Organizing People for Technological Change: System-Building in the Energy-Efficient Mortgage Movement

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ABSTRACT

Most energy-efficient devices have had little market success despite evidence that many are economically and technically sound. The problem is a lack of a well-developed sociotechnical system to support these technologies. The solution is to develop such a system, i.e., a interrelated set of consumers and producers, organizations, institutions, cultures, and technologies that facilitate the market success of a given technology.

Energy-efficient mortgage (EEM) advocates have been assembling such a system in the residential housing sector. As an institutional innovation, EEMs enable bankers to give better loan terms for energy-efficient homes and introduce homebuyers to a network of energy professionals. After home energy rating organizations assess the cost effectiveness of energy efficiency, bankers promote EEMs because the energy savings increase homeowners' incomes, qualifying more people and larger loans.

This preliminary research suggests that a theory and method of system-building can be derived from the case of EEMs to further advance EEMs and alternative technologies in general. Also, criteria can be developed to help identify points of resistance in the development of emerging sociotechnical systems. Likewise, tactics, strategies, and policy solutions can be devised to remove these points of resistance.

Introduction

Currently, hundreds of devices, materials, and techniques are available to make housing more energy efficient. Despite much of it being technically and economically feasible, most have had little market success (DOE/BTS 1999). Are homeowners simply irrational? Or are there other reasons for the lack of market success? This preliminary case study research suggests that the problem is not irrationality, but rather the lack of a well-developed sociotechnical system (Bijker, Hughes & Pinch 1987; Hughes 1989) to support energy-efficient technologies. The solution is to develop such a system of organizations, institutions, networks, values, and attitudes to facilitate the market success of energy-efficient technologies.

To build the missing system, energy efficiency advocates have been promoting energy-efficient mortgages (EEMs) with some success. The movement created the EEM as an institutional arrangement where lenders give advantageous loan terms for energy-efficient homes. Because energy savings is a way to increase the effective income of borrowers, lenders can qualify more people and larger loans. Lenders also assist homeowners and buyers by introducing them to a network of energy efficiency professionals within the residential building industry. To provide bankers with confidence about lending money for energy efficiency, a type of organization called Home Energy

Rating Systems (HERS) are used to rate the energy efficiency of existing homes and the cost effectiveness of energy efficiency improvements. A growing number of financial organizations are promoting EEMs, including Fannie Mae, the Federal Housing Administration (FHA), the Veterans Administration, and the Rural Development Agency (Farhar and Eckert 1993; Farhar, Collins & Walsh 1997). EEM advocates have been slowly reconstructing the process of technological choice within the residential building industry. This paper suggests that a theory and method of system-building can be deduced from the case of EEMs to further advance EEMs and alternative technologies in general.

The Energy-Efficient Mortgage

There are different kinds of EEMs, and the type largely depends on who in the secondary mortgage market is intended to buy or insure mortgages from the primary market. The Federal National Mortgage Association (i.e., Fannie Mae) allows lenders to stretch the debt-to-income ratio by 2% for energy efficiency. (However, a few primary lenders have assembled their own EEM packages.) The federal government supports energy efficiency financing by insuring EEMS in the secondary market. For example, the FHA allows homebuyers to finance the value of a home plus $4000 or 5% of the property value (up to $8,000) for energy efficiency improvements. No extra down payment is required, and loan limits may be exceeded by the costs of energy efficiency improvements that pay for themselves. Also, through the Nebraska Energy Office, mortgage interest rates can be reduced by 1/4% or 1% with EEMs. The Veterans Administration and the Farmer's Home Administration also have EEM packages as well (Farhar, Collins & Walsh 1997; Farhar and Eckert 1993; Luboff 1995; Nebraska Energy Office n.d.).

The concept of EEMs has been around since 1979, although with little use until the early 1990s. Since then, the number of EEMs has been growing steadily in most states. Consider the FHA, one of the largest handlers of EEMs. From 1996 to 1998, there was a five-fold increase in the nation-wide dollar value of EEMs insured by the FHA. However, the total number of EEMs still appears to be a small percentage of all mortgages. For example, in 1998 1.6 billion dollars of EEMs were insured by the FHA out of a total 100.1 billion dollars of FHA mortgages. However, in some states EEMs are doing disproportionately better, such as in Texas where 5.1% of the total dollar value of FHA mortgages in 1998 were from energy-efficient financing (calculated using data from Gulledge 1999). The trend of an increasing number of EEMs is encouraging in consideration of the small budgets for marketing EEMs relative to the size of the national mortgage market. Also, the present mortgage market offers difficult competition for EEMs. During the last few years of low interest rates, lenders have been doing so well with conventional mortgages and the refinancing of old loans that they have had little incentive to pursue innovative financial products such as EEMs, suggests Lowrie (1999).

