Categorizing Barriers to Energy Efficiency: An Interdisciplinary Perspective

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1. Introduction

This chapter presents theoretical perspectives on barriers to energy efficiency identified in different scientific disciplines, and briefly describes each barrier and its mode of operation. In an attempt to categorize barriers to energy efficiency, the chapter addresses socio-technical regimes, leading to a novel interdisciplinary categorization of barriers to energy efficiency in *three categories*: the technological system, the technological regime, and the socio-technical regime.

The threat of climate change resulting from the use of fossil fuels is posing a threat to the environment, and energy efficiency is one of the most important means of reducing this threat (IPCC, 2007). Despite this, there are a number of publications stating the existence of a "gap" between potential cost-effective energy efficiency measures and measures actually implemented—the so called "energy efficiency gap" or "energy paradox" (York et al., 1978; Blumstein et al., 1980; Stern and Aronsson, 1984; Hirst and Brown, 1990; Gruber and Brand, 1991; Stern, 1992; DeCanio, 1993; Jaffe and Stavins 1994; Sanstad and Howarth, 1994; Weber, 1997; Ostertag, 1999; Sorrell et al., 2000; Brown, 2001; de Groot et al., 2001; Schleich, 2004; Sorrell et al., 2004; Schleich and Gruber, 2008). This "energy efficiency gap" or "energy paradox" exists due to barriers to energy efficiency. A barrier may be defined as a postulated mechanism that inhibits investments in technologies that are both energy-efficient and economically efficient (Sorrell et al., 2004).

Barriers are explanations for the reluctance to adopt cost-effective energy efficiency measures derived from mainstream economics, organizational economics, and organizational and behavioural theories. There are also institutional or structural barriers to energy efficiency that do not directly affect the "gap", even though it does affect the overall level of energy efficiency. Barriers may be divided into three broad categories: *Economic*, *Organizational* and *Behavioural*. Inspired by an extensive review of the existing literature on barriers to energy efficiency, Sorrell et al. (2000) compiled a barrier framework categorized into different barriers (see Table 1; the barriers are explained in greater detail in the following sections of this chapter). It should be noted that the above classification of barriers is not unambiguous; one type of real-world phenomena may be explained by several of the theoretically derived barriers presented (Weber, 1997).

Jaffe and Stavins (1994) outlined a number of different levels of "energy efficiency potential", or "energy efficiency gaps" (see Figure 1). The figure states that the actual potential level of energy efficiency depends on which view is applied—while the technologist's potential is real in a sense, the economist's potential is actually real for that person or organization, with the difference between the two levels depending on which theoretical perspective is being applied.

Theoretical Barriers	Comment
Imperfect information (Howarth and Andersson, 1993)	Lack of information may lead to cost-effective energy efficiency measures opportunities being missed.
Adverse selection (Sanstad and Howarth, 1994) (Jaffe and Stavins, 1994)	If suppliers know more about the energy performance of goods than purchasers, the purchasers may select goods on the basis of visible aspects such as price.
Principal-agent relationships (Jaffe and Stavins, 1994)	Strict monitoring and control by the principal, since he or she cannot see what the agent is doing, may result in energy efficiency measures being ignored.
Split incentives (Jaffe and Stavins, 1994) (Hirst and Brown, 1990)	If a person or department cannot gain benefits from energy efficiency investment it is likely that implementation will be of less interest.
Hidden costs (Jaffe and Stavins, 1994) (Ostertag, 1999)	Examples of hidden costs are overhead costs, cost of collecting and analyzing information, production disruptions, inconvenience etc..
Access to capital (Hirst and Brown, 1990) (Jaffe and Stavins, 1994)	Limited access to capital may prevent energy efficiency measures from being implemented.
Risk (Hirst and Brown, 1990)	Risk aversion may be the reason why energy efficiency measures are constrained by short pay-back criteria.
Heterogeneity (Jaffe and Stavins, 1994)	A technology or measure may be cost-effective in general, but not in all cases.
Form of information (Stern and Aronsson, 1984)	Research has shown that the form of information is critical. Information should be specific, vivid, simple, and personal to increase its chances of being accepted.
Credibility and trust (Stern and Aronsson, 1984)	The information source should be credible and trustworthy in order to successfully deliver information regarding energy efficiency measures. If these factors are lacking this will result in inefficient choices.
Values (Stern, 1992)	Efficiency improvements are most likely to be successful if there are individuals with real ambition, preferably represented by a key individual within top management.
Inertia (Stern and Aronsson, 1984)	Individuals who are opponents to change within an organization may result in overlooking energy efficiency measures that are cost-effective.
Bounded rationality (Sanstad and Howarth, 1994)	Instead of being based on perfect information, decisions are made by rule of thumb.
Power (Sorrell et al., 2000)	Low status of energy management may lead to lower priority of energy issues within organizations.
Culture (Sorrell et al., 2000)	Organizations may encourage energy efficiency investments by developing a culture characterized by environmental values.

