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An Economist Looks at Solar Energy: The Government's Role

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ABSTRACT

The economist speaks in terms of free enterprise, and of competition. This most pure state of economic existence, where all economic textbooks begin, is a rare occurrence in the real world, however. The energy market is a notable example of how government involvement has skewed consumer choices. This is as it should be, for we expect the public decision-making process to involve more than just considerations of economy.

This paper will place solar energy in the context of a marketplace for energy, and justify the role of government in influencing solar energy market development and market penetration. It will also examine the concept of commercialization, the effect of government incentives, and the proper timing of government involvement.

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I. BACKGROUND - THE FREE MARKET - FACT OR FICTION?

The economist speaks in terms of free enterprise, and of competition. In the absence of market externalities, such as government involvement[1] and natural monopolies, the marketplace will operate of its own momentum so as to perfectly answer the questions: <u>What</u> shall be produced? <u>How</u> shall it be produced? and <u>For Whom</u> shall it be produced?[2] Suppliers meet demanders in the marketplace and conduct "arms-length" transactions that optimally determine the resource utilization, prices, distribution, manufacture and wages (the list is far from exhaustive) of all goods and services available to consumers at a point in time. In theory, the marketplace is a massively complex and ideally oiled machine where private decisions are in sum equivalent to public good. As another economic theorist has offered:

- Every individual endeavors to employ his capital so that its produce may be of greatest value. He generally neither intends to promote the public interest, nor knows how much he is promoting it. He intends only his own security, only his own gain. And he is in this led by an invisible hand to promote an end which was no part of his intention. By pursuing his own interest he frequently promotes that of society more effectually than when he really intends to promote it.[2a]

Macro-economics, however, uses the model of perfect competition only to depart from it. Free enterprise is a reference point to be departed from in seeking to illuminate some portion of the real economic world, where externalities commonly operate.

The government long ago decided to involve itself in the marketplace for energy. Notable examples of this include the regulation of utilities and the dissolution of the Standard Oil monopoly. For better or for worse, it has been a function of government since that time to skew consumer choices for energy. Certain energy sources have been subsidized or otherwise encouraged, and others have been restricted or discouraged.[3] Government involvement in energy in some form is a foregone conclusion, particularly in these times of disturbing energy shortages, strong environmental and social concerns, and potential embargoes. Only the proper nature and level of involvement is at issue.[4]

It is hypothesized that federal incentives for energy production result from economic, political, and legal pressures to rectify perceived market failures. When price signals from the marketplace do not coincide with the goals and objectives of industry, consumer groups, or public institutions, the perception is one of market failure. Using perceived market failure as justification, industry allocates resources to affect energy policy in order to gain greater profits. Consumer groups seek lower prices. Research scientists and administrators of public institutions also affect energy policy.

If all the incentives to increase energy production were attributed to structural deficiencies of the industries or to externalities of the processes, an analysis of incentives could be approached totally within an economic framework. If, on the other hand, incentives are the result of perceived market failure, alternative frameworks would result in a greater utilization of federal incentives to energy production.

Consider curve S_e presented in Figure I as a secular supply curve for U.S. energy. The curve is secular because it represents all of the energy that exists in known forms over time. It represents the range of energy quantitites that would be marketed at various prices in the absence of government incentives. The shape of the curve is primarily determined by the existence and location of known energy resources and the rate at which a stream of technology can be utilized to transform these resources into power. As more of the energy resources are used, the supply becomes more inelastic. This is so because it costs more to dig or drill deeper or to utilize lower grade resources.

The price of energy is established at the intersection of S_e and the demand curve for energy, D_e. Changes in the demand and the resultant effect on the price could be perceived as market failure. The result could be pressure from industry, consumers, or public institutions to create incentives to increase energy production at some historic price. These pressures can be viewed from an economic, political, institutional, or legal perspective.

