Experiences from Energy Efficiency Policies in Sweden During the Last 30 Years: Looking at the Building Sector

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ABSTRACT

The improvements during the seventies in energy efficiency in the Swedish building sector came to a halt and stagnated in the late eighties and nineties. Moreover the development of energy efficiency in the new construction of buildings has also come to a stand-still at an average specific energy use for heating twice as high as the best performing buildings 20 years ago.

The aim of this paper is to highlight the role of policies for the development of energy efficiency in the building sector. We find that two most influential instruments have been taxes and buildings regulations. The impact of energy and environmental taxes has been analyzed by using econometric studies. These show that declining specific energy use for heating (kWh/m^2/yr) has a high correlation with increasing energy prices and that price elasticities have not changed markedly over time. This implies that the stagnation to a large extent can be explained by energy price trends.

Literature review and interviews with actors in the building sector have been carried out to better understand the role of building energy standards and other instruments. The interview results show that the most common investment criterion in the new construction is the requirement of the national building energy standard. The standard has been more or less constant during the observed time period and has developed into a norm rather than a minimum for energy performance. Other measures, such as subsidies and information schemes, have been too much characterized by rapid variations and interruptions to have any major impact.

Introduction

From a European perspective Sweden has a high level of energy efficiency in its buildings. Sweden and Denmark have the hardest buildings regulations (Eichhammer & Schlomann 1999) and the market penetration of double glazing windows and roof insulation is at 100% (Eurostat, 1996). With time-series from 1970 to 1983, Schipper (1985) held up Sweden as a model country for energy-wise housing. But the gap to the other countries has been closing in. Schipper et al (2001) show, as an example, that the indicator *useful space heating energy per floor area and degree-day*, was about 25 percent higher in the USA than in Sweden in the mid seventies. However, unlike for Sweden where the efficiency improvements stagnated in the eighties, the US efficiency continued to improve and reached the Swedish level in 1989. In 1995 the indicator was already more than 10 percent lower in the USA.

The aim of this paper is to study how the development of energy efficiency policies has influenced the level of energy efficiency in residential buildings in Sweden between 1970 and 2000. To do this we have studied the relevant literature, carried out interviews with actors in the Swedish building sector and assessed the role of taxes by calculating price elasticities for specific energy use in residential buildings. We focus on policies addressing mainly the construction and refurbishment of residential buildings and are not specifically concerned with the operation of buildings.

As an indicator for energy efficiency we study how specific energy use (kWh/m^2/yr) for space and water heating in one and two dwelling buildings and multi-dwelling buildings, has decreased between 1970 and 2000. Thereafter we look at various policy instruments starting with economic instruments, moving over to regulatory instruments and last informative instruments. We conclude the paper by summarizing the lessons learnt from these 30 years and how they can be used to improve today's policies for energy efficiency.

What Are the Trends?

The development of specific energy use in residential buildings 1970-2000 can be seen in figures 1 and 2. Figure 1 shows specific energy use for space and water heating (kWh/m^2/yr) for both the total stock and new one- and two dwelling buildings. Examples of low energy buildings are included to illustrate the gap to Best Available Technology (BAT). Figure 2 shows the corresponding development for multi-dwelling buildings.

