RVA CYBER RESEARCH

CYBERSECURITY, AI GOVERNANCE, AND RESILIENT INSTITUTIONS

No One Is Expendable

Life’s essentials secured for everyone—through sustainable, regenerative, and resilient systems, with human development open-ended under known physics.

The Bright Commons
The essentials are solved. The future is open.
Abundance secures · sustainability endures · resilience recovers · rights include

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In 90 seconds

One page: the problem, the operating architecture, the roadmap, and the rule.

The destination. The goal is not infinite goods. It is **the Bright Commons**: clean water, nutritious food, reliable energy, safe shelter, clothing, healthcare and caregiving, education, mobility, communication, and computational capability secured for everyone; sustainable, regenerative, and resilient systems; and human development open-ended under known physics. “Commons” names the guarantee, not a mandatory owner or lifestyle.

The five-part test. A service is abundant only when sustainable capacity includes a reserve; delivery meets reliability and recovery standards; nobody is excluded by price, place, disability, documentation, or discrimination; entitlement includes appeal and remedy; and full-life-cycle ecological, safety, privacy, and security effects stay inside public budgets and red lines. Fail one, and the service is not abundant.

Sustainability and resilience. Sustainability is not austerity or a ceiling on ambition. It means expanding capability without destroying or exporting its foundations. Clean energy, responsible new supply, substitution, repair, recovery, restoration, redesign, and evidence-gated off-world resources can expand headroom. Resilience is a funded duty of systems—not a demand that households endure failure.

The roadmap. Build a seven-layer Abundance Stack and advance through evidence gates: measure; build essentials; automate bounded bottlenecks; complete unconditional access; regenerate and harden; maintain the Bright Commons; and open an optional off-world resource frontier only when full-cost, safety, rights, and governance tests pass. A Solar System resource frontier is physically plausible but not required. Galactic resources are a far-horizon possibility, not a forecast.

Three implications. Build real supply with purchasing power. Match markets, public systems, and commons to their functions. Broaden ownership and protect every person’s material right to leave.

The rule. Build the stack. Pass the gates. Share the gain. Preserve the right to stop. Never sacrifice people for the destination. **No one is expendable.**

The short version ends here; the extended takeaway adds evidence and sequence.

For the claim-by-claim map, evidence boundaries, limitations, and deeper reading, see the companion Evidence, Limits & Further Reading guide.

Help improve this paper. Found a factual error, stronger source, missing tradeoff, implementation example, or serious objection? Open RVA Cyber’s contact information. Identify the passage and, where possible, include supporting evidence. Please do not send confidential, personal, medical, or proprietary information.

Extended Executive Takeaway

A Star Trek–like future is possible only after we remove most of the magic from *Star Trek*. Known physics gives us no warp drive, transporter, anti-gravity, or box that rearranges energy into any object on command. It does give us a far less cinematic opportunity: civilization can produce clean electricity, computation, knowledge, food, water, shelter, medicine, manufactured goods, and mobility at scales that make severe material deprivation avoidable. That would not be infinite abundance. It would be something morally larger: a world in which nobody's access to the means of living depends on winning a daily bidding war.

This paper calls that destination **the Bright Commons**: a civilization in which life's essentials are universally secured; the systems providing them are sustainable, regenerative, and resilient; and human development remains open-ended under known physics. "Commons" does not require every possession or provider to be collective. It means that foundational capabilities are guaranteed to every person and governed so that no employer, company, ministry, platform, household, or accident can monopolize the means of living.

The phrase also rejects a false choice. Sustainability is not a doctrine of permanent austerity, a fixed material ceiling, or a command to freeze human development. It is the engineering and governance requirement to expand capability without destroying or exporting the foundations that make continued expansion possible. When an ecological budget binds, the answer is to solve the bottleneck: cleaner energy, responsible new supply, substitution, repair, circularity, restoration, better design and siting, or—when full-life-cycle, safety, rights, and governance tests pass—off-world energy and materials. Ecological budgets constrain destructive methods and locations, not human aspiration. Sustainability is the minimum condition; regeneration is the positive work of increasing ecological and productive headroom.

A service qualifies as **abundant** only when five conditions hold together: sustainable capacity exceeds ordinary need with a reserve; delivery meets published reliability and recovery standards; price and other barriers do not exclude people; access is an enforceable right rather than a favor; and provision passes full-life-cycle ecological and safety tests. A country with surplus electricity and households that cannot afford it has capacity, not abundance. A free service that fails every week has a promise, not abundance. A rich society that exports its pollution and coercion has displaced scarcity, not overcome it.

The path is not one breakthrough. It is an **Abundance Stack**. Reliable low-emissions power supports communication and computation. Networks support controlled artificial intelligence and automation. Automation expands fabrication, construction, agriculture, logistics, laboratories, and administration. Those capabilities lower the real cost of essential services. Regenerative material systems, ecological accounting, and resilience keep the gain durable and expandable. Rights, broad ownership, competition, public infrastructure, and democratic legitimacy convert capacity into freedom. Miss those cross-cutting conditions and technology produces affluent but brittle enclaves surrounded by dependence.

The roadmap therefore uses gates rather than prophecies. Its dates are illustrative horizons, not forecasts. Between 2026 and roughly 2040, jurisdictions can build and connect power, grids, storage, water, housing, clean cooking, sanitation, and broadband with technologies that exist now. From the 2030s into the 2050s, they can automate structured bottlenecks without assuming a flawless humanoid robot or artificial general intelligence. As the essential basket becomes easier to supply, societies can make access unconditional through universal basic services, portable social protection, a cash floor, shorter working hours, and shared ownership of automated capital. Sustainability, resilience, and rights shape every phase from the start; later gates prove system-wide regeneration and hardening rather than introducing them after growth. Off-world industry can eventually widen the resource frontier, but Earth's essential floor never depends on it.

This transition is radical. It changes the relationship among work, property, public goods, and citizenship. It may require organized labor, electoral realignment, constitutional change, antitrust breakups, public utilities, social wealth funds, civil resistance, and new international bargains. It does **not** require accepting mass death. Atrocity is disallowed because people are the point of the project. It also fails instrumentally: war and state terror destroy expertise, infrastructure, health, trust, supply

chains, public finance, error-correcting institutions, and the legitimacy needed for a century of coordinated construction. Recent World Bank analysis estimates that high-intensity conflict is typically followed by GDP per person about 20 percent below its pre-conflict projection after five years.[1] A path that burns the productive and moral foundations of abundance is not a shortcut to abundance.

The hard problem is no longer whether humanity can imagine enough output. It is whether productive power can be governed without turning people into inputs, dependents, or obstacles. Abundance secures the essentials. Sustainability keeps expansion durable. Resilience keeps the floor intact through shocks. Rights keep every person a participant rather than an input. The practical rule is simple: **build the stack, pass each public gate, share the gain, and preserve the right to stop.** No average, growth rate, or distant utopia may compensate for a population stripped of rights along the way.

Abstract

This paper develops a dependency-ordered pathway from the world of 2026 toward the Bright Commons, a physically plausible form of broad material abundance. It rejects two symmetrical errors. The first is technological pessimism: the claim that finite matter prevents civilization from guaranteeing a high material floor or expanding human capability. The second is technological salvation: the claim that artificial intelligence, fusion, robotics, or space resources will automatically eliminate scarcity. Evidence supports neither conclusion. Much of the required productive capacity can be built with demonstrated technologies, while universal access, ecological solvency, resilience, political power, rights, and safety remain independent requirements that the system must solve together.

Five contributions organize the argument. First, the **Conjunctive Abundance Test** defines abundance through sustainable capacity, reliable delivery and recovery, effective access, enforceable entitlement, and full-life-cycle sustainability and safety. Failure of any one condition is not offset by excellence in another. Second, the seven-layer **Abundance Stack** links power, networks, machine capability, production, provisioning, regenerative material systems, and legitimate distribution, with sustainability, resilience, and rights applying throughout. Third, a seven-gate roadmap orders investment from measurement and infrastructure through automation, unconditional access, system-wide regeneration and hardening, mature Bright Commons, and an optional off-world resource frontier. Each gate has entry conditions, public metrics, failure triggers, and a recovery branch. Fourth, the **Abundance Compact** combines competitive markets, public utilities, universal basic services, social protection, shared capital ownership, labor power, civil rights, and international technology diffusion. Fifth, the **Universal Capability Ledger** records capacity, reliability, burden, access, entitlement, distribution, autonomy, sustainability and regeneration, and resilience and security without collapsing them into one score. Those nine dimensions operationalize the five-part Test across services, groups, and time.

The pathway does not depend on commercial fusion, human-level general intelligence, general-purpose humanoid robots, asteroid mining, interstellar travel, or any timetable for them. It uses frontier technologies only after they pass empirical cost, safety, rights, lifecycle, and governance gates. The Solar System can enlarge the future feasible set without sitting on Earth's critical path; interstellar and galactic resource use remains a far-horizon possibility under known physics, not a forecast or commercial claim. The pathway also rejects violent revolution and mass-casualty transition as both impermissible and self-defeating. Radical nonviolent institutional change remains within scope.

Sixteen attack–repair cycles test energy and grid cost, fusion failure, material limits, rebound, robotic brittleness, AI risk, ownership concentration, supply and fiscal stress, loss of meaning, democratic delay, authoritarian coordination, global asymmetry, malicious use, and space economics—followed by a combined attack on conflict, timetable realism, and positional scarcity. The resulting thesis is deliberately defeasible: if jurisdictions cannot reduce the resource cost of a guaranteed essential basket while expanding capability and improving sustainability, regeneration, distribution, resilience, and rights indicators together, this pathway has failed even if aggregate output rises.

1. Correcting the destination

The humane part of *Star Trek* is not the starship. It is the background assumption that a person may learn, heal, travel, create, investigate, or simply exist without first proving economic usefulness. Material security makes exploration possible. That is the feature worth reverse-engineering.

This paper names that destination **the Bright Commons**: a civilization in which life's essentials are universally secured; the systems that provide them are sustainable, regenerative, and resilient; and human development remains open-ended under known physics. "Commons" describes the guaranteed foundation, not one required form of ownership. Public, private, cooperative, nonprofit, household, and mixed systems can all contribute when they pass the same capacity, access, rights, sustainability, and resilience tests.

The fictional technologies cannot be imported wholesale. Faster-than-light travel conflicts with the relativistic limit that no matter or information is known to exceed the speed of light in vacuum.[2] Teleporting a person would require solving problems of measurement, information, reconstruction, identity, and energy that no existing engineering program approaches. A replicator that turns undifferentiated energy into a meal or violin is not an advanced 3-D printer; mass–energy conversion at useful scale would impose extreme energy and radiation problems, while atomically precise fabrication remains research rather than infrastructure.

Literal post-scarcity is therefore the wrong target. Scarcity has at least four forms.

Physical scarcity follows from finite time, land, energy flux, rare locations, ecological assimilative capacity, and unique objects. There can be only one original painting, one house on a particular shore, and a finite number of quiet hours in a city. No roadmap abolishes those facts.

Engineering scarcity exists when a useful service is physically possible but expensive, unreliable, labor-intensive, or difficult to scale. Solar modules, vaccines, semiconductors, desalination, heat pumps, robots, and modular construction live here. Learning, standardization, infrastructure, and manufacturing can move the boundary.

Institutional scarcity exists when capacity is present but law, income, market power, discrimination, conflict, or administrative failure blocks access. Almost 92 percent of humanity had basic electricity access in 2023, yet 666 million people remained without it and more than two billion still relied on polluting cooking fuels.[3] Nearly three quarters of the world was online in 2025, but 2.2 billion people remained offline and affordability and quality gaps persisted.[4] Those gaps are not explained by a missing law of physics.

Positional scarcity concerns rank and relative advantage. Attention, prestige, selective membership, competitive victory, and status locations remain scarce even when calories and computation are plentiful. A serious abundance program guarantees dignity and capability; it does not promise everyone first place.

This paper uses **abundance** to mean a condition in which every person has a reliable, rights-protected material floor and many goods and services have low marginal cost, while the system continually solves ecological, safety, and resilience requirements rather than exporting them. It uses **universal basic services** for guaranteed access to service systems such as healthcare, education, water, sanitation, connectivity, energy, mobility, and shelter support. It uses **cash floor** for income support that preserves choice where markets work. Neither is sufficient alone. A cash payment cannot summon homes in a city that forbids building, and a public clinic is not universal if reaching it requires a day's travel.

The **lifeline tier** is the immediately enforceable minimum; the **essential tier** is the mature guaranteed basket. "Essential basket" and "essential bundle" refer to that tier. "Unconditional" means access is not contingent on employment, income, documentation, or political loyalty; it does not mean unlimited use.

The Conjunctive Abundance Test

A service qualifies as abundant within a jurisdiction only when all five conditions are met:

1. **Capacity:** sustainable supply covers normal demand, predictable growth, and a declared reserve margin.
2. **Delivery:** users receive the service at a published reliability and recovery standard.
3. **Access:** price, location, documentation, disability, discrimination, and digital requirements do not exclude a person from the essential tier.
4. **Entitlement:** the person has a legal claim, notice, appeal, remedy, and meaningful alternatives when provision fails or becomes coercive.
5. **Sustainability and safety:** full-life-cycle carbon, land, water, biodiversity, waste, safety, privacy, and security effects remain inside public budgets and red lines while restoration expands future headroom.

The test is **conjunctive**, not additive. A 99 percent national access average cannot compensate the one percent being deliberately excluded. Cheap power cannot offset a grid that can be switched off to punish dissent. A clean system cannot justify forced displacement. The framework keeps a ledger of unlike dimensions precisely so that a favorable average cannot launder a rights violation.

The target is also service-based rather than object-based. Nutrition can be abundant without unlimited steak. Mobility can be abundant without a private car for every trip. Thermal comfort can rise while building energy falls. The IPCC's assessment of demand, services, and well-being finds that decent living standards are compatible with high-efficiency, relatively low-demand pathways; with medium confidence, it estimates a context-dependent minimum of roughly 20–50 gigajoules of final energy per person per year and concludes that better service provision can improve well-being while reducing resource input.[5] This is not a prescription for one lifestyle. It is evidence that human capability and material throughput are related but not identical.