Consider curve $S/_e$ as an apparent secular supply curve for energy. Some of the real costs of energy production are borne by the federal government through the creation and administration of policies, programs, and projects. The effect of these incentives is to increase the production of energy at a lower price. The cause is the inclusion of participants whose goals are other than the sale and purchase of energy and who are not relatively interchangeable with relatively equal power. Participants who are less interchangeable and whose power is less than buyers and sellers operate in the political arena rather than in the marketplace. Actions of participants who are still less interchangeable and have less power can be described from an institutional point of view. The legal point of view can be used to understand the resulting pressures by participants with the least power and the least interchangeability.

Therefore, whereas it is entirely fitting to ask, "Could not energy be delivered to end users more expeditiously and economically in the absence of government interference?", this purist argument fails on two major counts:

1) The reality of our economic history is already heavily weighted in the opposite direction, and

2) There are considerations other than economy that must receive attention (i.e. unemployment, pollution, quality of life), and government is the only entity in our society fully responsible for addressing them and capable of integrating both economic and non-economic influences into policy decisions and legislation. Political economy is inclusive of the political, institutional, and legal frameworks, and it is the concept of importance in the marketplace for energy. "Net economic welfare" is another term for expressing this concept.[5] How does solar energy fit into this context?

II. SOLAR ENERGY - IN THE NATIONAL INTEREST?

As one of the energy options available to consumers, businessmen, and policy makers alike, solar energy for heating and cooling of buildings (SHAC) is a prime candidate for government incentives to encourage its greater utilization. Among other advantages, it offers 1) the opportunity to reduce the use of nuclear and fossil fuels, 2) a net reduction of pollution over power produced by more conventional means, 3) a renewable alternative to finite fuel sources, 4) a decentralized versus centralized quality affording greater citizen control than our present energy delivery system, and 5) the promise of cost competitiveness in many areas of the country today.[6] Clearly, economics is not the whole story of solar energy.

However, most consumers will not incorporate the full range of solar energy benefits into their decision process. They will include first costs and a limited range of other variables depending on the application (residential, commercial, industrial). In all applications, reasons 1-3 above would likely be outside the consumer decision process; it remains for government to correct for this market failure.

In recent years, the working of our political economy has spawned substantial solar legislation at all levels of government. As the federal level alone, these laws have encompassed and mandated research and development, demonstration projects, standards development, information dissemination, and other activties broadly construed as commercialization (see section III).[7] The "feds" are engaged in actively promoting a consumer technology. How far should the government go?

In order to conceptualize the possible government role in solar energy, it is useful to describe the solar marketplace as a "technology delivery system" (TDS). By this is meant a model of all the potential influencers of solar market status from scientists to manufacturers to final consumers.[8] Figure 2 depicts such a model.

The TDS is the context into which all government policies affecting solar energy must fit. It is a complex environment that lends itself to incentives of both an economic and non-quantifiable nature. Examples of the former include tax credits, (property, sales, income) low interest loans and grants, while the latter ecompasses standards, consumer information and protection, and building codes, all of which set the "rules of the game." Whatever incentive is chosen, the question to answer is not only <u>what incentive</u> is appropriate, but also <u>what level</u> of incentive is advisable, and <u>what TDS member(s)</u> should be stimulated if greater use of solar energy is the objective? Incentives could be devised for every

TDS member.[9] Appendix 1 and Table II analyze one potential incentive in depth.

Lastly, there is a danger that government involvement will become prolonged beyond its useful life. Our tax system in particular is riddled with such anachronisms. An additional question then is <u>when</u> does the government get out of the business of incentives and allow a return to normal market forces. That is, can the government <u>measure</u> when there is a self-sustaining solar industry so it can cease at least its economic measures.[10] The last section of this paper suggests a possible measure to use as indicator of program utility. When can SHAC systems be officially considered "commercialized"?

III. COMMERCIALIZATION

Having accepted some measure of government involvement in SHAC, we are left with four fundamental questions:

1) What incentives to use?

