PINE
Evaluation report on auditing activities

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1 General information

A monitoring system was set up in WP4, in order to account properly for the impact of PINE project, considering the following kinds of energy savings:

- potential savings, i.e. energy savings presented in the energy audit report
- actual savings i.e. energy savings due to actions implemented by the companies within the time frame of PINE project
- actual savings within 3 years i.e. energy savings due to actions planned within the time frame of PINE project, that will be implemented within 3 years in order to fit properly in the economic and financial planning of each SME.

In total, the full audits which were performed in the course of the PINE project resulted in almost 500 improvement suggestions to improve the energy efficiency of 140 European SMEs. The calculated technical savings (potential savings) are about 60,319 MWh or 16,912 tCO_2.

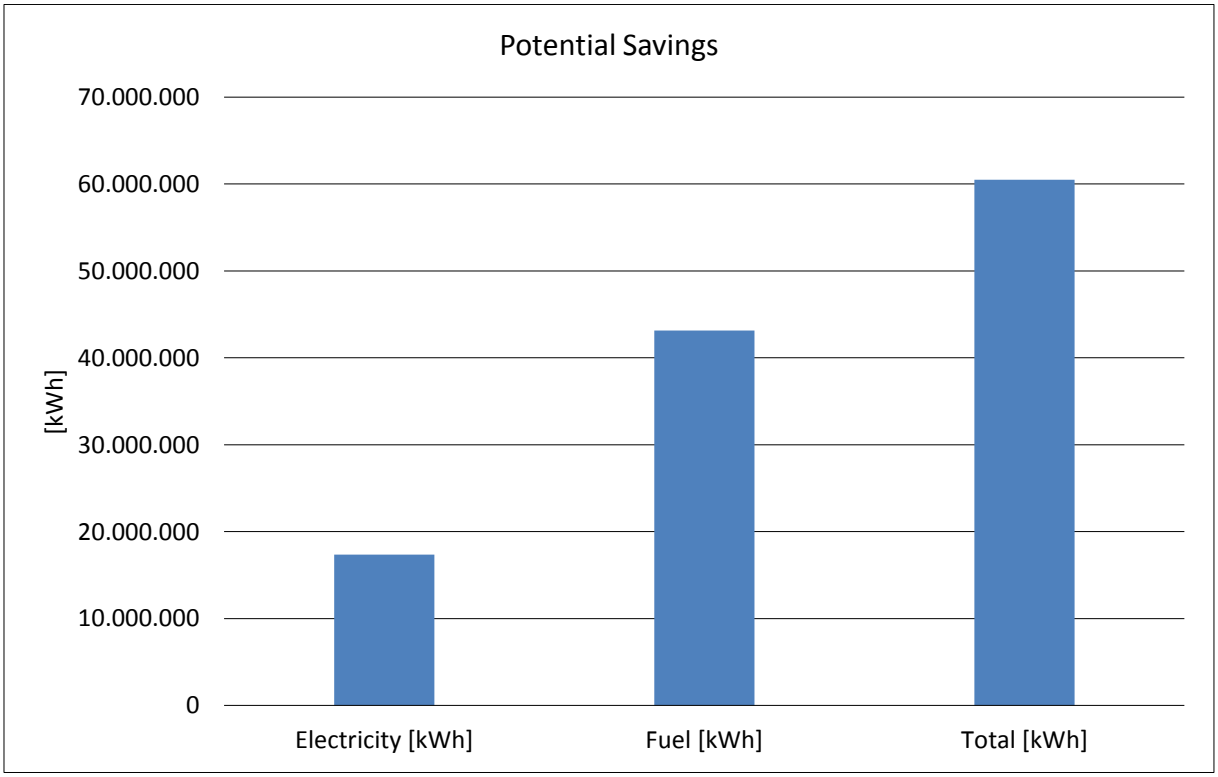

Figure 1 shows the share of the savings for each country. The fuel or heat savings amount for about 70% of the total energy savings. The reason for this might be twofold. On the one hand, a large part of the analysed SMEs are from sectors which require rather high amount of heat for their processes, and on the other hand, electricity is responsible for higher specific costs making savings more attractive at an earlier stage. About 70 percent of the recommended measures are already or will be implemented within the next 3 years. This corresponds to about 46,000 MWh energy per year.

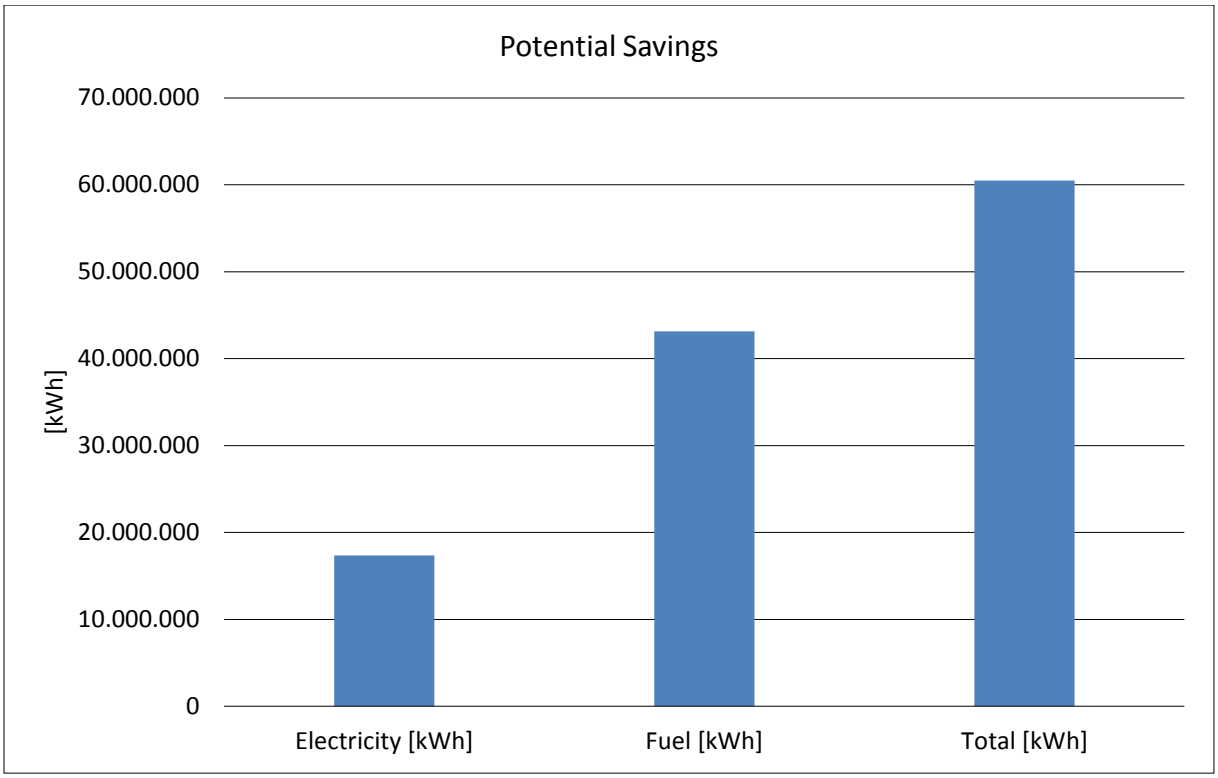

Figure 1: Potential energy savings

As a result of the PInE project, 10,753,000 EUR are invested in sustainable energy and energy efficiency. Table 1 shows the monetary savings and the percentage of energy reductions which are reached by the implementation of the improvement suggestions. The project leads to annual savings of more than 3 million EUR. Compared to the original situation, on average the savings are about 6.7 % of the energy cost of the SMEs.

Table 1: Monetary savings from measures implemented within the project period and within the next three years

Country	Savings [EUR]	Actual Savings [% of energy consumption]
Austria	1,004,000	29,1 %
Bulgaria	405,000	11,8 %
Cyprus	278,000	8,1 %
Italy	605,000	17,6%
Romania	493,000	14,3%
Slovakia	298,000	8,6%
Spain	363,000	10,5%
Total/Average	**3,446,000**	**100 %**

At the end of each energy audit, the technical partners of the project PInE collected feedbacks from the analysed SMEs. Besides questions on the quality of the PInE project, these feedbacks include all suggested improvements and according confirmations, which measures will be implemented.

Figure 2 shows the potential savings of the improvements which will not be implemented. According to the feedback of the responsible persons, the main reasons for not implementing the recommendations is the payback period and the investment costs respectively. Generally, payback periods beyond 4 years are not attractive to most of the company managements.

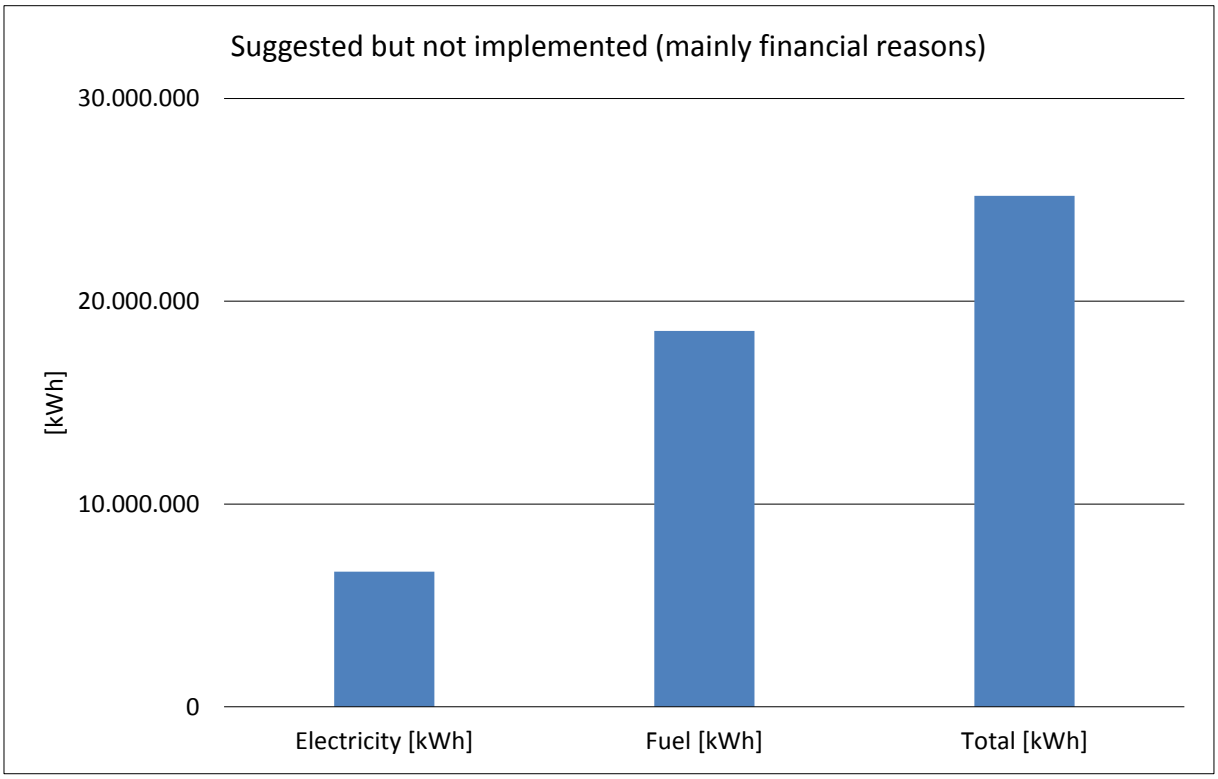

Figure 2: Potential energy savings, which will not be realised within the next three years

There are some improvements which are relevant in all or most countries. The optimisation of the lighting is responsible for about 20% of the potential electricity savings. Improvements dealing with compressed air have a potential of about 10% electricity savings, and the optimised use and installation of high efficiency drives has a total potential to save about 25% of the original electricity consumption. Other improvements, which are strongly dependent on the individual circumstances in each company, are dealing with the use of renewable energies, the installation of monitoring and control systems, reactive power compensation, replacement and exchange of single production plants, and many more.

For the fuel or heat savings respectively, heat recovery of production processes and building refurbishment have the highest potential with about 60% of the original heat demand. Especially for those two improvement types, it seems as if the investment costs are rather high leading to payback periods, which are not attractive for a lot of enterprises. Other relevant improvement actions are: isolation of the heat distribution system, improved control of the heating and boiler system, and reduction of heat losses at production steps requiring heat.

