The Energy Performance of a Location: Successes, Setbacks and New Approach

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ABSTRACT

After introducing the Dutch building code, which focuses on single buildings, the national government concluded that further reductions in energy could be achieved by looking at entire locations. The ministry of Economic Affairs commissioned Novem[1], the Dutch Agency on Energy and the Environment, to develop and implement the Energy Performance on Location (EPL) method. This is a voluntary, but well-defined, method to improve energy efficiency and reduce CO_2 emissions of the built environment. After six years, we can demonstrate the program's success. Surveys show that locations can be improved by 10 – 30% when compared to "just using building codes." We managed an overall annual reduction of 0.17 Mton CO_2 emissions, a large amount by Dutch standards. We encountered, however, some setbacks in gaining acceptance and cooperation from municipalities and housing associations. We therefore performed extensive marketing research to determine which policy instruments influence the energy-relevant behavior of the key players (target groups) in the urban renewal process. With these players, we are striving for not only more energy efficiency, but also a healthier, more comfortable and safer area to live in. As the process of getting "Beyond HERS" was described before, this paper concentrates on getting marketing information about the target groups and turning this knowledge into a working program.

Introduction

The Netherlands is a densely populated country and the development of new housing areas needs careful planning. Like most highly developed countries, the Netherlands has incorporated within its building code an Energy Performance Code (EPC). This code provides a numerical indicator (simply called the EPC) that reflects building characteristics, energy systems and standard human behavior[1]. Every couple of years the code is evaluated and, if possible, sharpened. The building code, however, focuses on individual buildings, and the EPC, consequently, focuses on energy issues for single buildings only.

In theory, integrating energy efficiency into the design of a residential area as a whole will further reduce energy consumption[2]. Such an integral design can profit from building orientation with respect to the sun, using local sources of energy such as wind or heat sources, using cleaner or sustainable energy, using a centralized Combined Heat & Power (CHP) plant, a well-designed infrastructure etc. Such measures not only reduce energy consumption, but also reduce CO_2 emissions of the entire building location.

A building "location," for our purposes, refers to 300 or more homes that can be integrally approached as a single "energy consuming unit." A location can be a new suburb, the

[1] The agencies Novem and Senter merged on 1 May 2004. As a number of publications were made by Novem, both the names Novem and SenterNovem are used in this text.

extension of existing areas or even a new municipality. A location could also be a neighborhood to be renovated.

As a first step to study the "location" approach, SenterNovem designed the Energy Performance of a Location (EPL) method to measure reductions in CO_2 emission that could be realized through an integral approach to the energy needs of a location. The method quantifies CO_2 reductions resulting from better insulation, sun orientated building design, the use of cleaner (or even sustainable) energy, Combined Heat & Power (CHP) etc.

Apart from the technical aspects, reductions in CO_2 emissions depend upon municipalities, housing associations and other key players accepting the method and cooperating with each other to realize the goals. We have been developing a strategy for using existing policy instruments to change the energy related behavior of key players, and in this article we report on how we are applying this strategy to promote the EPL method.

Specifically, in this article we address two questions:

- Does the location approach lead to lower over-all CO_2 emission than the single house approach?
- Is it possible to select a tailor-made set of existing policy instruments to promote the EPL method within municipalities and housing associations?

Energy Performance of a Location (EPL): The Method

The EPL method has three main parts:

1. a formula to calculate the EPL value, which is an indication of CO_2 emission
2. a program that calculates the added cost of energy related options, and
3. a decision making process wherein the municipality decides on the options to implement in a building or renovation project. The municipality must also decide on the ways to implement their options.

The EPL formula (Figure 1) returns a value between 1 and 10 that reflects CO_2 emission: no CO_2 emission gives a score of 10. The standard building techniques specified in the Dutch building codes lead to an EPL value of "6" for building locations. This is based on heating dwellings with a highly efficient boiler on natural gas. To estimate the EPL for new locations, we set "$F_{reference}$" equal to the "F" value of an existing and similar building in the EPL formula (Figure 1). Implementing sustainable energy options, improving the insulation or more advanced techniques than a highly efficient boiler, will lead to a higher value of F_{choice} and thus to a higher EPL.

