SOLAR HOT WATER: A MANAGEMENT FAILURE OF THE AMERICAN UTILITIES

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Abstract

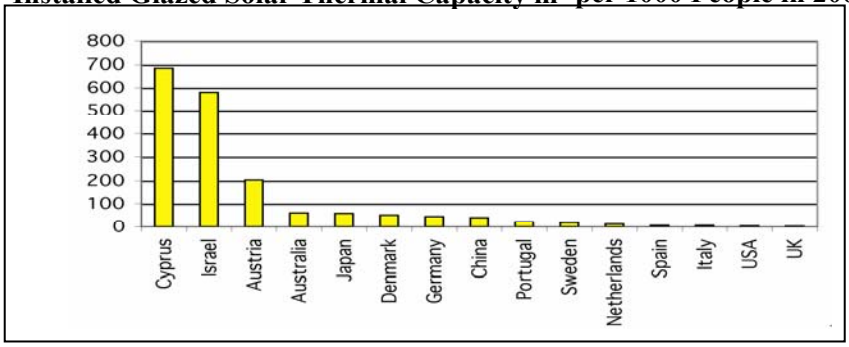
Solar hot water is a convenient, efficient, and economical solution for part of our ongoing energy supply crisis; after all, the sun comes up every day. To bring solar hot water back to the U.S. we need to do our accounts properly to include all costs. When we do this, we will see that solar hot water is 1/3 to 1/10 the cost of fossil fuel heated hot water. If true cost accounting is done; then homeowners will demand solar hot water from the utilities and home builders.

The Sad History of Solar Hot Water in America

At the turn of the century (1900), solar hot water was emerging in the U.S.; but by the turn of the next century (2000), it had virtually disappeared in the U.S. At the same time had become a fact of life in Cyprus (95% of homes) and Israel (90% of homes). Photovoltaic systems that are 10 to 20 times as costly and one fourth as efficient as solar hot water systems are now widely recognized in the U.S. and supported by a range of tax incentives and subsidies, but domestic solar hot water systems remain rare and forgotten (Davidson, 2005). Solar hot water's disappearance has been a "cold case," attracting no attention from the energy pundits, politicians, and news media. Perhaps we should ask CSI to investigate!

The management failure in solar hot water can provide insight into other management challenges and can help guide reform of other unsustainable practices in the U.S. and abroad. The causes for this tragic failure include a complex set of historical factors, disincentives, and perverse incentives that have made solar hot water unattractive to the primary players and eliminated competition. The utility companies see themselves as gas and electric companies, not energy companies, and have failed to innovate or participate in the potentially enormous and lucrative solar market. Federal policy has been dominated by powerful lobbying from fossil fuel and nuclear interests. As a result domestic solar hot water remains a small niche market in North America with little installed capacity, as shown in Figure 1 (ESTIF, 2003, 2005). In most areas little or no research has been done to see how many of the systems installed in the 1970's are still working, so installed capacity does not reflect functioning capacity. Data is weak, but surveys of manufacturers and data suggest that perhaps only 6,000 domestic solar water heaters were installed in the U.S. in 2004 (IEA, 2000; Davidson, 2005). Fewer than 10,000 a year have been installed for the last 15 years, and half of these have been in Hawaii (Butler, 2006).

Figure 1 **Installed Glazed Solar Thermal Capacity m^2 per 1000 People in 2004**



Common sense and conservative economics would suggest that solar hot water should be installed in every home in the Sun Belt and in many homes with good sun exposure in much colder climates. This would help reduce critical summer peak energy supply problems, reduce fossil fuel consumption, limit greenhouse gas emissions, and limit nitrogen pollution problems (Bainbridge, 1997, 2004; Vitousek et al., 1997). As China and Austria have demonstrated, the new evacuated tube thermosiphon systems solar hot waters are also economic in sunny, cold climates. Ironically, the evacuated tube systems that have proved to be so successful in China were developed at Owens-Illinois in the United States. China is now installing as many as 5 million solar water heaters a year and has 5,000 companies and ten brands with annual sales over 100 million RMB (Martinot, 2006).

