Title: Policy R&D: Outline of a Methodology with Reference to Decision Making in the Fields of Energy, Transportation and Environment

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Abstract:
This paper elaborates on the methodology of a prior policy study of transportation energy conservation. It demonstrates that this methodology is applicable to other problems and issues, particularly those involving social uses of resources and technology, and their results and impacts. Policy R&D is defined as the process of transforming science and technology data into a comprehensive and evaluated basis for concrete decision making. The current modes of policy making are outlined and contrasted with policy R&D. Elements, typical steps and sequence, and implications of policy R&D are analyzed. Technology and environmental-impact assessment are identified as specific applications of the policy R&D methodology. The value of this method for decision making under conditions of uncertainty is highlighted. Main implications and perceived practical obstacles are listed. The principal conclusion is that policy R&D is a necessary and useful dimension of any decision-making process, from the first identification of the problem or issue to the selection of the means to deal with it. Effective utilization of knowledge in decision making requires that the policy R&D dimension be appropriately integrated into the whole process from data to decision. It needs to be recognized that policy R&D is not an extrapolation of any existing discipline (such as economics, planning or management) but a new discipline which links the specialized technical R&Ds to societal decision making and facilitates their effective and sustained application.

Preface:

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The present paper is a follow up on the policy study of "Energy Conservation in...

"Transportation in Puerto Rico," was prepared by Professor Jaro Mayda in 1978. This regional study addressed specific problems of energy use in transportation. It focused on converting concrete data into policy "baselines." The analytic model was only briefly described. The need for comprehensive policy analysis is now widely recognized. This is reflected on the national level in activities of the Office of Technology Assessment and the Office of Science and Technology Policy. The Council on Environmental Quality recently revised its regulations to make environmental impact statements more "policy-oriented." The 1979 research program of the Urban Mass Transit Administration emphasized the need to make planning and predictive models more "policy sensitive." The model of policy R&D underpinning the Puerto Rico transportation energy conservation study is considered applicable beyond this specific topic and occasion. As this paper explains, problems such as energy, environment, and transportation are in fact about resource use and allocation in the context of societal needs. While the data, goals, and capabilities may vary, the method of analysis and the development of solutions are highly comparable. I believe Dr. Mayda's

Table of Contents

Transitional Node TH Variant: Aborted "policy making" ©) Comments. Policy R&D: The "organic" mode. Typical steps and sequence in policy R&D. a) Comments on Figure 4. b) Purpose of key steps. ©) Concrete implications. 1. Emphasis on system synthesis. Contrast between the typical planning and policy R&D. Possible uses of the output before the process is complete. 4. Work on data. Precision v. synthesis. Hard data. Soft data. Categories (type of input). 4. Political/institutional data. iv) Public perception as a policy datum. Policy modeling. 8. Definition and distinctions. Elements of policy development. Goals. Means. Opportunities/Constraints. Indices/Scales. Selection and ranging of Policy options. 10 12 4 16 16 18 19 20 21 22 22 23.

IV 6. Risk assessment. Technology. Environmental impact assessment. Data. Policy process. Role of uncertainty. Some implications for practice. 1. Preconditions. 6. Understanding of the nature and mission of policy R&D. Identification of some major obstacles. The principal implications.

List of Figures:

INTRODUCTION

1. The purpose and topic of this paper. This paper is a concise elaboration of the methodology used to prepare "Energy conservation in transportation in Puerto Rico: A policy study" (19)," referred to in the following text and notes as TEC/PR. The methodology, now termed "policy

research and development," was central already to the concept of eco-management (20 [1967] and

The text is implicit in the U.S. National Environmental Policy Act of 1969. Rather than being only a project-specific technique, it is a perspective and an approach to problem-solving that is akin to system analysis. It was recognized long ago that system analysis is primarily a state of mind. Since the policy problems which interest us here involve the social uses of resources and technology, and the resulting environmental impacts, the policy R&D dealing with them is a form of applied social system analysis--with significant modifications, especially a shift toward synthesis, to be explained later.

The broad applicability of such a methodology is apparent at first sight. It goes beyond TEC and even beyond the areas to which this paper expressly addresses itself. Nevertheless, policy R&D is not widely understood under any name, and even less widely practiced. And yet, if there is one common factor in the decreasing relative capability of the governments to deal effectively with major problems before they "solve" themselves by means of a crisis, the lack of systematic and rigorous policy development is likely to be this factor.

Such a hypothesis suggests that policy R&D may be the most important branch of the whole R&D process, because the socially beneficial and sustainable applications of all other R&Ds depend on adequate social policies. The present paper cannot aim at an elaborate demonstration, as feasible as it appears. It must remain an outline of the elements and the model, with practical illustrations and implications. It is, however, written against a broad background of antecedents, development of concepts (25, 28, 12, 16, 26, 24, 15) and practical applications (28, 22, 29, 19, 21, 23).

Underscored numbers refer to the bibliography (pp.3 ff.) where necessary, they are followed by plain page number(s) or other symbols which specify the reference. Superior numbers identify notes (pp. 31 ff.).

The extensive reference apparatus of these various studies and reports (TEG/PR alone has

The following text is a bibliography of 150 items. This appended bibliography, although it outlines several new items, is only a small sample of the full reference. The propositions and generalizations presented in this paper can therefore be considered as more broadly based and justified than the scope and reference would indicate at first sight. They will hopefully serve as a base for further useful application and refinement.

This is a synopsis of the transportation energy conservation policy study. The immediate point of departure for this paper is TEC/PR, making it convenient to start with a brief summary of the characteristics and results of that project.

a) Topic and Goals: These were described in the report itself as follows: "The use and waste of energy in transportation in Puerto Rico is such a massive and complex social event that it is particularly suited for a major exercise in policy research and development for decision-making. Such an effort must be collective and should aim at specific recommendations and timelines, as well as the development of the methodology used to analyze and identify the systemic nature of important social and resource problems so as to enhance public decision-making related to them."

"The present study is an initial effort by a single policy generalist to apply social system analysis to transportation energy conservation, in order to prepare the ground for a team effort of transportation and energy specialists, regional planners, policy specialists, and government administrators—with additional inputs from commerce, industry, and the community at large."