Energy Performance on location in formula:

$$EPL = 10 - 4x \frac{F_{choice}}{F_{reference}}$$

- F = fossil fuel use = energy demand * C-factor
- C-factor = fossil carbon mass in primary energy carrier
- Choice = location for which the EPL is calculated
- Reference = reference location

Figure 1: EPL New Build Areas

If the entire location as a whole is considered, however, new possibilities arise to further increase the EPL value. Such possibilities include using local energy sources, such as wind, and economies of scale. Municipalities use the EPL method when developing a new housing location. With it, they can compare different options to create an energy efficient location by comparing the EPL values.

Energy Performance at a Location (EPL): Implementation Program

To implement the EPL method, the Dutch government commissioned SenterNovem to develop a method to aid municipalities in planning a "location." We call this method the Optimal Energy Infrastructure (OEI) method. It encourages the parties involved to cooperate with the municipality in focusing on energy issues during the planning process such as use of Combined Heat & Power (CHP), sustainable energy, better insulation etc. The method incorporates planning software and EPL. The OEI program, co-financed by the Ministry of Economic Affairs and the Ministry of Spatial Planning, Housing and the Environment, started in 1997.

Although originally intended to promote CHP and especially district heating within the OEI program, the range of EPL applications has broadened. A number of instruments such as scans, project plans, a software tool to compare energy options, (small) subsidies for inventories and process support are now available.

New building areas. The method was first launched in areas of at least 300 new dwellings. Just over one hundred locations adopted the program. A wide variety of solutions was implemented. Especially combinations of options proved to be effective in the new developed locations.

The benefits, which arose from cooperation in the early stages of the development of the locations, were not only environmental. The economy of scales made it possible to build better locations without extra costs.

Renovation areas. In 2000, the first surveys of renovation locations were held. In contrast to the 80,000 new homes to be built per year, about 2,500,000 homes are to be renovated during coming ten years. For this reason we are focussing on renovation areas. The EPL values calculated for the existing situations were far worse than ever expected. The lack of insulation, single glazing and old heating systems led to EPL scores of less than 2. These existing EPL values aid decision makers to decide which areas will be renovated and in which order.

We cannot expect a high EPL after renovation. In contrast to new construction, the existing situation often limits energy options to the extent that we achieve a final EPL of less than 6. Furthermore, in large renovation areas improvements in the EPL values will not be realized if only a small part of the area is renovated.

The method of EPL has shown its value in those areas. Again, projects of more than 300 dwellings can produce much more comfortable and energy efficient houses when a municipality has clear goals and well defined ways to achieve them. With renovation projects of that size, sustainable energy, CHP and extra insulation can become cost effective options. For these locations, we calculate the ΔEPL Figure 2). We only look at

$$\Delta EPL = \frac{((EPL\text{-}E_{new} - EPL\text{-}E_{ref}) \times D_{renovation} + (EPL\text{-}N - 6.0) \times D_{new})}{D_{renovation} + D_{new}}$$

- $EPL\text{-}E_{new}$ = EPL for the renovated dwelling after restructuring
- $EPL\text{-}E_{ref}$ = EPL for the renovated dwelling before restructuring
- EPL-N = EPL for new dwellings
- 6.0 = Reference EPL for new dwellings
- $D_{renovation}$ = Number of dwellings to be renovated
- D_{new} = Number of new build dwellings

Figure 2: EPL restructured Areas

the part of the neighborhood that is to be renewed or rebuilt, and calculate the improvement of that area.

Results of the EPL Survey

Overall results. Existing new-home building sites offered realistic reference calculations for new locations. The calculated annual reduction on CO_2realized in new locations was 0.17 Mton, This reduction was calculated by comparing the reference EPL with the actual achieved EPL for the all of the new-dwelling areas. Note that this reduction is for new-home building locations only. Utility buildings and renovated dwellings were excluded because we had no reliable reference situation.

Considering the national goal of 2 Mton CO_2 for the whole field of dwellings, this is a remarkable figure. Sustainable or more efficient energy supply accounted for 60% of our calculated reduction. Buildings made more energy efficient than required by the EPC accounted for the other 40%.

Results from the EPL monitor. The EPL is a voluntary instrument and the participants are quite willing to share their results. To collect and disseminate the participants' results, we created and carry out an annual survey called the EPL monitor[3]. We conducted the original survey in 1998, and modified it to consider planning changes in 2003. At that time, three categories were created for new areas:

- *Planned Energy goals* for locations that are still in the planning stage, chances to realize location according to plan are less than 75%
- *On the road to realization* for locations that have been realized for at least 50% or where the chances of realization are greater than 75%.
- *Realized* for locations that were realized for at least 70% and where the energy supply has been built.

