CASCADE INSTITUTE

POLYCRISIS CORE MODEL

Technical synopsis of results of PCM v2.5

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Summary:

A detailed model of the human global "system of systems" identifies three distinct, probable outcomes for humanity in 2040. Two would entail a deterioration in human wellbeing, while the third would bring an enormous improvement.

The challenge: Understanding the causal mechanisms driving the global polycrisis

Powerful accumulating stresses are affecting the global ecological, technological, and social systems that sustain human wellbeing.[1] They include climate heating, biodiversity loss, outbreaks of novel zoonotic disease, economic precarity and inequality, accumulating public and private debt, forced migration, pernicious impacts of social media, ideological extremism, and geopolitical instability.

Acting singly and in combination in an ever-more connected world, these stresses appear to be overwhelming our societies' problem-solving and adaptive capacities. As a result, they are both increasing in force and inducing steadily greater social dislocation and human harm.[2]

The most overt, visible manifestation of this convergence is the rising incidence of near-simultaneous, apparently causally entangled crises, such as the recent conjunction of the COVID pandemic, extreme weather events, food price shocks, and war. Many scholars and policymakers are now calling this conjunction the "global polycrisis."[3]

Yet we have only a weak understanding of how the stresses combine; how their combined effects propagate through global ecological, technological, and social systems to change

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[1] See https://cascadeinstitute.org/global-systemic-stresses/.
[2] Homer-Dixon, Thomas, "Why is so much going wrong at the same time?" *Vox*, Oct. 18, 2023.
[3] Lawrence, M. et al., "Global polycrisis: the causal mechanisms of crisis entanglement," *Global Sustainability*, Volume 7 , 2024 , e6; DOI: https://doi.org/10.1017/sus.2024.1.

those systems' behaviours; and how those changes in turn can cause the polycrisis and human harm. Without a better understanding of causal mechanisms, we cannot adequately foresee the longer-term dangers and opportunities humanity faces.

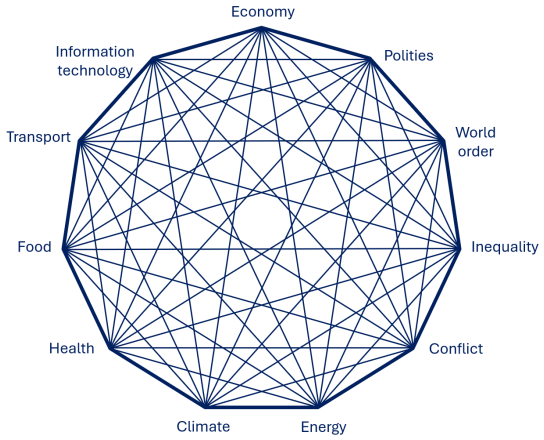
Prevailing approaches to mapping and modeling these mechanisms are not up to the task.[4] When applied to multiple, entangled global systems, the most widely used *quantitative* approaches—including system dynamics, general equilibrium, and integrated assessment models—demand unrealistically precise estimates of a vast array of parameters and input variables. Common *qualitative* approaches that instead use mostly "fuzzy" input data—generated through expert elicitation, scenario-based foresight, and causal loop analysis—cannot effectively integrate the different magnitudes of causal influence across diverse, connected systems.

Researchers have not yet rigorously applied a mid-range approach to global systems modeling—one that uses *quantitative* methods to map, assess, and integrate experts' *qualitative* intuitions about causal relationships within and among these systems.

The response: Create a mid-range model of polycrisis dynamics

To address these gaps of understanding and method, the Cascade Institute's polycrisis research team has built a detailed model of the human global "system of systems." Called the **Polycrisis Core Model** (PCM), it uses cross-impact balance analysis to mathematically integrate an enormous number of qualitative judgments about the causal relationships among the global system's constituent systems. It then predicts the entire global system's most likely future states.