"The task of this study is to inventory the principal factors and inputs in the field of transportation energy demand and possible conservation, to estimate their magnitudes and relations, and to arrange them in a tentative but reasoned pattern—where there have been only so many scattered data, technical studies with a limited focus, sectoral programs and decisions, and vague impressions about the serviceability, impacts, and the social implications."

Value of the results: "The data are analyzed in a policy perspective, with emphasis on their order of magnitude, their relation to the whole system, and a cost/benefit analysis which encompasses the whole energy, economic, and socio-environmental costs of the present transportation system..."

b) Execution: The project was carried out under conditions of incomplete, unavailable, or contradictory data, as well as other uncertainties. Many assumptions and interpolations were necessary. These were facilitated by the fact that passenger auto traffic, accounting for over 90 percent of transportation volume and energy in Puerto Rico, is comparable with urban traffic in the continental U.S. and other industrial countries. Moreover, uncertainty about data and variables is a normal condition in policy R&D. This situation was to some extent balanced out by the systematic effort to overcome the severe policy constraints inherent in the usual narrow techno-economic perspective on energy and transportation problems. The technological and economic factors were integrated with, and analyzed in the light of, social purposes and environmental considerations.

The policy development took place on three levels:

1) A macro-analysis of the transportation system and energy demand aimed at an integration of all the variables and a preliminary model of the total transportation energy budget.

2) A micro-analysis of the energy demand aimed at the identification of the causes of fuel penalties, the removal or mitigation of which would bring about fuel economies (conservation).

3) A cost/benefit analysis was directed at a tentative evaluation of the auto owner's cost, full economic cost of the passenger-vehicle sector, and full social (that is also environmental) cost.

c) Limitations and results: The goals of TEC/PR were determined and limited by these characteristics:

1) It was a first attempt at a synthesis of a system for which no model or study design existed.

2) It was not a full-fledged

Policy R&D. The "R" phase was multidisciplinary in terms of the scope of data, but not in terms of direct participation from various disciplines. The "D" phase proceeded with the transformation ("conversion") of the "raw" data into policy data, which was then expressed in an organized form. However, it did not involve any systematic interaction with the users- decision makers, planners,

and administrators.

4. For these reasons, the study did not aim at the development of positive policy options. Its goal was to formulate "policy baselines," which are summaries of the policy data in a form that could be fine-tuned and developed into specific alternative recommendations for action, priorities, combination of means, and implementation schedules tied to numerical TEC goals.

The value of the result for the purpose of further policy development and decision making can be judged on the basis of the following synopsis of the policy baselines:

1. Transportation in Puerto Rico consumes directly (fuel) and indirectly about as much energy as all the other sectors put together. The share of transportation energy in the total energy budget may be as much as 10% higher than in the U.S. as a whole. (The categories of indirect energy use are listed on the opposite page, originally Figure 3 in T50/FR. The acronym TDTE means "total direct transportation energy." The category "All other energy uses" includes residential and municipal consumption, light and heavy industry, commerce, communications, and services.)

2. Upward of 60% of transportation energy is consumed by private automobiles. This transportation sector is highly publicly subsidized. The users of automobiles do not pay the full economic cost of gasoline [due to the equalization of the prices of U.S. domestic crude and the foreign crude used in Puerto Rico], of highway use, and parking. They are also subsidized on a number of other accounts. This situation seriously discriminates against public transportation.

3. Concrete measures in such categories as...

Maintenance, use of power equipment, driver demand and behavior, and traffic engineering could reduce consumption by as much as 50%, while still satisfying the need for safe essential mobility by means of private automobiles. However, transportation energy conservation cannot be effectively implemented without adequate transportation system planning and management, integrated with the whole social and resource system. The lack of such system management has created adverse impacts on public and environmental health, land use, and environmental aesthetics. These are assumed to be comparable in magnitude with the energy and real economic cost of the present transportation system. The figure on pages 6-7 (based on Table 1, TEC/PR) elaborates on baseline TIT and indicates how it can be translated into public implementation measures.

Figure 1. Elements of a model of total energy consumption in Rico. TOTAL TRANSPORTATION ENERGY indicates elements like gasoline, manufacture, construction, accidents, refining, transportation, maintenance, evaporation, and vehicles' contributions. The broken lines suggest some obvious TDTE resulting from transportation-related activities/events, and the multiple system effects of a minor factor--the example of underinflated tires.

Figure 2. A synoptic table of the categories and estimated potential for transportation energy conservation (TEC) in Puerto Rico. Causes of consumption, fuel efficiency, and potential conservation measures are listed. For example, vehicle maintenance could be increased by 5% as indicated in the Puerto Rico fleet's perceived state of maintenance. Fuel consumption could be

reduced by adjusting driving speed and fuel/air ratio, using only urban lubrication, adjusting tire type and inflation, and aligning the infrastructure. Automatic power management is also a potential conservation measure.

2 | Wetland Transmission 35 [Urban only] D5 a country only Air conditioning 2 | Weight 20 | Urban, hot weather | 22 other convenience | 1.5 | Weight: equipment 1 | Petition 1 [TRAFFIC Flow Traffic engine _—_ ing & control Demand Short trips; low 35 occupancy' 8 Driver behavior average >> Erratic driving! Extra weight carried at each 50 kg 1 Laws, regulations, administrative standards & procedures Traffic system management; Engineering. Maintenance. Monitoring. Enforcement. 'Agency coordination. Budgeting. Formal; vocational; ad hoc and continuing; media.

2 Necessity and possible public actions favoring fuel economy in transportation Categorized various recommendations | Favor [specification? i.e., Distance and RAINING Boating, August gasoline Regulation face "gph equal by Yields Hydrocarbon content ions testing Introduce two Hex gasoline price *E gata/week '@ current price Extra fuel, '@double price' a year Revise. i Deliver education Acetone: Deter gene, Soho Profession Testing_t Nors [Estimated cost (/e "re. fiavene ae fresher") — Se Excise taxes: vextend [restructure Improve transit and public transportation Seansportation ® Tearei More adequate Traffic Code |arartic engi- dome fh | "neering f/ersensitive traffic police shan 'Oster speed|Better use of — speed limits: existing com— SBE site abet "SEE gl PO Slt [Demand] Penalties: fret of License year) -Repeaters professional ice ce cestssacee See ae 'peak hours: each PEAKS cubsia' "arrh aet eS. Flexitime Information a awareness Clear Fringe benefits He ae

STATE OF THE ART 1, Initial summary definitions. Policy is defined here as the comprehensive, analytical and evaluated basis for concrete decision making. Policy R&D is the process of formulating policy options (alternatives, recommendations). This process consists of the gathering, selection and synthesis of the relevant data, and their eventual expression in a form that allows the respective decision maker(s) a) to understand the problem, b) to make a decision with a reasonable assurance that + the option or

The recommendation that appears the most favorable is based on a rigorous analysis of all relevant data. Important factors and priorities are clearly stated and evaluated. All costs, including both direct and indirect impacts, and benefits are stated, evaluated, projected and compared, with possible trade-offs indicated. The recommended decision, or each possible one, is coordinated in terms of all the sectors it will affect. The process can be simply schematized in this fashion: Problem Definition > Options Base > Analysis > Recommendations > Decision Making.

