M MESSAI·IO

A WHITE PAPER FOR INVESTORS · VERSION 1.0 · APRIL 2026

Unlocking the Bioelectrochemical Economy.

The first AI-powered data infrastructure platform purpose-built for microbial electrochemical systems — the operating system for an entire emerging industry.

MESSAI.IO
FOUNDED 2025 · OPERATIONAL

10,018 + PAPERS | 687 + PARAMETERS | 42 RESEARCH GAPS

ISMET EU 2026 · TOULOUSE

Pre-Seed / Seed
INVESTOR COMMUNICATION
MESSAI.IO

LETTER FROM THE FOUNDER

A six-year wait, by design.

To prospective investors,

In 2019, I learned that microorganisms growing on conductive surfaces could generate electricity from wastewater, produce hydrogen from organic waste, and synthesize valuable chemicals from carbon dioxide. I learned that these microbial electrochemical systems could, in principle, transform the economics of clean water, renewable energy, and sustainable chemistry simultaneously. I was smitten — not just with the elegance of the science, but with the sheer scope of what it could solve.

I also learned why it hadn't solved those problems yet.

The research was scattered across more than ten thousand papers in hundreds of journals. Experimental results were reported in incompatible formats, with critical parameters missing or buried in supplementary files. Researchers in São Paulo were repeating work done in Beijing because they never found the paper, or found it but couldn't compare the data. The field didn't have a science problem. **It had an information infrastructure problem.**

I recognized it immediately because building information infrastructure is what I've spent my career doing — from behavioral health to agricultural technology to circular construction to biodiversity monitoring to humanitarian response. Every role sharpened the same conviction: that the most leveraged thing you can build is the infrastructure that lets an entire community work from shared, structured, accessible truth.

I knew by 2019 that MES needed exactly this. I also knew the technology to build it didn't yet exist. The AI models available at the time couldn't reliably extract quantitative parameters from the messy, heterogeneous text of scientific papers — not at the accuracy or cost that a real platform would require. So I did something that felt counterintuitive for someone obsessed with a problem: *I waited*. I studied the field deeply. I mapped its data landscape, its institutional players, its commercial trajectories, and its failure modes. And when the models finally matured to the point where I could build what I'd been designing in my head for years, I built it.

I knew I hadn't hit a dead end when, during my Master of Science in Sustainability at the City College of New York, I went searching for expertise on microbial electrochemical systems and none of the faculty in the architecture school could help me. They pointed me to the bioprocess engineering department. That's where I met **Dr. Lane Gilchrist**, who now serves as our Chief Scientific Officer. Standing in a department that had nothing to do with my degree program, talking to a scientist whose training was entirely different from mine, I realized something that has only become clearer with time: the fact that I am not a bioelectrochemist — not a biologist, not an electrical engineer, not a chemist — is not a liability. It is precisely what made this vision possible. A domain expert sees the next experiment. I saw the missing platform. MESSAI.IO lives in the gap between disciplines, by design.

The platform is now operational. We have ingested and enhanced over **10,018 research papers**. We have extracted and structured **687+ parameters** into the only queryable database of its kind. Our AI has identified **42 critical research gaps** that the field's own practitioners hadn't systematically mapped. We have built a functional 3D modeling laboratory and an economics calculator for techno-economic analysis. We are presenting at ISMET EU 2026 in Toulouse — the premier international conference for this community — and engaging directly with the researchers, engineers, and industry leaders who will drive adoption.

> *When I imagine what success looks like, it is not an abstraction. It is a world where there is finally a reliable, evidence-based way to validate what works in these extraordinarily complex systems — and a world where microbial electrochemical technology is understood not as an obscure corner of academic research but as a foundational paradigm shift in sustainable development.*

I have spent six years preparing to build this company and I intend to spend the next decade making it indispensable. The opportunity ahead of us — to become the operating system for an entire class of technologies that the world urgently needs — is vast, and it is ours to define. No one else has the data, the domain knowledge, the platform, or the head start.

I invite you to examine the evidence in this paper and consider what it means to invest at the ground floor of the infrastructure layer for the bioelectrochemical economy.

Sam Frons

FOUNDER & CEO · MESSAI.IO · APRIL 2026

CONTENTS

What this paper covers.

EXECUTIVE SUMMARY

The investment thesis.

$600B	10K+	687+	42
TAM — COMBINED	PAPERS INGESTED	PARAMETERS STRUCTURED	AI-MAPPED RESEARCH GAPS

Microbial electrochemical systems (MES) use living microorganisms to catalyze electrochemical reactions — generating electricity from wastewater, producing hydrogen and valuable chemicals from CO_2, and creating self-powered biosensors. The end markets MES address — wastewater treatment, green hydrogen, biochemical production, environmental monitoring — collectively exceed $600 billion and are undergoing simultaneous regulatory disruption and digital transformation.

Despite over 10,000 published research papers and two decades of laboratory validation, MES technologies have not achieved commercial scale. **The bottleneck is not the science.** It is the absence of data infrastructure: fragmented experimental results, non-standardized reporting, no shared parameter databases, no predictive modeling tools, and no systematic way to translate laboratory findings into engineered systems. This is the same infrastructure gap that held back drug discovery before Schrödinger, synthetic biology before Benchling, and materials science before the Materials Project.

MESSAI.IO fills this gap. It is the first and only AI-powered data infrastructure purpose-built for microbial electrochemical systems — already operational with 10,018+ enhanced papers, 687+ extracted parameters, 42 AI-identified research gaps, a functional 3D modeling laboratory, and an economics calculator for techno-economic analysis. The AI prediction engine and multi-objective optimization module are in active development.

COMPARABLE PLATFORMS — THE PRECEDENT

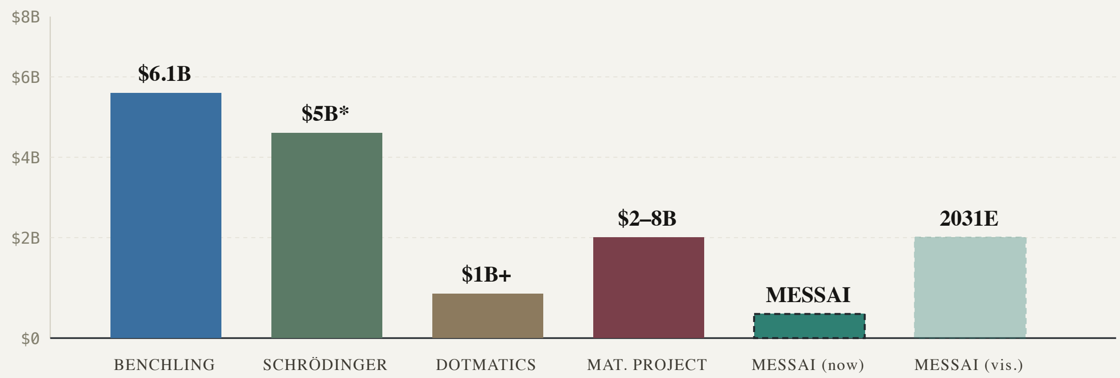

FIGURE 0·1 Precedents for domain-specific scientific data platforms. Benchling $6.1B (a16z Series F, 2021); Schrödinger NASDAQ:SDGR market cap range; Dotmatics acquired by Thermo Fisher 2023. MESSAI.IO occupies equivalent white space for environmental and microbial biotechnology. *Materials Project valuation indicative of platform impact rather than market cap.

