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STANDARDS, WARRANTIES AND COMMERCIALIZATION

OF NEW ENERGY TECHNOLOGIES

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ABSTRACT

Several federal energy programs aim to "commercialize" new energy technologies, i.e., to bring them from research to the market. Product standards and warranties are sometimes a part of these programs. Yet the benefits which the standards and warranties are to achieve are rarely articulated, and how these benefits will be achieved is often even less clear.

This article takes the view that the substantive goals of standards and warranties can be articulated. It examines the functions of standards and warranties and the processes which produce them, and casts their effects in terms of impacts upon the new technology's demand, supply and industrial market structure. The relevance of these impacts upon commercialization programs is then discussed, covering the role of standards in the new industry's development, the need for standards and warranties in demonstration projects and in the private financing of new energy systems, and mechanisms for development of standards and warranties. The need for basic research on standards and warranties is then addressed.

STANDARDS, WARRANTIES AND COMMERCIALIZATION OF NEW ENERGY TECHNOLOGIES*

I. INTRODUCTION

The introduction of a new product into the marketplace requires adjustments and raises concern, or at least questions, about the new product. Its proper and safe use must be explained to consumers. How it meshes with related products must be understood. The reliability and safety of the product must satisfy the customer, preferably in advance of sale. Information concerning the product such as size, rating, and operational characteristics must be presented to the potential consumer to allow him to evaluate the product and compare it with others. Responsibility for the product's failure to meet expectations must be established.

Product standards and warranties help to regulate the interactions among buyers, sellers, manufacturers, and repairers concerning the vast array of products in our society. By addressing the concerns raised above, they flesh out many aspects of marketplace transactions. Such transactions, being far more than mere exchanges of "goods for bucks," involve questions of the product's usefulness: whether the product will perform a certain function, whether it will operate in conjunction with another piece of equipment, etc. It is not merely from ownership of the good that the consumer derives benefit; rather it is from the uses to which the good may be put. Standards and warranties help to indicate what those uses are and how adequately a given product fits them.

Historically, articulation of standards and warranties so that they achieve these purposes has occurred mostly through voluntary private procedures. Once a product had become established and experience with its use had accrued, the needs which standards and warranties could fulfill became clearer, and groups such as trade associations would from time to time respond to such needs. More recently, various consumer and regulatory groups have begun to recognize the usefulness of standards and warranties for shaping the workings of the marketplace; mandatory use of standards and warranties for policy purposes has risen.

Nevertheless, while development of standards and warranties has proceeded when the need has been generally recognized, planning to achieve identified substantive goals has not been emphasized. Rather, the emphasis has been on the process by which the standards are reached; if the process is voluntary and open, then the results are considered satisfactory. The validity of this process has come into question recently, and so have the resulting standards and warranties.

The need to determine whether a standard or warranty is "good" or not increases with the importance of the benefits which the standards and warranties can bring. The current "energy crisis" has raised this importance because of efforts to "commercialize" several new energy technologies. (Commercialization is the process by which a governmental agency assists a technology's progress from research all the way through introduction of the product into the marketplace.) Many of these commercialization efforts call for development of standards, warranties, or both in furtherance of their goals. Yet by and large these efforts rely upon the voluntary process not merely to produce the standards and warranties but also to legitimize them. In essence, the resulting standards and warranties are judged by the process which produces them and not by their substance.

Whatever the validity of the process model for established technologies, differences for technologies undergoing the process of commercialization cast doubt upon process as the sole source of legitimacy. The technologies involved are undergoing technological change, in some cases rapid; the effects of standards and warranties upon the rate and direction of technological change must be considered. That no market or only a very limited one exists for these technologies indicates that little user experience exists upon which to draw for formulating the standards and warranties. And the accelerated nature of the development efforts may yield further complications for information flow.

It is argued herein that the use of standards and warranties in the commercialization of new energy technologies can proceed on a planning basis instead of merely relying upon process, i.e. that purposes for standards and warranties can be established and strategies for achieving them detailed instead of allowing the process to determine the standards and warranties. Furthermore, this planning basis can best be understood by examining the market functions of standards and warranties and the developing market context in which the standards and warranties will operate; from examining this conjunction of possible effects with desired ones, intelligent plans can be developed. While the market context surrounding any particular new energy technology is not explored below, some generic problems of commercialization efforts are examined. The analysis begins with an examination of how standards and warranties function in markets.

II. THE OPERATION OF STANDARDS AND WARRANTIES

Standards and warranties each serve several distinct functions in markets. Moreover, each serves some functions which the other does not, even though they are closely related. Furthermore, the processes involved in the creation and operation of each are different. These various functions and processes, the understanding of which is essential to analysis of the issues, are discussed below.

A. STANDARDS

For the uninitiated, a few examples of standards may help. Measurement of time (hours, days, years, etc.) is the classic (one is tempted to say "standard") example of standards; without agreement on these units, the entire operation of today's world might grind to a halt. Size (inches, meters) and weight (grams, tons) are other examples of standards in commmon use. Standards for uniformity such as those for nuts and bolts constitute another type of standards. Safety standards such as those for the flammability of children's sleepwear are one example of quality standards.

While standards are not susceptible of precise definition, they seem to be fully described by their two basic attributes: the information they provide to their users and the agreements they represent among some or all users. For example, size classification standards for tires provide the following information and more: they tell consumers the number and variety of tire sizes offered in the marketplace, they inform producers what sizes to produce (and what sizes other producers are producing), and they inform consumers that a tire of a particular classification can be used to replace another tire of the same classification, regardless of the manufacturer. Similarly, they represent at least the following agreements: that manufacturers will all limit size variety the same way, that the classifications established suit all major users of the tire (e.g., commercial vs. pleasure driving), and how tire manufacturers and automobile wheel manufacturers will coordinate so that tires will mesh with wheels.

