# 25 years of experiences with the voluntary agreement scheme for large industries in Denmark

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#### Abstract

Danish energy efficiency policy directed at the industrial sector took its beginning in the early 1990s. In 1990, the government launched an overall energy plan on how to reach its ambitious climate and energy policy goals. Analysis showed that cost-effective CO2-reductions could be achieved in the industrial sector, but governmental action was necessary to overcome several barriers. The Voluntary Agreement Scheme for Large Industries (VA scheme) was launched in 1992 as a central measure targeting the industrial sector. It has continued to be a central measure targeting industrial energy efficiency in Denmark until today. The basic principles of the VA-scheme laid down in the 1990s are still the same: Energy intensive industries can get a tax refund in return for signing a binding three-year agreement to implement energy management systems and energy saving projects with the Danish Energy Agency (DEA). The VA-scheme has resulted in documented energy savings in the large energy intensive industries in Denmark. Typically, energy savings in the companies in the average of 11/2 per cent a year can be attributed to the VA-scheme.

The success of the Danish VA-scheme is caused by a variety of reasons. First, the VA-scheme has been administered in a dynamic manner. The scheme has changed and has been significantly developed over the last 25 years while the basic mechanisms have remained the same. The drivers have been political decisions and also to a large extend experiences gained through evaluations of the VA-scheme, analysis of developments in energy consumption and potentials for energy savings in industry. The development of energy efficient technologies and solutions has also played an important role. Secondly, the VA-scheme has had a strong technical approach and set strict requirements to the participating companies on which focus areas to address etc. DEA is responsible for administering the VA-scheme. Throughout the past 25 years, DEA has maintained close dialogue with all stakeholders resulting in a broad understanding of regulatory requirements as well as business challenges.

#### Introduction

Denmark has a long tradition of leading an active energy policy. Numerous actions have been taken to reduce energy consumption by increasing energy efficiency and the share of renewable energy backed by a broad political support from the Danish Parliament. In 1990 the Danish Government launched the Plan of Action for Sustainable Development - Energy 2000. The plan outlined how Denmark was to reach its ambitious climate and energy goal - a reduction of CO<sub>2</sub> emission by 20 per cent in 2005 compared to 1988. As a result of the action plan a CO<sub>2</sub>-tax on energy was introduced in Denmark in the early 1990s. In order, not to burden the competiveness of the energy intensive companies it was decided that companies could get a CO2-tax refund if they carried out energy audits. The combination of tax reductions and a request to implement energy saving projects has existed since. Some adjustments have been made over time, but the basic idea still exists 25 years later. This paper will describe and discuss why the Danish VA-scheme still has success through a description of experiences and with a focus on achievements, the role of authorities, various technological focus areas, etc.

# The principle of the Danish Voluntary Agreement Scheme

In 1992 the basis of the Danish Voluntary Agreement Scheme (VA-scheme) was laid down. It was a result of the introduction of a  $CO_2$ -tax and the possibility for some energy intensive companies to get a  $CO_2$ -tax reduction (a subsidy for payment of the tax) if energy efficiency audits were carried out. Since, the VA-scheme has been amended several times, mainly due to changes in taxation structures and to conclusions of various evaluations of the scheme.

The first major change came in 1996, due to an increase in energy taxes. In 1999 the VA-scheme was extended with the possibility to include energy for space heating. The next big change entered into force in 2010, as a result of the fact that energy taxes on fuel in industry was reduced to a minimum EU limit. This meant that the VA-scheme shifted focus from energy savings for all energy sources (i.e. electricity, natural gas, oil etc.) to address merely energy savings in companies' electricity consumption (which was still covered with taxes).

From 2013 to 2015 the VA-scheme didn't enter into force until the current version entered into force in September 2015 with a minor adjustment in December 2016. The current VAscheme subsidizes electricity-intensive companies' payment of electricity tax (the PSO-tax).

Over the years, the energy tax reduction has varied, depending on end use of energy (i.e. heavy processes, light processes, space heating and electricity) and the type of energy. The variation has been between approximately 10 per cent to more than 20 per cent compared to companies not covered by the VAscheme. In the present VA-scheme companies get a subsidy of approximately 30–50 per cent of the PSO-tax. The full PSO-tax varies, but was 0.03 Euro per kWh (DKK 0.23 per kWh) in average in 2016. In 2016 the subsidy rate was 0.013 Euro per kWh (DKK 0.1 per kWh).

