H HEURISTICS

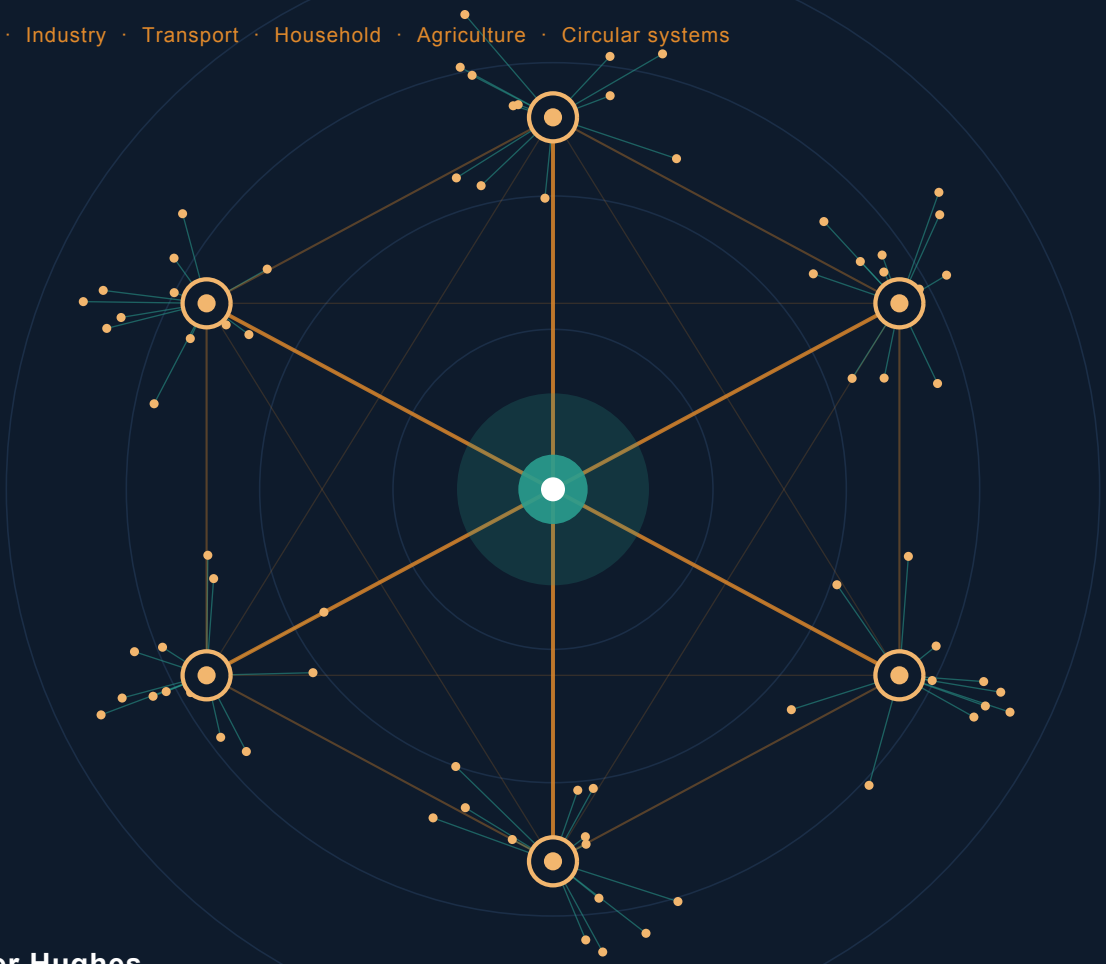
RESEARCH REPORT · NOVEMBER 2026

Polycrisis Resilience

Clean Transition

How cleaner energy, industry, transport, homes and farms can reduce interconnected risks and strengthen human survivability

Energy · Industry · Transport · Household · Agriculture · Circular systems



Hunter Hughes

Founder, H Heuristics · A concept developed by Hunter Hughes

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About This Report

This report is part of the **Polycrisis Resilience** research series developed by Hunter Hughes, Founder of H Heuristics. The founding report in the series defined Polycrisis Resilience as the capacity of people, communities, economies, institutions and interconnected systems to anticipate, withstand, adapt to, recover from and reduce the cascading and compounding effects of multiple interconnected crises. This report takes one mechanism from that framework, the **clean transition**, and examines it in depth.

The question it asks is simple. If humanity's biggest risks are connected, can one large shift in how we make energy, goods and food, move around, cook and handle waste lower several of those risks at once? And if so, what would it take to make that happen, and how would we know it was working? The report draws on published evidence from energy, health, development and climate research and adds original H Heuristics concepts: a central proposition, six pillars, a measure called the **Clean Transition Resilience Dividend**, and three scenarios to 2050.

How to read this report

Each chapter opens with a short summary box and can be read on its own. **Chapters 1 and 2** set out the idea and explain why one transition can affect many pressures. **Chapter 3** reviews where the transition stands today. **Chapters 4 and 5** describe the six pillars and the concept of multi-dimensional resilience. **Chapters 6 and 7** turn to emerging economies and the feedback loop that can make the transition self-reinforcing. **Chapters 8 and 9** introduce measurement and scenarios. **Chapters 10 and 11** cover trade-offs, criticism and next steps. Readers short of time can read the Executive Summary and Chapter 1.

Evidence grades

Claims are graded on the four-level scale used across H Heuristics research. The grade describes the state of knowledge, not the importance of the claim. Illustrative analyses by H Heuristics are always grade C or D.

Table 1. Evidence grades used in this report

Grade	Meaning	Example from this report
A: Established	Confirmed by multiple independent lines of evidence and assessed as such by leading scientific or statistical bodies.	Air pollution is linked to about 7.9 million deaths a year.
B: Well supported	Strong evidence from several lines of work, with some unresolved detail or range.	Clean energy investment is now well above fossil-fuel investment worldwide.
C: Plausible or contested	A credible argument with partial evidence; specialists disagree on size or mechanism.	Clean-transition benefits feed back to speed up further adoption.
D: Speculative	A scenario or hypothesis offered for evaluation, labeled as such.	That a single Clean Transition Resilience Dividend can be estimated usefully.

Source: H Heuristics.

Illustrative exhibits. Three exhibits are H Heuristics constructions rather than reported data, and each is labeled where it appears. **Figure 1** rests on qualitative scores assigned by the author from the literature (grade C). **Figure 5** uses a hypothetical program to show how a dividend could be calculated (grade D). **Figure 6** is a stylized model that shows how mechanisms combine, not a forecast (grade D). Every other figure reports data from the cited source.

How to cite. Hughes, H. (2026). *Polycrisis Resilience: Clean Transition.* H Heuristics Research Report, November 2026.

Executive Summary

The central thesis

The clean transition is not merely an environmental transformation. It is an opportunity to reduce interconnected systemic risks while expanding the productive, technological and adaptive capabilities of societies. By accelerating the adoption of cleaner energy, industrial processes, transportation, household technologies and resource systems, humanity can address several dimensions of the global polycrisis at the same time. H Heuristics examines the clean transition as a mechanism of long-term resilience, connecting environmental risk reduction with economic convergence, technological diffusion, sustainable development and human survivability.

> **THE CENTRAL H HEURISTICS PROPOSITION**
>
> Accelerating the global clean transition can reduce interconnected environmental and socioeconomic risks while strengthening the development and adaptive capacities necessary for long-term human survivability.

Key numbers

Table 2. The clean transition in numbers

Number	What it measures	Source
About 7.9 million	Deaths linked to air pollution in 2023, including about 2.8 million from household air pollution	HEI, 2025
33.8% vs 33.0%	Renewables' share of global electricity versus coal's in 2025, the first time renewables led	Ember, 2026
About $2.2 trillion	Projected 2026 clean-energy investment, against about $1.2 trillion for fossil fuels	IEA, 2026
About 25%	Share of new cars sold worldwide in 2025 that were electric	IEA, 2026
About 655 million	People without electricity in 2024; about 2 billion also lack clean cooking	SEforALL et al., 2026
More than 2x	How much higher the cost of capital is for clean projects in emerging and developing economies than in advanced ones	IEA, 2024
Seven of nine	Planetary boundaries assessed as transgressed	Steinert et al., 2025

Sources as shown; figures are rounded.

Principal findings

- **The pressures are connected, and so are many of the solutions.** Climate change, air pollution, water contamination, ecosystem loss, energy insecurity and economic vulnerability reinforce one another. Burning fossil fuels, for example, drives climate change and causes much of the outdoor air pollution linked to about 4.9 million deaths a year, while also tying countries to volatile fuel markets (Chapter 2).
- **The transition is already well under way, but unevenly.** In 2025, renewables generated slightly more of the world's electricity than coal for the first time, about one in four new cars sold was electric, and the IEA

projects clean energy will attract roughly $2.2 trillion of investment in 2026 against about $1.2 trillion for fossil fuels. Yet about 655 million people still lack electricity, about 2 billion lack clean cooking, and Africa receives only about 2% of clean-energy investment (Chapter 3, grade B).

