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Energy conservation and investment behaviour of firms

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Abstract

This paper analyzes the determinants and barriers of energy conservation investment behaviour. A number of barriers were found in a literature survey. A three-phase investment model on the micro level was constructed. Hypotheses derived from the model were empirically tested by analyzing a survey of more than 300 Dutch Firms. Economic variables seem to determine investment behaviour to a large extent.

1. Background and problem description

To reduce the emissions of Greenhouse gases (GHG), a reduction in CO_2 emissions is necessary. Energy conservation (EC) is considered as one of the major strategies to achieve this. Industry (in its broad sense: agriculture, manufacturing, services) is one of the main users of energy and potentially an important energy conserver. A main objective of Dutch policy is to speed up the energy efficiency improvement from approx. 1% p.a. to 2.2% p.a. in the year 2000 (Nota Energiebesparing, 1989) to reduce CO_2 emissions by 3-5% in 2000.

It has been recognized (Blok 1991) that there exists large potentials for energy conservation in industry. Calculations with the data base ICARUS (see De Beer *et al.* 1993) show that the technical potential for energy conservation can be as much as 30% on average. Not all technologies are profitable. However, if one applies economic evaluation criteria, there still remains a *profitable* potential for energy conservation of about 20% (V.d.Werff and Opschoor 1992; Ayres 1994).

Problems arise when one tries to apply the results of ICARUS to industry: large differences exist between what ICARUS indicates as profitable and what firms think is profitable.

This study analyzes the differences between ICARUS's results and observed implementation behaviour of firms, in terms of determinants and barriers to the adoption of EC-technologies. The result is a theoretical implementation model which is empirically validated. In a second part of the study a set of realistic energy policy scenarios are constructed and these scenarios are applied to the implementation model of the first stage. The result here will be a simulation model that assesses the impacts of energy policy instruments on implementation behaviour and estimates how much the adoption process of EC-technologies can be accelerated and what the results are in terms of additional energy conservation.

2. Methodology

A literature survey looked into investment decision in general and an application of investment theory to energy conservation and identified theoretical barriers that might arise. In this framework important theoretical determinants and barriers to energy conservation adoption have been derived and a conceptual model was constructed (section 3). Next, a survey among more than 300 Dutch firms was held. Its results were used to empirically validate or reject the hypotheses derived from the theoretical framework about the determinants of and barriers to the investment decision (section 4). One part of the survey focused on the information on and implementation of the six most applicable EC-technologies in a sector. Another part of the survey focused on variables related to the theoretical determinants and barriers. Thus, it is possible to estimate the impacts of the variables on investment behaviour (section 5).

The second part of this study entails the estimation of the effects of additional energy policy on investment behaviour of firms. A set of plausible energy policy scenarios for the future (1994-2015) was constructed. These scenarios are used as an input for a simulation model that is currently built. For a schematic synthesis, see figure 1.

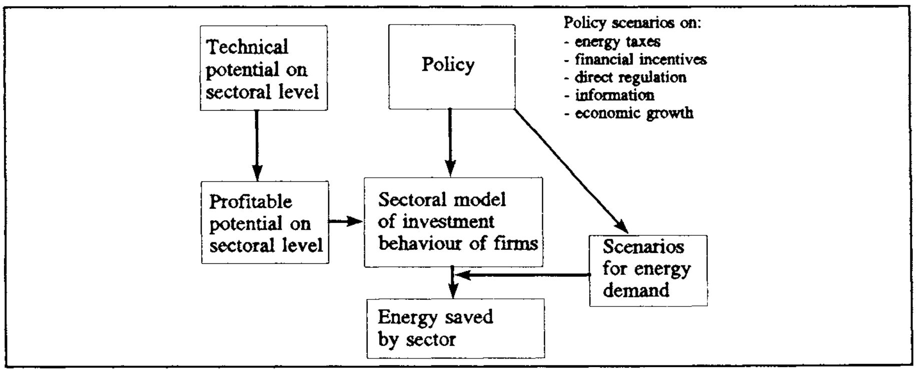

Figure 1: Schematic representation of project structure

3. Potential determinants and barriers

In a perfect world (e.g certain cash flows, free and full information, independence between technologies and unlimited access to capital markets), a profit maximizing firm would implement all available technologies that have a positive net present value. However, introducing imperfections lead to the existence of barriers that prevent firms from implementing EC-technologies. The potential barriers can be categorized in the following groups (see Gillissen, 1994a):

a. economic barriers: i) low expected energy prices; ii) uncertainty due to

expected fluctuations in energy prices; iii) low expected revenues due to low energy bill; iv) budgetary problems; v) too high required return on investment;
b. physical/technology barriers: i) reduction in production quality; ii) bounded rationality; iii) "technology-lock"; iv) information gap;
c. management barriers: i) no specialized personnel; ii) no interest in energy conservation by management; iii) no priority to conservation (high opportunity costs); iv) present technologies are not fully depreciated; v) lack of pressure.

Potential determinants of energy conservation are, for example, firm size, the presence of an energy coordinator and R&D department. External pressure and bilateral agreements may also speed up the implementation process.

4. Modelling energy conservation implementation behaviour

As a complement to ICARUS (where only EC-technologies are listed), our model provided detailed information to which extent the EC-technologies in are actually being implemented by firms. The model consists of three "modules". The first module analyses the information process of firms. Variables that describe the information capacity for energy conservation are: the number of information channels, the presence of an energy coordinator, R&D department or environmental care system. Other important variables that represent the importance of energy conservation technology information are: firm size, the energy bill, the complexity and costs of a EC-technology. Together, these variables serve as explanations for the level of information of a firm. Lack of information might lead to an information gap, which is a barrier to the adoption process.

