Barriers and drivers for energy efficiency: Different perspectives from an exploratory study in the Netherlands

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1. Introduction

Large energy efficiency improvement potentials are found among European small and medium-sized enterprises (SMEs), where more than two thirds do not implement even simple rules to manage energy use [12]. Despite policy-making efforts, policy makers and environmental associations do not seem to act effectively in promoting energy efficiency measures (EEMs), as they neither tackle the existing barriers nor are they able to address the relevant drivers. Therefore, it is necessary to find new and more effective ways to assess the importance of barriers and drivers on the firms' decision-making process for adopting EEMs and to understand the role of the actors responsible for drivers' promotion, highlighting the key mismatches between the companies' and external actors' perspectives. Based on a theoretical framework recently developed, we have carried out an exploratory investigation analysing a set of metalworking SMEs participating in the Dutch voluntary agreements. To gain different perspectives, the study involved the major external actors, i.e. the national energy agency, the governmental and the industrial organisations, to map their views in the decision-making process.

In this paper we first present the approaches adopted to investigate barriers and drivers in the decision-making process (Section 2). In Section 3 we provide a brief overview of the Dutch policy instru-ments on energy efficiency and a discussion on the relation of policy instruments to the drivers and barriers. Section 4 describes the research framework and methods, while Section 5 presents and discusses the research findings. Conclusions and suggestions for further research are reported in Section 6.

2. Barriers and drivers for industrial energy efficiency

To analyse barriers, many different theoretical approaches can be found (e.g. [28,6], as well as empirical studies (see [8,5] for

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recent reviews). On the contrary, scarce recent contributions on drivers exist, focused merely on highlighting which drivers should be fostered (e.g. [4,7,10], without characterizing them in the decision-making process, and just a few taxonomies have emerged recently [29]. After a comprehensive and exhaustive literature review, we have chosen a recently developed framework for the analysis of both barriers and drivers, encompassing the latest taxonomies of barriers and drivers, as well as their effect on the decision-making process [6,35]. Cagno et al. [6] identify 27 barriers categorized into 7 groups: economic, organisational, behavioural, technological, competences, informative and awareness (Table 1). Trianni et al. [35] identify 23 specific drivers, divided into 4 groups according to the type of action, respectively: regulatory, economic, informative and vocational training (Table 2).

Previous empirical research has not fully analysed the decision-making process and the involved actors. A broader perspective can help to understand which barriers are experienced and how to overcome them. According to the framework developed by Trianni et al. [35], to achieve an improvement in energy efficiency, it is necessary to go through several steps constituting the decision-making process. If a decision-maker encounters a barrier during one or more of these steps, the progress of the investment assessment will be delayed or interrupted. In the first step of this process, awareness on energy efficiency issues must be achieved, followed by needs and opportunities identification, technology identification, and planning of the effective intervention. Financial analysis and financing represent the fifth phase, while the last step regards the effective installation, start-up and train-ing. In each step, different drivers or barriers can be important. The model [35] identifies the major actors in the various stages of the decision-making process: government, financial institutions, industrial associations (IAGs), technology providers, manufactur-ers, installers, energy service companies (ESCOs), energy suppliers, competitors, allies, clients and also the individual enterprises.

Table 1
Synthesis of the taxonomy of barriers adopted for empirical investigation. *Source:* Cagno et al. [6].

Barrier groups	Specific barriers
Technology-related	Technologies not adequate Technologies not available
Information-related	Lack of information on costs and benefits Information not clear by technology providers Trustworthiness of the information source Information issues on energy contracts
Economic	Low capital availability Investment costs External risks Intervention not sufficiently profitable Intervention-related risks Hidden costs
Behavioural	Other priorities Lack of sharing the objectives Lack of interest in energy-efficiency interventions Imperfect evaluation criteria Inertia
Organisational	Lack of time Divergent interests Lack of internal control Complex decision chain Low status of energy efficiency
Competence-related	Implementing the interventions Identifying the inefficiencies Identifying the opportunities Difficulty in gathering external skills
Awareness	Lack of awareness

Table 2
Synthesis of the taxonomy adopted for drivers for empirical investigation. *Source:* adapted from Trianni et al. [35].

Driver groups	Specific drivers
Regulatory	Clarity of information Efficiency due to legal restrictions External energy audit/submetering Green image Increasing energy tariffs Long-term energy strategy Technological appeal Trustworthiness of information Voluntary agreements Willingness to compete
Economic	Cost reduction from lower energy use Information about real costs Management support Public investment subsidies Private financing
Informative	Availability of information Awareness External cooperation Knowledge of non-energy benefits Management with real ambitions Staff with real ambitions
Vocational training	Programs of education and training Technical support

3. Relation of drivers and barriers to policy instruments

3.1. Overview of Dutch energy policy instruments

The Netherlands has a long history of policy on energy savings and efficiency, starting in 1973 in the first oil crisis. Since 1990, voluntary agreements (VAs) form an important part of the Dutch policy mix on energy efficiency in industry. We focus on present instruments explicitly directed to industry. A more elaborate description can be found in Gerdes [14]. The instruments are arranged according to the typology introduced by Tanaka [30] in three different types: prescriptive policies are regulations, mandates and obligations that directly compel specific actions by companies. Economic policies are taxes and tax reductions, direct financial support, tradable permits and price policies. Supportive policies are tools to identify opportunities for energy efficiency, cooperative measures, capacity building and information policies. This classification resembles that of the drivers in the framework described in the previous section. In Fig. 1 an overview of Dutch pol-icy instruments on energy efficiency in industry from 2000 onwards is presented. Table 3 provides a description of these instruments.

3.2. The role of VAs in the Dutch policy mix

VAs have been part of the policy mix on energy efficiency since 1990. Since 1990, five different agreements on industrial energy efficiency have been implemented, each with particular characteristics. In 2014, two different agreements on energy efficiency are in force: LTA3 and LEE. Companies joining a VA endorse both rights and duties stemming from the text of that agreement: [20] for LEE, [19] for LTA3. The most important obligation for companies within the VAs is to plan and implement EEMs. Therefore, they have to deliver an Energy Efficiency Plan (EEP) every four years and an annual monitoring report. Participating companies must plan and implement all profitable measures, whereby profitable means measures with a positive net cash value at an internal dis-count rate of 15%. Alternatively, a payback period of five years can be used [19,20]. Fig. 2 presents a schematic view of the interaction between the different actors in the LTA3. In 2013, both LTA3 and LEE have been evaluated. The LTA3 evaluation report concluded