2. Overview of current practice.

a) Terminology. The discussion of current practice in the field of policy must begin with terminology. As semanticists and linguists have long taught us, the set of words which describes a phenomenon reveals how we think about it. The conceptual and analytical infrastructure of current policy language is not in accord with the simple linear model above. Examples are selected completely at random for the sole purpose of concrete illustration. No critical or other implication beyond that is intended.

The concern is not about the precise language being used, but about the precision and consistency of the language which is in fact used. To start with the keyword, policy is a big, fashionable and multi-purpose word. Consequently, there is little uniformity in its use. A few indicative examples must suffice:

+ Leading dictionaries invariably define policy in terms of "a course of action". This definition can be found even in contemporary major studies (e.g., 1,19). It fails to distinguish between policy as a possible or recommended directive, and the direction which was in fact selected (20, 114).

+ In the same context, the meaning of policy can range from goal or norm (e.g., speed reduction) to operational or technical improvement (e.g., increased vehicle efficiency; ja, 31-32). A research prospectus of a major foundation (1978) proposed all the following.

"Conceptions as "legitimate": "Policy as the pursuit of public good [goals, values]; policy as politics [partly a data category; mostly the arena of decision and implementation]; policy as decision making [see below the comments on "policy making"]; policy as social process [policy reflects or indicates future direction of social process]; policy as argument [policy development includes the assessment of conflicting data or possible choices]."

The very common term "science and technology policy" is at best ambiguous. Does it mean policy for the enhancement of science and technology? Or, policy in the development of which science and technology represent data input; or the relation between science and technology policy (as directions for technical application of science)?

The current expression "policy making" merges policy R&D with decision making. In this sense, the term policy making describes, perhaps more than it intends to, the greatest weakness of the current practice. In such expressions as "to control the development of policy" (W.M.Blumenthal, then Secretary of Commerce, on 29 Jan. 1979) it sounds almost like a Freudian slip. A kindred expression is "...power to decide that this is the policy [the decision maker] wants to develop." This is almost the exact reverse of the rational progression--a policy "development" to justify a prior decision, or simply planning to implement such a decision, misleadingly described as policy development.

Two quotations from the current national press sum up the lack of clear understanding of the proper place and function of policy R&D: Statement on Alfred E. Kehn, Chairman, Council on Wage and Price Stability: "Substantially, his first love is policy, particularly regulation... Still broader questions--policies with regard to money supply" (Si, 20 May 1979). Charles Duncan, as the now Secretary of Energy, "...his nomination has raised several questions, particularly about whether he knows enough about energy to formulate policies for the..."

HDMI integration, perhaps more to the point is whether the senior staff of the White House, ever more ready to make decisions on energy, will permit him to function as a policy maker (34, 29 July 1979). Comments: The usual meaning of "regulation" is the detailed administration, at an administrative level, of a "framework" or "enabling" legislation, which expresses the policy formulated and selected for the session. Thus, regulation is not in ordinary technical language in the same category as policy but is rather twice removed from it. "Money supply" is an instrument of

a particular economic policy; the quantity of money supply's decision within this policy framework. What is in fact meant? Translated into the terms of the policy R&D model, the key phrases would read: "...whether he knows enough... to define the problems and goals and then to understand and to evaluate the alternatives or recommendations put forth by his policy staff;" and "...whether the senior staff of the White House has preempted both policy development and decision making to an extent that will not permit effective policy input from the outside." The current modes of "policy making" If we reduce a complex process with multiple variations and combinations to the three basic components and phases--Data (generation), Policy (analysis/development/evaluation) and Decision--we can express the current practice by means of the following schematized modes:

In an unstructured route, the traditional mode of information flow and perception of problem is intuitive. In this mode, policy and decision are completely undifferentiated, in spite of possible rhetoric. If the "hunch" decision is correct in terms of result, it is more a product of serendipity-- an accidental fortunate discovery--than of an organized rational process.

Inverted mode [Information flow and perception as above] includes a request for response, which can lead to a naive confirmation and justification of policy decisions on certain grounds. A common variety of this mode is more...

Subtle: The policy staff are so close to the decision-making center that they do not have to be asked to justify decisions already made; they formulate policies which anticipate the preferences of the decision-makers.

Transitional mode [tentative]: decision analysis modification(s) proposed adjusted analysis. All these modes have in common the typical professional qualifications and the ad hoc status of the policy advisers. Most frequently, they are either data generators (scientific or technological experts) or economists with macro-orientation and/or economic backgrounds.

The proper place and function of economists in policy R&D would require a separate extensive discussion. The role of scientists as policy advisors has often been a variant of mode III; policy advice (in the vague current sense) is requested but comes in a form that is not usable. This variant can be schematized as follows:

III. Variant: The aborted "policy-making" Non-government "Let's call on scientific experts" experts.

Mass of information, not processed, scientific decision-making & policy input.

Comments: The preceding discussion of the current "policy-making" modes has only the purpose of better defining and contrasting the full-fledged policy process which is the focus of the remaining portion of this paper. No effort will be therefore made to even sample the mass of available illustrations--local, national, and international. But these various modes and their combinations figure implicitly in the later appraisal of the difficulties with and obstacles to policy R&D (pages 26-29).

Two comments appear necessary and useful before turning to the policy R&D model:

(4) The term "intuitive," as used above, is well defined by a statement ascribed to President Carter: "Once the details of a subject are mastered...decisions come naturally." (20, Aug. 1976, 210). The experience summarized later: "The more [Carter] studies, the more it becomes apparent not...