Table 1. Classification of barriers to energy efficiency (inspired by Sorrell et al., 2000).

1.1 Economic barriers – market failures

One important category with regard to barriers is the group of barriers that may be seen as market failures violating the underlying axioms of mainstream economic theory. According to mainstream economic theory, a market failure may justify public policy intervention. However, the mere existence of a market failure may not in and of itself be sufficient to justify intervention. As Brown (2001) writes:

"The existence of market failures and barriers that inhibit socially optimal levels of investment in energy efficiency is the primary reason for considering public policy interventions. In many instances, feasible, low cost policies can be implemented that either eliminate or compensate for market imperfections and barriers, enabling markets to operate more efficiently to the benefit of society. In other instances, policies may not be feasible; they may not fully eliminate the targeted barrier or imperfection; or they may do so at costs that exceed the benefits." (Brown, 2001).

The elimination of a market failure barrier may thus only be put into operation if the benefits arising from an intervention exceed the cost of implementation.

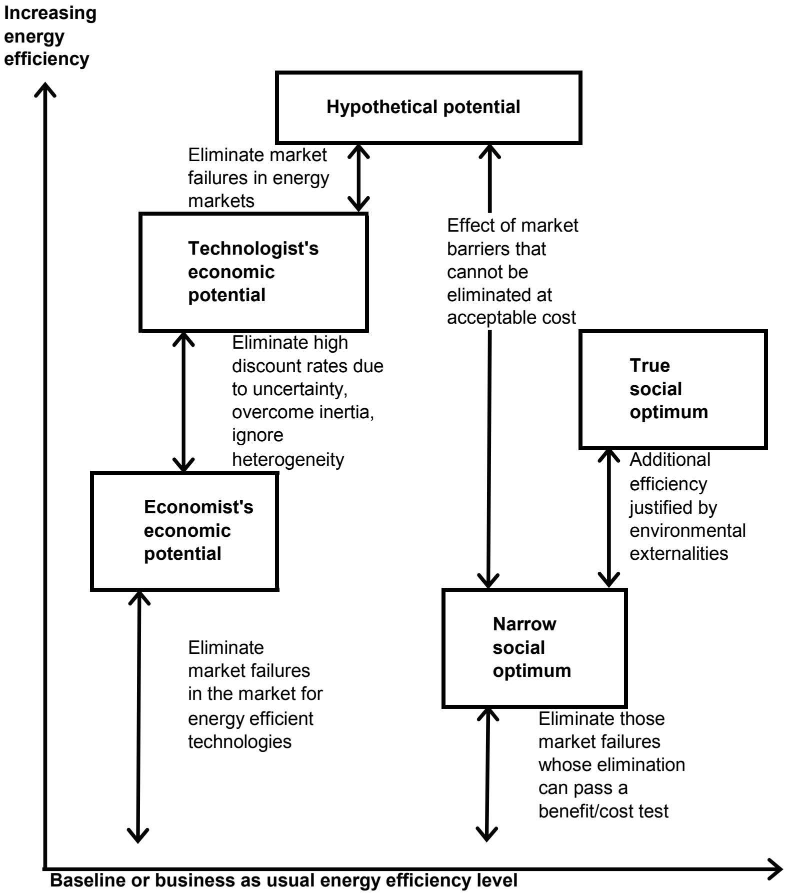

Fig. 1. Different levels of energy efficiency potential (Jaffe and Stavins, 1994).

