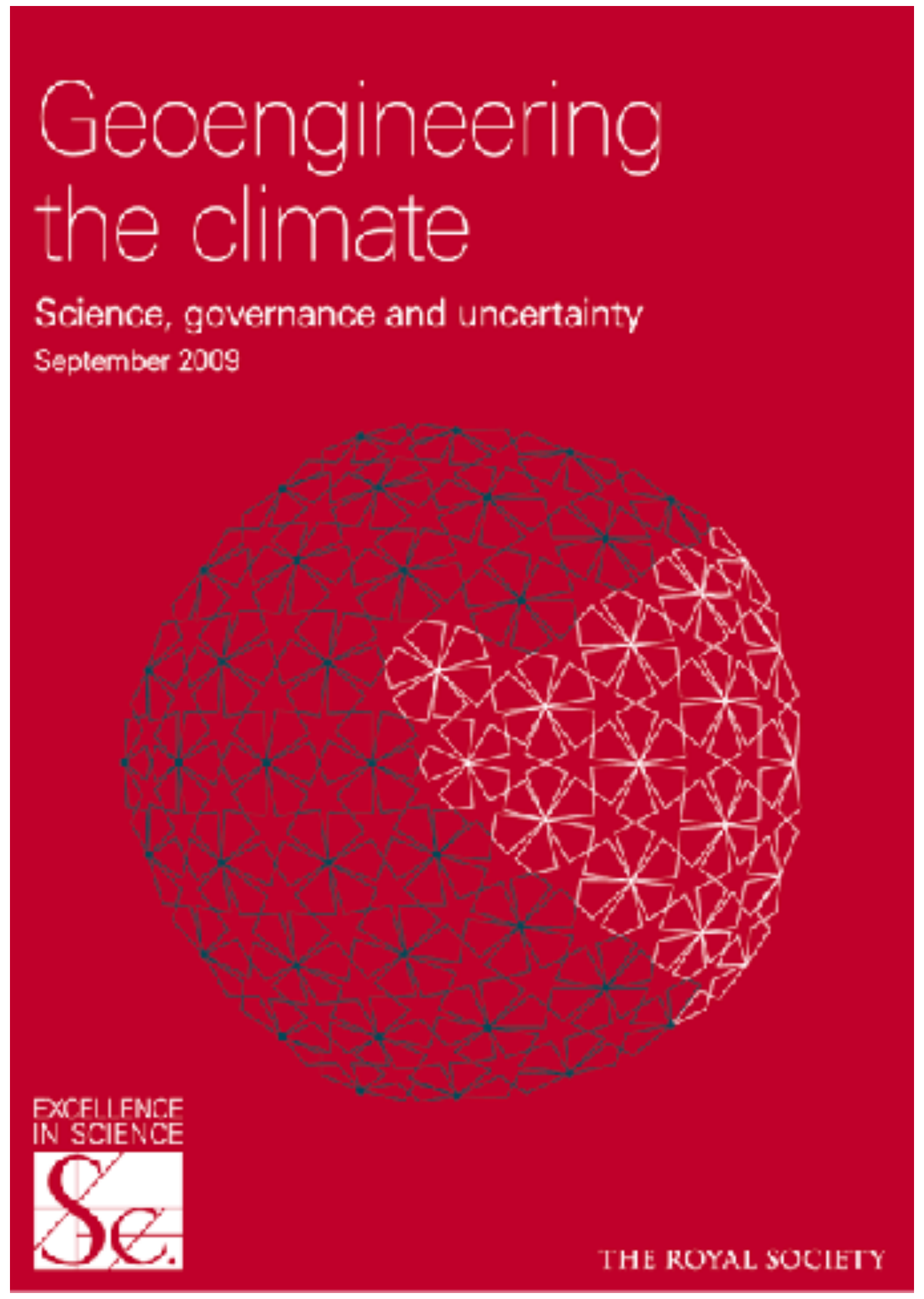
Climate intervention: Integrative research needs

Climate Intervention in an Earth Systems Science Framework: A Workshop

Holly Jean Buck / June 20, 2023

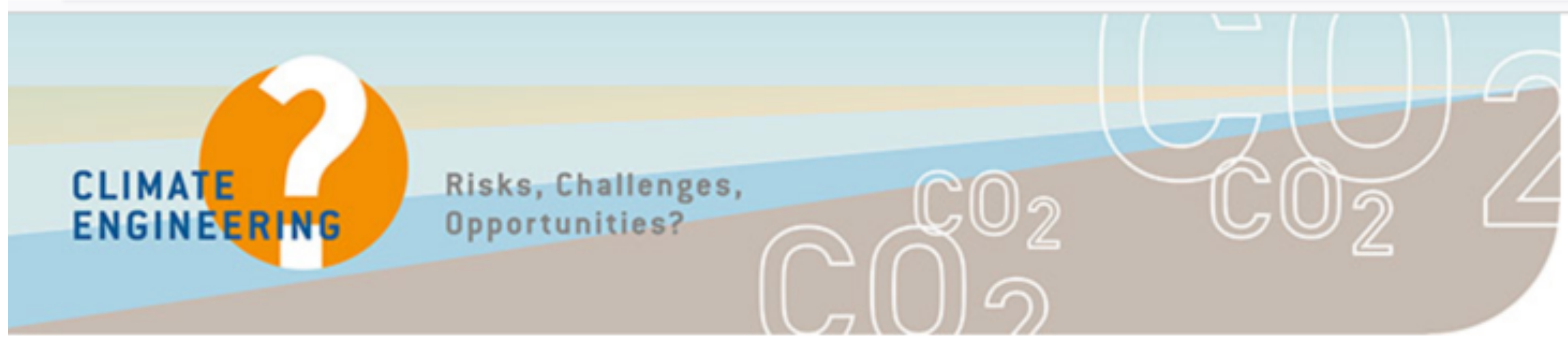
2010s: Interdisciplinary, assessment-focused paradigm



UK Research Councils: "Integrated Assessment of Geoengineering Proposals", 2010 - 2015, GBP 1.7 million

German Research Foundation: "Climate Engineering – Risks, Challenges, Opportunities?" SPP 1689, 2013 - 2019, EUR 10 million

European Union: "European Transdisciplinary Assessment of Climate Engineering", 2012 - 2014, EUR 1.3 million



DFG Deutsche Forschungsgemeinschaft

Integrating physical, engineering and social sciences to construct a framework for assessing effectiveness and side effects of geoengineering proposals.