Generally, the types of recommendations and the related potentials for energy savings are strongly dependent on the sector the analysed company belongs to and its size.

Table 2 gives an overview of the savings in kWh and the percentage of the recommended actions which were not implemented due to the above mentioned reasons.

Table 2: Overview savings

	Austria	Bulgaria	Cyprus	Italy	Romania	Slovakia	Spain	Total
Potential SAVINGS								
Potential Savings Electricity [kWh]	2.685.633	3.047.624	981.370	4.363.700	2.201.663	445.270	3.652.492	17.377.752
Potential Savings Fuel [kWh]	12.043.700	7.542.937	0	4.826.168	8.778.479	8.518.709	6.615.550	48.325.543
Total [kWh]	14.729.333	10.590.561	981.370	9.189.868	10.980.142	8.963.979	10.268.042	65.703.296
Actual SAVINGS (3 years)								
Actual Savings Electricity [kWh]	1.625.172	1.983.322	981.370	3.021.500	2.128.703	376.060	2.128.703	12.244.830
Actual Savings Fuel [kWh]	9.872.700	6.899.685	0	3.436.888	1.350.000	5.600.159	6.615.550	33.774.982
Total [kWh]	11.497.872	8.883.007	981.370	6.458.388	3.478.703	5.976.219	8.744.253	46.019.812
SUGGESTED BUT NOT IMPLEMENTED SAVINGS								
Electricity [kWh]	1.060.461	1.064.302	0	1.342.200	72.960	69.210	1.523.789	5.132.922
Fuel [kWh]	2.171.000	643.252	0	1.389.280	7.428.479	2.918.550	0	14.550.561
Total [kWh]	3.231.461	1.707.554	0	2.731.480	7.501.439	2.987.760	1.523.789	19.683.483
SHARE OF NOT IMPLEMENTED MEASURES								
Electricity: Not implemented [%]	39,5%	34,9%	0,0%	30,8%	3,3%	15,5%	41,7%	29,5%
Heat: Not implemented [%]	18,0%	8,5%		28,8%	84,6%	34,3%	0,0%	30,1%
Total NOT IMPLEMENTED [%]	21,9%	16,1%	0,0%	29,7%	68,3%	33,3%	14,8%	30,0%

For each country, the applied conversion factor is 0.086 toe/MWh. The emission factors for heat are depending on the country and the fuel type. According to the individual electricity mix of each country, the saving potential was calculated by using the factors of Table 3.

Table 3: Conversion and emmission factors for electricity

Country	Conversion factor [toe/MWh]	Emission factor [toe CO_2/kWh]
Austria	0.19	0.21
Bulgaria	0.25	0.48
Cyprus	0.21	0.87
Italy	0.25	0.48
Romania	0.35	0.48
Slovakia	0.24	0.29
Spain	0.19	0.33

Table 4 shows the main results of the project. The “POTENTIAL” savings correspond to the amount of energy which could be saved if all suggested improvements would be implemented. “ACTUAL” savings exclude the measures which will not be implemented within the next three years. In addition to financial and technical reasons, in Italy, some companies did not hand back the feedbacks in time. Therefore, the potential savings of these companies are not included in “ACTUAL” savings. In some countries, the potential savings are much higher than the actual savings, since the potential savings include different options for the same improvement (e.g. building refurbishment with different materials), but the companies could only chose to implement one of the actions.

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Table 4: Main results

	Austria	Bulgaria	Cyprus	Italy	Romania	Slovakia	Spain	Total	Project objective	% achievement
Number of energy audits	20	20	20	20	20	20	20	**140**	140	100%
Number of customer satisfaction questionnaires	18	20	20	18	20	15	20	**131**	--	94%
Average customer satisfaction	88%	89%	92%	80%	90%	90%	84%	**88%**	70%	Ok
POTENTIAL: sum of all actions										
POTENTIAL Final Energy Savigns [toe]	1.267	911	84	790	1.304	771	454	**5.580**	2.172	257%
POTENTIAL Primary energy saving [toe]	1.540	1.411	207	1.506	1.519	1.102	890	**8.174**	3.085	265%
POTENTIAL GHG emission reduction [tCO2]	3.393	2.985	672	3.140	2.510	2.490	1.721	**16.912**	7.682	220%
POTENTIAL Investment sustainable Energy €	€ 699.451	€ 1.453.260	€ 1.186.000	€ 3.260.450	€ 1.187.650	€ 4.205.511	€ 4.264.911	**€ 16.257.233**	€ 700.000	2322%
ACTUAL: sum of actions that company implemented within project time frame actual/potential	57%	17%	5%	13%	44%	5%	20%	**27%**		
Final Energy Savings [toe]	771	87	4	72	589	34	110	**1.668**	2.172	77%
Primary energy saving [toe]	878	233	11	201	671	54	177	**2.224**	3.085	72%
GHG emission reduction [tCO2]	2.332	455	44	369	1.303	111	336	**4.949**	7.682	64%
savings €	€ 713.000	€ 93.000	€ 12.650	€ 109.000	€ 262.000	€ 23.000	€ 93.000	**€ 1.305.650**		
Investment sustainable Energy €	€ 130.000	€ 181.000	€ 15.000	€ 134.000	€ 477.000	€ 314.000	€ 363.000	**€ 1.614.000**	€ 700.000	231%
ACTUAL: sum of actions that company will implement soon or within 3 years actual/potential	88%	77%	100%	70%	86%	68%	85%	**80%**		
Final Energy Savings [toe]	1.106	764	84	555	1.100	514	375	**4.498**	2.172	207%
Primary energy saving [toe]	1.353	1.089	207	1.051	1.308	744	759	**6.511**	3.085	211%
GHG emission reduction [tCO2]	3.075	2.342	672	2.173	2.119	1.661	1.464	**13.506**	7.682	176%
Savings €	€ 1.004.000	€ 405.000	€ 278.341	€ 605.000	€ 493.000	€ 298.000	€ 363.000	**€ 3.446.341**		
Investment sustainable Energy €	€ 447.000	€ 724.000	€ 1.186.000	€ 1.598.000	€ 1.110.000	€ 3.253.000	€ 2.435.000	**€ 10.753.000**	700.000	1536%

2 Brief overview of the results of each participating country

The following figures present the outcomes of the most important results of each country. To offer a complete overview of the possibilities, the data used in the following graphs corresponds to the savings of all suggested measures including improvements which might not be implemented within the next three years.

2.1 Austria

In Austria, 25% of the analysed companies had an appointed energy manager, mostly the bigger companies. None of the SMEs in the audit had a certified energy management system.

Figure 3 shows that there was a positive correlation between specific cost of electricity and savings: the higher the specific price of electricity, the higher the savings potential identified. This correlation is not valid for fuel.

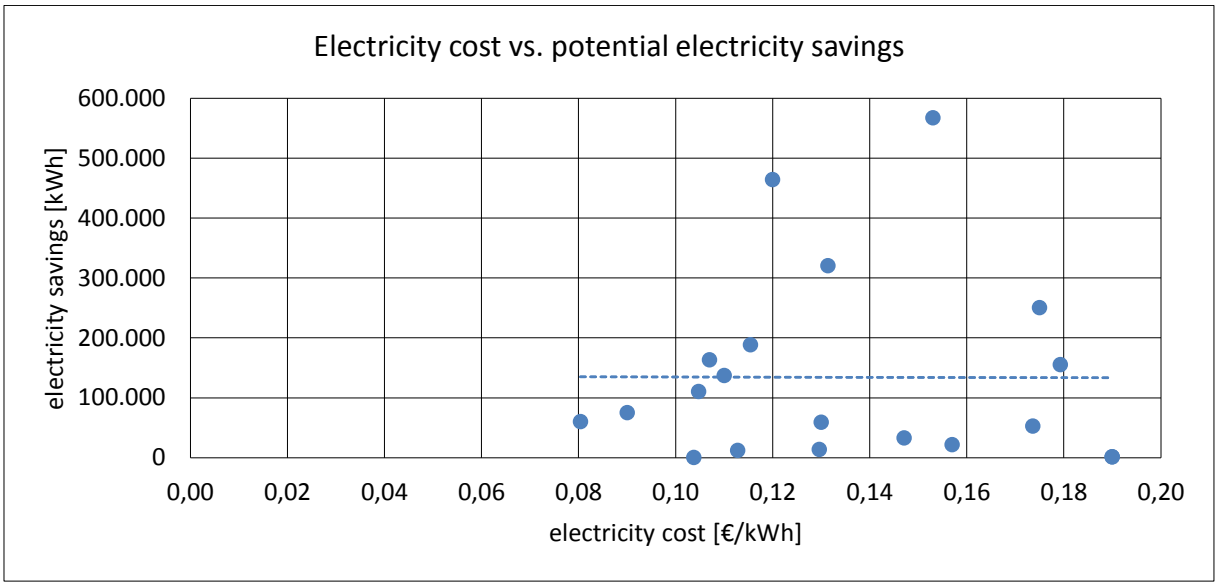

Figure 3: Electricity costs vs. potential electricity savings in Austria

There was a slight correlation between consumption and identified savings potential for electricity (Figure 4) and heat: the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

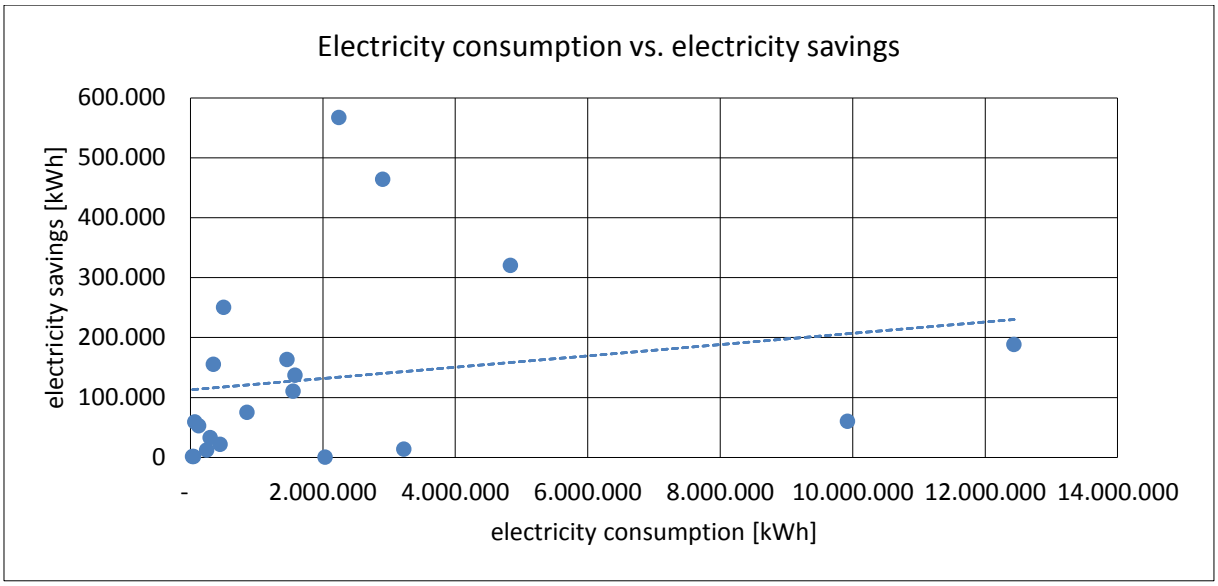

Figure 4: Electricity consumption vs. potential electricity savings in Austria

The potential for electricity savings is on average about 16% (with a maximum of almost 90%, in a joiner, by installing a photovoltaic plant). Figure 5 illustrates the percentage of potential electricity savings correlated to the total electricity consumption of each investigated Austrian company.

