# EVALUATION OF THE DUTCH ENERGY PERFORMANCE STANDARD
## IN THE RESIDENTIAL AND SERVICES SECTOR,

WITHIN THE FRAMEWORK OF THE AID-EE PROJECT

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# Table of contents

# 1 Characterization of the Dutch Energy Performance Standard (EPN)

Since December 1995 the Netherlands has had a standard for the energy performance of new buildings. The standard stimulates packages of energy saving measures, integrated concepts, and is not focused on specific individual measures. There are differences in the energy performance standard for new houses in the residential sector and the standard for new buildings in the services or commercial sector. These differences are taken into account in the evaluation and are separately reported.

## 1.1 Targets, including relation to end-use sector and relation to national Kyoto target

The energy performance standard introduced in 1995 aimed at an energy saving of 15% to 20% compared to the building practice valid under the building regulation until 1995. The energy performance standard applies to residential buildings as well as buildings in the service (non-domestic) sector.

Table 1 Primary energy use and $CO_2$-emissions in buildings in 1995 and 2002 (ECN, 2003a)[1], (ECN/RIVM, 2005)[2]. Distinguished are direct emissions (e.g. combustion of natural gas for space heating and hot water in buildings) and indirect emissions (due to use of electricity in buildings)

| Sector | Energy use (PJ_prim) | | $CO_2$-emission (Mton) | | Direct $CO_2$-emission (Mton) | | Indirect $CO_2$-emission (Mton) | |
|---|---|---|---|---|---|---|---|---|
| | 1995 | 2002 | 1995 | 2002 | 1995 | 2002 | 1995 | 2002 |
| Residential | 573 | 546 | 34 | 32 | 22 | 19 | 12 | 13 |
| Tertiary | 369 | 459 | 23 | 28 | 12 | 12 | 12 | 16 |
| Total | 942 | 1005 | 57 | 60 | 33 | 31 | 24 | 29 |
| | | | | | | | | |
| % total NL | 32% | 32% | 32% | 34% | | | | |

[1] ECN, 2003a: Energy use and direct CO2 emissions according project, email p. Boonekamp, 8 August 2003

[2] ECN/RIVM, 2005: Reference estimations Energy and emissions 2005-2020, Petten, March 2005

Within the framework climate change policies the Netherlands government aimed at reaching the Kyoto target by setting 'target values' for the maximum amount of greenhouse gases a sector should emit in the period 2008-2012. The Dutch government aims at a direct emission of 29 million ton $CO_2$ in buildings sector in 2008-2012 (residential building and buildings in the service sector) (ECN/RIVM, 2005). In 2002 these direct emissions were 31 million tonnes $CO_2$.

## 1.2 Period the policy instrument was active

New houses have to comply with the energy performance standard as of 15 December 1995. Since 1995 the Energy Performance Standards were revised and reviewed several times. An overview is given in Table 2. In order to comply with the standard a certain Energy Performance Coefficient (EPC) is required. A low value of the EPC corresponds to a house with a high energy performance.

Table 2 Required Energy Performance Coefficient (EPC) for new residential houses

| From | EPC |
|---|---|
| 15 December 1995 | 1.4 |
| 1 January 1998 | 1.2 |
| 1 January 2000 | 1.0 |
| 1 January 2006 | 0.8 |

For new buildings in the service sector the energy performance standard was also introduced at 15 December 1995. Just as in the residential sector, only following some delays, the standards have tightened since 1995. The required Energy Performance Coefficient (EPC) needed to comply with the energy standard depends on the function of the building space. Table 3 presents an overview of the required EPC for different types of building space.

Table 3 Required Energy Performance Coefficient (EPC) for new buildings in the service sector

| From | 15 December 1995 | 1 January 2000 | 1 January 2003 |
|---|---|---|---|
| ***Building space function*** | | | |
| Meeting facility (Theatre, musea, etc. and since 2003 hotel and catering) | 3.4 | 2.4 | 2.2 |
| Prison | 2.3 | 2.2 | 1.9 |
| Health care, non-clinical | 2.0 | 1.8 | 1.5 |
| Health care, clinical | 4.7 | 3.8 | 3.6 |
| Hotel and catering | 2.2 | 1.9 | - |
| Office | 1.9 | 1.6 | 1.5 |
| Accommodation | 2.4 | 2.1 | 1.9 |
| Education | 1.5 | 1.5 | 1.4 |
| Sport facilities | 2.8 | 2.2 | 1.8 |
| Shop | 3.6 | 3.5 | 3.4 |

## 1.3 Actions, specific technologies and/or energy efficiency measures

In the method of determining the EPC of new residential houses energy saving options concerning the building fabric (e.g. insulation), the installations for space heating, hot water and ventilation, and the use of solar energy are considered.

The main difference between the old building decree and the energy performance standard is that the new standard is aimed at realising energy efficient buildings with flexibility in the applied energy saving options. The old building decree contained insulation standards and certain requirements for installation systems for space heating and hot water. The policy moved away from the stimulation of individual techniques, and the focus shifted towards integrated energy efficient packages of measures.

## 1.4 Target groups

It is intended that all parties within the building process are aware of the energy demand requirements; from the design phase until the actual realisation of the building, therefore the target groups are:

- Architects
- Designer engineers, consultants
- Installers of energy systems
- Suppliers of energy efficient/saving techniques
- Building contractors
- Building inspectors

In order to reach these targets groups different types of indirect instruments (supporting instruments) were put in place that had to ensure that the EPN would be properly applied and would achieve its targeted effect (15% to 20% energy savings compared to building practice at the beginning of the 1990s). Applied supporting instruments were communication campaigns, guidebooks, demonstration programmes and subsidies.

## 1.5 National context

In the nineties the climate agenda started to play a more important role in policies targeted at the building sector. These policies were built on energy saving policies that were already in place. In order to comply with the old building decree builders only had to apply a limited number of energy saving techniques. Cheap energy saving opportunities such as energy efficient design or energy efficient installations were beyond the scope of the building decree.

At the same time scientific research centres stressed the importance for the integration of individual techniques into one overall energy efficiency concept. In addition the introductory period of the Energy Performance Standard was embedded in the sustainable building policy that started in the mid-nineties. Energy use is only one of the themes in the Sustainable Building Action Plan of 1995; other items were among others use of water and materials. In the beginning it was not always clear to the stakeholders in the field what the government exactly meant with sustainable building. To overcome this issue, National Sustainable Building Packages were developed. The first package for the construction of new houses was available in 1996. The second package followed in 1997 and was wholly devoted to measures for non-residential buildings. The package contains a list of all possible measures in the area of sustainable building, divided into fixed measures (measures that in principle can always be implemented without many extra costs) and variable measures (measures that can be applied depending on financial or practical conditions). The

National Sustainable Building Package is a collective product for a large number of parties from the political and building field (SEV, 2000)[3].

## 1.6 International context

It was mainly a national initiative to introduce the energy performance standard. The introduction of the standard also was a response to recommendations made in the European directive of 13 September 1993 to limit $CO_2$ emissions by energy efficiency improvement (EC, 1993)[4]. The directive was set within the framework of the SAVE-program. It called among others upon member states to take thermal insulation measures in new buildings (Stb, 1997)[5].

In the last couple of years, policy developments from Brussels became more important. In December 2002 the parliament and the council approved the European directive Energy Performance of Buildings (EPBD) (EC, 2002)[6]. Two requirements within this directive are: a general framework for a methodology of calculation of the integrated energy performance of buildings, and an application of minimum requirements on the energy performance of new buildings. In the Netherlands the requirements in the Directive for new buildings are fulfilled through the energy performance standard and the corresponding calculation method.

## 1.7 Market failures to overcome

In the Netherlands, real estate project developers typically realise new buildings and developments. There is no economic incentive for these project developers to implement energy savings measures, as they don't have to pay the energy bill and energy performance is not a major selling point. The aim of project developers is to build as cheap as possible. In case of social housing projects developers are also restricted by the fixed price municipalities' demands. This led to the situation that even cost effective energy measures with favourable payback profiles were overlooked, mainly because from the project developer perspective they involve the investment of capital which in theory will not be recouped at sale. The national government initiated the energy performance standard to overcome this split incentive and to stimulate cost effective energy savings in new buildings.

