



Evaluation of Follow-Up Reports, Estimation of Energy Saving Potential (D3.2, D3.3)

EINSTEIN II Long Term Evaluation

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EINSTEIN II

**EXPERT SYSTEM FOR AN INTELLIGENT SUPPLY OF THERMAL ENERGY IN INDUSTRY
AND OTHER LARGE SCALE APPLICATIONS**

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1 Introduction

As part of the Intelligent Energy Europe-funded project EINSTEIN II, a systematic follow-up of the EINSTEIN audits was performed: to give support to companies with their decision making and to learn about their technical and non-technical barriers against proposed saving measures.

This report summarizes all audits performed on a quantitative level, including all relevant information (e.g. primary energy consumption, primary energy savings, energy consumption and possible savings on fuel level, information on potential savings of CO₂ emissions and total energy costs, and others).

In addition, the report provides feedback from all countries to all audits, based on a standardized, short questionnaire including questions on the current decision stage of the implementation of the energy saving measures and reasons for implementing or not implementing so far. Moreover, general comments on the audits were summarized.

This report is arranged as follows:

- First, an overall summary of the energy audits, including all quantitative information on the energy carriers and energy saving potential will be given (chapter 2).
- Second, an analysis of the sector results will be given.
- Chapter 4 compiles the feedback from all of the 10 countries.
- The summary country results from all audits are presented in chapters 5.1 to 5.10 for: Austria, Bulgaria, France, Germany, Ireland, Italy, Luxembourg, Spain, and the UK.
- The report ends with summaries and conclusions

2 Summary of all EINSTEIN Audits

2.1 Total Primary Energy Consumption

This summary utilizes 67 out of 72 EINSTEIN audits. For the rest, the economic data of the saving measures was insufficient or not available during a quick EINSTEIN Audit.

The overall total primary energy consumption of the 67 companies comprised in this evaluation was 1,370 GWh. The main energy carriers were natural gas 617 GWh (45%) and electricity 701 GWh (51%), with both energy carriers together scoring 96.3%. In addition, 11.5 GWh gasoil and 18.2 GWh of renewables and 15.5 GWh district heat (fossil) were used in the audited companies. The total energy costs were 45.4 million EUR.

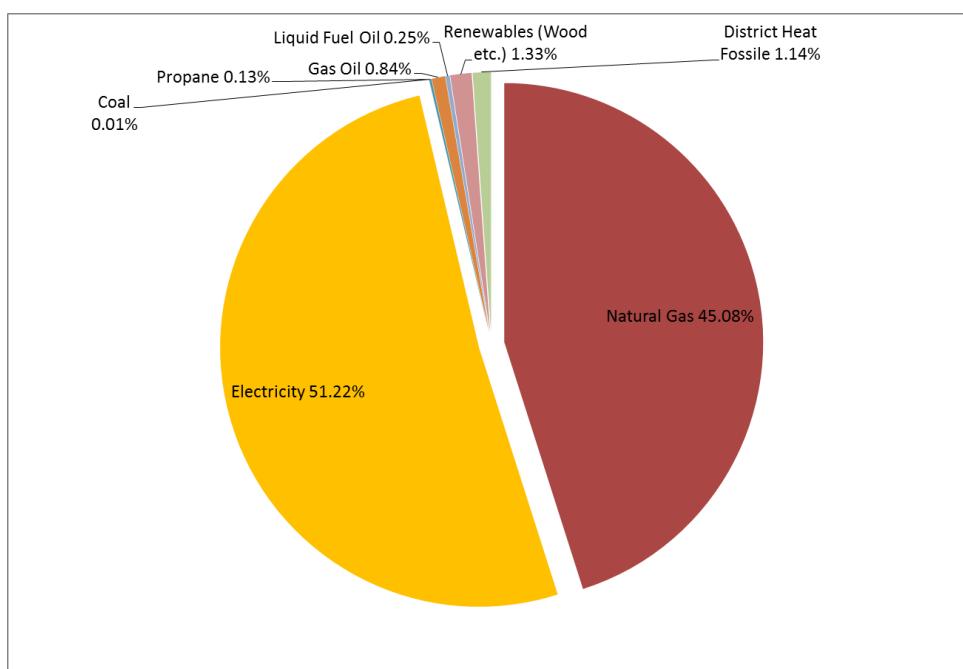


Figure 2-1 Share of different energy carriers of the total primary energy consumption EINSTEIN-audited enterprises

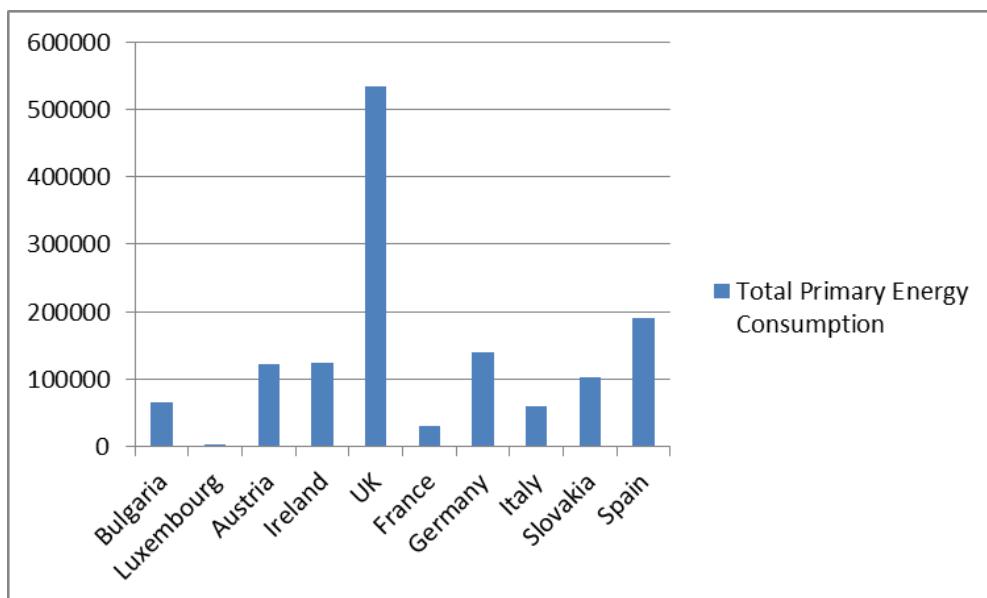


Figure 2-2 Total primary energy consumption of the audited companies in the different countries

Two very big organisations only (primary energy consumption above 200 GWh) are responsible for the high total primary energy consumption in the UK.

2.2 Primary Energy Savings

The measures proposed in consequence of the EINSTEIN audit reports would save 259 GWh or 19% of total primary energy consumption¹. The gas consumption would increase by approx. 20% (by 122 GWh), the electricity consumption would be reduced by 367 GWh or 52%. This is due to the fact that especially for the bigger sites the installation of combined heat and power plants was suggested, needing some additional gas, but showing a significant higher total energy efficiency. All EINSTEIN CHPs are heat led (heat operated), meaning that the total amount of heat generated in the course of the electricity production can be used in the company.

The district heat consumption could be reduced by 4.7 GWh (31%), renewable energy carriers by 3.3 GWh (18%) (because of more sufficient use of this energy carrier) and liquid fuel oil by 2.2 GWh (64%).

These savings in primary energy would correspond to monetary savings of 7.6 million EUR or 17% of total energy costs.

From the calculated 281,894 t of CO₂ emissions 38,654 t or 14% could be saved.

The total investment needed would be 29.5 million EUR.

The renewable energy production triggered would be 39 GWh, the investment in sustainable energy would be 4.6 million EUR.

The mean average of the payback-time is 6 years.

In almost all countries only one, two or three companies were responsible for most of the primary energy consumption and therefore also the savings achieved (in MWh). Therefore in addition the relative savings were calculated as mathematic means: This calculation gives a payback (arithmetic mean) of 6 years.

The highest savings were achieved on a country level in Spain, France and Germany with proposed average energy savings between 29 and 34% (mathematic mean). The lowest savings on a country level were reached in Slovakia, Ireland, Luxembourg and UK (3–7%). There was no relation between average savings and payback time: The highest average payback times were in the UK (9.5 years), Bulgaria (8.7 years) and Slovakia (7 years).

¹ All data in this report refers to calculations done with the EINSTEIN software, therefore the savings are expected or estimated savings based on the EINSTEIN methodology.

	Primary Energy Consumption [MWh]	Primary Energy Savings [MWh]	Primary Energy Savings [%]
Total Energy Consumption	1,370,153	258,690	19%
Natural Gas	616,872	-121,560	-20%
Electricity	700,886	367,351	52%
Coal	157	86	55%
Propane	1,807	200	11%
Gas Oil	11,518	2,123	18%
Liquid Fuel Oil	3,437	2,206	64%
Renewables (Wood etc.)	18,160	3,297	18%
District Heat Fossil	15,552	4,746	31%

Table 2-1 Primary energy consumption and energy savings by energy carriers

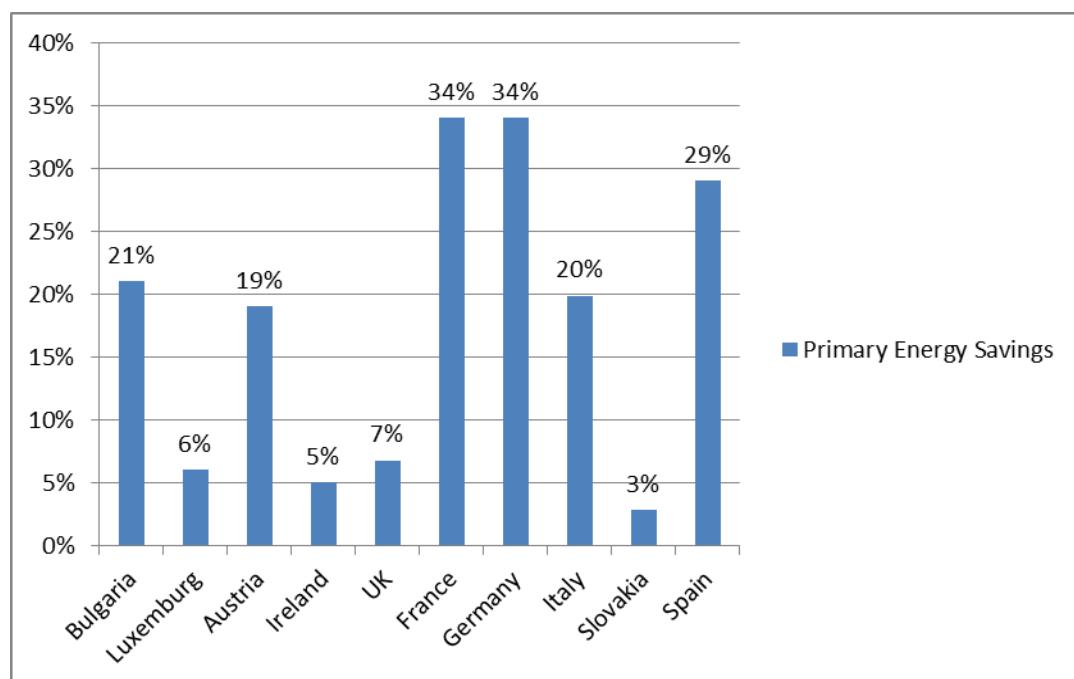


Figure 2-3 Primary Energy Savings in %, per country

Total CO ₂ emissions, current status	281,894 t p.a.
Total CO ₂ savings	38,654 t p.a.
Total CO ₂ savings in %	14%
Total energy costs, current status	45,365,764 EUR p.a.
Savings total energy costs, incl. O&M and annuity [EUR]	7,579,826 EUR p.a.
Savings total energy costs, incl. O&M and annuity [%]	17%
Own investment (excl. subsidy)	3,778,448 EUR
Total investment (incl. subsidy)	29,465,904 EUR
Renewable energy production triggered [MWh]	39,452 MWh
Investment in sustainable energy	4,658,874 EUR

