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ORIGINAL ARTICLE

Planning versus implementation of energy-saving projects by industrial companies. Insights from the Dutch Long-Term Agreements

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Abstract Companies participating in the Dutch voluntary agreements on energy efficiency are required to announce the energy-saving projects that they have planned for a specified reporting period in an Energy Efficiency Plan (EEP). All projects with a payback period less than 5 years should be implemented. The aim of this paper is to provide insight into the differences in planning and implementation of energy efficiency investments by companies. This analysis is based on the EEPs submitted in the period 2009–2012. By comparing the characteristics of projects that have been implemented with those that were planned, insight is gained in the adjustments that companies make in their energy efficiency investment plans. We look at external circumstances that could explain these adjustments. Our results show that over 12,000 projects have been planned by the 904 long-term agreement (LTA) participants, about half of which are planned 'certain', which means that companies are certain that these projects will be implemented. However, we find a large difference between the planned and realised savings of companies and a huge variation in the payback period of both planned and implemented projects. We do not find a correlation between implementation rate and payback period. This suggests that the payback period in the EEPs was not assessed properly or that other than economic motives are more decisive for investment decisions. Our results can be used to improve the effectiveness and efficiency of voluntary agreements.

Keywords Energy efficiency · Investment · Voluntary agreement · Energy policy

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Introduction

Energy savings can have multiple benefits. For individual energy users, the main benefit is a lower energy bill, although other, non-energy benefits like better product quality or lower maintenance costs might be as important (Worrell et al. 2003). For a country, benefits are a lower dependency on fuel imports and a contribution to the reduction of carbon emissions. As there is still a large untapped potential in energy savings (Boßmann et al. 2012), there is increasing attention to implement policies to realise this potential (Harmsen et al. 2014). An overarching objective of energy efficiency policies is to realise or accelerate investments in energy-saving technology. To achieve this, policy instruments need to be successful in influencing the investment decisions of companies. Different policy instruments apply different techniques to reach this objective. The Dutch industrial energy efficiency policy is an example of a mix of instruments influencing different factors that drive investments in energy efficiency (IEA 2011). For more than 20 years, long-term agreements (LTAs) have

formed an important part of the Dutch policy on energy efficiency for (industrial) companies (IEA 2008). The LTAs have always been linked to other instruments such as the Energy Investment Allowance (EIA; a tax deduction scheme for energy-saving technologies) and the Environmental Management Act ('Wet Milieubeheer') (Tanaka 2011).

Two separate LTAs are currently in place in the Netherlands: Long-Term Agreements on Energy Efficiency (LEE) for companies participating in the EU Emissions Trading System (EU-ETS) and LTA3 for companies not participating in the EU-ETS. The ultimate goal of LTA3 is an improvement of energy efficiency with 30 % in 15 years (2005–2020) (Senter Novem 2008a). For LEE, the goal is a 'significant contribution' to improving energy efficiency for their facilities (NL Agency 2009). Almost 1100 companies currently participate in the two agreements. These companies are mostly industrial, but some non-industrial sectors like academic hospitals, universities and financial institutions are also included. There is no minimum threshold for participation for individual companies, but only sectors with an energy use of more than 1 PJ can join, when more than 80 % of all companies in that sector join the voluntary agreement (NL Agency 2009). Together, the participating companies cover almost all industrial energy use (>80 %). Most of the participating companies have an energy use of around 0.1 PJ, but the largest companies use over 50 PJ. In the study by Abeelen et al. (2013), an extensive description of the Dutch LTA scheme is provided.

Companies participating in one of the LTAs have to file an Energy Efficiency Plan (EEP) every 4 years. In these plans, companies state which energy-saving measures that they intend to implement. EEPs form an important part of the agreements. The purpose of the EEP is comparable to an energy audit. They oblige companies to critically observe their own energy use and to look for energy-saving opportunities. The Dutch Environmental Management Act directs this process and obliges companies to implement all projects with a payback period (PBP) of up to 5 years. Most economic studies claim that industrial companies require a PBP less than 3 years to justify an investment decision and even lower for energy efficiency projects (Swigchem et al. 2002; Fleiter et al. 2011; Sorrell et al. 2011). By setting the limit at 5 years, this law thus obliges companies to implement more projects than they would do autonomously.

Several industrial energy efficiency programs have methods comparable to the EEPs in the Dutch LTAs. In Australia, the Opportunities Program requires companies to perform an audit, in which projects with a PBP less than 4 years have to be identified. Implementation of identified opportunities is, however, a decision made by the companies (Commonwealth of Australia 2011). The Swedish Programme for improving energy efficiency in energy-intensive industries (PFE[1]) asks companies to perform an audit and identify profitable electricity-saving measures. The list of identified measures is submitted to and approved by the Swedish Energy Agency. Measures with a PBP less than 3 years are obligatory to implement; other measures are pursued on a voluntary basis (Stenqvist and Nilsson 2012). The design of the Danish Energy Agreements contains some elements that are fairly similar to the Dutch LTAs: companies have to make an individual action plan based on energy audits, in which energy-saving projects are identified. Some of those, subject to specific profitability criteria, are to be carried out (IPP 2012).

The aim of this paper is to provide insight into the differences in planning and implementation of energy efficiency investments by companies. In this article, we compare the information in the EEPs (number and type of projects, expected energy savings) with actual implementation data and assess if the evaluation criteria used in the LTA fit to the evaluation criteria and decision making process used by industrial firms. In doing so, we will answer the following research questions:

1. Are planned projects actually implemented? This question is especially relevant for projects with a PBP of less than 5 years, since these projects are supposed to be compulsory. Are companies deviating from this rule when projects with shorter PBP are not implemented?
2. What is the effect of changing circumstances during the time of planning and implementation of projects?
3. What is the PBP of planned projects?
4. Is there a relation between implemented projects and their PBP?
5. Are projects with a short PBP also profitable according to criteria the companies use themselves?

[1] PFE stands for Programmet för Energieffektivisering: Program for Improving Energy Efficiency

6. Are more sophisticated methods better suited for a voluntary agreement like LTA?

The structure of this article is as follows. "Data and methodology" section introduces the LTAs and describes the role of the EEPs in the instrument. It describes the dataset and the methodology. "Results" section shows the results of our analysis. "Conclusion and discussion" section discusses the results and refers back to the research questions to draw conclusions and formulate policy implications.

