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Impatient Capital:
Leveraging the Intelligence Explosion and Natural Resources to Make the Transformation to Net Zero Feasible

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Abstract

Earth-system degradation has pushed seven of nine planetary boundaries into overshoot, raising the question whether civilization can restore safe operating conditions in time. This paper offers a constructive answer turning on three converging forces: (a) capital willing to act with urgency; (b) the intelligence explosion visible in Large Language Models (LLMs), Large Quantitative Models (LQMs), and agentic AI; and (c) disciplined sourcing of the critical minerals on which net zero depends. After the planetary-emergency arithmetic, we read the benefits and risks of powerful AI systems, the future of work, and economic redistribution. A dedicated chapter on the intelligence explosion examines the five-layer AI industrial stack, the rise of LQMs in physics, materials, biotechnology, and quantum information science (QIS), and the now-disproven 2016 prediction that AI would eliminate radiology—illustrating instead a Jevons-paradox dynamic of expanded demand and new job categories. A chapter on critical minerals proposes a sequenced hierarchy across three horizons: efficiency and circularity first; decarbonized terrestrial supply and AI-discovered substitution second; fusion, on-orbit infrastructure, and eventual asteroid sourcing as the long-term frontier—paired with a precautionary pause on commercial deep-sea polymetallic-nodule mining and enforced terrestrial conservation. The paper closes by anchoring its recommendations in the Integral Investing framework—the Investment Turnaround—and the case for steering capital from ego-centric toward world- and Kosmos-centric horizons. Net zero is principally a coordination problem; the Impatient Capitalist's task is to deploy capital and intelligence at the tempo the Earth system requires while ensuring abundance for all.

"Love is wise, hatred is foolish," and in an increasingly interconnected world, charity and tolerance are "absolutely vital to the continuation of human life on this planet."

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1. Introduction: Russell's Mandate in an Interconnected Century

In a celebrated 1959 BBC interview, Bertrand Russell was asked what he would say to a future generation. He offered two messages, one intellectual and one moral. The intellectual message was that when studying the world, we should look only at the facts and at what they entail, never letting ourselves be deflected by what we wish were true. The moral message was that "love is wise, hatred is foolish," and that in an increasingly interconnected world, charity and tolerance are "absolutely vital to the continuation of human life on this planet."[1]

If India, South America, and Africa simply reach today's global average—as basic equity demands they must—worldwide emissions could surge by roughly one-third.

More than six decades later, by every measurable index—trade intensity, human mobility, supply-chain complexity, instantaneous communication—we live in the most interconnected civilization in history. International arrivals reached 1.52 billion in 2025,[2] and global internet exchanges processed a record 79 exabytes of data.[3] Yet we appear to be drifting from Russell's two principles at the moment they would matter most. Open inquiry is challenged by a widening "war on science",[4] and the political will for the charity required to manage shared planetary risk has fractured into resource nationalism, tariff cycles, and protectionism. The result is a widening gap between what humanity could in principle do and what it currently chooses to do.

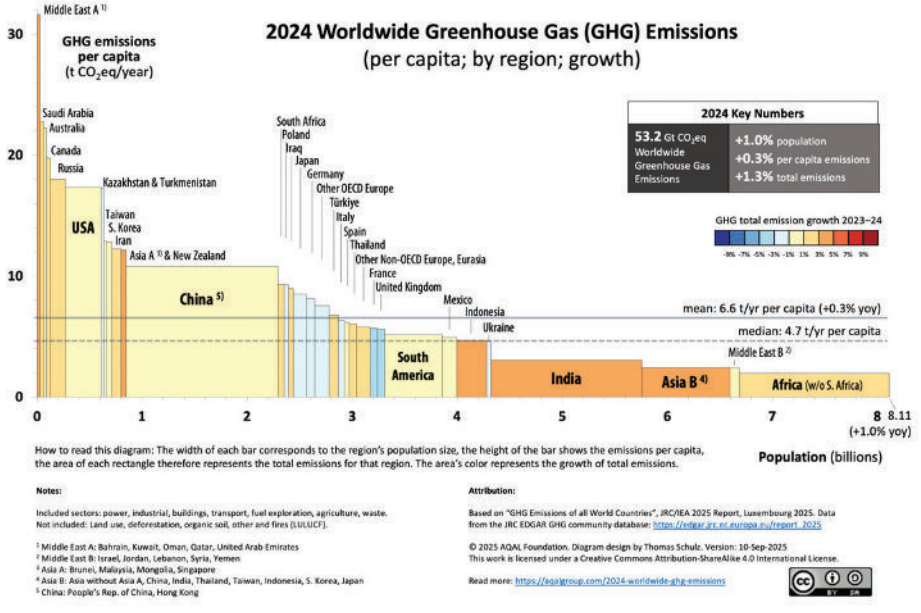
Resource nationalism on critical minerals has produced a "sovereignty tax" on the habitability of Earth itself.