The PCM identifies 11 constituent systems (see figure at right) collectively called **descriptors.** For each descriptor, the model stipulates between 3 and 5 discrete **states** that the descriptor might assume in the future. For instance, the Health Descriptor has three possible states: low, medium, and high global burden of disease. "Burden of disease" is defined (for humanity as a whole) as both premature death and loss of quality

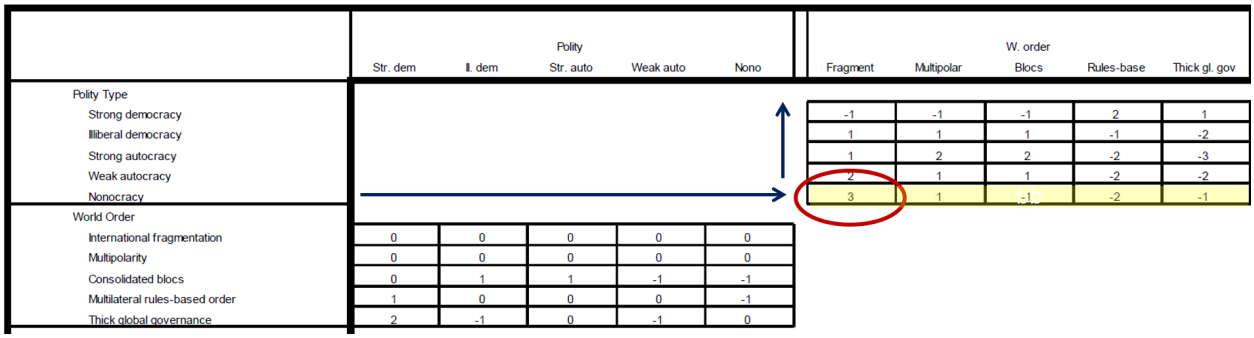


[4] Gambhir, Ajay et al., "A systemic risk assessment methodological framework for the global polycrisis," *Nature Communications*, 2025, forthcoming.

of life due to illness, as captured by disability-adjusted life years (DALYs).[5] Appendix 1 lists all descriptors and descriptor states.

At the Polycrisis Core Model's heart is a large matrix containing numerical judgments about the hypothesized causal impact, in the year 2040, of every descriptor state on every other descriptor state. The **PCM v2.5 matrix**, which the polycrisis team generated in spring 2025 after 18 months' preliminary work, includes over 1,800 judgments of this kind. The team grounded these judgments in empirical data, scientific studies, and other forms of expert knowledge.

The following figure includes a small portion of the matrix. (See Appendix 2 for the full matrix.) It shows two descriptors (Polity Type and World Order), those descriptors' respective states, and a subset of matrix numbers. Descriptor states acting as causes are listed in the vertical column on the left; the same descriptor states, but this time in the role of effects, are listed horizontally in the row across the top. Each number in the matrix represents a judgment—on a 7-point Likert scale (-3 to 3)—as to the influence of the descriptor state to the left on the descriptor state directly above.



	Polity					W. order				
	Str. dem	Il. dem	Str. auto	Weak auto	Nono	Fragment	Multipolar	Blocs	Rules-base	Thick gl. gov
Polity Type										
Strong democracy						-1	-1	-1	2	1
Illiberal democracy						1	1	1	-1	-2
Strong autocracy						1	2	2	-2	-3
Weak autocracy						2	1	1	-2	-2
Nonocracy						3	1	-1	-2	-1
World Order										
International fragmentation	0	0	0	0	0					
Multipolarity	0	0	0	0	0					
Consolidated blocs	0	1	1	-1	-1					
Multilateral rules-based order	1	0	0	0	-1					
Thick global governance	2	-1	0	-1	0					

A positive number indicates a "promoting" influence; a negative number indicates an "inhibitory" influence. A number of greater magnitude (3 compared to 2, for example, or -3 compared to -2) represents greater judgment confidence. For instance, the 3 circled in red indicates that the Cascade Institute polycrisis team had high confidence that the wide prevalence in 2040 of the "nonocracy" polity type (defined as the absence of a central state, perhaps involving state failure) would promote "international fragmentation" of the world order (as indicated by the arrows in the figure).

