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Project Report

Solar Radiation Management: Foresight for Governance

Miranda Boettcher (IASS)
Johannes Gabriel (Foresight Intelligence)
Sean Low (IASS)

Abstract

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This report addresses the emerging debate regarding the governance of solar radiation management (SRM). It draws heavily on outcomes from three workshops held in Potsdam in July, August, and November 2015. However, this piece is both a summary and a reflection on the part of the authors on these meetings and does not necessarily reflect the views of all participants or organisers.

Since solar radiation management (SRM) technologies do not yet exist and capacities to model their impacts are limited, governance proposals are implicitly designed not around realities, but possibilities – baskets of risk and benefit that are often components of sociotechnical imaginaries. The project Solar Radiation Management: Foresight for Governance (SRM4G) aimed to make discussion of such imaginaries explicit, and to nudge the mode of thinking about the future of an engineered climate from predictive to anticipatory.

Leveraging the participation of scholars and practitioners heavily engaged in early conversations on SRM governance, SRM4G applied scenario construction to generate a set of alternative futures, each exercising different influences on the need for – and challenges associated with – development of SRM technologies. The scenarios then provided the context for the design of systems of governance with the capacity and legitimacy to respond to those challenges, and for the evaluation of the advantages and drawbacks of different options against a wide range of imaginary but plausible futures.

In doing so, SRM4G sought to initiate a conversation within the SRM research community on the capacity of foresight approaches to highlight how central sociotechnical imaginaries are to discussions of SRM's risks and benefits, to examine and challenge the assumptions embedded in conceptualizing SRM's aims, development and governance, and to discuss the capacity of (or the need for) governance options to adapt to a wide range of possibilities.

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1. Introduction

1.1 Governing solar radiation management

Debate has grown in recent years around the controversial idea of solar radiation management (SRM): a set of hypothetical approaches that suggest that reflecting a small portion of incoming sunlight back into space can reduce climate warming and mitigate some of its impacts. SRM is often subsumed under the broader term of "geoengineering" or "climate engineering," generally defined as deliberate and large-scale interventions in the climate system aimed at counteracting the impacts of climate change (Royal Society 2009; IPCC 2012, 2014; NAS 2015; EuTRACE 2015).

The promise of certain SRM approaches lies in their apparent potential to lower global temperatures swiftly and inexpensively in comparison to decarbonising the world's energy economy at a time-scale and cost necessary to forestall severe climatic impacts. Some note that SRM might halt or slow the rate of temperature rise for a limited period, complementing more comprehensive mitigation efforts by buying time for them to take effect. Others argue that SRM might provide a targeted response to abrupt and non-linear "climate emergencies" or an option for managing the risks from committed climate change. Others, however, fear that the physical impacts of SRM use could prove very damaging, that SRM would be difficult to deploy or govern fairly or effectively, or that even considering SRM might lead to states and other actors reducing their mitigation and adaptation efforts.

SRM, however, currently does not exist as full-fledged technologies and deployment strategies, but as immature and un-scaled research activities. As SRM emerges into a complex landscape of issues, actors, and agendas in global politics, it will pose challenges at every stage, from conceptualisation, to research and development, to deployment. Most of these challenges – ranging from SRM's potential to reduce mitigation efforts, to impacts upon state and human security – have entwined societal, technical and environmental dimensions and could consist of sequences of events that cannot be concretely predicted.

Questions of how to govern SRM have thus been central to early discussions. What are the actors, institutions, mechanisms, and criteria needed to explore and navigate these challenges? How best to hold conversations on the objectives of SRM? How to provide funding and set guidelines for research and experimentation, or to monitor and modulate the impacts of deployment, should it be deemed necessary?

Proposals for governing different stages of the development or deployment of SRM range from self-governance by scientific communities (at least in the research context), to leveraging national legislation on an ad-hoc basis, to governance by one or several international bodies (a non-exhaustive list includes Victor 2008; ETC Group 2010; Rayner et al 2013; Zuern and Schaefer 2013; Morgan, Nordhaus & Gottlieb 2013; Bodle and Oberthuer 2014; Parker 2014; Lin 2015). However, these proposals differ in many ways: the range of technologies addressed, the stage of innovation targeted, the mandate, membership, capacity, perceived legitimacy of the institution or mechanism, and the threats and opportunities that are emphasised as the most important for governance to navigate.

1.2 Applying scenarios to SRM governance

Solar Radiation Management: Foresight for Governance (**SRM4G**) focuses upon this last point. Since SRM technologies do not yet exist and capacities to model their impacts are limited, governance of stages of activities from development to deployment is implicitly designed not around realities, but possibilities. Proposals refer to baskets of risk and benefit that are often components of sociotechnical imaginaries: visions of futures in which SRM research and deployment has (or has failed to) become a reality, positing a range of imaginary but compelling outcomes that influence how SRM is engaged with in the here and now. Yet, these imaginaries are subject to implicit, ambiguous assumptions about the shape of future developments, and to the biases which accompanies the expertise of their proponents. This can make it difficult to compare and evaluate individual proposals.

SRM4G aimed to make discussion of such imaginaries explicit, and to nudge the mode of thinking about the future of an engineered climate from predictive to anticipatory: a reorientation from "navigating 'what will be'" to "preparing for alternative 'what ifs?'". Can scholars and practitioners involved in debates over SRM governance engage experimentally with conceptions of the future derived from a broad field of perspectives? Can the capacities of various governance designs be explored within a space of possibilities rather than a "predict and control" paradigm?

SRM4G thus sought to apply foresight methods – namely, the construction of *scenarios* – to enable structured thinking about complex systems and possible futures containing many unknown unknowns, and to provide an initial framework for a future-oriented discussion of SRM governance proposals.

1.3 What are scenarios?

Scenarios are "illustrations of possible pictures and histories of alternative futures" (Gabriel 2014: 3). Scenarios do not claim to predict the future; they are hypothetical thought experiments. According to Max Weber, a thought experiment is an instrument to construct relations between cause and effect under the assumption of an objective possibility (Weber 1985). Ideally, such thought experiments force participants to consider alternative future developments, linkages, threats and opportunities – including those on the outer edges of plausibility – in order to "chart a middle ground between under- and overprediction" (Schoemaker 1995: 27), and to imagine the future with an adequate rate of change.

This project makes use of **explorative scenarios**, which focus on the broader context of a topic in order to explore alternative future environments. These lie in contrast to policy scenarios, which examine alternative courses of action and their consequences. Explorative scenarios trace the complex interactions of a broad range of political, economic, technological, and social factors in a variety of hypothetical futures. They act as thought experiments that deal with alternative assumptions about and developments in the future, not with facts. Thus, they are context-dependent, subjective and not predictive.

For this reason, scenarios are not products of traditional scientific investigation, which aims at producing generalised explanations based on empirical evidence. However, they can be created in a rigorous manner. Scenarios draw upon inputs from multiple disciplines, as well as alternative assumptions, expectations, and worldviews. As individual biases lead to one-sided or linear thinking, **scenarios should be constructed by mutual learning in a process of group communication**. A methodologically sound process for scenario construction is goal-oriented, promotes critical reflection of the scenario development process, and allows for intersubjectivity, contributing to shared meanings and understandings (Gabriel 2014: 5–7). In short, scenario construction provides a **platform for structured communication** that facilitates interdisciplinary thinking about possible futures.

Moreover, scenario construction is a process that aims at the creation of consistent and plausible scenarios. A consistent scenario is composed of logically coherent parts called projections (see Section 2.3 for a comprehensive definition) that in their entirety describe a future situation. A plausible scenario provides a credible and comprehensive illustrative pattern of events that leads to a consistent future situation, exemplifying structural changes necessary to end up in a certain future situation.

Scenarios have nothing to do with probability, however plausible and consistent they may be. Scenarios force reflection on plausible directions and dimensions of change, and on collective capacities to influence those processes. Probability is a criterion for the reliability of explanations in social science. Probabilistic explanations, or prognoses, can examine only a very limited number of uncertainties by keeping everything else constant, and their explanatory power typically comes from extrapolating past trends. Making prognoses about the future assumes that change will happen to only a few uncertainties in an otherwise constant world (Gabriel 2014: 2–3). Still, probability is often used to express current expectations about future developments based on many ceteris paribus clauses and often implicitly assumes static (social) systems – which goes against the idea of scenarios based on alternative assumptions and expectations (Figure 1).

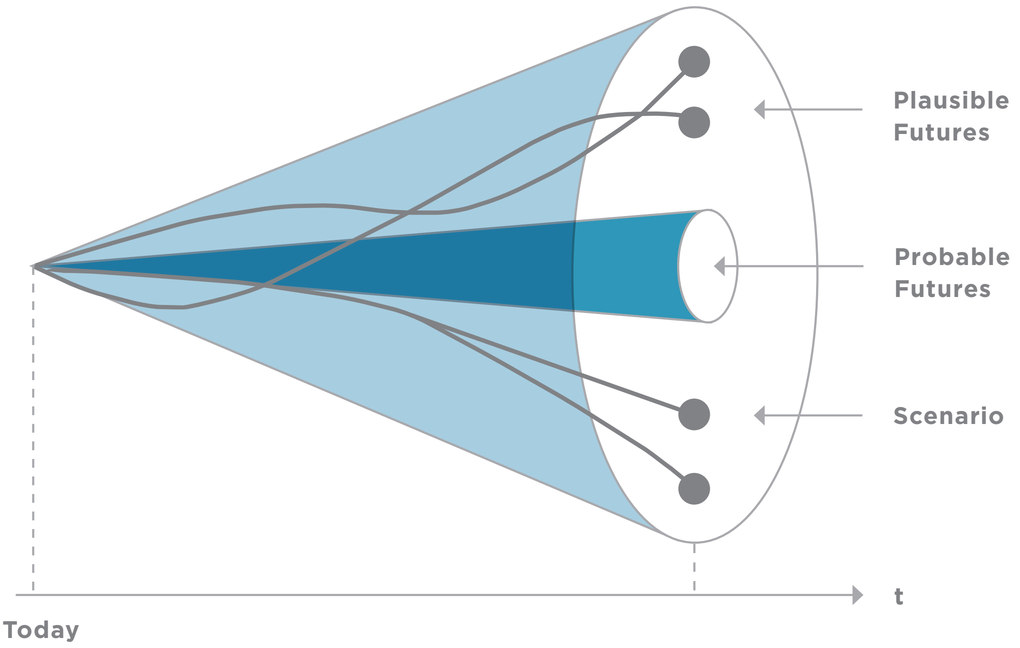

Figure 1: Scenarios describe plausible future situations to force reflection on dimensions of change that cannot be extrapolated from past trends.

Source: IASS SRM4G

1.4 Project aims

SRM4G, conducted in three workshops over the course of 2015, sought to design and test an interdisciplinary, participatory, and structured communication platform to enable future-oriented deliberations on the governance challenges facing the research and development of SRM technologies.

The project team, consisting of personnel from the Institute for Advanced Sustainability Studies and Foresight Intelligence, was responsible for overall process design, workshop facilitation, and production of the workshop report. Participants were primarily drawn from researchers and practitioners engaged in early conversations on SRM governance to ensure a level of basic literacy in the subject matter. Participants were also selected to reflect current nodes of research in Europe and North America, with the aim of creating a multidisciplinary group combining a wide range of expertises. Participants were responsible for content discussions, scenario construction, and deriving implications for SRM governance in both plenary settings and in breakout groups of 2–4 people, as well as for reflecting afterwards on the value of the scenario methods and results (for shortcomings in group composition, refer to Section 3, particularly Reflections on Scenarios Process).

The project applied foresight methods – centrally, the construction of imaginative scenarios – to generate a set of alternative futures suitable for exploring environments and contingencies that SRM governance options might potentially need to navigate. The richly-detailed storylines of events and actor landscapes of these scenarios each exercised different influences on the need for – and challenges associated with – the development of SRM technologies. The scenarios then provided the context for the design of systems of governance with the capacity and legitimacy to respond to those challenges, and for the evaluation of the advantages and drawbacks of different options against a wide range of imaginary but plausible futures.

In doing so, SRM4G sought to:

1. **Facilitate future-oriented communication in the SRM research community:** to initiate a conversation among scholars and practitioners involved in early discussions on SRM governance regarding the capacity of foresight and scenarios approaches to methodologically ground discussions of governance design regarding such future-oriented technologies.

2. **Consider plausible, not probable outcomes:** to highlight the centrality of sociotechnical imaginaries to discussions of the risks and benefits of SRM, and to consider an expansive range of challenges that cannot be derived from technical assessments or climate models.

3. **Increase critical reflection:** to examine and challenge the assumptions embedded in conceptualising SRM's aims, development, and governance.

4. **Explore and evaluate capacities of governance options against multiple futures:** to evaluate how well SRM governance options perform under alternative societal, political and environmental conditions, and to discuss the capacity of (or the need for) SRM governance options to be adaptable or resilient to a wide range of possibilities.

5. **Discuss but not recommend policy:** to generate future-oriented discussion on governance designs, without providing policy advice on specific SRM governance mechanisms.

1.5 Project design: timeframe and core assumptions

Every scenario project requires a clearly defined timeframe in order to set bounding conditions for the details and plausibility of the futures generated by its participants. The timeframe for SRM4G scenarios was set to 2030 because it is a reasonable period within which to anchor the imaginations and expertises of the participants, and because it was believed plausible by the project designers that ongoing research, as well as expanding conversations into policymaking and civil society, could lead to the development of SRM technologies requiring governance within fifteen years. It is less plausible that SRM technology could develop significantly within a shorter timeframe, and a longer timeframe (for instance, till 2050) would negate policy relevance and open up the room for discussion of barely recognisable developments due to a massive increase of future space.

In reference to the relatively short timeframe, further core assumptions were made in order to provide a foundation for the scenario construction process:

1. SRM field experiments of various intents and scales are plausible within the next 15 years (a useful initial typology can be found in Keith, Duren & MacMartin 2014). The upper boundary of such experimentation (in physical impact) was set at a "climate response test" (ibid. 3).

2. Project organisers made the decision to exclude the sustained deployment of SRM technologies

from the timelines of the scenarios for two reasons: because they did not consider it a plausible development within the next 15 years, and in order to focus more on the challenges of technological development than the long-term implementation and maintenance of a planetary sunshade. However, as the process developed, participants considered the governance challenges of deployment as well.

3. Whenever necessary, SRM is specified as stratospheric albedo modification (SAM). SAM was chosen due to its high profile in climate engineering assessments and the amount of attention paid both to its potential risks and its purported capacity to swiftly reduce global temperatures for what some estimate would be a low direct implementation cost (McClellan, Sisco, Suarez & McKeogh 2011).

4. It was also assumed that SRM and its possible futures cannot be analysed without reference to carbon dioxide removal, mitigation, and adaptation measures because the wider context of global climate governance influences the desirability and feasibility of climate engineering technologies. Thus, scoping the scenario project resulted in the definition of the topic as **"Global Responses to Climate Change in 2030"**, and the scenarios developed included a wide range of climate response strategies, including – but not limited to – SRM development.

