

Socio-technical networks and the sad case of the condensing boiler

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ABSTRACT

Actor-network theories and work on social construction of technological systems suggest the use of the concept of a socio-technical landscape (STL). This is a virtual space where symbolic, institutional, technical and economic properties of technological systems are woven seamlessly together. The resulting mapping of the gradients and features allows new ways of seeing our evolving interaction with the systems in which we are embedded. This paper applies these concepts in a discussion of the diffusion of condensing boiler technology. This innovative and proven design saves substantial amounts of energy yet its penetration into the homes of many European states remains pitiful. As such it remains a potentially important, but as yet unused, weapon in the struggle to heat our homes more sustainably. Interviews with the range of actors from builders and trades associations to heating installers and householders are used to map the general shape of its STL whilst quantitative survey analyses are used to characterise the steepness of the some of the gradients. Some tractable policy recommendations are set out in the context of the UK government's attempts to increase the spread of condensing boiler technology.

Introduction

Conventional boilers lose around one third of the energy of the fuel in the flue gas. Condensing boilers (CBs) have a larger or secondary heat exchanger and are arranged so that not only the "sensible" heat of these flue gases is extracted but also the latent heat of vaporisation. This causes a condensate to form. In this way, boilers with an efficiency approaching 100% can be produced. The best that could be achieved with conventional boilers is under 80% (ETSU, 2000). The technology to do this is not new: a boiler with a heat exchanger capable of condensing flue gases was first designed in the 1930's. However the use of "town gas" at that time (made from driving off the volatile gases from coal) produced a highly corrosive condensate that quickly destroyed the iron heat exchanger surface. The development of stainless steels and aluminium alloys provided a corrosion resistant material whilst a widespread switch to natural gas in some EU states produced less acidic flue gases. Consequently a condensing boiler for domestic use became a viable technological proposition and the Dutch gas industry was able to produce a working prototype in 1979.

In most northerly EU states, space and water heating constitute the largest share of the domestic energy load. As such, widespread adoption of this technology offers potentially huge and cost effective energy savings in those countries with extensive gas infrastructures. For the EU, it is estimated that if condensing boilers were installed instead of the best of conventional boilers from 1990 onwards, the emission of 20 million tonnes of CO₂ would have been avoided by 2005 (IER, 1998). Clearly, given commitments under the Kyoto agreement, this is a politically significant figure. At a household level, the adoption of a CB also seems desirable. Although CB units are more expensive, paybacks can be relatively quick - between one and four years. Despite the evident advantages, penetration of this technology, particularly in some

countries, has been dismal. The Germans and the Dutch remain notable exceptions where CBs have 18% and 60% of the market for new installations respectively. Both have taken different routes to encouraging uptake. In Germany this has been through firm regulation of boiler emissions whilst in the Netherlands there has been an extensive series of subsidy schemes, backed up by installer training programs and national advertising campaigns.

Ostensibly, the Dutch success story should be the model which the UK, with its similar gas supply network, should follow. However, the UK has had a number of subsidy and information campaigns running since in 1991 and yet the fraction of new condensing boiler sales in the housing market remains very small - at around 5%. What is more, 80% of these sales are to local authorities and housing associations rather than private individuals. Ten years after the introduction of the Dutch promotion programmes, CBs were already taking some 30% of the market of new sales. Are Dutch householders really so different from the British or can the different penetration rates be explained by structural factors and the orientations of other actors?

The conventional policy paradigm - the rational action model, would tend to assume that the disparity in adoption rates is due to differences in the information environment. Social scientists have powerfully criticised such a view – again and again pointing out that technology transfer is a thoroughly social processes (for a review see Lutzenhiser, 1993) involving issues of values, norms and identity. This basic insight is now increasingly elaborated into descriptions of the organisational and institutional networks in which the technologies are embedded. This entails an appreciation of technology as an actor in an evolving system of actors – all connected by social, institutional and regulatory relationships. Much like a body rejecting a foreign antibody technologies will not diffuse until the system as a whole is able to accept them. Schwartz Cowan's (1989) work on the diffusion of the domestic stove being a well worked case in point. More recently, a sociology of domestic technologies has begun to emerge which draws on insights from science studies – particularly the work of Bruno Latour. This work focuses on the properties of the technology itself in actively shaping the context into which the technology is introduced. The technology becomes an active player in the same sense that other actors are active in the network. The technology “speaks” and imposes its own agenda through its design. As such, in some views, it makes no sense to speak of the social on the one hand and the technical on the other. They are woven seamlessly together, changing and being changed by one another; evolving the possibilities and potentials for other technologies and ways of life yet to emerge. This virtual space is sometimes called a socio-technical landscape.

