HUMAN BEHAVIOR AND GLOBAL CHANGE*

I. INTRODUCTION

The United States, with 5% of the world's population, is responsible for approximately 20% of global fossil fuel consumption and 21% of global greenhouse gas ("GHG") emissions.[1] Because energy use is clearly a product of life-style, so too is the discharge of GHGs directly related to life-style. The flow of materials and energy in a society is basically a function of five interrelated factors:

(1) final demand;
(2) technologies used in producing desired goods and services, including resource extraction and processing;[2]
(3) quality of natural resources used;[3]
(4) extent of use and recovery of energy and recovery and reuse of materials; and
(5) governmental actions and policies affecting the other four factors.[4]

The impact of human behavior on global climate is most apparent in the first factor. Final demand is the aggregate of the goods and services society desires. It reflects the life-styles of individuals, non-governmental and

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1. Office of Technology Assessment, U.S. Congress, Changing by Degrees: Steps to Reduce Greenhouse Gases OTA-O-482, 3-5 (1991).

2. The unit processes and operations used by an activity to produce products and services, and, in the case of households, utility and services.

3. The quality of raw materials increases energy use per unit of output in at least two ways. As an example, first, as the quality of raw copper ore decreases, more ore must be processed to yield the same amount of copper. At the same time, the amount of mining and processing solids which has to be transported for disposal increases. Regardless of improvements in energy efficiency of extraction and processing, the demand for land for disposal of residuals will always increase as the quality of ores decrease. Second, the decline of water quality and/or air quality in some areas means that some activities must provide extensive treatment of intake water and air in order to produce with a consequential increase in energy use per unit of output.

4. Some governmental actions may affect consumer energy choices regarding the combination of raw materials used, production processes selected and products to be produced. A few examples of such actions include: product grading and labeling; energy design standards for buildings or appliances; zoning restrictions; pricing of water, energy and wastewater and solid residuals handling and disposal; subsidies for the installation of particular technological options in industrial, agricultural, and municipal operations; and tax depreciation incentives.

governmental entities,[5] and includes considerations of product mix,[6] product output specifications, characteristics of leisure time activities,[7] demands for ambient environmental quality ("AEQ") and the spacial pattern of activities.[8]

Final demand and life-style are dynamic forces, changing with economic conditions, social tastes, technology and governmental policies. The possible mix of types and quantities of materials and energy to meet a given specified final demand at any one time is affected by changes in life-style and changes in the final demand itself.

No attempt is made herein to indicate how suggested life-style changes might be induced in developed or in developing countries. Also, both individual and institutional life-styles involve a set of personal value judgments. What is deemed "essential" is a personal matter but may be reviewed on a societal level through aggregate behavior. This excerpt attempts to illuminate how human behavior—reflected in various components of life-style—affects materials and energy use that in turn affects the discharge of GHGs. The types and magnitudes of GHG emissions are directly related to the products and product output specifications demanded by voters through the political process and accepted by purchasers in the economic arena. The choices made by individual, household and institutional purchasers are the catalysts for the eventual generation and emission of GHGs.

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5. It is important to realize that energy users or those that contribute to the "final demand" for energy are not limited to individuals. Many purchasers of goods and services are institutions such as corporations, universities and governmental agencies. Of course individuals in those institutions make the decisions, but they do so as *institutional* purchasers, not as individual purchasers. These institutions have life-styles of their own, represented by numerous purchasing decisions affecting the entire institution. A government agency that equips each desk with three sizes of message pads, three sizes of Post-It notes and a "while you were out" carbonless message diary is making a like-style choice that has a tremendous impact on energy and product consumption, and therefore, on the global climate.

6. Produce mix refers to the variety of products and/or services produced by a given public or private activity. For example, a paper mill may make only one size of unbleached toilet paper, or it may produce different sizes and colors of toilet paper, paper towels, napkins and facial tissues all in bleached and unbleached versions. In general, increasing the range of products produced in a single plant complicates the production process and results in increased material and energy use per unit of product output. To produce a final product with specific characteristics limits the combinations of raw materials-production processes that can be used. The typical result of broadening product mix and increasing product specifications is increased energy use per unit of product output.

7. The energy intensiveness of some of our leisure activities is one indicator of the related energy demand. For example, all-terrain vehicles, snowmobiles, Jet Skis and power boats are highly energy intensive and have major adverse impacts on ecosystems.

8. Spacial pattern of activities refers to the distribution of human activities over the landscape, whether dispersed or concentrated, linear or nodal. The more dispersed a population, the more materials and energy required per capita or per household to provide water, sewage, electrical energy and solid wastes management for any given level of service and level of reliability.

II. LIFE-STYLE CHARACTERISTICS AFFECTING ENERGY DEMANDS AND GHGs

Life-style characteristics which affect energy demands and therefore the discharge of GHGs can be divided into four general categories: (1) change in behavior, with the structural conditions remaining the same; (2) change in product specifications, the function and the capability of performance of the product remaining the same; (3) change in product use, producing a different quality and perhaps utility of service; and (4) production of nonessential products and services.