"Not only is each problem difficult, but each is also connected to other problems" (i2, 5 Feb. 1979, 11). The opposite of plain intuition in the field of social policy is not econometric decision-making; rather, it is the educated intuitive selection of policy options developed through a rational, systematic process (including electronic data processing where possible and indicated) from all available and relevant information.

13. Any decision to develop and/or apply new technology requires an assessment of the full social and environmental costs and benefits. Only simple and straightforward technical problems belong in the currently predominant category of decisions made directly on the basis of engineering data and economic cost (29). (44)

Most important for analytical purposes is the "aborted" variant. Even in the form of the schema, the process is not always entirely negative. Although the decision maker may not have received the policy guidance they sought, they retire from the encounter with a possibly more profound sense of just how complex the problem is and what uncertainties it involves. This may improve the decision by making it more careful and/or extending its time horizon.

However, the gap between the data generators and decision makers remains as wide as ever. This fact has been the subject of several philosophical expositions. Better known among these are the 'theses of the "two cultures" (12) or two "disciplines" - science and law (8), each with fundamentally different mindsets. Despite valid examples and arguments, this is a two-dimensional analysis, a syllogism without a middle term.

"Scientists," in the broadest sense, are trained to gather and analyze data and to contribute to their technical application. Politicians and bureaucrats (many of them indeed trained in law) are by nature and circumstances single-decision makers, not policy makers. No amount of incidental, ad hoc extrapolation of the

The talents and experience of either the data or the decision group directed towards the policy center can close the gap between them. If it is concluded that the direct input of scientific data into specific decisions does not work very well (e.g., 421 30 4), it is like saying that it is difficult (and at times impossible) to cross a river without a bridge. This missing bridge, "middle term" or, even better, the necessary third dimension, is the distinct, specialized social technology termed policy R&D.

3. Policy R&D: The "organic" mode

If a label were to be put on policy R&D, as it was on the various current modes, it would be "organic." The relevant definitions of "organic" are "made up of systematically interrelated parts"; "similar in its complexity and organization to living organisms." In the current terminology of policy and management sciences, we would speak of "operational systems" instead of organisms, and of "systemic" rather than systematic relationships.

The policy R&D mode was already reduced to a schema on page 8. A more complete graphic presentation is Figure 3 on the opposite page. This figure is, in turn, tied in with Figure 4. The emphasis in both figures, as well as in the accompanying discussion, is on the process of developing policy options (the area enclosed by the full line) rather than on the always changing substance of the options (the area enclosed by the broken line).

An example of the progression from policy options [various energy conservation scenarios] through the decision [specific fuel economy targets and measures to achieve them] to implementation, is outlined in Figure 2 on pages 6-7.

Planning is incorporated in Figure 3 in its proper PPB [planning, programming, budgeting] function. This kind of planning elaborates the selected policy for the purpose of implementing it. It is therefore termed microplanning and is distinguished from the evidently different level of strategic planning on the policy level (macroplanning). The latter could also be described by the

The current term is "policy planning." However, this term is not ideal. It is vague and does not distinguish between various planning levels. Policy R&D, at first glance, is fundamentally different from modes I and II. The overpowering decisional factor in both is the political aspect, supported, where indicated, by straight economic cost-benefit analysis. In the era of mass media, it is also important to consider how a particular decision will appear or can be presented. Policy R&D is similar to mode III in that the initial decision to address a perceived problem is followed by an initiation of a policy analysis. From this point on, the two modes differ substantially. Even in the most favorable instance of mode III, where the policy analysis is competent and leads to a significantly better decision than would otherwise have been the case, the practice is ad hoc. Therefore, it is by definition, sectoral and fragmented. For the same reasons, it is not conducive to the institutionalization and progressive development of a full-fledged policy process. In the worst case, the result is an accumulation of information with no policy value. This has been the history of the bulk of the environmental impact statements, which are nothing more than legally mandated policy-like evaluations of prior tentative decisions to undertake an activity subject to impact assessment—a prototype of mode III.

4. Typical steps in policy R&D
a) Comments on Figure 4

Figure 4 on the opposite page elaborates the framed-in portions of Figure 3 by breaking the process into steps and sequences. Although most of this particular schematization (as far down the middle column as "Policy baseline(s)") reflects the specific application in TEC/FR, it follows a kind of algorithm—a necessary one.

Sequence of steps from problem to solution, considered to be adaptable and applicable to policy R&D in general. Due to the self-explanatory nature of Figure 4, only the purpose of the key steps, and the components 'Data' and 'Policy Model' are further elaborated below.

b) Purpose of key steps

The following list summarizes some points already discussed above in a form intended to supplement Figure 4 in the perspective of purpose, which is:

i) Put together all the available data

ii) Raise questions about the first definition of the problem, goal(s), means, and approach(es)

iii) Indicate broader systemic relations

iv) Stimulate and guide the redefinition of the elements in step i above, and the generation of needed additional information.

v) Analyze the now more complete data base and develop an integrated problem model

vi) Transform it into a preliminary policy model ("policy baselines") by expressing in the form of possible bases for decision

vii) Revise, supplement, and elaborate the preliminary model into a policy model--further discussed below in section 5

viii) Provide the decision maker with a complete, evaluated and projected base for his task. Reduce thereby the purely intuitive component in decision making and the chance of wrong, irreversible or counterproductive decisions.

Figure 4. Typical steps and sequence in policy R&D

The key steps and terms in Figure 4 and the accompanying text, supplemented by other current terminology, can be simply tabulated as follows:

—> Problem perception, problem definition, and key questions need to be considered in policy/decision-making. A well-planned strategy is crucial, as exemplified by the list on page 16. Three important features of policy R&D stand out:

1. Emphasis on system synthesis - items (iii) to (v). This is most evident in the theory and practice of system analysis, mentioned on page 1. For example, conventional U.S. regulations for oil and gas exploration on the outer continental shelf consist of 1300 pages of descriptive scientific and engineering data and 30 pages discussing social and environmental impacts. The new regulations from the U.S. Council on Environmental Quality (47, November 1978) aim to correct this imbalance, shifting from data processing to policy processing.

2. Optimal techno-economic means - items (ii) to (iv). An example can be found in the policy analysis of plans for rapid transit in San Juan. The policy approach is summarized as follows: "Planning any transportation system is not primarily a techno-economic problem, but a complex, interrelated process of decision-making about the allocation and management of human, energy, environmental, and economic resources. The policy analysis here aims to supplement the technical submodel for the San Juan transit with considerations derived from the broader social model."