- **Six pillars carry the transition:** clean energy, clean industrialization, clean transportation, household energy and pollution reduction, clean agriculture and resource systems, and pollution prevention and circular systems. Each reduces several pressures, and together they cover most of the sources of risk in an economy (Chapter 4, grade C).
- **One well-designed investment can pay off in seven ways.** A solar-plus-storage and grid program can cut emissions and air pollution, power businesses, protect health, diversify energy supply, spread modern technology and support clinics and schools. This is multi-dimensional resilience, though no project delivers every benefit (Chapter 5, grade C).
- **For emerging economies, the transition is a development strategy.** Electricity poverty, household air pollution, industrial pollution and fossil-fuel dependence each have a clean-transition pathway. The binding constraint is often the cost of capital, which the IEA finds is more than twice as high for clean projects in emerging and developing economies as in advanced ones (Chapter 6, grade B).
- **Benefits can reinforce themselves.** Cleaner air and cheaper energy improve health and productivity, which strengthen institutions and budgets, which can fund further clean investment. The same loop can run in reverse when pollution and energy poverty trap a country (Chapter 7, grade C).
- **A broader measure is needed.** The proposed **Clean Transition Resilience Dividend** adds climate, air, health, energy security, economic and resilience gains while removing double-counting. In a hypothetical illustration, gross benefits of 190 fall to 162 after overlap, against a program cost of 100 (Chapter 8, grade D).
- **Decarbonization alone is not enough.** In a stylized model, an integrated scenario that pairs the clean transition with adaptation, health, water and institutions ends 2050 with a vulnerability index of 20 against 41 for acceleration alone and 87 for delay (Chapter 9, grade D).

What this report proposes

- A shared **central proposition** and a six-pillar map of the clean transition as a resilience mechanism.
- A **Clean Transition Resilience Dividend** that measures combined climate, health, economic and systemic-risk benefits, with rules to avoid double-counting.
- A three-scenario framework, delayed, accelerated and integrated, for testing policies and investments.
- A **Clean Transition Resilience Test** of six questions, and a research and action agenda for governments, funders, companies and researchers.

What remains unsettled

The benefits of a clean transition are not automatic. Their size depends on how it is carried out, what energy sources and industrial processes are used, the quality of regulation and infrastructure, and the wider development context. Critical minerals, land use, grid reliability, affordability and fairness for workers in fossil-fuel regions all need careful management. Chapter 10 sets out these trade-offs and the evidence that would lead H Heuristics to revise the framework. The report's own illustrations, including the dividend example and the scenario model, are labeled as hypothetical and should be read as tools for thinking, not as forecasts.

PART I · THE IDEA

1. The Clean Transition as a Mechanism of Resilience

IN BRIEF

- The clean transition is a strategy for reducing several connected sources of systemic risk, not only an environmental policy goal.
- It addresses climate, air, water, ecosystems, energy security, food, economic vulnerability and health together, but its benefits are not automatic.
- In the Polycrisis Resilience framework it is a mechanism that expresses all six defining properties of the concept.

1.1 The central idea

The clean transition is a fundamental mechanism of Polycrisis Resilience. The shift away from pollution-intensive, environmentally damaging and inefficient systems toward cleaner energy, industry, transportation, agriculture and infrastructure represents more than an environmental policy objective. It is a strategy for reducing multiple interconnected sources of systemic risk.

Climate change, air pollution, water contamination, ecosystem degradation, energy insecurity and economic vulnerability interact. These pressures can reinforce one another and create cascading consequences for public health, food security, economic productivity, political stability and human survivability. The clean transition can address several of these pressures at once. That is what makes it different from a single-issue policy and why H Heuristics treats it as a core part of Polycrisis Resilience.

THE CENTRAL H HEURISTICS PROPOSITION

Accelerating the global clean transition can reduce interconnected environmental and socioeconomic risks while strengthening the development and adaptive capacities necessary for long-term human survivability.

The proposition has two halves, and both matter. The first is *risk reduction*: cleaner systems lower the chance and severity of harm from climate, pollution and fuel-market shocks. The second is *capacity building*: cleaner systems can also expand what societies are able to do, by providing cheaper and more reliable energy, healthier workforces, new industries and more resilient infrastructure. A transition that cuts emissions but leaves communities more fragile meets only the first half; one that raises incomes but locks in pollution meets only the second. The aim is both.

1.2 Why it is more than environmental policy

Environmental policy usually starts from a specific problem, such as greenhouse gases, smog or a polluted river, and asks how to reduce it. That approach has produced real gains. But it tends to treat each problem as separate, with its own ministry, budget and metrics. The polycrisis perspective starts from a different observation: the problems share causes and feed one another. Fossil-fuel combustion is a good example. It is the main source of the carbon dioxide that is warming the planet. It also produces the fine particles (PM2.5) that harm lungs and hearts, and it leaves many countries dependent on imported fuel whose prices can swing suddenly. One cause, three kinds of risk.

When risks are connected in this way, the most valuable actions are those that reach the shared cause. The clean transition does exactly that: by changing how energy, industry, transport, agriculture and waste systems work, it reaches many of the common roots of risk together. This is the idea behind the *intersectional* property of Polycrisis Resilience: solutions become especially valuable when they address several vulnerabilities at once.

The idea overlaps with climate mitigation, the energy transition, green growth and the just transition, but it differs by counting every pressure the transition touches and by asking how adaptive capacity grows. It also connects to the *developmental* property. Cleaner technologies are increasingly the lowest-cost way to supply new energy, and they come with industries, skills and infrastructure attached. For countries that are still building their electricity grids, factories and cities, choosing cleaner options can mean building capacity and reducing exposure in the same step. H Heuristics examines this link with two related research themes, Convergence as Polycrisis Resilience and Technology Diffusion as Polycrisis Resilience, which Chapter 6 brings together.

1.3 Eight pressures, one transition

Table 3 lists the eight systemic pressures that the clean transition can help to reduce, together with the main way it contributes and a data point that shows why the pressure matters. The contributions are not equal in size or certainty, and they differ by country and by how the transition is carried out.

Table 3. How the clean transition contributes to eight systemic pressures

Systemic pressure	Clean-transition contribution	Why it matters (evidence)
Climate change	Reduced greenhouse gas emissions	2025 was about 1.43 °C above the 1850–1900 baseline (WMO, 2026).
Air pollution	Reduced combustion-related pollution	Air pollution was linked to about 7.9 million deaths in 2023, 4.9 million from outdoor fine particles (HEI, 2025).
Water contamination	Cleaner industrial and agricultural processes	Untreated wastewater, fertilizer runoff and industrial discharge contaminate water in many regions.
Energy insecurity	Diversified and cleaner energy systems	About 655 million people lack electricity; many importing countries face fuel-price shocks (SEforALL et al., 2026).
Ecosystem degradation	Reduced environmental pressures	Seven of nine planetary boundaries are assessed as transgressed (Steinert et al., 2025).
Food insecurity	More sustainable agricultural systems	Food systems produce roughly one-third of global greenhouse gas emissions (Crippa et al., 2021).
Economic vulnerability	Reduced exposure to some fuel and resource shocks	3.4 billion people live in countries spending more on interest than on health or education (UNCTAD, 2025).
Public health burdens	Lower exposure to harmful pollutants	About 2.8 million deaths in 2023 were linked to household air pollution from cooking fuels (HEI, 2025).

Sources as shown. The middle column states the direction of effect; magnitudes vary by setting.

1.4 The benefits are not automatic

An important distinction: these benefits are not guaranteed. Their size depends on implementation, the sources of energy used, industrial processes, regulation, infrastructure and the broader development context. A coal-fired grid that powers a fleet of electric vehicles still pollutes, only elsewhere. A solar farm built without attention to land, water or local communities can create new conflicts. A cleaner factory that is unaffordable to small producers can concentrate economic power. The objective is to reduce multiple forms of environmental risk through *coordinated* transformation, and the word coordinated carries much of the weight.

For that reason this report treats the clean transition as a means, judged by what it achieves, and not as an end in itself. Chapter 8 proposes a way to measure results across several dimensions, and Chapter 10 sets out the main trade-offs.

1.5 How the clean transition expresses the six properties

The Polycrisis Resilience framework is defined by six properties. **Table 4** shows how the clean transition expresses each of them, and where it is weakest if done poorly.

Table 4. The clean transition viewed through the six defining properties

Property	How the clean transition expresses it	Where it can fall short
Multidimensional	Acts on climate, pollution, energy, health and economic systems together.	Optimizing for emissions alone and ignoring local pollution, land or jobs.
Preventative	Lowers the source of future harm, not only the cost of repair.	Treating clean technology as a substitute for adaptation to harm already locked in.
Developmental	Builds energy access, industries and skills that raise incomes.	Imported solutions that create little local capacity or employment.
Intersectional	One investment can reduce several vulnerabilities at once.	Single-purpose projects with unpriced side effects.
Distributive	Distributed technologies can reach people far from the grid.	Benefits flowing mainly to wealthier regions with cheaper finance.
Long-term	Avoids lock-in to polluting infrastructure that lasts for decades.	Short-term cost focus that delays investments with long payoffs.

Source: H Heuristics, building on the six defining properties in the founding Polycrisis Resilience report.

1.6 What the proposition claims, and what it does not

A good proposition is specific enough to be wrong. **Table 5** states what the central proposition does and does not claim, so that readers can test it fairly.

Table 5. Reading the central proposition

The proposition claims that	The proposition does not claim that
Cleaner systems can lower several linked risks together.	Every clean technology reduces every risk in every place.
The transition can build productive and adaptive capacity as well as cutting pollution.	Growth alone, or technology alone, will deliver resilience.
Benefits can feed back and speed up further adoption.	The feedback loop is automatic or guaranteed.
The transition is a necessary part of long-term human survivability.	It is sufficient; adaptation, health, water and institutions are also needed.

Source: H Heuristics.

PART I · THE IDEA

2. How Interacting Pressures Respond to One Transition

IN BRIEF

- Pressures are linked through shared causes, shared victims and cascades from one system to another.
- The clean transition works through four mechanisms: removing shared sources, reducing exposure to shocks, creating capacity, and freeing resources.
- Different pillars reach different pressures, so a full transition needs all of them (qualitative assessment, grade C).