Energy Efficiency in the Residential Housing Industry

The argument that EEMs can promote energy efficiency is premised on the assumption that bankers can influence technological choices in the residential housing

industry. Of course, decision making is spread among homeowners, builders, bankers, code officials, etc. Of these, one might think that homebuyers would have a particularly large influence on technological choices. However, homeowners usually defer decisions to the judgment of builders, architects, contractors, and code officials. In many cases, decisions have already been made by these other individuals and organizations before the homeowner even enters the picture (Lutzenhiser 1994). Likewise, Kempton and Montgomery (1982) suggest that homeowners give little thought to energy savings. The environment or the economic returns on real estate investments are minor factors among many other competing values for convenience, aesthetics, and the social prestige of owning large, lavish homes. There are also codes, regulations, and laws that pre-empt many decisions by homeowners (Farhar 1991; Lutzenhiser 1992, 1993; Stern 1986; Stern & Arson 1984).

Among many significant actors in the housing industry, bankers have perhaps more potential power and self-interest in influencing technological choice that can be used to the advantage of EEM advocates. Their power comes from their control of investment capital. That is to say, if all banks withheld financing from energy inefficient housing, much of the residential housing industry would have little choice but to comply. To protect their own banking interests (e.g., reducing default rates) there is a history of banks influencing the means by which their money is used by corporate borrowers. Especially in tight credit markets, banks have shaped the direction of entire industries and against the agendas of corporate giants like Howard Hughes and the Hunt brothers (Mintz and Schwartz 1985).

In the housing industry the historical role of banks in shaping technological choice is not as well documented. However, EEMs are evidence of a small, but growing number of banks and loan officers willing to shape decisions toward energy efficiency. Furthermore, there are tangible incentives for banks to influence how homebuyers use the banks' money for residential energy technology. Banks want to make sure that potential borrowers have enough income to qualify for mortgages and not default. To this end, energy efficiency can increase effective incomes and reduce the costs of home ownership, as well as increase the comfort of homes, which may increase the marketability of these homes after instances of foreclosures (Farhar, Collins & Walsh 1996; Farhar, Collins & Walsh 1997; Farhar and Eckert 1993; National Renewable Energy Laboratory 1992).

The System Is First

If the above is true, then why have not more bankers encouraged energy efficiency? And why have not more homeowners and buyers been pursuing energy alternatives? To answer these questions, imagine that you want to install a solar water heater on a house that you are soon to purchase, and you are hoping your banker will also finance the solar appliance. After a frustrating few weeks off trying to find a local retailer that will sell and install the solar water heater, you find a business. Quite pleased with yourself, you approach your loan officer and start talking about the technical marvels of solar water heaters and the money to be saved on utility bills. Your loan officer says, "Perhaps, but it's just not my area of expertise. However, my cousin in Colorado bought one. When the solar water heater broke down five years later, he was not able to find anyone to fix it

because the retailer had gone bankrupt due to a lack of business." Then a nearby secretary says, "Solar water heaters? I looked at a house a while ago that had one. It looked kind-of strange on the side of the house, so I didn't buy the property." You and your loan officer start to think the same thing. In addition to the hassle of purchasing a solar water heater, even if it did work perfectly, it could end up being a liability to your home. Still attached to your idea, you say, "Yes, but a solar water heater will save me money and that should make me a better risk on a loan. Also, it should increase the market value of my home." Your banker responds, "Do you have any hard data?" Both of you know that you do not. At that point, you realize that your banker will not finance a solar water heater, and perhaps for the best. You conclude that despite any technical and economic superiority of solar water heaters, the most rational decision is to stay with conventional appliances. The root problem is that energy-efficient technologies have not been well supported by a sociotechnical system of institutional arrangements for financing, networks between bankers and energy professionals, and organizations to rate the cost effectiveness of energy efficiency. While the above is a hypothetical story, each element can be found in the literature on alternative technologies (Cowan 1996, 1990; Farhar, Collins & Walsh 1996; Farhar and Eckert 1993; Lutzenhiser 1992; National Renewable Energy Laboratories 1992) and in preliminary interviews (Lowrie 1999; Masters 1996; Tarnai 1999).