In what follows, an analysis of the diffusion of the condensing boiler is offered which tries to view the technology as such an actor in system or socio-technical relations. Each actor in the chain of specification of heating systems is isolated and their social, economic and institutional orientations to one another described. This was achieved by conducting interviews lasting at least one hour with a number of representatives of each actor group (between 5 and 10 interviews were conducted for each group) and the analysis of a questionnaire of householders who had recently changed their heating systems (n = 522). This results in a network diagram as shown in Figure 1.

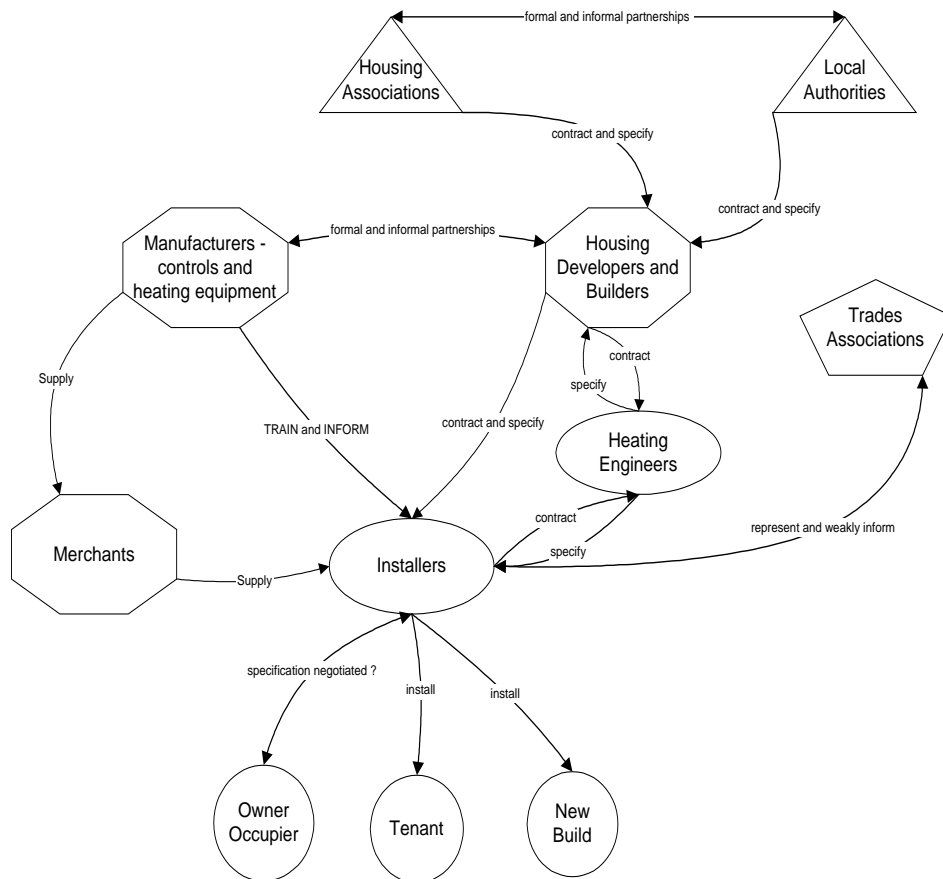


Figure 1: Network of actors implicated in the specification of domestic heating equipment

Householders

Positive attitudes to efficiency are virtually unanimous but generally qualified by the extent to which investments in efficiency will save money or add comfort rather than solely benefiting the environment.

I mean we all try and do our bit for the environment to a certain extent. So I do try to be as energy efficient...actually its probably more money motivated actually.

DH

In contrast to the widely shared idealism of heating the home in an environment friendly manner an interest in innovative heating techniques is confined to only a few as shown in Table 1.

Table 1: Interest in innovative heating techniques

Agree Strongly	Agree Slightly	Neither Agree nor Disagree	Disagree Slightly	Disagree Strongly
9	10	11	34	37

This response is not entirely surprising. Adoption of an innovation is, almost by definition, confined to a minority. It requires some measure of personal risk and that the individual either has a strong normative motivation for the adoption and/or an appreciation of the relative advantages of the adopted system (Rogers, 1983).