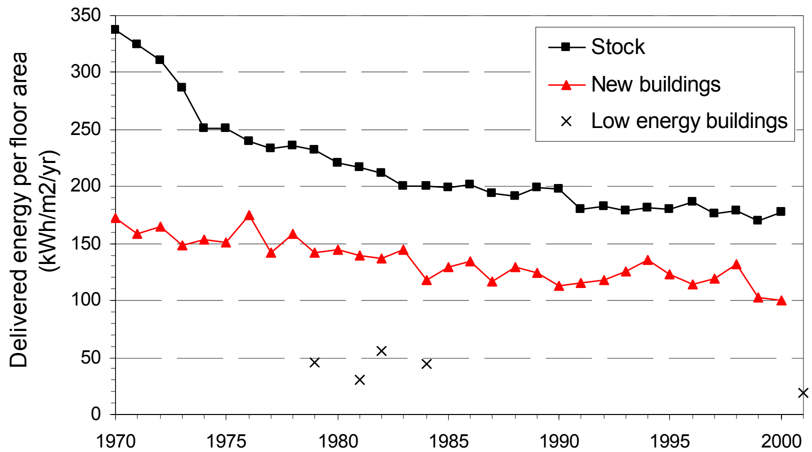
The main source of data on space and water heating and floor areas is Statistics Sweden's series EN 16 "Summary of energy statistics for dwellings and non-residential premises". For the seventies, data is also taken from Carlsson (1992). For data on specifc energy use in the new construction, Statistics Sweden carried out separate data extractions from their 2001 databases, to supply energy intensity against year of completion (1970-1999 for 2000 and 1970-2000 for 2001). All energy use for heating is adjusted for annual changes in the climate, using degree-day[1] statistics from the Swedish Meteorological and Hydrological Institute (SMHI).

The figures show that the major improvements in energy efficiency occurred before 1985 and thereafter specific energy use has stagnated at a level that is approximately the double of the BAT from the mid eighties.

About 10% of the reduction in energy use can be attributed to the substitution from decentralised oil combustion within the buildings (with low efficiency) to electric heating in one and two dwelling buildings and district heating in multi-dwelling buildings. Conversion and distribution losses were thus shifted to outside of the buildings.

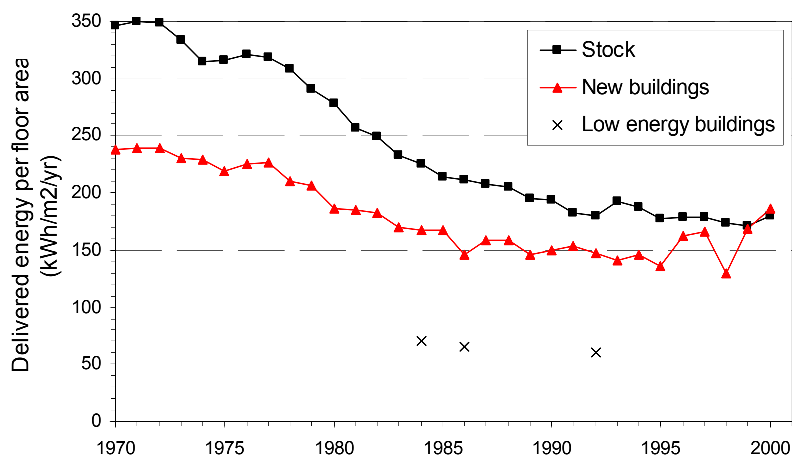
[1] The number of degree-days is defined by the SMHI as the difference between +17°C and the daily average temperature summed over all days in January, February, March, November and December, days with <+12°C in April and September, days with <+10°C in May, June and July, days with <+11°C in August and days with <+13°C in October.

Figure 1. The Development of Delivered Energy Use for Heating per Floor Area of One and Two Dwelling Buildings. The Stock Represents all Heated Floor Area in a Certain Year. The Curve for New Buildings Shows the Energy Use in the Year of Completion. Examples of Low Energy Buildings Are Included to Illustrate the Gap to Best Available Technology.



Source: **Nässén, Holmberg, 2005**

Figure 2. The Development of Delivered Energy Use for Heating per Floor Area of Multi-Dwelling Buildings. The Stock Represents all Heated Floor Area in a Certain Year. The Curve for New Buildings Shows the Energy Use in the Year of Completion. Examples of Low Energy Buildings Are Included to Illustrate the Gap to Best Available Technology.