2.1 Why risks interact

Researchers describe three ways in which crises become entangled (Lawrence et al., 2024; Janzwood and Homer-Dixon, 2022). In a **common driver** pattern, one stress affects several systems at once. In a **cascade**, failure in one system spills into the next. In **compounding**, several stresses land on the same people or places together. Energy and pollution systems show all three.

- **Common driver.** Burning coal, oil, gas and biomass produces greenhouse gases, fine particles, sulfur and nitrogen oxides, and mercury at once. A change in the fuel changes all of them.
- **Cascade.** A fuel-price spike raises transport and fertilizer costs, which raises food prices, which strains household budgets and public finances. Fuel-importing countries are the most exposed, as many learned in the 2022 energy crisis.
- **Compounding.** A household that cooks with wood or charcoal breathes indoor smoke, spends hours collecting fuel and contributes to forest loss. When a heatwave or flood arrives, that household is already weaker.

2.2 Four mechanisms

The clean transition reduces interacting risks through four mechanisms (Table 6). A single investment, such as rooftop solar with a battery, can work through all four.

Table 6. Four ways the clean transition reduces interacting risks

Mechanism	What it means	Example
1. Remove shared sources	Replace a process that produces several harms with one that produces fewer.	Replacing a coal plant with solar and storage cuts carbon dioxide, fine particles and water use together.
2. Reduce exposure to shocks	Lower dependence on volatile or distant supplies.	Domestic solar and wind supply cannot be cut off or repriced overnight by a fuel exporter.
3. Create capacity	Provide the energy, tools and infrastructure that people and institutions use to cope with stress.	Reliable electricity keeps vaccine fridges, water pumps and cooling running during a heatwave.
4. Free resources	Reduce costs of illness, imports and clean-up so that budgets can be used elsewhere.	Fewer pollution-related illnesses means lower health spending and more working days.

Source: H Heuristics, building on the common-driver, cascade and compounding mechanisms in Lawrence et al. (2024).

2.3 Three illustrations

Fossil combustion: one source, three crises

The Health Effects Institute estimates that air pollution was linked to about 7.9 million deaths in 2023, roughly one in eight deaths worldwide. About 4.9 million were attributed to outdoor fine particles, much of it from burning fuels in power plants, vehicles, factories and homes (HEI, 2025). The same combustion drives climate change, so replacing it lowers a health burden and a climate risk with one action.

Energy shocks: from fuel prices to food and debt

Many developing countries import fuel, pay for it in foreign currency and carry heavy debt; UNCTAD reports that 3.4 billion people live in countries that spend more on interest than on health or education (UNCTAD, 2025). A price spike can push such a country toward a currency or debt crisis, which limits spending on the services that build resilience. Domestic renewable supply reduces, though does not eliminate, this chain.

Cooking: health, time, forests and climate

About 2 billion people still cook with polluting fuels (SEforALL et al., 2026). The consequences span health (about 2.8 million deaths in 2023 linked to household air pollution), time (hours spent collecting fuel, largely by women and children), forests and climate. Clean cooking shows how one change in household energy can touch several crises.

2.4 Which pillars reach which pressures

The clean transition is not one action but a set of actions across six pillars, described in Chapter 4. **Figure 1** gives a qualitative view of how strongly each pillar reaches each of the eight pressures. Energy and industry reach the widest span, scoring medium or high on six of eight pressures. Household energy is narrower but deepest on health, and agriculture and pollution prevention lead on water and ecosystems.

Figure 1. Which pillars reach which pressures: a qualitative assessment

	Climate change	Air pollution	Water contamination	Energy insecurity	Ecosystem degradation	Food insecurity	Economic vulnerability	Public health burdens
Clean energy	**High**	**High**	Low	**High**	Medium	Low	Medium	Medium
Clean industry	**High**	Medium	Medium	Low	Medium	-	**High**	Medium
Clean transport	Medium	**High**	-	**High**	Low	-	Medium	Medium
Household energy	Low	**High**	Low	Low	Medium	Low	Low	**High**
Clean agriculture	Medium	Low	**High**	Low	**High**	**High**	Medium	Low
Pollution prevention and circular systems	Low	Medium	**High**	-	**High**	Low	Medium	Medium

Source: H Heuristics qualitative scores (illustrative, grade C), based on the literature cited in this report. Scores are judgments, not measurements.

No single pillar is enough. A country that decarbonizes its grid but ignores wastewater, farming or household cooking will find that several pressures remain. The resilience benefit comes from a *portfolio* chosen to cover the pressures that matter most in a given place.

PART I · THE IDEA

3. Where the Transition Stands Today

IN BRIEF

- Clean technologies have become cheap, and investment, power generation and vehicle sales are shifting quickly.
- Progress is uneven: hundreds of millions lack electricity, billions lack clean cooking, and capital for clean projects costs much more in emerging economies.
- The evidence shows that a faster, fairer transition is feasible, not that it is assured.

3.1 Momentum is real

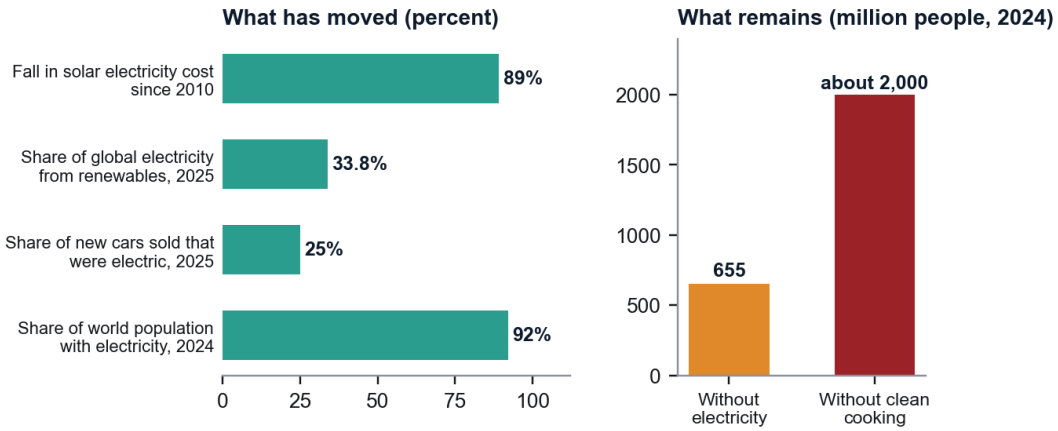
A decade ago, the clean transition depended largely on subsidies and ambition. Today it also rests on economics. **Table 7** collects eight indicators from recent assessments. Three themes stand out: the main technologies are competitive in many markets, deployment is moving fast, and the gaps are concentrated in lower-income countries, where the resilience payoff may be greatest.

Table 7. Eight indicators of the clean transition

Domain	Indicator	Source	Grade
Electricity	In 2025 renewables supplied about 33.8% of global electricity, slightly above coal at 33.0%, for the first time. Solar generation grew by about 636 TWh; wind and solar together met roughly 99% of demand growth.	Ember, 2026	B
Investment	Global energy investment is about $3.4 trillion in 2026, of which roughly $2.2 trillion is clean energy and $1.2 trillion fossil fuels.	IEA, 2026	B
Costs: solar	Solar electricity cost about $44 per MWh in 2025, level with 2024 and about 89% below 2010.	IRENA, 2026	B
Costs: storage	A four-hour utility-scale battery cost about $140 per kWh, down roughly 30% in a year; about a quarter of new solar was paired with batteries.	IRENA, 2026	B
Transport	Electric cars were about 25% of new car sales in 2025 (over 20 million cars); the IEA projects about 23 million in 2026.	IEA, 2026	B
Access: electricity	About 655 million people lacked electricity in 2024; the global access rate was 92%.	SEforALL et al., 2026	A/B
Access: cooking	About 2 billion people lacked clean cooking; household air pollution was linked to about 2.8 million deaths in 2023.	SEforALL et al., 2026; HEI, 2025	A/B
Employment	Energy employment was about 76 million in 2024, growing about twice as fast as the wider economy; clean-energy jobs are estimated at about 35 million, slightly more than fossil-fuel jobs.	IEA, 2025	B

Sources as shown. Totals vary with definitions of clean energy; figures are rounded. Some 2026 values are projections or early estimates.

Figure 2. What has moved and what remains



Sources: IRENA (2026); Ember (2026); IEA (2026); SEforALL et al. (2026). Clean cooking value is rounded to about 2 billion; published estimates range from about 2.0 to 2.1 billion.

3.2 Progress is uneven

The same assessments show where the transition is falling short. The 2026 Tracking SDG 7 report finds that the global electricity access rate has stalled at 92%, that most people without electricity live in sub-Saharan Africa, and that about 2 billion people still depend on polluting cooking fuels. On current trends, hundreds of millions would still lack electricity and well over a billion would still lack clean cooking in 2030 (SEforALL et al., 2026).

Investment follows the same pattern. Emerging and developing economies other than China account for a small share of global clean-energy investment even though they hold most of the world's people. Reported estimates put Africa's share at only about 2% (IEA, 2026), and the IEA has estimated that clean-energy investment in these economies would need to rise from about $270 billion to roughly $1.6 trillion a year by the early 2030s to meet climate goals (IEA, 2024).

3.3 The cost of capital is the hidden barrier

Clean technologies such as solar and wind have high upfront costs and low running costs. That means the price of borrowing money matters enormously. The IEA's Cost of Capital Observatory finds that financing for clean projects in emerging and developing economies is more than twice as expensive as in advanced economies, because of currency risk, uncertain regulation, weak grid access and other real and perceived risks. The IEA estimates that narrowing this gap by one percentage point could cut clean-energy financing costs by about $150 billion every year (IEA, 2024).