The IAGP project was funded from October 2010 to February 2015.

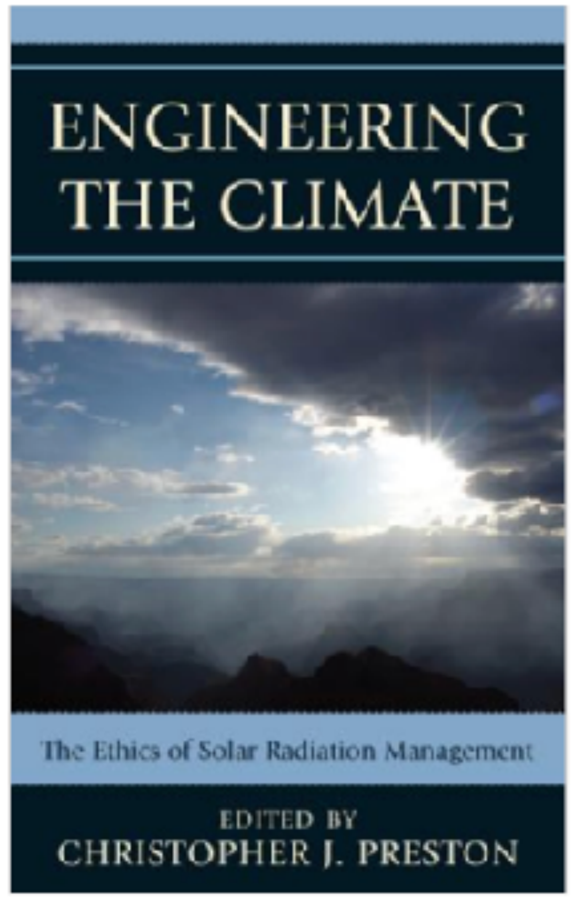
IAGP Research: What have we learned?

IAGP
Integrated Assessment of Geoengineering Proposals

2010s: NSF funding within interdisciplinary, assessment-focused paradigm

- The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management - University of Montana, 2010 - 2014, $375K

- What are Sustainable Climate-Risk Management Strategies? Penn State, 2012 - 2019, ~$~12 million — "What are sustainable, scientifically sound, technologically feasible, economically efficient, and ethically defensible climate-risk management strategies?"



What do we have today?

What happened?

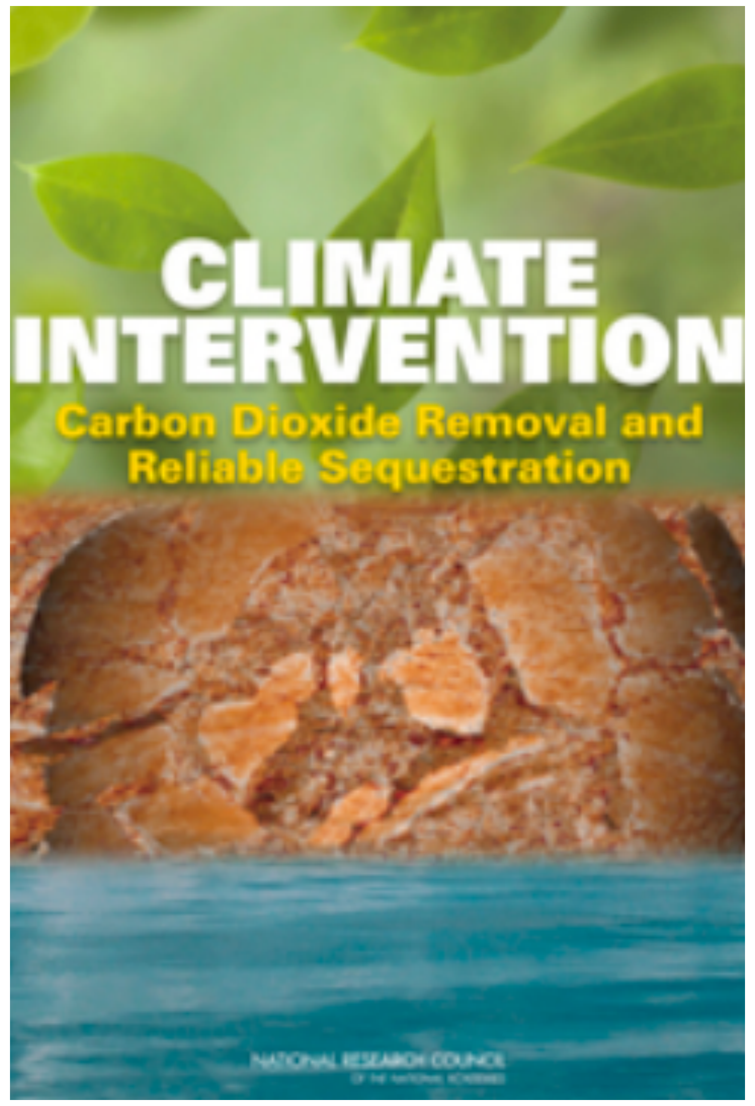
- We said what there was to say on SRM, without more field research?
- Lack of progress on climate change and CDR becoming “real” led to more trepidation about researching them?
- Decreased social science interest in doing interdisciplinary research with these kinds of scientists on these topics?
- NAS laid out the next steps on interdisciplinary assessment-oriented research, and we chose not to take them?

So then what?

- Do we need more assessment, or something else?
- Do we need a different style of assessment?

