Procedures for the Establishment of Standards

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EXECUTIVE
SUMMARY

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The increased public awareness of the risks and hazards of modern technologies has led to a variety of regulatory actions to reduce detrimental effects of development and production processes on human health, safety, and psychological well-being. These regulatory actions include market approaches (incentives, taxes), standards, and direct intervention. Among these regulatory tools standard setting has emerged as the most practical and commonly used means for reducing risks and hazards of environmental pollution. Since the late sixties environmental and regulatory agencies all over the world have issued numerous standards, for example on SO_2 emissions from coal fired power plants, on ambient BOD (biological oxygen demand) levels in rivers and lakes, on noise levels from trains and aircraft, or on radiation losses from nuclear plants. What emerged on the one hand as a powerful and practical tool for environmental management, on the other hand became a major constraint for industrial operations and a driving force for technological development. Especially in the energy sector standards began to shape long- and short-term decisions, ranging from operational decisions about singel plants to long-term planning decisions about optimal energy mixes. The influence of standards on energy systems development has been studied within IIASA's Energy Systems Program for example for radiation standards, SO_2 standards, particulates, etc. But standards also had more subtle effects, which were not always intended and seldom foreseen. Car emission standards turned out to increase fuel consumption, a fact which was particularly highlighted during the energy crisis. Restricting pollution from one source (for example, hydrocarbon emission from cars) tended to produce more pollution of another kind (for example, sulphuric acid mist). Restricting risks of one kind (for example, population risks) tended to increase risks of another kind (for example, occupational risks).

When in the mid-seventies these adverse effects and inconsistencies of standards were felt, government officials, environmental managers, and researchers began to ask new challenging questions: How well do standards fulfill the role of mediating between environment and development interests? How much do standards cost the economy, and how much does the public benefit from standards? And finally: How good are regulatory procedures for the establishment of standards? The answers seldom turned out to be encouraging. Environmental managers and researchers are especially critical of the quality of standard setting procedures. Anecdotal evidence of arbitrary numerical standard levels are not uncommon. But if such irrationalities are obvious and easy to discard, the underlying reasons for the seemingly poor quality of standard setting procedures lie in the enormous difficulties which standard setting agencies typically face:

- There usually exists a substantial uncertainty about the effects of pollutants on human health and well-being. Experts often differ widely in their estimates or are unwilling to make judgments because of a lack of information;

- Standards have to be set in the light of conflicting objectives such as environmental, economic, engineering, and political objectives. Many of these objectives are hard to quantify, and few are commensurable;

- The regulator is seldom a single decision maker, but usually various administrative units and experts interact in the decision making process, often confronting each other with different values and opinions. In addition, different groups with conflicting interests are affected by standards;

- Effects of pollution and regulations are distributed unevenly over time. Crucial trade-offs have to be made between costs and benefits today and costs and benefits in the future.

Realizing these difficulties the Volkswagenwerk Foundation project on "Procedures for the Establishment of Standards" was initiated in 1975 as a joint effort of the Nuclear Research Center, Karlsruhe, FRG, and the International Institute of Applied Systems Analysis, Laxenburg, Austria. The objectives of this research were to analyze existing procedures for standard setting, and to develop new techniques for improving standard setting procedures. An initial literature survey soon revealed that such a project stepped into relatively unexplored territory, and progress was therefore necessarily slow, particularly in the initial phase of the study. Several possible research directions were identified:

- legal studies;

- environmental economics;

- policy analysis;

- cost-benefit analysis;

- simulation and simulation gaming;

- decision theory;

- game theory.

Based mainly on the expertise of the researchers involved in the study, several initial decisions for shaping the research were made: First, standard setting procedures were to be studied at the hand of actual cases in close cooperation with environmental decision makers. Second, two main lines of research were to be performed: policy analyses of past or ongoing standard setting processes with a largely problem oriented and descriptive focus; and development and application of decision and game theoretic models for standard setting with a more normative emphasis.

The policy analyses were meant to provide the case material to describe how standards are presently set, to identify problem areas in standard setting, and to provide inputs to the decision and game theoretic models. A policy analysis framework was elaborated and applied to two standard setting cases: chronic oil discharges from North Sea oil production platforms, and noise standards for Shinkansen trains in Japan. In each case in-depth interviews were held with the main participants in the standard setting process focusing on the three main actor groups which the policy analysis framework identified as the key actors in standard setting: the regulator group, the developer (producer) group, and the impactee group.

The two cases turned out to be quite different in character. Chronic oil discharges were essentially set on the basis of equipment availability, costs, and performance. The reason for this technical orientation in standard setting was that biological information on the effects of low-level hydrocarbon concentrations in the seas is still very sparse. Noise standards for Shinkansen trains, on the other hand, were set almost exclusively on the basis of noise complaint relationships with the intention to set the noise standard at a level where the number of complaints remains small. Available technical and cost data were more or less ignored. This difference reflects differences in the national definitions of standards and the legal basis on which standards are issued. While chronic oil discharges in the United Kingdom were set on the basis of the "best practical means" principle, noise standards in Japan were set as environmental quality standards, i.e., targets or desirable goals for the future without direct binding force. Other definitions include, for example the "best applicable means" definition used in Norway, or the "best available technology" definition used in the U.S. Such definitions together with the different institutional setups and political constraints in standard setting procedures appear to shape the outcome of standard setting procedures substantially.

