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SERI/TR-53-081

A METHOD TO ASSESS AND AGGREGATE THE EFFECTS OF SOLAR TECHNOLOGY DEPLOYMENT ON SOCIAL AND ECOLOGICAL SYSTEMS

October 1978

by:

James M. Ohi*

*The views, opinions, and interpretations expressed in this paper are solely those of the author and do not reflect any policy, position, or view of the Solar Energy Research Institute.

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A Division of Midwest Research Institute

Prepared for the
U.S. Department of Energy
Division of Solar Technology
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PREFACE

This paper was prepared in compliance with Contract Number EG-77-C-01-4042 for the U.S. Department of Energy. The paper was prepared as part of a larger task to assess the economic and social costs and benefits of solar energy technologies. The assessment and aggregation method presented in the paper should be read in conjunction with other parts of the overall task and with the objectives set forth in the research task plan.

I would like to thank the many people who helped me prepare this paper. Task team leader, Bob Odland, and team members Kathryn Lawrence, Peter Pollock, and Bruce Green provided valuable review and discussion about the approach and scope of the paper. Lucille Black, Barbara Farhar, Lewis Perelman, and Michael D. Yokell are other SERI staff members who critiqued earlier drafts, and some of the rough places which undoubtedly remain would be much more noticeable had it not been for their help. I would especially like to thank Charles D. Unseld, staff social scientist at SERI, who helped to guide me through the arduous paths of SIAM, that is, social impact assessment methodology. Murrey D. Goldberg, also of SERI, helped me obtain needed documents which facilitated research. Finally, I would like to acknowledge the assistance of many staff members at U.S. Forest Service and Bureau of Land Management offices in many parts of the country who sent me documents, maps, and reports which were valuable source material for this paper. In thanking all of these people, I do not wish to indulge their generosity by having them share any of the shortcomings of this paper, all of which remain the sole property of the author.

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ABSTRACT

This paper presents a method to assess and aggregate the effects of solar technology deployment on social and ecological systems. Although the general approach upon which the method is based can be applied to study the impacts of technology deployment upon any environment of interest, the paper is addressed to solar energy technology deployment within the contiguous 48 states of the country.

The method is based on a "bottom-up" approach to technology assessment and proceeds on the assumption that energy technologies must have a proper fit with the ecological and social system within which the technologies are to function. If technology is to "fit in," both the intervenor and the host must be measured in parameters, or indicators, which will reveal potential harmonies and disharmonies. Part II of this paper, the interaction component of the method, proposes that this measurement of fit proceed through an analysis of the interaction between the selected indicators. Part III of the paper outlines a procedure to aggregate the impacts identified under the preceeding part of the method so that "indirect" and cumulative impacts can be assessed.

The second major purpose of the paper is to present a procedure to regionalize the potential impacts of technology deployment so that a bottom-up approach may contribute to the formulation of national energy policy. This procedure is set out in Part IV of the paper and is based on the use of "ecoregions" and "county-type" as units of aggregation.

Part I
INTRODUCTION

As we enter the second half of the first decade of our "energy crisis," we find the simplistic notion of "energy independence" gradually being displaced by an understanding of the complex dependencies that tie energy supply and use to our economy, social structures, and ecological processes. John P. Holdren (1978, p. 1) points out that the environmental, social, and economic costs of energy options, not resource limits, actually define the nation's long-term energy dilemma. Similarily, the U.S. Department of Energy (DOE) (1978b, p. ix), referring to a study of advanced energy technology deployment in California, also concludes that ". . . problems of environmental, social and institutional acceptability . . . more than strictly technical feasibility may provide the most difficult issues of transition . . ." to the use of indigenous, sustainable energy resources in that state.

The purpose of this paper is to present a method which provides for a comprehensive accounting of the environmental, social, and institutional problems which may be caused by the widespread deployment of solar energy technologies. Although the impacts of solar energy technologies are expected to be "benign," particularly in comparison to those of technologies based on fossil and nuclear fuels, these expectations are based more on credo than on credence. Without exception, the potential impacts of any new energy technology must be assessed in a comprehensive manner before deployment takes place on a large scale. While detailed, inclusive analysis must be site-specific, decisions on the kind and extent of technology deployment must be based on a regional, if not a national, level of assessment. One method to link local site assessment to national policy formulation is presented in this paper.

A. APPROACH

The short but litigious history of environmental assessment activity in our country illustrates the evolution of the environmental impact statement (EIS) process from perfunctory project justification, to exhaustive but very particularized project analysis, to inclusive, policy and direction-setting assessment keyed to land and natural resource management responsibilities. Examples of the last are "programmatic" statements covering a single activity of an agency, "overview" statements covering the major activities of an agency within a geographical region, and statements which incorporate the EIS into an agency's resource and land management planning activities.* Although these more inclusive efforts have generally failed to assess adequately the cumulative effects of program and project impacts, they indicate an increasing awareness on the part of federal agencies that the essential questions for environmental impact assessment are those that deal with interactions and interrelationships and that the details of the site-specific analysis must be related to a larger context of policy and management objectives.

As environmental impact assessment becomes an integral part of a planning and management process and as increasing attention is devoted to the intricate interrelationships inherent in natural and social systems, one discovers more and more affinities with technology assessment and ecological analysis. Technology assessment, which predates the enactment of the National Environmental Policy Act (NEPA) by several years (Hetman 1973, p. 54), emphasizes the need to critique alternative technologies and technological futures and also brings a welcomed focus on social impact assessment for the purpose of assisting the decision-making process. Ecological analysis, on the other hand, places emphasis on the interrelationships and dependencies between habitat and inhabitant and helps to establish the natural limits and boundaries within which technology can be applied for societal benefts. Recent literature points to a continued integration of natural and social sciences toward improved methods to assess the effects of the interventions of

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*For EIS "histories," see Curlin (1975), Lynch (1975), Heyman (1974), Heer and Hagerty (1977, pp. 73-97), and Llewellyn and Peiser (1973). Examples of these synthesizing efforts include EISs concerning the Bureau of Land Management's (BLM) coal leasing program, EPA's basin-wide water quality management planning and construction grant program ("208" and "201"), and the Forest Service's Unit Management Plans. For a discussion of BLM's efforts to incorporate social and economic concerns into its land use planning program, see Frankel (1978).

man and technology upon our natural and social systems.* The method presented in this paper attempts a synthesis of those features of environmental impact assessment, technology assessment, and ecological analysis that are germane to a comprehensive accounting and evaluation of the social, economic, and environmental consequences of widespread solar technology deployment.

Although environmental assessment has for the most part shed its project justification mantle, there is still a substrate notion that environmental considerations are supplementary, something for which room must be made after more essential matters have been accounted for. This notion is evident in "energy scenario" assessment in which pollution, resource depletion, and social disruption, unfortunately termed "residuals," are studied as consequences of meeting our energy needs at various levels of appetite. Perhaps this perspective is too deeply ingrained in our habit of mind to be changed after 300 years of exploiting our resources with little regard for the healing and assimilative capacities of ecological processes. The enactment of NEPA, though an extraordinary event in our legislative history, did little to alter the environment-as-residual perspective. As our country gropes its way out of the age of oil, there is an opportunity to achieve the state of "productive harmony" between human beings and nature envisioned in NEPA, for the use of energy is pervasive and "strategically central to our way of life" and, if we can get our energy policy on the right track, policy in other areas will tend to fall into place.** The answers that we provide to questions of how much and what kind of energy technology to develop and when and where to deploy them, will determine whether we re-establish or sever completely a harmonious tie between people and nature.

The method presented in this paper seeks to provide a continuous path between site analysis and energy policy formulation. Such a path must begin at the site, and its tack must respect the limits set by the ecological and social

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*For examples see Boulding (1973), Odum (1969), Cooper and Vlasin (1973), Van Zele (1978), Miller (1976), Harte (1977), Holdren (1978), and Holling and Goldberg (1973).

**Lovins 1977, p. 6.

processes which sustain life and society. Two critical issues lie at the heart of this approach. The first is whether one should begin with national futures related to energy supply and usage and disaggregate these futures to determine potential impacts ("top-down"), or whether one should assemble such futures by aggregating from the local level ("bottom-up").* The second issue is whether one should determine energy policy based on projected consumption levels and mitigate as best as possible the impacts resulting from such consumption levels ("moving in"), or whether one should base energy policy on the level and type of energy consumption that our natural and social systems can sustain and adjust our energy use to these sustainable levels ("fitting in"). Of course, these two issues are related in that a top-down approach assumes a certain intractability in energy consumption and looks for the best way out of a bad bargain, while the bottom-up approach assumes that a bargain of our own making can be unmade and renegotiated on a long-term basis.**

1. Top-Down versus Bottom-Up

The top-down approach perhaps is best characterized by national energy scenarios developed by computer modeling based on certain macroeconomic assumptions. Energy scenarios can be defined as "internally consistent examples" of potential future energy supply mixes created for the purpose of studying the consequences of alternative futures (SRI 1978, p. ix). The usual procedure is to develop a baseline scenario reflecting most likely conditions for input assumptions. Alternatives reflecting different levels of technology deployment, for example, a "low solar" and a "high solar," are then developed, and the consequences of each are compared to the baseline scenario. Such scenarios can be valuable tools to compare average costs and benefits of various alternatives, and to identify issues of importance for national

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*Of course, one can take a precedural middle-path and extrapolate from site-specific data where such data are available and use disaggregated national estimates where they are not (Yokell 1978, p. 41).

