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Carbon Reward Policy: Economics for Managing Climate Risk

The 20th ISDE International Lectures

Climate Change Risk and Regenerative Economics: Implications for Digital Earth

Organized By: International Society for Digital Earth (ISDE)

Date: 13 May 2026

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Mainstream Policies are Inadequate

Why is the carbon reward needed?

Standard Policy or Approach	Common Shortcomings
Carbon Taxes & Cap-and-Trade	✗ Prone to political conflict and delay when scaling-up
Regulations & Standards	✗ Prone to political conflict and delay with rising stringency
Subsidies & Fiscal Spending	✗ Limited by fiscal constraints and short-term priorities
Nationally Determined Contributions	✗ Prone to free-riding and gridlock by fossil fuel exporters
Net-Zero Pledges	✗ Non-binding and pledges often lack details
Voluntary Carbon Markets & Offsetting	✗ Weak carbon pricing, weak additionality, and zero-sum
Climate Bonds	✗ No statistical correlation with the Paris climate goals
Debt for Nature Swaps	✗ Not scalable

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Gap Between Systemic Risks & Mainstream Policies

The carbon reward policy was developed to address the systemic risk to the carbon cycle

Urgent Needs

1. Climate finance is needed at speed and scale to address the Paris targets and avoid tipping points

2. Global political cooperation is missing

3. A mechanism is needed to backstop the insurance sector and stabilise the financial system

4. Communities and ecosystems need support for protection and resilience

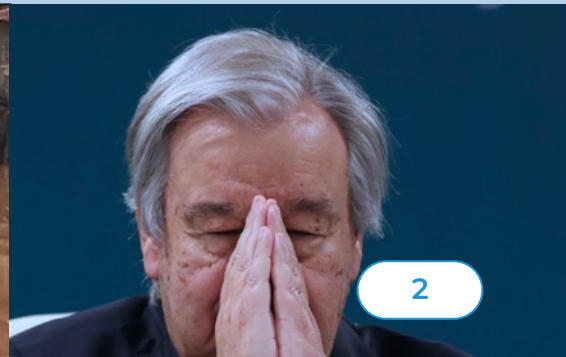
Policy Solution

1. Scalable grants — called carbon rewards (XCR) — would enable rapid market-driven decarbonisation

2. “Carrot and stick” carbon pricing (including carbon rewards) would enable global cooperation

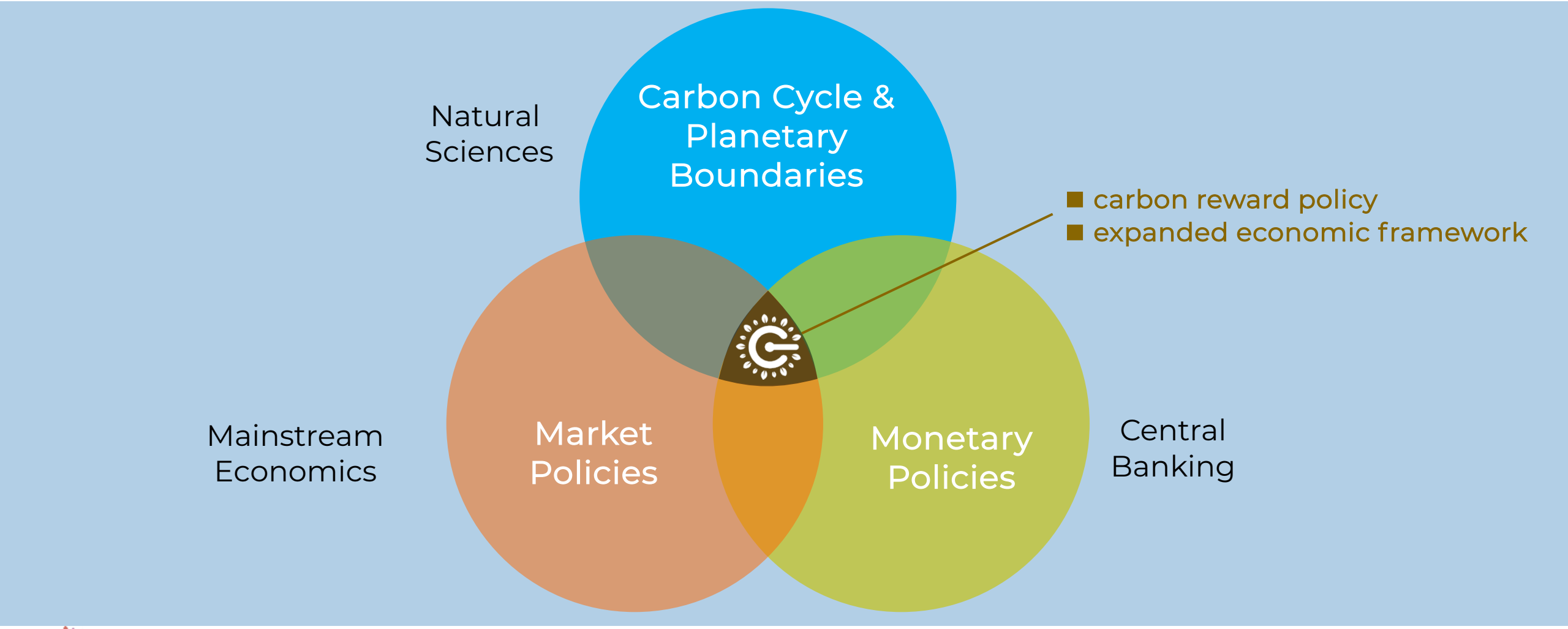
3. A guaranteed XCR price floor will enable rapid decarbonization and stabilise the financial system

4. Adaptive XCR finance would be provided for community co-benefits and protecting ecosystems



An Interdisciplinary Approach to Policy Development

How was the carbon reward policy developed?



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Understanding Planetary Boundaries