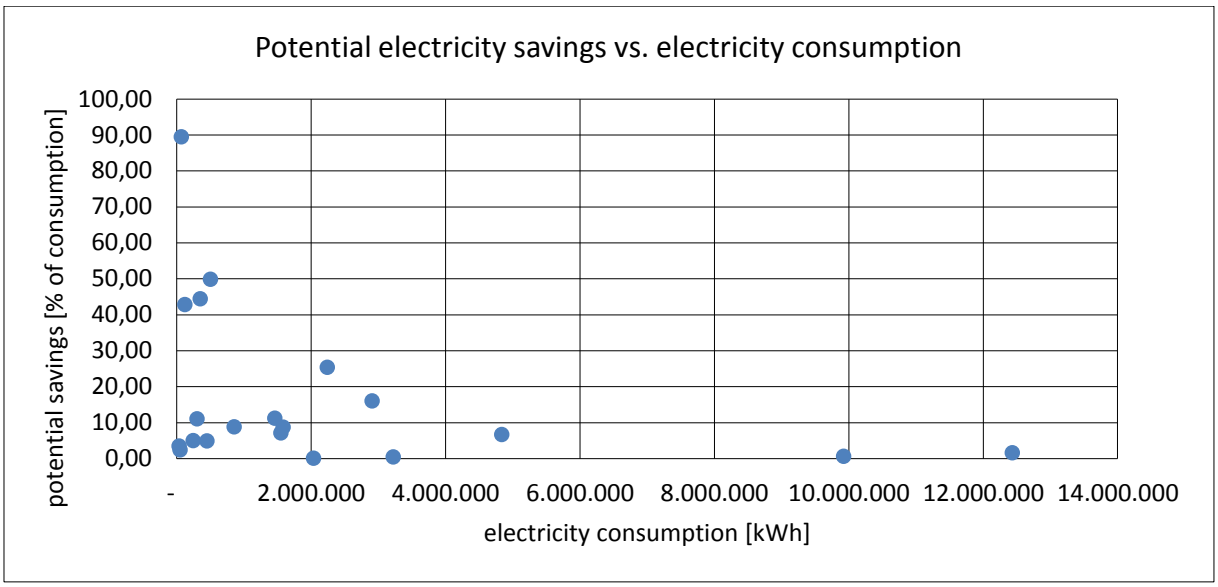

Figure 5: Potential electricity savings vs. potential electricity consumption in Austria

10% of electricity savings could be contributed to optimisation of air compressors (the total reference basis however includes the installation of PV plants and the renovation of a hydroelectric power plant).

15% of electricity savings could be contributed to optimisation of lights, including change to T5 and/or LEDs.

The biggest single potential for saving electricity is new air compressors, change of lights, refurbishment of hydroelectric power stations, installation of photovoltaic plants, and control of drives.

As can be seen in Figure 6, the potential for heat savings is on average about 10%, with maxima up to 50% (replacement of gas fired steam boiler by a wood fired hot water boiler).

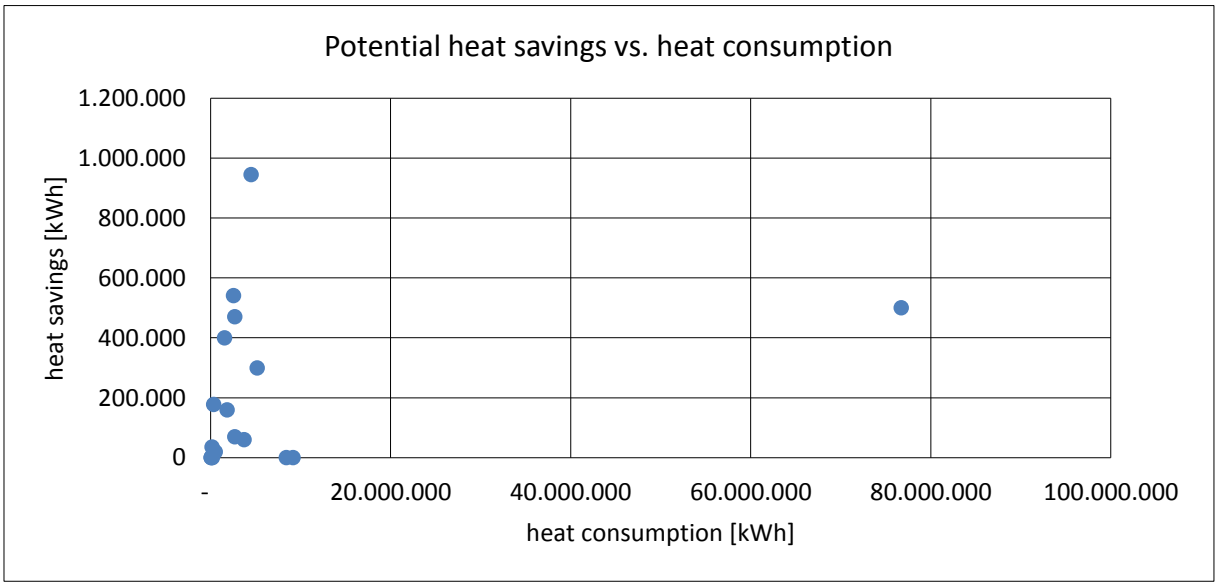

Figure 6: Potential heat savings vs. heat consumption in Austria

Heat recovery by heat exchange accounts for a potential to reduce heat consumption of 25%, improved insulation including insulation of buildings, about 10%.

The biggest single potential for saving heat is change to district heating from renewable energy, insulation of buildings and heat recovery from compressors and furnaces.

The audited companies in Austria have given the feedback that they would be ready to pay 1625 EUR on average for an energy audit. Some of the companies did not specify a desired price in their feedbacks. But there is a slight tendency to pay more in the companies with the bigger savings potential (generally the bigger companies).

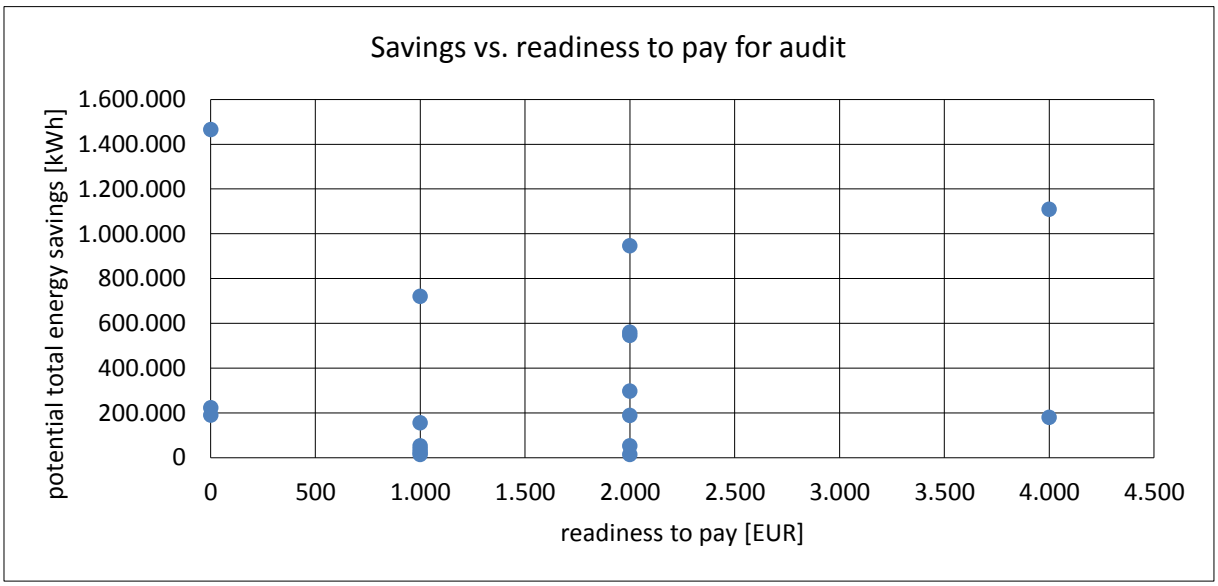

Figure 7: Potential energy savings vs. readiness to pay for audit in Austria

2.2 Bulgaria

In Bulgaria, 60% of the analysed companies had an appointed energy manager who was responsible for the data acquisition during the PInE project, mostly the bigger companies.

There was a slight correlation between consumption and identified savings potential for electricity (see Figure 8) and heat: the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

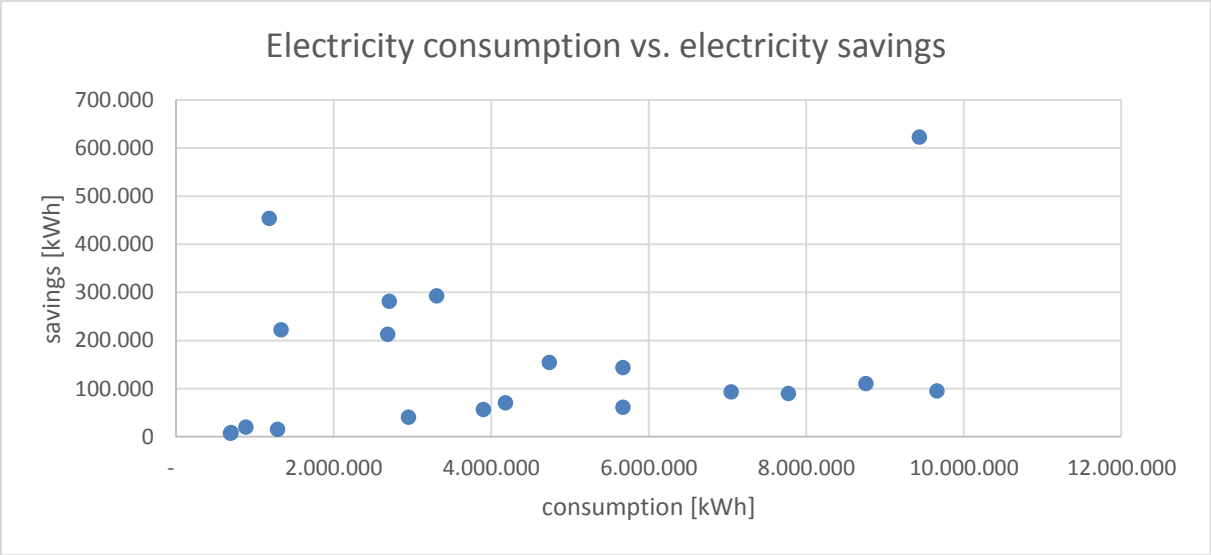

Figure 8: Electricity consumption vs. electricity savings in Bulgaria

About 25% of electricity savings could be contributed to adjustable control of asynchronous motors.

10% of electricity savings could be contributed to optimisation of lights, including change to T5 and/or LEDs, and automated lighting control.

The biggest single potential for saving electricity is the optmisation of electric drives, adjustable speed control, and improvement of lighting.

There is a slight correlation between the potential electricity savings and the total electricity consumption of the companies (Figure 9).

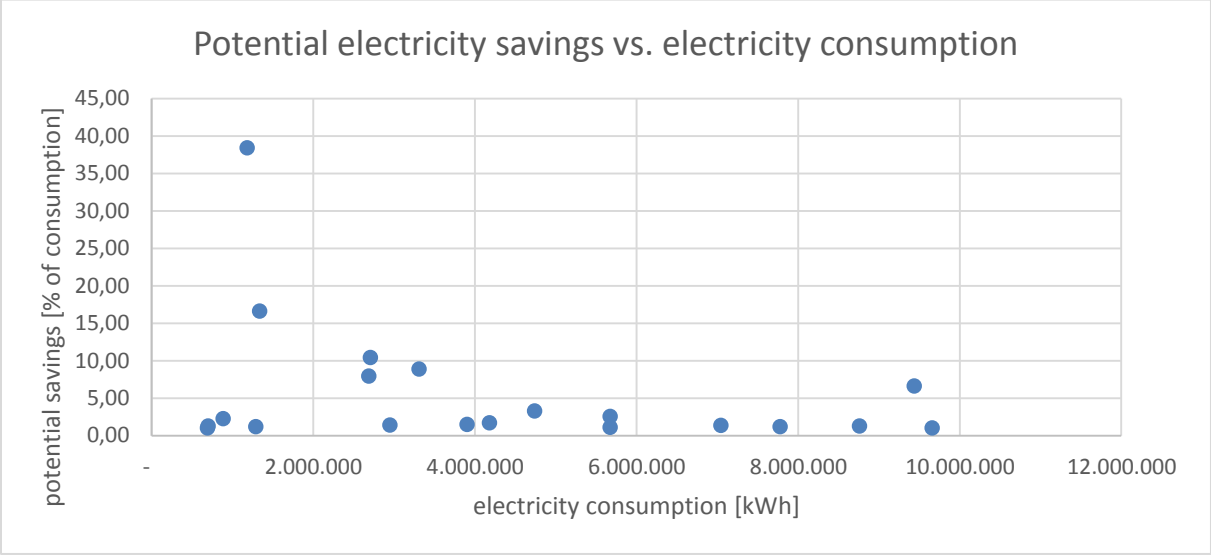

Figure 9: Potential electricity savings vs. electricity consumption in Bulgaria

In Bulgaria, there was a strong correlation between the total heat consumption of the investigated companies and the potential heat savings which were assessed. The higher the annual fuel consumption, the higher the potential for savings.