**This discussion of procedure should not be taken to mean that there are not very important substantive differences between local, regional, and national impacts and concerns and that proper means to address these differences must be studied and understood.

economic, social, and environmental policies, but they provide little indication of what actual impacts may be experienced at any particular location. The magnitude and nature of impacts are determined largely by site-specific factors,* and average costs and benefits cannot be disaggregated and spatially assigned in a way that is meaningful to localities which may be impacted by technology deployment. On the other hand, the bottom-up approach, which begins with a specific technology at a specific site and then attempts to aggregate the findings of the analysis to larger geographic or spatial units, cannot play a meaningful role in national energy policy formulation unless site analysis is performed as part of a larger aggregated analysis applicable to at least a multistate region of the country.

The method presented here is bottom-up in approach for several important reasons:

- There are available in the literature many studies of scenarios depicting a variety of potential energy futures, all proceeding top-down from different macroeconomic assumptions.
- There are also available many project and site-specific studies of energy projects which provide a wealth of detail on local impacts and which can be aggregated to help determine what regional effects can be anticipated from widescale development.
- If a proper context for aggregation can be developed, these local studies can be used to anticipate local impacts of similar projects in comparable areas and thus shorten the time and reduce the cost required for local impact studies.**
- Impacts are felt most immediately and directly at the local level, and the social and environmental effects of energy .technology deployment programs can be more accurately assessed through aggregation of these effects rather than through disaggregation of scenarios based in macroscale assumptions.
- Aggregation provides a way to account for cumulative effects, even those that are induced or indirect, to which site-specific analysis can only allude and which top-down methods can only assume will be distributed somewhat evenly throughout the lowest level of disaggregation.

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*Peelle (1978) defines the determinants of community impacts; Van Zele (1977) describes this generalization as the most useful one which has emerged from impact studies of nuclear power plants.

**Van Zele (1977) develops this and the preceeding point.

2. Moving In versus Fitting In

The language of NEPA seems to envision a harmonious partnership between nature and people, at least in the United States.* The immediate and most evident result of the enactment of NEPA, however, has been the many thousands of EISs that federal agencies have produced to meet the requirements of Section 102 of the Act. These statements have primarily sought to design around nature, to describe unavoidable destruction of natural systems, and otherwise to proceed with programs and projects usually conceived with production rather than harmony in mind. One manifestation of this approach is the usual chapter on mitigation of impacts found in most impact statements. The term "mitigation" is not to be found in NEPA, which emphasizes a more holistic approach to the environment than doing and correcting. The term is found in the guidelines promulgated under NEPA by the Council on Environmental Quality and has unfortunately become institutionalized in agency guidelines promulgated under CEQ directive.

Human activity would be far more benign if we would mitigate our traditional approach to resource use rather than the impacts of those uses. If we "design with nature" in resource use as well as in land use, we will find that production and harmony are not necessarily antithetical and that we can with sustained effort fulfill our responsibilities under NEPA as ". . . trustee of the environment for succeeding generations." The notion of fitting in requires that we not only minimize our intrusions upon ecologically sensitive areas but that we also design and place our technologies in consonance with the natural processes that regulate and maintain material and energy balance in the environment. This, too, is a bottom-up approach in that the design and deployment of technologies would begin with an awareness that the integrity of local environmental processes must be respected because they are manifestations of larger global processes about which we know little and with which we should tamper with some hesitance. This approach also requires that social issues become an integral part of the impact assessment/policy

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*The applicability of NEPA to federal activities overseas is controversial. See Science 201 (19 Aug. 1978) pp. 598-599.

formulation process and not be treated as subsidiary issues of risk, externalities, or side effects.* In other words, the technology must fit into the social system as well as the ecological system.

B. COMPONENTS OF THE METHOD

The method is structured upon the following propositions:

- The severity and permanence of impacts result from the nature and severity of interactions between host systems and intervening technologies.
- The more detailed understanding one obtains about host systems, the better technologies can be designed, scaled, located, and operated in consonance with such systems.
- An accounting of impacts will be complete to the degree to which technologies are evaluated on a life-cycle basis.
- An accounting of impacts is more useful to the degree to which results can be aggregated with other impact accounting efforts.

To test these propositions, the method can be divided into two major components, the first dealing with interaction between host systems and technologies and the second with aggregation of impacts caused by this interaction. The component dealing with interaction will provide for site-specific analysis and will be most useful to local officials faced with land use decisions concerning siting of solar energy technologies. The component dealing with aggregation will provide a way to conjoin site-specific impacts in a manner that will permit regional and national level analysis of proposed programs and policies on solar technology deployment and should be most useful to federal officials who must determine program priorities and make policy decisions. Through careful selection of test cases, "prototype regimes"** can be postulated, and the potential impacts of selected solar technologies can be aggregated for the purpose of policy and program evaluation. A schematic of the interaction and aggregation process is shown on Figure 1.

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*Unseld (1978, p. 222).

**Van Zele (1977) has developed the technique of "surrogate site analysis." The aggregation process is discussed in Parts III and IV below.

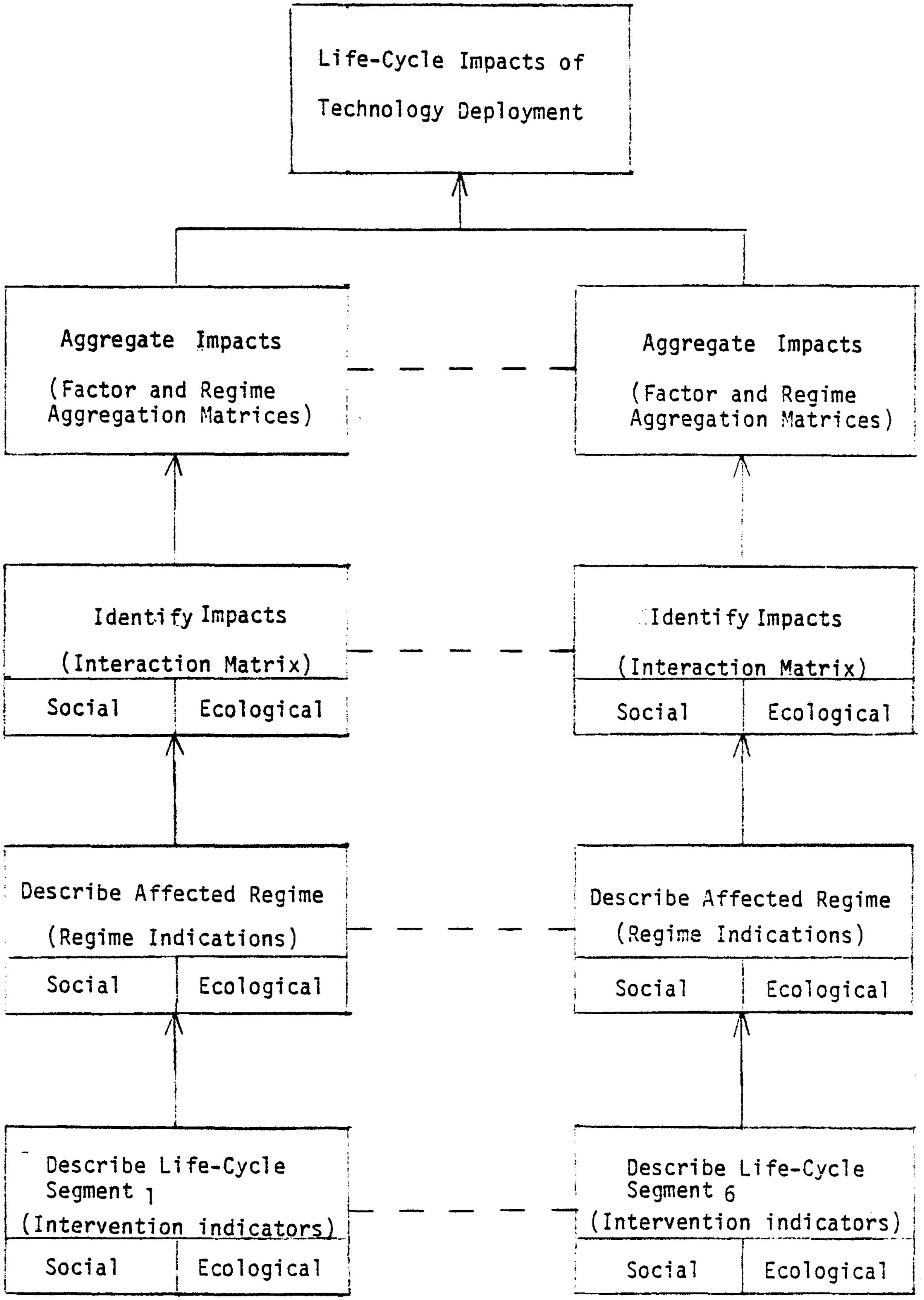

Figure 1:

