

# PInE

## Final Report on Auditing Activities

Deliverable 4.1

March 2015

[www.PInEaudit.eu](http://www.PInEaudit.eu)



Co-funded by the Intelligent Energy Europe  
Programme of the European Union

---

*The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.*

---



# Contents

- 1 Introduction..... 4
- 2 Methodology ..... 5
- 3 Experiences..... 8
  - 3.1 Austria..... 8
  - 3.2 Bulgaria ..... 9
  - 3.3 Cyprus ..... 11
  - 3.4 Italy ..... 12
  - 3.5 Romania..... 14
  - 3.6 Slovakia..... 15
  - 3.7 Spain ..... 16

# Figures

- Figure 1: Steps of an energy audit according to EN 16247 ..... 5

# Tables

- Table 1: Technical partners ..... 7
- Table 2: Sectors audited in Austria..... 8
- Table 3: Sectors audited in Bulgaria ..... 9
- Table 4: Sectors audited in Cyprus ..... 11
- Table 5: Sectors audited in Italy ..... 12
- Table 6: Sectors audited in Romania ..... 14
- Table 7: Sectors audited in Slovakia ..... 15
- Table 8: Sectors audited in Italy ..... 16

## 1 Introduction

The European Commission has stated that energy efficiency has to be increased at all stages. By publishing the Energy Efficiency Directive, the EU has already produced a guideline for all the Member States in order to reach future energy saving targets. The consumption should be reduced by 20 % of the projected energy use in 2020, and by 27 % or greater by 2030 (European Commission, 2015).

Studies show that about 80 % of the industry induced global greenhouse gas emissions are from energy use and that energy efficiency measures have a high potential for cost-effectively mitigating industrial greenhouse gas emissions (Worrell et al, 2009). The efficient use of energy is linked to a number of benefits in different areas. Besides positive effects such as energy security, resource management, and employment it provides economic benefits by reducing the energy bills. Furthermore, the reduction of energy demand and emissions respectively has influence on the climate and local air pollution.

The project PInE dealt with increasing energy efficiency in industrial SMEs establishing a cross-sector, large-scale system, based upon auditing schemes and the subsequent provision of professional technical advice for the implementation of customized measures. The optimization of energy input requires detailed knowledge of the energy flows which are linked to the production processes. As a basis for the definition of improvement suggestions to reduce the energy demand, an analysis of the current energy consumption has to be done.

After the scouting phase of the project, which identified the potential for action through preliminary audits in a number of SMEs, the technical partners in Austria, Bulgaria, Cyprus, Italy, Romania, Slovakia, and Spain have analysed and audited 140 companies into more detail. These detailed audits, which were dealing with modelling the structure of the current energy demand and finding numerous recommendations to reduce the consumption were based on the PInE Audit Tool which was developed at the very beginning of the project in order to assist the auditors in carrying out an in-depth analysis.

In total **33,600** MWh final energy can be saved as a result of the performed energy audits and identified measures to increase the energy efficiency in producing SMEs. This savings exceeded the project goal. This report gives an overview of the activities performed in relation to the auditing phase of the project. A brief description of the used methodology for the detailed audits is presented and followed by a description of the activities carried out in the single regions.

## 2 Methodology

To get a better overview of the steps and contents of the performed energy audits,