Table 2-2 Results of the proposed savings of the EINSTEIN audits

2.3 Detailed Analysis of Key-Indicators and Saving Measures

2.3.1 Primary Energy Consumption

On an average (mathematic means), the companies audited within EINSTEIN had a primary energy consumption of 20.5 GWh. Eight companies had considerably higher energy consumption (above 50 GWh to 260 GWh), and 50% (or 33 companies) had an energy consumption between 1.7 and 17.1 GWh. Therefore the median is only 6.3 GWh.

	1.Quartile	Median	2. Quartile
Primary Energy Consumption	1.7 GWh	6.3 GWh	17.1 GWh

Table 2-3 First, second and third quartile of the primary energy consumption of the audited companies

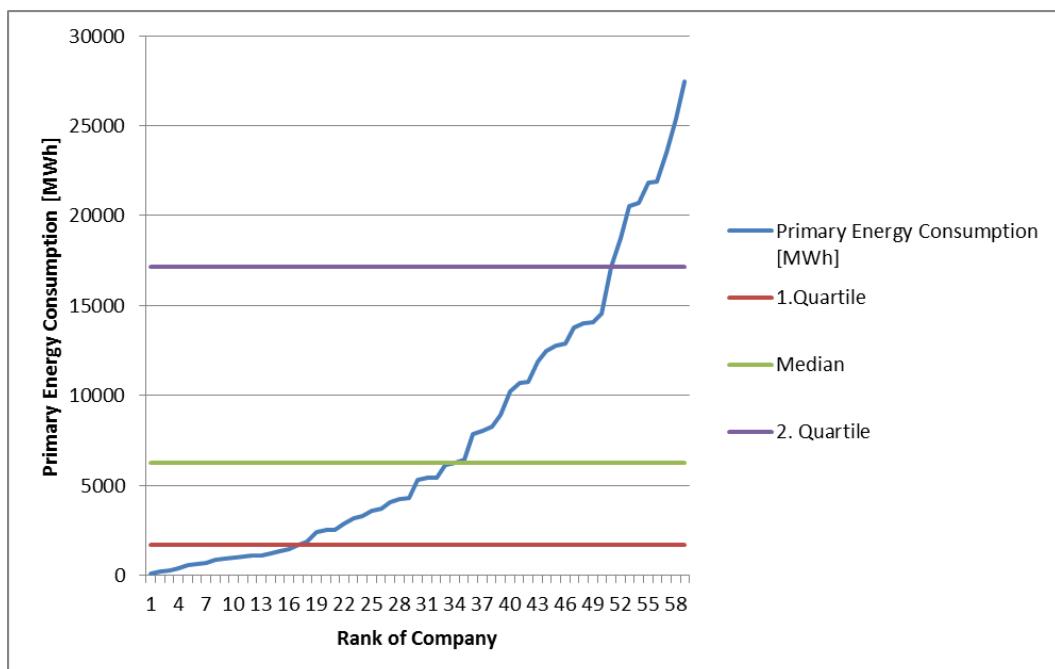


Figure 2-4 Companies ranked by primary energy consumption with first, second (median) and third quartile (this means: 25% of all companies lie below the first line (1. quartile), 50% of the companies below the second line (median)), the eight biggest companies are excluded from the graph).

There is no relation between the primary energy consumption and the proposed savings, as the following graph shows.

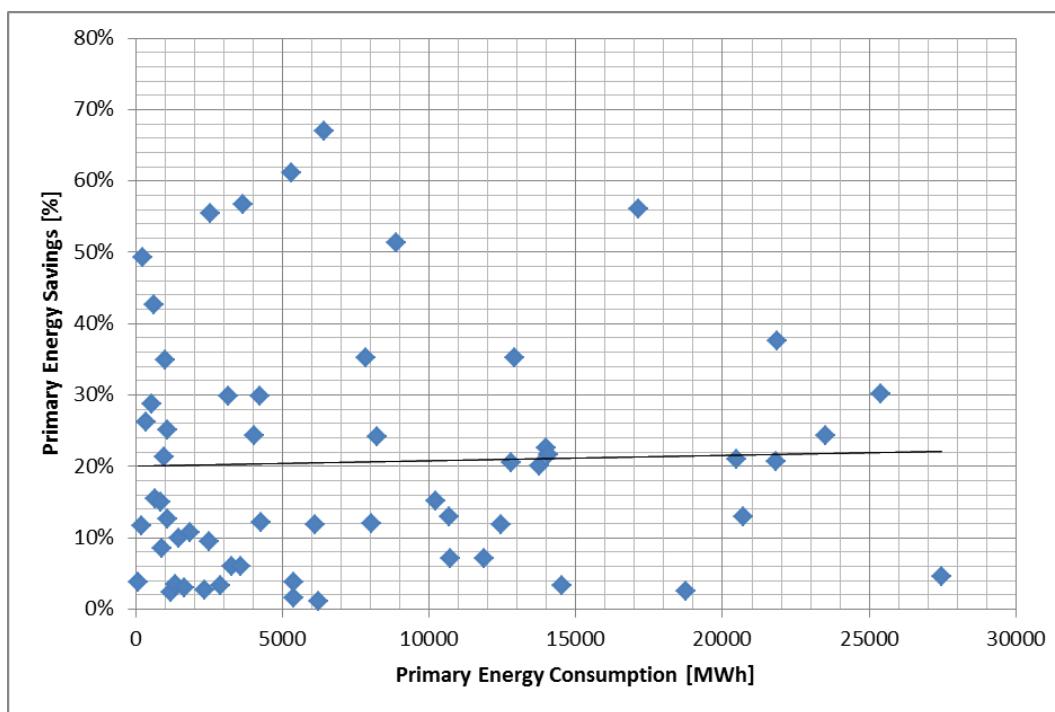


Figure 2-5 Correlation between the primary energy consumption and the primary energy savings of the audited companies (8 biggest companies are excluded from graph)

Among the 17 smallest companies (first quartile) in only one case a CHP was proposed as energy saving measure. In 12 cases only one kind of saving measure was proposed. Only in one case a combination of three different kinds of measures was proposed.

Regarding the 17 biggest companies (third quartile), in eleven cases the installation of a CHP was proposed as at least one saving measure. In five cases only one saving measure was proposed, in six cases a combination of at least three different kinds of measures.

2.3.2 Primary Energy Savings

50% (33 companies) of the energy audits brought about recommendations leading to primary energy savings between 6.2 and 30%, the median being 15.1%. (the mathematic mean is 20%).

	1. Quartile	Median	2. Quartile
Primary Energy Savings	6.20%	15.10%	29.90%

Table 2-4 First, second and third quartile of the primary energy savings of the audited companies

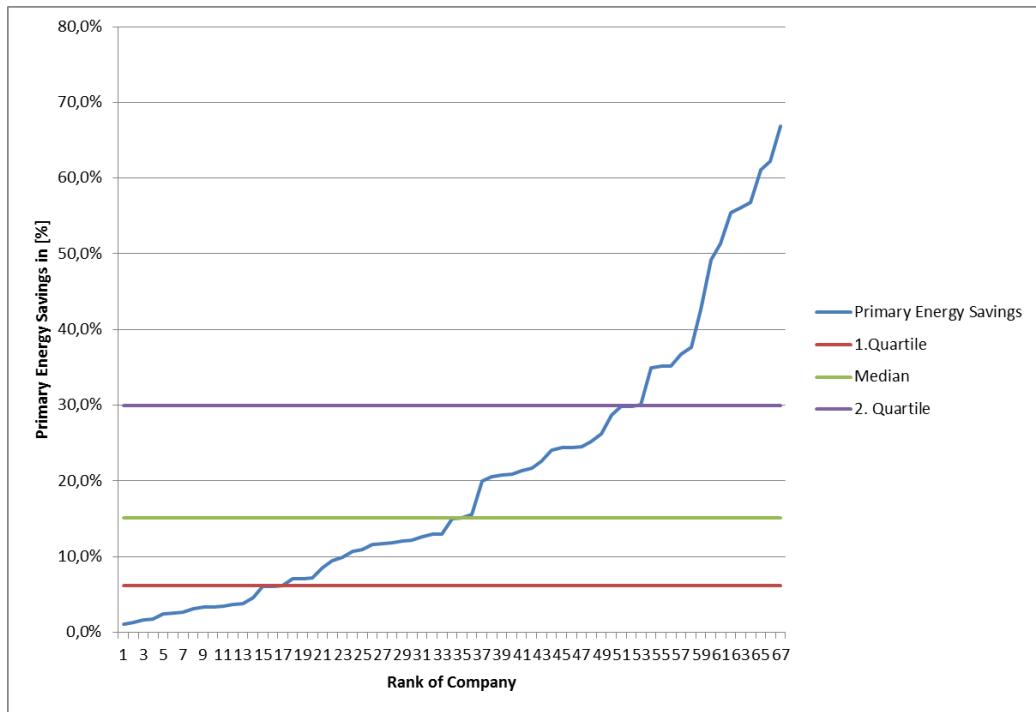


Figure 2-6 Companies ranked by primary energy savings with first, second (median) and third quartile (this means that 25 % of the companies lie below the first line, 50 % of the companies below the second line and 75% of the companies lie below the third line)

For 23 companies a saving potential between 1 and 10% was proposed, for 13 companies a saving potential between 10 and 20% was proposed (Figure 2-7).