Impact Identification and Aggregation Procedure

The method is designed to assist government at all levels achieve economy of research and analysis in matters involving energy technology deployment. At the local level, the method can be applied without expensive statistical data gathering and computing which are usually beyond the means of local governments. Findings from local-level analyses, however, can be used as inputs for national level efforts using electronic data processing. Information based on local assessment will more likely enable formulation of more realistic scenarios upon which energy policies and programs can be built.

Part II

INTERACTION COMPONENT

This component is made up of elements that permit description of host systems and intervening technologies and identification of the impacts caused by their interaction. These elements are:

- regime description
- intervention attributes
- impact identification.

A. REGIME DESCRIPTION ELEMENT

The term "regime" is used to signify the boundaries of assessment for the social and ecological systems that are affected by the deployment of a specific technology. These boundaries will vary with each segment of the life-cycle of the technology and must be discovered through the assessment process on a case-by-case basis. These boundaries are operational in that they are to be defined for the purpose of analysis, but they must also accommodate ecological and social community boundaries. Ecological community boundaries will be defined by such natural limits as drainage basins, airsheds, vegetation zones, etc., and initial determination of regime boundaries will depend upon the type and extent of technological intrusion anticipated and the location of the technology deployment and concommitant activities. Social regime boundaries will generally follow politial boundaries and should be at least at the county level. Regime boundaries will most probably be adjusted as analysis proceeds. Test-case analysis will assist in determining likely initial boundaries for selected technologies.

A bottom-up, fitting-in approach begins with the premise that social and ecological systems are dynamic and structured upon certain critical relationships among components which permit the systems to assimilate exogenous change whether it be caused by the intervention of natural forces or technology. This approach must begin with an understanding of the factors that are responsible for system behavior, particularly those that determine the nature, rate, and direction of endogenous change. As a first step, a taxonomy of social and ecological systems was developed under the following guiding requirements:

- The taxonomy must delineate the structural and dynamic relationships that are key to the functional integrity of the system.
- It must delineate those characteristics of the system which are critical in determining the resilience of the system when subjected to change caused by exogenous factors.
- It must delineate those characteristics of the system which are sensitive to the effects of specific temporal, spatial, and design parameters of a given technology so that questions pertaining to local siting can be addressed.
- It must delineate characteristics in such a way to permit aggregation of results to larger geographic and socio-political units so that assessment based on the method can assist policy determination on the distribution, timing, and level of technology deployment.

The taxonomy developed for this method consists of "regime indicators" which delineate critical locations at which social and ecological systems will intersect the deployment of energy technologies. The taxonomy was bifurcated into social and ecological regimes to facilitate research and for convenience of analysis. This was done with an understanding that the resulting ragged edges will be rejoined through the process of aggregation discussed later.

1. Ecological Regime Indicators

The ecological regime indicators were selected to focus on those processes and internal relationships which must be respected if solar technologies are to fit in rather than intrude upon natural systems. The demarcation of indicators to describe the dynamics of ecosystems is an area of active research and some controversy, particularly where indicators are put forth to enable the prediction of ecosystem response to impacts or stress. Harte (1977) delineates the major aspects of this controversy, particularly in relation to the concept of ecological stability.* Harte also lists the major

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*See Goodman (1975), Van Voris (1976), Preston (1969), Lewontin (1969), Connell and Slatyer (1977), and Margalef (1963) for additional discussion of the stability issue.

sources of uncertainty in predicting the response of ecosystems to stress. This list is reproduced in Table 1. Harte's list of sources of uncertainty presents formidable obstacles to predicting the response of ecosystems to technological intrusions. Of particular concern is the uncertainty regarding long-term ecosystem behavior and how fluctuations in ecosystem behavior affect assimilation of impacts over a period of time. In Harte's report, these uncertainties are accommodated under "risk" analysis.

In the method presented here, an attempt was made to avoid the controversy about stability by considering stability as one of many properties of an ecological regime rather than as a single underlying concept. Indicators were selected to reveal the characteristics of ecosystems that are known to be especially sensitive to sudden alteration. The assumption is that abiotic and biotic processes, structures, and relationships inherent in ecosystems are intrinsically worth preserving and that the principal task at hand is not so much to predict ecosystem response to disturbance, but to design (in terms of location, type, size, timing of installation, and operating procedures) technologies to minimize the scope, intensity, and untimeliness of the intrusions. The question remains, of course, how one designs for the minimum intrusion without knowing precisely how ecosystems will respond to different types and intensities of intrusions. One obvious way is to look at history as human beings have left a rich and varied record of intrusion upon all major ecological systems. Examples in the literature of technological intrusion upon different types of ecosystems can be analyzed and those factors particularly critical to an ecological blunder, or in those rare instances, to an ecological success, can be isolated and some causal inferences made between intrusion and ecosystem response.

The indicators were determined primarily through a search of the literature. Major sources include Fenneman (1928), Odum (1971), Dickert (1974), Harte (1977), Holdren (1978), Dasmann (1976), and Cooper and Vlasin (1973). These indicators are shown on Table 2. The indicators are grouped under four factors: land form, vegetation, soil, and aquatic. Indicators under the land form factor are based on Fenneman's classification of the surface area of the United States based on the geomorphology of land forms. The indicators

TABLE 1

MAJOR SOURCES OF UNCERTAINTY IN PREDICTING THE RESPONSE OF ECOSYSTEMS TO STRESS

- Difficulty of performing controlled, replicable experiments which provide in-situ information about ecosystems
- Lack of models allowing the use of measurable data to predict detailed ecological responses to stress
- Overconfidence in untested ecological dogma

Lack of data on and understanding of:

- energy and nutrient needs of organisms (so-called limiting factors)
- effects of long-term, low-level effluents on ecosystems
- effects of acute stresses on ecosystems (especially synergistic effects)
- critical stability indicators and correlates of stability
- population fluctuations
- environmental fluctuations
- ecological-meteorological interactions
- microbial ecology and nutrient chemistry
- sources of stress (both gross effluent levels and pollution levels in the micro-environment of organisms)
- genetic parameters governing ecosystem dynamics and response to stress
- cumulative effects on populations of successive small habitat losses.

Source: Harte (1977, p. 28).

TABLE 2
ECOLOGICAL REGIME INDICATORS

Land Form Factors

- physiographic division
  - location
  - area
- structure
- process
- stage (history)
- energy and non-energy mineral resources
  - type
  - grade
  - known reserves

Vegetation Factors

- ecoregion
  - location
  - land area (km^2) % of U.S.
- biomass
  - net primary production (gmC/m^2)
  - distribution
    - standing crop
    - humus
  - specie distribution
- ecotones
- nutrient cycling
- climate
  - zone
  - growing season (no. of days)
  - precipitation
    - amount
    - distribution
  - temperature
    - seasonal max/min
  - insolation
    - seasonal distribution
- biociation
  - principal animal communities
    - endangered species
  - niche specialization
    - migration patterns
    - breeding grounds (strutting, etc.)
    - nesting, calving areas
    - symbiotic relationships
  - specie diversity
    - variety
    - stratification
    - equitability
  - food web
  - successional state
  - stability
    - evidence of disturbance
    - scale
    - intensity
    - duration
    - time (yr. ago)

Soil Factors

- principal soil series
  - distribution
  - location
  - horizons (depth, composition)
    - C
    - B
    - E (A_2)
    - A
    - O
- renewability
  - weathering regime
  - organic regime
  - drift regime
- aquifers
  - water bearing strata
  - recharge areas

Aquatic Factors

- major rivers
  - flow
  - drainage patterns
- major lakes
- estuaries
  - location
  - area
- principal aquatic species
  - see biociation indicators
- vegetation
  - principal species
  - net primary production
  - nutrient cycling

include structure, process, and stage. Structure covers "all the work of constructional agencies" of geologic forces; process refers to the "erosive agency . . . which produces . . . characteristic forms, differing according to the structure upon which it acts;" stage indicates position within a "regular cycle of changes" that land forms pass through and which differs according to "the process at work and the structure involved" (Fenneman 1928, pp. 266-267). Geomorphological indicators are useful since by "understanding the processes acting on a landscape, one will be able to predict uses that conform to these processes rather than conflict with them" (U.S. Dept. of Agriculture, Forest Service 1977b, pp. 26-27). Energy and non-energy mineral resources are also included as indicators under land form factors since deposits of such resources are formed by geological processes.