Data and methodology

This paper used micro data from Energy Efficiency Plans (EEPs) of a large group of companies that participate in the Dutch LTAs. The data sample covered more than 80 % of industrial energy use in the Netherlands. By comparing the EEPs with the monitoring reports of these companies, we were able to follow implementation of the projects, providing a unique insight into the applicability of EEPs to contribute to a policy instrument. In 2012, all companies have filed new plans for the period 2013–2016. At the same time, 2012 is the last year of the plan period 2009–2012.

Some of the obligatory elements of an EEP are as follows:

- An energy balance of the company
- A description of the energy management system
- A process scheme of the most important processes of the company
- A list of energy-saving projects

A full description of the format is provided in NL Agency (2012a, b).

RVO.nl[2] is the designated government agency for implementation of the agreements. All EEPs are reviewed by RVO.nl. This review comprises two elements: a check on completeness and a check on the level of ambition. If a company does not meet a certain minimum ambition, it has to provide an explanation for this lack of ambition. The reviewing process is closed with an advice from RVO.nl. If this advice is positive, the company can start implementation of its EEP. After completion of the reviewing process, all project information is uploaded to the monitoring database. In annual monitoring reports, companies report if and how the planned projects are implemented. If a company fails to implement the EEP, this is mentioned in the company reports, but until 2013, this had no consequence for the participation of individual companies.

The ultimate goal of an EEP is a list of energy-saving projects that the company intends to implement in the next 4 years. This list should be the result of a careful consideration, being in line with company strategy, environmental context and legal requirements. The EEP should prove that the company has considered all possible options to improve energy efficiency. A description of this planning process, including the considerations of the company, is an obligatory part of the EEP (NL Agency 2012 a, b). There is no official definition of a 'project', but it should be a delimited activity being the result of actions of the company itself.

A 'project' can range from introducing a new metering system to the building of a completely new plant. This leaves some room for interpretation, as companies can define project boundaries themselves. A company might choose to merge all lighting projects (new lights in building A, B, etc.) into one project. As each project must be monitored separately, companies (especially large ones) may be tempted to merge projects, to keep the number of projects manageable. On the other hand, it might be smart to keep projects in different buildings or business units separate if this is easier for the company's project administration or their implementation strategy.

For each energy-saving project, inter alia, the following data was available:

- Category (*process efficiency*, *supply chain efficiency*, or *renewable energy*)
- Subcategory
- Certainty level ('certain', 'conditional' or 'uncertain')
- Planned year of implementation and year of implementation
- Deemed and realised primary energy saving (in Joules)
- PBP
- For conditional projects, conditions that might block implementation

[2] Rijksdienst voor Ondernemend Nederland (RVO.nl) or Netherlands Enterprise Agency is the name of a new merger organisation. The former NL Agency is part of this organisation. NL Agency is itself a merger of a.o. SenterNovem.

Table 1 Characteristics of used datasets

Number	Period	Covenant	Research questions
1	2009–2012	LTA3	1, 2, 3, 4, 5
2	2013–2016	LTA3 + LEE	1, 2

- For uncertain projects, studies that need to be carried out before a project can start

A typical and important element of the project information is the so-called 'certainty level'. For each project in the EEP, a company indicates how probable it is that this project will indeed be implemented. Projects with a PBP of 5 years or less have to be labelled certain unless technical or other conditions exist which may hamper implementation. Companies face the threat of eviction from the covenant if they do not implement these projects, replace them for other projects or provide a valid explanation for why a project is not implemented.

If a specific condition has to be met before a project can be implemented, a project can be labelled conditional. Such a condition might be a successful pilot project or a permit that has to be granted. Projects which might be possible but for which the company is not yet able to assess the deemed savings or the actual practicability can be labelled uncertain.

Under the covenant rules, a company is allowed to replace a planned project with another project, if this new project realises at least the same amount of savings. When projects have been implemented that were not originally identified in the EEPs, they are labelled 'additional'.

In order to analyse the research questions, we assembled two different datasets: one for the period 2009–2012 (LTA3 only) and one for 2013–2016 that also includes the companies of LEE. Table 1 indicates for which research questions the datasets are used.

Data from LEE companies are also available for the period 2010–2012 but could not be merged with LTA3 data because of differences in plan period and the used format.[3] Analyses of the LEE data over 2010–2012 show the same results as those of LTA3. Data from the EEPs for the 2013–2016 period cannot yet be used to assess implementation. The 2013–2016 plans do, however, give information on the conditions that might limit implementation of projects, information which is not readily available for the 2009–2012 period. Therefore, dataset 2 is used in "Conditions for implementation" section to answer research question 2.

Only part of an EEP—the list of projects—was directly suitable for analysis, as it was available in a uniform format. The rest of the EEP was available as qualitative descriptions that were not directly relevant to our analysis.

To analyse the research questions, only EEPs that were filed completely were used. To allow a comparison analysis, we excluded all companies that did not report for the complete monitoring period 2009–2012. This was the case for companies that entered the agreements after 2010, companies that left the agreement before 2012, or that did not file all monitoring reports for other reasons. All in all, 133 LTA3 were left out of the analysis for this reason, whereas data of 904 LTA3 were suitable for analysis. Because information on PBPs was not provided for all projects in the period 2009–2012, the analyses on this topic ("Use of payback periods" section) were based on a lower number of companies: 798 for LTA3. To find a relation between PBP and implementation, a dummy variable for implementation was introduced and regressed against 12 classes of PBP.

Results

Planned projects

Table 2 shows the number of projects that have been planned by LTA3 companies for the period 2009–2012. In total, almost 12,000 projects have been planned by 904 companies. On average, this is almost 13 projects per company, but considerable differences exist between companies: 99 companies have planned no projects at all[4], while 8 companies have planned more than a hundred projects (Fig. 1).

By far, the largest number of projects is found in the category process efficiency, especially in the

[3] LEE companies used a shorter plan period, as the LEE agreement was not signed until 2010, when EEPs of LTA3 companies were already filed.

[4] The fact that plans without any projects are approved might puzzle the reader of this paper. However, companies without a saving target (i.e. without identified projects) will have to provide an additional explanation why they are not able to implement saving projects. The approval is based on the combination of past achievements, the level of ambition and the credibility of the explanation.