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2. The Crisis of Divergence: Earth Systems Under Compound Stress

The planetary data illustrate the divergence. After a brief plateau, global anthropogenic greenhouse-gas emissions resumed climbing in 2024, posting a 1.3 percent year-on-year increase to a new record high (Figure 1).[5] The European efficient-and-nuclear model—France stands at roughly 5.7 t CO_2eq[6] per capita—suggests that decoupling growth from carbon is feasible, but those gains are being offset by industrial expansion in Russia, much of Asia, and parts of Africa. The global average sits at 6.6 t CO_2eq per capita, masking a volatile reality: half of humanity lives below 4.7 t while Qatar (53 t) and the United States and Canada (≈18 t) define the ceiling. If India, South America, and Africa simply reach today's global average—as basic equity demands they must—worldwide emissions could surge by roughly one-third.

Figure 1. 2024 worldwide greenhouse-gas (GHG) emissions per capita and country, displayed as a variwide chart. Source: Schulz (2025).*

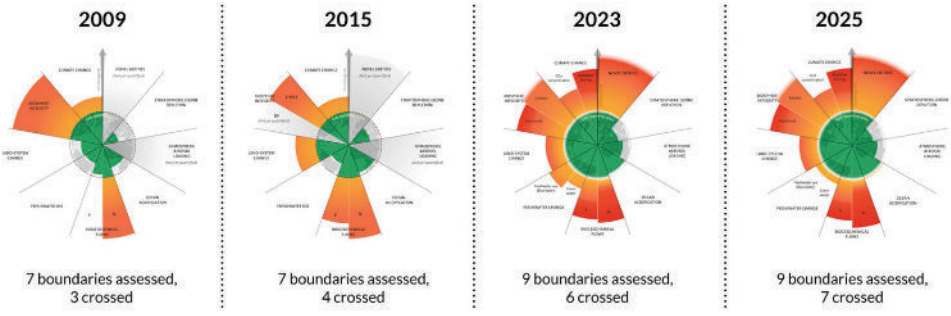


This is not a fantasy of escape from Earth; it is the engineering pathway by which Earth's biosphere becomes something we can choose to live within rather than from.

This trajectory meets a planet whose buffer has been largely depleted. In 2024 Earth experienced its hottest year in 100,000 years and the 1.5 °C boundary was crossed for the first time. The Planetary Health Check 2025 reports that seven of nine planetary boundaries have now been transgressed, with ocean acidification entering the high-risk zone in 2025.[7] Forests and soils, our primary terrestrial sinks, are showing resilience weakness and beginning to release carbon under heat stress rather than absorb it. The framework Rockström and colleagues introduced in 2009 is no longer a warning but a balance sheet (Figure 2),[8] and the broader picture is not improving on its own: protectionist measures on solar cells, lithium-ion batteries, and electric vehicles may raise the capital cost of the energy transition by an estimated $137 billion through 2030, while resource nationalism on critical minerals has produced a "sovereignty tax" on the habitability of Earth itself.[9]

* Editorial note: A "variwide" (variable-width) bar chart represents each country with a bar whose width is proportional to its population and height to its per-capita emissions, so the area equals total national emissions. Bars are sorted from highest to lowest per capita, allowing the reader to see at a glance who emits the most per person (height), who has the largest population (width), and who contributes most overall (area).

Figure 2. The evolution of the planetary boundaries framework. Licensed under CC BY-NC-ND 3.0 (Credit: Azote for Stockholm Resilience Centre, Stockholm University. Based on Richardson et al. 2023, Steffen et al. 2015, and Rockström et al. 2009).



3. The Case for the Impatient Capitalist

After four decades of well-meaning impact investing, fair-finance initiatives, corporate social responsibility, Paris Agreement signatures, and UN Sustainable Development Goal pledges, the gap between commitment and outcome has become impossible to ignore. We do not need more reporting on the crisis. Action goes where money flows. The traditional net-zero framework moves slowly because it relies on terrestrial political trade-offs and siloed regulation while planetary tipping risks compound non-linearly.[10]

The Impatient Capitalist takes the view that waiting for a unified global government may not be a winning strategy and that fragmentation is, in market terms, an inefficiency capital can help unlock. If trade frictions slow the cross-border flow of "atoms"—minerals and hardware—deep technology offers complementary paths around the bottlenecks: AI-driven discovery of substitute materials, and the gradual relocation of the most resource- and energy-intensive industrial functions—primary energy generation, hyperscale compute, eventually heavy manufacturing—into orbital and space-based infrastructure. This is not a fantasy of escape from Earth; it is the engineering pathway by which Earth's biosphere becomes something we can choose to live within rather than from.

4. The Intelligence Explosion: From Language Models to a New Industrial Architecture

Most public conversations still treat AI as a chatbot. That description is out of date. AI has emerged as a new computing architecture, displacing the software-development model of past decades. Leading practitioners describe a transition through three rapid phases: (a) generative AI producing text, image, and video from prompts; (b) reasoning AI in which models "think" through chains of tokens; and (c) agentic AI in which systems understand intent, plan, and use external tools autonomously.[11] The theoretical groundwork was laid sixty years ago: I. J. Good's "first ultraintelligent machine" thesis described the recursive self-improvement loop today's frontier labs operationalize as the scaling of compute, data,

and algorithms.[12] Nick Bostrom's analysis remains the most disciplined framework for take-off dynamics,[13] while Leopold Aschenbrenner's situational-awareness essay[14] and Dario Amodei's "Machines of Loving Grace"[15] represent the two poles of the current insider conversation: probabilistic concern about national-security and alignment risks on one side, and a credible upside scenario of compressed biomedical and energy progress on the other.