This systems perspective provides a powerful, general theoretical explanation of the poor market activity for many energy-efficient technologies. Clearly, technical and economic feasibility are not enough. To achieve market success, the technical nature of pieces of hardware is secondary, and the entire sociotechnical system is primary (Hughes 1989). The system to which we have been referring has been called a "sociotechnical system"--an organized, functionally interrelated set of physical/technical, social, cultural, and economic components. These components are inter-connected in the sense that the absence of, or change in, one will affect others. Thus, often a system does not function well, if at all, without all its components, nor can one part be adequately understood in isolation from the rest (Benniger 1986; Bijker, Hughes & Pinch 1987; Hughes 1989).

Successful captains of industry have long known that the path to success is to build a supportive sociotechnical system around a piece of hardware, whether it be the personal computer, nuclear plant, or automobile. Consider the automobile. Henry Ford engineered, financed, and advocated a system of factories, auto and auto part dealers, automobile mechanics, financial credit for automobile buyers, the petroleum industry, highways, traffic laws, and the American culture of the automobile (Hughes 1989). Without such a supporting system, internal combustion automobiles probably could not have succeeded against their historical competitors, including horses, electric cars, and steam-powered cars, despite the apparent superiority of the former. Indeed, system-building in one form or another is the only way technology ever widely succeeds.

Energy-Efficient Mortgages as a System Phenomenon

The calculative or intuitive genius of EEM advocates has been to start constructing a sociotechnical system with EEMs at the center to support a market for energy-efficient

technologies. Advocates have not been building a new system, but rather reshaping the existing system of the residential housing industry of builders; architects; manufacturers and dealers of materials, supplies, and appliances; lenders; appraisers; real-estate professionals; code officials; and government agencies.

Without a well-developed sociotechnical system, at least two basic market problems have plagued many energy-efficient technologies. 1) These technologies have lacked a convenient market place where information and transaction costs have been low enough not to impede market activity, and 2) since most of the economic benefits of energy-efficient technology are in the moderate to long term, these technologies have often lacked the short-term market incentives to entice buyers.

EEM advocates have helped address these problems by using primary lending organizations as a surrogate market place for energy-efficient building technology. By a surrogate market place, I mean that energy-efficient technology has not actually been sold in banks, but that lucrative loan terms have been held conditional to energy efficiency. Because homebuyers are already sitting across from a loan officer willing to assist them in the process of technological choice, some information and transaction costs are conveniently reduced. Loan officers explain EEMs to borrowers, help with the paper work, and introduce them to a network of energy professionals. Also, bankers can often offer the short-term incentive of either qualifying for a loan or a larger loan and sometimes a lower interest rate than otherwise possible.

However, the matter is not that simple. Just because there are incentives and reduced transaction costs for homebuyers, this does not mean that homeowners will necessarily adopt energy-efficient technologies. In past conventional energy efficiency programming efforts, rebates, low-interest loans, and reduced transaction and information costs have often failed to motivate a large percentage of homeowners to adopt energy efficiency. Thus, social scientists have concluded that homeowners and buyers are not rational economic actors and that it is very difficult to teach them to become so (see a review of the literature by Lutzenhiser 1993 and Stern 1986). In contrast, EEMs do not rely on the assumption that homeowners are rational economic actors, nor do homeowners need to be taught to be economically rational for EEMs to succeed. Instead, EEMs place technological choice into the organizational and institutional context of the banking industry where long-term economic rationality is held at a premium, if not demanded by loan officers. That is to say, EEM advocates have changed the social context, instead of trying to change the individual.

Thus, banks are another part of the evolving sociotechnical system as organizations with profit-maximizing goals that are consistent with energy efficiency. Loan officers can make borrowers think realistically about whether they will have the income to make monthly mortgage payments. In this context, energy efficiency is one logical way to increase a borrower's effective income so they can more easily make mortgage payments.