The carbon cycle underpins many planetary boundaries

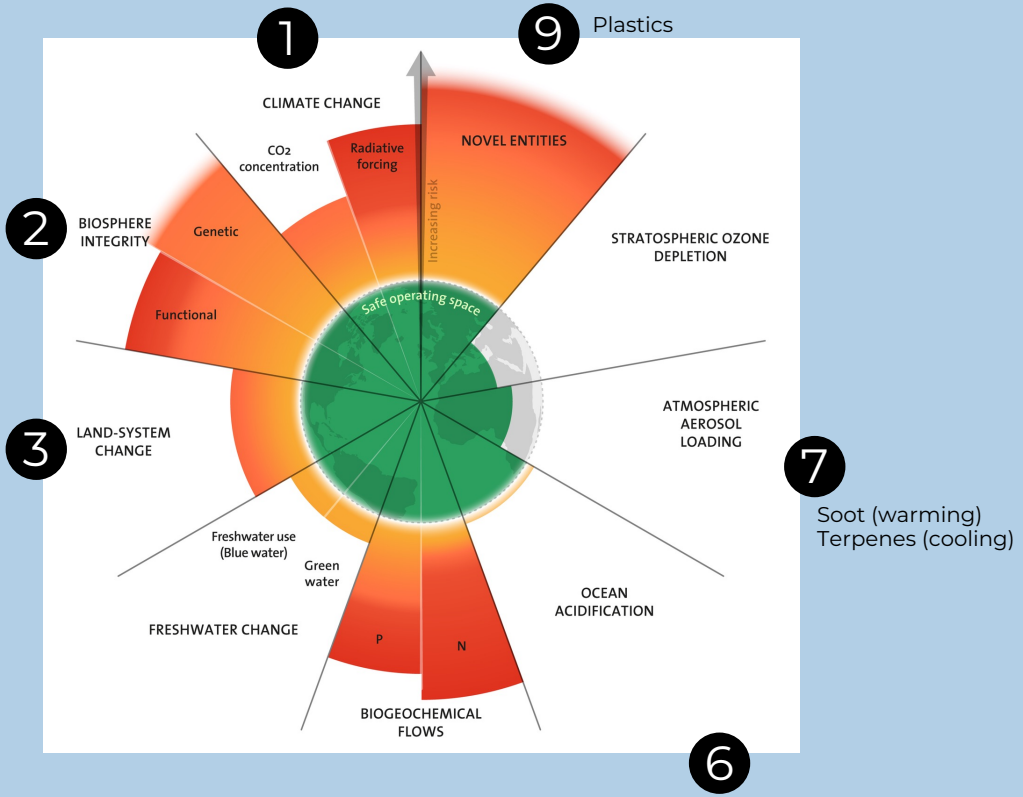


Figure 1. The planetary boundaries are a dashboard for civilization

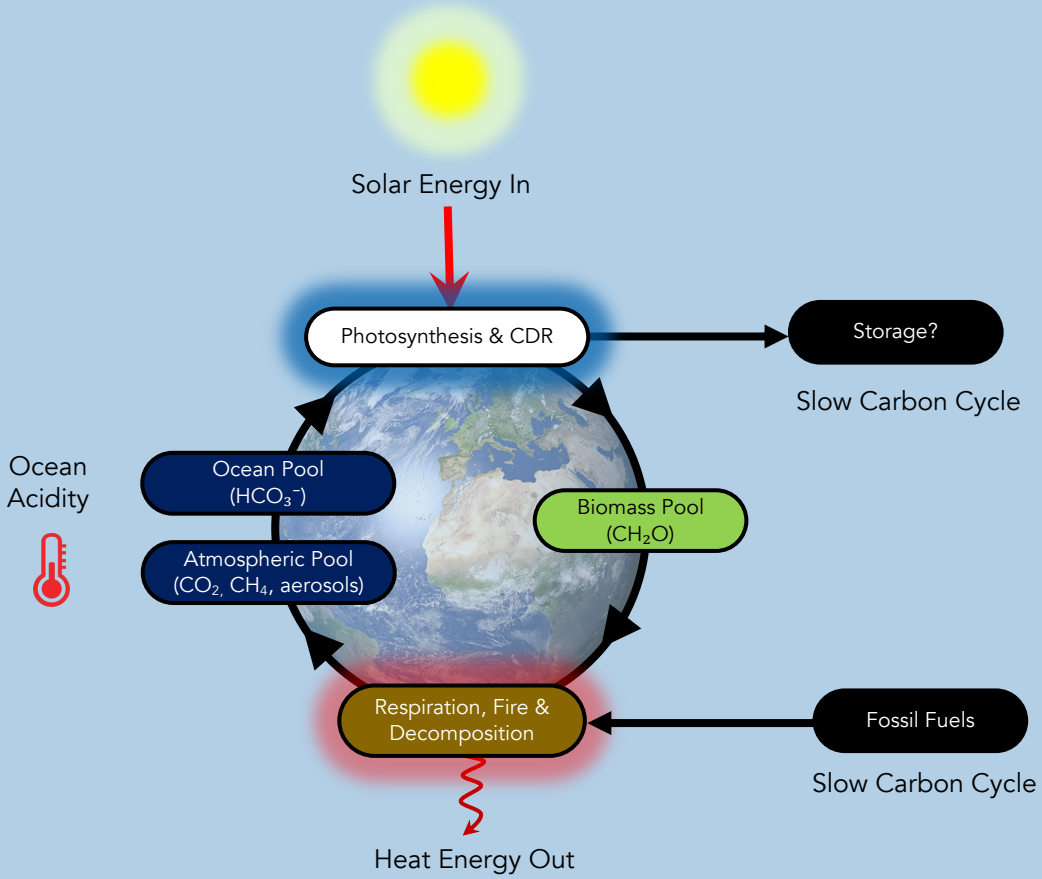


Figure 2. The fast carbon cycle

Understanding the Carbon Cycle

The 2x2 Gibbs Free Energy Matrix explains the thermodynamics of the carbon cycle

Josiah Gibbs (1876-78)

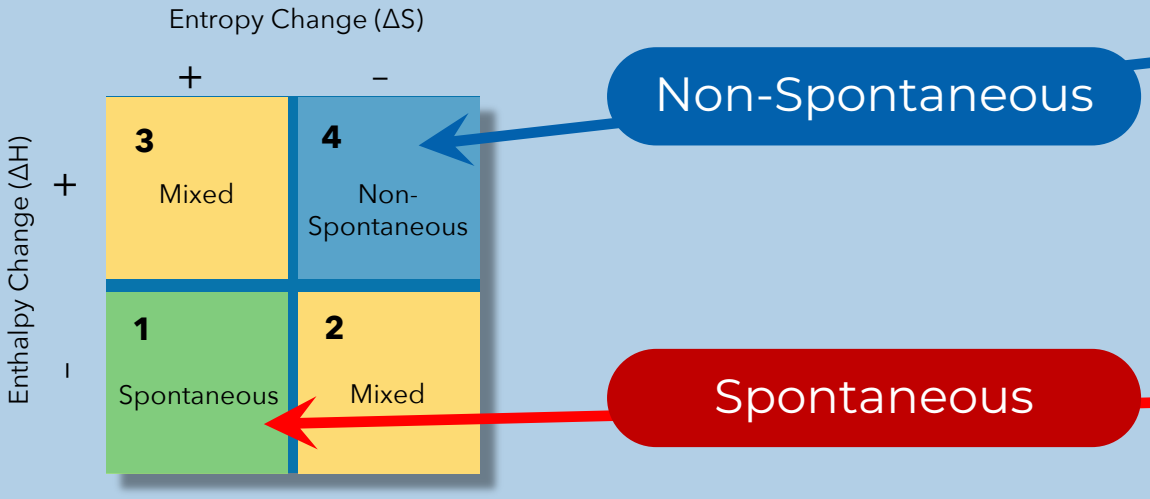


Figure 1. Free energy matrix
($\Delta G = \Delta H - T\Delta S$)