In addition to "defining" standards as both containing information and representing an agreement, standards can be described in at least two different ways: function and process of development. Each is discussed in turn.

1. Function

Standards can perform many different functions. These functions include establishment of product uniformity, compatibility, product quality, and test and measurement methods.

Product uniformity can be established through standards. Here it is defined as one product's being identical to another of the same type in certain designated aspects such as size and weight. Writing tablets, for example, come in only a few basic sizes and line widths. By making products uniform, the range of variety (and its associated inventory and distribution costs) required for doing business falls; this decline in variety encourages economies of scale. For example, standardized window and door sizes greatly simplify construction of new housing. Also, product characteristics are better defined, and consumers are more likely to absorb information concerning the product when a reduction in variety simplifies the consumer's choice.

Related to the uniformity function is compatibility; standards can be established which ensure that, for example, a solar device is compatible with other components necessary to complete the system or with devices of another manufacturer. Compatibility often follows from uniformity (a good example is bricks which must be compatible with themselves), but it adds another aspect in that it insures that the product fits with related products. Nuts and bolts are the classic example; while each can be made uniform, they are worthless unless they are compatible with one another. Because compatibility standards permit the use of interchangeable parts, they are often referred to as interchangeability standards. Interchangeability of, say, one nut for another necessarily results from nuts and bolts designed to fit one another; the principal point is that they fit, however, and not that one nut can be substituted for another.

Quality levels can be established using standards; lifetime of a solar system might be one example. Quality can be established implicitly by uniformity and compatibility standards; one example is a 2 x 4 piece of lumber, which in addition to being a standard size (1-5/8" x 3-5/8") has known and specified structural characteristics. Also, quality standards perform some of the risk-allocation functions of warranties (see below) in that they determine what level of prevention of accidents (in, e.g., a safety context) the manufacturer will build into the product, the costs being borne by all consumers of the product. Auto safety standards are an obvious example.

Finally, test methods for agreeing upon lifetime or reliability (for example) can be established using standards. The importance of test methods cannot be underestimated; through these, compliance with all other standards is verified. The test method may vary from a simple measurement (using a standardized yardstick) to a complex test involving a determination of whether a solar heat collector filled with its working fluid will stagnate and fail if pumps are inoperative for 30 days.

2. Process

Standards can also be described by the process used to develop them. Different processes representing different levels of public involvement distinguish the various processes. They range from company standards which reflect no public involvement to industry standards, full consensus standards, and finally mandatory standards, the last being backed by the full force of law. Differences in the reasons why producers, consumers, and regulators might want to participate at any level in the standardization process influence the development of policy for using standards in commercialization.

At the lowest level of public involvement is the company standard, applicable only to the goods of one firm. The standard is very likely internal to the company, applying only to the company's assembly line to ensure interchangeability of parts during assembly and thus being invisible to the marketplace. Such standards function essentially as management tools for the individual firm, and as such are beyond the reach of wise policy.

When the need for intercompany, or industry, standards arises, trade or technical associations often develop standards. These standards often free the industry from dependence upon individual suppliers of parts. Such was the case for the young automotive industry, which standardized screw and bolt sizes, steel composition, wheel and rim sizes, and spark plugs, among many others.[1] Participation by the companies affected, and usually in relation to the products purchased from other industries, characterize industry standards.

The private standard employing the widest participation is the full voluntary consensus standard, developed under the auspices of one of the private standards organizations such as the American Society for Testing and Materials. Often the content is similar to that of industry standards, but the process of arriving at the standard differs. While procedures vary from organization to organization, several common aspects emerge. After establishing the need for standards in a particular area, participation is invited (with varying degrees of inclusiveness) and committees begin drafting the standards. After completion of committee work the standards are approved or rejected by the organization as a whole. Despite the term "consensus," unanimity is not usually required, nor are all groups necessarily represented. Also, use is voluntary; no sanctions (other than "market sanctions" which might follow from being out of step with others) result from failure to follow the standards agreed upon.

Somewhat different in terms of participation are standards mandated by federal or state law. Mandatory standards, while possibly identical in content to voluntary ones, differ in their operation; additional legal rights and duties often exist and governmental agencies may have a right to intervene or dispense justice in cases of dispute. In many ways mandatory standards are less flexible than other standards; their use is best justified when standards would not be forthcoming from private sources, e.g., when large numbers of consumers find reaching agreement or even initiating action too difficult.

B. WARRANTIES

Warranties form part of the contract between buyer and seller. As such they are legal creatures, governed by contract law. Yet they perform economic functions as well. While many of the functions are similar to those of standards, especially in the case of industry-wide warranties, a few functions are special to warranties.

1. Function

Warranties function primarily by reference to standards, thus making the standards part of the contract. For example, a contract for the sale of tires of a specified size (F70-14) incorporates the standards describing that tire into the contract; the description of the tire becomes a warranty that the tires will conform to the description. This is the predominant, if somewhat mundane, function of warranties: to make the terms of contracts more certain.

The standard referred to in the contract may be specific to that contract (i.e., created by the contract) or may apply to all sales in that industry. Through the device of reference, any of the functions of standards can obtain if the warranties are industry-wide. Returning to the example, if all contracts for sale of tires refer to the sizes specified in the tire standards, then the simplification of variety contemplated by the standardization scheme is achieved.

But warranties perform further functions, functions of greater interest here. Most important of these functions are: 1) insurance, or spreading the risk of product failure among buyers; 2) distributing the risk between buyers and sellers; and 3) improving the quality of information. Each is discussed in turn.

Warranties can serve as a form of insurance, spreading the cost of various possible mishaps among all consumers of the product. They achieve this result in the following way. For a given volume of sales there exists a mishap cost, i.e., a percentage of units which will fail in some way and require repairs, thus incurring cost. While the incidence of this cost will vary from one consumer to another, the total of these costs is likely to be a relatively constant fraction of total sales revenues if many units are sold. A warranty places this cost burden upon the manufacturer. The manufacturer, in order to stay in business, will raise the price of each unit sold under warranty by the <u>average</u> mishap cost per unit. This increase in price over the price of an unwarrantied unit represents the insurance "premium" paid by the consumers to protect them against above-average mishap costs.