Barriers to Solar Hot Water

The barriers to solar hot water in the United States include: flawed accounting (low natural gas and electricity prices that fail to consider global warming, environmental damage, and depletion costs); enormous subsidies for non-renewable fuels; perverse incentives; regulatory problems; and most critically, management failure in the utility industry.

Flawed accounting is at the root of most of our energy problem. If we factor in the full costs of fossil fuel burning (environmental and health impacts, global warming), we would see solar hot water start to appear overnight (Bainbridge, 2004). No careful accounting of external costs of energy has been done in the U.S., in itself an indication of who runs American energy policy.

Based on my experience, research, and some very crude estimates, I would suggest the true cost of energy are closer to the numbers presented in Table 1 (Bainbridge 2004). True cost accounting by itself would lead to widespread solar installation for residential, commercial, and industrial applications.

Table 1 **Energy Costs**

	Current Cost kWh Equiv.	with Health and Environmental Cost Local Regional and Global	
Integral solar water heater†	1¢	2¢	P
Active solar water heater†	2¢	4¢	P
Hydro-large	4¢	8¢	H+, D+, P, fish kills, GW*
Natural gas	6¢	12¢	N, GW, H, D, P
Photovoltaic	10¢-$1+	12¢-$1+	P
Oil	7¢	20¢	N, GW, (Gulf Wars), H, P, X
Coal	7¢	21¢	N, GW , P+, AR, H+, D, X
Nuclear	10¢	20¢+	H, D, P, X (risk)

†produced and installed in large numbers
AR = acid rain, acid fog, D = habitat destruction and degradation, GW = global warming, H = habitat loss, N = nitrogen pollution, P = Pollution (from manufacturing, installation, transportation), X = human death and disease from mining, processing, accidents and disposal,
*GW from cement production

Perverse incentives also limit solar water heater installations. Developers design and build “spec” homes for unknown clients and have powerful incentives to keep first costs low. Buyers often expect to resell homes in a few years and see no need to add solar features. In addition, new buyers are often strapped for cash and have little incentive to install solar systems. When options, including photovoltaic

systems are offered, buyers rarely choose them (Showley, 2006). These factors combine to limit installation of solar hot water systems.

When significant solar subsidies were offered in the past to offset massive subsidies for non-renewable fuels and nuclear power, the parasitic costs (regulators, rules, forms, and lawyers) for solar hot water systems also increased. The prices of solar hot water systems increased, rather than the expected decrease from greater volume. Fly-by-night builders and installers entered the market, further distorting the market and hurting established quality companies, who were tarred by the same brush and often invested time and money in fixing competitors' systems in an effort to improve public perception.

The failure of most subsidies to include a performance requirement compounded the problem. This led to installation of overly costly, and in other cases, poorly designed and built systems. Today, improved technologies and more sophisticated simulation programs allow for installation and predictable performance in almost any climate, and any subsidy offered should include a performance component.

Profound ignorance about solar hot water in the building industry, utility industry, regulatory agencies, building permit and inspection departments, banks, design firms, and homeowners is also a problem. Very few people understand the available options, their advantages and disadvantages, and their economics. The educational system has largely ignored energy and water issues from K-12 and through graduate school. This has been aggravated by clever fossil fuel company support for groups like the National Science Teachers Association, which recently refused to distribute global warming information because it might affect their funding support from oil companies (David, 2007).

Widespread ignorance, perverse incentives for non-renewable fuels, and disincentives for renewable energy have made it impossible for small solar water heater manufacturers in the U.S. to sell the volume needed to reduce manufacturing and installation costs. As a result, solar hot water systems are usually installed as a specialty item, driving up the cost and the challenge of installation. With limited markets and thin margins, manufacturers have been unable to mount effective educational campaigns.

Sales may also be compromised by the internal dynamics of the water heater market. Gas and electric water heaters are more profitable for manufacturers because they have a much shorter service life. Given current economic calculations it makes sense that the Japanese parent company that owns one of the major American water heater manufacturers, and is also the owner of one of the more successful international solar hot water manufacturers, would prefer to sell heaters that need to be replaced every 5-10 years instead of every 10-30 years for solar water heaters. Conventional water heaters are also more popular with utility companies because they ensure continued sales of gas and electricity.

