Governing the Air
The Dynamics of Science, Policy, and Citizen Interaction

edited by Rolf Lidskog and Göran Sundqvist

The MIT Press
Cambridge, Massachusetts
London, England
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Series Foreword

As our understanding of environmental threats deepens and broadens, it is increasingly clear that many environmental issues cannot be understood, analyzed, or acted upon in a simple way. The multifaceted relationships between human beings, social and political institutions, and the physical environment in which they are situated extend across disciplinary as well as geopolitical confines and cannot be analyzed or resolved in isolation.

The purpose of this series is to address the increasingly complex questions of how societies come to understand, confront, and cope with both the sources and the manifestations of present and potential environmental threats. Works in the series may focus on matters political, scientific, technical, social, or economic. What they share is attention to the intertwined roles of politics, science, and technology in the recognition, framing, analysis, and management of environmentally related contemporary issues and a manifest relevance to the increasingly difficult problems of identifying and forging environmentally sound public policy.

Peter M. Haas
Sheila Jasanoff
Scientists Learn Not Only Science but Also Diplomacy: Learning Processes in the European Transboundary Air Pollution Regime

Atsushi Ishii

International environmental governance is so complex that its entirety cannot be properly envisaged from the beginning. Governance is therefore inherently a learning process and at the same time is one of the best arenas for studying such processes. Learning generally means the recognition and acceptance of information that can change the actors' motives and behavior. A rich collection of literature explores how various actors have learned in governance processes and the factors that explain such learning. However, the scientific community, which has occupied a very important role in the political process of governance, remains an underresearched actor despite the fact that scientists, who usually live in the “Republic of Science” (Polanyi 1962), must overcome enormously complex interactions between science and policy through learning. This chapter focuses on how advisory scientists to the Convention on Long-Range Transboundary Air Pollution (CLRTAP) regime have collectively learned in the process of scientific assessment for the 1994 Protocol on Further Reduction of Sulfur Emissions (Second Sulfur Protocol, SSP).

Why is the analysis of learning processes in the CLRTAP assessments important for the regime? Three potential contributions come to mind. First, such analysis can shed light on one of the few missing pieces to produce a more comprehensive explanation and nuanced understanding of the regime's scientific assessments: the internal dynamics of scientific assessment and its outputs and outcomes in terms of learning. Although the existing literature does indeed focus very often on the regime's scientific assessment, it is focusing mostly on the assessment as a given "objective" input to the governance process or on surrogate variables such as advisory scientific communities that undertake the assessments (Zito 2001), assessment processes (communication) (Tuinstra 2006), discourses (Sundqvist, Letell, and Lidakog 2002), and institutions for science–policy interaction (Wettestad 2000). What is lacking, in other
words, is a treatment of the process, institutions, actors, scientific knowledge, and the production of scientific knowledge as an integral part of the regime's scientific assessment and an analysis of these elements in a systematic way in the context of CLRTAP governance.

Second, an analysis of the CLRTAP learning process can contribute to the transition management of European transboundary air pollution policies (see Lidskog and Sundqvist, chap. 1 in this volume). Such transition management should include enhancing the transparency of the science–policy complex developed thus far. Göran Sundqvist (2003) argues also that such transparency should be complemented with a profound understanding of the internal dynamics of scientific assessments and specifically the strategies employed by the advisory scientists to achieve credibility for their advice. An intensive focus on the learning process of CLRTAP assessments can make a major contribution to achieving these suggestions by opening up the assessment process and explaining the learning process, including how the scientists learned strategies to enhance the credibility of their advice.

The third contribution, which is related to the second, is that such an analysis may elicit strategies for designing proper learning processes for scientific assessment. There is an obvious and urgent need for the regime to design such learning processes, given the challenge of overcoming the growing scientific and political complexities of transboundary air pollution (cf. Lidskog and Sundqvist, chap. 1 in this volume). Analyzing past CLRTAP assessments can systematically explain the factors that encouraged or discouraged collective learning and thus led to the outcomes of the assessments and can identify which learning strategies worked better or worse (Siebenhüner 2002b). Analyzing past cases in the CLRTAP process can generally contribute to accelerating learning in environmental assessments (Siebenhüner 2002a), but it also has the advantage of situating them in a context relatively more similar to the current context of the European transboundary air pollution governance than to the context of other governance issues. Therefore, the lessons from the past can at least be insightful and possibly applicable to the current transition period for the European transboundary air pollution policy.

To discuss these contributions fully, a proper conceptual framework of learning and its factors is essential. According to Edward Parson and William Clark (1995), every conceptualization of learning needs to answer the following questions: Who or what learns? What is to be learned? What counts as learning? Why bother asking? Seminal work by Bernd Siebenhüner (2002a, 2002b) takes up the challenge of answering these questions by using an institutionalist approach. However, the resulting conceptual framework cannot avoid a fundamental criticism of institutionalism, which is that it does not give scientific knowledge a distinct role in the learning process. Therefore, this framework cannot provide the necessary foundation for pursuing the contributions made in this chapter and for achieving the general task of accelerating learning processes in scientific assessments. This criticism does not mean, however, that the institutional approach is useless. On the contrary, it provides a very useful starting point for developing an alternative conceptual framework.

In this chapter, I first briefly summarize the institutionalist approach to learning and critically review it to specify how the alternative conceptual framework for learning assessments should be developed. I then establish the alternative framework based on the critical review and apply it to the cases of the critical-loads (CLs) concept and the integrated assessment model Regional Air Pollution INformation and Simulation (RAINS) utilized in the negotiations of the SSP, thereby explaining the learning assessment and its stimulating or discouraging factors. I conclude with some notes on the extent of the alternative framework's usefulness and with suggestions for transition management in the European transboundary air pollution policy that can be derived from the case study.

Developing an Alternative Conceptual Framework

The Institutionalist Approach

The institutionalist approach to learning assessments has thus far been interested in explaining how assessments improve procedures and enhance effectiveness of scientific advice to the policy process through collective learning. The research questions are: "How did the assessments at hand learn over the years and in the different phases of the assessment process? How could the learning process be characterized? Which factors did influence learning in assessments? Which conclusions can be drawn to improve learning processes in assessments in general?" (Siebenhüner 2002a, 411–412). This approach identifies lessons and promising learning strategies applicable to future scientific assessments. Here, I focus on some features of the institutionalist approach categorized mainly by the questions Parson and Clark (1995) pose.

First, based on the fields of social learning and organizational learning, the institutionalist approach defines learning by scientific
assessments as "a process of long-lasting change in the behavior or the general ability to behave in a certain way that is founded on changes in knowledge" (Siebenhüner 2002a, 412). This definition is rather general in that it can be applied not only to scientific assessments, but also to other institutions and actors. However, it is less general in terms of the prescribed direction of what learning should deliver: change in the behavior in a certain way.