For example, suppose that a solar system with a five-year warranty covering system failure costs 10% more than a solar system without any warranty. The 10% increase in price is paid by all consumers and protects them from the cost of a breakdown in the system. Consumers of unwarrantied systems will average out to paying the same 10%, but the loss is spread unevenly; if failure is total when it occurs, nine out of ten will face no loss while one out of ten will face total loss over the five-year period. Facing the risks this way (without warranties) is self-insurance; its desirability will depend upon the cost of the warranty and the cost of the consumer's own actions to avoid mishaps.

Also, warranties distribute the risk for preventing failures between the seller and buyer. For example, a warranty against an instrument's failure in an environment of 100% humidity will cost the buyer more than a warranty against failure at lower humidity, but it saves him the cost of dehumidifying the operating environment. The rational buyer, in order to lower the total cost of purchasing and using the product, will demand a warranty which will minimize the sum of production, warranty, and failure avoidance costs. Either party can prevent the accident (instrument failure at high humidity); the warranty determines who faces the burden of failure and encourages that party to take appropriate action. If the warranty against failure at 100% humidity is chosen, the manufacturer will redesign the product to minimize production and warranty costs; if the weaker warranty is chosen, the buyer will face lower product and warranty costs and will take steps to dehumidify the instrument room. Warranties can be used to allocate responsibility of action to the party which can avoid the accident at the least cost, thus minimizing the total social cost of producing and using the product. (Quality standards can be made to operate similarly, by setting the quality level such that further improvements in quality are cheaper for the buyer/user to provide than for the seller/manufacturer.)

Finally, warranties can be used to help assure the quality of information. Acquisition of information has a cost, and it is often easier for, say, an auto manufacturer to provide the information on the safety of the brakes and the engine through a warranty than for the consumer to develop that information through special testing. The warranty helps to assure the information regarding the auto's safety by making the seller responsible for the warranty's truthfulness.

2. Process

Warranties fall into three basic types: express warranties, warranties of merchantability, and warranties of fitness for a particular purpose. An example of the first type is given in the preceding section: an express statement which forms part of the agreement and concerns the product's quality results is an express warranty, and its breach gives the buyer legal remedies. This is the familiar form of warranty, enforced ultimately by state courts of general jurisdiction. Deceptiveness in express warranties is also governed by the Magnuson-Moss Act which empowers the Federal Trade Commission to regulate warranty practices.

The other two types of warranties are called implied warranties because they are not explicit but rather arise from the context of the transaction and the market environment; in short, they are implied from the facts surrounding the contract. Both form a backstop to the extent to which caveat emptor is followed by courts. While relevant to the problem of warranties in general, they are important here only to show the "baseline" warranties without express warranties.

C. EFFECTS OF STANDARDS AND WARRANTIES

Standards and warranties can affect the market for the product they cover in any of three principal ways. They can affect the cost of the goods supplied, they can affect the demand for the goods, or they can alter the competitive structure of the market. A single standard or warranty is also likely to have multiple effects. For example, a standard which effectively bans all but quality products when quality is difficult for the consumer to determine has the effect of elevating the average quality in the marketplace, thus increasing demand (shifting the demand curve outward) by reducing the likelihood of purchasing a "lemon." But it also is likely to raise prices, thus reducing consumption (moving up the demand curve), and to exclude certain firms from the market, thus limiting competition. All the various effects which might result must be weighed before any intelligent judgment concerning the desirability of a standard or warranty can be made.

The potential of each type of effect for a developing technology is discussed below, with possible pitfalls.

1. Effects Upon Demand

Standards and warranties have the potential for expanding demand for a new product in several different ways. They can provide quality assurances to prospective buyers, they can provide other product information to buyers, and they can ensure that the product is compatible with related equipment. Each possible route to increased demand is explored below.

Quality assurance. Standards and warranties can assure a product's prospective purchaser of the product's quality in one of two ways: they can raise the average quality of the goods available in the marketplace or they can increase the buyer's certainty that the goods purchased are of a predictable (to the buyer) quality.

In the first case, demand increases because goods of inferior quality, which are in many instances indistinguishable from goods of higher quality, vanish from the marketplace; with assurances to the consumer of minimum quality, the item for sale thus appears more attractive. Minimum quality levels can be established by either mandated standards or warranties or can be reached through the usual voluntary process. In situations in which the industry demand would increase if goods of lower quality were excluded, industry associations have an incentive to establish minimum standards and warranties and governmental intervention might not be necessary.

Similarly, grading of products (e.g. grade A eggs, choice beef) can assure the prospective purchaser that the particular item selected for purchase more closely approaches a given quality, thus narrowing the range of uncertainty facing the purchaser and reducing the cost of obtaining information concerning the product's quality. Minimum quality standards and related warranties will also do this, though grading is a sharper instrument.

These are the only two ways standards and warranties can increase the quality of goods in the marketplace. They cannot make an inferior good superior. The best they can do is to focus manufacturers upon particular quality levels, thus directing all productive resources toward producing items of minimum or graded quality. Further, this additional quality comes at a cost, since superior goods cost more than inferior ones. Additionally, by excluding goods below a minimum quality or confining consumer choices to specified grades, the variety of products available to the purchaser narrows, thus reducing demand somewhat. These negative concerns must be balanced against the benefits which might flow from using standards and warranties for quality assurance.

