BEING AHEAD

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CO_2ST: AN INTEGRATED PLATFORM FOR CONCURRENT COST ENGINEERING AND ENVIRONMENTAL IMPACT OPTIMIZATION

STC Company's vision of business development, considering current trends

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1. Introduction: The Paradigm Shift in Manufacturing Strategy

The manufacturing sector is at a pivotal juncture. A convergence of global challenges, including climate change, resource scarcity, and volatile energy markets, is forcing companies to fundamentally reassess their operational strategies. What was once a neatly divided landscape—with cost engineering residing in one domain and environmental sustainability in another—has evolved into a complex, intertwined matrix of responsibilities and performance metrics. Organizations can no longer afford to pursue cost optimization and environmental goals in isolation.

This shift is not merely philosophical but deeply structural. It redefines how design choices, sourcing decisions, and production methods are evaluated. Decision-making frameworks that once prioritized lowest unit cost must now incorporate lifecycle environmental costs, including embedded carbon, end-of-life recovery potential and upstream energy intensity. Consequently, firms require integrated tools that facilitate concurrent evaluations across economic and environmental axes.

STC S.r.l. has responded to this systemic transformation by developing CO_2ST, an advanced digital platform that unifies Should Cost analysis with Life Cycle Assessment (LCA) under a single computational framework. More than a software suite, CO_2ST represents a paradigm shift in product engineering and strategic sourcing. It equips cross-functional teams with the ability to make informed decisions that optimize both cost-efficiency and environmental footprint in a single, dynamic environment. By fusing these two disciplines, CO_2ST lays the groundwork for a new era of eco-intelligent manufacturing.

2. The Strategic Context: Regulatory and Market Drivers

The acceleration of environmental regulation and the evolution of market expectations form the dual engine driving the need for integrated platforms like CO_2ST. Regulatory instruments across Europe and beyond are not merely increasing in volume but are becoming significantly more granular and punitive. The **European Green Deal** commits to net-zero greenhouse gas emissions by 2050, with intermediate targets like the **Fit for 55** packages requiring a 55% reduction in emissions by 2030.

Beyond headline targets, a constellation of sector-specific policies is shaping the new compliance landscape. The Corporate Sustainability Reporting Directive (CSRD) obliges large companies to disclose standardized, verifiable environmental metrics. The EU Taxonomy defines what constitutes "environmentally sustainable activities," directly influencing investment flows and procurement decisions. The Carbon Border Adjustment Mechanism (CBAM), meanwhile, imposes a carbon price on imports, effectively internalizing environmental externalities into financial cost structures.

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Market forces are equally catalytic. Supply chain transparency is becoming a prerequisite for customer trust and business-to-business partnerships. Original Equipment Manufacturers (OEMs) are incorporating Scope 3 emissions into supplier scorecards. Retail consumers increasingly expect product-level environmental declarations. Institutional investors, under pressure from ESG mandates, are scrutinizing corporate carbon intensity as a proxy for long-term risk exposure.
Amid these transformations, CO_2ST functions not merely as a compliance tool but as a strategic asset, enabling firms to quantify, model, and optimize the environmental and economic trade-offs that define competitive advantage in a decarbonized economy.

3. CO_2ST Architecture: From Fragmented Data to Digital Cohesion

At the heart of CO_2ST is an architectural design that embodies the principles of interoperability, modularity, and semantic consistency. The platform acts as a digital twin ecosystem, integrating diverse datasets into a coherent and manipulable representation of products, processes, and supply chains.

CO_2ST utilizes a relational and object-oriented data model capable of representing hierarchical product structures (multi-level BOMs), manufacturing routings, facility-specific process characteristics and logistic pathways. Each digital object within the platform – from raw material nodes to assembly operations – is annotated with rich metadata encompassing unit costs, energy consumption, GHG emissions, resource utilization rates and waste streams.
This design philosophy allows for dual-view modeling: users can seamlessly toggle between economic and environmental dimensions of the same object without duplicating effort or compromising data fidelity. Furthermore, CO_2ST supports RESTful APIs and adheres to ISO-compliant data exchange formats (e.g., ISO 10303-21 STEP, EN 15978 for building materials, and ILCD+EPD standards for impact modeling), ensuring compatibility with enterprise systems such as CAD, PLM, ERP, and MES platforms.
In practice, this means that a change in a CAD model – for instance, replacing a component material – can trigger a cascade of cost and carbon recalculations within CO_2ST, reflecting not only the new material price but its upstream emissions profile, processing energy demands, and transportation implications. The result is a living digital model that supports rapid iteration, scenario testing, and cross-disciplinary collaboration.

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4. Integrating Should Cost Analysis and Environmental Accounting

The analytical engines within CO_2ST are designed to perform simultaneous evaluations of cost and environmental impact, supporting multi-criteria decision analysis (MCDA) frameworks.
Should Cost analysis is underpinned by a hybrid methodology that integrates:

- **Bottom-up modeling**, using granular inputs such as machining parameters, tooling lifecycle, labor content, facility overheads, and secondary processes.
- **Parametric costing**, leveraging mathematical functions to estimate cost based on key geometric or performance variables.
- **Benchmarking datasets**, allowing alignment against best-in-class industry standards or supplier quotations.