A. Change in Behavior

The easiest life-style changes to identify for energy saving purposes are those designed to conserve resources. These types of changes are likely to come to mind in the context of energy conservation. Examples include lowering thermostats to 65°F in winter and raising them to 76°F in summer, turning off lights when not in use, and making efficient use of water in household and industrial activities.

This type of change is exemplified by behavior during the 1976-77 drought in Marin County, California where water intake was reduced by about 50%. Subsequent to the drought, water intake did not return to the pre-drought level; behavior patterns for a significant portion of the population had changed.[9]

Another example in behavior change would be a reduction in the weekly operating hours of retail stores. Unfortunately, the trend in the United States has been to increase "open" hours. Supermarkets are commonly open 24 hours a day, requiring more space heating and cooling. In the Netherlands and Austria, store hours are limited to 40 hours per week. Behaviors analogous to the 24-hour supermarket exacerbate the GHGs problem.

B. Change in Product Specifications

This change takes one of four forms: (1) proliferation of product styles or models; (2) annual changes in product models; (3) increased product complexity and products designed for obsolescence; and (4) more stringent product specifications. The net effect of all four trends is increased energy use per unit.

1. Proliferation of product styles and models has occurred in products ranging from oat bran cereal to automobiles. Only four to five years ago, canned coffee was found in two basic sizes—16 ounces and (occasionally)

9. Of course, the critique of this position argues that people's perceptions of the complexity and adequacy of their water delivery system and supporting infrastructure were so altered by the drought that they actually had less access to water, not that they chose to use less.

32 ounces. Now supermarkets carry at least nine different size cans ranging in size from $11\frac{1}{2}$ to 39 ounces. Twenty-five years ago, canned vegetables came in three sizes. Today, canned vegetables can be found in at least 22 different size cans, ranging from $4\frac{1}{4}$ to 105 ounces. Not only have can sizes changed, but product content has been "downsized". Today, a typical 16- ounce can of green beans is likely to contain only $14\frac{1}{2}$ or 15 ounces of beans.[10]

Table 1 shows the number of new grocery products introduced in the United States every year between 1985 through 1990. Note that there were 10.3 thousand new food products and 2.9 thousand new nonfood products introduced in 1990, compared with 5.6 thousand and 1.7 thousand, respectively, in 1985. In 1989, 1,155 new bakery products alone were introduced.

Table 1

INTRODUCTION OF NEW GROCERY PRODUCTS, 1985-1990
all values in thousands

Year	Food products	Nonfood products	Total
1985	5.6	1.7	7.3
1986	6.1	1.9	8.0
1987	7.9	2.31	0.2
1988	8.2	2.41	0.6
1989	9.2	2.81	2.0
1990	10.3	2.91	3.2

SOURCE: J. Harwood, *U.S. Baking Industry Responds to Consumers,* Food Review, Feb. 14, 1991 at 39-45.

The significance of this proliferation of product options is that the more types of containers used for a given total output, the less efficient the production process. The smaller the container, the more containers it takes to package the same amount of product, hence the more materials and energy used per ton of final product.

2. *Annual changes in product models* are standard practice in the automobile, clothing and appliance industries. The increase in energy and materials

10. Data on can sizes for coffee and canned vegetables are based on a survey in one supermarket, which was not the largest of its kind. (This survey was noted in a December 14, 1991 draft of this keynote paper provided by Blair T. Bower. On file with *Arizona Journal of International and Comparative Law*—Eds.).

use is significant when combined with the proliferation of models in any given year. Of course, reducing the number of models and the frequency of changing models would have an adverse impact on other industries, such as the companies supplying materials for increased production, but would decrease energy use and GHG discharge.

3. *Increased product complexity* is exemplified by the doubling of the average number of parts in a mid-size U.S. automobile over the last two decades. More parts make production and repair more difficult. The same increase in complexity has occurred with respect to appliances. "Design for obsolescence" also impacts energy use. In recent years, many products are designed to be discarded and not replaced. Personal stereos are perfect examples.

4. *More stringent product specifications* can cause increased energy use when items designed for similar uses have differing specifications. Higher brightness specifications for such items as paper napkins, paper towels and tissues provide an example. The effect of such specifications is illustrated in Table 2, which shows the residuals (nonproduct outputs) generated in the production of one ton of tissue paper in an integrated kraft mill using softwood as raw material. Producing the unbleached tissue paper requires at least one-third less energy than producing the bleached tissue paper. In addition, less raw material is required for the unbleached paper because of eliminating the 4% to 5% fiber loss in bleaching.

C. Change in Product Use, Producing a Different Quality and Perhaps Utility of Service

As technology increases, the amount of energy expended per unit of activity also increases. Exponential growth in toys and electronic equipment requiring the use of batteries provides an excellent example. Model cars, "boom boxes", camcorders, personal stereos and cordless drills all require batteries, and the trend is toward an increase in portable power, meaning more batteries.

Another example is the increased application of fertilizers, pesticides and water to household lawns in arid regions where the "hearty green look" is not native. About 50% of the total water use in Sydney, Australia is for the purpose of maintaining humid area vegetation in an arid climate. The same order of magnitude may well apply to other arid climate urban areas.