2. Process description and scenarios

This section describes the methodology used to create explorative scenarios on global responses to climate change in 2030 (2.1–2.5), to identify the consequences of those scenarios for the governance of SRM (2.7), and to design and evaluate governance options (2.8 and 2.9). This section also includes the scenarios descriptions (2.6). For participants' reflections on these steps and the resulting scenarios, see Section 3.

The following illustration (Figure 2) is a schematic representation of the SRM4G scenario construction process, referring to the most important intermediate results. The individual steps are described below.

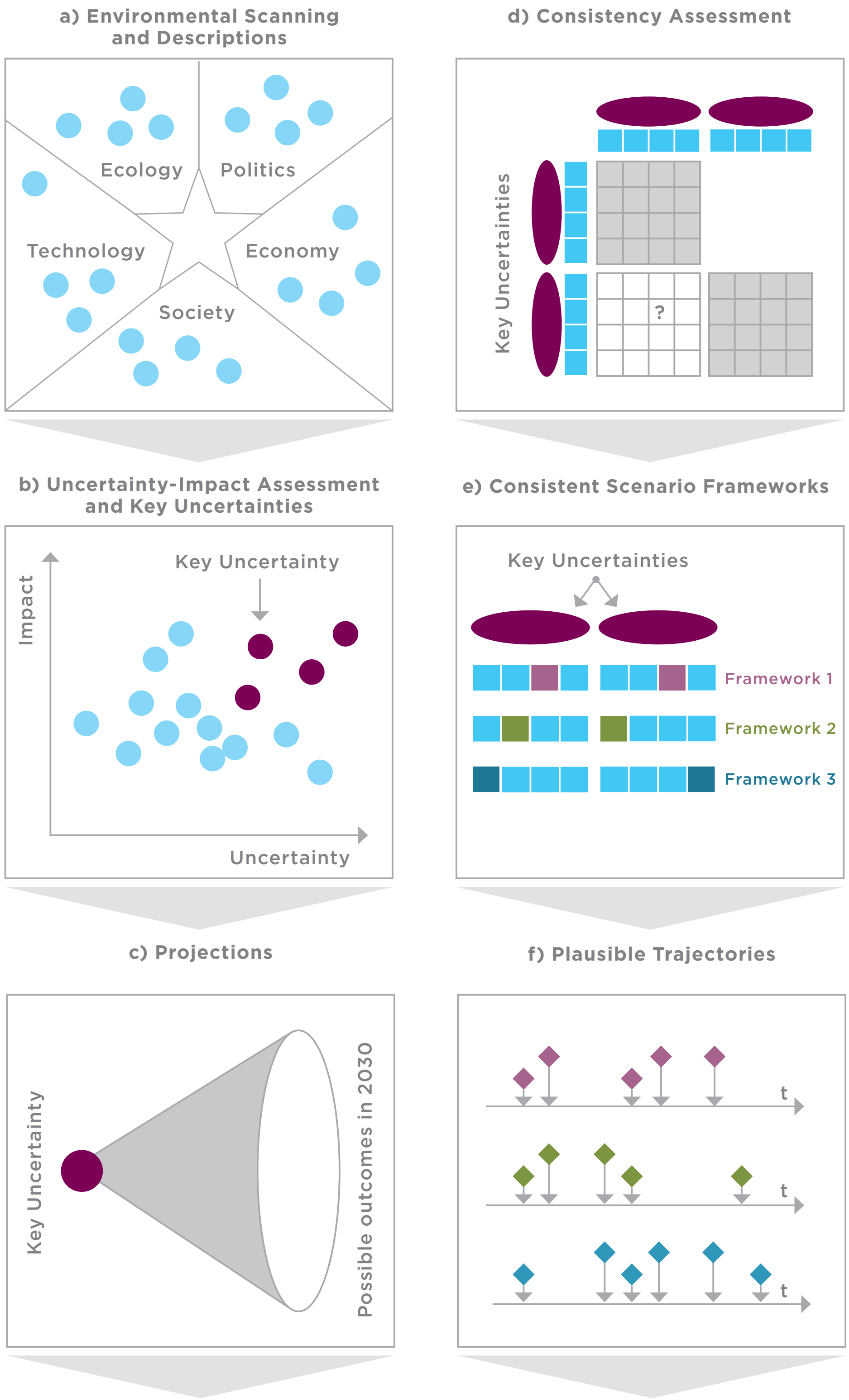

Figure 2: The SRM4G scenario construction process consisted of a series of steps, from conceptualising key influences on the future of global climate governance, to incorporating them into "histories of the future".

Source: Foresight Intelligence

For further information, see the detailed workshop agendas and the list of participants in the appendix.

2.1 Exploring the broader context

After the project team presented the core assumptions and the scenario topic, the group engaged in an "environment scanning" process to identify a broad range of political, economic, social, technological, environmental, and other factors that could shape global responses to climate change up till 2030. These factors were compiled as a list of around 50 "descriptors" (Figure 2–A). The purpose of this step was to open up complexity and integrate factors from the broader environment into the construction of the explorative scenarios.

2.2 Narrowing down to key uncertainties

Following an expansive first compilation of descriptors, an uncertainty-impact analysis was conducted to reduce complexity and focus on "key uncertainties". These uncertainties were intended to be variables that (in the participants' collective estimation) bear a very high potential impact on global responses to climate change, and whose plausible future outcomes have a significant range or spread (Figure 2–B). Breakout groups rated the **uncertainty** (unpredictability or potential variety in outcomes) and **impact** (comparative influence on global responses to address climate change in 2030) of all the descriptors gathered during the environment scanning phase using an online real-time assessment tool. The group then finalised eight key uncertainties in a plenary discussion of the results (Table 1 on pg 12–13).

2.3 Creating projections for key uncertainties

To ensure shared understanding within the group, and critically reflect on and focus on the process outcomes, the eight key uncertainties were collectively defined. Participants then developed four distinct outcomes for each key uncertainty in 2030 – a set of "projections" intended to indicate the full spectrum of alternative plausible states of a key uncertainty (Figure 2–C). The goal was to break the complex question of what alternative futures of global climate change response could look like in 2030 into smaller components. The result of this step was a matrix for raw scenarios, illustrating alternative expectations for a multitude of factors that influence future developments in responses to climate change (Table 1 on pg 12–13).

Table 1: Key Uncertainties and Projections Source: IASS SRM4G

	Key Uncertainty Name	Short Name	Short Definition	Current State (2015)	Projection A – Title	Projection A – Description
1	**Perception of Climate Events/Perception of Climate Change**	Perceptions	Seriousness, awareness and framings of climate change, causes and impacts by global publics.	Fragmented but widespread awareness. Concern variable, but often higher in more vulnerable regions. Framings highly contested.	**Chronic concern**	Chronic intensification of slow-onset impacts drives global convergence of growing public concern. Fragmentation and contestation reduced.
2	**Domestic and Regional Stability**	Stability	Social, economic and political stability at domestic and regional scales.	Relatively stable. No regions in particular turmoil, but some flashpoints (e.g. Ukraine) and drivers of instability and concerns in many.	**Major power destabilised**	Substantial regional instability in a region of global political and economic significance: e.g. China turns inwards to address unrest resulting from inequality, pollution etc.
3	**CDR Technology Advancement**	CDR	Technologies to remove GHGs from the atmosphere and sequester them.	Techs are either at the concept stage or are economically infeasible.	**"Saying No" Zero progress**	Technologies proven to be economically unviable or have unacceptable social and/or environmental side effects. RCP2.6 discounted. Realisation of the scale of lockedin climate change. Renewed pursuit of mitigation, along with increased support for SRM development.
4	**Mitigation technology advancements/ Emissions 2030**	Emissions	The extent, speed of adoption, and expected future pathways for GHG emissions at 2030.	Some tech in development, some emissions reduction commitments, some national and local actions, none of which have been enough to prevent GHG emissions from continuing to rise quickly.	**"Indulgences" Fast emissions growth – BAU**	Political smugness on some minor progress in changing the emissions growth trajectory UNFCCC process grinds on, emitting more carbon than it saves. A global C cap-and-trade scheme is agreed, but it lacks bite and the C price drops to insignificant level. Sleepwalking towards disaster.
5	**US-China relationship (G2)**	G2	The political and economic relationship between the US and China, as this relates to climate change and responses thereto. This can include how they relate to other global powers.	These are the two dominant global powers, and the two largest current GHG emitters. Economic and political non-adverserial rivals. They are major trading partners. They recently jointly announced their nonbinding commitments on the road to COP21. Background negotiations (outside of the global process) on climate responses continue, which in turn shapes others' response.	**The happy couple**	Increased trade. Military cooperation. Joint respones to international crises including extreme weather events, climate migration, etc. Cooperation in scientific research, technology transfer, and climate responses.
6	**Acceptability of SRM**	SRM	How popular is SRM (field research) and is it perceived to be legitimate?	There is not widespread awareness of SRM.	**Broad global support for SRM**	SRM research (including field research) is widely supported, including 'elites', broader populations, global North and South.
7	**Methane Feedbacks/ Severe physicals climate impact**	Climate risk	Severity of observed and expected climate impacts.	See IPCC Summary for Policy Makers in Fifth Assessment Report of 2013.	**Climate Schmimate**	Small temperature change than anticipated, ocean absorbs larger amount of energy, carbon cycle feedbacks moderate, moderate impacts of climate change realized, some suffering. Improved understanding leads to projections of climate change being less severe.
8	**Global Economic Stability**	Economic stability	General trends and events affecting global economy, incl. recessions, growth, distribution.	(Dubious) economic recovery after recession. Some risks to stability reduced, others not. Significant inequality, growing in many regions.	**Developing nations surge**	Global growth continues but is dominated by "developing" nations, "Western" nations show little growth. global inequality reduced but domestic inequality continues to rise.

Projection B – Title	Projection B – Description	Projection C – Title	Projection C – Description	Projection D – Title	Projection D – Description
Polarisation by extremes	Extreme events and variability attributed to climate change raise salience and concern, but regionally variable with regard to vulnerability and capacity, generating polarised views on responses.	**Shifting baselines**	Chronic impacts grow slowly, competing concerns enable adaptive preferences to dominate. Concern stable or declining. Residual demands for climate responses still fragmented.	**Variable + growing concern**	Scale and extent of extreme events grows, with global repercussions, leading to widespread increase concern.
Peripheral regional instability	Mulitple countries in a more peripheral global region experience instability (e.g. an "African Spring"), with limited near term impacts on global climate response.	**Stabilisation**	Instability declines or at worst remains dispersed, low-level, but chronic.	**Multi-region instability**	Social and political instability intensifies in many countries across multiple regions (responding to economic or climate stressors, or perhaps ideological values shifts and contagion).
"Honey Trap" Jam tomorrow	Always a tech of the future, but influences climate thinking especially with regard to mitigation. Large moral hazard effect, CDR has no effect on emissions. CDR becomes a resource sink for climate research funds (might be deployed in the future).	**"Icarus" Rollout then backlash**	Biological methods open for carbon credits. Dash for land. Suffering and backlash. CDR discredited. Step change for new GM CDR tech held back by public opposition.	**"Pangloss" Cheap, robust, safe tech developed**	Carbon price crystallises based on CDR at $50/t. Each tonne of emission matched by tonne of removal. Rollout of tech underway by 2030. Countries and companies hold C liabilities on balance sheet. Carbon cleanup costs are less than 0.5% of GDP.
"Paradigm Shift"	Substantial transformation, whether in technology or political agreement. Emissions decline due to radical change. Breakthroughs in energy storage tech and ultra-low cost, ultra-high efficiency solar or major political breakthrough. Techs starting to come to market by 2030. Economy starts to adapt based on projections, including recognizing long-term change process. Effects on fossil fuels – rapid divestment.	**"Panic" Super fast emissions growth**	India and Africa experience high growth rate and emissions trajectories. Panic over climate changes and projections. Continued finger pointing.	**"Backlash" Hyper mitigation**	Very aggressive mitigation on the back of a globally agreed carbon price. Markets adjust high costs to economies in the short term. Temps continue to rise. Backlash.
Suspicious "frenemies"	Continued status quo. "Messy competition." Second tier rivalry over territory and resources. Limited cooperation in scientific research, technology transfer, and climate responses.	**The Dragon vs. the Eagle**	Military threats. Proxy conflicts. Flare ups. Explicit territorial and resource conflict, potentially climate driven. Breakdown in cooperative behavior with respect to scientific research, technology transfer, and climate responses, in turn impacting global cooperation on climate.	**China crumbles**	Social unrest leads to an end to Communist rule in China.
International contestation	Support and opposition for SRM (field research) are held by significantly powerful blocks. This may (or may not) align along lines such as North-South or US-China-Europe etc.	**Elite – popular split**	Scientists and decision-makers worldwide are supportive of an SRM field research programme. Resistance among voters/ citizens/broad populations/ environmental and social justice groups.	**Broad global opposition for SRM**	SRM research (including field research) is widely opposed, including 'elites', broader populations, global North and South.
Hot mess	Temperatures rise rapidly, climate sensitivity estimates revised upwards, ocean absorbs less energy, arctic ice free in summer. Impacts of climate are evident in many regions, including the Global North. Uncertainty on key climate factors reduced (e.g. climate sensitivity, etc.).	**Biome bomb**	Temperature rise continues, no great improvements in projections. Impacts of climate change become more severe, especially in sub-tropical regions. Severe climate/earth-system shift, e.g. Amazon die-back, large-scale permafrost collapse, perrenially weak monsoon.	**Disparate climate**	Moderate temperature increase, carbon, etc. Regional projections very wrong, regional differences larger than expected, e.g. larger warming in arctic, less in tropics AND larger regional hydrological differences. i.e. change in winners and losers of climate change.
That's not fair	Global economic growth with strong technological advancements: increasing inequality of income and wealth is concentrated in fewer hands (global phenomena).	**Swamp economy**	Global growth stalls, by 2030 more-or-less no economic growth. Massive recession in US, some developing nations 'catch up' with developed nations.	**The greatest recession**	2029 massive economic crash, international finance system frozen.

2.4 Analysing consistency and selecting scenario frameworks

Participants then sought to create a set of scenario frameworks. Each scenario framework would be formed by a package of one projection from each of the eight key uncertainties (Figure 2–E). Scenario frameworks would in turn form the basis of the fully developed scenarios.

With four projections for each key uncertainty, there were approximately 65 000 possible scenario frameworks. However, not all of them were conceptually consistent; certain projections could be mutually antagonistic. Consequently, the aim was to identify the most consistent scenario frameworks, composed primarily of projections that were either mutually reinforcing or orthogonal.