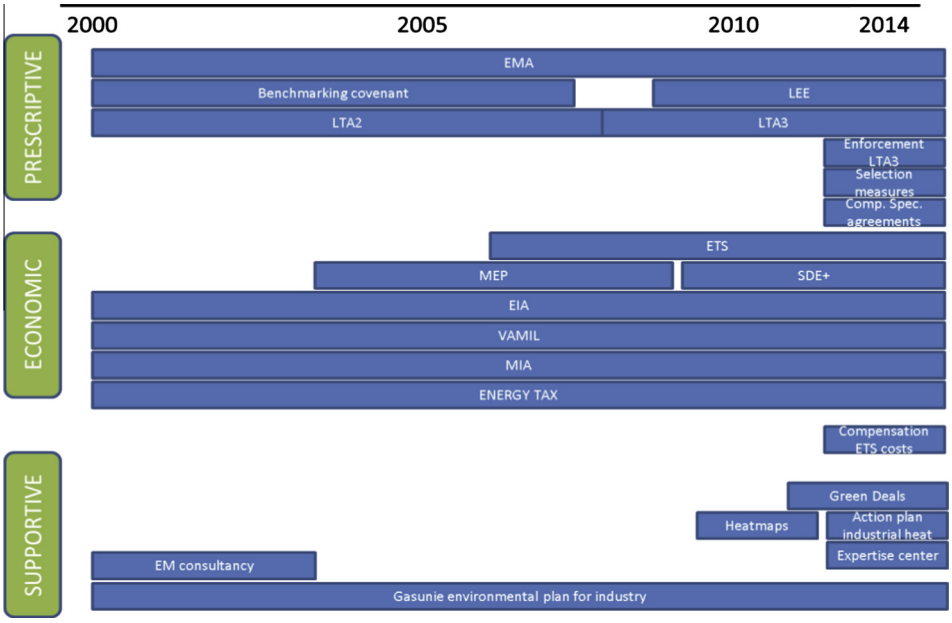

Fig. 1. Overview of Dutch policy instruments on energy efficiency in industry from 2000 onwards. *Source:* Gerdes [14], SER [27].

that the covenant partners had so far reached their objective to realise savings of 2% per year (including supply chain efficiency and renewable energy). The researchers encountered difficulties in establishing additionality, but concluded that the contribution of the LTA-program in these savings was limited; a large part of the savings would have been realized anyhow. They also concluded that the process within the agreements had helped raising awareness in covenant partners [39]. The evaluation of LEE concluded that LEE contributed to the identification and planning of energy saving measures, including the long-term perspective for sectors and companies. Participants thought LEE contributed more to the implementation of measures than other policy instruments (EU-ETS, energy tax and Vamil [16].

3.3. Relation between policy instruments and drivers

The description in Section 3.1 gives an overview of the mix of different Dutch policy instruments. In this section we deal with the issue of defining which drivers are affected by such instru-ments (as summarised in Table 4).

The EU-ETS, as an economic instrument, affects only one driver: cost reduction of lower energy use, and that only indirectly (assuming a reduction of CO_2-emission is realized by lowering energy use, which is not always the case). The VAs LEE and LTA3 are aimed at several drivers: mostly informative, but also some of the drivers within the category regulatory. The driver 'cost reduction' is not directly affected, but is often used as a motiva-tional argument to stimulate participants to invest in energy sav-ing projects. The fiscal instruments EIA and VAMIL use the same mechanisms: as a public investment subsidy, they lower invest-ments costs. Arguably, they could also use the 'technological appeal' driver; companies could show a higher acceptance of new technological equipment if information on this technology gives an impression of a modern, appealing and fashionable instal-lation. The EMA is a purely regulatory instrument. By obligating profitable measures, it tries to speed up these investments. However, it also restricts freedom of choice for companies.

Generally speaking, different instruments affect at least one driver in both regulatory, economic and informative driver types. Only the vocational type is not affected. Also on the level of individual drivers, most drivers are affected by one or more instruments. The driver 'public investment subsidies' is affected by the fiscal instruments EIA and VAMIL. 'Management with real ambition' is a goal for the VAs. However, a recent evaluation concluded that targets in LTA3 were modestly ambitious [39]. One could therefore doubt if this driver is successfully targeted. Two of the economic drivers and the vocational drivers, are not affected by any of the main instruments.

3.4. Relation between policy instruments and barriers

ETS is predominantly meant to deal with economic barriers (see Table 5). By increasing the price of CO_2 (and hence energy), energy efficiency projects will become more profitable. One could argue that the 'awareness' barrier is relevant as well, as the price increase could increase attention as well.

VAs can relate to a host of barriers, mainly behavioural and organisational. Which barriers are tackled depends on the design of the agreement. Tanaka [30] categorizes VAs in 6 types, according to their design on two axes: incentives and the degree of certainty that rewards or penalties are exercised. Some VA's have strict obligations and tend towards a prescriptive instrument, others rely more on self-action, supported by networking and information sharing, appealing more to behavioural or organisational barriers. The Dutch agreements tend more towards the latter. However, as the agreements have stronger obligatory elements (EEP's, monitoring) than for instance subsidy schemes [39] it seems reasonable to categorize them as prescriptive policies. According to Tanaka [30], they are categorized under types II (agreements with annulments/exceptions from existing measures) and IV (agreements with government support for actions). Covenants contribute to awareness, commitment of all parties and exchange of information, thereby making optimal use of the knowledge of other companies [14]. The two fiscal instruments EIA and VAMIL appeal predominantly to economic barriers, by effectively lowering investment costs. By providing a list of possible profitable investments, the instruments are supposed to deal with the information barrier as well. The EMA is mainly focused on behavioural barriers: by making energy saving investments compulsory, the Act forces companies to change behaviour.

Table 3
Overview and typology of current policy instruments on energy efficiency in the Netherlands.

Instrument	Description
Prescriptive	
Environmental Management Act (EMA)	This act sets out an integrated approach to environmental management in the Netherlands and provides the legal framework by defining the roles of national, provincial or regional, and municipal government. One of the obligations under this act is that companies are obliged to implement all energy saving measures with a payback period of up to 5 years
LEE (Long term agreement on Energy efficiency for ETS-companies)	Signed by most of the companies that formerly participated in the Benchmarking covenant. Although LEE is meant in particular for companies that fall under the EU-ETS scheme, not all LEE companies actually participate in EU-ETS. In total, 114 companies in 7 sectors joined the LEE-covenant, with a combined energy use of 602 PJ (2011). Only a few of the LEE-companies fall under the definition of SME
LTA3	The LTA3, combined energy use 237 PJ (2011), is joined by over 900 companies in 32 sectors, mostly industrial, but also some services and rail transport [1]. Although there is a large diversity in terms of size, the majority of LTA3 companies fall under the definition of SME's
Energy Agreement for sustainable growth	Signed by more than forty organisations – including central, regional and local government, employers' associations and unions, nature conservation and environmental organisations, and other non-governmental organisations and financial institutions. The overarching goal of the Energy Agreement is to achieve a completely sustainable energy supply system by 2050. The parties to the Energy Agreement will strive to achieve a.o. a saving in final energy consumption averaging 1.5% annually and a 100 petajoule (PJ) saving in the country's final energy consumption by 2020; In total, more than 100 actions have been identified in the Energy Agreement, of which 5 (mentioned in this table) are relevant to industry. The great diversity of the actions makes it difficult to characterize the agreement as a policy instrument. Part of the actions are prescriptive, part is economic or supportive
Energy Agreement: Enforcement LTA3	An agreement with municipalities and regional government agencies to prioritize enforcement of the energy-saving obligation in the EMA
Energy Agreement: Selection recognized measures	A list of specific approved measured that have proven to be profitable in other companies. Municipalities and regional government agencies could use this list in the enforcement of the EMA (http://www.infomil.nl/onderwerpen/duurzame/energie/erkende-maatregelen/)
Energy Agreement: Company specific agreements	Agreements with individual companies to implement certain projects, in exchange of specific support
Economic	
Regulating Energy Tax (REB)	A yearly set levy on the use of electricity, coal and natural gas. The height of the levy decreases with increasing energy use (tariffs on Belastingdienst.nl). Large industrial customers (>10 million kW h) can get a retribution of the tax on electricity when they are participating in the VAs
EU-ETS	The largest industrial companies can trade emission certificates
Compensation ETS-costs	A subsidy scheme for ETS companies to compensate for rising electricity prices. Budget 2015 is €50 million
SDE+	A € 3.5 billion subsidy scheme for production of renewable energy and combined heat and power (CHP) Companies
EIA	investing in energy-efficient technologies can deduct part of the investment costs from their profits. A list of possible energy investments is set yearly. There are five application areas, each with its own energy performance requirement: corporate buildings; processes; transport resources; sustainable energy; energy advice. Total 2013 budget for EIA was 151 Million euro [25]
MIA/VAMIL[a]	Tax deduction schemes for investments in environmental friendly products or business resources. Total 2013 budget of €125 Million (website [25])
Supportive	
Green Deals	In a Green Deal, central government signs a deal with market parties to overcome one or more problems that hamper progress towards a sustainable society. In fact, a Green Deal is a sort of mini-covenant, with a limited number of participants and a focused objective. Green Deals focus largely on non-financial barriers [2]
Action Plan industrial heat	A plan to utilize industrial waste heat
Expertise centre energy efficiency	An independent centre of expertise to assist businesses and funding bodies in identifying the most effective measures (preparations are underway)
Gasunie environmental plan for industry	Free advice on energy saving possibilities