Table 2 Number of planned projects in LTA3 period 2009–2012 (904 companies)

Category	Certainty level				
	Certain	Conditional	Uncertain	Total	Share (%)
Process efficiency	5022	3129	2048	10,199	89
Energy management	1215	384	156	1755	15
Utilities and buildings	1852	1492	884	4228	37
Adjustments in processes	1808	1214	929	3951	34
Strategic measures	92	39	60	191	2
Other/unknown	55	0	19	74	1
Supply chain efficiency	367	180	181	728	6
Reduction of raw materials use	146	74	54	274	2
Optimisation of distribution	105	39	47	191	2
Improving product performance	32	14	21	67	1
Lifetime extension	6	2	1	9	0
Optimisation of disposal and re-use	37	31	21	89	1
On site cooperation	16	7	29	52	0
Energy performance of product	25	13	8	46	0
Renewable energy	210	112	248	570	5
Waste and biomass	64	28	72	164	1
Purchase of renewable electricity	84	55	19	158	1
Ambient heat	44	12	50	106	1
Water power	1	0	0	1	0
Wind power	5	2	63	70	1
Solar power	9	8	30	47	0
Solar heat	3	7	14	24	0
Total	5599	3421	2477	11,497	100
	49 %	30 %	22 %	100 %	

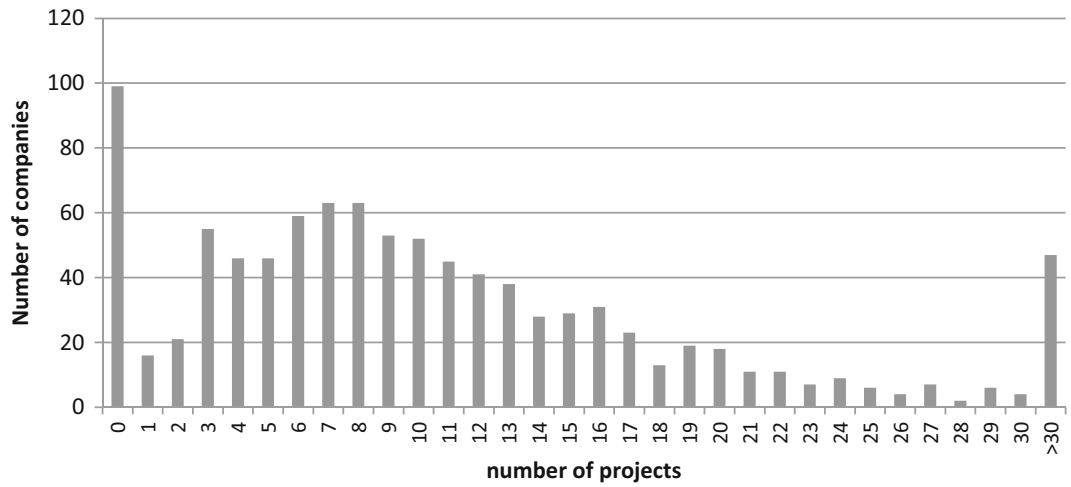

Fig. 1 Distribution of projects per company planned in EEP 2009–2012 (LTA3, 904 companies)

subcategories *adjustments in processes* and *utilities and buildings*. Within the category supply chain efficiency, most projects can be found in the subcategories *reduction of raw materials* and *optimisation of distribution*. Within the category renewable energy, most projects are found in subcategories *waste and biomass* (mostly companies in the food and drinks industry), *ambient heat* (heat pumps, etc.) and *purchase of renewable electricity*. The latter subcategory is under discussion within the covenant, as it is a relatively easy way for companies to reach significant covenant results against no or just limited extra costs, while the purchase of renewable energy mainly contributes to a decarbonisation of the energy supply and not to final energy savings.

As Table 2 shows, about half of the projects are qualified certain, which means that companies are certain that these projects will be implemented.

Table 3 shows the deemed savings for the projects that are planned for the period 2009–2012. In this table process efficiency is the largest category as well, although the average savings per project in this category (2.1 TJ/project) is smaller than in supply chain efficiency (6.4 TJ/project) and renewable energy (25.4 TJ/project). Within process efficiency, the largest subcategories are adjustments in processes and utilities and buildings, as these subcategories had most projects and these projects are often larger. In the subcategory *energy management*, projects are generally smaller (1.0 TJ/project). Projects labelled certain are, on average, a little bit smaller in terms of energy savings than other projects.

Implementation of projects

Table 4 shows the number of planned projects that has actually been implemented. For process efficiency, 80 %

Table 3 Deemed savings (TJ) of planned projects LTA3 period 2009–2012 (904 companies)

Category	Certainty level				Share (%)
	Certain	Conditional	Uncertain	Total	
Process efficiency	10,801	6307	4931	22,039	53
Energy management	1161	483	200	1845	4
Utilities and buildings	3146	2352	1084	6582	16
Adjustments in processes	4762	3384	3135	11,282	27
Strategic measures	1728	87	511	2326	6
Other/unknown	4	0	0	4	0
Supply chain efficiency	1966	1190	1824	4980	12
Reduction of raw materials	1260	318	434	2011	5
Optimisation of distribution	135	54	27	216	1
Improving product performance	83	170	526	779	2
Lifetime extension	5	12	0	16	0
Optimisation of disposal and re-use	271	120	158	549	1
On site cooperation	107	113	208	428	1
Energy performance of product	106	403	471	980	2
Renewable energy	5762	4106	5073	14,941	36
Energy from waste and biomass	436	1169	2068	3673	9
Purchase of renewable electricity	5185	2804	244	8233	20
Ambient heat	130	121	26	378	1
Water power	1	0	0	1	0
Wind power	5	3	518	525	1
Solar power	4	3	104	111	0
Solar heat	1	5	2013	2020	5
Total	18,529	11,602	11,828	41,960	100
	44 %	28 %	28 %	100 %	

Table 4 Planning versus implementation of projects in 2009–2012 (LTA3, 904 companies)

Certainty level	Number of projects			Savings (TJ)		
	Planned	Implemented	%	Planned	Implemented	%
Process efficiency						
Certain	5022	4020	80	10,801	7891	73
Conditional	3129	1164	37	6307	1825	29
Uncertain	2048	528	26	4931	537	11
Additional to EEP	0	1783	–	0	3685	–
Delayed[a]	0	334	–	0	196	
Total	10,199	7829	77	22,039	14,135	64
Supply chain efficiency						
Certain	366	179	49	1966	1001	51
Conditional	182	57	31	1190	841	71
Uncertain	180	28	16	1824	128	7
Additional to EEP	0	382	–	0	6100	–
Delayed[a]	0	106	–	0	1098	–
Total	728	752	103	4980	8071	162
Renewable energy						
Certain	218	92	42	5762	5253	91
Conditional	114	13	11	4106	182	4
Uncertain	251	24	10	5073	23	0
Additional to EEP	0	298	–	0	31,312	–
Delayed[a]	0	7	–	0	205	–
Total	583	434	74	14,941	36,770	246

[a]Projects which were originally planned in the former planning period (2005–2008) but were delayed

of certain projects have been implemented. Besides, not all of the implemented projects realised their deemed saving potential: only 73 % of the originally planned saving potential is realised. Still, one can conclude that the largest part of certain savings is realised. This is not the case for projects labelled conditional or uncertain: Almost two thirds of conditional projects are not implemented, while three quarters of uncertain projects are not implemented. The realised saving potential of these projects is even lower.