Since the manual evaluation of many thousands of possible scenario frameworks is quite time-consuming, the group conducted a **computer-aided consistency analysis**. In this analysis, all projections were evaluated in reference to their consistency with all other projections (Figure 2–D). Eight key uncertainties with four projections each made 448 single evaluations (from 1 = full inconsistency, to 5 = high compatibility) in total. The aim of this highly formalised step was to force participants to think about every single possible combination of projections in order to avoid selective perception and linear thinking. A computer program then assessed the consistency of all 65 000 scenario frameworks that are mathematically possible and clustered approximately 100 consistent frameworks (with less than two inconsistent projections within a framework) into eight clusters. The project team pre-selected the 15 most distinct scenario frameworks, out of which the group chose four for further development, mostly based on variety, potential worst cases, and potential best cases. To further distinguish the scenario frameworks from each other and incorporate the widest possible variety of uncertainty projections, the group tweaked one of the chosen frameworks slightly (Table 2).

2.5 Creating pictures and histories of the future

In four breakout groups, the participants then fleshed out the abstract scenario frameworks. They first described a coherent “picture” of the future in 2030, based on the projections in their respective scenario frameworks.

They then created a corresponding “history”, or trajectory that could plausibly lead to the situations they described by conducting a backcasting exercise in which they created timelines that led to their described pictures of the future, and created titles for their respective scenarios (Figure 2–F). The aim of this step was to justify and substantiate their futures by illustrating a plausible chain of events that could have led to their occurrence.

Table 2: Participants chose four scenario frameworks for further development, based on variety of uncertainty projections.

Source: IASS SRM4G

		"Fragmented"	"Sandcastle"	"Creek"	"Lucky"
Perceptions	1A Chronic concern			X	
	1B Polarisation by extremes	X			
	1C Shifting baselines				X
	1D Variable + growing concern		X		
Stability	2A Major power destabilised				
	2B Peripheral regional instability		X		
	2C Stabilisation			X	X
	2D Multi-region instability	X			
CDR	3A "Saying No" Zero progress			X	
	3B "Honey Trap" Jam tomorrow	*			X
	3C "Icarus" Rollout then backlash	X			
	3D "Pangloss" Cheap, robust, safe tech developed		X		
Emissions	4A "Indulgences" Fast emissions growth – BAU	X			
	4B "Paradigm Shift"		X		X
	4C "Panic" Super fast emissions growth	*		X	
	4D "Backlash" Hyper mitigation				
G2	5A The happy couple			X	
	5B Suspicious "frenemies" (friends+enemies)		X		X
	5C The dragon vs. the eagle				
	5D China crumbles	X			
SRM	6A Broad global support for SRM			X	
	6B International contestation	X			
	6C Elite – popular split		X		
	6D Broad global opposition for SRM				X
Climate risk	7A Climate Schmimate				X
	7B Hot mess			X	
	7C Biome bomb		X		
	7D Disparate climate	X			
Economic stability	8A Developing nations surge			X	X
	8B That's not fair	X	X		
	8C Swamp economy				
	8D The greatest recession				

* Original computed results

2.6 Writing scenario descriptions

The project team compiled the breakout groups' results into written scenario descriptions in order to document the results of the brainstorming sessions and to create a product that could be understood and subjected to critique by those external to the scenario development process. In a review round, the project team and the breakout groups again reviewed the consistency of the future situations and the plausibility of the respective storylines.

The scenario descriptions are key because they serve as a focal point of everything that had been thus far discussed by the participants, containing the narratives of how SRM had come to form part of the climate response portfolio (or not), as well as the background contexts and contingencies that SRM governance designs would have to navigate. Therefore, all four scenario descriptions are presented – in no particular order – in the following section before the next steps are described.

2.6.1 "Fragmented world struggles to handle unpredictable climate"

Today, in 2030, climate change is having more diverse impacts on regions around the world than was expected in 2015, with both the magnitude and distribution of these impacts differing significantly from prior expectations. Temperatures have not risen as dramatically as predicted, but the hydrological cycle has been severely affected, especially in Europe and Africa. Effective adaptation is proving difficult due to the unpredictability of impacts and its higher-than-expected costs. Global mitigation has failed due to economic and political instability in many regions: China is facing internal conflict; the European Union is falling apart under an influx of refugees; nationalism and protectionism are fragmenting and polarising the international community. Carbon dioxide removal (CDR) by bioenergy with carbon capture and storage (BECCS) is unviable due to its negative effects on food prices. The global community is also divided on solar radiation management (SRM). Germany, France, and the United Kingdom, with the support of several African countries and Australia, are pushing for the development of SRM techniques to counteract the environmental and socio-political climate change impacts they are experiencing. Although not suffering uniformly from climate change, Brazil is interested in SRM as a means to optimise its climate and accelerate economic development. Russia, Canada, and the US believe they are benefiting from climate change and strongly oppose SRM.

Looking back from 2030, the global response to climate has historically been influenced by four main drivers: 1) widespread economic and political instability and a fragmented international community; 2) a collapse of mitigation efforts; 3) varying regional climatic impacts that have led to polarised perceptions of climate change risks; and 4) environmental and socio-political climate impacts leading to calls in some places for quick-fix solutions. The interplay of these four drivers that ultimately led to today's divided stance on climate response strategies can be traced over the past fifteen years.

Fifteen years ago, the international community was jointly concerned about dangerous climate change and was attempting to reach a consensus on how to respond to it. In 2015 many people still pinned their hopes on mitigation, but after a series of post-Paris COP conferences ended in deadlock and a global economic slowdown resulted in less investment in renewable energy technologies, it became clear that the UNFCCC process might fail to achieve its goals. As the international research community and some national governments began to realise that consensus on mitigation was unlikely, high hopes were placed on BECCS, which took off in 2018. Numerous power plants began using biomass, and in countries around the world plans were drawn up to install carbon capture and storage technologies developed in Australia. Farmers changed from food to biomass, particularly in developing countries. Food prices began to increase, and some analysts suspected that the shift to BECCS was partly responsible. In an attempt to protect their economies from a potential food crisis, the US, Europe and Africa introduced a series of increasingly aggressive trade barriers in 2021. This trade war resulted in a spiral of increasing protectionism and distrust. The stagnating economy and increasing international distrust led to the nascent global cap and trade agreement being abandoned and the Kyoto/Paris process expiring in 2020. Since then, an increasing unwillingness to cooperate within the international community, together with ongoing regional conflicts, has made any attempt to re-establish a global mitigation strategy impossible.

Evidence of this pattern of regional instability and an increasingly fragmented international community can be clearly seen in the examples of China and Europe. A second global economic slowdown, in 2022, hit China especially hard. Decreasing exports, falling production, and rising unemployment have been causing widespread protests against the Chinese central government since 2023. After an initial campaign of violent repression failed to quash anti-government uprisings in several major cities including Beijing, the Communist Party decided to turn its focus inward, withdrawing from international politics and focusing on rebuilding its domestic legitimacy. In addition to no longer participating in many international fora, China cut most of its foreign direct investment (FDI) in Africa in order to revive domestic economic development, triggering a further economic downturn in African countries already suffering not only from high food prices, but also from several years of higher-than-normal temperatures and low rainfall, which were widely blamed on climate change. Europe was also struggling with a stagnating economy and extreme weather blamed on climate change. African refugees migrated northward to Europe. The combination of rising unemployment rates due to the slowdown of the global economy and the influx of so-called "climate refugees" caused increasing nationalist sentiment throughout Europe by 2025. As right-wing parties rose to power in many European countries, conflict over the division of responsibility for the refugees escalated, leading to controlled borders within Europe and the restriction of international financial transactions. After the UK left the Union and several other nations threatened to follow suit, the EU fragmented into a spaghetti-bowl of treaties between its former members, leaving the former organisational structure paralysed.

Table 3 – A: Scenario Frameworks

Source: IASS SRM4G

Fragmented world struggles to handle unpredictable climate		
Perceptions	Polarisation by extremes	Extreme events and variability attributed to climate raise salience and concern, but regionally variable with regard to vulnerability and capacity, generating polarised views on responses.
Stability	Multi-region instability	Social and political instability intensifies in many countries across multiple regions (responding to economic or climate stressors, or perhaps ideological values shifts and contagion).
CDR	"Icarus" Rollout then backlash	Biological methods open for carbon credits. Dash for land. Suffering and backlash. CDR discredited. Step change for new GM CDR tech held back by public opposition.
Emissions	"Indulgences" Fast emissions growth – BAU	Political smugness on same minor progress in changing the emissions growth trajectory. UNFCCC process grinds on, emitting more carbon than it saves. A global carbon cap-and-trade scheme is agreed, but it lacks bite and the carbon price drops to insignificant level. Sleepwalking toward disaster.
G2	China crumbles	Social unreset leads to an end to Communist rule in China.
SRM	International contestation	Support and opposition for SRM (field research) are held by significantly powerful blocks. This may (or may not) align along lines such as North-South or US-China-Europe etc.
Climate risk	Disparate climate	Moderate temperature increase, carbon, etc. Regional projections very wrong, regional differences larger than expected, e.g. larger warming in Arctic, less in tropics and larger regional hydrological differences. i.e. change in winners and losers of climate change.
Economic stability	Developing nations surge	Global growth continuous but is dominated by "developing" nations, "Western" nations show little growth, global inequality reduced but domestic inequality continues to rise.

Relations between the US and many European countries had also deteriorated in recent years, providing further indications of weakening international partnerships. The US imposed particularly strong restrictions on trade with European countries during the food crisis that developed in 2019, alienating many former allies who had expected at least a show of solidarity. Additionally, as the US economy has benefited from consistently low fossil fuel prices driven by the development of new fracking methods and the exploitation of newly accessible northern gas reserves in the early 2020s, many European leaders have indicated they hold the US increasingly responsible for the continued emissions growth and the apparent negative climate change impacts in Europe and Africa. The relative strength of the US economy has led Europe to call on the US for help in dealing with the ongoing migrant crisis. However, fearing it will suffer a similar financial fate to many struggling European countries, the US has so far refused to take in more than a handful of "climate refugees," further straining transatlantic relations.

Today perceptions of climate change risk vary greatly around the world, adding to the fragmentation of the global community. On the one hand, European states that continue to struggle with both apparent climate change impacts and a flood of "climate refugees" see climate change as a major threat. On the other, as northern regions become increasingly inhabitable and previously inaccessible Arctic resources become exploitable, Russian and Canadian leaders and citizens begin to believe climate change is environmentally and economically beneficial. The US, while suffering from some droughts, has been experiencing bumper crops since 2022 in its fertile northern plains, something many believe may be due to slightly higher temperatures and more rainfall as a result of climate change. US public and political opinion on climate change has therefore shifted considerably since 2015, as both conservative and liberal politicians, disillusioned with mitigation efforts, expound the benefits of a warmer, wetter climate. Similarly, Brazil, whose economy has grown surprisingly fast, no longer considers climate change such a great risk, as its temperatures have remained steady, if not slightly lowered. A previous important player in climate change politics, China is now completely focused on reviving its economy and on ensuring the Communist Party's legitimacy, meaning climate change risk is not on its agenda at all.

In addition to creating environmental and socio-political "winners and losers" in different regions around the world, climate change impacts have increased international geopolitical tensions. In 2023, a military stand-off ensued between Russia on the one side and Canada and the US on the other as they tried to assert their presence in newly accessible Arctic Sea regions. Besides wanting to secure strategic control of new shipping lanes, all three countries have an interest in the potential exploitation of suspected crude oil and natural gas reserves in the area. Old tensions between Taiwan and Japan in the South China Sea have also escalated as the two countries try to take advantage of China's weakened position by reasserting their claims to numerous islands and maritime territories in the region. These developments, together with increasing nationalist and protectionist tendencies as a result of the stagnating global economy, have led to the further deterioration of international relations. Today, nearly all global security, climate response, and economic cooperation efforts are deadlocked, while CO_2 emissions are still on the rise. With atmospheric carbon levels passing 450 PPM, global mitigation impossible due to a lack of international trust, CDR apparently unviable due to high food prices, and adaptation ineffective due to the unpredictability of future impacts, the countries experiencing negative environmental and socio-political climate change impacts have begun looking for an alternative solution.

Although Europe remains divided, Germany, France, the Netherlands, and the UK – bearing the brunt of the "climate refugee" crisis – have a common interest in a quick fix for climate impacts in Africa. Encouraged by SRM modelling research and equipment tests, which have produced consistently promising results since 2017, the four countries started a joint SRM research programme in 2022. These efforts were intensified in 2025 when a disastrously intense and prolonged European drought and heatwave in the summer was followed by a string of intense storms throughout the autumn bringing the worst floods Northern Europe had ever seen in recorded history. Despite opposition from the US and Russia, the European SRM champions have conducted the first large field trials in 2026 and 2028. So far, the stratospheric aerosol injection tests have yielded favourable results, indicating that the concerns of some atmospheric chemists over the effects of the aerosols on ozone concentrations were unwarranted. Furthermore, climate model and climate impacts studies continue to suggest that a global deployment would readjust the hydrological cycle, returning rainfall to Africa, Australia, and southern Europe while reducing precipitation and flooding in northern European countries. Therefore, with support from Australia and several African nations, the European coalition is working on plans for imminent global SRM deployment.

Brazil has experienced rapid growth over the last decade following the discovery of extensive new shale gas reserves and is increasingly becoming an economic force to be reckoned with. The government there has expressed interest in developing its own SRM program to assess the potential for "climate optimisation" as a way to make its climate patterns more hospitable and viable for food production for its large population, and for export. Therefore, although wary about the European deployment plans, it is not openly opposed to the current SRM programme. Russia, the US (led since 2020 by religious conservatives who are hostile to intervening in "God's Creation"), and Canada strongly oppose any SRM deployment, fearing it will undo the positive effects of climate change that they have been experiencing. A US State Department spokesperson last week announced the results of a report that projected that SRM would worsen extreme weather events in the US, and the Russian Ministry of Defence recently presented a Russian Academy of Sciences report showing that the European plan for the deployment of SRM would dramatically reduce Russian crop yields. Thus, the pattern of fragmentation and polarisation prevalent in other fields of international politics seems set to continue in SRM policy.

2.6.2 "Building sandcastles under the shadow of a tidal wave"

Today, in 2030, there has been a paradigm shift in global climate response policies. Global mitigation has been accepted as the central climate response policy. Emissions have been successfully decoupled from economic growth due to breakthroughs in energy storage and renewable energy technologies, effective carbon dioxide removal (CDR) technologies have been deployed on a large scale and adaptation spending is high. However, climate sensitivity is high and positive feedbacks from permafrost collapse and melting ice caps have provided clear evidence that a number of climate tipping points have been passed and that the worst is yet to come. There is a global consensus on need for urgent action on climate change, but there is elite-public disagreement over what kind of action should be taken. While scientists and politicians worldwide believe the best option would be to deploy solar radiation management (SRM) techniques for a couple of decades in order to "buy time" to achieve negative emissions, globally publics strongly oppose SRM and are instead calling for increased global adaptation and CDR efforts.

Looking back from 2030, it is possible to identify three major, slightly overlapping phases in the development of global climate response policies. During the first phase (2017–2022), extreme climate events built social and political consensus on the need for action on climate change. The second phase (2022–2025) brought an international paradigm shift towards global mitigation, coupled with renewable energy and CDR breakthroughs. Now, during the third phase (2025–2030), as it has become clear that high climate sensitivity means that the worst impacts of climate change are still to come, SRM research is being done secretly due to strong public resistance. Reviewing the events that took place during each of these phases can help us to understand the historical developments that led to the current situation.