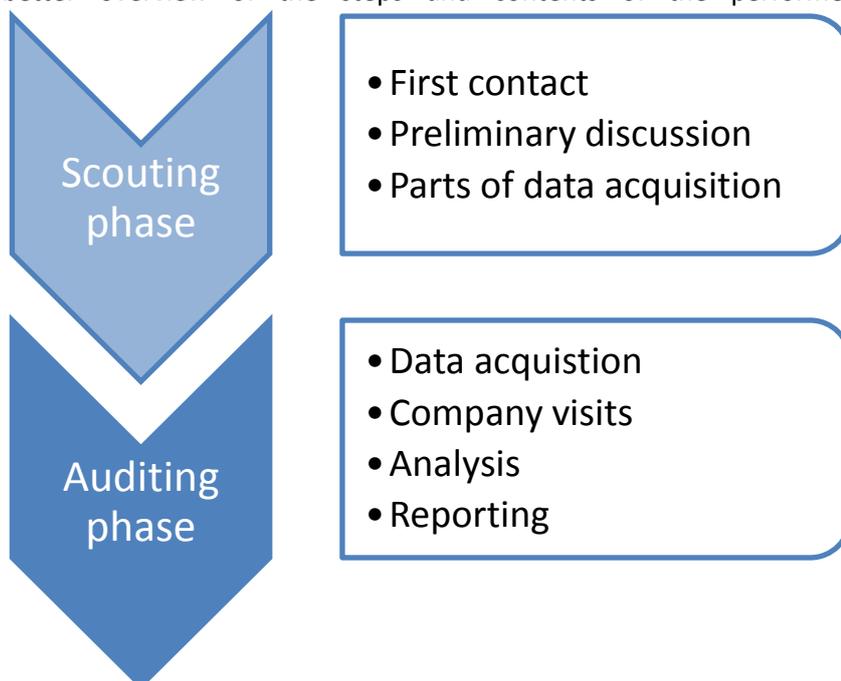
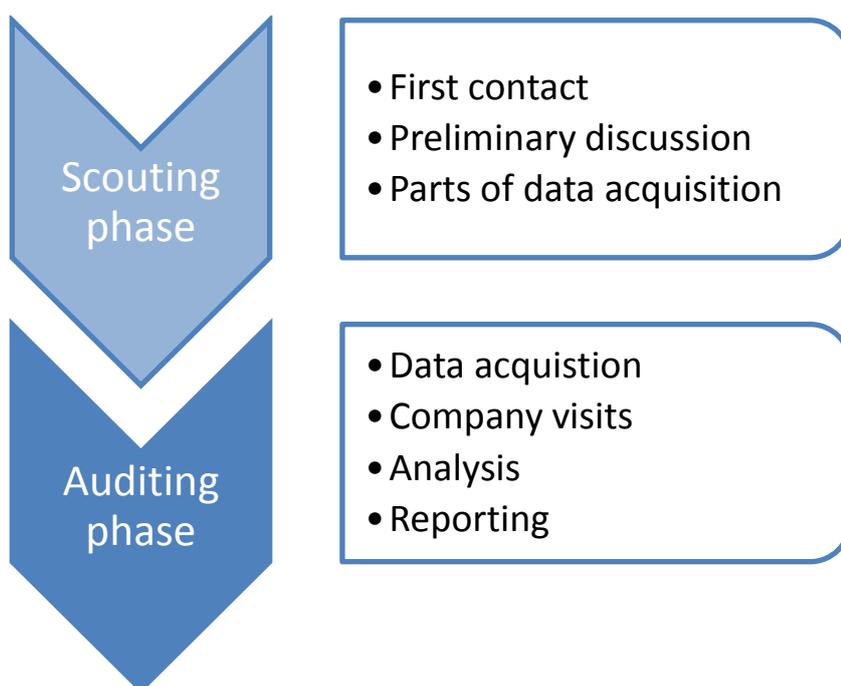


Figure 1 shows the single stages of the two main phases of the PInE project. The single stages are similar to the ones in the European Standard 16247 part 1 which is dealing with energy audits. Unfortunately, the standard was published only in July 2014, therefore parts 2 to 4, which deal with requirements for auditing buildings, processes and transport are not yet considered in the PInE format. The PInE auditing format focuses mainly on processes. Buildings are also included. Transport is not analysed in detail.

The PINE audit consists of two stages, a scouting phase and a detailed audit phase (figure 1).



### Figure 1: Steps of an energy audit according to EN 16247

The basis of the scouting phase was a brief interaction with the company, including a short walkthrough, on basis of which the scouting tool is filled in. The tool generates a report with suggestions and a rough estimate of potential savings. On basis of the scouting phase, which identified the most motivated companies with the highest potential for energy savings, the technical partners of each participating country contacted the relevant companies and informed them about the contents of the detailed audit.