Sustainability is a problem to solve, not a ceiling

The Bright Commons does not treat present-day technologies, supply chains, or environmental damage as permanent limits on human development. It treats them as design problems. When a material, energy, land, water, toxicity, or habitat budget binds, civilization should climb a transparent solution ladder: use cleaner energy; open responsible new supply with consent and restoration; substitute less harmful materials; extend product life; repair and recover; redesign infrastructure and services; restore damaged systems; and, when evidence warrants it, develop off-world energy and materials. Sufficiency protects the floor while the next solution is built. It is not the final aspiration.

That distinction matters. An ecological budget says that a destructive method, location, or rate cannot continue—not that people must stop learning, building, exploring, traveling, creating, or improving their lives. Sustainability is the minimum requirement that development remain durable. **Regeneration** is the higher ambition: increase ecological and productive headroom so that future people inherit more capability and more options. **Resilience** is the funded ability to preserve the essential floor through drought, outage, pandemic, cyberattack, supply disruption, recession, conflict, and political turnover. Neither burden is transferred to households as a moral demand to endure institutional failure.

The threshold is high

Humanity is far from passing the test. The World Bank's March 2026 data vintage estimated that, in 2024, 846.8 million people lived below the $3.00-per-day international extreme-poverty line and 3.751 billion lived below $8.30 per day, both measured in 2021 purchasing-power-parity dollars.[6] The 2025 global health-coverage report estimated that 4.6 billion people lacked coverage for essential health services in 2023 and 2.1 billion experienced financial hardship from out-of-pocket health spending in 2022.[7] The WHO–UNICEF monitoring program records enormous progress in water and sanitation since 2000, but its 2025 assessment still emphasizes persistent geographic, income, and fragility gaps.[8] UN-Habitat reports billions without adequate housing, while UNESCO estimates 273 million children and youth remained out of school in 2024.[9][10]

These numbers should prevent a common mistake. "Abundance" is not a branding exercise for affluent countries with faster delivery. The first measure of progress is whether the last-connected person gains durable capability. The second is whether the method can survive climate, conflict, cyberattack, recession, demographic change, and political turnover. The third is whether the gain expands freedom rather than merely replacing dependence on an employer with dependence on a platform or ministry.

2. What the Bright Commons guarantees

The roadmap needs an explicit object. "Universal essentials" cannot remain a warm phrase while the machinery for building them becomes precise. The Bright Commons therefore begins with a public service catalog: twelve families of capability that together make material security, participation, and a practical right of exit possible. The list identifies what is guaranteed, not one required provider, owner, technology, or lifestyle.

Three tiers for every service

Every service family has the same three-part structure.

1. The **lifeline** is the emergency minimum nobody may lose while a fuller service is repaired or built. It prevents a technical, financial, administrative, or political failure from becoming a threat to life or legal personhood.
2. The **essential tier** is the mature abundance guarantee: dependable, rights-protected service available without proving economic usefulness. Its quality, quantity, reach, continuity, and remedy are specific enough to enforce.

3. The **open frontier** contains additional variety, personalization, speed, luxury, and resource-intensive use above the guarantee. Markets, cooperatives, households, public institutions, and other plural systems may provide it, subject to the same safety, rights, and ecological red lines.

This structure avoids two symmetrical errors. A survival ration is not abundance. Unlimited free consumption is not abundance either. The guaranteed tier must be sufficient for health, dignity, participation, development, and exit; provision above it can remain differentiated where resources, preferences, and genuinely scarce goods differ.

Twelve service families

1. **Energy and thermal comfort:** dependable power for lighting, clean cooking, food and medicine preservation, communication, safe heating and cooling, learning, care, and ordinary participation. Abundance means a falling and affordable service burden, sufficient reserve, and practiced recovery—not a promise of zero-cost unlimited energy.
2. **Water, sanitation, and hygiene:** safe water at the point of use; toilets, wastewater treatment, drainage, and hygiene; continuity through contamination or network failure; and basin-level stewardship. A nearby pipe that is unsafe, intermittent, unaffordable, or inaccessible does not pass.
3. **Food and nutrition:** reliable access to a safe, varied, nutritious, and culturally workable diet across age, health, disability, and household conditions. The essential tier is more than calories; premium dining, rare ingredients, luxury quantities, and unusually resource-intensive choices remain above the floor.
4. **Housing and shelter:** a safe, stable, accessible, climate-appropriate home with adequate space, privacy, utilities, tenure protection, and practical reach to community life. Empty units do not establish abundance while homelessness, unsafe crowding, arbitrary eviction, or geographic isolation persists.
5. **Healthcare:** timely preventive, primary, emergency, reproductive, mental, dental, chronic, rehabilitative, and pharmaceutical care without financial ruin. Coverage on paper is insufficient when distance, waiting time, staffing, cost, discrimination, or an unappealable denial blocks treatment.
6. **Caregiving and daily support:** childcare, eldercare, disability support, home assistance, respite, assistive technology, and supported decision-making. This is a distinct service family because medicine, cash, and automation cannot substitute for sustained human care, autonomy, and relief from impossible unpaid burdens.
7. **Education and knowledge:** safe foundational learning plus lifelong access to teachers, peers, libraries, laboratories, arts, vocational routes, research, devices, and trustworthy knowledge. Abundance is demonstrated capability to learn and act—not enrollment, content volume, or an AI subscription alone.
8. **Mobility and transportation:** safe, affordable, accessible movement to food, shelter, care, education, work, family, civic life, and refuge. The service is reach and participation, not a private vehicle for every trip; travel time, reliability, injury, land, energy, and fallback all count.
9. **Communication and connectivity:** reliable voice, messaging, broadband, emergency alerts, an adequate device, accessibility, language support, privacy, portability, and usable fallback. Nominal network coverage fails when price, equipment, skills, censorship, surveillance, or a single provider can disconnect a person from social existence.
10. **Computation and digital capability:** secure computing, software, public-interest digital tools, and bounded artificial-intelligence assistance sufficient to learn, create, work, transact, and use public services. Human appeal, data portability, cybersecurity, and non-digital alternatives prevent convenience from becoming compulsory machine authority.
11. **Essential personal and household goods:** adequate clothing, hygiene supplies, bedding, cooking and food-storage equipment, basic furnishings, and the ability to maintain or replace them. Low factory cost is not abundance when

goods are unsafe, inaccessible, disposable, produced coercively, or designed to become waste.

12. **Civic, legal, and financial access:** practical legal personhood; payments; benefits; voting and public participation; legal assistance; notice, appeal, and remedy; and the material means to leave an abusive employer, household, institution, platform, or locality. Formal rights fail when a lost document, frozen account, inaccessible court, or automated denial can erase them in practice.

These families interact without collapsing into one another. Electricity supports water treatment, but a megawatt is not a glass of safe water. Connectivity supports education, but a broadband connection is not a teacher, laboratory, or protected place to learn. Cash preserves choice, but it cannot create a vacant home, clinician, caregiver, bus route, or transformer where supply does not exist. Rights govern every family but do not operate themselves; each promise needs institutions, workers, physical capacity, maintenance, finance, and recovery.

What counts as abundance in one place

The unit of proof remains one **service × jurisdiction** module. Each module must specify its lifeline, essential tier, open frontier, responsible institutions, quantitative thresholds, subgroup floors, evidence window, continuity service, and recovery branch. The Conjunctive Abundance Test then asks whether sustainable capacity includes a reserve; delivery meets reliability and recovery standards; access survives price, place, disability, documentation, discrimination, and digital barriers; entitlement includes notice, appeal, and remedy; and full-life-cycle sustainability and safety remain inside public budgets and red lines.

The Universal Capability Ledger supplies the evidence: capacity, reliability, burden, access, entitlement, distribution, autonomy, sustainability and regeneration, and resilience and security. No national average substitutes for the last-connected person, and no strength in one dimension cancels failure in another. A service becomes part of the Bright Commons only when people can actually use it, rely on it, recover it, and challenge its abuse.

The companion What the Bright Commons Guarantees guide expands every family into its lifeline, essential tier, open frontier, proof signals, failure condition, and major dependencies.

3. The physics ledger

A roadmap that invokes “known physics” needs an explicit ledger of what physics permits, what engineering has demonstrated, and what remains speculative. The categories matter because a plan fails if a speculative technology sits on its critical path.

Energy cannot be free

Mass and energy are conserved within the accounting boundary. Real processes generate entropy, destroy some available exergy—the portion of energy capable of useful work—and generally reject waste heat. Devices have finite efficiency. Networks lose power. Storage requires materials, land, conversion equipment, maintenance, and replacement. Computation has thermodynamic costs even though present machines operate far above some fundamental limits. “Too cheap to meter” is not the same as zero resource cost.

Yet useful energy can become far cheaper and cleaner relative to the services it enables. IRENA reports that in 2024, 91 percent of newly commissioned utility-scale renewable projects produced electricity below the cost of the cheapest new fossil-fuel alternative; its global weighted averages were about $0.034 per kilowatt-hour for onshore wind and $0.043 for solar photovoltaic generation.[11] Those are generation estimates, not retail bills. Transmission, firm capacity, storage, financing, land, interconnection, distribution, and risk still matter.

The immediate bottleneck is often the network. The IEA reported in 2026 that indicative 2025 grid-connection queues contained more than 2,500 gigawatts of renewable, storage, and large-load projects at mixed development stages; not all are viable, and new grid infrastructure can require five to fifteen years, far longer than many generation and load projects.[12] An abundance roadmap that counts modules but not transformers, substations, skilled labor, permitting, cybersecurity, and reserves is an equipment catalog, not a power system.

The practical path is plural: renewables where they are economical; existing and new nuclear where institutions can build and regulate it safely; geothermal, hydro, and other local resources where appropriate; storage across minutes, days, and seasons; expanded transmission; flexible demand; efficiency; and limited firm fuels or carbon management where alternatives are not yet adequate. No single technology is awarded a monopoly on the future.

Fusion is an option, not a premise

Fusion obeys known physics. Commercial fusion power has not been demonstrated. The distinction is easy to lose because scientific energy gain and whole-facility electricity gain are different thresholds.

The National Ignition Facility has repeatedly produced more fusion energy from a target than the laser energy delivered to that target. Its own explanation notes that the electrical energy needed to operate the facility remains far larger, and that a power plant would need net facility gain plus repetition, target production, heat capture, materials endurance, maintenance, and competitive cost.[13] ITER is designed to produce 500 megawatts of fusion power in its plasma from 50 megawatts of injected heating power, but it will not generate electricity; it is an experiment intended to study burning plasma and integrated technologies.[14]

The roadmap therefore spends on fusion research and makes room for successful plants, but every terrestrial abundance gate must be passable without them. If fusion becomes safe and economical, it enlarges the margin. If it arrives late or never, diversified fission, renewables, storage, networks, geothermal resources, efficiency, and demand design must still carry the plan.

Matter remains matter

Cheap energy does not erase material accounting. Ore grades, refining, water, land, toxic byproducts, geopolitics, construction time, and ecosystem disruption constrain every machine. The International Resource Panel reports that global natural-resource extraction tripled over the preceding five decades and could rise another 60 percent by 2060 under current trends.[15] A peer-reviewed 2023 update to the planetary-boundaries framework concluded that six of nine assessed Earth-system boundaries were already transgressed.[16] These frameworks contain uncertainty and normative choices about risk; they are warning systems, not precise civilizational thermostats. They nevertheless undercut the notion that more efficient extraction alone creates a safe abundance.

Circularity reduces but never eliminates virgin input. Buildings, grids, sanitation, and transport for populations that lack them require new stocks. Materials dissipate, contaminate, corrode, and become uneconomic to recover. Population and infrastructure growth need net additions. The relevant target is not “100 percent recycling.” It is a service system designed for durability, repair, disassembly, reuse, high-value recovery, substitution away from harmful materials, responsible new supply, restoration, and absolute ecological budgets.

Those budgets are feedback signals for invention and investment, not a command to freeze civilization at its current scale. A binding pressure should trigger the solution ladder: cleaner processes, better siting, new terrestrial supply under enforceable host-community rights, substitution, longer life, high-value recovery, ecological restoration, better service design, and

eventually off-world supply where it offers a verified net advantage. A proposal that simply moves extraction, waste, or coercion out of sight has not solved sustainability. A proposal that expands capability while restoring ecological headroom has.

Information is unusually scalable, not immaterial

Software, designs, lessons, scientific findings, and entertainment can be copied at very low marginal cost. That makes knowledge the closest existing analogue to fictional replication. But servers use electricity and water; chips require specialized facilities and supply chains; networks exclude people who lack devices, skills, language support, or rights; and intellectual property, secrecy, market power, and safety rules determine which knowledge moves.

Artificial intelligence can lower the cost of translation, tutoring, design exploration, coding, administration, and scientific search. It cannot be treated as an oracle or autonomous sovereign. NIST's AI Risk Management Framework centers continuous governance, mapping, measurement, and management of risks across a system's life cycle.[17] That life-cycle discipline belongs inside the abundance stack: bounded tasks, independent evaluation, incident reporting, cybersecurity, human authority over legitimate ends, and a rollback route. A model that raises nominal capacity while making critical services opaque, insecure, or unappealable has failed the Conjunctive Test.

Space is large; economics is local

The Solar System contains immense matter and energy. Accessing them requires launch energy, reliable transportation, autonomous construction and repair, radiation protection, closed-loop life support, communications delay management, law, and a customer willing to pay more than the delivered cost. NASA's current Moon-to-Mars architecture is explicitly incremental: human return, foundational exploration, sustained lunar evolution, and eventual Mars missions.[18][19] NASA also maintains an active in-situ resource-utilization program to develop and test ways of locating, extracting, and processing water, oxygen, metals, and other local resources.[20] Those facts establish a legitimate engineering frontier. They do not show that commercial off-world supply can beat terrestrial alternatives.

Any resource frontier also inherits political and ecological obligations. The Outer Space Treaty makes exploration and use subject to international law, for the benefit and in the interests of all countries; rejects national appropriation; and requires due regard and avoidance of harmful contamination.[21] The United Nations' long-term sustainability guidelines add a voluntary framework for preserving the space environment and sharing benefits, but they are not a complete resource regime.[22] NASA's planetary-protection discipline addresses forward contamination of other worlds and backward contamination of Earth.[23] A Bright Commons cannot claim to escape terrestrial externalities by reproducing enclosure, contamination, labor coercion, debris, or conflict elsewhere.