Fact-finding for the new areas is quite simple: a digital questionnaire was sent to the municipalities. It questioned the number of dwellings that had been built and their specific EPC and energy supplies. The results were compared with the energy goals and checked by a SenterNovem process manager and then the results were ranked. (Table 1)
The calculation of the EPL for renovation areas is a job for consultants. With a list of reference dwellings and the knowledge of energy saving projects in the past they can compile the EPL. The work includes a visual scan of the neighborhood. The results are matched with the facts found in the municipal questionnaire. If necessary, extra checks are carried out by the SenterNovem process manager, before the results are finalized.

Table 1. The top 5 of Each Category Is Presented Below

Monitor 2003: New build areas – Ambition				
Municipality	Location	Number of dwellings	EPL	CO_2 reduction kton/Year
Etten-Leur	Schoenmakershoek	365	10	1.2
Heerhugowaard	Stad van de Zon deel 2	1410	8.5	3.0
Amersfoort	Vathorst	10.900	8.2	21.5
Heerlen	Stadspark Oranje Nassau	300	8.0	0.5
Leeuwarden	Zuid	6000	8.0	9.9
Monitor 2003: New build areas - *On the road to realization*				
Municipality	Location	Number of dwellings	EPL	CO_2 reduction kton/Year
Almere	Poort	9400	9.6	31.4
Apeldoorn	Groot-Zonnehoeve & Zuidbroek	3635	9.6	12.9
Lelystad	De Landerijen	1600	8.2	3.8
Amsterdam	Ijburg fase 1	6900	7.8	8.1
Tilburg	De Wijk	3000	7.8	4.0
Monitor 2003: New build areas – *Realization*				
Municipality	Location	Number of dwellings	EPL	CO_2 reduction kton/Year
Breda	De Kroeten	875	8.6	1.7
Harderwijk	Drielanden Centrum	369	6.8	0.2
Doetichem	Romantische Buurt	458	6.7	0.3
Deventer	Grachtengordel	800	6.6	0.4
Langendijk	Mayersloot	914	6.5	0.5

Monitor 2003: Reconstruction areas			
Municipality	Location	Number of dwellings	ΔEPL
Gouda	Oost	2200	3.4
Bergen op Zoom	Fort Zeekant	2050	3.0
Apeldoorn	Tannhauser & Ankelaar	850	3.0
Delft	Poptahof	1300	2.0
Delft	Spoorzone	1500	2.0

The Setbacks

Although our results show that the voluntary program works in the Netherlands, we encountered three setbacks that we summarize below.

Legislation was not successful. After the first successes, it was decided to oblige municipalities to establish an energy targets for each project of more than 500 dwellings. An annex to the Electricity and Gas Laws was formulated and became effective the 1st of May 2001. This Building Energy Infrastructure decree (In Dutch AMvB-BAEI) gives municipalities the possibility to tender the construction of the energy infrastructure. As the EPL was not put into legislation (the local component differs too much) the decree was not specific enough. The first municipality that used the decree ended up with lawsuits that delayed the project. Although the result was overwhelming (Almere Poort, see table monitor 2003), the stories about lawsuits had a very negative effect in the market. Energy targets have been established since then, but no other

municipality has tendered the construction of the infrastructure since then. These problems were signaled in the study "OEI in the future"[4]. Although the government has announced that the AMvB-BAEI will be evaluated, no date has been set.

Damaging accusations in a tense market. Since 2002, the production of new houses as well as the number subject to renovation has been much lower than the national prognosis. Looking at the cause of this, contractors often point at (among others) the energy and environmental regulations stating that these regulations complicate the process and lead to excessive costs. Although no study or any other evidence supports this thesis, it can damage the method's image. Extra costs for energy efficiency are usually less than 1% of the building costs. From an economics point of view, this is quite acceptable. When comfort and safety are taken into consideration, the consumer tends to prefer energy efficient houses.