The full audit is based on the preliminary data collection of the scouting phase. During the auditing phase, the PinE Audit Tool, which was produced in the very beginning of the project, was used to assist both the external auditors (technical partners) and the persons in charge at the companies in collecting the energy specific data on-site by company visits and at the desk.

Before the detailed audits were performed, the project partners were trained by the project partners who established the assessment tool. The PINE Audit Tool consists of a set of worksheets, which on the one hand deal with qualitative energy related questions which have to be answered according to the companies energy related characteristics (energy management) and on the other hand offers the possibility to enter all relevant data of the single energy consumers. On basis of the entries in the tool, the structure of the current energy demand of the company is calculated and illustrated.

As already stated in the guidelines which were defined by the project partners in the very beginning of the project, the focus of the full audits was on the:

- Detailed analysis of costs for electricity and heat and efficiency of use;
- Written documented analysis of consumers accountable for at least 80 % of energy consumption (regarding technology used, operational procedures, control) using the PINE guidebook as reference and the PINE webpage for reference measures;
- Wherever necessary and helpful, metering of specific energy consumption system will be performed to gather data;
- Performed these audits together with an internal auditor, who was qualified to carry on with the improvement process after the end of the PinE audit;
- Focus not only on main production process, but also on infrastructure and premises.

In addition to the PinE Audit Tool, the auditors used other tools such as metering devices to collect process or plant specific energy data. Methods or tools like Sankey diagrams, which illustrate the energy flows according to the size of the flow, or thermodynamic calculations, were applied wherever feasible in order to receive a better overview of the energy situation. For example, methods like pinch analysis, which assists in determining the optimum heat quantities of single processes, was also used if applicable. The analysis of the collected data and the current energy situation of the company is an important step of the auditing phase. It dealt with the definition of improvement suggestions. The experience of the technical partners in the field of energy analysis resulted in a large number of recommendations.

After analysing data on consumption, identifying points of potentially inefficient use of energy and deriving suggestions for improvement the auditors prepared a report for each company. The technical partners reported to the company about the current energy demand and included suggestions for corrective measures, estimations of costs and calculations of simple payback periods, comprehensive recommendations to decide upon implementation, and identified potential funding sources. The companies were asked to give feedback to the quality, adequateness of effort and the perceived usefulness of the service by filling in questionnaires.

Some of the suggested improvements which were elaborated during the PInE project are:

- Building refurbishment (exterior walls , windows , top floor ceiling )
- Installation of a heat recovery system at air compressors
- Detect parasitic consumers and reduction of the base load
- Heat recovery and maintenance at/of chillers; Use free cooling function of the chiller plants
- Isolation of the pipes and connections in the boiler room and the production area
- Changing the whole system by making use of district heating instead of oil
- Exchanging inefficient lighting systems
- Reduction of compressed air leakages
- Installation of a photovoltaic plant
- Using smaller motors and variable speed control
- Preheating of the combustion air
- Improved control of the heating system
- Monitoring of the natural gas demand for painting and hot water
- Making use of more daylight
- Exchanging v-belts by direct drives
- Isolation of the upper ceiling to reduce heat losses
- Reduce idle and operation time
- Increase the product capacity
- Install double glazed windows to reduce energy demand for air conditioning in summer and heating in winter
- Installation of a power factor correction

The participating SMEs had the opportunity to sign an agreement of confidentiality in the very beginning of the project. The agreement was fully honoured at all stages, and data is reported only with the written consent of the companies or in an aggregated way.

The goal of the project and the auditing phase respectively was to perform 140 detailed audits in small and medium enterprises in 7 European countries. As 140 companies were audited, this goal was reached. The total savings which were reached and will be implemented are about 23,290 toe primary energy. Compared to the original goal of 3,085 toe, the goal was outperformed.

Table 1 shows the participating countries and the corresponding technical partners. The technical partners were responsible for carrying out the detailed audits.