Table 3.2 Continued

	Point-Source Capture	Direct Air Capture	Biological Land Based	Biological Ocean Based	Accelerated Weathering Land Based	Accelerated Weathering Ocean Based
NOTES:	Fuel/fuel gas		Afforestation, soil, land management	Ocean Iron fertilization		
Negative environmental consequences						
Minor: mostly local impacts; can be mitigated consistent with current national environmental protection standards		●				●
Medium: potentially serious impacts that may be difficult to mitigate to current environmental protection standards	●		●		●	
Major: severe national or global impacts incompatible with current environmental protection standards; impacts may exceed environmental benefits of climate change mitigation				●		
Environmental co-benefits						
High: numerous and/or very likely co-benefits, such as protection of watersheds from erosion, wildlife habitat and diversity, recreational opportunities, or reduction in ocean acidification			●			
Medium: modest or uncertain co-benefits						●
Low: very few or no co-benefits	●	●		●	●	
Sociopolitical risks (include national security)						
Minor: limited and mostly local economic and social impacts	●	●				
Medium: potential for serious national or regional economic, social, political, or security impacts that may be difficult for governments to manage			●	●	●	●
Major: potential for severe national and regional economic hardship, social dislocation, political instability, and civil or military conflict						



NAS (2015)

What went right with CDR / geoengineering assessment

- Basic idea that approaches would have risks as well as (co)benefits
- Development of high-level principles
- Built interdisciplinary understanding and common language

What was missing

- Focus on "technical potential" without social constraints
- The social implications inhere in the implication, not the technology
- Understanding that policymakers rarely choose based on these assessments

The energy piece at scale

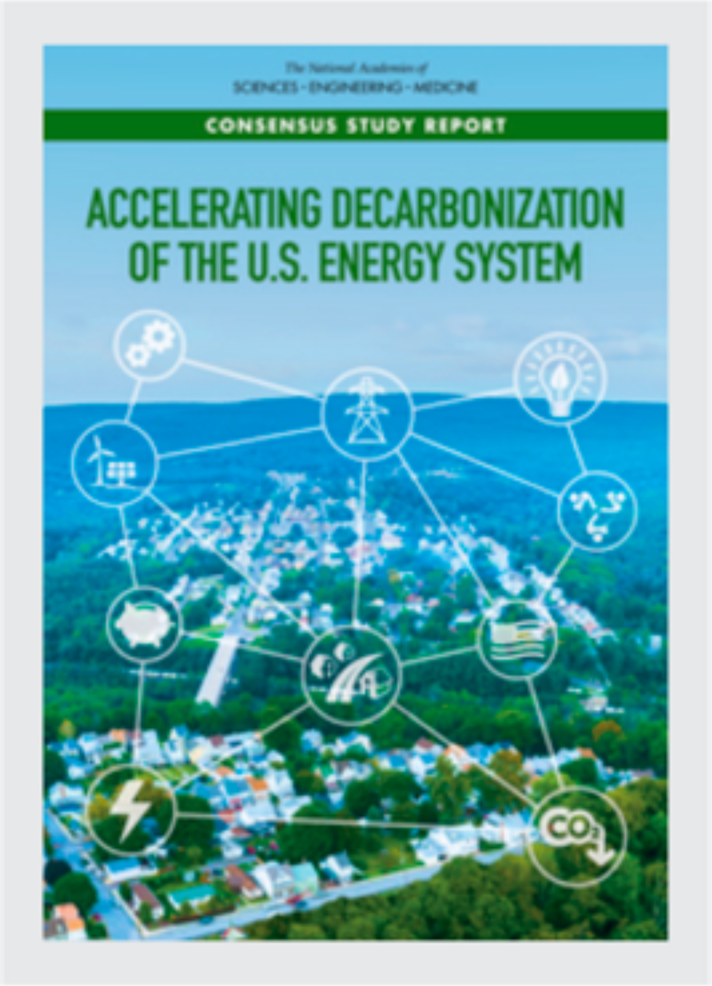
- Critical minerals
- Land availability for renewables
- Global networks for H2
- Geopolitics of fossil fuel phaseout / support for producer nations

The land piece at scale

- International support to end deforestation, destruction of wetlands, peatlands, etc.
- Conversion of grazing land to forest
- Increased soil carbon sequestration

Decarbonization is an intentional, planetary-scale project to change climatic conditions

- Have we gone through and created these assessments of various technologies / approaches that should be included in the portfolio?
  - If not, why not?
  - Should we?



8. There are many pathways to zero emissions, and they share several core features.

All plausible pathways to zero emissions share core features: decarbonizing electricity; switching to electricity and other low-carbon fuels for energy services in the transportation, industry, and buildings sectors; increasing energy efficiency in each of those sectors, in the power sector, and in materials; increasing carbon sequestration, and reducing emissions of non-carbon climate pollutants.

In particular, there is strong agreement among deep decarbonization studies on the following points:

- *Energy and materials efficiency:* One of the lowest-cost decarbonization opportunities helps to reduce the overall need for low-carbon fuels and electricity, and will continue to be important across all economic sectors through the next 30 years (Williams et al., 2014; White House, 2016).
- *Zero-carbon electricity:* The electric power sector should cut emissions faster and deeper than other sectors of the economy in order to meet economy-wide targets, owing to the comparative ease and wide range of zero-carbon generation options (Kriegler et al., 2014; White House, 2016; Morrison et al., 2015; Williams et al., 2014; Krey et al., 2014).
- *Electrification and fuel switching:* Electrification of energy services where possible—for example, space and water heating in buildings, light-duty cars and trucks, and some industrial processes—is key to further reducing the use of fossil energy in the end-use sectors (Kriegler et al., 2014; White House, 2016; Morrison et al., 2015; Williams et al., 2014; Jacobson et al., 2015; Steinberg et al., 2017). Zero- and low-carbon fuels can then meet much of the remaining demand for liquid and gaseous fuels (de Pee et al., 2018; ETC, 2018; Davis et al., 2018).
- *CCS:* Important for mitigating industrial process emissions, CSS may also be a useful option for the power sector (IPCC, 2018; de Pee et al., 2018; Rissman et al., 2020; Friedmann et al., 2019; ETC, 2018; Sepulveda et al., 2018).
- *Non-CO_2 gases:* These are more challenging to address, although options exist to transition away from hydrofluorocarbons (HFCs) in refrigeration and cooling, and to minimize emissions of methane and nitrous oxide (IPCC, 2018).
- *Negative emissions:* Enhancing carbon sequestration through land sinks and negative emissions technologies is important to counter residual emissions from non-CO_2 gases and hard-to-abate energy sectors that are impossible or prohibitively expensive to eliminate completely (IPCC, 2018; NASEM, 2019).