Phase One started abysmally with Amazon forest fires, monsoon failure and famine in India, as well as with series of massive droughts in China and the US in 2017/18. Dust Bowl conditions last experienced in the 1930s returned and large tracts of agricultural land became too arid to be productive. The jet stream wavered – a system of high pressure sat over central Europe leading to the coldest winter there on record and warm air flowing into the Arctic region – the following summer ice cover in the Arctic diminished to a new record low. The social and economic effects were dramatic. In India and China, already crowded cities were overrun with rural families forced to leave their waterless, infertile lands. The first ever migration on a scale exceeding one hundred million persons was recorded. Struggling to accommodate and feed the displaced masses, regional politicians and administrators began demanding that their countries' leaders take action on climate change. Similarly, in the US, as drought emergencies were declared in numerous southern and western states and unemployment in agricultural areas skyrocketed, rallies across the nation made action on climate change a fundamental issue that spanned the bi-partisan divide. In Europe the price of heating oil skyrocketed and several deaths were reported in southern countries where homes were not built for the frigid temperatures, catching some older people unprepared. As a direct consequence, politicians around the world began to call for coordinated global action on climate change. Domestic adaptation budgets increased significantly in the wealthier nations, and the international community began seriously working towards a global mitigation and CDR strategy. Thanks to the increasing consensus on the need for joint action, COP 26 resulted in a stronger cap and trade agreement in 2020. The following two COPs cemented CDR as central to the global response to climate change and led to the establishment of an international patent pool in 2022. The compulsory cross-licensing system of new CDR technologies within the patent pool – regulated by an NGO based in Stuttgart and overseen by an international Governmental Advisory Committee – reduced fears of patent conflicts, encouraged more companies to invest in CDR research and development, and eventually made the commercialisation of the technologies easier.

During the second climate response phase, a stronger shift towards mitigation measures was initiated. As the world's wealthy countries' fear of climate change increased, so too did international investment in renewable energy technologies. As the price of solar and wind energy decreased, and economic development slowly started to decouple from fossil fuel consumption, global emissions growth began to slow down. Meanwhile, in 2020, united by ongoing devastating droughts and food shortages in both countries, China and the US agreed upon a revenue-neutral carbon price, meaning that corporate taxes are reduced to compensate for the new carbon tax.

Table 3 – B: Scenario Frameworks

Source: IASS SRM4G

Building sandcastles under the shadow of a tidal wave

Perceptions	Variable + growing concern	Scale and extent of extreme events grows, with global repercussions, leading to widespread increase concern.
Stability	Peripheral regional instability	Multiple countries in a more peripheral global region experience instability (e.g. an "African Spring"), with limited near term impacts on global climate response.
CDR	"Pangloss" Cheap, robust, safe tech development	Carbon price crystallises based on CDR at $50/t. Each tonne of emission matched by tonne of removal. Rollout of tech underway by 2030. Countries and companies held carbon liabilities on balance sheet. Carbon cleanup costs are less than 0.5% of GDP.
Emissions	"Paradigm Shift"	Sustantial transformation, whether in technology or political agreement. Emissions decline due to radical change. Breakthroughts in energy storage tech and ultra-low cost, ultra-high efficiency solar or major political breakthrough. Tech starting to come to market by 2030. Economy starts to adapt based on projections, including recognizing long-term change process. Effects on fossil fuels – rapid divestment.
G2	Suspicious "frenemies" (friends + enemies)	Continued status quo. "Messy competition." Second tier rivalry over territory and resources. Limited cooperation in scientific research, technology transfer, and climate responses.
SRM	Elite-popular split	Scientists and decision-makers worldwide are supportive of an SRM field research program. Resistence among voters/citizens/broad populations/ environmental and social justice groups.
Climate risk	Biome bomb	Temperature rise continues, no great improvements in projections. Impacts of climate change become more severe, especially in sub-tropical regions. Severe climate/earth-system shift, e.g. Amazon die-back, large-scale permafrost collapse, perennially weak monsoon.
Economic stability	That's not fair	Global economic growth with strong technological advancements: increasing inequality of income and wealth is concentrated in fewer hands (global phenomena).

Following the lead of two of the world's largest emitters and encouraged by the promise of increased international funding for adaptation, the international community agreed on a global carbon price in 2023, when the International Carbon Fund was founded in order to finance both adaptation measures and CDR research projects. To allow consumers, companies, and economies to gradually adapt, the carbon price was increased incrementally until it reached US$50 a tonne in 2030. This strategy triggered large decarbonisation investments and ensured a steady research budget for CDR. The robust competitive CDR landscape led to rapid innovation of the technologies and widespread deployment by 2025. However, despite large-scale CDR deployment and significant reductions in emissions as many economies around the world have continued to shift from fossil to renewable energy sources, it has become clear that net negative emissions are still a long way off.

The third phase of the global climate response story has so far been characterised by ever-growing concern about the pace of climate change. Despite the global community pooling its decarbonisation efforts and deploying CDR at a large scale, the IPCC has confirmed that climate sensitivity is at the pessimistic end of the spectrum and that the CO_2 already in the atmosphere has triggered unanticipated positive feedback loops in the climate system. In 2025, it became clear that the monsoon cycle has been permanently disrupted, which will cause ongoing widespread food and water shortages and massive changes in regional biodiversity. The Amazon is expected to die off completely by 2050, with unknown effects on the carbon and hydrological cycles. The melting ice caps are triggering increased emissions from permafrost and sea levels are expected to rise significantly over the next decades. Many world leaders fear that future climate impacts will exceed their adaptation capacity.

Recognising that CDR and adaptation may fall short, in the early 2020s US government research institutions began looking at the possibility of SRM as a way to stave off the worst effects of climate change and give the world time to achieve negative emissions. The initial results of small-scale tests yielded positive results. However, shortly after the first large scale SRM field test was conducted off the coast of Florida in 2025, a Category 5 hurricane almost destroyed Miami. Over 200 people were killed and tens of thousands more lost their homes. Despite a lack of evidence that the hurricane was in any way related to the test, the American public attributed the unusually violent storm to the SRM field test. Strong opposition to further SRM testing came from a range of civil society sectors. Environmental groups protested that the planet "should not be used as a laboratory for these unjust and risky technological fixes." Human rights organisations suggested the federal researchers involved in atmospheric testing could be held responsible for violations of the hurricane victims' right to life. As emotions ran high, the dramatic images of death and destruction in Miami fuelled widespread fear about the risks of SRM. The nation-wide backlash led to a congressional hearing that ultimately resulted in a complete ban on SRM research and testing in the USA being passed in 2026.

Despite the national ban, the US government remained convinced of the need to investigate the possibilities of SRM. As was later revealed, this led the US to provide financial and scientific support to a clandestine SRM research and development programme being carried out by the Chinese government, which also has a strong interest in SRM. With the help of an anonymous researcher involved in the project, WikiLeaks released details about the secret programme in 2028. The leaked documents revealed that a large-scale SRM atmospheric field test had been conducted over the Chinese mainland between 2026 and 2027. The testing coincided with dramatic changes in the course of the Yellow River that had caused massive flooding and loss of life during that period: over 500 000 people were killed and approximately 4 million people were displaced in the "cradle of Chinese civilisation". The Yellow River has historically changed its course many times due to flooding caused by collapsing upstream ice barriers, but this time the public and the media suspected a link between SRM testing and extreme temperature and snowfall fluctuations, which they believed led to the creation and subsequent collapse of unusually large, unstable ice dams. Although scientists emphasised that there was no evidence linking the test to the flooding, with the memories of Miami still fresh on their minds, and believing that the subsequent US ban had confirmed a connection between environmental side effects and SRM testing, the global public blamed SRM testing for the devastating damage in the Yellow River delta. After details of the test became public, the US attempted to distance itself from the project, claiming the American researchers involved were not affiliated with US federal research facilities. Diplomatic relations became strained between China and the US as the latter refused to admit its involvement in the SRM programme. China was further affronted at "America's hypocrisy" after the US president publicly suggested the Chinese government should not have "hidden the testing from its citizens."

Growing global public opposition to SRM has recently been strengthened by CDR industry advertising campaigns promoting carbon dioxide removal methods as a "safe" and "natural" way to return the climate to its natural state while demonising SRM techniques as "dangerous tech-fixes." Thus, attribution of extreme climate events to SRM testing and the CDR industry fuelled fears about the risks of SRM, together with environmental and human rights groups' vehement objections to further human interference with the climate, have led to widespread public opposition to SRM. Societies around the world are outraged at what they perceive as an attempt by elites to take the risky "cheap and easy way out" by deploying SRM. According to recent polls, the prevailing public opinion is that governments should "act responsibly" by investing far more funding in adaptation and additional CDR infrastructure. However, many government leaders are continuing to insist that CDR will not halt the massive climatic changes that have already been set in motion, and that they lack both the financial resources and the time to adequately adapt. Therefore, many suspect that governments around the world are secretly continuing SRM testing.

2.6.3 "Up the proverbial creek without a paddle"

Today, in 2030, the dangerous impacts of climate change are causing global panic. The media is full of news about the devastating effects of ice-free Arctic summers and the dieback of the Amazon, extreme weather events and food shortages are causing widespread suffering, and international polls show that most of the world's population believes the global climate system is on the brink of collapse. These fears have been intensified by the knowledge that mitigation has failed as a climate response strategy, global emissions are still rising, and carbon dioxide removal (CDR) techniques are not viable. Desperate for a quick response to the "hot mess", civil societies and governments around the globe are calling for the rapid deployment of Solar Radiation Management (SRM) techniques. However, as little research has been carried out in the last 15 years, the international community lacks the knowledge and tested capability to safely and effectively deploy SRM.

Looking back from 2030, two major failures have led to this desperate state of affairs: firstly, the complete failure of the UNFCCC process due to a prevailing paradigm of economic development, and secondly, total CDR failure as a result of technological setbacks and land-use conflicts. A review of key developments between 2015 and today illustrates how we ended up so far up this creek without the proverbial paddle.

Retrospectively, many political analysts see 2018 as the beginning of the demise of the UNFCCC process. The optimism stimulated by the non-binding Paris accord in 2015 had dissipated, and in 2018, the US, recognising the importance of economic ties with a growing China, used its military and diplomatic strength to settle China's disputes with its neighbours in the South China Sea. In return for help with establishing control over several strategically important maritime territories, China agreed to sign a series of favourable trade deals with the US in 2019. From that point on, growing economic interdependence led to better diplomatic relations between the two powerful nations as they collaborated to achieve their common goal of continued economic development. After China publically denounced calls for it to radically curb its still growing emissions in the lead up to the UN climate conference in 2020, the US government's decision to boycott the "deadlocked" talks was clearly a strategic move designed to appease its carbon-dependent new partner. The US and China subsequently agreed to limited bilateral mitigation and adaptation efforts, but the focus of their relations remained on mutually beneficial economic cooperation. The joint US-China prioritisation of economic development over climate response strategies was cemented at the G2 summit in 2024, when the controversial issue of climate sensitivity was cut from the agenda completely to accommodate additional panels on joint strategies to deal with a potential economic slowdown both states feared as growth rates had been steadily declining since 2020. The G2's blatant disregard of a newly released IPCC report on the dangers of higher-than-anticipated climate sensitivity led to sharp criticism from several increasingly powerful South American countries suffering from unprecedented fires in the Amazon basin.

The widespread economic development paradigm that ultimately led to the demise of the UNFCCC process was also evident in other (mostly developing) countries around the world as energy demand escalated. When increasing economic growth, a ballooning population and increasingly inhospitable temperatures led to the mass installation of air conditioning units throughout India, the country turned to new coal gasification technologies already being widely implemented in China instead of investing in a more expensive push for solar energy solutions to meet the growing energy demand. Similarly, Uganda announced the opening of the world's largest coal mine in 2021 to "affordably fuel the East African Miracle." The final nail in the UNFCCC coffin came in 2026 when the US and China, with their economies stuttering, comparing their relatively stable emissions to the rapid per capita increases in India and other developing nations, called for these countries to "act responsibly" by mitigating. Furious at the "hypocrisy" of the world's highest per capita emitters (Chinese and US per capita emissions had stabilised at 12 and 19 tonnes respectively) and citing their own "right to economic growth," the members of the South Asian Association for Regional Cooperation (SAARC) announced their decision to withdraw from the UNFCCC process. In a show of solidarity, the African Union followed suit and, lacking the support of more than 60 countries, the UNFCCC process was abandoned.

Table 3 – C: Scenario Frameworks

Source: IASS SRM4G

Up the proverbial creek without a paddle		
Perceptions	Chronic concern	Chronic intensification of slow-onset impacts drives global convergence of growing public concern. Fragmentation and contestation reduced.
Stability	Stabilisation	Instability declines or at worst remains dispersed, low-level, but chronic.
CDR	"Saying No" Zero progress	Technologies proven to be economically unviable or have unacceptable social and/or environmental side effects. RCP2.6 discounted. Realisation of the scale of locked-in climate change. Renewed pursuit of mitigation, along with increased support from SRM development.
Emissions	"Panic" Super fast emissions growth	India and Africa experience high growth rate and emissions trajectories Panic over climate changes and projections. Continued finger pointing.
G2	The happy couple	Increased trade. Military cooperation. Joint respones to international crises including extreme wheather events, climate migration, etc. Cooperation in scientific research, technology transfer, and climate responses.
SRM	Broad global support for SRM	SRM research (including field research) is widely support, including 'elites', broader populations, global North and South.
Climate risk	Hot mess	Temperatures rise rapidly, climate sensitivity estimates revised upwards, ocean absorbs less energy, Arctic ice free in summer. Impacts of climate are evident in many regions, including the Global North. Uncertainty on key climate factors reduced (e.g. climate sensitivity, etc.).
Economic stability	Developing nations surge	Global growth continues but is dominated by 'developing' nations, 'Western' nations show little growth. Global inequality reduced but within-nation inequality continues to rise.