**Table 1: Technical partners**

Country	Technical partner	Contact
<b>Austria</b>	STENUM GmbH, Energieagentur Obersteiermark GmbH	<a href="http://www.stenum.at">www.stenum.at</a> <a href="http://www.eao.st">www.eao.st</a>
<b>Bulgaria</b>	REAP	<a href="http://www.reap-bg.eu">www.reap-bg.eu</a>
<b>Cyprus</b>	Stratagem	<a href="http://www.stratagem.com.cy">www.stratagem.com.cy</a>
<b>Italy</b>	AREA	<a href="http://www.area.trieste.it">www.area.trieste.it</a>

<b>Country</b>	<b>Technical partner</b>	<b>Contact</b>
<b>Romania</b>	IPA	<a href="http://www.ipa.ro">www.ipa.ro</a>
<b>Slovakia</b>	TUKE	<a href="http://www.tuke.sk">www.tuke.sk</a>
<b>Spain</b>	CIRCE	<a href="http://www.fcirce.es">www.fcirce.es</a>

### 3 Experiences

The following section deals with the companies and experiences of the national auditors made during the project. This section shall give a brief overview of the key features and practical experiences made during the energy audits.

#### 3.1 Austria

In Austria, the 20 analysed enterprises are from different sectors with different company sizes. Since the scouting of the companies was done by the Styrian chamber of commerce, most of the companies are situated in the federal state of Styria. Table 2 shows the sectors and accordingly the number of companies which were audited in Austria.

**Table 2: Sectors audited in Austria**

Sector	Companies
Mineral and mining industry	4
Food and beverages	8
Metal industry	6
Others	2

Most of the companies were audited by two external auditors. Depending on the size and complexity of the production processes, some companies required additional visits. Generally, the average time spent for an energy audit cannot be determined easily, since the required effort for the analysis depends on several factors. The factors include amongst others the size and complexity of the company, the level of data quality which is already available, the commitment of the management and the employees, and the experience of the internal auditor. Another fact worth mentioning is that many companies were kind of irritated by the new energy efficiency law in Austria. During the project time, it was not clear to the companies which activities they have to take (with respect to whether or not to do external audits, whether or not there would be an obligation to report measures or results of implementations to the authorities, etc.). Furthermore, some companies considered to withhold reporting several measures to be able to demonstrate savings also in the upcoming years, since they will be obliged to present savings each year.

The recommended improvements varied according to the sector, but some suggestions like the exchange of the existing lighting by more efficient installations, or the insulation of pipes to reduce heat losses was applicable in all investigated sectors. The companies prefer improvement measures with a payback period less than two years, but some managements (mainly “smaller” companies) also accept rather longer payback periods. The reason for this is mainly the company philosophy and the company owner’s attitude towards sustainable development. Generally, the motivation to implement energy saving measures seems to be strongly dependent on the respective company management and the internal philosophy.

In addition to the analysis of the companies’ energy systems by the PiNE Audit Tool, the Austrian auditors also used detailed checklists, from other programmes (like klima:aktiv), installed power

clamps to measure the actual power consumption of single plants and processes, drew Sankey diagrams to illustrate processes and parts of processes, took infrared pictures to detect possible thermal losses, and did exhaust gas measurements to investigate potential inefficiencies of combustion processes.

The results of the additional measurements were very useful in investigating the current energy situation on the one hand and to investigate and prove possible savings to the company. Another fact worth mentioning is that some companies already have installed metering systems to record different parameters such as process specific temperatures or load curves, but they do not use the data to analyse and reduce the energy demand. Most companies state that the time resources for dealing with the recorded data is limited, and therefore, a lot of potentials which could actually be worked out internally without the need for an external auditor are not discussed at all. Furthermore, it seems that the level of knowledge to analyse data sets regarding energy loss is limited, but again depending on the company philosophy.

The PINE audits have shown that there is always a potential for reducing the energy demand of companies, even if they have already been very active in reducing the energy consumption in the past.

### 3.2 Bulgaria

In Bulgaria, half of the assessed companies belong to the metal and electro technical industry. As in the other countries, the 20 companies have been selected among 40 industrial SMEs which were contacted during the scouting phase. The selection criteria were:

- Identified energy saving potential
- Willingness of managerial staff to collaborate during auditing procedure
- Realistic potential to implement the proposed energy saving measures within a three-year period

The selected companies have a total of 2,858 employees and they are operating in traditional Bulgarian economic sectors. Table 2 lists the single sectors analysed in Bulgaria.