Of course, there is much more to this system than lending organizations and their short-term incentives and reduced information and transaction costs for homebuyers. These incentives are not available simply because banks tack up signs reading "Energy-Efficient Mortgages." Short-term incentives and reduced information and transaction costs exist because EEM advocates have constructed a larger sociotechnical system of networks,

new and old organizations, institutional rules, and values and beliefs that are supportive of EEMs. First, reduced information costs appear to have resulted because EEM advocates have forged networks of trust between bankers and energy professionals through which information can be more easily given to homeowners. Second, transaction costs appear to have been reduced because, in part, institutional arrangements between primary mortgage lenders, secondary lenders, and government agencies have led to simplified paper work and procedures. Third, the short-term incentives of qualifying for loans, larger loans, and lower interest rates exist largely because HERS organizations are giving lenders increased confidence in financing energy efficiency. HERS organizations have done this through a set of institutional rules to access the cost effectiveness of energy-efficient technology. This cost-benefit analysis is then factored into financial formulas to account for the risks associated with lending. Fourth, EEM advocates have prompted organizations such as Fannie Mae and the FHA to provide primary lenders with dependable, relatively risk-free secondary markets for EEMs. Fifth, EEM advocates have been building awareness about the benefits of energy efficiency within the residential building industry to increase the market value of energy-efficient homes.

The point is that EEMs are truly a systems phenomenon that cannot be viewed simply in terms of financial incentives. EEMs work only because of the larger organizational, institutional, and network components of the residential building industry.

Toward a Theory and Method of System-Building

Although system-building is a proven path to success, it has mostly been used as an intuitive process by the captains of industry to advance conventional technologies. The task in this paper is to begin to explicitly articulate a theory and method of system-building for advocates of alternative technologies. Several bodies of research can serve as a useful beginning, including Benniger 1986; Bijker, Hughes & Pinch 1987; Callon 1987; Cowan 1996, 1990; Hughes 1989; Law 1987; and Lutzenhiser 1994. From different perspectives, these authors all suggest that as a sociotechnical system develops it has to contend with certain aspects of itself that are less effective, reliable, and well developed than others. Because of the interrelatedness of all components in a system, Hughes (1989) suggests that the weakest components will limit the performance and development of the entire system. Callon (1987) calls these "points of resistance," which must be removed by system-builders before the system can developed forward. Of course, as Hughes (1989) states, when a system does move forward in this way, it will soon encounter new points of resistance that will again hinder system development and must then be addressed. This is a continual process of finding points of resistance and removing, abating, and circumventing them. It should also be noted that points of resistance can either be social aspects or physical pieces of hardware.

Any of a large number of components that are not fully developed could be a point of resistance holding back a system. However, Hughes (1989) suggests that some points of resistance hold back a system more than others. In which case, it should be possible to construct a list of theoretical characteristics to identify places in a system where major points of resistance may exist and where system-building efforts can be focused to

strengthen the system. First, it is helpful to view sociotechnical systems as consisting of interacting processes that yield social, economic, and technical products. If a point of resistance is at the *beginning* of an important process, resistance at that point may disproportionately hinder outcomes farther along in that process. Second, there may be certain critical phases/places in a decision-making process where only one organization or industry participant has authority to make a key decision that greatly constrains the technological choices of others participants acting as a *bottleneck* in system-processes (see Clegg 1989 as well as Law and Callon 1992 for a similar discussion). Third, a *lack* of financial or other vital resources in a key process can hinder that process and the entire system from functioning as intended. These first three characteristics have examples in the residential building industry. A point that is a bottleneck and that occurs relatively early in the process of residential home construction is the decision of lending organizations to give or not give financing for the construction of new homes and associated energy technologies. Without financing, most residential construction projects will not occur.

Fourth, paradigmatic beliefs and values shared by a profession, group of consumers, or an entire society can place broad constraints (Hughes 1989) on how people diagnose problems and what they view as solutions. For example, despite the existence of objective cost savings from energy efficiency, the consumer preferences of most homebuyers and owners are of such that they do not prioritize energy efficiency in decision-making. Other values dominate the buying and remodeling of residential housing, such as convenience, aesthetics, and the social prestige of owning large, lavish homes (Lutzenhiser 1992, 1993). The reason is probably not that most homeowners are opposed to cost savings or that energy efficiency is always at odds with these other goals. Instead it appears to be that the paradigmatic outlook of the average homeowner does not include energy-efficient technology as a salient solution to achieve economic well being and well being in general.