Importantly, within the PCM, judgments regarding a particular descriptor state's possible impacts on another descriptor's states must add to zero. For instance, the judgments highlighted in yellow in the figure, which represent nonocracy's posited impacts on World Order states, sum to zero. This requirement reflects a "balance of confidence" constraint:

[5] See https://ourworldindata.org/grapher/dalys-rate-from-all-causes?time=latest&country=~CAF.

confidence that a descriptor state will promote (or inhibit) a state of another descriptor must be accompanied by an equivalent countervailing confidence that it will inhibit (or promote) some other possible states of the same descriptor.

A zero in a matrix cell indicates that team members judged either that the descriptor state would have little or no influence on the other descriptor state, that its promoting and inhibitory influences would largely counter-balance each other, or that uncertainty made an accurate judgment about the state's likely degree and direction of influence impossible.

Once all influence judgments were entered into the matrix, the polycrisis team applied the mathematics of cross-impact balance (CIB) analysis—using a specialized software package called ScenarioWizard—to generate model predictions.

The PCM includes a total of 45 states across the 11 descriptors. Combining one state from each descriptor creates a unique representation of a possible world outcome—called a **scenario**—in 2040. The 45 states, in their various possible combinations, create 4.05 million scenarios.

But only a very small number of these scenarios represent stable states that could persist over the long term. CIB mathematics identifies these stable scenarios by adding up a given scenario's promoting and inhibiting influences (called **impacts**) across all descriptor states to determine these influences' net effects. It then assesses, for each descriptor, whether the state that the scenario promotes most (its output state) is the same as the scenario's input state for that descriptor. If a scenario's input and output states are the same across all descriptors, it is **fully consistent**.

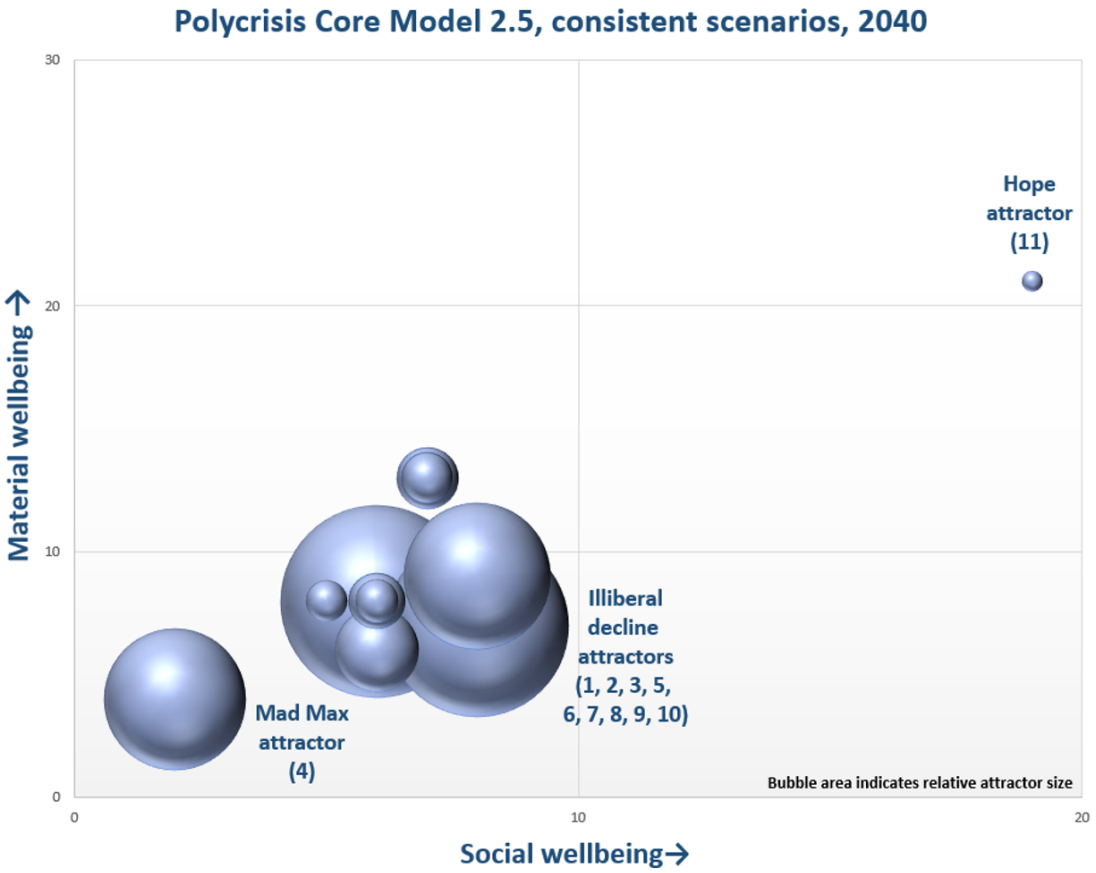
Fully consistent scenarios represent self-reinforcing equilibria in the global system of systems; their stability and persistence mean they represent the world's most probable futures. In complexity-science terminology, they are "basins of attraction" or "attractors." Each is like a dip in a landscape into which a ball (representing the global system's overall state) can settle and remain stable.