**Table 3: Sectors audited in Bulgaria**

Sector	Companies
Chemistry	3
Food and beverages	3
Electrotechnical, Electronics	4
Metal industry	7
Others	3

According to the feedbacks and the experience of the auditors, the work in Bulgaria was structured well, and there was good collaboration between the scouting and the auditing organisations, as well as between these two project partners and the audited companies. The scouting organisation

initiated contacts with more than 40 industrial SMEs and collected the initial information, which was needed to estimate companies' energy saving potentials. Both partners selected the 20 SMEs with highest energy saving potential and REAP had to proceed with the collection of a more detailed energy data for the part of detailed audits. A number of energy saving measures was prepared for every SME. The measures were listed and discussed with the management teams of the respective companies. Then second versions of the lists of measures were prepared – a shorter version with fewer measures, which has been approved for implementation. We call the first list – “Long list”, while the second list of measures – “Short list”. The measures from the Short lists will be implemented within the next 3 years by every participating company. The key point in this successful model was the active collaboration which we received from management teams and energy experts working in audited SMEs who collaborated with REAP and NEST at every step of the PInE model implementation.

Talking about challenges in Bulgaria, the responsible organisations faced problems which were related mainly to the collection of detailed energy data needed for audits. It was difficult to collect data for energy consumption for past periods in some companies, while in other cases it was difficult to collect energy data for separate technological production lines or separate energy intensive equipment. Another obstacle was the insufficient number of measuring meters.

By using data loggers, the electricity consumption was registered for a period of 24 hours under a normal production load. This approach was applied also to different production lines, and separate machines with large energy consumption. With the assistance of experts from companies the period that equipment is running idle was established. By measuring current load, the real maximal and minimal load of most energy intensive machines were registered. The power factor was measured as well in order to assess performance of the system for compensation of reactive energy. A thorough inspection was carried out of lighting systems in order to find energy saving potentials. The performance of energy-transforming units (boilers, compressors, etc.) was also inspected. A production analysis in terms of energy consumption was carried out in every company. All collected data was compared with data from invoices for supply of electricity, natural gas and boiler fuel. After that, by carrying out an analysis, the efficient use of energy carriers and energy saving potentials were determined.

The Bulgarian partners are going to offer PInE style energy audit on a contractual basis with industrial enterprises. This means the following approach: it is intended to work together with potential SMEs, offer them an audit, support them during application phase, and ask them to reimburse the expenses of the auditors once they are approved for funding by the OP 'Energy Efficiency in SMEs'. This OP is a specific Programme which is being implemented by Bulgarian Government and it aims to increase competitiveness of Bulgarian enterprises. It provides funding up to 75% for different actions. Some actions might be: energy audits, implementation of EE and RES measures, etc. It will be functioning at least until 2020.

### 3.3 Cyprus

In Cyprus, the project partners have chosen a variety of companies, but the majority belongs to the food sector (such as wineries, dairies, soft drink factories, sweets factories). In addition, SMEs from the paper, plastic, and metal sector were audited. Concerning their sizes, there is a big range of the number of employees. It ranges from 3 employees up to 178 employees, and apart from the largest and the smallest companies, the average was about 29 employees for each company.

**Table 4: Sectors audited in Cyprus**

Sector	Companies
Food and beverages	13
Paper	3
Metal	1
Others	3

Regarding measurements done and the suggestions made, the Cypriot technical partners concluded that the optimisation of the lighting had a significant energy saving potential in every company. Therefore, each company was suggested to improve their lighting, especially by replacing their existing lamps with LED lamps. Other important suggestions concerned either the voltage optimisation (which was proposed to 8 out of 20 companies and saves a potential amount of 10% on their total consumption), or the installation of Photovoltaics (which was proposed to 12 out of 20 companies).