Two of those interviewed had bought condensing boilers. Both were established professionals in a technical area - one a micro-electronics engineer, the other a physicist. Following installation both had problems with their respective boilers. MT entered into a lengthy correspondence with the manufacturers concerning, amongst other things, the technical information provided in the installation instructions whilst the other went to the point of designing a home-made electronic device which solved the boiler's control problems. It is likely that these kinds of skill and awareness give prospective buyers the confidence to invest in such technologies regardless of countervailing forces. They are the "early adopters", having a certain amount of technical confidence, financial resources to take a small risk and networks of friends and peers who would sanction such behaviour.

Such characteristics are not randomly distributed throughout the population. Early adoption is invariably associated with individuals from higher socio-economic groups (e.g. Fisher and Price, 1992; Hackett and Lutzenhiser, 1990). Condensing boilers seem no exception. The UK's Energy Savings Trust, the body responsible for overseeing the government's strategy on the promotion of the condensing boiler, compared those that had purchased a condensing boiler and obtained a rebate through the trust with those that had purchased a conventional boiler during the same period. A disproportionately high number of scheme participants were from socio-economic groups A and B (EST, 1994).

Buying a replacement boiler is generally considered a "distress" purchase. The questionnaire sought to gauge how distressing the purchase of a replacement boiler really is. Surprisingly, only 35% of respondents described the situation as an "emergency" whilst 70% felt that they had time to gather information prior to the work being done. This suggests that the need to replace a system immediately, without opportunity for prior consultation other than with the installer, only occurs in a third of cases. Hence, there is the potential for innovative or efficient technologies to be assessed and considered by the majority. Despite this opportunity 71% had *only* used information and advice provided by the installer when choosing the particular type of equipment to be installed. Evidently, most householders are dependent on the advice of the installer in deciding the specification of their new heating system. Since only around half of respondents obtained more than one quote for the work and given a general reliance on installer advice (to the point where price may become a secondary issue) it is apparent that there is a great opportunity for an enthusiastic installer to encourage the householder to invest a little more in efficient equipment.

Conclusion

There seems to be a stubborn assumption in the policy making community that when presented with information all groups will use it in a logical way to come to the optimal decision. Although it is undoubtedly true that a few highly competent individuals will come to considered decisions and then ensure that they are executed it is unlikely that this is the case for many or most. This is particularly evident in the specification of heating systems. Much will depend on

recommendation, hearsay, what is available, what is trusted etc. What is more, even assuming a fully knowledgeable and motivated householder, many of the most important decisions influencing what is installed will be taken by the installer. What then, are the orientations of this actor group?

Installers

There are a number of constraints on what the installer can choose. Most obviously, there is the issue of cost. The installer knows that the householder may get more than one quote for the job so it is important to put in a good price. However, self-employed plumbers seem to get much of their work through recommendation and therefore can trade on their reputations as well as the bottom line.

Installers feel that there is a number of boiler manufacturers in the marketplace all making good quality products and that all comparable boilers are similarly priced. How then do they choose between them? Each installer seemed to have a preference for one or two manufacturers depending on what kind of boiler was being installed. For instance, two mentioned "Worcester" as the best for combination boilers, whilst "Baxi" make great "back" boilers. Other than such pieces of "insider knowledge" and a respect for established brands, particular manufacturers tend to be selected based on individual experience of the products over the years. This is because reliability of the new installation is paramount for an installer. An installer does not want to be called back to fix something. It is not good for one's professional reputation and the time spent is not usually chargeable.

We tend to stick to what we know. The last thing we want is for them to say, "this boiler you've just installed isn't working" because we don't get paid for going back and the customer doesn't want it. To be honest we just want to put it in and forget it and carry on with the next one. You don't try things just for the cost - to try and save £30-40 on a boiler.

RP

Each boiler is different and there is a limit to the detailed understanding that an installer can have of all manufacturers and all models. It makes sense to specialise in a few for which one knows that one has the right tools and spares should anything go wrong.

[Interviewer] So once you have got training in a certain range of products you don't have to keep going back learning about other boilers?

[Respondent] That's right and of course we keep a range of spares for that one make of boiler. Whereas if you are going to start using say, Potterton or Glowworm you are going to need to keep a range of their spares as well because they all like to make things a little differently - they are not interchangeable.

JH

We do an awful lot of work for Baxi. All the Baxi boilers I know inside out. My tools are not necessarily geared to Baxi, but I know what tool to pick up for a particular part of a boiler. I just naturally do it because I know that screwdriver will fit that and I know that adjustable will fit that whereas with another make I might be fumbling around until I get the right tool.