A decision theoretic model was developed that directly relates to the given standard setting cases of chronic oil discharges and noise. The model is a one-stage three-decision-maker model which comprises the decision making of a regulator, a developer, and an impactee unit. The purpose of the model is to provide a structure, a language, and quantification and analysis tools for regulatory agencies to use when performing standard setting tasks. The model assumes that the regulator announces his standard r, and then determines an optimal decision $d(r)$ of the developer in response to the standard. The impactees in turn are assumed to respond to the developer decision d(r) with an optimal response a[d(r)]. This triple of decisions, together with the associated utilities U_R, U_D, and U_A accruing to the three decision units, allows to explore the relative benefits of standards from the point of view of all parties affected before actual decisions are made.

This model was applied to setting chronic oil discharge standards for North Sea oil production platforms. A detailed expected utility model was constructed to determine the optimal treatment response of the developer (oil company) to a standard set by the United Kingdom's Department of Energy, considering equipment cost and performance, and probability estimates of possible detections of regulation violations and sanctions. Results include that the developer response to standards is controlled by cutoff points along the standard measure. These cutoff points are determined almost exclusively by the performance uncertainty of equipment, and the regulator's monitoring and inspection procedure. Penalties and risk attitudes incorporated in the developer model did not change the cutoff points substantially. Further analyses of the three utility functions of the regulator, developer, and impactee show that there are many dominated standards, where the regulator's utility dominates the utilities of the developer and the impactee. This result is typical when the regulator's decision (i.e. the standard) is discrete, and the impactees are considered sufferers. Non-dominated standards tend to cluster around cutoff points. Another result is that a standard is not equal to a standard. Standards with the same numerical value can have quite different economic implications, depending on external conditions (performance uncertainty of the treatment) and the monitoring and inspection procedure of the regulator.

The multistage nature of standard setting processes with the possibility of learning and adaptation and the possible multiple interactions between the decision makers were not explicitly considered in the decision theoretic model. In order to overcome these limitations a multistage game theoretic model was developed which is also based on the three generic decision units. In contrast to the single-stage decision model, however, the game theoretic model treats multiple stages in which the transitions from one stage to another are probabilistic, either because of probabilistic changes in the environment, or because of probabilistic responses of the players involved in the standard setting. The purpose of the game theoretic model is to parametrically explore the possible futures of standard setting procedures under given solution concepts. The model was applied to CO_2 standards and to noise standards for Shinkansen trains. Since the model uses highly aggregated and simplified utility functions and transition probabilities, no precise behavioral implications or recommendations can be drawn. However, the model results do provide a structure for exploring extreme reactions of the players and reactions to regulation (for example, compromise offers for noise standards to avoid a law suit). In addition the model points out differences in the optimal strategies depending on the game theoretic solution concept (for example, equilibrium points, or Pareto optimality), and allows the regulator to explore consequences of his regulation and the reactions of players under different solution concepts.

The results of these studies were presented together with research approaches of other environmental study groups at a workshop held at the International Institute for Applied Systems Analysis at Laxenburg in May 1978. The purpose of this workshop was to identify major problem areas in standard setting, to review the usefulness and limits of formal approaches to setting standards, and to make recommendations to regulatory agencies about improvements of standard setting.

Uncertainty, conflict, and institutional constraints emerged as the main areas of regulatory concern in standard setting. Particularly the problems of evaluating research, of quantifying and summarizing information in a format useful for regulatory decision making, and of conflicting opinions and values were identified as the main obstacles in standard setting. In addition the statutory framework for standard setting, international and national regulations, and institutional constraints were considered by regulators to be limiting factors in standard setting, which often force the regulator to make legalistic and political decisions rather than decide on the basis of scientific evidence.

Our studies identified several possible uses and limitations of the three analytical approaches (policy analysis, decision theory, game theory) used. A summary of the main conclusions is shown in the Table following. The last row in the Table indicates where in the standard setting process such approaches could be used to improve standard setting. Of course, these recommendations to use policy analysis, decision theory, and game theory in standard setting procedures are not meant to be exclusive. Other approaches such as cost-benefit analysis, gaming and simulation models should be further explored. In addition the question of institutional changes matching such methodological improvements arises. For example, decision and game theoretic models could be used on an experimental basis in "standard setting laboratories", in which regulators, developers, and impactees would interact at the hand of models before they take their final decisions. Other institutional innovations such as science courts and public participation should also be considered in the light of the methodologies available. The problem of striking a match between methodological improvements in decision making and the institutional and political reality (as well as necessary changes in institutions) could be a major focus of such future research.

USES AND LIMITATIONS OF POLICY ANALYSIS,
AND DECISION THEORETIC AND GAME THEORETIC APPROACHES TO STANDARD SETTING

	POLICY ANALYSIS	DECISION THEORETIC MODELS	GAME THEORETIC MODELS
USE	-to create a wide perspective of standard setting problems -to create problem structure, to identify groups involved, alternatives, and necessary information.	-to structure decision problems -quantify intangibles and uncertainties -to make trade-offs explicit -for conflict and sensitivity analyses	-to structure dynamic decision process -to explore parametrically the future of standard setting processes -to identify sensitive decision points
LIMITS	-mainly descriptive and qualitative -problem, not solution oriented -possible misperceptions	-static, limited feedbacks -problems of intergroup trade-offs -problems of quantifying political objectives	-highly abstract and aggregated utility functions and transition probabilities -arbitrariness of solution concept
RECOMMENDED USE IN STANDARD SETTING PROCEDURES	-in the *pre-standard setting phase* for: -structuring; -sorting out obviously unsatisfactory alternatives	-in the *standard setting phase*, after a clear decision problem has been formulated for: -evaluating information; -quantification; -trade-offs and sensitivity analysis	-in the *standard setting and post-standard setting phases* for: -simulation of future changes; -sensitivity and conflict analyses