Vegetation factors include indicators of trophic structures and patterns of energy flow characteristic of a major ecological community. A major community is ". . . any assemblage of populations living in a prescribed area or physical habitat . . . which [is] of sufficient size and completeness of organization that [it is] relatively independent . . . [needing] only to receive sun energy from the outside . . ." (Odum 1971, p. 140). These indicators place emphasis on the structural and functional unity of ecological communities and provide critical loci for assessment of the effects of technology deployment.

Soil factor indicators are based on soil profile horizons since "the terminology and nature of . . . horizons is a basis for the classification of soils" (Dasmann 1976, p. 95).* Soil horizons are also good indicators of the interaction between biotic and abiotic components of an ecological community. The renewability indicators describe the natural processes to which soils are exposed and also provide an indication of how suitable soils are for continued agricultural uses (Dasmann 1976, p. 102).

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*Also see Cline (1949).

Aquatic factor indicators delineate major suface water areas and systems and the vegetative and biociation dimensions of these areas and systems.

2. Social Regime Indicators

Social regime indicators were selected to delineate the structural and functional characteristics of a social community. A social community can be defined in terms of physical territory, legal boundaries, psychological identification, statistical differentiation, and many other ways. In this study, the focus is placed on the units of a community system (in terms of demographic differentiation), how these units interact within the community, and upon the tasks which the community performs as a social system (Watkins 1977, pp. 36-37). The indicators are grouped under demographic, economic, and institutional factors and are shown in Table 3. Primary sources for these indicators are Finsterbush (1978, 1977a, 1977b), Peele (1978), Gilmore (1976), Olsen and Merwin (1977), Miller (1976), and C-b Oil Shale Project (1976).

Demographic factors were selected to differentiate the population of a community into units which permit analysis of how the effects of technology deployment will be diffused through a community. Since decisions to deploy technology are usually imprinted with the values of people comprising a small segment of the community or of people outside of the community, differentiation of the community into smaller units which are likely to have shared values provides a way to determine whether the type, scale, location, and timing of deployment are consonant with the values and aspirations of the entire community and whether some segments of the community will be more adversely affected than others.

Economic factors were selected to differentiate employment and economic activity within the community, again to enable analysis of how and to what degree different sectors of the community may be affected by technology deployment.

TABLE 3
SOCIAL REGIME INDICATORS

Demographic Factors

- quantity
  - number
  - density (average of geographic sectors)
  - differentiation
  - age
  - race
  - ethnic groups
  - income
  - sex
  - length of residence
  - education
  - household type
- distribution
  - SMSA
  - small urban
  - non-urban
- dynamics
  - rate of change
  - birth/death rate
  - migration
    - rates
    - patterns (in terms of population, differentiation and distribution)
- family structure
  - no. of families
  - aver. family size
  - no. of families receiving public assistance
  - no. of households
  - head of household by age, sex, marital status
  - married/unmarried population (18 to 45 years of age)
- housing
  - no. of units
    - conventional/mobile/prefabs
    - no. of occupants
  - housing types and occupancy rate
    - aver. length of occupancy
    - owned/rented
    - single family
    - multiple family
    - yr. around/seasonal

Economic Factors (include rate of change)

- employment
  - no. of employed by sector and % by sector
  - unemployed by sector and % by sector
  - unionized/non-unionized labor force
  - access to metropolitan labor pools
- individual income
  - median income
  - income distribution (per demographic differentiation factors)
- economic activity
  - personal income by employment sector
  - retail sales
  - retail trade by business class
  - value of goods by industrial sector
  - property values
    - assessed valuation by class of property
    - aver. market value for each class
    - tax rate
- land use
  - type and intensity
  - availability of vacant land
- major markets
  - imports
  - exports

Institutional Factors

- local government structure
  - governing authority
  - special districts and taxing authorities
  - governing body expenditure by category
  - government revenue by source
  - planning and land use regulations
- educational system
  - area of district
  - no. of schools

  * student distribution by grade
  * pupil/teacher
  * average classroom size by grade
- police/fire protection
  * number police, firemen/1000 population
  * fire insurance rating
  * crime rate
    - per population differentiation
- other public services
  * parks and recreation facilities (no. and distribution)
- libraries (no. and distribution)
- public and environmental health
  * public health
    - mortality rate
    - incidence rates for various diseases
  * occupational health
    - accident rates/industrial sector
    - incidence and types of disability
  * hospitals (no. of beds, occupancy rate)
    - types of services available
  * water supply
    - source
    - capacity
    - use by sectors
  * sewage treatment
    - type of treatment
    - capacity
    - pt. and quantity of discharge
- transportation
  * access to major highways
  * rail, car, public transportation
  * major arterials
    - location
    - capacity

Institutional factors delineate those tasks that the community performs as a social system. Such tasks include self-government, education, social control, and environmental and public health, all essential tasks which bind a community together and which in certain circumstances can be easily disrupted by outside forces.

B. INTERVENTION ATTRIBUTES ELEMENT

The deployment of a technology will intervene upon ecological and social structures and processes throughout the life-cycle of deployment. This element identifies those attributes of technology deployment, from resource extraction through system decommission and disposal, that characterize this intervention. The characteristics of technology deployment are delineated to enable differentiation of the impact-causing attributes of deployment. Such characterization will assist in determining how variables of deployment (type, location, timing, design) can be manipulated to minimize intrusion and maximize fitting in. This element will also be of use in selecting test-case technologies that may provide empirically validated generalizations concerning degrees of benignity among alternative technologies. Also, if intervention "taxonomies" can be developed, the results of site- and technology-specific studies can be transferred, as a first order approximation, to other sites and other technologies as long as similarities in regime characteristics are shared.* This, too, would result in economy of research.

Host regimes and intervening technologies will interact through transpost pathways.** For the ecological regime, impact transport will occur through land, air, and water pathways, and the "physical" portion of the intervention indicators are grouped under those three pathways. Impact transport pathways in the social regime are more difficult to assign, but primary paths are

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*Peele, Bronfman, _et_ _al_. (1978, p.13) report that few formulas to do this kind of transferring exist but that some progress has been made in identifying methods to distinguish levels of population increase and secondary employment impacts in rural areas.

**See Holdren (1978), pp. 6-8.

provided through its economy and institutions,* and intervention indicators are grouped under these two pathways. These indicators, shown on Table 4, characterize the agents of technological intervention, in terms of material, capital, labor requirements; chemical, physical, and biological make-up of effluents; and land modification activities, to name a few.

The regime modification indicators are to be applied to each segment of the life-cycle of the particular technology considered for deployment. These segments are:

- resource extraction
- resource processing
- equipment manufacturing
- facility construction
- facility operation and maintenance
- system decommission, disposal, and recycling.

Within the life-cycle of a given technology, different segments will most likely take place in different locations and encompass different regimes. The impacts of each segment will be acounted, and impacts will be summed over all regimes in all segments of life-cycle. A schematic of the interaction component is shown in Figure 2.

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*Isard, Reiner, Van Zele, Stratham, et al. (1976, p.85) in their study of nuclear energy centers identify land use controls, tax structure and degree of urbanization as the most important variables in determining the magnitude and distribution of impacts at the local level; Gilmore (1976) describes the problems of boom-towns in terms of the inability of local institutions to respond to a sudden and large capital investment in the local economy; Peele (1978) identifies degree of urbanization, community characteristics, and institutional arrangements, along with input characteristics, as the primary determinants of the magnitude, scope, and direction of community-level impacts of energy development.