This prescribed direction is not left as an open question. A second feature of this approach is that it identifies learning endeavors only when learning procedural knowledge results in enhancing three criteria that characterize the learning assessment: saliency, credibility, and legitimacy (Siebenhüner 2002a, 412). These criteria are in line with the work of the Harvard University's Global Environment Assessment (GEA) project and are considered the necessary conditions to design influential scientific assessments in international negotiations (e.g., Mitchell, Clark, Cash, et al. 2006).

The field of organizational learning holds that to choose the appropriate theoretical and analytical approach, it is crucial to distinguish individual from collective learning (Siebenhüner 2002a). A third feature of the institutionalist approach is that it justifies learning by scientific assessments as a collective action by arguing that, given the complexity of the mandate of scientific assessments, division of labor among the assessment's participants allows for the possibility of collective learning, which goes beyond the simple aggregation of individual learning. This justification is also espoused in the alternative conceptual framework explained later.

Fourth, the institutionalist approach sets procedural knowledge as the cognitive element to be learned. Procedural knowledge "is concerned with how the assessment is designed referring to questions like who participates in it, which decision-making procedures are adopted, on which scale and scope of the problem at hand it will focus, and how uncertainty is dealt with" (Siebenhüner 2002a, 412). The counterpart of procedural knowledge is substantive knowledge, which refers to knowledge generated by research about, for example, cause-and-effect relationships, adverse impacts, and abatement strategies (Siebenhüner 2002a, 412). If we apply these categories to the case of the RAINS model, procedural knowledge encompasses the fact that the RAINS model is used in the decision-making process, and substantive knowledge encompasses the actual acidification impacts and abatement strategies suggested by the model.

A fifth feature concerns the typology of learning modes, which answers the question "Learn to what extent?" The modes are distinguished according to the direct effects of learning on scientific assessments. The institutionalist approach employs the typology that Chris Argyris and Donald Schön (1978; 1996) developed in the field of organizational learning: single-loop and double-loop learning. The former consists of error correction only, with the organization's objective and underlying beliefs held constant. The latter "occurs when error is detected and corrected in ways that involve the modification of an organization's underlying norms, policies and objectives" (Argyris and Schön 1978, 3). In short, this typology distinguishes between incremental error correction and more complex learning.

A Critical Review of the Institutionalist Approach to Learning

Cross-fertilization of the institutionalist approach with science and technology studies (STS) approach provides a critical perspective of the former. Whereas "co-production" (Jasanoff 2004; Lidskog and Sundqvist, chaps. 1 and 2) emphasizes primarily the interaction between science and policy (and the broader society), the STS approach is also concerned with what kind of science such interaction constructs. The STS literature has established that the production of scientific knowledge exhibits diverse modes with diverging practices, norms, and behavior contingent on their situated context. With respect to these modes, academic (or research) sciences offer a good contrasting case to scientific assessments in the CLRTAP regime and in global governance in general.

Academic sciences are done by citizens of the "Republic of Science" and have four social norms, often called "Mertonian norms": communitism (knowledge open to public), universalism (evaluation based on universal criteria), disinterestedness (not pursued for personal gain), and organized skepticism (knowledge must be critically scrutinized by empirical and logical criteria—through, for example, peer review) (Ziman 2000). Robert Merton also suggested empiricism as one of the technical norms that is obeyed by academic sciences, accompanying and consistent with these social norms (Schuster 1995). Empiricism is "a family of traditions in philosophy of science, which argue that scientific truths grow out of, and are properly generalized from, appropriate empirical observations" (Law 2004, 16). Closely related to empiricism is positivism, which says that "scientific truths are rigorous sets of logical relations or laws that describe the relations between (rigorous) empirical descriptions" (Law 2004, 16). These kinds of (at least conceptually) coherent sets of
social and technical norms correspond to the concept of paradigm, which provides a defining framework of what science should and should not do in a given context. Though I am aware of the heated debates about this concept, throughout this chapter I generally refer to the social and technical norms that define science as a "paradigm" (e.g., Smokler 1983).

As Sheila Jasanoff (1990) proposed and Karin Bäckstrand (2001) has argued, the most relevant mode for the science-policy interaction involved in the CLRTAP regime is "regulatory science." This mode becomes operational in the context of producing policy advice in domestic settings and involves heterogeneous actors that include at least policymakers and advisory scientists as well as, more broadly, industry. Whereas scientists pursuing academic sciences are held accountable only to the "Republic of Science," regulatory scientists must be socially accountable to policymakers, courts, and the media through regulatory peer review, judicial review, and legislative oversight. Although Jasanoff (1990) does not explicitly name citizens, they can also be included in the list of "accountability checkers" and thereby can render regulatory science more reflexive to multiple views. The quality-control system of regulatory science accordingly becomes more complicated in that the traditional peer-review system is supplemented by additional social dependent criteria such as policy usefulness, fairness, and communicability. The overall "science policy paradigm" (Jasanoff 1990, passim) in regulatory science thus emerges from complex interactions of these attributes and is heavily context dependent.

This brief discussion of the modes of science has important implications for analyzing learning assessments. First, it reconfirms that the production of scientific knowledge pursued by learning assessments cannot be explored in any way unless the norms, institutions, procedures, and research involved in such production are treated in an integrated way. The implication is that the output and effectiveness of learning assessments should be regarded as a consequence of learning all aspects of scientific assessments, including procedural and substantive knowledge.

Second, it demonstrates that for a learning assessment to be effective in the governance process, scientific assessment may have to develop an enabling paradigm and thereafter constantly adjust to reflect on the context of policy application in which it is situated. The advisory scientists obviously cannot accomplish such development and adjustment of an appropriate paradigm beforehand. The case studies of regulatory science show how regulatory scientists learned to construct their work socially and to adjust the prevailing paradigm over time to maintain their cognitive authority in the deconstructive science-policy interaction while taking into account the internal dynamics of the scientific community, external social factors, and their interactions (Jasanoff 1990, 1992). Therefore, it is very important for analysts of learning assessments to distinguish between those learning modes that achieve new paradigm development or adjustment of the existing paradigm (paradigm shift) through learning and those that hold the dominant paradigm of knowledge production constant. By employing this kind of typology, the analysis of learning assessments can provide answers to questions such as: Which factors lead to a paradigm shift? What kind of paradigm shift leads to enhanced or diminished political acceptance? When is it appropriate to avoid paradigm shift to enhance political acceptance of learning assessments?