4.1. A Five-Layer Industrial Stack

What unites these perspectives is the recognition that AI has matured into a five-layer industrial stack (Table 1): (a) energy and land; (b) chips and systems; (c) infrastructure and cloud; (d) foundation models; and (e) the application layer delivering value to healthcare, financial services, manufacturing, education, robotics, and autonomous vehicles.

Table 1. The five-layer AI industrial stack.

Layer	Function	Examples
5. Applications	Vertical AI-native products in healthcare, finance, manufacturing, education, robotics, autonomous vehicles	Clinical-grade diagnostics; trading and risk; factory copilots; tutoring; surgical and warehouse robots
4. Foundation Models	Large-scale models providing general intelligence	GPT-class, Claude, Gemini, Llama, multimodal and reasoning models
3. Infrastructure & Cloud	Compute scaled and managed at hyperscale	AWS, Microsoft Azure, Google Cloud, AI-specialist clouds (CoreWeave, Lambda)
2. Chips & Systems	GPUs, CPUs, networking fabrics, cooling	NVIDIA, AMD, TSMC, Broadcom, ASML, advanced packaging
1. Energy & Land	Power and physical space for data centers	Renewables, advanced nuclear (SMRs), eventually fusion; land and water permitting

This could become the largest infrastructure build-out in human history; trillions of dollars of capital are being committed across the stack in the coming decade, and it is already pulling forward the modernization of antiquated grids and the financing of low-carbon power sources—advanced nuclear, geothermal, hydropower with storage, and long-duration battery systems that can deliver electricity on demand regardless of weather or time of day—that might otherwise have been delayed. The geopolitical implication is significant: market-scale purchase orders for AI factories—Microsoft's Stargate initiative, Alphabet's data-center

capex programs, SpaceX's orbital compute roadmap, and Amazon Web Services' multi-gigawatt Anthropic compute cluster among them—are proving more effective than subsidy regimes at restoring industrial capacity.[16]

4.2. The Complementary Paradigm: Large Quantitative Models and Quantum Information Science

The complementary paradigm to LLMs is the rapidly emerging field of Large Quantitative Models (LQMs), which apply the scaling laws of modern AI to physics, chemistry, biology, and engineering rather than language. LQMs are already accelerating materials discovery, fusion-plasma control, climate modeling, electrolyte and electrode design for batteries, protein folding and de novo enzyme design, and the simulation of catalysts for ammonia synthesis—the latter alone responsible for roughly 1.4 percent of global CO_2eq emissions.[17] Together with quantum information science—now operating at the noisy-intermediate-scale-quantum (NISQ) frontier of 1,000 to 4,000 physical qubits with the first demonstrations of error-corrected logical qubits—LQMs are making the net-zero technology stack tractable in ways the climate models of even five years ago could not assume.[18]

The disciplined reading holds both sides of the AI ledger at once. On the benefit side, LLMs already function as a universal cognitive amplifier: novice researchers can interrogate the global scientific literature in their own language; clinicians and lawyers can draft and check work in minutes; educators in under-resourced contexts can deliver near one-on-one tutoring at marginal cost. On the risk side, the same systems can generate plausible disinformation at scale, lower the technical barrier to bio- and cyber-misuse, and—if alignment research lags capability—produce agents whose internal goals diverge from the intentions of those deploying them. The Impatient Capitalist's stance is to invest energetically in the benefit pathway while funding alignment, evaluation, and governance with equal seriousness, anchoring both in one overriding objective: that the productivity gains of the intelligence explosion translate into abundance for all, put food on people's tables, and forestall the polarization and social unrest that follow when transformative technologies enrich only a few.

4.3. The Future of Work: From the Hinton Prediction to the Jevons Surge

The future of work follows from this stack rather than being threatened by it, and the most-cited cautionary tale has become an instructive counter-example. In 2016, Geoffrey Hinton—the Turing Award winner widely called the "godfather of AI"—famously argued that medical schools should stop training radiologists within five years because deep learning would render the profession obsolete.[19] A decade later, that prediction has not materialized. AI has become ubiquitous in radiology, but in a supportive rather than substitutive role: pre-reads, flagging of acute findings, prioritization of urgent examinations, and structured reporting—leaving diagnostic judgment and patient-facing work to the physician. The number of practicing radiologists has risen, not fallen, in every major market.[20]

The clearest explanation is the Jevons paradox: AI-assisted imaging made diagnostic screening faster and cheaper, so demand expanded. Hospitals ordered more scans, extended screening to new populations, and added imaging pathways for conditions previously under-investigated. AI did not replace radiologists; it made radiology efficient enough that demand

exploded.[21] The same dynamic is unfolding in nursing in the United States—where the country is roughly five million caregivers short—and in the European Union, the United Kingdom, Japan, and across the OECD, where AI-driven charting, transcription, and triage are returning a substantial portion of each nurse's working day to direct patient contact.[22] One concrete example is the AI-based wound documentation and decision-support system developed by CureVision, which removes much of the manual burden from clinicians and care workers in hospitals and long-term-care settings, freeing time for direct patient interaction while improving documentation quality and clinical outcomes.[23]