Technology cost is no longer the main obstacle in many places; finance, institutions and infrastructure are. That is why Polycrisis Resilience treats the clean transition together with economic development and institutional capacity.

3.4 Setbacks and volatility

Progress is not a straight line. The IEA reports that global electric-car sales fell about 8% in the first quarter of 2026 compared with a year earlier, which it links to policy changes in China and the United States (IEA, 2026). IRENA finds that solar costs flattened in 2025 after years of decline, even as battery costs kept falling (IRENA, 2026). Policy reversals, trade barriers and interest-rate shifts can all slow adoption. A resilience framework should expect bumps and favor measures, such as distributed solar and diversified supply chains, that are robust to shocks. The overall message is that a faster, fairer transition is feasible but not assured.

PART II · THE PILLARS

4. Six Pillars of Clean-Transition Resilience

IN BRIEF

- The flagship research program organizes the clean transition into six interconnected areas: energy, industry, transport, household energy, agriculture and resource systems, and pollution prevention.
- Each pillar reduces several pressures and adds capacity; together they cover most sources of risk in an economy.
- Every pillar has a catch: the benefit depends on how it is done.

The flagship research should organize the clean transition into six interconnected areas. They are chosen to cover the main places where economies create pollution and consume resources, and the main ways households and communities are exposed to the results. The pillars overlap on purpose: clean power makes clean transport and clean cooking possible, and clean industry builds the equipment for all of them.



PILLAR I

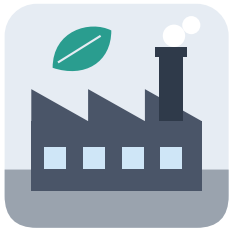
Clean Energy Transition

Renewable electricity, energy storage, grid modernization, electrification and decentralized energy systems.

Resilience contribution: *Reduced emissions, improved energy security and expanded access to reliable electricity.*

Why it matters. Electricity is the base of the other five pillars. In 2025, wind and solar met about 99% of global growth in electricity demand, and renewables edged past coal as the largest source of electricity (Ember, 2026). Because solar and batteries come in small units, they can also serve villages and neighborhoods that a central grid has not reached, which matters for the 655 million people still without power.

Watch for. Grid reliability as the share of variable power rises, the need for storage and transmission, the mining of critical minerals, and affordability for the poorest customers.



PILLAR II

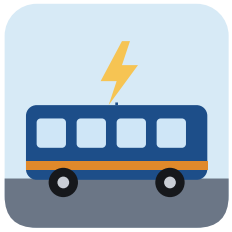
Clean Industrialization

Industrial efficiency, low-carbon manufacturing, cleaner production processes, material innovation and industrial decarbonization.

Resilience contribution: *Lower pollution intensity while expanding productive capacity and economic development.*

Why it matters. Industry, including steel, cement and chemicals, is responsible for about a quarter of energy-related carbon dioxide emissions and a large share of local air and water pollution. Many emerging economies are still building their industrial base, so they can choose efficient, cleaner plants from the start rather than retrofit old ones later. Making clean technologies such as panels, batteries and electric buses is itself an industrial opportunity.

Watch for. Hard-to-abate processes that still lack cheap alternatives, high upfront costs for smaller firms, trade barriers, and emissions from making the clean equipment itself.



PILLAR III

Clean Transportation

Electric mobility, public transportation, rail infrastructure, efficient logistics and sustainable urban transport.

Resilience contribution: *Reduced transport pollution, improved urban air quality and lower dependence on petroleum.*

Why it matters. Transport is the largest single use of oil, so it ties many countries to imported fuel, and it is a major source of urban air pollution. Electric cars reached about 25% of new sales worldwide in 2025, led by China and Europe (IEA, 2026). Electric buses, trains and two- and three-wheelers are often a bigger resilience gain than private cars, because they move more people per unit of energy and cost less to run in lower-income cities.

Watch for. Charging infrastructure, the cleanliness of the electricity supply, battery materials, and designing cities so that people have affordable choices beyond private cars.



PILLAR IV

Household Energy and Pollution Reduction

Clean cooking, household electrification, efficient heating, ventilation and affordable clean energy access.

Resilience contribution: *Reduced household air pollution and preventable health burdens.*

Why it matters. About 2 billion people cook with polluting fuels, and household air pollution was linked to about 2.8 million deaths in 2023, although such deaths have fallen 36% since 2000 as cleaner cooking spread (HEI, 2025; SEforALL et al., 2026). Clean cooking also saves time and reduces pressure on forests. Efficient cooling and heating protect people during heatwaves and cold snaps, which are becoming more frequent.

Watch for. Affordability of fuels and appliances, households that keep using old stoves alongside new ones, and supply chains in rural areas.



PILLAR V

Clean Agriculture and Resource Systems

Sustainable agricultural practices, water efficiency, fertilizer management, soil conservation and lower-impact food systems.

Resilience contribution: *Reduced environmental pressures and stronger food and water security.*

Why it matters. Food systems produce roughly one-third of global greenhouse gas emissions (Crippa et al., 2021) and are a leading source of water contamination through fertilizer and manure runoff. Better fertilizer use, efficient irrigation, soil care, solar-powered pumping and less food waste can cut pollution while raising yields and making farm incomes steadier in a changing climate.

Watch for. Yield and income risks for smallholders, groundwater overuse when pumping energy is nearly free, and land-use conflicts.



PILLAR VI

Pollution Prevention and Circular Systems

Wastewater treatment, waste management, recycling, industrial pollution controls and circular material systems.

Resilience contribution: *Reduced toxic exposure, resource depletion and environmental degradation.*

Why it matters. The world produced about 2 billion tonnes of municipal solid waste in 2016, a figure projected to reach about 3.4 billion tonnes by 2050 (Kaza et al., 2018). Only about a fifth of the roughly 62 million tonnes of electronic waste in 2022 was documented as collected and recycled (Baldé et al., 2024). Treating wastewater and keeping materials in use protects water and ecosystems, reduces methane from landfills, and cuts demand for new mining.

Watch for. Livelihoods of informal waste workers, unsafe recycling of hazardous materials, and the cost of treatment systems for small cities.

4.1 How the pillars depend on one another

The pillars are not independent, as **Figure 1** suggested. Clean power is the base on which several others are built, and the pillars that protect people most directly often depend on infrastructure from the others (**Table 8**). Pillars I and II most change the national emissions picture; Pillars IV, V and VI most directly protect the health and livelihoods of ordinary people, and are often the least funded. A plan that funds one pillar and neglects its supports can stall.

Table 8. Dependencies among the six pillars

Pillar	Depends on	Makes possible
I. Clean energy	Grids, storage, finance and permitting	Electric transport, industrial electrification, clean cooking, solar pumping, water treatment
II. Clean industry	Clean power, efficient equipment, skilled workers	Local production of panels, batteries, buses and efficient appliances
III. Clean transport	Clean power, charging, urban planning	Lower oil imports, cleaner city air, cheaper commuting
IV. Household energy	Reliable supply, affordable appliances and fuel	Better health, time savings, evening study and work
V. Clean agriculture	Clean power for pumping, finance, extension services	Steadier yields, less runoff, more resilient farm incomes
VI. Pollution prevention	Clean power for treatment, municipal budgets, rules	Safe water, recovered materials, fewer toxic exposures

Source: H Heuristics.

Sequencing therefore matters. In a country with little electricity, early priorities are often distributed power and clean cooking, because they reach people quickly. In a country with a growing industrial base, the early gains may come from efficiency standards and cleaner plants. In a rapidly growing city, public transport and waste systems may come first. The six pillars are a map, and each place must choose its own route through it.

PART II · THE PILLARS

5. Multi-Dimensional Resilience: One Investment, Many Benefits

IN BRIEF

- A single well-designed investment program can contribute to seven kinds of benefit at once.
- This is the concept of multi-dimensional resilience: interventions that generate benefits across several risk categories.
- Not every intervention delivers all benefits, and lifecycle impacts, land use, mining, grid reliability and affordability must also be considered.

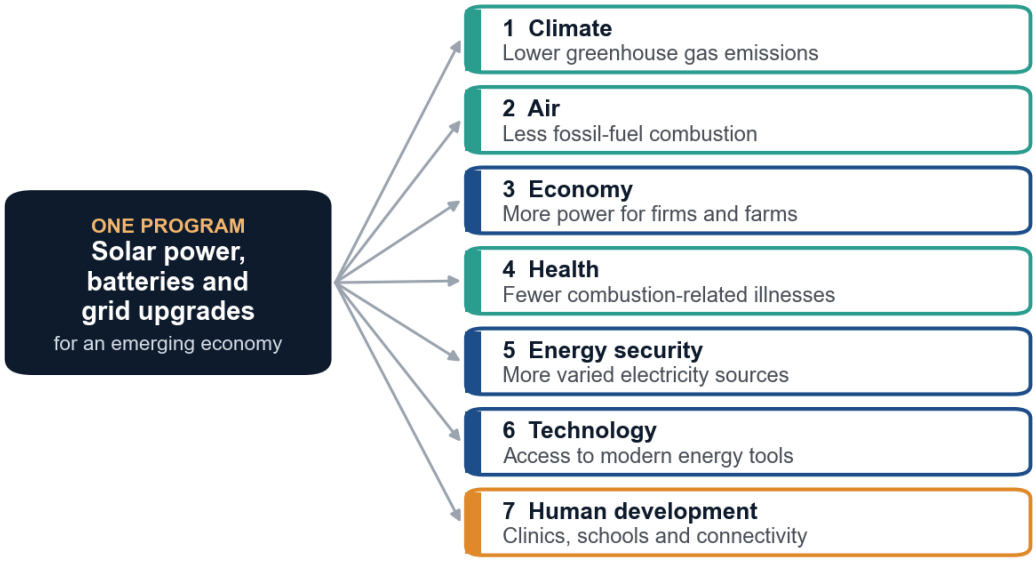
5.1 The idea of multi-dimensional resilience

Most project appraisals ask one question: does this investment deliver what it was built to deliver? A power plant produces electricity. A clinic treats patients. An air-quality rule reduces smog. Polycrisis Resilience adds a second question: what else does this investment change, for whom, and over what period? When an action reduces several kinds of risk at the same time, we call the result **multi-dimensional resilience**. The idea echoes earlier work on the "triple dividend" of resilience investments, which found that avoiding losses, unlocking economic potential and creating social and environmental benefits often come together (Tanner et al., 2015).