Identified Refinements
First, setting only procedural knowledge as what is to be learned by assessments should be replaced with focusing on all the knowledge and experience relevant to the learning assessment. In addition, it is extremely difficult to discern the results of learning procedural knowledge from learning substantive knowledge; in other words, the causal relationship between procedural knowledge, which is set to be what learning assessments learn, and the results of such learning may suffer indeterminacy. The actual case study on the CLRTAP assessments using the institutionalist approach (Siebenhüner 2002b) is self-revealing on this point. In that study, the narrative shows clearly that the adoption and utilization of the CLs concept and the RAINS model resulted not from just error correction, but from more complex learning. Although I believe this conclusion to be correct, it implicitly argues that what the CLRTAP assessment learned is a mixture of procedural and substantial knowledge relevant to CLs and RAINS. This argument contradicts the case study's own conceptual framework, though, which sets procedural knowledge as the only cognitive element to be learned by scientific assessments. This contradiction may have been inevitable because it is quite inconceivable that the assessment participants adopted novel concepts such as the CLs concept only from learning the procedural elements related to CLs. Moreover, because analyzing learning assessments has just begun, in order to maximize the theoretical and practical potential of this analytical challenge we should not prescribe what kind of knowledge should be acquired through them (e.g., Clark, Jäger, and van Eijndhoven 2001).
Second, prescribing the direction of the learning process using the GEA criteria should be avoided. The GEA criteria, though cited extensively, have not gained consensus among scholars, and there are other criteria derived by various approaches (e.g., Jasanoﬀ 1996). Even if we assume that the GEA criteria are correct, there is a clear possibility that learning may result in diminished political acceptance of the assessment’s policy advice, which I call “detrimental learning.” One can easily imagine that a person who learned too many things may complicate the situation rather than arrive at the right solution. Some experts in the CLRTAP assessments are concerned about the relative, if not excessive, complexity of the scientiﬁc assessment for the Protocol to Abate Acidification, Eutrophication, and Ground-Level Ozone (Gothenburg Protocol) compared to assessment for the SSP (Lidskog and Sundqvist, chap. 1 in this volume). In fact, the former was less politically accepted than the latter in terms of the level of the recommended reduction targets calculated by the RAINS model (Ishii 2001). Perhaps the former assessment learned too much so that it became incomprehensible and therefore resulted in lower political acceptance. More careful analysis is certainly needed to make this explanation compelling. The point here for analyzing learning assessment is that a prescription of the direction of learning makes it impossible to explore very important and policy-relevant research questions such as the detection of factors that stimulate (or discourage) detrimental learning. Therefore, the prescription incorporated in the institutionalist approach should be abandoned. Instead, we should carefully reconsider the complex causal relationship between the learning processes of scientiﬁc assessments and various types of effectiveness to the political process, which is outside the scope of this chapter.

Third, as argued in the discussion of the STS literature, the typology of learning modes should be changed to distinguish between learning assessments that achieve paradigm shift through learning and those that hold the dominant paradigm of knowledge production constant. The institutionalist approach cannot detect this distinction because it distinguishes only between error correction and more complex learning.

Establishing the Alternative Conceptual Framework

I basically share the research questions outlined for the institutionalist approach. Hence, my intention in establishing the alternative framework is not to replace the institutionalist agenda entirely, but to make its framework more suitable to answering important research questions on its agenda.

The deﬁnitions of scientiﬁc assessments and their learning endeavor have to be determined to establish the alternative approach. For the former, I employ a modiﬁed version of GEA’s deﬁnition (GEA 1997, 53): the entire social process by which expert knowledge related to a policy problem is produced, organized, evaluated, integrated, and documented to inform policy or decision making. The word produced is added to reﬂect on the preceding critical review, which makes it clear that production should not be ignored in explaining scientiﬁc assessments.

Although espousing Siebenhüner’s justiﬁcation of analyzing learning as a collective behavior (2002a, 413), I adopt a deﬁnition of learning that does not prescribe the direction of learning; learning in scientiﬁc assessments is a deliberate attempt to adjust the operation of scientiﬁc assessments in response to relevant experience and knowledge. The emphasis is on the deliberative nature of learning, which means that any changes in response to experience and knowledge have to be intentional, and, conversely, that any unintended changes do not count as learning. From an empirical point of view, the participants of the learning assessments must recognize experience and knowledge and explicitly change the operation of the learning assessments in response to those cognitive elements, which makes it possible to establish causal pathways between the cognitive elements and the resulting changes. It is important to note that this deﬁnition does not exclude detrimental learning. The deﬁnition automatically answers the “what to learn” question: relevant experience and knowledge.

I now turn to learning modes. I have argued that the institutionalist typology of learning is not appropriate for the study of learning assessments. Because no other typologies have been proposed so far in the literature, it may be useful to return to the basics: Gregory Bateson’s (1972) general logical categorization of learning. Bateson argues that theories of learning must establish a typology of learning according to the theory of logical types to avoid logical contradictions and thereby to develop robust theories of learning. Bateson speciﬁcally proposes the following typology as being applicable to all kinds of learning theories.

Learning I is error correction within a set of alternatives. Learning II is change in the process of Learning I, which is change in the set of alternatives from which choices are made. Learning III is change in the process of Learning II, which is change in the system of sets of alternatives, from which choices are made. According to Bateson (1972), logical contradiction in learning means, for example, applying any theory or factors of Learning I to Learning II. More examples of such logical contradictions
may include treating Learning I and II as having the same level of learning or misidentifying change in the set of alternatives resulting from learning as mere error correction in the same set of alternatives (in other words, misidentifying Learning II as Learning I). If strict logical typing of learning is not applied, one can never be sure about the applicability of any theory or factors because any theory or factors about Learning I should strictly be applied to and validated by the same level of learning. Given the general typology of learning, the question now is how to adapt it to the context of the study of learning assessments.

I begin with the simplest type of learning, Learning I—namely, error correction within the same set of alternatives. This type of error correction in the context of scientific assessments may include adjusting parameters of a numerical model or the number of participants in the assessment because it is a choice from the same set of the alternative parameters or number of participants. In other words, Learning I occurs when the scientific or institutional methodology of scientific assessments is adapted while other things remain equal. Learning II must change the set of alternatives from which the methodology is chosen. A crucial feature of scientific assessments that change the set of alternative methodologies would be the assessment's objective. For instance, the choice between investigating water acidification and investigating soil acidification as the objective demands different sets of alternative methodologies. Of course, there is some overlap between those methodologies, but the point here is that a different set of methodologies corresponds to each objective. Learning III requires changing the system of sets of alternative objectives. The brief discussion of the STS literature has implications for this discussion as well. It suggests that the system of sets of alternative objectives can be changed by paradigm shift because the shift changes the underlying definition of science and thereby the system of sets of alternatives. For example, a shift from academic science to regulatory science changes the sets of overall objectives and methodologies from those consistent with academic norms to those oriented toward policy.

In sum, Learning I occurs when scientific assessments engage in error correction by changing the methodology while the objective and paradigm remain the same. Learning II does not change the overall paradigm but changes the assessment's objective and accordingly the methodology. Learning III requires a fundamental shift in the dominant paradigm, followed by an often drastic change in the overall objective and methodology of the learning assessment. For more clarity and direct reference to the traits of the learning modes, I name Learning I, II, and III “adaptive learning,” “reformative learning,” and “paradigmatic learning,” respectively.