[a] MIA (Environmental investment rebate) and VAMIL (Arbitrary depreciation of environmental investments).

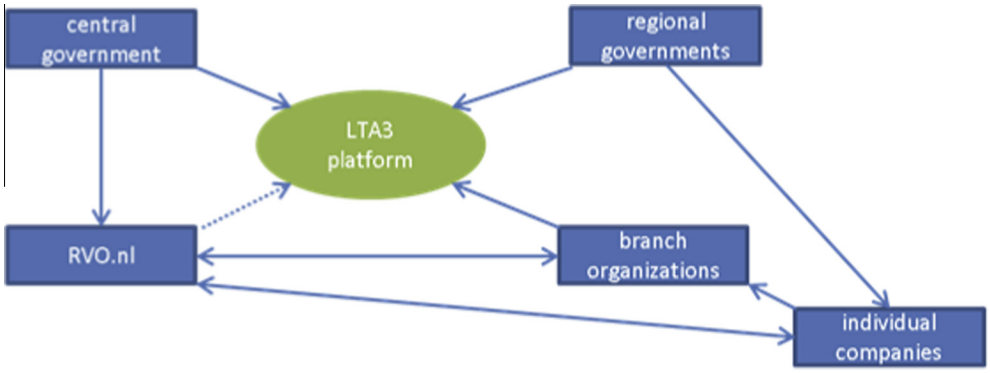

Fig. 2. Overview of actors in LTA3.

Table 4
Relation between instruments and drivers.

Drivers		EU ETS	LEE + LTA3	EIA	VAMIL	EMA
	Instrument type	E	P	E	E	P
	Instrument subtype	TP	VA	IS	IS	OC
Regulatory	Clarity of information	–	+	–	–	–
	Efficiency due to legal restrictions	–	–	–	–	+
	External energy audits/sub metering	–	+	–	–	–
	Green image	–	+	–	–	–
	Increasing energy tariffs	+	–	–	–	–
	Long-term energy strategy	–	+	–	–	–
	Technological appeal	–	–	+	+	–
	Trustworthiness of information	–	+	–	–	–
	Voluntary agreements	–	+	–	–	–
	Willingness to compete	–	+	–	–	–
Economic	Cost reduction from lower energy use	+	+	+	+	–
	Information about real costs	–	–	–	–	–
	Management support	–	+	–	–	–
	Public investment subsidies	–	–	+	+	–
	Private financing	–	–	–	–	–
Informative	Availability of information	–	+	–	–	–
	Awareness	–	+	–	–	–
	External cooperation	–	+	–	–	–
	Knowledge of non-energy benefits	–	+	–	–	–
	Management with real ambitions	–	+	–	–	–
	Staff with real ambitions	–	+	–	–	–
Vocational	Programs of education and training	–	–	–	–	–
	Technical support	–	–	–	–	–

Instrument types: E = economic; P = prescriptive.
Instrument subtypes: TP = tradable permits; VA = voluntary agreements; IS = incentives and subsidies; OC = Obligations/commitments (see for explanation of drivers Table 2).
'+' Means this driver is used as a mechanism by the instrument to achieve its goals, '–' means this is not the case.

Table 5
Relation between instruments and barriers according to policy design.

Barriers		Main instruments				
		EU ETS	LEE/ LTA3	EIA	VAMIL	EMA (Wm)
		Instrument (sub)type				
		E	P	E	E	P
		TP	VA	IS	IS	OC
Technology	Technologies not adequate	–	–	–	–	–
	Technologies not available	–	–	–	–	–
Information	Lack of information on costs and benefits	–	–	+	+	–
	Information not clear by technology providers	–	–	–	–	–
	Trustworthiness of the information source	–	+	–	–	–
	Information issues on energy contracts	–	–	–	–	–
Economic	Low capital availability	–	–	–	–	–
	Investment costs	+	–	+	+	–
	External risks	–	–	–	–	–
	Intervention not sufficiently profitable	–	–	–	–	–
	Intervention-related risks	–	–	–	–	–
	Hidden costs	+	–	+	+	–
Behavioural	Other priorities	–	+	–	–	+
	Lack of sharing the objectives	–	+	–	–	+
	Lack of interest in energy-efficiency interventions	–	+	–	–	+
	Imperfect evaluation criteria	–	+	–	–	–
	Inertia	–	+	–	–	–
Organisational	Lack of time	–	+	–	–	+
	Divergent interests	–	+	–	–	–
	Lack of internal control	–	+	–	–	–
	Complex decision chain	–	+	–	–	–
	Low status of energy efficiency	–	–	–	–	–
Competences	Implementing the interventions	–	+	–	–	–
	Identifying the inefficiencies	–	+	–	–	–
	Identifying the opportunities	–	+	–	–	+
	Difficulty in gathering external skills	–	+	–	–	–
Awareness	Lack of awareness	+	+	–	–	+

Instrument types: E = economic; P = prescriptive; S = supportive.
Instrument subtypes: TP = tradable permits; VA = voluntary agreements; IS = incentives and subsidies; OC = obligations/commitments (see for explanation of barriers Table 1).
'+' Means the instrument aims to lower this barrier, '–' means this is not the case.

Overall, the mix of policy instruments addresses most barriers. On an aggregated level, 6 of the 7 barriers are covered at least partially. Only the technology barrier does not seem to be covered. On a more detailed level however, some barriers are not covered by any instrument. Within the economic barriers for instance, 'low capital availability', 'intervention related risks' and 'external risks' are not covered by any instrument. Behavioural and organisational barriers are covered best, only 'lack of internal control' is not covered by any instrument.