An often cited market failure barrier is *imperfect information*. Other market failure barriers include *asymmetric information*, a special form of imperfect information where *split incentives*, *adverse selection*, and *principal-agent relationships* may also be categorized. These market failure barriers are presented below.

1.1.1 Imperfect information

A large body of research states that consumers are often poorly informed about market conditions, technology characteristics and their own energy use. The lack of adequate information about potential energy-efficient technologies inhibits investments in energy efficiency measures (Sanstad and Howarth, 1994). Insufficient information is one form of imperfect information, such as when the energy performance of energy-efficient technologies is not made available to agents. Another form of imperfect information is the cost of information, meaning that there are costs associated with searching and acquiring information about the energy performance of an energy-efficient technology. Yet another form is the accuracy of information, meaning that the information provider may not always be transparent about the product being offered. Imperfect information is likely to be most serious when the product is purchased infrequently, performance characteristics are difficult to evaluate either before or soon after purchase, and the rate of technology change is rapid relative to the purchase intervals (Sorrell et al., 2000), which is the case for many energy efficiency measures. Issues related to imperfect information may be countered with different forms of information campaigns.

1.1.2 Adverse selection

Adverse selection means that producers of energy-efficient equipment are, in general, more informed about the characteristics and performance of equipment than prospective buyers. In other words, the information between the two parties engaged in the transaction is asymmetric. Since asymmetric information is extremely common in real world markets, inefficient outcomes may be the rule rather than the exception (Sanstad and Howarth, 1994).

1.1.3 Principal-agent relationship

The principal-agent relationship arises due to a lack of trust between two parties at different levels within an organization or transaction. The owner of a company, who may not be as well-informed about the site-specific criteria for energy efficiency investments, may demand short payback rates/high hurdle rates on energy efficiency investments due to his or her distrust in the executive's ability to convey such investments—leading to the neglect of cost-effective energy efficiency investments (DeCanio 1993; Jaffe and Stavins, 1994).

1.1.4 Split incentives

A split incentive may occur when the potential adopter of an investment is not the party that pays the energy bill. If so, information about available cost-effective energy efficiency measures in the hands of the potential adopter may not be sufficient; adoption will only occur if the adopter can recover the investment from the party that enjoys the energy savings (Jaffe and Stavins, 1994). This is often referred to as the landlord-tenant relationship For example, if a mid-level executive pays the energy bill for his or her division based on number of employees, this decreases interest in the organization's overall in-house energy program to lower energy costs (including investments in energy efficiency technologies), since there is “nothing in it” for him or her. This is a restriction to adopting energy-efficient technologies, in particular those with higher initial costs but lower life cycle costs than conventional technologies (Hirst and Brown, 1990). The lack of sub-metering within multidivisional organizations may also be classified as a split incentive.

1.2 Economic barriers: non-market failures

Apart from market failure barriers, there are a number of barriers that explain the “gap” but which cannot be categorized as market failures, but are rather *non-market failure* barriers or market barriers. A market barrier, according to Jaffe and Stavins (1994), may be defined as *any factor that may account for the “gap”*, while Brown (2001) defines market barriers as *obstacles that are not based on market failures but which nonetheless contribute to the slow diffusion and adoption of energy-efficient measures.* Barriers that may be categorized as market barriers are, for example, hidden costs, limited access to capital, risk, and heterogeneity. These barriers are presented below.

1.2.1 Hidden costs

Hidden costs are often used as an explanatory variable for the “gap” (DeCanio, 1998). In short, the argument is that there are high costs associated with information-seeking, meeting with sellers, writing contracts and other such activities; if these costs are higher than the actual profit from implementation, they inhibit investment. Accordingly, cost-effective measures are not cost-effective when such costs associated with the investment are included. A study by Hein and Blok (1994) found that hidden costs in large energy-intensive industrial firms ranged from three to eight percent of total investment costs. In smaller, non-energy-intensive firms, such costs are thus likely to be even higher. Hidden costs are a frequently used argument against the existence of an energy efficiency gap; it is argued that engineering-economic models are not able to see the full cost of an energy efficiency measure (Sorrell et al., 2000).