In this context, the scattered pieces seem to come together enough to enable a threshold decision. The ball is then back in the technical planners' court - item (iv) in the list above (9, i, iv: reproduced in 19, Append.A).

3. Completed item (vi). The first step in decision-making is to determine whether and how to proceed toward an elaborated policy model; this often already suggests the direction for necessary actions.

Preferable decisions. For example, the policy baselines summarized above on page 4 suggest the direction for a number of first-order decisions about the system, as well as specific approaches to TEC. The San Juan transit analysis provided the basis for an alternative approach (light rail), which is more feasible on account of energy, economic cost, and human-environmental considerations.

4) More on data. Several additional comments on the component 'Data' appear to be convenient:

(4) Content. The discussion up to this point should be sufficient to support the proposition that the content of the data, in terms of substance and field of knowledge as determined by the problem, does not affect the applicability of the policy RAD matrix. Policies with regard to 'Data/Problem' pairs as different as those listed at random below are susceptible to being developed with the help of this methodology. Some have, in fact, been so analyzed and developed, at least in part.

Data Problem:
- Scientific Ecological: Wetlands management
- Chemical: Crude oil spill prevention
- Meteorological: Coal conversion impact
- Technological: Energy use optimization
- Economic social: Population/Resources (Human ecosystems)
- Employment training/retraining

This small sample also indicates the inevitable multidisciplinary input in practically any problem/policy analysis. Major problems may require all the listed and additional classes of data.

20 (34) Categories (type of input). The multidisciplinary input in terms of content is typically matched by the variety of the types of data needed and available. One of the major obstacles in the way of development and application of policy analysis has been the erroneous, pseudoscientific premise that only numerical data are useful and legitimate. Quantified data can be manipulated with the help of mathematical forms and electronically processed. This permits attractive exercises in projection and simulation. Alternative parameters and approaches to solution can be explored. But that does not necessarily...

Produce reliable predictions, even in situations where most of the data are measurable and interact within a relatively controllable framework. Thus, for example, it was concluded with regard to the transportation system management in the central business district in Singapore that "long-run measurements in quantitative terms are probably unrealistic" and more subjective methods should be used (36, 187). Some of the world's best planners participated in this project.

An even more significant defect of the "quantification syndrome" (36; 32) or "numerical-mathematical fetishism" (31) is the narrow data base, which excludes most of the all-important information on social and institutional behavior--values, perceptions, probability of acceptance, capability to implement, etc. Another disadvantage was summarized in an evaluation of 18 regional environmental management projects sponsored by the U.S. National Science Foundation: "Most projects invested heavily in data/information systems to support model development and use. Many of these models require large data sets in new applications, which will be a limiting factor in their use" (33,441).

The other side of the coin is the fact that much information available has not been used. The reason is often political: the objective data contradict preconceived decisional preferences. At least equally important is the fact that the art of transforming various types of raw data into policy data has not been sufficiently developed and widely applied. As Figure 4 shows in a schematized form, this process often requires interpolation and adaptation of data from other places and systems, extrapolation and imaginative enhancement of data fragments, and similar techniques. Much information comes in a neutral statistical or narrative format. Only as the problem and the policy questions are being defined does this data acquire meaning and begin to fall in place.

The situation can be summed up under three rubrics: Precision vs synthesis. There is a fundamental

Difference between scientific/technical data on the one hand, and policy/decisional data on the other. The former are judged by their precision and predictive powers, the latter by their value for the purpose of the best overall problem solution. Paradoxically, for all their exactness and format, scientific data are mostly only raw material for decision making. Moreover, decisions must and will be made with whatever data and understanding are available. Although the central place of policy synthesis in the search for best overall solutions was recognized early (e.g., the call for "specialists in generalizing," 20, 10,125t.), it has been recognized more widely only in recent years that sound decisions must be made even when "all the data" are not in or when they are "fuzzy," and what the power of policy synthesis is to produce feasible options under these conditions. The "fudge factor," the bane of technicians, has a legitimate place in policy R&D if it is used with professional judgment and explicitly acknowledged.

Hard data: These are numerical, quantified, classified, systematic data of a type that is compatible with mathematical modeling and electronic data processing. Where such data exist, they must be used to the extent they are relevant to the problem definition and solving. In the kind of problem situations to which this paper addresses itself, as well as in similar situations of social decision making, the hard data or quantified models will at best represent an input (submodel) in the policy model. To state the obvious, hard data are not limited to science and technology or to statistics. For example, the organogram of a government that provides information as to what agencies are related, and how, to the particular policy problem, decision and implementation, is a hard input into the development and evaluation of policy recommendations on that problem.

Soft data: Soft data are all those that are not hard. In socially-oriented policy R&D that appears to be the great majority of information. Some

The current types of soft data have been described as "gross, generalized, order-of-magnitude data, trend data, interpolated, impressionistic, estimated, random, 'fuzzy,' etc." The related concerns in the policy use of such data are about the degree of evaluation, the degree of reliability, the "confidence coefficient," and similar standards.

22. RAD, which proceeds within a mandatory legal/normative framework, or which prepares the way for a change in law or regulation, encounters a particular combination of hard and soft data. The letter of the law is hard; the interpretation, precedent, and practice are softer than it is generally realized and admitted.

(11) Political/institutional data

Except for what was stated about law and institutions above, these data are soft and are a necessary input into any policy RAD which is expected to lead to a public decision and its implementation. Policy analysis and recommendations cannot be realistic if the willingness and capability of the government to decide and to execute the decisions are not taken into account along with other data. This input is fundamentally different from mode II (page 12, note), it must also be distinguished from the political/executive process of selecting among objectively elaborated policy options or recommendations.

The situation can be illustrated by a contemporary event, the Kemeny commission investigating the Three Mile Island nuclear accident. The political and administrative decision making was represented here by the President and the Nuclear Regulatory Commission respectively. An apparent effort to practice mode II was the President's statement that he would accept the panel's recommendations "if they are at all practical," with added specifications as to what might be "impractical." The objectively-oriented policy process was represented (a) by the response of the commission that the President's statement had "absolutely no impact" on its work and that he will be free to accept or reject the recommendations.