4. Research methods

The research has adopted a novel approach to seek the mechanisms between policy instruments, drivers and barriers in the decision-making process of SMEs, focusing on the role different external major actors play in the various stages of the decision-making process, based on the taxonomies of barriers and drivers for industrial energy efficiency. Fig. 3 shows the main features of the model. At the bottom, the steps of the decision-making process are shown (following [35], they will be six). Each step is affected by different barriers (in the figure barriers are shown with bars placed on the respective step). The height of the barriers will show the importance attributed to the barrier by the respondents in the

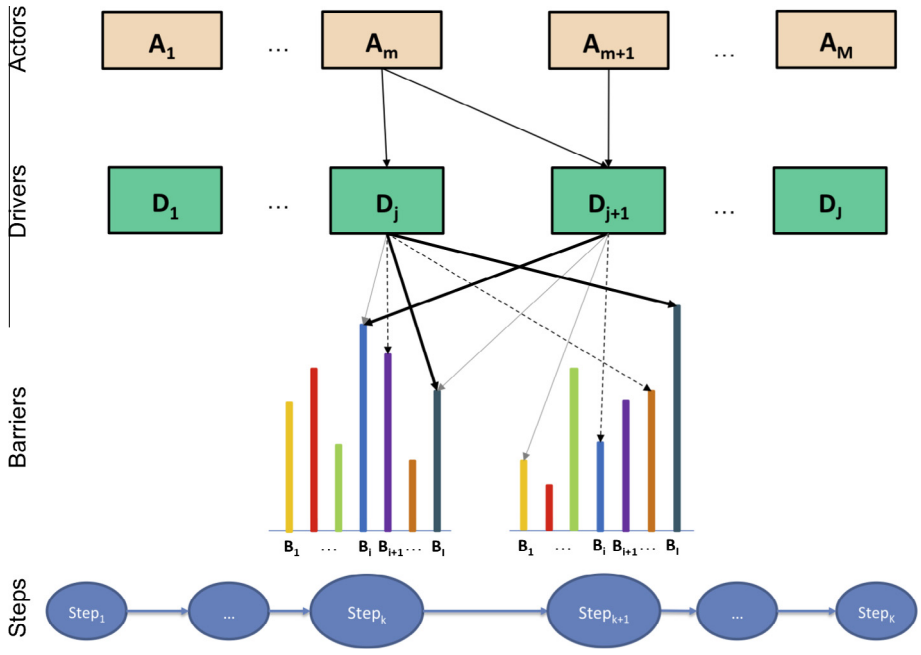

Fig. 3. The framework to describe the mechanisms connecting barriers, drivers and actors in the decision-making processes to undertake an investment in an EEM.

investigation. It is possible to represent the categories of barriers (following [6], they will be seven) with reference to their impact on the decision-making steps. The width of the arrow from drivers to barriers shows how strongly a driver could affect one or more barriers in a decision-making step. Additionally, the top half of the figure shows the drivers (following [35], they will be twenty-three) and the actors most responsible for promoting such drivers.

The investigation has been conducted interviewing the people knowledgeable and responsible for energy issues within a set of fifteen Dutch metalworking manufacturing SMEs in the province of Utrecht. Our study takes place in one of Europe's most competitive countries, with historical concern on industrial energy efficiency and environmental policies [11]. Furthermore, it is the Netherlands' most sustainable region with the most favourable expectations for economic growth of all the regions in Western Europe [13]. Due to the exploratory nature of this study, firms have been randomly chosen within the metalworking sector. All firms participated on a voluntary basis. Semi-structured interviews, as described by Patton [21] and taking inspiration from Yin [40], were conducted during a visit to the production site. During the interview, a relatively detailed understanding of the firm has been acquired. We have collected general data about the enterprise (e.g. number of employees, annual average net turnover for the last five years, firm's organisation), information regarding the characteristics of the production process, and information about how energy management activities are conducted (Table 6).

Next, the interviewee was asked to complete a short, guided questionnaire regarding his/her view of the barriers, highlighting their roles in the decision-making process (step by step), as well as which drivers could act on the barriers on the single decision-making steps. Furthermore, the external actors that were able to influence the drivers were interviewed. As information on drivers, decision-making steps and external actors in literature are scarce, we decided to use the highest level of details given by the taxonomies; whilst for barriers we asked for type of barriers (i.e. group), always specifying which specific barriers were to consider within that group. The questions were scored on a 4-point Likert scale, which ranged from 1 ("not important/absent") to 4 ("very important/very strong"). Even though the sample size is limited

Table 6
Firms' characteristics.

Firms	Size	Sector	Products/activities
C1	ME	C25	Manufacture of metal components for the medical sector
C2	ME	C24	Production of customized steel castings
C3	SE	C24	Cast of non-ferrous alloys
C4	SE	C24	Design and manufacture of aluminium castings
C5	SE	C25	Manufacture of metal grills, hangers and plates
C6	ME	C25	Surface treatment of automotive, aviation and semiconductor components
C7	SE	C24	Anodizing of aluminium profiles and construction components
C8	SE	C24	Manufacture of castings in metal alloy
C9	ME	C25	Manufacture of locker systems
C10	SE	C25	Manufacture of metal components
C11	ME	C25	Production of zinc coils, strips and sheets
C12	SE	C25	Production of metal fences and screens
C13	SE	C24	Manufacture of aluminium castings
C14	SE	C25	Manufacture of metal components
C15	SE	C25	Production of stainless coils, strips and sheets

Size: ME = medium-sized enterprise; SE = small-sized enterprise.
Sector: C24 = manufacture of basic metals; C25 = manufacture of fabricated metal products.

due to the exploratory nature of this study, we still consider the findings to be of interest for their ability to help us form initial impressions, some of which may be expanded upon in future research.

To study the perceptions of firms and national external actors, five additional semi-structured interviews (with the same questions as for the firms) have been conducted with governmental institutions at a national (A1), regional (A4) and local (A5) level, as well as national (A2) and local (A3) metalworking IAGs (Table 7). In this way, different perspectives can be identified, not only between firms and other actors, but also between govern-mental and industrial organisations.

5. Results

This section has been structured as follows: we analyse barriers, decision-making steps, drivers and most relevant actors from the

Table 7
Governmental and industrial organisations' characteristics.

Organisation	Description	Role	Tasks
A1	National energy agency	Link between EU, the Dutch government and society	Implementing policies regarding sustainability, innovation and international business
	Governmental institution belonging to the Ministry of Economic Affairs		
A2	National metalworking IAG	Link between the government and metalworking companies; national network in the metal sector	Guaranteeing expertise and knowledge, advising on social, legal, economic and fiscal field, and providing information about changes in laws and polices
	Large industrial association group in the metal sector		
A3	Local metalworking IAG	Local network in the metal sector	Promoting new technical developments and spreading information about technical and regulations changes
	Local industrial association group in the metal sector		
A4	Regional government	Assessing success and failure of regional environmental policy; connection between EU directives and regional implementation	Releasing licenses and certifications, monitoring compliance standards
	Environmental protection agency		
A5	Local government. Municipality	Governing the province	Favouring economic growth and developing processes for innovative and sustainable change in the province

perspective of the sampled SMEs and the other actors (i.e. governmental and industrial organisations) involved in the study. The final part of the section discusses the link of the Dutch VAs (LTA3) to the results of our investigation. Due to the limited number of responses, only the major and significant findings will be discussed.

