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GOALS: OBJECTS AND MEASURES OF PROGRESS

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ABSTRACT

One of the most useful outputs of systems and market analysis is a concise statement of technology goals. This short paper introduces the concept of goal-setting as previously developed in other programs of research and development. In this context "goals" are merely the visible output of a systematic translation of market requirements into research and development actions. Cost goals are one type of information linkage between market and research, although a complete statement of technology goals must include both tangible and intangible physical requirements as well. The process of devising goals and measuring progress against these goals is briefly illustrated in an example from the Solar Industrial Process Heat Program. The process of establishing a program framework and program goals has not been completed for solar process heat; it is hoped that this paper will encourage steps in this direction.

THE MEANING OF GOALS

It has been said that if you have no goal, then any path will get you there. Restated, this precept implies that a lack of goals leads to some degree of aimlessness; in fact, that the absence of a goal is the absence of any guarantee of progress. For most of us there has always been a clear and unreserved need for goals. What is unclear, however, is the precise meaning of the term "goal" in given situations, particularly with respect to technology development. Is a goal a single number, like \$/MBtu or mills/kWh, or is a goal a set of many related numbers? Is a goal quantitative like "ft^2 installed" or qualititative like "acceptance"? And finally, are goals set once and for all, or are they variable, destined to swing with the vagaries of the market or the realities of research? Goals for new technology, just as goals in management, politics, or human relations, are not effective unless these questions are answered and precise and useful definitions obtained. This paper attempts to define the meaning of research and development goals by describing their purpose, the framework in which they are determined and utilized, and the process of program development to which they contribute.

Webster defines a goal as "the end toward which effort is directed" hence, an "objective." The definition of a goal as an object of effort is undoubtedly the most familiar to us. However, Webster also indicates that goals are a form of scoring system, that is, "measures" of our progress toward some end. It will become clear in the following discussion that goals must be both objects and measures of progress. Effective goal-setting provides both ultimate and intermediate targets, and through the process of program review, goals provide a measurement of our success.

A PROGRAM FRAMEWORK

Federal support of solar energy research and development is predicated on the ability of solar technologies to contribute significantly to the energy supply of the United States. Therefore, solar research must be an applied research program with accountability to the energy needs of various users. This accountability does not require that the market always dictate technological advances nor that research always contribute directly to meeting or modifying those needs. Accountability does require, however, that the relationship of research and development (R&D) activity and market needs be recognized and that development programs have a structure such that information flows freely from market to research activities and such that the accomplishments of research activity impact current market needs. (See Fig. 1).

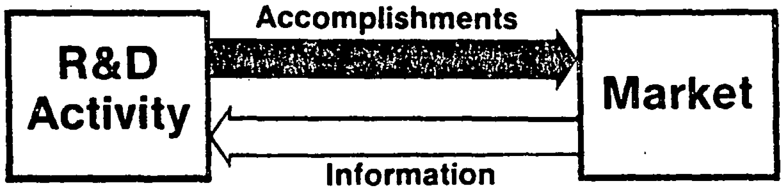


Figure 1. The Relationship of R&D Activity and Market Needs in an Applied Research Program

In the private sector the communication between market needs and research occurs with little conscious effort required to facilitate it. Private market forces of supply and demand are at play to allocate effort devoted to commercially viable technology. For developing technologies where government support is elected, however, this private market communication mechanism does not exist. By setting program goals, we are attempting to reproduce in an imperfect way a market structure for which no free market presently exists.

In Fig. 2, two basic functions of market/research communication are suggested. These functions are primarily related to cost since cost (or price) relationships are the traditional mechanism through which the market and R&D activities communicate. Beginning with an assessment of energy use, including the status of competing energy prices, required investment returns, risk and other application related factors, a "cost model" is constructed to interpret market needs and to yield a competitive price goal for the new technology. Given this price goal, the analyst must provide a "goal allocation", that is, the translation of a price goal into specific technological goals. Goal allocation consists of identifying required system performance and required system, subsystem, or even component costs. The level of detail to which this allocation is taken depends upon the detail required to direct R&D activities.