To reiterate, the failure to adopt energy-efficient technology can be best understood from a systems perspective. While many different points of resistance can hinder the development of a system, the seriousness of a point of resistance theoretically depends on how that point relates to the rest of the system: whether it is at the beginning of important processes, if it involves key decision-making at a bottleneck, et cetera.

According to the first three characteristics of possible locations of major point(s) of resistance, the mortgage lending industry appears to be a location of major resistance. Of course, lending organizations may not be the only location of major resistance, and the intent is not to place blame on the lending industry for low adoption rates of energy-efficient technology. Instead, the systems perspective is a heuristic that merely suggests that mortgage lenders are in a key position to place leverage on the rest of the system, particularly with further system-building to strengthen their ties to the rest of the system.

However, thus far, little has been said about the actual nature of those underdeveloped or missing components at the location of the mortgage lenders in the residential building industry. If a hypothetical participant in the residential housing industry is to effectively promote energy efficiency or itself engage in energy efficiency, it would be conducive for that participant to have or have access to several things. These include *direct economic benefits* from energy efficiency with minimal risks and low

information and transaction costs; a *paradigmatic outlook* that recognizes cost savings from energy efficiency as part of a solution to achieve larger economic goals; the availability of the necessary *investment capital* for energy efficiency; the *authority* to make technological choices in the residential housing industry; and the *technical expertise* to understand energy efficiency and the economic costs and benefits of it.

Historically, the mortgage lending industry has only had, or has had access to, one of these—investment capital—and the absence of each of the others can be considered to have been a major point of resistance toward the development of energy efficiency. These other elements have historically been scattered among other participants in the residential housing industry and with little coordination with the mortgage lending industry. Thus, the system-building approach is to link industry participants together with institutional, organizational, and network arrangements that can help coordinate the vested interests, resources, skills, and paradigmatic outlook of each participant so they can function relatively smoothly together—each making a unique contribution to the functioning of the system. The general typology of how this is apparently starting to work in the residential housing industry with the EEM-HERS linkage was discussed in the previous section. In addition it should be noted that the past lack of these arrangements to link together industry participants could itself be considered a point of resistance.

However, the question becomes: What specific tactics and strategies can be use to construct institutional, organizational, network, cultural arrangements that can tie the participants of a system together into a well-oiled effort? The efforts of the EEM movement suggest a number of possibilities including some that would not be intuitive without pointing to the movement and some that would be. Although not exhaustive, the most obvious include 1) building networks based on tangible incentives and mutual gains to allow cooperation among industry participants in a sociotechnical system, 2) constructing new organizations to perform necessary but previously unattended to functions (which is exemplified by the HERS organizations assessing the cost-benefits of energy technologies) and linking them to the rest of the system. Perhaps less intuitive is 3) the effort of the EEM movement to provide lending organizations a vested interest in energy efficiency by linking the interests of bankers for lending more money with little or no extra risk with that of homeowners' interests in qualifying for more loans, larger amounts, and lower interests rates. Also, the EEM movement 4) has placed decision-making about energy efficiency into the organizational and institutional context of the mortgage industry that encourages if not demands economically rational decision-making, instead of trying to re-educate homeowners into rational actors.

It has been suggested that the most serious historical weaknesses (i.e., points of resistance) in the residential housing industry has been that lending organizations have not had information about the economic costs and benefits of residential energy efficiency. Because reliable information on the cost savings of energy-efficient technology was not readily available to lending organizations, lenders often viewed energy efficiency as risky and were very reluctant to finance it (Farhar, Collins & Walsh 1996). HERS are now addressing this problem by providing cost-benefit information to the mortgage industry.

As mentioned above, when major points of resistance are removed, the entire system often develops forward. In addition, it should be noted that these processes can be

very dynamic. The structural changes that occur in the system from the removal of major points of resistance create new opportunities for industry participants. In pursuit of these new opportunities, industry participants themselves engage in system-building that can resolve additional points of resistance allowing the system to develop forward even further. Although further research is need, a preliminary look at the residential building industry suggests that establishing the EEM-HERS link may have done this. By providing cost-benefit information to reduce some of the uncertainty about residential energy efficiency, lenders have been given an incentive to 1) develop a surrogate market for energy efficiency in the mortgage lending industry and 2) build stronger networks with energy efficiency professionals in the rest of residential building industry thus reducing information and transaction costs for their borrowers.