DR

Evidently, these orientations will encourage a rather conservative orientation to new products and techniques. Indeed, despite generally positive attitudes to the notion of making heating systems more efficient attitudes to the condensing boiler were equivocal. All knew of the

technology and most had fitted one. Even those who had not fitted one before did not perceive a difficulty in doing so: creating the drain for the condensate does not seem to be an issue.

There is a perception that there is no demand for the CB and, bearing in mind that householders may ask for a number of quotes, it makes no sense to suggest one thereby quoting a price that may be up to several hundred pounds more - unless given a clear lead to do so by the householder.

If you stick another £300 on for a condensing boiler that can make the difference between getting you to do the job or not. So unless they actually stress a condensing boiler, you don't price for it.

DR

Despite these perceptions of the importance of the quote, evidence presented above suggests that installers may have considerably more leeway than they imagine. In addition to the extra cost there also seems to be a perception that the condensing boiler is not really appropriate for ordinary domestic use where boilers don't have to work hard enough for long enough to get into "condensing mode" and hence generate the savings.

And certainly a condensing boiler isn't much more efficient or cheaper to run, unless it is in full condensing mode all the time which really doesn't happen.

[Interviewer] What conditions would allow that to happen?

If it was very cold and the boiler was working hard all the time...I think the big sell on condensing boilers is their green properties rather than savings on running costs.

JH

This is actually a myth (and a seemingly very widely held one). The extra energy saving through capturing the latent heat of vaporisation (thereby causing the flue gas to condense) is small compared to the extra sensible heat gained over conventional boilers due to the CB's larger area of heat exchangers. Consequently, CBs are substantially more efficient than conventional types whether they are causing flue gas to condense or not. Given a perception of a marginal energy saving when installed in domestic properties it is hardly surprising that the substantial extra costs do not seem justified.

No-one ever asks you for one [a condensing boiler] unless they are really clued up and I've never come across one myself. But anyway, anything average like a terrace or a semi, condensing boilers are of no benefit because of the extra cost - big houses, yes.

JD

A perception of lack of demand and misconceptions over the possible savings do not explain reticence to install the condensing boiler when the householder makes a clear and unprompted request for the product. Both of the CB buyers amongst those interviewed had encountered extreme resistance to the products.

..I found a perceived hostility amongst many heating installers to condensing flue boilers when I made enquiries. Very striking that. I received the impression that they were expensive, unreliable, dodgy, untrusted technology.

MT

This resulted in one of these individuals installing the boiler himself,

[Interviewer] So you were thinking of actually installing it yourself?

Yes - I did do that. And there is a good reason for that. I phoned about seven heating installers about installing condensing boilers of which only two would actually consider installing them. Five of them varied from being, "are you sure you know what you want" to "Oh no - we don't install those". So they were questioning me about my choice of boiler which I was quite surprised at.

DF

In sum, a vicious circle seems to be operating. Installers don't suggest CB's to householders because they are, with good reason, conservative. In addition the boilers cost a little more and installers do not perceive any overt demand for them (because there is almost none). Therefore, householders who may have been interested are not made aware of the CB as an option when discussing the proposed work with the installer. Consequently, a conventional boiler is installed where, had the condensing type gone in, it is likely that the householder would have told others thus helping to stimulate further demand in the wider marketplace. In addition, through installation of the condensing type and observation of its reliable functioning, installer conservatism would begin to be broken down. Instead, demand for this technology remains small, economies of scale cannot be levered and so the price of the CB remains relatively high. Consequently, installers do not suggest them and so on. This seems to be an instance where both demand and supply need to be simultaneously encouraged so that the market takes off. At present, the two sides act negatively on each other.

Manufacturers and Merchants

Most of the big manufacturers make condensing boilers and they want to see the market grow for a higher value product. In addition to this commercial imperative a stream of regulation is beginning to emerge from Europe which will drive up the average efficiency of all boilers made. As one boiler manufacturer put it, "the future is condensing!" The manufacturers of control systems are also particularly keen on promoting the efficiency credentials of their product and bemoan the lack of electrical skills amongst most installers who shy away from installing these systems. It is quite clear that manufacturers see their principle marketing target as the installer.

So the installer is what we call "pulling product from the merchants shelf". So a lot of our marketing activity is actually aimed at the installer and it's all about trying to get them to buy our products. Because they are, from our point of view, the specifier of the product.