For the factors that stimulate or discourage learning, I employ those used in the institutional approach with some additions (see Siebenhüner 2002a for factors not explained here). The dynamics of production of scientific knowledge has strong path-dependent elements once they are institutionalized (Hans 2007). Moreover, it is easy to imagine that the learning endeavors of scientific assessments can be affected by collective perception of the performance of past operations as a failure or a success (Brown and Kenney 2006). Therefore, to the alternative framework I add “path-dependent factors” such as evaluative perceptions of the past operations of the scientific assessment itself, including the science-policy interaction. Table 6.1 summarizes the differences between the institutionalist approach and my alternative approach, focusing on learning assessment.

As I demonstrate in the next section, the main methodology to operationalize this framework is process tracing of the scientific assessments in question. One should first identify concretely the changes in a scientific assessment that resulted from collectively learning relevant knowledge and experience as well as the stimulating/discouraging factors incorporated in the framework. Next, one should assess the resulting changes in terms of the extent of learning based on the framework's typology. However, for clarity's sake, the presentation structure of the case study in the next section does not correspond to this order of action.

The Case Study: Learning Assessments for the Second Sulfur Protocol

The focus of this case study is the twin pillars of the scientific assessment for the SSP: the CLS approach and the integrated assessment model RAINS. The empirical data comprise interviews and written communications with participating scientists and review of primary and secondary materials (both natural and social sciences).

To provide the basis for analyzing how scientists collectively learned in this case, I begin by examining the relevant scientific activities in the pre-case study period to identify the prevailing paradigm, objectives, and methodologies because learning modes focus on changes in those elements of learning assessments and therefore can be examined only by comparing them to past operations. I then apply the alternative framework to the scientific assessments of the CLS concept and the RAINS
Table 6.1  
Comparison between the Institutionalist Approach and the Alternative Conceptual Framework

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<tr>
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<th>Institutionalist Approach</th>
<th>Alternative Conceptual Framework</th>
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</thead>
<tbody>
<tr>
<td>Who learns?</td>
<td>Collective learning by participants in scientific assessments</td>
<td>Relevant knowledge and experience (no separation between procedural and substantive knowledge)</td>
</tr>
<tr>
<td>What is to be learned?</td>
<td>Only procedural knowledge</td>
<td></td>
</tr>
<tr>
<td>What counts as learning? (What is the definition of learning?)</td>
<td>A process of long-lasting change in the behavior or the general ability to behave in a certain way (that is, enhancing saliency, legitimacy, or credibility of the scientific assessment) that is founded on changes in knowledge</td>
<td>A deliberate attempt to adjust the operation of scientific assessments in response to past experience and relevant knowledge</td>
</tr>
<tr>
<td>Learn to what extent?</td>
<td>Distinguishing between error correction (single-loop learning) and more complex learning (double-loop learning)</td>
<td>Adaptive learning (error correction)</td>
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<td></td>
<td>Structural factors (the factors with respect to formal structure in learning assessments)</td>
<td>Reformatory learning (changes in methodology and objective under constant paradigm)</td>
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<td></td>
<td>• Storage of knowledge</td>
<td>Paradigmatic learning (changes in methodology, objective, and paradigm)</td>
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<td>• Hierarchy/leadership</td>
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<td></td>
<td>• Communication structures</td>
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<td></td>
<td>• Reflective mechanisms</td>
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<td></td>
<td>Personal factors (the factors with respect to the individuals involved in learning)</td>
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<td></td>
<td>• Individual capabilities</td>
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<td>• Dissatisfaction and conflicts</td>
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<td></td>
<td>Cultural factors (the factors with respect to human relations)</td>
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<td></td>
<td>• Values, norms, and beliefs</td>
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<td></td>
<td>• Informal communication networks</td>
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<td></td>
<td>Contextual factors (factors external to scientific assessments)</td>
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<td></td>
<td>• Political pressure</td>
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<td>• New scientific findings</td>
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<td>• Media coverage</td>
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<td>• Other assessments</td>
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<td></td>
<td>Path-dependent factors</td>
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<tr>
<td></td>
<td>• Evaluative perception of the past operations of the scientific assessment itself, including the science-policy interaction</td>
<td></td>
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Note: The institutionalist approach is discussed in Siebenhüner 2002a, 2002b.

The Relevant Scientific Activities in the Pre–Case Study Period (1970s to Early 1980s)

Because there is no space to summarize all the scientific activities with respect to the SSP in this period, I focus mainly on large research projects, which were generally regarded as of international importance in the European context: the Organisation for Economic Co-operation and Development (OECD) Programme on Long-Range Transport of Air Pollutants (1972–1977, with eleven participating European countries) and the Norwegian research project Acid Precipitation—Effects on Forest and Fish, or the so-called SNSF project (1972–1980). The Norwegian Institute for Air Research was the body responsible for coordination of both projects, so the two projects were closely connected (Roll-Hansen 2002).

The two projects were obviously not pursuing academic science. Instead, as their objectives indicate, they were planned and designed to answer policy-relevant research questions. The OECD program had the objective of determining “the relative importance of local and distant sources of sulfur compounds in terms of their contribution to the air pollution over a region” (OECD 1977, 3), and the SNSF project had the objective of establishing “as precisely as possible the effects of acid precipitation on forest and freshwater fish” and investigating “the effects of air pollutants on soil, vegetation and water” (Overeijn, Seip, and Tolland 1981, 3). However, they were far from being policy prescriptive and made no explicit policy recommendations.

The two projects were accordingly organized to incorporate and maintain this policy-relevant focus. The established organizational setting can be characterized as securing relatively close relationships between scientists and policymakers to the extent that policymakers were involved as supervisors and “accountability checkers” of the scientific work but never directly participated in research activities. For the SNSF project, it was found that due to this close contact “the [Norwegian] Ministry of Environment greatly influenced the development and content of the project and that this [influence] was somewhat disadvantageous” (Roll-Hansen and Hestmark 1990, quoted in Seip 2001, 4). The point is that at that time a clear separation with close contacts between science and policy was regarded as a tool for maintaining scientific integrity (Seip 2001).
The mandate of policy relevance also affected the scientific methodologies employed in these projects. The entire scientific endeavor can be characterized as interdisciplinary in the sense that the two projects set research objectives that formed a common goal for involved disciplines and necessitated development of comprehensive theories of long-range transboundary atmospheric transport of pollutants and their effects by integrating relevant disciplines: for the OECD program, meteorology, atmospheric chemistry, and physics; and for the SNSF project, atmospheric chemistry, limnology, and physiology. For instance, the OECD program developed several types of atmospheric dispersion models that integrated meteorological and emission data to calculate atmospheric concentration and ground deposition of air pollutants. These calculations were then compared to measured data of the same kinds. The SNSF project developed conceptual models to investigate causal relationships between acid precipitation and freshwater acidification. As a result of these interdisciplinary studies, there was close agreement among the participating scientists that long-range transboundary atmospheric transport of air pollutants was very likely and that it may have caused significant decline in fish populations in southern Scandinavia. However, no agreement was reached on the quantification of such effects (Rosenqvist and Seip 1986, cited in Seip 2001).