Companies eligible to the VA-scheme have changed slightly over the years. In the current VA-scheme eligible companies must belong to a sector defined to be both electricity and trade intensive in accordance with the European Commissions' Guidelines on State aid for environmental protection and energy 2014–2020. Approximately 120–130 companies have or are about to enter an agreement with the DEA. Approximately half of these companies have had an agreement earlier and some even from the very start of the VA-scheme. The companies in the current scheme have a total yearly energy consumption of 52 PJ, representing approximately 60 per cent of total energy consumption in Danish manufacturing industry, and approximately 8 per cent of total final energy consumption in Denmark (climate adjusted).

The key element in the VA-scheme has always been and still is the agreement on energy efficiency. An agreement between a company and DEA<sup>1</sup> is a binding contract between an authority and a private company. If the company ceases to fulfil the contract the subsidy/reduction of the energy tax will not be given. The agreement lasts for a period of maximum three years.

One company can enter an agreement alone or with a group of companies with similar production and energy conditions. A collective agreement is typically made with an industrial trade organization. This possibility is especially interesting for small and medium-sized companies (SMEs).

#### HOW TO ENTER AND MAINTAIN A VOLUNTARY AGREEMENT (VA)

Due to the fact, that it is a voluntary scheme, the companies must apply to enter it. The steps from the company apply for subsidy/tax reduction to entering and maintaining a Voluntary Agreement (VA) is explained in this section.

- 1. The company applies for entering the VA-scheme using a specific application form.
- 2. The DEA evaluates and approves the application. If the company is eligible for subsidy, DEA will give the company a conditional commitment to subsidies. The condition is that the company must prepare for and enter the VA within a specific time limit of maximum up to ten months.
- 3. The DEA notifies the Danish TSO<sup>2</sup>, Energinet.dk.
- 4. Energinet.dk monitors the companies' electricity consumption (and pays the subsidy based on the conditional commitment of subsidy). The subsidy in the current scheme is based on the total, measured electricity consumption of the company.
- 5. The companies prepare for entering the VA with DEA by:
  - a. Implementing an ISO 50001 certified energy management system. The energy management system must be certified before the VA-scheme can be entered.
  - b. Carry out a broad screening of energy efficiency opportunities, which will identify potential energy saving projects and special investigations. The result of the screening is a screening-list and a plan of action, which is a part of the agreement. The screening-list and the action plan must follow the format prepared by DEA. Thus, the description of the energy efficiency projects and the special investigations will include information about the potential energy savings, the investment, and the payback time. All projects with a payback time up to five years must be included in the action plan.
  - c. Describe the energy policy and concrete objectives of the company.
- 6. The company and the DEA negotiate and sign the VA. Often the scope and ambitions of the special investigations are subject to negotiations.
- DEA gives the company a final commitment to subsidies/ tax reduction. The commitment lasts for three years from the date of the application.

<sup>1.</sup> The Danish Energy Agency is a governmental authority. It was established in 1976, and is an agency under the Ministry of Energy, Utilities and Climate. The Agency employs about 400 people. The Danish Energy Agency focusses on matters relating to energy production, supply and consumption, as well as Danish efforts to reduce  $CO_2$ -emissions. The Agency is also responsible for supporting the economic optimisation of utilities, which in addition to energy includes water, waste and telecommunication. The Danish Energy Agency is also responsible for user conditions, supply obligation and telecommunication statistics as well as water supply and waste management.

<sup>2.</sup> Transmission System Operators.

- 8. DEA informs the TSO, and they continue to monitor electricity consumption and pay subsidies to the company.
- 9. The company maintains the VA by:
  - a. Undertake energy efficiency measures.
  - b. Maintain the energy management system.
  - c. Conduct special investigations
  - d. Report to DEA a yearly report on the plan of action (including an update with new projects), the energy consumption (both electricity and other energy consumptions), progress on special investigations, audit reports from ISO 50001 certifying body etc. In addition to yearly reports a final report must be send to DEA at the end of the VA.
- 10. DEA monitors the companies' reports and finally approves them.
- 11. By the end of the agreement period the company can apply for a new agreement, and a new negotiation process starts.