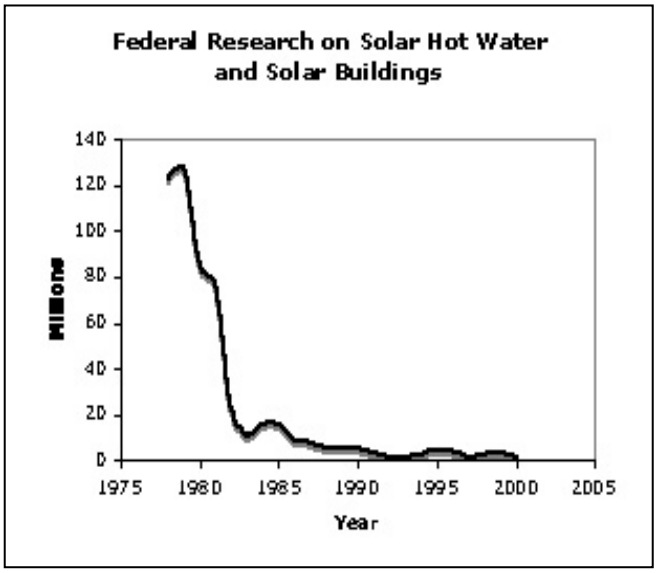
The High Cost of Monopoly

I would argue that the biggest factor in the solar debacle is the lack of competition arising from market and management failure. This has been compounded by ineffective and often inappropriate utility regulation, which has helped maintain the energy supply monopolies that dominate the country. With no competition there is rarely effective management or innovation. Recent attempts at partial deregulation made the situation even worse and cost consumers billions of dollars. Cronyism and ill-conceived attempts to privatize energy production in several states led to obscene profits, catastrophic losses of perhaps $50 billion dollars for California alone (Coile, 2003), massive lawsuits, no innovation (except in fraud and book keeping), and no solar investment. It has proved to be harder to reform the American energy utilities than it was to privatize Soviet factories.

The uncertain regulatory environment has compounded the problem by encouraging utilities to split into generation and transmission services. This has also encouraged utilities to underfund maintenance and invest very little in infrastructure or equipment improvements. Utility profits have been virtually guaranteed for decades, and the reward system was commonly linked directly to power consumption. The greater the demand, the more power required and the greater the regulated profit potential. Many of the managers in utilities are still frozen in this Soviet era mind set. They remain fixated on "grow consumption" and "build big technology" (Hirsh, 2006).

Innovation is rarely important in non-competitive markets, and the regulated utility market is no exception. The utilities sector invests less in research and development than any other industry measured. In recent years they have spent an astonishingly low <0.1% a year on R&D, compared to 3.2% for all industries and 20% or more in competitive industries (NSF, 2003). After a minor investment in R&D during the twin 1970s energy crises, the utilities cut funding, and both private and public funding have continued to decline (Dooley, 1997). The association groups (such as the Electric Power Research Institute) have reduced their research budgets as well and were never very interested in solar applications. All the energy utilities combined probably spend less on R&D than some individual biotech and technology companies (Kammen and Nemet, 2005). Tragically, most public investment in R&D has remained for nuclear research, which Amory Lovins correctly identified as a "future technology whose time is past." President Reagan helped cut funding in solar research for buildings and hot water from $127 million a year to $8 million within a few years. An annual expenditure of less than the option cost for a good football or baseball player will not support much innovative research. Federal policy has been controlled by fossil "fools" and utility pressure for the last 25 years. Investment in practical solar research is practically non-existent, as shown in Figure 2 (Sklar, 2007). While Federal research is not often as effective as private research, it often helps stimulate innovation and develops research skills sets in people, universities, and institutes.