5.2 A worked example

Consider a program, designed by a government and a development bank, to expand solar power, battery storage and grid upgrades in a lower-income region that relies heavily on diesel generators and a weak central grid. This is an illustrative case, not a specific project. Figure 3 shows how a single well-designed investment of this kind could contribute to seven kinds of benefit.

Figure 3. One program, seven potential benefits



Source: H Heuristics illustration (grade C). The benefits are potential, not guaranteed; see Section 5.4.

The seven benefits

- **1. Climate mitigation.** Lower greenhouse gas emissions relative to fossil-fuel alternatives. Replacing diesel and coal generation removes a long-lived source of carbon dioxide.
- **2. Air pollution reduction.** Reduced emissions from fossil-fuel combustion, so fewer fine particles, sulfur and nitrogen oxides in nearby towns.
- **3. Economic development.** Expanded electricity availability for businesses and industry. Reliable power lets workshops, cold stores, mills and small factories operate longer and with less spoilage.
- **4. Public health.** Reduced exposure to certain combustion-related pollutants, and fewer illnesses linked to them.
- **5. Energy security.** Diversification of electricity sources, so the region is less exposed to fuel price swings or supply cut-offs.
- **6. Technological convergence.** Increased access to modern energy technologies, including digital meters, mobile payments for energy and efficient appliances.
- **7. Human development.** Better access to electricity-dependent healthcare, education and communications, from vaccine refrigeration to evening study and internet access.

5.3 Why the whole is more than the sum

The seven benefits are linked, and the links are where much of the resilience comes from. Reliable power for a clinic is a health benefit and a human-development benefit. Cleaner air raises the productivity of workers, which feeds the economy. A more diversified grid cushions households when fuel markets lurch. The relationships mean that a program can be justified on several grounds at once, which makes it easier to finance and more robust to political change. A project that would look marginal on climate alone may look compelling when health, jobs and energy security are counted too. That is the practical meaning of the *intersectional* property.

Multi-dimensional thinking also guides design: if health and human development matter most, storage and grid upgrades should go where clinics, schools and small businesses are, not only where land is cheapest.

5.4 What must also be considered

Not every intervention produces all these benefits, and lifecycle impacts, land use, mining, grid reliability and affordability must also be considered. **Table 9** lists the main cautions and how a good program would address them.

Table 9. Cautions that qualify the seven benefits

Consideration	Why it matters	How a well-designed program responds
Lifecycle impacts	Making panels and batteries uses energy and materials, and end-of-life equipment becomes waste.	Choose lower-carbon supply chains; plan collection and recycling from the start.
Land and nature	Large solar and wind farms and transmission lines take land and can affect habitats and livelihoods.	Prefer rooftops, degraded land and shared use; consult local communities.
Mining and minerals	Lithium, cobalt, copper and other minerals have environmental and social costs and concentrated supply.	Diversify supply, improve standards, invest in recycling and chemistries that use less critical material.
Grid reliability	Variable power needs storage, flexible demand and stronger networks to keep supply stable.	Pair generation with batteries and grid upgrades; plan for evening peaks.
Affordability and fairness	If better-off households leave the grid, remaining customers can face higher tariffs.	Tariff reform, targeted support, community and shared systems.

Source: H Heuristics synthesis of the cautions discussed in the literature cited in this report.

PART III · DEVELOPMENT AND FEEDBACK

6. Emerging Economies: Development, Convergence and Technology Diffusion

IN BRIEF

- The research question is not simply how developing countries can reduce emissions, but how they can industrialize and raise living standards while reducing exposure to pollution, climate change and other systemic threats.
- Each development challenge has a clean-transition pathway, and three H Heuristics research themes meet here.
- Finance, institutions and local capacity decide whether pathways turn into outcomes.

6.1 The research question

The research question is not simply how developing countries can reduce emissions. It is:

THE RESEARCH QUESTION

How can emerging economies achieve industrialization, economic convergence and improved living standards while simultaneously reducing their exposure to pollution, climate change and other systemic threats?

The framing matters because poorer countries have a right to grow, and growth has historically meant more energy, more industry and more pollution. Treating the clean transition as a restriction on development would be unfair and unrealistic. Treating it as a *way* of developing, one that avoids damage earlier industrializers later had to repair, changes the discussion.

6.2 Challenges and pathways

Table 10 pairs eight common development challenges with the clean-transition pathway that addresses each and the kind of resilience gain involved.

Table 10. Development challenges and clean-transition pathways

Development challenge	Clean-transition pathway	Resilience gain
Electricity poverty	Distributed renewable energy	Access to light, communications, refrigeration and productive power
Household air pollution	Clean cooking transitions	Fewer deaths and illnesses; time saved; less deforestation
Industrial pollution	Cleaner manufacturing technologies	Healthier workers and neighbors; lower regulatory and clean-up costs
Urban air pollution	Electrified public transport	Cleaner air, lower fuel imports, better access to jobs
Water insecurity	Efficient treatment and reuse	Safer water supply and less contamination of rivers and groundwater

Development challenge	Clean-transition pathway	Resilience gain
Agricultural vulnerability	Sustainable irrigation and adaptation	Steadier yields and incomes under heat and drought
Fossil-fuel dependence	Diversified energy systems	Less exposure to price shocks and supply cut-offs
Infrastructure deficits	Resilient, efficient infrastructure	Networks that keep working during storms, floods and heatwaves

Source: H Heuristics. Pathways are options, not guarantees; outcomes depend on design and finance.

6.3 Three themes, one system

This creates a direct connection between three major H Heuristics research themes: **Convergence as Polycrisis Resilience**, **Technology Diffusion as Polycrisis Resilience** and **Clean Transition as Polycrisis Resilience**. These should be treated as complementary mechanisms rather than independent research subjects.

- **Convergence as Polycrisis Resilience.** Poorer economies catching up in income, productivity and capability gain the resources, skills and institutions that resilience needs.
- **Technology Diffusion as Polycrisis Resilience.** The spread of proven tools beyond the places that invented them decides how fast cheaper clean technology reaches ordinary users.
- **Clean Transition as Polycrisis Resilience.** The shift to cleaner systems supplies the direction of travel: the technologies that reduce pollution and climate risk while supporting growth.

6.4 Latecomer opportunities

Economic historians have long argued that late industrializers can sometimes move faster because they adopt proven technology rather than invent it (Gerschenkron, 1962). Mobile phones are a familiar example: many households reached telephone service without ever having a landline. Clean energy offers a similar chance, since solar panels, batteries and electric vehicles have become cheaper through years of learning in a few countries and others can now buy them at the lower price.

Pakistan offers a vivid, if mixed, example. After grid prices rose sharply, households and businesses imported about 17 gigawatts of solar panels in 2024, roughly double the year before, largely without a government program (Ember, 2025). The shift cut some bills, but it also raised concerns about grid stability and about higher charges for customers who stayed on the grid. Diffusion can move faster than planners expect, and policy then has to catch up on tariffs, storage and fairness.

6.5 What turns pathways into outcomes

Three conditions recur in successful transitions. **Affordable capital:** because clean technologies are costly to build and cheap to run, a high cost of capital makes them look dearer than they are, and guarantees, development-bank lending and local-currency finance can lower it (IEA, 2024). **Institutions and standards:** clear tariffs, reliable utilities and equipment standards give investors and households confidence. **Local capability:** trained installers and technicians, and local assembly and maintenance, keep more of the benefit in the economy and make systems last.

PART III · DEVELOPMENT AND FEEDBACK

7. The Reinforcing Loop: From Clean Technology to Resilience and Back

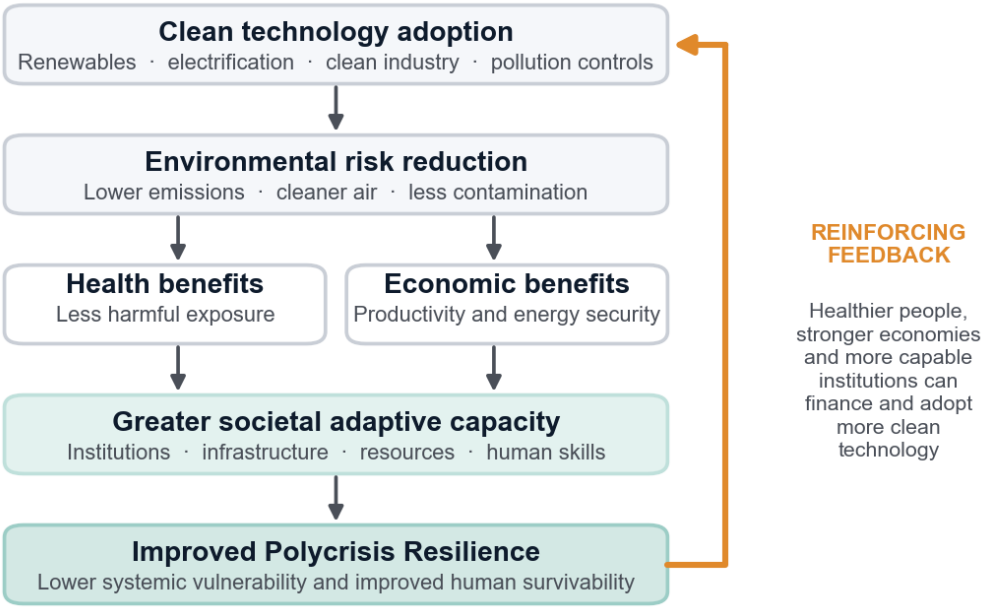
IN BRIEF

- The clean transition can create reinforcing relationships between environmental quality, economic development and human wellbeing.
- The loop also works in reverse: healthier populations, stronger economies and more capable institutions can finance and implement further clean-transition investments.
- The loop can stall or reverse if finance, institutions or fairness fail.