WHY MESSAI.IO IS DEFENSIBLE

The business model is multi-tier SaaS: freemium researcher tier driving adoption and network effects, paid individual and lab-group subscriptions, enterprise licensing for water utilities and chemical companies, publisher partnerships, and data/API services. The SAM is conservatively estimated at **$500M – $1.5B within the decade**, situated within a broader environmental biotech digital transformation market exceeding $5B. Defensibility rests on four moats: a proprietary structured dataset that does not exist elsewhere, a domain-specific parameter ontology encoding expert knowledge, compounding data network effects, and deep community embeddedness through ISMET and direct researcher engagement.

PART I

The Opportunity.

Four converging forces. A $600 billion market locked behind a data gap. The arithmetic of TAM, SAM, and SOM for an emerging infrastructure platform.

CHAPTER 1

Why Now — Four Converging Forces

Timing is the most important variable in venture outcomes. MESSAI.IO's timing is driven by four forces converging simultaneously for the first time.

Force 1 · Regulatory tailwinds forcing technology adoption

The EU's 2024 revision of the Urban Wastewater Treatment Directive introduces binding energy-neutrality requirements for large treatment plants. The US EPA's tightening nutrient discharge limits combined with the $55B Infrastructure Investment and Jobs Act allocation, and China's 14th Five-Year Plan environmental targets, are creating both regulatory push and capital availability for new treatment technologies. Simultaneously, carbon pricing mechanisms (EU ETS, California cap-and-trade) are creating economic value for technologies that avoid GHG emissions from wastewater treatment — precisely what MES enable.

Force 2 · AI maturation enables small-data domain science

Foundation models, transfer learning, and few-shot learning mean predictive models can be trained effectively on datasets of thousands — not millions — of examples. NLP has advanced to the point where automated extraction of quantitative parameters from unstructured scientific text is reliable enough for production. Five years ago this extraction would have required manual curation at a pace and cost that made the platform economically unviable.

Force 3 · Water utility digital transformation creates pre-educated buyers

The global digital water market was ~$20B in 2023 and is projected to reach $40–50B by 2030 at 10–12% CAGR (Bluefield Research; GWI). Buyers — utility CTOs, consulting engineers, procurement — are already educated on AI-enabled infrastructure tools and have budgets for them. MESSAI does not need to convince them that AI adds value; only that MES is the next technology class to evaluate, and that MESSAI is the tool for doing so.

Force 4 · MES science has reached the scale-up inflection

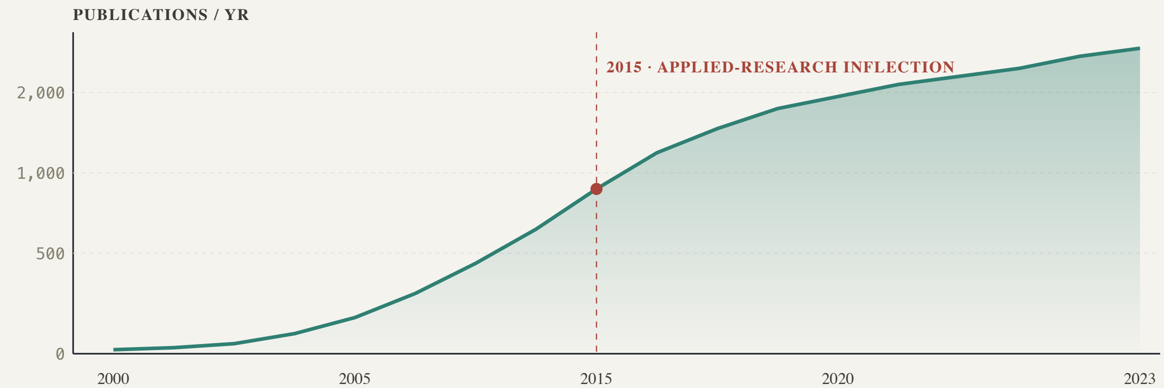

FIGURE 1·1 Annual MES-related publications, 2000–2023. From <100/yr in the early 2000s to >2,000/yr by the early 2020s (Web of Science; Scopus). After 2015, the literature shifts from foundational questions to applied: reactor optimization, long-term stability, integration with existing treatment trains, and pilot-scale demonstration. The bottleneck is no longer "does the science work?" but "how do we systematically optimize, de-risk, and scale?"

CHAPTER 2

A $600B market locked behind a data gap.

MES technologies span four families — **MFCs** (electricity from wastewater), **MECs** (hydrogen from organics + small voltage), **microbial electrosynthesis** (multi-carbon chemicals from CO_2), and **MDCs** (simultaneous wastewater treatment and brackish desalination). The end markets exceed $600B annually. Yet despite proven science and vast markets, MES has not crossed the commercialization threshold at meaningful scale. The reason is a systemic infrastructure deficit that manifests in four interlocking ways.

MANIFESTATION 1 · DATA FRAGMENTATION

Over 10,000 papers, but the experimental data within them is trapped in unstructured PDFs, scattered across hundreds of journals, and reported in inconsistent formats, units, and levels of detail. **No centralized, structured database of MES experimental results exists.** Answering even a simple comparative question takes weeks of manual tabulation and is prone to error and omission.

MANIFESTATION 2 · THE REPRODUCIBILITY CRISIS

MES experiments are notoriously difficult to reproduce. **Reported power densities for ostensibly similar MFC configurations vary by orders of magnitude** across studies (Ge et al., 2016), with much of the variation attributable to differences in unreported experimental conditions: electrode pretreatment, inoculum source and age, internal resistance measurement, temperature control, substrate composition.