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[3] SEV, 2000: Sustainable Building, frameworks for the future, commisioned by Steering group for Experiments in the Housing sector, Rotterdam, October 2000

[4] EU,1993: Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency (SAVE)

[5] Stb, 1997: Bulletin of act, orders and decrees, decision of 6 October 1997, concerning changes in the building decree (sharpening of energy performance coëfficiënt for buildings in the residential sector 1998)

[6] Directive 2002/91/EC: of the European Parliament and of the council of 16 December 2002 on the Energie Performance of Buildings

## 1.8 Organisations, which are responsible for implementation and execution

All parties involved in the building process are responsible in their specific field to ensure that the energy performance standard is correctly implemented. Architects and installation engineers have to design in such a way that the energy performance standard is met. The contractor has to build according the technical specifications set. Building inspectors have to check if the design, calculations and realisation are in accordance with the standard.

Next to this the energy agency (SenterNovem) is responsible for informing the market. They introduced a wide range of supporting instruments such as guide-books, introduction workshops, demonstration projects etc., to prepare the market for the introduction and tightening of the EPN standards.

## 1.9 Available budget

The energy performance standard is a legal obligation. This means that energy saving measures have to be implemented without financial support from the government. The assumption is that required energy saving measures in general can be carried out in a cost neutral manner, where the pay back time is less than the lifetime of the measures (i.e. cost efficient at end-users level).

The budget for the implementation program carried out by the national authority and energy agency is estimated to be between 10 and 25 million euro. (Joosen et al, 2004)[7]. An overview of more detailed information is presented in Table 15 and Table 16.

## 1.10 Available information on initial expected effectiveness and cost-efficiency of the instrument

In the first Action Plan for sustainable buildings ex-ante estimates were made of the expected energy consumption of an average new single-family house at a certain EPC value (VROM, 1995)[8]. These expectations are shown in Table 4.

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[7] Joosen S, M Harmelink, K Blok (2004): Evaluation of climate change policies in the built environment 1995-2002. Ecofys, Utrecht, The Netherlands. June, 2004.

[8] VROM, 1995: First Action Plan Sustainable Buidings: investments in the future, 1995

Table 4 Expected average annual natural gas consumption (space heating and hot water) of a new single-family house (VROM, 1995)

| Year | EPC | Natural gas consumption (m3/year) |
|---|---|---|
| 1992 | 1.65 | 1650 |
| 1996 | 1.4 | 1400 |
| 1998 | 1.2 | 1200 |
| 2000 | 1.0 | 1000 |

The baseline "state of the art" energy performance of buildings within the service sector before introduction of the Energy performance standard was investigated (DHV, 1994)[9]. It appeared that there was a wide range of EPC-values for new buildings. This is why the EPC-value depends on the functional characteristics of the building space. The level of the EPC-values is set in such a way that energy savings of 10% to 20% can be realised compared to the typical buildings constructed before 1996.

## 1.11 Side effects

Several studies indicated substantial spill over effects of the energy performance standard (ECN, EnergieNed). The energy performance standard contributed to the growth of the market share of for instance condensing boilers and high performance glazing, to such an extent that they have now become the standard techniques within the marketplace.

[9] DHV, 1994: Study of costeffectiveness of marginal value of the energy performance coëfficiënt of buildings in the tertiary sector, Amersfoort, November 1994

# 2 Policy theory

## 2.1 Cause-impact relations, indicators and success and fail factors

The assumptions behind energy performance standard for new buildings are described by means of cause-impact relations. For each cause-impact relation suggestions are made for indicators and success and possible failure factors. These will be used to monitor the effect and to establish the learning experiences.

1. The government prepares the market for the changes in the building decree, which brings the energy performance standard into operation. The energy agency Novem introduces a special implementation program. This program includes guidebooks, a helpdesk, introduction days and courses. The assumption is that for proper functioning of the new obligation in the building decree there has to be a commitment with all involved parties within the building process. A pre-condition for commitment is that the market is well informed and prepared. At the same time the national authority prepares the market for the tightening of the standard in the near future. The assumptions are that all involved parties are aware of this sharpening in an early stage such that they can anticipate the impacts at an appropriate point. In this way the market is stimulated to innovate. The preparation of the market on the sharpening of the standards was supported by:
    - Financial support for energy efficient buildings with an energy performance that go beyond the introduced standard.
    - Valuation of very energy efficient buildings in the National packages of sustainable building. In the period 1996-1998 an EPC-value of equal or lower than 1.3 in the fixed measure list and an EPC-value of equal or lower than 1.2 was awarded[10]. Municipalities use these national packages in their local energy planning for the new building stock. For instance they stimulate the real estate project developers to implement all measures of the fixed list and a certain percentage of the variable list. This means that the standard is embedded in the sustainable building policy.
2. The government introduces the energy performance standard. As of 15 December 1995 the changes in building decree went into force. From that moment new buildings have to comply with a certain energy performance coefficient (EPC). The assumption is that all buildings are built according the new stan-

[10] When the energy performance is sharpened the requirements in the national sustainable buildings packages are sharpened too, for instance from january 2000 the required EPC-value is 1.0,

dard. This implies that all involved stakeholders are aware of their new tasks and responsibilities and carry them out carefully. The details are discussed at each phase of the building process.

3. Architects, constructional and installation engineers design and calculate in such a way that the new standard is achieved. The assumption is that there is attention for energy saving measures during the appropriate design phases, and that investment in these energy saving measures is taken up as a matter of course.
4. The officer of the local building department checks the design and sees to it that it fulfils the building decree. This is done by checking the energy performance calculation, which is a required document within the request for a permit. The assumption is that only in case the energy performance standard is met the building permit is granted.
5. During the building phase a building inspector makes a random inspection to ensure buildings are built according the granted permit.
6. The contractor builds the building in accordance with the technical specifications. The building directorate is informed about changes in the specifications during the building process.
7. The new energy efficient building is realised. People start using the new building. Their lifestyle and behaviour, amongst other operational and management issues determines the realised energy performance.

## 2.2 Interaction with other policies

The energy performance standard interacts with several other policy instruments. For instance through the regulating energy tax, energy saving measures become more cost-effective. The regulating energy tax has a larger impact on energy prices in the residential sector than on energy prices in the service sector, because end-users in the latter sector have larger energy consumption and the level of energy tax decreases as more energy is consumed. In the service sector financial support through subsidy programmes (EINP, MAP)[11] and fiscal measures (EIA, VAMIL)[12] play a role to make energy measures economically feasible. In addition there were long term agreements between the national authority and several branches (supermarkets, hotel and catering etc.).

To prepare the market for the stricter standard (in 1998 and 2000 for residential buildings, in 2000 and 2003 for buildings in the tertiary sector) instruments as the national sustainable building packages and the sustainable building covenants with municipalities were used. Building more energy efficiently than the standard was supported by financial incentives. Several supporting instruments are summarised

[11] EINP stands for Energie Investment deduction in the Non-Profit sector; MAP: Environmental Action Plan by the energy companies

[12] EIA stands for Energy Investment deduction; VAMIL: voluntary depreciation of environmental measures

in Table 5. The assumption was that realisation of good demonstration projects would be of major importance for the market acceptance of new techniques. In addition the demonstration projects had to prove that the sharpening of the standard was possible with minimal additional costs.