5.1. Analysis of the involved SMEs

The studied SMEs agree on the priority of the **main barriers** expressed in general terms (see Table 8). They put economic, organisational, behavioural barriers in first positions, in line with past studies [36,34,37,26,23]. Moreover, firms also agree on the most relevant barrier in each step of the **decision-making process**, as follows (Fig. 4):

- 1st step: awareness and behavioural barriers;
- 2nd step: information-related barriers, followed by economic and organisational;
- 3rd step: technology-related followed by information-related;
- 4th step: organisational barriers;
- 5th step: economic barriers; and
- 6th step: behavioural barriers.

Moreover, firms also agree on the criticality of the decision-making step. As from Fig. 4, the needs and opportunities identification (step 2) and financial analysis (step 5) are deemed as the most critical steps. Interviewees seem to underestimate the very first step (awareness). Nonetheless, it is worth remarking that without proper awareness of the relevance of energy efficiency, the whole decision-making process of adopting an EEM could be stopped at its very beginning.

Table 8
Ranking of barriers. The ranking was built on the basis of the number of firms deeming the barrier as important or very important.

Barrier	Important or very important
Economic	12
Organisational	7
Behavioural	6
Information-related	5
Competence-related	5
Awareness	4
Technology-related	4

As most important **drivers** (Table 9), confirming previous studies, we find long-term energy strategy [23,24,31,32,9], clarity of information [7], cost reduction from lower energy use [10,15,32]; Hasanbeigi et al., 2010; [33], public investment subsidies [10,7], technical support [18], and trustworthiness and availability of information [7]. Interestingly, the interviewees showed a strong alignment on some **mechanisms** (Fig. 5), i.e. which driver, promoted by which external actor, acts on a main barrier of a given decision-making step.

It is observed that, though a large number of **actors** could be responsible for stimulating a single driver (Table 10), firms frequently cite just one of them. Other firms and technology suppliers are deemed as the most relevant, differing from other studies where the role of financial institutions was considered of primary importance (see e.g. [7]. Firstly, firms feel themselves to be responsible for promoting the following drivers: long-term energy strategy, having ambitious staff and management, management support, and promoting programs of education and training. Secondly, technology suppliers are responsible not only for technical support, but also for information-related drivers such as availability, clarity, trustworthiness as well as knowledge of the non-energy benefits (NEBs). This is crucial, in line with recent literature highlighting that a greater knowledge of all benefits could effectively enhance the EEMs' adoption rate [38,17]. Thirdly, beside public investment subsidies, the authorities are considered as important for the promotion of VAs and regulations, thus pushing enterprises to improve energy efficiency.

Table 11 synthesizes the main mechanisms relating barriers and drivers in the decision-making steps. In detail, long-term energy strategy and clarity of information are the most relevant factors in the first stage. Understandable information is necessary in order to develop consciousness about energy efficiency, but hav-ing a long-term energy strategy is important to make the company aware of chances. There is a kind of causal link between them. In fact, any effective approach to energy efficiency must be first of all perceived as important [3]. Then, actions to be undertaken and expected results from implementing any EEM should be as clear and concrete as possible. Awareness could be the logical strongest driver in support of the first step. Nevertheless, intervie-wees have not placed it in first position, even though still consid-ered as important, possibly reflecting their need to have something more tangible to incentivize their personnel to improve energy efficiency, as found by Aflaki et al. [3]. It is also possible to

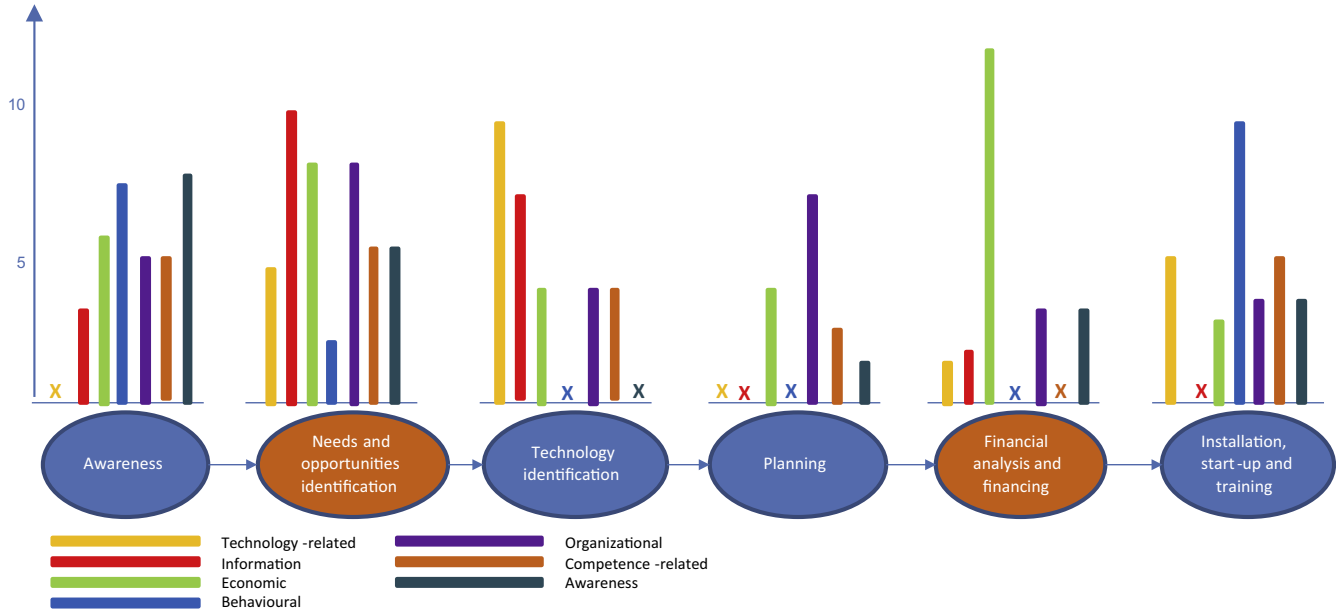

Fig. 4. Barriers on the decision-making steps. The ranking was built on the basis of the number of the firms that consider the barrier important or very important on the particular decision-making step. Step 2 and step 5 were identified as the most troubled, even if step 1 and 2 were affected by more barriers.

Table 9
Ranking of drivers. The ranking was built on the basis of the number of firms deeming this driver as important or very important.

Driver	Important or very important
Long-term energy strategy	8
Clarity of information	8
Cost reduction from lower energy use	8
Public investment subsidies	7
Technical support	7
Trustworthiness of information	7
Availability of information	7
Increasing energy tariffs	6
Staff with real ambitions	5
Awareness	5
Voluntary agreements	4
Green image	4
Management with ambitions	4
Management support	4
Information about real costs	4
Efficiency due to legal restrictions	3
External energy audit/submetering	3
Private financing	3
Knowledge of non-energy benefits	3
External cooperation	3
Willingness to compete	2
Programs of education and training	1
Technological appeal	1

state which actors are responsible for the promotion of the drivers involved in the first stage: the technology suppliers and the firm. The existence of VAs is also recognized as driver, even if to a lesser extent.

High information-related barriers mainly affect the second step, mostly tackled by having clear, available and trustworthy information. Technology and energy suppliers are the main actors involved in their promotion.

