

The rise and fall of Luz

The company proved that their solar energy technology worked, but they needed subsidies to be competitive.

Reuel Shinnar

The promise of solar energy is 10 or 20 years away. It's been that way ever since 1973 when the energy crisis started. Fifteen years ago, several large companies were actively engaged in developing photovoltaic (PV) units, but most have dropped out and left the development to Japan or Europe. There are several photovoltaic demonstration power plants in California (less than 7 MW); the main use is in remote homes. Total U.S. photovoltaic capacity is about 25 MW. Projected prices for a complete power plant based on PV vary from \$8 to \$10 per peak watt installed. It is claimed that if we could reduce the cost of photovoltaic electricity to \$3 per watt installed, solar electricity would become competitive.

In the search for renewable power the United States has established tax credits (subsidies, if you will) for power plants that use solar or wind energy. These tax credits are, of course, eventually paid by the taxpayers and must be justified by the politicians. And there's the rub. When a solar plant becomes big, the taxpayers' contribution grows so large that politicians have a hard time justifying it.

The experience of Luz describes how this company's success in building solar plants inevitably led to its demise. It brings into question whether we're serious in our pursuit of solar power or whether we merely pay lip

service. Here is the story of what happened.

A few years ago an American mechanical engineer, Arnold Goldman, went to Israel and decided to take solar energy seriously. He has an interesting, old-fashioned approach to solving technical problems. He believes that if a problem is urgent one should look for the best technical approach based on proven principles and then do a good engineering job. He developed a thermal solar power plant that consisted of a simple double tracking mechanism for solar collectors, a heat exchange fluid to transfer heat to a steam cycle, and a high-efficiency steam turbine. Most previous thermal solar demonstration plants were built by physicists and aerospace engineers and were expensive. However, we don't need to track missiles, only the sun, and we don't have to track that accurately.

In Israel, Goldman got some money to demonstrate his collector. Teamed up with a partner who was a financial wizard, he soon built a 15 MW demonstration plant in the California desert. He later improved the design, and now Luz has several units totaling 350 MW in operation, producing about 80% of today's solar electricity. Until recently there were near-term plans to at least double the currently installed capacity.

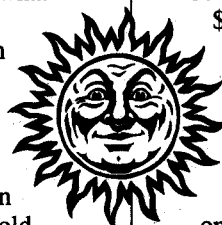
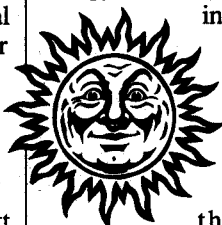
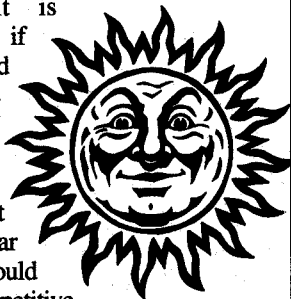
The latest plant modules built by Luz have a nominal peak capacity of

80 MW and cost \$3.00-3.50 per watt installed.

That's a goal in most development efforts for the year 2000. The design of Luz solves one of the most important obstacles for large-scale solar plants: It can supply power reliably between 8 a.m.

When Luz grew large the government abandoned it by revoking the tax credits.

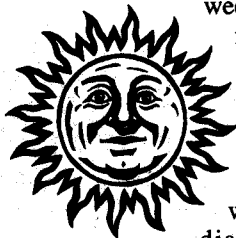
and 9 p.m. because the plant's steam turbine is driven by heat from the working fluid. This fluid is maintained at a high temperature by heat from the sun or from its natural gas backup, which makes up 25% of the energy input. The backup is an integral part of the plant and its cost is included in the price of the plant. Any solar plant needs a backup during periods when the sun does not shine. The backup need not be in the same plant, but the power company has to provide it. The advantage of Luz over PV power plants that rely on backup gas turbines is that the heat maintained by the working fluid prevents the penalties incurred by large temperature swings. The plant does not cool down and therefore doesn't need to be warmed up.