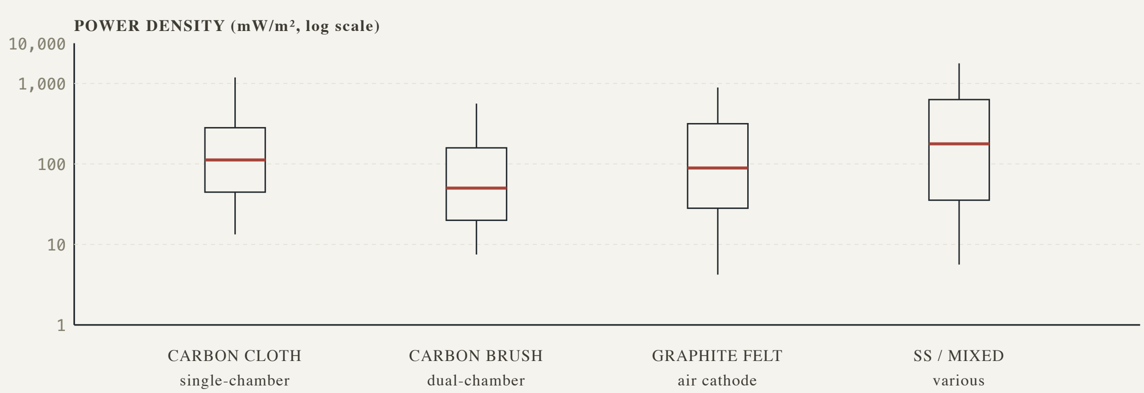

FIGURE 2·1 Reported power density across four common MFC anode configurations. Each box spans ~2–3 orders of magnitude within a single configuration class. Red bar = median. The corpus-wide coefficient of variation for power density is ~1,285%. Point estimates without context are scientifically meaningless — which is why MESSAI extracts and exposes the full distribution and its conditions.

MANIFESTATION 3 · ABSENCE OF PREDICTIVE TOOLS

Schrödinger enables drug-likeness prediction before synthesis. The Materials Project provides computed properties for 150,000+ inorganic materials. **No equivalent predictive infrastructure exists for MES.** Researchers design experiments from intuition and incomplete reviews rather than data-driven optimization.

MANIFESTATION 4 · THE VALLEY OF DEATH BETWEEN BENCH AND INDUSTRY

Industrial adoption requires reliable performance data at relevant scales, validated TEA, and risk-quantified specs. **The MES field produces none of these systematically.** ML-scale lab results cannot be reliably extrapolated to m^3 scale without intermediate modeling, and those modeling tools do not exist in a form accessible to the average researcher, let alone an industrial engineer.

These four problems compound. Fragmented data prevents systematic analysis. Lack of analysis prevents predictive modeling. Lack of prediction prevents rational scale-up. Failed scale-up discourages investment. Reduced investment slows the generation of the pilot-scale data that would enable better models. **It is a vicious cycle, and breaking it requires a platform-level intervention.**

CHAPTER 3

Market sizing — TAM, SAM, SOM.

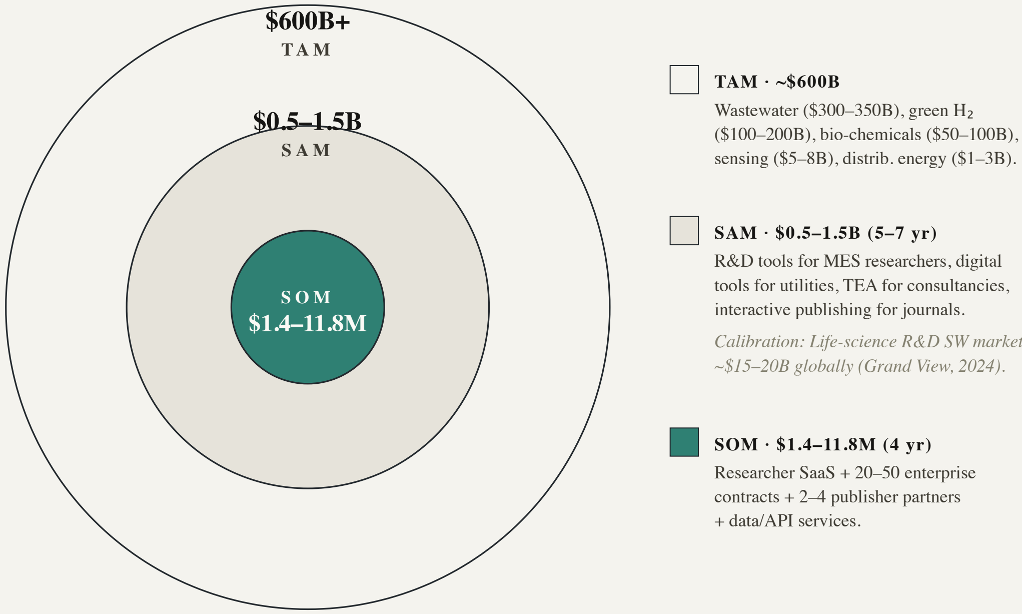

FIGURE 3·1 Market sizing arithmetic. TAM is presented for context, not as a capture claim. Platform companies create value as enablers, not operators — SOM is the realistic 4-year ARR target as the platform scales commercial operations.

SOM build-up by tier

TIER	TARGET CUSTOMERS (Y4)	ARPU / CONTRACT	ANNUAL REVENUE
Researcher SaaS (Tier 1)	500–1,000 paid subs	$1,200–4,800 / yr	$0.6–4.8M
Enterprise licensing (Tier 2)	20–50 customers	$25K–100K / yr	$0.5–5.0M
Publisher partnerships (Tier 3)	2–4 publishers	$50K–250K / yr	$0.1–1.0M
Data & API services (Tier 4)	Third-party developers	Usage-based	$0.2–1.0M
Total SOM (Y4 ARR)			**$1.4–11.8M**

Significant upside accrues as the platform expands into adjacent domains (conventional bioelectrochemistry, anaerobic digestion, general bioprocess engineering) and as MES commercialization accelerates over the medium term.

PART II

The Solution.

Four pillars — Explore, Build, Analyze, Learn — that turn a decade of scattered MES research into queryable, predictive, computationally tractable infrastructure.

Chapter 4
Platform deep dive — the four pillars

Chapter 5
Competitive landscape & the moat

CHAPTER 4

MESSAI.IO — platform deep dive.

MESSAI.IO provides an integrated suite spanning the full MES R&D workflow — literature discovery through system design, performance prediction, and techno-economic evaluation — organized around four functional pillars. Each pillar addresses a specific failure mode in the current process.

EXPLORE 01

10,018 PAPERS → KNOWLEDGE

Research Papers, Interactive Demos, Parameter Database, Parameter Correlations. Custom NLP pipeline extracts power densities, current densities, coulombic efficiencies, electrode materials, communities, substrates, and operating conditions into a 687-parameter ontology.

BUILD 02

CONCEPT → SYSTEM IN MINUTES

3D Laboratory (Three.js, in beta) for interactive reactor design — anode/cathode materials, membrane types, geometries, flow configurations — with real-time visual feedback. Parameter Sweep tool replaces costly trial-and-error.

ANALYZE 03

DATA → DECISIONS

AI Predictions (in development) with confidence intervals + sensitivity analysis, supplemented by physics-informed constraints. Economics Calculator for capex/opex, revenue from recovered products, and ROI across system designs and local conditions.

LEARN 04

BUILDING THE NEXT GENERATION

Comprehensive manual, explanatory content on MES mechanisms, application guides, sustainability assessments. Interactive integration with the 3D Laboratory and real research data differentiates from static textbooks and lectures.

