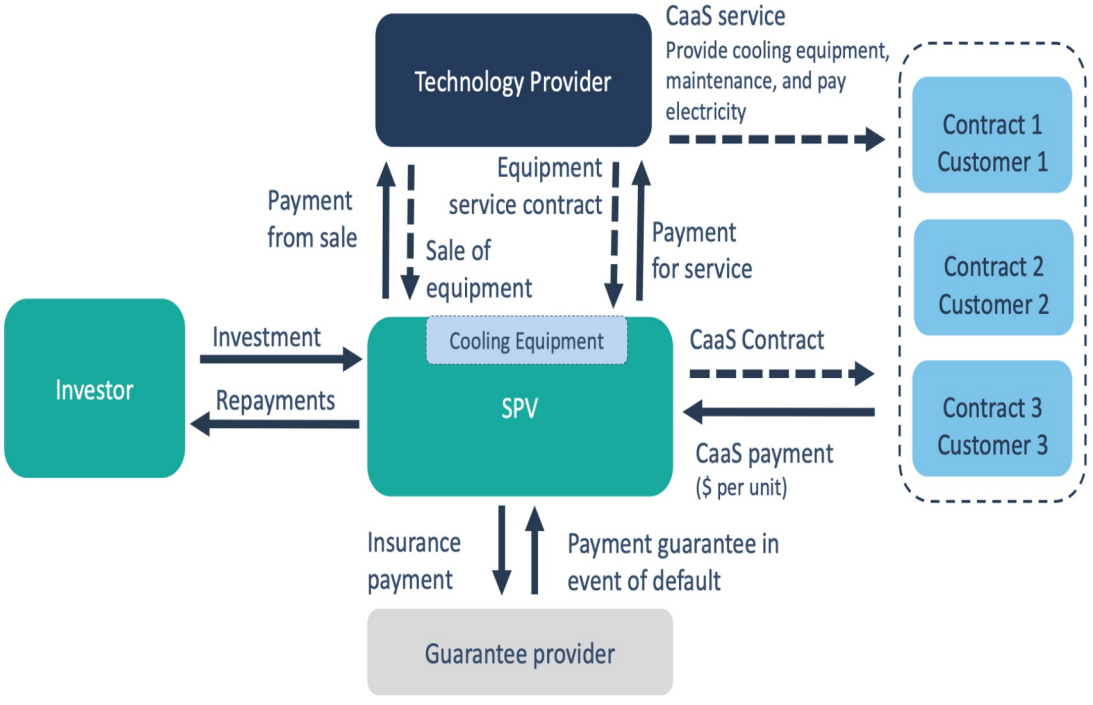
Exhibit 7a: Recapitalization Structure - sale and lease back
Example of Cooling as-a-Service model



- Upfront cash injection into providers
  - Selling the energy-efficient equipment to the FI and receive use right through lease back
- Financial institutions can get the CaaS contract as collateral as well
- Enables providers to derecognize the assets for B/S flexibility
- Guarantee providers can derisk the repayment and make financial institutions more willing to invest

source: https://www.caas-initiative.org/wp-content/uploads/2024/08/CaaS_SETAlliance_PPT.pdf