Table 5 Instruments that promote realisation of buildings with a better energy performance than required by the standard

| Instrument | Characterization |
|---|---|
| Energy subsidy programs (BSE), for entire built environment, specific energy-efficient and sustainable energy techniques, | Financial support (e.g. innovative applications and demonstration projects) |
| Steering group experiments public housing | Realisation of good examples in practice |
| Green investment, green mortgage | Financial support, lower interest for very energy efficient house or building |

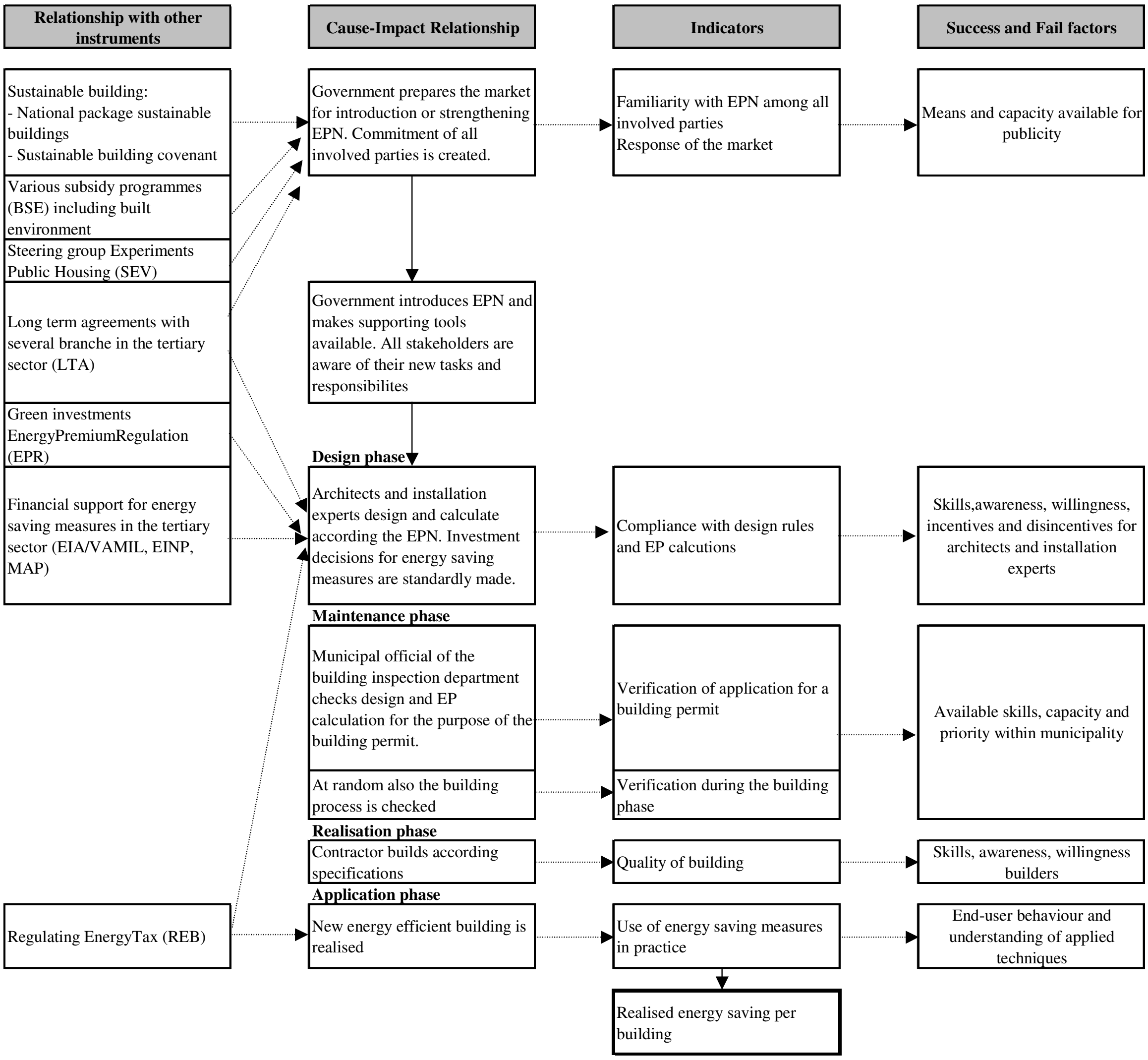


Figure 1 Overall picture of assumed functioning of the Energy performance Standard (EPN): cause-impact relations, indicators, success and failure factors and interactions with other instruments

# 3 Evaluation

## 3.1 Familiarity with the energy performance standard

The familiarity with the EPN within the building community was investigated immediately after the obligation went into force (BBB, 1997)[13]. From this study it appeared that the familiarity with the EPN was very high. At the confrontation with the first building plan in the residential sector designed according the EPN, 95% of the designers (architects, installation experts), and 97% of the municipality officials were familiar with the EPN. In the service sector these shares were lower; respectively 92% of the designers and 93% of the municipality officials being familiar with the EPN. Parties who actually had to implement the energy saving measures (contractors, installers) were less familiar with the EPN: about 75% knew what the EPN was at the time they were for the first time confronted with it.

It must be noted that the size of the survey sample was small. In general it can however be concluded that most involved stakeholders in the building process are well informed (BBB, 1997) (CEA, 2001a)[14].

This implies that the national government invested sufficiently in publicity. The available financial means, estimated -for the total preparation process-between 10 and 30 million euro, and capacity have been sufficient to inform most stakeholders about the EPN (Joosen et al, 2004).

## 3.2 Response of the market

When the national authority announced the concept of the EPN, subsequently announced a sharpening of the EPN, the general response of the market is to protest against these changes in the building decree. Their main objection was/is that the packages of energy saving measures that have to be taken to meet the obligation are too expensive. Therefore the government commissioned an investigation into the cost of the energy savings measures that had to be implemented in order to comply with the energy performance standard (DHV,1994; DHV, 1998)[15], [16] In general it

[13] BBB, 1997: Investigation evaluation energy performance standard (EPN), BBB management and policy consulting , pro Communication, DHV on behalve of the ministries of economic affairs and housing, spatial planning and the environment, July 1997
[14] CEA, 2001a: Monitoring National Environmental Action Plan campaigne, 8 measurement, 11 measurement, drs. J.C.S. van Boetzelaer, drs. H.C, Schneider, report no. 9924, 0052, Rotterdam, July 1999, January 2001
[15] DHV, 1994: Study cost effectiveness marginal values of energy performance coefficient of buildings in the service sector, Amersoort, November 1994

was concluded that it was possible for end-user to reach the energy requirements in the building decree with no or small additional costs.

Another objection of the market against sharpening of the standard concerns the need to implement relatively new techniques. This barrier was overcome through subsidising demonstration projects, which proved that new techniques (such as balanced ventilation based on heat recovery and heat pumps) do work properly in practice, and are applicable to the mainstream construction and property market.

On the other hand there are signs that the market has anticipated the introduction and sharpening of the standard. For instance some the buildings are realised with a better energy performance than required (VROM, 1999)[17]. In addition the application of the condensing boiler and high-insulated glazing became standard techniques halfway through the nineties.

## 3.3 Compliance with design rules and EP calculations

The standard, which went into force by the end of 1995, was closely related to the building practice current at the time. In the largest part of the residential sector it was reached by the application of double-glazing and condensing boilers. From the evaluation carried out just after introduction of the EPN, it became clear that the majority of the customers and designers in the service sector said they do not take more energy saving measures than before (BBB, 1997). This indicates that, for both residential and the service sector, it was relatively easy to comply with the EPC set in 1995. This was according the governmental memorandum concerning the introduction of the EPN (Stb, 1995a)[18].

In addition many designers already applied the guidelines for sustainable buildings. In the national sustainable building packages, building according a better energy performance than required by law is one of the options that is valued. Each time the standard is sharpened, this option in the national sustainable building package is also adapted (see paragraphs 1.5 and 2.2).

In due course standard packages of energy saving measures, with which the sharpened standard can be fulfilled, were developed. Most architects, constructors and installers used these standard packages.

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[16] DHV, 1998: Study cost effectiveness marginal values of sharpened energy performance coefficient for building in the services sector, Amersfoort, February1998
[17] VROM, 1999: monitoring sustainable building Results Action Plans 1995-1999, November 1999
[18] Stb, 1995a: Bulletin of acts, orders and decrees, Decision of 1 Augusts 1995, concerning the determination of the time of going into force of the decision to change the building decree with regard to energy performance, memorandum of information

From the evaluation in 1997 it became clear that about 20% of the Energy Performance calculations for houses included mistakes or imperfections. Around 3% of these mistakes are considered so serious that the standard was not actually achieved (BBB, 1997).