"Once they are made," and (b) by the rebuff to NRC for planning to resume the issuing of licenses before the recommendations are delivered--they may affect the present standards and procedures. A prominent editorial concluded that the attitude of the Kennedy commission suggests that it will produce a truly independent evaluation (3, 26 Aug. 1979).

4. Public perception as a policy datum

5. Policy modeling

a) Definition and distinctions

A policy model is a systemic arrangement of policy data in such a form as to indicate possible solution(s) and project/evaluate the (relative) cost/benefit ratio(s). An evaluated option or recommendation for decision making has the qualities of a vector in the mathematical sense of a quantity with a direction, and in the navigational sense of a (recommended) course to follow. Thus, it can be said that the policy model indicates decisional vectors. As distinguished from the raw data and quantified

Submodels, the decisional options/vectors need to be expressed in terms on which decision makers can fully understand and act upon. The complete process of policy RAD involves two kinds of transformations: first, the "conversion" of the data input into policy data; second, the translation of the policy model into a "readout" in the language of political, legislative, and administrative decision making and execution. The "data pollution" and the "quantification syndrome" have led to the erroneous notion that most models are mathematical, and that only such modeling is a worthy undertaking. In fact, modeling is primarily a conceptual process. It starts when data are being organized and gaps are identified as the problem is defined in the policy perspective. Therefore, even if the eventual model is fully quantified, its preliminaries are conceptual. In a controlling study of environmental simulation modeling for decision-making purposes (40), model development was

described as a "sequential, iterative process...from simple, relatively crude conceptual models to increasingly refined [quantified] products" in terms of state selection, theory enrichment, and validation procedures.

In the present and foreseeable state of the art, mathematical models can be constructed and applied with regard to such issues as specific energy demand, localized air pollution, vehicular traffic patterns, and the like. Almost inevitably, they "tend to treat the components of the... system separately. Therefore, essential interactions of the system may be ignored" (40, IV-48). This reason, as well as the demonstrated need for extensive reference to soft data in any social decision-making about resource use and allocation, limits the role of mathematical models without reducing their importance. Much of the apparent confusion about the role and value of the hard vs. soft data and models stems from the lack of a clear distinction, already suggested in the preceding discussion of the data base: Mathematical models (including their...

Economic and sociometric forms correspond to the scientific goals of precision and prediction. Policy modeling should obviously incorporate all the available predictive data, but its real purpose is synthesis for decision making. It would be ideal, indeed, if decisional models could be accurate predictive models, such as a judicial process by computers.

Elements of Policy Development:
This event is about as probable as the replacement of any major social policy model. Any model is likely to be developed with reference to the appropriate selection and combination of the following elements:

1. Goals: What is the preferable response/solution?
2. Type
3. Substance
4. Short-term considerations
5. Alternative futures
6. Performance modes
7. Systemic considerations: Opportunities/Limitations
8. Resource availability
9. Environmental impact
10. Community values
11. Political constraints
12. Other specific constraints
13. Other lack of means
14. Human resources
15. Natural resources
16. Technology
17. Economic and Social organization
18. Indices/Scale
19. Time/space frames
20. Alternatives
21. Priorities
22. Trade-offs
23. Socio-economic accounts

24. Quality of life index
25. Cost/benefit analysis

Continuation:

26. What are the possibilities?
27. What appears to be most possible?
28. What appears to be most favorable?
29. Why was a particular option selected, ranked first, recommended?
30. Effectiveness of response/solution
31. Comparison with other possibilities
32. Nature and evaluation of trade-offs
33. Impact assessment ("side effects")
34. Cost feasibility
35. Acceptability
36. Adaptability to future changes in variables

Risk Assessment:
It is important to point out separately, and thus to emphasize, that the two major techniques of risk evaluation--technology assessment and environmental impact assessment--are in fact specific applications of policy RAD. In the area of environmental impact, the policy orientation implicit in the U.S. National Environmental Policy Act of 1969 was not the predominant feature of practice and had to be reemphasized through new regulations in 1978 (as already discussed on page 18). With regard to technology

Assessment: The inherent policy R&D nature of risk analysis for decision making can be highlighted with the help of a few short comments.

Data: Risk assessment is a type of policy analysis which requires a particular emphasis on obtaining as complete quantified data as possible. An increase in objective data reduces the area where subjective opinion, impressionism, and emotionalism, often associated with risk issues, can originate. However, public perception, social, and cultural values are also important data inputs.

Policy Process: As with other areas, scientific and technical data by themselves are not a sufficient basis for decision making. They need to be transformed into policy options, evaluated, projected, and arranged in terms of the anticipated risks and possible trade-offs, and expressed in decisional terms. In addition to the objective difficulties inherent in this process, high-risk issues have been complicated by the fact that scientists and technologists have assumed roles of competitors, advocates, or even representatives of vested interest.

A proposed solution - the "Science Court", which was much debated in 1975-76, is an additional piece of evidence about the philosophical and analytical distance between the world of objective information and the needs of social decision making. Even if adversary proceedings (recalling medieval public disputations between theologians) could determine that one set of data or technological recommendations is more correct than another - for example, radwaste should be encapsulated in glass rather than in ceramic - sound public decision making would still require that the technological option and risk assessment be coordinated with numerous other factors and

considerations, such as logistics, timing, regulations, monitoring, protection, and enforcement, costs, etc. In other words, no matter how dominant and reliable the scientific and technological data are in the stage of risk assessment, the policy process still needs to intervene to ensure proper implementation.

Prepare the ground for the final political decision. Role of uncertainty. The most important "end-use" orientation of Policy R&D is toward enabling sound decisions under conditions of uncertainty. This role is particularly crucial in the area of risk assessment. No degree of competence and conscientiousness in the technical analysis is likely to eliminate—rather than to define more precisely—the inherent uncertainties. Thus, the role of decisional intuition becomes much greater, and there's a need for policy synthesis to make it educated.