The width of a fully consistent scenario's basin of attraction is a function of the number of inconsistent scenarios that ultimately migrate to it. A CIB mathematical procedure called **succession analysis** determines this width by taking each inconsistent scenario and makes it incrementally more consistent, thus migrating that scenario through a series of steps to its closest fully consistent scenario.

The PCM v2.5 results: Three main futures and a possibility of hope

Of the more than 4 million possible world outcomes in 2040, only 11 were fully consistent and could therefore be characterized as attractors. Appendix 3 presents the model's detailed ScenarioWizard results for these 11 scenarios. The results include each scenario's specific descriptor states, the attractor basin's width (which ScenarioWizard calls "weight"), and the basin's depth or degree of self-reinforcing stability (called "total impact score").

The following figure shows these 11 scenarios arrayed in two-dimensional space, with each scenario's aggregated level of social wellbeing on the horizontal axis and aggregated level of material wellbeing on the vertical axis.[6] The area of each bubble represents the scenario's weight or its attractor width.[7]



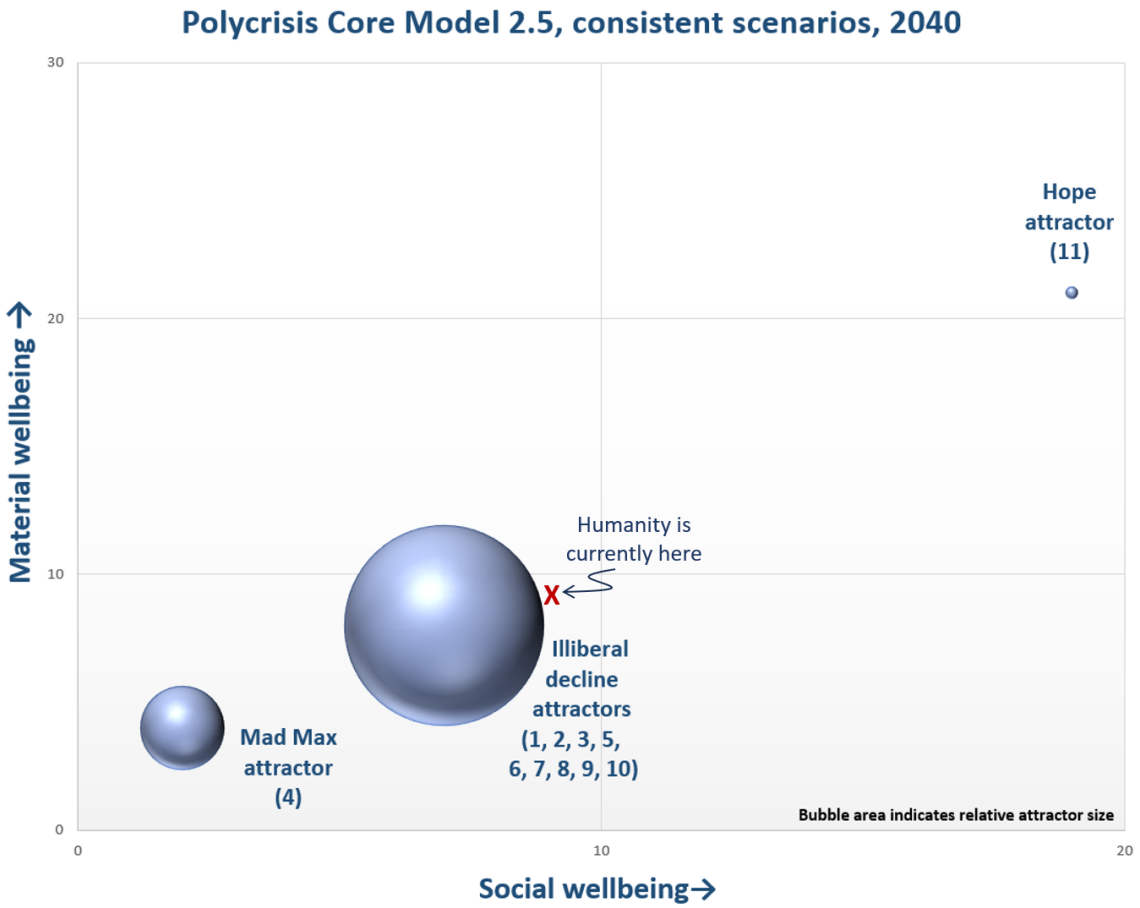
[6] The polycrisis team assigned a normative wellbeing score on a 5-point scale (from 0 to 4) to each descriptor state. A scenario's material wellbeing score is the sum of its state scores for the energy, climate, health, food, transportation, and information technology descriptors; its social wellbeing score is the sum of its state scores for the conflict, polity type, world order, economy, and inequality descriptors.