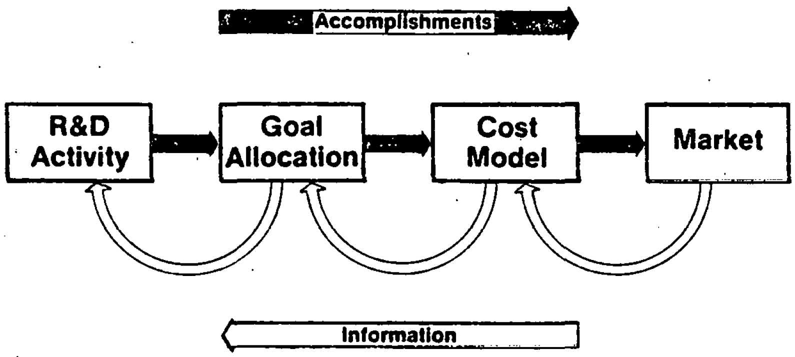


Figure 2. The Conventional Economic Linkage Between Market and R&D

In the same way that information is transferred from the market to R&D activity, progress in research and development can be compared against market needs by reconstructing a price from new performance and cost information. In this direction (see the "Accomplishments" arrow in Fig. 2) the analyst must model the performance of the new system, subsystem, or component and calculate new overall costs of energy. This cost is compared directly to the price goal earlier established or to new or modified market conditions through the cost model.

Actual free market communication is considerably more complicated than shown in Fig. 2. Figure 3 shows a more complete framework in which traditional economic factors link market and R&D activities across the top and where noneconomic factors are shown across the bottom. Note that a behavioral model and an economic model are shown separately. Information on decision behavior contributes to the construction of the economic model and also provides some noneconomic information (such as attitudes toward risk, public awareness, innovative spirit, etc.). In addition, the interpretation of the physical performance requirements of the user is shown contributing to the formulation of system simulation models (a part of "cost goal allocation") while also contributing to the transfer of information directly to research that is not directly associated with measurable cost or performance (such as simplicity or environmental acceptability).

Figure 3 is a complete representation of a goal-oriented program framework. Functions, data, or activities are shown in boxes, while information linkages, indicated by blank arrows, result from the goal-setting process. As an example of the process of program review within this framework, a typical problem in solar process heat applications will be examined.

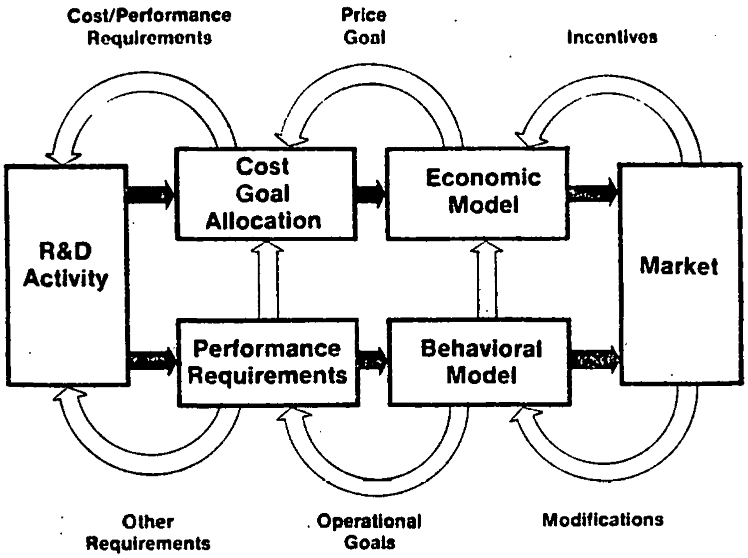


Figure 3. A Complete Goal-Oriented Program Framework

AN EXAMPLE OF GOAL ALOCATION

A great deal of work has been done in designing representative solar thermal systems for industrial process heat (IPH) and in projecting levelized costs and/or rates of return for such projects. Much less has been done in determining the contribution of manufacturing and installation to the costs of solar thermal IPH systems. Without an allocation of price goals among categories such as the cost and productivity of field labor, the cost and efficiency of solar collectors, costs of field piping and so on, R&D activity cannot be directly linked to market needs.

Cost goal allocation is basically a process of cost engineering analysis. For example, Fig. 4(a) illustrates the process of deriving the required cost of collector equipment (in $\$/ft^2$) from an initial price goal of \$6/MBtu, given a system average annual output of 0.30 $(MBtu/yr)/ft^2$. Such an analysis indicates that collectors must cost $\$4.13/ft^2$ given the current status of field installation practice. More significantly, the analysis indicates that other more important areas for cost reduction may exist (such as a reduction in field labor-to-materials ratio). Using projections for improved field labor-to-materials ratio and indirect cost allowances, the analyst can also work backward through the cost goal allocation process to compare the current cost and efficiency of collectors ($\$19.00/ft^2$ and 0.30 $MBtu/ft^2/yr$) to the established IPH Program goal of \$6/MBtu [See Fig. 4(b)].