2) What level of incentive to use?

3) What TDS member to "incentivize?"

4) When are solar systems commercialized?

Only by being able to satisfactorily answer these questions can the government devise coherent programs that help create the conditions in which a private market for SHAC systems can grow and flourish.

For the purpose of this paper, "Commercialization" is defined as the entire range of possible government activities in support of the development of a viable solar marketplace. This definition includes demonstration projects, research and development, standards development, tax credits, and all programs that have as their objective the hastening of SHAC systems to the marketplace. All TDS members are potential targets of government commercialization efforts.

It is not only important that commercialization activities be properly selected, but also that they be properly phased. For example, it would be inappropriate to grant low interest loans to a technical concept that was still on the drawing board. In theory, commercialization activities will flow on a continuum from left to right on Figure 2, but in practice, many programs will proceed concurrently.

Some commercialization activities are more critical at one time than at another. Clearly, the choice between provisions for SHAC grants, tax subsidies, low interest loans, accelerated depreciation and the like becomes academic if the hardware is unrealiable or unavailable. It is only when the seed of a marketplace exists that "end use" (final consumer) incentives become salient, whereas manufacturing incentives may continue for the lifetime of government commercialization activities. If a cell in Figure 2 is empty (a null set), incentives to that TDS "member" are inappropriate. End use incentives, though potentially shorter in duration, are at the cutting edge of public policy, are the most politically visible, and enter into consideration just at the time when the SHAC market is ready to expand vigorously or to fizzle. Table 1 lists a range of possible end use economic incentives.

Lastly, the choice of incentive will depend on the climatological, alternative energy, financial, legal, institutional and attitudinal environments in which SHAC systems exist. Commercialization at this level of specificity includes distinctly regional, state, and local geographical areas and organizations. For each subset of the TDS, incentives must be tailored to these environments.

In practice, the federal government has developed consumer decision models that predict consumer purchase reactions based on a set of economic incentives in a given market environment (see Appendix 1). Such tools must continue to be refined as our understanding of energy behavior grows.[11] Again, economics is not the whole story.

TABLE 1
END USE ECONOMIC INCENTIVES

Interest Subsidy	Grants
Tax Credit	Insurance and Reinsurance
Tax Deduction	Equity Investments
Rapid Amortization	Utility Incentives
Property Tax Credit	Tax on Alternative Fuels
Sales Tax Credit	Government Procurement
Guaranteed Loan	

Source: <u>Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems</u>, Bezdek, Roseman, et al, Behavioral Studies Group, The George Washington University, Washington, D.C., April 1977, pp 102 and 108.

These models go to the heart of the government's dilemma in constructing an effective commercialization package. What incentives will have what impact? What magnitude of incentive will "do the trick"? The model used in appendix 1 based its predictions on life cycle costs, annual savings, and first costs, but it is only informed speculation that allows us to pick out these few key criteria while the others recede into the periphery. Careful survey, analysis, and actual market experience of TDS members allow model builders to contribute to the design of accurate models and responsible policies.

Two incentive philosophies that emerge from this debate include "demand-pull" and "supply push." The former involves lowering the relative cost or risk of solar systems to end users, and the latter involves the lowering of cost or risk to intermediate TDS members.[12] The first accelerates consumer desire for the technology, the second makes that technology more available. The mechanisms in table 1 are all demand-pull incentives; a demonstration program would be an example of supply push. The decision model will predict which philosophical strategy, or mix of strategies, will generate the most market penetration for each government dollar invested.

However, model predictions are devoid of meaning in a situation where clearly perceived and accepted goals have not been set. Only when the evaluation criteria are agreed upon can the model's numbers assume any qualitative value. Is 2.5 million solar homes enough by 1985? Are we trying to install solar collectors or save energy? How many barrels of oil do we wish to displace in year X? Only within the context of goals do a model's predictions take on meaning. Success can only be measured if the yardstick for measuring it is accepted beforehand by government policy makers.