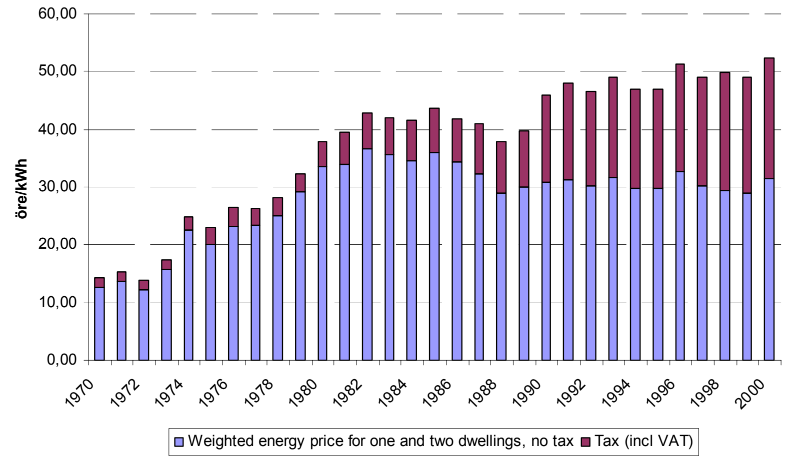
Source: **Nässén, Holmberg, 2005**

Economic Instruments

Taxes

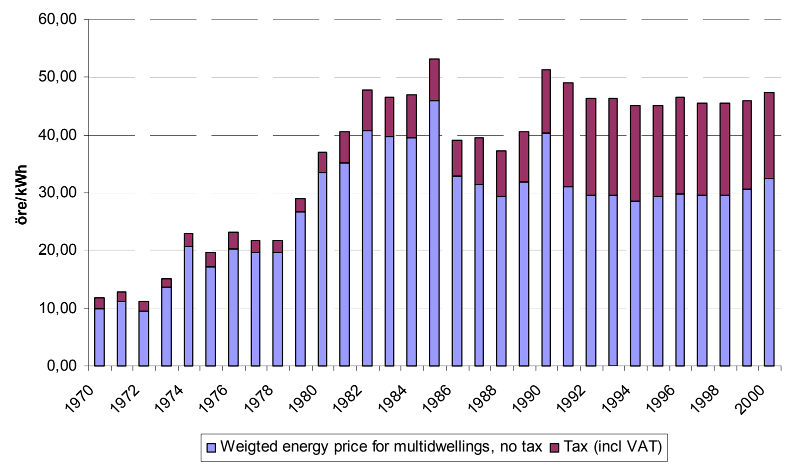
In Sweden energy taxes on oil and electricity have been used since the late 1950s mainly out of fiscal reasons. In 1991, as an element in the Swedish climate strategy, part of the energy tax was converted into a carbon dioxide tax on fossil fuels. From 1990 a VAT of 25% applied on the sum of the fuel price and energy tax, has also been charged for the major energy carriers.

Figure 3. The Development of Weighted Energy Prices for One and Two Dwelling Buildings. Each Bar Illustrates the Share of Fuel Prices and of Weighted Energy Tax. All Prices Are Converted to the Price Level of 2000 by Means of Consumer Price Index.



Source: Swedish Energy Agency, 2002

Figure 4. The Development of Weighted Energy Prices for multi-dwelling building. Each Bar Illustrates the Share of Fuel Prices and of Weighted Energy Tax including VAT. All Prices Are Converted to the Price Level of 2000 by Means of Consumer Price Index.



Source: Swedish Energy Agency, 2002

Figure 3 and 4 illustrated the composite development of energy use weighted fuel prices and tax levels, including VAT, between 1970 and 2000. The share of taxes has increased over time but not as markedly as for certain fuels/energy carriers. For heating oil tax levels have increased from 16% in 1970 to over 60% (including VAT) in 2002. For one and two dwelling buildings the share of taxes has increased from approximately 12% in 1970 to 40% in 2000 a share similar to that of electric heating in 2000 (42%)[2]. Since increased consumer prices have also been driven by increased taxes (especially after the oil crisis of the seventies), substitution to

[2] About 40% of energy supplied for space and water heating in one and two dwelling buildings in 2000 was electricity.