We risk failing at the energy transition if we don’t do a better job with evaluating the full impacts of our mitigation portfolio and composing it with care / including publics

The primary project is to fully roadmap the transitions

- Analysis of social impacts / EJ analysis
- Global impacts across supply chains, from critical mineral extraction and processing of renewables to end-of-life
- Land use implications
- Full roadmaps for how each country can multi-transition each sector
- Anticipation of the international dimensions / geopolitics of fossil fuel phaseout

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We are starting to do this now, but not at the scale required, not in an interdisciplinary and global fashion, and we should have done it twenty+ years ago

Our framework should deal with carbon removal alongside decarbonization

- What's special about carbon removal technologies that's distinct from mitigation technologies / approaches?
- From a human dimensions standpoint, they seem deeply entwined
  - Residual emissions policy: the more sectors that are "hard-to-abate", the more CDR needed
  - Business case for frontier approaches (biomass gasification, electrochemical ocean approaches) may rest on producing H2
  - Geological storage and associated infrastructure fundamental to CDR and CCS mitigation
  - Renewable energy needs for DACCS, others critical to whether they can scale
  - Biomass management associated with BECCS / power sector
  - Agricultural decarbonization interactions with enhanced weathering, soil C, etc.

Carbon removal already happens

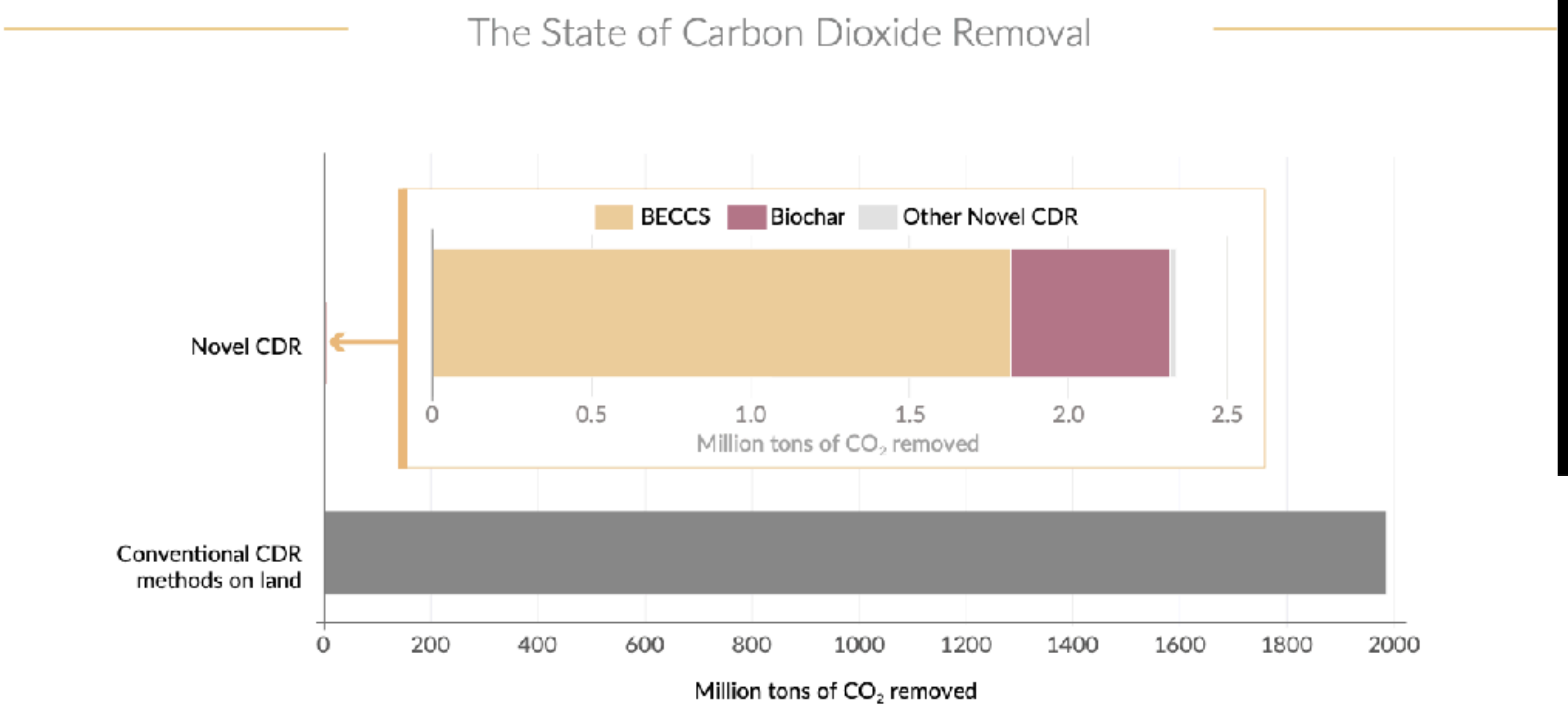
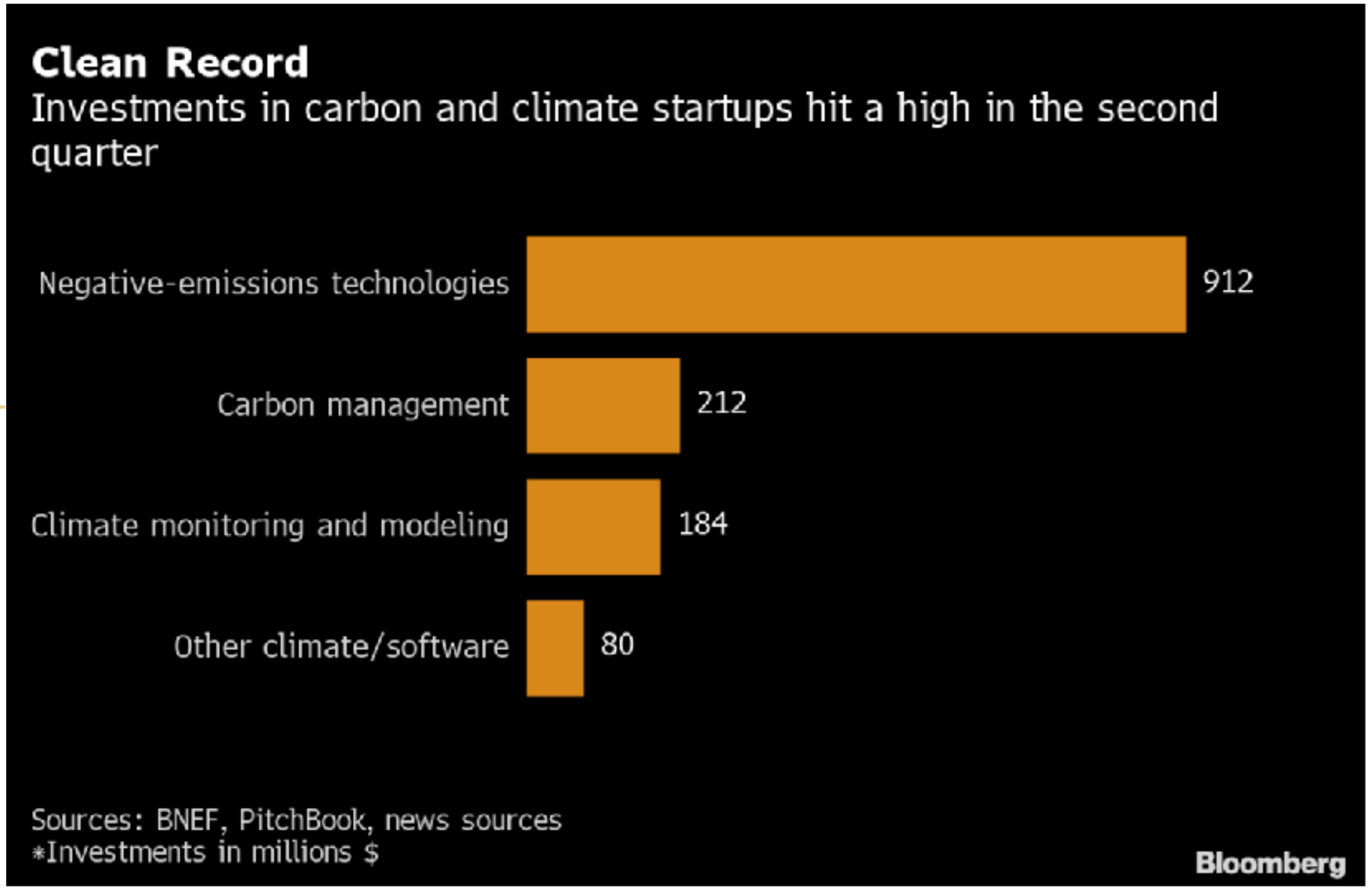


