Expected effects of the Energy Performance of Buildings Directive (EPBD) for the indoor climate

Milou Beerepoot

OTB Research Institute for Housing, Urban and Mobility Studies, Delft University of Technology, P.O. Box 5030, 2600 GA Delft, The Netherlands
email: m.beerepoot@otb.tudelft.nl http://www.otb.tudelft.nl

Summary: Energy performance policy is a way of incorporating energy standards into building regulations. Its recent influence is illustrated by the fact that the European Commission is now urging all European member states to introduce energy performance policies for the building sector by the year 2006. One of the expected benefits of energy performance policy is that it can help to introduce new techniques, for example in the field of ventilation management of buildings. This paper discusses to what extent the introduction of Energy Performance policy will influence the indoor climate. The effects of energy performance policy for the indoor climate in the Netherlands are presented, using the results of an empirical study, complemented by desk research.

Keywords: energy performance policy, EPBD, indoor climate, policy evaluation
Category: 5. Policies and practice issues in creating healthy buildings

1 Introduction

The European Union recognizes the importance of reducing CO₂ emissions in the building sector and in early 2003 the European Parliament accepted Directive 2002/91/EC on the Energy Performance of Buildings (EC, 2003). One of the four key elements described in the Directive is the introduction of energy performance regulations for new building and for extensive refurbishment of existing building. Energy performance regulations in the building sector aim to limit energy consumption from heating, hot water production, lighting, cooling and ventilation by calculating an estimate of the energy consumption by these features according to a standardized occupant pattern and limiting this energy consumption to a certain standard. The energy performance calculation allows the user to choose a set of energy features and to trade off between these features, e.g. a higher insulation level against poorer heating installation efficiency or the other way around, as long as the energy performance standard is not exceeded. Although several member states already use energy performance regulations, none has investigated the effect of energy performance regulations on the appliance of energy techniques for the building sector including techniques that influence the indoor climate. Ideally, the implementation of the EPBD could be used for improvement of the indoor climate. The knowledge from this research can be helpful in designing energy performance regulations in such way that a maximum improvement of the indoor climate can be expected.

This paper examines the effect of energy performance policy for buildings, focusing on the appliance of techniques that can influence the indoor climate. The paper uses the experience with energy performance policy in the Netherlands as an illustration. The primary research question of this paper is as follows: What are the effects of energy performance policy with regard to the indoor climate of buildings? Section 2 explains the concept of energy performance policy and discusses the position of energy performance policy within the range of policy instruments aimed at reducing carbon dioxide emissions. Section 3 addresses the research approach that was chosen for this research. Section 4 discusses the results of the empirical analysis. Section 5 examines the relation between energy performance policy and indoor climate. Finally, conclusions are drawn in section 6.

2 Energy performance policy

Policy instruments that aim to reduce carbon dioxide emissions are often discussed in terms of the effectiveness of financial instruments (e.g., subsidies on capital, feed-in-systems and carbon taxes). Market-based policy instruments are often preferred because of their ability to increase competitiveness, and they optimize the allocation of costs relative to the reduction of carbon dioxide [1]. On the other hand, regulations are considered rigid. For example, in a recent review of renewable energy policies in the European Union, Blok mentions that the feed-in system won the first strike from renewable obligations [2]. Nonetheless, most countries use regulations to limit energy consumption in buildings. In the European Union, all member states use energy regulations for buildings, although there is considerable variety in their approaches. Few recent studies have explored energy regulations for buildings...
in European countries [3], [4], [5], [6], [7], [8]. One elaborate study in energy regulations for residential buildings used in eleven European member states distinguishes four main approaches [6]:

1. Unit approach
2. Transmission loss calculation
3. Heat demand calculation
4. Energy use calculation

Figure 1 illustrates these four approaches and shows the level to which each of them integrates issues that determine the energy consumption of a building.