The first three questions posed at the outset of this section have been implicitly answered in the foregoing discussion of models and goals, and may be summed up in the phrase "divide and calibrate." After selecting the objective(s) divide the market into its components (TDS members) and calibrate their responses to given levels of given incentives in given environments. Aggregate these to the local, regional, or national level as appropriate, and compare to the original evaluation criteria.

How does one know when SHAC systems are commercialized? The following measure is herein proposed: Suppose the government goal is to equalize the life cycle costs of competing systems. Use the traditional logit model of market penetration and closely monitor systems costs and market sales (Figure 3) to pinpoint when the curves inflection point is or will be reached or slightly passed. This is the second triangle in Figure 3. Consistent with our objective, positive government incentives should be winding down, by this point, possibly leaving only regulatory and consumer protection programs in place to control abuses.

This measure has the aesthetic and numerical appeal of occuring approximately at the point that life cycle costs for the conventional energy system with and without SHAC systems are equivalent.

As has been pointed out, the government has a long history of involvement in the delivery of energy to end users. In so doing, the initial and operating cost of the conventional systems have been effectively lowered. The inflection point in figure 3 represents that point at which SHAC systems have attained par lifetime value with fossil and nuclear energy delivery techniques. Incentives continued beyond this point tend to supplant private mechanisms and capital that are drawn out as soon as full lifetime competitiveness is achieved.

This is a diffcult mark to hit precisely. In practice, incentives can be designed to continue until one is certain that the inflection point has been passed. Then, the government can pull out, knowing that SHAC systems can now compete on their own merits.

Other goals such as equalizing first costs with competing systems would use other measures to determine a program's effectiveness. Whatever the goal, policy decisions must only be made in the context of detailed knowledge of the TDS and its members likely reaction to cost, risk, and other environmental elements.

APPENDIX I*

INTRODUCTION

Much debate has recently occurred in the U. S. concerning the proper type and level of economic incentives to encourage the use of solar energy. Prior to the National Energy Plan (NEP) tax credits for homeowners, investment tax credits for businesses, low interest loans and guaranteed loans and a range of other possible incentives were discussed to encourage the use of solar energy. President Carter's NEP, however, has narrowed this debate focusing on the homeowner tax credit as the major device for promoting the use of solar energy. This example provides an analysis of the following incentive option:

Incentive I: Purchaser Tax Credit of 30% on the First $1,500 of System Cost, 20% on Next $8,500, up to a Maximum of $2,150 Tax Credit, Effective 1977-1984.

See Table II for market penetration results.

METHODOLOGY

A modified version of the MITRE/METREK Solar Heating and Cooling Market Penetration Model was utilized. This model disaggregates the U. S. into 16 climatic regions. In this analysis, simulations were run for the seven of the 16 regions containing approximately 70% of the existing and the anticipated new buildings through 1985. The results were then scaled accordingly to derive comprehensive national estimates. The nine building types contained in the model were aggregated here to two types: residential and commercial. It was assumed that inflation would proceed at an annual rate of 5%, that fuel prices would increase at an annual rate of 7%, and that no incremental property taxes would be assessed on the SHAC systems.

System costs varied by building type (residential, commercial), by system type, and by region. The following average costs were used. Residential water heating systems in 1977 cost $17.40 per square foot, plus a fixed cost of $397. Residential combined water and space heating systems cost $29.31 per square foot plus a fixed cost which is region dependent. Commercial water and space heating systems in 1977 cost $22.61 per square foot plus a fixed cost of $13,615. Commercial water and space heating systems cost $27.64 per square foot plus a fixed cost that is region dependent. A moderate "learning curve" effect was incorporated into the analysis which gradually reduced system costs as total production increased.