About a quarter of implemented projects were not originally planned and are labelled additional in Table 4. The number of additional projects is growing from 13 % in 2009 to 38 % in 2012, showing that most projects are planned for the first 2 years. Especially, the number of certain projects reduces drastically after 2 years: only 25 % of the certain projects are planned in the last 2 years of the plan period (see Fig. 2). There is a small portion of projects that were originally planned in the former plan period (2005–2008) but were delayed (labelled as 'delayed' in Table 4). The overall ambition for LTA3 companies was to realise the saving potential of all certain and conditional projects (17.1 PJ). Of these projects, only 9.7 PJ (57 %) has been realised. Of the total amount of planned savings for process efficiency (22.0 PJ), only 14.1 PJ (64 %, including the additional projects) was realised. When comparing these figures with the results of programs in other countries, the following figures are found: just over half of the improvements suggested through the American IAC program have been adopted by industrial users (Shipley and Elliott 2006), whereas the Australian EEAP found an adoption rate of 80 % (Harris et al. 2000). In the Belgian Auditing Covenant, which is highly comparable to the Dutch LTA, it was found that after 2 years, 60 % of the proposed measures were implemented or being implemented (Cornelis and Reunes 2012).

For projects under the category supply chain efficiency and renewable energy, the situation is very different, although we have to take into account the fact that the number of projects in these categories is much smaller than in process efficiency. For supply

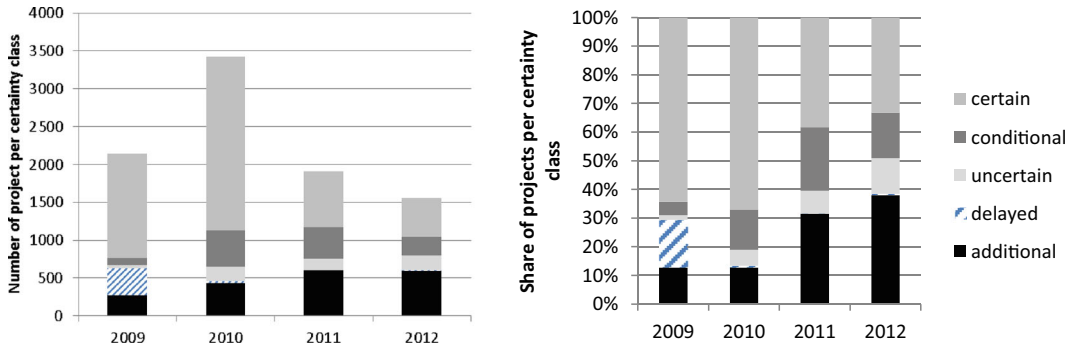

Fig. 2 Distribution of projects per certainty class from 2009 to 2012 (LTA3, 904 companies)

chain efficiency, about half of planned certain projects are implemented. The share of implemented conditional and uncertain projects is even lower than for process efficiency[5]. The large amount of savings from projects that were not planned in the EEPs is notable. The savings from additional projects are even larger than the original saving potential. For renewable energy, these projects mainly consist of purchase of renewable electricity. A possible reason for the high number of extra supply chain efficiency projects could be that in many sectors, special covenant projects were carried out to promote supply chain efficiency[6]. Another remark considering supply chain efficiency projects is the fact that savings in this category are dominated by a few very large projects: five projects account for 30 % of total savings.

Overall, LTA3 companies have reached the targets set in the EEPs mainly because of additional projects in supply chain efficiency and renewable energy.

Conditions for implementation

If a project is labelled conditional, a company has to provide the condition which has to be fulfilled before the project can be implemented. There is a shortlist of default conditions to choose from (see Table 5), or a company can provide an additional explanation.

Table 6 shows the conditions that are linked to the planned conditional projects for the period 2013–2016. About 3500 of the planned projects (out of a total of 12,452) are labelled conditional. For 2967 of these projects, one of the conditions listed in Table 6 is actually registered.[7] For 250 projects, more than one condition is stated. In our analysis, we use the first stated condition, assuming that this is considered the most important one.

About half of all stated conditions have to do with availability of resources (money or time). This is in line with Masselink (2008), who found that 'availability and allocation of capital' showed up as most important hurdle for investments.

For supply chain efficiency, financial conditions are less important than for other categories, although financial conditions are still mentioned most often. For supply chain efficiency, conditions like 'positive test outcome' or 'acceptance by market' are stated often as well.

For process efficiency projects, financial conditions are stated most often too, except for *energy management projects*. This is not surprising as these projects often require small investments. For this category, positive test outcome is stated most often.

About one fifth of the conditions mentioned by the companies are technical in character: companies have to await positive outcome of experiments or pilot tests, before a final decision on implementation can be made.

[5] Only the share of realised saving potential for 'conditional' *supply chain efficiency* projects is higher, because of one very large project.

[6] Examples of tools developed to help companies plan, implement and report *supply chain efficiency* projects can be found on http://www.rvo.nl/subsidies-regelingen/meerjarenafspraken-energie-efficiency/tools/berekenen-keteneffecten

[7] Providing a condition is obligatory. Of the 500 projects where a condition is not registered, most are provided in additional documents, email, etc.

