Climate Clubs and Next-Generation Technologies

Accelerating DAC, Fusion, and SAI through International Cooperation

Joseph E. Aldy · Kevin R. Wagner · Eric Werker

Big Picture

Climate clubs could accelerate next-generation climate risk technologies (NGCRTs)

- Existing climate policy insufficient to hit Paris goals
- DAC, Fusion, and SAI hold promise but face underinvestment
- Clubs can solve investment and legitimacy failures blocking DAC, Fusion, and SAI

Introduction

- 30 years of climate policy = rising emissions
- Need portfolio beyond abatement:
  - **Abatement** (emissions cuts)
  - **Amelioration** (temperature mgmt)
  - **Adaptation** (risk mgmt)
- NGCRTs: **Direct Air Capture (DAC)**, **Nuclear Fusion**, and **Stratospheric Aerosol Injection (SAI)**

The Technologies

DAC

DAC is technically feasible, but still too costly

- Pulls CO_2 directly from air
- Geologic storage or reuse in fuels, concrete
- Costs falling, but still well above $100/t target

DAC Today

- 27 DAC plants currently commissioned worldwide capture **0.01 Mt CO_2/yr**
- Need ~85 Mt CO_2/yr by 2030; ~1,000 Mt CO_2/yr by 2050
- 130 DAC facilities currently in development
- Funding gap: billions required for hubs, R&D, and cost reduction

DAC Faces High Costs and Fragmented Support

- Still far above commercial viability despite falling costs
- Reliant on subsidies, tax credits, and philanthropic support
- Fragmented national programs; some projects tied to Enhanced Oil Recovery, fueling legitimacy concerns

Nuclear Fusion

Fusion promises dispatchable, zero-carbon energy, but remains elusive

- For decades, “always decades away”
- 2022: U.S. NIF achieved scientific breakeven (historic milestone)
- Since 2021, startups raised **$6B+** (e.g., CFS, TAE, Helion)

Fusion Momentum

- Helion–Microsoft PPA (2023): target electricity by 2028
- UK, Japan, Korea, EU launching national fusion roadmaps
- DOE Milestone-Based Fusion Development Program: $50M round for private developers

Fusion Challenges

- Still long horizon: cost, reliability, grid integration uncertain
- High fixed costs, uncertain IP, geopolitical sensitivity
- Risk of fragmentation into national “industrial strategies”

SAI

- Mimics volcanic eruptions by reflecting sunlight
- Potential to keep warming <1.5°C
- Cheap relative to adaptation: est. $2–20B annually

SAI: Technically Plausible, Politically Unsettled

- No active deployment pathways; research funding remains weak
- Civil society resistance (e.g., canceled field tests) highlights “moral hazard” fears
- Public opinion divided and easily mobilized against experiments
- Normative divide: U.S. emphasizes feasibility; Europe emphasizes safeguards

SAI Research Landscape

Research is fragmented and underfunded

- Most work: climate modeling & social science inquiry
- Very limited outdoor testing; high-profile projects canceled
- New entrants (philanthropy, startups, UK ARIA) raise legitimacy concerns

Governance & Legitimacy I

Cautious research raises unique political risks

- “Paradox of prudence”: even small, transparent experiments can provoke stronger opposition
- Early tests often framed as a slippery slope toward deployment

Governance & Legitimacy II

Institutions lag behind the risks

- Competing visions: calls for a **non-use agreement** vs. cautious research frameworks
- CBD moratorium on large-scale deployment remains unresolved
- No multilateral oversight; fragmented national approaches, weak transparency