To understand the economics on which the viability of solar energy depends, let's examine how electricity costs are incurred by the utility and charged to the customer. The utility's expenses consist of:

- The cost of fuel,
- Amortization and maintenance of equipment, and
- Maintenance of supply lines, both long distance and locally.

The first item, fuel, is less than one-third of the cost. The cost of the third item varies strongly nationwide. The second item is important for understanding solar energy. Electricity consumption fluctuates during the course of the day, the week, and the year. It is low at night and during



weekends; it is lower in spring and fall than during winter and summer. Although the variation is complex, we can distinguish three main periods. A base load is the minimum steady load during the whole year, a cycling or intermediate load occurs five days a week from 6 a.m. to 10 p.m., and a peak load occurs during short periods (about 200-400 hours a year). Table 1 shows the duration of these periods for Southern Edison, which serves Los Angeles and is the main customer for the present Luz plants.

In the past, electric utilities took care of these fluctuations by designing steam-fired power plants that could take large swings. But large efficient power plants are expensive. In the past this was no problem. Not only was there stronger growth than today, but utilities had a built-in incentive to overinvest. The law guaranteed them a fixed return on investment; the bigger the investment, the better the profitability.

Today, this policy has changed, as power commissions no longer follow this law because of political pressures. Power companies now look to minimize investment and meet peak demands by installing gas turbines, which are significantly cheaper than conventional power plants even with their lower thermal efficiency. As peaking plants operate only 200-400 hours a year, the lower efficiency is almost irrelevant. The capacity required for cycling power is today equal to or greater than the needed

Table 1. Classification of power consumption in Southern California

	Winter October-May	Summer June-September
Peak	No peak power required	12 p.m.-6 p.m.
Cycling	8 a.m.-9 p.m.	6 p.m.-11 p.m.
Off-peak (low requirements)	9 p.m.-8 a.m.	11 p.m.-6 a.m.

All weekends and holidays are off peak.
Base power plants operate all the time.
Cycling power plants also operate during peak hours.

capacity for base power. Today, it has become attractive to build special power plants for cycling power. The most popular are combined cycle power plants, which consist of gas turbines coupled with a steam cycle using the heat of the gas turbine's exhaust. These are normally fueled with natural gas and could also serve to supply base power. As a result, we see separate cost accounting for peak and cycling load. Peak power costs more than 20 cents per KWh and cycling power based on natural gas 6-7 cents, compared with fuel costs of 2 to 3 cents for natural gas.

Note that the hours in which cycling power is needed overlap strongly but not completely with available sunlight; if solar energy could supply power reliably during that period the utility would use it as an alternative to investing in a conventional system.

Luz, with its natural gas backup, can reliably supply cycling power like any other power plant. But unlike an independent backup, which is required for PV plants, it does not need the additional investment and maintenance.

Small is beautiful

However, a problem arises with cost accounting for some alternative energy sources such as wind and PV if these are constructed without storage facilities. The present law forces utilities to supply any customer installing such sources with power at the same rate as other customers.

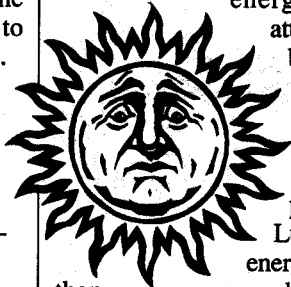
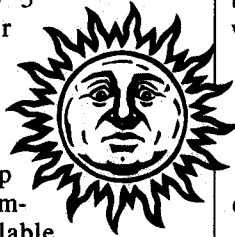
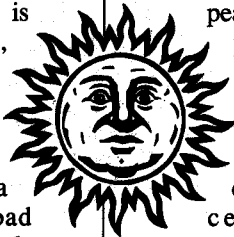
The current regulations also force the utility to buy this electricity whenever the customer generates it at the so-called avoided cost, which is basically fuel cost. The utility continues to incur the whole cost of maintaining