Learning effect is low. The evaluation[5] of the OEI program at the end of 2002 showed that 96 percent of the responding municipalities thought the method was efficient and gave the desired results. But the government had hoped that the good examples of comfortable and energy efficient neighborhoods would lead to a method that would need no further support. This assumption turned out to be wrong. In the first 8 months after the program stopped, the number of new building locations that adopted OEI dropped from 71 to 44%. Big projects occur regularly only in cities of more than 100,000 inhabitants (like Apeldoorn). In smaller places, knowledge is not preserved but must be re-presented with each building project. SenterNovem, therefore, aims to disseminate the lessons learned.

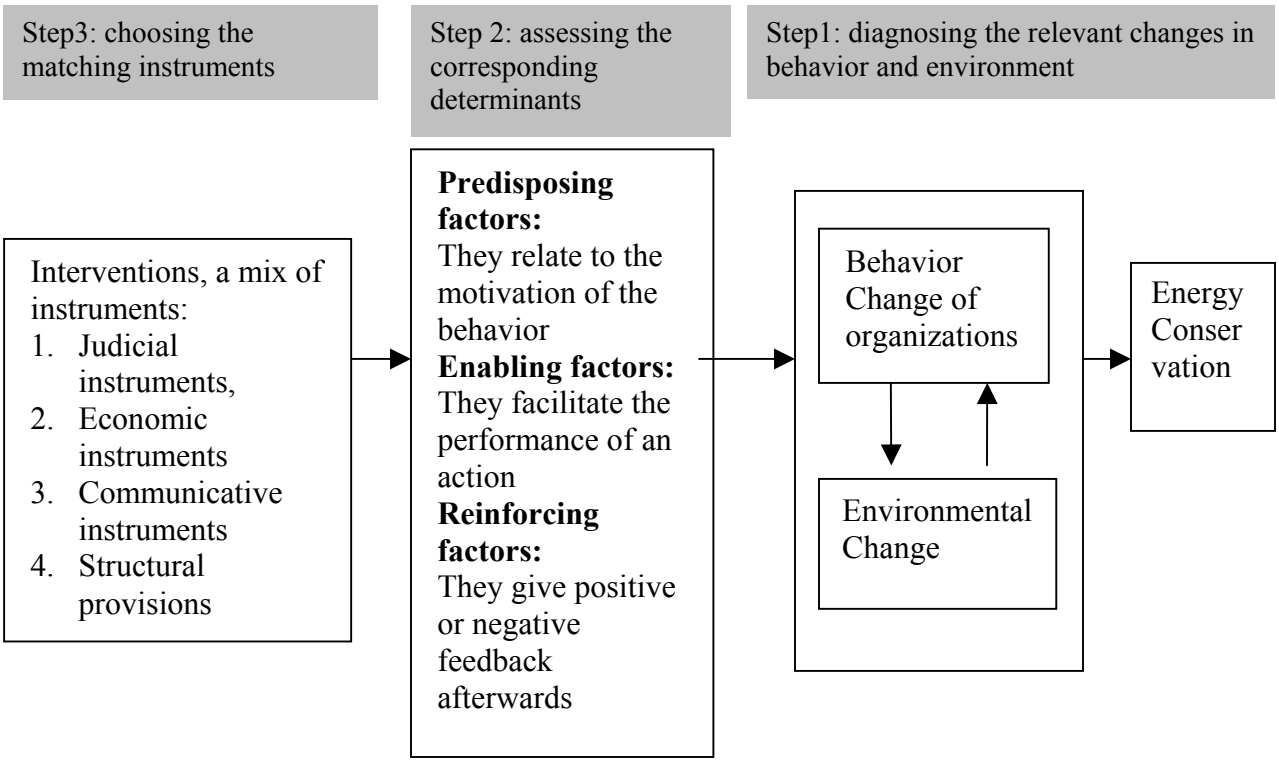
Obviously, a sound method has no value unless the key players accept it and implement it. The core problem is not finding technical options, but getting the right parties together in the most efficient way—getting all the noses pointed in the same direction. In short, only behavioral changes of the key players will lead to large-scale success.

New Approach

Achieving energy related goals depends on changing the behavior of those people who either use or influence the use of energy. To more sharply focus on changing the behavior of key players in the EPL project, primarily municipalities and housing associations. We needed to take into account the specific situations of those key players. We also needed to know more about the factors that trigger the key players to act in an energy relevant way. We call these factors "determinants of energy-relevant behavior." Green & Kreuter established a theoretical framework for changing behavior. In essence, their theory says that by knowing the determinants of behavior and by knowing what methods effectively influence those determinants, interventions can be developed that will stimulate a desired behavioral change.