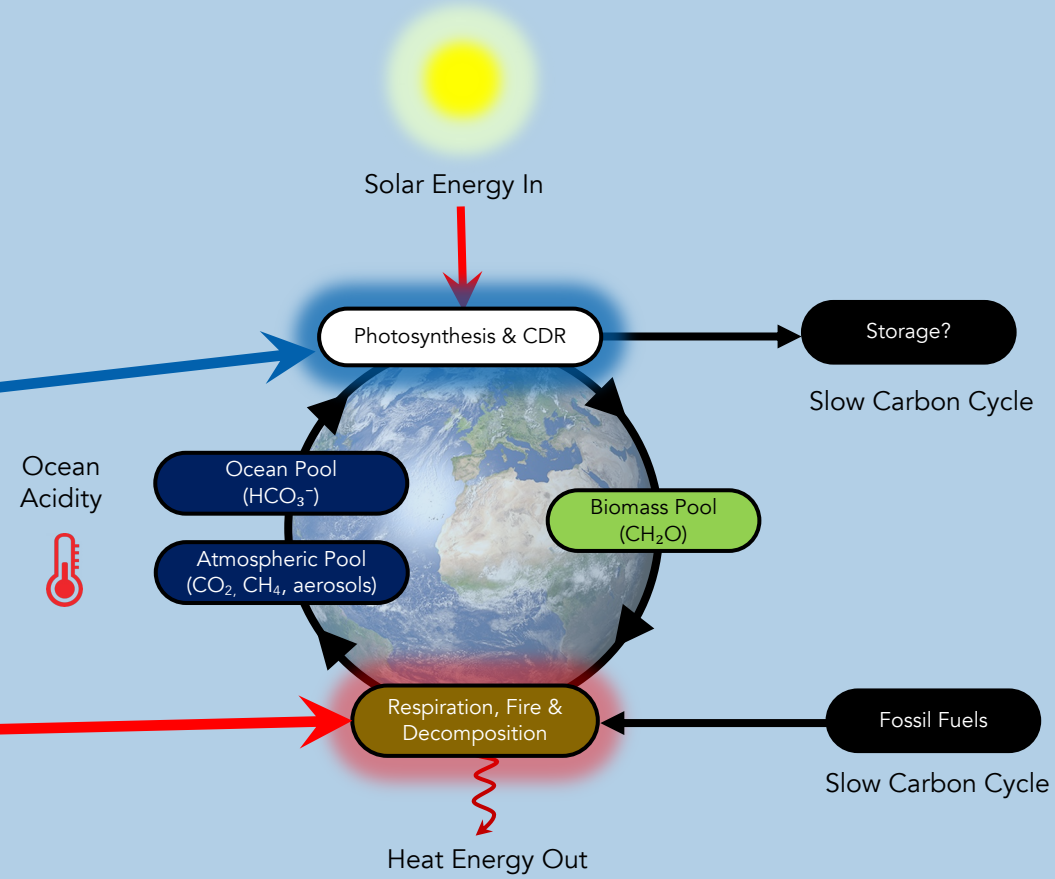


Figure 2. The fast carbon cycle

Introducing the “2x2 Outcome Matrix”

The 2x2 Outcome Matrix is used to compare market policies with thermodynamic potential

Josiah Gibbs (1876-78)

Delton Chen (2025)

Arthur Pigou (1920)

Ronald Coase (1960)

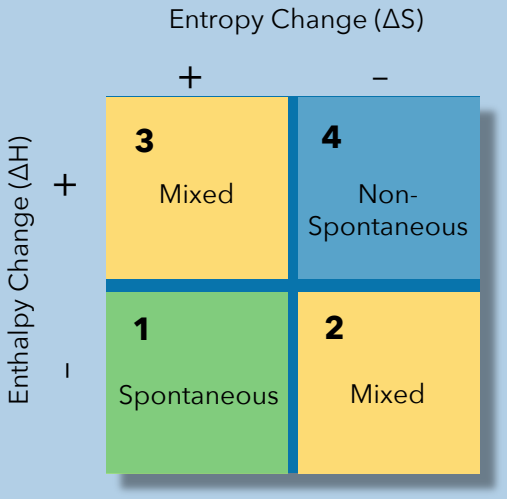


Figure 1. Free energy matrix ($\Delta G = \Delta H - T\Delta S$)

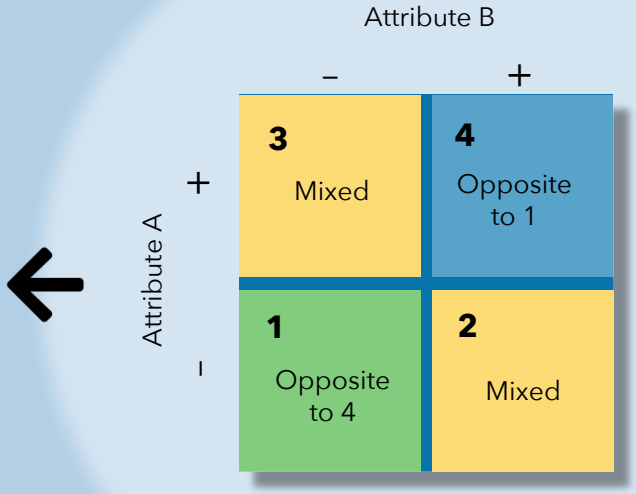


Figure 2. The 2x2 outcome matrix for describing patterns in complex systems

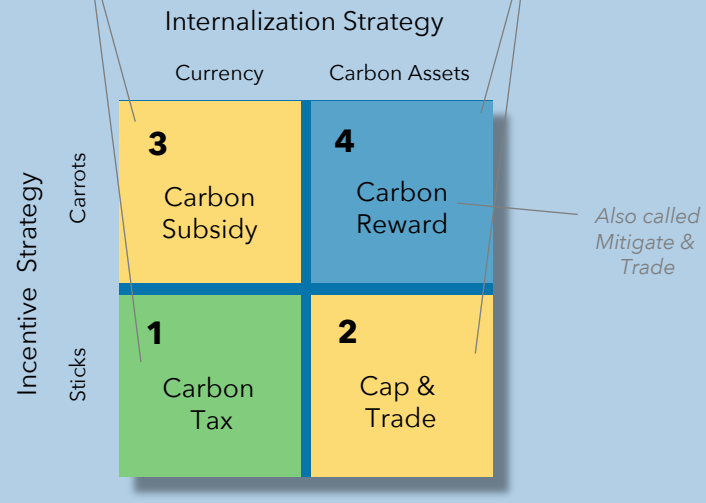


Figure 3. The policy matrix for classifying carbon pricing

Applying the “2x2 Outcome Matrix” to costs and risks

The 2x2 Outcome Matrix is used to classify externalities associated with costs and risks

Delton Chen (2025)

Arthur Pigou (1920)

Ronald Coase (1960)

Systemic Externality (Chen, 2025)

Risk Cost of Carbon (RCC)

Negative Externality (Pigou, 1920)

Social Cost of Carbon (SCC)

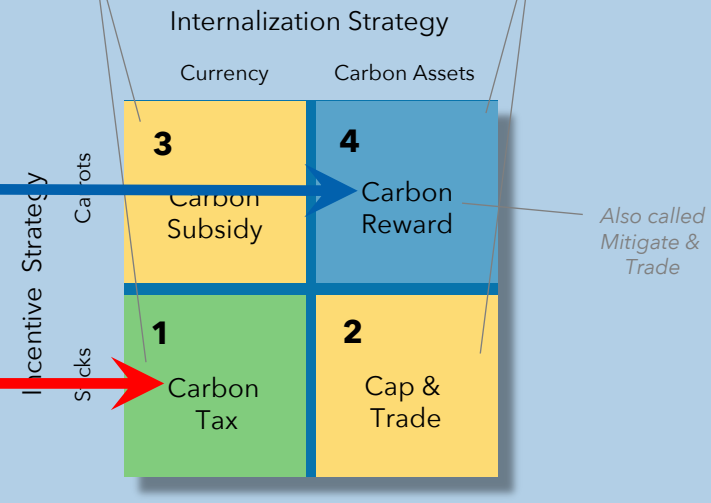


Figure 3. The policy matrix for classifying carbon pricing

Societal Systems pose a Systemic Risk

The systemic externality results from societal systems that preserve the status quo