Space infrastructure therefore belongs in the final, optional gate. It may eventually move selected hazardous processes away from sensitive terrestrial ecosystems, expand science, provide rare environments, widen material and energy options, and add resilience. It is not needed to feed, house, connect, educate, or medically serve everyone on Earth. Any roadmap that postpones justice until asteroid mining succeeds has confused an adventure with a dependency.

The horizon must remain honest. The Moon, near-Earth space, asteroids, and other parts of the Solar System sit inside known-physics engineering, however difficult and uncertain their economics. The nearest known star system is about 4.25 light-years away.[24] Without a demonstrated interstellar transport architecture, "galactic resources" belong to the possibility boundary of a civilization-scale vision—not to this roadmap's forecasts, budgets, or critical path. The Bright Commons keeps that frontier open without borrowing present credibility from it.

The physics ledger therefore yields a disciplined optimism:

- no unlimited energy, but much cheaper clean useful work;

- no magical replicator, but flexible automated fabrication and high recovery;
- no infallible machine mind, but scalable bounded intelligence;
- no abolition of material limits, but a widening ladder of cleaner supply, substitution, recovery, restoration, and responsible frontiers;
- no faster-than-light federation, but a plausible civilization across parts of one Solar System;
- no forecast of galactic industry, but no doctrine that human aspiration must end at Earth;
- no end to every scarcity, but an end to much involuntary deprivation.

4. “Here” in 2026

The starting point is neither technological infancy nor incipient utopia. Civilization already operates continental grids, global logistics, automated factories, desalination plants, vaccine platforms, satellite networks, high-yield agriculture, digital libraries, and machines that can translate, reason over bounded problems, and control industrial processes. It also leaves billions without the effective use of simpler systems. The contradiction identifies the work: expand capacity where it is missing, and repair the institutions that fail to deliver capacity where it already exists.

Power is scaling faster than its connective tissue

Low-emissions electricity supplied 43 percent of global generation in 2025, according to the IEA; renewables provided 34 percent and nuclear the remainder.[25] IRENA recorded 582 gigawatts of new renewable capacity in 2024.[11] These are industrial quantities. At the same time, coal remained the largest single source of electricity, many grids faced congestion, and people without basic access were increasingly concentrated in remote, low-income, and conflict-affected regions.

The next unit of progress is therefore not merely another gigawatt. It is a useful connection: generation plus network plus affordability plus appliances plus maintenance. In remote areas, the World Bank’s energy-access assessment points to mini-grids and off-grid systems as flexible complements to central grids.[3] In industrial regions, transmission, distribution, faster interconnection, flexible loads, storage, and firm capacity matter more. The architecture differs; the service test does not.

Essential systems are less universal than their component technologies

The world knows how to treat water, build sewers, vaccinate, teach literacy, and construct safe dwellings. At aggregate global scale, food availability coexists with hunger and malnutrition; conflict, poverty, prices, logistics, climate, and exclusion shape who can obtain nutritious food.[26] Universal delivery is still unsolved.

The 2025 WHO–UNICEF water assessment estimated that 2.1 billion people lacked safely managed drinking water and 3.4 billion lacked safely managed sanitation in 2024.[27] The latest global health monitoring finds both vast unmet service need and financial exposure.[7] Housing shortages can reflect land regulation, infrastructure, construction productivity, finance, ownership, conflict, and local vetoes as well as material supply; the mix varies by market (OECD, 2026). Education depends on teachers, safety, language, care, connectivity, and institutions, not content alone.

This is why the roadmap refuses a favorite futurist shortcut: “AI will make knowledge free, so education and medicine will be solved.” A model can extend a clinician, teacher, engineer, or caseworker. It cannot by itself create clean water, a safe room, a trustworthy institution, a laboratory specimen, legal remedy, or hands-on care. Digital capability is a multiplier of functioning systems and sometimes a bridge around their gaps. It is not a substitute for the physical and social world.

Automation is real, general autonomy is not

The International Federation of Robotics counted roughly 4.66 million industrial robots operating worldwide at the end of 2024, more than double the stock ten years earlier.[28] That is strong evidence that automation scales in structured environments. It is weak evidence that one general machine will soon cook, repair a roof, comfort a child, clear a blocked sewer, and improvise safely in every household.

Industrial automation succeeds by redesigning the environment around machines: fixtures, standard parts, marked lanes, controlled lighting, safety cages, machine-readable inventory, and repeatable tests. The near-term roadmap applies the same lesson outside factories. It standardizes interfaces, modularizes components, instruments infrastructure, improves data, and automates tasks with reliable evaluation. It does not wait for a humanoid to master the unstructured world.

Generative AI has a different profile. The ILO estimates that one worker in four is in an occupation with some exposure, while concluding that transformation is currently more plausible than whole-job replacement for most occupations.[29] Exposure is not adoption; adoption is not reliability; task automation is not employment; and employment is not the same as income, authority, learning, or dignity. The transition has to track all of them.

The social state is broad but incomplete

The world has already demonstrated public pensions, universal healthcare systems, free schools, unemployment insurance, child benefits, cash transfers, utility regulation, social housing, libraries, and public research. The question is not whether humans can invent a non-market claim on essential services. It is whether coverage can become universal, adequate, portable, responsive, and financially durable.

The ILO estimated that 52.4 percent of humanity received at least one social-protection benefit in 2023.[30] The World Bank's 2025 assessment found two billion people inadequately covered across low- and middle-income countries.[31] These are not arguments for replacing every program with one payment. They reveal a missing floor and fragmented systems. Cash transfers can reduce poverty and often improve food security, health, schooling, savings, or investment, but outcomes vary and cash cannot correct constrained supply by itself.[32]

Ownership is the hinge

Automation can lower the resource cost of services while reducing the labor income through which households buy them. If a small set of firms owns models, chips, energy, platforms, logistics, land, and robotic production, lower technical cost may appear as higher rents rather than lower household burden. Conversely, bluntly suppressing returns can choke investment and experimentation. The institutional task is not to eliminate capital. It is to keep entry open, regulate bottlenecks, protect public options, strengthen worker and consumer power, and broaden ownership of productive assets.

Competition policy matters because essential sectors are unusually vulnerable to lock-in, network effects, local monopoly, and cartel behavior. The World Bank notes that cartels in essential products can raise prices substantially and frames competition, pro-competitive regulation, and competitive neutrality as development tools.[33] The OECD likewise emphasizes competition enforcement as digitalization changes entry, data, mergers, and market power.[34] Abundance requires productive scale without private government.

Conflict subtracts from every layer

High-intensity conflict simultaneously destroys energy systems, water, housing, clinics, schools, data, skills, public revenue, trade, investment, trust, and law. Nearly 40 percent of people in fragile and conflict-affected economies live in extreme poverty, and these economies are projected to contain almost 60 percent of the world's extreme poor by 2030.[1] Security and

peacebuilding are therefore not side constraints on the roadmap. They are productive infrastructure.

The baseline can be summarized without romance: humanity has demonstrated components of abundance, distributes them radically unevenly, operates them too extractively, and has not built a durable bargain for the gains from automation. There is no missing miracle that must be invented before work can begin.

5. The Abundance Stack

Abundance is a system property. It appears only when seven dependency-linked layers work together.

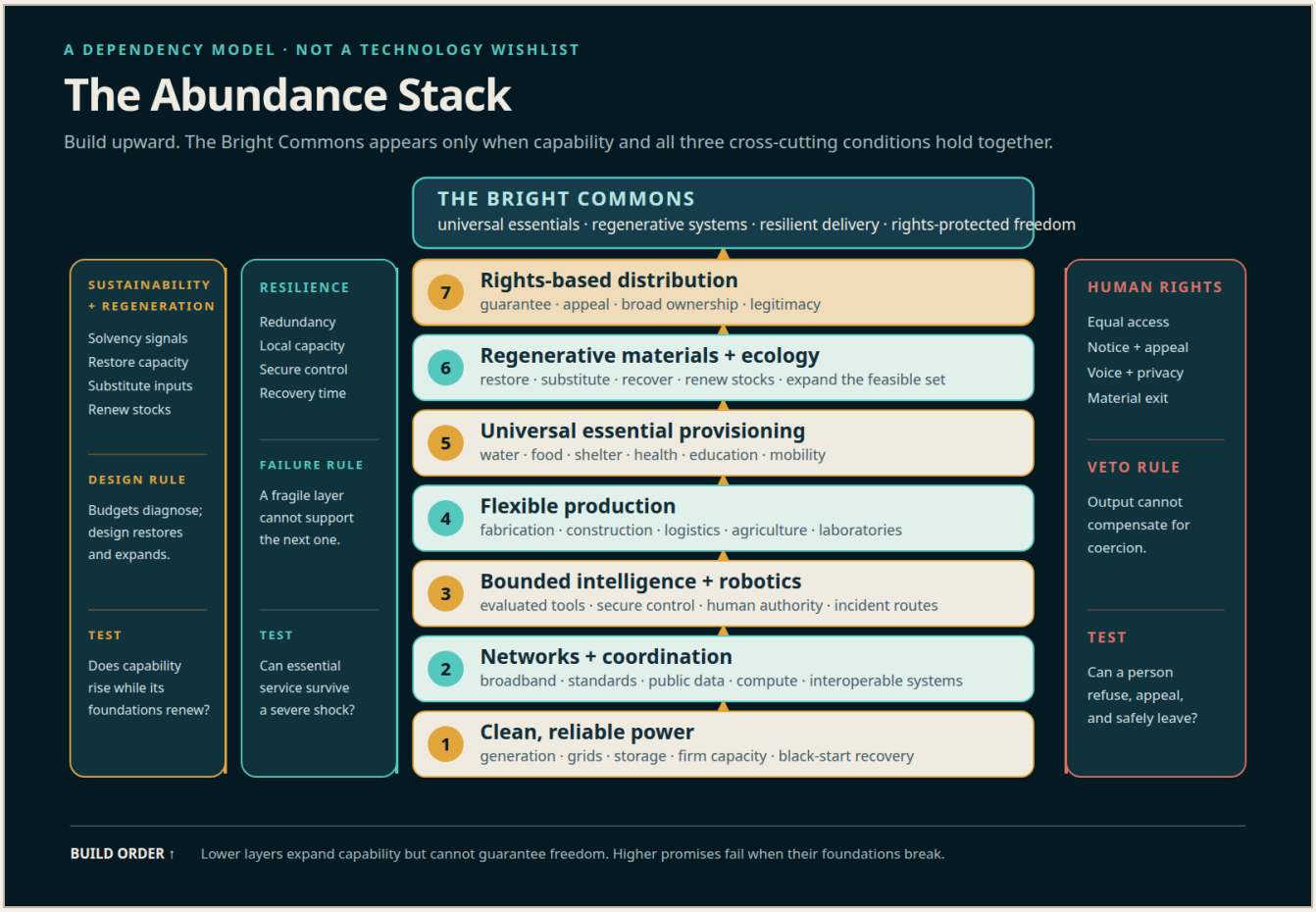

Figure 1. The Abundance Stack. Lower layers create capability but cannot guarantee freedom; higher layers cannot remain credible when lower layers fail. Sustainability and regeneration, resilience, and human rights are cross-cutting rails—not a final coat of governance applied after construction.

Layer 1: clean, reliable power

Power expands the feasible set. It pumps, heats, cools, lights, computes, purifies, moves, fabricates, and substitutes for some direct fossil combustion. The layer includes generation, storage, networks, flexible demand, protection, maintenance, reserves, skilled workers, fuel and component supply, black-start capability, and recovery. An abundance grid is not optimized only for average price. It carries sufficient redundancy that a storm, cyber incident, drought, equipment failure, or trade disruption does not turn a technical fault into a humanitarian crisis.

Layer 2: networks and coordination

Electric grids, fiber, wireless links, payment rails, identity systems, logistics data, technical standards, and public statistics allow capacity to find demand. Open interfaces prevent a single provider from controlling every transaction. Offline and human alternatives prevent convenience from becoming compulsion. The layer is successful when people can communicate and transact securely, switch providers, authenticate without permanent surveillance, and recover when a network fails.

Layer 3: bounded machine intelligence and robotics

This layer performs search, prediction, scheduling, translation, drafting, sensing, control, manipulation, and verification. “Bounded” does not mean weak. A system may outperform people in a task while remaining restricted by scope, permissions, tests, and shutdown paths. Critical uses require documented authority, independent evaluation, incident reporting, liability, and appeal. The objective is high-capability infrastructure that can be distrusted intelligently.

Layer 4: flexible production

Automated and semi-automated farms, factories, laboratories, construction systems, warehouses, repair facilities, and recycling plants turn energy, information, materials, and human judgment into useful goods. Flexibility matters because a civilization optimized for one product or one giant supplier is brittle. Modular design, common interfaces, spare capacity, local repair, distributed inventories, and rapid retooling trade a little steady-state efficiency for survival under shock.

Layer 5: universal provisioning

Production becomes human capability through systems for food, water, sanitation, shelter, healthcare, care, education, mobility, and communication. This layer specifies a guaranteed essential tier, service levels, geographic coverage, staffing, funding, maintenance, and remedy. Provision may be public, private, cooperative, nonprofit, household, or mixed. The test concerns outcomes and rights, not an ideological monopoly over providers.

Layer 6: regenerative material and ecological systems

Products are durable, repairable, modular, traceable, recoverable, and safe. Waste from one process becomes feedstock for another where life-cycle evidence supports it. Responsible virgin supply remains available where recovery cannot meet need. Absolute carbon, habitat, water-basin, nutrient, toxicity, and material budgets trigger cleaner processes, substitution, new supply, redesign, and restoration where efficiency alone would invite rebound. Resource-rich communities possess consent, compensation, monitoring, and a durable share of benefits. Ecological systems are restored as productive infrastructure. Future generations are represented through budgets and fiduciary duties rather than vague sentiment.