This differs from the situation for the buildings in the service sector. From the evaluation in 1997 it appears that in 72% of the investigated files the Energy performance calculations were not correct. In about 10% of the cases the mistakes were so serious that the required standard was not met (BBB, 1997). Six years later another assessment of building permits showed that about 30% of the files the numbers entered on insulations degrees were very unlikely (SenterNovem, 2001; PRC, 2003b)[19], [20]

Another investigation, about the implementing practice of the EPN in 21 offices, showed that in all cases there were deviations between the energy performance according the building permit and the energy performance of the realised buildings (DHV, 2001)[21]. It concerned deviations leading to a lower as well as a higher energy efficiency of the building. This indicates that it is not a matter of fraud but that the knowledge of the EP calculation is insufficient.

A small survey held by Ecofys within the framework of this case study confirms the findings of these studies. Most officials find (5%- to 75%) the EP-calculations to be incorrect. They point out the mistakes to the person who submit the building permit. Only after adjustments the building permit is awarded (Ecofys, 2006).

## 3.4 Verification of application for a building permit

According to information from the ministry of housing (VROM, 2003b)[22] and an interview with a responsible officer of the energy agency (SenterNovem, 2003a)[23] it was common practice till 2000/2001 that the EP-calculation was not comprehesively checked by the municipality official. The building permit was simply granted in case the final outcome and/or the standard package of energy saving measures was included. It is important to realise that this not only applies to the EP-calculation but also to the verification of other requirements in the building permit. An investigation in 2000 confirms this: from the municipalities which participate in the Energy savings Approach for local authorities (GEA) 31% checks the EPN at

[19] SenterNovem, 2001: Sharpening of EPC-demands for new buildings in the tertiary sector, possibilities and preconditions, ing.E.A. Blankestijn, SenterNovem, 15 March 2001
[20] PEC, 2003b: Energy performance of new offices nased on building permits, PRC building centre on behalf of SenterNovem, May 2003
[21] DHV, 2001: Research implementing practice EPN, DHV, Amersfoort
[22] VROM, 2003b: information by phone, A. van der VEN, VROM inspection service, December 2003
[23] SenterNovem, 2003a: Interview with Haary Vreuls, SenterNovem, 4 September 2003

project level, 29% randomly, 17% apply no checks and 23% do not know if checks are performed (NIPO, 2000)[24].

From the development of various instruments to check the EP-calculation (e.g. program EP-check and a specific website, handbook) it can be concluded that in the period 2000 - 2002 it was recognized that municipality officials needed additional support for their verification duties. In 2003 there have been workshops to stimulate the correct use of the developed software (SenterNovem, 2003b)[25]. Evaluations show that at the end of 2004 about 85% of the municipalities are familiar with these tools. However, only 31.4% of the municipalities uses one or more of the developed tools in their daily practice (BMT Consultants, 2005)[26] (Van Diggele Onderzoek, 2005)[27]. Several indicated reasons for not using the tools are: usage of their own method (22.2%), outsourcing (13.9%), no time (11.1%), little to no maintenance (12.5%)[28], and no priority for maintenance of the standard (12.5%). Nevertheless, the situation by the end 2004 is improved compared to the situation before 2001, in that most municipalities check the EP-calculations (BMT consultants, 2005; Van Diggele Onderzoek, 2005, Ecofys, 2006).

From various sources (PRC Building Centre, 2004) (BMT Consultants, 2005) (DGMR, 2005)[29] (Ecofys, 2006)[30]the conclusion can be drawn that the enforcement of the Energy Performance Standard has insufficient priority within most municipalities. After two disasters -the firework disaster in Enschede (2000) and pub fire in Volendam (2001)- which caused a great public indignation, the focus is on maintenance of safety regulations (fire resistance, construction) in buildings rather than on energy performance.

[24] NIPO, 2000, Municipailty research , 3 measurement, situation with FEA and VOGM and nonactive municipalities, M. Zuidema, et al. A6452, SenterNovem, July 2002
[25] SenterNovem, 2003: information phonecall J.Meyer, 24 November 2003
[26] BMT Consultants, 2005: Analysis of usage EPN maintenance instruments within municipalities, assignment by SenterNovem, January 2005
[27] Van Diggele Onderzoek, 2005: Evaluation of usage instruments which support the EPN, assignment of SenterNovem, March 2005 (results of 180 municipalities, in the Netherlands in total about 450 municipalities)
[28] In most cases small municipalities with small amount of building permits per year.
[29] DGMR, 2005: Note concerning outcomes of a survey on the telephone in framework of the project Pilot maintenance of the EPN at the building site, assignment by SenterNovem, 9 December 2005 (results of 105 municipalities)
[30] Ecofys, 2006: Small survey about the maintenance of the EPN, in frame of the AID-EE project, December 2005 and January 2006.

## 3.5 Verification during the building phase

As with the verification of the EP-calculations, the impression exists that the random building inspections during the realisation did not take place in general during the first period (till 2000) of the EPN. Exceptions to this rule are projects that were financially supported by the government (SenterNovem, 2003a).

Reasons behind this are lack of time and specific knowledge with municipality officials. The impact on the end-result is probably low because in the period 1996-2002 the taken energy saving measures for the majority of the houses were relative standard.

Nowadays, the enforcement of the EPN during construction still has little priority[31]. The verification of the implementation of the energy measures form a part of the overall check up if the building regulations are met. In general the quality of insulation measures and the presence of the appropriate installations (heating and ventilation systems, sometimes solar energy systems) are checked and verified. Sometimes attention is paid to filling up of cracks, seams and joints (to improve air tightness of a building). The lengths of pipes for transport of warm water are rarely checked. Furthermore, the standards of commissioning for installations is often overlooked (DGMR, 2005) (PRC Building Centre, 2005) (Ecofys, 2005). This is closely connected with the educational background of the inspectors, which are often constructional instead of technical engineers, and therefore lack a thorough understanding of mechanical and electrical installations. This is important, because a careful implementation of energy savings measures is essential to achieve the energy savings.

In case the measures do not correspond with the building permit, it is examined if the building nevertheless fulfils the required energy performance standard. If so, then no additional adaptations are required, otherwise the contractor has to take the necessary corrective action. In general no sanctions are impose on non-compliance with the EPN (DGMR, 2005)(Ecofys,2005).

During inspections of 40 offices it was found that 35% of the buildings had a cooling system, 22% had a humidifier which was not foreseen in the EP-calculation. In addition the capacity of ventilation and lighting was larger than reported (PRC building Centre, 2004). This indicates that the maintenance by municipalities of the EPN in the service sector is poor.

[31] Except in case high ambitions are set by the municipality to realise buildings with a low energy consumption.

## 3.6 Quality of building

In the first period (until 1998 for residential buildings, and until 2000 for other buildings) to build according the standard required little deviation from standard building practice at that moment. It is likely that the implementation of the required energy saving measures caused few problems. From a spot check during the building of 21 offices it appeared that even in some cases the buildings were more energy efficient than was indicated in the building permit (DHV, 2001). However, the stricter the EPN gets, the more difficult correct implementation of all energy savings measures will become due to little experience with the required specific applications (high insulation degree, heat pump, etc.).

The users' experiences of best practice projects were investigated. The results show that application of certain techniques requires extra attention. For instance commissioning and operation of new techniques and technologies, which are responsible for the in-door climate (RIGO, 2002a; RIGO, 2002b)[32],[33]

## 3.7 Use of energy saving techniques in practice

The research of user experiences with energy saving techniques is concentrated on the very energy efficient building types, i.e. exemplars, buildings with a better energy performance than was required at that time.

In the residential sector habitants are not always well informed about the implemented techniques. Not everyone visits the information meetings and these are only accessible for the first tenants or owners of newly built houses. User instructions are often too technical for their intended audience. Succinct information about the way one can check the functioning of the technique and possible preconditions for an optimal result is more important than purely technical specifications and data. In case the habitants are poorly informed this can result in inproper use of the technique or technology, reducing or eliminating the efficiency potential. This problem especially arises with complex systems, and heating and ventilation systems in particular. A known example is the fact that habitants are not aware that in case they open their windows (natural behaviour) they disturb the functioning of a balanced ventilation system (RIGO, 2002a; ECN, 2000a; WE, 2001)[34],[35].