1.2.2 Limited access to capital

Technologies that are energy-efficient are often more expensive to purchase than alternative technologies (Almeida, 1998). Moreover, obtaining additional capital in order to invest in energy-efficient technology may be problematic. Apart from low liquidity, limited access to capital may also arise due to restrictions on lending money (Hirst and Brown, 1990). Sometimes such restrictions may be self-imposed.

1.2.3 Risk

Even though, for example, managers know what the capital cost is for an energy efficiency investment, there can be uncertainty about the long-term savings in operating costs; this means the investment poses a risk. Such concerns have been found to be very important to decision-makers (Hirst and Brown, 1990).

Stern and Aronson (1984) also identify risk as a barrier to energy efficiency, since accurate estimates of the net costs of implementing energy efficiency measures depend on future economic conditions in general, and on future energy prices and availability in particular. Energy prices have fluctuated as long as there has been a market for energy, leading to perceptions of uncertainty about future prices. *How are consumers to make "rational" choices about the purchase of new energy-using systems such as cars, heating equipment, new buildings, and motors when the basis for estimating long-term operating costs is so uncertain? ... Uncertainty about fuel prices is a barrier to investment in both the manufacture and purchase of energy-efficient systems* (Hirst and Brown, 1990). Studies among small and medium-sized enterprises have found that some may not even be able to reduce uncertainty to a calculated risk due to a lack of time and money to calculate the required estimates (Stern and Aronson, 1984).

1.2.4 Heterogeneity

The heterogeneity barrier is associated with the fact that even if a given technology is cost-effective on average, it will most likely not be so for some individuals or firms. Heterogeneity particularly impacts production processes of companies that often specialize in one type of goods, and where a potential energy efficiency measure may be difficult to implement in another company. Even though similar goods are produced, small differences in the products, such as different size and shape, can inhibit the implementation of the measure in another firm (Jaffe and Stavins, 1994). Heterogeneity may be an explanatory variable for the "gap" when constructing (economic) models of a population of companies, but is less likely to hold if site-specific information exists regarding a cost-effective energy efficiency measure resulting from, for example, an energy audit.

1.3 Behavioural barriers

Apart from the explanations for the "gap" outlined above, there are also a number of barriers derived from behavioural sciences that explain the "gap", such as the form of information, credibility and trust, values, inertia, and bounded rationality. These barriers are presented below.

1.3.1 Form of information

One barrier to energy efficiency is the form of information, meaning that information does not always receive as much attention as anticipated, since people are (often) not active information-seekers but rather selective about attending to and assimilating information. Research points out some characteristics in the way information is assimilated; some people, for example, are more likely to remember information if it is specific and presented in a vivid and personalized manner, and comes from a person who is similar to the receiver (Stern and Aronson, 1984; Palm, 2009, 2010).

1.3.2 Credibility and trust

Another factor that may inhibit adoption is the receiver's perceived credibility of and trust in the information provider. Energy users cannot always easily gain accurate information about the ultimate comparative cost of different investment options; they will rely on the most credible available information. The following example from the household sector may illustrate this. Pamphlets describing how to save energy in home air conditioning systems were sent out to 1,000 households in New York. Fifty percent of the households received the information in a mailing from the local electricity utility, and the other half received it from the state regulatory agency for utilities. The following month, households that had received the pamphlet from the state agency used about eight percent less electricity than the households that had received the same pamphlet from the local electricity utility (Stern and Aronson, 1984). The effective spread of information thus depends on a trustworthy information provider. As regards the industry, intermediaries such as sector organizations or consultants may play an important role, as these entities or individuals often tend to be regarded as trustworthy (Ramirez et al., 2005; Stern and Aronson, 1984).