Layer 7: rights, distribution, legitimacy, and security

The top layer determines who may use the rest and on what terms. It includes civil and political liberties; independent courts and media; privacy; collective bargaining; anti-discrimination; competition; public finance; social insurance; broad capital ownership; transparent administration; nonviolent succession; and protection against domestic and international coercion. It also gives every person a **material right of exit**: enough independent access to identification, communication, money, shelter, transport, healthcare, and legal process to leave an abusive employer, household, platform, care institution, or locality.

The order is causal but not chronological. Rights cannot wait until the grid is complete; they shape whose land is taken, whose home is connected, whose data trains a model, and who receives the gain. Sustainability cannot wait until production is automated; it shapes energy, materials, siting, lifecycle design, and restoration from Gate 0. Resilience cannot wait for a

disaster; reserves, redundancy, local repair, fallback, and recovery are designed and funded from the start. The layers must grow together while respecting dependency.

Four design rules

The stack follows four rules.

No miracle dependencies. A jurisdiction may invest in fusion, advanced robotics, synthetic biology, and space resources. Its current gate cannot require an unproven technology. A failed research program narrows options; it does not collapse the floor.

No single point of social failure. No company, ministry, party, identity provider, payment network, model, or database should be able to disconnect a person from all work, money, communication, healthcare, and public benefits. Interoperability, separation of functions, plural providers, manual fallbacks, and judicial remedy are abundance infrastructure.

No compensation across red lines. Higher output cannot compensate for mass repression, collective punishment, coerced displacement, indiscriminate surveillance, discriminatory exclusion, or irreversible ecological damage. These conditions force a pause or rollback; they are not negative entries in a cost-benefit spreadsheet.

No imposed ceiling on human development. Ecological budgets constrain destructive methods and locations, not learning, discovery, mobility, beauty, comfort, exploration, or ambition. When a budget binds, climb the solution ladder—clean supply, responsible new supply, substitution, longer life, recovery, restoration, redesign, and evidence-gated frontiers—while preserving the essential floor. A society may choose restraint; this framework does not confuse involuntary deprivation with virtue.

6. How abundance compounds—and how it reverses

The optimistic loop is straightforward:

> cheaper clean useful energy → cheaper computation and controlled automation → higher productive capacity → lower real cost of essential services → broader capability and participation → more learning, experimentation, trust, and investment → still better systems

The loop is plausible because its pieces are already visible. Renewable generation costs have fallen. Digital knowledge copies cheaply. Automation raises output in structured domains. Public-health and infrastructure investments improve capability. Social protection cushions shocks. Open standards and competitive entry spread technology. None proves the entire sequence, but together they define a testable causal chain.

The loop contains a decisive boundary: **capacity must be converted into a universal claim**. Before that boundary, the owner of a system can lower internal cost while maintaining price, reducing labor income, or using access as leverage. After it, every person receives an enforceable essential tier and a fair share of productive gain, while markets continue to allocate differentiated and discretionary goods. The boundary is political, not thermodynamic.

Five counter-loops can reverse the result.

Rent capture

Automation raises productivity; control of bottlenecks raises markups; profits buy competitors and political influence; entry becomes harder; the next gain accrues to the same owners. Household abundance stalls even while technical capability accelerates. The repair is competition, structural separation where needed, open standards, public options, worker power, and broad equity ownership.

Rebound and overload

Efficiency lowers the cost of a service; consumption rises; total energy, land, water, or material use falls less than expected or increases. The IPCC treats rebound as a real risk of technological change and argues for service-system design rather than device efficiency alone.[35] The repair is to guarantee the essential tier while enforcing absolute ecological budgets for aggregate pressure, using transparent scarcity prices and equal or progressive rebates where pricing is suitable.

Dependency and deskilling

Automation completes tasks; people receive less practice; independent expertise shrinks; verification and recovery become harder; failures become more correlated. The repair is protected apprenticeship, simulation, manual fallback, rotation, independent testing, and explicit measurement of unaided capability in safety-critical domains. The goal is not a ceremonial "human in the loop," but enough distributed competence to challenge and recover from the machine.

Surveillance and control

Universal digital provision becomes a reason to centralize identity, payments, health, communication, movement, and political behavior. Efficiency then supplies the infrastructure of social exclusion. The repair is data minimization, purpose limits, decentralized credentials, warrants, short retention, offline access, interoperability, independent privacy regulators, and a human service path. Any loyalty condition on food, healthcare, identity, or communication automatically fails the gate.

Fragile optimization

Highly integrated systems remove inventory, local skill, redundancy, and spare capacity; average cost falls; one shock cascades across energy, logistics, finance, and care. The repair is published resilience targets, diverse suppliers, strategic reserves, islandable networks, local repair, cyber segmentation, exercises, and a measured recovery-time objective.

The compounding model is not a forecast. It is a set of mediators. If power becomes cheaper but essential service burdens do not fall, investigators look for networks, scarcity, rent, finance, or exclusion. If automation rises but leisure and bottom-half income do not, they look at ownership and bargaining. If access rises but ecology worsens, they look at rebound and provisioning design. The model earns its keep only when failure at one link can be located and repaired—or shown to be fatal.

7. A gate-based roadmap

Calendar dates tempt writers to turn uncertainty into theater. This roadmap uses overlapping deployment windows because technologies, institutions, climates, and starting conditions differ. A city's housing module can pass its current band while its health module fails; a low-income region may leap to distributed power while an industrial region spends a decade rebuilding transmission. Each numbered **Gate** below names a build-and-test band; its **exit gate** is the promotion decision into the next band. The evidence—not the year—authorizes that commitment.

All dates in this roadmap are **illustrative planning horizons**—not forecasts, promises, deadlines, or gate criteria. A module may advance sooner, later, or never; only evidence at its gate authorizes scale.

Figure 2. The gate-based path. Date bands are illustrative horizons, not forecasts. Phases overlap, and jurisdictions advance independently. Sustainability and regeneration, resilience, and human rights govern every gate; capacity, finance, access, safety, and distribution tests must also pass together.

How a gate actually opens

The unit of decision is a **service × jurisdiction** module: for example, potable water in a province or primary care in a city. A nation does not pass as one block, and success in electricity cannot conceal failure in housing. Gates 0–4 are certified module by module; Gate 5 is jurisdiction-wide only when every essential-service module passes; Gate 6 is certified project by project. Gate 0's rights, audit, privacy, procurement, non-regression, and ecological-screening rules are prerequisites for every module.

Before scale-up, one public gate packet names the lead authority, funder, operator, regulator, statistical certifier, independent auditor, appeal venue, and official empowered to pause the project. It states capital and recurring operating costs, replacement-reserve and contingency requirements, user burden, local- and foreign-currency exposure, debt stress, workforce and material bottlenecks, and the funding source for every recurring obligation. It pre-registers metric definitions, denominators, baselines, numeric thresholds or bounds, subgroup floors, minimum evidence windows, uncertainty rules, failure triggers, continuity service, recovery actions, and a re-entry test. "Unknown" cannot be converted into "pass"; changing a metric or threshold after deployment restarts its evidence window.

An independent statistical body certifies facts; an elected legislature authorizes budgets and explicit tradeoffs; regulators enforce service rules; courts enforce rights red lines. Affected people have standing, timely reasons, human appeal, and access to interim relief. Gate decisions publish evidence, dissenting assessments, conflicts, and votes. Authorization for further scale-up lapses unless recertified at least annually. Continuity and rollback are funded before expansion.

Work may overlap, but safeguards may not. Gate 2 automation can help build Gate 1 infrastructure only where power headroom, worker representation and transition support, field safety, cybersecurity, competition review, ecological screening, and tested fallback already pass for that use. This is parallel engineering under common constraints, not permission to skip a gate.

Gate 0: measure and de-risk

Illustrative horizon: 2026–2030.

Entry condition: a government, region, city, or coalition can publish budgets and performance data, enforce contracts, protect basic opposition and labor rights, and conduct independent audits. Where those conditions are absent, a pre-gate fragility track keeps lifeline services operating through local providers and neutral humanitarian, regional, or multilateral fiduciaries; uses beneficiary audits and ring-fenced funds; excludes political and immigration enforcement from service data; and links larger commitments to civilian protection, accountable security, peacebuilding, and lawful institutional milestones.

Build: establish the Universal Capability Ledger described later in this paper. Map generation, grids, housing, water, sanitation, clinics, schools, broadband, logistics, material flows, hazards, and ownership. Begin consumption-based carbon and material accounts plus labor-rights, displacement, and host-community screens for supply chains. Establish a legally enforceable lifeline tier and non-regression rule now, then ratchet its quantity and quality as capacity expands. Require large infrastructure and high-impact AI systems to publish responsible owners, service levels, incident routes, and shutdown authority. Create interoperable technical standards, product and materials passports, procurement cost databases, and public inventories of critical spares. Register government algorithms and give people a human appeal before an automated system terminates a right or benefit.

Run pre-registered pilots rather than national slogans: reduced-hour schedules; automatic benefit enrollment; social housing; clean mini-grids; water reuse; modular construction; public-interest compute; open-access fiber; regional automation centers; and employee or community ownership. Publish failures. A pilot that cannot survive disclosure is not a foundation for abundance.

Finance and actors: routine administrative budgets fund measurement and audit; research grants and challenge procurement fund prototypes; utilities, standards bodies, universities, labor organizations, civil society, insurers, and local governments define tests. Elected governments retain lawful taxing and enforcement authority. Randomly selected citizens' assemblies can study long-horizon tradeoffs, but supplement rather than replace elections; OECD documents hundreds of such deliberative processes and their use on polarized, value-laden questions.[36]

Exit gate: the jurisdiction has disaggregated baseline data; independently auditable accounts; stable civil liberties and appeal; recurring revenue identified for recurring promises; public pilot results; and a supply-constraint assessment covering labor, land, grid equipment, construction, finance, and inflation.

Pause or recover: stop discretionary, surveillance-heavy, or capture-prone scaling if emergency powers become permanent, procurement concentrates without explanation, baseline data are manipulated, or existing benefits are withdrawn before replacements work. Continue maintenance and necessary essential expansion through ring-fenced, independently supervised channels while courts, auditors, elections, and public reporting are repaired.

Gate 1: electrify, connect, and build

Illustrative horizon: 2026–2040.

Entry condition: Gate 0 has identified real bottlenecks and legitimate routes for siting, compensation, and appeal.

Build power as a system. Expand the least-cost regional portfolio of low-emissions generation, transmission, distribution, storage, flexible demand, existing firm power, and efficiency. Reform interconnection around project readiness and regional planning. Berkeley Lab found 1,570 gigawatts of proposed U.S. generation and 1,030 gigawatts of storage in queues at the end of 2023, with projects completed that year spending a median five years in the queue.[37] The numbers are U.S.-specific; the general lesson is not. Plans must count networks and institutional throughput, not just equipment.

Electrify heating, vehicles, and appropriate industrial processes. Heat pumps can deliver several units of heat for each unit of electricity under suitable conditions, making efficiency a capacity resource.[38] Use distributed solar, storage, and mini-grids where extending a central network is slow or uneconomic. Make hospitals, water systems, communications, shelters, and emergency logistics islandable. Maintain black-start plans, spares, cyber segmentation, and trained operators.

Build universal physical capabilities. Extend safe water, sanitation, drainage, wastewater treatment and reuse, clean cooking, affordable devices and broadband, transit, primary care, schools, childcare, and adequate housing. Housing policy combines lawful density, infrastructure, public and nonprofit construction, community land trusts, competitive private supply, modular production, and assistance targeted to people. A printed shell is not a finished home; land, foundations, reinforcement, utilities, interiors, inspection, transport, finance, and neighborhood services remain.

Finance and actors: regulated utility investment and rates fund network assets; public debt fits long-lived infrastructure; land-value capture helps pay for transit and utility extensions; competitive grants and concessional finance cover low-income and remote access; taxes fund services with weak user-revenue models. Regulators publish unit costs and reliability. Siting requires alternatives and least-harm analysis, meaningful participation, independent adjudication, compensation before impact, safe resettlement where lawful displacement is truly unavoidable, restitution, and appeal. Free, prior, and informed consent applies where Indigenous or comparable collective rights require it. Decision timelines constrain authorities; they do not extinguish substantive rights.

Exit gate: effective access to electricity, safe water, sanitation, basic connectivity, primary care, education, clean cooking, and adequate shelter is near-universal; bottom-half household burdens are falling; essential networks meet published reliability and recovery standards; and the region has a credible absolute emissions and ecological trajectory. “Coverage” measured by a nearby wire or nominal program does not pass.

Pause or recover: if cash demand outruns housing, clinical, energy, or food capacity, protect vulnerable people but redirect marginal expansion toward supply. If large projects repeatedly miss cost and schedule, modularize procurement, qualify more suppliers, replace managers, or change technology. If long-duration storage, advanced nuclear, geothermal, or another frontier fails, substitute a diversified portfolio; no research bet may hold the gate hostage.

Gate 2: automate bottlenecks

Illustrative horizon: 2032–2050.

Entry condition: power and networks can support new industrial loads without worsening exclusion or reliability. Affected workers have funded transition benefits, advance notice, independent representation, and bargaining power; the use has passed field-safety, competition, life-cycle ecological, cybersecurity, and fallback review.

Automate where truth is available. Begin with structured, measurable domains: machine tending, inspection, packing, warehouse movement, routing, preventive maintenance, translation, scheduling, paperwork, laboratory execution, grid forecasting, and design search tied to physical tests. The corrected A-Lab record reports 36 synthesized compounds among 57 targets in seventeen days, while only about 30 percent of 353 attempted recipes produced their targets. A post-publication manual reanalysis confirmed 36 of 40 originally reported successes and left four inconclusive.[39] That illustrates the maturity this roadmap assumes: valuable bounded autonomy with human validation and correction, not autonomous civilization.

Standardize parts, fasteners, data, interfaces, tests, and repair documentation. Build flexible cells that handle product families, regional finishing facilities for customization, and global specialist supply for semiconductors and other concentrated goods. Use additive manufacturing where complexity, customization, low volume, or replacement logistics outweigh slower throughput; retain casting, extrusion, rolling, molding, machining, and continuous processes where they dominate.