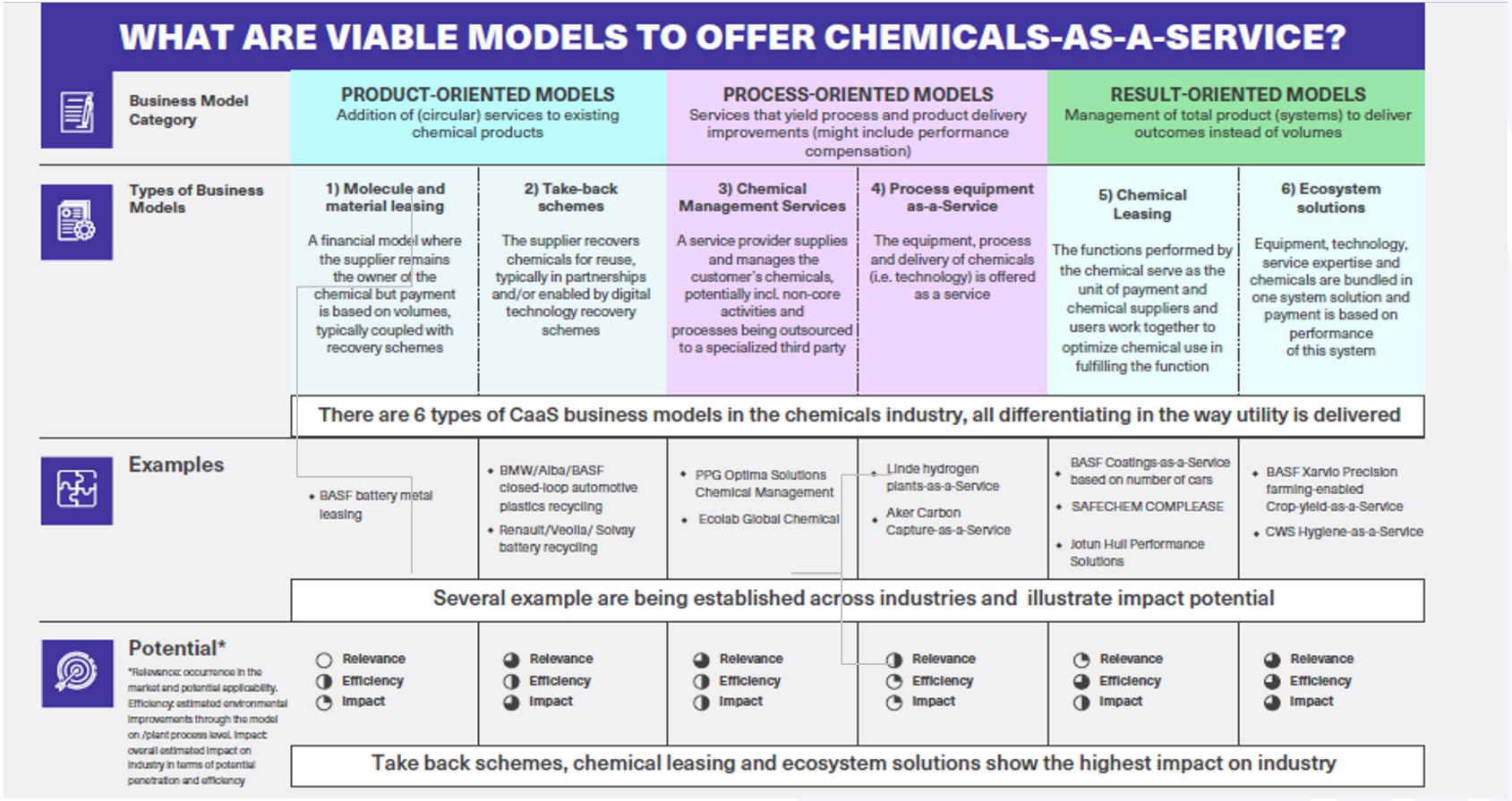
Exhibit 7b: Recapitalization Structure – SPV
Example of Cooling as-a-Service model



- Project Finance scheme
  - Enabling to attract third-party investors
- The SPV purchases the equipment from the technology provider and the SPV signs CaaS contracts with clients.
- Under an agreement between the SPV and the technology provider, the technology provider is responsible for the maintenance and operation of the equipment and payment of utilities.
- The technology provider does not own the equipment. **This enables the technology provider to derecognize the assets**

source: https://www.caas-initiative.org/wp-content/uploads/2024/08/CaaS_SETAlliance_PPT.pdf

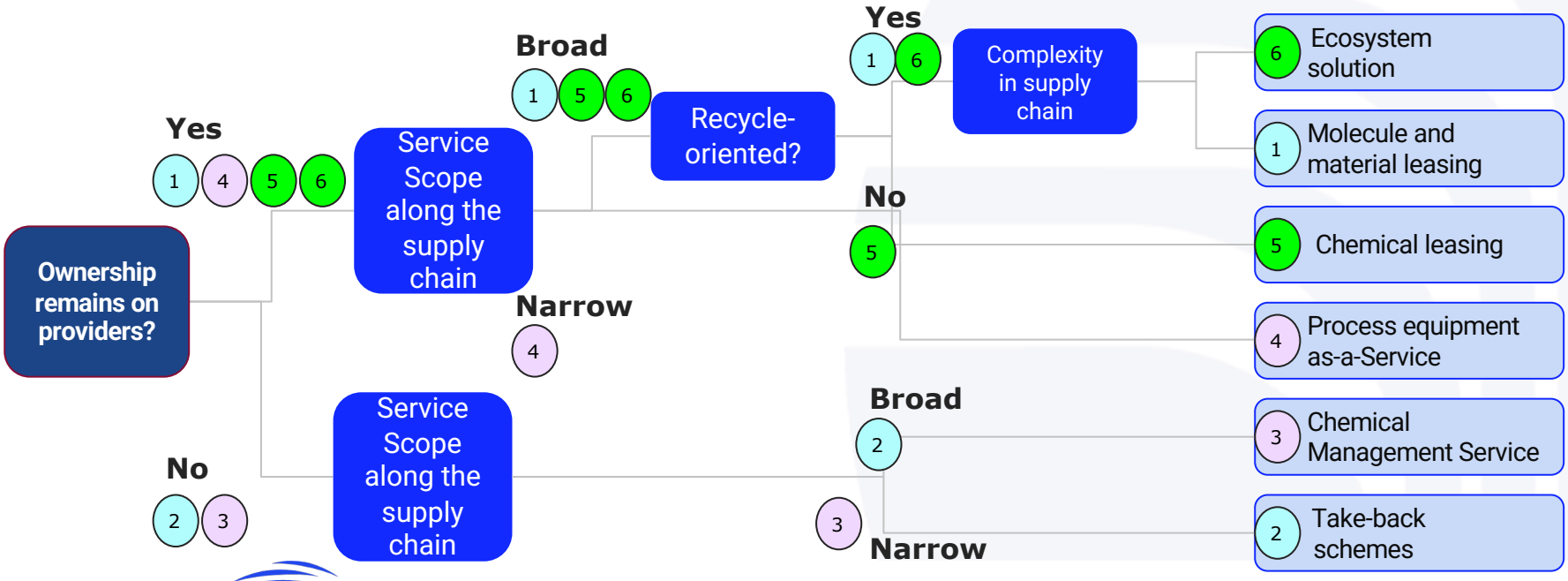
Exhibit 8a: Chemical as a service archetypes