In parallel, the environmental accounting engine adheres to **ISO 14040** for LCA and includes impact categories from recognized methodologies such as ReCiPe 2016, TRACI and ILCD. Users can configure system boundaries – cradle-to-gate, gate-to-grave, gate-to-gate or cradle-to-grave – depending on the decision context. Impact results include not only **Global Warming Potential (GWP)** but also metrics like **Cumulative Energy Demand (CED)**, **Photochemical Ozone Creation Potential (POCP)** and **Abiotic Depletion (ADP)**.
The true innovation of CO_2ST lies in its **bidirectional optimization capabilities**. The system can model how cost reductions impact environmental performance, and vice versa. For example, choosing a cheaper alloy might increase machining time, thus raising energy use and CO_2 emissions. Conversely, investing in advanced forming technology could reduce both scrap rates and electricity consumption. CO_2ST allows for **sensitivity analysis** and **trade-off visualization** in real time, enabling engineers and buyers to converge on solutions that are optimal across multiple objectives.

5. Practical Applications and Industry Use Cases

CO_2ST has been deployed across a wide spectrum of industrial sectors, serving as a decision-support system for design engineers, cost analysts, and sustainability officers. Its capability to simulate manufacturing scenarios and evaluate trade-offs between financial and environmental outcomes lends itself to a multitude of practical use cases.
In the **automotive sector**, CO_2ST has been instrumental in light-weighting and material substitution initiatives. For instance, in a redesign of an internal combustion engine bracket, CO_2ST enabled a comparative analysis between machined aluminium and die-cast magnesium. While the latter incurred higher material costs, it significantly reduced processing energy and mass, thus lowering the vehicle's lifecycle carbon footprint. Using the platform's lifecycle scenario engine, it was

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demonstrated that over a 200,000 km driving horizon, the lighter component resulted in net CO_2 savings despite the initial cost premium.
In **consumer electronics**, where procurement is global and margins are razor-thin, CO_2ST allows sourcing teams to validate supplier quotations by reverse-engineering production costs and embedded emissions. For example, electronics manufacturer used CO_2ST to audit PCB suppliers in Southeast Asia, uncovering inconsistent energy intensities across production lines. This led to the renegotiation of contract terms and the rerouting of procurement to facilities powered by renewable electricity, achieving a 40% reduction in Scope 3 emissions with no net cost increase.
Within **fast-moving consumer goods (FMCG)**, CO_2ST has been employed to quantify the economic and environmental implications of packaging innovations. A notable application involved replacing conventional PET bottles with bio-based alternatives. Using CO_2ST's mass-flow modeling and end-of-life modules, the firm demonstrated a 23% GHG emissions reduction and a slight cost increase, offset by improved brand perception and market differentiation.
These examples illustrate CO_2ST 's versatility across sectors and its role in enabling evidence-based, multi-objective optimization in real-world decision environments.

6. Data Infrastructure and Analytical Engines
CO_2ST 's analytical prowess is underpinned by a high-fidelity data infrastructure, architected to ingest, normalize and process heterogeneous data from multiple tiers of the product ecosystem. Its environmental impact calculations are powered by deeply integrated libraries such as Ecoinvent v3.11, GaBi Databases and the EU PEF library, all of which are continuously updated to reflect evolving scientific consensus and regional parameters.
The cost estimation engine is built on a multi-layered schema capable of accommodating:

- Direct costs: materials, labor and machine time.
- Indirect costs: facility overheads, quality assurance, logistics.
- Dynamic costs: energy pricing volatility, carbon pricing and tax incentives.

CO_2ST enables bottom-up cost modeling from time-driven activity-based costing at the work-center level and augments this with AI-enhanced regression tools for rapid estimation. This hybrid mechanism allows for precise costing at both the concept phase and RFQ stage.
Environmental modules incorporate geospatial granularity, differentiating energy mixes and process efficiencies by region. For instance, producing steel in Poland versus Sweden can yield a

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twofold difference in GHG emissions due to energy source variance - CO_2ST accounts for this automatically.
Crucially, users can upload custom process models and supplier-specific data, ensuring that analyses reflect actual, not generic, conditions. This makes CO_2ST not just a tool for design, but a platform for continuous performance benchmarking and supplier development.

7. Strategic Implications and Competitive Advantage

In a landscape where both regulators and consumers are demanding transparency, traceability, and accountability, CO_2ST provides a strategic instrument for differentiation and resilience. It allows companies to:

- Proactively comply with CSRD, PEF, and CBAM.
- Justify pricing through verified cost-carbon metrics.
- Reduce supplier dependency by improving sourcing intelligence.
- Elevate brand value by substantiating sustainability claims.

Moreover, CO_2ST fosters **systemic innovation** by enabling design teams to evaluate alternative architectures such as modularity, remanufacturability and material circularity, with quantitative backing. This opens pathways to new business models such as product-as-a-service (PaaS) and closed-loop logistics.As industries converge toward net-zero commitments, the ability to optimize simultaneously for cost and carbon will distinguish leaders from laggards. CO_2ST situates its users on the leading edge of this transformation.

8. Conclusion: Engineering the Future with Purpose

The future of industrial competitiveness will be defined not only by how efficiently companies produce goods, but by how intelligently they align performance, cost and planetary boundaries. CO_2ST enables this alignment.
It is not merely a digital tool but a strategic enabler that embeds environmental intelligence into the DNA of product development and supply chain management. By providing an integrated platform for Should Cost analysis and environmental accounting, CO_2ST empowers organizations to navigate complexity with confidence, rigor and purpose.
In a world where sustainability is no longer an option but a mandate, CO_2ST is more than a response, it is a proactive instrument of transformation. It equips companies not just to comply with regulations but to thrive in a climate-constrained economy. In doing so, it heralds a new industrial age, one where excellence is defined by eco-efficiency, innovation and long-term value creation.

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