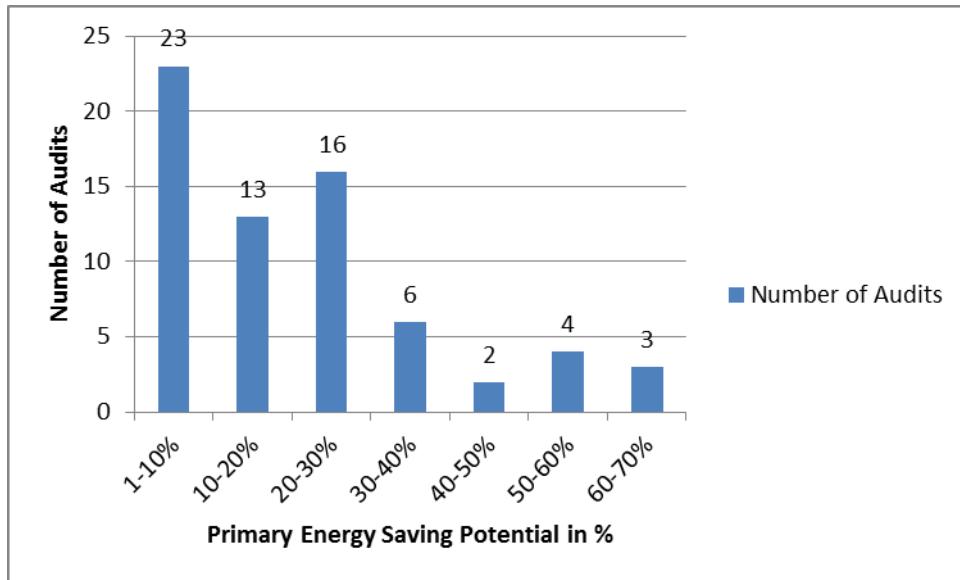


Figure 2-7 Number of companies per proposed range of primary energy savings

As to the 17 energy audits with equal or more than 30% energy savings (third quartile), in 12 cases the installation of a CHP in combination with at least heat recovery has been proposed. In 12 cases out of these „high saving proposals“ a combination of equal or more than three kinds of different saving measures has been

proposed. In eight cases it is a combination of heat recovery, process optimisation and CHP.

Most of these „high end“-audits are from Germany (six times), Spain (four times), Bulgaria (three times), France and Italy (two times).

No audits from Ireland, Slovakia, Austria and UK proposed savings of more than 30%.

Out of the 17 energy audits with less than 6.2% of energy savings, in eight cases only heat recovery has been proposed, in four cases the installation of a solar thermal plant (two cases only solar, one case in combination with process optimisation, one case with heat recovery). Among these „low end“-audits there are no audits from Germany, Spain and France. Mostly audits from Ireland (3 times), Slovakia (3 times) and UK (3 times) are in those ranges.

2.3.3 Payback Time

The average payback time (arithmetic mean) of the proposed measures is six years.

For 50% of the energy audits the payback time is between 2.5 (first quartile) and 8 years (third quartile), with the median being 3.6 years (50% of the audits having higher and 50% of the audits lower payback times).

	1. Quartile	Median	2. Quartile
Payback time of the proposed energy saving measures	2.5 years	3.6 years	8 years

Table 2-5 First, second and third quartile of the payback time of the proposed energy saving measures

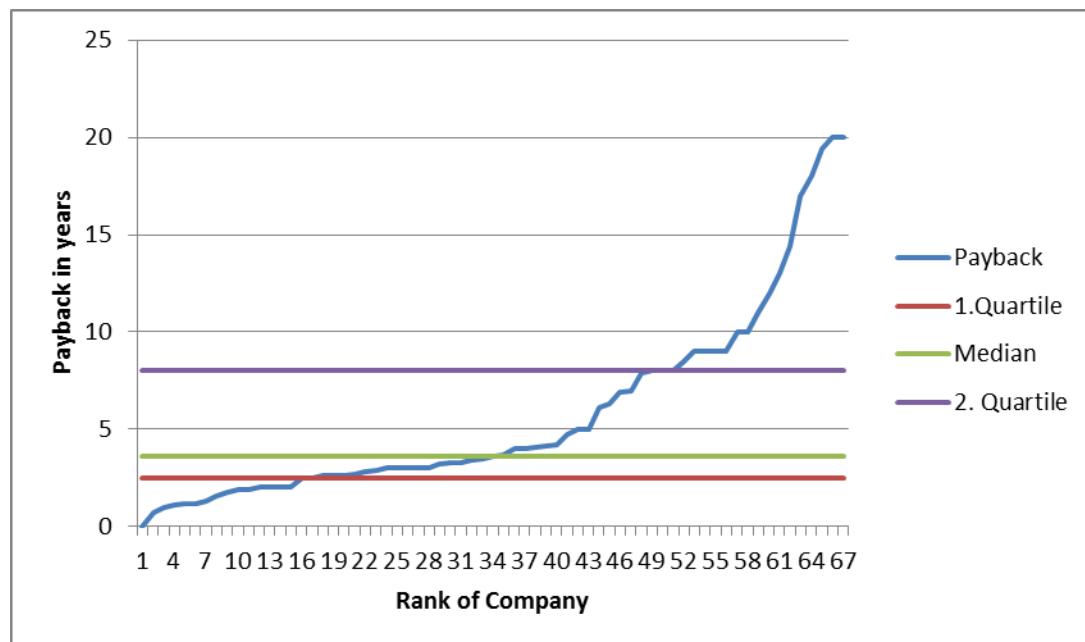


Figure 2-8 Companies ranked by payback time in years with first, second (median) and third quartile (this means that 25 % of the companies lie below the first line, 50 % of the companies below the second line and 75% of the companies lie below the third line)

The lowest quartile (saving measures with a payback below 2.5 years) in nine cases includes the installation of a CHP, whereas no proposed saving measure includes a solar thermal plant.

In the highest quartile (saving measures with a payback of more than eight years) eight times the installation of a solar thermal plant was proposed and only in one case a CHP.

Kind of saving measure proposed	Number of energy audits proposing the energy saving measure
Stand-alone proposals (only one kind of saving measure proposed)	Sum 30
Boiler efficiency	2
CHP	7
Heat recovery	12
Solar thermal	6
Process optimization	3
Combination of two different saving measures	Sum 21
Heat recovery and boiler efficiency	2
Heat recovery and CHP	10
Heat recovery and solar thermal	7
Process optimization and chiller	1
Process optimization and solar thermal	1
Combination of three different saving measures	Sum 16
Combinations, incl. process optimization, heat recovery and CHP (all 3 of them)	10
Other combinations of at least three different saving measures (excl. mentioned above)	6

Table 2-6 Number and kind of saving measures proposed in the EINSTEIN audits

2.3.4 Combined Heat and Power Plant

In 29 cases CHP (also in combination with other saving measures) was proposed (seven times as stand-alone version, ten times with heat recovery only), CHP was only once combined with a solar thermal plant. Those saving measures would lead to primary energy savings of 27% (average) with a payback of 3.6 years.

	Number of CHP proposed (mostly in combination with other measures)
Germany	9
Spain	7
UK	4
Austria	3
Italy	3
France	2
Bulgaria	1
Sum	29

Table 2-7 Number of proposals including CHP in the different countries

All (8) audits carried out in Spain proposed the installation of a CHP, in Germany in nine out of ten cases a CHP was proposed, in the UK four times (out of nine), in Italy and Austria three times, in France two times. In Ireland, Slovakia and Bulgaria no CHP was proposed.

In the countries mentioned above (esp. Germany and Spain) there is a large still un-exploited potential for CHP in almost all sectors. It is worth mentioning that in many cases CHP has been the selected option, competing with renewable energies (especially solar thermal) as possible 2nd choice.

This preference for CHP is owed to two facts:

- Economic performance of CHP exceeds that of solar thermal when supported by feed-in tariffs and when there is no funding for solar thermal.
- In countries with rather inefficient electricity grids high efficient CHP often leads to equivalent or even higher net primary energy savings than renewable heat & cooling.

This means that in certain situations fossil CHP is the key technology for obtaining substantial impact (primary energy savings) in the short term, combined with a good economic performance (depending on circumstances like feed-in tariff, size of company and heat demand, running hours, grid efficiency, financing issues). Nevertheless, on the medium and long term, renewable heat and cooling generation will become ever more the favourite choice, as primary energy savings associated with CHP will become less in the same degree in which the public electricity grids become more efficient (more efficient power plants + higher fraction of renewables).

2.3.5 Solar Thermal Plant

Suggested energy saving measures which include solar thermal plants had average primary energy savings of 24% with a payback of 9.4 years. Energy savings proposals (including solar thermal) with a very short payback time (2-4 years) were combinations of solar thermal with heat recovery, CHP, heat pumps and others.

	Solar Thermal (mostly in combination with other measures)
Bulgaria	5
Austria	3
UK	3
France	2
Italy	2
Slovakia	1
Germany	1
Sum	17

Table 2-8 Number of proposals including solar thermal plants in the different countries

Solar thermal plants were proposed in 17 cases: six times as stand-alone concept, six times with heat recovery only. The other cases are combinations with heat pumps and/or chillers and process optimisation.

Solar thermal plants were suggested five times in Bulgaria, three times in the UK and Austria, two times in France and Italy and in one case only in Germany and Slovakia. No solar thermal plants were suggested in Ireland and Spain.

3 Sector Analysis

Generally speaking, there is almost no correlation between sector and proposed saving measures, energy saving potential and payback time.

Sector	Number of EINSTEIN Audits	Countries
Industrial Laundries	5	Austria
Breweries	6	Austria, UK, Luxembourg, France, Germany, Spain
Bakeries	5	Austria, Italy, Bulgaria, Germany
Manufacturing of food (others than mentioned above)	21	Ireland (4), Italy (6), UK (2), Germany (3), Bulgaria (2), France (2), Austria (1)
Thermal bath	4	Germany
Service Companies (Buildings)	14 Office buildings 3 Schools 2 Hospitals 2 Universities 1 Casino 1 Data centre	UK (5), Bulgaria (4), Spain (3), Luxembourg, Germany, Austria
Metal Treatment	3	UK, Austria, Bulgaria
<ul style="list-style-type: none"> • Chemical industry • Manufacture of chemicals, • Pharmaceutical industry, • Production of expanded polystyrene 	6	Italy, France, Spain (3), Slovakia, Luxembourg

<ul style="list-style-type: none"> • Others • Sports • Automotive Head Sets • Photovoltaic • Biodiesel 	4	Bulgaria (2), Slovakia (2)
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Table 3-1 Number of EINSTEIN audits in the different sector

The number of the audits differs slightly to the total number of audits conducted, as some of the audits were not included in the quantitative analysis, because of missing or unrealistic data (esp. for payback time, see for details in the country reports).