The four-pillar architecture, end-to-end

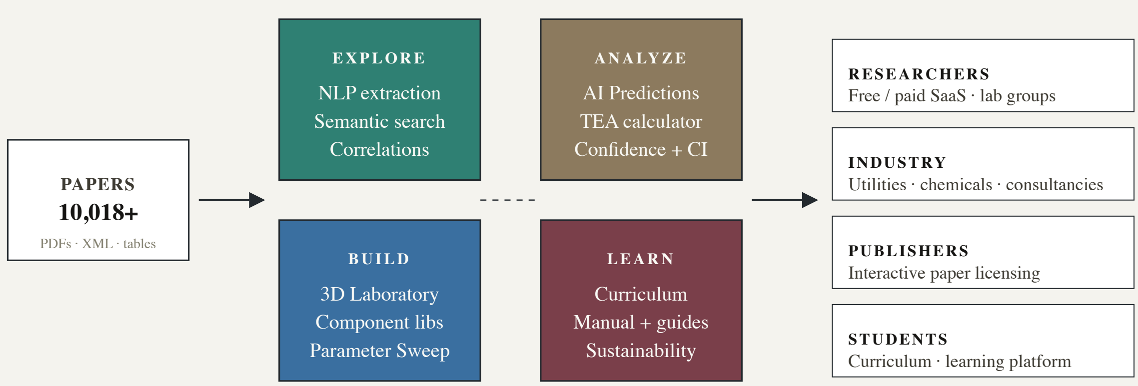

FIGURE 4·1 MESSAI.IO end-to-end. Raw heterogeneous research input is transformed by NLP extraction into a structured ontology, then surfaced through four pillars to four distinct user personas. Each persona has tailored interfaces and pricing.

THE 42 RESEARCH GAPS · AI AS STRATEGIC COMPASS

Analysis of topic distribution, density, and interconnections across the 10,018-paper corpus has identified **42 specific areas where the published literature is sparse relative to the topic's importance, where contradictions remain unresolved, or where intersections of subdisciplines have not been addressed**. These gaps are simultaneously a strategic roadmap for the field and for MESSAI.IO's own product development — each gap is a space where the platform's tools can create outsized value.

CHAPTER 5

Competitive landscape and the moat.

MESSAI.IO occupies a market position for which **no direct competitor currently exists**. The competitive landscape is therefore defined by adjacent platforms in different domains, generic tools that lack MES specificity, and the status quo of manual processes.

Adjacent platform comparison

PLATFORM	DOMAIN	MES COVERAGE	REFERENCE POINT
Benchling	Biotech R&D cloud	None	$6.1B (a16z F, 2021)
Schrödinger	Computational chemistry	None	$2–8B mkt cap
Materials Project	Inorganic materials	None	DOE-funded; 150K+ materials
CAS SciFinder	General chemistry literature	Generic search	$10–50K+/inst
Dotmatics	Life sciences informatics	None	$1B+ acq, Thermo Fisher 2023
MESSAI.IO	**MES · bioelectrochemistry**	**Purpose-built**	**White space**

The four moats

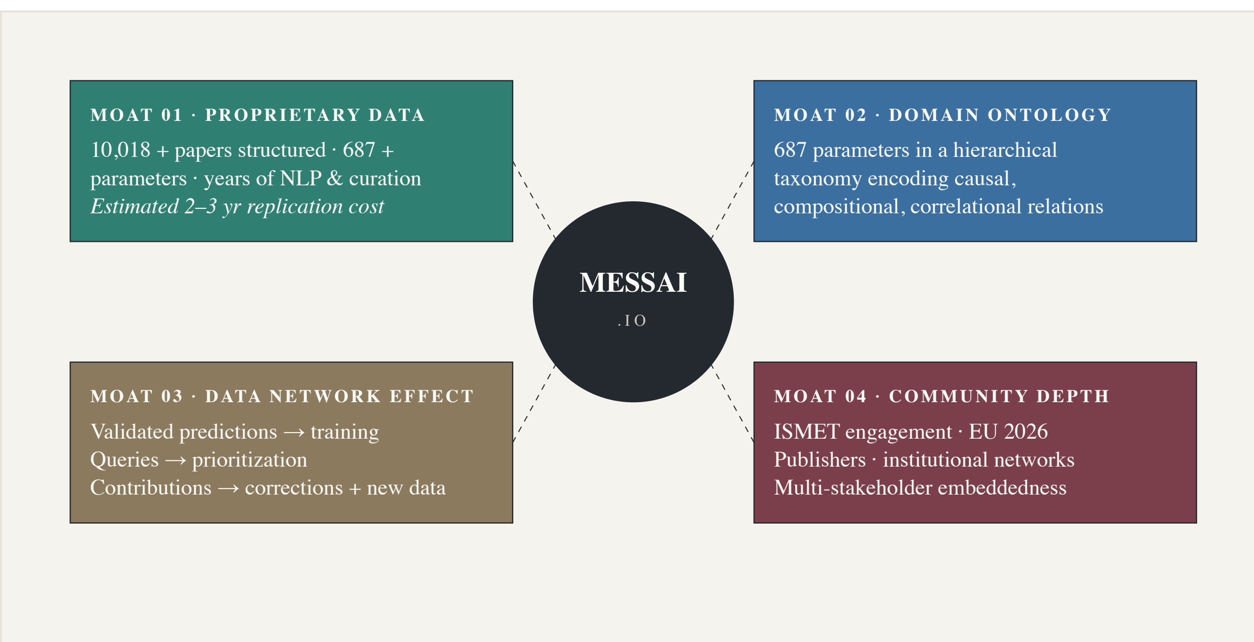

FIGURE 5·1 Four interlocking moats. Each independently raises the cost of replication; together they compound. The Materials Project required federal funding and a decade to build comparable infrastructure for inorganic materials — MESSAI's head start in MES would be similarly difficult to overcome.

Specific competitive threats — addressed

Could a major tech company (Google DeepMind, Microsoft Research, IBM) enter? In theory, yes. In practice, MES is too niche to attract organizations optimizing for billion-user products. Domain expertise — not compute — is the binding constraint, and MESSAI's team has it.

Could an existing water-tech company build an equivalent? Xylem (acquired Evoqua for ~$7.5B in 2023), Veolia (acquired Suez for ~€13B in 2022), and SUEZ deploy proven technologies at scale — they do not build research infrastructure for emerging classes. They are far more likely to become MESSAI enterprise customers or acquirers than competitors.

Could individual research groups build their own tools? They already try. Numerous one-off databases, models, and analysis scripts have been published in the MES literature. None have achieved sustained use beyond their originating lab — they lack the scale, maintenance, UX quality, cross-institutional data integration, and ongoing development that a platform company provides.

PART III

The Business.

Multi-tier SaaS, enterprise licensing, publisher partnerships, and data services — each tier reinforces the others, and every dollar of the raise maps to a milestone that de-risks Series A.

CHAPTER 6

Business model & revenue architecture.

MESSAI.IO's revenue model is multi-tier SaaS with additional streams from enterprise licensing, publisher partnerships, and data services. The model generates immediate value from the existing research user base while building toward higher-value enterprise and partnership revenue as MES technologies move toward commercial deployment.