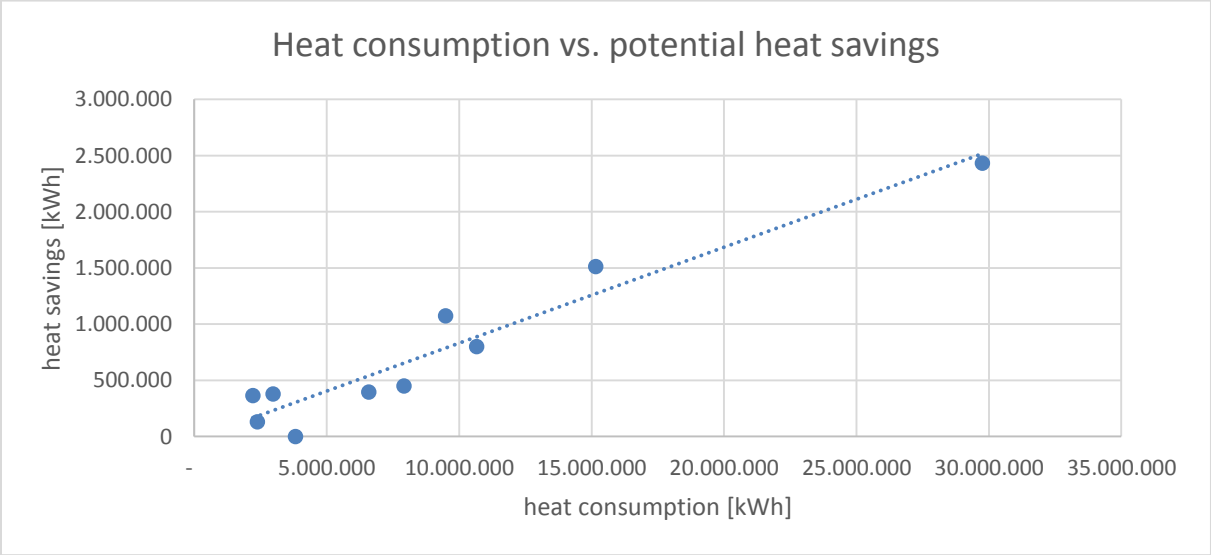

Figure 10: Heat consumption vs. potential heat savings in Bulgaria

The installation of an automated control of the heating system and pipe insulation account for the largest part of heat savings in Bulgaria.

The readiness to pay for an energy audit in Bulgaria is on average 2,550 EUR. Figure 11 shows that there is no tendency that companies are ready to pay more if the audit leads to higher savings.

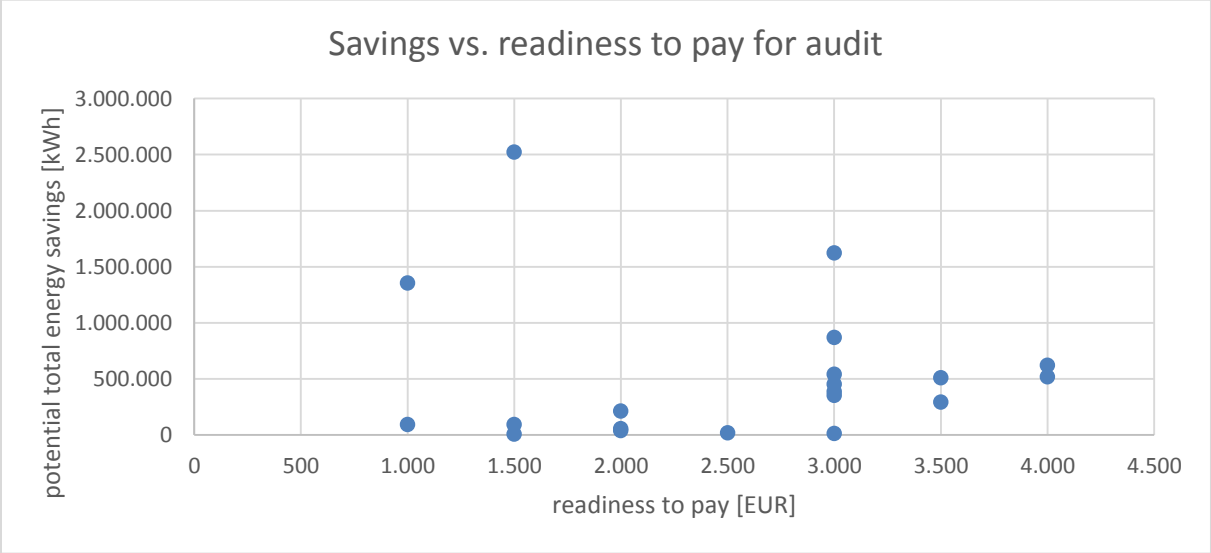

Figure 11: Energy savings vs. readiness to pay for audit in Bulgaria

2.3 Cyprus

In Cyprus, none of the audited SMEs has an appointed energy manger or has installed an energy management system

Figure 12 shows, that there is a correlation between the electricity consumption of the companies and the potential electricity savings – higher consumption leads to higher savings. However, as can be seen in Figure 13, compared with the relative savings potential, higher consumption means lower savings.

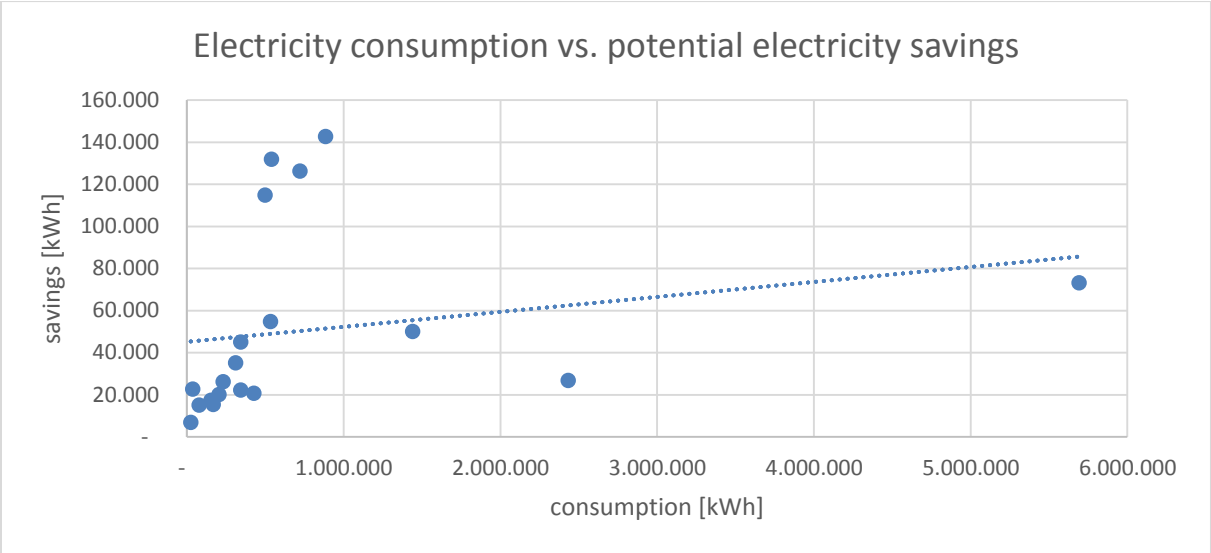

Figure 12: Electricity consumption vs. potential electricity savings in Cyprus

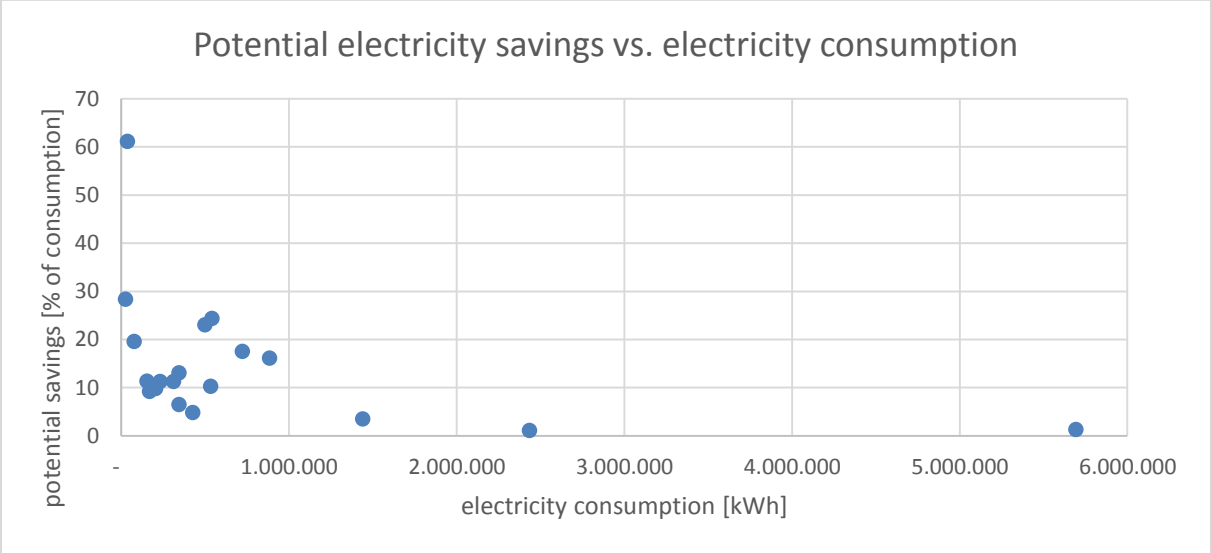

Figure 13: Potential electricity savings vs. electricity consumption in Cyprus

As for the electricity consumption, in the case of Cyprus, larger company size or number of employees respectively means lower relative electricity savings per SME (Figure 14).

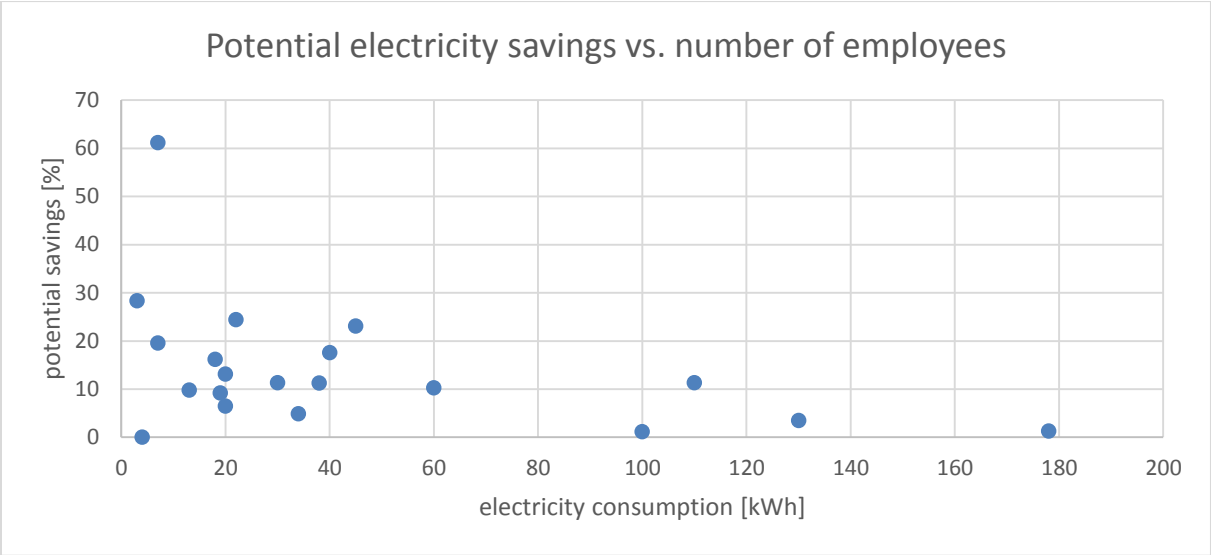

Figure 14: Potential electricity savings vs. number of employees in Cyprus

2.4 Italy

The customer satisfaction questionnaire has been sent to all the 20 companies, to assess progress in implementation and customer satisfaction. Only 18 companies completed the questionnaire, and all are implementing the suggested actions.