For the **six breweries** the average savings were 30.2% with an average payback time of 6.4 years. The proposed energy savings had a broad range: in two cases more than 60%, in one case only 6% energy savings, the payback had a range from 3 to 12 years. The main proposed energy saving measures were CHP (4 cases) and heat recovery (4 cases), incl. combinations of both of them.

For the **four bakeries** the average savings were 13% with an average payback of 4.1 years. The savings ranged from 2 to 24%, the payback from 2 to 8 years. The main proposed energy saving measures was heat recovery (mainly combined with process optimisation, solar thermal, chillers or CHP).

For the **other companies of the food industry** the average energy savings would be 25% with an average payback of 4.3 years. The energy savings percentage was extremely unevenly distributed, ranging from 1 to 67%.

The proposed energy saving measures had a wide range from heat recovery to CHP, efficiency of boilers, heat pumps and solar thermal.

For the five **industrial laundries** the average savings were 21% (between 10 and 29%), average payback time 3.1 years. The main proposed energy saving measures were heat recovery (mainly from the exhaust gas of the driers and calanders, for pre-heating of the air for the driers and heating up of the washing water) and CHPs (in 2 cases).

The **thermal baths** had average savings of 24%, with a payback of 4.7 years. The main proposed saving measures were process optimisation, heat recovery, CHP and chillers.

The **14 service companies** are very different (hospitals, data centre, schools). The average savings were 14%, ranging from 3 to 43%. The payback was 8.4 years (ranging from 2 to 20 years). The highest payback times (20 years) had two solar thermal proposals. One solar thermal has a payback of 5 years.

For the **other sectors (metal, chemistry)** the energy savings were even more unevenly distributed than for the sectors mentioned above. That is why no calculation of mean values is reported here.

4 Summary of Audit Follow-Up

This chapter gives an overview of the EINSTEIN audit follow-up. All local partners in the different countries called all audited companies to ask for the status of the implementation of the saving measure, the main reasons for implementing or not implementing and for lessons learned or other issues.

The Austrian Energy Agency developed a template to be filled in for this purpose. The individual country results are shown in the next chapter.

From the 69 companies evaluated 9 cancelled the implementation of the proposed saving measures, 25 postponed their decision. 15 companies believe that further investigation is necessary, four already contracted further analysis, four already contracted detailed analysis, seven are inviting offers for equipment and five already implemented the proposed (or at least some of the proposed) saving measures.

This means that more than the half of the companies audited is planning to invest in energy saving measures.

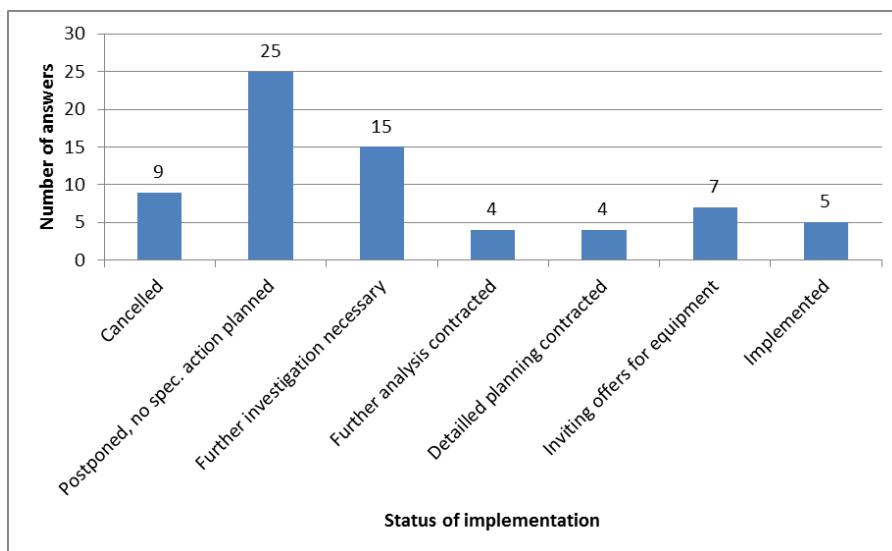


Figure 4-1: Status of implementation of the proposed EINSTEIN energy saving measures

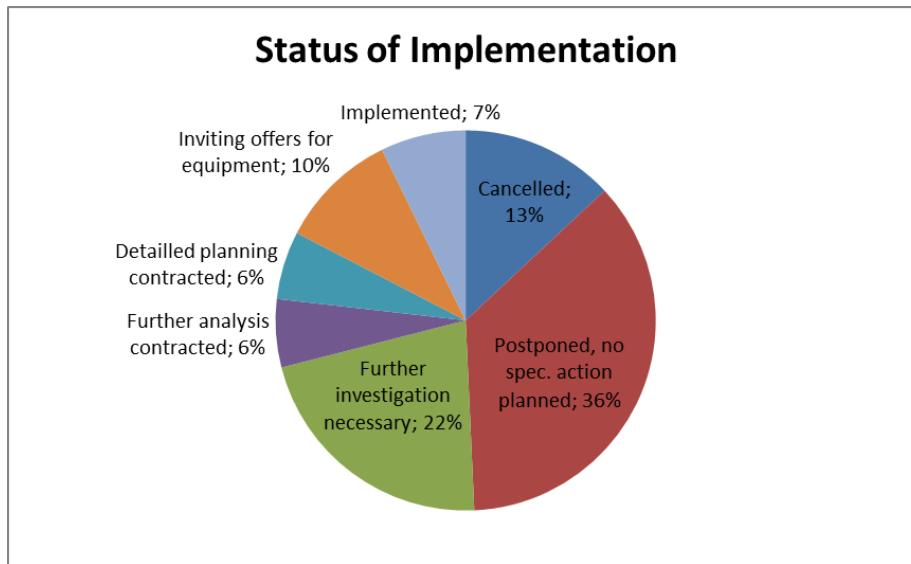


Figure 4-2: Status of implementation of the proposed EINSTEIN energy saving measures

Concerning the main reasons for not implementing the energy saving measures (so far), financial reasons rank foremost (38% in total: in eight cases financial risk, in five cases too long pay-back and in three cases too high initial costs for equipment was stated), followed by “not the right time” (in 13 cases or 31% of the answers). Other reasons such as too high technical risk and lack of time (each one two answers), not enough accurate data, personal reasons or unclear responsibility (three cases each) were not seen as the main issues.

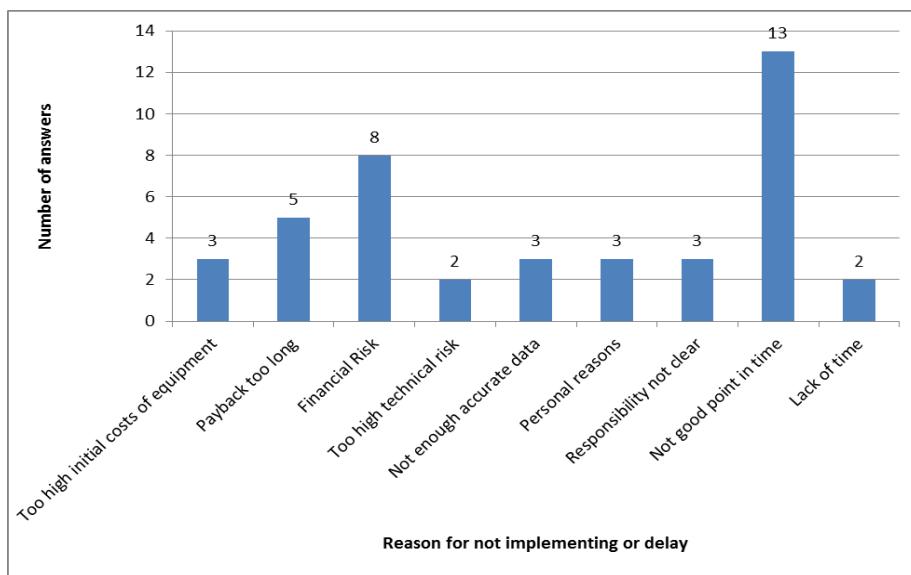


Figure 4-3: Reasons for not implementing or delay in the implementation of the proposed EINSTEIN energy saving measures

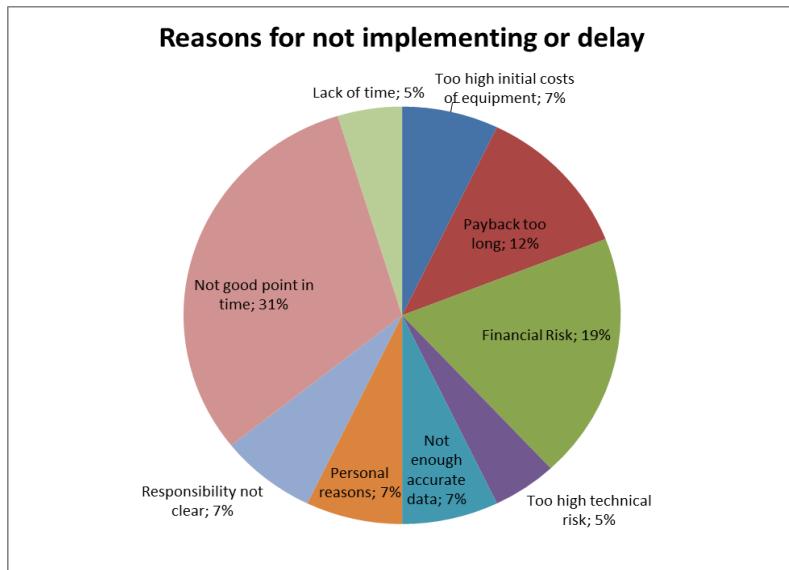


Figure 4-4: Reasons for not implementing or delay in the implementation of the proposed EINSTEIN energy saving measures

For the reasons for (planned) implementation of the saving measures proposed within the EINSTEIN reports, 22 companies answered that the high expected energy savings and the corresponding monetary savings are the main reasons. In four cases personal engagement could be identified.