[7] Ideally, we would show the attractors in this and the next figure as basins in a three-dimensional state space, but conventional graphing software does not support such representations. We will address this shortcoming in future drafts of this report.

Ten of the 11 attractors show a deterioration of human wellbeing by 2040. Nine are similar enough that they we call them collectively “Illiberal Decline.” These are futures of poverty, inequality, authoritarianism, violence, and environmental degradation. Another attractor, which we call “Mad Max,” represents thoroughgoing social, economic, and environmental collapse and deeply entrenched human misery.

But the model also generates one additional stable scenario that is remarkably good. This attractor represents an outcome with strong democracy, competent governance, guided economic growth, relative economic equality, sustained technological innovation, and declining environmental impact. It entails an enormous improvement in human wellbeing. We call this scenario the "Hope attractor."

Since 9 of the 11 consistent scenarios are clustered together and very similar, the following figure combines them into a single attractor. This figure makes it clear that PCM v2.5 identifies three distinct possible outcomes for humanity in 2040.



The figure's now-consolidated Illiberal Decline attractor is extremely large. In CIB's succession analysis, it acts like an enormous cosmological black hole—with its gravity sucking in over three million of the model's 4 million inconsistent scenarios. The Mad Max attractor is not as large, absorbing about half a million inconsistent scenarios. The Hope attractor is comparatively small, drawing in only about ten thousand inconsistent scenarios. But it has a high total impact score, indicating that its basin is deep, with strong self-reinforcing stability, relative to most of the other 11 consistent scenarios.

The Hope attractor's existence as a possible future for humanity is a finding of great significance.

The figure also shows humanity's current position in this well-being state space relative to the other attractors. The Cascade Institute's polycrisis team is working to find feasible pathways away from this current position towards the Hope attractor.

Final remarks: Modeling's benefits and risks

"All models are wrong, but some are useful," wrote the British statistician George Box in the 1970s.[8]

A model is an attempt to discriminate a system's signals from its noise—to discern vital patterns hidden in a myriad of detail. Modelers make simplifying assumptions to find those signals and patterns. Modelers should strive to clearly identify their assumptions and to ground them in the best available scientific research and empirical data, yet their decisions will always be somewhat arbitrary. And modelers will always face tough trade-offs between maximizing their model's real-world accuracy and achieving parsimony of the model's insights.