TIER	CUSTOMER	PRICE (USD)	YEAR-4 REVENUE
Tier 1 · Freemium Researcher SaaS	Individual researchers, lab groups	\$19–49 / mo individual; \$199–499 / mo lab group	\$0.6–4.8M
Tier 2 · Enterprise Licensing	Water utilities, chemical co's, consultancies, MES startups	\$25K–100K+ / yr	\$0.5–5.0M
Tier 3 · Publisher Partnerships	Elsevier, Springer Nature, Wiley, ACS, RSC	\$50K–250K / yr / publisher	\$0.1–1.0M
Tier 4 · Data & API Services	Third-party developers, integrators	Usage-based / monthly tiers	\$0.2–1.0M

4-year revenue mix — base case

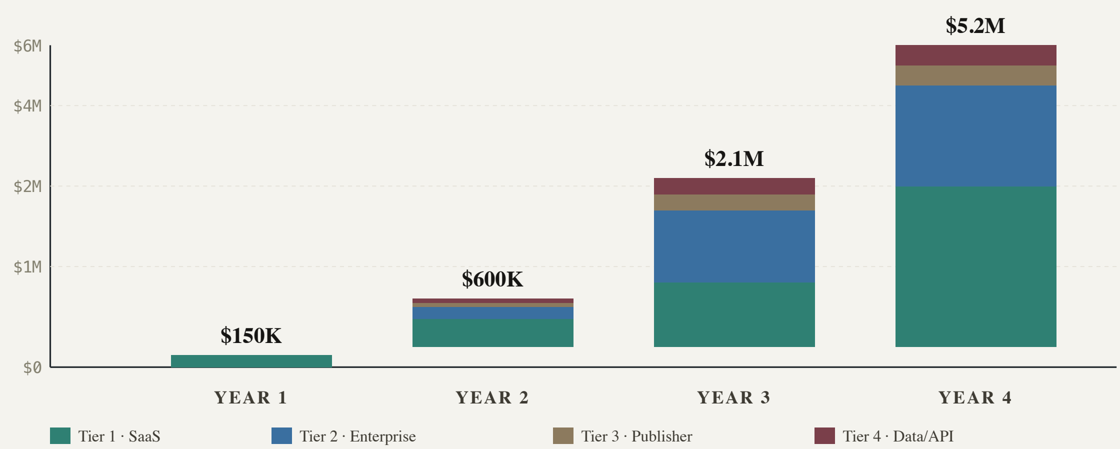

FIGURE 6·1 Stacked ARR projection through year 4 (base case). Tier 1 (researcher SaaS) drives early adoption and network effects; Tier 2 (enterprise) becomes the revenue engine as MES commercialization accelerates; Tiers 3–4 add high-margin, strategic revenue with long contract cycles.

Unit economics

Marginal cost of serving an additional user is near zero (cloud hosting scales sublinearly). Content acquisition costs are low (open access + publisher APIs; extraction amortized across the user base). Primary cost drivers are engineering talent, domain expertise, and go-to-market investment. **Gross margins for comparable SaaS platforms typically exceed 70–80%;** MESSAI projects similar margins post the initial development phase. Net revenue retention for well-executed research SaaS exceeds 110–120% via seat expansion and upsells (Benchling early trajectory, Overleaf/ShareLaTeX, Mendeley pre-Elsevier).

CHAPTER 7

Traction & milestones.

MESSAI.IO is not a concept or a prototype. The following capabilities are **live and operational** as of April 2026.

10,018+	687+	42	4
RESEARCH PAPERS · INGESTED	PARAMETERS · STRUCTURED	AI-IDENTIFIED GAPS	USER PERSONAS LIVE

The Research Papers module contains 10,018+ enhanced papers. The Parameter Database contains 687+ parameter types in a domain ontology. The 3D Laboratory (beta) provides Three.js–powered interactive reactor visualization and design. The Parameter Correlations tool enables cross-study statistical analysis. The Economics Calculator provides preliminary techno-economic analysis. Four personas — researchers, students, industry engineers, publishers — have tailored interfaces.

Community engagement

MESSAI.IO is actively engaging with the MES research community through **ISMET** (International Society for Microbial Electrochemistry and Technology). The platform will be presented at **ISMET EU 2026 in Toulouse**, providing direct exposure to the field's leading researchers, a forum for soliciting feedback and partnership interest, and visibility with ISMET's institutional membership — which includes the world's most active MES research groups. ISMET endorsement or adoption would be a transformative credibility signal.

Forward-looking milestone plan

MONTHS 1–6	Launch AI Predictions module with confidence scoring for MFC + MEC metrics. Onboard 5 enterprise pilot customers (paid pilots, defined evaluation criteria). Reach 1,000 registered platform users. Publish 1+ peer-reviewed paper demonstrating MESSAI-enabled discovery or meta-analysis.
MONTHS 7–12	Convert 3+ enterprise pilots to paid annual contracts. Reach 50,000 monthly platform queries. Launch public API (beta). Initiate conversations with 2+ scientific publishers re: interactive paper partnerships. Expand corpus to 15,000+ enhanced papers.
MONTHS 13–18	Sign first publisher partnership. Achieve profitability on researcher SaaS tier. Launch multi-objective optimization in AI Predictions. Begin adjacent-domain

expansion (anaerobic digestion, conventional bioelectrochemistry).

MONTHS 19–24	Reach **$1M ARR**. Demonstrate platform-driven discovery: a novel MES insight or design enabled by MESSAI that is validated experimentally and published. Begin Series A fundraising with demonstrated PMF, paying enterprise customers, and a clear growth trajectory.

CHAPTER 8

Team.

The founding team combines deep MES domain expertise with AI/ML engineering and platform product experience — the rare combination that constitutes both founder–market fit and a meaningful barrier to entry for potential competitors.

FOUNDER & CEO

Sam Frons · Information-infrastructure builder across behavioral health, agricultural technology, circular construction, biodiversity monitoring, and humanitarian response. Master of Science in Sustainability, City College of New York. Six-year self-directed study of the MES field's data landscape, institutional players, commercial trajectories, and failure modes — preparing the platform thesis before AI capabilities matured to support it.

CHIEF SCIENTIFIC OFFICER

Dr. Lane Gilchrist · Active faculty bioprocess engineer; long-standing collaborator. Provides the bench-side authority that anchors the parameter ontology, validates extractions, and grounds the platform's scientific direction. Bridges MESSAI to ISMET and the broader research community.

The advisory board is being assembled with recognized names from MES research (scientific credibility), the water technology industry (commercial insight, customer introductions), and the venture/startup ecosystem (fundraising experience, governance). A planned **VP of Sales** hire with water-sector or scientific-software enterprise sales experience, funded from the current raise, addresses the most explicit team gap. VCs respect founders who know what they don't know.

CHAPTER 9

Use of funds.