7.1 The loop in outline

The clean transition can create reinforcing relationships between environmental quality, economic development and human wellbeing. **Figure 4** shows the chain. Adopting clean technology reduces environmental risk, through lower emissions, cleaner air and less contamination. That produces health benefits, from reduced harmful exposure, and economic benefits, from higher productivity and better energy security. Together these raise a society's adaptive capacity: its institutions, infrastructure, resources and human capabilities. Greater adaptive capacity then improves Polycrisis Resilience, lowering systemic vulnerability and improving human survivability.

Figure 4. Clean transition to Polycrisis Resilience, and back



Source: H Heuristics conceptual model (grade C). Each link is supported by evidence cited in this report, but the full loop has not been measured end to end.

7.2 The feedback runs in reverse too

The feedback relationship also works in reverse: healthier populations, stronger economies and more capable institutions can finance and implement further clean-transition investments. A country with lower sickness rates has more working days and lower health costs. A country with a steadier economy borrows more cheaply. A country with better institutions can write tariffs and standards that attract investors. Each makes the next round of clean investment easier.

This is why early gains are worth more than their immediate size. A first clean-cooking program, a first reliable mini-grid or a first clean factory can set the loop in motion. The reverse is also true. Where pollution, energy poverty and weak finance reinforce one another, the loop runs downward: sickness reduces productivity, which reduces revenue, which limits investment in clean systems, which leaves pollution in place. The task of policy is often to move a country from the downward loop to the upward one.

7.3 Links in the loop

Table 11 breaks the loop into its main links and indicates the strength of the supporting evidence. Several links are well established in the health and development literature. The strength of the *whole loop*, and the time it takes to turn, are research questions rather than settled facts.

Table 11. The main links in the clean-transition feedback loop

Link	Mechanism	Evidence
Clean technology to cleaner environment	Replacing combustion and uncontrolled discharge lowers emissions and contamination.	Strong. Household air pollution deaths fell 36% from 2000 to 2023 as cooking cleaned up (HEI, 2025). Grade A/B.
Cleaner environment to better health	Lower exposure to fine particles and toxins reduces illness and early death.	Strong. About 7.9 million deaths a year are linked to air pollution (HEI, 2025). Grade A.
Health and energy to productivity	Healthier workers, reliable power and time savings raise output and learning.	Moderate. Effects vary by setting and are hard to isolate. Grade B/C.
Productivity to adaptive capacity	Higher incomes and revenues fund infrastructure, institutions and insurance.	Moderate. Resilience investments tend to return more than they cost (UNDRR, 2025). Grade B.
Adaptive capacity to resilience	Stronger systems absorb shocks and recover faster, reducing systemic vulnerability.	Plausible and widely supported, but difficult to measure. Grade B/C.
Resilience back to clean investment	Stable, healthy, wealthier societies can borrow cheaply and build more.	Plausible. Lower country risk reduces financing costs (IEA, 2024). Grade C.

Sources as shown; grades by H Heuristics.

Timing matters as well. Some links work within months, such as lower smoke exposure after a household switches stoves. Others take years, such as the effect of healthier children on adult earnings, or of reliable power on industrial investment. Because the payoffs arrive at different speeds, programs that show quick, visible gains can build the public and political support needed for the slower ones.

7.4 What can break the loop

Four things can stop the loop. **Finance:** if borrowing is too expensive, the first step is never taken. **Institutions:** unreliable utilities, unclear rules and corruption raise risk. **Fairness:** if gains reach only the better-off, support erodes and vulnerable groups stay exposed. **Shocks:** conflict, disasters or debt crises can interrupt progress, which is why diversified and distributed systems are valuable.

PART IV · MEASUREMENT AND FUTURES

8. Measuring the Clean Transition Resilience Dividend

IN BRIEF

- H Heuristics should develop a measurement framework that captures more than carbon emissions.
- The proposed concept is the Clean Transition Resilience Dividend: the combined environmental, health, economic and systemic-risk benefits of transitioning toward cleaner production and consumption systems.
- The report should distinguish direct from indirect benefits and avoid double-counting improvements across indicators.

8.1 Why carbon alone is not enough

Most clean-transition scorecards count tonnes of carbon dioxide avoided. That matters, but it leaves out much of what the transition does. A cooking program that saves little carbon may prevent thousands of deaths, and a wastewater plant that does not touch emissions may protect a city's water supply. Measuring only carbon undervalues exactly the actions that cut several kinds of risk together. A broader measure also helps explain to finance ministers and voters why the transition is worth paying for, since many benefits arrive locally and quickly.

Clean Transition Resilience Dividend

H Heuristics proposed concept

The Clean Transition Resilience Dividend is the combined environmental, health, economic and systemic-risk benefits generated by transitioning toward cleaner production and consumption systems.

The term builds on the “resilience dividend” idea, that investments in resilience pay off in ordinary times as well as in crises (Rodin, 2014), and applies it to the clean transition.

8.2 Potential indicators

Table 12 proposes nine measurement categories, with example indicators and typical public data sources. The aim is to draw on data that already exists wherever possible, so that a first version of the dividend can be built without new surveys.

Table 12. Measurement categories and indicators for the dividend

Measurement category	Indicators	Example data sources
Climate	CO_2 and methane emissions, emissions intensity	National inventories; EDGAR; IEA
Air quality	PM2.5 exposure, ambient pollution	Satellite estimates; HEI State of Global Air; monitoring networks
Household energy	Clean cooking and electricity access	Tracking SDG 7; household surveys
Energy security	Grid reliability, energy diversification	Utility outage data; IEA energy balances

Measurement category	Indicators	Example data sources
Industry	Industrial emissions intensity, resource efficiency	IEA; UNIDO; company reporting
Transportation	Transport emissions and electrification	IEA; national vehicle registrations
Water	Safe water access, wastewater treatment	WHO/UNICEF Joint Monitoring Programme; national utilities
Health	Pollution-attributable disease burden	Global Burden of Disease; WHO
Economic development	Productivity, employment, energy affordability	ILO; World Bank; national accounts
Resilience	Climate vulnerability, disaster exposure, adaptive capacity	ND-GAIN; INFORM Risk; UNDRR data

Source: H Heuristics. Data sources are examples of existing public datasets; availability varies by country.

8.3 Direct and indirect benefits

A credible dividend separates **direct** from **indirect** benefits. Direct benefits are the immediate, measurable effects of an action: tonnes of carbon avoided, a fall in fine-particle exposure, kilowatt-hours delivered to households that had none. Indirect benefits follow from those: fewer sick days because the air is cleaner, higher incomes because power is reliable, lower borrowing costs because the economy is less exposed to fuel shocks. Indirect benefits are usually larger in the long run and harder to prove, so they should be reported with ranges and with their evidence grade.

8.4 Avoiding double-counting

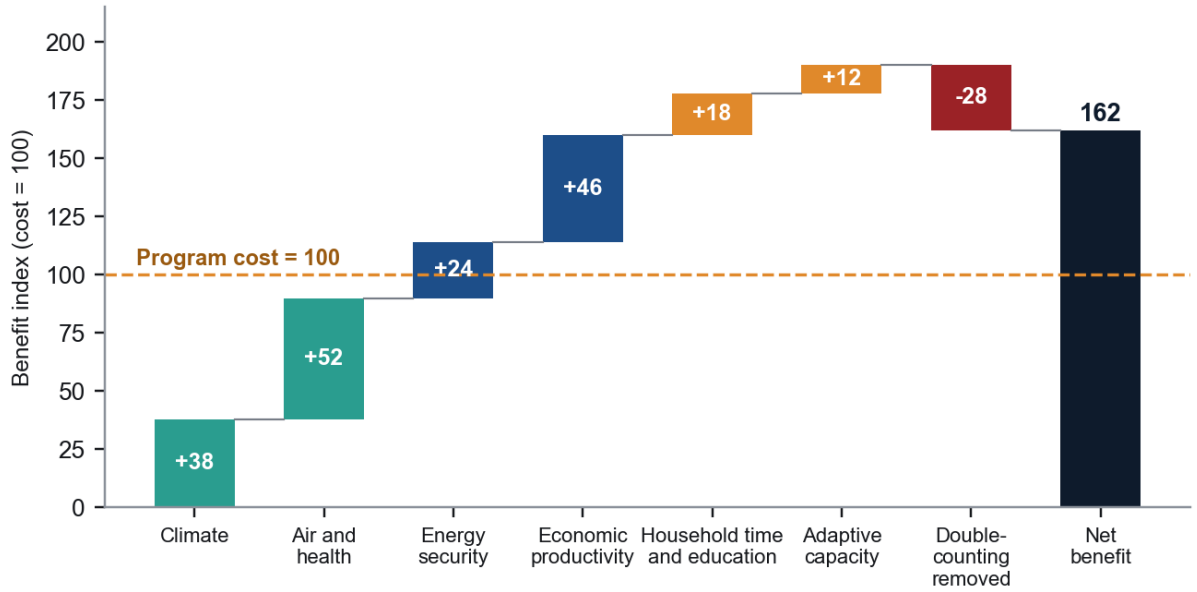
The most common way to overstate a dividend is to count the same gain twice. Cleaner air raises productivity, and productivity raises income, and so a project that counts both “health benefits” and “economic benefits” may be counting one improvement in two columns. Four simple rules help.