Figure 2 **Federal R&D**



The failure to innovate within the utility industry is also ultimately a failure of utility managers. When the management literature discusses the range of management response along a continuum from innovation to exploitation (Gupta et al., 2006), it fails to capture the problem of regulated industries. In fact the regulated utility industries have been little studied (Bonardi et al., 2006). Here management invests energy, intelligence, and money in manipulation and gaming the regulators--admittedly often in

response to the regulators attempts to game the utilities (Lyon and Mayo, 2000). But the utilities are better funded and usually win. Manipulation can be much more profitable than innovation and creating lasting value. One power plant deal in Texas netted "investors" $5 billion in 18 months for doing nothing (Johnson, 2006). The same amount of money invested in solar water heaters could have provide 30 years of low cost and reliable energy for 2.5 million Texas homes.

The Solution

Solar hot water is a convenient, efficient, and economical solution for part of our ongoing energy supply crisis; after all, the sun comes up every day. To bring solar hot water back to the U.S. we need to do our accounts properly to include all costs. When we do this, we will see that solar hot water is 1/3 to 1/10 the cost of fossil fuel heated hot water. If true cost accounting is done; then homeowners will demand solar hot water from the utilities and home builders.

We also need to institute time-of-use (real time) metering which will reflect the value of solar hot water in reducing peak demand. This is much easier today thanks to telemetering advances; and the country would benefit from universal installation of time of use metering, as Puget Sound Energy has done, and SDG&E and others are now considering (Jones, 2001; Rose, 2005).

The long-term goal should be for a fully deregulated utility industry that is accessible to all, transparent and competitive. This will remain challenging but is essential. The transition will not be easy, but regulators and politicians should recognize the failure of partial deregulation as the failure of cronyism and partial deregulation, not as flaw in the concept of open and competitive markets.

While deregulation is restarted, states and cities can "encourage" or require utilities to install domestic solar hot water heaters. This could be done by the utility itself or through contracts with existing solar companies. Lakeland Electric in Florida has set an excellent example (Anon, 2002). This utility installs the solar hot water system and then charges for the energy provided by the system at normal prices as the solar energy is delivered. This spares the homeowner from the cost of buying and installing the system (just as we don't ask everyone to pay for added generation capacity at the power plant their home requires).

Each system installed in Lakeland saves 1570 kWh a year, avoiding emissions of 1392 kg CO_2, 5 kg SO_2 and 4 kg NO_x. Each solar system also reduces peak demand about 0.2 kW in the summer and 0.7 kW in the winter (Lakeland's winter peak is larger, so this really helps). As fossil fuel energy prices rise, the utility's profits will increase.

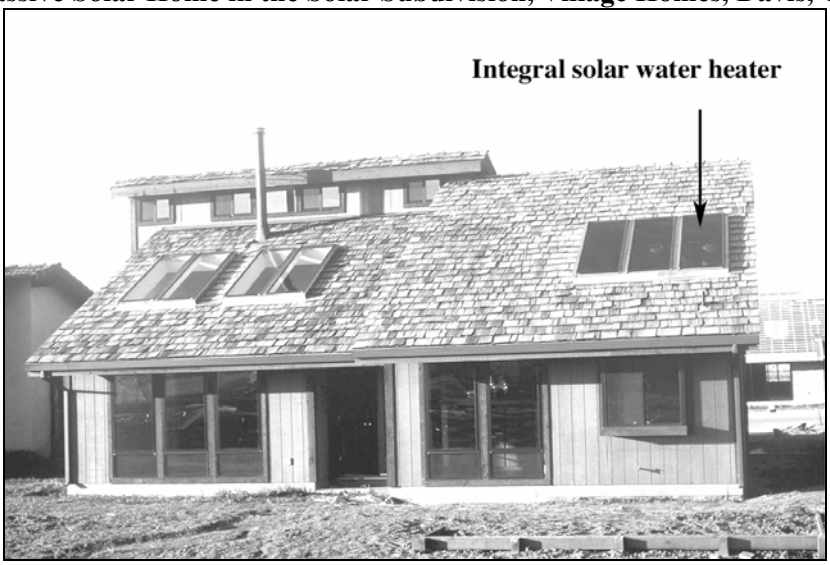
Retrofitting older subdivisions, rather than one house at a time, will be essential; and utilities would be well suited for this task. An innovative "solar utility" could also find the best street orientations, best home layouts (least obstacles, shortest pipe runs) for minimal installation cost. They could then pop in 200, 500, or 1,000 solar water heaters a month. If the energy market was open and competitive, this would already have happened. The utility or solar utility could also remove and replace heaters when homes needed reroofing at a modest cost and provide regular checkups and performance tuning.