MESSAI.IO is raising seed/pre-Series A financing to fund 18–24 months of operations — from current operational state to demonstrated product–market fit, paying enterprise customers, and a revenue trajectory supporting Series A.

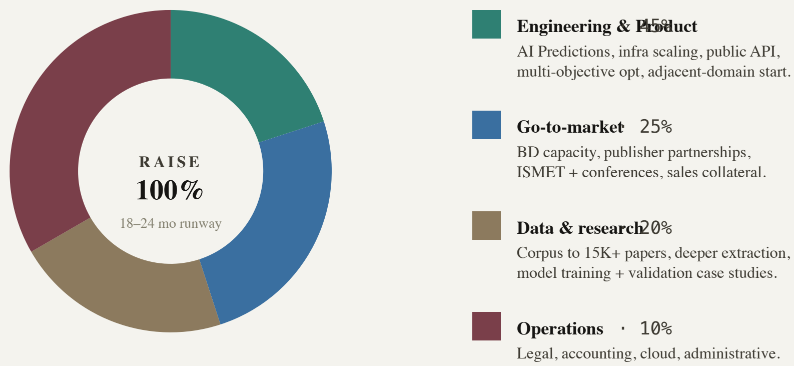

FIGURE 9·1 Use of funds allocation. Every dollar maps to a specific deliverable in the Chapter 7 milestone plan. The raise is sized to reach the milestones that de-risk Series A and demonstrate a clear path to product–market fit.

PART IV

The Technical Foundation.

The moat is not the model. The moat is the data, the ontology, and the validation infrastructure that turn a general-purpose language engine into a reliable scientific platform.

CHAPTER 10

Why AI changes the feasibility calculus for MES.

The MES field's data problem is not merely one of quantity but of **heterogeneity and structure**. The same physical quantity — power density — may be reported in mW/m^2, W/m^3, or mW/g, normalized to anode, cathode, membrane area, or reactor volume. Substrate concentrations as COD, BOD, or specific compound. Microbial communities at phylum, genus, or species level under different taxonomic nomenclatures.

This heterogeneity is why manual meta-analysis is so labor-intensive and why previous attempts to build MES databases have stalled. Recent advances in NLP, named entity recognition, relation extraction, and unit normalization have made it possible to automate the extraction and harmonization of this heterogeneous data at scale and at a cost that is commercially viable.

The extraction pipeline — five stages

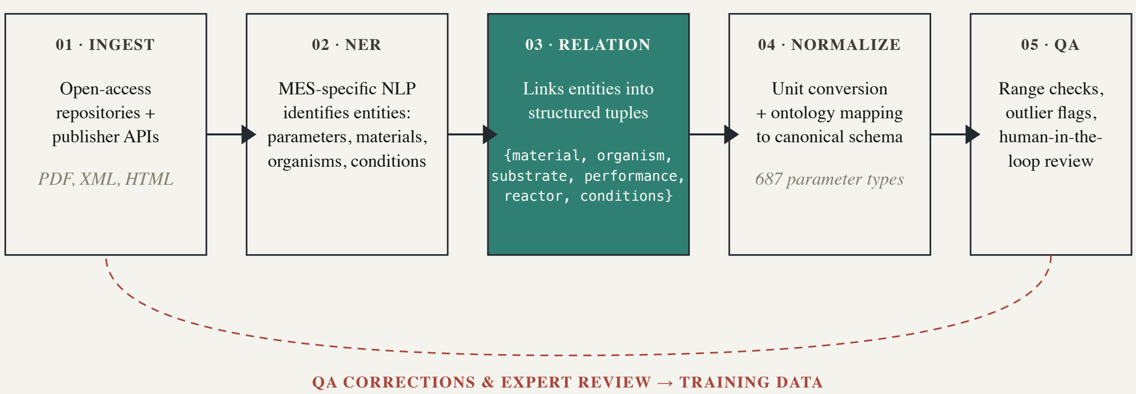

FIGURE 10·1 The MESSAI extraction pipeline. Every QA correction becomes a labeled training example. Over time, the validated corpus — not the foundation model — is the asset. The platform's ability to swap underlying foundation models without losing its ontology, validation logic, or expert-corrected ground truth is itself a moat.

THE MODEL VS. THE ALGORITHMS

The foundation model provides language comprehension as a service. **MESSAI's algorithms define what to comprehend, how to reason about it, what output structure to produce, how to validate it, and what to do with it once validated.** The model is stateless and general. The algorithms encode domain knowledge, quality standards, and product logic. Swap the foundation model tomorrow and the algorithms remain the same — you just get better raw extraction feeding into the same validation, structuring, and analysis pipelines. The moat is the data flywheel, not the model.

CHAPTER 11

The 42 research gaps — a strategic roadmap.

MESSAI's AI-driven analysis of the 10,018-paper corpus has identified 42 specific research gaps — areas where published knowledge is insufficient relative to the topic's importance for advancing the field toward commercial deployment. The gaps cluster into four thematic categories.

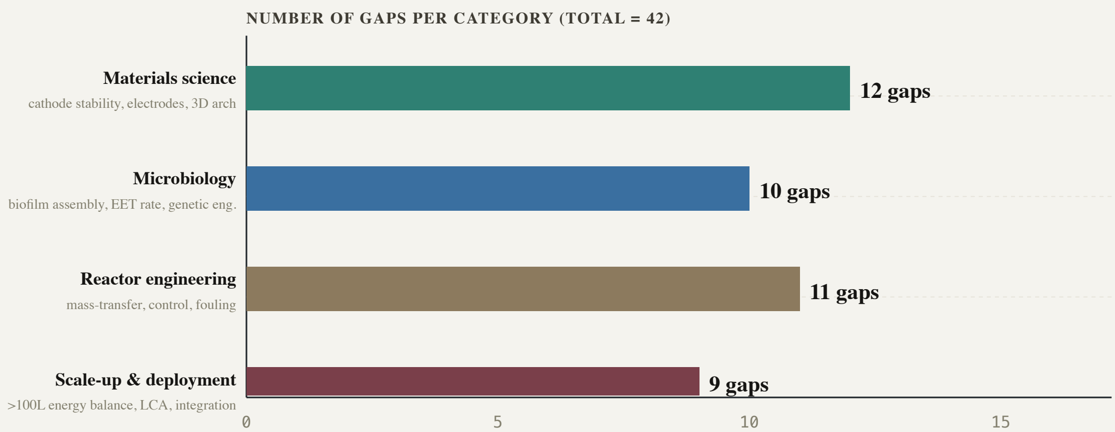

FIGURE 11·1 42 AI-identified gaps clustered by thematic category. Each gap defines a specific knowledge deficiency that, if filled, would materially advance MES commercialization — and a space where MESSAI's tools (predictive models, 3D design, parameter database) can create outsized value. A representative example is provided in Appendix A.