- **Count outcomes once.** Assign each gain to the point where it is first measured, and treat later effects as the pathway, not a new benefit.
- **Separate stocks from flows.** Do not add the value of an asset, such as a power plant, to the yearly benefits it produces.
- **Use a consistent baseline.** Compare with a clearly stated alternative, such as continuing with the existing fuel mix.
- **Report costs and harms alongside benefits.** Include land, minerals, waste and fairness effects, so the dividend is net, not gross.

8.5 An illustration

Figure 5 shows how a dividend could be built for a hypothetical program costing 100 units. Gross benefits in six categories add up to 190. After removing 28 units of overlap, the net benefit is 162, or 1.62 times the program's cost. The numbers are invented to show the method and carry no empirical weight (grade D). The key message is the shape: the largest gains sit outside the climate column, and the adjustment for double-counting is large enough to matter.

Figure 5. Hypothetical Clean Transition Resilience Dividend



Source: H Heuristics illustration (grade D). All values are hypothetical and expressed as an index in which the program's cost equals 100.

8.6 From dividend to profile

Over time, the same indicators could feed a **Clean Transition Resilience Profile** for countries and regions, in the same spirit as the broader Polycrisis Resilience Profile proposed in the founding report. A profile would show each category separately and flag the weakest link. A country with excellent power-sector progress but poor household air quality, for example, would be flagged as having an uneven, and therefore fragile, transition.

8.7 Building a first version in five steps

A first version of the dividend does not need perfect data. It needs a clear method that others can repeat and criticize.

- **Step 1. Choose the unit.** A national program, a city, a utility territory or a single project. Smaller units give cleaner attribution; larger ones capture more spillovers.
- **Step 2. Select indicators.** Pick one to three indicators for each category in **Table 12**, favoring those with public, regularly updated data.
- **Step 3. Set a baseline and a counterfactual.** State what would have happened without the transition action, so that the dividend measures a difference and not a trend.
- **Step 4. Report in physical units first.** Show deaths averted, tonnes avoided, people served and hours of supply, and add money values only as a second step, with ranges.
- **Step 5. Adjust, grade and publish.** Remove overlap, subtract costs and harms, attach an evidence grade to each line, and update the figures each year.

8.8 Limits of measurement

Some benefits resist measurement. It is hard to say how much of a village's rising income came from a new mini-grid, health effects take years to appear, and money values for lives saved depend on contested choices. Data are thinnest where the gains may be largest. A rough measure that is honest about its range is still more useful than a precise number that counts only carbon.

PART IV · MEASUREMENT AND FUTURES

9. Three Scenarios for the Clean Transition

IN BRIEF

- A major flagship component should explore three potential trajectories: delayed, accelerated and integrated.
- Decarbonization alone cannot resolve the entire global polycrisis; the third scenario adds adaptation, health, water security, institutions and human capabilities.
- A stylized model shows how the three differ, without forecasting.

9.1 The scenarios

A major flagship component should explore three potential trajectories. They are not predictions but structured ways to ask what could differ.

SCENARIO A

Delayed Clean Transition

Fragmented adoption, continued pollution-intensive development, insufficient infrastructure investment and persistent technological disparities.

Potential outcome: *Greater cumulative environmental exposure and continued vulnerability in many regions.*

SCENARIO B

Accelerated Clean Transition

Faster renewable energy adoption, industrial modernization, clean cooking expansion and increased technological diffusion.

Potential outcome: *Substantial opportunities for simultaneous climate, pollution, health and economic improvements.*

SCENARIO C

Integrated Polycrisis Resilience Transition

Clean transition combined with economic convergence, adaptation, healthcare, water security, institutional development and human-capability expansion.

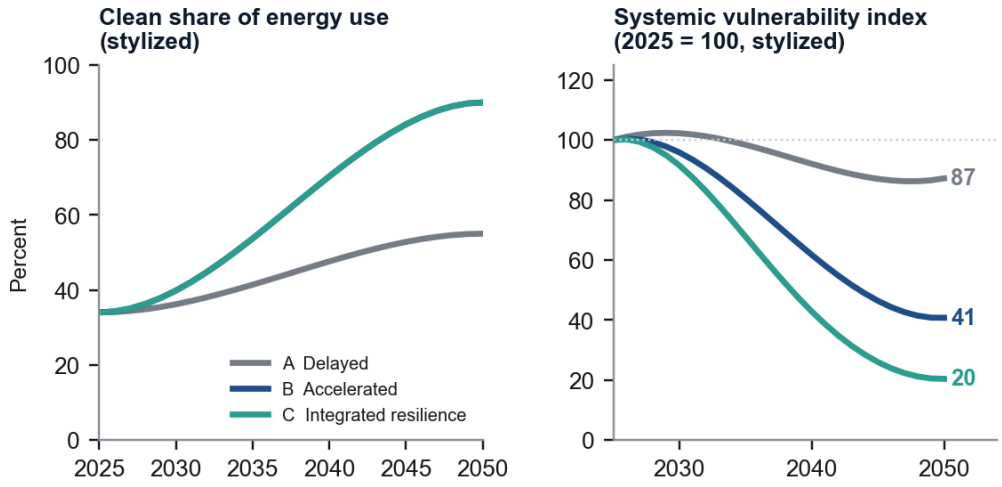
Potential outcome: *A more comprehensive reduction in interconnected systemic vulnerabilities.*

The third scenario is particularly important because decarbonization alone cannot resolve the entire global polycrisis. Some harms from past emissions are already locked in and call for adaptation, and some vulnerabilities, such as weak health systems or fragile institutions, are not caused by fossil fuels at all. H Heuristics should therefore examine how the clean transition interacts with other development interventions to produce broader resilience outcomes.

9.2 A stylized model

To show how the scenarios differ in mechanism, H Heuristics built a small stylized model of an emerging-economy region from 2025 to 2050 (**Figure 6**). It combines three ingredients. **Hazard** grows faster in the delayed scenario because less global mitigation means more warming. **Exposure** to avoidable pollution falls as the clean share of energy use rises, by up to 60% when that share reaches 90%. **Adaptive capacity** rises with development and investment in health, water and institutions. The vulnerability index is hazard multiplied by exposure multiplied by the share of capacity still lacking, set to 100 in 2025.

Figure 6. Three stylized trajectories to 2050



Source: H Heuristics stylized model (grade D). Not a forecast. Parameters were chosen to illustrate mechanisms; see text. Clean share starts at 34% in 2025.

In the model, the delayed scenario ends 2050 with a clean share of 55% and a vulnerability index of 87, barely below today. The accelerated scenario reaches a 90% clean share and an index of 41. The integrated scenario shares the same clean share but also raises adaptive capacity, and ends at 20. Adding up vulnerability over the whole period, the accelerated path is 25% lower than delay and the integrated path 39% lower. The key result is the gap between B and C: once clean energy is in place, further reduction depends on whether societies also build the capacity to cope.

9.3 What would separate the scenarios

Table 13 lists signposts, observable indicators that would tell us which path the world, or a particular region, is following. Many are published each year already.

Table 13. Signposts for distinguishing the three scenarios

Signpost	Pointing to A (delayed)	Pointing to B or C (faster)
Clean investment	Stagnating or concentrated in a few rich economies	Rising fastest in emerging and developing economies
Cost of capital	Gap with advanced economies stays above 2x	Gap narrowing through guarantees and local-currency finance
Access	Electricity and clean-cooking access stall	Clean cooking and electricity access rise faster than population
Adaptive capacity	Health, water and institutional gaps persist	Clean-energy projects paired with health, water and skills programs

Source: H Heuristics.

PART V · ACTION

10. Trade-offs, Critiques and Limits

IN BRIEF

- A fair assessment must set out where the clean transition creates new risks and where the framework could be wrong.
- Ten trade-offs recur: they can be managed, but only if they are named and planned for.
- Several critiques of the framework are serious; the report states the response and the evidence that would change H Heuristics' view.

10.1 Ten trade-offs to manage

The clean transition reduces many risks, but it creates some of its own. A resilience framework that ignores them would be promoting the same kind of narrow optimization that it criticizes. **Table 14** sets out ten recurring trade-offs and how each could be managed.

Table 14. Trade-offs of the clean transition and possible responses

Trade-off	What can go wrong	Possible response
1. Critical minerals	Supply is concentrated in a few countries; mining can harm communities and ecosystems.	Diversify sources, enforce standards, invest in recycling and lower-mineral designs.
2. Manufacturing concentration	A few countries make most panels and batteries, creating supply and political risk.	Spread manufacturing, hold stocks, support local assembly.
3. Land and nature	Large installations can displace people or habitats.	Use rooftops and degraded land; consult communities; share benefits.
4. Grid reliability	High shares of variable power can strain networks that lack storage.	Storage, flexible demand, regional interconnection, grid investment.
5. Affordability	Upfront costs and tariff changes can burden poorer households.	Targeted support, pay-as-you-go models, tariff reform.
6. Fossil-dependent workers and regions	Jobs and public revenue in coal, oil and gas areas can collapse.	Early planning, retraining, regional investment, diversified revenue.
7. Embedded emissions and waste	Making and disposing of equipment has its own footprint.	Cleaner manufacturing, recycling mandates, lifecycle accounting.
8. Rebound effects	Cheaper energy can raise total use and offset some savings.	Efficiency standards, pricing, tracking absolute outcomes.
9. Weak governance	Corruption or poor oversight can divert funds or cut corners.	Transparent procurement, independent regulators, open data.
10. Unequal finance	Capital flows to safer markets, leaving the neediest behind.	Blended finance, guarantees, concessional lending.