In step 3 the technology-related barrier is significant, and technical support is the strongest driver during technology identification. Other potential active driving forces are trustworthiness of the information source and clarity of information. Both technology suppliers and installers play a relevant role. Organisational barriers arise in the fourth step (planning). Technical support is still very relevant and also long-term energy strategy is crucial, as it can shorten the process and contribute to leaner, more efficient planning, thus also acting effectively on the economic barrier. Additionally, organisational hurdles seem to be influenced by competent and ambitious management. Installers, technology suppliers, and the firm itself can act on this step, having the power to activate those drivers. Three of the 5 active drivers in step 5 belong to the economic group. Public investment subsidies may represent an important stimulus in making investments more appealing and economic, as well as cost reduction through reduced energy use. A long-term energy strategy, which was a significant factor in the previous step, may also be beneficial in this stage, improving the success of energy management, and taking long-term benefits into consideration when evaluating the profitability. Increasing energy tariffs and information about real costs of energy may stimulate considering the adoption of EEMs and to compare different investment opportunities once the decision of intervention has been made. Also, VAs may help in this step. Whilst the government has a major responsibility in fostering public subsidies and VAs, the energy suppliers and the company, together with technology suppliers and IAG are also relevant actors. In the installation phase (sixth step), behavioural issues emerged as major troubles. At the same time, committed staff and technical support are the highest ranked drivers. According to the respondents, staff with real ambition is the main stimulating factor in the installation period, able to reduce the behavioural barriers. Whilst motivated staff may increase firm's efficiency, technical help provides support to the real implementation of the new EEM, aiding the staff with the start-up phase. Interestingly, while technical support is mainly related to installers and technology suppliers, the promotion of staff with real engagement is a firm responsibility.

Of course drivers could also have a secondary effect on other barriers rather than the highest ones. For example, clarity of information is very effective on information-related barriers, but has also secondary impact on awareness, behaviour, and technology-related obstacles. Interviewees have also pointed out that some drivers have influence on almost every barrier, like energy auditing and sub-metering, knowledge on non-energy benefits, and collaboration with external actors, although not being listed within the highest ranked drivers.

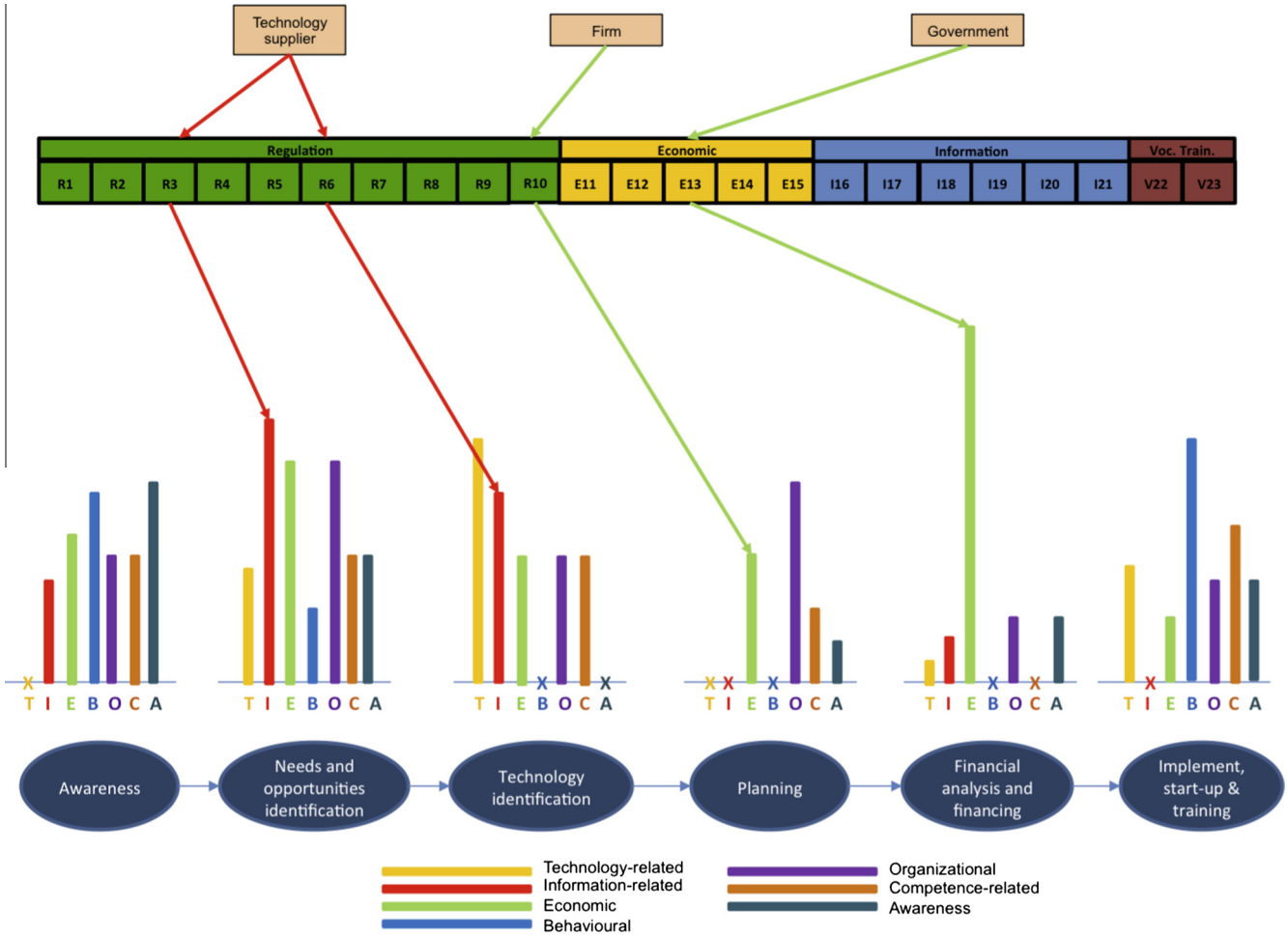

Fig. 5. Different mechanisms of barriers, drivers, actors and decision-making process. In particular, same actor promoting different drivers to act on the same barrier on different decision-making steps (in red); and different actors promoting different drivers to act on the same barrier on different decision-making steps (in green). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

To summarize, the investigation allowed us to understand the relevance of firm itself, as well as external actors, which was evident in particular regarding the first (and most troubled) steps of the decision-making process. On the one hand, the firm itself has often the power to activate the drivers in several decision-making steps. On the other hand, regarding technology suppliers, they emerge in all the decision-making steps as main actor responsible for different drivers acting on the main barriers, sometimes in collaboration with other actors (installers, energy suppliers, and government).

5.2. Analysis of other actors

When we look at the other actors involved in the study (i.e. governmental and industrial organisations), results show a substantial agreement on the fact that the financial crisis is holding firms back from new investments in general, and even more if energy efficiency is not considered as an urgent matter. Beside this agreement, even a general common understanding of the barriers is disputed, and the ranking of barriers differs from what is indicated by the studied SMEs. As a first example, only the involved national IAG does not deem competence-related issues as relevant (similarly to SMEs). This could be explained by the fact that the IAG is in charge of guaranteeing skills and knowledge about the sectorial activities, therefore deeming its own activity as sufficient. The other investigated actors, nonetheless, evaluate competence-related barriers of enterprises as a primary issue. Secondly, the national energy agency does agree with firms on the importance of 'lack of awareness', but this opinion is not shared by the IAGs.