the connection and transfer lines and must invest in the equipment needed to supply the power reliably. Thus the present law allows small users who generate their own power to get a much higher value for it than its real direct economic value. In addition to tax credits they get an indirect subsidy from other users because they use the utilities' connections and lines. There are many such indirect subsidies in our society. Thus, when I go to the hospital my insurance also has to pay for some of the charity cases the hospital treats. As long as those hidden taxes and subsidies are small, there is no problem. When they become large they may endanger the whole system, as has happened with health insurance. The higher cost of alternative energy may still be justified by the avoidance of emissions and savings of nonrenewable fuel, but we should directly face the real economic costs.

This leads to a paradox. In our present system, some alternative energy sources are attractive and viable only as long as their total contribution is negligible. The fall of Luz happened because Luz wanted solar energy to be more than a negligible curiosity.

Proponents of solar power often argue that conventional power at best has only an 80% availability, which is about the same as the availability of the sun in the desert. But this is misleading. The maintenance of conventional power plants can be scheduled, and forced outages are unlikely. On the other hand, the uncertainty of weather requires a backup for solar power plants.

The state of California and the federal government under PURPA (Public Utilities Regulatory Act) have legislated tax credits and other incen-



tives to encourage development of alternative energy despite its higher cost. The most important incentives are tax credits, both federal and state, which for Luz amounted to about 4.5 cents/kilowatt. The tremendous achievement of Luz was to bring solar energy to a point where it became competitive under the conditions of this legislation. All studies for future solar energy sources always based their cost estimates on these same incentives. This is a questionable approach, as the history of Luz teaches us.

Energetic juggling

The other part was a generous computation by the regulatory commission of the ascribed cost of the utility. This is a general scheme for alternative energy. Any electricity supplied to the utility during the hours defined as peak is priced as peak power whether the utility needed it at that time or not. The utility also has to buy the power at other times designated for cycling power at the cost of cycling power, and on weekends as base power. If, on the other hand, the utility had bought a combined cycle power plant, the plant would have supplied the same power during peak period at the cost of cycling power. Peak power is defined as the excess over the combined consumption of base power and cycling power. But solar plants can supply only cycling power. It is therefore hard to understand the argument (used by advocates of solar power) that when solar power is supplied during peak periods it should be priced as peak power. The only reason for doing so seems to be a desire to encourage and subsidize solar or other alternative energy. The amount of this subsidy is about 2.5 cents/KWh.

Luz cleverly maximized the tax subsidies by creating attractive tax shelters for individual investors. This scheme is not available to utilities. If they invest in a new technology successfully they cannot recover a high profit. On the other hand, if they fail they bear the full cost of the failure. This puts a strong brake on introducing new technologies. Private investors can reap a profit and justify the risk of a loss.

With those subsidies (which figure prominently in all estimates for solar energy), Luz could make a profit. The fact that its backers were able to install 350 MW capacity is a tremendous achievement, which transformed

the concept of solar energy from a faraway dream to industrial reality. But this success also led to the downfall of Luz. The investors assumed that our society really wanted solar energy. But as soon as Luz became large the attitude changed. If Luz had not been constrained, California Edison and other utilities in the Southwest might have been faced with real solar energy generating several gigawatts (1000 MW) in a few years.

The attack

Several facts made this vision unattractive to the state and to the utilities. First of all, the Southwest and the whole Pacific power grid have a large installed overcapacity, about 50%.

Luz's success was not only due to current tax incentives for renewable energy development, but to good engineering.

They only need more peak power, which solar energy doesn't supply. Second, the Pacific grid is not connected to the national grid because the companies do not want to be connected. So if they have to accept large amounts of solar electricity at a price above the fuel value, they would lose money. As long as we deal with small demonstration projects, their publicity value is larger than their incremental cost. Public utility commissions also like them as long as they don't have to foot the bill.