There is a correlation between consumption and identified savings potential for electricity (Figure 15): the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

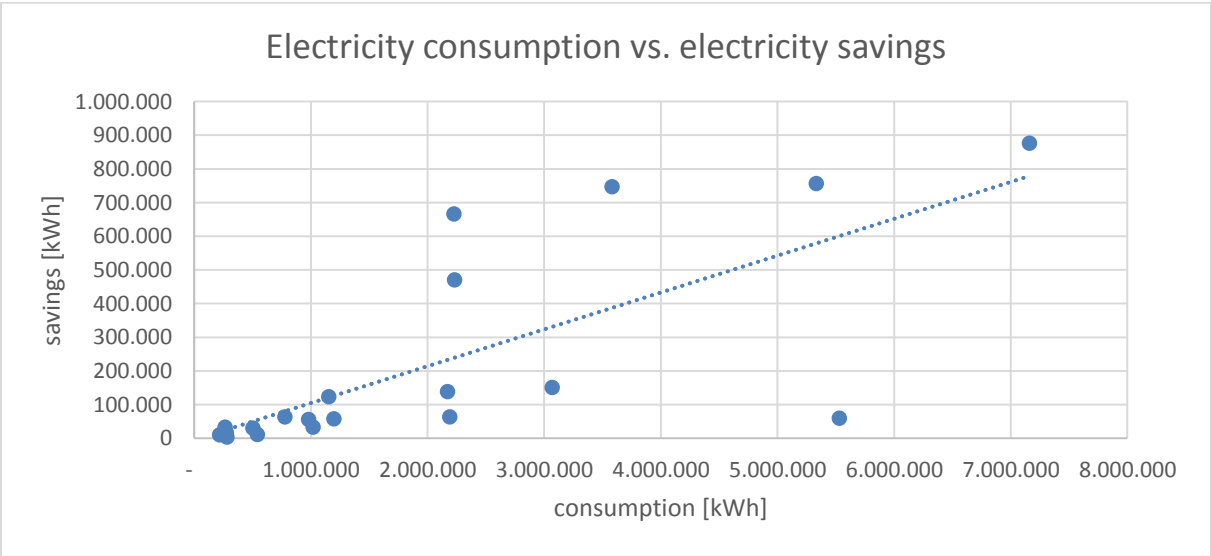

Figure 15: Electricity consumption vs. potential electricity savings in Italy

Around 63% the proposed heat saving potentials and about 56% of the electricity savings could be reached by heat recovery. Other relevant improvements are dealing with the compressed air systems, reactive power consumption, replacement of conventional lamps with LED lamps/intelligent lighting, and efficient motors.

As can be seen in Figure 16, in Italy, the companies with lower heat consumption had higher heat saving potentials than the ones with higher demand.

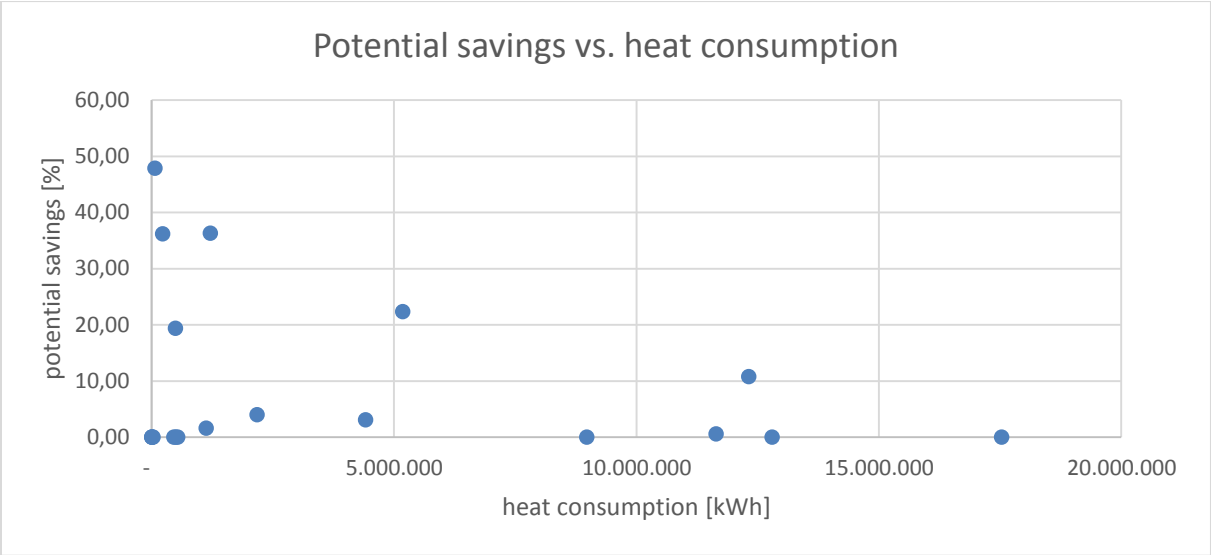

Figure 16: Potential heat savings vs. heat consumption in Italy

The audited companies in Italy which have given a feedback would be ready to pay 1444 EUR on average for an energy audit. There is a strong tendency to pay more in the companies with the bigger savings potential.

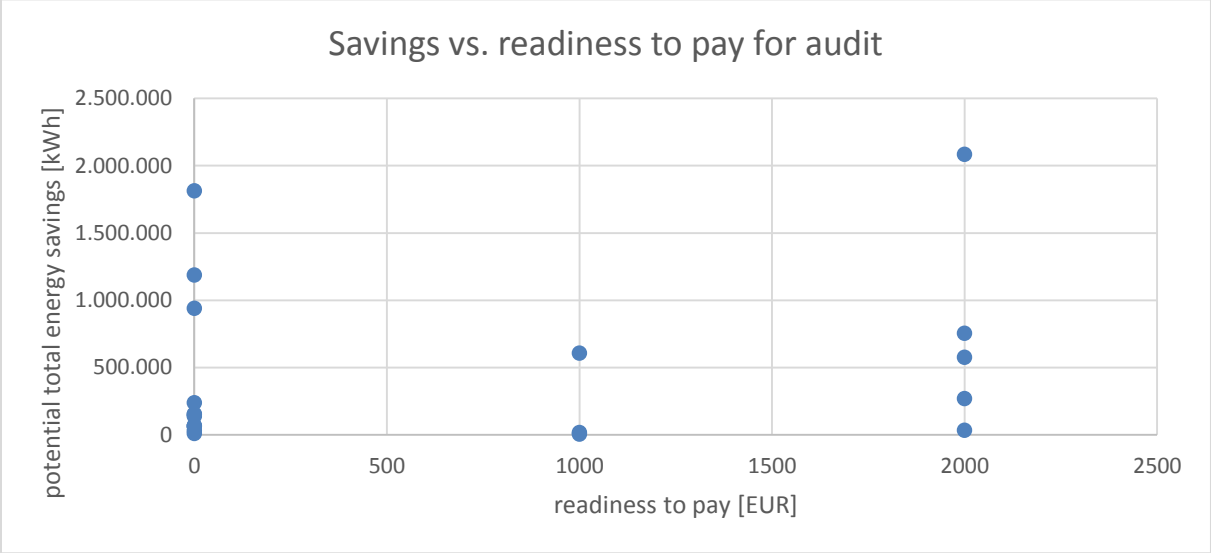

Figure 17: Potential savings vs. readiness to pay for audit in Italy

As in other countries, in Italy there is a slight correlation between the relative potential of electricity savings and the number of employees: the more employees, the higher the potential for savings. This does not apply for the relative potential of heat savings.

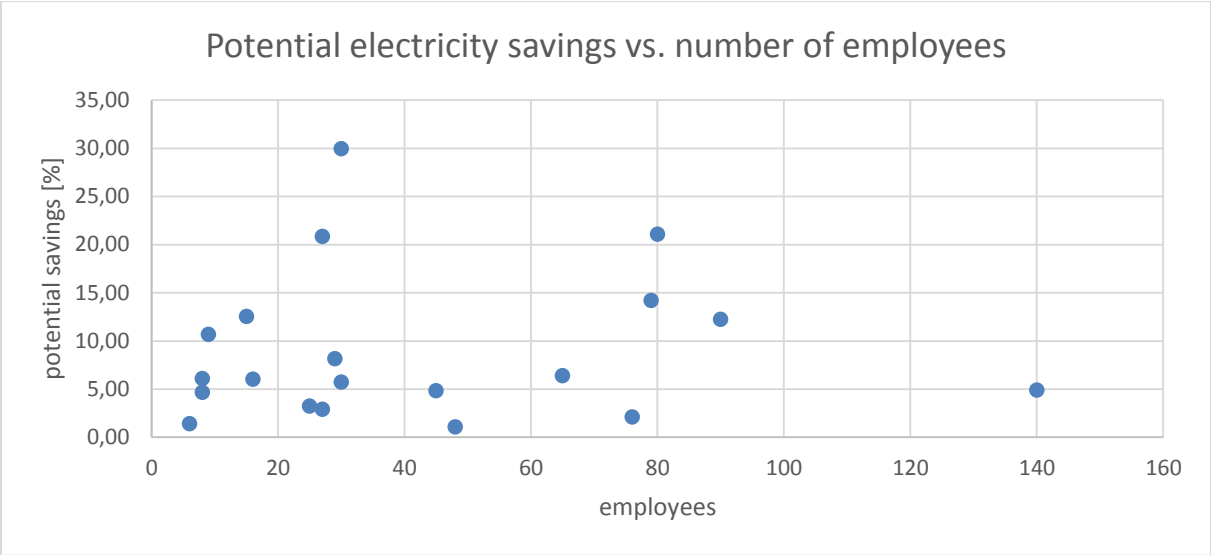

Figure 18: Potential electricity savings vs. number of employees in Italy

2.5 Romania

In Romania, 20% of the companies had an appointed energy manager who was acting as internal auditor during the PInE project.

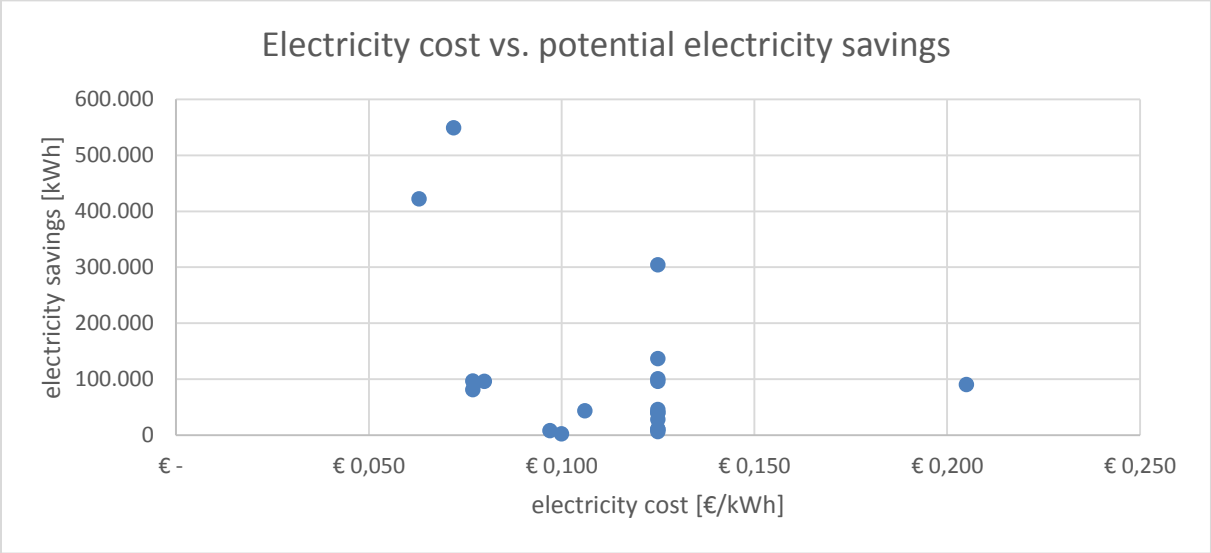

Figure 19 shows that in Romania there is no correlation between specific cost of electricity and savings.