More broadly, AI is acting as a powerful engine of job creation. Patterns visible in the 2026 labor data include: (a) new "new-collar" AI roles—LinkedIn's Economic Graph reported roughly 1.3 million new AI-related jobs added to the global economy in two years, with "AI Agent Engineer" alone growing 240 percent year over year and adjacent specialties such as RAG engineer, AI safety / red-team engineer, and forward-deployed engineer expanding similarly;[24] (b) a data-center construction boom that has added an estimated 216,000 U.S. jobs since 2022, with ≈500,000 net new U.S. energy-sector jobs needed by 2030 and comparable expansion in Europe, Japan, and India; (c) Jevons-style expansion of professional services in software, accounting, law, and consulting; and (d) a redesign of entry-level work, where junior staff supervise AI outputs and conduct micro-experiments previously requiring years of seniority. Robert J. Marks's argument that creativity, judgment under genuine uncertainty, embodied care, and meaning-making remain non-computable frames what humans uniquely contribute.[25]

On the regulatory side, a calibrated response looks more constructive than a blanket one. Rather than regulating the underlying mathematics, applications can be regulated where the harms manifest: (a) medical-grade AI under medical-device law; (b) financial-grade AI under financial law; (c) aviation-grade AI under aviation law; and (d) licensing for autonomous agents analogous to driver licensing. AI literacy can be invested in across schools, professional training, and lifelong learning, so that productivity gains are widely shared.

4.4. The Industry's Moral Obligation and the Alignment Imperative

The industry also carries a corresponding moral obligation to build in safety guardrails comparable to those of commercial aviation. As Mustafa Suleyman argues in *The Coming Wave*, the combination of falling cost, rising capability, and proliferation pressure means that containment is no longer optional: alignment research, red-teaming, evaluations against catastrophic-misuse benchmarks, mandatory pre-deployment safety cases, and transparent reporting on capability frontiers are now baseline expectations. Brian Christian's framing of the alignment problem makes the same point at the level of value-loading: the technical challenge of ensuring that increasingly capable systems robustly pursue the goals their developers intend—and that those goals are themselves humane—deserves at least as much capital and talent as the capability race itself.[26]

The redistribution question follows from the productivity question. If LQMs and agentic systems compress decades of scientific work into single-year cycles, the surplus they generate need not concentrate in a handful of frontier-lab equity holders. Proposals on the

table—Universal Basic Services (UBS) for housing, healthcare, education, transport, and connectivity, complemented by Universal Basic Income (UBI) and Universal Service Income (USI) pilots financed by carbon dividends, compute taxes, and sovereign-AI funds—deserve more serious consideration now than they received when first proposed at scale during the 2015–2017 technological-unemployment debates.

As investors mature from ego-centric toward world-centric and Kosmos-centric stages of meaning-making, capital begins to flow in the direction the planet requires—not because regulation forces it, but because the consciousness allocating it has expanded.

These ideas are not nostalgia for twentieth-century welfare design but recognition that the political legitimacy of the transition depends on whether ordinary households experience the intelligence explosion as abundance rather than dispossession.[27]

5. The Material Bottleneck: Critical Minerals and the Net-Zero Stack

No intelligence explosion can substitute for the metals on which an electrified civilization runs. Limiting global warming to well below 2 °C requires roughly a fourfold increase in critical-mineral demand by 2040 in the IEA Sustainable Development Scenario,[28] and a sixfold increase under the IEA Net Zero by 2050 Roadmap (2023 update).[29] Lithium demand grows by an order of magnitude; copper, nickel, cobalt, manganese, graphite, and the magnet rare earths each grow several-fold. Copper has no near-term substitute at the scale of grid conductors; rare-earth permanent magnets enable the highest-power-density wind generators and motors; high-purity manganese, lithium, and class-1 nickel remain hard to displace at vehicle scale even after the rapid rise of lithium iron phosphate (LFP) and sodium-ion chemistries.[30]

5.1. Why Supply Is Structurally Constrained

Average copper ore grade has fallen from above 2 percent in 1900 to roughly 0.5–0.6 percent today, so each metric ton of metal requires more rock moved, more energy, more water, more tailings to manage.[31] Concentration is a geological as well as a geopolitical problem: cobalt sits overwhelmingly in the Central African Copperbelt; mined and refined rare-earths are dominated by China; class-1 nickel splits between sulfide deposits in mature jurisdictions and tropical laterites in Indonesia and the Philippines. Owen and colleagues estimate roughly 54 percent of energy-transition mineral projects are located on or near the lands of indigenous and peasant peoples.[32] These realities call for direct engineering and policy response.

5.2. The Deep-Sea Question

One frontier alternative under active discussion is deep-sea mining of polymetallic nodules in the Clarion–Clipperton Zone (CCZ). According to recent scientific-consensus

models compiled by academic institutions and geological surveys, the total dry mass of nodules across the roughly 6-million-square-kilometer CCZ is estimated at 21.1 billion dry tons containing not only cobalt and manganese but also "high concentrations of nickel, copper, and cobalt, as well as other metals such as molybdenum, rare earth elements, and lithium, all of which are critical to high-tech industries and hold significant economic value."[33] These are extraordinary aggregate numbers and explain why the resource has attracted serious investment attention. The abyss, however, is not a biological desert: 2023 molecular work cataloged more than 5,500 putative metazoan species in the CCZ, of which approximately 90 percent are undescribed, and the DISCOL natural experiment in the Peru Basin found that disturbance tracks remained clearly visible and biologically distinct twenty-six years after a simulated mining pass.[34] Industry-commissioned lifecycle assessments make a real case for lower greenhouse-gas, land-use, and tailings footprints than coal-powered laterite-nickel comparators, but the most rigorous independent global mine-by-mine modeling finds that a moratorium without complementary terrestrial protection may simply displace nickel mining into the most biodiverse tropical contexts.[35] On balance, the precautionary case for a pause therefore looks stronger when it is paired with enforced "no-go area" protection on land, so that capital and political effort flow in the same direction rather than across one another.