After the SMEs were contacted, a meeting with the technical manager and a date for the energy audit was arranged. During the audits, the partner used the PiNE Auditing tool to collect relevant data. The time required for each company was varying. It was mainly depending on the size and complexity of each factory. On average, it took about one to two full working days for completing each audit. The cooperation of the technical managers was something that could be seen as a problem, because in some companies it was extremely hard to get some company specific data and some technical managers could not provide us with relevant information (manual of equipment, data sheets). Thus, the Cypriot partner had to make the audit on a very detailed level to collect all data, which was very time consuming.

Another problem the auditors faced was that almost all companies asked for a funding to make technical changes, because they were reluctant to spend money for energy savings due to the economic crisis and related risks. Though the measures were also evaluated financially, and some of the improvements would have paid back rather early, single enterprises were not willing to invest for energy saving.

Concerning the equipment and tools used and to collect all necessary data, watt meters, polymeters with clamp rings, infrared thermometers, and lux meters were used. The lux meters were very useful in relation to measurements of the light intensity, and as already stated, the exchange of the existing lighting leads to high potentials in all assessed Cypriot companies.

### 3.4 Italy

In Italy, the energy audits have started with the selection of the 20 SMEs, agreed between CONFAPI and AREA Science Park. Most of the companies are in the metal sector, producing steel coil and wire, steel structures, steel fixtures, metal furniture and nets. A second relevant cluster is food, including production of bread, cakes, processed meats, chocolate and wine bottling. The size of selected companies ranges from around 70toe (primary energy) for the smallest ones, to over 2.000toe for the largest.

**Table 5: Sectors audited in Italy**

Sector	Companies
Chemistry	2
Food and beverages	5
Mechanical	2
Metal industry	8
Others	3

AREA Science Park started the activities in WP4 in month 23 (February 2014), some months later than originally scheduled (month 17) due to delays in the preliminary audit phase (WP3).

Auditing activities followed the methodology developed during the project and the initial delay has been recovered, thanks to an efficient schedule of company visits that involved appropriate preparation and grouping company visits by region.

The recommended methodology requires distributing the worksheets to the companies, to be filled in before the actual visit. Only a few companies responded with sufficient data.

The main measurements taken during the company visit are temperatures (using thermometers and thermography), proved to be useful to identify on energy wastes or possible sources or heat recovery. A remarkable lack of data on energy consumption is common to all companies involved in WP4. The main sources of information on energy consumption are the data available through the energy bills, and only a few companies had regular readings and submeters installed.

Energy savings have been calculated using the “PINE Audit tool” (the spreadsheet developed in WP2) to analyse data on the overall consumption of heat and electricity, monthly load profiles. Three specialized spreadsheets have been developed, and integrated in the PInE Audit Tool, in order to assess the following features:

- linear regression analysis of electricity consumption data
- linear regression analysis of fuel consumption data
- ORC (Organic Rankine Cycle) waste heat recovery

An in-depth analysis of monthly data provided some additional information on consumption patterns, while load curves on hourly basis were used to identify base loads, power peaks and more

detailed patterns. In Italy load curves are generally available, but none of the companies had used such data as a basis for energy efficiency.

Four companies provided sufficient data to develop a Linear Regression based on 12 months time series from the general meters, temperature and production volumes. Linear regression proved to be a powerful tool to overcome the lack of energy consumption data, providing a clear insight on energy use within the company, therefore a good basis to identify priorities for energy efficiency measures.

The energy audit reports were compiled and sent to the person in charge of the energy audit, followed by a telephone call to make sure that the report has been understood and implementation is ongoing.

The energy saving potential depends on the company size and the kind of energy efficiency measures that can be adopted. The smallest companies reported savings below 8 tep (corresponding to 15 tons CO<sub>2</sub>) It relative terms, such savings range from 1% of energy consumption, to 15% (or more in a few cases).

Compressed air was the single most common recommendation (almost all companies had at least one recommended action about compressed air, namely reduce excessive pressure, improve maintenance procedures, reduce air leakages, replace obsolete compressors and recover heat for building or process heating.

Electric motors showed significant energy saving potential in 13 companies, and the suggested action was to replace obsolete motors with new high efficiency motors (IE3).

The highest impact however is due to waste heat recovery in large companies using an ORC generator (Organic ranking cycle). 12 such actions were recommended and 6 are being implemented (or will be implemented within 3 years), for a total 289 toe primary energy savings.