#### THE OBLIGATIONS OF A VA

The agreement comprises a number of obligations for the company to fulfil, which form the basis of the energy efficiency activities in the company. Before signing the agreement some of the obligations are negotiated between DEA and the company whereas others are non negotiable.

The obligations are the following, which will be explained in more detail below:

- Implement and maintain an ISO 50001 certified energy management system
- Implement energy saving projects with a simple payback time up to five years
- Carry out special investigations (analysis of savings in difficult areas)
- Report to DEA.

The company must implement an energy management system before entering into an agreement. Since 2011 the energy management system must be certified according to the ISO 50001 standard (and before that EN16001). It also includes some additional requirements from DEA regarding energy efficient design and procurement as well as requirements to the technical knowledge of the certifying body, i.e. a technical expert<sup>3</sup> must be a part of the yearly, physical energy audit at the production facility of the company. The energy management system must target all significant energy matters in the company, even though the subsidy is only related to the electricity consumption in the present scheme.

As part of the energy management system an updated energy audit must be carried out at least once a year. Before entering the VA the company must carry out an energy audit in order to find all profitable energy saving projects, i.e. projects with a simple payback time up to five years. The payback time is calculated based on energy prices including energy tax in absence of an agreement. The company must make a plan of action in order to implement these projects within one year<sup>4</sup>. As part of the yearly energy audit the company must find new energy saving projects and implement them within the next year and so on throughout the agreement period. The action plan is a part of the signed agreement. As the present VA-scheme is focusing on electricity, it is only mandatory to carry out projects with relevance to electricity savings, whereas other energy saving projects also can be part of the agreement. Former VA-schemes were focussing on both electricity and other energy saving opportunities. The ISO 50001 certifying body including the technical expert must approve the action plan before it is finally approved by DEA.

In addition to the energy management system and the energy saving projects with a payback time up to five years the company must carry out a number of special investigations as a part of the agreement. The purpose of the special investigations is to identify energy saving projects that require more detailed or in-depth analysis than normally covered in an energy audit. For collective agreements part of the special investigations are typically carried out by the trade organization or in collaboration with two or more companies to lower the costs and to share the knowledge gained in the process. Furthermore, the results of a special investigation must be shared with other companies in the collective agreement. If a special investigation shows possibilities for profitable energy savings, i.e. with a payback time up to five years, the project has to be implemented. The requirements for the special investigations including the technological focus areas have changed over the years. The change of the requirements for the special investigations will be discussed in the next section.

Throughout the agreement period the companies must report on different matters to DEA. The purposes of the requirements for reporting are multiple. One purpose obviously is to secure that the companies meet the requirements in the agreement. Thus, they must provide a yearly report on energy consumption, development of energy performance indicators, progress on implementing energy saving projects including the special investigations, a new energy action plan for the coming year etc. The certifying body must approve the report, typically as a part of the yearly energy audit. The company must also report on the energy management system. Another purpose of reporting is for DEA to collect specific and general information regarding energy consumption and energy savings incl. saving potentials in the industry to evaluate and develop the VA-scheme, produce general energy saving information, develop new policies etc.

The VA-scheme has been evaluated several times since the start in the early 1990s – those include both evaluations carried out by private, independent consultants as well as evaluations made by DEA. The development of the VA-scheme is to a

<sup>3.</sup> Under the agreement scheme, DEA operates a competence scheme with nominated energy consultants and nominated technical experts for selected technologies (by example furnaces, distillation columns, boilers and steam systems, dryers and evaporators etc.).

<sup>4.</sup> Implementation of all identified energy efficiency projects with a payback up to five years is a strict requirement, but first it should be explained that companies achieve a significant tax reduction participating scheme, and secondly, a comprehensive grant scheme for energy efficiency investments are operated by DEA and provides significant economic support.

broad extent based on these evaluations. The evaluations show, the fact that companies in the VA-scheme in average obtain energy savings of five per cent in an agreement period. This paper will not go into details about the evaluations, but describe and discuss the development of some of the central elements in the VA-scheme and the lessons learned.