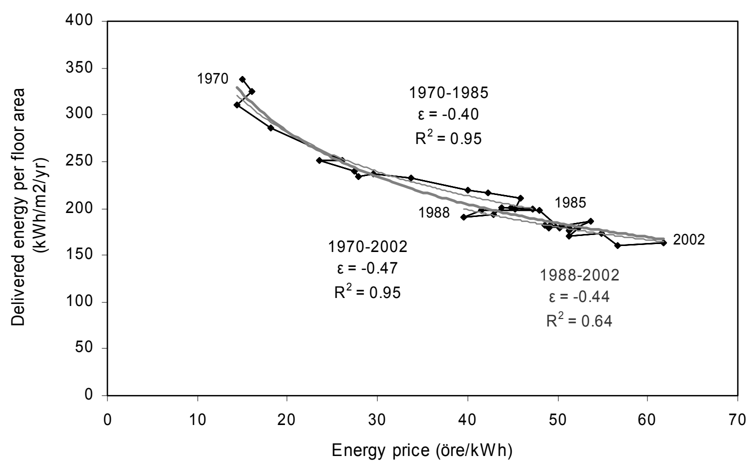
cheaper fuels has also meant a substitution to fuels with reduced tax, e.g. wood fuels which are exempted from taxes.

This phenomenon is more prominent for multi-dwelling buildings, see figure 4, where the tax share has approximately doubled from 16% in 1970 to 31% in 2000. Multi-dwelling building have to an increasing rate been supplied with district heating. In 2000 the share of energy supplied through district heating was 84%. The choice of energy carrier and thus tax level has been shifted to the district heating firms. These firms may have a larger incentive and capacity to substitute to tax exempted fuels such as wood fuels. Empirical evidence suggests that this has been the case since district heating today is mainly supplied by biomass.

The substitution effect has been one of the desired effects of increasing energy taxes, especially for oil. When oil prices started to fall again after the oil crises the energy tax on oil was raised to counteract the decrease in price and avoid a re-substitution to oil[3]. Sweden had by then started its nuclear program and an increased demand for electricity, through electric heating, was thus welcomed.

But how effective have taxes and energy prices been in reducing the actual demand for specific energy use, e.g. how responsive are households to raising energy prices? To address this question energy price elasticities for specific energy use have been calculated. Graphic analysis with least square estimates is applied to three different time periods: 1970-2002 (the whole length of the time series), 1970-1985 and 1988-2002. The shorter time-periods were chosen because energy prices rose during these periods, while between 1985 and 1988 energy prices decreased. The results are shown in figure 5 for the stock of one and two dwelling buildings and in figure 6 for the stock of multi-dwelling buildings.

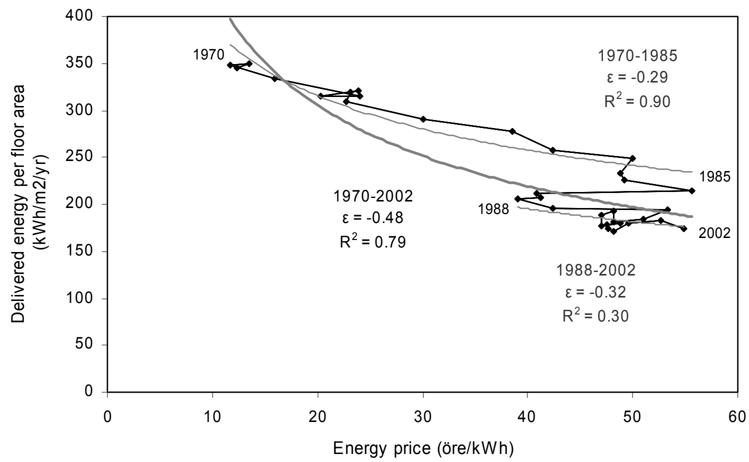
Figure 5. Delivered Energy Use per Floor Area for One and Two Dwelling Buildings Relative to Weighted Energy Price. Estimated Price Elasticity (ε) for each Time Period Is Presented As Well As the Corresponding R-Square Values. The Bold Line Corresponds to 1970-2002, and the Thin Lines to 1970-1985 and 1988-2002.



Source: Nässén et al, 2006

[3] The falling oil price between 1985 and 1988 still lead to a slightly increasing share of oil for heating in one and two dwelling buildings.

