

1 ***Introduction***

2 This report examines the development and use of scenarios in global climate change
3 applications. It considers scenarios of various types – including but not limited to emissions
4 scenarios – and reviews how they have been developed, what uses they have served, what
5 consistent challenges they have faced, what controversies they have raised, and how their
6 development and use might be made more effective. The report is Synthesis & Assessment
7 Product 2.1b of the US Climate Change Science Program. By synthesizing available literature
8 and critically reviewing past experience, the report seeks to assist those who may be conducting,
9 using, or commissioning scenarios related to global climate change.

10 Scenarios are used to support planning and decision-making when issues have deep or
11 poorly characterized uncertainty and high stakes, often accompanied by long time horizons.
12 These conditions apply to the major decisions of how to respond to global climate change. As
13 scientific research advances our knowledge of the climate’s present state and trends, its patterns
14 of variability, and its responses to external forcings, we are gaining an increasingly clear view of
15 risks that may be realized late this century or beyond. Although this growing knowledge is not
16 fully certain or precise, it shows that these future risks are linked to near-term socio-economic
17 trends and decisions in both public and private sectors. Some near-term decisions – such as
18 investment in long-lived capital equipment in the energy sector, or development of new energy
19 resources and technologies – can exercise long-term influence over trends in the emissions
20 contributing to climate change, and how readily these trends can be deflected in the future.
21 Other near-term decisions – such as investment in long-lived capital equipment in water
22 resources, infrastructure, or coastal development – can exercise long-term influence over how
23 adaptable and how vulnerable future society will be to the impacts of climate change.

24 Although decisions of all these types are being made in the near term, making them
25 responsibly requires considering their potential consequences over the longer term, including the
26 substantial associated uncertainties. This requires thinking about the future conditions that will
27 shape their consequences, not just next month or next year but 10, 30, 50, or 100 years in the
28 future – longer periods than we are practiced at thinking about systematically, and longer than
29 the horizon of conventional methods of planning or analysis.² Attempting to describe potential
30 future conditions over this long time horizon presents a seeming paradox. On the one hand,
31 conditions this far in the future are deeply uncertain, not just in the values of important factors
32 but in the identity of the most important issues and the factors and actors influencing them.³ On
33 the other hand, we have a great deal of knowledge that is relevant to making informed
34 assumptions about future conditions, even over such long horizons. This includes well
35 established scientific knowledge about physical, chemical, biological processes; more weakly,
36 certain relatively well established mechanisms of causal influence in the domains of economics,
37 sociology, and politics; and more weakly still, certain seemingly robust empirical regularities in
38 patterns of historical change in population, economics, and technology. These all provide some
39 guidance to support judgments about future conditions that are more or less likely, virtually

² Morgan et al 1998.

³ Lempert et al 2006.

1 certain, or virtually impossible. In some respects we might be highly confident that the future
2 will resemble the present, e.g., in the radiative properties of atmospheric trace gases. In others,
3 we might judge it highly likely that future conditions will lie within some envelope extrapolated
4 from present conditions and recent trends, e.g., in projecting rates of change in fertility,
5 mortality, or labor productivity. In still other areas, such as the development and social
6 consequences of major technological advances, or large-scale political events such as wars,
7 political realignments, or epidemics, there may be more fundamental uncertainties, which might
8 be adequately represented as larger uncertainty bounds on known quantities or might represent
9 discontinuities or other changes that lie outside what we can presently imagine.

10 Despite pervasive uncertainties, people must make decisions related to climate change
11 that have long-term consequences, including the possibilities of long-term irreversibility or lock-
12 in from near-term decisions. Scenarios are tools to help inform these decisions by gathering and
13 organizing available relevant knowledge, organizing associated uncertainties, and structuring and
14 disciplining associated speculation. This report reviews and assesses experience to date in
15 developing and using scenarios for global climate change.

16 Early climate-change debates mainly concerned scientific questions such as whether and
17 how the climate is changing, how much change is being caused by human activities, and how
18 sensitive the climate is. Scenarios did not figure prominently in these early debates. As climate
19 science has advanced, however, many former disputes have been clarified or settled and many
20 remaining uncertainties have been better characterized. As this advance of knowledge has
21 increasingly shifted the climate-change debate from confirming and describing the problem
22 toward deciding what to do about it, the need for long-term decision-support tools like scenarios
23 has increased, as has the scrutiny and criticism these have attracted.⁴ In a contentious public-
24 policy area like climate change, controversy over scenarios is to be expected: scenarios are a
25 method to structure and communicate the most important uncertainties, and conflicting
26 judgments about uncertainties are a major source of disagreements over what to do.
27 Consequently, we expect the trend of scenarios' increasing prominence and contentiousness to
28 continue – particularly for emissions scenarios, since these are the relevant metric of human
29 environmental burden and the point of most contested proposed intervention.