Parallel to these developments, the second major failure was already in progress. Global emissions had long been rising due to fossil-fuelled economic growth in many nations. From 2017 onwards this trend was increased by summer "drilling bonanzas" as fossil fuel reserves were discovered in increasingly accessible Arctic waters and new coal gasification technologies made the exploitation of unconventional coal reserves possible. As worries about the climatic effects of elevated atmospheric carbon concentrations increased, many countries invested heavily in promising carbon dioxide removal (CDR) techniques. Billed as an efficient way to reduce atmospheric carbon levels without having to reduce fossil fuel use, CDR seemed like the ideal solution for emitters and non-emitters alike. However, despite massive public and private investment in CDR research and development efforts, the technologies ultimately proved unviable. The first signs of CDR failure came in 2018 after companies looking to cash in on government subsidies for bioenergy with carbon capture and storage (BECCS) plantations started "grabbing" huge tracts of land in many countries. The resulting mass protests by farmers and graziers led to a UN World Food Programme report that made it clear that the amount of land needed for successful bio-based CDR measures would conflict with global food supply, making it impossible to satisfy growing meat demand and thus possibly breaching the human right to food. As it became clear that "BECCS would have to be buried," the UN established a global commission to pursue high-tech CDR alternatives in 2019. Although promising nano-tech results continued to keep official hopes in CDR high for a few years more, public opposition to any techniques involving underground storage of CO_2 remained strong, especially after some of the first poorly-maintained storage sites began to leak. Then, in 2024, leading experts from Massachusetts Institute of Technology (MIT) admitted that their early results had been misleading, and the research was "going nowhere fast." With the US and Chinese economies stuttering, both public and commercial funding of CDR research and development was subsequently cut dramatically and in 2027 the UN CDR commission conceded that the techniques were "too expensive" and "too slow" to be a viable climate response option.

Today in 2030, it is widely believed that the global climate system is in deep trouble. Temperatures have risen rapidly in the last decade, and in recent years climate sensitivity estimates have been revised upwards as it has become clear that the ocean absorbs less heat than previously thought. A global ecosystem assessment report recently found that "100% of all ecosystems have now been compromised" by climate change. The Arctic has been ice-free for three consecutive summers and multi-million hectare fires in the drying Amazon rainforest have burned an area approaching the size of Texas. Ecosystem emissions from these massive fires and melting permafrost exceed even the largest countries' emissions. In addition to increasing anthropogenic emissions, these unstoppable CO_2 "pulses" are threatening rapid warming, which in turn would exacerbate the melting and forest dieback, pumping more carbon into the positive feedback loop. Faced with the knowledge that the climate system is set to change beyond recognition, global concern is turning into panic.

Following the dual failures of mitigation and CDR, and faced with what NATO and the G2 are terming a "global climate emergency," the international community is now considering SRM as a last resort. However, as the techniques have long been considered risky, research into SRM has not progressed significantly in the last 15 years. Indeed, in 2018 a conference of leading international climate scientists in Asilomar committed to adhere to the Oxford Principles and refrain from conducting large-scale SRM field tests until due diligence and governance frameworks were established. During the following years, as all hopes were pinned on CDR techniques, interest in SRM and effort to produce governance frameworks faded into the background. The only significant research so far has been a small joint Indian-Chinese test initiated in 2025 to assess the potential of SRM for preventing changes to regional monsoon patterns. Although the research team concluded that regional deployment of SRM might be practical, they acknowledged that the tests were too limited to provide meaningful knowledge about the effects of large-scale SRM deployment, whether regionally or globally.

Although the global scientific community lacks the knowledge and tested capability to safely and effectively deploy SRM, and a governance framework is yet to be established, widespread fear of an imminent climate system collapse means that nations, companies, and wealthy individuals are uniting to push for rapid deployment-readiness. Under Norway's presidency the Arctic Council endorsed an international SRM research call in 2027; in 2028 an anonymous Indian billionaire announced a prize for the first testable SRM technology, which the King of Saudi Arabia promptly offered to double; the US and China have set up a joint SRM research centre; and last year Boeing announced it is developing a "SRM ready" high altitude aircraft. The global community is now pooling its climate response resources, but it is becoming increasingly clear that public and political momentum is likely to lead to rushed SRM deployment with little understanding of the technique's potential consequences.

2.6.4 "Life's easy when you're lucky"

Today, in 2030, the global population is not concerned about climate change. This is largely because the impacts of climate change have been much less severe than predicted in 2015, and recent studies have confirmed that climate sensitivity is lower than previously thought. Additionally, there has been a substantial decline in greenhouse gas emissions, thanks to technological advancements in energy storage and renewable energy generation. As the clean energy revolution has spurred economic growth in the developing world, the global population is becoming wealthier and thus better able to adapt to ongoing moderate changes in the climate system. People are also not too worried about the long-term effects of atmospheric greenhouse gas levels, as they have been led to believe that there will soon be a major breakthrough in carbon dioxide removal (CDR) technologies. As low climate sensitivity means fewer climate risks in the near term and as the decarbonisation of the global economy and the development of CDR technologies are expected to reduce the long-term risks from the greenhouse gases already released, the two main arguments for the development of solar radiation management (SRM) have disappeared. SRM is broadly opposed as a relic of the past; a risky, outdated idea no longer necessary in light of recent developments.

Looking back from 2030, the history of climate response has been driven by two major developments: by a technological innovation in energy storage that enabled swift global emission reductions, and by the discovery that climate sensitivity is much lower than expected. In hindsight, it is possible to re-trace the effects of these two developments over the past fifteen years.

In 2015, the global level of concern about climate change was much higher. Between 2016 and 2018, extreme heatwaves and droughts in the United States, China, India, and Sub-Saharan Africa were driving

Table 3 – D: Scenario Frameworks

Source: IASS SRM4G

Life's easy when you're lucky		
Perceptions	Shifting baselines	Chronic impacts grow slowly, competing concerns enable adaptive preferences to dominate. Concern stable or declining. Residual demands for climate responses still fragmented.
Stability	Stabilisation	Instability declines or at worst remains dispersed, low-level, but chronic.
CDR	"Honey Trap" Jam tomorrow	Always a tech of the future, but influences climate thinking especially with regard to mitigation. Large moral hazard effect, CDR has no effect on emissions. CDR becomes a recource sink for climate research funds (might be deployed in the future).
Emissions	"Paradigm Shift"	Substantial transformation, whether in technology or political agreement. Emissions decline due to radical change. Breakthroughts in energy storage tech and ultra-low cost, ultra-high efficiency solar or major political breakthrough. Tech starting to come to market by 2030. Economy starts to adapt based on projections, including recognizing long-term change process. Effects on fossil fuels – rapid divestment.
G2	Suspicious "frenemies" (friends + enemies)	Continued status quo. "Messy competition." Second tier rivalry over territory and resources. Limited cooperation in scientific research, technology transfer, and climate responses.
SRM	Broad global opposition for SRM	SRM research (including field research) is widely opposed, including 'elites', broader populations, global North and South.
Climate risk	Climate Schmimate	Smaller temperature change than anticipated, ocean absorbs larger amount of energy, carbon cycle feedbacks moderate, moderate impacts of climate change realized, some suffering. Improved understanding leads to projections of climate change being less severe.
Economic stability	Developing nations surge	Global growth continues but is dominated by 'developing' nations, 'Western' nations show little growth. Global inequality reduced but domestic inequality continues to rise.

public concern about the warming planet. As these countries' populations faced food and water shortages, support for SRM development and testing grew. In many countries, the call for SRM research and testing was backed by the fossil fuel industry, which saw the technologies as an opportunity to reduce the pressure for cuts to CO_2 emissions. Similarly, in the USA, SRM was advocated by right-wing politicians who, in the face of increasing extreme weather events and the resulting public pressure, had changed their position on climate risk but who considered SRM to be compatible with previous promises to voters that they should not have to change their lifestyles as a result of climate change. At the same time, damaging climate change impacts encouraged scientists and corporations around the world to increase their efforts towards the development of promising CDR technologies, and a breakthrough seemed likely in the near future.

The situation changed dramatically between 2020 and 2025. In 2020, a joint US consortium of researchers from the International Center for Nanotechnology and Advanced Materials (ICNAM) and the MIT started a joint research project on the durability of nano-pins. In the course of this project, the scientists also developed a nanotechnology electrolyte. Two of them, both former researchers at the (US) Joint Center for Energy Storage Research, realised the electrolyte's potential for the commercial production of a cheap and highly reliable lithium-oxygen battery with an energy density ten times higher than common batteries. They also realised that, since their research was paid for by the United States' federal government, the new technology would not be made freely available if they proceeded under the terms of their contract, which gave full ownership of any discoveries to the US Department of Energy. The battery's commercial and strategic importance was so great, the scientists believed, that the US would not share it openly unless it had no choice, and the 2018 WTO trade round had definitively placed energy technology outside of the realm of compulsory licensing.

Believing in the truly revolutionary implications of their innovation, the MIT scientists looked for a way to tie their government's hands. They kept their discovery secret, but began to conspire with a high-ranking government official and two government scientific advisers who were sympathetic to their cause. In the preparations for the UNFCCC COP 27, held in 2021, the official and the advisers directed the American climate negotiators to offer an expansive technology transfer system (which they characterised as a relatively small and acceptable concession) in order to secure developing world consensus on an unambitious climate plan consisting only of an energy research fund and a weak cap and trade system. As soon as the agreement was ratified, the US researchers publicly revealed the ground-breaking implications of their invention. The terms of the newly-ratified technology transfer deal effectively removed intellectual property rights over the electrolyte, and it was legally and freely distributed around the world. The official was immediately fired, but her book on the subject became a bestseller and she received an academic appointment almost immediately.

Despite furious protests from some American politicians over lost licensing income, culminating in an ultimately unsuccessful dispute before the WTO, and a massive media campaign run by the fossil fuel industry in the early 2020s attempting to discredit the safety and efficiency of the new energy storage system, the free-to-use process was quickly implemented around the globe. Initial capital costs were addressed when a partnership between Engineers Without Borders, Bill Gates, and the Swedish government's Energy to People Initiative provided financial and technical support to developing countries willing to produce the new batteries and make them available to households. The new battery essentially solved the problem of intermittency for renewable energy technologies and immediately took many dirty "peaker" plants off the grid. When innovations to solar power generation started to come to market, spurred by the newly vitalised Energy Research and Development Fund (ERnDF) established after COP 27, new solar plants quickly reached, and then exceeded, grid parity with existing coal plants. This triggered a massive shift to green energy in the mid-2020s.

The benefits of the energy revolution accrued much more quickly to developing countries that to developed nations. The widespread availability of affordable energy led to booming growth in many developing countries, as it began to unlock the educational and entrepreneurial potential of the urban and rural poor. Meanwhile, the economies of industrialised nations began to plateau as international finance, technology development, and cultural and artistic production became much more evenly distributed around the globe.

Today, with growing numbers of companies relocating production and service centres to developing countries, industrialised countries are being forced to compete for favour with increasingly powerful new global players. This was especially noticeable within the "Afrozone," created in 2028, which solidified almost all West African countries – and some Central and East African ones – into a single currency trading block and an economic force to be reckoned with. China and the US in particular continue to struggle for relative influence in developing economies.

As the energy revolution gained momentum and emissions growth slowed, the issue of climate change began to seem less serious. This perception was reinforced by the fortunate fact that the extreme climate effects of 2016 to 2018 did not repeat themselves. Climate patterns in the US China and India re-stabilised in 2020, and although rainfall patterns in Sub-Saharan Africa continued to fluctuate, its population was better equipped to deal with these moderate effects of climate change as the region became more prosperous and infrastructure improved.

In 2020, a renowned climate scientist surprised the international community by publishing a paper presenting data that indicated that the extreme events of the previous decade were likely anomalous and chiefly driven by a rare interaction between two multi-decade oscillations. She ended by predicting only moderate climate change for the future. Although many initially doubted her findings, many further studies began to support her conclusion, and it started to become clear that the world was facing a less risky climate future than the 2015 data suggested. In 2024, the IPCC's best estimates of climate sensitivity were released; their central estimate was at the low end of what had been previously thought. New findings indicated that the moderate changes to the climate expected in the foreseeable future would probably happen slowly enough for human communities to adapt. The more serious risks related to species extinction, particularly in biodiversity hotspots, but general wealth and greater urbanisation made the tourism and ecosystem services aspects of these areas less economically crucial to humans than they once were. (It was not uncommon by 2025 for people in cities to keep small robots as pets). Although the report did indicate that the effects of carbon uptake in the ocean could be quite serious, public belief in long-promised breakthroughs in carbon dioxide removal technologies meant that this was not considered a politically salient risk.

Compared to the situation fifteen years ago, it seems that the world has rolled double sixes repeatedly. An efficient new energy storage system has been developed; the global economy is on its way to becoming carbon neutral; global prosperity and equality are on the rise; and climate sensitivity to CO_2 is much lower than was previously thought. However, some scientists remain concerned that the promise of CDR may not materialise, opening up some questions about how to deal with long-term marine carbon uptake effects. Another small group, sometimes referred to as "neo-denialists," are sceptical of the scientific credibility of (and political motivations behind) the IPCC's revised results and doubt that we have really heard the final word on climate sensitivity. By 2030, this group, along with "deep greens" who are worried about preserving endangered ecosystems, are the only constituencies who remain interested in pursuing SRM research. Rumours of secret agricultural (and even military) geoengineering programmes have not yet been substantiated.

2.7 Identifying potential consequences for governance design

The intent behind developing these scenarios was to pose challenges that governance for SRM technology development would need to navigate. The following step was to elaborate upon what these might be. In the same scenario breakout groups, participants produced a list of potential opportunities and threats to SRM governance presented by their respective scenarios in order to paint a comprehensive picture of the positive or negative conditions under which SRM governance would have to function in each hypothetical future.

Fragmented world struggles to handle unpredictable climate	
Opportunities	**Threats**
International contestation over SRM creates demand for governance	International contestation, in general and specifically over climate & SRM, likely to block ageement
Chance of influential norms emerging among states, similar to nuclear non-first strike use during Cold War	High potential for SRM implementation by a small number of states, contrary to the desires and interests of others
China's collapse reduces the number of major players on the international arena	China is a big uncertainty
Fragmentation could facilitate diversity of strategies and adaptability while avoiding lock-in	Potential for states to (want to) implement SRM in order to gain relative advantage over other states
Climate impacts (& high emissions and BECCS collapse) likely to put SRM governance on the agenda early	Unstable Europe is an uncertainty
India's intentions could broaden scope of SRM governance considerations to include SRM for purposes other than countering climate change	Quasi-emergency conditions could lead to hasty decions and actions
Existing forum for international debate (UNFCCC) which may be resistant to discussing SRM is absent	Existing forum for international debate (UNFCCC, which is a logical site to discuss SRM) is absent
	Swamp economy may cause governments to focus on priorities that are higher than SRM

Table 4: Opportunities and threats paint a picture of the positive and negative conditions SRM governance must navigate in each scenario.