SOME IMPLICATIONS FOR PRACTICE:

1. Preconditions:
a) Understanding of the nature and mission of policy R&D: The purpose of this paper is to enhance the understanding of policy R&D with a view to its effective practical application. The preceding discussion of the nature and mission of policy R&D can be summarized in a few simple points:
(4) Despite the necessary technical analysis, policy R&D is simply a particular form of rational problem-solving. It responds specifically to the nature of social problems involving or affecting environmental resources, and to the characteristics and needs of the related decision-making.
(Ai) Scientific and technological data are not decisional data. By themselves, they are usually not sufficient even to define the whole problem. This fact has been recognized in the form of technology assessment, i.e., the evaluation of what is likely to be the social impact of the engineering application (in the broadest sense, from mechanics to genetics) of a scientific discovery.
(441) The effective use of scientific and technological information for decision-making typically requires that these data be complemented by social data (again in the broadest sense). This multidisciplinary database needs to be selectively generalized and set into its system context. Then, it needs to be transformed into policy data (elements of a policy model), and finally, it should be expressed in terms of political, legal, and/or administrative decision-making.

Making and execution. (iv) Policy R&D is defined as this progression from the definition of "the problem or issue" (a planning idea, a possible new technology, a new use of a resource for economic purposes, etc.), through the identification of the data needed for policy development, to the statement of the evaluated options or recommendations for decision making. (v) Policy R&D expressly recognizes that social decision making normally takes place under conditions of uncertainty about data, projections, and broader systemic implications. The ultimate mission of the methodology is to make decision making under these conditions as rational and sound as possible.
b) Identification of some major obstacles (1) Lack of understanding of the fundamental difference between the "raw" basic data and the policy/decisional data, and of the consequent need to practice organized policy analysis ("conversion") so as to make the data input useful for the purpose of the decisional output. (2) Failure to recognize the separate and special nature of the policy process, which no outreach by the scientist/technician and the decision maker toward the "policy making" center can substitute. This is the source of the assumption that the social policy dimension will be added automatically if "a sociologist and economist" join the team of natural scientists and resource managers, or it produces merely conditional recommendations. More

extreme is the flat statement of the "fact that the tools to do the [policy] analysis required by the environmental impact statement concept are not available" (Letter, S.K.Fairfax, Science 202, 8 Dec. 1978, 1040). Contrast 21).

(3) No matter in which particular discipline he was originally trained, the successful practitioner of policy R&D will be above all a specialist in generalization. But the prevailing

Scientific and professional ethos does not favor generalists (52). Voices that emphasize the need for interdisciplinary synthesis of existing knowledge to help solve a social problem or advance knowledge about a new issue" (39, 26 March 1977, p. 205, quoting S. K. Schneider, climate and food research scientist) and compare it in importance to the generation of new disciplinary knowledge, are recent and rare. (iv) Much "policy making" is performed by administrators or advisers who are trained economists or planners. However, current economic and planning theories and methods are not directly convertible to policy R&D as it is discussed here; they are only very important disciplinary inputs. The undiscriminating identification of micro-planning with policy R&D (macro-planning) has resulted in documents in which policy rhetoric substitutes substance. (v) A lack of articulate understanding of the nature and mission of Policy R&D may result in counterproductive overreach, "telling the decision makers what to do" instead of "concentrating more on the facts [the transformation of facts into policy data] and couching pronouncements [presentation and justification of options and recommendations] in a more neutral language" (34, 20 Feb. 1977, Sec. 3). (vi) Institutional fragmentation, both internal and interagency. This general nature of public government, coupled with the complexity of major problems/issues and the recognized difficulty of objective policy analysis, have generated a host of proposals for better integrated (that is centralized) policy development and review, and also some experiments. For examples: An early proposal for a governor's policy council on human and natural resources (20, 1978). A national environmental policy institute, officially and financially independent (1971). A recent plea by the Federation of American Scientists for a full-time independent professional organization to "work on complex issues" (3, vol. 2030597996). The

On-again-off-again President's science adviser, now heading the Office of Science and Technology Policy. Both in name and facts, this is a sectoral policy gone.

29 But the structure of bureaucracy and the established lines of command inside the agencies, as well as on the cabinet level, do not favor an effective interposition of policy review and integration. The failed effort to do this in the Department of Defense (1977-78) appears to be a classic scenario--even if personality factors need to be considered alongside conceptual and institutional constraints.

The failure, limited success, or demise of the various attempts to institutionalize policy R&D point to the ultimate and probably most important obstacle--the conflict between the rational thrust of objective policy analysis and the prevailing conceptions of political and bureaucratic decision making. This conflict is particularly sharp in areas such as those to which this paper addresses itself. Energy, environmental and transportation issues have massive social implications; therefore they become "political" issues. Moreover, major regulatory agencies which perform important policy development tend to identify with the special interests over which they have jurisdictions and they also control the base data. They can "narrow the definition of the problem to match the narrowness

of [their] own capability" (38, vol. 202[1979]949, on smog standards setting) or their perception of the interests involved.

One aspect of the inherent conflict discussed in the preceding paragraph deserves a separate mention. It is of the nature of genuine policy analysis that it reaches comprehensive and even radical conclusion. It is of the nature of public government that its decisions are disconnected and incremental (except, of course, for sweeping but oversimplified approaches--the Puerto Rican "Operation Bootstrap" is the closest example at hand--the longer-term results of which are often even worse). The principal

The main difficulty in policy R&D implications does not lie in the analysis or justification, but rather in the effective application of its methods. Four considerations emerge from the preceding discussion.

Policy R&D is understood as a methodological dimension of decision-making. This concept traces back to the initial depiction of policy R&D as a type of applied social system analysis. It is also viewed as a specific form of rational problem-solving. An approach can be practiced without being institutionalized, enabling it to blend more easily with the predominant modes of policy formation and the governmental modus operandi.

Experience has shown that institutionalizing policy R&D in the form of a specific office does not guarantee the quality or permanence of policy analysis. Therefore, policy R&D must be integrated into the decision-making process from the very beginning. The "beginning" is when a problem is first perceived, or when technical data are collected and examined within the context of a public issue or application.

Policy R&D is not fully effective when it operates outside the decision-making process and merely attempts to "transfer policy research results" into it. If a policy analyst is consulted in the later stages of the decision-making process, they face two possibilities: either they redefine the problem and system relations, causing the process to revert to "square one" and likely being viewed as a nuisance and a spoiler by other parties; or they conform and merely add to the preconceived decision the rhetoric and aura of policy respectability.