RCC

Systemic risk is caused by
- societal systems
- climate dynamics

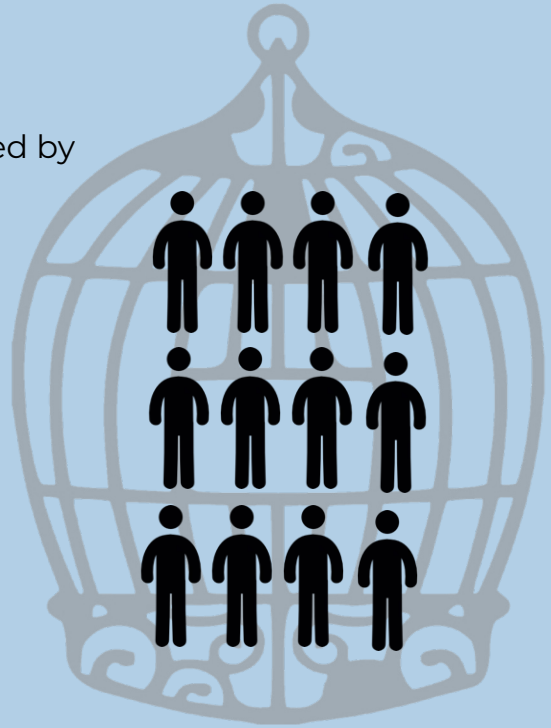
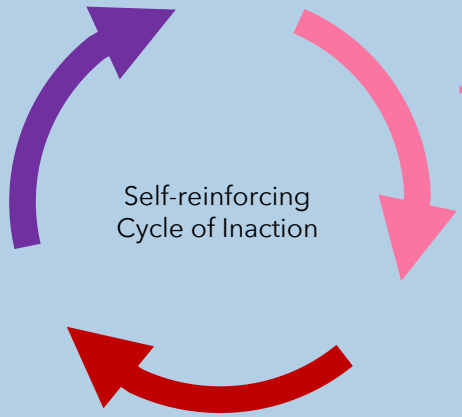


Figure 1. Societal systems create political lock-in that restricts the utility of standard policies – thus creating risk



1. GHGs accumulate in the atmosphere driving even worse climate change

2. The SCC increases with additional warming and when scientific knowledge of climate damages and tipping points improves

3. Rising taxes, stringent regulations, rising costs, and asset stranding typically attract political resistance to preserve the status quo

SCC

Figure 2. The self-reinforcing cycle of inaction is not addressed in Pigou's (1920) original theory

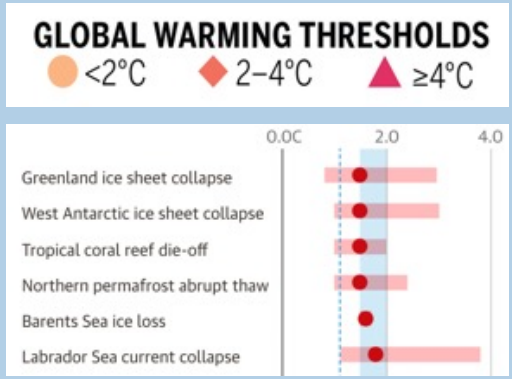
Earth Systems pose a Systemic Risk

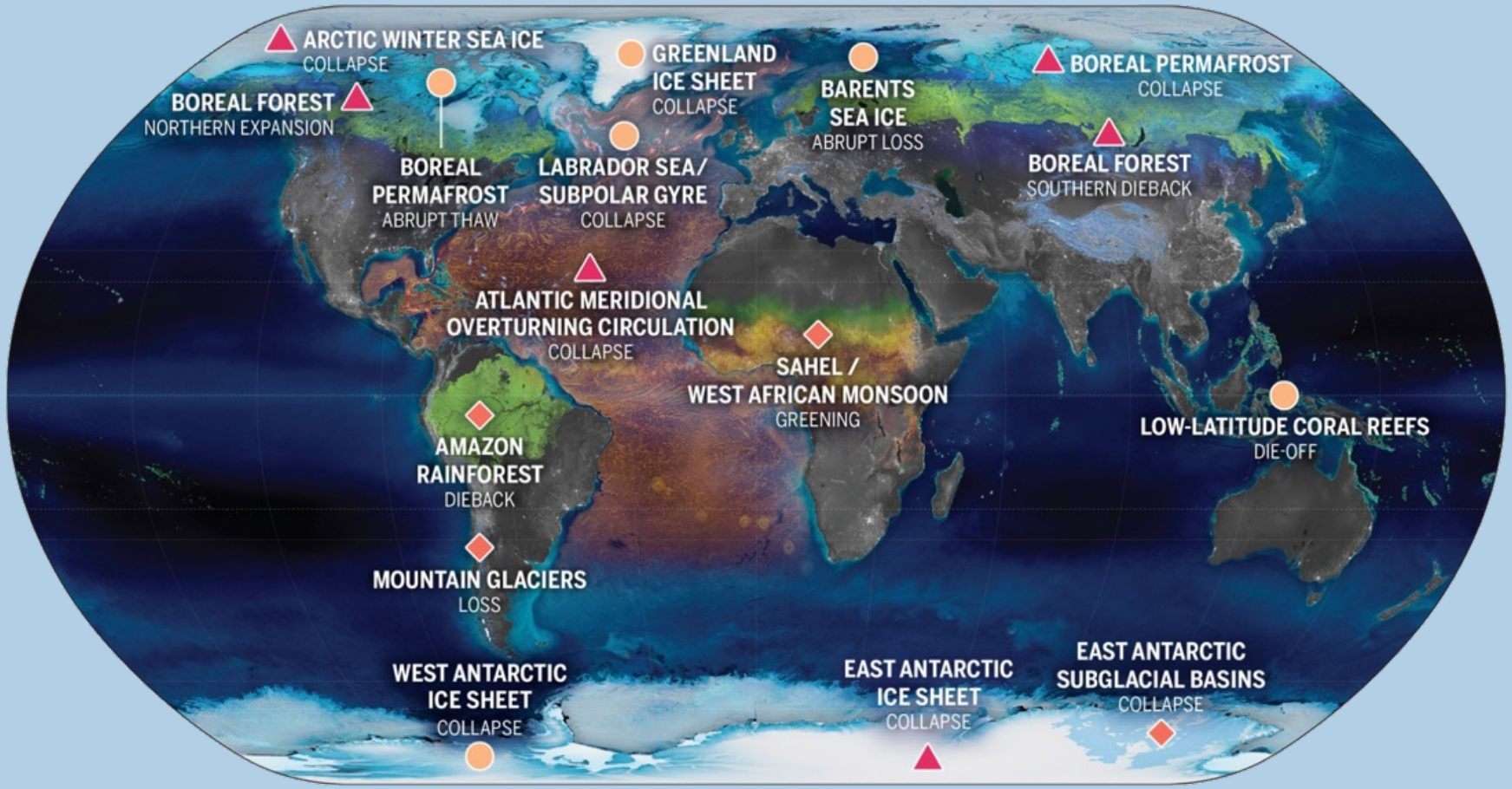
The systemic externality of earth systems is caused by scientific uncertainty, feedbacks, and tipping points

RCC

Systemic risk is caused by
- societal systems
- climate dynamics

Climate Tipping Elements





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Footnote: The Risk Cost of Carbon (RCC) needs to rise sufficiently to avoid passing dangerous climate tipping points
Graphic: Updated assessment of the climate tipping elements (McKay et al., 2022, Science)

Introducing the “Market & System Failure” Concept

The expanded economic framework identifies two externality types

Negative Externality & SCC

This is the (unpriced) cost imposed on third parties who are not involved in the transaction of goods that generate carbon emissions (pollution).

- Social Cost of Carbon (SCC) refers to the average time-discounted marginal damage caused by 1 tCO_2e emitted.
- The ideal policy is a carbon tax set equal to the SCC.

Arthur Pigou (1920)

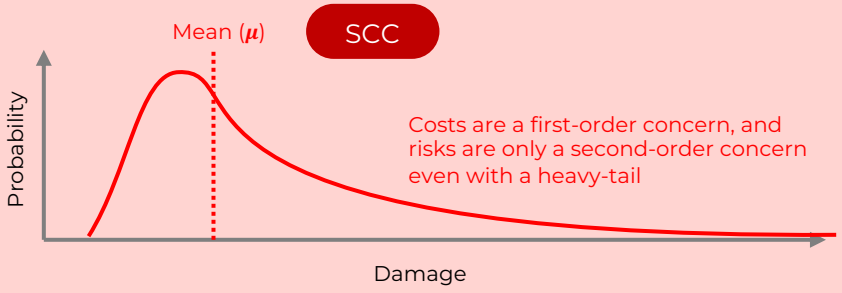

Figure 1. Pigou (1920) assumed that social costs are manageable with taxes.