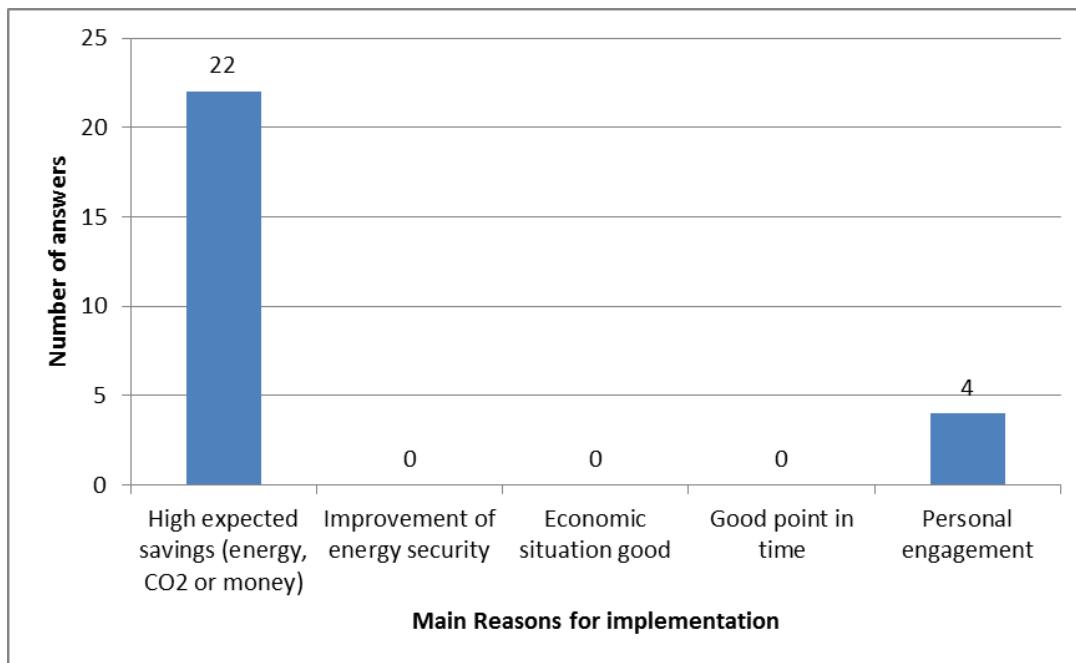


Figure 4-5: Reasons for the implementation or the specific planning of the proposed EINSTEIN energy saving measures

5 Individual Country Results

In this chapter the summary results from all audits are presented for each individual country: Austria, Bulgaria, France, Germany, Ireland, Italy, Luxembourg, Spain, and the UK.

This report summarizes all audits performed on a quantitative level per country, including all relevant information (e.g. primary energy consumption, primary energy savings, energy consumption and possible savings on fuel level, information of potentially savings of CO₂ emissions and total energy costs, and others).

In addition, it provides feedback from all countries to all audits. For this feedback a standardized, short questionnaire was developed. This questionnaire included questions on the current decision stage of the implementation of the energy saving measures and reasons for implementing or not implementing so far. In addition, general comments on the audits were summarized. Some of the topics mentioned in the company feedback which were rather similar in some countries and the lessons learned for the project are summarized here.

Although the number of realised measures based on the results of the audits is not as high as expected and hoped for, it can be stated that the general feedback from the companies on the support by the auditors, the audits themselves, the reports and presentation has been very good. Besides the very positive feedback also some suggestions for improvements for future audits and for further optimizing the EINSTEIN methodology can be concluded.

- In the beginning of an audit, it is very important to clearly define the expected results and scope of a fast audit in order to avoid disappointment or even the regret to have invested time in the audit. A fast audit gives an overview of the present state of the energy demand of the processes and the supply and shows the potential for optimisation starting from the process optimisation and heat integration going to the substitution of existing inefficient equipment by efficient ones with a special focus on renewable energy sources. Although the very high quality of the algorithms developed and used in the background ensures the reliability of the economic, energetic and ecologic evaluation it is still a fast audit. In case of optimisation potential identified a detailed analyses might be necessary before measures can be realised. Unfortunately, support in the direct realisation phase of measures suggested could not be covered within the project. All these topics have to be highlighted in the beginning of the project including a fast check of available data in order to avoid the needs for detailed data analyses even in a fast audit.
- It is the mission of an auditor and should be always part of an audit to show the theoretic potential for optimisation and energy efficiency and to increase the awareness of the company owner or its energy manager for future optimisation. An audit should not always "only" support the company in conclusion or decision already made on economic evaluation without an audit. Nevertheless, the solutions suggested and proposals designed and especially

the final solution has to be developed in close cooperation with the industry in order to avoid too complex solutions with no chance to be realised.

- The time schedule between the start of an audit and the presentation of the results is a very critical point. In the EINSTEIN project the time schedule for 72 audits in 10 partner countries had been very tough and due to higher effort of software development and necessary adaptions of the software to the needs of an audit, delays in the audit finishing occurred. In these cases it has been very important to communicate these delays realistic and/or highlight the contribution to an on-going research project to avoid dissatisfaction. Moreover, due to budget restrictions it was necessary to do the company visits at once but the audits (elaboration of alternatives and writing of the report) had to be done one after another. By this, partly longer audit duration as expected could not have been avoided. Generally it is a conclusion of the project to minimise the period of time of an audit, close cooperation and support by the company assumed.

As already mentioned, the audits have been performed by 5 partners in 10 partner countries covering 8 different languages. In most cases language problems could be avoided by the support of the local partners. Within the project some local differences in technical terminology have been identified leading to some misunderstandings.

It is part of the EINSTEIN methodology that preliminary work of the auditor is essential before the company visits. Especially in a project like EINSTEIN, covering audits in different sectors and sub-sectors of the industry, a huge range of technologies used and available present a challenge for the auditor to have a knowledge in most of the topics discussed. Nevertheless, the feedback from most of the companies gave a very good reference for the auditors.

5.1 Austria

5.1.1 Summary of Audit Results

In Austria 11 companies from the following branches were audited:

- Laundries (5)
- Hospitals (2)
- Food industry (brewery, bakery, chocolate factory)
- Metal treatment

For one company (hospital) the proposed CHP was not economic, therefore it has been excluded from the further analysis.

The average primary energy consumption is 12.2 GWh. The total primary energy consumption of the audited companies was 121.6 GWh (mainly natural gas 72.8 GWh and electricity 47.2 GWh), corresponding to total energy costs of 4 million EUR.

The main proposed measures were heat recovery and process optimisation.

The proposed measures would save 4.8 GWh or 7% of gas consumption and 22.2 MWh or 47% of electricity consumption. The total GWh savings would be 27 GWh, the percentage of savings would be around 22%.

This would correspond to money savings of 0.75 million EUR or 18.3% of total energy costs.

From the approx. 27,683 t of CO₂ emissions 4,716 t or 17% could be saved (19% for the arithmetic mean).

The total investment needed would be 2.9 million EUR.

The primary energy savings due to renewable energy would be around 1.5 GWh.

The average payback time: 5.2 years

	Present State	Savings-Suggested	%
Total primary energy	121.6 GWh p.a.	27 GWh p.a.	22% (19%)
Natural gas	72.8 GWh p.a.	4.8 GWh p.a.	7%
Electricity	47.2 GWh p.a.	22.2 GWh p.a.	47%
District heat fossil	1.7 GWh p.a.	0.05 GWh p.a.	3%
CO ₂	27,683 t p.a.	4,716 t p.a.	17%
Total energy costs	4 million EUR p.a.	743.016 EUR p.a.	18.3%
Investment	2.8 million EUR p.a.		
Av. pay back time	5.2 years		
Primary energy savings due to renewable energy	1,473 MWh		

Table 5-1 Summary table for the results of the energy audits performed in Austria

5.1.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay	Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment	High expected savings (energy, CO ₂ or money)	2
Postponed, no spec. action planned	6	Payback too long	Improvement of energy security	
Further investigation necessary	1	Financial Risk	Economic situation good	
Further analysis contracted		Too high technical risk	Good point in time	
Detailed planning contracted	2	Not enough accurate data	Personal engagement	1
Inviting offers for equipment	1	Personal reasons	-	
Implemented		Responsibility not clear	1	
-		Not good point in time	4	
		Lack of time		

Table 5-2 Summary table for the replies to the EINSTEIN audit – follow up

From the 10 companies in this evaluation 6 postponed their decision out of several reasons:

- In one case the responsibility changed, but the idea itself is still alive and will be considered.
- In one case an implementation would need a change in distribution system and general change of energy supply.
- In one case process optimization was used for the optimization of the running time of the dryers (and no heat recovery is planned at the moment).
- In one case the saving measure has to be discussed on a higher level, the technicians support the saving measure.
- In one case the proposed heat exchanger will not be installed because the payback is longer than the expected life-time of the equipment. However, some optimization of the steam system is investigated
- One company was only interested in the evaluation itself.
- For one company further investigation is necessary, as the company will change its location and will implement changes then.
- Two companies already contracted detailed planning. A heat exchanger was already proposed for subsidy, the financial circumstances in Austria (bank guarantee needed, which is quite expensive) are not so good, therefore currently it will not be implemented. On the other hand further investigation in the second heat exchanger is done.
- In one case the funding situation is good in Austria for solar heat.
- One company already invited companies for offers for equipment, but not exactly for the measures proposed but for the heat flow identified (no heat recovery but air recirculation), the second proposed heat exchanger is currently not considered.

5.2 Bulgaria

5.2.1 Summary of Audit Results

In Bulgaria 10 companies from the following branches were audited:

- Secondary Schools
- Food Industry (bread, dairies, mushrooms)
- Production of aluminium
- Production of photovoltaic modules
- Biodiesel production

The average primary energy consumption of the companies/schools is 6.6 GWh. The total primary energy consumption of the audited companies was 66 GWh (mainly electricity 35.7 GWh, renewables 14.2 GWh, natural gas 8 GWh and district heat 7.8 GWh) corresponding to total energy costs of 2.3 million EUR.

The main proposed measures were: heat recovery, process optimisation, CHP, boiler efficiency and solar thermal systems.

The proposed measures would save 5.3 GWh or 15% of Electricity consumption: 3.3 GWh or 23% of biomass and 3 GWh or 38% of district heat.

The total savings of primary energy consumption would be around 12 GWh; the total percentage of savings would be around 18%.