However, when a system develops forward because a major point of resistance has been removed, it only does so until another major point of resistance is encountered, which is undoubtedly the case with the residential housing industry regarding energy efficiency and EEMs. Although more research is needed to locate the current major points of resistance, a number of candidates are possible. Two of these are mentioned below.

Despite the cost-benefit information from HERS on energy technology, there does not yet exist information about whether energy savings will actually lead to lower default rates on mortgages. On a related issue, there does not exist information on the extent to which additional money can be loaned through EEMS without borrowers defaulting at higher default rates. However, there is some nation wide data of reasonable quality that lower home energy costs are reflected in the re-sale value of a home (Nevin et al. 1999, 1998). However, it has been suggested that the overall lack of feedback information about the effects of energy efficiency and EEMs on the residential housing industry is a significant reason why the risk-averse banking industry has been reluctant to more fully support the use of EEMs (Holman 1999; Lowrie 1999).

Also, it may be that the financial incentives for the mortgage lending industry are not large enough to encourage immediate, widespread participation with EEMs. The major incentives to the lending industry appear to be qualifying a few more people for loans and lending a few thousand more dollars per mortgage. This may not be a large enough incentive considering that 1) all the financial risks to lending industry have yet to be quantified, 2) EEMs require a little bit of extra paper work, and 3) sometimes there are delays in the lending processes. Also, as mentioned above, 4) because of the low interest rates in the late 90s, lenders have been doing so well with conventional mortgages and refinancing of old loans that they may have little incentive to pursue innovative financial products such as EEMs.

In sum, the system-building approach to energy efficiency varies greatly from conventional approaches that try to inject isolated policy instruments into the residential housing industry, such as rebates, low interest loans, or educational information about the economic benefits of energy efficiency—not building integrated systems. These conventional approaches have been almost entirely dependent on external funding and government administration that are vulnerable to changing political climates. In contrast, EEMs are a market-based approach with its own internal set of incentives for energy efficiency that have the potential to be largely self-sustaining in the long term. In this way,

EEM advocates are slowly making fundamental changes in the process of technological choice in an industry traditionally skeptical of energy alternatives.

Conclusion

Although adoption rates are still low for the EEM, it is an innovation that is growing in usage and appears to have market potential. However, the EEM faces many challenges as a new innovation up against the dominant way of doing things in an entrenched residential building industry. An objective assessment of the possible future of EEMs must also include the possibility of eventual failure. As a fledgling institutional innovation, it will be vulnerable to historical events, such as possibly unforeseen changes in the mortgage market or a sudden drop in energy prices, that could lead to its demise. Until EEMs are fully institutionalized, they remain particularly vulnerable.

Assessing the future of EEMs is difficult, and it is not appropriate to use the same assessment tools as for conventional energy efficiency programs. The success of conventional programs has been largely defined as the short-term adoption rates of energy-efficient technologies and behaviors (see Vine 1994 for a review of the energy program evaluation literature). This has a fundamental bias against EEMs and other system-building efforts that are trying to make fundamental structural changes that are inherently long-term projects. Also, many of the existing changes in the residential building system brought about by the EEM movement could perhaps continue to encourage energy efficiency for many years to come, even if EEM advocates ended their efforts tomorrow. On the other hand, if external funding for conventional approaches came to an end, there would likely be no further adoption of energy-efficient technology due to these conventional approaches.

In popular speech "the system" is equated to an ominous, entrenched entity that cannot be beat, i.e., "you cannot beat the system". Because EEM advocates have taken on the formidable task of trying to change the "system," they deserve much respect even though usage rates are still low. Also, given the goal of fundamental structural change in an entrenched industry, should we really expect success to occur at a faster rate? Whether EEMs eventually fail as an institutional innovation or become the next big thing in energy policy, EEMs and HERS presented us with important lessons to be learned about system-building. If the history of technology is any guide, system-building in one form or another is the only way that alternative technology will ever widely succeed.

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