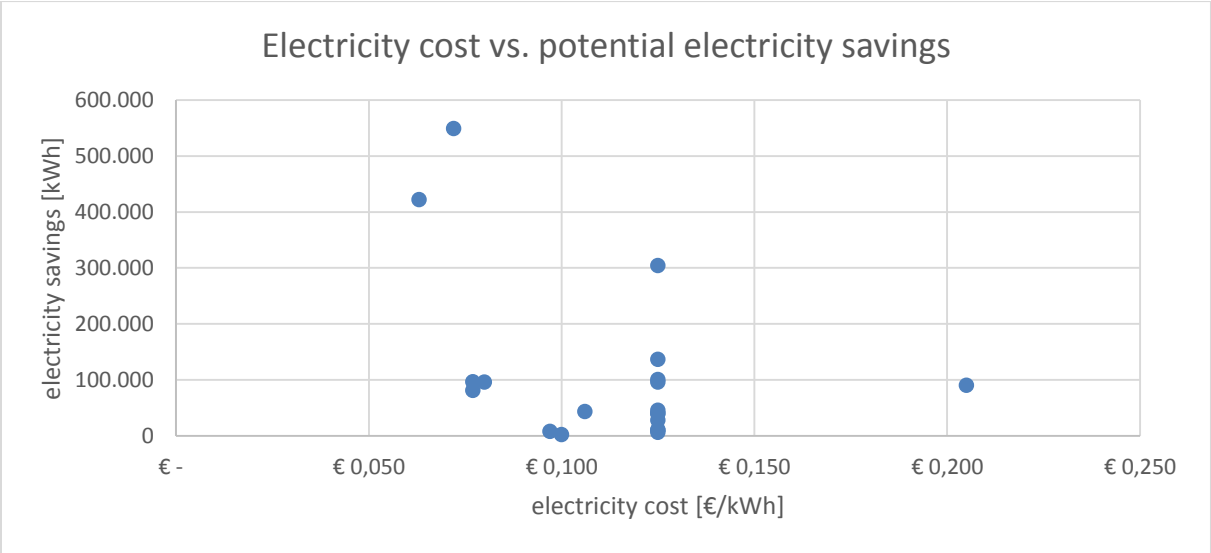

Figure 19: Electricity costs vs. potential electricity savings in Romania

There is a correlation between consumption and identified savings potential for electricity (Figure 20): the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

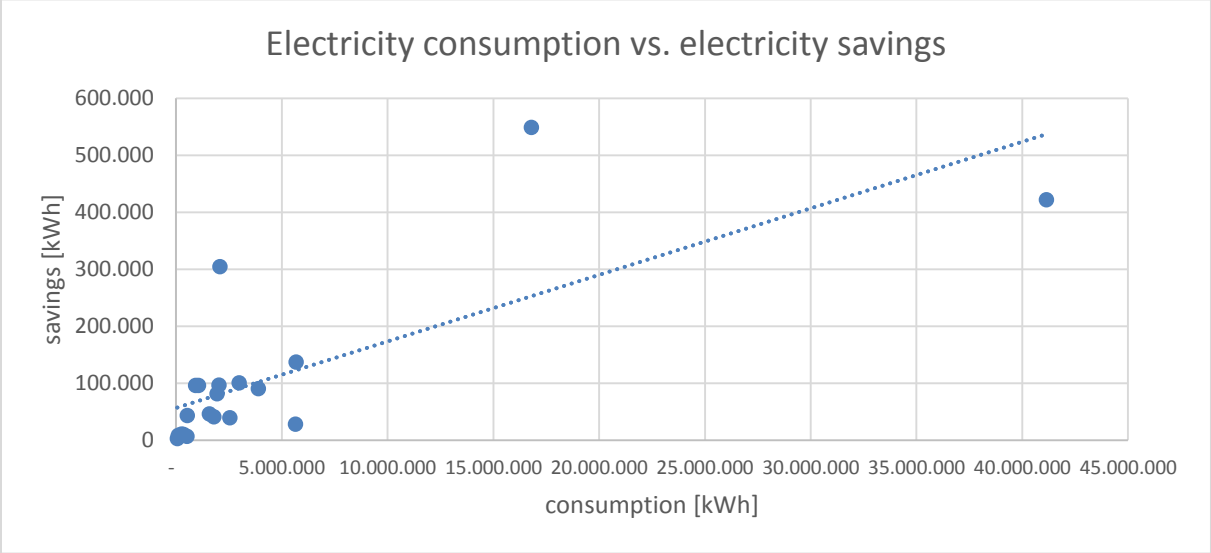

Figure 20: Electricity consumption vs. potential electricity savings in Romania

Around 60% the proposed measures in Romania were on: heat recovery (12%), reactive power consumption (11%), replacement of conventional lamps with LED lamps/intelligent lighting (20%), building refurbishment (9.5%) and reduction of compressed air leakages (7.5%). About 40% of the improvements dealt with new packaging technology, autoclaving process automation, use of frequency converters, partial replacement of drives and transmission, purchase and installation of a cogeneration plant, VSD for ventilation, and replacement of electric motors.

Figure 21 shows the correlation between actual heat consumption and potential savings.

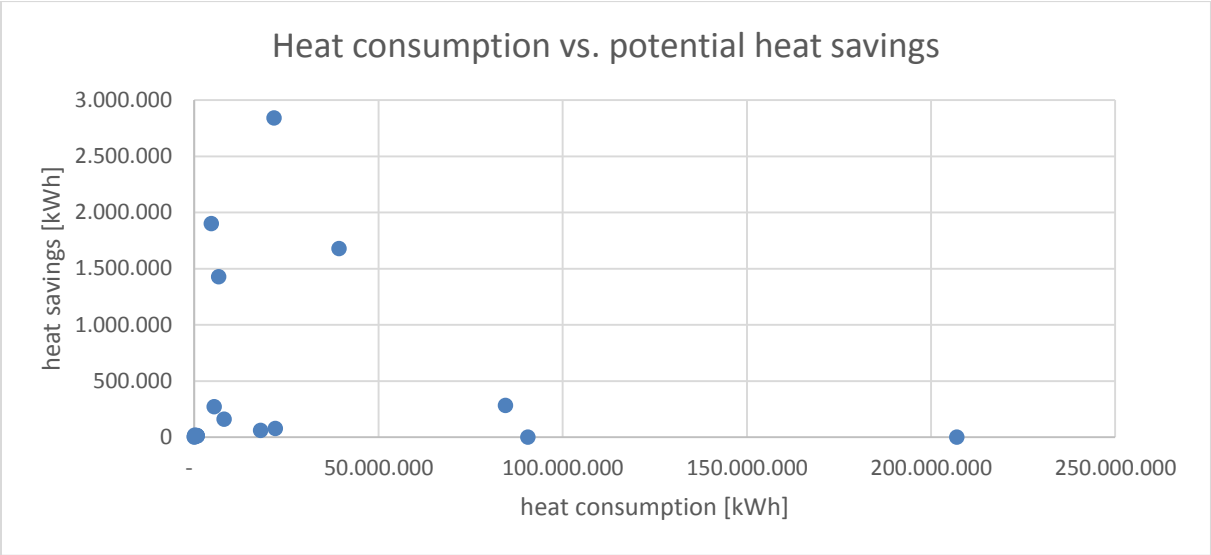

Figure 21: Heat consumption vs. potential heat savings in Romania

As can be seen in

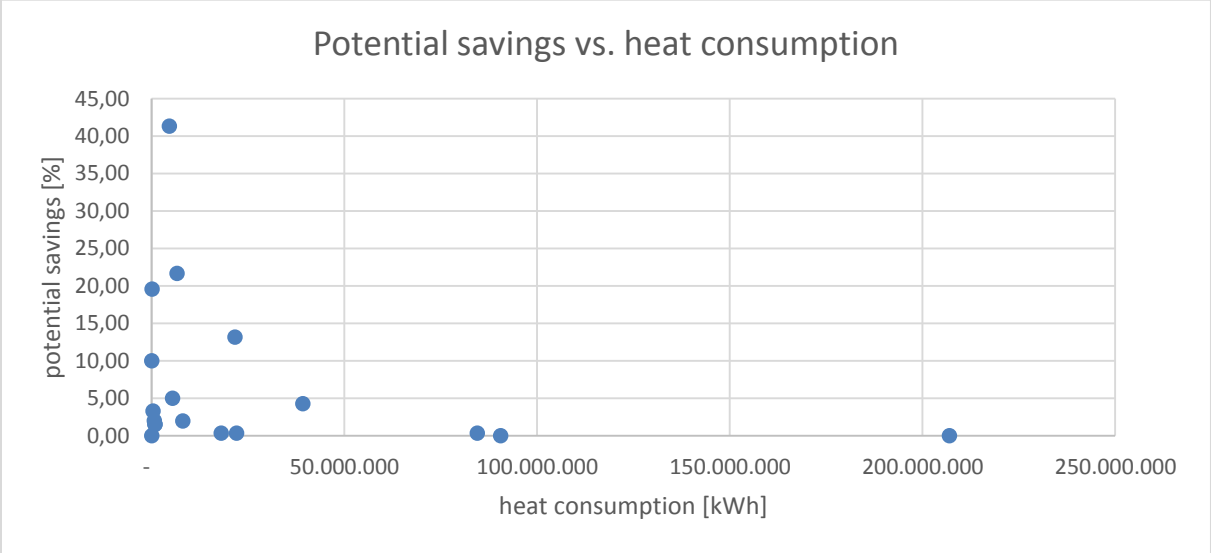

Figure 22, some companies did not have a potential for heat savings at all. The main reason for this is that the processes of the regarded enterprises do not require additional thermal energy or a large part of the buildings do not need to be heated. The maximum potential for heat saving is more than 40% (new technology of drying).

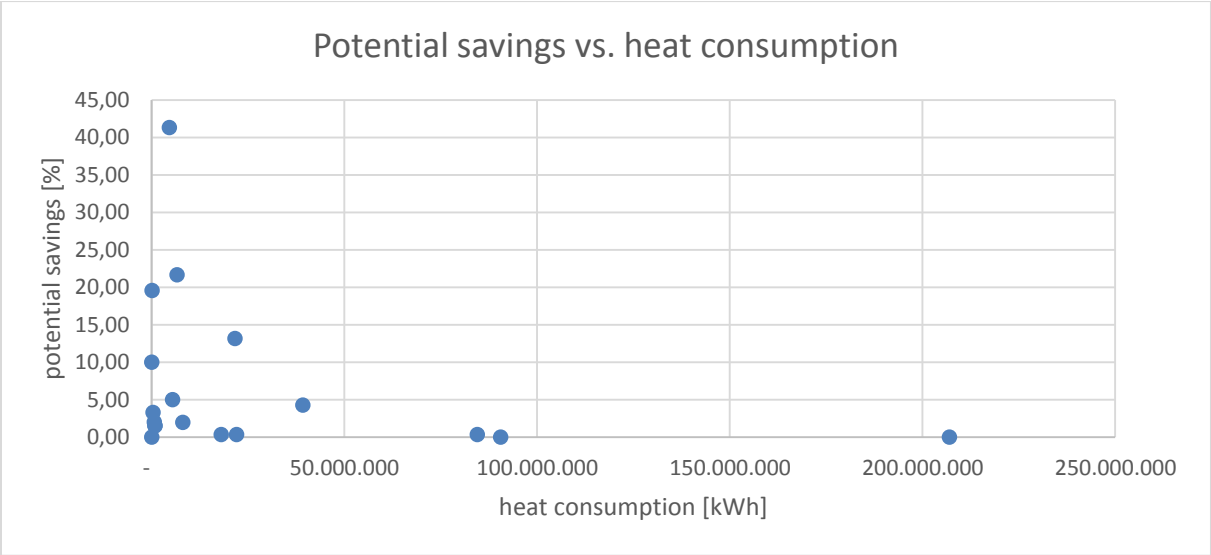

Figure 22: Potential heat savings vs. heat consumption in Romania

The audited companies in Romania have given the feedback that they would be ready to pay 1450 EUR on average for an energy audit. There is a strong tendency to pay more in the companies with the bigger savings potential.