This would correspond to money savings of 257,000 EUR or 10.9% of total energy costs.

From the approx. 9,727 t of CO₂ emissions 1,677 t or 17% could be saved. (21% as arithmetic mean of the different audits)

The total investment needed would be 2.2 million EUR.

The average payback time: 8.7 years.

The possible saving measures were discussed in detail with the companies before suggesting the measures in the reports.

	Present State	Savings-Suggested	%
Total primary energy	66 GWh p.a.	12 GWh p.a.	18% (21%)
Electricity	35.7 GWh p.a.	5.3 GWh p.a.	15%
Renewable energy	14.2 GWh p.a.	3.5 GWh p.a.	23%
Natural gas	8 GWh p.a.	0.4 GWh p.a.	
District heat	7.8 GWh p.a.	3 GWh p.a.	38%
CO ₂	9,727 t p.a.	1,677 t p.a.	17%
Total energy costs	2.3 million EUR	257,000 EUR	10.9%
Total investment	2.2 million EUR		
Av. pay back time	8.7 years		
Primary energy savings due to renewable energy	2,797 MWh		
Investment in sustainable energy	712,683 EUR		

Table 5-3 Summary table for the results of the energy audits performed in Bulgaria

5.2.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay		Main Reasons for Implementation	
Cancelled	3	Too high initial costs of equipment		High expected savings (energy, CO ₂ or money)	6
Postponed, no spec. action planned	1	Payback too long	1	Improvement of energy security	
Further investigation necessary	4	Financial risk	1	Economic situation good	
Further analysis contracted		Too high technical risk		Good point in time	

Detailed planning contracted	1	Not enough accurate data		Personal engagement	
Inviting offers for equipment	1	Personal reasons		-	
Implemented		Responsibility not clear			
-		Not good point in time	2		
		Lack of time			

Table 5-4 Summary table for the replies to the EINSTEIN audit – follow up

Currently no measure has been implemented but two companies are quite close to implementation, one of them is planning to implement the measure during the next winter. Four are considering to implement measures and will try to get subsidy for implementation (esp. for solar thermal systems suggested). One postponed the decision for budgetary reasons at the moment. The main reasons for implementation are the expected high savings of CO₂, money and/or energy.

Three companies cancelled the implementation of the saving measures, mainly for financial or time reasons.

One company answered that there was “no money for improvements at all”, one company believes that it is not worth that investment and fears drawbacks for the production process during installation, one organisation currently implemented other saving measures and will therefore not consider those presented by EINSTEIN.

5.3 France

5.3.1 Summary of Audit Results

In France 6 companies from the following branches were audited: five companies of the food industry (brewery, manufacturer of cookies and others), one company of the chemical industry (manufacturer of cosmetics).

As for two audits the implementation of optimisation measures would imply a huge investment and changes in the production chain, these audits were excluded from the analysis, so the data below refers to 4 audits only. (for the qualitative analysis below 5 companies were included)

The total primary energy consumption of the audited companies was 29.8 GWh (mainly natural gas 16.6 GWh and electricity 12.5 GWh and 214 MWh gasoil), corresponding to total energy costs of 0.8 million EUR.

The main proposed measures were: solar thermal, heat recovery and process optimisation, CHP, efficient boilers.

The proposed measures would save 12.8 GWh or 43% of total primary energy consumption, 172 MWh or 1% of gas consumption, 12.5 GWh or 100% of electricity consumption and 107 MWh or 50% of gasoil.

The total savings would be 12.8 GWh or 43% of total primary energy consumption (34% as arithmetic average).

This would correspond to money savings of 146,722 EUR or 16.3% of total energy costs.

From the approx. 4,293t of CO₂ emissions 459 t or 11% could be saved.

The total investment needed would be 1.3 million EUR.

The primary energy savings due to renewable energy would be 1,664 MWh.

The average payback time is 5.8 years.

	Present State	Savings-Suggested	%
Total primary energy	29.8 GWh p.a.	12.8 GWh p.a.	43% (34%)
Natural gas	16.6 GWh p.a.	0.1 GWh p.a.	1%
Electricity	12.5 GWh p.a.	12.5 GWh p.a.	100%
Gasoil	0.2 GWh p.a.	0.1 GWh p.a.	50%
CO ₂	4,293 t p.a.	459 t p.a.	11%
Total energy costs	0.8 million EUR	146.722 EUR	16,3%
Total Investment	1.3 million EUR		
Av. pay back time	5.8 years		
Primary energy savings due to renewable energy	1,664 MWh		
Investment in sustainable energy	503.488		

Table 5-5 Summary table for the results of the energy audits performed in France

5.3.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay		Main Reasons for Implementation	
Cancelled	1	Too high initial costs of equipment		High expected savings (energy, CO ₂ or money)	1
Postponed, no spec. action planned	2	Payback too long		Improvement of energy security	
Further investigation necessary	1	Financial Risk	1	Economic situation good	
Further analysis contracted		Too high technical risk	1	Good point in time	
Detailed planning contracted		Not enough accurate data	1	Personal engagement	
Inviting offers for equipment		Personal reasons		-	
Implemented	1	Responsibility not clear			
-		Not good point in time	1		
		Lack of time			

Table 5-6 Summary table for the replies to the EINSTEIN audit – follow up

Out of the 5 companies in this review one cancelled the project because it was no good point in time. Two companies postponed the action because of too high technical risk and of the financial situation in the company. One of these companies replaced the boiler by a more efficient one as well as some equipment of the distribution circuit. The company saved around 10% of the previous energy consumption per product.

One company has to do further investigation as the data is not accurate enough.

One company implemented the heat exchanger system because of the high energy, CO₂ and money savings.

5.4 Germany

5.4.1 Summary of Audit Results

In Germany companies from the following branches were audited:

- Food industry (five companies: production of canned vegetables, brewery, bakery, juice and production and packaging of meat and sausages)
- Thermal baths (four companies)
- One office building

The main saving measures were: heat recovery, CHP, process optimization, solar thermal, chillers, and heat pump

The average primary energy consumption is 15.5 GWh. The total primary energy consumption of the audited companies was 139 GWh (mainly natural gas 64.2 GWh and electricity 58.6 GWh, gasoil 8 GWh and district heat fossil 6.1 GWh), corresponding to total energy costs of 6 million EUR.

The main proposed measures were: heat recovery and process optimisation.

The proposed measures would increase gas consumption of 11.9 GWh or 20% of gas consumption, whereas the 58.6 GWh or 96% of electricity consumption, 2 GWh or 25% of gasoil consumption and 1.9 GWh or 28% of fossil district heat would be saved. The total GWh savings would be around 50.5 GWh, the percentage of savings would be around 36%.

This would correspond to money savings of 2 million EUR or 36% of total energy costs.

From the approx. 29.084 t of CO₂ emissions 8.751 t or 30% could be saved. (34% for the arithmetic average)

The total investment needed would be 4.9 million EUR.

The primary energy savings due to renewable energy would be around 939 GWh, the investment in sustainable energy would be 519,043 EUR

The average payback time: 3.1 years.

	Present State	Savings-Suggested GWh/t/EUR	%
Total primary energy	139 GWh p.a.	50.5 GWh p.a.	36% (34%)
Natural gas	64.2 GWh p.a.	11.9 GWh p.a.	-20%
Electricity	61 GWh p.a.	58.6 GWh p.a.	96%
Gasoil	8 GWh p.a.	2 GWh p.a.	25%
District heat fossil	6.1 GWh p.a.	1.7 GWh p.a.	28%
CO ₂	29.084 t	8.751 t	30%
Total energy costs	6 million EUR	2 million EUR	36%
Total	4.9		
Av. pay back time	3.1		
Primary energy savings due to renewable energy	939 MWh		
Investment in sustainable energy	519,043 EUR		

Table 5-7 Summary table for the results of the energy audits performed in Germany

5.4.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay		Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment		High expected savings (energy, CO ₂ or money)	4
Postponed, no spec. action planned	4	Payback too long	1	Improvement of energy security	
Further investigation necessary	1	Financial Risk		Economic situation good	
Further analysis contracted	1	Too high technical risk		Good point in time	
Detailed planning contracted	1	Not enough accurate data		Personal engagement	1
Inviting offers for equipment	2	Personal reasons	1	-	
Implemented	1	Responsibility not clear			
-		Not good point in time	2		
		Lack of time			

Table 5-8 Summary table for the replies to the EINSTEIN audit – follow up

Out of the 10 companies one company already implemented the saving measure because of the high expected energy savings: One of the proposed supply alternatives for the thermal bath was a CHP engine. This machine was already ordered when the audit took place and is meanwhile installed. Thus it can't probably be counted as an audit success, however the audit results underlined that the Bath management is on the right way. Other proposed measures were not yet tackled mainly because of

capacity reasons (man power and financial constraints) but will follow in the mid-term. (heat recovery, optimization of the ventilation system).

Two companies are already inviting offers for equipment:

- In one case the CEO was already aware of the problem and was looking for confirmation in his investment strategy. In that respect the EINSTEIN audit came at exactly the right time. Triggered by the audit results the CEO decided to go for a heat recovery system including all the bakery ovens as heat sources combined with a 20 m³ hot water storage tank. Thus the implemented system will be even more extended than originally suggested by the audit results. According to the planning engineers fuel savings and economic benefits will equally be larger than suggested by the audit results. The system is planned to start working by the end of 2012.
- In the second case the company is currently checking the feasibility of the installation of a CHP engine to partly cover electricity and heating supply of the building which was one of the results of the EINSTEIN audit and the outcome of an independent engineer's investigation on saving potential in the company. Primary energy savings and positive environmental effects however don't have to be expected because the current supply is heat from the CHP-driven district heating system of Berlin. Concerning heat recovery in ventilation systems there is awareness that the old systems are partly not up to date, there are however no plans to improve the old installations. In case old installations have to be replaced new standards will be applied. In this Audit case improvements of the energetic building envelope are the most urgent step, which is however not covered by EINSTEIN. Despite of costs and obvious waste of energy the management board insisted in getting active air-conditioning in their floor to cool down offices which in a way foils efforts towards more energy efficiency.

In one case detailed planning is already contracted: There is a long history in optimizing processes and energy supply in order to use resources in a sensible and sustainable way. For instance does the company have CHP installations working since 15 years, a PV installation has been erected on the roof, the ventilation systems is up to date, currently the light system is switched to LED. EINSTEIN audit results do match with other studies in this area, so the recommendations are under way of being implemented.