30 In this report, we try to cast some light on current and coming debates over climate-
31 change scenarios. These debates are presently quite confused, to the level of basic confusion
32 about what “scenario” means, what purposes scenarios are used for, and what benefits they can
33 provide. We aim to provide clarification and practical advice to two related audiences: those
34 conducting climate-change assessments or analyses that involve developing or using scenarios;
35 and those commissioning, receiving, or using these products. For the first group, we seek to
36 provide an organized summary of relevant experience in past similar efforts, discussion and
37 clarification of key choices and challenges, and – to the extent present knowledge allows –
38 practical guidance regarding pitfalls, challenges, and opportunities in particular approaches. For
39 the second group, we seek to provide guidance on what to ask for, how much and in what way to
40 be involved in its production, how to interpret what you get, and what questions to ask.

⁴ E.g., See, e.g., Lomborg, Michaels, Castles and Henderson 2003a, 2003b, UK House of Lords.

1 Because the charge of this report is quite unlike those of other Synthesis and Assessment
2 products, the approach we have taken to producing it is necessarily different as well. We were
3 not tasked with a focused question about present knowledge, and there is not a well developed
4 scientific literature on which we can draw for answers. Rather, we were tasked with reviewing,
5 interpreting, and evaluating experience with scenario methods in global climate change
6 applications. To accomplish this, we have engaged in several different types of activity. We
7 have reviewed the existing literature on scenarios, most of it concerned with scenarios in other
8 decision domains than global climate change. We have reviewed several major recent exercises
9 that have used scenarios in global-change applications. In this review, we have drawn on
10 published materials, both publications from the exercises themselves and published commentary
11 and criticism, as well as documentary materials and records, interviews with participants and
12 users, and the experience and judgments of team members.

13 It is important to note that our review of global-change scenario experience has not been
14 entirely independent, since members of this writing team were involved in two of the scenario
15 exercises we review, the IPCC SRES process and the U.S. National Assessment, as participants,
16 reviewers, and critics. While we have drawn on the experience of these team members, we have
17 attempted to limit the risk of idiosyncratic interpretations and bias by drawing on other sources
18 as well, and by engaging all team members in developing our summary and discussions of these
19 exercises. Moreover, our purpose is not to either attack or defend these past exercises, but to
20 seek to understand the decisions they made, the factors that influenced them, and the constraints
21 under which they operated, in order to assess their experience, identify both successes and
22 pitfalls, and to the extent possible, provide guidance to advance the practice of scenario methods
23 for climate change and other similar environmental issues. Because the experience we review
24 does not provide a sufficiently large, well defined, or random sample to support strong scientific
25 inference, the diagnoses, interpretations, and recommendations we present rely on our collective
26 judgment in view of the information and experience we have reviewed. We have endeavored to
27 follow our own advice to scenario developers, and be as transparent as possible about the
28 foundation and reasoning underlying our conclusions and recommendations.

29 The report is organized as follows. Drawing on the broader literature on scenarios – most
30 of which concerns domains other than climate change – Section 1 introduces scenarios, sharpens
31 their definition, and outlines a few major dimensions of variation and decisions that must be
32 made in developing a scenario exercise. Section 2 focuses specifically on scenarios for global
33 climate change, and outlines the types of decisions that could use scenarios and the main types of
34 scenarios that have been developed for this issue. Section 3 reviews four major experiences in
35 developing and using global-change scenarios. Section 4 discusses several key issues that have
36 posed particular challenges in climate-change scenarios and that are likely to require particular
37 attention in designing new scenario exercises. In addition to drawing on the material in Section
38 3, this discussion also takes advantage of briefer discussions of eight other examples of global-
39 change scenario development or use that illustrate particular issues or challenges, which are
40 presented as short boxes spread throughout Section 4. Section 5 provides our conclusions and
41 recommendations for future development and use of global climate-change scenarios.