These gaps are not academic curiosities. MESSAI's identification of them serves three purposes. **First**, it directs the research community's attention to the highest-value problems, potentially accelerating progress by years. **Second**, it guides MESSAI's own product development — the platform's predictive models, 3D design tools, and parameter database are prioritized to address these gaps. **Third**, it demonstrates the unique analytical capability that arises from having the field's entire literature ingested and structured — a capability that no individual researcher or lab could replicate.

PART V

Impact & Vision.

A venture-return business model built on a platform that, if successful, will measurably accelerate the deployment of technologies addressing some of the world's most pressing environmental challenges.

CHAPTER 12

ESG impact & SDG alignment.

MESSAI.IO is fundable under both traditional venture-return frameworks and impact-investment mandates. The societal outcomes MES technologies enable — and that MESSAI accelerates — align directly with multiple UN Sustainable Development Goals.

6	7	9	13	14
CLEAN WATER & SANITATION	**AFFORDABLE CLEAN ENERGY**	**INDUSTRY & INNOVATION**	**CLIMATE ACTION**	**LIFE BELOW WATER**
Decentralized, low-energy treatment for the 1.7B people lacking basic sanitation (WHO/UNICEF, 2023).	MFC electricity from organic waste; MEC hydrogen with lower energy input than conventional electrolysis.	Research-infrastructure innovation that reduces time + cost of R&D and enables data-driven design.	Energy-neutral / -positive wastewater treatment; CO_2 → chemicals via microbial electrosynthesis.	Reduced nutrient and pollutant discharge directly addresses eutrophication and marine dead zones.

The IEA estimates the water sector accounts for ~4% of global electricity consumption (IEA, 2023). Conventional aerobic treatment is energy-intensive and a net carbon emitter; MES offers pathways to energy-positive, carbon-negative treatment. For impact investors, MESSAI offers a rare combination: a viable venture-return model built on a platform whose success measurably advances global environmental health.

CHAPTER 13

The 2035 vision.

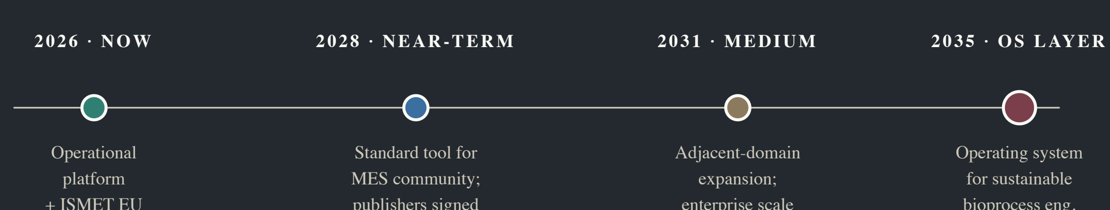

FIGURE 13·1 By 2035, MESSAI.IO is positioned to be the definitive infrastructure platform for bioelectrochemical innovation — analogous to what the Materials Project is for materials science, what the PDB is for structural biology, and what Benchling is for synthetic biology, but purpose-built for the intersection of microbiology, electrochemistry, and environmental engineering.

The vision is ambitious but grounded in trajectories of comparable platforms. The Materials Project started as a DOE-funded database and now serves 400,000+ registered users worldwide. Benchling started as a free molecular biology notebook and now serves 1,200+ enterprise customers at a $6.1B valuation. The pattern is consistent: **domain-specific platforms that start by serving the research community, build data moats, and then expand into adjacent markets can achieve outsized outcomes.**

PART VI

Risk, Returns, Next Steps.

Transparent risk analysis with specific mitigations · exit pathways supported by recent transaction comparables · and the explicit invitation to join at the ground floor.

CHAPTER 14

Risk analysis & mitigation.

We are transparent about the risks inherent in this investment. Each risk is real, and for each we describe a specific mitigation.

TECHNOLOGY RISK · CAN THE AI PREDICTIONS ACTUALLY WORK?

The core technical bet is that ML models trained on the structured MES literature can produce predictions accurate enough to meaningfully reduce the experimental search space. **Mitigation:** (1) the 10,018-paper dataset is large by domain-specific scientific-AI standards; (2) physics-informed constraints bound the prediction space; (3) the product is designed to provide predictions with confidence intervals + sensitivity analysis, not point estimates — the tool is valuable as long as it narrows the search space.

MARKET RISK · WILL MES TECHNOLOGIES ACTUALLY COMMERCIALIZE?

The timing of MES commercialization is uncertain. **Mitigation:** MESSAI's value proposition does not depend entirely on mass-market MES adoption. The research tools are valuable to the existing academic community regardless. The platform architecture is designed for expansion into adjacent domains (anaerobic digestion, bioelectrochemistry broadly, bioprocess engineering), providing optionality. And regulatory + carbon-pricing trends provide structural tailwinds independent of any single technology.

ADOPTION RISK · WILL RESEARCHERS AND ENGINEERS USE IT?

Academic adoption of new tools is notoriously slow. **Mitigation:** the freemium model (no barrier to trial), ISMET community engagement (social proof and peer recommendation), publisher partnership strategy (embedding MESSAI in the publication workflow so researchers encounter it naturally), and product design focus on delivering immediate value — a researcher should get a useful result from their *first* search query.

COMPETITIVE RISK · COULD SOMEONE BUILD THIS FASTER OR BETTER?

The most realistic competitive threat is not a direct competitor but a generic AI tool becoming good enough at MES-specific questions. **Mitigation:** focus on capabilities generic tools cannot replicate — structured quantitative data (not just text answers), interactive 3D modeling, multi-objective optimization, the economics calculator. A language model can summarize papers; it cannot simulate a reactor.

TEAM RISK · CAN THIS TEAM EXECUTE?

Best mitigated by the team itself. The founding team's credentials, track record, and domain expertise are presented in Chapter 8. Where gaps exist (notably enterprise sales), the hiring plan and use of funds in Chapter 9 address them explicitly.

CHAPTER 15

Exit & return analysis.

MESSAI.IO's investment returns can be realized through several exit pathways, each supported by recent transaction comparables.

PATHWAY	STRATEGIC LOGIC	REFERENCE TRANSACTION
Water technology acquirer	Strategic acquirers have demonstrated willingness to pay significant premiums for technology + digital capability as MES moves toward commercial deployment.	Xylem · Evoqua ~$7.5B (2023); Veolia · Suez ~€13B (2022)
Scientific data / software	Elsevier (RELX), Clarivate, and Thermo Fisher are actively acquiring scientific data and software assets.	Thermo Fisher · Dotmatics $1B+ (2023)
Industrial AI / cloud	Microsoft, Google, Amazon, Siemens building vertical AI for industrial and sustainability applications — MESSAI as a showcase for domain-specific industrial AI capability.	Premium-to-standalone multiples
IPO	If MESSAI expands beyond MES to a general-purpose bioprocess + environmental engineering AI platform, independent IPO becomes viable.	Schrödinger IPO 2020 · multi-billion mkt cap

Return modeling. At conservative exit ($50M), base-case exit ($150–300M), and upside exit ($500M+, analogous to lower bound of Benchling-like valuations once platform has expanded beyond MES) — detailed return sensitivity tables at various exit valuations and ownership levels are provided in Appendix B.