Source: H Heuristics synthesis of issues recurring in IEA, IRENA and development-finance literature.

10.2 Critiques of the framework

"Too broad to be useful"

Critics may say that if the clean transition addresses everything, it explains nothing. The response is to keep the claim narrow in each case: the transition reduces *specific* pressures through *specific* mechanisms (Chapter 2), and the dividend must be measured, not assumed. If the evidence shows that a pillar has little effect on a pressure, the map in **Figure 1** should change.

"Technology cannot fix political problems"

Clean technology does not resolve inequality, conflict or poor governance. The framework agrees. That is why Scenario C and the feedback loop stress institutions and fairness, and why weak governance is listed above as a trade-off. The clean transition is necessary for resilience in this view, not sufficient.

"Growth and the planet conflict"

Some argue that industrialization cannot be reconciled with environmental limits. Evidence that clean technologies are now cheaper than fossil alternatives in many places supports a more hopeful reading, at least for energy. The harder cases are materials, land and consumption, which this report treats as unresolved.

"Benefits are overstated"

The report agrees that benefits are not automatic (Section 1.4) and proposes strict rules on double-counting (Section 8.4). Its own illustrations are labeled as hypothetical or stylized.

"Measurement invites false precision"

A single dividend figure could be quoted without its caveats. The proposed safeguards are to report components separately, show ranges, attach evidence grades and publish the method (Chapter 8). A profile that exposes weak links is harder to misuse than a headline number.

"It diverts attention from adaptation and urgent needs"

Poor communities face present dangers, such as floods, disease and hunger, that clean technology does not remove. The framework agrees, and for that reason puts adaptation, health and water inside Scenario C. The clean transition is one mechanism among several, and its benefits should be pursued where they also meet urgent local needs.

10.3 What would change our view

- Evidence that clean-transition programs consistently fail to deliver the health, economic or security gains assumed in Chapter 5.
- Evidence that the feedback loop in Chapter 7 is too weak or too slow to matter within policy horizons.
- Evidence that critical-mineral, land or governance constraints cannot be managed at the scale required.
- Evidence that finance gaps are so large that distributed and local approaches cannot close them.

10.4 Principles for managing the trade-offs

- **Name the risk early.** Put land, minerals, jobs and affordability on the table at the design stage, not after complaints arise.
- **Share benefits locally.** Communities that host projects should gain jobs, power or revenue.
- **Prefer reversible and diversified choices.** Several smaller, varied sources are usually more robust than one large dependency.
- **Monitor and adjust.** Track outcomes using the indicators in Chapter 8 and be prepared to change course.

PART V · ACTION

11. Action Agenda, Research Questions and Conclusion

IN BRIEF

- Different actors can act now: governments on rules and planning, funders on finance, companies on supply chains, researchers on evidence.
- A six-question Clean Transition Resilience Test can screen policies and investments.
- The concept succeeds if it changes how clean-transition investments are appraised and who is protected.

11.1 What different actors can do

Table 15 translates the framework into practical priorities for five groups. They are suggestions for discussion and not a policy blueprint, and the right mix will differ by country.

Table 15. Priorities by actor

Actor	Priorities
National and local governments	Plan the six pillars together; reform tariffs and standards; build grid and storage capacity; target clean cooking and clean water; support workers in fossil-dependent regions.
Development banks and funders	Lower the cost of capital through guarantees and local-currency lending; finance household and community systems, not only large projects; appraise projects on several benefits, not carbon alone.
Companies and investors	Build clean supply chains; invest in local manufacturing and skills; report multiple outcomes; finance small and medium enterprises.
Communities and civil society	Voice local needs, monitor outcomes, run shared systems, and hold institutions to account.
Researchers and statistical agencies	Test the feedback loop, collect data for the indicators in Chapter 8, and publish methods and results openly.

Source: H Heuristics.

11.2 The Clean Transition Resilience Test

Building on the Polycrisis Resilience Test in the founding report, H Heuristics proposes six questions to screen any clean-transition policy, investment or technology.

- **1. Which pressures does it reduce?** Name them, and count how many of the eight in Table 3.
- **2. Who benefits?** Does it reach people who are most exposed, not only those who are easiest to serve?
- **3. What capacity does it build?** Does it leave behind skills, institutions or infrastructure that last?
- **4. What new risks does it create?** Check the ten trade-offs in Table 14.
- **5. Is it robust to shocks?** Would it still work during a price spike, a storm or a policy reversal?
- **6. Can it be measured?** Which indicators from Table 12 will show whether it is working?

11.3 Open research questions

- How large is the combined dividend of clean transition programs when measured across health, economy, security and ecosystems?
- How strong, and how fast, is each link in the reinforcing loop in different settings?
- Which combinations of pillars give the most resilience per dollar in low-income and middle-income countries?
- How can the cost of capital for clean projects in emerging economies be reduced fastest?
- How do distributed systems affect grid stability and fairness, and what tariff designs work best?
- What is the right way to aggregate indicators so that weak links are not averaged away?
- How does the clean transition interact with adaptation, health and water investment in practice, and what does Scenario C require?

11.4 The H Heuristics program

H Heuristics proposes to develop the clean-transition work through three connected pillars, following the structure of the wider Polycrisis Resilience program.

Table 16. A proposed program in three pillars

Pillar	Purpose	Proposed outputs
1. Framework	Establish and refine the central proposition, six pillars and the Clean Transition Resilience Test	This report; a one-page summary; the test as a usable worksheet; a public comment and revision process
2. Research	Test the dividend, the feedback loop and the scenarios against data	Pilot Clean Transition Resilience Profiles; papers on the loop and on the cost of capital; an open data repository
3. Public education	Explain the clean transition as a resilience strategy in plain language	Visual explainers; teaching materials; briefings for policymakers and journalists; case studies of multi-benefit projects

Source: H Heuristics. The program is a proposal; timing and resourcing are to be determined.

11.5 Conclusion

The clean transition is often described as a cost to be borne, or as a technical fix for a single problem. This report has argued for a different view. The pressures facing humanity are connected, and so the actions that reduce them can be connected too. Cleaner energy, industry, transport, homes, farms and waste systems reach many of the shared roots of climate change, pollution, energy insecurity and economic vulnerability, and they bring the technologies and capabilities that societies need in order to adapt.

That is the central H Heuristics proposition: accelerating the global clean transition can reduce interconnected environmental and socioeconomic risks while strengthening the development and adaptive capacities necessary for long-term human survivability. It is a proposition to be tested, not assumed. The benefits are not automatic, the trade-offs are real, and decarbonization alone cannot resolve the global polycrisis. But the evidence reviewed here suggests that the tools are cheaper and more widely available than ever, and that the gap between what is possible and what is happening is mostly one of finance, institutions and attention. Closing that gap, fairly and in coordination with the other mechanisms of Polycrisis Resilience, is among the most promising opportunities for reducing human suffering and improving long-term survivability.

Glossary

Adaptive capacity	The ability of people, institutions and systems to adjust to changing conditions, take advantage of opportunities and cope with consequences.
Cascade	The spread of failure or stress from one system to others through dependencies.
Circular system	An economy or process that keeps materials in use through reuse, repair and recycling to reduce waste and the need for new raw materials.
Clean cooking	Cooking with fuels and stoves that produce little harmful smoke, such as electricity, gas, biogas and the cleanest improved stoves.
Clean transition	The shift from pollution-intensive and inefficient systems toward cleaner energy, industry, transportation, agriculture and infrastructure.
Clean Transition Resilience Dividend	The combined environmental, health, economic and systemic-risk benefits generated by moving to cleaner production and consumption systems (H Heuristics).
Common driver	A single stress that affects several systems at the same time.
Convergence	The process by which lower-income economies narrow the gap in income, productivity and capability with wealthier ones.
Cost of capital	The minimum return investors require to fund a project. It is higher where risks, real or perceived, are higher.
Distributed energy	Small-scale energy systems located near where the energy is used, such as rooftop solar and mini-grids.
Double-counting	Counting the same benefit more than once, for example in both a health category and an economic category.
Feedback loop	A circular causal path in which an effect returns to influence its own cause, either reinforcing or dampening it.
Household air pollution	Harmful smoke and particles indoors, mainly from cooking and heating with solid fuels or kerosene.
Multi-dimensional resilience	Resilience gained when one intervention reduces risk across several categories at once.
PM2.5	Fine particles smaller than 2.5 micrometers that can enter the lungs and bloodstream and are linked to heart and lung disease.
Polycrisis	A condition in which crises in multiple systems become causally entangled in ways that worsen overall prospects.
Polycrisis Resilience	The capacity of individuals, communities, economies, institutions and interconnected systems to anticipate, withstand, adapt to, recover from and reduce the cascading and compounding effects of multiple interconnected crises (H Heuristics).
Technology diffusion	The spread of a technology from its early adopters to wider users across places and income groups.
Weakest-link aggregation	A way of combining scores that penalizes low values, such as a geometric mean or a minimum.

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