The Polycrisis Core Model tilts towards parsimony. It is, by design, extremely course-grained. To use Nobelist Murray Gell-Mann's famous words, it is a "crude look at the whole." We believe this kind of coarse-grained analysis can generate important insights for two reasons. First, we believe the powerful forces influencing humanity's possible pathways into the future, as well as the interactions among those forces, are not overly sensitive to micro-differences in specific causal mechanisms. Second, we believe careful construction of the model can help ensure that its errors representing the world—for instance, errors in

[8] Box, G.E.P. "Robustness in the Strategy of Scientific Model Building." *Robustness in Statistics*, edited by Robert L. Launer and Graham N. Wilkinson, Academic Press, 1979, pp. 201-36. *ScienceDirect*.

its characterization of descriptor states or its scoring of influence judgments—are generally unbiased and will therefore tend to cancel each other out.

The Cascade Institute's polycrisis research team has tried to make the model as unbiased as possible by rigorously describing and justifying the model's descriptors, descriptor states, and causal-influence judgments. But team members are human beings whose values and perceptions inevitably influence their expert judgment, particularly when evaluating highly complex and emotionally evocative scenarios. And although the team includes a diversity of scholars, it cannot reflect all worldviews.

For these reasons, the polycrisis team is using CIB mathematical procedures to test the PCM for bias. It is also writing a detailed codebook and a set of stand-alone academic papers that explain, for each descriptor, the team's simplifying assumptions, rationales, and trade-offs. Additionally, the matrix itself, when released, will include documented justifications of all influence judgments.

We will make this background information available online for researchers to examine and critique. It will also appear as supplements to academic publications.

The PCM will therefore be an "open" model: anyone will be able to access the matrix online, enter their own judgments, and use ScenarioWizard to see how their results differ from ours, and to perform sensitivity testing. The CIB method allows for far greater model transparency than dominant quantitative modeling approaches, such as system dynamics and integrated assessment models.

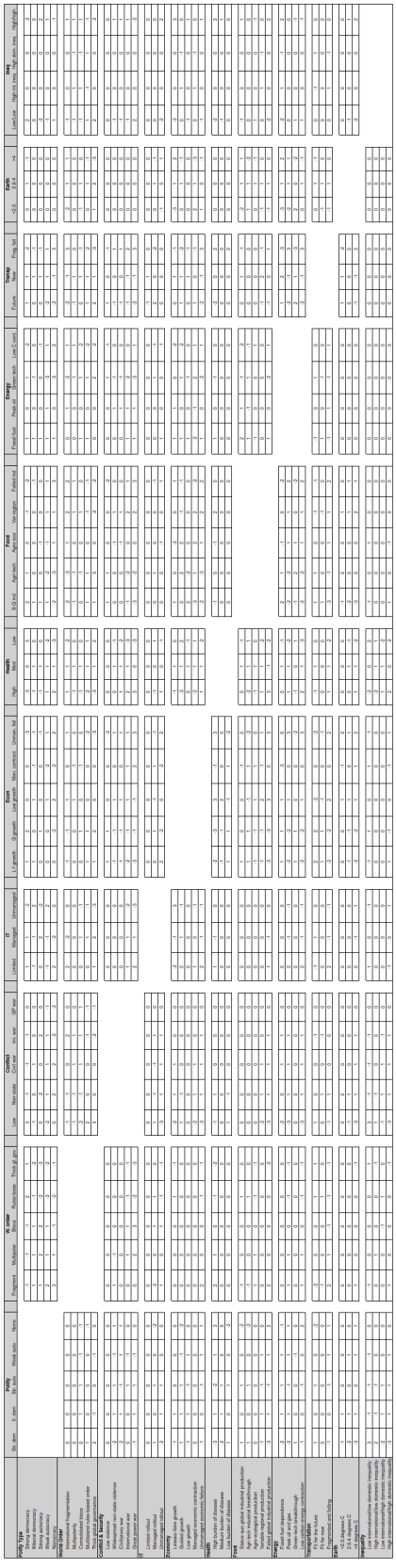
The CIB method's capacity to apply mathematics to "fuzzy" expert knowledge is both a strength and a weakness. It is a strength, because today's expert judgments are invariably trapped in silos and encoded in data with different levels of measurement (nominal, ordinal, interval, and ratio). Because CIB mathematics can integrate data of all levels, it can help break down these silos, so the knowledge they hold can be synthesized into one revealing picture of our world and its prospects. But quantification of expert intuition can also remove nuance and introduce subjectivities that will dismay some of the very experts whose knowledge the model encodes.