During the implementation phase AREA has provided technical support, with some more company visits and, for the great majority of the companies, one or more follow up telephone calls with the person in charge of the energy audit.

A “customer satisfaction questionnaire” has been sent to all the 20 companies, to assess progress in implementation and customer satisfaction. Only 9 companies out of 20 completed the questionnaire, and 8 of them declared they are implementing the suggested actions. One of the companies reported that they will not implement the recommended actions due to excessive payback time, compared to the expected payback for investment in their sector (this is a common barrier to energy efficiency). The 11 companies that did not deliver the questionnaire have not been considered in the estimate of impact indicators.

### 3.5 Romania

In Romania, the largest part of the audited companies are producing building materials like autoclaved aerated concrete or bricks. The enterprises are located all over Romania. Table 6 lists the sectors which were analysed in Romania.

**Table 6: Sectors audited in Romania**

Sector	Companies
Building material	16
Wood	2
Food	1
Energy	1

Since there was a lack of measurement devices, most of the measurements could not be made during the visit, but fortunately a majority of the companies has already measured different relevant parameters in the past or during the project. The audits were done by two auditors most of the time. If needed, the companies were visited twice to complete the data. Besides the visits, the communication between the technical partner and the company representatives was done via e-mails and phone calls, especially if the company site was located further away.

As already mentioned, the audited organisations are located all around Romania, and therefore, the travel costs were varying strongly.

Besides the PiNE Auditing Tool, the Romanian technical partners used other manuals such as:

- “Modern principles of energy management” concluded in 2005 by the Technical University of Cluj Napoca and EnergoBit Cluj Napoca - Romania, within a project funded by the European Commission
- “Energy Audit Manual” - prepared by: NEW APPLIED TECHNOLOGY, EFFICIENCY AND LIGHTING IMITATIVE (NATELI), and COOPERATIVE AGREEMENT NO. 114-A-00 – 0 -00106 -00 (concluded in 2010);
- Support tables for various calculations related to energy consumption and estimates of expected savings
- Different sources for emission factors for electricity and conversion for fuels

Basically, in Romania it seems as if SMEs are rather hard to engage in this kind of activities and some of the persons in charge involved in the audits did not have accurate knowledge on energy efficiency. Additionally, the time resources for collecting data and dealing with the audit were often rather limited.

According to the experiences made in Romania, there are a few conditions that must be met in order to perform a successful energy audit:

- Sufficient time resources: including a specialist in company, as responsible person for energy efficiency (energy manager)
- Availability of measurement and control instruments, installed at the main consumers

- Efficient collaboration between the responsible persons in order to identify the most appropriate energy saving measures

The audits have shown that the PInE project and energy audits respectively have a high potential in assessing different kinds of improvement measures to increase the energy efficiency of Romanian SMEs. However, some companies were not aware that an energy audit requires support and a certain amount of time in order to collect data internally. Therefore, it took some effort to motivate some of the representatives, but in the end, all the data were collected and analysed in time.

### 3.6 Slovakia

In Slovakia, a number of different sectors were analysed during the PInE project. Table 7 shows the sectors and the number of companies respectively.

**Table 7: Sectors audited in Slovakia**

Sector	Companies
Textile	2
Food and beverages	2
Mechanical	6
Metal industry	6
Energy	1
Others	3

The measures which were proposed in Slovakia fully reflect the problems and requirements of SME owners. In 80 % of the companies, measures dealing with the reduction of heat losses of the buildings (additional insulation of envelope structures and replacement of windows) have been proposed. Further measures dealt with lighting systems aiming to reduce power consumption, in approx. 75 % of the companies. 60 % of the companies were consulted on "balancing (hydraulic regulation) of the heating system". The measures related to the exchange of heat sources (15 %) and exchange of electrical equipment and compressor units (approx. 10 % of companies) had only a small representation.

In two companies no measures have been proposed to reduce energy consumption, since the management of these enterprises were fully dedicated to reducing energy consumption already in the past and already use the waste heat from realized production processes to a maximum, as well as other available technologies for saving energy in every respect.