Apply the same realism to essentials. Agriculture remains a portfolio of field crops, improved genetics, soil and nutrient management, greenhouses, precision irrigation, sensing, selective robotics, storage, refrigeration, and logistics. Controlled-environment systems suit fragile produce and hostile climates, not necessarily staple calories; current indoor systems make grains and root crops energetically unattractive.[40] Fermentation can supply selected proteins, fats, enzymes, and ingredients without pretending to replace every farm.

Water systems first fix leakage, protect watersheds, meter large withdrawals, recover wastewater, and reuse it according to public-health evidence. A 2017 U.S. Department of Energy engineering study placed the seawater reverse-osmosis process near three kilowatt-hours per cubic meter in state-of-the-art plants; actual full-system demand varies with source water, intake, pretreatment, recovery, brine management, and conveyance or distribution.[41] Singapore's NEWater demonstrates nationally integrated reuse: four operating plants combine membrane filtration, reverse osmosis, and ultraviolet disinfection for industrial supply and indirect potable use.[42]

Health systems automate administration, screening, logistics, quality surveillance, and validated decision support while expanding primary care, vaccination, sanitation, nutrition, reproductive care, dentistry, mental health, and chronic-disease management. CRISPR therapy is real but illustrates the gap between scientific success and abundance: Casgevy—the first FDA-approved therapy using CRISPR/Cas9, approved for sickle-cell disease—requires collection of stem cells, intensive conditioning chemotherapy, specialized infusion, and long-term follow-up.[43] The abundance target is a platform and workforce that can safely deliver breakthroughs, not a press release announcing them.

Finance, ownership, and actors: firms invest where cost savings are commercial; public research and development (R&D) and prizes support spillovers; development banks finance first-of-a-kind plants; public procurement creates early markets; extension centers help small firms adopt proven tools. Subsidies include milestones, open standards where appropriate, labor and community conditions, clawbacks, and equity warrants or royalties when the public absorbs material risk.

Exit gate: the real labor, energy, and material cost of a published essential basket is falling; safety and quality are stable or improving; intervention rates and total life-cycle costs support claimed autonomy; critical systems retain tested human and non-AI fallback; market entry remains possible; and bottom-half income, leisure, or public consumption shares in the gain.

Pause or recover: withdraw systems whose incident, discrimination, cybersecurity, intervention, or maintenance record fails a predeclared limit. If general robots remain brittle, continue environment-specific automation. If AI benchmarks rise without field outcomes, fund evaluation and integration rather than bigger deployment. If productivity becomes rent, activate competition and ownership remedies before expanding dependence.

Gate 3: complete unconditional access

Illustrative horizon: 2035–2060.

Entry condition: the enforceable lifeline begun at Gate 0 is operating; essential-service capacity is sufficient that completing universal entitlement will not simply bid up constrained supply; and recurring fiscal commitments have recurring revenue.

Build a floor in layers:

1. universal financing for essential health, education, care, water, sanitation, connectivity, basic public digital and computational tools, mobility, and a lifeline quantity of household energy;
2. social insurance for childhood, disability, caregiving, unemployment, illness, and old age;
3. automatic minimum-income top-ups with gradual withdrawal;
4. housing assistance backed by actual housing and emergency shelter capacity;
5. a universal social dividend paid only from realized returns and scarcity rents.

The mix preserves both security and choice. Services cover areas with natural monopoly, externalities, high information asymmetry, or catastrophic risk. Cash works where competitive supply can respond. A dividend does not replace disability support, healthcare, education, or housing policy.

Negotiate the **automation bargain**. Employers give notice and consult workers before major reorganizations. Benefits become portable. Wage insurance, unemployment protection, pension bridges, care support, apprenticeship, and training linked to real vacancies reduce transition risk. Bargaining, works councils, employee ownership, and gain-sharing distribute firm-level gains. As measured productivity rises, standard hours, paid leave, and sabbaticals expand gradually. People remain free to work more; the objective is an option to refuse, not compulsory leisure.

Finance and actors: legislatures and service regulators match recurring guarantees to recurring taxes, premiums, rates, or trust income. Employers, unions, training institutions, municipalities, care providers, and social insurers administer the transition bargain under published service and fiscal tests. Diversified social wealth funds receive some combination of land-value gains created by public infrastructure; spectrum, mineral, carbon, congestion, and monopoly-franchise rents; equity warrants from public subsidies; inheritance or windfall taxes; and returns from public intellectual property and development-bank investments. Independent fiduciaries publish every holding and fee. A fixed share of smoothed real returns funds dividends; forecasts and debt do not.

Alaska supplies a narrow but useful counterexample to claims that every unconditional dividend eliminates work. A peer-reviewed study found no aggregate employment reduction from its long-running dividend and an increase in part-time work; the result does not establish the fiscal or inflation effects of a full income guarantee.[44] Scale, supply, funding, and institutional context remain decisive.

Exit gate: no person may lawfully be denied the essential bundle for lack of employment or market income; every service × jurisdiction module meets its pre-registered individual and subgroup floor for the full evidence window; every measured denial or outage has a time-bound continuity service and remedy; catastrophic health spending, hunger, unsheltered homelessness, utility disconnection, and digital exclusion are no longer systemic; recurring services survive recession scenarios; and every automated denial carries notice, human appeal, and remedy.

Pause or recover: if inflation persists in a constrained essential sector, slow untargeted cash growth, preserve the floor, accelerate supply, and investigate market power. If a public service stagnates, publish outcomes, change management, and allow accountable nonprofit, cooperative, municipal, or regulated alternatives. Universal finance need not imply one provider.

Gate 4: regenerate, close loops, and harden systems

Illustrative horizon: 2045–2080.

Entry condition: universal provision is operating, and its material footprint is measured across borders rather than hidden in imports.

Design durability, repair, modularity, disassembly, materials identification, take-back, and safe recovery into products and procurement. Build automated sorting, remanufacturing, urban mining, industrial symbiosis, low-emissions primary production, responsible new supply, and substitution capacity. Material efficiency can be large without becoming perfect: IEA modeling estimated that efficiency strategies could reduce 2060 demand relative to its reference case by roughly 24 percent for steel, 15 percent for cement, and 17 percent for aluminum.[45] Those are modeled reductions, not a claim that growth needs no virgin material.

Establish absolute carbon, habitat, watershed, nutrient, toxicity, and material-pressure budgets where evidence permits. Use regulation, procurement, caps, scarcity prices, and equal or progressive rebates according to the problem. Treat a binding budget as an instruction to solve the method, supply, design, or location—not as a permanent cap on human capability. Restore soils, forests, wetlands, fisheries, aquifers, and urban habitat as productive assets; measure whether restoration actually increases future headroom. Avoid calling a product circular because a recycling symbol exists; follow it through collection, yield, energy, contamination, and actual secondary use.

Harden every essential system. Diversify suppliers. Maintain inventories of transformers, pumps, medicines, seeds, machine tools, and network equipment. Run pandemic, grid, cyber, climate, financial, and conflict exercises. Require islanding, manual fallback, geographic redundancy, and published recovery objectives. Resilience has a cost; an abundance system pays it before the emergency.

Finance and actors: producer-responsibility fees and material charges fund collection and recovery; pollution and resource rents fund restoration and citizen rebates; insurers and regulators price correlated failure; public balance sheets finance resilience whose returns are social rather than billable. International agreements prevent rich jurisdictions from satisfying budgets by exporting extraction and waste.

Exit gate: essential capability and future options continue rising while absolute ecological pressure declines toward safe budgets; restoration produces verified ecological gains; critical services meet stress and recovery targets; high-value recovery and product life increase; harmful exposure falls in frontline communities; and resilience is not purchased through militarized exclusion.

Pause or recover: when efficiency produces rebound, shift from intensity to absolute limits while accelerating cleaner supply, substitution, and redesign. When recycling increases toxicity or energy use, redesign or use responsibly sourced virgin material. When a source or site fails ecological or rights tests, protect the floor through reserves and alternatives while the next solution is built. When central optimization raises systemic risk, accept higher average cost for modularity and spare capacity.

Gate 5: maintain the Bright Commons

Illustrative horizon: 2060–2100 and beyond.

Entry condition: the universal floor, sustainability and restoration budgets, recovery systems, and rights red lines established through Gates 0–4 have survived repeated recessions, political transfers, extreme events, and technology failures without abandoning a region or group.

At this gate, survival no longer depends on accepting any particular job. The essential tier is reliable and rights-protected; markets remain for differentiated goods, luxury quantities, scarce locations, and entrepreneurial discovery. People still work for income, craft, status, care, ambition, duty, community, or curiosity. Average working time can fall without treating a person who wants more work as deviant.

Education becomes lifelong; care, science, culture, maintenance, sport, exploration, ecological restoration, and democratic work gain status because income is no longer the sole evidence of contribution. Public, cooperative, household, nonprofit, and private systems compete and collaborate. No central planner chooses a single good life.

Maintain and expand: the task is not stasis. Replacement funds, intergenerational accounts, open opposition, peaceful policy reversal, continual audits, repeated stress tests, research, restoration, and responsible frontier development maintain the floor while widening the feasible set. Wealth differences persist, but deprivation and coerced submission do not. Unique land, attention, prestige, risk, and time remain scarce and must be allocated openly.

Finance and actors: mature systems rely on a diversified, transparent mix of service taxes and premiums, utility rates, scarcity rents, land-value revenue, endowment returns, competitive enterprise, and household payment above the essential tier. Legislatures set rights and budgets; independent courts and auditors enforce the red lines; utilities and plural providers operate services; communities govern local tradeoffs; and social wealth trustees may distribute only realized, smoothed returns. Replacement and resilience reserves remain funded before discretionary dividends.

Exit gate: there is no final exit. The Bright Commons is a maintained and expanding condition. A society falls back a gate if essential reliability, rights, ecological headroom, resilience, or universal access deteriorates.

Pause or recover: freeze dividend growth and nonessential expansion before cutting the floor; draw declared reserves; restore damaged capacity; investigate capture or exclusion; and return the failing service to the last gate whose tests it can pass. A mature society proves itself by repairing decline without inventing an internal enemy.

Gate 6: an optional off-world resource frontier

Illustrative horizon: 2080 and beyond.

Entry condition: Earth's essential systems work; off-world investment does not displace the floor; and each project passes delivered-cost, full-life-cycle sustainability, planetary-protection, debris, safety, labor, rights, liability, and governance tests.

Build progressively: reusable transport; orbital inspection, repair, refueling, and assembly; closed-loop habitat demonstrations; robotic lunar prospecting and pilot processing; scientific settlements; then larger industry only where a customer exists. The U.S. segment of the International Space Station demonstrated 98 percent total water recovery in its life-support system in 2023, an extraordinary closed-loop milestone that still depends on imported food, gases, parts, equipment, and consumables.[46] A settlement is a supply system, not a photograph of a habitat.

Early space resources are most plausible **in space**, where they may avoid launch from Earth. Later projects may widen material and energy supply for Earth or relocate selected processes only if they outperform terrestrial alternatives after launch, infrastructure, recovery, contamination, security, and decommissioning are counted. Space-based energy, asteroid mining, rotating habitats, and independent settlements remain physically compatible but speculative. None receives a date simply because it is imaginable.

Finance and actors: public science budgets may fund exploration and shared infrastructure; firms, cooperatives, and consortia finance commercial systems against real customers; insurers and investors bear ordinary project risk. No project may borrow against speculative future resources to weaken Earth's guaranteed floor. Space agencies, scientific bodies, launch and habitat operators, labor organizations, environmental and debris regulators, treaty institutions, and affected publics publish jurisdiction, liability, rescue, decommissioning, and conflict rules before scale-up.

Exit gate: the delivered service beats terrestrial or Earth-launched alternatives after full life-cycle cost; crews and workers possess enforceable rights; benefits and burdens are governed across nations and generations; debris, contamination, planetary protection, and security risks are controlled; rescue and failure plans are credible; and no actor can convert infrastructure into

unaccountable territorial rule.

Retire condition: if an off-world project cannot pass those tests, end it without weakening terrestrial abundance. Exploration is a human good and the Solar System is a legitimate frontier. Neither is a blank check.

Interstellar and galactic resource use has no gate date. It would require transport, energy, communication, governance, and economics not demonstrated today. It may remain part of humanity's open horizon under known physics, but it is not evidence for any terrestrial promise and cannot finance, excuse, or delay one.

8. The Abundance Compact

Technology supplies options. The Compact decides how those options become a durable public settlement. It rejects both monopoly capitalism, which can convert falling technical cost into rent, and comprehensive command, which concentrates information and coercion while suppressing choice and correction.

No allocation mechanism fits every good.

- **Competitive reproducible goods** belong mainly in markets with low entry barriers, consumer protection, income support, and antitrust.
- **Natural monopolies** such as water networks, grids, rail rights-of-way, and core fiber need public ownership, regulated utilities, or structurally separated open-access networks.
- **Essential services with large information asymmetries or catastrophic risk**, including healthcare and education, need universal public financing with accountable plural provision where useful.
- **Knowledge goods** support prizes, public research, open standards, patent pools, buyouts, limited exclusivity, and open-license conditions on publicly funded work.
- **Ecologically scarce goods** need absolute limits, rationing, or scarcity prices according to context, with revenue returned to citizens and affected communities.
- **Inherently positional goods** such as unique land cannot be made universal. Transparent allocation, land-value taxation, public access, anti-discrimination, and non-market rules where justice requires them are more honest than pretending supply is infinite.