KT

It is felt that once the installer is comfortable with a particular manufacturer that they will tend to stick with that manufacturer. Interviews with installers confirm this. Brand loyalty is often fostered at an early stage - those systems that are trained on as an apprentice tend to be what is specified as a matter of course in later life. Consequently, the manufacturers are very keen to be involved in the provision of training materials. Indeed, one respondent mentioned that his company had provided, free of charge, the boilers for 44 technical training colleges.

These people are going to train on our boilers so when they go away and start specifying boilers for themselves they will pick the ones they know - that's the long term thinking in this.

NS

A range of other techniques are employed to encourage the installer to choose one manufacturer over another including points schemes, sophisticated web-sites, help-lines offering advice and

promotions in the trade press and at the builders and plumbers merchants. The latter technique is not seen as particularly effective given that the decision about boiler type is usually taken before arrival at the merchants.

Merchants, although they probably won't admit it – they influence about 10% of installers that come across their counters. They could switch sell about 10% of people which is very low.

BF

As such it seems that the merchants simply act as a counter and distribution system for the manufacturers – taking a credit risk on the products and being rewarded accordingly. Consequently, the merchants have no great brand loyalty: so long as installers are requesting a particular boiler in large enough numbers they will continue to stock it.

It seems that the manufacturers do not see a commercial conflict between their efforts to stay in business and the promotion of energy efficiency. They actually work together very well. The manufacturers would like to sell more boilers and therefore would like to see an increase in the turnover of the boiler stock. Even a conventional modern boiler will be substantially more efficient than the older boiler it replaces. They would also like to sell more of their higher value products such as the condensing boiler. The stumbling block identified by all is the installer who is considered to be conservative and not a sufficiently good salesman to convince the householder of the benefits of energy efficiency. Installers also suffer from something of an image problem in the UK – 60 % of the sample felt they could not, “trust an installer I didn't know to do a good job at a reasonable price”. This lack of faith in the profession can act as a profound disincentive in taking the initial steps to improve ones heating system (Joseph Rowntree, 1998)

It is considered that this situation will only get worse in the medium term. The workforce of installers is ageing with very few new apprentices coming into the industry. Those that do come are “often not the brightest students”. Hence, a conservative old guard remains whilst those few new boys that are in the industry may not have quite the initiative and appetite for further training that they otherwise might. Hence the manufacturers are very supportive of organisations such as the Institute of Plumbing who wish to see the average plumber becoming more professional and for the craft professions in general to be given a higher status. It is thought this will encourage higher calibre apprentices back into the trade who will be better at selling the benefits of greater efficiency.

Housing Developers

It seems that beyond complying with the regulations, energy efficiency or greenhouse gas reduction is not a priority when designing, building and equipping new homes. Designing in efficiency may impose extra costs which sales managers and managing directors do not feel will add value to the house in the eyes of a potential buyer. This may be partly because many new homebuyers are also first time buyers. Such purchasers are generally looking to move on after a few years having got to the first rung of the property ladder. Consequently, considerations of the cumulative running costs of the heating systems over the longer term may be less salient.

If you are talking about energy efficiency, of course you could have it much higher than it is today and the cost of it could be measured in a few hundred pounds, but the market won't pay for it

There remains the issue of the invisibility of many energy efficient building practises and products such that the *idea* of the efficiency must be sold rather than a tangible feature of the house such as UPVC window frames.

[referring to the invisibility of efficient building design] You can't touch so how do you sell energy efficiency. You know - its not something you can say, "see that - that's energy efficient - that's going to save you £300 pounds a year."

DM

Innovation in building practises is also suppressed by mortgage lenders.

We have another problem which is lenders - if we build a product that they won't lend on we can't sell the product. So even though people want to buy our products we have to persuade the lenders to lend money on it

[Interviewer] Why would a lender refuse?

Because they feel that the house is built in such a way that they would not be able to resell it in ten years time should that mortgage go bad.

DM

This reticence to lend on something unusual ultimately depends on the lenders' perception of what the house-buying market finds desirable. At present it is thought that most buyers are extremely conservative in their tastes. Certainly, it is established that the appearance of the home gives potent information about what the likely lifestyle and social standing of the occupants may be. This extends right down to the texture of the walls and the type of brick used (Sadalla and Sheels, 1993).

You could build something that looked like something out of 2001 which is fine until you try and sell it because you find that people don't want to live in a house like that.