TABLE 4
INTERVENTION INDICATORS

Land

- location
- major land modification activities
- area (m^2) acquired/leased
- excavation
    - surface area
    - depth
- drilling
    - number of bores
    - depth
    - spacing
- cuts
    - angle
    - fill
- land use
    - type
    - duration

Air

- location (airshed)
- effluents (all processes)
    - particulates
    - SO_x
    - HC
    - CO, CO_2
    - NO_x
    - O_x
    - trace elements

Water

- consumption (gpd) (acre-ft/yr)
    - source
    - transportation
    - storage
    - treatment
    - re-use
- effluent
    - amount
    - type (pt. and non-pt.)
        - physical (temp., turbidity, color, humidity [for cooling], radioactivity)
        - chemical (pH, BOD, toxicity, trace elements)
        - biological (fecal coliforms)
    - pt. of discharge
        - waterways
        - air (for cooling)
        - land (on-site disposal)

Economy

- labor
    - skills required
    - no. and duration of employment
    - wage scales
    - payroll (amount, duration)
- capital
    - amount
    - sources
    - interest rates
    - amortization/payback schedules
- equipment
    - type
    - cost
    - maintenance
    - life expectancy
- materials
    - type (include fuels)
    - amount
    - source
    - storage

Institutions

- utilities required
    - electricity, natural gas, sewage treatment
- transportation
    - labor
    - materials and equipment
- health and safety
    - police and security requirements
    - hazardous materials and processes
- taxation
    - assessed valuation of property and equipment
    - royalties, leases, fees

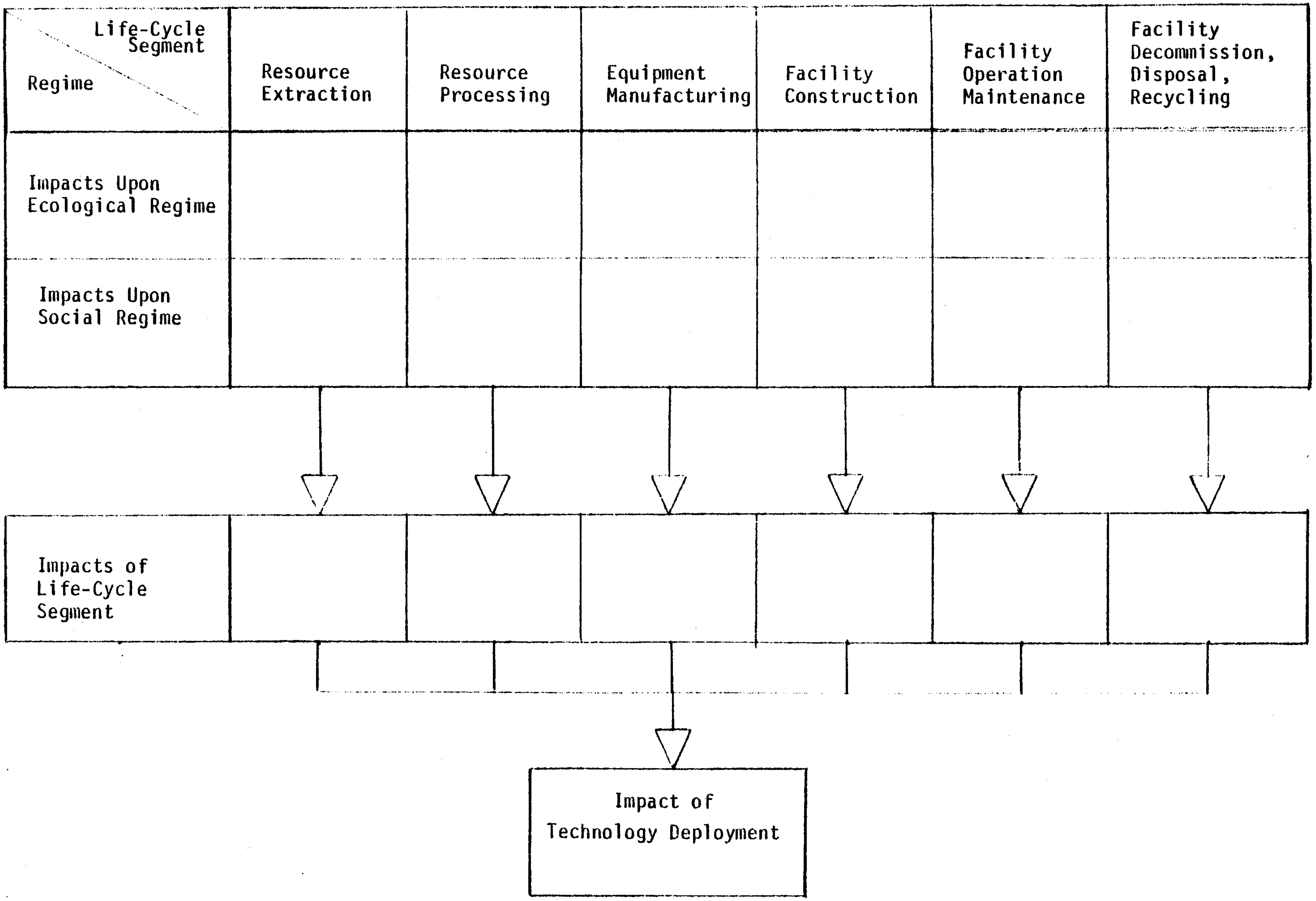

Figure 2
Interaction Component Schematic

C. IMPACT IDENTIFICATION ELEMENT

The traditional EIS typically focuses on this element as a prelude to sections on unavoidable impacts and mitigation measures. In this method, impacts are identified through interaction matrices for the ecological and social regimes, as shown on Figures 3 and 4, respectively. The regime indicators are shown in rows, the intervention indicators in columns under pathway groupings. The matrix is intended to display how regime processes and structures, as represented by indicators, will be affected by technology deployment activities, as represented by intervention indicators. The display will at the minimum identify impacts, which can be defined under this matrix as loci of interaction. Where sufficient data concerning regime indicators are available, the matrix will display a quantitative measure of direct impacts, for example, the effect on river flow of a given consumptive use of water. Indirect impacts, for example, the effect of reduced river flow upon nutrient cycling and niche specialization, will be identified, but any quantification of second- and third-order effects will be attempted under the aggregation component.

Figure 3
Impact Identification Matrix
Ecological Regime

Regime Modification / Regime Description	LAND			AIR		WATER	
	Location	Area	Land Use	Location (airshed)	Effluents	Consumption	Effluents
Land Form							
location							
area							
structure							
process							
stage							
Soil							
Series							
location							
area							
Horizons							
Renewability							
Aquifers							
Vegetation							
Ecosystem							
location							
area							
Biomass							
Net Primary Production							
Distribution							
Climate							
Precipitation							
Temperature							
Insolation							
Biociation							
Principal Animal Communities							
Nutrient Cycling							
Food Web							
Niche Specialization							
Sucessional State							
Stability							
Ecotones							
Aquatic							
Major Rivers							
Location							
Flow							
Drainage Patterns							
Major Lakes							
Location							
Water Source							
Water Quality							
Estuaries							
Location							
Nutrient Cycling							
Biociation							
(see Vegetation)							

Regime Modification / Regime Description	ECONOMIC				INSTITUTIONAL			
	Labor	Capital	Equipment	Materials	Utilities Required	Transp. Needs	Health Needs	Taxation
Demographic								
Population								
Density								
Differentiation								
Distribution								
Dynamics								
Family Structure								
Housing								
Economic								
Employment/Unemployment								
Number								
Duration								
Sector								
Union/non-union								
Skills								
Individual Income								
Median								
Distribution								
Duration								
Economic Activity								
Retail Sales								
Industrial Goods								
Property Values								
Land Use								
Import/ Expert								
Markets								
Institutional								
Local Government								
Governing authority								
Special districts								
Expenditures								
Revenues								
Regulations								
Educational System								
Student Population								
Number								
Distribution								
Pupil/Teacher								
Classroom size								
Police/Fire Protection								
Water/Sewage Facilities								
Transportation								
Medical Care								
Other Public Services								

Figure 4
Impact Identification Matrix
Social Regime

Part III
AGGREGATION COMPONENT

Under the preceding component, application of the method culminates with the identification of impacts for each life-cycle segment in the specific deployment of a particular technology. Under the aggregation component, the identified impacts are aggregated for associative and cumulative effects. The elements of this component are:

- factor aggregation
- regime aggregation.

Impacts once identified must be evaluated for significance. Quantitative measures of direct impacts, for example, the extent and duration of ambient concentrations of a pollutant or the number of new employees attracted to a community, usually have little significance in themselves. Rather, it is the effect of these impacts upon ecological and social structures and processes that determines impact significance. As the next step, identified impacts must be assessed in terms of their spatial, temporal, and functional dimensions. As a simple example, impacts created by a given quantity of water consumption will vary in significance depending on the location of diversion, the seasonal fluctuation of surface flow and of water needs of competing users, and the relationship of river flow fluctuation to breeding patterns of wildfowl and fish. The usual term for these considerations is "indirect" (or "secondary") effects. This term is not used here because such effects are of primary concern and are often magnified as they wend their way through ecological and social systems.