Warranties can also function apart from the related standards to reduce the variation of quality which the buyer receives. By warranting against certain types of failures, the buyer has some assurance that he will be reimbursed for deviations from expected quality, thus increasing the buyer's confidence that he is getting what he wants. This use of warranties becomes much like any insurance policy against failure, and the cost of this policy must be paid up front, thereby increasing the initial cost. This increase in cost to gain an increase in demand does not necessarily result in a standoff, however. If buyers are averse to bearing risks regarding quality, the insurance function of warranties will produce a net increase in demand. Increased warranty coverage will not always result in increased demand, however. Some failures are easier (less costly) for the user to avoid or repair than for the manufacturer; a full-coverage lifetime warranty would require manufacturers to cover these failures, thus raising costs in the long run. (See discussion of allocating risk between seller and buyer above.)

Providing product information. Standards establish the yardsticks by which many product attributes other than quality (such as weight, size, and color) can be described. These "yardstick" standards differ from quality standards in that they describe rather than prescribe; better or worse is not at stake. They are needed to implement any quality standards or warranties. The yardstick standards can be used to provide to prospective purchasers much information needed for comparing different products.

The obvious basic information needed for solar products will be items such as voltage, peak power, size, weight, etc. Development of test methods and measurement techniques is essential. But some evaluative bits of information will also prove quite useful. Because many factors affect the value of a solar system to a prospective user (e.g. insolation, system efficiency, cost of an alternative source of power such as the utility, and cost of storage), simply presenting the information may be of limited usefulness. Some standardized method of translating these factors into value to the consumer would provide additional product information.

Compatibility. To be useful, solar equipment must be compatible with related system equipment, and the systems which result must be compatible with the electric utility grid for grid-connected applications. Standards which establish this compatibility will permit the demand for new energy technologies to expand by insuring that an interface with complementary technologies will exist. One expects that manufacturers will work to achieve this compatibility because it will expand the demand for their product.

2. Effects Upon Cost

Both standards and warranties can affect the cost of products. Standards can be used to affect both the costs of production and the rate and direction of technological change for the product; warranties can distribute the total social costs of using and maintaining a product between buyer and seller so as to minimize those costs. Each effect upon cost is discussed in turn.

Production costs and technological change. Standards can affect the cost of products in several ways. Assuming no technological change, company standards can facilitate the use of assembly lines. Having a set of established sizes for a product (such as lumber) can reduce inventory needs by reducing the variety of products requiring storage and can allow greater economies of scale for the fewer items in production. These uses of standards are important and are considered to be the major benefit of standards by some; their pursuit was the focus of standardization activities in the 1920's under the direction of then Secretary of Commerce Herbert Hoover.[2]

But the interaction between standards and technological change proves the most interesting for new energy technologies, because most cost reduction expected for the technologies will come from technological change. While ordinarily standards are developed for technologies already established, many new technologies are under development, and the possibility of effects of standards upon technological change in these technologies becomes important.

Several types of effects which might follow from the interaction between standards and technological change are of concern here. Some notion of the proper timing of standards in the technology development process is important; the differences between the consequences of early versus late standards development may be critical. Also, ways in which standards might affect the rate and depth of technological change should be addressed. Finally, the effects of the two possible types of errors (developing standards when unneeded vs. not developing standards when needed) must be compared.

Despite the complexities of the process of technological change[3], two basic insights will highlight the major interactions between standards and technological change. First, because the process of technological change for any product is fraught with multiple uncertainties, some staging of the process is necessary to keep costs in line and the research manageable. Breaking the process down into the stages of research, development, introduction, and diffusion,[4] one can see that the need for information and consensus varies as the technology moves from research to diffusion.

Table I summarizes these differences. The key point to be drawn from it is that only some standards need to be developed at any given stage of a product's development. As the details of the technology become clearer, standards can become more rigid without interfering unduly with subsequent technological change.

A second insight is that experience with one technological option will result in learning effects which will reduce the cost of that option, thus making it comparatively cheaper than other options. This may be called the bias of experience and has some implications for standards development for a technology such as photovoltaics which is undergoing rapid technological change.

If one distinguishes between learning-by-doing[5] on the one hand and discrete technological change (which requires reorientation of productive activities) on the other, one can see that standardization of a product will essentially block out the possibility of discrete technological change while permitting all production efforts to focus upon learning activities. So, ideally, standards should be developed when the likelihood and possible benefits of further discrete technological change is low compared to the opportunities for learning effects to accrue.

Ideal timing is, however, unlikely. But the errors which flow from being early or late are not the same. While the magnitudes of these errors cannot be measured with any certainty, they can be compared qualitatively. If standards development occurs while opportunities for discrete technological change are high, technological options with great long-run potential may be excluded; the standardized option accrues learning effects, thus making it increasingly favorable when compared to

TABLE I

ROLE OF STANDARDS IN THE VARIOUS STAGES OF TECHNOLOGY DEVELOPMENT

STAGE OF DEVELOPMENT	APPROPRIATE STANDARDIZATION ACTIVITIES	INAPPROPRIATE STANDARDIZATION ACTIVITIES
RESEARCH	Only the most elemental terminology	Detailed technology or measurement procedures Any product standards
DEVELOPMENT	Terminology Measurement and test procedures Late in stage, production technology characteristics	Fixed product standards Product grade and quality standards
INTRODUCTION	Obvious interchange-ability standards Preliminary grade and quality standards	Detailed interchange-ability standards Full product standards
DIFFUSION	Full product standards	Standards which lock out future advances Standards which detrimentally affect non-technological concerns such as market structure and consumer welfare.

SOURCE: Bottaro (2)

undeveloped options. Such an error can produce a permanent change in the opportunities for long-term cost reduction by closing out an option which might achieve greater long-run cost reduction. But if standards development occurs late, the main consequence (as far as technological change is concerned) would be a delay or postponement of learning effects for the ultimately dominant design. The starting date for accruing learning effects is postponed, but the risks of errant selection of the dominant design are reduced, thus reducing the risk of delaying technological change or placing an artificial ceiling on the extent of technological change obtainable. So when the matter of timing is in doubt, erring on the late side is preferable from considerations of technological change. (Other considerations discussed elsewhere must, of course, be balanced.)