Figure 6.3. *Estimate of current Carbon Dioxide Removal (CDR) deployment. Definition: Bioenergy with Carbon Capture and Storage (BECCS).*

State of CDR report



US long term strategy includes CDR

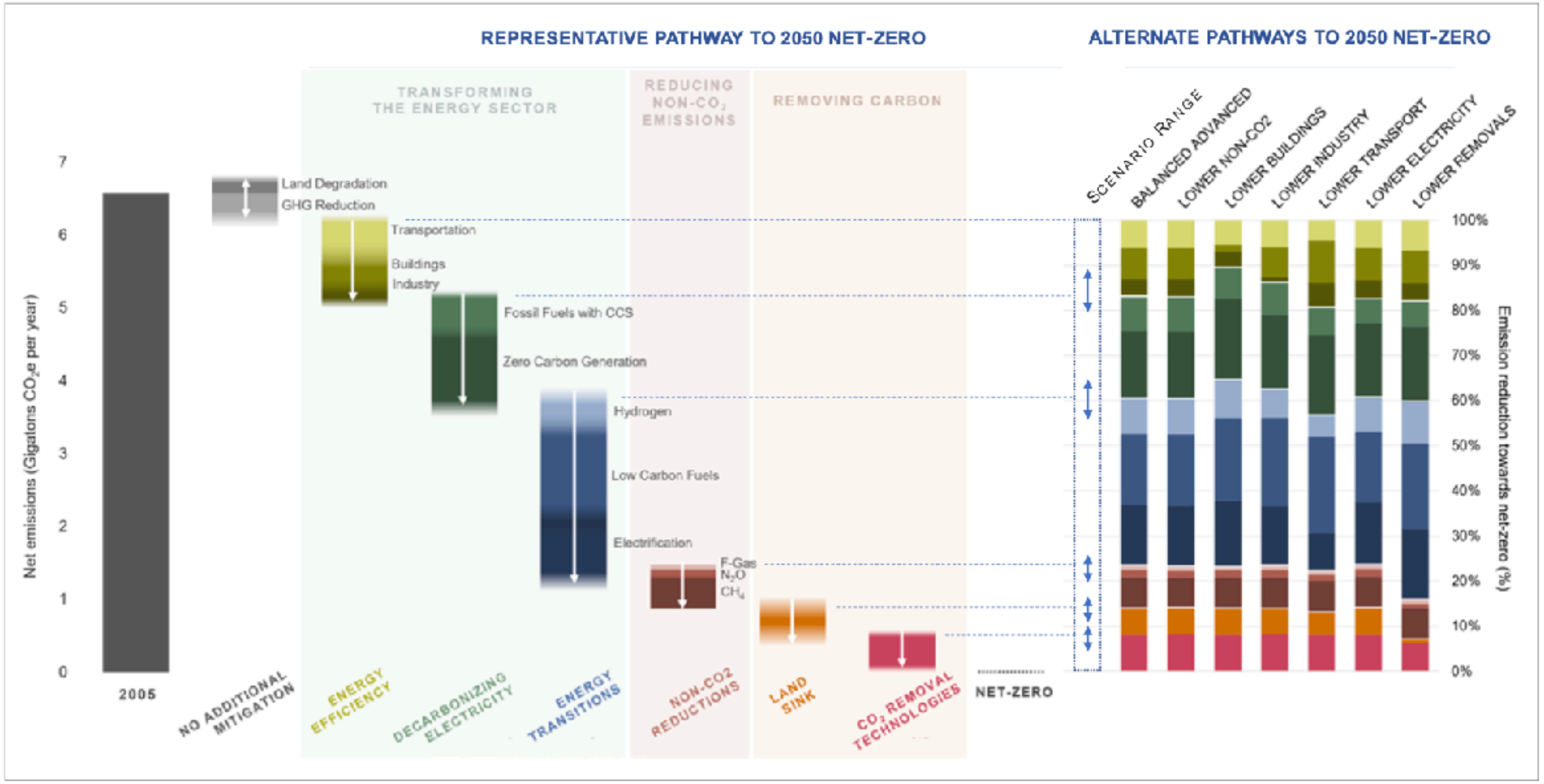


Figure ES-2: Emissions Reductions Pathways to Achieve 2050 Net-Zero Emissions in the United States. Achieving net-zero across the entire U.S. economy requires contributions from all sectors, including: efficiency, clean power, and electrification; reducing methane and other non-CO_2 gases; and enhancing natural and technological CO_2 removal. The left side of the figure shows a representative pathway with high levels of action across all sectors to achieve net-zero by 2050. The right side shows a set of alternative pathways depending on variations in uncertain factors such as trends in relative technology costs and the strength of the land sector carbon sink.