The second module analyses the economic evaluation process by firms. Technologies are judged on their expected profitability. The profitability as *perceived* by the firm might differ from the profitability as calculated in ICARUS, because of uncertainty and firm specific expectations about for instance energy prices. Other variables include possible biases in perceptions through a low priority for energy conservation in comparison with "core business activities".

The implementation stage is analyzed in the third module. Rational behaviour theories predict that a firm will only implement technologies it considers to be profitable. However, there may be physical barriers that prevent a profitable technology from being implemented, whereas non-economic influences cause an unprofitable technology to be implemented. Possible barriers and positive influences were named above. Figure 2 shows the conceptual framework of the implementation process in firms.

5. Results of modelling energy conservation implementation

The empirical modelling stage consisted of two steps. The first step empirically identified the most important determinants and barriers from a set of more that 100 possible influential factors (see Gillissen and Opschoor, 1994). Indicators of the degree of information and implementation were constructed and the influ-

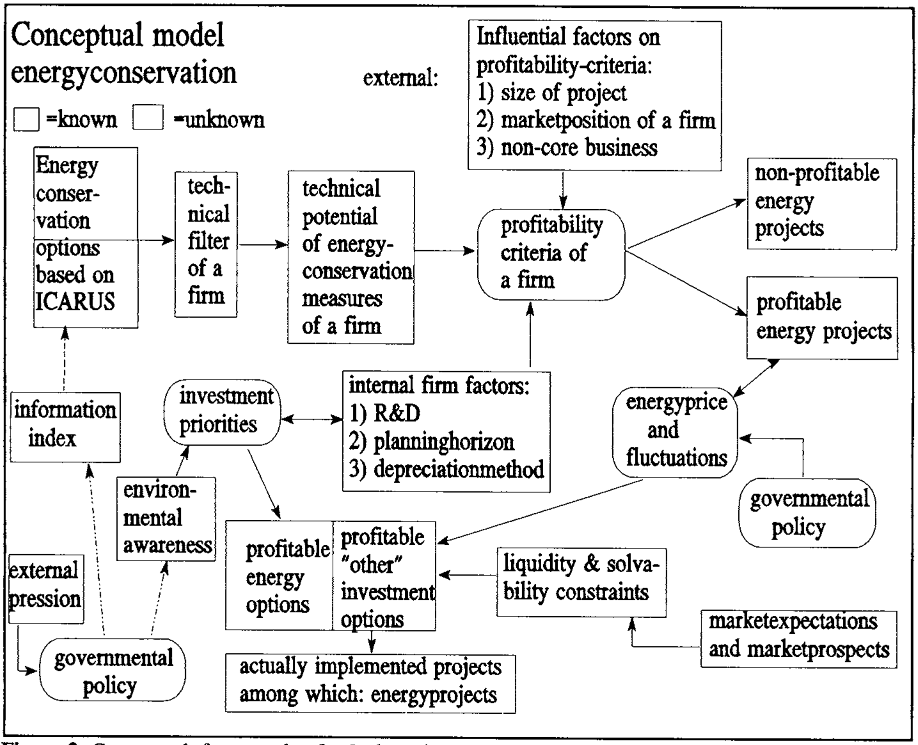

Figure 2: Conceptual framework of a 3-phase investment model

ence of firm specific variables was assessed. The results suggest that energy in considered as one of the production factors, and that investments to reduce the use of energy i.e. by EC-technologies are made largely on a economic evaluation, taking into account the physical and financial constraints. Determinants are: firm size, return on investment, the availability of capital, the possibility of early depreciation. Barriers that prevail are: uncertainty due to fluctuations in energy prices, budgetary problems, poor financial market expectations, a lack of knowledge of EC-technologies and the complexity of those technologies. Variables that do not seem to influence the implementation decision are the "core business" argument, the size of energy bill and the presence of an energy coordinator or R&D department. Decisions on EC-investments do not basically differ from the decisions on "core business" investments (see table 1).

The three phase investment model was estimated in the second stage (see Gillissen, 1994b). Preliminary results seem to confirm the results of the first step, with a few changes: the role of covenants stimulates the information and knowledge about EC-technologies. Also the expected positive role of the energy coordinator could sometimes be proven. Again, complex technologies were less known that simple measures.

6. Policy simulation

The policy simulation part evaluates constructed energy policy scenarios on their contribution to energy savings. Scenarios consist a set of economic and regulatory instruments, combined with expectations regarding economic growth and energy prices. The instruments are constructed on the basis of actual and intended energy policy (VNEB, 1993); other scenarios line with "Scanning the future" and "Milieuverkenning 3". The advances in implementation, as a consequence of such a policy, will be calculated on a yearly basis up to the year 2015. Energy policies are then evaluated on their estimated contribution of additional energy savings. Instruments (control variables) that are analyzed include energy taxes, energy subsidies, the effectiveness of covenants, and information policy to reduce the information gap.

Table I: Determinants of EC-investment decision process

Important variables	Less important variables
- Firm size	- Size of energy bill
- Information sources	- Distance to core business
- Availability of capital	- Low expected energy prices
- depreciation moment	- competition

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