Given that many discrete options are still being considered for many new energy technologies, delay in standards development may be warranted here. Because of the relative costs of error, standards development for new energy technologies should probably await some settling down of the technologies before full product standards are developed. However, standards covering terminology and test procedures would help develop and exchange information.

Total social cost. Warranties can reduce the total social cost of using and maintaining a product. They can achieve this result because of differences in the situations of the consumer and producer.

The consumer and producer of a product have access to different information concerning the product and its use and face different costs of action for modifying the product or affecting its use. The producer knows more about the product's design and operation, how to install it and maintain it and, in many cases, how the product is likely to fail and how to fix it. It is easier for the producer to modify the product's design and to make many types of repairs on the product. The consumer, on the other hand, knows more about the product's actual use and installation, what types of failures are common to that use, and what actually happened when a failure did occur. It is easier for the consumer to undertake day-to-day preventive maintenance of the product according to the producer's instructions and to customize the product for the special use of the consumer.

Warranties can take advantages of these differences to minimize total social costs; the following example, by no means exhaustive, shows how this might occur.

Warranties can place the burden upon the producer for losses resulting from design and manufacturing flaws while leaving responsibility upon the consumer for losses flowing from improper use and installation. They can place the burden upon the producer for repairs of properly maintained systems while releasing the producer from liability when the consumer has not adhered to maintenance procedures. And they can, by expiring after a specified period of time, protect producers from responsibility for mishaps occurring many years after sale, mishaps occurring after many events which only the consumer knows of and can control have transpired.

Using warranties in this way can minimize the aggregate of producer and consumer costs incurred through production and use of the product. Since producer costs are ultimately born by the consumer, warranties can be used to lower the total costs which consumers must ultimately bear.

3. Effects Upon Market Structure

Standards can have effects upon the competitive nature of the standardized product's industry. While in some cases standards only reinforce the existing industrial behavior by making a competitive industry more competitive (by facilitating the flow of information) and an uncompetitive industry less so (by facilitating collusion), they can also counter existing circumstances; they do not necessarily mirror market conditions. Product standardization can reduce product differentiation, thus allowing smaller and new competitors to compete more effectively. Similarly, it might reduce the effects of brand names, thus lowering barriers to entry into the industry. If product standardization results in increased interchangeability of products of diverse manufacturers, markets for the product will widen as sellers' capture of particular submarkets weakens; further lowering of barriers to entry may result. The effects are not all positive; the economies of scale derived from variety reduction and other effects of standards may result in larger and fewer plants; the high capital cost of a larger plant may become a barrier to entry, especially for smaller firms. Furthermore, standardization by its very nature facilitates coordination among the suppliers of a product; such coordination might result in monopolistic activities such as price-fixing and could result in legal (anti-trust) problems.

Since the effects of standards upon market structure and competition are unclear, it is hard to evaluate how they should be taken into account for new energy technologies at present. A key factor influencing the effects a given set of standards has upon an industry producing new energy products is the industry's behavior, which is changing as rapidly as the industry is growing. The matter is clearly of concern and merits attention over time. Since anticipating anticompetitive effects is difficult, the role of standards may be limited to after-the-fact aid.

III. COMMERCIALIZATION PROGRAMS AND STANDARDS AND WARRANTIES

During the course of a commercialization program the product and production technology are undergoing technological change. Selection of a "dominant design" occurs late in the program, if ever. Throughout the program's duration information is being gathered. Demonstration projects are one key element for gathering information concerning the operation of various systems and components; there is also pressure to use the demonstrations to "prime the market," i.e. to kindle an interest in the product. Since many solar technologies have high capital costs, concern about the availability of financing for the systems arises. The need to protect consumers from shoddy merchandise is also raised. Since standards and warranties are often invoked to address these concerns, the mechanisms by which they are created are of interest.

This section applies the background of section II to four specific issues which often arise during the course of a commercialization effort: 1) the role of standards in the development of new energy technology industries; 2) the need for standards and warranties for demonstration projects; 3) the need for standards and warranties for financing new energy technology systems; and 4) mechanisms for developing standards and warranties. Finally, the need for basic research concerning standards and warranties is addressed.

For the purposes of examining the standards and warranties, it is assumed that efforts to produce them have succeeded, i.e. that standards are being complied with and warranties followed. If not, then efforts to produce them are failures of a rather obvious kind; it is only when the efforts succeed that the analysis becomes interesting. So, in effect, the analysis treats the standards and warranties as if they were mandatory by assuming compliance.

A. STANDARDS AND NEW ENERGY TECHNOLOGY INDUSTRY DEVELOPMENT

One key concern of most demonstration programs is the development of a self-sustaining industry to produce and market the product. After the technology is developed, this embryonic industry will invest in production equipment and grow large, the product having been successfully commercialized. The effect of standards development upon this industry's ability to become established and producing low-cost products is important, particularly if premature standards development can inhibit growth or freeze the technology. Standards which affect the technology or the rate and direction of technological changes are particularly important here, as they may lead to investment in inappropriate production equipment or perhaps discourage investment altogether; these effects upon investment would, or course, slow the industry's long-run growth.

Section II identified several potential benefits of standards and warranties in markets. They are summarized below. If these benefits follow from appropriate standardization activities, industrial growth will be encouraged.

> Demand benefits: elimination of inferior goods, narrowed range in product quality, insurance against defects, measurement of product characteristics, and assurance of compatibility of related components;

Supply benefits: furthering of learning effects (cost reduction) with a dominant design, cost reduction through optimal allocation of responsibility; and

Market structure benefits: furtherance of competitive market structure.

Two potentially significant counterconsiderations were also identified:

the cost of increased quality; and

the dangers of locking out technological options with potential for great cost reduction.