Table 5 Conditions for implementation

Condition	Explanation/example
1. Acceptance by market	Potential product changes must be accepted by clients.
2. Budget availability	Availability of project funding. Large overlap with 3.
3. Positive economic situation	Project profitability must be high enough, within company budget. A company's profitability must be sufficient. Large overlap with 2.
4. Product quality unaffected	Potential product or process changes are not allowed to affect product quality, the robustness of the production process or labour conditions
5. Positive investment decision	Project must be profitable, and costs must be small enough to take a positive investment decision. Overlap with 2 and 3
6. Management approval	Management/shareholders still have to take a decision on implementation. Large overlap with 5.
7. Company changes	Project implementation is dependent on implementation of other changes in the company, e.g. a large renovation or a new building.
8. Positive test outcome	Pilot test must show practicability of the project
9. Permit	Project implementation is dependent on a permit that has to be granted.

Our results show that for projects with short PBP (2 years or less), financial conditions are relatively less important and technical conditions are more important.

Table 6 Conditions which could block 'conditional' projects 2013–2016 (LTA3 + LEE, 726 companies)

	Condition[a]									
Category	1	2	3	4	5	6	7	8	9	Total
Process efficiency	32	572	187	246	410	165	328	304	22	2337
Energy management	10	37	11	40	15	18	28	43	1	215
Utilities and buildings	9	316	89	68	221	74	170	123	7	1101
Adjustments in processes	9	212	79	135	153	70	124	138	12	965
Strategic projects	4	7	8	3	21	3	6	0	2	56
Supply chain efficiency	94	29	51	48	35	48	14	71	14	451
Reduction of raw materials	40	12	20	29	12	9	6	28	3	177
Optimisation of distribution	17	6	12	5	7	25	3	18	4	112
Improving product performance	3	2	2	1	6	2	0	3	1	23
Lifetime extension	3	0	0	1	0	0	0	2	1	7
Optimisation of disposal and re-use	6	6	12	7	6	8	3	15	2	72
On site cooperation	9	2	0	0	2	3	0	2	2	22
Energy performance of products	16	1	5	5	2	1	2	3	1	38
Renewable energy	7	44	31	5	27	12	10	14	16	179
Energy from waste and biomass	4	4	13	3	8	1	9	9	3	62
Purchase of renewable electricity	3	15	9	2	9	10	0	0	5	56
Ambient heat	0	6	2	0	3	0	1	2	2	16
Wind power	0	2	1	0	0	0	0	0	4	7
Solar power	0	13	6	0	5	1	0	2	2	31
Solar heat	0	4	0	0	2	0	0	1	0	7
Total	133	645	269	299	472	225	352	389	52	2967

[a] For explanation of the numbers, see Table 6

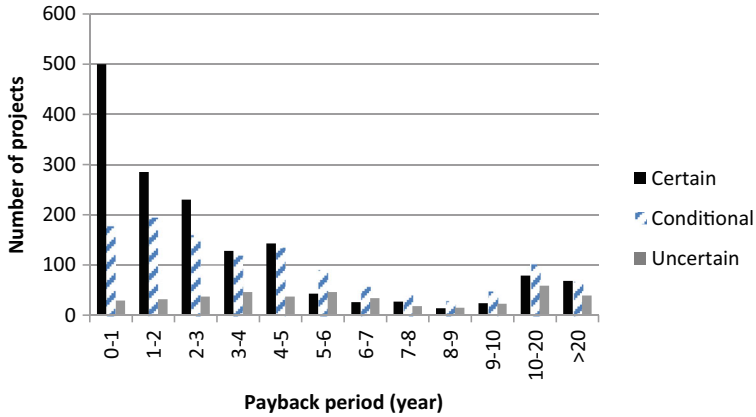

Fig. 3 Used payback period of process efficiency projects planned for 2009–2012 (LTA3, 3113 projects, 798 companies)

Use of PBPs

Dutch LTA companies can apply three possible methods to determine if a project is profitable: net present value (NPV) and two versions of the payback period (PBP)[8]. The 'simple' PBP accounts only for benefits from lower energy costs ('energy-only') whereas the 'variable' PBP includes all cash flows (i.e. also the ones not related to energy). Note that these definitions are different from the general definitions for PBP used in literature (i.e. simple and discounted payback, where simple payback does not account for the time value of money).The guidelines for the EEPs do not dictate a preferred method (SenterNovem 2008b), although in a separate instruction, some basic guidance is provided when to apply which method: NPV for larger projects and projects with varying cash flows and PBP for smaller projects (NL Agency 2011).

Almost all companies (>95 %) have used the simple PBP method. This is in line with Russell and Young (2012) stating that simple payback is the most frequently cited investment metric. Despite the fact that it is obligatory to provide a PBP for every planned project, there are many projects for which no value is provided. In most of these cases, a PBP is not given since the company has insufficient data to calculate a PBP. The number of projects without a PBP is highest in uncertain projects. Cornelis and Reunes (2012) also reported a high number of IRRs that were reported semiquantitative (e.g. '>15 %') instead of quantitative or not at all. In total, 3113 process efficiency projects with a PBP were used for the analysis.

Figure 3 shows the result of an analysis of the PBPs of planned projects for the 2009–2012 period for the category process efficiency (LTA3). For supply chain efficiency and renewable energy, this analysis is not meaningful, because of the smaller number of projects and the many projects for which no PBP is given.

Most projects (2045) have a PBP of less than 2 years, of which 63 % are certain. This is in line with other studies, like Anderson and Newell (2004) who observe that 79 % of companies have payback thresholds less than 2 years[9]. Bundgaard et al. (2013) found that many of the energy-saving projects in industry use a PBP as short as 1–2 years and 20 % have PBP less than 1 year. Stenqvist and Nilsson (2012) report an average PBP of 1.5 years for measures reported under the Swedish PFE. Most recommended projects in the US Industrial Assessment Center program have simple PBPs of less than 1 year (Shipley and Elliott 2006). Considering these outcomes, it is notable that we find that 29.8 % of planned projects have a PBP over 5 years and 12.6 % of projects with a PBP over 10 years and, in some cases, even more than 20 years, also for projects that are labelled certain. These are projects that would never be implemented according to neoclassical investment decision theory. This observation is more in line with Martin et al. (2011) who find an average PBP of 4 years for

[8] A project is called profitable if the net present value (NPV) is positive using an internal rate of return (IRR) of 15 %. Alternatively, a company can calculate the payback period: a PBP of 5 years or less (using the energy-only PBP method) is considered profitable.

[9] Although the IAC program is specifically focussed on SME's and LTA is focused on larger, energy-intensive plants as well, there is a large overlap, as a majority of the companies in the LTA3 program fall under IAC's definition of SME.