In another case further analysis is contracted because of high expected savings: Implementation of the improvement of heat recovery from the sterilisation process is being worked on. The proposed heat exchanger network including the existing 20 m³ storage tank will be installed step by step. The equally proposed CHP installation is not on the agenda.

In one case further investigation is necessary: The company owners are highly interested, yet there haven't been taken any decisions which measures to implement.

Four out of 10 companies postponed their decisions on investing in the suggested measures. The reasons were quite different:

- In one case the head of production and technical manager wanted to have some external support for his improvement ideas towards the CEO and the company's headquarters abroad. His focus would rather be on general efficiency, unfortunately the outcome of the EINSTEIN Audit did not match the expectations. The manager blamed too long pay-back periods and too high initial investment for not dealing with suggested measures but stated that they did some "other minor things".
- In one case implementation was postponed because of "no good point in time".
- In one case the technical manager is generally aware of the energy issues. Because of his background in electrical engineering there is a focus on electricity issues whereas the thermal energy related EINSTEIN suggestions seem to be not fully understood. Asked whether he would aim to implement one of the suggested measures he would say yes and named electronic frequency converters for the ventilation system as most urgent measure.
- In another case the decision was postponed as the CEO of the Spa was changed in the time between the audit visit and handing over the audit report. The new CEO did not have time so far to deal with the audit results. However he is interested and a follow up meeting to present and discuss audit results has been agreed on.

5.5 Ireland

5.5.1 Summary of Audit Results

In Ireland all four companies were from the branch food industry (fish, ice cream, dairy).

The average primary energy consumption is 30 GWh. The total primary energy consumption of the audited companies was 124 GWh (mainly naturals gas 83 GWh and electricity 39GWh), corresponding to total energy costs of 4.7 million EUR.

The main proposed measures were: heat recovery and process optimisation.

The proposed measures would save 8.4 GWh or 10% of gas consumption and 200 MWh or 11% of propane consumption. The total percentage of savings would be around 7%. (5% arithmetic mean), one company is responsible for 97% of savings.

This would correspond to money savings of 353,000 EUR or 7.5% of total energy costs.

From the approx. 38,700 t of CO₂ Emissions 1,736t or 7.5% could be saved.

The total investment needed would be 1 million EUR.

The average payback time is 2.5 years.

	Present State	Savings-Suggested	%
Total primary energy	123.9 GWh p.a.	8.7 GWh p.a.	7% (5%)
Natural gas	83 GWh p.a.	8.4 GWh p.a.	10%
Electricity	38.8 GWh p.a.	0.02 GWh p.a.	0%
Propane	1.8 GWh p.a.	0.20 GWh p.a.	11%
Liquid fuel oil	0.3 GWh p.a.	0.03 GWh p.a.	10%
CO ₂	38,689 t p.a.	1,763 t p.a.	5%
Total energy costs	4.7 million EUR	0.353 million EUR	7.5%
Total investment	1 million EUR		
Av. pay back time	2.5 years		

Table 5-9 Summary table for the results of the energy audits performed in Ireland

5.5.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay	Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment	High expected savings (energy, CO ₂ or money)	1
Postponed, no spec. action planned	1	Payback too long	Improvement of energy security	
Further investigation necessary	2	Financial Risk	Economic situation good	
Further analysis contracted		Too high technical risk	Good point in time	
Detailed planning contracted		Not enough accurate data	Personal engagement	
Inviting offers for equipment		Personal reasons	-	
Implemented	1	Responsibility not clear		
-		Not good point in time		
		Lack of time	2	

Table 5-10 Summary table for the replies to the EINSTEIN audit – follow up

In Ireland one company already implemented the saving measures because of the high expected savings.

In this case the company's boiler service contractor had previously advocated the installation of an economiser, but without the estimated potential savings, the company was unwilling to invest. Once estimated savings within EINSTEIN were provided via the project, the company went ahead. The actual costs were higher than estimated in EINSTEIN.

In two companies further investigation is necessary and one company postponed the decision.

The main reasons for not implementing were lack of time or not enough accurate data:

- In one case the report has only been issued relatively recently.

- In another case additional investigation is needed and certain parameters need to be more accurately quantified. In addition the impact of solids particulates on the heat exchanger surfaces will need to be assessed.
- In the third case the options examined in terms of replacement of boilers or solar thermal options all had very long payback periods as the site is small in size.

5.6 Italy

5.6.1 Summary of Audit Results

In Italy 8 companies from the following branches were audited:

- Food industry (bakery, production of salami and cooked ham, industrial catering, snack pellets and pre-cooked lasagne)
- Food packaging

The average primary energy consumption is 7.4 GWh. The total primary energy consumption of the audited companies was 59.2 GWh (mainly naturals gas 22.2 GWh and electricity 34.1 GWh), in addition 2.2 GWh Liquid Fuel Oil and Gas Oil (0.5 GWh), corresponding to total energy costs of approx. 3 million EUR.

The main proposed measures were: heat recovery, solar thermal, CHP, Boilers, heat pump and process optimisation.

The proposed measures would save 11.8 GWh or 20% of total energy consumption. The gas consumption would increase by approx. 13% (by 2.8 GWh), the electricity consumption would be reduced by 11.9 GWh or 35%.

This would correspond to money savings of 497,615 EUR or 16.7% of total energy costs.

From the approx. 12,600 t of CO₂ emissions 2,400 t or 19 % could be saved (20% for the arithmetic average).

The total investment needed would be 1.8 million EUR.

The average payback time: 2.8 years.

One company was responsible for 39% of savings, one for 36% and one for 18%.

	Present State	Savings-Suggested	%
Total primary energy	59.2 GWh p.a.	11.8 GWh p.a.	20% (20%)
Natural gas	22.2 GWh p.a.	-2.8 GWh p.a.	-13%
Electricity	34.1	11.9 GWh p.a.	35%
Gasoil	0.7 GWh p.a.	0.5 GWh p.a.	69%
Liquid fuel oil	2.2 GWh p.a.	2.2 GWh p.a.	97%
Renewables			
CO ₂	12,593 t. p.a.	2,399 t. p.a.	19%
Total energy costs	3 million EUR	497,615 EUR	16.7%
Total investment	1.8 Mio		
Av. pay back time	2.8		
Renewable energy triggered	1.6 GWh		
Investment in sustainable energy	130,000 EUR		

Table 5-11 Summary table for the results of the energy audits performed in Italy

5.6.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay		Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment	2	High expected savings (energy, CO ₂ or money)	2
Postponed, no spec. action planned	1	Payback too long		Improvement of energy security	
Further investigation necessary	3	Financial Risk	1	Economic situation good	
Further analysis contracted	2	Too high technical risk		Good point in time	
Detailed planning contracted		Not enough accurate data		Personal engagement	
Inviting offers for equipment	2	Personal reasons		-	
Implemented		Responsibility not clear			
-		Not good point in time	1		
		Lack of time			

Table 5-12 Summary table for the replies to the EINSTEIN audit – follow up

Of the eight audits three companies still have to investigate the energy saving options proposed during the EINSTEIN audits.

Two companies already contracted further analysis; two companies are already inviting offers for equipment. The main reasons for not implementing so far are: too high initial costs of equipment, not good point in time and financial risk. The main reason for planning implementation is the high expected energy savings.

In detail one audit was assessed very positively and accurate in many aspects, in future several measures will be implemented.

Another audit was a positive experience that has provided the company valuable information on the best way for the implementation of actions for the recovery of energy in the future. Perhaps supported by public funding to lower the initial cost of the investment the measures will be implemented.

In another case the experience was very positive and constructive. The method of analysis has focused on innovative energy saving and efficiency measures.

One company will replace the oversized boiler by a hot water storage tank fed from water condensate with a small heat exchanger.

In one case at the moment the audit results did not give an advantage in terms of energy savings, such as to justify the investment costs.

In two cases the audit results have to be investigated.

5.7 Luxembourg

5.7.1 Summary of Audit Results

In Luxembourg 3 companies from the following branches were audited: brewery, health (hospital) and plastics.

The average primary energy consumption is 5 GWh. The total primary energy consumption of the audited companies was 15 GWh (mainly natural gas 32.8 GWh and electricity -17.8 GWh).

The main proposed measures were: heat recovery, CHP and chillers optimisation (see for details below).

The proposed measures would save 3.2 GWh or 10% of gas consumption and 1.4 or -3% of electricity consumption. The total primary energy savings would be 4.2 GWh, the percentage of savings would be around 28%.

From the approx. 4,208 t of CO₂ emissions 1,218 t or 29% could be saved.

The total investment was only calculated for one company, for the two others general research for possible savings was done.

	Present State	Savings-Suggested	%
Total primary energy	15 GWh p.a.	4.2 GWh p.a.	28%
Natural gas	32.8 GWh p.a.	3.2 GWh p.a.	10%
Electricity	-17.8 GWh p.a.	1.4 GWh p.a.	-3%
CO ₂	4.208 t p.a.	1.218 t p.a.	29%
Total energy costs	1.2 Mio	0.41 Mio	3.5%
Investment	n.a.		

Av. pay back time	n.a.		
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Table 5-13 Summary table for the results of the energy audits performed in Luxembourg

5.7.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay	Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment	High expected savings (energy, CO ₂ or money)	
Postponed, no spec. action planned	2	Payback too long	Improvement of energy security	
Further investigation necessary	1	Financial Risk	1 Economic situation good	
Further analysis contracted		Too high technical risk	1 Good point in time	
Detailed planning contracted		Not enough accurate data	Personal engagement	
Inviting offers for equipment		Personal reasons	-	
Implemented		Responsibility not clear		
-		Not good point in time	1	
		Lack of time		

Table 5-14 Summary table for the replies to the EINSTEIN audit – follow up

Of the three organisations, 2 postponed their implementation of saving measures:

One company believes that further investigation is necessary for the final decision for the investment.

The reasons that the proposed saving measures are not implemented so far are financial and high technical risk and not good point in time.

Overall, the collaboration with the companies went very well, and the implementations of some of the suggested optimization measures are currently under discussion.

In the case of the first company (brewery), the auditors suggested the integration of several heat exchangers in the process line. Unfortunately, the most sensible alternative had already been implemented beforehand, a fact that was not communicated on time to the auditors. Nevertheless, due to various discussions, the company is currently assessing additional heat recovery concepts that were initially, at the company's request, excluded.

The second audit conducted was on a trigeneration plant of a hospital. The objective here was to analyse the impact of the plant's real working schedule (considering technical interruptions and limited working hours) versus a theoretical use of the Combined Heat and Power (CHP) units working continuously as heating base load. According to the EINSTEIN audit's outcome, a reduction of 43% in primary energy demand could be obtained if the CHP plant could work continuously. The company was interested in this outcome, and will consider how to increase the CHP's use in the future.