However, the two projects' dominant paradigm in this period is one of the few attributes they have in common with academic sciences: empiricism and positivism. This commonality can be detected by the prevailing method of comparing the calculated data and measured "ground truth" and constructing models to connect the "ground truths" in a rigorous and logical way; it is also evident in the fact that the success of the scientific assessment was measured against the demonstrated reproducibility of the "real" world in light of the policy-relevant objectives. Interdisciplinary scientific methods were inevitably chosen as a way to accomplish the policy-relevant objectives because traditional disciplinary studies were not suited to this daunting task.

In sum, although the given objective in these projects was to answer policy-relevant research questions, the chosen scientific methodology was interdisciplinary research based on a combination of empiricism and positivism as the dominant paradigm (hereafter, I refer only to positivism for brevity). It is well known that the political acceptability of scientific advice regarding transboundary air pollution in this period was limited, but it was also positive to the extent that more and more countries had come to recognize that transboundary air pollution might be a significant international problem (e.g., Wettstad 2000).

Examining the Learning Process

The Critical Loads

The emergence of the CLs concept can be conceived as an intersection of at least three environmental discourses that had been emerging at the time. First, given the definition of CLs as a critical threshold of adverse ecosystem effects, the concept can be conceived as an attempt to operationalize the notion of an ecosystem’s "carrying capacity" embedded in the sustainable development discourse. Second, because the definition inherently entails science to operationalize it, it can also be conceived in line with the overall discourse of ecological modernization (Bäckstrand 2001). This discourse regards science and technology as powerful tools to manage environmental problems. The third discourse is on the precautionary principle. Because some of the uncertainties surrounding the CLs concept and the possibility of ignorance were irreducible, the CLs concept was embedded in and thereby justified in part by the precautionary discourse (e.g., Bull 1993). These discourses altogether have certain affinities and synergies with each other, and it is very likely that they provided an enabling context for the CLs concept to be operationalized.

The direct origin of the CLs approach can be traced back to the idea of Swedish scientists who had close channels of communication with policymakers (Bäckstrand and Selin 2000). The initiative to develop the CLs approach and operationalize it in the CLRTAP regime was basically motivated by the need to accommodate the criticism that the flat-rate reduction protocols adopted to date (in both the Protocol on the Reduction of Sulfur Emissions [First Sulfur Protocol] and the Protocol Concerning the Control of Nitrogen Oxides [Nitrogen Oxides Protocol]) were politically biased (the reduction targets were achievable without any additional national reduction policies), and arbitrary. In 1986, a core group of Scandinavian scientists was formed to hold a workshop in Oslo under the auspices of the Nordic Council of Ministers. An additional 30 experts participated in the Oslo workshop as peer reviewers. The overall conclusion of the workshop was positive, and a scientific definition of "critical loads for sulphur and nitrogen" was adopted: "the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecosystems" (Nilsson 1986, 4). The results of the
various national acidification research projects (such as the SNSF project) and the International Institute of Applied Systems Analysis's (IIASA) RAINS model were used and referenced in the resulting workshop report. The latter especially indicates the early linkage of CLs development with the RAINS model. Despite the positive outcome, it was observed that “the concept had to be evaluated further in order to get more reliable figures and to cover a larger variety in ecosystems” (Nilsson and Grennfelt 1988b, 4).

Expansion of this scientific community and more political involvement came soon when the CLRTAP’s Working Group on Effects decided to hold a workshop on CLs during its fifth session in June 1986. This move was somewhat natural to respond to the criticisms raised against the First Sulfur Protocol agreed to in 1985, including the lack of scientific basis of its 30 percent flat-rate reduction target. This workshop was held in Skokloster, Sweden, in March 1988 and was attended by the United Nations Economic Commission for Europe (UNECE) secretariat and experts from 16 countries. The workshop participants experienced problems in defining CLs and therefore decided to use the definition agreed upon by the UNECE Working Group on Nitrogen Oxides in February 1988 in a deliberation in which both negotiators and scientists participated (Nilsson and Grennfelt 1988a). This was the birth of the famous definition: “[a] quantitative estimate of an exposure to one or more pollutants, below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge” (Nilsson and Grennfelt 1988c, 9). The difference between this definition and the one given in the previous paragraph lies in the shift in focus from the previous “most sensitive ecosystems” to “significant harmful effects,” along with the added wording “according to present knowledge.” This shift is interpreted elsewhere as rendering a “more politically qualified concept” (Tickle 1995, 82). To put it differently, this shift and the added wording broadened the political applicability and strengthened the robustness of the scientific assessments of the CLs concept; the previous definition cannot be applied unless the most sensitive ecosystems are identified and is thus vulnerable to criticisms of the surrounding uncertainties because it does not acknowledge them.

The participants in the Skokloster workshop also “agreed on the usefulness of the concept of critical load as well as on best estimates for critical loads to various ecosystems [sic]” and recognized that “[t]he concept of critical load is only in its infancy. The underlying scientific knowledge is in many cases weak and the importance of different processes involved is not always quantified” (Nilsson and Grennfelt 1988b, 4). More specifically, for forest soils and groundwater, CLs values were proposed according to a classification scheme based on characteristics of soil material. For surface waters, CLs for sulfur deposition were estimated based on available information and proposed with the recognition that “[c]ritical loading estimates must be made specific to the area of application” (Nilsson and Grennfelt 1988c, 22).

As for the basic methodology for calculating CLs, the Steady-State Mass Balance (SSMB) method was adopted for soils, surface waters, and ground water (see Sverdrup, de Vries, and Henriksen 1990). The idea behind the method can be traced to a background document prepared for the Skokloster workshop in which the CLs values, derived from a steady-state soil chemistry model, were compared to empirical data, which confirmed that the two gave nearly the same results (Sverdrup and Warfvinge 1988). The SSMB ignores time-dependent variations in chemical interactions relevant to acid rain effects (Hettelingh, Downing, and de Smet 1991b). As many “outside” scientists became increasingly involved in the CLs debate, they criticized these kinds of oversimplifications of representing ecosystems but largely joined the advocating scientists to form consensus when they were challenged to suggest alternative approaches and realized that simple science can influence policy. The dynamic modeling method, which takes time-dependent variations into account, was not chosen as the standard method for two reasons: first, it was too complex in terms of applicability to a European scale, in which not all countries have the necessary data needed for it, and in terms of comprehensibility to the policymakers; second, it could not be mapped and applied to policy. There were other battles, “for instance, between the soil experts and water experts who proposed different methods. Eventually groups accepted that there was more than one way to look at the problem and do the calculations.” As a consequence, the steady-state water chemistry method was suggested for application to surface waters also (Hettelingh, Downing, and de Smet 1991b). An empirical method based on a Skokloster workshop recommendation was also suggested for application when no sufficient data are available for the methods using models.