# The different phases of the scheme and how it has developed

As described above, the VA-scheme has changed and been developed over the last 25 years. Political decisions have driven these developments such as changes in energy taxes and a continued focus on upholding the competitiveness of industries and ease the administrative burden.

To a large extent, however, the development has been driven by the experience gained through evaluations of the VAscheme, analysis of the development of the energy consumption, and changes in potentials for energy savings in industry. Another important role is contributed to the general development of energy efficient technologies and solutions as well as experiences gained in the most ambitious companies in the scheme.

This section will describe some of the lessons learned and explain the development of two essential areas in the VA-scheme. Energy management system as a tool to ensure energy savings are achieved on a daily basis and in the long term, as well as during the ongoing process of changing the technical focus areas.

#### ENERGY MANAGEMENT SYSTEM AND ADDITIONAL REQUIREMENTS

In the beginning of the 1990s the VA-scheme was based on energy reviews, i.e. the companies had to carry out energy reviews and implement the identified energy saving projects to get the  $CO_2$  tax refund. However, this approach had some difficulties due to the fact that it needed specially trained staff or experts to find energy improvements in large companies with complicated processes. At the time, Denmark had a lack of experts and companies were not satisfied with the energy audits, which in some cases lead to problems with getting the tax reduction.

On the other hand, it appeared that external experts could provide useful knowledge in less process-intensive companies where energy consumption was dominated by well-known and well-described processes (e.g. cooling, ventilation, lighting, etc.). For large companies the early experiences showed that management focus and energy management systems were necessary measures to achieve energy savings.

Based on the early experiences management focus and energy management systems became a central part of the VAscheme from 1996. From now on implementing an energy management system according to guidelines set up by DEA became mandatory in order to get the tax reduction.

The first version of energy management was drafted by DEA and DEA was responsible for the approval of certifying bodies.

A few years later the accreditation of the certifying bodies was handed over to DANAK (the Danish Accreditation Fund). In 1999 the first Danish energy management standard, DS 2403 was launched as a key element in the VA-scheme. The DS 2403 standard was based on the principles of the European environmental standard EMAS. In 2009 the European energy management EN 16001 replaced the Danish standard. And since the international energy management standard, ISO 50001, was launched in 2011. It replaced the European standard in the VA-scheme.

It is the experience from the Danish VA-scheme, that the certified energy management system combined with some additional requirements are needed in order to ensure energy efficiency in industry. Thus, companies in the Danish VA-scheme have to fulfil a number of additional requirements in accordance with the guideline from DEA (DEA, 2015), i.e. energyefficient design and procurement, special investigations and yearly audits of the energy management system including a technical expert.

The annual energy audit must be carried out in relation to the ISO 50001 standard and must include a broad screening of energy efficiency opportunities. The screening must be documented in a screening-list including possible energy saving projects with a simple payback time of up to eight to ten years. The screening-list will form the basis of an action plan for the coming year containing at least all the energy saving projects with a payback time up to five years. The screening list must be updated regularly, at least once a year in relation to the energy audit. Thus, a new action plan must also be produced.

There are no absolute requirements of how the screening should be done. Experience has taught us, that many companies investigate only conventional areas. It is thus a requirement that participating companies investigate both conventional energy saving areas as well as new areas. In order to guide and inspire companies in areas to take into consideration when carrying out a broad screening a simple tool is included in the requirements specification (DEA, 2015).

The screening approach illustrated in Figure 1 has proven very well suited for inspirational workshops in VA-industries and covers approaches most often not considered in traditional energy audits.

#### DEVELOPMENT IN THE TECHNICAL FOCUS AREAS

Described below are some examples of technical focus areas under the Danish VA-scheme – all focus areas developed in close cooperation with VA-industries via pilot- and demonstration projects.

#### The "Onion Diagram"

Initially (early 1990s) the technical approach of special investigations in the Danish agreement scheme was quite traditional addressing utility plants like boilers, steam distribution, compressed air etc.

The results of the first evaluations of the scheme showed a relatively low success in terms of implemented energy efficiency projects, which can be explained by the fact that energy consumption in energy intensive industries first of all is bound in production processes. Only limited energy consumption is found in traditional utility systems.