In this analysis, the total costs for a solar hot water and a solar heating and hot water system have been divided into two categories: Those that will be subject to cost decreases due to experience, and those which will not decrease. System costs that are subject to experience include the collector and its hardware, control systems, and some design, installation, and markup charges. Those costs not subject to experience include pumps, heat exchangers, plumbing material, auxiliary units, tanks, etc. The experience related costs represent approximately 25% of the total system costs.

For each region in each year, life cycle cost ratios (LCR) are computed. This is the ratio of the life cycle cost of the solar system to the life cycle cost of the conventional (electric) system and it is the driving parameter of the model. Separate ratios are computed for residential water heating systems, residential water and space heating systems, commercial water heating systems, and commercial water and space heating systems. The new construction market is considered separately from the retrofit construction market. For each system type, the potential new construction market is the number of new buildings constructed scaled by an adjustment factor. The retrofit construction market is the existing number of electric systems, adjusted by a suitability factor.

MARKET SHARE COMPUTATION

Once the model produces estimates of the life cycle costs for conventional and solar installations, there remains the task of converting the two cost estimates into market penetration estimates for solar energy. Following a long line of researchers, we shall adopt the logit model developed by MacFadden, and first applied in the fuel choice literature by Jaskow and Baughman.[1] The specific mathematical form is due to Case.

$$\frac{D_s}{D_s + D_c} = \frac{\left[1 + m\left(\frac{P_s}{P_c}\right)^{\alpha}\right]^{-1}}{\left[1 + m\left(\frac{P_s}{P_c}\right)^{\alpha}\right]^{-1} + \left[1 + 1\,m\left(\frac{P_c}{P_s}\right)^{\alpha}\right]^{-1}}$$

Where: D_s = solar sales
D_c = conventional sales
($\therefore D_s/D_s + D_c$ = solar market penetration)
P_s = price of solar
P_c = price of conventional
α, m = parameters

In this analysis, the price of conventional and solar are calculated on a life-cycle basis, using a discount rate of 9%. Since the logit model has two parameters, two data points are needed to fit the curves. The first point is taken from 1976 estimated 1.9% market penetration by solar - 5000 solar systems installed on a target housing population of 30,000, our estimate of the number of residential and commercial structures built in 1976 that were (a) all electric; (b) oriented to the sun, plus the retrofit target population, which were (a) all electric; (b) oriented to the sun, and (c) had more than 20 years useful life remaining. The second point on the surve is based upon an estimate that solar hot water heating will achieve 50% market penetration when it has a four-fold life cycle cost advantage over conventional systems. This is a conservative assumption, since one might expect 50% market penetration when the two prices are approximately equal. Our choice of the much more conservative number is based upon the uncertainty associated with future solar maintenance and operating costs.

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*This example of the use of a model based upon economic decision criteria has been taken from "Costs and Impacts of Financial Incentives for Solar Energy Systems" by Dr. Roger H. Bezdek and Elliot J. Roseman presented at the International Solar Energy Society (ISES) conference held in New Delhi, India, January 16-21, 1978.

[1]Some would say government "intervention" or "intrusion", thus begging the question of its propriety.

[2]Paul A. Samuelson, Economics, 9th edition, McGraw Hill Book Company, New York, 1978, p.23

[2a]Ibid, p. 41, Adam Smith, Wealth of Nations

[3]In a soon-to-be-release report, Battelle Northwest Laboratories documents the numerical incentives that government has provided to the fuels commonly in use today-nuclear, coal, oil, natural gas, and hydroelectric power. In each case, the aggregate amount is in the billions of dollars. This capital has supplemented private capital to create new energy realities. For example, the commercial nuclear industry would not be where it is today without the active weapons program of the 1940's and 50's, nor would the oil industry have reached its current magnitude without the depletion allowance. Some incentives, such as the Price-Anderson Act, (limiting nuclear plant liability in the event of accidents) are non-quantifiable but tangible. See An Analysis of Federal Incentives Used to Stimulate Energy Production, Battelle Pacific Northwest Laboratories, September, 1977

[4]"Commercialization" is the term currently employed to describe the range of activities that government at all levels can undertake to bring about a market reality. Section III expands on this concept.