1.3.3 Values

Values such as helping others, concern for the environment and a moral commitment to use energy more efficiently are influencing individuals and groups of individuals to adopt energy efficiency measures. However, studies of households indicate that norms only have a strong impact on cost-free energy efficiency and energy conservation measures (Stern and Aronson, 1984). A study by Aronson and O'Leary (1983) on showering in a university building showed that the number of students taking short, energy-saving showers increased from six percent when a sign encouraging short showers was put up, to 19 percent when an intrusive sign was used, to 49 percent when the researchers used a student to set an example for others by always turning off the water and soaping up whenever someone came into the facility, and to 67 percent when two students serving as examples were used (Aronsson and O'Leary, 1983). Consequently, a lack of values related to energy efficiency may inhibit measures from being undertaken.

1.3.4 Inertia

In short, inertia means that individuals and organizations are, in part, creatures of habit and established routines, which may make it difficult to create changes to such behaviours and habits. This is stated as an explanatory variable to the "gap". People work to reduce uncertainty and change in their environments, and avoid or ignore problems (Stern and Aronson, 1984). Also, people who have recently made an important decision often seek to justify that decision afterwards—convincing themselves and others that the decision was correct. This description of inertia may partially explain the failure of many energy users to take economically justifiable actions to save energy; energy efficiency also often begins with small commitments that later lead to greater ones (Stern and Aronson, 1984).

1.3.5 Bounded rationality

Another explanation for why cost-effective energy efficiency measures are not undertaken is bounded rationality (Simon, 1957). Most types of market failures are concerned with problems in the economic environment that impede economic efficiency even when assuming fully rational agents—that is, utility-maximizing consumers and profit-maximizing firms (Palm and Thollander, 2010). In the case of energy efficiency-related decisions, this hypothesis formally requires decision-makers to solve what may be extremely complex optimization problems in order to obtain the lowest-cost provision of energy services (Sanstad and Howarth, 1994). Studies of organizational decision-making identify two major features of organizations that affect the linkage of a simple rational view to their actions. First, the organization is not a single actor but rather consists of many actors with different, sometimes conflicting, objectives. The interests of one employee or department may, for example, be in conflict with those of others. Second, according to

Sanstad and Howarth (1994), organizations (just like individuals) to some extent do not act on the basis of complete information but rather make decisions by rule of thumb (Stern and Aronson, 1984).

1.4 Organizational barriers

Apart from economic and behavioural barriers, there are also barriers such as power and culture that emerge from organizational theory. These barriers are presented below.

1.4.1 Power

Lack of power among energy efficiency decision-makers (e.g., the energy controllers), is often put forth as an explanatory variable for the “gap”. The low importance of energy management within organizations leads to constraints when striving to implement energy efficiency measures (Sorrell et al., 2000).

1.4.2 Culture

Culture is closely connected to the values of the individuals forming the culture. An organization’s culture may be seen as the sum of each individual’s values, where the executives’ values or the values of other workers who have influence within the organization may have more impact on the organization’s culture than “lower status” workers (Sorrell et al., 2000).

1.5 Different ways of categorizing barriers to energy efficiency

A review of research on barriers to energy efficiency reveals that a number of different means of categorizing barriers exists.

A barrier model specifies three features: the objective obstacle, the subject hindered, and the action hindered. The methodological question of how to determine a barrier model is: what is an obstacle to whom reaching what in energy conservation (Weber, 1997)?

- What is an obstacle (persons, patterns of behaviour, attitudes, preferences, social norms, habits, needs, organizations, cultural patterns, technical standards, regulations, economic interests, financial incentives, etc.)
- ... is an obstacle to whom (consumers, tenants, workers, clerks, managers, voters, politicians, local administration, parties, trade unions, households, firms, non-governmental organizations)
- ... reaching what (buying more efficient equipment, retro-fitting, decreasing an energy tax, establishing a public traffic network, improving operating practices, etc.)

Different ways of categorizing barriers to energy efficiency have been developed. Sorrell et al. (2000) distinguish three main categories: market failures, organizational failures and non-failures, while Weber (1997) classifies the barriers as institutional, economic, organizational and behavioral barriers. Hirst and Brown (1990) made yet another distinction of barriers to energy efficiency, which divides the barriers into two broad categories: structural barriers and behavioral barriers.