This experience gradually developed the technical approach in the scheme, primarily in order to engage management in developing an energy efficiency approach in each company, secondly by developing the "Onion Diagram" as an analysis tool to apply when carrying out energy audits in energy intensive industries.

The "Onion Diagram" was originally introduced for energy efficiency purposes as a part of process integration studies



Figure 1. Inspiration tool for energy screening (DEA, 2015).

(BREF and O'Sullivan and Petersen, 2012), but was refined and expanded under the VA-scheme, see Figure 2.

The diagram aims to target all aspects of energy efficiency from the "energy service" specified by the basic planning and design parameters to "operator behavior". It is divided into steps in seemingly logical order to establish a structured approach to energy efficiency. A comprehensive example of the use of this diagram is found in (O'Sullivan and Petersen, 2012).

#### **Energy Efficient Design**

One of the lessons learned from the use of this approach was the fact that the most central energy efficiency aspects in an industrial plant at best should be addressed during the design phase of new facilities if the full energy saving potential should be realized. Following this experience, comprehensive methodology studies were carried out (F.R.I., 2001) and guidelines and tools for application of energy efficient design was developed. Comprehensive pilot projects were implemented demonstrating energy saving potentials in large industries of up to 30 per cent or even more compared to current design practices (O'Sullivan and Petersen, 2012). This approach has later been adopted and expanded under the Irish program for large industries (SEAI, LIEN), and a regular Irish standard for energy efficient design was published in 2015 (SEAI, IS399).

Use of such EED is still an additional requirement in the VAscheme. Companies must demonstrate the fact that all major new investments are designed according to best practice in terms of energy efficiency and that Danish guidelines have been used. The experience is, that such an approach is not addressed fully in energy management standards.

#### Productivity

Another important development initiated during 2000–2002 was to allow companies in the VA-scheme also to address productivity projects as a part of the agreement with DEA. A pilot project (DEA, 2003) demonstrated significant overlaps in methodologies and approach of by example LEAN-tools and the "Onion Diagram" described above, by example:

- Methodologies for mapping energy consumption are to a wide extent similar to mapping value streams (VSM) in productivity projects.
- A focus on KPIs is an important focus area in energy management systems as well as in productivity projects.
- Customer value and core qualities in productivity projects are to a wide extent similar to the approach of the "Onion Diagram".
- Continued improvements are a cornerstone in energy management systems as well as in LEAN.

The experience was also that even in large companies huge energy losses can be caused by idle operation of process plants and utility systems, see Figure 3.



Figure 2. The "Onion Diagram" (O'Sullivan and Petersen, 2012).



Figure 3. Operational hours for large processing plant.

- 20 % of operational hours are cleaning
- 30 % of operational hours are recirculation
- 50 % of operational hours are processing

Figure 3 shows processing hours for an oil filtration plant in the VA-scheme, where only 50 per cent of running hours are used for processing of products. The remaining time the product is recirculated or the plant is cleaned – in both cases with significant energy consumption for pumps, vacuum systems, heating etc.

A LEAN & energy-team addressed these energy losses in the facility and gained significant progress regarding increasing the amount of production time and minimizing cleaning and recirculation. Figure 4 shows how the specific energy consumption (kWh/ton) of the plant developed by increasing OEE (Overall Equipment Efficiency) for the plant.

This pilot project was of inspiration for many other companies under the Danish agreement scheme and from the period 2005-2010, more than 100 special investigations of LEAN/productivity/energy were carried out addressing reduction of the specific energy consumption in companies.

A range of the agreement companies based on these conclusions have chosen to anchor energy management systems in their LEAN-organization as the productivity teams have comprehensive experience in using EnPIs and follow up on deviations in consumption data in order to stimulate "continued improvements" – a cornerstone also in ISO 50001.

#### Utilization of waste heat and heat pumps

A final example of focus area addressed under the Danish VAscheme is utilization of waste heat – either internally in the companies or externally for district heating purposes in nearby cities with district heating networks.

Surveys (Viegand Maagøe, 2013) have identified large potentials for utilizing waste heat in most industrial sectors and especially when heat pumps are applied for upgrading heat to a satisfying temperature level.

DEA have defined "waste heat utilization" as an obligatory opportunity to include as special investigations and during the period 2008–2015 more than 100 comprehensive assessments have been carried out according to requirements defined by DEA.