3. Research approach

The Dutch situation offers a good case to evaluate the effects of energy performance policy since it was already introduced in 1996 as the only way to comply with energy requirements in building regulations. To analyse the effects of energy performance regulations in the diffusion of solar thermal systems, energy performance calculations that were submitted to municipal building control between 1996 and 2001 were collected. The research was restricted to residential buildings. In total, 296 energy performance calculations for residential buildings were collected from various sources. These 296 energy-performance calculations were randomly selected from municipal archives, and they represent each year equally (about 50 per year). The fifty energy performance calculations from each year are expected to represent at least 350 residential units, as many residential building projects in the Netherlands consist of housing that is developed in a series of equal housing (detached housing), for which only one or two energy performance calculations must be submitted. Apartment buildings are also required to make only one performance calculation, even though they represent many housing units.

The Dutch Building Decree prescribes an energy requirement by means of a dimensionless figure that is the output of the energy performance calculation. At the introduction of the EPC in 1996, this requirement was set at 1.4 as a maximum for residential buildings. This requirement represented almost the usual building practice at that time and therefore was not considered to be difficult to realise. In 1998, the standard was tightened to 1.2 for residential buildings, in 2000 it was tightened to 1.0 and recently in January 2006 it was tightened to 0.8.

4. Empirical analysis

From the database of 296 energy performance calculations from 1996 through 2001, many different types of energy features such as insulation, the installation types for heating and hot water and ventilation systems, that have been applied in new residential buildings can be identified. Figure 2 lists the water-heating systems that were applied in the Netherlands from 1996 to 2001 in new residential buildings.
While the efficient gas condensing boiler was already problematic market introduction [9] (Brezet, 1994). condensing boiler has for a long time suffered from a higher caloric value) and high-efficiency gas-condensing boilers (efficiency 95% on higher caloric value) became more common. Though it was not possible to find data about the penetration of efficient gas condensing boilers in new residential buildings before 1995 (as penetration data in existing studies always appear to be aggregated for both new and existing building) it was found that the efficient gas condensing boiler has for a long time suffered from a problematic market introduction [9] (Brezet, 1994). While the efficient gas condensing boiler was already developed in 1981 only after 1995 it became the reference for new building [10] (Jeeninga, et al., 2002). After the standard was tightened in 2000, the high-efficiency gas-condensing boiler became the most common installation for domestic hot water. An increase in the use of district heating for heating hot water is also evident; beginning in 2000, the heat pump was also used to some extent to produce hot water. Figure 2 shows a slight increase in the use of solar thermal systems for domestic hot water during the years, varying from 4% in 1996 and 1997 to 5% in 1998 and 1999, followed by 8% in 2000 and 2001. This apparently does not correspond with the expected large increase of solar thermal systems applied after introduction and tightening of the energy performance policy. Changes in the application of efficient gas condensing boilers towards high efficient gas condensing boilers and techniques such as district heating and heat pumps are much more at hand and the increase in solar thermal systems applied is not striking.

The development of installations for space heating shows a similar development, with the exception that heat pumps and solar thermal systems were hardly used for space heating between 1996 and 2001.

Figure 2: Water-heating systems applied in new residential buildings in the Netherlands from 1996 to 2001

As shown in Figure 2, a remarkable shift occurred between 1996 and 2001 in the types of water-heating systems that were applied. While it was still possible to use regular gas-condensing boilers (efficiency 80% on higher caloric value) in 1996 and 1997, that type of boiler disappeared after the first tightening of standards in 1998, and efficient (efficiency 90% on higher caloric value) and high-efficiency gas-condensing boilers (efficiency 95% on higher caloric value) became more common. Though it was not possible to find data about the penetration of efficient gas condensing boilers in new residential buildings before 1995 (as penetration data in existing studies always appear to be aggregated for both new and existing building) it was found that the efficient gas condensing boiler has for a long time suffered from a problematic market introduction [9] (Brezet, 1994). While the efficient gas condensing boiler was already developed in 1981 only after 1995 it became the reference for new building [10] (Jeeninga, et al., 2002). After the standard was tightened in 2000, the high-efficiency gas-condensing boiler became the most common installation for domestic hot water. An increase in the use of district heating for heating hot water is also evident; beginning in 2000, the heat pump was also used to some extent to produce hot water. Figure 2 shows a slight increase in the use of solar thermal systems for domestic hot water during the years, varying from 4% in 1996 and 1997 to 5% in 1998 and 1999, followed by 8% in 2000 and 2001. This apparently does not correspond with the expected large increase of solar thermal systems applied after introduction and tightening of the energy performance policy. Changes in the application of efficient gas condensing boilers towards high efficient gas condensing boilers and techniques such as district heating and heat pumps are much more at hand and the increase in solar thermal systems applied is not striking.