Source: www.systemiq.earth/wp-content/uploads/2022/09/Main-report-v1.20-2.pdf

Exhibit 8b: Chemical as a service archetypes

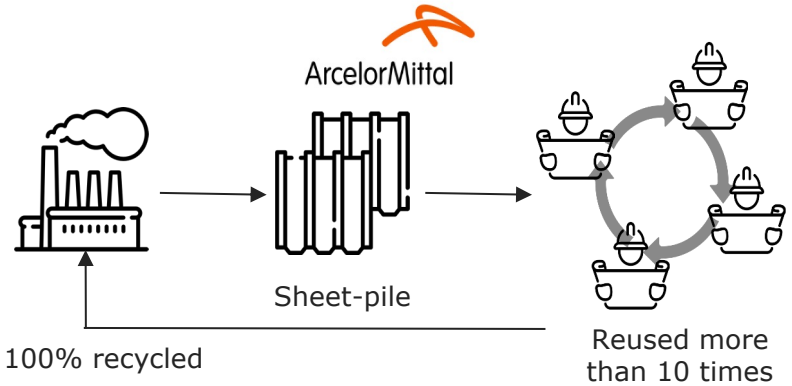
Business Model Category	PRODUCT-ORIENTED MODELS Addition of (circular) services to existing chemical products		PROCESS-ORIENTED MODELS Services that yield process and product delivery improvements (might include performance compensation)		RESULT-ORIENTED MODELS Management of total product (systems) to deliver outcomes instead of volumes	
Types of Business Models	**1) Molecule and material leasing** A financial model where the supplier remains the owner of the chemical but payment is based on volumes, typically coupled with recovery schemes	**2) Take-back schemes** The supplier recovers chemicals for reuse, typically in partnerships and/or enabled by digital technology recovery schemes	**3) Chemical Management Services** A service provider supplies and manages the customer's chemicals, potentially incl. non-core activities and processes being outsourced to a specialized third party	**4) Process equipment as-a-Service** The equipment, process and delivery of chemicals (i.e. technology) is offered as a service	**5) Chemical Leasing** The functions performed by the chemical serve as the unit of payment and chemical suppliers and users work together to optimize chemical use in fulfilling the function	**6) Ecosystem solutions** Equipment, technology, service expertise and chemicals are bundled in one system solution and payment is based on performance of this system



Source: www.systemiq.earth/wp-content/uploads/2022/09/Main-report-v1.20-2.pdf, CCSI Carbon Trust analysis

Exhibit 9a: Example of MaaS applied to construction

1. Steel Sheet-Pile Rental Model (ArcelorMittal) for temporary construction projects



	Pros	Cons
ArcelorMittal	• Secure closed loop supply chain - minimizing primary material uses	• Uncertain financial viability • Heavy technical support burden • Lack of regulatory incentives
	• Inventory optimization • Lower and stabilized upfront costs • Less carbon footprint	• Construction delay risks due to logistics and availability issue

Key learnings:

- Leasing model with limited fungibility can be less applicable to products with long lifespan and/or long supply chain (ex. cars, infrastructure)
- A stock of available products for leasing will be necessary to make the model financially viable
- Limited to local circularity due to quick turnaround and expected recovery to the manufacturing sites

Source: Steel sheet-pile rental model https://sheetpiling.arcelormittal.com/products-services/services/sheet-pile-rental-service
https://europe.arcelormittal.com/newsandmedia/europenews/news-2017/Rental-business-model-for-steel-sheet-piles

Exhibit 9b: Other example of MaaS

2. Base & Specialty Metals leasing model(Kilo Capital) - Finance, Supply and Pricing model

- Kilo Capital owns the metal, stores it at customers' location, and finances up to 100% of its commodity value
  - Customers have anytime access to the stock (≒ renting the products)
  - Make payment, including service fee, as they draw on the inventory(select inventory finance (SIF) model)
  - Transfers metal price risk to Kilo Capital
  - Help customers minimize the loss deriving from supply chain disruptions
- Offers fixed or variable pricing based on their preference
- Kilo can buy customers' metal inventory with the buy-back agreement when customers need
- Kilo enables borrowing against the metal inventory through a repo agreement: turns inventory into working capital

3. Aluminum tracking model with QR code(Norsk Hydro)

- Putting QR codes to products - enabling customers to verify the material composition, carbon footprint, and process history

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Source: Copper Leasing Model https://kilocapital.com/base-and-specialty-metals
Hydro products with QR code https://www.hydro.com/en/global/about-hydro/stories-by-hydro/the-certificates-of-hydros-greener-brands-feed-into-digital-product-passports/