Figure 5 shows an example of a detailed mapping of cooling and heating requirements in a food facility. Figure 5 is developed from a careful mapping of all process streams in the facility and provided the basis for a heat pump project which the company later implemented, resulting in saving of more than 30 per cent of their energy bill.

#### Inspirational catalogues

The areas described above are examples of technical focus areas promoted by DEA over the years. Specific investigations and the character of these have been defined over time in order to stimulate energy efficiency projects of a decent quality in the companies.

An important conclusion from the Danish VA-scheme is the fact that such a scheme must be dynamic and new focus areas must continuously be promoted to "push" the companies to address new saving potentials.

ISO 50001 is a strong methodology platform for systematic energy efficiency work, but it is the experience that a majority of the agreement companies tend to be very conservative in their approach to energy efficiency and as a result must be inspired and sometimes also pushed to carry out the right assessments.

#### The authority's management principles

Besides the companies and DEA the main stakeholders in the VA-scheme are Energinet.dk, DANAK, the certifying bodies, technical experts and energy consultants.

It has been and still is important for DEA to be aware of a continuous development of the VA-scheme and improvements of the administration of the scheme, thus, it is important to invite central stakeholders to participate in an open dialogue etc. This has been achieved through various approaches.

Within DEA a small, specialized, and dedicated team was (and still is) established to administrate and develop the scheme. This team has provided DEA with its own resources to negotiate and – if necessary – adjust agreements. It has also focussed on reviewing progress reports from companies etc.

The certification of companies' energy management systems, the companies draft agreement text, and the annual control of the agreement companies have been outsourced to external, accredited certifying bodies within energy management systems (ISO 50001). DEA have a close dialogue with both DANAK and the certifying bodies where regulations and their interpretation are discussed and experiences are shared.

In the early start of the VA-scheme an energy consultant competence scheme was developed in order to support industries with competences within energy efficiency of industrial processes and utility systems. This scheme still operates and approximately 60 very experienced energy consultants are active today. DEA is chair of the board of the scheme. The technical experts are typical members of this scheme (http://energisynskonsulent.dk).

DEA has also continuously sought close dialogue with industry in order to understand priorities and new agendas for integrating energy efficiency activities with company life. For certain periods, an industrial advisory board was formed to guide DEA in developing the VA-scheme into new areas. Furthermore, DEA initiated informal knowledge-sharing groups among large companies. These groups are still active and meet regularly meetings – often with DEA as a participant.

It has been crucial for DEA to uphold this continuous close contact to companies; as well in regards to better understand-



Figure 4. Specific energy consumption for processing plant with increased availability (OEE).



Figure 5. Temperature requirements for heating and cooling in a food industry.

ing progress and barriers towards success of the scheme as well as to develop/change requirements and recommend focus areas as new lessons have been gained.

Beside the dialogue with stakeholders frequent evaluations of the VA-scheme have been carried out by independent parties, i.e. private consulting companies. This has been done in order to assess achieved energy savings, cost efficiency, and new barriers towards continued success of the scheme.

A range of supportive measures have been applied by DEA to develop and secure the success of the VA-scheme. Some examples are technical guidelines, fact sheets, and case-stories. A range of surveys and assessments have also been carried out to establish a database for industrial energy use. For example, surveys of energy saving potentials, review of experiences from special investigations, and analysis of potentials for use of renewable energy.

From close cooperation with industries and industrial experts, the primary lesson learnt, is that supportive measures targeting the industrial sector should take into consideration that industries usually do not have the time to read and apply comprehensive guidelines, information materials, and case stories. Supportive measures have been planned by DEA to identify new focus areas and to inspire industries to initiate new steps within energy efficiency. However, the aim has also been to inspire energy consultants and utility companies to find new ways of developing their business.

#### Results from continued evaluations of the scheme

Since 1996 until today more than 250 companies have been part of the VA-scheme for a shorter or longer period. Today 120–130 companies have entered an agreement of which about half have had an agreement earlier.

The VA-scheme has been evaluated several times with different approaches. In order to analyse the energy savings achieved as well as other benefits from the VA-scheme the yearly reported data from companies have formed a valuable information base.