After adoption of the SSMB, some additional modifications were implemented. The most significant is the division between CLs for sulfur and other acidifying substances. This division was required based on the request from the CLRTAP’s Working Group on Strategies, the main negotiation arena for protocols, to produce a map showing the ecosystem
To facilitate its use, the model should have interactive inputs and clear graphical outputs.

What the RAINS team tried to do with this set of guidelines was to improve the RAINS model dynamically through interactive learning among potential users, mainly the policymakers in charge of the acid rain issue, other experts, and the team members themselves. In other words, this interaction made it clear that the RAINS team did not consider learning from external actors as a “residual,” but rather incorporated it into the modeling process as an inherent component from the outset to win policymakers’ acceptance of the RAINS model.

The first guideline means opening communication channels among the modelers, outside experts, and policymakers (or their advisors) to enable the modelers to learn policymakers’ needs as well as submitting the RAINS model to peer review and addressing the peer experts’ concerns. However, communication is not enough. Academic modeling exercises usually end up with a model that policymakers can never comprehend. The third and fourth guidelines indicate the facilitation of comprehensibility for policymakers by emphasizing simplicity and visibility in the model structure and results. A clear example is the way the modelers dealt with the EMEP atmospheric transfer model (ATM),9 because the ATM is too complex and too demanding of time and data to be a communication tool, the modelers instead incorporated the submodel consisting of the source–receptor matrix (the so-called “blame matrix” because it clearly visualizes the polluting and victim countries) into the RAINS model (Alcamo, Kauppi, Posch, et al. 1984). As analysts put it, “This represents a great simplification of the detailed work on atmospheric chemistry and meteorological modeling to construct a heuristic that, in the eyes of the experts at EMEP, provided an adequate representation of pollutant import and export in Europe” (Gough, Castells, and Funtowicz 1998, 24). The model can become more detailed if model users and scientific experts feel that more detail is required (Alcamo, Hoekstra, Kääriäinen, et al. 1983, 49). The last requirement for the model to reflect on what was learned from outside actors is that it should be flexible enough to incorporate the things learned. This reflection is done by following the second guideline: a model with a modular structure (for example, dividing the model structure into parts that handle emissions, technology costs, atmospheric processes, and environmental impacts of acid rain) enables the modelers to make changes or to add new perspectives more easily than does a model without a modular structure because modelers do not have to examine the whole model, only the relevant parts. The RAINS model, for instance, can be divided into the following modules: emission inventory, atmospheric transport and transformation, deposition, and impact assessment.
modules, to ensure the model's consistency and integrity, which can be compromised because of the model change.

The RAINS team began with a very simple model having atmospheric transfer coefficients borrowed from the EMEP's ATM. In addition to avoiding complex and demanding computations, this decision was made because the spatial coverage of the EMEP model covers the negotiating countries of the CLRTAP, and scientists and policymakers recognized the EMEP as having sufficient scientific quality with an international status (Hordijk 1991, 600). The pollutant initially focused on was sulfur because the team felt that there was consensus on the primary importance of sulfur in transboundary air pollution (Alcamo, Kauppi, Posch, et al. 1984).

To implement the first guideline, a series of review meetings took place beginning in the mid-1980s. After two rounds of review meetings, the RAINS team concluded from participants' written and verbal comments that "(1) the modular and flexible design of RAINS makes it possible to easily update the model, as additional expert opinion and data become available; and (2) RAINS links many different parts of the acidification problem in Europe in a comprehensible and usable manner to both scientists and non-scientists" (Alcamo, Hordijk, Kämärä, et al. 1985, 61).

According to the then project leader Leen Hordijk, the initial changes were mainly fourfold. First, the fixed available energy scenarios were made flexible so that the user could generate the scenario for use. Second and third, control cost and optimization modules were added to the model, which enabled the model to perform optimization aimed at the least costly abatement strategies and other forms of optimization. Fourth, more attention was paid to model uncertainties, not by incorporating stochastic variables or uncertainties into the model, but by making supplementary (and basically post hoc) analysis of the model outputs and maintaining the model's decisive character. This last change came in part from Hordijk's personal experience: "I found a tendency among policymakers to use the uncertainty ranges as excuses for non-action, and as vehicles for questioning the credibility of the work. Later, I realized that making uncertainty explicit was very important." This change also constituted one of the reasons to abandon cost–benefit analysis as explained below.

In the later stage, the environmental impact modules underwent significant changes. The first impact module was concerned with forest soil acidification, and the coverage of ecosystems later expanded to lake surface water and direct forest impacts. However, as it became clear that "the link between forest damage and acid rain was not as strong as believed in the 80s," and the uncertainties in soil acidification was so high that RAINS could not use this module (Skeffington 1990, cited in Hordijk 1991), the RAINS team dropped the forest soil module and turned to the CLs concept in 1991 (Hordijk 1991, 601). The subjected pollutant was concurrently largely expanded from the initial focus of sulfur to nitrogen and ammonia to reflect on review meeting participants' opinion that "it was not until the inclusion of NOx that RAINS was considered to be good enough for policy use" (Hordijk 1991, 601).

What advice was not included in the RAINS model? First, a suggestion for a cost–benefit analysis was rejected. This decision was made in part because of Hordijk's experience:

Several times [Hordijk] had conducted [cost–benefit analysis], and had been careful to warn policymakers about the great uncertainties inherent in the benefits estimations, uncertainties often extending over an order of magnitude. Repeatedly, he had observed policy-makers use just one number, taken from within that range of uncertainty, as a single point estimate to justify their preferred policy. Hordijk had been personally criticized, and had found the selective use of data by policy-makers troubling and counterproductive. He decided that similar problems could occur within LRTAP, undercutting the legitimacy of the RAINS model. (Putt 1999, 119

The additional reason for rejecting cost–benefit analysis was the Soviet Union's resistance to it because its orientation toward market economy was inconsistent with the Soviet system.

The second piece of advice rejected was to use more detailed ATMs than those used in the EMEP. RAINS was occasionally criticized for using the EMEP's simple (in terms of process characterization and the low resolution) ATM, so it is understandable that more detailed ATMs were suggested. However, the suggested alternative did not cover the UNECE region, so it was rejected on the grounds that "[this [spatial coverage] is a necessity for a model that should be used in a negotiation setting" (Hordijk 1991, 600).