CHAPTER 6:

REMOVING CARBON THROUGH 2050 AND BEYOND

6.1 THE NECESSITY OF CO_2 REMOVAL TO REACH NET-ZERO

Efficiency, electrification of end uses, decarbonization of the electricity sector, and reduction in non-CO_2 emissions are the most important levers for decarbonizing the U.S. economy and will be the emphasis of the overall strategy to reach net-zero by 2050.

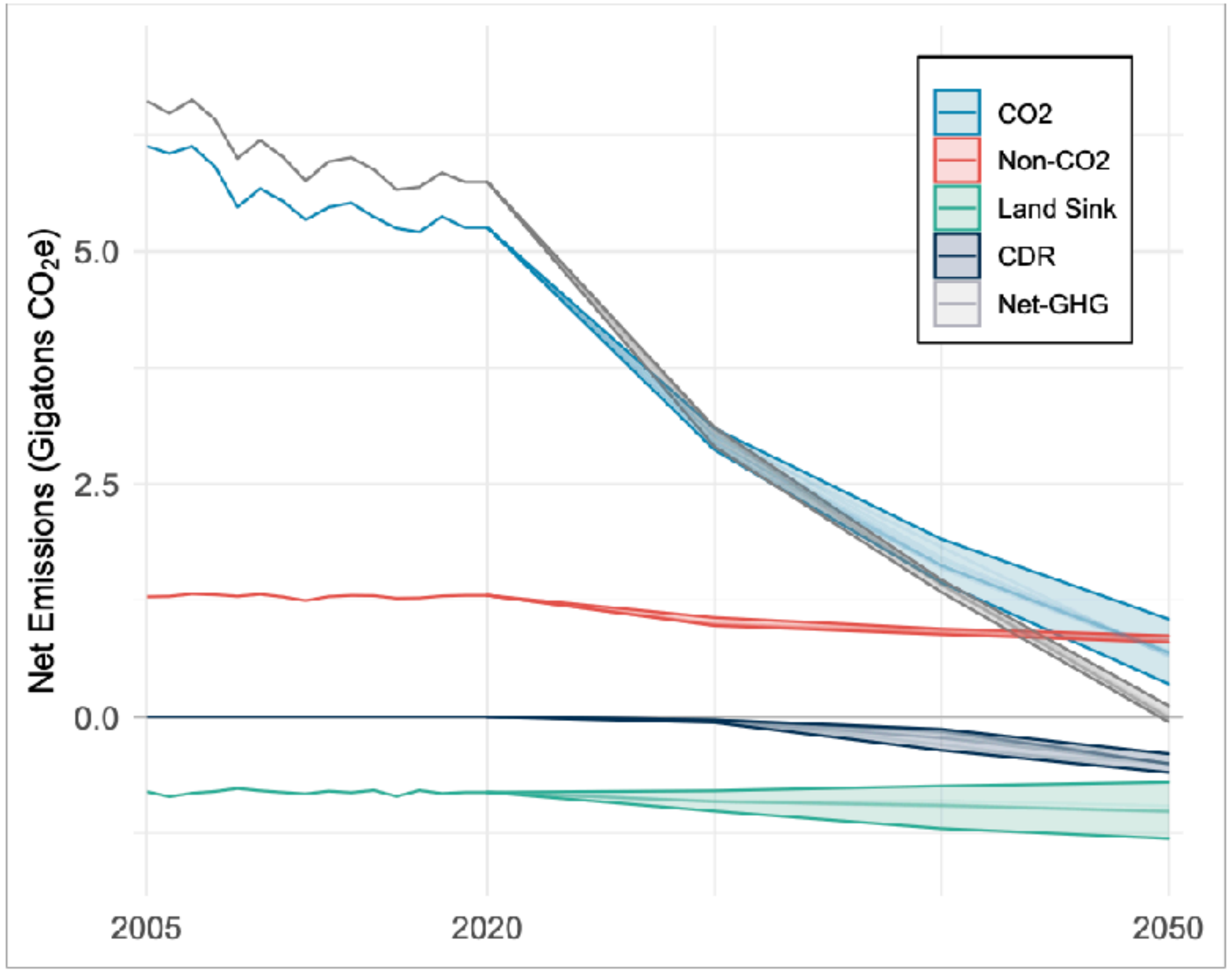


Figure 17: Balancing Emissions Reductions and Removals to Reach 2050 Net-Zero. This figure shows the range of outcomes for mitigation pathways as well as removals pathways to achieve net-zero by 2050. Some sources of non-CO_2 emissions, and potentially some CO_2 emissions, cannot be reduced to zero, and these must be balanced by CO_2 removals. CO_2 removals can happen through land sinks, such as forest growth and soil carbon sequestration, or through carbon dioxide removal technologies such as direct air capture or carbon capture and sequestration in industry or electricity generation. Note: Historical data in this figure are from the U.S. GHG Inventory (2021).