In 2005 (COWI, 2005) an evaluation showed the fact that companies participating in the agreement scheme in average saved 5.5 per cent of their energy consumption in the period 1996–1999 and in average 4.8 per cent in 2000–2003. In 2013 (HHS Teknik, 2013) an evaluation showed the fact that the av-

Evaluation made by		COWI, 2005	HHS Teknik, 2013	Andersen and Petersen, 2017
Period covered by evaluation		1996–1999 2000–2003	2006–2011	2010–2013
Final energy consumption, DK	PJ	666	633	611
Energy consumption, total manufacturing industry	PJ	113	96	85
– share of DK energy cons.	%	17	15	14
Energy consumption, VA-companies	PJ	58	45	59
- share of manu. industry energy cons.	%	51	47	69
- share of DK energy cons.	%	9	7	10
Obtained energy savings	PJ	2.8	2.4	3.3
- share of energy cons., VA-companies	%	5	5	6
- share of energy cons., manu. industry	%	2	3	4
- share of energy cons., DK	%	0.4	0.4	0.5

Table 1. Energy consumption and savings obtained by the companies in the VA-scheme. The achieved results, based on the three evaluations.

erage energy saving was 5.4 per cent in the period 2006–2011. In 2017 (Andersen and Petersen, 2017) an evaluation showed an average energy saving from 2010 to 2013 of 5.7 per cent of the companies' energy consumption, which corresponds to about 3 per cent of the total energy consumption of the entire Danish industry sector (except refineries).

These calculations are based on annual reports, which companies have sent to DEA and in the evaluation from 2005 (COWI 2005) supplemented with interviews of a number of companies. The 2005 and 2013 evaluations concluded the fact that more than half of the achieved energy savings could be attributed directly to the VA-scheme while others must be considered as "free-riders", i.e. energy saving measures, which the companies would have carried out in absence of the VAscheme.

In regards of the present VA-scheme DEA has made a first, not verified and concluding, analysis of the plan of action from 90 companies. This shows that more than 500 energy saving projects will be carried out within the coming year. Data from around 400 of these projects predicts a total energy saving potential of approximately 200.000 MWh and an investment of 33 mio. Euro (DKK 250 mio.).

The evaluation from 2017 also contains an analysis of which technical areas the energy savings have been implemented. Approximately 650 projects in 100 companies have been analysed and the result shows the fact that more than half of the energy savings have been achieved in the production processes, which are traditionally a difficult area to get companies to implement projects within. However, the vast majority of projects – more than 500 – are in relation to other areas, i.e. cooling, ventilation, compressed air systems, lighting etc. The evaluation also shows that the companies tend to invest in energy savings with a relative short payback time as the majority of the projects have a payback time of less than two years. Compared to an analysis of the potential of energy savings in industry in Denmark (Kromann, 2015) it shows that there is a continuous potential for energy savings in industry.

With this knowledge in mind, DEA reviewed the requirements of the present VA-scheme and is now more aware of the payback time of the projects. Based on the above mentioned analysis of the present VA-scheme, approximately 75 per cent of 400 projects in the action plans have a payback time of more than two years. And 25 per cent of projects have a payback time of five years or more.

Even though the companies in the VA-scheme get a tax reduction and save energy the costs for being in the scheme must be considered before companies decide to join. To fulfil the obligations internal time must be allocated to manage energy management systems and certification costs must be expected. Furthermore, fees for external specialists must be expected for most companies. For most energy intensive companies these costs, however, are much smaller than the economic benefit (tax relief). Nevertheless, it is and has been an important focus area for DEA to ensure, that the administrative burden for the companies are at the lowest possible level.

In 2008 (Togeby, 2008) an independent analysis of the socioeconomic level of all energy efficiency measures in Denmark concluded, that the VA-scheme was by far the best energy efficiency measure.

#### Conclusions

25 years of experience from Denmark show that a VA-scheme is a very effective measure to achieve energy savings in industry. The Danish VA-scheme targets large energy-intensive industries. The current VA-scheme is representing a yearly energy consumption of 52 PJ, corresponding to 8 per cent of the final Danish energy consumption and 60 per cent of energy consumption of the Danish manufacturing industry.