Behaviour of habitants has a large impact on the energy use and is one of the causes for the large variety in energy use per house type with a certain EPC. However, re-

[32] RIGO, 2002a: User-experiences example projects sustainable and energy efficient building, residential sector, RIGO research and consulting on behalf of SEV and SenterNovem, no. 79120/w, March 2002
[33] RIGO, 2002b: User-experiences example projects sustainable and energy efficient building, tertiary sector, Reijden H. et al., RIGO research and consulting on behalf of SEV and SenterNovem, July 2002
[34] ECN, 2000a: Lifestyle and domestic energy consumption, M.A. Uyterlinden, H.Jeeninga, ECN-C-00-083, August 2000
[35] WE, 20001: Evaluation zero-energy houses, W/E consultants in co-operation with Verhoef Solar Energy Consultancy on behalf of SenterNovem, WandR 5789, August 2001

search indicates that on average the energy use of newly built single family houses are in accordance with expectations for the standard set. Only the houses with a very strict standard (EPC<=0.8) have on average a somewhat higher natural gas use (PRC, 2003a)[36]. These results are based on random-checks of a considerable number of surveys and different sources: about 4800 municipality files, about 800 questionnaires among habitants, and about 500-600 energy data files from the energy companies.

In the service sector the operation of in-door-climate installations (heating, cooling and ventilation) requires very specific expertise. This is often one of the tasks of the facility manager of the building. An investigation shows however that energy saving is not a priority for them. Another survey showed that complaints of users of very energy efficient building could be traced back to capacity of ventilation, cooling and heating not being tuned in accordance with the building characteristics (RIGO, 2002b)[37].

## 3.8 Net impact

## 3.9 Residential sector

The relation between the energy performance standard and the actual energy-use in newly built houses has been investigated (PRC, 2003a; SenterNovem, 1999a). From these studies some important conclusions can be drawn:

- The actual average gas consumption for space heating and hot water is lower in house with a lower EPC (better energy performance).
- The actual average energy use for space heating and hot water is in general lower than the reference use in energy performance calculations. However this is only true to a point; for houses with a very low EPC (high energy performance) this is not the case.

In the researched period (1996-2004) 685645 new houses were built. From end 1995 the demanded EPC was 1.4, from January 1998 an EPC of 1.2 and from January 2000 an EPC of 1.0 (again a lower EPC corresponds to a higher energy performance). The point in time an application is made for a building permit determines the required level of the energy performance. This means that the effect of the introduction and sharpening of the standard is only visible over a longer time period (ie: there is some inertia). On average there is about 1.8 year between introduction or sharpening of the standard and the actual realisation of the first dwelling according to the standard. For instance of the realised new houses in 2000 about

[36] PRC, 2003a: EPC and energy use of newly built houses, PRC Building cenre BV on behalf of SenterNovem, Utrecht, 11 September 2003

[37] RIGO, 2002b: User expericience demonstration project Sustainable and energy efficient building in the service sector, Reijden H. et al., commissioned by Senternovem and SEV, July 2002

14% was built according to the standard of 1996 (EPC<=1.4), more than 80% according to the standard of 1998 (EPC 1,2) and only 4% according to the standard of 2000 (EPC<= 1.0). The calculation of the realised energy saving by the energy performance standard takes this effect into account.

The numbers houses built within certain EPC-categories is presented in Table 6. According to information from the sustainable building program, a small share of the houses is built with a lower EPC than required (VROM, 1999a). This is taken into account in the calculations.

Table 6 Realised new house per EPC category in the period 1996 up to and including 2004

| EPC-category | Number of new houses | |
|---|---|---|
| EPC 1.4-1.6 | 251106 | 37% |
| EPC 1.2-1.4 | 138251 | 20% |
| EPC 1.0-1.2 | 147956 | 22% |
| EPC 0.8-1.0 | 146086 | 21% |
| EPC <= 0.8 | 2244 | 0% |
| Total | 685645 | 100% |

The actual annual average natural gas consumption for space heating and hot water for an average new house is for each EPC-category shown in Table 7. Also the used assumptions and sources are given.

Table 7 Annual average natural gas consumption (space heating and hot water) per average new house and per EPC-category

| EPC-category | Annual natural gas | | Assumptions and sources |
|---|---|---|---|
| | $m^3$/year | MJ/year | |
| EPC 1.4-1.6 | 1480 | 46842 | average use of an house built in the period 1991-1995 (Energiened, 2000) |
| EPC 1.2-1.4 | 1330 | 42095 | average use of an house built after 1996 (Energiened, 2000) |
| EPC 1.0-1.2 | 1286 | 40712 | energy use per house type (PRC, 2003a)<br>division house types over total housing stock ( CBS, 2003g) |
| EPC 0.8-1.0 | 1133 | 35865 | energy use per house type (PRC, 2003a)<br>division house types over total housing stock ( CBS, 2003g) |
| EPC <= 0.8 | 1029 | 32553 | energy use per house type (PRC, 2003a)<br>division house types over total housing stock ( CBS, 2003g) |

*Reference situation, autonomous development*

The assumption is that an EPC of 1.4-1.6 is representative for the building practice by the end of 1995. Saving resulting from the introduction and sharpening of the energy performance standard occurs after houses are realised with an EPC lower than 1.4. The data in Table 6 and Table 7 are used to calculate the net impact of the energy performance standard. The results of the energy savings (expressed in million $m^3$ natural gas and primary energy PJ) are included in Table 8.

Table 8 Realised energy savings per EPC category, expressed in additional PJ in 2004 in case there was no policy in the period 1995 up to and including 2004

| EPC-category | New houses in period 1996-2004 | Natural gas savings | Avoided primary energy |
|---|---|---|---|
| | # | million $m^3$ | PJ |
| EPC 1.4-1.6 | 251106 | | |
| EPC 1.2-1.4 | 138251 | 20.7 | 0.7 |
| EPC 1.0-1.2 | 147956 | 28.7 | 0.9 |
| EPC 0.8-1.0 | 146086 | 50.7 | 1.6 |
| EPC <= 0.8 | 2244 | 1.0 | 0.0 |
| Total | 685645 | 101.1 | 3.2 |

*Uncertainties*
Several assumptions in the calculation include uncertainties. Main elements, which bring uncertainties along, are:

- How many new houses are realised within an certain EPC category, due to the delay effect
- Energy use and energy savings per EPC-category

It is estimated that this leads to an uncertainty of 50% in the outcome.

*Net-impact*
The net impact of the energy performance standard is that end 2004 the annual primary energy saving is about 3 PJ (uncertainty ± 1.5 PJ).

## 3.10 Service sector

In comparison to the residential sector there are few reliable statistics relating to the service sector. Even various basic data such as floor space and specific energy consumption are uncertain. For this reason, the results are expressed in ranges.