Inclusion of energy models was the third suggestion rejected even though it came from the CLRTAP Executive Body (Hordijk 1991, 601–602). The lack of energy models was in fact considered a limitation of the RAINS model because without them it is impossible to investigate policy measures that abate pollutants through structural changes in the energy sector, such as energy conservation and market-based abatement measures. This suggestion was rejected because the technical task of including a country-scale energy model for all participating countries and
linking them to RAINS was considered enormous and difficult (Hordijk 1991, 602). However, some supplementary studies were made for consideration of the SSP. Because RAINS was not the only model built for use in the international negotiations, the RAINS team learned from the competition among those models as well. The other candidates were the Abatement Strategies Assessment Model developed by the Imperial College London and the Coordinated Abatement Strategy Model developed by the Stockholm Environment Institute, which were broadly similar in design and scope but had slightly different optimization procedures (Castells and Ravetz 2001, 414-415). The competition was also one of the driving forces to make RAINS more relevant and acceptable to the policymakers. In addition, "[the competition] . . . stressed the need for a very clear explanation of what we were doing, how we were using EMEP, how the cost functions had been derived and how the institutional position of IIASA [as an international institute] could be better used. Moreover, . . . [it] forced the IIASA team to explain the differences in model outcome between RAINS, [the Abatement Strategies Assessment Model and the Coordinated Abatement Strategy Model]." In actual negotiations, the RAINS model was finally chosen as the guiding model, and other models were used for checking (or relativizing) its runs and outputs.

Learning Mode
To what extent did the scientific assessments for the SSP learn to develop the CLs approach and the RAINS model? As shown, the advisory scientists abandoned their positivist paradigm and shifted to a more diplomacy-oriented paradigm that would hold them accountable to country parties, which is a prerequisite in diplomatic settings and makes scientists adhere to the overall norm of usefulness in the diplomatic context. A contrasting point is that whereas in the pre-case study period the overinvolvement of policymakers and political influence was regarded as an obstacle to maintaining scientific integrity, such involvement was contrarily regarded as a necessary condition and not an afterthought to secure the assessment's integrity in the diplomatic context.

Specifically in the CLs case, the definition of CLs was changed as a result of learning, going from the early form where only most sensitive ecosystems were focused on to a more politically robust form in the context of CLRTAP diplomacy. The data were calculated according to an agreed-upon methodology, but at the same time the participating countries were given choices of the type of ecosystem and the relevant parameters, and no data were used without an "official stamp" on them, which countries could interpret as a fulfillment of the advisory scientists' obligation to respect the countries' sovereign rights. A separation between the acidifying effects of nitrogen and sulfur was even introduced through supplementary research, although it was scientifically indefensible, in order to make the CLs approach useful in the SSP diplomatic context, in which only sulfur was subject to negotiations and nitrogen was out of the scope.

This paradigm shift is easier to detect in the RAINS case because it is explicitly stated in the RAINS guidelines. The inclusion of optimization modes, incorporation of the simple "blame matrix," the choice of spatial scale, and resistance to both non-EMEP ATMs and complex energy models were pursued to secure accountability to policymakers and usefulness in the SSP diplomacy and would have never been realized if the positivistic norm of the pre-case study period had dominated.

The objective and the dominant methodology were accordingly shifted to materialize the paradigm shift. The objective was set to guide the diplomatic negotiations in terms of the least-cost abatement strategy to achieve CLs all over Europe stipulated in the 1988 Nitrogen Oxides Protocol, which is a more diplomacy-oriented and policy-prescriptive objective compared to the pre-case study period. As for methodology, transdisciplinary research methods were introduced to meet the objective. They were transdisciplinary in the sense that scientists and nonscientists (policymakers) had been integrated into the assessment process to produce integrated knowledge about the necessary political choices of reduction targets and their costs to achieve certain environmental targets and, conversely, about the environmental consequences of political choices of reduction targets and measures. Therefore, the case study exhibits paradigmatic learning: a shift in the dominant paradigm, objective, and methodology of scientific assessments compared to the pre-case study period.

Stimulating/Discouraging Factors
One of the stimulating factors is certainly the continuity of participating organizations and scientists, which enabled storage of knowledge and experience within the learning assessment (structural factor) (Siebenhüner 2002b). For example, the Norwegian Institute for Air Research was the organization responsible for coordinating the OECD program and the SNSF project and was one of the EMEP's Meteorological Coordinating Centers as well. This continuity in participating institutions and
boundary air pollution declared by the 1972 Stockholm Conference and
basically shared among all the participants of the science–policy complex
(cultural factor) (Siebenhüner 2002b) as well as the criticisms of the First
Sulfur Protocol and the Nitrogen Oxides Protocol regarding the lack of
scientific basis for their reduction targets (contextual factor of political
pressure).

What about discouraging factors? As observed earlier, the criticism by
the “outside” scientists and the conflict between soil and water scientists
in the CLs case might have become discouraging factors, but they did
not. Instead, the advisory scientists learned to manage such criticisms
and conflicts. Some scientist continued to criticize the CLs approach as
being oversimplified, arbitrary, and not scrutinized by the usual scientific
peer-review process, and they argued for an ecological approach that
encompasses living organisms in soils and waters as an alternative to the
CLs approach (Skeffington 1995). However, such criticism was never
given serious attention in the learning assessments, perhaps in part
because it was not valid in the diplomacy-oriented paradigm in which
the learning assessment operated.

Conclusion

This case study demonstrates the usefulness of the alternative framework
by showing that a focus on procedural and substantive knowledge, a
paradigm shift acquired through learning, and path-dependent factors
are important when explaining learning assessments. For the first two,
the cross-fertilization between STS and institutionalist approaches
enabled the alternative framework to emphasize their importance. It may
now be established that, in addition to the existing literature, the shift
in the dominant paradigm of the learning assessment from positivism to
a diplomacy-oriented one can be one of the candidate factors that
explains the high political acceptability of the integrated assessments
using the CLs and the RAINS model in the SSP negotiations. However,
the political effectiveness of learning assessments is complex and requires
careful examination of causal pathways between learning processes and
such effectiveness.

In the chapter introduction, I argued that analysis of learning assess-
ments can contribute to the democratization of expertise in the European
transboundary air pollution governance by explaining the learning process,
including how scientists learn what kind of strategies enhance the credi-
abilty of their advice, and that the analysis can suggest useful ways to enhance
the learning process needed for the democratization process. I conclude with some implications of the case study to these ends.

Again, the case study showed that the main strategy advisory scientists employed to enhance credibility of their advice was paradigmatic learning. The resulting diplomacy-oriented paradigm, however, is substantially different from an ordinary understanding and image of science and may therefore be very difficult for an outsider to understand. This difference becomes particularly important when it comes to the democratization of expertise because the diplomacy-oriented paradigm introduces newcomers to the science–policy complex who generally have no idea of this diplomacy-oriented paradigm. The necessary communication for the democratization process can function properly only when the context and the corresponding paradigm are well understood and shared. When they are not, miscommunication may result among the experienced personnel and the newcomers, and the situation may turn out to be detrimental to the democratization process. Therefore, it is of the utmost importance to explain the paradigmatic learning and the resulting paradigm to the newcomers.