Figure 6. Delivered Energy Use per Floor Area for Multi-Dwelling Buildings Relative to Weighted Energy Price. Estimated Price Elasticity (ε) for each Time Period Is Presented As Well As the Corresponding R-Square Value. The Bold Line Corresponds to 1970-2002, and the Thin Lines to 1970-1985 and 1988-2002.



Source: Nässén et al, 2006

The price elasticities during the shorter periods (1970-1985 and 1988-2002) are lower than in the longer time-span, being approximately -0.3 in multi-dwelling buildings and -0.4 in one- and two-dwelling buildings. An interesting observation is that the magnitude of the elasticities is more or less equal in the two periods despite the fact that prices in the first period rose much more dramatically, especially during the two oil crises, in 1973 and 1979.

Not only energy prices but also the income of households plays a role for the level of energy efficiency. In 1970 approximately 2% of a household's expenditures were dedicated to space and water heating. In 1980 this share had increased to 5% but decreased again to 3.5% in 2000. Energy efficiency measures that reduce energy expenditures with e.g. 20 % have a small effect on the overall budget of the household. Behavioural studies on energy use underline the importance of this observation; while saving money is often an argument for saving energy, in the end many households do not think that the economic gains from reducing their energy use are worth the trouble (see for e.g. Erickson, 1997; Kuehn, 1998).

To include income and dynamic effects we also calculated elasticities using a standard dynamic constant elasticity function of demand (Pyndick and Rubinfeld, 1991). Income elasticities were not significant and the long-run price elasticity was around -0.3 in one- and two-dwelling buildings and -0.4 in multi-dwelling buildings. As expected short-run price elasticities were small (-0.08) in multi-dweling buildings, while being larger for one and two dwelling buildings (-0.20).

The calculated energy price elasticities are in the lower range of energy price elasticities from the literature, implying that a change in specific energy use requires relatively large increases in energy price. E.g. assuming that the price elasticity will not change dramatically in the future, a 30 % reduction of energy use – the goal of the voluntary agreement between the government and the building sector (Bygga-Bo, 2003) –would correspond to approximately a three-fold increase of energy prices.

Subsidies and Loan Schemes

In the 1970s there existed various subsidies and loan schemes for the households that wanted to improve their heating system. Between 1974 and 1983 about 25% of the financial support was given through subsidies and the rest through loans. Between 1977 and 2000 the typical period of implementation of a subsidy scheme for multi-dwelling buildings has been 1-2 years and the majority of these have been focused on substitutions on the supply side such as conversion from oil to electric heating or district heating. E.g. between July 1st 1984 and January 1st 1986 half of the support for multi-dwelling buildings was addressed to "energy saving measures", but one third of these were supply oriented (Statens Energiverk, 1986). For one and two dwelling buildings there were no financial support schemes between 1983 and 1997.

The goal of subsidies has not always been energy conservation and the trends have often followed unemployment rates in the construction sector. Support for increased insulation from the early eighties has a high correlation with unemployment levels for construction workers. When unemployment disappeared so did the support schemes (Kjaeng, 2006).

In evaluations of the subsidy programs until the mid eighties it is argued that the general goals set for energy savings were more or less achieved. But these evaluations also point to the fact that many of the measures probably would have been taken anyway due to increasing energy prices (Nutek, 1993). For the last 15 years a focus on supply, irregularities for subsidy programs for multi-dwelling buildings, and a long interruption in subsidies to one and two dwelling buildings, limit the possibilities for subsidies to contribute to an increase in energy efficiency in Swedish residential buildings.

An Uncertain Price Picture

A prerequisite for price signal to be an effective policy measure is that the price picture is clear. We see four reasons why this is not always obvious in the building sector:

1. The *life cycle cost (LCC)* of new buildings is not known. The results from our interview study show a remarkable consensus that LCC calculations are scarce in the building sector, with answers spreading from 'quite uncommon' to 'negligible'.
2. Even when LCCs are calculated they may be based on uncertain data, such as future energy prices, including future tax-levels. Presuming that future trends will follow historic trends, increasing energy prices are expected. The uncertainty then lies in the rate of increase.
3. The irregularities concerning subsidy schemes make these hard to include in prospects and investment decisions.
4. Investments are often connected to loans and thus future interest rates will also contribute to an uncertain price picture. High interest rates for smaller clients have many times been mentioned as one of the barriers for energy efficiency (Golove & Eto, 1996).Well designed loan schemes can thus be successful policies, as in Germany where low-energy houses warrant loans with interest rates set below the capital market level and fixed for 10 years.