The position of the main barriers on the decision-making steps is clearly quite inconsistent with that of firms (see Fig. 6). As an example, the IAGs (either national or local) believe that the highest barriers are found in the last step, when real implementation happens. Nevertheless, they have completely opposite opinions on the most suffered barriers: the national IAG cites organisational, technology-related, economic, information-related barriers, whilst the local IAG highlights the others, i.e. behavioural, competence-related, awareness barriers. Additionally, we found a misalignment in the perception of the most critical decision-making steps. In fact, according to the external actors, technology identification (step 3) and installation (step 6) represent the most critical steps, while step 2 and 5 are most critical according to firms. This means that external actors just highlight where problems are seen, and not where the problems are generated. This misalignment might really affect the effectiveness of policies proposed.

When dealing with drivers to energy efficiency and the interaction between barriers, drivers, decision-making steps and actors, misalignments between enterprises and other actors are even more evident, as shown by the following two examples considering the two most important drivers perceived by firms (long-term energy strategy and clarity of information). The local IAG does not see energy strategy as a relevant driver. For the national energy

Table 10
Main actors responsible for drivers according to firms.

Driver	Actors												
	Firm	Tech. supplier	Govern.	Installer	Energy supplier	Client	IAG	Financial Instit.	Compet.	ESCO	Manuf.	Partner	Other
Clarity of information		S		W	w								
Efficiency due to legal restrictions			S										
External energy audit/submetering	w				w								
Green image						S							
Increasing energy tariffs			w		S								
Long-term energy strategy	S		w		w								
Technological appeal		w											
Trustworthiness of information		S			w								
Voluntary agreements			S										
Willingness to compete									S				
Cost reduction from lower energy use		w	w		w								
Information about real costs			w		w		S						
Management support	S												
Public investment subsidies			S										
Private financing								S					
Availability of information		S	w		S		w						
Awareness	S						w						
External cooperation							S					w	
Knowledge of non-energy benefits		S					w						
Management with real ambitions	S												
Staff with real ambitions	S												
Programs of education and training	S												
Technical support		S		S									

("S" = if the promotion is considered to be strong; "w" = if it is weak).

Table 11
Main mechanisms (decision-making step – barrier(s)–driver(s)–actor(s)) identified by firms.

D–M step	Main barrier(s)	Main driver(s)	Main actor(s)
1st	Awareness and behavioural	Long-term energy strategy	Firm
		Clarity of information	Technology suppliers
		Voluntary agreement	Government
2nd	Information-related	Clarity of information trustworthiness of information	Technology suppliers
			Technology suppliers
		Availability of information	Energy suppliers
3rd	Technology-related	Technical support	Installers + technology suppliers
		Trustworthiness of information clarity of information	Technology suppliers
			Technology suppliers
4th	Organisational and economic	Technical support	Installers + technology suppliers
		Long-term energy strategy	
		Management with real ambition	Firm
			Firm
5th	Economic	Public investment subsidies	Government
		Cost reduction from lower energy	(Technology suppliers + energy Suppliers + government)
			Firm
		Long-term energy strategy	Energy suppliers
		Increasing energy tariffs	IAG
		Information about real costs	Government
		Voluntary agreements	
6th	Behavioural	Staff with real ambition	Firm
		Technical support	Installers + technology suppliers

agency and local government this driver is important to tackle organisational and awareness barriers. According to the regional government, it tackles economic, organisational and technology-related barriers, whilst for the national IAG the information-related and behavioural barriers are important. The sampled SMEs believe this driver affects primarily economic barriers, followed by organisational and awareness barriers. Clarity of information is considered a strong factor among governmental institutions, whilst industrial associations deem it as marginal. Despite every actor being aware of its great potential in abating informative barriers, the effect on other barriers is disputed. Indeed, according to the national energy agency, also economic and technological issues could be tackled, whereas the local IAG and the regional government extend its action also to behavioural and awareness barriers.

Two additional comments regarding economic drivers are worth noting. First, the role of cost reduction from lowered energy use is deemed very important by the political institutions and less relevant by the industrial ones. Additionally, the role of public subsidies is disputed. In fact, according to IAGs, public subsidies have a marginal role, whilst for the governmental institutions they are quite important. Moreover, besides economic barriers, regional government and national energy agency believe that public subsidies are able to reduce technology-related barriers, whilst other actors strongly disagree on that.

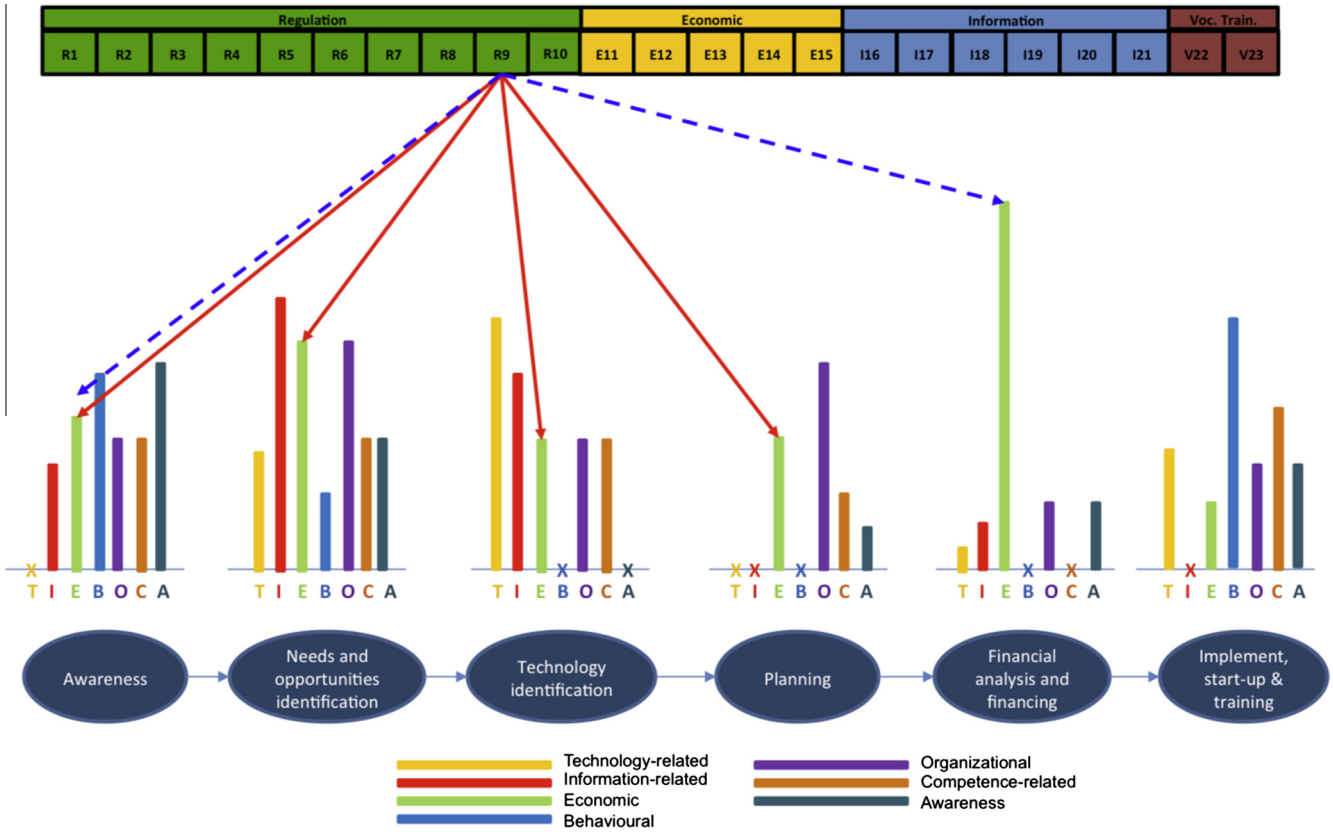

Fig. 6. Comparison of mechanisms of barriers, drivers, actors and decision-making process between firms (in blue) and the national energy agency (in red). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Finally, the analysis of drivers pointed out an additional interesting finding. External actors indicate as most relevant factors the ones that they can act on. For example, the national energy agency suggests VAs and subsidies as very important stimuli.