US Long-Term Strategy

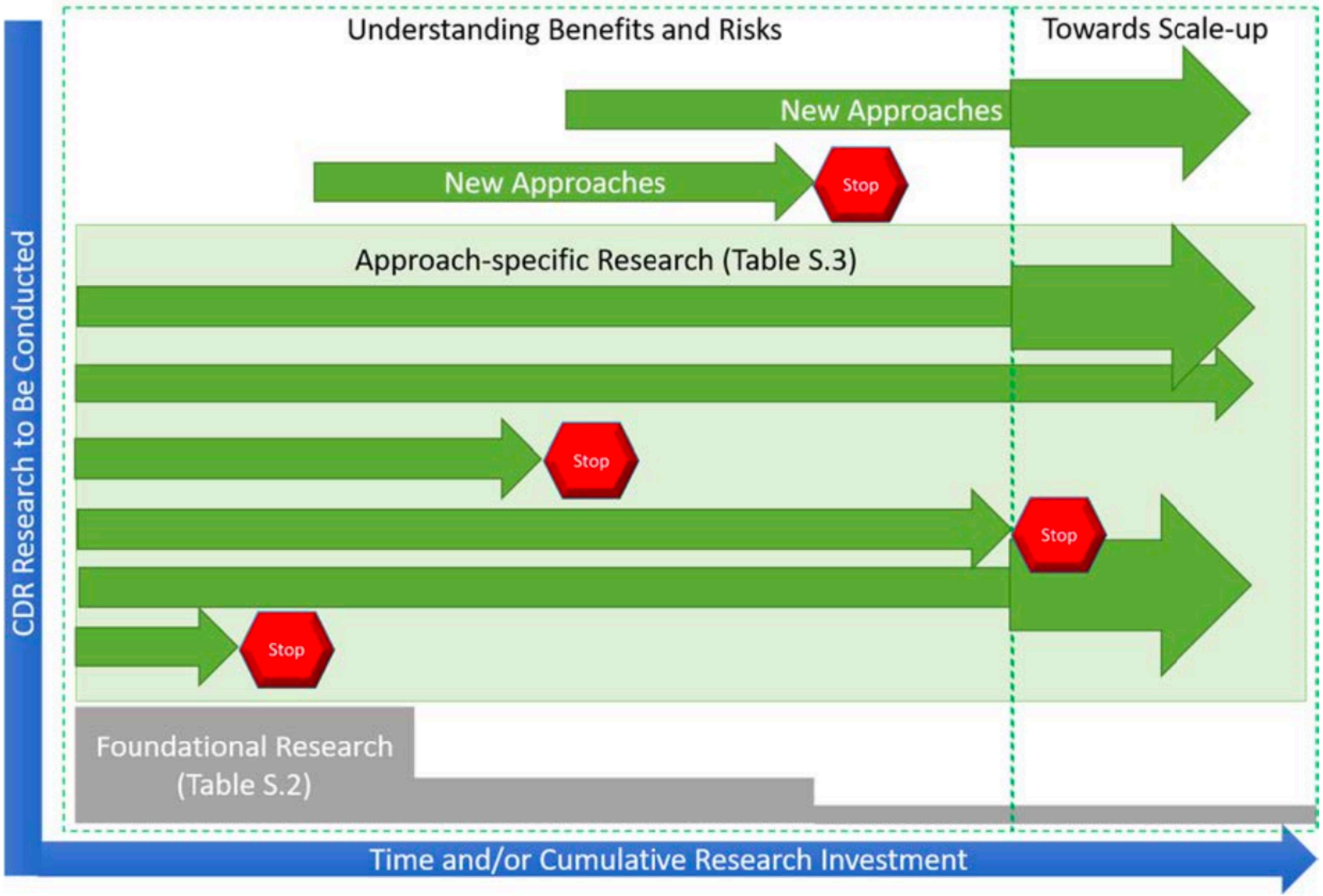


FIGURE S.2 Conceptual timeline of ocean-based CDR research based on Tables S.2 and S.3. Stops included on the diagram represent possible internal and external showstoppers or barriers to a particular approach.