The first point can be seen as a specific problem of the building sector, while point 2 and 4 are inherent also in other long term investments. Still the combination of these uncertainties in the price picture may warrant further policy interventions if ambitious energy efficiency levels are to be reached.

Regulatory Instruments - Building Energy Standards

The first time specific energy requirements where introduced in the Swedish Building code was in 1977 (SBN75). Specific requirements were set on the thermal conductivity of walls, roofs, grounds and windows. The area designated to windows was also limited. Changes and amendments in the regulations were thereafter made in:

- 1980: Requirements for heat exchanging in larger buildings were strengthened.
- 1982: Stricter standards were imposed on electrically heated houses.
- 1988: Specific requirements were shifted to performance based targets based on universal U-values for the entire building. The required level of efficiency was only marginally improved compared to the 1980's level.
- 1995: Heat recovery requirements for multi-dwelling buildings were lifted for buildings heated with less than 50 percent fossil fuels. This exception includes district heating, which is the most common energy carrier in multi-dwelling buildings.

In addition, the number of inspections has decreased since the rewriting of the law in 1995. Some municipalities do not make inspections at all (Boverket, 2001). This may be especially problematic given the imbalanced relation between contractors and building companies. All regulations apply only to new buildings, no energy requirements for the retrofitting of buildings exist today.

Figures 1 and 2 do not show any major declines of specific energy use due to changes in standards, despite a general decrease. But as seen in the section about taxes, the general reduction in specific energy use could instead be attributed to the increase in energy prices. In contrast to this the interview study shows that for new buildings, building energy standards directly determine the level of energy efficiency investments. One example of this is the previously mandatory heat recovery for ventilation systems. When exceptions to this regulation were introduced in 1995 (BBR 94), heat recovery became uncommon. One reason of the low impact may thus have been that the improvements have been too weak and that in periods of rising energy prices the level of energy use has been overestimated.

In our interview study we also found that a majority of the interviews were critical to the current building energy standard. The three major discontents were:

1. While the building energy standard was designed to ensure a lowest level of energy performance, it has also developed into a norm with very few clients trying to go further based on other criteria such as LCC, even though studies show that this may be profitable (Lindahl et al, 2003).
2. Follow-ups indicate that the measured energy use often substantially exceeds calculated values (40-60 % in Nilsson, 2003 and 50-100 % in Elmroth, 2002).
3. A majority of the interviewees consider the building energy standard to be too weak in general.

Even though critical comments regarding the design of the building energy standard were numerous in the interviews, none of the interviewees questioned the validity of building energy standards in general.

Information Tools

Energy Counseling

Energy counseling for households has mainly existed in Sweden during two time periods 1977 to 1985 and from 1997 to today. Counseling has been organized at a municipal level but with financial support from the Government. During the first period the counseling started with an inspection and control of the heating system, water installations, heat distribution, insulation and ventilation. After the inspection energy saving advices was given.

In 1984 it was estimated that 20% of the one and two dwelling buildings and 50% of the multi-dwelling buildings had been inspected by an energy counselor. No major evaluation of the first period of energy counseling has been carried out, but comments are included in other evaluation and these reach differing conclusions. However positive evaluations had difficulty separating the effect of counseling from that of increased energy prices (Kjaeng, 2006; Statens Energiverk, 1984; Bostadsdepartementet 1984:11).

Most municipalities chose not to continue their energy counseling when the financial support from the Government was withdrawn in 1986. The State owned energy utility Vattenfall made attempts to continue some form of counseling. A few studies were undertaken but no larger counseling projects were initiated (Kjaeng, 2006).