Also identified were the types of standards for which information would be available at a particular stage in the technology development process (see Table I above). As the table indicates, the earliest efforts for standards development should focus on terminology and test methods, and only when the product has left the research stage. These first efforts must be accomplished before technically sound standards pertaining to the later stages of the technology development process can be developed. Since the information necessary to develop standards of any greater detail (e.g. for system configurations) is not available until final development and introduction, full product standards should await the development of the requisite information; the feasibility and desirability of such standards should be reassessed with the technology's progress.

Concern about technological change and its effects upon investment requires only basic standards and warranties development before the diffusion stage. Two basic concerns suggest this result. First, the uncertain nature of the technology development process and the cost of obtaining information require those involved to break the process into stages to permit sequential acquisition of technical and market information concerning the product under development. At each stage different amounts and types of information are available, and at different costs. It is not until the introduction stage that investment in the technology has reached the point at which the first actual user experience occurs. Because this user experience is critical to many aspects of product design, development of standards before this stage is completed would ignore this experience, and the standards developed would be favorable to long-range success only by chance.

Second, concern about the bias of experience suggests delaying the development of full standards if the matter is uncertain, considerations other than technological change aside. Failure to heed concerns about the bias of experience and opportunities for discrete technological change can result in overinvestment in a technology which will never achieve the low costs of some presently immature, "miracle" technology which may reach technological maturity later. Several solar programs are presently experiencing an <u>increase</u> in funding for basic research and development, thus (by design) increasing the likelihood of discrete technological change; hence, the risks of standardizing a stock technology to the exclusion of a presently embryonic but potentially dominant one are great. And as the markets are still small, postponement of many of the benefits of standards is not too serious.

Furthermore, aside from considerations of technological change, delay of standardization activities until the diffusion stage will produce greater benefits in the long run by allowing knowledgeable consumer participation to occur. In many cases, the user of a product has the best (and possibly the only) source of information concerning details of the product's use. Without this information, intelligent choices concerning establishment of relevant sizes, voltages, etc., cannot be made, nor can one determine the characteristic problems which should be addressed by a warranty. Since ultimately it is the consumers who will determine the industry's success, consumer participation in the development process for standards and warranties is necessary for satisfactory results.

Without an active market, user experience is necessarily scant. Hence the development of many standards and warranties best follows the existence of a market rather than precedes it. For example, in the case of photovoltaics, the present market is remote, stand-alone applications; the experience garnered there is very different from what one might expect in the grid-connected market expected in the future. Therefore, putting a hold on the development of full product standards and warranties for the time being allows for subsequent consumer input to be effective and prevents the standards and warranties from being developed solely by technical persons outside a market context. This will help ensure investment in equipment for producing products with the greatest chances of long-range success.

However, nothing suggests that the development of basic standards and product information should be pursued any way but vigorously. It is suggested only that standards development efforts beyond that point can wait (from the viewpoint of ultimate cost reduction). The delay in development of full standards suggested by considerations of technological change and lack of information will provide a useful interlude in which to advance our knowledge concerning the solar market to come and the effects standards and warranties will have on that market. (See III.E below.)

B. STANDARDS, WARRANTIES, AND DEMONSTRATION PROJECTS

Most commercialization efforts include plans for "demonstrations" of the resulting products, primarily to spread information concerning the product's desirability. It is thus hoped that demand for the product will be stimulated. Demonstrations are also done for another less obvious purpose: to obtain information concerning the product's operation and field performance and also some feedback from consumers about the product. While pursuit of this latter purpose is inconsistent with fully developed standards and warranties, standards and warranties are often invoked as tools for controlling the quality of the demonstrations and thus increasing their chances of success.

Concerns that demonstrations be of high quality, thus stimulating demand rather than stifling it, are well-placed. Some assurance that the systems placed in the field perform as planned is necessary. But are standards and warranties the right tools? And, if so, should the standards and warranties used for demonstration projects be the same ones which it is hoped will be used industry-wide to produce the benefits discussed above? In analyzing these questions, two factors should be considered: the information needed to create standards and warranties and to be derived from the demonstrations, and the role of standards and warranties in meeting the concerns surrounding demonstrations.

1. Standards and Warranties and the Information Content of Demonstrations

The systems used in demonstrations will not represent the final word in solar technology. On the contrary, a major purpose of the demonstrations is to gain technical and economic information. This information should cover the system's operating experience, the costs of operating and maintaining the system (and how to reduce those costs), installation problems and procedures, and the problems and advantages of particular designs.

Also, the existence of the demonstrations provides the first widespread user experience with the systems. Upon gaining this experience, many gaps in information become filled; only at this time does adequate information for establishment of many aspects of standards and warranties become available. For example, user needs first become known, and the failure modes which are most likely to occur and are most severe (and hence of most concern for warranty development) are discovered.

One key area of concern is installation procedures. One lesson learned from the solar heating and cooling (SHAC) experience is that development of standardized installation procedures suited to the installer's level of expertise will help insure satisfactory installations.6 However, as with SHAC, one should expect problems with installation that will not be discovered until actual installations are attempted. Hence, development of installation standards should respond to the demonstration rather than determine it.

In short, much information will be gained which can provide the <u>basis</u> for technically sound standards; establishing the standards before the demonstrations occur puts the cart before the horse. In other words, many standards should be developed in connection with demonstrations rather than for the demonstrations.

2. Role of Standards and Warranties in Demonstration Projects

Some way of satisfying the need for certainty of performance in the demonstrations must nevertheless be found, and consideration of standards and warranties is logical. What are the relative merits of adoption? In order to obtain funds from the agency demonstrating the system, industry must satisfy the standards and warranty requirements; firms will be induced to produce according to the standards, whatever their wisdom, or not participate at all.[7] Attempts to change the standards later will be resisted because of investments made to produce according to the original standards. Furthermore, some products (and the firms which produce them) may be excluded from the demonstration market; the HUD standards allegedly excluded many cost-effective systems.[8] Such a result may prove disastrous to the industry's development.