CHAPTER 16

Call to action.

MESSAI.IO is operational, growing, and positioned at the intersection of three megatrends: the global water crisis, the bioeconomy transition, and the AI-driven digitalization of scientific R&D.

We are raising to take the platform from demonstrated technology and early community engagement to proven product–market fit, paying enterprise customers, and a revenue trajectory that supports Series A fundraising at a significant step-up in valuation.

> *We invite investors who share our conviction that the next great scientific infrastructure platform will be built not for drug discovery or materials science — where incumbents already exist — but for the environmental biotechnologies that will define the sustainable economy of the 2030s and beyond.*
>
> — THE MESSAI THESIS, IN ONE SENTENCE

For further information, a platform demonstration, or to begin diligence, contact sam@messai.io or visit messai.io.

Sam Frons

FOUNDER & CEO · MESSAI.IO

APPENDIX E

Glossary.

Microbial Electrochemical System (MES). Devices that use microorganisms to catalyze electrochemical reactions at electrode surfaces. Includes MFCs, MECs, microbial electrosynthesis, and MDCs.

Microbial Fuel Cell (MFC). An MES that generates electricity directly from microbial oxidation of organic substrates. Microorganisms on the anode oxidize organic matter and transfer electrons to the electrode, which flow through an external circuit to the cathode.

Microbial Electrolysis Cell (MEC). An MES that produces hydrogen gas from organic substrates by applying a small external voltage to supplement the energy generated by microbial metabolism.

Microbial Electrosynthesis. An MES configuration in which electrical energy drives microbial reduction of CO_2 to multi-carbon chemicals and fuels at the cathode.

Microbial Desalination Cell (MDC). An MES that simultaneously treats wastewater and desalinates brackish water.

Power Density. Rate of electrical energy production per unit of electrode area or reactor volume; typically mW/m^2 or W/m^3.

Coulombic Efficiency (CE). Fraction of electrons liberated from the substrate that are captured as electrical current, expressed as a percentage.

Extracellular Electron Transfer (EET). The biological mechanism by which microorganisms transfer electrons from intracellular metabolic processes to an external electrode surface.

Biofilm. Structured community of microorganisms attached to a surface, embedded in a self-produced matrix of extracellular polymeric substances. In MES, the anode biofilm is the catalytic engine of the system.

Techno-Economic Analysis (TEA). Systematic evaluation of technical performance and economic viability of a technology, including capital costs, operating costs, revenue streams, and ROI.

SaaS (Software as a Service). Software distribution model in which applications are hosted in the cloud and accessed by users via the internet on a subscription basis.

ARR (Annual Recurring Revenue). The annualized value of recurring subscription revenue — a key SaaS valuation metric.

TAM / SAM / SOM. Total Addressable Market (entire market), Serviceable Addressable Market (portion targetable with current capabilities), Serviceable Obtainable Market (realistic near-term capture).

ISMET. International Society for Microbial Electrochemistry and Technology — the professional society and standard-setting body for the MES field.

NLP / NER / RE. Natural language processing; named entity recognition (identifying terms like “carbon cloth”, “Geobacter”, “COD” in text); relation extraction (linking those entities into structured tuples).

APPENDIX F

References & sources.

Andreessen Horowitz. (2021). *Benchling raises $200M Series F at $6.1B valuation*. Press release.

BloombergNEF. (2024). *Hydrogen Economy Outlook: 2024 Update*.

Bluefield Research. (2023). *Digital Water: U.S. Water Sector Trends & Forecasts, 2023–2030*.

European Commission. (2024). *Revision of the Urban Wastewater Treatment Directive*. COM/2022/541 final, as adopted.

Ge, Z., Li, J., Xiao, L., Tong, Y., & He, Z. (2016). Recovery of Electrical Energy in Microbial Fuel Cells. *Environmental Science & Technology Letters,* 1(2), 137–141.

Global Water Intelligence. (2024). *Digital Solutions in Water and Wastewater*. GWI Market Report.

Grand View Research. (2023). *Water and Wastewater Treatment Market Size, Share & Trends Analysis Report, 2023–2030*.

Grand View Research. (2024). *Life Science Analytics Market Size Report, 2024–2030*.

IDTechEx. (2024). *Energy Harvesting Microwatt to Megawatt: 2024–2034*.

IEA. (2023). *Global Hydrogen Review 2023*. IEA Publications.

IEA. (2023). *Water-Energy Nexus: World Energy Outlook Special Report*.

Logan, B. E., Rossi, R., Ragab, A., & Saikaly, P. E. (2019). Electroactive microorganisms in bioelectrochemical systems. *Nature Reviews Microbiology,* 17, 307–319.

MarketsandMarkets. (2023). *Environmental Monitoring Market — Global Forecast to 2028*.

McKinsey & Company. (2023). *The net-zero transition in chemicals: Opportunities and implications*.

Research and Markets. (2024). *Wastewater Treatment Services Market Outlook*.

Schrödinger, Inc. (2020). *S-1 Registration Statement*. U.S. Securities and Exchange Commission.

State Council of the People's Republic of China. (2021). *14th Five-Year Plan for National Economic and Social Development*.

Thermo Fisher Scientific. (2023). *Thermo Fisher completes acquisition of Dotmatics*. Press release.

White House. (2021). *Fact Sheet: The Bipartisan Infrastructure Deal*. Briefing Room Statement.

WHO/UNICEF Joint Monitoring Programme. (2023). *Progress on Household Drinking Water, Sanitation and Hygiene 2000–2022*.

Xylem Inc. (2023). *Xylem completes combination with Evoqua Water Technologies*. Press release.

DISCLAIMER AND NOTE ON SOURCES

This white paper has been prepared as an investment communication by MESSAI.IO. All market-size estimates, company valuations, and financial projections cited are based on publicly available sources as referenced. Market-size figures are estimates subject to the assumptions and methodologies of their respective sources. Valuations and transaction values for comparable companies are based on publicly available press releases, SEC filings, and media reports. Forward-looking statements regarding MESSAI.IO's milestones, revenue projections, and market capture are based on management's current expectations and are subject to risks and uncertainties. Prospective investors should conduct independent due diligence and consult professional advisors before making investment decisions. Platform statistics (10,018+ research papers, 687+ parameters, 42 research gaps) are as reported on the MESSAI.IO platform as of April 2026.

M MESSAI·IO

END OF WHITE PAPER · V1.0 · APRIL 2026

The operating system for an entire emerging industry.

If you reached the back cover, you have read more carefully than most investors read most decks. Thank you. We'd like to speak with you.

Contact
SAM FRONS · FOUNDER & CEO
SAM@MESSAI.IO · MESSAI.IO

Next steps
PLATFORM DEMO · DATA-ROOM ACCESS
ISMET EU 2026 · TOULOUSE