Source: IASS SRM4G

Building sandcastles under the shadow of a tidal wave	
Opportunities	**Threats**
Extreme effects of climate change lead to agreement on the "need to act"	Emergency narrative could lead to normal rules being overwritten, leading to rushed decision-making on SRM
Emissions growth slowing could mean less SRM research is needed due to better mitigation	Environmental migration at record levels could lead to political pressure for "quick fix"
Introduction of a significant revenue-neutral carbon price gives a clear signal for mitigation action	Development of low-cost energy storage could lead to less urgency for SRM governance/public discourse
Increased investment in adaptation to address climate change impacts leads to reduced mortality and avoided economic damage and less migration	CDR industry lobbying against SRM – commercial interests undermine legitimacy of the discourse. Lobbying power can distort the discourse on SRM governance
Low-cost solar/wind power leads to a low carbon economy which offers a way to safely exit SRM	Hurricanes destroy Miami – Public backlash against SRM research
Open research by the US off the coast of Florida could lead to a gain in scientific knowledge on SRM	Ban on SRM research in the USA – leads to research on SRM stalling and continued ignorance about the pros and cons of the technologies
Hurricanes destroy Miami – creates an opportunity for informed public discourse on the attribution of climate events	Decline of emissions leads to less impetus for SRM research, less information is entered into the SRM debate
Carbon price declines as CDR competition thrives, limiting one-sided lobbying power and windfall politics	Secret testing in China with US backing – secrecy undermines legitimacy of SRM discourse
Pathway to zero-carbon reduces pressure for SRM	Yellow River changes course, resulting in massive destruction – false attribution of extreme weather events to SRM testing leads to irrational decisions. Irrational public reaction leads to further elite-public polarization
Wiki-leaks reveals secret China/US SRM test – enhanced transparency	Backlash against SRM research leads to lack of information on which to make decisions
News of declining emissions empowers political momentum	
US-China agreement on carbon price strengthens mini-lateral decision making (could be positive for SRM governance)	US-China agreement on carbon price strengthens mini-lateral decision making (could be negative for SRM governance)

Up the proverbial creek without a paddle

Opportunities	Threats
US-China resolve South China Sea dispute – possibility of transcending "territorial" or long-standing political/social conflicts, making cooperation easier (Belief: violence is bad, governance that encourages cooperation is good)	G2 dominance (global hegemony) privileges particular forms of governance (Belief: Diversity of governance is good)
Emerging economies converging with developed nations leads to better prospects for weaker/poorer societies to gain greater influence	Emerging economies converging with developed nations raises risk of more ingrained inequalities
India/China collaboration on SRM research – Independent/indigenous scientific capacity enhances autonomy and diversity (Belief: diversity and autonomy are good)	Global governance structure is basically reinforced (dissent reduced). (Belief: current economic order is incompatible with fair participative politics)
BECCS buried – stimulus for more integrated approach to governance of bio-productivity (for food, nature, forestry, Bio-CDR, energy etc. (Belief: integration is good for sustainability)	Declaration of climate emergency threatens diversity, participation, deliberation (Belief: deliberation and participation are good)
	SRM research patchy, scarce public funds - lack of international science governance means no coordination. (Belief: World would benefit from coordinated science)
	Oxford Principles on abstaining from SRM testing – self-regulation of SRM science could be undermined by Chinese culture or Indian rejection of "colonial values" (Belief: Collaboration & integration are good)
	CDR land-grabs, conflict – descent into conflict and violence rather than peaceful and deliberative debate undermines governance (Belief: violence is bad)

Life's easy when you're lucky

Opportunities	Threats
	Promise of CDR reduces interest in SRM research
Effective mitigation can also be seen as an opportunity to limit SRM research	Effective mitigation is a threat to SRM research by limiting one side of the argument for it
Serious steps forward on mitigation would remove moral hazard effect and allow less fractious consideration of SRM making an institution easier to form	Following tech transfer revelation, US tightens up secrecy around government funded science on SRM
Energy revolution in the developing world – increased domestic capacity/self-determination regarding energy systems could increase climate/SRM conceptual category	Remaining climate risks seen as niche – Reduced perception of risk to humans risks creating environment that undervalues other species
New findings about the state of climate change take some of the heat out of climate discussion: Less acrimonious discussion of SRM	Creation of Afrozone – two distinct single currency zones create risk of excessive economic competition, negatively affecting scientific research
As developing economies boom, more balanced international arena allows for more equitable decision-making over SRM	Continued US-China competition reduces the likelihood of cooperation on SRM research governance
Strong scientific voices emphasising climate insensitivity leads to reduction in interest in SRM when it looks like SRM is less necessary	Rejection of SRM could prove a threat if climate change is more severe than projected

2.8 Creating governance options

Each scenario breakout group then developed an SRM governance framework; a coherent construct intended to avoid potential threats and make use of potential opportunities of their respective scenarios, incorporating:

- **Regulatory mandates** (What is the purpose or function? What technology and innovation phase is targeted? Does it relate to other climate response mechanisms?)
- **Membership** (What kind of members? How inclusive? How flexible?)
- **Structures/mechanisms** (Degree of institutionalisation? What are decision-making procedures?)
- **Outputs/decisions** (How is compliance encouraged? Is non-compliance sanctioned? How does monitoring work?)

This framework explicitly served as a structure for thinking about governance in a broad sense, including everything from bottom-up or self-governance mechanisms to highly institutionalised international organisations.

The breakout groups then "sliced" their governance frameworks into several governance options in order to break the frameworks down into communicable parts. As a result, every scenario breakout group produced a set of connected governance options which they believed were suited to effectively handle SRM under the conditions of their scenario.

Table 5: Four SRM governance frameworks were designed, each responding to the opportunities and threats of individual scenarios.

Source: IASS SRM4G

Fragmented world struggles to handle unpredictable climate
SRM Governance Options

Name	Mandate	Membership	Structure and Mechanism	Decisions/ Output
Scientific advisory board	Provide sound advice concerning consequences	Scientifc excellence with diversity criteria	■ Open public review ■ Consensual but with publication of dissenting views	■ Periodic scientific summaries of evidence and argument ■ Arms-length policy informative
Non-scientific advisory bodies	Represent sectoral interests and perspectives	Security expertise; NGOs; environmentalists; ethics committee; union groups	Publicly minuted meetings, open reports	Reports and advice – unsolicited or by order
ICEO (International Climate Engineering Organization)	■ Make positive contribution to climate policy as a whole ■ Ensure SRM potential is explored ■ Minimize risk of international conflict by: ▪ Avoiding securitization of climate ▪ Avoiding militarisation of SRM ▪ Avoiding sudden termination ▪ Avoiding rogues ■ Comply with international norms ■ Minimize transboundary harm	■ Membership by qualification: ▪ States ▪ Non-state and Intergovernmental organisations linked in somehow ■ Criteria for membership: ▪ Good mitigators – e.g. falling carbon intensity/GDP ▪ Contribute appropriately to global adaption efforts ▪ Transparent, responsible research practice ▪ Firewall between SRM & military	Parties form a General Assembly, which can: ▪ Agree to CE implementation with a two-thirds majority of countries and global population (double majority). ▪ Issue statements on a consensual basis (if need be, voting).	Double 2/3 majority lock for SRM deployment Compliance: ▪ Facilitating compliance ▪ Naming and shaming ▪ Ejection ▪ Good research practices ▪ Dispute settlement forum ▪ Talks towards mechanism for compensation fund ▪ Research and intellectual property pool ▪ Coordination of outdoor tests

Building sandcastles under the shadow of a tidal wave
SRM Governance Options

Name	Mandate	Membership	Structure and Mechanism	Decisions/ Output
Science-informed assessment of SRM	■ Socio-technical assessments of implications at levels of deployment ■ Improve ability to attribute climate impacts	Diverse: Scientists (diverse in disciplines social science, natural science researchers and policymakers (representative interationally) (i.e. science-policy body e.g., IPCC subgroup or independent)	■ Mixed diverse panel defining guidelines (rather than treaty) ■ Working analogously to the London Convention (re the law of the sea) ■ Learning organization – iterative process with adaptive decision-making standards	■ Determination of what constitutes a material termination effect and corresponding scale of deployment ■ Improved public discourse on attribution and impacts
Climate change emergency procedures	■ Define "climate change emergency" aka. understand 'degrees of emergency' ■ Preventing irrevocable decisions; international norms	■ Track 1: States emphasizing most vulnerable countries ■ Track 2: Civil society/non-state actors/earth systems	■ Science-based pre-agreed: ▪ indicators on 'earth system vitals' ▪ monitoring of indicators ▪ scales of indicators defined ■ Values	■ Minimum thresholds defined for consideration for declaration of an emergency ■ Procedures that can be put to work in a climate emergency including: ▪ do nothing ▪ disaster relief ▪ adaptation ▪ possible SRM deployment pathways incl. ▪ conditions & exit strategy ▪ outdoor tests
SRM Agreement	■ Create procedures and deliberative processes ■ Establish conditions under which SRM could be deployed ■ Ensure adequate decisionmaking on SRM	■ Countries (sufficiently representative) ■ Social science, natural science based information ■ Civil society	■ Possibly a treaty ■ Possibly a moratorium linked to specific conditions under which it is lifted ■ Stage-gating initial SRM deployment to ensure regular review and knowledge-development to keep up with political decisions; ■ Preventing irrevocable decisions	■ Physical monitoring systems to detect SRM deployment/ effects ■ Procedures in place that guide reactions to climate emergencies ■ Agreement on exit strategies & mitigation commitments as necessary conditions for SRM deployment/ allow for immediate exit without a material termination effect

Building sandcastles under the shadow of a tidal wave (continued)

SRM Governance Options

Name	Mandate	Membership	Structure and Mechanism	Decisions/ Output
Transparency	▪ Prevent mistrust and possible geo-political conflict by creating transpar-ency in SRM research and potential SRM deployment	▪ Researchers and research organiza-tions; (National or private) funding agencies ▪ National govern-ments (esp. with regard to military)	▪ Registry of re-search proposals and results of research open to the public; ▪ Content subject to public guidelines ▪ The objective is to nudge researchers to disclose information in order to encour-age their peers to do the same.	▪ Publicly accessible data, information, and results on SRM ▪ Enhanced academ-ic/political debate Increased transpar-ency ▪ Increased trust in research (and evidence based decisionmaking) processes ▪ Increased research coordination
SRM Ban	▪ Prevent SRM deployment ▪ Ensure agreement is kept through sanctions and incen-tives; ▪ Monitor non-com-pliance	▪ UN Security coun-cil/General Assem-bly/Minilateral group of countries ▪ NGO observers	▪ Physical monitor-ing system to detect SRM deployment	▪ Ban ▪ UN resolution

Up the proverbial creek without a paddle
SRM Governance Options

Name	Mandate	Membership	Structure and Mechanism	Decisions/ Output
Intergovernmental Office of Science (IGOS)	To evaluate, screen and govern science and technology of global relevance (including SRM)	National governments (ideally universal – 'inclusive' if 'mini-lateral'), represented by e.g. national academies or relevant government departments	Undertake assessments of technologies similar to ~IPCC; supported by public participation/deliberation; two stage process to assess first whether an area is 'in scope', and second, if so, to suggest how research should be governed and directed.	Assessments/ reports, if necessary protocols about the conduct of research and the nature of acceptable experiments (potentially extending to IP); funding
Safe Operating Space for Science (SOS-Science)	To promote responsible science on a voluntary basis	Self selected researchers, research institutions and NGOs	Voluntary, self-regulating network establishing and promoting a code of conduct for scientific research (including climate and climate engineering)	Code of conduct to preserve safe zone, serve as bar for funding outdoor tests
Pope's Climate Governance Commission (PCGC)	Assess climate policy responses from cultural and ethical perspectives	Appointees – leaders from ethical, cultural and artistic communities	Issue and promote one or a series of reports	Broad evaluations of climate response options, suggesting new alternatives and encouraging ethical and sustainable cultural and behavioural change
Global Deliberative Exercise	To ensure full public participation and deliberation on questions of controversial technologies	Civil society/publics	Using – Worldwide views or similar organisation/methodology (online or f2f); nontraditional deliberative organizers	Inputs to other processes; legitimacy
Corporations/ Intellectual Property	To ensure that technologies are open access/public good	Aerospace, chemicals, etc.	Voluntary with broad stakeholder engagement (little profit potential)	Code of conduct, open access regime

Life's easy when you're lucky SRM Governance Options				
Name	**Mandate**	**Membership**	**Structure and Mechanism**	**Decisions/ Output**
Inertial Dampeners – self-organising expert groups provide expert advice to society and to policymakers in order to dampen any sudden shifts in opinion regarding SRM	Smooth any excessive swings of opinion	■ Existing science/ policy actors ■ Multiple modes of independent expert advice	■ Low degree of institutionalisation, as one would expect with a loose association of expert advisers ■ No attempts of individuals or groups to seek preeminent authority ■ P2P monitoring with expert community	Myriad outputs fed into policymaking at all levels
Transition Protocol – a smaller group of self-organising experts seeks to move forward the conversation around SRM, to encourage consideration of its use for other, non-climate change purposes	Transition out of climate SRM to planetary management SRM international norms	Concerned experts	Self organising group of concerned experts begin to lobby for consideration of the nonclimate change uses of SRM	Members of loose expert networks begin to solicit for a formal institutional response to the prospect that SRM be used for nonclimate goals

2.9 Cross-evaluating governance options

One of the project's aims was to consider ways SRM governance mechanisms could be evaluated in the face of deep uncertainty. Thus, participants also engaged in a cross-evaluation exercise. In the context of a scenario project, the cross-evaluation works like a "wind tunnel": scenarios (including their respective consequences) can be seen as alternative airstreams and the governance options as different models, in which the models' dynamics are evaluated under alternative conditions. Participants, in breakout groups, therefore evaluated each of the governance options against the other scenarios in order to explore if they could effectively govern SRM across a variety of potential futures, and not just the future for which they were specifically designed.

These **"robust"** governance options – options that from a *current* perspective seem to be useful in more cases than **"selective"** options that are only helpful in one specific future – appear, *at the moment*, more adequate to deal with a highly uncertain future (meaning that we really do not know what the future will look like). Nevertheless, selective governance options are not useless; they are just designed for one specific scenario.

It has to be highlighted here that the cross-evaluation of governance options does not aim at finding any best solution. Strategic activities are not one-time exercises, and require constant readjustment over the long-term. However, cross-evaluation can be used as a tool to stimulate thinking by making the abilities of certain governance options to handle many, or only one, alternative future visible.

Each group used a scale from 0 to 3 to assess how effective, feasible and legitimate a certain governance option could be under the alternative conditions posed by each scenario (Figure 3). This evaluation refers to the practical utilisation of governance options and therefore touches upon the domains of policy planning and political decision-making. However, although the results of the cross-evaluation might provide a rough heuristic as to which governance options seemed more robust to the group, it has to be emphasised that they were never intended to deliver any recommendations for decision-making.