Governmental support to municipalities for energy counseling was reintroduced in 1998. However the yearly financial support has been about 5 times lower than in the first period. In 2004 all municipalities had some form of energy counseling to offer households, business and local organizations. Instead of house specific inspections the energy counseling of today consists of general advice not specifically directed to individual buildings. Moreover most of the focus is towards supply issues such as wood pellets and heat pumps instead of efficiency measures (Kjaeng, 2006).

What Can Policy Makers Learn from the Experiences of Energy Efficiency Policies in the Swedish Building Sector?

The stagnation in energy efficiency in the Swedish building sector since the mid eighties can mostly be explained by the weak pressure exerted on the sector since the mid eighties. Explicitly, energy prices have not increased markedly, building regulations have not been strengthened and other measures such as subsidies have been too irregular to have a major impact.

Considering the long life time of buildings, putting pressure on a traditional sector such as the building sector to construct and refurbish buildings to reduce energy use is a key strategy in handling the challenge of climate change. Despite the general stagnation important positive guiding examples do exist such as: 20 terrace houses built with passive house standard (Wall, 2005), a multi-dwelling building to be constructed in 2006 with heat recovery but without radiators (Alvstranden, 2006), and refurbishment of a multi-dwelling building following passive house standards. These are also examples of how it is possible to "tunnel through the cost barrier" (Lovins, 1996), i.e. the extreme solution may be more cost-effective than a small incremental improvement in energy efficiency. The reduction in costs is realized by making one building component unnecessary, e.g. in passive houses the heating system is removed (for an example see Schnieders & Hermelink, 2006).

The challenge is thus how to ensure that these examples, mainly driven by visionary actors, become the norm and not the exception. The German *Passivhaus*[4] market is an interesting success story in this aspect with a fast diffusion from 120 dwellings in pilot projects 1998 to 4000 dwellings in 2003 and with projections of a continuous high growth rate (Bühring et al, 2004).

The high correlation between specific energy use for heating (kWh/m^2) and energy prices shows that price instruments, such as energy taxes, are important to drive improvements in energy efficiency. However to achieve e.g. a 30% reduction of energy use[5], only through price signals, a three-fold increase of energy prices would be needed. The political feasibility of increasing energy prices to such an extent is questionable.

A key issue is to create a clearer price picture in the building sector. One implication is that subsidy schemes should be characterized by continuity. E.g. the special loans for low-energy buildings in Germany are a successful subsidy scheme that partly explains the rapid diffusion of passive houses. Even more important is spreading the use of LCC calculations, since they not only clarify the true costs of buildings, but also stimulate the learning process in construction companies. The EU directive on Energy performance (2002/91/EC) can be one way of implementing the use of LCCs. The directive requires minimum energy performance regulation (without stating any performance levels) for retrofitting of large buildings, as well as mandatory energy certificates of all buildings. An important part of the implementation should be the inclusion of good reference values along with recommendations for cost-effective improvements. One way to strengthen the certification system would be to define easily comprehensible energy classes and link some economic incentive to these classes.

In order to avoid future stagnation, standards should have a dynamic dimension, i.e. include regular updates that follow the technical development in the sector. A revision of the current Swedish building code is taking place. Heat recovery for all multi-dwelling buildings has been reintroduced, but unfortunately no further strengthening of requirements is planned. For the continuous work on the building energy standards dynamic standards such as the Top Runner program in Japan or TEPS (target energy performance standard) in Korea (for information on TEPS see e.g. du Pont, 2006), may constitute a source of inspiration.

Conclusions

Summarizing, the main lessons learned are:

- The pressure on the Swedish building sector so far has been too weak.
- Price signals are important but not sufficient.
- Policies should aim at making the price picture clearer, e.g. through the spreading of LCCs.
- Policies have to be characterized by continuity and there is need for a dynamic process for the updating of codes.

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[4] In these passive houses, the calculated energy use for heating should not exceed 15 kWh/m^2/yr.

[5] 30% reduction of energy use is the goal of the voluntary agreement between the government and the building sector (Bygga-Bo, 2003).

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