What kind of learning strategy does the case study offer? As shown, reflective mechanisms are promising learning strategies to be used in undertaking the democratization process (see also Siebenhüner, chap. 4 in this volume). Based on a proper understanding of the contexts and paradigms in past science–policy interaction, a good first step might be to ask the experienced participants and newcomers to consider jointly what context should be taken into consideration and what kind of corresponding paradigm should be developed through deliberate and interactive workshops. Unless those elements have been decided, it is very difficult to determine an effective objective and methodology. In addition, these kinds of workshop will certainly contribute to developing trust among the experienced participants and the newcomers, which was also an important stimulating factor in the case study discussed here.

Although the case study does not reveal any necessary changes in the alternative framework, needless to say the framework should be reevaluated and updated by further case studies. Exploring the learning process is itself a learning process.

Acknowledgments

An earlier version of this chapter was presented at the 2007 Annual Convention of the Japan Association of International Relations, Fukuoka, 27 October 2007, and at the Forty-ninth Annual Convention of the International Studies Association, San Francisco, 26 March 2008. I am grateful to Arne Henriksen, Leen Hordijk, and Keith Bull for providing me with very useful information. I also thank the editors of this book, Göran Sundqvist and Rolf Lidskog; three anonymous reviewers; as well as Yasuko Kameyama and Norichika Kanie for their very valuable comments. This work was funded in part by Grants-in-Aid for Scientific Research (ref. no. 17310025 and 20310025) of the Japan Society for the Promotion of Science.

Notes

1. Most of the later works by Siebenhüner (for example, Siebenhüner 2006, 2008) are not very different from earlier works (Siebenhüner 2002a, 2002b). Siebenhüner 2002a and 2002b represent the most explicitly tailored and comprehensive approach to analyzing international scientific assessments and therefore the most relevant for this chapter.

2. I use the term learning assessment(s) as shorthand to refer to "scientific assessments of learning."

3. Siebenhüner provides the following examples of procedural and substantive knowledge, respectively, to be learned in the introduction of the CLs: "Previous pollution abatement strategies concentrated on overall emission reductions at all sources largely irrespective of the actual damages of specific emissions in certain regions" (2002b, 422); and "In the critical-loads approach, the different emission reduction requirements could be deduced for different regions. This allows for more cost-effectiveness in abatement strategies" (2002b, 422).

4. I use the definition of the terms interdisciplinary and transdisciplinary summarized in Tress, Tress, and Fry 2006.

5. This argument was made with reference to Henriksen and Brakke 1988.

6. Keith Bull, secretary to the CLRTAP, e-mail message to author, 5 March 2007.

7. Ibid.

8. Ibid.

9. For detailed description of the EMEP model, see Eliassen and Saltbones 1983.


11. For RAINS versions one to five, uncertainty analysis was done only of a limited number of modules. For RAINS version six, which was actually used in the SSP negotiations, no uncertainty analysis was done (Hordijk and Kroeze 1997, 412).
13. Ibid.
14. Ibid.
15. Ibid.
16. Ibid.
17. For example, see Rentz, Haasis, Jattke, et al. 1994.
19. Ibid.

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Fewer Boundaries and Less Certainty: 
The Role of Experts in European Air Policy

Göran Sundqvist

Scholars in the field of science and technology studies (STS) often repeat the message that the relationship between science and society is unstable. Spurred by regulatory failures in dealing with problems such as “mad cow disease” (bovine spongiform encephalopathy) and public criticism of genetically modified organisms, the European Commission has prioritized expert credibility as an important issue in need of political attention. In preparing for the White Paper on Governance published in 2001, the commission set up a working group on “democratizing expertise” whose main objective was to propose ideas on how to restore the credibility of expertise (EC 2001). In 2005, the commission established an expert group consisting of STS scholars to address the widely recognized problem of public uncase with science ( Wynne and Felt 2007). These events and activities obviously indicate that the relationship between science and society must be strengthened; they also suggest that STS insights can contribute to this strengthening.

According to STS scholars, the problem is that the public receives conflicting advice from experts about what to think and how to act. The solution to this problem, however, is not unanimous advice, but a better understanding of how to handle disagreeing experts. The problem consists of naïve expectations as to what expert advice can in fact deliver—expectations arising from the widely held but misleading view that scientific advice is certain. This false aura of certainty surrounding the role of the scientific expert is the main problem and the source of unrealistic expectations (Collins and Pinch 1993, 1998, 2003; Shapin 1995; Latour 1998; Hilgartner 2000; Wynne 2001; Jasanoﬀ 2003; Irwin 2006; cf. Callon, Lascoumes, and Barthe 2009). When conflicting advice is understood from the perspective of certainty, problems arise. The solutions to the problem, according to STS, are for scientiﬁc experts to stop presenting their work as about certainty and for the public to lower its
**Governing the Air**

*THE DYNAMICS OF SCIENCE, POLICY, AND CITIZEN INTERACTION*

EDITED BY ROLF LIDSKOG AND GÖRAN SUNDSQVIST

Governing the Air looks at the regulation of air pollution not as a static procedure of enactment and agreement but as a dynamic process that reflects the shifting interrelationships of science policy, and citizens. Taking transboundary air pollution in Europe as its empirical focus, the book not only assesses the particular regulation strategies that have evolved to govern European air but also offers theoretical insights into dynamics of social order, political negotiation, and scientific practices. These dynamics are of pivotal concern today, in light of emerging international governance problems related to climate change. The contributors, all prominent social scientists specializing in international environmental governance, review earlier findings, analyze the current situation, and discuss future directions for both empirical and theoretical work.

The chapters discuss the institutional dimensions of international efforts to combat air pollution, examining the effectiveness of CLRTAP (Convention for Long Range Transboundary Air Pollution) and the political complexity of the European Union; offer a broad overview and detailed case studies of the roles of science, expertise, and learning; and examine the "missing link" in air pollution policies: citizen involvement.

Changing political conditions, evolving scientific knowledge, and the need for citizen engagement offer significant challenges for air pollution policymaking. By focusing on process rather than product, learning rather than knowledge, and strategies rather than interests, this book gives a nuanced view of how air pollution is made governable.

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"Governing the Air" is a much welcomed and needed book within the area of risk governance and management. Arguably the popularity of transboundary air pollution studies peaked in the 1980s and early 1990s, after which the field became eclipsed by discussions surrounding climate change. With this book, professors Lidskog and Sundqvist and their stellar cast of authors have once again put transboundary air pollution studies into the limelight. This is a must-read book for policymakers, academics, and others active in the air pollution debate of the present day."

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