We present the Polycrisis Core Model and its results with all these risks in mind. But we believe that the care we have taken to document and explain our descriptor choices, our bounding of descriptor states, and our judgment scores—all soon to be publicly available along with the model itself—make the risks acceptable given the insight gained.

APPENDIX 1: PCM v2.5 descriptors and descriptor states

	Descriptor	Descriptor states
Social	Economy	Laissez-faire growth Guided growth Low growth Managed economic contraction Unmanaged economic failure
	Polity Type	Strong democracy Illiberal democracy Strong autocracy Weak autocracy Nonocracy
	World Order	International fragmentation Multipolarity Consolidated blocs Multilateral rules-based order Thick global governance
	Inequality	Low international/low domestic inequality High international/low domestic inequality Low international/high domestic inequality High international/high domestic inequality
	Conflict & Security	Low violence Widespread non-state violence Civil/proxy war International war Great power war
Material	Energy	Fossil-fuel dependence Peak oil and gas Green-tech breakthrough Low-carbon energy contraction
	Climate	<2.5 degrees C in 2100 2.5-4 degrees C >4 degrees C
	Health	High burden of disease Medium burden of disease Low burden of disease
	Food	Status-quo global industrial production Agri-tech industrial breakthrough Agro-ecological production Variable regional production Failed global industrial production
	Transportation	Fit for the future Fit for now Fragmented and failing
	Information technology	Limited rollout Managed rollout Unmanaged rollout