Systemic Externality & RCC

This is the (unpriced) cost of managing systemic risks to the carbon cycle, where the risk is caused by societal systems and earth systems.

- Risk Cost of Carbon (RCC) refers to the average marginal cost of 1 tCO_2e of CDR that is sufficient to limit systemic risks.
- The ideal policy is a carbon reward set above the RCC.

Delton Chen (2025)

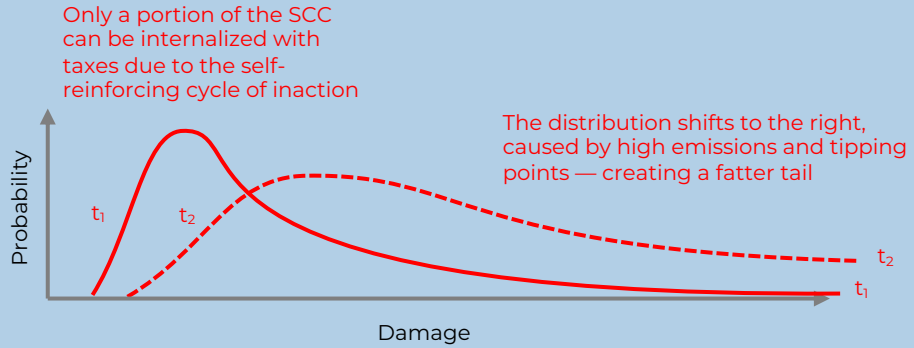

Figure 2. Chen (2025) argues that systemic risks are manageable with rewards.

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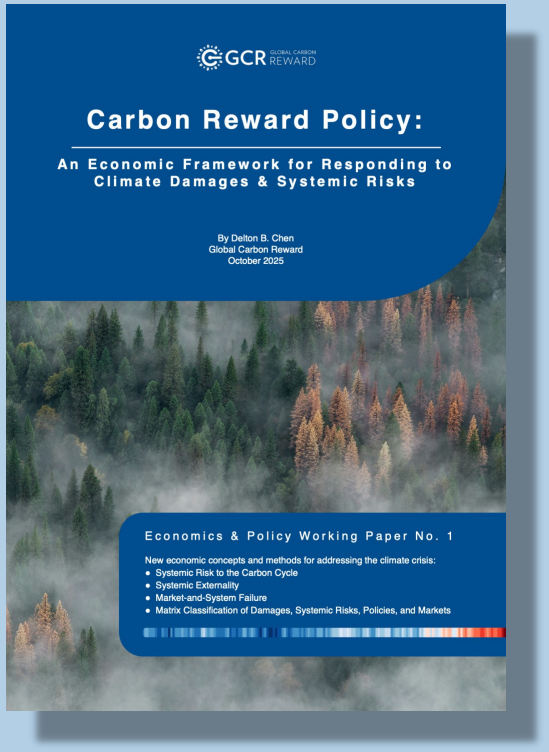
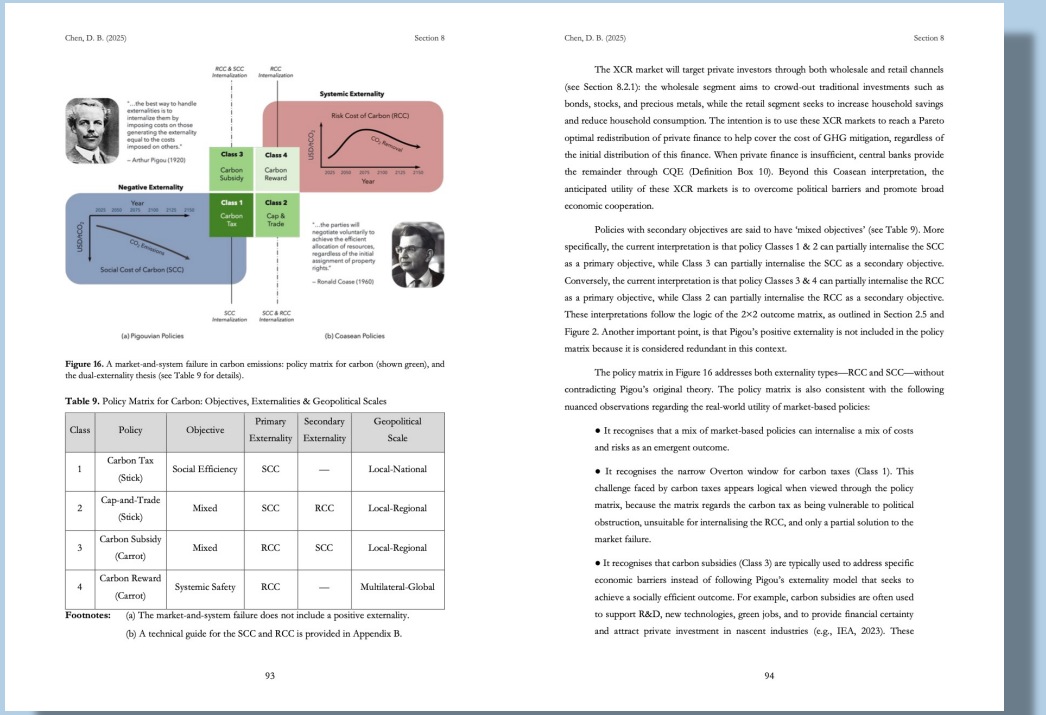
Carbon Reward Policy — Working Paper

This paper presents the new economic framework and explains why the “carbon reward” is needed

Could this be a Policy Tipping Point ?





Chen, D. B. (2025) Section 8

Figure 16. A market-and-system failure in carbon emissions: policy matrix for carbon (shown green), and the dual-externality thesis (see Table 9 for details).

Table 9. Policy Matrix for Carbon: Objectives, Externalities & Geopolitical Scales

Class	Policy	Objective	Primary Externality	Secondary Externality	Geopolitical Scale
1	Carbon Tax (Stick)	Social Efficiency	SCC	—	Local-National
2	Cap-and-Trade (Stick)	Mixed	SCC	RCC	Local-Regional
3	Carbon Subsidy (Carrot)	Mixed	RCC	SCC	Local-Regional
4	Carbon Reward (Carrot)	Systemic Safety	RCC	—	Multilateral-Global

Footnotes: (a) The market-and-system failure does not include a positive externality.
(b) A technical guide for the SCC and RCC is provided in Appendix B.

93

Chen, D. B. (2025) Section 8

The XCR market will target private investors through both wholesale and retail channels (see Section 8.2.1): the wholesale segment aims to crowd-out traditional investments such as bonds, stocks, and precious metals, while the retail segment seeks to increase household savings and reduce household consumption. The intention is to use these XCR markets to reach a Pareto optimal redistribution of private finance to help cover the cost of GHG mitigation, regardless of the initial distribution of this finance. When private finance is insufficient, central banks provide the remainder through CQE (Definition Box 10). Beyond this Coasean interpretation, the anticipated utility of these XCR markets is to overcome political barriers and promote broad economic cooperation.