Solar System Types

The simplest solutions for domestic solar hot water are often best. Integral systems that combine the collector and storage in one tank or thermosiphon systems, where circulation is driven by temperature differences rather than pumps, are ideal in warmer climates (Bainbridge, 1981a,b; Reiss and Burton,

1981; Owens, 2003; Smyth et al., 2004, 2006). Evacuated tube collectors (much like a clear thermos bottle) used in thermosiphon systems work well even in colder climates. For new homes in warmer climates building-integrated integral systems offer the lowest freeze risk and easiest long-term maintenance because they do not have exposed pipe runs and do not need to be pulled off the roof for reroofing (see Figure 3).

Figure 3 **A Passive Solar Home in the Solar Subdivision, Village Homes, Davis, CA**



Packaged solar hot water heating systems are now available that will work in virtually any climate for any home that has solar exposure. Advances in evacuated tube collectors, improved pumps and control systems, and heat exchangers can make solar hot water feasible in virtually any climate. Butler Sun Solutions sells a clever photovoltaic-powered active solar hot water system (in effect a passive–active system that will work even when the power lines are down) that can be easily retrofit in a wide range of climates.

The Chinese investment in renewables ($18 billion committed) has made China the largest market and biggest manufacturing base in the world for domestic solar hot water systems (see Table 2). If the American utilities fail to act, we may find that an innovative Chinese company will do what our domestic utilities have proved incapable of doing: investing in the least costly method of heating water for America's homes, commercial, and industrial buildings. The growth in sales in solar hot water in China has averaged 55% a year since 1999 (Martinot, 2006). The top ten companies control less than 20% of the market, a very competitive marketplace. Prices are very low, typically about $100 m^2, although some systems reach $300 m^2.

Table 2 **Thermal Solar Glazed Collectors Installed (Thousands of Square Meters, 2004)**

China*	15,000
Germany	750
Greece	215
Austria	183
Italy	58
Netherlands	26
Sweden	20
U.S.	18
*2005	

Source: ESTIF, 2005, Davidson, 2005, Martinot, 2006. Data for the U.S. is very weak.

The Challenge Ahead

We don't need 20,000 domestic solar hot water systems installed in the U.S. a year, or even 50,000; we need a million a year or more. As we pass Hubbert's Peak of world oil production (Deffeyes, 2003), we have no alternative that is as attractive. We need to finally get smart and return to solar water heating. Israel made the commitment after the Yom Kippur War in 1973. We should make the commitment now, making solar hot water a patriotic essential. This convenient and reliable solar application is just waiting for us to open our eyes. We have known what to do since F. A. Brooks' marvelous booklet on solar hot water in California was published in 1936; but we have not had true cost accounting, competitive markets, or innovation in utility management to make it happen.

Rapid adoption can help master increasing electrical system unreliability, infrastructure weakness, and supply problems that can cripple American productivity and competitiveness (Anon, 2003; Gibbs, 2003; Thibodeau, 2006; Yergin, 2006). The pending retirement of many utility executives and managers (Silvano, 2004) may offer a good turning point for a new approach to utility management. It is crucial to manage for innovation not to simply manipulate regulators, speculators, and shareholders. These new managers may benefit from training in sustainability, such as the Royal Academy of Engineering E21C program, and the triple bottom line approach that is finally, slowly entering business schools and engineering programs (Zoë, 2006; Bennett and James, 2000; Bainbridge, 2006; Mulder, 2006; Kanneberg and LeCompte, 2007). Utilities may rediscover that they are service providers not energy supply companies--and begin exploring a wide range of missed opportunities in solar hot water for home and industry, district heating and cooling, daylighting, climate responsive design assistance, and natural ventilation. The day may yet come when the utility will call you and ask if they could install a solar hot water heater, solar clothes dryer, whole house ventilation fan, solar greenhouse or insulated windows at no cost to you, to be paid for as the energy is delivered by the sun or climate resources.

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