Table 7 Average PBP of planned and implemented process efficiency projects (based on the number of projects)

	Certainty level			
Dataset	Certain	Conditional	Uncertain	Total
Planned LTA3 2009–2012 (904 companies)	6.4	6.8	10.6	7.1
Implemented LTA3 2009–2012	5.9	5.8	10.0	6.0

A weighted average would give very different results but is not appropriate here, as there is no relation between certainty level and project size

investments in energy-saving measures and 10 % of investments with a PBP of more than 7 years. Also, Aalbers et al. (2004) observe a significant (5–15 %) share of technologies with PBP of more than 20 years. These projects are likely to be implemented because of strategic reasons, not for profitability.

The average PBP (not weighted for project size) for planned certain process efficiency projects for 2009–2012 is 6.4 years[10] (see Table 7). The average PBP of certain projects is lower than the PBPs of conditional and uncertain projects. As some projects have a very high PBP of over 50 years, a better indicator would be the median (2.1 years for planned certain projects), as it is less sensitive to outliers. For projects with that high PBP values, the simple PBP method does not lead to meaningful results. The average PBP of certain projects is higher than found by Martin et al. (2011). This can be explained by the following:

1. The fact that projects with a PBP of 0 have not been taken into account, as no distinction could be made between projects with a PBP of 0 and those without a PBP (unknown or missing). Within the group of projects without a PBP, there are several hundred projects without an investment and, hence, a PBP of 0. If these projects would be counted, the average PBP would be much lower.
2. The use of an energy-only PBP method. By taking into account only the benefits of energy savings, the resulting PBP will be higher than when other benefits are taken into account as well.

The average PBP of implemented projects is slightly lower than that of planned projects, but the difference is small (see Table 7). Especially for conditional and uncertain, one would expect companies to implement projects with the lowest PBP first. To delve deeper into the reasons for this small difference, we made a comparison of the share of implemented projects for different classes of PBP, which is shown in Table 8. For both planned and implemented projects, there is a negative correlation between the frequency and PBP. However, once planned, projects with a low PBP are implemented just as often as projects with a higher PBP (>5 years). For all classes, about 80 % of the certain projects are actually implemented. For conditional and uncertain projects, the share of implemented projects is lower but shows no significant difference between low and high PBPs. On the one hand, our observations show that not all profitable projects are implemented. This phenomenon has been observed earlier and is called the efficiency gap (Hirst and Brown 1990). On the other hand, many projects are implemented that are not profitable, at least not at the time of planning. This can lead to two possible conclusions: at the time of planning, it was not possible to make a correct calculation of PBP, because input parameters like energy prices were uncertain, or PBP is not that an important criterion for the actual decision to implement many of the projects. This issue is further discussed in "Conclusion and discussion" section.

In the guidelines for the EEPs, a positive NPV at a discount rate of 15 % is presented as an alternative for a PBP of 5 years. Given the fact that virtually, all companies use the PBP criterion in their EEPs, it is interesting to see if the alternative NPV method would lead to other results. The simple PBP method differs from the NPV method in that it does not take into account the time value of money and the lifetime of projects. This means that the same project could be considered 'profitable' according to one method, but not according to the other:

- PBP becomes irrelevant when the PBP exceeds the lifetime of a project. A project with a PBP of 4 years might be considered profitable according to the

[10] Standard error 0.73, standard deviation 28.83)

Table 8 Implementation of process efficiency projects per class of PBP (period 2009–2012, LTA3: 3113 projects in 904 companies)

		Certain			Conditional			Uncertain			Total		
PBP (year)		Project implemented?			Project implemented?			Project implemented?			Project implemented?		
		No	Yes	Total	No	Yes	Total	No	Yes	Total	No	Yes	Total
0–1	#	82	393	475	104	61	165	26	4	30	212	458	670
	%	26.1	32.3	31.0	13.7	15.0	14.2	7.5	5.8	7.2	14.9	27.0	21.5
1–2	#	62	223	285	116	74	190	26	7	33	204	304	508
	%	19.7	18.3	18.6	15.3	18.2	16.3	7.5	10.1	7.9	14.4	17.9	16.3
2–3	#	53	167	220	102	56	158	34	4	38	189	227	416
	%	16.9	13.7	14.4	13.5	13.8	13.6	9.8	5.8	9.1	13.3	13.4	13.4
3–4	#	28	97	125	82	32	114	36	8	44	146	137	283
	%	8.9	8.0	8.2	10.8	7.9	9.8	10.3	11.6	10.6	10.3	8.1	9.1
4–5	#	36	106	142	88	40	128	30	9	39	154	155	309
	%	11.5	8.7	9.3	11.6	9.8	11.0	8.6	13.0	9.4	10.9	9.1	9.9
5–6	#	10	34	44	50	37	87	36	8	44	96	79	175
	%	3.2	2.8	2.9	6.6	9.1	7.5	10.3	11.6	10.6	6.8	4.7	5.6
6–7	#	2	24	26	34	20	54	28	8	36	64	52	116
	%	0.6	2.0	1.7	4.5	4.9	4.6	8.0	11.6	8.6	4.5	3.1	3.7
7–8	#	5	22	27	28	16	44	15	4	19	48	42	90
	%	1.6	1.8	1.8	3.7	3.9	3.8	4.3	5.8	4.6	3.4	2.5	2.9
8–9	#	3	11	14	22	7	29	14	0	14	39	18	57
	%	1.0	0.9	0.9	2.9	1.7	2.5	4.0	0.0	3.4	2.7	1.1	1.8
9–10	#	8	16	24	32	15	47	20	3	23	60	34	94
	%	2.5	1.3	1.6	4.2	3.7	4.0	5.7	4.3	5.5	4.2	2.0	3.0
10–20	#	14	67	81	64	29	93	48	8	56	126	104	230
	%	4.5	5.5	5.3	8.5	7.1	8.0	13.8	11.6	13.4	8.9	6.1	7.4
>20	#	11	58	69	35	20	55	35	6	41	81	84	165
	%	3.5	4.8	4.5	4.6	4.9	4.7	10.1	8.7	9.8	5.7	5.0	5.3
Total	#	314	1218	1532	757	407	1164	348	69	417	1419	1694	3113
	%	100	100	100	100	100	100	100	100	100	100	100	100

covenant rules, but if this project has a short lifetime of 3 years, it will not be profitable using the NPV method.