In the following section we will discuss another way of understanding technological development and changes in organizations, namely transition theory and socio-technical regimes.

2. Socio-technical regimes

At this stage it is useful to introduce Geels et.al.'s evolutionary model for socio-technical change, which focuses on the dynamics in changing artifacts, technologies, regimes and overall society. The model relies on the work of science and technology studies (STS), which argues that technological and social change are interrelated.

In this model, radical novelties are developed in special spaces or technological niches, where they are sheltered from mainstream competition (Schot and Geels, 2008). These can be small market niches or technological niches where resources are provided by public subsidies. Niches need protection because new technologies initially have low price/performance ratios. Since small networks of actors protect the niches, when initiating new technology building social networks is a vital activity (Verbong and Geels, 2007).

Niches form the micro level at which radical novelties emerge. The meso level is the regime level, and includes routines, knowledge, defining problems and so on embedded in institutions and infrastructures (Shove 2003). The macro level is the socio-technical landscape, which is the environment that changes slowly. Verbong and Geels (2007) describe the relationship between the three levels as a "nested hierarchy". New technologies have problems breaking through because of deep-rooted, established regimes. Transition only takes place when all three levels link up and reinforce each other.

Geels (2004) has developed Nelson and winter's "technological regimes" and discusses socio-technical regimes. Technological regimes refer to cognitive routines that are shared in a community of engineers and that guides research and development activities. The technological regime is the rule-set embedded in "engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems; all of them embedded in institutions and infrastructures". It highlights the fact that engineers act in a social context of social structures, regulations and norms (Geels and Kemp, 2007, pp 443). Technological regimes are broadened to include socio-technical regimes by including the institutional and market aspects needed to make the technical regime work. A socio-technical regime is characterized by the set of rules that guide technical design, as well as the rules that shape market development such as user preferences and rules for regulating these markets (Schot and Geels, 2007). The use of socio-technical regimes also implies the existence of different regimes and the existence of a connection and mutual dependency between them. In a company, different social groups can be distinguished by their own special features. Actors within these groups then share a set of rules, or a regime. Because different groups share different rules, it is possible to distinguish different regimes, such as technological regimes, science regimes, and financial regimes and so on. They share aims, values, problems, agendas, professional journals, etc. However, rules are not just linked within regimes but also between regimes, and regimes influence each other; this is why socio-technical regimes are a better concept for explaining this (Geels, 2004). When regimes are widened to socio-technical regimes, they include interaction with other social groups, besides engineers and firms, in society such as users, policy-makers and social groups. Regimes not only refer to cognitive routines and belief systems, but also to regulative rules and normative roles. From this perspective, different regimes are relatively autonomous, but also interdependent. A socio-technical regime thus binds producers, users and regulators together.

As mentioned above, the socio-technical regime forms the meso level, which accounts for the stability of existing large-scale systems such as energy systems. The macro level is formed by the socio-technical landscape, and cannot be under direct influence of niche and regime actors. Changes at the landscape level occur slowly. Niche actors hope that novelties will eventually be used in the regime. Niche actors can contribute to changes in the practices and routines of existing regime actors. Sometimes niches can also replace the existing regime. It is not easy, however, to replace an established regime, not least because of lock-in effects wherein new technology often needs to fit into existing system solutions (Schot and Geels, 2008).

Socio-technical regimes highlight the fact that actors are embedded in structures that shape their preferences, aims and strategies. But from this perspective, actors also have agency and perform conscious and strategic actions. The model confirms Gidden's duality of structure, and when that structure produces and mediates action. Actors can then act upon and restructure these systems (Geels, 2004). Regimes then implement and (re)produce rules in social activities that take place in local practices. By implementing shared rule systems, the regime actors generate patterns of activity that are similar across different local practices. There may be variation, however, between local practices due to the fact that there are differences between group members, so regimes can have somewhat different strategies, resources, problems and aims. Strategies, aims and the like are also not very flexible within a regime, and undergo only incremental change over time (Geels, 2004). In addition, incremental innovation still occurs in stable regimes and is important because these changes can accumulate and result in major performance improvements over time (Geels and Kemp, 2007).