Policies with secondary objectives are said to have ‘mixed objectives’ (see Table 9). More specifically, the current interpretation is that policy Classes 1 & 2 can partially internalise the SCC as a primary objective, while Class 3 can partially internalise the SCC as a secondary objective. Conversely, the current interpretation is that policy Classes 3 & 4 can partially internalise the RCC as a primary objective, while Class 2 can partially internalise the RCC as a secondary objective. These interpretations follow the logic of the 2×2 outcome matrix, as outlined in Section 2.5 and Figure 2. Another important point, is that Pigou’s positive externality is not included in the policy matrix because it is considered redundant in this context.

The policy matrix in Figure 16 addresses both externality types—RCC and SCC—without contradicting Pigou’s original theory. The policy matrix is also consistent with the following nuanced observations regarding the real-world utility of market-based policies:

- It recognises that a mix of market-based policies can internalise a mix of costs and risks as an emergent outcome.
- It recognises the narrow Overton window for carbon taxes (Class 1). This challenge faced by carbon taxes appears logical when viewed through the policy matrix, because the matrix regards the carbon tax as being vulnerable to political obstruction, unsuitable for internalising the RCC, and only a partial solution to the market failure.
- It recognises that carbon subsidies (Class 3) are typically used to address specific economic barriers instead of following Pigou’s externality model that seeks to achieve a socially efficient outcome. For example, carbon subsidies are often used to support R&D, new technologies, green jobs, and to provide financial certainty and attract private investment in nascent industries (e.g., IEA, 2023). These

94

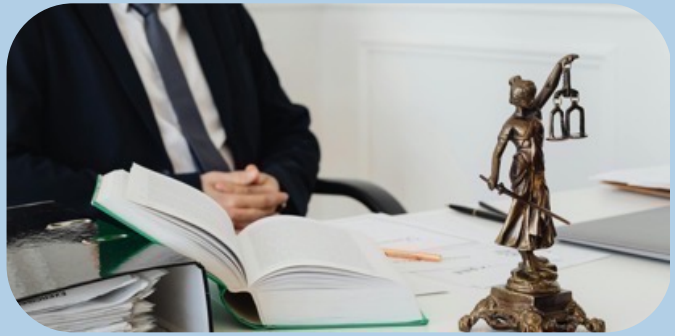
zenodo

https://doi.org/10.5281/zenodo.17341212

Carbon Rewards (XCR) for Mobilizing Trillions of Dollars

How does the financial mechanism mobilize US $3–6 Trillion per year?

Grantor



Carbon Exchange Authority

- XCR grantor for climate mitigation
- manages the XCR registry and rules
- offers XCR via long-term contracts

Foreign Exchange

XCR Settlement System

- XCR is for investing (not a currency)
- XCR would be registered in ISO4217
- XCR (carbon) is analogous to XAU (gold)

Guarantor & Investors

Central Bank Alliance

- mandated as the “XCR buyer of last resort”
- guarantor for the XCR price floor
- encourages private investment in XCR

XCR Supply → XCR Price Discovery ← XCR Demand

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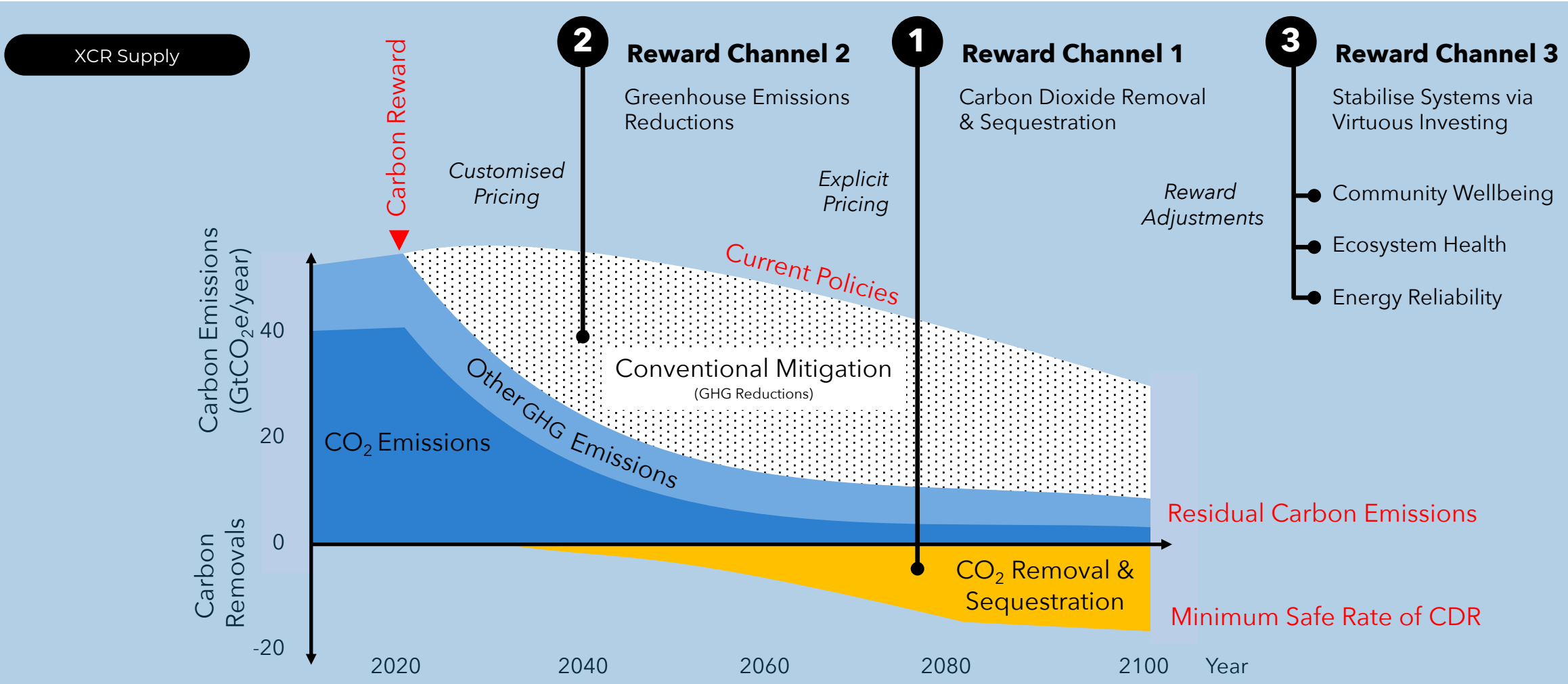
Three Channels for Earning Carbon Rewards (XCR)

How is the carbon reward (XCR) supplied to the market?