The California legislature also soon lost its enthusiasm. When we start talking about hundreds of megawatts, or even gigawatts, we suddenly talk about billions of dollars in tax credits. The governor and legislators had to value the advantage of demonstrating their support for "clean energy" against the damage of having to vote for tax increases somewhere else. So California revoked credits for solar energy. And the Utility Regulatory Commissions changed the rules of PURPA to reduce the tax credits.

The federal government started to

question if Luz really qualified for the status of a solar plant because it used natural gas. (By law a project receives tax credits for solar energy if no more than 25% of the thermal energy comes from natural gas). The utility claimed that if the plant had to rely on solar energy alone, then owing to the unreliability of the weather the plant would cease to be a reliable source and the value of the electricity would be only fuel value. This catch-22 applies to all solar energy. But Luz has a tremendous advantage. Its use of 25% methane gives 25% more kilowatt hours with no incremental investment; the only cost is the natural gas, which is cheaper than collectors. Being able to sell the electricity at cycling or peak price is a benefit essential to the project. One can also look at it as a sensible double use of the equipment because one generates extra cycling electricity at fuel cost.

All these forces together finally undermined Luz, as the elimination of the tax credits made Luz noncompetitive. Luz has filed for bankruptcy, and everybody can breathe quietly again and talk about the great need for solar energy, as the chairman of Southern Edison is doing now.

Another interesting aspect of the Luz episode was the attitude of the solar research establishment toward Luz, both in universities and DOE. It's hard to justify a research project leading to a solar plant which (with an optimistic estimate) will cost \$4 a watt in the year 2000 when Luz sells plants installed for \$3 a watt. The prize, however, goes to a DOE report justifying more research funds in which I found the statement that Luz is a foreign technology and therefore does not lead to energy-independence.

Why not license Luz? Every weak point was attacked, and not surprisingly, one point was the use of methane natural gas. Nobody faces the fact that this is a problem generic to solar energy and that here Luz has a tremendous advantage. If they did, the shortcomings of present research focusing on PV would become apparent. Because the sun does not shine constantly, solar energy has a variable output, which has to be made up by fossil fuels. For cycling power one must do this every day in the evening. PV requires not only the same methane but also a backup power plant. Recent reports about solar energy hardly mention Luz.

I don't want to say that we should stop research. Far from it. Nor do I

say that photovoltaics don't have potential advantages over thermal plants. They do, as they can operate with diffused light and are better suited for remote locations. Nor has Luz completely proven itself. Luz plants have only operated for several years, and a life of 20 years with reasonable maintenance costs has yet to be demonstrated. But the experience with Luz should force us to reevaluate our approach to large-scale use of solar energy. According to the Electric Power Research Institute (EPRI), the long-range potential cost of large photovoltaic power plants, \$2.50 a watt installed, is close to what Luz does today. Such plants require less maintenance but also lack the backup capabilities of Luz. It is clear that within the near future solar energy will not be competitive. Still, the hidden costs of fossil fuels are probably larger than we think, but we bear them by indirect taxation. We at least should understand these hidden costs. Strangely, our society gives tax credits in the form of immediate write-off of drilling for fossil fuels and not to solar energy.

However, we must understand what a policy to introduce higher cost solar energy implies, and we must learn how to introduce such energy into the system. If we don't learn how to control utilities in a changing environment we'll never have a rational policy on alternative energy.

Why do anything at all? Why not wait till solar energy becomes economically competitive? This is a strong argument and I won't totally refute it. But let me list some sensible counter arguments. One is the environmental burden of NO_x and CO_2 , and particulates in the case of coal. Another is a need to preserve and effectively use our finite hydrocarbon resources. In addition, availability of alternative sources puts a lid on the cost of imported oil. Questions remain: At what incremental cost should we develop solar power? Twice as much? At 50% more, or what? California and PURPA legislated a factor of two, probably without detailed knowledge of what the factor might be. The fact remains that we have no accepted way to compute the hidden costs of environmental impacts or energy independence.