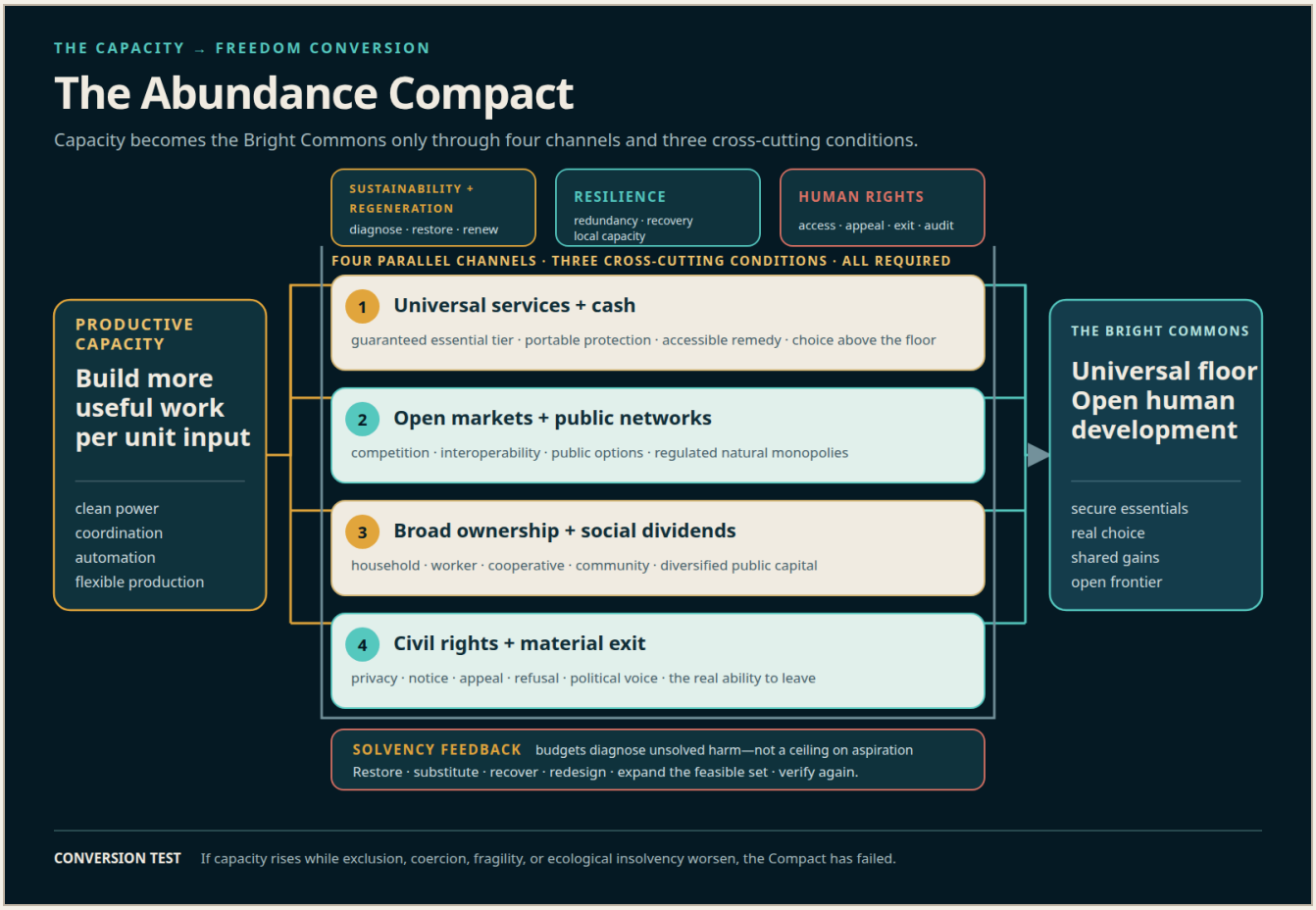

Figure 3. Capacity becomes freedom only through distribution architecture. Services, markets, ownership, and rights solve different problems; sustainability and regeneration, resilience, and human rights remain independent cross-cutting conditions so no channel can consume or coerce the others.

Universal services plus cash

Guarantee an essential service tier and provide a cash floor for choice. The tier is specific enough to enforce: service radius, waiting time, reliability, quality, quantity, accessibility, and remedy. Above it, prices can ration scarce or luxury quantities. “Free at the point of essential use” never means physically free or unlimited.

Automatic enrollment, portable eligibility, gradual benefit tapers, offline access, and simple appeals reduce administrative scarcity. Disability, care, health, housing, and education remain distinct needs; a generic payment is not permission to abandon them.

Competition plus public options

Scale is useful when it lowers unit cost, supports research, or coordinates a network. Scale becomes private government when users cannot leave, rivals cannot enter, workers cannot bargain, and the provider controls the rules of identity, speech, trade, and remedy. Require portability, interoperability, nondiscriminatory access, transparent public procurement, and sector-specific scrutiny of durable bottlenecks. Structurally separate a bottleneck from businesses competing over it when repeated exclusion defeats behavioral rules.

Public options can discipline price and guarantee service without outlawing private alternatives. Cooperatives and employee-owned firms broaden experimentation and ownership. Industrial policy earns legitimacy through competitive calls, technical review, milestones, published unit costs, sunset dates, clawbacks, and public upside—not permanent patronage.

Broad ownership plus social wealth

Income follows both labor and capital. As machines perform more tasks, a society that distributes only labor income constructs a contradiction: more capacity and a weaker claim on it. The solution is plural ownership rather than one national owner.

Households can own diversified retirement and savings assets. Workers can gain equity and profit shares. Cooperatives can own local production. Communities can own land and infrastructure. Public wealth funds can own diversified stakes and receive rents. The public may take warrants when subsidies absorb first-loss risk. Competition prevents any form—private or public—from becoming unanswerable.

Social wealth funds require hard governance: staggered fiduciary terms; removal only for published cause; protected audit budgets; beneficiary representation; conflict, related-party, and cooling-off rules; full publication of holdings, fees, votes, and beneficial owners; bans on day-to-day political direction; judicial review; intergenerational protection of principal; and dividends based on a fixed share of smoothed real returns. A fund that promises returns before assets earn them is fiscal theater.

Labor power plus time

Workers need notice, consultation, bargaining, portable benefits, transition insurance, and a claim on gains before an automation decision, not charity afterward. Training is useful when linked to verified work, apprenticeship, or a person's chosen capability; it is not an all-purpose answer to lost bargaining power.

Shorter hours convert some productivity into time. Reduce them sector by sector, monitor service levels and work intensification, and preserve choice. Maintain premium compensation for dangerous, unpleasant, scarce, or socially necessary tasks. Temporary public employment in care, maintenance, resilience, and ecological repair can stabilize a transition, but the roadmap does not preserve pointless work to justify income.

Rights plus a material exit

Civil liberties, due process, privacy, independent courts and media, political competition, collective bargaining, bodily autonomy, and peaceful succession are productive institutions because they surface error and permit correction. A major cross-country study estimates that democratization raises long-run output through channels including investment, schooling, health, reform, and reduced unrest; like all macro-historical work, its identification is debated, but it provides evidence against the claim that accountability has no economic value.[47]

The distinctive abundance right is a **material exit**. A person must retain enough independent access to identification, communication, money, shelter, transport, healthcare, and legal process to leave an abusive employer, household, platform, care institution, or locality. Without that capability, nominal choice hides domination.

Global diffusion rather than fortified plenty

An affluent enclave surrounded by debt, deprivation, climate damage, and conflict is neither stable nor abundant. Trade, migration, disease, ecology, supply chains, and security bind outcomes together.

The global compact includes transparent debt and collateral records; disaster standstills; faster restructuring; grant-heavy finance for the poorest countries and global public goods; larger multilateral development capacity; local-currency and concessional finance; and protection of minimum health, food, education, and climate-resilience spending during crises. Donors fund global spillovers; multilateral and regional banks absorb part of currency and first-loss risk; recipient institutions choose accountable local systems and disclose procurement; debt-sustainability triggers slow lending before essential budgets are raided. Every cross-border gate packet covers local ownership, host-community rights, migrants, refugees, informal workers, and people lacking conventional documents. The World Bank reported that developing countries paid $741 billion more in external debt service than they received in new financing from 2022 through 2024, illustrating how financial flows can subtract from capacity.[48]

Trade remains valuable, but diversified rather than naive: multiple suppliers, reciprocal reserves, humanitarian carveouts, adjustment insurance, regional capability, and labor and environmental standards paired with finance. WTO research argues that trade has contributed to income convergence while emphasizing that infrastructure, education, finance, labor, and adjustment institutions determine inclusion.[49]

Technology diffusion combines open science, public-interest licensing, patent pools, regional manufacturing and regulatory hubs, training, local-language tools, shared safety evaluation, and South–South research. WHO's mRNA technology-transfer program is a practical example: patents alone do not create capacity; know-how, training, regulation, equipment, quality systems, and regional institutions must travel together.[50] UNESCO's Open Science Recommendation similarly frames shared knowledge, infrastructure, assistance, and participation as a public project.[51]

The Compact is polycentric. It does not require a benevolent world sovereign or identical national systems. Jurisdictions can choose different providers, taxes, ownership forms, and cultural priorities while recognizing common rights floors, interoperability, ecological duties, security rules, and evidence standards.

9. Why atrocity is not a shortcut

This section answers the paper's intentionally extreme originating challenge—whether revolutionary violence or even billions of deaths could be justified if they seemed necessary to reach abundance—and rejects that bargain on both moral and practical grounds.

The first answer is moral. A civilization of abundance is valuable because people can flourish. Persons are not raw material to be consumed in its construction. No future average can restore the lives, relationships, experiences, cultures, and possibilities deliberately erased. Under radical uncertainty, no planner can know that a concrete atrocity produces a speculative century of welfare. Rights preserve both human standing and the option to correct mistakes.

The second answer is technical. Mass violence destroys every layer of the Abundance Stack:

1. **Human capital:** the dead and displaced include builders, caregivers, operators, scientists, teachers, children, and the tacit knowledge held inside teams and communities.
2. **Physical capital:** war breaks grids, water, factories, laboratories, housing, farms, transport, hospitals, communications, and archives.
3. **Coordination:** supply chains, credit, insurance, standards, professional trust, and international exchange fracture.
4. **Information:** secrecy, propaganda, fear, and loyalty tests suppress the criticism that complex systems need.
5. **Institutions:** armed organizations that win through command, patronage, and coercion enter the new order controlling weapons and appointments.

6. **Legitimacy:** collective punishment and dispossession create durable grievance, sabotage, flight, sanctions, and external intervention.
7. **Public finance:** tax bases collapse while military, reconstruction, debt, care, and security costs explode.
8. **Ecology and health:** famine, disease, contamination, uncontrolled extraction, and displacement amplify the original scarcity.

World Bank evidence on conflict, poverty, health, schooling, and the roughly 20 percent five-year output loss after high-intensity conflict makes the instrumental direction clear.[1] The exact effect varies by war and counterfactual, but no credible evidence makes civilizational destruction an abundance technology.

Violence also changes what succeeds. Organizations optimized to defeat enemies are not automatically capable of governing open scientific, technical, and plural institutions. A movement may promise to relinquish extraordinary authority after victory; the victory has already selected leaders, incentives, and structures built for secrecy and force.

Comparative evidence on mass campaigns is observational and subject to selection, classification, and historical limits. It nevertheless points away from armed transition. Chenoweth and Stephan found nonviolent campaigns more likely than violent campaigns to achieve maximal political goals, with broader participation and defections central to the mechanism.[52] Later work links nonviolent transitions to more durable democracy; a 2024 comparative study of successful revolutions associates nonviolent cases with lasting gains in liberal democracy, rule of law, civil liberties, and government accountability, with important causal and selection caveats.[53][54]

“Nonviolent” does not mean passive, polite, or incremental. The admissible toolkit includes elections, constitutional campaigns, labor organizing, strikes, boycotts, antitrust, public-utility conversion, cooperative ownership, participatory budgeting, citizens’ assemblies, litigation, investigative journalism, sanctuary and mutual aid, parallel civic institutions, and disciplined civil resistance where accountable routes are closed. Those methods can redistribute power radically without normalizing killing as public policy.

Nor does nonviolence require surrender to aggression. Lawful protection remains bounded by civilian control, necessity, proportionality, international humanitarian law and international human rights law, accountable policing, investigation and remedy, emergency sunsets, and demobilization. Nuclear launch and lethal force never pass to an autonomous system. Security preserves persons and institutions; it does not license collective punishment or permanent rule by emergency.

No jurisdiction passes an abundance gate while committing mass repression, collective punishment, coerced displacement, discriminatory exclusion, or deprivation conditioned on political loyalty. If such conduct appears, the roadmap requires protection of essential services, independent scrutiny, suspension of coercive automation and exceptional data collection, and restoration of lawful correction. Output milestones do not compensate.

10. Financing real abundance

Money is a claim on resources, not the resources themselves. The binding constraints are skilled labor, energy, materials, land, equipment, knowledge, construction time, logistics, ecological headroom, and institutional capacity. Finance organizes those constraints; it cannot wish them away.

Match the instrument to the asset.

- **Public debt** fits long-lived grids, water, transit, housing infrastructure, laboratories, and resilience when future tax or rate capacity can service it.

- **Regulated rates** fit network services, with lifeline tiers and public subsidy for people who cannot pay.
- **Taxation** funds universal services, redistribution, administration, and public goods whose benefits are not billable.
- **Equity, royalties, and warrants** fit scalable productive projects where upside is uncertain and the public takes material risk.
- **Land-value capture** returns part of the value created by transit, utilities, zoning, and public amenity.
- **Resource, pollution, spectrum, congestion, and monopoly-franchise rents** charge for scarce public assets or imposed costs and can support equal dividends, restoration, or host communities.
- **Grants and concessional finance** fit global public goods and regions too poor or fragile to carry commercial debt.
- **Prizes, procurement, and public research** fit knowledge spillovers and first-of-a-kind learning.

The instrument list becomes a plan only after a jurisdiction publishes a finance packet using one or a combination of three archetypes:

- A **high-income, grid-constrained** packet normally centers regulated network capital, long-lived public debt, rates, targeted affordability support, connection and workforce bottlenecks, and stress tests for interest rates and construction overruns.
- A **low-income, access-constrained** packet emphasizes grants and concessional local-currency finance for first access, explicit operations and replacement funding, lifeline subsidy, imported-equipment and exchange-rate exposure, and a path from external support to recurring domestic revenue.
- A **fragile or conflict-affected** packet favors modular assets, grant finance rather than new commercial debt, ring-fenced payment and maintenance, multiple local providers, neutral fiduciary supervision, and a loss-and-access plan before large irreversible works.