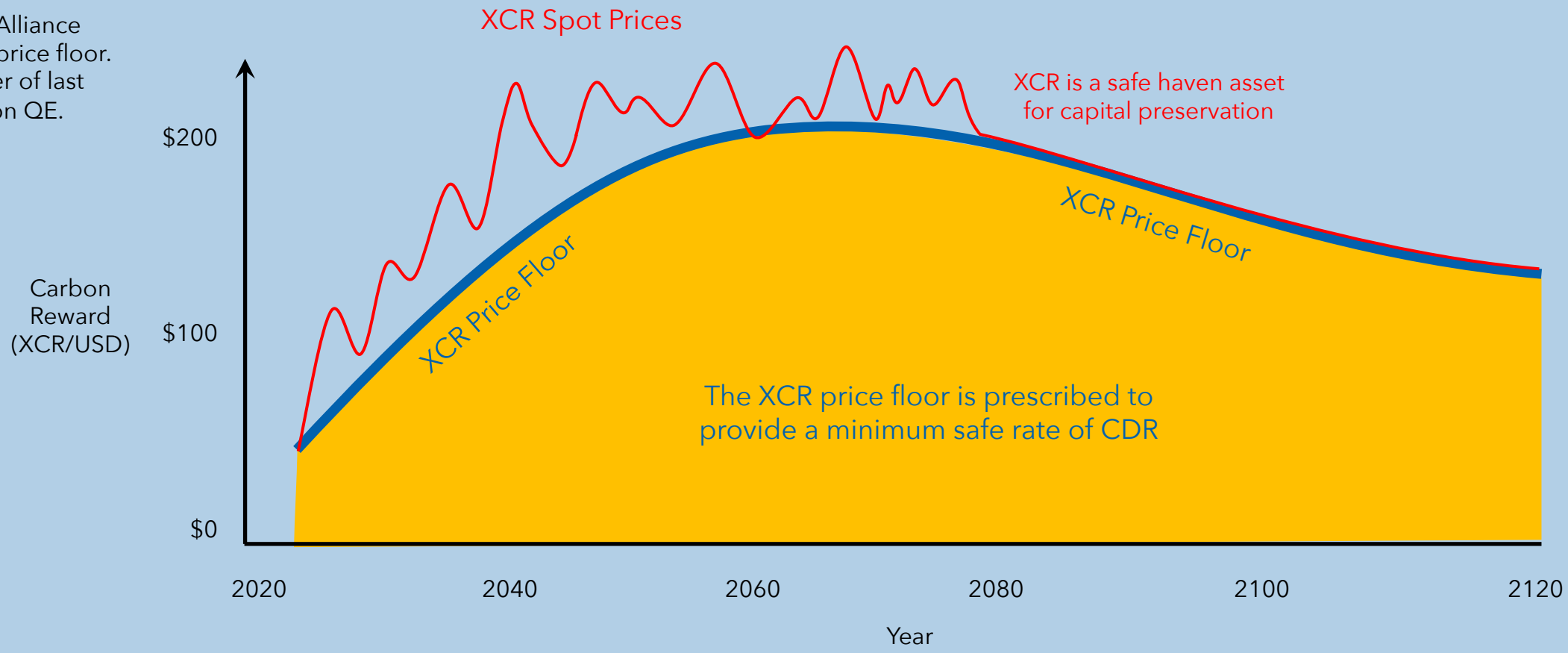


The XCR Price Floor for Mobilizing Finance

The XCR price floor is calibrated to price the minimum rate of CDR that is needed

XCR Demand

The Central Bank Alliance guarantees the XCR price floor. They are the "buyer of last resort" via Carbon QE.



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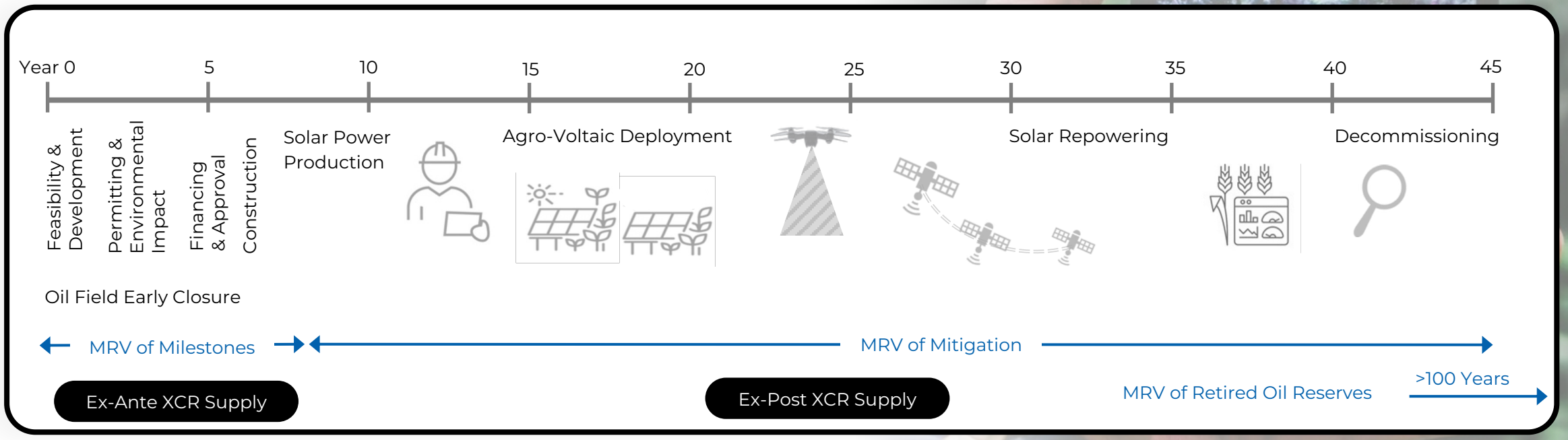
Long-Term Reward Contracts

Example of an “Energy Asset Exchange” for a Transition Away from Fossil Fuels (TAFF)

Example: Contract for Replacing an Oil Field with a Solar Plant

- greater cooperation with FF producing companies and countries
- addresses the high capital cost of renewable energy plants
- coordination of global energy supplies and demand for an orderly TAFF
- avoids stranding of FF assets and stabilizes financial markets



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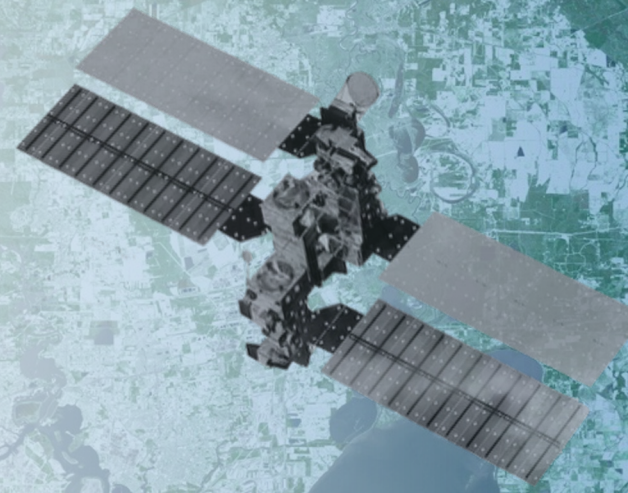
Operational Use of Satellite Services

Digital Earth would grow and evolve with the carbon reward market

The carbon reward market would grow to US $3-6 Trillion p.a.

XCR Supply



Earth Observation (EO) Requirements Include:

- **Baseline Monitoring**
  measurement of baseline conditions before projects launch—to help quantify existing vegetation, infrastructure, and emissions baselines.
- **Milestone Verification**
  confirming the completion of construction for ex-ante reward payments, and checking against permitting and design claims.
- **Performance Tracking**
  monitoring of ongoing mitigation outcomes for ex-post reward payments and verifying alignment with contractual targets.
- **Long-Term MRV**
  formalization of satellite services through long-term contracts that are designed for consistency and trust.
- **Early Warning**
  detecting project risks, such as environmental stress (e.g. deforestation), equipment failures, or misconduct.
- **Data Integration**
  fusing hyperspectral data with ground data for accuracy and context.
- **Digital Process Automation**
  automated execution of specific contract clauses, possibly using AI, may be efficient or necessary in certain situations.
- **Specialized Analyses**
  forecasting, forensics, and dispute resolution.

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Implementation Pathway

How can you support this initiative?

Policy implementation will be a collaborative process, unfolding in stages

Possible ISDE Taskforce ?

- Aligned with Digital Earth Framework 6
- Defined ISDE mandate
- Defined deliverables
- Aligned with ISDE governance model

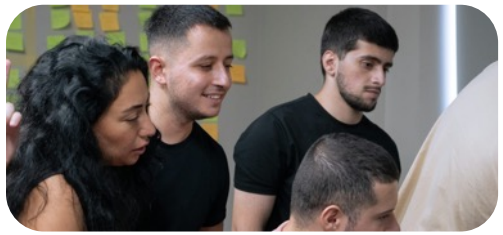
International Society for Digital Earth

Disclaimer: This slide does not imply endorsement by the ISDE. No formal agreement currently exists between the Global Carbon Reward and ISDE.