Decision-makers must understand and therefore desire policy R&D. Despite recurring expressions of doubt (e.g., "NEPA authors erred by assuming that environmental decision-making by federal agencies is rational or can be; S.K.Pairfax, quoted on page 27), it is permissible and necessary to assume that if the decision-makers come to understand

The multiple optimizing effects of policy R&D act as the transmission belt between data and decision-making. Despite their undiminished, and perhaps unfortunate, power to select the least favorable alternative solution, even in the face of fully analyzed and projected better alternatives, they will want policy R&D to become a standard operational procedure. Policy R&D needs to be recognized as a discrete professional "specialty in generalization," not a mere ad hoc extrapolation of such disciplines as economics, planning, social sciences, management, or information processing. The task of multidisciplinary synthesis and conversion for social applications deserves to be regarded as equally important as, if not more important than, the generation of new knowledge.

Notes:

1. My source on this is B.S. Quade (then RAND, now ITASA), sometime in 1969-70.

2. Historical as well as contemporary illustrations of the "policy paralysis of the nation" (N.Y. Times, 8 July 1979, sec. 4) abound. President Carter concluded that "the American people...feel their own government can't deal adequately with crucial issues" (press conference, cited in U.S. News & World Report, 31 June 1979, p. 17). With regard to the issue of energy, outgoing Secretary Schlesinger confirmed that (more than two years after the 1977 energy message) the United States had no energy policy (in the comprehensive sense). See the apposite summary from a critique of the limited planning related to rapid transit in San Juan, on page 25, below. The reductionist analysis is still apparent, at least with regard to the evaluation of light-rail transit, in a 1977 congressional study. The link-up between transportation and environmental planning (air quality) appears in DOI/EPA guidelines. It is not surprising that the initiative for such a cross-agency effort came from the President. There is no other specific point in the system where policy integration could originate, unless mandated by the enabling congressional legislation. The Council on...

Environmental Quality is, of course, a part of the executive system of the President. A project titled "Alternative Scenarios for Transportation Energy Conservation in Puerto Rico, 1980-85" is scheduled for FY 1980. It will seek to "transform the basic policy analysis of the TEC/PR study into a set of concrete, quantified scenarios, elaborated in the following dimensions: TEC targets / Time frames and sequences / Alternative combinations of (i) the indicated public government measures, (ii) possible or anticipated technical, modal and institutional innovations." The composite figure on pages 6-7 above represents a first conceptual matrix for the purpose of structuring the scenarios, and some gross but comparative base data with which to begin the setting of quantified fuel economy targets. Also see the warning by P. Handler, President of the U.S. National Academy of Sciences: "Don't use science and technology as though they were one word." Science 205(1979)283. For example, to use current Puerto Rican policy documents and to focus on transportation, (i) while transportation in and access to the coastal zone is one of the crucial management factors, the state CZM plan (1978) contains the obligatory chapter on transportation, but it lacks any substantive policy content; there has also been no apparent coordination with the highway building program of another government department. (ii) A simultaneous "Plan for Integral Development" (Planning Board, 1978) limits itself to advocating further highway building (the still predominant public policy, affected also by the availability of federal funds, although Puerto Rico has one of the densest road networks in the world); it makes no mention of the ongoing planning for a rail transit. The "Plan" also illustrates another characteristic of modern documents: the tacit use of policy vocabulary without evidence of the corresponding analytical "deep structure".

32. To cite just one instance: When the pesticide division of the U.S. Environmental

The Protection Agency was formed when the U.S. Department of Agriculture transferred its data "bank" to it. This bank consisted of one million documents, among them 300,000 toxicological studies. However, the material was not indexed. It took two years to organize and there were tremendous gaps (Science 202(1978)600). Just how widespread the weakness of theory and analysis is, not only in matters pertaining to policy R&D, can be illustrated from a completely different field. A review of "Ecological and sociological studies of Gelada baboons" speaks of "a

mass of descriptive information and no theoretical framework within which to order the quantitative data that is presented" (Science 203(1979)741).

The approach of the electronic data processors to "data pollution" is described as "computer mapping". It aims to provide more information with fewer data by illustrating the "relationships among massive amounts of data...that become apparent only as they are seen" (Prospectus of the Center for Management Research and the Laboratory for Computer Graphics and Spatial Analysis, Harvard University, 1979). It is this kind of narrow-scope planning in a social vacuum that is being referred to when it is stated that "interest and confidence generally in long-range transportation planning has declined" (48, 37).

There is a close and unsurprising analogy between this approach and the narrow economic cost/benefit calculation of resource use ("internal" cost), as distinguished from "external" cost--exhaustion and deterioration of resources, public health impacts, lowering of the quality of life and environment, etc. This was already emphasized by a UNESCO conference in 1968 (43).

These are some representative references: (i) "Lack of data is not an insurmountable obstacle...When data are lacking, even the crudest observation will often yield viable results...A small amount of data is sufficient" (2, 653,56); (ii) "Where empirical data is missing, extrapolation of [available] data...based on sound engineering judgment is possible."

Here commented, G2: "The use of new concepts that recognize data limitations and promote decision making with fuzzy information" should be encouraged (33, iv). A practical advice from a totally different field is apposite: a successful stock analyst prefers to be "vaguely right" rather than "precisely wrong" (Forbes, 1 March 1977, p. 75). This is also an example of the conflict of special interests noted earlier in the text: the advocates of these particular solutions to the problem of solidification and subterranean disposal of radioactive wastes have had long-standing and well-funded research programs in the respective areas they promote as the best solution. This includes by definition monitoring data and relevant past experience, except in Figure 3, feedback loops to the data base are omitted for the sake of graphic simplicity.

Herbert Simon, the recipient of the 1978 Nobel Prize in economics, distinguished himself since the mid-1950s by debunking conventional notions, such as that of "rational choice"; the presumption of knowledge by the decision makers of the alternatives and their consequences; and the assumption that decision makers "optimized" decisions, rather than choosing the first solution that was "good enough." Simon's analysis was along lines compatible with the operational premises of policy RAD. See the review article by J.G. March, 38, vol. 20, 1978, p. 858.

Another example of the lag of economic theory as a contributory discipline to policy RAD can be found in the crucial area of cost/benefit evaluation, principally with reference to the difficult-to-quantify, but nonetheless essential external (social, environmental) costs of economic activities.

The language of this report on the criticism of, and response by, the Congressional Budget Office reveals a vague understanding of the conceptual structure, as pointed out by the added comments in brackets. In such a crucial area as energy policy, the government has had.

The text largely relies on data supplied by the petroleum industry.

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