An alternative would require that each demonstration have a service contract which provides that the system is in working order at all times and that defective or other nonworking parts will be replaced. This permits nonstandardized products to be used in the system so that information can be gathered concerning those products' performance. It also avoids the problem of industry investing to meet the standards rather than the market. This is not likely to produce an incentive for producers to supply inferior merchandise to the demonstration efforts, as poor workmanship will repel prospective consumers of that manufacturer's products.

Proper planning, implementation, and monitoring of demonstrations can make certain that all needed information is obtained while insuring the demonstrations' success. Therefore, the service contract option is preferred for insuring demonstration success. The existence of standards and warranties is unlikely to produce better actual success in the demonstrations than a service contract; furthermore, acceleration of standards and warranties will likely ignore the information acquired by the demonstrations, thus resulting in inferior standards and warranties. Use of service contracts allows development of standards and warranties to proceed at a pace determined by the acquisition of pertinent information since the development does not then have to be tied to the progress of demonstrations.

C. STANDARDS, WARRANTIES, AND FINANCING CONSIDERATIONS

Standards and warranties play a role in the financing of solar systems. Most of these systems have high first costs and long lifetimes, and financing will be necessary. Their effects occur in two principal cases: systems bought using wholly private financing, and those which take advantage of various state and federal incentives.

1. Standards, Warranties, and Private Financing

The availability of private financing for solar systems is in part affected by the information available concerning those systems. For the lending institution, this information becomes available as experience with the new technology increases. With an increase in experience, the lending institution's ability to assess the value of the system as collateral increases, thus increasing their certainty and hence their willingness to finance photovoltaic systems.

Standards and warranties are not the equivalent of experience. Nevertheless, they may improve the collateral value of solar systems somewhat and convey some of the necessary information to the lending institutions. To the extent that they represent a synthesis of operating experience with solar systems, they reflect a certain stage of maturity of the technology. Activities which lead to the production of the information necessary for development of standards and warranties help new energy technologies reach technological maturity. However, the existence of standards and warranties not supported by adequate technical data will not, in the long run, increase the availability of financing because actual operating experience and not the mere existence of standards and warranties becomes the dominant factor. Undue acceleration of standards and warranties development will therefore not do the job.

The duration of warranty coverage may also affect the collateral value of solar systems. As warranty length increases, so does the collateral value and hence the availability of capital. But the warranties must be backed by a producer likely to be around when the trouble arrives. While subsidiaries of established firms might not be hindered, a new firm may find difficulty in financing its warranty requirements. Federal guarantees of warranties of small firms may help to relieve this situation.

2. Standards, Warranties, and Public Financing

Many state and federal incentives for the development of solar technologies are conditioned upon the solar system meeting specified standards and warranty requirements. Two concerns arise from this use of standards and warranties: the diversity of the requirements and the potential impact upon technological change.

Since the requirements of the various governmental bodies are not uniform, manufacturers of photovoltaic systems and components face a diverse set of requirements which they must satisfy if their products are to compete effectively against other qualifying systems and components. The cost of meeting these diverse requirements may be substantial, and uniformity is desired. However, attempts to legislate standard requirements for all states may not prove fruitful. Federal leadership in the field, with clear indications of the appropriate stage of development of standards and warranties for the various solar technologies, may prove more successful in achieving uniformity.

Also, the existence of rigid standards and warranty requirements for solar incentives is potentially harmful to technological development. The dangers discussed above of interfering with the process of technological change come into play. Again, federal leadership, coupled with an information dissemination program which informs the pertinent governmental bodies of the appropriate stage of standards development for each of the various technologies, is probably the best way to alleviate the situation.

D. MECHANISMS FOR DEVELOPING STANDARDS AND WARRANTIES

Prior sections have indicated that, by and large, efforts to develop standards and warranties should proceed only as the needed information becomes available. For the present this implies limited action, with action increasing throughout the course of the programs.

Even though the need for action on standards and warranties for most solar systems is not pressing, analysis of the mechanisms for their development is still useful now because it helps to determine the eventual course of action. Also, to some extent private mechanisms are already in operation, and the eventual course of action must recognize this.

This section analyzes the two principal possibilities for implementing standards and warranties: standards and warranties established through the voluntary consensus process, or mandatory standards and warranties. After discussing both options, some concerns with the voluntary consensus system are addressed, including the regulatory environment surrounding the system.

1. Mandatory Standards and Warranties

Mandatory standards and warranties are those contained in legislation or regulation and therefore are backed by the force of law. They determine what the substance of the standards and warranties must be, and how the transactions covered by the statute or regulation must be conducted. Legal consequences follow from failure to conform to the mandated standards and warranties.

Implicitly, mandatory standards and warranties reject the solutions reached through private market mechanisms (including the voluntary consensus standards system). While certain problems (discussed below) do exist with the voluntary consensus standards system, these same problems may well apply to mandated standards and warranties also. Furthermore, standards and warranties developed according to legislatively mandate are likely to be developed according to a set timetable, regardless of the availability of the needed information.

2. The Voluntary Consensus System

Development of standards through the voluntary consensus system usually begins with an informal determination of the need for the standards in a particular area. After the need has been agreed upon, the organization supervising the standards-writing activities will announce the existence of the committee; interested persons may participate, usually depending upon their ability to allocate time and resources (theirs or their employer's) to the task. Standards are drafted by the committee and submitted for approval to the organization as a whole. Upon acceptance by the supervising organization, the standards are published, for use by anyone so desiring.

Warranties can also be developed using this process, as warranties may be viewed as one attribute of the whole product. By developing them through this process they, like the standards so developed, can become used industrywide.

3. Some Concerns with the Voluntary Consensus System

The voluntary consensus system does not work perfectly. Concern over the adequacy of participation by consumers in the process has arisen, as have concerns over possibly anticompetitive consequences of voluntary standards, particularly those arising from failure to maintain technically updated standards.