The impact dimensions can be further described as follows:

- spatial
  - location (where)
  - areal or volumetric extensiveness (how much)
  - density or concentration (how intense)
- temporal

    - time (when)
    - duration (how long)
    - frequency (how often)
- functional
    - relationship of the spatial and temporal dimensions to ecological and social structures and processes

The spatial and temporal dimensions, once identified, must be integrated, for it is the functional dimension that determines the significance of impacts within a specific regime in which deployment takes place. The functional dimension is determined through, first, an analysis of the interaction of impacts among factors within the ecological and social regimes (factor aggregation), and, second, an analysis of the interaction between the two regimes (regime aggregation). The analytic procedure will be, first, to aggregate impacts through cross-impact matrices for factor interaction in the ecological and social regimes, and, second, to aggregate impacts between the two regimes through a third cross-impact matrix. These cross-impact matrices provide a framework to assess so-called second- and third-order effects, or, under this method, cross-over effects.* Synergestic effects are interactions between or among cross-over effects and will be identified, although it is not anticipated that application of this method will make these effects any more tractable to quantitative analysis.

A. FACTOR AGGREGATION ELEMENT

Factor aggregation represents an attempt to assess how impacts interact with other impacts. The cross-impact matrices shown on Figures 5 and 6 provide a framework to determine how impacts from one factor affect other factors within the ecological and social regimes, respectively. Cross-over effects are not uni-directional, and the matrix allows assessment of the effects of impacts arising in one factor upon all other factors, albeit the analysis must proceed

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*Cross-impact analysis can also be expressed in terms of the occurrence of one event increasing or decreasing the probability of occurrence of another event. See Enzer (1972).

	LAND FORM			SOIL			VEGETATION			AQUATIC				
	Structure a	Stage b	Process c	Horizon d	Renewability e	Aquifers f	Biomass g	Climate h	Biocia. i	Rivers j	Lakes k	Estuar. l	Biocia. m	*
Land Form *														
Structure A														
Stage B														
Process C														
Soil														
Horizon D														
Renewability E														
Aquifers F														
Vegetation														
Biomass G														
Climate H														
Biocia. I														
Aquatic														
Rivers J														
Lakes K														
Estuar. L														
Biocia. M														
Cum. Impacts														

Figure 5
Factor Aggregation Matrix
Ecological Regime

* Cross-over impacts

		Demography						Economic				Institutions							
		Pop	Diff	Dist	Dyn	Fam.Strut	Housing	Employ.	Ind.Ig.	Econ.Act.	L.G.	Educ	Pol.	Fire	W/S	Tran	Med	Rec	*
		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	
Demography																			
Population	A																		
Differentiation	B																		
Distribution	C																		
Dynamics	D																		
Family Structure	E																		
Housing	F																		
Economy																			
Employment & Unemploy.	G																		
Indiv. Income	H																		
Econ.Activity	I																		
Institutions																			
Local Government	J																		
Education	K																		
Police Protect	L																		
Fire Protection	M																		
Water/Sewage	N																		
Transportation	O																		
Medical Care	P																		
Recreation	Q																		
Cum. Impacts																			

Factor Aggregation Matrix
Social Regime
Figure 6

* cross-over impacts

sequentially and in one direction at a time. In the matrices, impacts identified for each factor shown in rows (horizontal) are to be applied to other factors shown in columns (vertical) in sequential steps. As an example, in Figure 5, vegetation impacts should be assessed for effects on land form, soil, and aquatic factors in that order. Impacts identified for each of the remaining factors should be assessed in similar fashion from left to right.

As an illustration of how application of the matrices can identify cross-over effects, deployment of a technology which reductes vegetative cover (biomass) could impact land form by magnifying the effect of erosive agents (process), which, in turn, may affect the aquatic factor by increasing siltation and interfering with nutrient cycling (biociation). In the social regime, increased activity in the construction sector of the economy may affect demography by increasing in-migration of certain skilled laborers and altering the age and sex distribution of the local population. These alterations, in turn, may affect the institutional factor by reducing community cohesion and by requiring established institutional structures to adapt to new situations and problems.

Figures 5 and 6 allow systematic assessment of cumulative and cross-over effects. Impact inputs (rows) are designated by capital letters, impacted indicators (columns) by small letters. Cumulative effects within each factor can be assessed by proceeding down each column, cross-over effects of altering one regime indicator by proceeding horizontally. Potential synergestic effects are identified by capital and small leter pairs, for example, C-g and G-c identify biomass and land form process interaction.

B. REGIME AGGREGATION ELEMENT

In the final step of aggregation, the interaction of social and ecological regime impacts must be assessed. A format for this assessment is shown in Figure 7. Cumulative effects determined through factor aggregation in the preceding step are displayed for the ecological and social regimes in rows and columns, respectively. Ecological and social factors are paired, and each pair is assessed for interaction in both directions. Interactions can then be

Social Regime Ecological Regime	Demography Cumulative effects	Economy Cumulative effects	Institutions Cumulative effects	
Land Form Cumulative Effects				Total Effect of Social Regime Alteration Land Form
Soil Cumulative Effects				Total Effect of Social Regime Upon Soil
Vegetation Cumulative Effects				Total Effect of Social Regime Upon Vegetation
Aquatic Cumulative Effects				Total Effect of Social Regime Upon Aquatic Factors
	Total Effect of Ecological Regime Alteration Upon Demography	Total Effect of Ecological Regime Alteration Upon Economy	Total Effect of Ecological Regime Alteration Upon Institutions	

Figure 7
Regime Aggregation Matrix

aggregated vertically to assess the total effect of ecological regime alteration upon each of the social regime factors. Aggregation horizontally provides assessment of the total effect of social regime alteration upon each of the ecological regime factors. This final step of the aggregation component provides an assessment of cross-regime effects and brings together to some extent the two regimes that were initially bifurcated for the purposes of analysis.

Part IV

REGIONALIZATION COMPONENT--FROM SITE TO SCENARIO

A. PROTOTYPE REGIMES

One of the propositions presented earlier in the paper stated that an accounting of impacts is more useful to the degree to which results can be aggregated with other impact accounting efforts. If a format for analysis which provides for aggregation is established before a site-specific study is begun, results and conclusions from such a study may be applied to other situations in which regime description and intervention indicators are similar. Such transferability will mean economy in research effort as well as in financial expenditure. In addition, if similarities in regime description indicators can be generalized to provide "prototype regimes," deployment impacts within regimes can be aggregated to permit a bottom-up approach to policy and scenario formulation. Such an approach, as discussed earlier, would be much more sensitive to social and ecological impacts than the top-down approach and would allow the design, location, and scale of technology deployment to fit in with social and ecological structures and processes. The purpose of this part of the paper is to propose a scheme to generalize regime description indicators so that a bottom-up process of impact identification and aggregation can lead to policy formulation.

Before proceeding further, it is important to distinguish "aggregation" as used in the preceeding section from "regionalization" as used in developing the concept of prototype regimes. Aggregation of impacts is the conjoining of site-specific effects for each "socioecological" regime affected by each life-cycle segment of technology deployment. Regionalization is also a process of aggregation, but, in this case, ecological and social characteristics, rather than impacts, are combined on the basis of spatial relationships.* The bottom-up process of policy and scenario formulation proposed in this paper is to combine aggregation and regionalization through the process of prototype case-study. This process is shown in Figure 8 and is discussed later in connection with criteria for case-study selection.

Regionalization requires definition of a context within which similar ecological and social properties can be aggregated for the purposes of program evaluation and policy analysis. For natural systems, there is a rich literature on the classification of natural physical characteristics of the United States. Major classification schemes which have been mapped are listed in Table 5. The regionalization format used for this paper is taken from Bailey's (1976) study, "Ecoregions of the United States," at the level of ecosystem "division." The ecoregion division is the second level of generalization in Bailey's system and is differentiated according to regional climate and vegetation. The geographic boundaries and characteristics of these divisions are shown in Figure 9 and Table 6, respectively.

Bailey's system was selected because it offers a level of generalization that is appropriate for policy formulation and that is comparable to that chosen for the regionalization of social regimes discussed below. It also offers a classification scheme based on factors used for ecological regime description in Part II of the paper, vegetation and soil, as well as climate, which is used as an indicator in regime description. Land form and aquatic factors are not directly evident in Bailey's system. However, Bailey's classification shows fairly good correlation with Fenneman's (1928) physiographic classification at the "major division" level. Aquatic factors must be assessed outside of terrestial classification schemes. Also, mountainous

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*See Bailey (1976) for a discussion of ecosystem regionalization. Van Zele (1977) describes a method to regionalize impact assessment, which he deems "an absolute necessity." Berry's (1964) discussion of aggregation for the purposes of regional geography has similarities with the method of aggregation proposed in this paper, although Berry's emphasis is on designing a systematic framework for the study of geography.