A dominant regime can be forced to restructure and invest in new technical directions. For example, changes in the socio-technical landscape can put pressure on the regime. Climate change has forced the energy and transport sector to find new technical strategies. Internal technical problems, change in user preferences and negative externalities such as health risks may also trigger actors to act. Competitive games between firms are another example of developments that can open up a regime (Geels, 2004).

If we cross-pollinate barriers theories with ideas from transition theories and socio-technical regimes, we have a new categorization of barriers and, therefore, a new way of reflecting on and discussing efficiency gaps. This will be discussed in the following section.

3. Conclusions: A proposed structure for empirical studies on barriers to energy efficiency

How we define a problem determines whether we can solve it; this is elementary knowledge in all of the sciences. Clear definitions are the foundation for all innovative thoughts, which is why it is important to discuss how barriers to energy efficiency can be categorized in potentially different ways. In an attempt to categorize barriers to energy efficiency, the 15 theoretical barriers are divided into three different categories, depending on each barrier's system complexity (see table 2). In the first category—the technical system—the results are quite restricted to technology and its associated costs. In the second category—the technological regime—the results are influenced by human factors but nevertheless coupled to the technology in question. In the third category—the socio-technical regime—the results are heavily influenced by human factors, and less influenced by the technology in question.

Classification	Theoretical Barriers
The technical system	Access to capital (Hirst and Brown, 1990)
	Heterogeneity (Jaffe and Stavins, 1994)
	Hidden costs (Ostertag, 1999)
	Risk (Hirst and Brown, 1990)
The technological regime	Imperfect information (Howarth and Andersson, 1993)
	Adverse selection (Sanstad and Howarth, 1994)
	Split incentives (Jaffe and Stavins, 1994)
	Form of information (Stern and Aronsson, 1984)
The socio-technical regime	Credibility and trust (Stern and Aronsson, 1984)
	Principal-agent relationship (Jaffe and Stavins, 1994)
	Values (Stern, 1992)
	Inertia (Stern and Aronsson, 1984)
	Bounded rationality (Sanstad and Howarth, 1994)
	Power (Sorrell et al., 2000)
	Culture (Sorrell et al., 2000)

Table 2. Proposed classification of barriers to energy efficiency.

Re-defining how we should categorize barriers could open up new ways of looking at the problem, which in turn might lead to other suggestions for addressing the energy efficiency gap. Energy efficiency problems are multi-faceted and should be approached accordingly. If a barrier is identified as belonging to a technological regime or a socio-technical regime, it should be approached differently and addressed via different policy means. If a barrier is seen as belonging to a technological regime, then more information on existing energy efficient measures could be a possible solution. If a barrier is more related to a socio-technical perspective on barriers, then aspects such as corporate culture and established internal values should be problematized and highlighted. In other words, how we perceive and define these barriers will lead to different solutions for overcoming the barriers and, ultimately, to different policy recommendations.

Finding solutions to the energy efficiency gap is vital for solving the climate change problem. To define and redefine the empirically identified barriers is therefore important for challenging existing solutions and developing new, creative ways of approaching companies and other actors. Employing this categorization of barriers would lead to a greater focus on social practices in companies and existing routines in decision-making and industrial processes.

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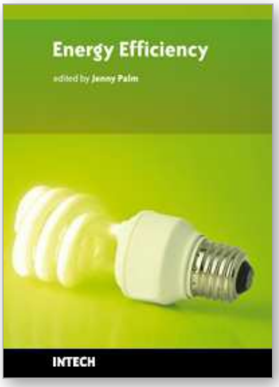

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Global warming resulting from the use of fossil fuels is threatening the environment and energy efficiency is one of the most important ways to reduce this threat. Industry, transport and buildings are all high energy-using sectors in the world and even in the most technologically optimistic perspectives energy use is projected to increase in the next 50 years. How and when energy is used determines society's ability to create long-term sustainable energy systems. This is why this book, focusing on energy efficiency in these sectors and from different perspectives, is sharp and also important for keeping a well-founded discussion on the subject.