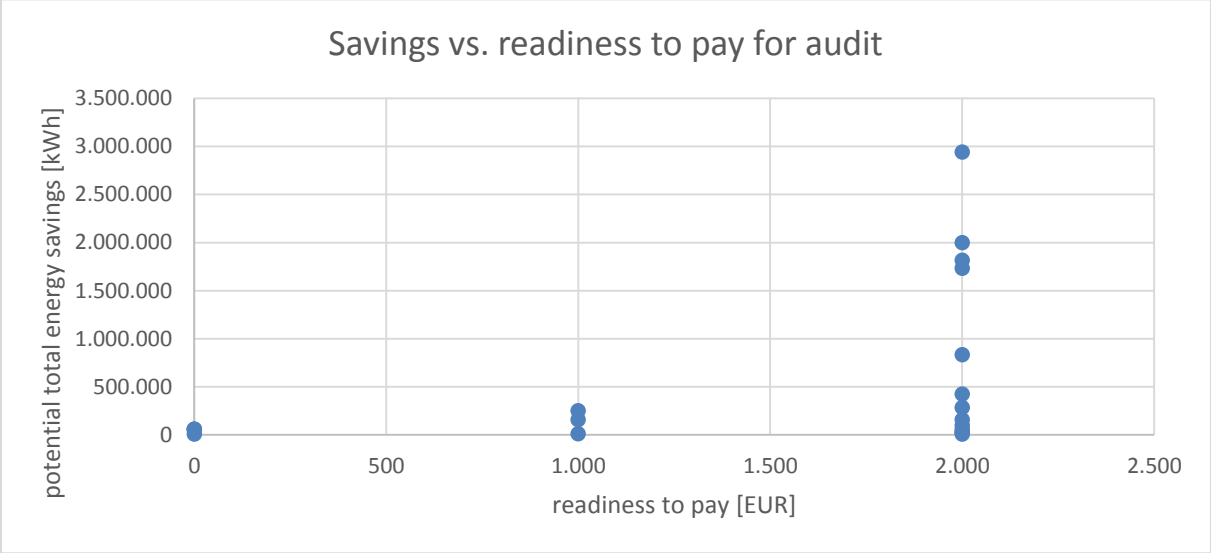

Figure 23: Potential energy savings vs. readiness to pay for audit in Romania

2.6 Slovakia

In Slovakia, all of the audited companies had an energy manager appointed. There was a correlation between consumption and identified savings potential for electricity (see Figure 24): the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

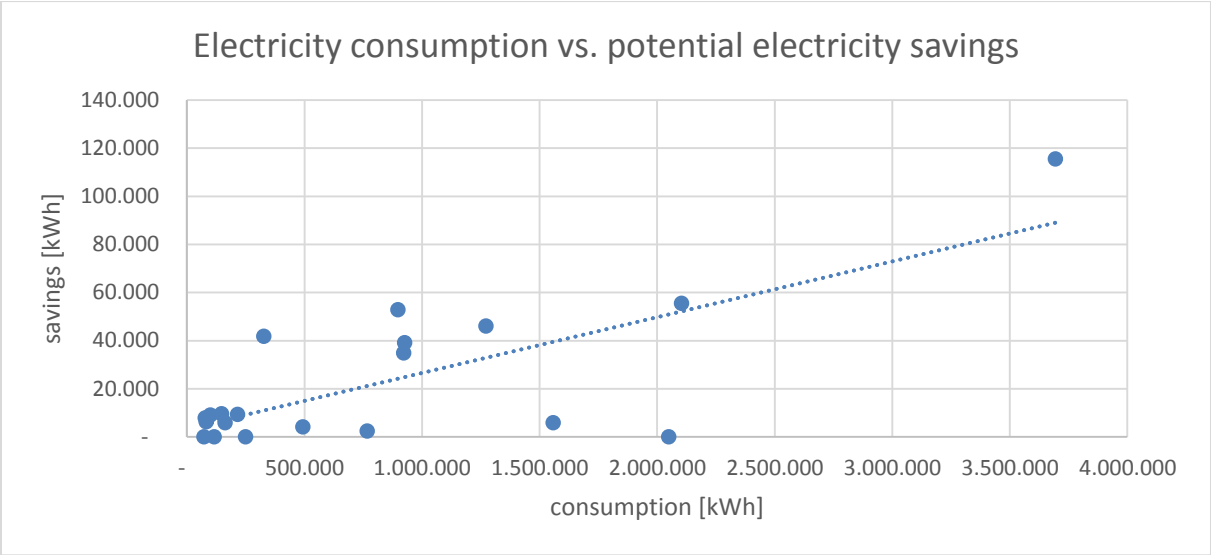

Figure 24: Electricity consumption vs. electricity savings in Slovakia

About 98% of electricity savings could be contributed to optimisation of lights, including change to T5 and/or LEDs, and automated lighting control.

In Slovakia, there was a correlation between the total heat consumption of the investigated companies and the potential heat savings which were assessed. The higher the annual fuel consumption, the higher the potential for savings.

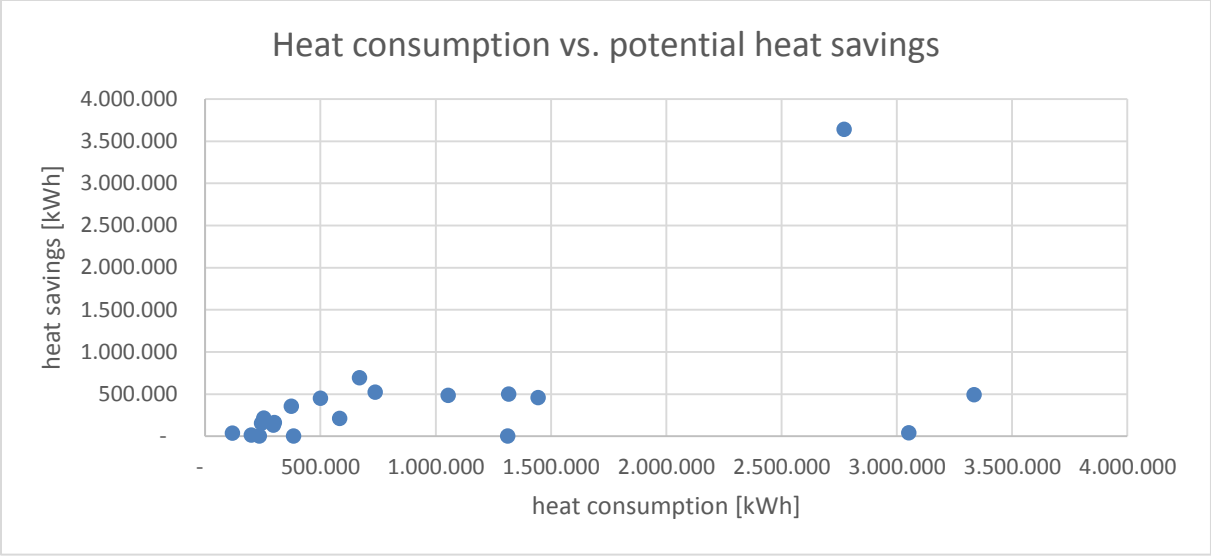

Figure 25: Heat consumption vs. potential heat savings in Slovakia

The Slovakian SMEs would be ready to pay 1,200 EUR on average for the service.

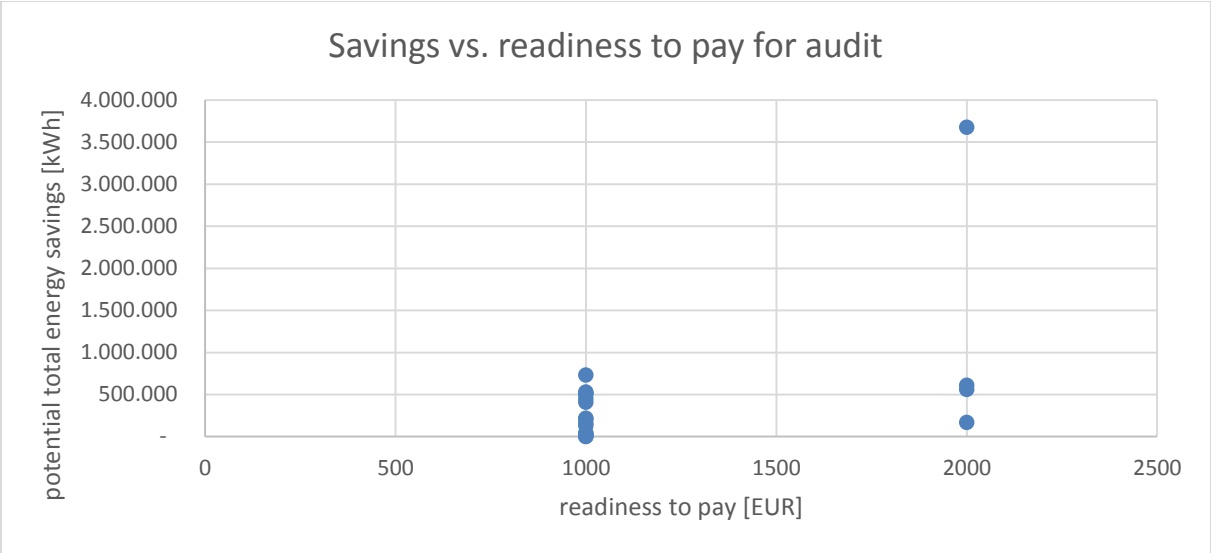

Figure 26: Savings vs. readiness to pay for an energy audit in Slovakia

In Slovakia, as you can see in

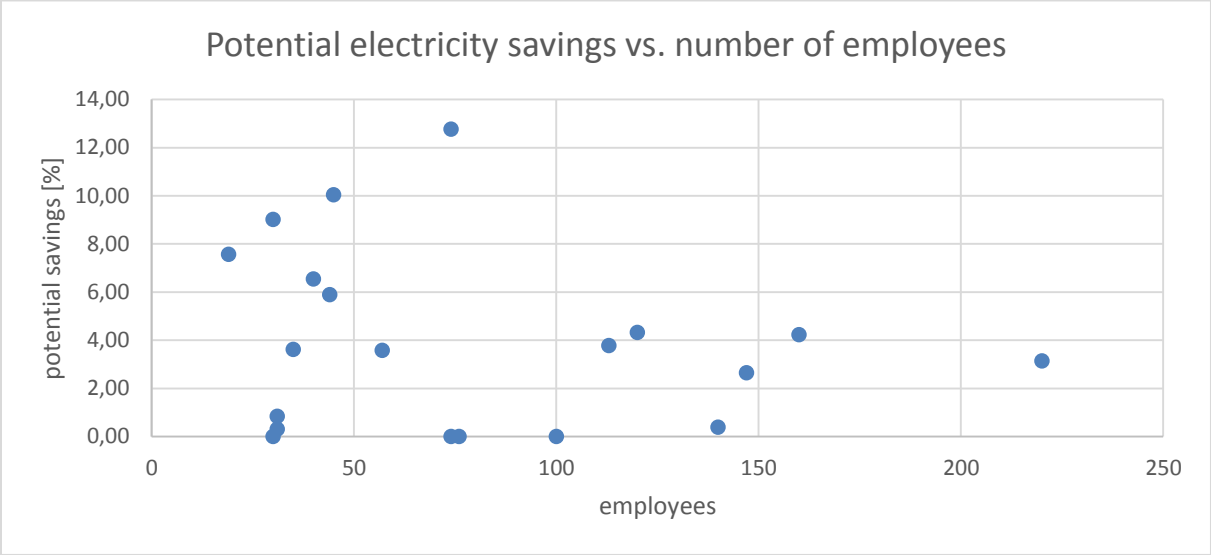

Figure 27, there is a slight correlation between the company size and the relative potential of electricity savings in each company: the more employees, the lower the saving potential. This also applies for heat.