In the other two companies renewable energy sources are used. These companies have installed photovoltaic panels to produce electricity. They generate electricity at a price determined by the Regulatory Office for Network Industries for a contracted period and sell it to the public network,. However, owners in these two companies did not have data on operating costs of producing electricity by the installed photovoltaic panels.

TUKE used information provided by the companies and obtained during visits and interviews with workers. No additional measurements were done. The time spent for the audits was depending on the scale of the processes and actions implemented by the companies (approx. 25-35 hours per company).

Own calculation procedures were used for each audit. It was elaborated according to national standards and rules, aimed at determining the heat demand for heating buildings (calculation according to STN EN 13790), the heat demand for hot water, but also for the purpose of estimating the demand for electricity for lighting systems on the base of an operating time and desired light intensity. Furthermore, the electricity demand for air conditioning and ventilation equipment, compressed air, etc. was calculated.

Basic problems were faced during the auditing process. Those problems are related to the following areas:

- The figures on energy consumption and invoiced prices were given in most cases on an annual basis, but the PInE Auditing Tool requires primary data on a monthly basis to produce a monthly diagram. The consumption of thermal energy was obtained by recalculating monthly data based on degree-days for buildings, or by the technical requirements of single processes.
- A big part of the assessed companies have measured the energy consumption globally for the whole company. Some had the data available for each building of the company site. Some energy consumptions were assessed on the basis of the equipment requirements and estimated operating time, which was significantly problematic for modulating installations.
- In some cases it was complicated to collect data on the consumption and the actual operation time of the enterprise respectively. The audits performed during the PInE project do not meet the requirements of the national legislation of the Slovak Republic about energy auditing. Its output cannot be used to demonstrate compliance with a legislative requirement to be processed by an energy audit. However the practical proposal to reduce energy consumption was appreciated by the companies.

### 3.7 Spain

In Spain, the majority of the assessed companies belong to the food and beverages industry. Table 8 shows the single sectors analysed in Spain.

**Table 8: Sectors audited in Italy**

Sector	Companies
Graphic arts	3
Food and beverages	9
Plastics and cardboard	3
Metal industry	2
Others	3

The Spanish auditors used different tools to gather the data required for the illustration of the current energy demand and to identify improvement potentials. The tools included:

- Thermographic camera
- Grid measurement device for AC/DC measurements
- Luxmeter
- Exhaust gas composition meter
- Humidity sensor
- Flow meter

The Spanish partner has summed up some problems they were facing during the project:

- Too long time since the project started to the end of the audit
- Audit phase started in June and August was lost. Audits were made in just 4 months
- In most cases no single action provides great savings. It is usually a combination of actions to sum up savings
- Specific and critical process machinery were considered black boxes and therefore difficult to assess on a technical level
- Critical process parameters are untouchable for many companies. Therefore the recommendations mostly apply to the building and facilities
- No winter measurements were available as audits all have taken place in summer
- Lower consumption than actually reported was observed due to lower production volume from 2012 data
- Very high expectations from many companies proved a challenge to meet
- Too small, too smart issues were identified in most companies. The result was low savings per action, many individual actions, and relatively high investment involved

The following key success factors were identified:

- involve at least temporarily highly qualified and experienced staff per technology However, it was an issue for some companies complaining about too many involved different persons from the auditing institutions
- Work in collaboration with equipment supplying companies to identify the best market solutions and most precise quotations for investment return estimations
- measuring real and actual data to better assess consumption patterns and inefficiencies
- Despite August, constant and continuous contact with company representatives by means of visits and phone calls
- Adaptation to company needs. Focus on the areas suggested by the company for a greater satisfaction and faster achievements

CAC and CIRCE have signed a collaboration agreement to continue with the PINE auditing methodology in Spain. The agreement also includes other areas of collaboration where the close contact of local and regional SMEs provided by regional chambers will be completed with the expertise of CIRCE to help companies be more efficient. CIRCE will continue to give support and offer consultancy services to companies wishing to go further in their purpose of achieving higher degrees of efficiency and competitiveness. The implementation of an energy management system according to ISO 50001 is also part of this service offer.