Approach Strategy

Figure 3. A Model for Developing an Intervention Strategy



Green and Kreuter originally designed their model[6] to change the behavior of individuals. One of us (see Egmond et. al.[7]) modified the model to change behavior of target organizations. For the EPL project, we wanted to target municipalities and housing associations. A behavioral determinant is a complex of factors that operates to change behavior in three ways: through predisposing change, through enabling change and through reinforcing change. Consequently, an intervention that will stimulate change must "match" the determinant and either predispose, enable and/or reinforce the desired changes (Figure 3). In our case, interventions are policy instruments and, given the wide range of policy instruments already available, the problem became one of matching available instruments to the target group's behavioral determinants. Specifically we asked:

- Which determinants influence the energy-relevant behavior of municipalities and housing associations?
- Which instruments best match these determinants to form an intervention strategy?

We approached these questions in four steps:

Step 1: Defining goals of behavioral change. The Ministry of Environmental Affairs defined the energy conservation policy goals and set priorities and targets. The goal of reducing CO_2 emission from the built environment by 21.5 Mton in 2010 is one example.

Step 2: Establishing the most influential determinants of behavioral change. Within our two target groups, we carried out surveys that consisted of questionnaires and interviews. These were designed to assess the relevant predisposing, enabling and reinforcing factors that make up the determinants of behavior specific to each target group. Furthermore, we determined the relative influence of those factors on the behavior of the target group. This analysis gave us a list of the most influential determinants and their factors (Table 2).

Step 3: Determining the influence of policy instruments on determinants. We studied and analyzed existing policy instruments to determine their "active ingredients"— their influence on specific determinants of behavior. This analysis resulted in an "instrument-table" (Table 3).

Step 4: Formulating an intervention strategy. We selected the most effective instruments by matching the factors that most influence behavior of each target group (Step 2) with the most active ingredients inherent in policy instruments (Step 3). Determinants are usually influenced by more than one instrument and, therefore, we formulated intervention strategies made up of various instruments.

How Determinants Influence Behavior

We subdivided each of the three main determinants into factors specifically relevant to our target groups (Table 2).

Table 2. The Determinant Table

Main determinants	Factors making up determinants	Score housing associations	Score municipalities
Predisposing factors	Awareness	1	1
	Knowledge	2	2
	Social norm	2	3
	Attitude	3	2
	Self-Efficacy	3	3
Enabling factors	External financial resources	2	2
	External technical resources	3	2
	External organizational resources	1	3
	New skills	1	2
Reinforcing factors	Feedback of peer organizations	3	2
	Feedback of experts	1	3
	Feedback of the authorities	3	2
	Feedback of Customers	1	2

In marketing surveys, we established the relative influence of the determinant factors on behavior for members of the two target groups. 1= Little influence, 2 = medium influence, 3= high influence. In the survey on the housing associations (total 623) we interviewed 235 of 445 reachable associations (response = 53%). In the survey on municipalities, 267 (62% of the Dutch total) were reached. In the statistical analysis, conclusions could be drawn on scientifically sound grounds. Note that we focused on the changeable determinants. Other, non-changeable, determinant also exist, but they are beyond the scope of this article.

How policy instruments influence determinants

The Dutch Scientific Counsel for Government Policy, in their report about policy instruments (WRR, 1992), distinguishes four main types of instruments. These four types of instruments are broadly accepted in policy science[8] and each influence behavior in a different way.

- *Judicial instruments* mainly influence behavior through *force*; Examples are general laws and rules, specific permits, enforcement, covenants and agreements
- *Economical instruments* influence behavior though *financial transactions*; Examples are subsidies, levies, tax differentiation and financial constructions;
- *Communicative instruments persuade.* Examples include information and promotion, training, personal advice, demonstrations and benchmarks.
- *Physical interventions* work by *force* and in a *facilitating* way. These include infrastructural provisions, technical interventions (speed bumps for example).

In Table 3, we listed specific instruments belonging to the four main types, and we have subdivided the three main types of behavior determinants into their factors. An instrument has an active ingredient if it influences a determinant factor. (See Egmond et all[7] for more details.) Furthermore, we weighted the active ingredients according to whether they directly influence a factor (2) or indirectly influence a factor (1).