NGCRTs: Main Barriers

Why DAC, SAI, and Fusion are stuck

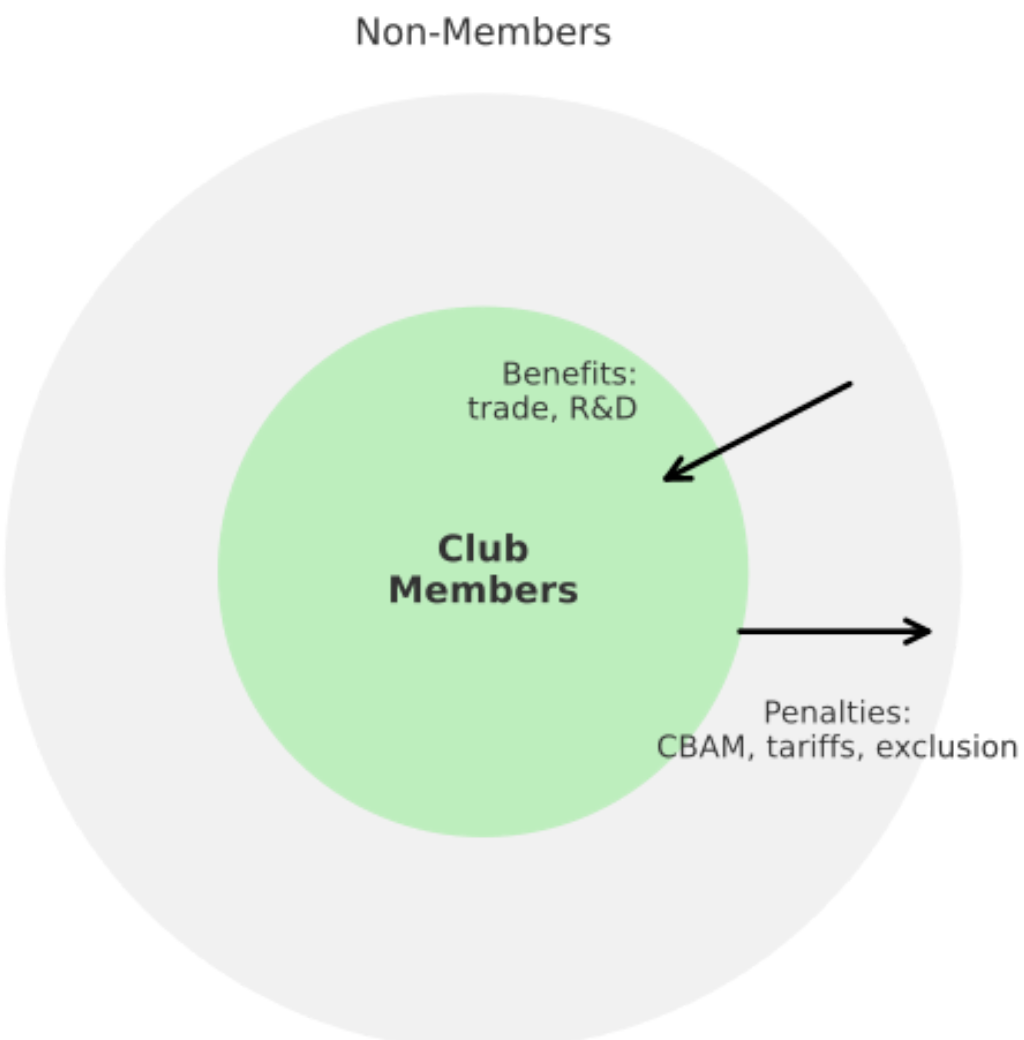
Technology	Core Failures	Domestic Policy Gaps
DAC	High costs, underinvestment	Carbon pricing & subsidies insufficient
SAI	No market, stigma, legitimacy deficit	Weak funding, NGO opposition, no regulatory framework
Fusion	Huge upfront costs, long horizon	Fragmented efforts, no commercialization path

Climate Clubs: The Idea

If national policies can't overcome these barriers, international cooperation may provide the missing piece

- Small group of states coordinate outside UNFCCC
- Nordhaus: provide club goods (e.g., trade benefits), exclude free riders
- Variants: bargaining clubs, normative clubs, transformational clubs

Climate Clubs: Visualized



Lessons from Past Clubs

- **Major Economies Forum (MEF):** bargaining, fell short on R&D
- **Clean Energy Ministerial (CEM):** coordination + standards, not binding
- **Mission Innovation (MI):** aimed to double R&D, fell short (38%)

Club Design 1: Portfolio of Innovation

Each member supports a different NGCRT, benefits spill over internationally

- Countries coordinate to **reduce duplication** while supporting domestic firms.
- Builds **clusters of expertise** (e.g., DAC hub, fusion champion)
- National firms gain first-mover advantages; other members benefit via spillovers
- Incentives: club members get both domestic rents + global risk reduction

Club Design 2: Pooled Resources for Innovation

Members collectively fund high-cost or stigmatized NGCRTs.

- Targets **early-stage, capital-intensive, or legitimacy-challenged** techs (fusion, SAI)
- Spreads **risks and costs** across members
- International cooperation provides **legitimacy shield** for controversial R&D.
- Incentives: reduces stigma at home, lowers costs per country

Comparing Club Designs

Portfolio vs. Pooled: Different tools for different technologies

- **Portfolio:** best for nearer-to-market NGCRTs (e.g., DAC)
- **Pooled:** best for long-horizon or stigmatized NGCRTs (fusion, SAI)
- Both approaches require **credible enforcement + stable financing.**
- Hybrid clubs possible: mix tech-specific leadership with pooled basic science

Policy Levers

Clubs need credible tools to shift incentives

- **Carbon border tariffs (CBAMs):** finance R&D or penalize laggards
- **Procurement coordination:** pooled offtake (e.g., DAC, fusion pilots)
- **Standards & certification:** harmonize MRV for NGCRTs, reduce market fragmentation

How Clubs Help

Clubs can address the very barriers stopping NGCRTs

Technology	Club Contribution
DAC	Coordinate subsidies, share procurement, integrate into CBAMs
SAI	Pool research funds, build legitimacy, coordinate governance norms
Fusion	Pool R&D resources, reduce duplication, share breakthroughs, provide legitimacy

SAI and Climate Clubs

Clubs could help provide legitimacy and governance for research

- Pool funding for open, transparent research (separating R&D from deployment)
- Develop common procedural norms: MRV, stakeholder engagement, codes of conduct.
- Provide **political cover** for cautious experimentation
- Manage risks of unilateral action or private capture

Conclusion

- NGCRTs are a necessary complement to emissions mitigation
- Current investments and governance fall far short of what's needed
- Climate clubs can align incentives, pool resources, and build legitimacy where domestic policies fail
- Without clubs, NGCRTs risk stagnation — with clubs, they can become viable tools for managing climate risk

Thank You

Questions?

(Draft – comments welcome)