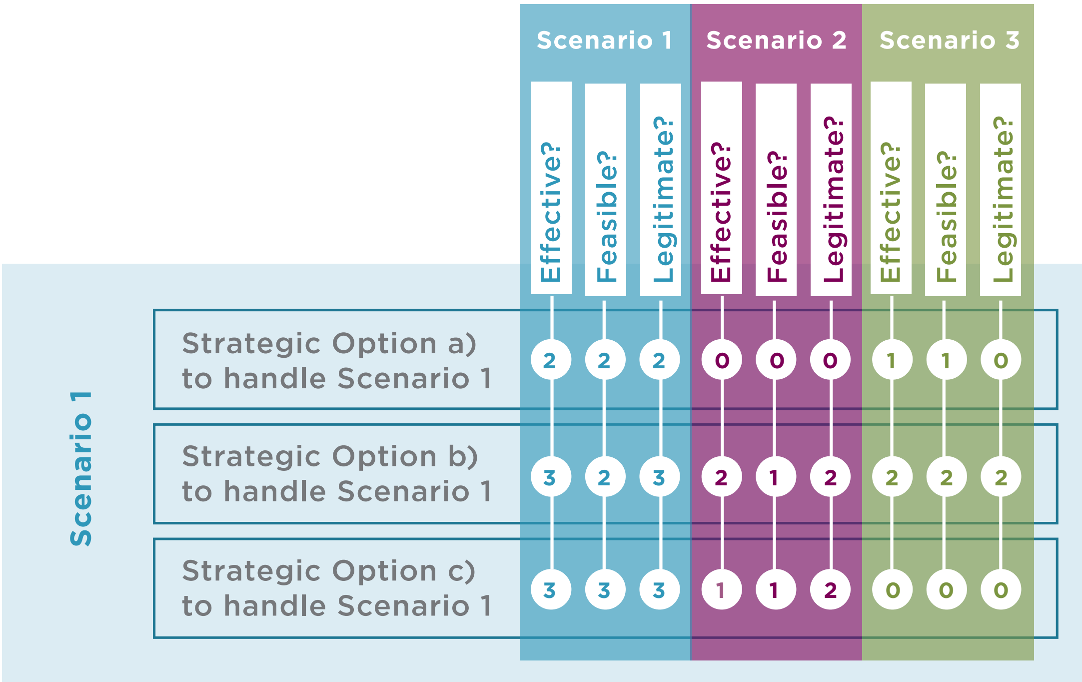

Figure 3: Each SRM governance framework was cross-evaluated across all scenarios to explore if it could effectively govern SRM across a variety of possible futures.

Source: IASS SRM4G

The cross-evaluation was meant as an exploration of robustness as a criterion for strategic governance design, to stimulate thinking among project participants and report readers on its usefulness as a concept. The evaluation was not intended to produce policy recommendations. Therefore, the full results of the cross-evaluation are not included here. The technique can be illustrated using an example:

The cross-evaluation indicated that the governance options designed to govern SRM under the conditions of the "Fragmented World" scenario might also be effective for the governance of SRM in all the other scenarios. More specifically, an "International Climate Engineering Organisation" (ICEO), including scientific and non-scientific advisory bodies, could also help to avoid rushed decisions on SRM (as illustrated in "Sandcastles"); it could help to avoid that the potential of SRM is not explored although needed (as illustrated in "Creek"); and it could also help to avoid secrecy surrounding SRM research (as illustrated in "Lucky"). However, the idea of setting up an ICEO would face difficulties under the conditions of effective mitigation and promising CDR innovations because that would reduce incentives for taking care of governing SRM ("Lucky"). It would also face feasibility problems under the condition of a strong G2 between the US and China as incentives for participation are low ("Creek").

For participants reflections on the usefulness of the cross-evaluation process and results, see the sections **Thinking about governance** and **Conclusion and outlook**.

3. Reflections

The workshops also integrated group discussions on the implications of using scenarios for designing SRM governance, as well as whether foresight methodologies, especially scenario construction, could be used as a tool for facilitating further discussions in the field of SRM governance research. This section summarises the learning experiences of SRM4G so that future projects can integrate and build on our deliberations, in four clusters roughly corresponding to the stages of our projects.

3.1 Understanding complex environments (sections 2.1 – 5)

Groupthink Some participants raised concerns that the second step of the environment scanning – the clustering of ideas for descriptors – was too long and may have encouraged groupthink instead of discouraging it. The participants judged that the value of retaining distinctions between ideas at this early stage was low in relation to the time investment and the risk of groupthink. For future scenario projects, stricter facilitation and the use of online-tools at this step was suggested.

Key uncertainties (**see 2.2**) After completing the scenario construction process, the group saw the potential to review the set of key uncertainties, the cornerstones of all scenarios. First, it was suggested that the key uncertainty "Climate Risk" could be specified and narrowed down to "Climate Sensitivity" because sensitivity was the actual driver in many scenarios. Second, the group also discussed possibilities to broaden the key uncertainty "G2" as relations between China and the US seemed rather to be an indicator of the general "geopolitical climate." It was suggested this key uncertainty could therefore be merged with the key uncertainty "Domestic and Regional Stability". Third, the opinion was expressed that "CDR Technology Advancement" could be the most decisive factor among the key uncertainties because its projections imposed strong and immediate consequences on almost all other key uncertainties' outcomes.

Projections (**see 2.3**) One of the major discussion points was the projections of key uncertainties. First, some participants raised concerns that the projections of "Climate Risk" did not match the 15-year timeframe, suggesting they seemed too extreme and thus unlikely to plausibly occur by 2030. In this regard, the group pointed out the underrepresentation of climate scientists and economists in this project. Second, despite repeated plausibility checks during the process, the group generally identified a bias towards extreme change in the definition of the key uncertainties' projections. This bias could be a result of the group's effort to construct extreme and interesting projections in order to avoid the status-quo bias that is common in scenario construction.

Blind spots The group also discovered a blind spot in its set of key uncertainties: participants pointed out that the "Results of SRM Research in the next 15 years" could be a decisive factor in several of the scenarios constructed. Therefore, this factor could qualify as a key uncertainty that may deserve further attention in future discussions. Some participants raised concerns that the groups' implicitly held assumptions, such as the persistence of the nation-state model and the low potential for cultural change, could have prevented them from considering factors that may have the potential for decisive change in the future. However, the group conceded the need for at least some basic assumptions about what can be considered a constant for the next 15 years.

The broader context The group discussed the value of starting to investigate SRM governance within a broader context and highlighted some of the insights from the scenario construction: not only climate impacts and technological advancements affect future pathways. On the contrary, the impact of social, cultural, and political factors, and their interactions was considered significant. Even if climate impacts seemed to indicate a case for SRM, the scenarios highlighted that social and cultural conditions could outweigh this "pull" and lead public or political opinion away from SRM.

3.2 Assessing alternative scenarios (section 2.6)

Participants' takeaways The group discussed some of the scenarios' noteworthy characteristics:

- First, a dysfunctional SRM governance system, as portrayed in the scenario "Fragmented World", was not solely the outcome of a conflict of SRM interests. The dysfunctionality was rather triggered by aspects related to protectionism, migration, geopolitics, and international security issues. "Fragmented World" illustrated the potential risks of regulating SRM under confrontational international conditions.

- Second, and conversely, the scenario "Up the Proverbial Creek" illustrated a pathway towards close US-China cooperation on climate emergency issues not because of the climate emergency itself, but due to closer cooperation in trade and security affairs.

- Third, the group mentioned that the "Up the Proverbial Creek" scenario described the risk of facing a climate crisis with a lack of SRM knowledge, partly because governance structures for SRM research had not been developed. This scenario suggests the relevance of early and ongoing discussions regarding governance structures for SRM research and development, including field testing.

- Fourth, "Sandcastles" specified a public-elite split regarding SRM triggered by misattribution of climate impacts. The combination of this misattribution and the secrecy surrounding SRM field tests highlighted the valid risk of a broad public backlash against SRM after some initial support.

- Fifth, perhaps the most remarkable aspect about the scenario "Life is Easy" was that it was not perceived as a wild card scenario triggered by a significant event with low probability. The technology innovation described in this scenario was considered a plausible option despite its disruptive character and impactful consequences. However, the group emphasised the wildcard character of the climate sensitivity projection this scenario is based on and recommended a second plausibility check of the projections developed.

- Sixth, another interesting discussion point raised by the "Life is Easy" scenario was the potential for an *unintended* consequence of successful mitigation: within the context of the scenario, mitigation and low climate sensitivity had the potential to lessen the hypothesised termination effect and therefore make SRM deployment seem less risky.

Plausibility The group discussed at length whether the scenarios they created were plausible and could be published. The group believed that their scenarios pushed the boundaries of plausibility and concluded that an additional review round with a particular focus on the physical climate science aspects was needed to "smooth the edges" without changing the scenarios' core narratives and underlying structures (projections). At the same time, the group felt that overly consistent and plausible scenarios could defeat their own purpose of encouraging innovative thinking.

The value of re-contextualisation The participants highlighted the value of the scenarios for the group itself: the scenarios offered participants alternative perspectives on complex pictures of and corresponding pathways into the future and allowed the group to engage in a useful re-contextualisation of the technologies under consideration.

3.3 Thinking about governance (sections 2.7 – 9)

Remarkable aspects (**see 2.8**) After designing and evaluating SRM governance options under alternative conditions, the group highlighted some remarkable aspects that could be worth exploring further:

- For instance, the governance of intellectual property rights as an instrument to make technology openly accessible was mentioned, as well as the idea of an ethical deliberative body on SRM.

- After evaluating options against alternative scenarios it was pointed out that – perhaps in contrast to initial expectations – SRM seemed more difficult to govern under the conditions of a "Fragmented World" scenario than under the terrifying conditions of an "Up the Proverbial Creek" scenario.

- The discussions also highlighted that, while transparency and scientific principles were essential minimal SRM governance mechanisms, they were not sufficient to govern SRM effectively under the conditions exemplified in the scenarios, indicating that more formalized governance approaches might need to be considered.

- While discussing governance options for alternative scenarios, the benefits of starting deliberations on SRM research governance sooner rather than later were highlighted. This was especially emphasised as it became clear that separating governance of SRM research and SRM deployment was difficult under the circumstances described in some of the scenarios.

Structured link between future and governance The group pointed out the value of the process itself, as it added structure to highly complex thinking processes involving alternative futures and numerous governance options. They considered the structured process implemented during the workshop more useful than creating governance ideas based on implicit assumptions about future developments, risks or potential threats.

Making assumptions explicit The process helped to surface norms, values, and implicit assumptions. It also helped to uncover the legitimacy, effectiveness or feasibility problems certain governance options presented under possible alternative conditions.

Cross-evaluation problems (**see 2.9**) However, concerns about the process of cross-evaluating governance options were raised. It was widely acknowledged that even when the same breakout groups rated the legitimacy, effectiveness, and feasibility of the same governance options, it was very difficult to find a common frame of reference. The group made it clear that the results of the evaluation could not be used in any policy or other research context.

3.4 Reflections on project aims, design, and group composition

Reflecting on the scenario development process itself as implemented in the SRM4G project, the participants focused on four topics: boundary conditions, group composition, the "insider-outsider problem", and resources.

Boundary conditions The group discussed the original boundary conditions set by the project team and raised several methodological issues:

- It was widely recognised that this scenario development process was "SRM permissive" because of the project's primary aim to enable future-oriented deliberations on SRM governance. Some participants further expressed concern that the nature and structure of the exercise may have drawn the group into developing scenarios which made SRM seem more relevant than it may actually be.

- The group also discussed whether setting the timeframe to 15 years suited the aim of the project and the scope of the scenarios. Although it seemed attractive from a foresight perspective, as it provided enough time for potentially significant change without forcing participants to think about a future so distant it became almost completely intangible, from a climate science perspective, the time horizon seemed to short, and from a policy-oriented perspective it seemed rather long.

- The opinion was expressed that, although the process enabled a valuable re-contextualisation of SRM technologies, a more comprehensive definition of the boundary conditions and core assumptions could have enhanced the communication structure. In addition, more sequencing of plenary and breakout sessions was suggested as a way to add even more structure and to avoid misunderstandings within the group.

- One participant brought up the idea of discussing drivers of history before engaging in a scenario process, suggesting it might help to understand the nature of transformations and the kind of change that is important in scenario construction.

- Although numerical figures were only used to structure discussions and to force participants to make the assumptions on which they made qualitative choices explicit, some participants expressed the opinion that every methodological step that involved numerical figures made them feel uncomfortable due, among other reasons, to the possibility of misleadingly signalling empiricism.

The group composition The participants discussed the extent to which the group's homogeneous composition on certain dimensions might influence its work. A group of predominantly white, male social scientists from western countries naturally lacks certain perspectives. It was suggested that future scenario development groups should be broadened to include, for instance, more women, greater international and ethnic diversity, and other professional and disciplinary backgrounds, such as economists and climate scientists.

Insider vs. outsider The group addressed multiple issues concerning a well-known shortcoming of scenario construction and foresight in general: communication between insiders and outsiders.

- Thought experiments can provide valuable insights into complex social issues. However, these insights are often restricted to those engaged in the experiment itself, because thoroughly explaining all the conclusions reached would require the publication of a comprehensive protocol of all group discussions. However, a written scenario description can be an adequate substitute for a lengthy protocol because it crystallises the group's thought process into a coherent and plausible description of the thought experiment results. The group raised two concerns related to this point. On the one hand, participants were worried that readers could easily take plausible scenarios out of context, reify, or instrumentalise them. On the other hand, they expressed the opinion that scenarios which could be perceived as implausible and incoherent might easily undermine the author's' scientific and professional credibility.

- The insider-outsider problem took on a second dimension with the transition from scenario construction to the drawing of implications. The group was reluctant to draw any concrete implications, expressing concern that even explicitly scenario-specific implications could misinterpreted as "real world" implications by outsiders. They also pointed out that they, as a group, needed to be aware of the potential effect the creation of such scenarios may have on the broader climate engineering discourse. However, the group wished to communicate the results of their structured thought process to the wider community to further inform the SRM governance debate.

- It was agreed that the best way to communicate results without risking misinterpretation was to "meta-talk about what was talked about" and be as detailed as possible when describing the scenario development process.

- Similarly, the group posed the question as to how their "insider" governance designs and the cross-evaluations they produced may speak to existing "outsider" SRM governance proposals. It was suggested that a clear line should be drawn between scenario construction and drawing implications by engaging two groups in the scenario planning process: scenario constructors and governance designers. The latter group should ideally be composed of governance experts who could cross-evaluate their own proposals under differing scenario conditions.

Resources Fourthly, it was recognised that process improvements always involve a trade-off against time investment by the participants.

Regardless of the above mentioned pitfalls, the group very much appreciated the scenario development experience. They indicated that it enabled the useful re-contextualisation of SRM technologies, facilitated interdisciplinary learning, challenged shorthand assumptions, and brought up some innovative new ideas. As one participant put it, the process added some rigour to thinking about how the future may develop. Although the scenarios developed remain subjective constructs, the systematic scenario development approach clearly has advantages over simple "hand waving."

4. Conclusion and outlook

Can foresight methods – and the treatment of the future as an experimental space – provide a useful toolbox for thinking through governance options for the research and development of SRM technologies under conditions of deep uncertainty? SRM4G sought to provide an initial framework to:

1. Facilitate future-oriented communication in SRM research community

2. Consider plausible, not probable outcomes

3. Increase critical reflection

4. Explore and evaluate capacities of governance options against multiple futures

5. Discuss but not recommend policy

The following evaluates the process and outcomes of the project against its aims. As a project that applies scenarios to the anticipatory exploration of climate engineering challenges, SRM4G represents a qualified success, and provides various outlets for further activity.