- PBP scores worse than NPV for projects with a much longer lifetime than the PBP, as PBP ignores cash inflows after the PBP: a project with a PBP of 8 years could have a positive NPV. In other words, this project is profitable (NPV >0) but is not obligatory (PBP >5 years) according to the covenant criteria. This phenomenon can be observed for projects with a long lifetime.

These examples are visualised in Fig. 4, which shows the relation between lifetime and the internal rate of return (IRR[11]), with the dark line visualizing a project with a PBP of 5 years. All projects below this line are profitable according to the covenant criteria regarding PBP, whereas projects above this line are not. In two of the four segments in Fig. 4, the outcome of IRR and PBP calculation lead to the same conclusion (i.e., a project is profitable or a project is not profitable), but in the other two segments, the two methods lead to opposing conclusions.

An important, but unknown element of the planned projects is the lifetime, because this is not part of the obligatory EEP format and is missing in the PBP

[11] An IRR of 15 % is the same as a NPV of zero using a 15 % discount rate.

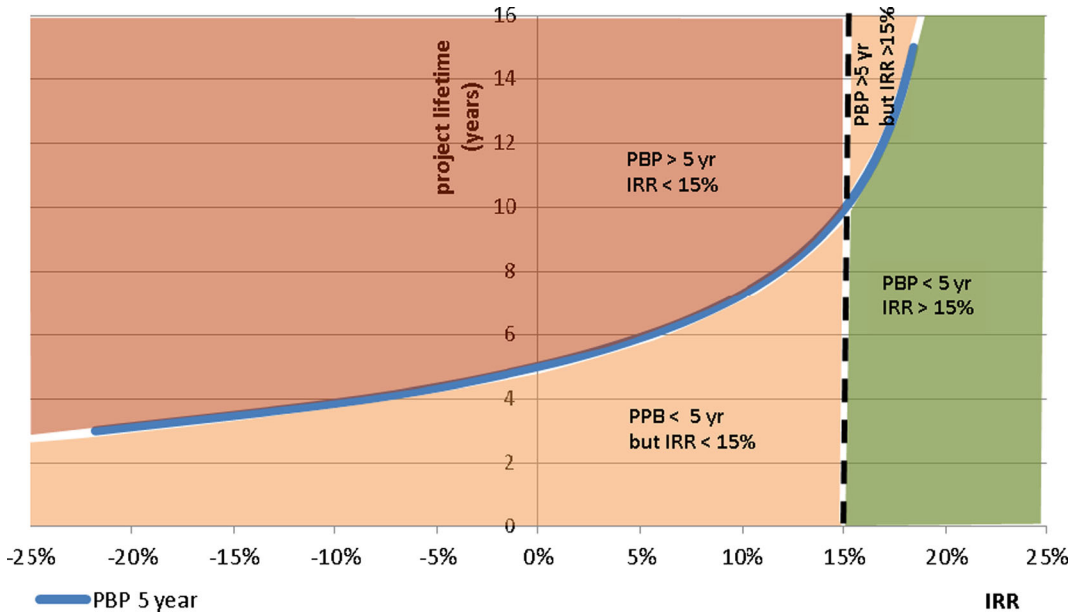

Fig. 4 Relation between project lifetime and IRR

calculation. Nevertheless, some general remarks are possible. Within the category of projects in 'energy management and good housekeeping,' part of the projects is behavioural, like awareness campaigns or audits, with an assumed short lifetime, often less than 3 years (CEN 2007). In the other categories (utilities, processes, strategic), lifetimes will generally be longer (>10 years). Within the Dutch LTAs, the assumption is that projects will have an effect during the complete duration of the covenant (12 years). In Annex V of the Energy Efficiency Directive (European Parliament and Council 2012), default lifetimes of 10–25 years are proposed for several replacement projects.

Potentially, the difference between the two calculation methods might explain the high share of implemented projects with a PBP longer than 5 years and a lifetime longer than 10 years. Although we are not able to determine this difference with current data, an indication is that in the group of implemented projects with PBP >5 years, a relatively large share of projects within the category 'adjustments in processes' has a long lifetime (>10 years).

Conclusion and discussion

Are planned projects actually implemented?

In "Implementation of projects" section, we observed a large difference between planned and realised savings. A large part of conditional and uncertain projects has not been implemented, whereas a great share of certain projects has been realised. Still, about 20 % of projects with a PBP less than 5 years have not been implemented. This suggests a deviation from the rule that all these projects should be implemented.

Overall, we can conclude that only the majority of certain projects are actually implemented and that a large share of realised savings stems from projects that were not originally planned in the EEPs. A noticeable aspect of the covenant is the rule that a company can substitute a planned project for another project with the same amount of savings. Basically, this rule provides an escape for the obligation to implement all profitable projects, even though the outcome in terms of implemented savings is the same. Therefore, the obligations of participating companies—and their enforcement—become unclear: should they implement specific projects or achieve a specific amount of energy savings independent from the projects? This might imply that the Dutch policy makers should reconsider the distinction between certain and other projects.

Considering the large amount of planned projects that are not implemented, we observed that the reason for not implementing a project is often formulated by companies in a very generic way. Better classification and monitoring of the reasons for non-implementation, especially for conditional projects, would improve the way how governmental bodies can facilitate companies.

What is the effect of changing circumstances during the time of planning and implementation of projects?

The difference between planned and implemented projects can have three possible reasons: at the time the EEP was drafted, companies were not aware of these saving possibilities, changing circumstances urged companies to change their plans or strategic behaviour by companies.

The first reason is probably true for most additional projects in the last 2 years of the planning period. This observation suggests that the planning period of 4 years is too long for reliable planning of projects, a conclusion that was also made in the evaluation of the LEE covenant in 2013 (Hendriksen and van der Kolk 2013). A plan period of 1 or 2 years might be better suited to the investment planning of companies and lead to a better match between planning and realisation. However, the current EEP format is so extensive that a biennial plan would result in a too high administrative burden. Thus, for a better fit to companies' investment planning, the instrument should aim for a shorter plan period and a more concise plan format. Especially, smaller companies have a shorter horizon and are faster and more flexible than larger companies, as they tend to be less sophisticated or deliberate in their approach to energy improvements (Russell and Young 2012). This is especially true in periods with uncertain economic conditions, such as experienced in the 2009–2014 period.