The Impatient Capitalist is not the antagonist of the patient steward but a partner.

5.3. A Sequenced Hierarchy of Recommendations Across Three Time Horizons

History suggests that wishful thinking—and reactive, piecemeal regulation drafted without systemic understanding—has not been enough. The Club of Rome has been warning for over five decades, since *The Limits to Growth* was published in 1972, that exponential growth on a finite planet ends badly; subsequent peer-reviewed work by Turner and others has found that real-world trajectories remain close to the original "business as usual" scenario, and the 2018 Club of Rome report *Come On!* by von Weizsäcker, Wijkman, and 34 co-authoring members has called for a new Enlightenment as the underlying response.[36] What has changed is capital's capacity to act with foresight. As investors mature from ego-centric toward world-centric and Kosmos-centric stages of meaning-making, capital begins to flow in the direction the planet requires—not because regulation forces it, but because the consciousness allocating it has expanded.[37] The Integral Investing framework operationalizes this through systematic, all-quadrants screens that combine financial return with planetary, social, and cultural integrity.[38]

Within that frame, the following sequenced hierarchy looks robust across the three-time horizons that matter most for net zero:

a. Urgency window (2025–2035): deploy demand-side levers (efficiency, modal shift, right-sized vehicles, LFP and sodium-ion chemistry); scale recycling and full circularity; decarbonize terrestrial supply through electrified haul fleets and renewable-powered comminution; accelerate the China-paced renewables build-out with parallel manufacturing capacity in Europe, North America, India, and the global South; and reform permitting across renewables, transmission, advanced nuclear, and battery manufacturing.

b. Consolidation window (2030–2050): scale commercial fusion alongside advanced fission—stellarator-based designs such as Proxima Fusion's peer-reviewed Stellaris architecture, tokamak-based programs such as Commonwealth Fusion Systems' SPARC/ARC roadmap, and pulsed-magnetic-fusion approaches such as Helion Energy's Polaris are now credible private-capital investment cases rather than government-only science programs;[39] demonstrate AI-discovered substitute materials at industrial scale; complete the circular-economy transition; and stand up orbital-infrastructure demonstrators.

c. Long-horizon frontier (beyond 2050): transition heavy energy generation and hyperscale compute to space-based architectures, with primary metals sourced from the asteroid belt rather than the seabed—turning the deep ocean from an extraction frontier back into a protected planetary commons.

5.4. Why On-Orbit Infrastructure Now—and What a Type I Civilization Means

The Type I civilization concept comes from the Kardashev scale (1964), which classifies civilizations by the total energy they can harness: a Type I civilization commands the full energy budget reaching its home planet from its star, on the order of 10^{16} watts.[40] The relevance is practical, not speculative. The terrestrial biosphere cannot indefinitely host both the energy throughput required for a fully decarbonized economy and the protected ecosystems on which that economy depends. Two engineering bridges matter: (a) space-based solar power (SBSP), which captures sunlight in orbit and beams it down via microwaves; and (b) on-orbit data centers, which place hyperscale compute where solar irradiance is continuous, cooling is radiative, and the marginal land and water cost on Earth is zero. The first orbit-to-ground power transmissions have been demonstrated, ESA's SOLARIS initiative has completed Phase 0, and orbital-data-center demonstrators are now venture-funded.[41] Read in this light, the deep-sea question turns on which planetary asset to spend first: an effectively irreversible deep-ocean ecosystem, or capital and engineering attention on a frontier that is renewable in the very long run.

One caveat is essential: the space economy carries its own irreversibility risk in the form of orbital debris. Donald Kessler's 1978 cascade analysis showed that beyond a critical density of fragments in low Earth orbit, collisions become self-sustaining and could render whole orbital regimes unusable for generations. The European Space Agency's 2024 environment report estimates more than 36,500 tracked objects larger than 10 cm and over a million fragments larger than 1 cm currently in orbit, with collision rates rising as launch cadence accelerates. A credible space-economy strategy must therefore include active debris removal (ADR)—pioneered by Astroscale and ClearSpace—alongside binding design-for-demise, end-of-life-disposal, and conjunction-management standards, lest the orbital substitute for terrestrial extraction become as foreclosed as the abyssal seafloor it was meant to spare.[42]

6. Conclusion: The 100x Mandate and the Integral Investing Turnaround

AI has compressed the research cycle by orders of magnitude: what once took a senior researcher months can now be achieved by a small team with frontier models in a day. The corresponding invitation to the Impatient Capitalist is to raise ambition by a comparable factor. The 100x mandate applies in three places at once: (a) materials and energy R&D,

where LQMs and quantum simulation make problems intractable five years ago now routine;[43] (b) capital allocation, where deep-tech-native funds and patient strategic capital can complement incremental ESG screens with the Integral Investing framework underlying the Investment Turnaround moonshot—combining financial return with planetary boundaries, social inclusion, and cultural integrity in a single decision lens;[44,45] and (c) worldview, where the cultural and consciousness work of the integral movement complements the technological stack with the moral framework Russell anticipated. Ken Wilber's integral theory and Susanne Cook-Greuter's research on later stages of ego development suggest that as decision-makers mature from ego-centric toward world-centric and Kosmos-centric meaning-making, capital naturally flows toward planetary stewardship rather than against it.[46]