Each packet reports annual capital and operating cost in currency, per resident, as a share of public revenue and output; payer; debt service; reserves; subsidy; foreign-exchange share; labor and material load; inflation response; and downside case. No universal percentage is honest, and no module passes without local orders of magnitude. Volatile windfalls never fund a permanent essential promise without smoothing, a protected reserve, and a backup tax base.

Neither monetary expansion nor high-wealth taxation can substitute for physical capacity. Monetary expansion can intensify bidding against bottlenecks; progressive taxation can finance public investment and distribution, but it does not itself manufacture transformers, train nurses, permit housing, or operate water systems. Progressive taxes, inheritance taxes, rent capture, and enforcement belong in the Compact; so do supply, maintenance, and competent administration.

Sequence demand with capacity. Universal cash is easiest where competitive supply can expand. Where housing, electricity, medicine, or food is constrained, build and regulate supply while protecting the most vulnerable. Expand permanent benefits only with recurring revenue across a recession scenario. Pay social dividends from realized assets, not forecasts of an AI windfall.

Fiscal prudence here is not austerity. Neglecting childhood, health, water, housing, grids, climate adaptation, and maintenance destroys future capacity. The distinction is between investment or durable insurance and promises untethered from resources. An abundance state should publish generational accounts, asset condition, deferred maintenance, distribution, ecological liabilities, and stress scenarios alongside conventional debt.

11. Sixteen attacks that change the roadmap

An unfalsifiable future absorbs every objection as a temporary setback. This section does the opposite. Each attack forces a concession, a repair, and a condition under which part of the roadmap should be retired.

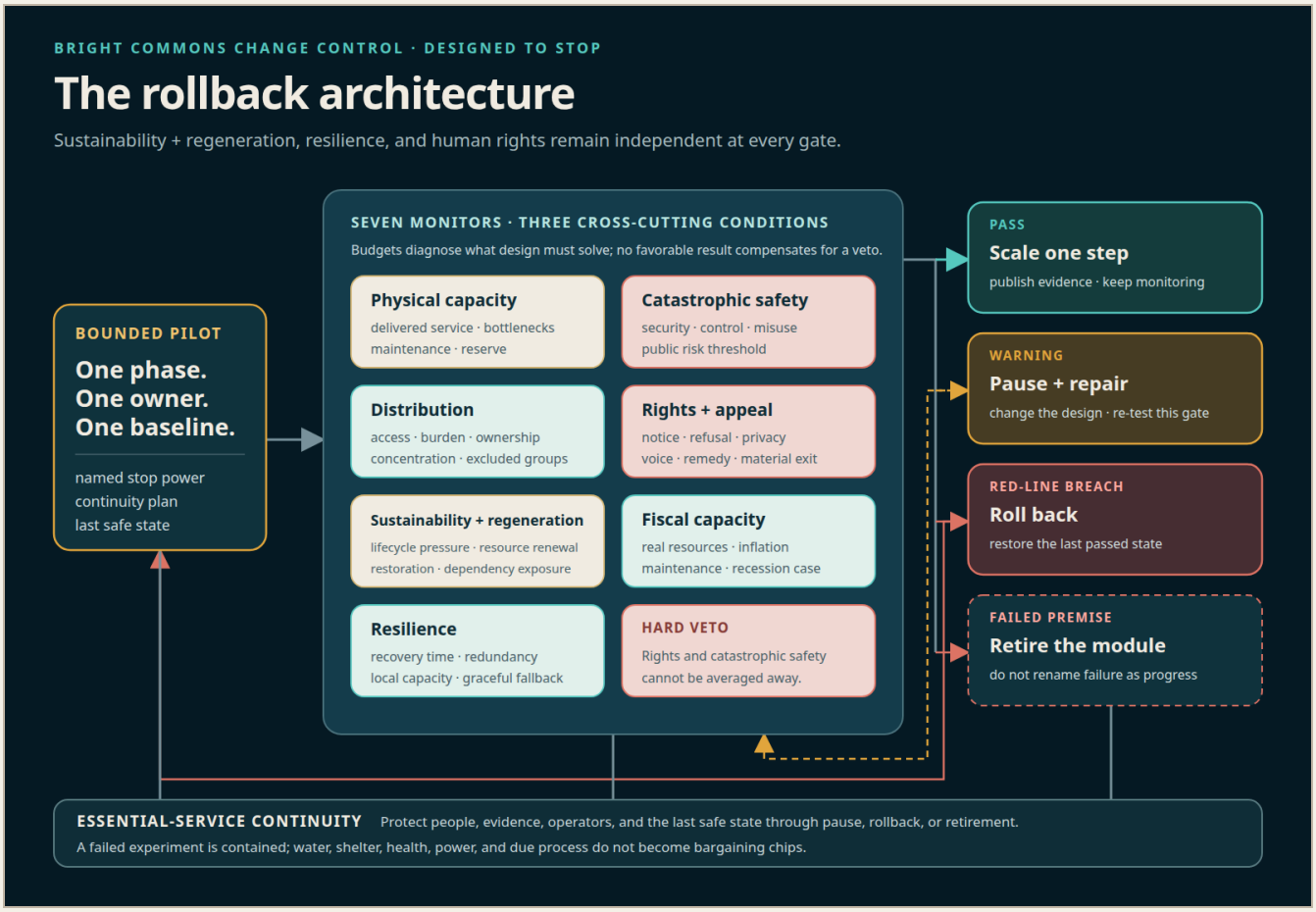

Figure 4. Designed to stop. Sustainability and regeneration, resilience, and human rights remain independent tests. No aggregate score can outweigh a rights or catastrophic-safety breach; a failed technology or policy returns to the last passed gate while essential services continue.

Attack 1: energy never becomes free

Attack. Retail power includes networks, firm capacity, storage, finance, maintenance, land, taxes, and risk even when solar or wind generation is cheap. **Concession.** “Free energy” is false and invites waste. **Repair.** Target a falling, predictable burden for an efficient essential service tier, not a zero price for unlimited consumption; build diverse supply and charge scarce or luxury use. **Surviving claim.** Clean useful work can become much cheaper. **Defeat condition.** If full-system cost, reliability, and ecological pressure cannot improve together over repeated investment cycles, power-led abundance narrows and demand redesign must carry more of the plan.

Attack 2: grids and institutions dominate technology cost

Attack. Connection queues, permitting, transformers, rights-of-way, skilled labor, local conflict, and regulatory delay can outrun module deployment. **Concession.** Learning curves for equipment do not predict delivered service. **Repair.** Treat planning, interconnection, transmission, distribution, spares, workforce, community benefit, and judicial timelines as core infrastructure. **Surviving claim.** The bottleneck is governable even when it is slow. **Defeat condition.** A jurisdiction that repeatedly cannot site, connect, maintain, or legitimate infrastructure should stop announcing generation targets and return to Gate 0 institutional capacity.

Attack 3: fusion arrives late or never

Attack. Target gain, plasma gain, engineering gain, net electricity, reliable operation, fuel breeding, component survival, and commercial cost are different milestones. **Concession.** Commercial fusion cannot anchor a dated plan. **Repair.** Keep it as research and a future portfolio option; pass terrestrial gates with demonstrated fission, renewables, geothermal, storage, networks, efficiency, and flexible demand. **Surviving claim.** Fusion could enlarge future margin without being necessary. **Defeat condition.** If whole-plant net electricity and competitive life-cycle cost never appear, retire fusion from deployment portfolios without revising the abundance thesis.

Attack 4: materials and land become binding

Attack. Electrification, housing, grids, chips, batteries, water systems, and transport require mines, factories, land, and ecological disturbance. **Concession.** Circularity cannot eliminate virgin input or physical conflict. **Repair.** Climb the solution ladder: reduce avoidable intensity; use cleaner energy; open responsible new supply; substitute; extend life; repair and recover high-value materials; restore damaged systems; redesign the service; and develop off-world supply only where its full lifecycle advantage is demonstrated. Enforce host-community rights and absolute budgets throughout. **Surviving claim.** Better service and human capability can grow faster than destructive throughput, and the feasible resource set can widen. **Defeat condition.** If one pathway's full material and land requirements exceed credible ecological and rights limits, abandon that pathway—not the human ambition it was meant to serve—and build a better one.

Attack 5: efficiency triggers rebound

Attack. Lower cost increases use and can erase expected energy or material savings. **Concession.** Efficiency is not an absolute environmental policy. **Repair.** Guarantee an efficient essential tier while governing total carbon, habitat, water, nutrient, toxicity, and material pressure through caps, standards, infrastructure design, or scarcity prices with fair rebates. Use the resulting signal to accelerate clean supply, substitution, redesign, recovery, and restoration rather than treating austerity as the default answer. **Surviving claim.** Efficiency expands capability inside a budget while innovation expands the budget's feasible solutions. **Defeat condition.** If total pressure rises beyond a declared limit, pause the harmful method or marginal use, preserve the floor, and build an alternative even when unit efficiency improves.

Attack 6: general robotics remains brittle

Attack. Factory robot counts do not imply a safe, economical machine for every home, street, farm, clinic, or repair job. **Concession.** Universal humanoid labor is not a dependency. **Repair.** Automate structured environments, standardize interfaces, redesign workflows, use teleoperation, and measure interventions, damage, energy, maintenance, and life-cycle cost. **Surviving claim.** Bounded, structured production tasks can be automated cumulatively where field-reliability and life-cycle-cost gates pass. **Defeat condition.** A task stays human or assisted when field reliability and total cost do not beat accountable alternatives; the roadmap does not rename demonstrations as labor capacity.

Attack 7: AI becomes unsafe, insecure, or epistemically corrosive

Attack. Powerful models can fail unpredictably, enable abuse, concentrate surveillance, homogenize errors, or erode independent expertise. **Concession.** Capability is not authority or trustworthiness. **Repair.** Use bounded permissions, independent evaluation, secure development, incident reporting, liability, appeal, manual fallback, protected apprenticeship, and prohibitions on unreviewable rights decisions or autonomous nuclear launch. UNESCO and NIST both emphasize life-cycle governance, traceability, monitoring, and remedy.[55][56] **Surviving claim.** Verified AI can lower selected coordination and knowledge costs. **Defeat condition.** Remove a system when risk cannot be bounded below the human and non-AI alternative; do not make critical provision dependent on it.

Attack 8: automation concentrates ownership and power

Attack. Falling production cost can enrich owners while reducing labor income and political competition. **Concession.** Productivity is not distribution. **Repair.** Strengthen competition, labor bargaining, employee and cooperative ownership, public options, social wealth funds, data and interoperability rights, and public upside from subsidies. **Surviving claim.** Automation creates shareable capacity, not an automatic share. **Defeat condition.** If concentration, bottom-half burden, political inequality, and dependence worsen persistently, the jurisdiction has not crossed the capacity-to-freedom boundary and must stop subsidizing further concentration.

Attack 9: transfers and promises outrun supply and revenue

Attack. Broad cash can raise rent, medical, food, or energy prices when supply is fixed, while permanent service promises can fail under recession, higher interest rates, demographic change, debt stress, or a shrinking tax base. **Concession.** Income is not capacity, and entitlement language is not a funding stream. **Repair.** Build supply first or concurrently; use direct services where markets are thin; fund recurring guarantees with recurring revenue; maintain replacement and recession reserves; stress-test rates, debt service, demographics, and foreign exchange; and pay universal dividends only from realized, smoothed returns. **Surviving claim.** Cash preserves choice and a service floor preserves capability when both capacity and finance survive adverse scenarios. **Defeat condition.** Persistent shortages or an inability to preserve the floor without inflationary, insolvent, or extractive financing triggers slower untargeted expansion, protected essentials, revenue and scope repair, and a return to the last financeable gate.

Attack 10: less work can mean less meaning and expertise

Attack. Jobs provide identity, practice, community, status, and routes to mastery as well as wages. **Concession.** Income replacement cannot reproduce those functions. **Repair.** Reduce hours gradually, protect apprenticeship and unaided practice, support civic, care, scientific, artistic, athletic, educational, and entrepreneurial institutions, and let people choose more paid work. **Surviving claim.** Survival can be separated from compulsory employment without erasing purposeful activity. **Defeat condition.** Rising isolation, skill loss, unwanted idleness, or mental distress requires redesign of institutions and work, not withdrawal of the material floor.

Attack 11: democracy moves too slowly

Attack. Election cycles, veto points, litigation, local opposition, and polarization can delay century-scale construction. **Concession.** Legitimate consent has transaction costs. **Repair.** Use polycentric pilots, published deadlines, one-stop permitting, citizen deliberation, community benefits, automatic triggers, sunset clauses, and independent review. Build visible

early wins across regions. **Surviving claim.** Democracy can supply error correction and durable consent that command systems lack. **Defeat condition.** If a process cannot decide after fair evidence, time limits, compensation, and appeal, reform the decision rule; do not infer permission for dictatorship.

Attack 12: authoritarian coordination looks faster

Attack. Centralized states can acquire land, direct capital, and build infrastructure rapidly. **Concession.** Some projects can be faster when opposition has no remedy. **Repair.** Compare full life-cycle performance: displaced people, hidden failures, corruption, maintenance, information quality, innovation, succession, and political risk. Preserve emergency capacity with narrow scope and expiry. **Surviving claim.** Accountable coordination can be strong without being absolute. **Defeat condition.** Any plan that requires permanent censorship, loyalty-conditioned essentials, one-party rule, mass surveillance, or collective punishment fails regardless of output.

Attack 13: rich states hoard technology and ecological space

Attack. High-income countries can monopolize capital, chips, medicines, minerals, patents, and carbon space while externalizing extraction and waste. **Concession.** National abundance alone can deepen global scarcity and insecurity. **Repair.** Combine debt reform, concessional finance, open science, regional manufacturing, technology extension, training, shared standards, migration routes, host-community rights, and consumption-based ecological accounting. **Surviving claim.** Convergence is technically possible and strategically necessary. **Defeat condition.** A jurisdiction cannot claim abundance while its imports depend on systematic coercion or while avoidable deprivation rises in the communities bearing its costs.