Solar geoengineering is different

Though it should be assessed holistically with mitigation, CDR, and adaptation

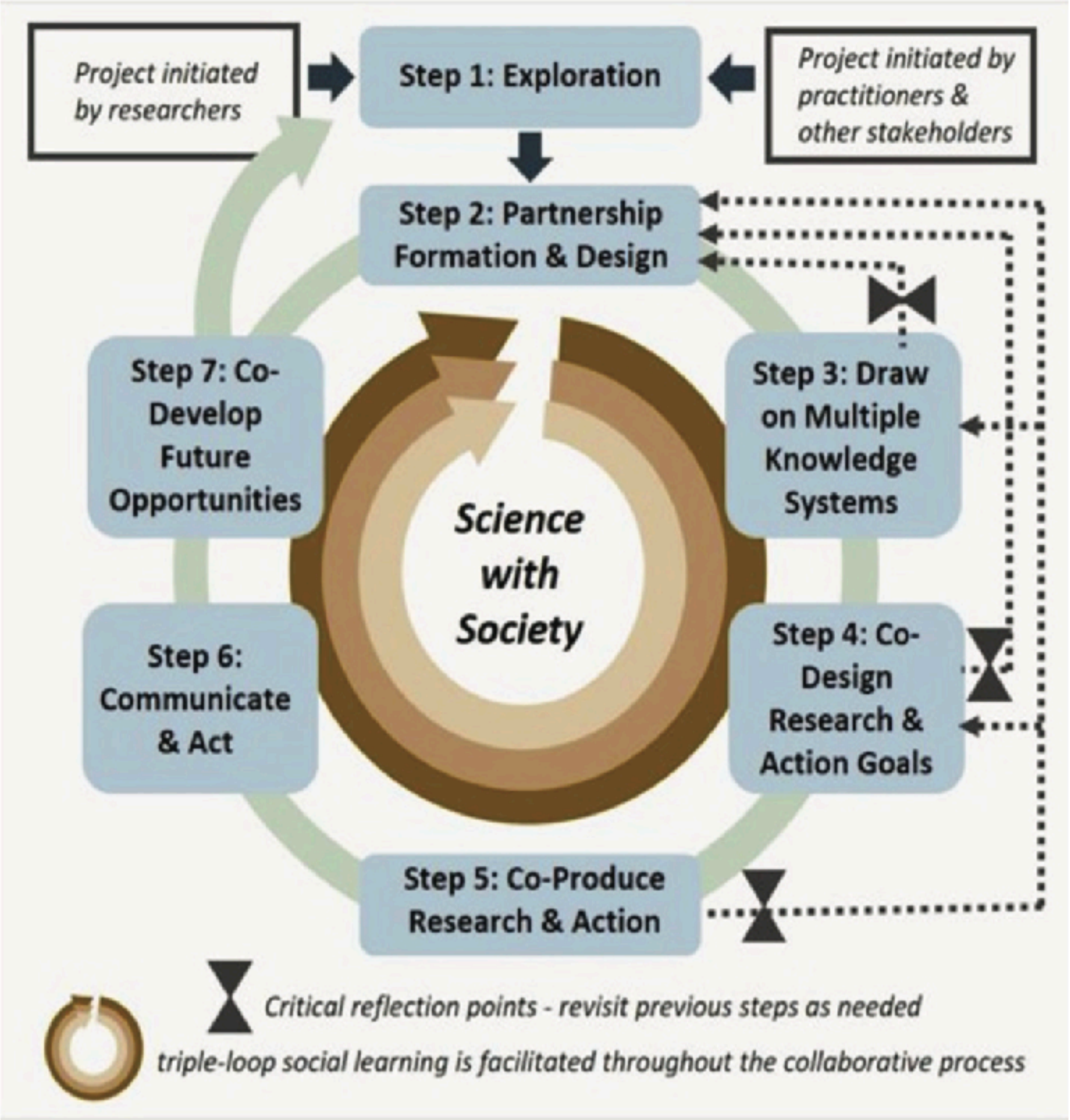


FIGURE 4.2 Conceptual model for transdisciplinary or convergence research, based on a survey of people around the world who have engaged in such research projects. SOURCE: Reprinted with permission from Elsevier from Steger, C., J.A. Klein, R.S. Reid, S. Lavorel, C. Tucker, K.A. Hopping, R. Marchant, T. Teel, A. Cuni-Sanchez, T. Dorji, G. Greenwood, R. Huber, K-A. Kassam, D. Kreuer, A. Nolin, A. Russell, J.L. Sharp, M.Š. Hribar, J.P.R. Thorn, G. Grant, M. Mahdi, M. Moreno, and D. Waiswa. 2021. Science with society: Evidence-based guidance for best practices in environmental transdisciplinary work. *Global Environmental Change* 68. https://doi.org/10.1016/j.gloenvcha.2021.102240.

NAS Next Generation Earth Systems Science report

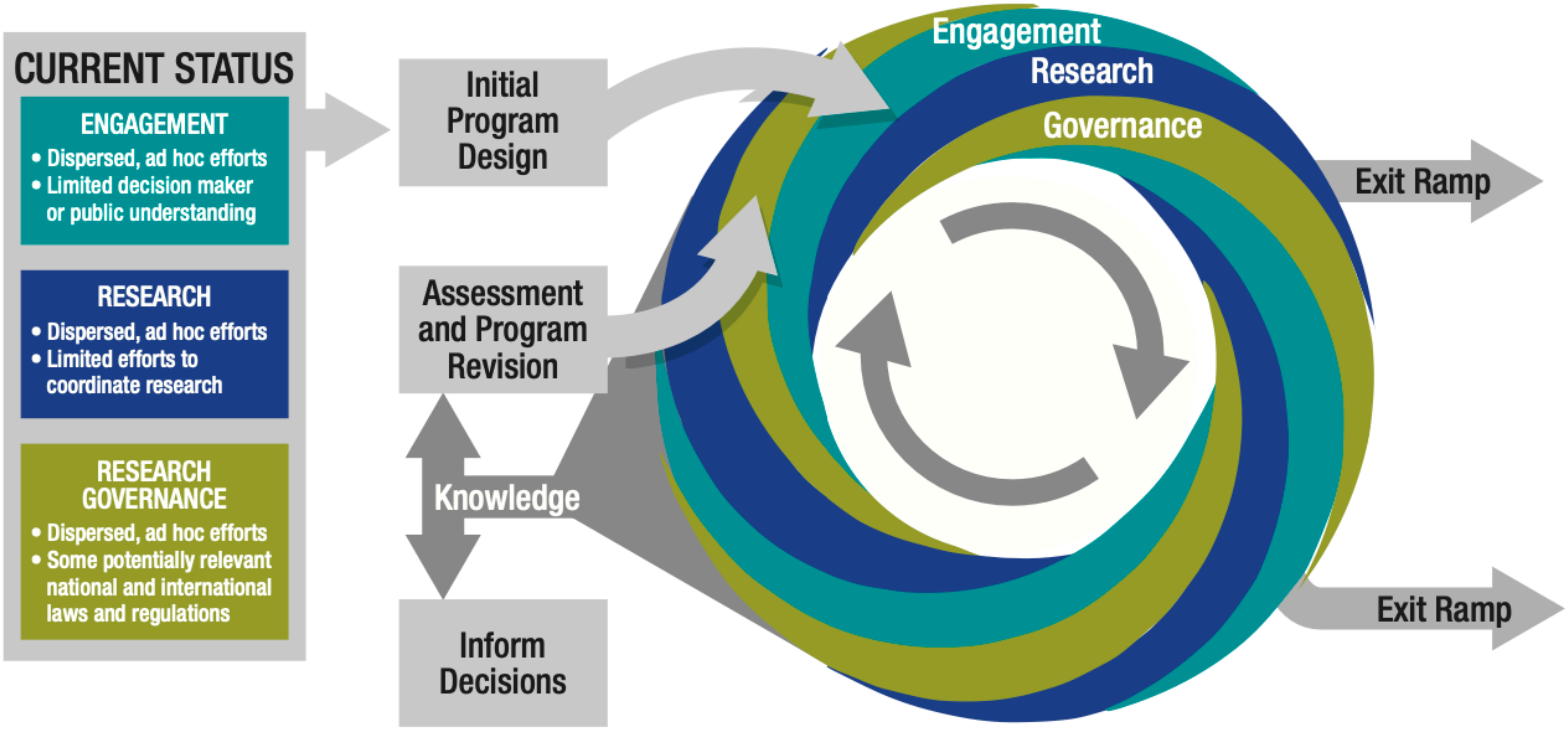


FIGURE S.2 Schematic of SG research and research governance environment.

Solar geoengineering research: core needs

1. Systematic examination of risks and failures
2. Multiscalar public understanding and engagement, to…
    - Scope questions of importance to local resource users, globally
    - Support domestic policymaking, globally

The research needs are global: international centers, international fellowship programs, international summer schools