4.1 Successes: scenarios as a platform for communication and critical reflection

Feedback from participants – selected from researchers heavily engaged in SRM governance discussions – suggests that scenario construction can be conducive to facilitating interdisciplinary communication and group learning (Aim 1). The process proved especially useful in helping participants "re-contextualise" their thinking about SRM technologies; it allowed participants to think outside their respective disciplines to conceptualise complex (future) contexts, which helped to broaden their perspectives on challenges that SRM governance may face (Aims 1 and 2). The scenario construction process also forced participants to make their assumptions about possible future developments explicit and in some cases the process even helped them to rethink those assumptions and systematically explore new dynamics between climatic conditions, societal stakeholders, and governance systems (Aim 3).

It must be stressed that the scenarios developed were thought experiments: they were plausible imaginaries designed to provoke thought on SRM governance, and they were produced within the bounds of one particular method for scenario construction by one particular group of participants. The SRM4G scenarios can and should be supplemented, supported or challenged by scenarios developed by different groups. The scenario construction methodology detailed here should allow follow-up projects to use the same boundary conditions and follow the same sequence of methodological steps, or to improve upon them. Smaller scenario projects could even use the intermediate results of this project to extend the set of scenarios developed using the key uncertainties and their respective projections. Furthermore, the scenarios described in this report could be used to test existing governance proposals in order to make them more robust or comprehensive in the face of high uncertainty. This could either be done by individual researchers who have created governance proposals, or as some participants suggested during the workshop, in a participatory group setting with an expanded range of stakeholders.

A word of caution: future project planners should be aware that when using scenario development to facilitate SRM governance discussions, the nature and structure of the exercise can lead to the development of scenarios which make SRM seem more relevant or central to the unfolding of global politics than it may actually be. All attempts should be made to create a wider context and landscape into which a discussion of SRM may emerge, as SRM4G sought to do by grounding SRM within global responses to address climate change and a wide array of uncertainties. However, it can also be argued that all such scenario exercises with particular foci (SRM development or otherwise) must tolerate a degree of myopia, or a predisposition towards (over)emphasising the game-changing nature of their topic.

4.2 Work in progress: evaluating SRM governance

The creation of governance options (see 2.8) and the cross-evaluation (see 2.9) of governance options, from the perspective of the project team, represent works in progress. The reason for the problems with the last project stages may have been a conceptual one that arose from an emergent conflict between two project aims: to explore and evaluate the capacities of governance options against multiple futures (Aim 4) without aiming for policy recommendations in favour of particular options (Aim 5).

Aim 4 required participants to assess how particular governance designs could make use of strategic opportunities and avoid strategic threats presented by the scenarios, both individually and collectively. It was quickly realised, however, that such strategic planning is usually done within the context of a policy agenda – for example, catering to the needs and goals of particular governments or organisations. However, SRM4G aimed to explicitly avoid providing policy advice on SRM governance mechanisms (Aim 5) and thereby created a paradox.

The participants were left without a decision-making framework since they saw their role not as "planners" for particular political constituencies or the wider climate engineering community, but as meta-analysts. In line with the project's aims, rather than discussing the pros and cons of specific strategic options for SRM governance, they highlighted the value of evaluating the scenario development process as a method of furthering discussions on SRM governance. Future projects could build on these conclusions and separate scenario construction and planning phases by having an additional group of "planners" representing particular interests take over after the scenarios have been developed to test their governance proposals.

SRM4G is the latest in a growing number of scenario development exercises on the topic of climate engineering (previous examples include Boettcher et al. 2015; Banerjee et al. 2013; Bellamy & Healey 2014; Milkoreit et al. 2011). SRM4G was one of the longest-running scenario projects of its kind in the field, and has arguably produced the most detailed results. Reflection on the project's process and outcomes suggests that scenario building can be a useful platform for future-oriented communication in SRM research community, and that the broad foresight methodology toolbox can be useful in considering the myriad of uncertainties associated with climate engineering governance.

5. Appendix

5.1 Workshop agendas

Workshop I: 13–14 July, 2015

Day I, 13 July

9.00–9.30
Welcome and Introduction
- Introduction round, discussion of participants' expectations
- Explanation of aims and motivations behind the project

9.30–10.15
Introduction to Scenario Planning
- Definition of the form and function of a social science scenario
- Step-by-step overview of the scenario development process

10.15–11.00
Plenary Session 1: Setting the Stage
Discussion defining scope, research questions, context, and scenario focus

11.15–13.00
Plenary Session 2: Environment Scanning
Structured brainstorming to identify influential factors for climate response in 2030 (approximately 50 factors)

14.00–14.15
Plenary Session 3: Introduction to Uncertainty-Impact Analysis
Explanation of method, purpose of analysis

14.15–15.45
Working Groups Session 1: Uncertainty Impact (UI) Analysis
Tandem groups rating potential impact and uncertainty of all factors identified during environmental scanning

15.45–16.00
Plenary Session 4: Selecting Key Uncertainties
Based on results of UI analysis, discussing and selecting eight highly uncertain factors likely to have a high impact on climate response strategies in 2030 (hereafter "key uncertainties")

16.00–17.00
Working Groups Session 2: Defining Key Uncertainties
Breakout groups of 2–4 participants refining definitions of key uncertainties and describing four alternative projections for each key uncertainty in 2030

17.00–18.30
External Presentation
"Cirrus Cloud Thinning: Do the right conditions exist, and how can it be tested with observations?" by David L. Mitchell from the Desert Research Institute, USA

Day II, 14 July

9.00–9.30
Continuation of Working Groups Session 2: Defining Key Uncertainties
Groups of 2–3 participants refining definitions of key uncertainties and describing four alternative projections for each key uncertainty in 2030

9.30–10.45
Plenary Session 5: Presentation of Key Uncertainties & Projections
Working groups present their key uncertainties & projections, open discussion, and revision where necessary

11.00–11.30
Plenary Session 6: Introduction to Consistency Analysis
Explanation of method, purpose of analysis

11.30–13.00
Working Groups Session 3: Consistency Analysis
Groups of 2–3 participants analysing consistency between projections of different key uncertainties

14.00–17.30
Continuation of Working Groups Session 3: Consistency Analysis
Groups of 2–4 participants analysing consistency between projections of different key uncertainties

17.30
Plenary Session 7: Retrospective, Outlook, and Homework
Review of process so far, plans for next workshop, what needs to be prepared between workshops

18.00
Feedback Round
Questions, concerns etc.

Workshop II: 27–28 August, 2015
Day I, 27 August

9.00–9.30
Welcome and Introduction
Introduction of new participants, recap of what was achieved in previous workshop, aims for this workshop

9.30–10.00
Presentation: Results of the Consistency Analysis and Scenario Frameworks
Short description of results of consistency analysis; six clusters of consistent scenarios, multiple consistent scenario frameworks (combinations of consistent key uncertainty projections) within each cluster

10.00–11.00
Plenary Session 1: Selecting Scenario Frameworks
Choosing four scenario frameworks from four different clusters, assigning scenario development groups

11.00–13.00
Working Groups Session 1: Describing a "Picture of the Future"
Four working groups of 3–4 participants developing scenario frameworks to create a detailed "picture of the future" in 2030

13.00–13.30
Plenary Session 2: Gallery Walk, "Pictures of the Future"
Four working groups present their picture of the future in 2030, question round, feedback from plenary on consistency, plausibility

14.30–17.00
Working Groups Session 2: Backcasting a "History of the Future"
Working groups of 3–4 participants backcasting the history of their respective future situations

17.00–17.30
Plenary Session 3: Gallery Walk, "Histories of the Future"
Working groups present their storylines/histories of the future, question round, feedback from plenary on consistency, plausibility

Day II, 28 August

9.00–9.15
Presentation: Deriving Opportunities and Threats
Explanation of method, purpose of analysis

9.15–11.00
Working Groups Session 3: Deriving Opportunities and Threats
Working groups of 3–4 participants list the opportunities and threats their respective scenarios present for SRM governance

11.15–11.30
Plenary Session 4: From Opportunities and Threats to Governance Frameworks
Discussion of how to use information on opportunities and threats to design a scenario-appropriate governance framework

11.30–13.00
Working Groups Session 4: Designing Governance Frameworks
Working groups of 3–4 participants design governance frameworks to suit their respective scenarios

14.00–16.00
Continuation of Working Groups Session 4: Designing Governance Frameworks
Working groups of 3–4 participants design governance frameworks to suit their respective scenarios

16.15–17.00
Plenary Session 5: Gallery Walk, Governance Frameworks
Working groups present their governance frameworks, question round, feedback

17.00–17.30
Presentation: Retrospective and Outlook
Review of process so far, plans for next workshop, what needs to be prepared between workshops

17.30–18.00
Plenary Session 6: Open Discussion & Feedback Round
What has been remarkable, new? What implications can be derived for the next steps? Questions, concerns, etc.

Workshop III: 12–13November, 2015

Day I, 12 November

9.00–10.00
Welcome and introduction
Introduction of new participants, recap of what was achieved in previous workshop, aims for this workshop

10.00–11.00
Plenary Session 1: Scenario Presentations and Discussion
Participants from each scenario development group present their respective scenarios and respective opportunities and threats for SRM governance. Question and discussion round.

11.30–12.30
Continuation of Plenary Session 1: Scenario Presentations and Discussion
Participants from each scenario development group present their respective scenarios and respective opportunities and threats for SRM governance. Question and discussion round.

12.30–13.00
Plenary Session 2: Open discussion, implications for scientific community
Discussion of "third layer implications" of process so far – how can we critically reflect upon process to contribute to constructive discussions within the scientific community?

14.00–14.30
Plenary Session 3: Criteria for Evaluating Governance Options
Discussion of criteria to be used to evaluate governance options within the context of different scenarios

14.30–15.30
Working Group Session 1: Reviewing Governance Frameworks
Working groups of3–4 participants review their own governance frameworks and isolate individual options/elements for evaluation

16.00–18.00
Working Group Session 2: Evaluating SRM Governance Options under alternative conditions
Working groups of 3–4 participants evaluate their own governance frameworks' performance under the conditions of each scenario

Day II, 13 November

9.00–11.30
Plenary Session 4: Presentation of Governance Evaluations
Each group presents the results of the evaluation of their own governance framework's performance under the conditions of each scenario. Discussion and revision of evaluation results based on feedback from respective scenario development teams.

12.00–13.00
Plenary Session 5: Open Discussion of Evaluation results
Critical discussion about usefulness of evaluation, implications for further research, communication within research community

14.00–14.30
Working Groups Session 3: Broadening the climate response perspective
Working groups of 3–4 participants brainstorm alternative/innovative climate response strategies to help deal with the threats in their respective scenarios

14.30–15.00
Plenary Session 6: Presentation and discussion of climate response strategies
Working groups of 3–4 participants present their alternative/innovative climate response strategies. Feedback and discussion.

15.30–17.00
World Café Sessions
Three rotating tables to discuss open questions/concerns/implications/ideas for future projects gathered in an "Idea Garage" over the course of the workshop

17.00–17.45
Plenary Session 7: World Café results, Open Discussion
Presentation of World Café discussion topics by table chairs, discussion of open questions, plans for workshop report, and follow up

17.45–18.00
Feedback Round
Overall impressions of workshop series, questions, concerns, etc.

5.2 Workshop organisers and participants

Organisers

Miranda Boettcher (formerly Foresight Intelligence, currently Institute for Advanced Sustainability Studies)
Johannes Gabriel (Foresight Intelligence)
Sean Low (Institute for Advanced Sustainability Studies)

Participants

Jamais Cascio (Open the Future) (WS 1)
George Collins (WS 2 & 3)
Olaf Corry (Open University) (WS 2 & 3)
Oliver Geden (German Institute for International and Security Affairs) (WS 1 & 3)
Alex Hanafi (Environmental Defense Fund) (WS 1, 2 & 3)
Matthias Honegger (Perspectives Climate Change) (WS 1, 2 & 3)
Joshua Horton (Harvard University) (WS 1 & 3)
Tim Kruger (Oxford Martin School) (WS 1, 2 & 3)
Duncan McLaren (Lancaster University) (WS 1, 2 & 3)
Christine Merk (University of Kiel) (WS 1)
Manjana Milkoreit (Arizona State University) (WS 1 & 3)
Simon Nicholson (American University) (WS 1 & 3)
Andy Parker (Institute for Advanced Sustainability Studies) (WS 1, 2 & 3)
Jesse Reynolds (Tilburg University) (WS 1, 2 & 3)
Stefan Schäfer (Institute for Advanced Sustainability Studies) (WS 1 & 2)
Michael Thompson (Forum for Climate Engineering Assessment) (WS 1 & 2)

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7. About the authors

Miranda Boettcher is a project scientist at the Institute for Advanced Sustainability Studies in Potsdam, Germany. Her research interests include climate engineering governance and the interplay of language, knowledge and power in political decision-making processes. She has previously worked as a research analyst for Foresight Intelligence in Berlin, Germany, an investigator at the Mintz Group in San Francisco, USA, and a research assistant at the University of Heidelberg, Germany.

Johannes Gabriel is the founder and managing director of Foresight Intelligence (www.foresightintelligence.de). He is also a non-resident fellow with the Global Public Policy Institute (GPPi) in Berlin, Germany. His areas of expertise include the theory and methodology of future studies and scenario development, and he teaches scenario planning at the Central European University in Budapest, where he is a visiting professor at the School of Public Policy. His research interests include international security, energy relations, and global health.

Sean Low is a project scientist at the Institute for Advanced Sustainability Studies in Potsdam, Germany. His research focuses on the uses and limits of scenario and gaming methods, as well as of analogies in previous debates on emerging technologies, to explore potential future contingencies in climate engineering. He has previously done research on the politics of climate engineering and global climate policy at the Centre for International Governance Innovation and the University of Waterloo, Canada.

Foresight Intelligence

Foresight Intelligence is a systemic consultancy based in Berlin. It supports strategic foresight and planning processes in organisations. Foresight Intelligence conducts inter-departmental strategic planning processes for the German Government, implements intercultural and multi-stakeholder strategic dialogues for leading think tanks, and supports collaborative research projects with foresight methods for research institutions. Since 2014, Foresight Intelligence has conceptualised and implemented more than 30 scenarios, visioning, road mapping, back-casting, and strategic conversation projects with more than 340 managers, officers, and researchers. For further information visit www.foresightintelligence.de

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Founded in 2009, the IASS is an international, interdisciplinary hybrid between a research institute and a think tank, located in Potsdam, Germany. The publicly funded institute promotes research and dialogue between science, politics and society on developing pathways to global sustainability. The IASS focuses on topics such as sustainability governance and economics, new technologies for energy production and resource utilisation, and Earth system challenges like climate change, air pollution, and soil management.

IASS POTSDAM

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Institute for Advanced Sustainability Studies Potsdam (IASS) e. V.

Contact:
Sean Low: sean.low@iass-potsdam.de

Address:
Berliner Strasse 130
14467 Potsdam
Germany
Phone 0049 331-28822-340
www.iass-potsdam.de

email:
media@iass-potsdam.de

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