The relation between the energy performance standard and the actual energy-use in new buildings in the service sector has been investigated (Damen, 2001; CDC, 2004; PRC Building Centre, 2004)[38, 39, 40]

[38] Damen, 2001: Monitoring EPN office buildings, Bouten E., and Sonnemans E. in order by SenterNovem, 22 February 2001
[39] CDC, 2004: Relation between EPC and actual energy use of office buildings, ir. E.R. van den Ham, Climatic Design Consult in order by SenterNovem, 9 July 2004
[40] PRC Building Centre, 2004: Energy performance calculation of offices versus actual carried out measures, P.W. van Calis, PRC building centre in order by SenterNovem, 6 July 2004

An important finding from these studies is:
There is a large range between actual energy use and the energy use according the Energy Performance calculation in the building permit. This is indicated by several studies:

- From accurate analyses of 33 office buildings the measured building related energy use is 4% higher as the calculated energy use. This is however not significantly proven, because too little buildings are included. For reliable results detailed analyses of 700 offices are needed (Damen, 2001).
- From building inspections of 40 office buildings it appears that in general the actual realised energy performance is lower than the energy performance in the building permit. The average deviation is 10% (range is from -19% to 55%). Furthermore the findings show that in 39 of the 40 inspected offices the measures in the energy performance calculation are not in accordance with the actual taken measures. This leads to less and more energy consumption in practice, the expectation is that the overall effects are negative; meaning higher energy consumption then could be expected on base of the energy performance coefficient. (PRC Building Centre, 2004).
- Another study including 94 office buildings concludes, based on regression analysis, a significant relation between the Energy Performance Coefficient and the actual energy use. On the average a low EPC (high energy performance) leads to a lower actual energy use, although there is a large differentiation between individual cases. (CDC, 2004)

The realised new buildings in the research period (1996-2004) are based on estimations (DHV, 1997) and expressed in terms of floor area. The floor space per building function, and thus per required energy performance, is distinguished. Likewise the residential sector the delay effect, i.e. time between building permit and actual realisation of measures, is taken into account. For the services sector this data is not available, but the period between building permit request and actual realisation is probably longer. It is estimated that is 3 year in the services sector compared to about 2 years in the residential sector. The distribution of the effect is assumed to be the same as in the residential sector. An overview of the realised new buildings with a certain EPC level is presented in

Table 9.

Table 9 Realised new floor space per building type in the periode 1996 upto and including 2004

| Building function | New buildings in period 1996-2004 Floor space in million m2 | | |
|---|---|---|---|
| | EPN 1995 | EPN 2000 | EPN 2003 |
| Meeting facility (Theatre, musea, etc. and since 2003 hotel and catering) | 2.38 | 1.28 | 0.12 |
| Prison | 0.01 | 0.01 | 0.00 |
| Health care, non-clinical | 1.00 | 0.54 | 0.05 |
| Health care, clinical | 0.84 | 0.45 | 0.04 |
| Hotel and catering | 1.78 | 0.96 | 0.09 |
| Office | 5.92 | 3.18 | 0.30 |
| Accommodation | 0.60 | 0.32 | 0.03 |
| Education | 0.83 | 0.45 | 0.04 |
| Sport facilities | 0.14 | 0.07 | 0.01 |
| Shop | 2.65 | 1.43 | 0.13 |
| Total | 16.16 | 8.69 | 0.81 |

*Energy saving*

There are only empiric data of actual energy consumption by certain energy performance level available for office buildings. This data shows significant scatter. The analyses show that on average the energy performance standard results in an lower actual energy use. However they also indicate that the energy use is not so low as could be expected. On average the actual energy use is about 4% to 10% higher. Based on these results it assumed that the energy savings have a large range and are somewhat lower than could be expected on their required energy performance. For example the introduction of the energy performance standard should lead to energy savings of 10% to 20%, it is assumed that these are 10% lower. The range of gross energy savings per building function, which are used in the calculations, are presented in

Table 10. These savings are compared to the reference situation in 1995.

Table 10 Range of energy saving at introduction and sharpening of the energy performance standard

| Building function | EPN 1995 | | | EPN2000 | | | EPN2003 | | |
|---|---|---|---|---|---|---|---|---|---|
| | min | max | average | min | max | average | min | max | average |
| Meeting facility (Theatre, musea, etc. and since 2003 hotel and catering) | 0% | 10% | 5% | 29% | 39% | 34% | 35% | 45% | 40% |
| Prison | 0% | 10% | 5% | 4% | 14% | 9% | 17% | 27% | 22% |
| Health care, non-clinical | 0% | 10% | 5% | 10% | 20% | 15% | 25% | 35% | 30% |
| Health care, clinical | 0% | 10% | 5% | 19% | 29% | 24% | 23% | 33% | 28% |
| Hotel and catering | 0% | 10% | 5% | 14% | 24% | 19% | 0% | 10% | 5% |
| Office | 0% | 10% | 5% | 16% | 26% | 21% | 21% | 31% | 26% |
| Accommodation | 0% | 10% | 5% | 13% | 23% | 18% | 21% | 31% | 26% |
| Education | 0% | 10% | 5% | 0% | 10% | 5% | 7% | 17% | 12% |
| Sport facilities | 0% | 10% | 5% | 21% | 31% | 26% | 36% | 46% | 41% |
| Shop | 0% | 10% | 5% | 3% | 13% | 8% | 6% | 16% | 11% |
| Total | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |

*Reference situation, situation in 1995*

The average to the building related energy consumption before the introduction of the standard is estimated by means of the specific average energy consumption per building function. The data originates from the energy agency (SenterNovem) and relates to the total existing building stock (SenterNovem, 2003)[41]. The data are corrected for the use of appliances (cooking apparatus, computer etc.), because the standard has no influence on their energy demand. The data for offices are verified with other research data (Damen, 2001). On average specific building related energy consumption for the different building categories from the standards are presented.

[41] SenterNovem, 2003: Figures and Tables, Sittard

Table 11 Assumed averaged building related energy use per building function in 1995 (SenterNovem, 2003)

| Building function | Average building related specific natural gas use ($m^3/m^2$) | Average building related specific natural gas use ($kWh/m^2$) |
|---|---|---|
| | | |
| Meeting facility (Theatre, musea, etc. and since 2003 hotel and catering) | 19 | 32 |
| Prison | 21 | 42 |
| Health care, non-clinical | 22 | 38 |
| Health care, clinical | 21 | 60 |
| Hotel and catering | 63 | 198 |
| Office | 18 | 66 |
| Accommodation | 32 | 77 |
| Education | 14 | 28 |
| Sport facilities | 15 | 40 |
| Shop | 17 | 136 |

*Autonomous development*

The savings per $m^2$ floor space per building type are calculated using the saving ranges and specific energy consumptions in respectively,

Table 10 and Table 11. The gross energy saving is calculated by multiplying saving ranges with the realised area of new floor space in the same period (

Table 9). The gross energy saving through the energy performances standard lies between 1.5 and 6 PJ primary energy. Autonomous developments, and the fact that many architects and commissioners indicated that they did not take additional measures after the introduction of the EPN have to be taken into account to determine the net impact of the instrument (EPN, 1997). In the explanatory memorandum in the legal introduction of the standard it is explicitly stated that the standard is close to the building practice of that time. Taking all these factors into account it assumed that 90% to 50% additional measures were taken compared to the situation before introduction of the standard. Under these assumptions the actual realised energy saving through the energy performance standard is between 1 and 6 PJ avoided primary energy.

*Uncertainties*
Due to the poor quality of the data for the service sector, the uncertainty of the outcomes for this sector is larger than for the residential sector. Many assumptions in the calculation include areas of uncertainty. The main uncertainties include:

- How many new buildings are realised within an certain EPC category, due to the poor statistics of realised floor space per building type. In addition the delay effect is not investigated for the service sector.
- The energy consumption per building category.
- Energy savings per EPC-category.

It is estimated that this leads to an uncertainty of about 80% in the outcome.
*Net Impact*
The net impact of the energy performance standard is that end 2004 the annual primary energy saving is about 3 PJ (uncertainty ± 2.5 PJ).

## 3.11 Overview

The net impact of the total building sector is shown in Table 12.

Table 12 Net-impact of the energy performance standard in buildings

| **Sector** | **Energy savings** |
|---|---|
| | PJ |
| Residential sector | 3 (± 1.5) |
| Tertiary sector | 3 (± 2.5) |
| Total | 6 (± 4) |

## 3.12 Effectiveness

## 3.13 Residential sector

Without the energy performance standard, the natural gas consumption for space heating and hot water for newly built houses in the period 1996-2004 would have been 11% higher in 2004. In this outcome the inertia effect, which occurs because the time of the building permit is decisive for the required level of the energy performance, is taken into account. The time between request of the building permit and actual completion is on the average 2 years. If delay effect is discounted, it is estimated that an energy savings of 19% are reached. The target of the policy instrument (EPN) was energy savings of 15-20% energy savings compared to the building practice in the early nineties. However, it was not indicated when these targets should be met (Stb, 1995). These savings are mainly realised by the gradually becoming more strict requirement of the energy performance. This leads to the conclusion that this target is probably met.