[5]Samuelson, p. 4

[6] See for example, An Analysis of the Current Economic Feasibility of Solar Water and Space Heating, U.S. Department of Energy, Division of Solar Applications, January, 1978, DOE/CS-0023

[7] To name a few, P.L. 93-473, "Solar Energy Research Development and Demonstration Act of 1974" P.L. 93-438, "Energy Reorganization Act of 1974" P.L. 93-409, "Solar Heating and Cooling Demonstration Act of 1974."
Also see, State Solar Legislation, published by the National Solar Heating and Cooling Information Center in Philadelphia.
This chart may be found in Solar Energy Incentives Analysis: Psycho-Economic Factors Affecting the Decision Making of Consumers and the Technology Delivery System, U. S. Department of Energy, Division of Solar Applications, January, 1978, HCP/M2534/01, p.5

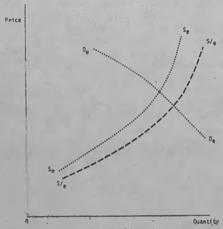
[8] A seminal article on the topic is by Dr. Arthur Ezra, "Technology Utiliztion: Incentives and Solar Energy", February 28, 1975, Science magazine.

[9] Solar Energy Incentives Analysis, pp. 34-39

[10] Philosophically, one can argue that the government can not do "marketing" competently and that it should stick solely to the area of preventing abuses (i.e. minimum performance levels and anti-trust enforcement). This ignores, however, the urgency of our energy situation -- the government must supplant private funds in order to shorten the lead time on product development through positive catalysts as well as protective measures. For further elaboration, see Government Support for the Commercialization of New Energy Technologies, MIT Energy Laboratory Report No. MIT-EL 76-009 (ERDA Contract E(49-18 2295), November, 1976.

[11] See Solar Energy Incentives Analysis (Reference 8) for an elaboration on the behavioral component of the energy marketplace

[12] An indirect supply push would involve the perceived or actual raising of prices or risk for alternatives to solar (nuclear, oil, gas).



The Real and Apparent Market for Energy

Figure 1

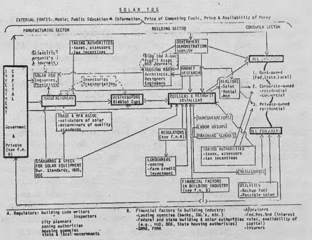
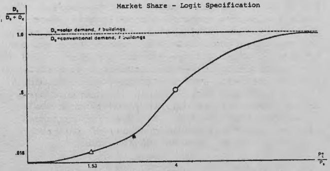


Figure 2



Source: "Assessment of Incentives to Accelerate Market Pentration of Solar Heating and Cooling Systems," Dr. Roger Bezdek and Dr. Arthur Ezra, International Solar Energy Society World Conference proceedings, Orlando, Florida, June 6-9, 1977, p3.

Figure 3

IMPACT AND COST ESTIMATES FOR INCENTIVE I

1. Total (cumulative) number of water and combined water and space heating installations, 1977-85:	Solar [illegible] of systems)
Residential water	[illegible]
Residential water and space	[illegible]
Total, all systems	[illegible]
[illegible] Total (cumulative) number of square feet of collectors installed, 1977-85:	[illegible] of ft.²)
Residential water	[illegible]
Residential water and space	[illegible]
Total, all systems	[illegible]
3. Energy Impacts in the year 1985:	Quads
Energy "produced"	.061
Energy "saved"*	.184
4. Total (cumulative) Installed Costs, 1977-85:	(millions of dollars)
Private	$5,285
Public	1,103
Total	6,361

*Based on a fuel conversion efficiency of [illegible]

Table II