Adequacy of consumer participation. Questions concerning both the level and quality of consumer participation in the voluntary consensus process have been raised. Notice to consumer groups of proposed standards development activities has been thought to fall short at times, and even when adequate, attendance has been discouraged by the burden to consumer interest groups of traveling to the meetings. Also, the ability of consumers to participate competently without the aid of technical consultants has been raised. Since the consumer very often possesses the best information concerning the actual conditions of operation of the system, failure to include the consumer can raise serious concerns about the substantive quality of the resulting standards. (See Section III.A above.)

To some extent the questions concerning notice and participation are addressed by a proposed Federal Trade Commission (FTC) rule for 16 C.F.R. Part 457 (43 F.R. 57269) covering standards and certification. The rule requires certain notice for proposed standards development activities and also requires that a voluntary consensus standards development body have certain appeal procedures for those wishing to challenge a standard. If the rule is passed, these requirements, while similar to some procedures of some voluntary consensus standards development organizations, will tend to alleviate concerns over adequacy of consumer participation in standards development for solar systems.

These concerns can be further alleviated by special funding for consumer participation and technical consultants for the consumer representatives. Furthermore, allowing standards to develop only as the needed information becomes available further insures that consumer participation will be informed and reasoned.

Anticompetitive potential of voluntary standards. The anticompetitive potential of standards has been discussed above. Voluntary and mandatory standards have the same potential for producing these effects; the most important concern for a developing technology is that the standards will not be updated frequently enough to permit free entry by competitors offering innovative products. Why this concern should be more important for voluntary instead of mandatory standards is not so clear. The need for updating is the same for both and, if both processes are equally responsive to the need for updating, then similar results are expected to follow.

Furthermore, the proposed FTC rule prescribes grounds for challenging standards developed through the voluntary consensus process as being anticompetitive in certain enumerated aspects. And §788 of the Federal Energy Administration Authorization Act of 1977, now by all appearances applicable to the DOE, requires consultation by DOE with the Attorney General and the Chairman of the FTC before DOE can incorporate voluntary consensus standards into rules governing non-procurement situations. These safeguards should be adequate to handle anticompetitive problems arising from voluntary standards.

4. A Preference for the Voluntary Standards System

On the whole, pursuing standards development through the voluntary standards system is preferred. The concerns raised above are not considered significant if the FTC rule is adopted in substantially the form proposed. More importantly, the slow and deliberate nature of the process is likely to result in added flexibility when compared to mandated standards; this is of special concern with a developing technology.

E. BASIC RESEARCH CONCERNING STANDARDS AND WARRANTIES

Many questions arise concerning the extent of the impacts standards and warranties will have upon solar markets, for the degree of impact helps to determine whether or not to use standards and warranties or some alternative to achieve the desired effects. One would like to know the maximum possible impact from standards and warranties and, most important in a planning context, what particular set of standards and warranties will produce that impact and whether any undesirable side effects will ensue.

The above analysis presents a qualitative approach to these problems. But is a quantitive approach possible and feasible? Since practically no academic work on standards and warranties has been undertaken, the question cannot be answered. It does seem, however, that it is possible to treat the subjects of standards and warranties analytically, and it is hoped that this work provides some structure for quantitative (including empirical) work on the subjects.

IV. CONCLUSION

This paper has attempted to show that the effects of standards and warranties can be systematically analyzed for use in commercialization programs. While the analysis is qualitative, it has substantive content and provides a framework of reference for evaluating particular standards and warranties and efforts for their development.

The general conclusion to be drawn concerning commercialization efforts is to allow standards and warranties to develop by the voluntary consensus process as the technology matures and the information collected will permit.

Though the field is understudied, it is not intractable. Given the increasing use of standards and warranties as policy tools, it is hoped that more academic efforts will address the subject.

FOOTNOTES

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1. The interesting case history of automotive standards is presented in Hemenway, pp. 13 et seq.

2. Hemenway, pp. 22 et seq.

3. The economics of technological change are complex because by its nature technological change challenges the neoclassical assumptions of free information and static technology. Furthermore, the process of technological change is filled with market failures; these market failures are reviewed in Linden, Bottaro, et al.

4. These or similar stages are common to the economic literature. See, e.g., Scherer, p. 350, and Jacoby, Linden, et al., pp. 41-44. While the names given to the stages give broad clues as to what occurs in each stage, a brief description follows.

During research the basic concepts for the product are developed; the product is little more than an idea, and essentially no information about the product is available. As the product enters the development phase, details concerning the product's design are settled, and basic problems concerning the product's manufacture are resolved. As introduction occurs, the product is first marketed, and "live" information about consumers' reactions to the product are first obtained. Also, user experience is first gained. The diffusion stage sees widespread marketing of the product as customer awareness spreads.

5. Learning-by-doing and discrete technological change are used to differentiate two qualitatively different types of technological change. In learning-by-doing product improvement occurs by small changes in the product design or manufacturing process coupled with lower labor costs from experience with the design; these effects result in lower product cost. Discrete technological change, on the other hand, refers to radical changes in the product design, changes that are "different" enough that manufacturing processes require substantial modification and experience gained elsewhere cannot be wholly transplanted. Simultaneous pursuit of the two is not possible because one works with the product design while the other rejects it. The distinction is obviously not hard and fast, but it gives some insight into the difference between the two. A longer discussion appears in the Appendix to Linden, Bottaro, et al.; the source for many of the ideas is David.

6. A summary of the problems with SHAC installations appears in Volume II of Jet Propulsion Laboratory, pp. 8-10 to 8-11.

7. There is evidence that "[b]ecause of the stringent warranties requirements imposed by HUD [on the SHAC demonstrations] some reputable manufacturers had declined to participate . . ." Central Solar Energy Research Corporation, p. 22.

8. Committee on Interstate and Foreign Commerce, p. 21.

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