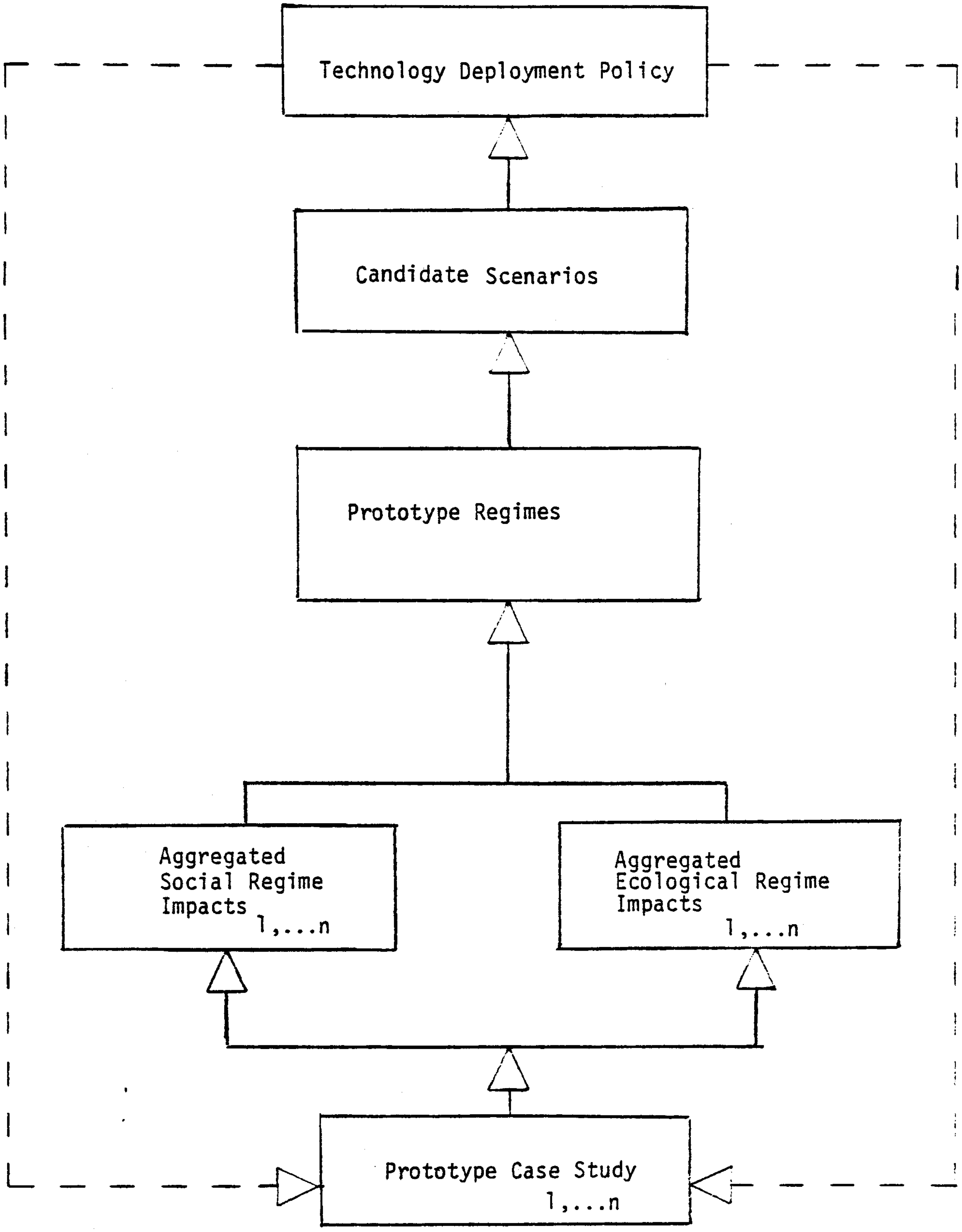

Figure 8
Regionalization Component
Schematic

Table 5
Ecological Regionalization Systems (Mapped)

Author	System Name	Principal Classification Basis	Reference
Morris E. Austin	Land Resource Region	Soil, Land Use	Austin 1972
Robert G. Bailey	Ecoregion	Climate, Vegetation	Bailey 1976
Raymond Dasmann	Biogeographic Province	Plant and Animal Distribution	Dasmann 1976 a
Nevin M. Fenneman	Physiographic Province	Geomorphology	Fenneman 1928
Edwin H. Hammond	Land Surface Form Class	Land Surface Form	Hammond 1964
A. W. Küchler	Potential Natural Vegetation	Vegetation	USDI 1970 pp. 90-91
Eugene P. Odum (after Frank A. Pitelka)	Biome	Climatic Climax Vegetation	Odum 1971
Society of American Foresters	Forest Cover	Tree species	Society of American Foresters 1954
USDA	Forest and Range Ecosystems	Vegetation	USDA, Forest Service, 1977a