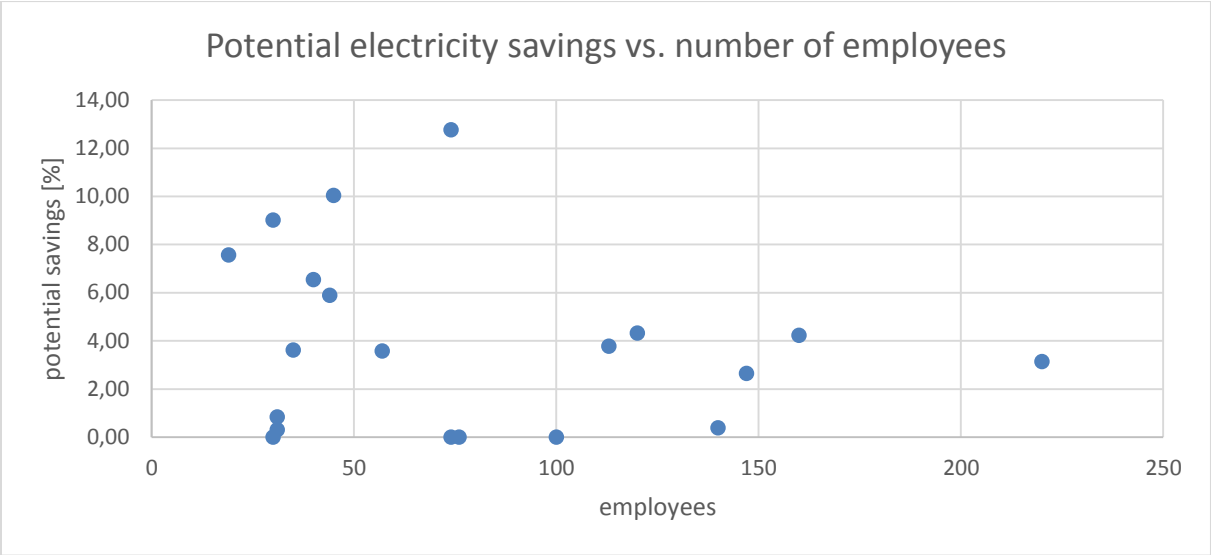

Figure 27: Potential electricity savings vs. number of employees in Slovakia

2.7 Spain

In Spain, 35% of the assessed companies had an appointed energy manager.

Figure 28 shows that there was a positive correlation between specific cost of electricity and savings: the higher the specific price of electricity, the higher the savings potential identified. This correlation is not valid for fuel.

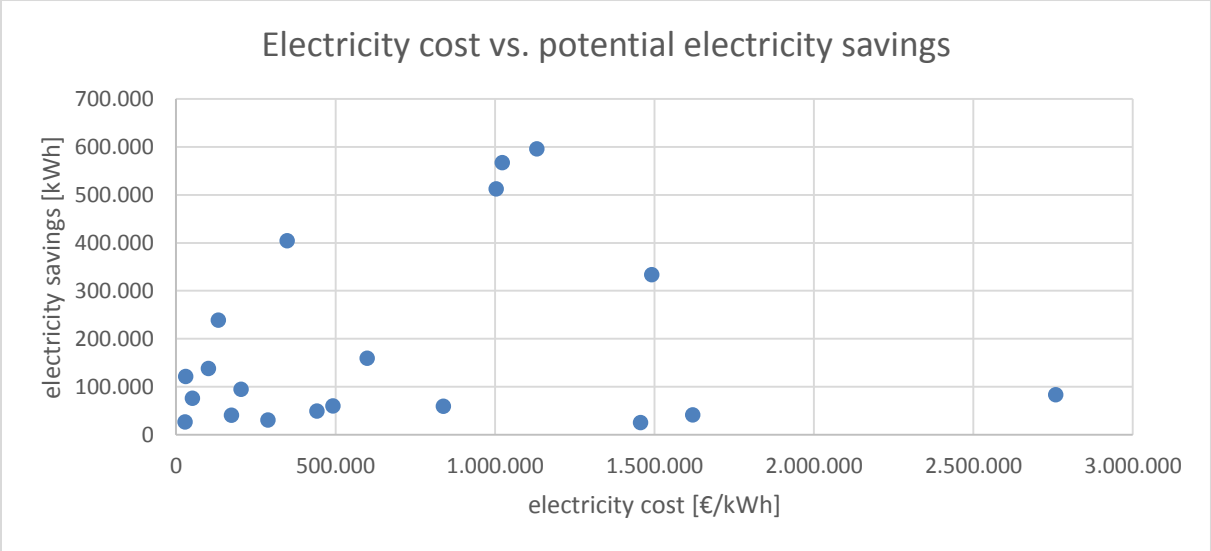

Figure 28: Electricity costs vs. potential electricity savings in Spain

There was a correlation between consumption and identified savings potential for electricity (Figure 29) and heat (Figure 30): the higher the consumption, the higher the savings potential expressed as a percentage of consumption.

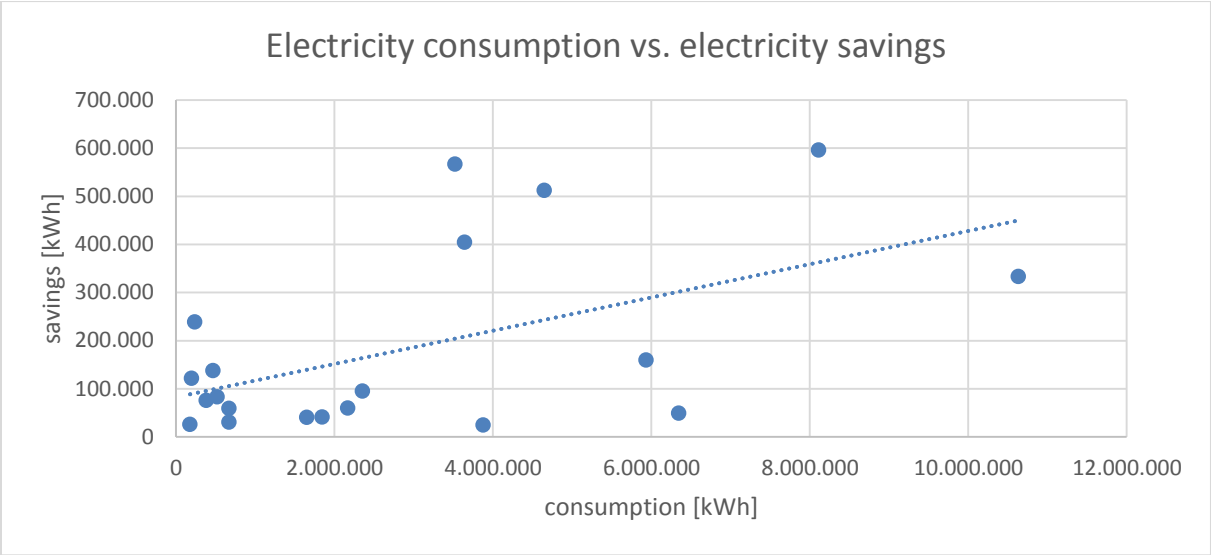

Figure 29: Electricity consumption vs. potential electricity savings in Spain

56% of the electricity savings could be contributed to the optimisiation of the lighting. The remaining savings are mainly reached by optimisation of air compressors and control of drives.

In Spain, there was a strong correlation between the heat consumption of the companies and the potential for heat savings. The higher the demand, the higher the assessed savings potential (Figure 30).

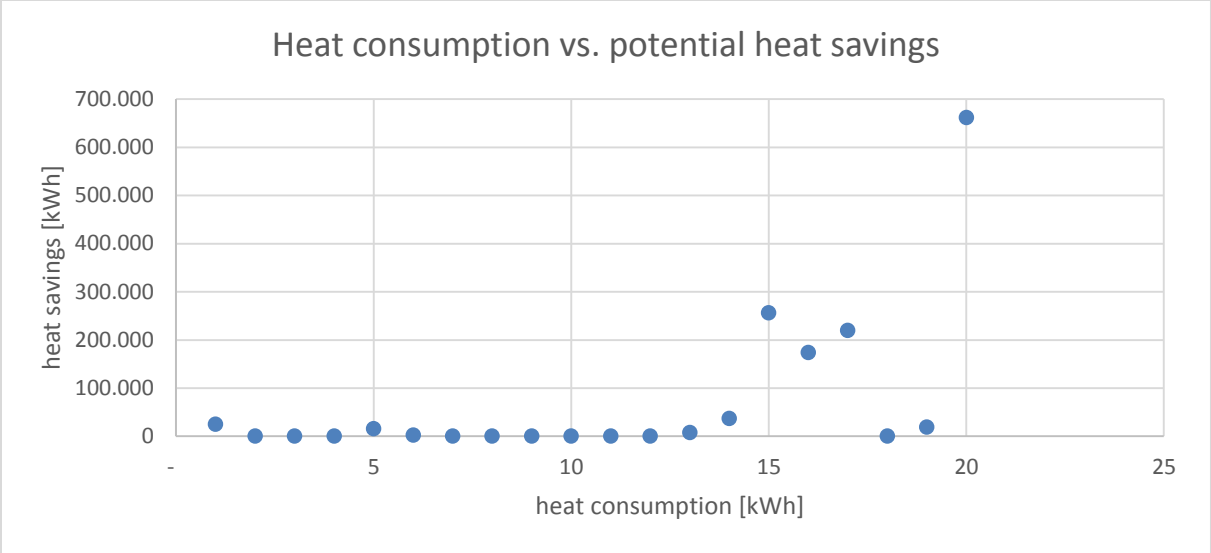

Figure 30: Heat consumption vs. potential electricity savings in Spain

The implementation of heat recovery systems is responsible for about 57% of the heat saving potentials in Spain.

Figure 31 shows that there is a trend: the higher the number of employees, the lower the relative electricity savings potential. This does not apply for relative heat savings in Spain.

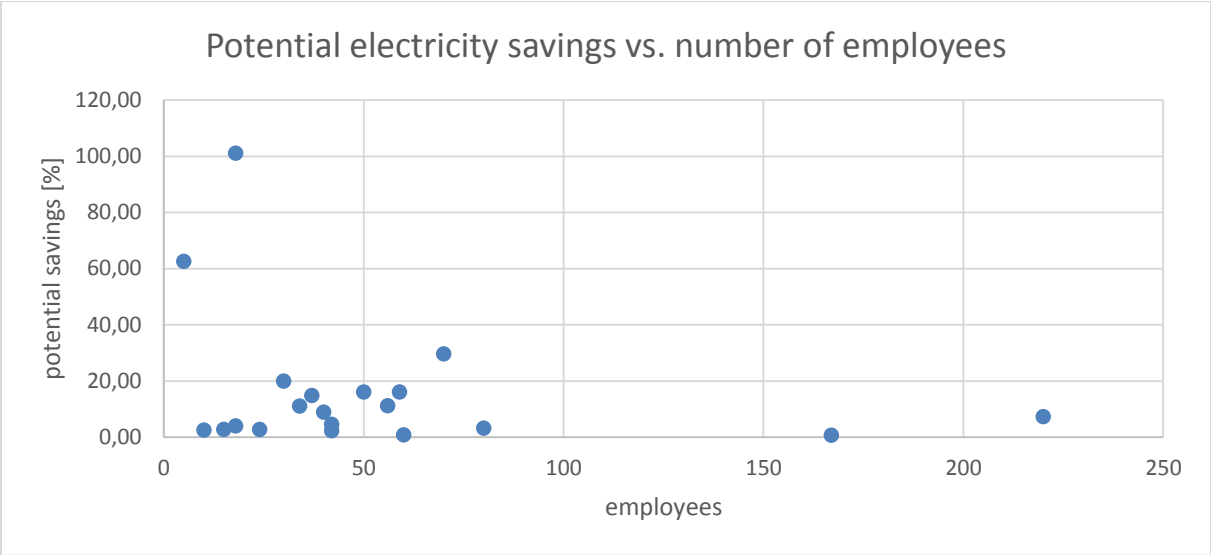

Figure 31: Potential electricity savings vs. number of employees in Spain

3 Overall trends

The analysis of the results and the experiences made (also see “Report on auditing activities”) during the full audits in the seven countries have shown that there are tendencies which apply in all or most of the cases:

- The company size is not necessarily correlating to the energy saving potential. The total relative savings potential is rather lower in larger companies. In most cases (except Slovakia), this trend is exactly the opposite for electricity and for heat
- Many SMEs do not have an energy management system and an energy manager respectively
- SMEs do not have appropriate energy metering / submeters, regardless of their size or energy consumption
- Cheap energy means little savings
- High consumption means high savings in most of the cases and especially for electricity
- High consumption means high awareness and involvement
- Cost of energy efficiency actions is (perceived as) a relevant barrier
- A payback time of more than 3 years of energy efficiency actions is (perceived as) a relevant barrier
- The readiness to pay for an audit is dependent on the achieved amount of savings
- Though the potential for different types of improvements are varying strongly in each country, for electricity, the optimisation of lighting has an average potential of about 20%, the efficient use of drives has an average of about 25%, and compressed air has a share of about 10% of the saving potentials in all the countries
- For heat, heat recovery and building refurbishment have the highest potential for savings, followed by insulation and process related heat loss reductions.

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