APPENDIX 2: Full PCM v2.5 matrix



APPENDIX 3: PCM v2.5 consistent scenario output

```
Consistent scenarios of CI matrix PCM2.0.scw:
Strong consistency
Attractor weights, Succession: Global


================================================================
Scenario No. 1
Weight            :  1009056
Consistency value :  0
Total impact score:  58
----------------------------------------------------------------
Polity Type        : Illiberal democracy
World Order        : International fragmentation
Conflict & Security: Civil/proxy war
IT                 : Unmanaged rollout
Economy            :  Low growth
Health             : Medium burden of disease
Food               :  Variable regional production
Energy             : Fossil-fuel dependence
Transportation     : Fit for now
Earth              : 2.5-4 degrees C
Inequality         : High international/high domestic inequality
================================================================

================================================================
Scenario No. 2
Weight            :  904447
Consistency value :  0
Total impact score:  62
----------------------------------------------------------------
Polity Type        : Illiberal democracy
World Order        : Consolidated blocs
Conflict & Security: Civil/proxy war
IT                 : Unmanaged rollout
Economy            :  Low growth
Health             : Medium burden of disease
Food               :  Status-quo global industrial production
Energy             : Fossil-fuel dependence
Transportation     : Fit for now
Earth              : >4 degrees C
Inequality         : High international/high domestic inequality
================================================================

================================================================
Scenario No. 3
Weight            :  585637
Consistency value :  0
Total impact score:  61
----------------------------------------------------------------
Polity Type        : Illiberal democracy
World Order        : Consolidated blocs
Conflict & Security: Civil/proxy war
IT                 : Unmanaged rollout
Economy            :  Low growth
Health             : Medium burden of disease
Food               :  Status-quo global industrial production
```

```
Energy             : Fossil-fuel dependence
Transportation     : Fit for now
Earth              : 2.5-4 degrees C
Inequality         : High international/high domestic inequality
=================================================================

=================================================================
Scenario No. 4
Weight            :  539844
Consistency value :  1
Total impact score:  116
-----------------------------------------------------------------
Polity Type        : Nonocracy
World Order        : International fragmentation
Conflict & Security: Widespread non-state violence
IT                 : Limited rollout
Economy            :  Unmanaged economic failure
Health             :  High burden of disease
Food               :  Failed global industrial production
Energy             : Low-carbon energy contraction
Transportation     : Fragmented and failing
Earth              : 2.5-4 degrees C
Inequality         : High international/high domestic inequality
=================================================================

=================================================================
Scenario No. 5
Weight            :  189685
Consistency value :  0
Total impact score:  62
-----------------------------------------------------------------
Polity Type        : Illiberal democracy
World Order        : International fragmentation
Conflict & Security: Civil/proxy war
IT                 : Unmanaged rollout
Economy            :  Low growth
Health             : Medium burden of disease
Food               :  Variable regional production
Energy             : Fossil-fuel dependence
Transportation     : Fit for now
Earth              : >4 degrees C
Inequality         : High international/high domestic inequality
=================================================================

=================================================================
Scenario No. 6
Weight            :  102994
Consistency value :  0
Total impact score:  60
-----------------------------------------------------------------
Polity Type        : Strong autocracy
World Order        : Consolidated blocs
Conflict & Security: International war
IT                 : Managed rollout
Economy            :  Low growth
Health             : Medium burden of disease
```

```
Food                :  Status-quo global industrial production
Energy              : Fossil-fuel dependence
Transportation      : Fit for now
Earth               : 2.5-4 degrees C
Inequality          : High international/high domestic inequality
=====================================================================

=====================================================================
Scenario No. 7
Weight             :  85395
Consistency value :  0
Total impact score:  62
---------------------------------------------------------------------
Polity Type         : Illiberal democracy
World Order         : International fragmentation
Conflict & Security: Widespread non-state violence
IT                  : Limited rollout
Economy             :  Low growth
Health              : Medium burden of disease
Food                :  Variable regional production
Energy              : Peak oil and gas
Transportation      : Fragmented and failing
Earth               : 2.5-4 degrees C
Inequality          : High international/high domestic inequality
=====================================================================

=====================================================================
Scenario No. 8
Weight             :  68604
Consistency value :  0
Total impact score:  53
---------------------------------------------------------------------
Polity Type         : Illiberal democracy
World Order         : Consolidated blocs
Conflict & Security: International war
IT                  : Managed rollout
Economy             :  Low growth
Health              : Medium burden of disease
Food                :  Status-quo global industrial production
Energy              : Fossil-fuel dependence
Transportation      : Fit for now
Earth               : 2.5-4 degrees C
Inequality          : High international/high domestic inequality
=====================================================================

=====================================================================
Scenario No. 9
Weight             :  48260
Consistency value :  0
Total impact score:  61
---------------------------------------------------------------------
Polity Type         : Illiberal democracy
World Order         : International fragmentation
Conflict & Security: Civil/proxy war
IT                  : Limited rollout
Economy             :  Low growth
```

```
Health              : Medium burden of disease
Food                :  Variable regional production
Energy              : Peak oil and gas
Transportation      : Fragmented and failing
Earth               : 2.5-4 degrees C
Inequality          : High international/high domestic inequality
=================================================================

=================================================================
Scenario No. 10
Weight             :  45213
Consistency value :  0
Total impact score:  63
-----------------------------------------------------------------
Polity Type         : Illiberal democracy
World Order         : International fragmentation
Conflict & Security: International war
IT                  : Limited rollout
Economy             :  Low growth
Health              : Medium burden of disease
Food                :  Variable regional production
Energy              : Peak oil and gas
Transportation      : Fragmented and failing
Earth               : 2.5-4 degrees C
Inequality          : High international/high domestic inequality
=================================================================

=================================================================
Scenario No. 11
Weight             :  11118
Consistency value :  2
Total impact score:  81
-----------------------------------------------------------------
Polity Type         : Strong democracy
World Order         : Multilateral rules-based order
Conflict & Security: Low violence
IT                  : Managed rollout
Economy             :  Guided growth
Health              : Low burden of disease
Food                : Agri-tech industrial breakthrough
Energy              : Green-tech breakthrough
Transportation      : Fit for the future
Earth               : 2.5-4 degrees C
Inequality          : Low international/low domestic inequality
=================================================================
```