Seen from this vantage, the Impatient Capitalist is not the antagonist of the patient steward but a partner. The technology stack exists; the capital exists; the materials exist; the orbital trajectory is open. What remains is the political and cultural will to deploy them in time.[47] The union of speed and integrity—pursued through Integral Investing, anchored in higher-stage consciousness, and disciplined by the planetary-boundaries framework and the alignment imperative—is what makes a world worth building actually buildable. It honors both halves of Russell's mandate: the rigor to look at the facts as they are, and the love that makes living together rather than dying together possible.

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Notes

1. Bertrand Russell, *Face to Face*, interview by John Freeman, BBC, March 4, 1959, BBC Archives.
2. United Nations World Tourism Organization, *World Tourism Barometer and Statistical Annex* 24, no. 1 (January 2026), https://www.untourism.int/un-tourism-world-tourism-barometer-data.
3. DE-CIX, "Global Data Traffic Volume Hits Record-Breaking 79 Exabytes at Internet Exchanges in 2025", press release, January 20, 2026, https://www.de-cix.net/en/about-de-cix/media/press-releases.
4. Lawrence M. Krauss, ed., *The War on Science: Thirty-Nine Renowned Scientists and Scholars Speak About Current Threats to Free Speech, Open Inquiry, and the Scientific Process* (Nashville: Post Hill Press, 2026).
5. Editorial note: CO_2eq (carbon-dioxide equivalent) expresses the climate impact of all greenhouse gases—methane, nitrous oxide, fluorinated gases, and others—on a single scale, using CO_2 as the baseline. "Tons of CO_2eq" denotes the combined warming impact of all greenhouse gases, not carbon dioxide alone.
6. European Commission Joint Research Centre and International Energy Agency, *GHG Emissions of All World Countries: 2025 Report* (Luxembourg: Publications Office of the European Union, 2025).
7. Potsdam Institute for Climate Impact Research, *Planetary Health Check 2025* (Potsdam: PIK, 2025); Katherine Richardson et al., "Earth Beyond Six of Nine Planetary Boundaries", *Science Advances* 9, no. 37 (2023), https://doi.org/10.1126/sciadv.adh2458.
8. Johan Rockström et al., "A Safe Operating Space for Humanity", *Nature* 461 (2009): 472–475, https://doi.org/10.1038/461472a; Will Steffen et al., "Planetary Boundaries: Guiding Human Development on a Changing Planet", *Science* 347, no. 6223 (2015): 1259855, https://doi.org/10.1126/science.1259855.
9. International Energy Agency, *Global Critical Minerals Outlook 2024* (Paris: IEA, 2024); BloombergNEF, *Energy Transition Investment Trends 2025* (London: BloombergNEF, 2025).
10. Tessa Möller, et al., "Achieving Net Zero Greenhouse Gas Emissions Critical to Limit Climate Tipping Risks", *Nature Communications* 15 (2024): 6192, https://doi.org/10.1038/s41467-024-49863-0.
11. Jensen Huang, keynote remarks, NVIDIA GTC, October 2025; NVIDIA Corp., "Investing in America: AI Factories and the Industrial Renaissance", company blog, 2025, https://blogs.nvidia.com.