Evaluations based on the reported energy saving projects show, that the companies have saved 5 per cent of their energy consumption in different agreement periods since mid-1990s. Analysis shows a continuous potential for more savings. It is also the experience that overall requirements of implementing and operating an energy management system according to ISO50001 is not necessarily enough to operate a cost-efficient agreement scheme delivering a significant amount of  $CO_2$ -reductions. Private companies tend to find the most "easy" way to fulfil requirements and the ISO50001-standard can be read in many ways. The key-points and recommendations from the Danish case are:



Figure 6. Evaluation of socioeconomic costs for various energy efficiency measures in Danish Energy policy (Togeby, 2008). "Energimærkning af bygninger": Energy Labeling of Buildings; "Bygningsreglementet": Building Code; "Elsparefonden": Electricity Saving Trust; "Energimærkning af apparater": Energy Labeling of appliances; "Krav om energibesparelser i det offentlige": Energy savings in public buildings; Energiselskabernes aktiviteter": Utility Companies' saving activity; "Aftaleordningen": the VA-Scheme. Bars with a value less than 1 equals that the measure has a socioeconomic benefit. The lover score, the higher the socioeconomic benefit.

- In order to deliver energy savings a VA-scheme must set requirements to companies, for instance detailed instructions and requirements towards which energy saving projects to implement.
- To get companies to join the scheme, i.e. to meet the requirements and achieve significant savings, it must comprise a strong economic incentive like tax reduction.
- A well-managed VA-scheme requires a dedicated team at the managing authority for continued follow-up, control, and development.
- An agreement scheme should regularly be evaluated to assess achieved results, cost efficiency, and barriers towards improving energy efficiency by independent parties.
- The responsible authority should take lead in identifying and developing new approaches, findings, and technologies, and these should be promoted continuously via pilot and demonstration projects if successful.
- Development of an agreement scheme requires close dialogue with industries and industrial experts to understand new agendas, challenges, and ways to integrate energy efficiency activities with company life.
- Surveys and data platforms are crucial to identify energy saving potentials and manage priority of new focus areas.

These key points are often referred to as a combination of "carrot and stick".

## References

Andersen, Ulrik Vølker and Petersen, Peter Maagøe, Viegand Maagøe A/S. 2017. "Energispareprojekter i aftalevirksomheder – evaluering af 4-års projekter indrapporteret for perioden 2010–2013".

- BREF, The "Onion" (Venn) diagram is described in the BREF document, see http://eippcb.jrc.es/reference/ene.html
- COWI, 2005. "Evaluering af aftaleordningen om energieffektivisering 1998–2003".
- Foreningen af Rådgivende Ingeniører, F.R.I., 2001. "Energibevidst Projektering, Metodebeskrivelse"
- HHS Teknik, 2013, "Vurdering af aftaleordningens effekt på grundlag af indberettede data".
- Kromann, Mikkel; Kragerup, Henrik; Dalsgaard, Mette, COWI. 2015. "Kortlægning af energisparepotentialer i erhvervslivet".
- O'Sullivan, John, SEAI and Petersen, Peter Maagøe, Viegand Maagøe A/S, 2012 "Energy Efficient Design – A Methodology Applied in Major International Projects", paper 2-016-12 presented at eccee Industry in 2012.
- SEAI, IS399, http://www.seai.ie/Your\_Business/IS-399-Energy-Efficient-Design-Management/
- SEAI, LIEN, http://www.seai.ie/LIEN-Report/
- Technological Institute, Competence Scheme, http://energisynskonsulent.dk/
- The Danish Energy Agency. 2003."Produktionsoptimering, logistik og energieffektivitet" (Report on

productivity and energy efficiency).

- Togeby, Mikael et al. Ea Energianalyse, Niras, RUC og 4-Fact, 2008. "En vej til flere og billigere energibesparelser Evaluering af samtlige danske energispareaktiviteter".
- The Danish Energy Agency. 2015. "Aftaler om energieffektivisering mellem elintensive virksomheder og Energistyrelsen – Kravsspecifikation" (The DEA requirements specification to the companies in the present VAscheme).
- The Danish Energy Agency, 2015 "Temahæfte Energieffektivisering med LEAN"
- Viegand Maagøe A/S. 2013. "Analyse af mulighederne for bedre udnyttelse af overskudsvarme fra industrien".