## 3.14 Tertiary sector

Without the energy performance standard the building related energy consumption in, the 1996-2004 period, realised new buildings in the service sector would have been about 6% higher in 2004. In this outcome the delay effect, which occurs because the time of the building permit is decisive for the required level of the energy performance, is taken into account. The time between request of the building permit and actual completion is on average 3 years. In case this delay effect is left out, it is estimated that an energy saving of 22% is reached. The target of the policy instrument (EPN) was energy savings of 15-20% compared to the building practice in the early nineties. However a target year was not indicated (Stb, 1995). These savings are mainly realised by the gradually becoming more strict requirement of the energy performance. This leads to the conclusion that this target is probably met.

## 3.15 Cost efficiency

*Uncertainty*

The cost efficiency calculations are surrounded by a number of uncertainties. The cost of the government are only indicative and there are no exact data available about which measures have been implemented in the new building stock. For this reason, the results are expressed in ranges.

## 3.16 Society

To determine the cost efficiency of the energy performance standard for the society estimations have to be made of the additional investment costs of the implemented energy saving measures (additional compared to the reference situation, i.e. building practice end 1995).

In Table 13 and Table 14 the used additional investment costs and the made assumption are given for respectively the residential and tertiary sector.

Table 13 Additional investment cost per house per EPC-category (residential sector) (Consumers association, 1999)[42]

| EPC-category | Additional investment cost society (euro/house) | Additional investment cost end-user (euro/house) | Assumptions and sources |
|---|---|---|---|
| EPC 1.4-1.6 | | | Reference situation |
| EPC 1.0-1.4 | 700 | 655 | Bulk of the measures high insulated glazing and condensing boiler, cost information (Consumers association, 1999) |
| EPC < 1.0 | 1438 | 1027 | High insulated glazing, condensing boiler, a solar heating system or balanced ventilation with heat recovery, cost information (Consumers association, 1999) |

[42] Consumer association, 1999: Energy guide for household, research Ecofys, 1999

Table 14 Additional investment cost service sector

| EPC-category | Additional investment cost society (million euro) | Additional investment cost en-user (million) | Assumptions and sources |
|---|---|---|---|
| Before 1996 | | | Reference situation |
| EPC since 1996 | 210 | 190 | Calculation of the total additional investment is based on information from two studies (DHV, 1994; DHV,1998)[43], [44] which give insight in the extra cost per $m^2$ floor space. The exact implementation of measures is unknown. It is assumed that half of the measures are constructional and the other half is in installations, lighting and appliances. The additional investment cost for the end-user are determined under the assumption that 20% of the additional cost are eligible for financial support (EIA/EINP,VAMIL). |

These investments are depreciated over the economic lifetime of a measure (10 year for installations, and 25 year for insulation measures) using the interest rate of the society (4%). These determined capital costs are recouped through operational cost savings on energy. The cost savings on energy are calculated by using the shadow prices, i.e. 0.11 euro per $m^3$ natural gas in the residential sector and 0,10 euro per $m^3$ natural gas in the tertiary sector. Finally, the costs are divided by net energy savings of the implemented measures.

From the society perspective, the energy measures, which are implemented as result of the energy performance standard, are not cost efficient in the residential sector: between 3 to 7 euro per GJ saved energy. This means that the benefits of the achieved energy saving are lower than the additional cost of the measures. It is important to be aware that in the calculation the external costs (i.e. avoidance of environmental damage) were not taken into account. -In 2006 the shadow price for

[43] DHV, 1994: Study of cost effectiveness of energy performance coefficient in buildings in the service sector, Amersfoort, November 1994

[44] DHV, 1998: Study of cost effectiveness of energy performance coefficient in buildings in the service sector, Amersfoort, February 1998

natural gas is about twice as high (about 0.22 euro/$m^3$, with this price the cost for society are between -1 to 5 euro per GJ saved energy.-
In the services sector the cost efficiency for the society is estimated to be between -2 and 5 euro per GJ saved energy. This means on the average a cost neutral implementation of measures in this sector.
-In case the calculations are based on the high gas prices of 2006 the cost for society turn out to be between -4.5 and 4.5 euro per GJ saved energy.-

## 3.17 Government

The costs for the government for the energy performance standard consist of:

1. Administration cost for the implementation and sharpening of the standard
2. Maintenance cost of municipalities

The made estimations for governmental cost in the residential and tertiary sectors, are presented in respectively Table 15 and Table 16.

Table 15 Estimated governmental costs for the energy performance standard in the period 1996-2004 (the residential sector)

| Governmental cost | Million euro | Assumptions |
|---|---|---|
| Implementation programme | 4 to 7 | BSE-program Houses over the period 1995-2000. Within this program knowledge transfer, feasibility and demonstration projects were financially supported. Individual subsidy programmes for innovative techniques (such as BSE and EPR) are not taken into consideration. |
| Maintenance cost of municipalities | 1 to 18 | • 50 houses with same design per project<br>• 1 till 20 hours for all additional activities (check EP-calculation, check during and after realisation)<br>• labour cost 65 euro per hour<br>As indication: the extra capacity within the municipalities during the research period based on above assumptions is 1 about 25 till FTE. |
| Total | 6 to 23 | |

Table 16 Estimated governmental costs for the energy performance standard in the period 1996-2004 (the tertiary sector)

| Governmental cost | Million euro | Assumptions |
|---|---|---|
| Implementation programme | 8 to 13 | BSE-program Services over the period 1995-2000. Within this program knowledge transfer, feasibility and demonstration projects were financially supported. |
| Maintenance cost of municipalities | 0.07 to 7 | • 1 to 10 buildings with the same design per project<br>• 1 to 20 hours for all additional activities (check EP-calculation, check during and after the realisation)<br>• average floor surface per building about 3000 m2<br>• labour cost 65 euro per hour<br>As indication: the extra capacity within the municipalities during the research period based on above assumptions is 1 about 16 till FTE. |
| Total | 10 to 18 | |

These investments are depreciated over the economic lifetime of a measure (10 year for installations and 25 year for insulation measures) using the interest rate of the government (4%). Subsequently, the outcome is divided by net energy savings of the implemented measures.

The governmental costs of the energy performance standard are small: about 0.2 to 0.9 euro per saved GJ in the residential sector and about 0.1 to 1.0 euro per saved GJ in the tertiary sector.

## 3.18 End-user

The estimation of the additional costs is based on the same assumptions as in the calculation for the cost-efficiency for the society (see Table 13 and Table 14). For the end-user these costs are compensated by awarded subsidies. For the residential sector the amount of subsidy is based on the available subsidy for assumed implemented techniques (MAP, EPR). For the tertiary sector it is assumed that 20% of the additional cost are subsidised for half of the additional measures. This is based on data from other policy instruments (EIA/VAMIL) (Joosen et al, 2004). Furthermore it is assumed that the additional costs are 50% for insulation measures and 50% for measures related to installation and appliances. The investments and subsidies are annuity depreciated over the economic lifetime of the energy saving measure (i.e. 25 years for measures connected to the building shell and 10 years for installations and appliances) against discount rate for the specific sector (i.e. 8% for the residential sector and 15% for the tertiary sector).

Subsequently the capital costs are decreased with the operational cost reduction achieved though energy savings. The calculation uses energy prices at the level of the end-user (including taxes, i.e. 0.37 euro/$m^3$ in the residential sector and 0.32 euro/$m^3$ and 0.11 euro/kWh in the tertiary sector).

In the end, the calculated amount of money is divided by the gross energy saving. On average the additional cost for investment in energy saving measures are compensated by the benefits of the saved energy. The cost efficiency for the end user was between –8 and 1 euro per saved GJ energy in the residential sector and in the services sector between -9 and 4 euro per saved GJ energy. It should be noted that not all implemented packages of measures were cost efficient for end-users.

## 3.19 Overview

In Table 17 the outcomes of the cost-efficiency calculations are summarised. The cost calculations deal with a lot of uncertainties, because the governmental costs are only known on an indicative basis, and exact data is not available to confirm the implemented measures. To improve the quality of the cost efficiency calculation, an insight into this information is essential.