12. Irving J. Good, "Speculations Concerning the First Ultraintelligent Machine", in *Advances in Computers*, vol. 6, ed. Franz L. Alt and Morris Rubinoff (New York: Academic Press, 1965), 31–88.
13. Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford: Oxford University Press, 2014).
14. Leopold Aschenbrenner, *Situational Awareness: The Decade Ahead* (June 2024), https://situational-awareness.ai.
15. Dario Amodei, *Machines of Loving Grace: How AI Could Transform the World for the Better* (October 2024), https://darioamodei.com/machines-of-loving-grace.
16. Microsoft Corp., "The Stargate AI Compute Initiative", press release, January 2025; Alphabet Inc., "AI Infrastructure Investment Plan", 10-K *Annual Report*, 2025; SpaceX, "Starlink Direct-to-Cell and Orbital Compute Roadmap", company briefing, 2025; Amazon Web Services, "Project Rainier: 2 GW Anthropic Compute Cluster", press release, 2024.
17. Mariana Bozesan, "Securing the Future with Deep Tech, Quantum Information Science, and AI", *Cadmus* 5, no. 4 (2025): 107–114.
18. Demis Hassabis, "Using AI to Accelerate Scientific Discovery", (Nobel Lecture, Stockholm, December 8, 2024); Alán Aspuru-Guzik et al., "The Coming Era of AI-Accelerated Scientific Discovery", *Nature Reviews Materials* 9 (2024): 1–4; Riccardo Manenti and Mario Motta, *Quantum Information Science* (Oxford: Oxford University Press, 2023); Marko Vukšić, "Comparative Analysis of Contemporary Quantum Computer Processors: Architectures, Performance and Perspectives" (working paper, 2024); Jia Zheng et al., "Where We Are and Where We Will Go to Achieve Carbon Neutrality: A Review of Quantitative Socioeconomic Modeling Research", *Fundamental Research* 4 (2024): 1696–1709, https://doi.org/10.1016/j.fmre.2023.12.020.
19. Geoffrey Hinton, keynote address, Machine Learning and the Market for Intelligence Conference, Toronto, 2016; see also Geoffrey Hinton, "Deep Learning, Radiology and the End of Expertise", video lecture, Creative Destruction Lab, 2017.
20. Pranav Rajpurkar and Matthew Lungren, "The Current and Future State of AI Interpretation of Medical Images", *New England Journal of Medicine* 388 (2023): 1981–1990, https://doi.org/10.1056/NEJMra2301725; American College of Radiology Data Science Institute, *AI in Radiology: 2024 Workforce and Adoption Survey* (Reston, VA: ACR, 2024).
21. On Jevons' paradox in clinical imaging, see Saurabh Jha and Eric J. Topol, "Adapting to Artificial Intelligence: Radiologists and Pathologists as Information Specialists", *JAMA* 316, no. 22 (2016): 2353–2354, https://doi.org/10.1001/jama.2016.17438; for the original economic principle, William Stanley Jevons, *The Coal Question: An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal-Mines* (London: Macmillan, 1865).
22. European Commission, *Skills Shortage in Healthcare: Nursing and Care Workforce in the EU* (Brussels: DG EMPL, 2024); World Health Organization, *State of the World's Nursing 2025* (Geneva: WHO, 2025); Organization for Economic Co-operation and Development, *Health Workforce Policies in OECD Countries* (Paris: OECD, 2023).
23. CureVision GmbH, "AI-Powered Wound Documentation and Decision Support for Nursing", company technical overview, 2025, https://curevision.com.
24. LinkedIn Economic Graph, *Future of Work Report: AI at Work* (January 2026); World Economic Forum, *Future of Jobs Report 2025* (Geneva: WEF, 2025); Goldman Sachs Global Investment Research, *Generative AI and the Labor Market* (New York: Goldman Sachs, 2024).
25. Robert J. Marks, *Non-Computable You: What You Do That Artificial Intelligence Never Will* (Seattle: Discovery Institute Press, 2022).
26. Mustafa Suleyman with Michael Bhaskar, *The Coming Wave: Technology, Power, and the Twenty-First Century's Greatest Dilemma* (New York: Crown, 2023); Brian Christian, *The Alignment Problem: Machine Learning and Human Values* (New York: W. W. Norton, 2020).
27. Andy Stern, *Raising the Floor: How a Universal Basic Income Can Renew Our Economy and Rebuild the American Dream* (New York: PublicAffairs, 2016); Guy Standing, *Basic Income: And How We Can Make It Happen* (London: Pelican, 2017); Anna Coote and Andrew Percy, *The Case for Universal Basic Services* (Cambridge: Polity, 2020).
28. International Energy Agency, *The Role of Critical Minerals in Clean Energy Transitions* (Paris: IEA, 2021, revised 2024); International Energy Agency, *World Energy Outlook 2024* (Paris: IEA, 2024).
29. International Energy Agency, *Net Zero Roadmap: A Global Pathway to Keep the 1.5°C Goal in Reach—2023 Update* (Paris: IEA, 2023), https://www.iea.org/reports/net-zero-roadmap-a-global-pathway-to-keep-the-15-0c-goal-in-reach.
30. International Energy Agency, *Global EV Outlook 2024* (Paris: IEA, 2024), https://www.iea.org/reports/global-ev-outlook-2024; BloombergNEF, *Lithium-Ion Battery Price Survey 2024* (London: BloombergNEF, 2024); Maximilian Fichtner et al., "Rechargeable Batteries of the Future—The State of the Art from a BATTERY 2030+ Perspective", *Advanced Energy Materials* 12, no. 17 (2022): 2102904, https://doi.org/10.1002/aenm.202102904.
31. U.S. Geological Survey, *Mineral Commodity Summaries 2024* (Reston, VA: U.S. Geological Survey, 2024), https://doi.org/10.3133/mcs2024; Gavin M. Mudd and Simon M. Jowitt, "Growing Global Copper Resources, Reserves and Production: Discovery Is Not the Only Control on Supply", *Economic Geology* 113, no. 6 (2018): 1235–1267, https://doi.org/10.5382/econgeo.2018.4590.

32. John R. Owen, et al., "Energy Transition Minerals and Their Intersection with Land-Connected Peoples", *Nature Sustainability* 6, no. 2 (2023): 203–211, https://doi.org/10.1038/s41893-022-00994-6.

33. Yu-Min Liu et al., "Quantitative Assessment of Polymetallic Nodule Resources in the Clarion–Clipperton Zone", F*rontiers in Marine Science* 11 (2024): 1489184, https://doi.org/10.3389/fmars.2024.1489184; International Seabed Authority, *Status Report on the Activities of the Authority and on the Status of the Area* (Kingston: ISA, 2024).