Attack 14: malicious actors exploit powerful tools

Attack. Cheap biology, cyber capability, autonomous systems, drones, and advanced AI can make catastrophic harm easier. **Concession.** Productive capability increases attack surface. **Repair.** Fund secure design, screening, access controls proportionate to consequence, public-health surveillance, rapid countermeasures, incident sharing, independent red teams, resilient infrastructure, arms control, hotlines, and meaningful human control over weapons. **Surviving claim.** Security can be layered without making all knowledge secret. **Defeat condition.** A capability whose expected catastrophic risk cannot be reduced below a public threshold remains restricted or unscaled, however productive it appears.

Attack 15: space industry never closes economically

Attack. Launch, assembly, radiation, maintenance, life support, communications delay, rescue, small markets, planetary protection, and governance can make off-world industry uneconomic or irresponsible for centuries. Interstellar freight adds light-year distances and undemonstrated infrastructure. **Concession.** Space resources are not a terrestrial supply forecast, and galactic supply is not a roadmap claim. **Repair.** Scale only projects with a real customer and a verified delivered-cost, sustainability, rights, safety, and governance advantage, likely beginning with communications, science, repair, and resources used in space. **Surviving claim.** A Solar System resource frontier is physically compatible and optional; a wider cosmic horizon may remain open without underwriting present promises. **Defeat condition.** If lifecycle economics, safety, rights, or governance fail, retire the project; Earth’s Bright Commons gates remain unchanged.

Attack 16: conflict breaks the timetable, and status scarcity survives

Attack. War, coercive rivalry, climate shocks, pandemics, politics, technological plateaus, and status competition make century dates unserious and can destroy gains already made. Even a wealthy society retains prestige, attention, unique land, and risk. **Concession.** No date or technology ends conflict, competition, or tragedy. **Repair.** Use gates, not deadlines; fund

peacebuilding, arms control, civilian protection, resilient lifelines, and recovery; maintain plural institutions; allocate irreducible scarcity transparently; and preserve reversibility. **Surviving claim.** Avoidable material deprivation can shrink radically without a final end of history. **Defeat condition.** If conflict, essential access, autonomy, ecological stability, and resilience do not improve together, call the project what it is—growth or spectacle—not abundance.

12. The Universal Capability Ledger

GDP records monetized and imputed production but cannot say whether a person can drink the water, leave an abusive job, appeal an automated denial, or survive a week-long outage. The Universal Capability Ledger is a public, disaggregated record designed for gate decisions. It refuses a composite “abundance score” because unlike values should not cancel one another.

For every essential service, the Ledger records:

- **Capacity:** physical output, reserve margin, bottlenecks, deferred maintenance, workforce, and credible expansion rate.
- **Reliability:** uptime, waiting time, quality, geographic reach, incident rate, recovery time, and performance under stress.
- **Burden:** money and time cost for households at the tenth, fiftieth, and ninetieth percentiles of the income distribution, including unpaid care and travel.
- **Access:** effective use by geography, income, disability, age, sex, and locally relevant groups; denials and exclusion reasons.
- **Entitlement:** notice, appeal, human review, remedy, switching options, and continuity when identity or payment systems fail.
- **Distribution:** wages, leisure, prices, ownership, labor share, public consumption, wealth concentration, market entry, and procurement concentration.
- **Autonomy:** privacy, surveillance, political conditions, employer or platform dependence, desired versus actual work, the material ability to exit, media and campaign-finance concentration, lobbying, and revolving-door conflicts.
- **Sustainability and regeneration:** absolute carbon, air pollution, water-basin stress, land, habitat, nutrients, toxicity, material footprint, waste-heat load, virgin and recovered supply, final waste, exported burden, restoration, and measured ecological headroom.
- **Resilience and security:** supplier diversity, inventories, manual fallback, cyber and biological incidents, displacement, conflict exposure, and exercised recovery plans.

Every measure carries a source, method, uncertainty interval where applicable, revision history, and responsible institution. Results are public and machine-readable, with privacy protection for individuals. An independent statistical authority produces the record; courts, legislatures, regulators, auditors, researchers, journalists, communities, and opposition parties contest its interpretation.

The Ledger is aggregate by default. Statistical and eligibility systems remain separated; data are minimized, retained only as long as justified, independently privacy-audited, and published with disclosure controls. No single universal or digital-only identifier is required to receive the lifeline tier, and Ledger data may not be repurposed for political or immigration enforcement. An institution that measures freedom by building a population-control database has failed its own autonomy test.

Gate decisions use a **dashboard plus red lines**, not a weighted average. A legislature can make an explicit tradeoff among cost, speed, and redundancy. It cannot average away torture, political exclusion, catastrophic unmanaged risk, or deliberate denial of essentials to a group. When evidence is missing, the Ledger marks “unknown” rather than converting ignorance into a passing value.

13. A research program designed to end the thesis

This paper proposes a pathway, not an established causal law. Its strongest claims should be tested against plausible alternatives with predeclared outcomes.

1. Essential-basket accounting

Build comparable regional accounts for the labor, energy, land, materials, capital, money, and time needed to deliver the guaranteed basket. Test whether automation and infrastructure lower real resource cost after networks, maintenance, housing, care, and resilience are included. A null over repeated cycles narrows the productivity premise.

2. Capacity-to-access comparisons

Compare regions adding similar physical capacity under different ownership, competition, service-guarantee, and benefit regimes. Measure household burden, reliability, exclusion, concentration, investment, and political support. If distribution architecture does not explain materially different access, the Compact is overclaimed.

3. Supply-first, cash-first, and combined sequencing

Randomize or exploit staged rollouts where ethical: targeted cash, direct services, supply investment, and combinations. Track prices, quality, utilization, mobility, poverty, provider entry, and spillovers. The hypothesis is not that cash fails; it is that supply elasticity determines when cash becomes real capability.

4. Automation ownership experiments

Compare ordinary capital ownership, employee equity, gain-sharing, cooperative production, public warrants, and social-fund stakes in firms adopting similar automation. Track investment, productivity, wages, hours, turnover, innovation, and distribution. Retire ownership mandates that suppress productive investment without delivering broader gains.

5. Reduced-hours trials

Run sector-specific trials with service-level, staffing, health, learning, care, productivity, and work-intensity measures. Distinguish fewer paid hours from hidden overtime and compressed stress. Scale only where people receive actual time or well-being rather than a slogan.

6. Public compute and open-infrastructure pilots

Test whether shared compute, datasets, evaluation tools, fiber, cloud portability, and extension services increase entry and useful innovation among universities, public agencies, small firms, civil society, and lower-income regions. Compare full cost and security with vouchers or private procurement.

7. Regenerative material-system demonstrations

Select product and infrastructure classes and measure durability, collection, disassembly, yield, contamination, energy, labor, toxicity, responsible virgin supply, verified displacement, restoration, life-cycle cost, and rebound. A “recycled” or “regenerative” label without verified material and ecological outcomes is not a positive result.

8. Resilience pricing

Compare systems optimized for average cost with systems purchasing redundancy, local repair, inventories, supplier diversity, islanding, and fallback. Use actual disruptions and exercises. Estimate the insurance value and identify cases where resilience spending is ritual rather than capability.

9. Rights and AI incident studies

Create interoperable incident and appeal records for high-impact AI. Test whether impact assessment, independent evaluation, auditability, liability, human review, and fallback reduce harm without freezing entry. A regime that produces compliance paperwork but no safer outcomes should be replaced.

10. Global diffusion mechanisms

Compare patent publication alone with bundles of licensing, tacit know-how, equipment, training, regulatory assistance, finance, and regional manufacturing. Measure local production, quality, resilience, prices, dependence, and spillovers. The hypothesis is that capability transfer requires institutions, not documents alone.

11. Resource-frontier economics and governance

Compare the full delivered cost and consequence of demand redesign, terrestrial new supply, substitution, repair, recovery, restoration, and off-world alternatives for selected materials and energy services. Count launch, infrastructure, energy, contamination, debris, planetary protection, labor, security, liability, rescue, decommissioning, distribution, and opportunity cost. Test governance models against the Outer Space Treaty’s benefit, non-appropriation, responsibility, and due-regard principles. Retire any proposal that relies on an imagined market, exports harm, or uses a distant frontier to delay a demonstrated terrestrial solution.

Modular falsifiers

The whole roadmap does not win merely because one component succeeds. Retire or narrow individual claims when:

- full-system clean power cost and reliability fail to improve despite adequate construction;
- structured automation does not lower verified life-cycle resource cost;
- service guarantees crowd out capacity or plural provision without improving effective access;
- shared-ownership tools materially suppress investment and do not improve distribution;
- ecological pressure rises beyond budgets despite cleaner supply, substitution, service redesign, recovery, and restoration;
- AI safeguards fail to reduce incidents or instead become a durable incumbent moat;
- democratic gate processes cannot decide, correct, or maintain infrastructure;
- off-world services never beat Earth-launched alternatives;

- universal capability rises only by exporting coercion, damage, or deprivation.

The thesis survives only in the modules that evidence supports.

14. What the destination would feel like

A mature abundance society would not feel like standing inside a machine that grants wishes. It would feel like the disappearance of certain fears.

That society is the **Bright Commons**. Clean water, nutritious food, reliable energy, safe shelter, clothing, healthcare and caregiving, education, mobility, communication, and computational capability are secured foundations rather than prizes. The systems behind them keep working through drought, outage, cyberattack, supply disruption, recession, and political change because redundancy, local repair, reserves, fallback, and recovery are funded duties. The commons is the guarantee; life above it remains plural.

A layoff would change work and income but not access to medicine, shelter, communication, education, food, water, heat, cooling, or legal personhood. A young adult could refuse an abusive workplace without risking untreated illness. A parent could care for a child without falling through every insurance system. A scientist, craftsperson, founder, teacher, athlete, artist, mechanic, farmer, or caregiver could pursue excellence without claiming that every human deserves life only through a payroll slot.

Markets would remain. People would pay more for rare land, bespoke craft, speed, seclusion, luxury energy, exclusive space, or another person’s scarce time. Firms would compete. Some people would accumulate more wealth, admiration, or responsibility. Politics would remain difficult because values conflict. Crime, grief, illness, failure, and mortality would not vanish.

What changes is the floor and the bargaining position above it. Essential systems are boringly reliable. Knowledge is broadly available. Products are easier to repair and customize. Routine production is heavily automated, but people retain authority over legitimate ends and enough competence to recover from failure. Working time becomes more voluntary and varied. Cities, towns, cultures, and institutions can choose different balances without condemning dissenters to destitution.

Sustainability is visible as expanding capability rather than imposed scarcity: cleaner energy, healthy watersheds, restored soils and habitat, long-lived infrastructure, responsible new supply, materials that circulate at high value, and continual invention when a budget binds. A flourishing settlement can be greener and more technologically ambitious at once. It may build denser cities, larger scientific instruments, faster mobility, new art forms, advanced medicine, and eventually settlements and industry beyond Earth—provided each expansion preserves rights, solves its full lifecycle effects, and leaves future people more options.

Medicine prevents and manages more disease without promising immortality. Mobility becomes cleaner and easier without eliminating distance. Human settlements may extend across parts of the Solar System, while the nearest stars remain years away even for light. Exploration is invited; prophecy is not required. The future is recognizable as human life with wider capability—not an optimized monoculture.

15. Limits

This is not a global construction estimate, macroeconomic forecast, or claim that one institutional model fits every country. The dates are illustrative horizons, not forecasts. The technical sources describe present systems, demonstrations, and models; they do not forecast a century. Political legitimacy, culture, war, ecological feedback, and unknown technologies cannot be engineered like a substation.

The roadmap separates evidence horizons deliberately. Current terrestrial infrastructure and institutions carry the critical path. Cislunar and near-Earth resource use is an active research-and-demonstration frontier. Larger Solar System industry is compatible with known physics but economically and institutionally speculative. Interstellar or galactic resource use is a far-horizon possibility, not a forecast, funding source, sustainability credit, or reason to postpone solvable work on Earth.

The Conjunctive Test contains normative judgments about which services are essential, which externalities are acceptable, and which rights are inviolable. Those judgments require democratic and legal specification. The Ledger can improve honesty but cannot automate politics.

Some interventions conflict at the margin. Redundancy can raise material use. Privacy can reduce useful coordination. Fast housing can threaten habitat or displace communities. Open science can increase misuse. Competition can sacrifice scale. Regulation can protect incumbents. Local consent can block regional need. The roadmap supplies procedures and red lines, not a universal solution to every tradeoff.

Artificial intelligence, biotechnology, climate change, nuclear weapons, cyber conflict, and geopolitical fragmentation create risks whose distributions are poorly known. Abundance raises the stakes of governance because powerful capabilities can produce powerful harm. The paper’s peaceful path does not guarantee that every actor remains peaceful; it makes prevention, resilience, verified arms control, public health, and lawful security part of productive capacity.

Finally, physical feasibility is not political inevitability. Societies can choose rent, hierarchy, spectacle, exclusion, or war even when another path is available. This paper argues that abundance can be built under known physics and without atrocity. It does not argue that history owes it to us.

Conclusion

The route from 2026 to the Bright Commons is less mysterious than the fiction and more demanding than its machines.

Build clean power and the networks that make it useful. Automate tasks whose results can be tested. Redesign products and infrastructure for repair, modularity, recovery, regeneration, and resilience. Expand food, water, housing, health, education, mobility, care, and communication as service systems. Guarantee an essential tier. Preserve markets where they discover and differentiate. Regulate bottlenecks. Broaden ownership. Convert realized productive gains into income, services, and time. Use ecological budgets to expose the next problem, then solve it through cleaner supply, responsible new supply, substitution, recovery, restoration, better design, and evidence-gated frontiers. Diffuse capability globally. Protect dissent, privacy, due process, association, and a material right of exit. Measure, pilot, audit, scale, pause, repair, or retire.

The radical act is not sacrificing people to a distant average. It is redesigning property, work, infrastructure, and citizenship so that every person is a rights-bearing participant in and beneficiary of civilization’s productive power. Abundance secures the essentials. Sustainability keeps expansion durable. Resilience keeps the floor intact through shocks. Rights keep every person a participant rather than an input. Regeneration leaves the next generation more headroom than the last.

The road has one rule that no breakthrough may repeal:

> **Build the stack. Pass the gates. Share the gain. Preserve the right to stop. No one is expendable.**

EVIDENCE TRAIL

Notes and sources

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