Attention only to simple cost and performance goals neglects important market needs that are not so easily quantified and yet are of critical importance to the acceptance of new technology. The analyst must interpret the general operational requirements of the user and obtain specific goals for components and subsystems. For example, interviews with plant engineers in several industries have indicated that energy supply systems will be required to meet acceptable safety standards, environmental standards, not interfer with plant processes, and be simple to operate and maintain. These general goals are easy for the user to state; the job of the analyst is to translate them into subsystem and component requirements that are concrete, e.g., restrictions on certain heat transfer fluids used, provisions for booster heating or buffer storage, and standards for solid-state controls. While translation in noneconomic areas is more difficult to accomplish, it is nonetheless crucial to the effective introduction of solar IPH systems into the industrial market.

PROGRAM REVIEW PROCESS

The proper definition of goals, the establishment of a program framework, and the creation of the models for goal-setting are only a part of effective R&D program review. Program review is a process with identifiable steps. Obviously, the process must begin with the gathering of data on the status of the market and on the state of the technology applicable to the market. These data support the development of appropriate models and also contribute to the formulation of various goals. R&D progress toward such goals should then be measured on a regular basis. In addition, due to changes in market needs and the advancement of competing technologies, these goals and models must be reviewed and revised regularly. In short, program review and management entails:

(1) The establishment of an appropriate comparative framework;

(2) the provision of timely data;

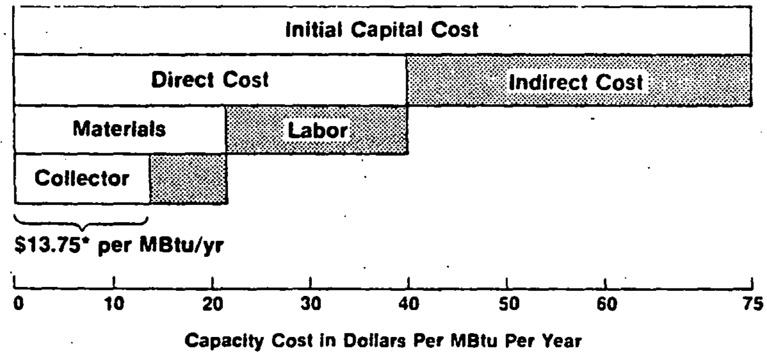
(3) the creation of required models;

(4) the fixing of goals; and

(5) regular review and revision of data, models, and goals.

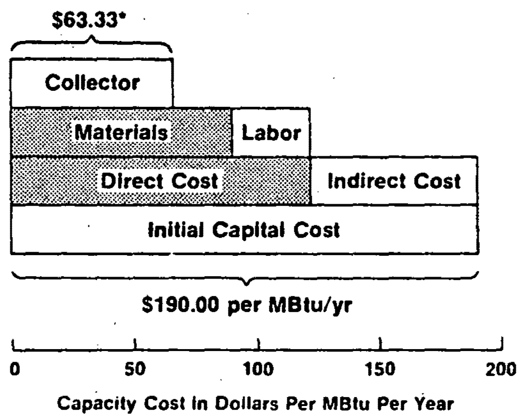
CONCLUSION

The principle of "management by objectives" has been widely advertised to almost every level of private and public administration. While the conventional meanings often attached to this principle may seem only distantly related to technological innnovation, it is still possible to apply "objective management" principles in the creation of goals that can be used to give emphasis and direction to a research and development program. To state that solar IPH can (or must) contribute 2.6 quads of energy by the year 2000 is not enough to guarantee success in meeting that goal. While "2.6 quads" is a goal, it is not a goal on which progress can be usefully measured or toward which research can be specifically directed. Long-term goals must be supported by more specific and short range objectives. Progress toward long-range targets must be measured regularly and new, more fruitful, directions identified quickly; this requires that a tactical framework for program review be adopted and followed. The goals we set, and more importantly, the roadmap which we select, are the only guarantees we have that "progress" will be more than just aimless wanderings along any path toward nowhere.



* For annual energy yield of 0.30 Btu/yr per square foot, the required collector cost is $4.13 per square foot.

Figure 4-a. Allocation of a Price Goal of $6.00/MBtu to Require Collector Costs in the Near Term. (An industrial fixed charge rate of 8% is assumed. The required initial capital cost is then $6.00 divided by 0.08 or $75.00 per (MBtu/yr) initial capacity cost.)



* For an annual energy yield of 0.30 MBtu/yr per square foot, and a collector equipment cost of $19.00/ft², the collector capacity cost is $63.33 per MBtu/yr.

Figure 4-b. Comparison of System Costs to a Goal Given Current Collector Costs and Projected Eventual Distribution Among Cost Categories. Using an 8% industrial fixed charge rate, the levelized cost of energy from the system is 0.08 × $19.00 or $15.20/MBtu. The cost per square foot installed is $190.00 × 0.30 = $ 57.00.