34. Muriel Rabone, et al., "How Many Metazoan Species Live in the World's Largest Mineral Exploration Region?", *Current Biology* 33, no. 11 (2023): 2383–2396, https://doi.org/10.1016/j.cub.2023.04.052; Erik Simon-Lledó et al., "Biological Effects 26 Years After Simulated Deep-Sea Mining", *Scientific Reports* 9 (2019): 8040, https://doi.org/10.1038/s41598-019-44492-w; Sabine Gollner et al., "Application of Scientific Criteria for Identifying Hydrothermal Ecosystems in Need of Protection", *Marine Policy* 132 (2021): 104641, https://doi.org/10.1016/j.marpol.2021.104641.

35. Daina Paulikas, et al., "Life Cycle Climate Change Impacts of Producing Battery Metals from Land Ores versus Deep-Sea Polymetallic Nodules", *Journal of Cleaner Production* 275 (2020): 123822, https://doi.org/10.1016/j.jclepro.2020.123822; Anna Hyman et al., "Global Mine-by-Mine Modeling of Deep-Sea Nickel Displacement and Terrestrial Biodiversity Priorities", *Nature Ecology & Evolution* (2026, in press).

36. Donella H. Meadows, et al.,, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books, 1972); Jørgen Randers, 2052: *A Global Forecast for the Next Forty Years* (White River Junction, VT: Chelsea Green, 2012); Graham M. Turner, "Is Global Collapse Imminent? An Updated Comparison of The Limits to Growth with Historical Data", MSSI Research Paper No. 4 (Melbourne: Melbourne Sustainable Society Institute, University of Melbourne, 2014); Ernst Ulrich von Weizsäcker and Anders Wijkman, with contributions from 34 members of the Club of Rome including Mariana Bozesan, *Come On! Capitalism, Short-termism, Population and the Destruction of the Planet—A Report to the Club of Rome* (New York: Springer, 2018).

37. Ken Wilber, *A Theory of Everything: An Integral Vision for Business, Politics, Science, and Spirituality* (Boston: Shambhala, 2000); Susanne Cook-Greuter, "Nine Levels of Increasing Embrace in Ego Development: A Full-Spectrum Theory of Vertical Growth and Meaning Making", working paper, 2013, https://www.cook-greuter.com.

38. Mariana Bozesan, "Demystifying the Future of Investing: An Investor's Perspective, Part 1", *Journal of Integral Theory and Practice* 8, no. 1 (2013): 19–56; Mariana Bozesan, "The Investment Turnaround: An Integral Approach to Sustainable Investing", in *The Routledge Handbook of Sustainable and Regenerative Finance*, ed. Thomas Walker et al. (London: Routledge, 2024); R. Edward Freeman et al., *Stakeholder Theory: The State of the Art* (Cambridge: Cambridge University Press, 2010).

39. Proxima Fusion, "Stellaris: The First Peer-Reviewed Stellarator Concept for a Commercial Fusion Power Plant", *Fusion Engineering and Design* (2025); Commonwealth Fusion Systems, *SPARC and ARC: Technical Roadmap to Commercial Fusion*, technical white paper, 2024; Helion Energy, "Polaris Update", company briefing, 2025.

40. Nikolai Kardashev, "Transmission of Information by Extraterrestrial Civilizations", *Soviet Astronomy* 8 (1964): 217–221; Freeman Dyson, "Search for Artificial Stellar Sources of Infrared Radiation", *Science* 131 (1960): 1667–1668.

41. Caltech Space Solar Power Project, "Space Solar Power Demonstrator: First Wireless Power Transmission from Orbit", *Engineering & Science* (2023); European Space Agency, *SOLARIS Initiative Phase 0 Report* (Paris: ESA, 2024); McKinsey & Company, "Data Centers in Space: An Emerging Frontier", report, 2024.

42. Donald J. Kessler and Burton G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt", *Journal of Geophysical Research* 83, no. A6 (1978): 2637–2646; European Space Agency Space Debris Office, *ESA Annual Space Environment Report 2024* (Darmstadt: ESA, 2024), https://www.esa.int/Space_Safety/Space_Debris; NASA Orbital Debris Program Office, *Orbital Debris Quarterly News* 28, no. 1 (2024); Astroscale Holdings, "ELSA-d and COSMIC Active Debris Removal Mission Reports", 2024–2025.

43. Demis Hassabis, "Using AI to Accelerate Scientific Discovery", Nobel Lecture, Stockholm, December 8, 2024; Riccardo Manenti and Mario Motta, *Quantum Information Science* (Oxford: Oxford University Press, 2023).

44. Mariana Bozesan, *Integral Investing: From Profit to Prosperity* (Cham: Springer, 2020).

45. Mariana Bozesan, "The Investment Turnaround: An Integral Approach to Sustainable Investing", in *The Routledge Handbook of Sustainable and Regenerative Finance*, ed. Thomas Walker et al. (London: Routledge, 2024).

46. Ken Wilber, *A Theory of Everything: An Integral Vision for Business, Politics, Science, and Spirituality* (Boston: Shambhala, 2000); Susanne Cook-Greuter, "Nine Levels of Increasing Embrace in Ego Development: A Full-Spectrum Theory of Vertical Growth and Meaning Making", working paper, 2013, https://www.cook-greuter.com.

47. Intergovernmental Panel on Climate Change, *AR6 Synthesis Report: Climate Change 2023* (Geneva: IPCC, 2023), https://www.ipcc.ch/report/ar6/syr.