DM

This leads to a rather paradoxical conclusion. Although, on the one hand, the marketing of efficiency is hampered by its invisibility on the other it is precisely because of its invisibility that it can be incorporated in design without putting off a conservative buying public.

The situation is analogous to that of electric utilities in the US supplying electricity generated with renewable sources. At present only 2% do so (some 85 utilities nationally). When the decision-making of utility managers who do supply renewably generated electricity is compared to the non-adopters it is found that there is little difference in the technical knowledge of the systems but large differences in what is termed "familiarity". This leads to the conclusion that simply bombarding utility managers with further information will fail. Instead, smaller scale projects should be encouraged which "familiarise" managers with the technology in question (Kaplan, 1999). There would seem to be a role here for housing associations and local authorities. If they could be encouraged to specify greenhouse gas reduction then the resulting familiarisation could create policy change when developers are building for themselves. The same effect would presumably work with subcontractors actually doing the work when they are in a specification role.

Policy conclusions

For replacement of heating systems in existing housing it is clear that decisions about the appropriate system type and make or model are generally left to the installer. Installers have good reasons to be conservative but, this research suggests, they have less reason to be overly concerned about suggesting equipment that may be slightly more expensive. Once recommended it seems that the installer is usually able to suggest more or less what he sees fit. In addition there seems no reason why installers should not, as a matter of course, make two quotes – one for the more efficient system and one for the conventional package. Householders can then choose and the installer does not risk losing the business.

Hence, an enthusiastic and trained installer is potentially the key to more efficient heating installations. Hence a training course should be established for installers. This should cover both the technicalities of CB installation and develop an enthusiasm for selling the idea of greater efficiency to the householder. The development of an A to G label rating for new boilers would also raise awareness of efficiency as an issue with installers. Such a label would also assist other specifiers such as architects, local authority housing officers and indeed the small number of householders who do take a more active role in specification.

However it is not thought that the offer of additional training is not something that many or most installers will jump at. Even the existing training for certification as a “competent” person fit to perform gas installations is considered a chore. Perhaps ways can be found to further incentivise installers to attend the course – for instance manufacturers might feel able to link attendance with their points schemes. In the longer term, the trade associations’ objective of registering all plumbers seems laudable indeed. This would increase the professionalism and standing of the trade. Consequently, a greater number of (higher calibre) apprentices may be encouraged back into the plumbing industry who in all likelihood would be trained on the newer, more efficient systems and who would consequently have a more positive orientation to the issue of efficiency in their working lives.

Difficulties with training installers switch the policy onus back to the householders who must be encouraged to ask for efficient systems. Indeed, the use of information strategies aimed at the householder rather than the installer is particularly important in creating demand for new boilers when the existing system has not yet broken down but is simply old and inefficient – an “early replacement” strategy. A modern boiler will always be more efficient than its older replacement regardless of whether it is condensing or not. Pursuing this strategy removes the onus on the installer to suggest the most efficient of the new systems available. Creating demand for new systems will not be easy. At present only around 5% of installations are motivated in this way whilst other evidence not presented here suggests that many householders will tolerate even barely functioning heating systems indefinitely (Fawcett *et al*, 2000). This suggests that the main route to early replacements will be through refurbishments, extensions and kitchen refits and targeted information.

What is more, there is much evidence to suggest that those that can least afford to have inefficient heating systems are also usually the least receptive to institutional initiatives in this respect. There is a nexus of issues concerning stake-holding, trust in institutions, equity, shared agenda's and social exclusion are at the heart of social marketing. In certain context's ones

orientation to institutions goes a long way in explaining contrasting adoption rates of efficient technologies between different strata within a society (Banks, 1999) or in responding positively to energy labels on cold appliances between this country and say the Netherlands and Denmark (Cool Labels, 1998; IER, 1998).

Although environmental attitudes are apparently similar in these countries (SCPR, 1999), their societies are much less stratified and more democratic (at a local level) than our own (Harrison *et al*, 1996). Consequently, there tends to be greater acceptance of institutional agendas at the grass roots level and correspondingly greater uptake of institutionally sponsored initiatives (Cames, 1999).

Householders seem particularly receptive to the idea of improving the infrastructure when moving to a new home. This suggests that the forthcoming sellers' pack to be prepared by vendors for distribution to potential buyers should include some form of energy audit. Equally kitchen centres, DIY stores and builders and plumbers merchants would be appropriate places to leave leaflets and posters. The alternative to information strategies is regulation on emissions levels allied with a monitoring regime - as practised in Germany.

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