D. Production of Nonessential Products

Only talented advertisers can convince us that we really need most items sold as essential for a satisfying life. Unfortunately, there are plenty of talented advertisers. These imaginative Americans have introduced colored plastic wrap to liven up left-overs and facsimile machines to receive weather satellite maps that indicate where the trout are concentrating on Lake Michigan. These are two of thousands of the similar types of items shown in every copy of the Hammaker-Schlemmer catalogue.

It should be noted that U.S. advertisers do not have a corner on the imagination market. In Japan, in April of 1989, scent-dispensing telephone booths made their debut on Namiki Street in Tokyo. Each hour the booths dispersed scents over shoppers passing by, accompanied by the tinkling of chimes. 1989 also saw the introduction in Japan of other interesting products, such as disposable paper watches (made in China), costing less than $4 each, and $1,000 toilet bowls that spray warm water and then blow warm air across one's backside. Within a short time at least 10% of Japan's western style toilets had this feature.[11] This imagination continues unabated. In 1991—the 200th anniversary of Mozart's death—the Japanese manufactured brassieres equipped with tiny speakers that play Mozart while tiny lights in the fabric flash.

III. PROBLEMS IN ASSIGNING ENERGY DEMAND VALUES TO LIFESTYLE CHANGES

Human behavior research has failed to produce convincing data regarding its effects on global climate. No quantitative, integrated research on a national scale has emerged from the discourse surrounding the effect of human behavior on global climate. This limitation fosters qualitative illustrations with little meat on their hypothetical bones. The dearth of available quantitative data makes it difficult to impute the relative importance of the different behaviors studied.

Part of the difficulty in assigning values to the relative impacts of life-style changes on energy demand is associated with their two way or ripple-back effect. A life-style change often results in a decrease in energy use in the production of the product, in the processing of materials and energy inputs to make the product, and in the extraction of raw materials that provide those inputs. For example, a shift from a bleached paper napkin to an unbleached napkin reduces the energy required at the paper mill and reduces the energy required in all steps of processing the materials before and after arrival at the mill, since not using bleach eliminates the fiber loss that occurs in the bleaching operation. This shift also reduces the pollution generated at the mill, which in turn reduces the energy required to modify the residuals that are generated. Any identifiable change that reduces aggregate energy use throughout a production system will result in a reduction in the discharge of

11. Of course, using this example could be an indication of cultural ignorance. Americans heat the whole bathroom even though we really only desire a comfortable seat, yet we criticize the Japanese for only warming the seat. Energy use and efficiency may well be a matter of perspective.

GHGs. A change that reduces aggregate materials use throughout a system will result in a net decrease in energy use provided that any substitution of energy for materials in the system does not result in an increase in net energy use.

The other difficulty in assigning values to the relative impacts of life-style changes on energy demand is related to AEQ. Degradation of AEQ has led to increased pressure to reduce discharges, which beginning in the 1970s primarily focused on decreasing the amount of sewage dumped at the end of a company's drainage pipe. This approach requires material and energy inputs that increase incrementally as the degree of removal increases. In addition, the material removed requires disposal and thus adds another element of energy demand. Even where the discharge-reducing measure is a change in an internal process, the result can still increase energy use.

As waste treatment technology improved, it became clear that the most efficient discharge reduction involved a reduction of nonproduct outputs in the first place. Decreasing nonproduct outputs can only be achieved in two ways. The first involves waste minimization, pollution prevention and source reduction. These terms often are used to describe the now preferred strategy in the context of *maintaining product and service specifications.* The second goes one step further to include *modification of life-style.*

There is quite a difference between making quantitative estimations of the *net* effect of production on energy and materials use in any given producing sector and understanding the interplay between resource use and energy consumption. For example, Department of Commerce data on water intake per ton of specific paper product output by the pulp and paper industry showed a substantial decrease between 1959 and 1969. However, investigation showed that *total* water use per ton (gross water applied) had increased substantially over the same period. Production efficiency increased, but so did overall production, and therefore, so did overall energy use.[12] A researcher's investigation into the interplay between resource use and energy consumption, therefore, can play a large role in data interpretation.

IV. SUGGESTIONS, CONCLUSIONS AND QUESTIONS

Life-style affects energy and materials use and hence impact the discharge of GHGs, despite the fact that the implications of life-style never became a central focus for any of the environmental groups. The elements of life-style presented above represent only a small subset of the life-style elements comprising final demand.

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12. It is also possible that this increase in total water use was a result of the industry's increased use of higher brightness products and bleached paper. Higher brightness, more bleaching and increased recirculation result in a significant increase in energy use and residuals generation at the mill.

The significance to be attached to the various dimensions of life-style must undergo long-overdue rigorous analysis. Moreover, the existing pattern of elements in final demand reflects only attitudes and perceptions. There has been a *failure* to relate individual and institutional behaviors to their effects on energy, materials and the environment—the connection has not been made.

These conclusions lead to a few questions:

> What do users perceive as the relation between life-style choices and resource use, waste generation and environmental quality?
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> Will perception of these relationships alone cause changes in life-style?
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> If not, what incentives might be used to induce significant changes in behavior of producers, and individual and institutional users?