Table 17 Cost efficiency for the society, government and end-users for energy performance standard in the period 1996-2004

| **Cost-efficiency In euro/saved energy GJ** | **Society** | **Government** | **End-users** |
|---|---|---|---|
| Residential sector | 3 to 7 | 0.2 to 0.9 | -8 to 1 |
| Tertiary sector | -2 to 5 | 0.1 to 1.0 | -9 to 4 |
| Total | -2 to 7 | 0.1 to 1.0 | -9 to 4 |

# 4 Conclusions

## 4.1 Net impact, effectiveness and cost efficiency

The net impact and effectiveness of the energy performance standard is presented in Table 18. It can be concluded that the introduction and sharpening of the energy performance has stimulated the market to take energy saving measures.

Table 18 Net impact and effectiveness of the energy performance standard (EPN) in the Netherlands in 1996-2004

| **Sector** | **Net impact (PJ)** | **Effectiveness**[45] | **Set Target** |
|---|---|---|---|
| Residential | 3 (± 1.5) | The estimation is that without the standard energy demand for space heating and hot water would be 19% higher. | 15%-20% energy saving of energy demand for space heating and hot water in new houses. |
| Services | 3 (± 2.5) | The estimation is that without the standard the energy consumption would be 22% higher. | 15%-20% |

The cost efficiency for the society, government and end-user is shown in Table 19. The cost for the society and government are relatively small compared to other policy instruments in the built environment (Joosen et al, 2004). For the end-users the energy performance standard is on average a cost-effective instrument among others due to the fact that subsidies were available to support the implementation process. This means that the government addressed a significant barrier, i.e. real estate project developers do not typically embrace measures which are cost effective for the end-user, is indeed overcome. In addition the set target of 15-20% energy saving on the building related energy demand (e.g. space heating and hot water) is met[46].

[45] The effectiveness without taken the delay effect – between the request of the building permit and the realisation of the dwelling is presented, because it assumed that this effect was not included in the set target either.
[46] It was not indicated when these savings should be reached.

Table 19 Cost efficiency for the society, government and end-users for energy performance standard in the period 1996-2004

| **Cost-efficiency In euro/saved energy GJ** | **Society** | **Government** | **End-users** |
|---|---|---|---|
| Residential sector | 3 to 7 | 0.2 to 0.9 | -8 to 1 |
| Tertiary sector | -2 to 5 | 0.1 to 1.0 | -9 to 4 |
| Total | -2 to 7 | 0.1 to 1.0 | -9 to 4 |

## 4.2 Success factors

The most important factors determining the success of the instrument were:

1. The government prepared the market for the introduction and sharpening of the energy performance standard. There were enough means invested to properly inform most of the stakeholders. In addition the government anticipated on objections of the market (e.g. measures are too expensive). At the start of the implementation process, the standard was closely tuned to the building practice of that moment. This was important for the acceptance of the new instrument. Secondly demonstration projects showed that it was possible to meet the standard with no or small additional cost and with technical properly functioning in practice. In this way commitment of most stakeholders was created.
2. For designers, the availability of standard packages of energy saving measures which were ready before EPN standards were tightened were good tools to limit additional development time required to comply with the new energy performance standard.

## 4.3 Fail factors

Several factors which influenced the impact of the instrument negatively were:

1. The knowledge of several stakeholders (designers, municipality officials, builders and end-users) about the measures to fulfil the energy performance standard is not always sufficient. For instance in the fomative period, designers were not always sufficiently skilled to perform satisfactory calculations. It is unknown to what extent this influenced the actual energy performance of the buildings.
2. In the period 1995-2001 the energy performance standard was seldom checked. Also there were few random checks during the building phase. It seemed that this was not a high priority within municipalities. In addition in general the responsible officials did not have the necessary skills and were not trained for the new demands of the standard. This was recognized by the national government and new activities and tools were developed to

support the building inspectors with their tasks. Through these actions the situation has now been significantly improved, and most municipalities audit the EP-calculations. However, the maintenance of the EPN has still low priority. The expectation is that till now this only had little impact on the actual energy saving, because most measures were relatively close to the building practice. However, with incremental tightening of the EPN - certainly from January 2006, energy performance will become more stringent again-, and careful implementation of energy savings measures becomes more important for the actual realisation of the energy savings. This means also the quality of building process itself becomes more important to actually achieve the required energy performance. In addition it is observed that correct implementation and tuning of installation become more relevant, and building inspectors do often not have the right expertise to check this. Their background is more construction related rather than technical engineering related, and a sound understanding of both elements is important for the appraisal of the EPN standard.

## 4.4 Monitoring and evaluation

At the moment the monitoring is carried out by the Dutch energy agency (SenterNovem). On their behalf, several studies have been undertaken to investigate the impact of the energy performance standard. Based on this information the impact of the instrument can be qualified. However, the outcome has broad range due to poor accuracy of information. Also for calculation of the cost efficiency many estimations have to be made.
In the ideal case the following additional data should become available to determine the impact, effectiveness and efficiency,:

- Characteristics of buildings in the services sector (floor space, volume, energy consumption patterns per building type etc.)
- Energy consumption per building type
- Accurate cost for the government (implementation programm, maintenance)
- Accurate overview of implemented measures in new buildings

Currently there are several developments in which the monitoring could be included. The government is more and more aware of their responsibility to give insight into the spent budget. In the past this data was often untransparent. The statical office is working on a linkage with information of energy companies, so that in the future information about energy consumption per building should become available. Furthermore within the framework of the European Directive on the Energy Performance of Buildings (EPBD) an energy certifcate is an obligation at the point of sale of a building. In case a energy certification system will be in place, information about the energy consumption per building type and perhaps

also implementated measures could become available. However, attention has to be paid for the importance of this type of information, because otherwise only the number of certificates and the label on the certificates will be monitored.
In case the collection of data will be integrated in systems which are already in place, the cost for monitoring will be certainly in proportion to the cost of the whole instrument. Under these circumstances it is the expectation that the cost for accurate monitoring will be recouped in the short term.

## 4.5 Summary: Learning experiences

Recommendations for a successful implementation of a energy performance standard are:

1. ***Give the market time to anticipate to the standard***
   The required energy performance for new buildings has gradually become more strict. The introduction level was close to the building practice of that moment. This strategy has been succesful, the market had time to anticipate on the new standard.
2. ***Show the feasibility of new technologies by way of demonstrations***
   Each time the standard was sharpened the market objected. Main objections were that the required packages of measures are too expensive and several measures would not function properly in practice. By research reports and demonstration projects these objections were addressed.
3. ***Make sure stakeholders are sufficienty skilled to check proper implementation of the standard***
   Till now it appears that insufficient knowledge of the energy performance standard at several stakeholder levels (designers, municipality officials, builders and end-users) and the lack of maintenance did not significantly impact on the end result. However, one can doubt if this still will be the case in the nearby future. As from 1 january 2006 the energy performance will be tightened further. This will require more specialised techniques (e.g. heat pumps) and accurate building (insulation) to achieve the corresponding energy savings, and therefore places greater demands on the ability of the market to adapt to new techniques.
4. ***Make sure checks are carried out***
   The maintenance of the energy performance standard has too little priority within municipalities. However, this is essential condition to guanrantee a proper realisation of measures towards end-users and to achieve the aimed energy savings (see also remark under point 3).
5. ***Set up a detailed monitoring system to minimise uncertainty in impact and cost-effectiveness calculations***
   With the monitoring system in place, it is possible to quantify the impact of the instrument. The uncertainties in the outcomes, however, are considerable. To minimise the broad ranges a more detailed monitoring

system is required. This is especially is true for the service sector, because there is a fundamental lack of information about its general characteristics.

# References - documents

See Annex I, guidelines report for the ex-post evaluation of policy instruments on energy efficiency.

# References – Small Survey

In December 2005 and January 2006 Ecofys held a small survey among several municipalities about their maintenance tasks in framework of the EPN. In total 15 municipalities were approached of which 7 responded. We compared the outcomes with other sources (DGMR, 2005).

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