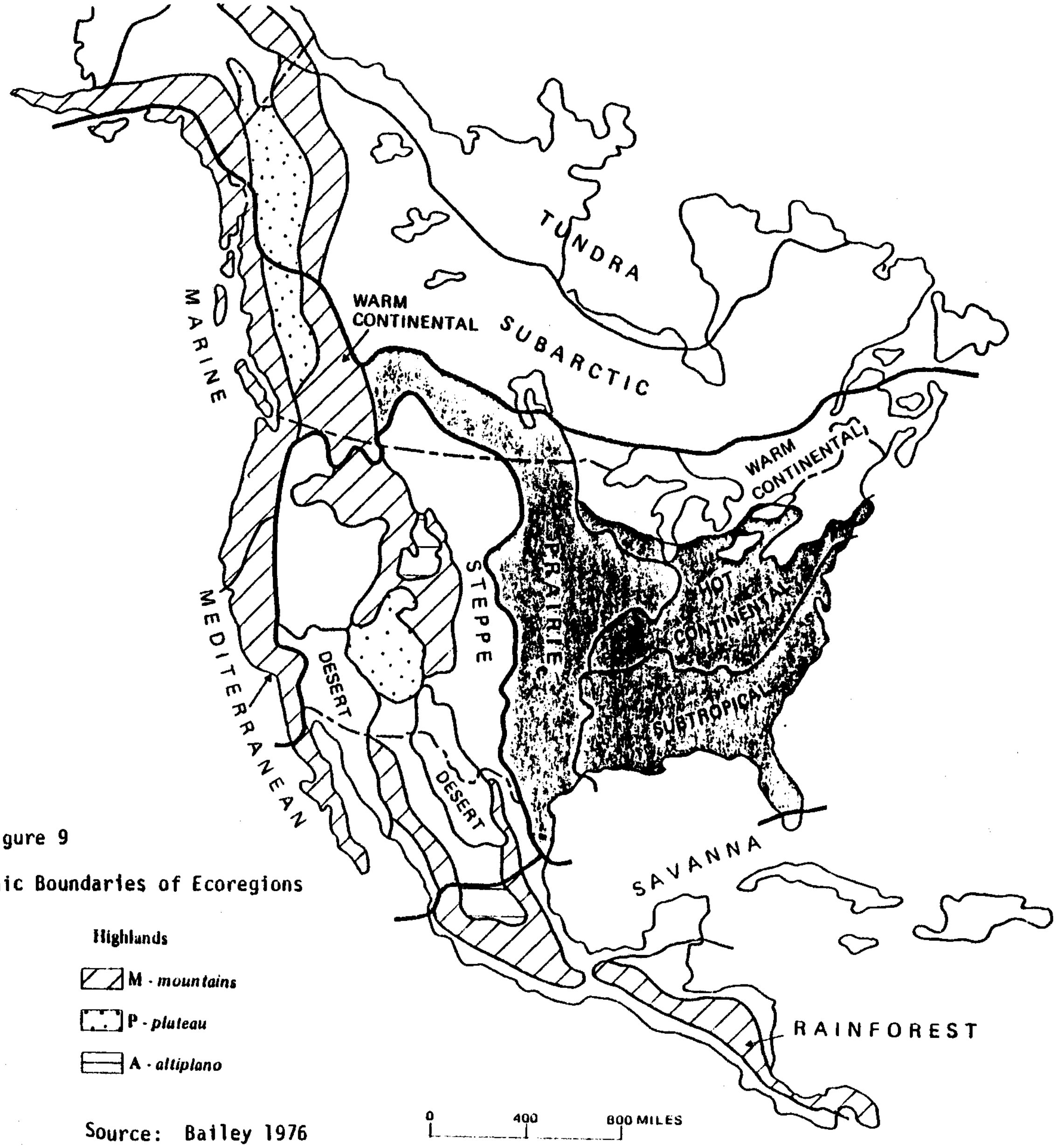

Figure 9

Geographic Boundaries of Ecoregions

Highlands

▨ **M** - *mountains*

⁘ **P** - *pluteau*

▤ **A** - *altiplano*

Source: Bailey 1976

DIVISION	TEMPERATURE	RAINFALL	VEGETATION	SOIL*
Warm Continental	Coldest month below 0°C, warmest month < 22° C	Adequate throughout the year	Seasonal forests, mixed coniferous - deciduous forests	Gray-Brown Podzolic (Spodosols, Alfisols)
Hot Continental	Coldest month below 0° C, warmest month > 22° C	Summer maximum	Deciduous forests	Gray-Brown Podzolic (Alfisols)
Subtropical	Coldest month between 18° C and -3° C, warmest month > 22° C	Adequate throughout the year	Coniferous and mixed coniferous - deciduous forest	Red and Yellow Podzolic (Ultisols)
Marine	Coldest month between 18° C and -3° C, warmest month < 22° C	Maximum in winter	Coniferous forest	Brown Forest and Gray-Brown Podzolic (Alfisols)
Prairie	Variable	Adequate all year, excepting dry years, maximum in summer	Tall grass, parklands	Prairie soils, Chernozems (Mollisols)
Mediterranean	Coldest month between 18° C and -3° C, warmest month > 22° C	Dry summer, rainy winters	Evergreen woodlands and shrubs	Mostly immature soils
Steppe	Variable, winters cold	Rain < 50 cm/yr	Short grass, shrubs	Chestnut, Brown soils and Sierozems (Mollisols, Aridisols)
Desert	High summer temperature, mild winters	Very dry in all seasons	Shrubs or sparse grasses	Desert (Aridisols)
Savanna	Coldest month > 18° C, annual variation < 12° C	Dry season with < 6 cm/yr	Open grassland, scattered trees	Latosols (Oxisols)

* Names in parentheses are Soil Taxonomy orders from 1970 National Cooperative Soil Survey.

Table 6

GENERAL ENVIRONMENTAL CHARACTERISTICS OF SECOND-ORDER ECOREGIONS

Source: Bailey 1976

areas must be assessed as special cases because of complex zonation which characterizes high elevation and large local relief, although Bailey's system offers a way to infer the general character of zonation based on climate at a third level of generalization (province). Bailey also delineates a fourth level of generalization, the section, which is based on local climatic variation and which provides more detailed boundaries for the divisions.

The literature on the classification of social systems is extremely sparse. Vlachos (1978) describes the use of scenarios for social impact assessment which can account for regional characteristics such as aridity. Williams, Kruvant, and Newman (1976) have studied how development in metropolitan areas may be affected by alternative energy futures. DeLuca (1978) has explored how community structure is related to community response to environmental problems. Peelle, Bronfman, *et al.* (1978) have studied classification of counties by three methods: expected rate of population growth resulting directly from increased employment, general level of development, and levels of trade multipliers.

The most useful work to date has been done by Van Zele (1977). Van Zele characterizes his approach to regionalization of social impacts as "surrogate site analysis." Briefly described, prototypical sites which can be viewed as being representative of classes of sites are chosen and the results of impact studies performed for these protypical sites are extrapolated for the purposes of regional analysis. What is of most interest for our purposes is Van Zele's method for classifying sites into "surrogate categories" to enable generalization of case-studies. Van Zele distinguishes seven "basic types of counties" for which in any one of the types the location of a particular energy facility would create similar impacts. These county types are characterized by Van Zele as follows:

- core of "large" SMSAs [Standard Metropolitan Statistical Area]
- suburbs of "large" SMSA's
- rim counties of "large" SMSA's (i.e., exurban counties)
- "small" urban counties with declining population
- nonurban counties with extensive economic activity (e.g., agriculture and tourism)

- nonurban counties with poor economic prospects.

Van Zele's system of surrogate categories is used as the context for the regionalization of social regimes as it provides an appropriate level of generalization in classifying types of social communities.*

Potential prototype regimes are displayed on a matrix formed by county type and ecodivision in Figure 10. The matrix displays 63 potential prototype regimes in which test-cases can be applied and which provide contexts for Van Zele's surrogate site analysis approach. Through judicious test-case and prototype regime selection, one can then proceed through analysis to assemble what Van Zele calls "candidate scenarios" to study the implications of future energy alternatives.

B. TEST-CASE AND PROTOTYPE REGIME SELECTION

The potential prototype regimes shown on Figure 10 should permit analysis of almost any socioecological environment in which a technology is to be deployed. A critical step in using this method will be the selection of test cases and prototype regimes. This selection should be preceeded by a preliminary analysis of the technology to be deployed and the feasibility of deployment with regard to the social and ecological environments in which the technology is to be applied. The technology profiles prepared as part of this overall task will assist in the process of selecting prototype regimes for test-case analysis. The following criteria are offered to guide test-case and prototype regime selection:

- The technology should be analyzed and found feasible for potential end-use applications in the location selected.
- The end-uses should be feasible within the social and ecological constraints posed by the location selected.

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*Van Zele (1978) also describes an alternative approach to derive classification systems through extensive statistical analysis which requires a considerable data base as well as large research funds.

Ecodivision* / County Type **	Marine (A)	Mediterranean (B)	Steppe (C)	Desert (D)	Prairie (E)	Sub-tropical (F)	Hot Continental (G)	Warm Continental (H)	Savanna (I)
SMSA core (1)									
SMSA suburb (2)									
SMSA Rim (3)									
Small urban (4) (population declining)									
Small urban (5) (population growing)									
Non-urban (6) (high economic activity)									
Non-urban (7) (low economic activity)									

* from Bailey (1976)
** from Van Zele (1977)

Figure 10
Potential Prototype Regimes

- The test location should be selected to bring out potential social and ecological sensitivities to deployment of technology.
- The test location and technology should be selected so that variables of size, timing, and design can be assessed for ecological and social impacts.
- Selection of both location and technology should be made with application to scenario assembly and policy formulation in mind.
- Selection should be made after examining the literature for impact analyses which may obviate further analysis of some of the potential prototype regimes.

The preliminary analyses referred to above will be performed as part of the test-case selection and method application process which are planned as subsequent parts of the task under which this paper was developed.

C. SCENARIO ASSEMBLY AND POLICY FORMULATION

As stated earlier, the bottom-up approach will be more useful (and used) to the degree that site-specific analysis can be related to larger geographic aggregations and, ultimately, to policy formulation. The matrix of potential prototype regimes will be useful in tracking various site-specific studies for particular technologies and in giving direction to such studies for the purposes of scenario assembly and policy formulation. For example, numerous studies for oil shale technologies have been performed for category 7-C, the nonurban county with low economic activity located in the steppe ecoregion, and we can begin to establish priority for the study of other technologies in other prototype regimes to establish a ground for comprehensive energy policy formulation based on potential local impacts. It is envisioned that this method can be used to determine research needs essential for sound national policy on energy technology development, and deployment.

Part V
CONCLUSION

A. LIMITATIONS OF THE METHOD

The usefulness of the method will be determined through hypothetical test-case analysis, and limitations of the method will become readily evident even in a hypothetical application. The method will be amended as shortcomings become evident through critique and test-case application, and this section of the paper will very likely be enlarged in future drafts. Data collection techniques will also be studied as part of the test-case process and determination of appropriate techniques will be made. As with any analytical method, limitations due to inadequate data are to be expected. Data relevant to social impact analysis will be just as difficult to come by as data on ecological system behavior, discussed earlier in the paper.

The data needed to apply this method to hypothetical test-cases will be acquired in part by a search of the literature. One way to test the usefulness of the taxonomical approach to regime description and intervention indicators is to attempt to abstract and extrapolate impact assessment across energy technologies. In other words, if the method is sound, one should not be limited to studies specific to location or technology in obtaining data needed to apply the method, and economy in research may be a long-term benefit of the procedure presented in this paper.

B. FUTURE TASKS

The technologies selected for study under this method are described in the task plan. As part of the bottom-up approach the task team placed priority on technologies which are small-scale and which have potential for decentralized applications. Also, solar technologies which have not yet received a great deal of attention in the literature were selected so that our work may further our understanding of the full potential of solar technology applications.

If the method proves useful in hypothetical test-case application, the task team would like to test the method under demonstration project conditions to obtain real-world evaluation of the limits and strengths of the method. We would also like to determine whether the selected indicators actually provide the measurements needed to assess whether or not a technology "fits" the social and ecological systems within which it is placed. Finally, we would like to apply the method to a full range of energy technologies and social/ecological regimes so that a bottom-up national energy policy and technology deployment program can be formulated.

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