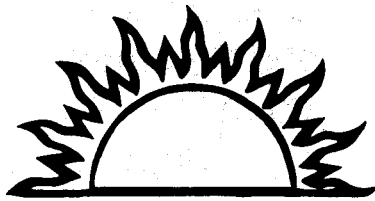
The lesson

There are, however, two additional important arguments. One is that in our society any new energy source

requires such huge investments that fast adjustment and changes are impossible owing to the large time lags involved. So at the time when we'll urgently need large-scale solar energy, it'll be too late.

An even more compelling argument is that no research breakthrough in solar energy is in sight. As Luz has demonstrated, costs are ultimately reduced by good engineering. Many of the promising developments in PV have no real place to go if they stay in the research stage.

Because the amount of solar energy per unit is small, we need wide areas of collectors, and we have to learn to construct them efficiently and cheaply and also keep them clean. The success of many of the ideas in advanced research will depend on the way these collectors are engineered.



And it is hard to gain experience if the only projects we have are directly government financed. The best way is to create conditions where private development becomes attractive. Luz showed how successful such a policy can be but showed one pitfall. If our energy source is still more expensive and we create a condition of tax credits or other incentives to make it competitive, than we are faced with a dilemma. If we don't set the incentives sufficiently high, we will not get any results. If we set them high enough, we would get more than we want or can afford.

This is a policy problem. Maybe the method legislated by the Swiss is more sensible. It mandates that a fixed percentage of all new generating capacity should be solar. Such a policy would again allow private competition to work and would also establish the size of the potential market. This merits discussion.

It is time that the technical community, including the AIChE and ACS, took a more active part in this discussion. We should try to understand the economic complications of alternative energy, and what realistically has to be done if we are serious about solar energy. At present the public and policy makers are fed a lot of totally unrealistic nonsense, such as the

imminent possibility of generating hydrogen from solar electricity in the South. Nobody mentions that we are talking, in the most optimistic cases, of energy about 10 times the present cost of oil. On the other hand, there is little discussion about more realistic goals.

We should be grateful to Luz for forcing us to face these issues. But most probably we'll go back to spending more billions on research, while talking about the tremendous potential of solar energy. Research in our society has become a valuable political tool for not doing anything while pretending that we do. Just look what happened to the acid rain problem. For 15 years, we postponed a large \$100 billion investment in scrubbers and cleaner power plants by claiming more research was needed. Now, we've finally decided to do something about it.

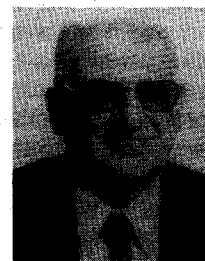
The discounted value of postponing an investment of \$100 billion for 15 years is so large compared with the \$1 billion the government spent each year on research that this was probably one of the most profitable research endeavors ever done—provided, of course, that we discount the damage acid rain and other emissions did to the environment over those 15 years. And if we are ready to discount that damage, why do what we do now? The only reasonable explanation is that the politicians have to face that the issues have changed and the problem has become more visible. Are we going to repeat this scenario with solar energy and the greenhouse effect?

Related articles

Shinnar, R. "Energy in Perspective," CHEMTECH, April 1975, p. 225.

Shinnar, R.; Shinnar, M. "Which Bottom Line?" CHEMTECH, July 1978, p. 418.

Reuel Shinnar is Distinguished Professor of Chemical Engineering at The City College of the City University (New York, NY 10031; 212-690-6679). He is a graduate of the Technion in Israel and obtained his



Ph.D. at Columbia University. He is a member of the National Academy of Engineering, and his publication topics include chemical reaction engineering, process control and process economics, and particularly development of advanced design methods. He was awarded the 1992 AIChE Founders Medal.