5.3. Alignment of voluntary agreements to drivers and barriers

If we take a closer look at the column for VAs (such as LTA3) in Table 5, we see that the design of the LTA3 is such that a host of barriers is addressed. Focusing on **behavioural** barriers: 'Lack of interest in energy efficiency' and 'other priorities' are supposed to be addressed by keeping energy on the agenda for companies, through compulsory energy efficiency plans and monitoring reports. 'Inertia' is addressed by showing opportunities, best practices and benchmarking information. This also helps to tackle 'imperfect evaluation criteria' and 'lack of sharing the objectives'. In theory, all behavioural barriers are covered. **Organisational** barriers are also incorporated in the original design of LTA3; 'Low status of energy efficiency' is addressed by keeping the subject on the agenda. 'Divergent interests' are prevented by sending information not only to energy coordinators, but also to management and use 'social pressure'. 'Complex decision chain' and 'lack of time' are addressed by providing information to energy coordinators.

Regarding **competences**, problems with 'identifying inefficiencies' are addressed by the obligatory energy balance in the EEP. The EEP also tackles the barrier of 'identifying opportunities' by an obligatory list of possible saving projects. Support for the barri-ers 'implementing interventions' and 'difficulty in gathering information' is provided by information on best practices. **Awareness** barrier is addressed by the same mechanism as behavioural barriers, namely by keeping energy on the agenda. One conclusion of the LTA3-evaluation was indeed that the LTA3-process has helped to raise awareness [39]. However, findings here show that awareness was not the most important barrier. Moreover, the importance of **economic** barriers by all respondents raises the question if the existing financial instruments are appropriate and sufficient. Most respondents in the LTA3-evaluation [39] claimed that cost savings are the most important reason to participate. A large majority of companies indicated that LTA-projects have been (very) profitable. However, about half of respondents indicate that they would have implemented those projects anyway, had LTA3 not existed [39]. As it is, the existing financial instruments focus solely on lowering the investment costs, not on other economic barriers. It would be advisable to investigate how the adjustment of the present financial instruments could lower other economic barriers.

According to Rezessy and Bertoldi [22], five conditions for successful implementation of VAs are needed: (i), ambitious, but realistic and quantifiable targets; (ii) a proper institutional framework; (iii) an evaluation mechanism; (iv) a credible and enforceable mechanism to discourage non-compliance; and (v) support for participants. According to Volkerink et al. [39], the design of LTA3 matched many of those conditions: there is a quantifiable target, a qualified supportive institution, an evaluation mechanism, support for participants and discouragement of non-participation. However, for three of these conditions, successful implementation is threatened. In particular:

- the targets do not seem to be very ambitious. The Energy Agreement has agreed upon company-specific agreements – thus meant to increase ambition levels –, but these are specifically meant for ETS-companies, so will not be relevant for most LTA3-companies;

- it remains unclear whether the threat of enforcement of the EMA is seen as credible, as in practice enforcement is rare. For this issue, the Energy Agreement has introduced an agreement to increase enforcement [27], but details still have to be agreed upon;
- customer satisfaction studies by the energy agency show that participants value the provided support, but fear that budget cuts will threaten proper support of the agreements.

Such issues may be responsible for the misalignment between the investigated SMEs and the national energy agency on the role of VAs and the corresponding pattern of action (Fig. 6). According to the sampled SMEs, VAs are of medium importance, whilst the national energy agency ranks this driver among the strongest. Moreover, the two patterns of action look pretty different. In conclusion, this kind of misalignment could give enterprises the perception of a minor relevance of the program (LTA3) promoted by the national energy agency.

6. Conclusions

Our exploratory study in the Netherlands among metalworking SMEs and the main governmental and industrial organisations aimed to analyse some mechanisms, i.e. which driver, promoted by which external actor, acts on a main barrier of a given decisional-step, and the different perceptions of the most relevant actors. Firm's responses reflected a very rational position. A structural alignment in views among enterprises could be observed, since they substantially agreed not only on the most relevant barrier in each step of the decision-making process, but also on the main drivers and the main actors responsible for them. The firm itself has often the power to activate important decision-making steps. Additionally, firm's suppliers, in particular those related to technologies and energy, sometimes together with other actors (installers, government) play a crucial role in all the decision-making steps as main actors responsible for different drivers acting on the main barriers. Nevertheless, when looking at the governmental and industrial organisations, results showed that a common understanding of the barriers is non-existent, as the interviewees only agree on the primary role of economic barriers. Mismatches appear when considering the mechanisms relating barriers, drivers, decision-making steps and actors. The most critical steps in the decision-making process according to governmental and industrial organisations do not correspond to those that emerged from enterprises' responses. This kind of misalignment may cause ineffectiveness of policies proposed by such actors.

Although the Dutch LTA3 appears to fulfil the conditions for a successful VA, their successful implementation is questionable. While companies agree on the high importance of a long-term energy strategy, they completely decouple the effect of a long-term energy strategy with the VAs impact on decision-making steps and barriers, even though the submission of an Energy Efficiency Plan in the medium-long term is included in the covenants. Although VAs represent the most popular energy policy on energy efficiency in the Netherlands, they do not seem to be considered by SMEs as a stimulus to improve energy efficiency. Despite the intention to address several barriers, the VAs seem to have little impact on the most important barrier (i.e. economic ones). Moreover, economic barriers are only partly addressed by other instruments. In conclusion, it is difficult to assess whether an energy efficiency project is implemented because of the agreements, or rather by autonomous initiatives.

Even though this study was focused on a small sector in the Netherlands and on a voluntary basis, we believe that the method could be applied to other sectors and to other policy instruments. Whenever a policy instrument uses a policy theory to impact specific barriers, our model could be used to test the policy theory.

As this is just an exploratory investigation, more extensive empirical work should be performed to generate further insights. We believe that future research should further investigate such issues, investigating the drivers for increased competitiveness and sustainability, as only scarce contributions in the literature can be found. In doing so, the difference between the design of the policy instrument and the perception by participants should be analysed. Such evidence could help external actors to fully understand the difficulties and needs of SMEs and thus develop the most appropriate policy instruments.

Furthermore, we believe that increased sample size – a limitation of this study – could provide more robust evidence of the various factors and mechanisms. Indeed, future efforts could be extended from Dutch metalworking SMEs other sectors, countries, regions, as well as firm size. Additionally, firm characteristics such as energy intensity, innovativeness, production complexity, market, supply chain position could affect enterprises' responses and therefore should be carefully considered by further research.

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