GCR Working Groups

GCR Working groups will:

- undertake policy reviews
- provide governance
- give strategic advice
- build support
- provide workshops
- disseminate the policy.



Feasibility Study

The feasibility study will:

- interview experts, industry leaders, and stakeholders
- assess the policy's mitigation potential
- assess the economic impacts
- asses the policy's legal & governance architecture.

Reward Pilots

A "club" of countries may:

- act as a provisional CEA
- set the XCR price floor, rules, and accounting standard
- issue XCR grants for a small portfolio of CDR and mitigation projects
- enable private XCR trading with regulatory approvals.

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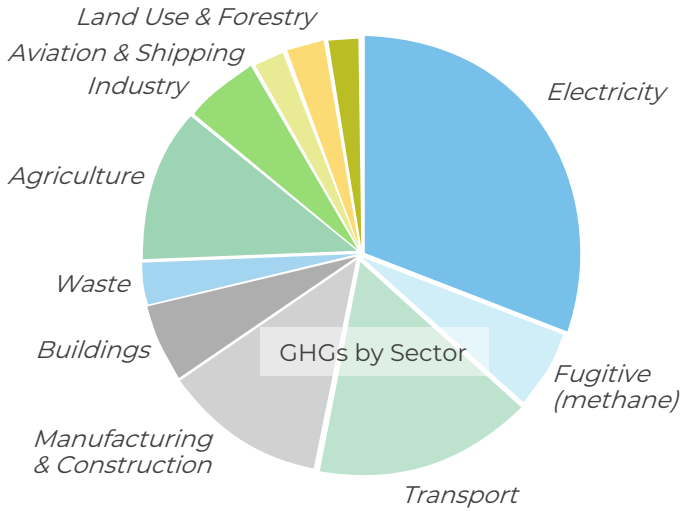
Feasibility Study & Pilots

What is the theory of change?

The focus will be consultations and telling a powerful story

Which industries will be included in the feasibility?



Policy consultations will be conducted with industry leaders from polluting sectors.

What kinds of pilots are recommended?

A "club" of countries will volunteer to undertake reward pilots, such as:

- **Energy Asset Exchanges**
  a small oil & gas reserve in a tropical rainforest, to be exchanged for a solar power plant
- **Avoided Deforestation**
  a vulnerable region of biodiverse Amazonian rainforest to be protected
- **Carbon Dioxide Removal (CDR)**
  a promising new CDR solution
- **Hard-to-Abate Transport**
  a cargo ship or commercial airplane solution
- **Carbon-Intensive Buildings**
  a multi-story apartment retrofitted for heating.

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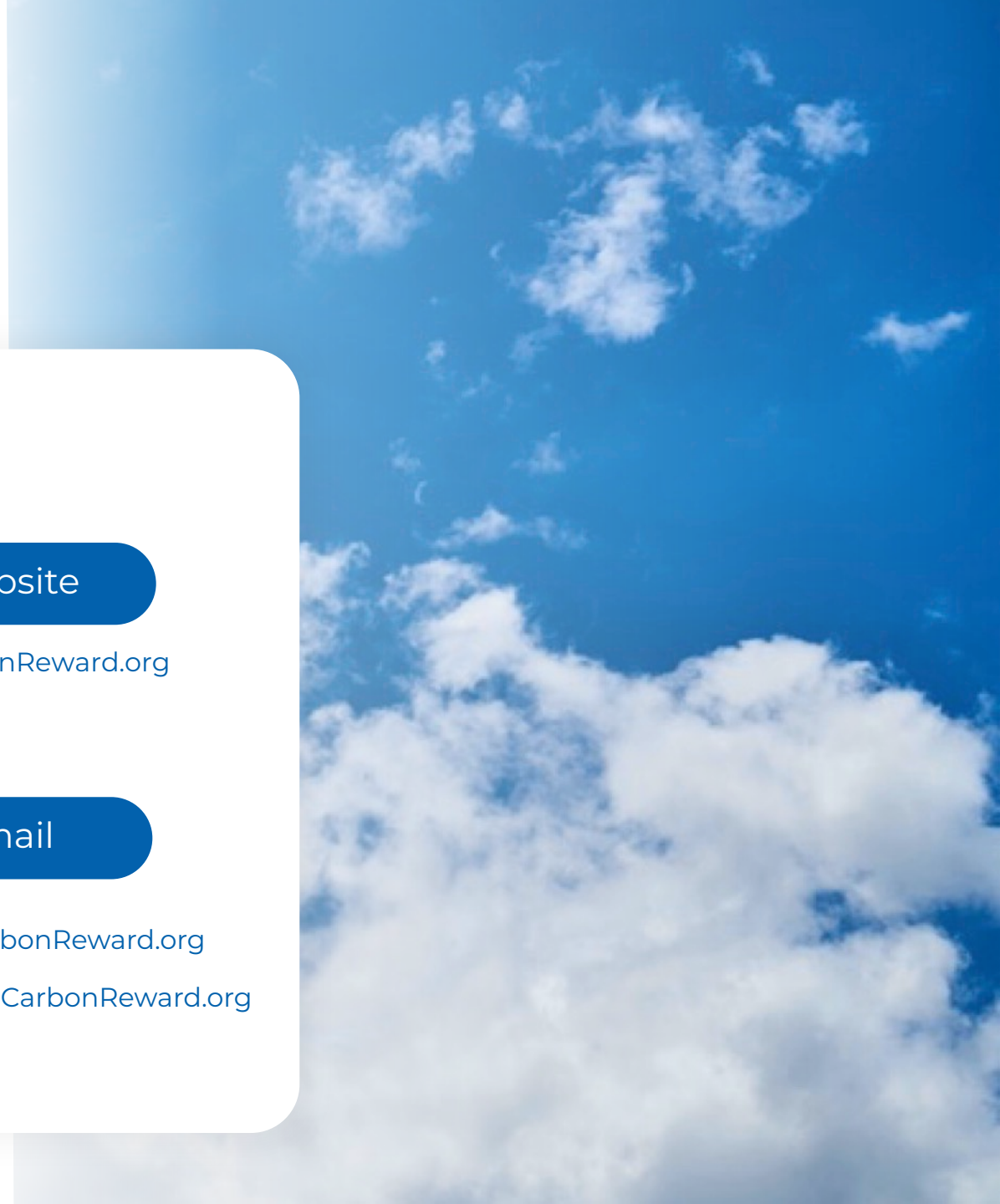
Thank You

We invite you to

- review the carbon reward policy
- join the GCR working group
- support the feasibility study

Be a pioneer who took meaningful action to preserve our planet.



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Additional Slides

Version: May 11, 2026

The XCR instrument is not a Carbon Credit!

The XCR is a carbon-linked sovereign-backed asset

1 Unit of Account for Reward Channel 1

1 XCR = 1 tonne of atmospheric CO_2e removed and stored for 100+ years

A uniform price signal will be created for a global CDR market (R=1)

2 Unit of Account for Reward Channel 2

1 XCR = 1/R tonnes of CO_2e emissions mitigated for 100+ years

R = a project specific “reward multiplier” for cost-effective outcomes

- XCR is not a carbon credit because carbon offsetting is not allowed
- XCR is not a cryptocurrency and is not money
- Carbon budgets are recorded in project-level carbon accounts
- The XCR supply is only an approximate measure of aggregate mitigation.