Due to lack of data, we cannot determine if changing circumstances between planning and implementation of projects have an influence on the realisation of projects. The development of prices of energy, technology and work could have an impact on the outcome of PBP calculations: rising energy prices will shorten the PBP, and rising prices of technology and labour will increase PBP. In the 2009–2012 period, electricity prices for industrial consumers decreased, on average, with 20.6 % according to Eurostat Statistics, after an increase from 2007[12]. This would result in less projects being profitable, although the effect is not large. For projects that save gas, no effect is to be expected, as gas prices remained constant during the period analysed. As there is no detailed information on prices of technology and labour, we cannot establish if these might have a significant impact. It is probable that the economic crisis in the period 2009–2012 affected the investment plans of companies, but it cannot be established how large this effect is.[13]

A third possible reason for the high number of additional projects is that companies are conservative in their planning: if they put more projects in their EEP, they might be forced to implement them. Stenqvist and Nilsson (2012, p. 234) also found that 'some companies are careful not to list measures they were not sure about' and found many additional projects being implemented. Although the design of the Dutch agreements tries to evade this phenomenon by providing the possibility of planning conditional and uncertain projects (i.e. projects that are not obligatory), still companies may be hesitant in planning projects that they are not absolutely sure about. Companies might also be tempted to report a too high PBP so that a project is not considered profitable—and obligatory. The fact that the minimum targets (consisting of only certain projects) were easily reached suggests that these targets are fairly conservative and more savings are possible than originally planned. This conclusion was shared in an evaluation of the LTA covenant in 2013 (Volkerink et al 2013). This implies that an adjustment in the EEP format regarding the distinction between projects of different certainty level should be considered.

The design of the simple PBP method which uses only energy benefits could also provoke strategic behaviour: excluding the non-energy benefits from the PBP calculation leads to a higher PBP. Whether this indeed leads to strategic behaviour cannot be proven.

What is the PBP of planned projects?

The PBP of planned projects varies widely. The median of planned projects is only 2.1, but 30 % of the projects have a PBP over 10 years. The average PBP of planned projects is 6.4, much higher than the median because some projects have a very high PBP of over 50 years. The fact that many companies plan projects with a PBP over 5 years is in line with Cooremans (2009, 2012), who concludes that 'financial factors play only a partial, or even secondary, role in investment decisions; the

[12] Electricity price components for industrial consumers, from 2007 onwards on http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_pc_205_c. Accessed 4-7-2014

[13] It would be interesting to delve deeper into the impact of the economic crisis on efficiency investments, but this falls out of the scope of this article.

strategic character of an investment seems to have more influence on decision-making than profitability' (p. 243). Howarth et al. (2000) claim 'there is substantial evidence that the usual workings of the market mechanism fail to support the full adoption of cost-effective energy-efficient technologies' (p. 479) and 'the neoclassical theory of the firm constitutes an overly constrained approach to understanding the economics of voluntary participation programs' (p. 485). DeCanio (1998, p. 453) as well states that 'organizational and institutional factors are important determinants of firms' investment behaviour'.

Is there a relation between implemented projects and their PBP?

There is a negative correlation between PBP and the number of identified projects: the lower the PBP, the higher the number of identified projects. However, we do not observe a relation between implemented projects and their PBP: there is no difference in the share of implemented projects with a high or low PBP. This implies that either PBP was not assessed properly in the EEPs or that PBP for projects with a higher PBP is not the most important criterion for implementation. Both conclusions might question the use of and focus on PBPs in the Dutch voluntary agreements and Environmental Management Act. Other criteria are probably more important than PBP. Anderson and Newell (2004) observed that adoption rates are higher for projects with shorter PBPs, lower costs, greater annual savings, higher energy prices and greater energy conservation. If investments are crucial for continuity of production, an investment will be made regardless of PBP; the energy savings are considered a co-benefit. If an energy-saving project has negative consequences for production, it will not be implemented regardless of the PBP. In other words, non-energy benefits of a project such as its strategic character, productivity gains or lower maintenance costs are more important than PBP. If PBP is indeed not important for investment decisions, then the obligation to implement projects with a PBP less than 5 years might lead to suboptimal outcomes, for instance when a project with small savings and PBP less than 5 years is compared to a project with high savings and a PBP more than 5 years.

Therefore, comparable policy instruments should consider other criteria to use as leverage to stimulate companies to invest. Fleiter et al. (2012) categorise projects according to 12 characteristics and 3 attributes, arranged on the likelihood of implementation. This classification scheme provides a starting point for another design of such a policy instrument.

Are projects with a short PBP also profitable according to criteria the companies use themselves?

We cannot determine whether projects with a short PBP are also profitable according to investment criteria used by the companies as we do not know if and what other criteria are used. The two methods to calculate PBP (energy-only vs all benefits) do not match with the methods generally used (simple and discounted payback). The use of a method that calculates PBP based only on benefits from energy savings will lead to a higher PBP.

The analysis of conditions for implementation in Table 5 shows that for projects with short PBP (2 years or less), financial conditions are relatively less important and technical conditions are more important. The fact that projects with a PBP less than 2 years are sometimes not implemented whereas projects with a PBP more than 20 years sometimes do get implemented suggests that companies have included other—non-financial—criteria in their own evaluation.

Should the covenants adopt more sophisticated methods?

Given our results and the results of other scholars, one might discuss the reliability of the simple PBP as evaluation method, especially for projects with longer lifetimes. The fact that the simple PBP does not take into account the time value of money or cash flows after the PBP makes PBP a worse indicator than IRR, especially for projects with longer lifetimes. Fleiter et al. (2012) claim 'the PBP is actually a poor indicator for profitability'. So, in theory, other methods are better predictors of profitability. This issue offers a dilemma. On the one hand, the simple PBP method seems too simple to provide correct information, especially years before a project is implemented, when project variables are only partly known. The current lack of project information on investment and lifetime prevents good enforcement of the rules on investment criteria. On the other hand, more sophisticated methods are not suitable for large amounts of projects—for governmental organisations with limited budgets, it is not possible to check if the right input

data is used. Here, it should be noted that even more sophisticated methods still have to deal with the same uncertainties in project variables. If profitability is less important than the strategic character of an investment using a more sophisticated economic evaluation, technique will not help in predicting which projects will be implemented. The PBP criterion should rather be seen as an indicator for profitability than as a stick for the government to force companies to invest.

One might try to avoid this dilemma by creating different rules for different type of projects, e.g. small and large projects or projects with shorter or longer lifetimes. It is, however, doubtful if such a distinction helps to solve this problem or only makes things more complicated. It is advisable to develop better guidelines to allow better judgement of profitability of projects.

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