Table 3. Instrument Table: The Active Ingredients

	Determinants													
	Predisposing factors						**Enabling factors**				**Reinforcing factors**			
Grey cells indicate that there is an effect on a determinant,	Awareness	Knowledge	Social norms	Subjective Norm	Attitude	Self-efficacy	External financial resources	External technical resources	External organizational resources	New skills	Feedback of peer organizations	Feedback of experts	Feedback of authorities	Feedback of customers
Policy instruments:														
1.1 General Laws and Rules			**2**		**1**								**1**	
1.2 Specific permits			**2**		**1**								**1**	
1.3 Enforcement	**1**		**2**	**1**	**2**		**1**	**1**					**2**	
1.4 Covenants and agreements	**1**		**1**	**1**	**2**						**2**		**1**	
2.1 Subsidy	**1**				**1**		**2**						**1**	
2.2 Levy	**1**				**1**		**2**						**1**	
2.3 Tax differentiation					**1**		**1**						**1**	
2.4 Financial constructions					**1**		**2**		**1**	**1**		**1**		
3.1 Information and promotion	**2**	**1**	**1**	**1**	**2**	**1**		**1**		**2**	**1**	**1**	**1**	**1**
3.2 Training		**2**				**1**		**1**	**2**	**2**		**1**		
3.3 Personal advice		**2**			**1**	**2**		**1**	**2**	**1**		**1**		
3.4 Demonstration	**1**	**1**			**1**	**2**		**1**		**1**	**1**	**1**		
3.5 Benchmarks	**1**			**1**							**2**	**1**		**2**
4.1 Infrastructural provisions	**1**				**1**	**1**		**2**	**1**					
4.2 Technical behavioral steering	**1**				**1**	**1**		**2**	**1**					
A number in a cell means: 2 is a primary effect; 1 is a secondary effect.														

Instrument Planner

To help policy makers select the most effective mix of existing policies to change the energy related behavior of target groups, we have developed a tool called the *Instrument Planner*: The heart of this simple computer program is the instrument table. The planner rated the relative efficacy of each instrument to change the EPL related behavior of municipalities and housing associations as shown in Table 4. We found the top five most relevant instruments for municipalities to be:

1. information and promotion (26),
2. personal advice (24)

3. demonstrations (21) and training (21)
4. enforcement (18), and
5. covenants and agreements (14).

We found the top five most relevant instruments for housing associations to be:

1. information and promotion
2. enforcement
3. demonstrations
4. covenants and agreements, and
5. personal advice.

The scores for the instruments are not to be taken as absolute values; they indicate relative relevance of the instruments.

Table 4.

Policy instruments	municipalities	Associations
1.1 General Laws and Rules	10	10
1.2 Specific permits	10	10
1.3 Enforcement	18(4)	21(2)
1.4 Covenants and agreements	14(5)	18(4)
2.1 Subsidy	9	9
2.2 Levy	9	9
2.3 Tax differentiation	6	7
2.4 Financial constructions	12(6)	7
3.1 Information and promotion	26(1)	26(1)
3.2 Training	21(3)	12
3.3 Personal advice	24(2)	16(5)
3.4 Demonstration	21(3)	20(3)
3.5 Benchmarks	8	10
4.1 Infrastructural provisions	11	13
4.2 Technical behavioral steering	11	13

Conclusion: A New Intervention Strategy

Although we found the EPL approach to energy issues to work, by itself, it is not enough. Municipalities and housing associations must change their behavior in such a way as to be willing and able to embrace the EPL approach, as they are the decisionmakers in this process. The changed behavior can be that they automatically take decisions, which lead to actions that lead to CO_2 reduction. Our approach offers an opportunity for the government to intervene nationally in the behavior of these groups with existing instruments. Specifically, in our case of stimulating municipalities and housing associations to use the EPL approach, the strategy would contain the following components. First, give information about the importance of energy efficiency and the advantages of EPL in the urban-renewal process. Then, promote and demonstrate it. In specific situations, establish covenants between municipalities and housing associations and back them up with firm enforcement. Support adherence to the covenants through personal expert advice.

The national government and its various agencies have responded positively to this approach to changing the energy related behavior of target groups. It offers them a systematic way of tackling the problems in very diverse situations. Specifically, SenterNovem is now implementing and monitoring this new approach with these components. Our purpose is to further stimulate the EPL approach to energy conservation and CO_2 emissions in the built environment and especially in renovation areas. SenterNovem will report the results in 2005.

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