The development of installations for space heating shows a similar development, with the exception that heat pumps and solar thermal systems were hardly used for space heating between 1996 and 2001.

Figure 3 illustrates insulation levels in new residential buildings from 1996 to 2001. The insulation levels of windows have gradually improved using double-glazing. Insulation levels of façade and roof were improved only slightly. For example, the average insulation level of façades was 0.36 W/m²K in 1996 and 1997; it had decreased to 0.32 W/m²K in 1998 and 1999, and it reached an average of 0.30 W/m²K in 2000 and 2001. The impression from the energy performance calculations studied was that it seemed that insulation levels were the first option to economize on. For example, when district heating was available – a technique that reduces the energy performance coefficient considerably without the need of other energy saving techniques – insulation levels appeared to be lowered to the minimum level possible as required by the Dutch Building Decree. The extent to which this has happened is subject for future study.

Figure 3 Insulation levels in new residential buildings in the Netherlands from 1996 to 2001

Figure 4 shows the changes in ventilation systems that were applied in new residential buildings in the Netherlands between the years 1996 and 2001. At first, the most common ventilation system consisted of a natural inlet and a mechanical outlet, but that system was gradually replaced by systems that made use of energy-saving ventilators (direct current) or reduced powers, and systems that combined heat...
recovery with the use of mechanical inlets and mechanical outlets. The amount of heat recovery by mechanical ventilation systems developed gradually from 65% for a regular system in 1996 to 95% after 2000. Specific new ventilation systems (e.g., the ‘Vent-o-system’, a natural ventilation system that makes use of demand-control features) have been developed. While almost all ventilation systems applied in 1996 and 1997 were ventilation systems using natural inlet and mechanical outlet, approximately 40% of all new residential buildings in 2000 and 2001 were equipped with ventilation systems that used mechanical inlets and mechanical outlets.

5. Energy performance and indoor climate

The analysis of energy techniques applied in new residential buildings in the Netherlands in the period 1996 to 2001 shows most of all – next to changes in water heating and heating systems applied and insulation levels chosen – a remarkable shift in ventilation techniques applied. The use of balanced ventilation systems is often said to introduce more risk in maintaining a healthy indoor climate since both fans and duct systems need to be maintained and cleaned on a regular basis. In the Netherlands, the tightening of energy standards in 2000 and recently in 2006 therefore both times has led to inquiries in expected effects for health related problems. It seems however difficult to demonstrate a causal relation between e.g. ventilation systems applied and health effects. Research that studied the “self-reported health” in relation to the energy standard concluded that tightening energy standards did not have an effect in the self-reported health of the inhabitants [11]. However, it was reported that also age, education of the inhabitants and time spent in their homes was of importance in the self-reported health. It appeared that homes with tight energy standards were above-average inhabited by persons of young age with high education that spend a lot of time outside their homes. Residential buildings with poorer energy standards often appear to be social housing, occupied with persons of older age and with lower incomes. Regarding the use of balanced ventilation system research showed that it was not possible to relate health problems to a specific type of ventilation system [12]. However it was noted that in case inhabitants do experience health problems, these often relate with indoor air and indoor climate problems that are thought to be connected with balanced ventilation systems.

6. Conclusions

The Netherlands has ten years of experience with energy performance regulations, an important component of the Energy Performance of Buildings Directive. An empirical analysis of the effects of energy performance policy in the Netherlands shows a remarkable shift in energy techniques applied, especially with regard to ventilation systems. Inquiries in the relation between tightening energy standards and expected effects for health related problems are difficult to perform but research so far did not relate tight energy standards to problems with the self-reported health of the inhabitants.

References

[9] Brezet, H., 1994, Van prototype tot standaard; De diffusie van energiebesparende technologie (From prototype to reference; The diffusion of energy saving technology, in Dutch), Denhatex BV, Rotterdam
[12] Pernot, CEE, LGH Koren, JEF van Dongen, JEMH van Bronswijk, 2003, Relatie EPC niveau en gezondheidsrisico’s als onderdeel van het kwaliteitsniveau van gebouwen, TNO Bouw, Delft