The last project focused on plastic injection molding machines, where plastic marbles are heated up and melted in a very short time. After the pieces are cast, the plastic must be cooled down quickly. The auditors assessed the possibility for heat recovery on the cooling of the casts as well as on the hydraulic part of the machines, to preheat the plastic marbles inflow. As the audit was conducted rather late in the project (as replacement of an audit of a company that had decided to opt out due to shifts in internal priorities) the company was not able to implement the suggested solution before the end of the project. They were nevertheless interested in the outcomes and will potentially consider heat recovery on their injection machines. The auditors also intend to present the outcomes of the audit to the machine's manufacturer to show the potential on heat recovery on their equipment.

5.8 Slovakia

5.8.1 Summary of Audit Results

In Slovakia 3 companies from the following branches were audited:

- Plastic industry
- Automotive
- Sports article

The average primary energy consumption is 34.3 GWh. The total primary energy consumption of the audited companies was 103 GWh (mainly natural gas 26.3 GWh and electricity 76.8 GWh), corresponding to total energy costs of 2.9 million EUR.

The main proposed measures were: heat recovery, solar thermal, and efficient boilers.

The proposed measures would save 2.9 GWh or 10.9% of gas consumption and -0.4 GWh or -0.5% of electricity consumption. The total GWh savings would be around 2.5 GWh; the percentage of savings would be around 2.4% (2.8% for the arithmetic average).

This would correspond to money savings of 52,000 EUR or 1.8% of total energy costs.

From the approx. 18,776 t of CO₂ emissions 560 t or 3.1% could be saved.

The total investment needed would be around 0.52 million EUR.

Primary energy savings due to renewable energy would be around 73 MWh, the investment in sustainable energy would be 198,660 EUR.

The average payback time: 7 years.

In Slovakia the companies used mainly electricity, therefore mainly energy savings to heat up hot water were evaluated and not directly for processes, therefore the savings are not that high than in other countries.

	Present State	Savings-Suggested	%
Total primary energy	103 GWh p.a.	2.5 GWh p.a.	2.4% (2.8%)

Natural gas	26.3 GWh p.a.	2.9 GWh p.a.	10,9%
Electricity	76.8 GWh p.a.	-0.4 GWh p.a.	-0,5%
CO ₂	18,776 t p.a.	590 t p.a.	3,1%
Total energy costs	2.9 million EUR	0.052 million EUR	1.8%
Total investment	522,860 EUR		
Av. pay back time	7		
Primary energy savings due to renewable energy	73 MWh		
Investment in sustainable energy	198,660 EUR		

Table 5-15 Summary table for the results of the energy audits performed in Slovakia

5.8.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay	Main Reasons for Implementation	
Cancelled		Too high initial costs of equipment	High expected savings (energy, CO ₂ or money)	1
Postponed, no spec. action planned	1	Payback too long	Improvement of energy security	
Further investigation necessary	1	Financial Risk	Economic situation good	
Further analysis contracted		Too high technical risk	Good point in time	
Detailed planning contracted		Not enough accurate data	Personal engagement	
Inviting offers for equipment		Personal reasons	-	
Implemented	1	Responsibility not clear		
-		Not good point in time		
		Lack of time		

Table 5-16 Summary table for the replies to the EINSTEIN audit – follow up

In Slovakia one company implemented the saving measure.

Based on EINSTEIN audit, the company started thinking about the possibilities of energy savings. They revised the original EINSTEIN proposal due to local conditions. The company management decided that the best solution for saving energy is to install a new and effective system for the collection and return of condensate, which is now unused.

For another company further investigation is necessary, the chief power engineer was delegated by the leadership of the company to develop a more detailed study for heat recovery. (as currently not enough accurate data is available).

For the third company the payback period of proposed measure is 9 years and it is too long from financial angle of view, therefore they postponed their decision.

5.9 Spain

5.9.1 Summary of Audit Results

In Spain 8 companies from the following branches were audited:

- Chemical industry (2 manufacture of plastic products, pharmaceutical industry)
- Food industry (slaughterhouse, brewery)
- Gambling activity
- Office building (2)

The average primary energy consumption is 24.1 GWh. The total primary energy consumption of the audited companies was 193 GWh (mainly natural gas 84.4 GWh and electricity 102 GWh), corresponding to total energy costs of 5.8 million EUR.

The main proposed measures were: CHP, combined heat and cooling, heat recovery and process optimisation.

The proposed measures would save 218.7 GWh or 214% of electricity consumption, on the other hand additional 119.8 GWh gas would be needed (-142% gas savings). That gas consumption would more than double in the alternative status. This is because of the CHP production and the selling of additional produced electricity to the grid.

The total savings would be 97.2 GWh, the percentage of savings would be around 51%. (29% for the arithmetic mean)

This would correspond to money savings of 2.1 million EUR or 51% of total energy costs.

From the approx. 37,495 t of CO₂ emissions 10,079 t or 27% could be saved.

The total investment needed would be 9.7 million EUR.

The average payback time would be 4.3 years.

One company (brewery) has a quite big energy consumption, the suggested efficiency measures (CHP and cooling) would lead to quite big energy savings (approx. 60%). For another company the CHP would bring a lot of savings (55%). The other companies have saving potential between 11 and 30%.

	Present State	Savings-Suggested	%
Total primary energy	193 GWh p.a.	97.2 GWh p.a.	51% (29%)
Natural gas	84.4 GWh p.a.	-119.8 GWh p.a.	-142%
Electricity	102 GWh p.a.	218 GWh p.a.	214%
Gasoil	2 GWh p.a.	-1 GWh p.a.	55%
CO ₂	37,495 t	10,079 t	27%
Total energy costs	5.8 million EUR	2.1 million EUR	51%

Total investment	9.7 million EUR		
Av. pay back time	4.3		

Table 5-17 Summary table for the results of the energy audits performed in Spain

5.9.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay	Main Reasons for Implementation	
Cancelled	2	Too high initial costs of equipment	High expected savings (energy, CO ₂ or money)	4
Postponed, no spec. action planned	4	Payback too long	Improvement of energy security	
Further investigation necessary		Financial Risk	Economic situation good	
Further analysis contracted		Too high technical risk	Good point in time	
Detailed planning contracted		Not enough accurate data	Personal engagement	
Inviting offers for equipment		Personal reasons	-	
Implemented	1	Responsibility not clear		
-		Not good point in time	2	
		Lack of time		

Table 5-18 Summary table for the replies to the EINSTEIN audit – follow up

From the 8 audits 7 are considered in this analysis as one company did not answer to the audit feedback.

One company is currently implementing the heat recovery system.

One company is planning to implement the saving measures during 2013.

Three companies postponed the implementation:

- One company does not have the money for the proposed investment at the moment.
- One company is planning to do the saving measures within one year (avert making urgent plant expansion).
- The data in the audit did not reflect reality as the data was from previous years.
- One solar thermal plant was built in another location and is not very profitable (therefore it will not be built in this location).

From those seven companies two cancelled the implementation of the saving measures.

The reasons were:

- Consumption has fallen due to economic crisis.
- Recommendations are a bit complex and high investment needed (no subsidies for saving projects).

5.10 United Kingdom

5.10.1 Summary of Audit Results

In the UK 9 companies from the following branches were audited: data centre, office building (2), university, hospital, metal industry (aluminium casting), food industry (3 companies: beer, potatoes and another one).

The average primary energy consumption is 59.3 GWh. (This average includes two organisations with a primary energy consumption of around 200 GWh or more). The total primary energy consumption of the audited companies was 534 GWh (mainly natural gas 237 GWh and electricity 292 GWh), corresponding to total energy costs of 15.7 million EUR.

The main proposed measures were: heat recovery and process optimisation.

The proposed measures would mean additional gas consumption of 4 GWh or 2% of gas consumption and save 39.2 GWh or 13% of electricity consumption. The total savings of primary energy consumption would be around 36.2 GWh, the total percentage of savings would be around 7%.

This would correspond to money savings of 1.3 million EUR or 8.2% of total energy costs.

From the approx. 102,832 t of CO₂ emissions 8,174 t or 8% could be saved (7% for the arithmetic mean).

The total investment needed would be 5.1 million EUR. The primary energy savings due to renewable energy would be 31.7 GWh, the investment in renewable energy would be around 2.6 million EUR

The average payback time would be 9.5 years.

The possible saving measures were discussed in detail with the companies before suggesting the measures in the reports.

	Present State	Savings-Suggested	%
Total primary energy	534 GWh p.a.	36.2 GWh p.a.	8% (7%)
Natural gas	237 GWh p.a.	4 GWh p.a.	-2%
Electricity	291.8 GWh p.a.	39.2 GWh p.a.	13%
Gasoil	0.6 GWh p.a.	0.6 GWh p.a.	100%
Liquid fuel oil	0.9 GWh p.a.	0	0%
Renewables	4 GWh p.a.	0	0%
CO ₂	102,832 t p.a.	8,174 t p.a.	8%
Total energy costs	15.7 million EUR	1.3 million EUR	8.2%
Total investment	5.2 million EUR		
Av. pay back time	9.5		

Primary energy savings due to renewable energy	31.7 GWh		
Investment in sustainable energy	2.6 million EUR		

Table 5-19 Summary table for the results of the energy audits performed in United Kingdom

5.10.2 Summary of Audit Follow-Up

Status of Implementation		Reason for not implementing or delay		Main Reasons for Implementation	
Cancelled	3	Too high initial costs of equipment	1	High expected savings (energy, CO ₂ or money)	1
Postponed, no spec. action planned	3	Payback too long		Improvement of energy security	
Further investigation necessary	1	Financial risk	1	Economic situation good	
Further analysis contracted	1	Too high technical risk		Good point in time	
Detailed planning contracted		Not enough accurate data		Personal engagement	2
Inviting offers for equipment	1	Personal reasons	2	-	
Implemented		Responsibility not clear	2		
-		Not good point in time			
		Lack of time			

Table 5-20 Summary table for the replies to the EINSTEIN audit – follow up

In the UK 9 audits have been made.

From the 9 audits 3 have cancelled the implementation of the saving measures: The reasons are on one hand financial risks (concentration on stability of company), unclear or complicated owner structure. Generally in the UK in big buildings the supply of heat and cold and generally the building management is done by another company and the user doesn't have the possibility to influence anything. New equipment would have to be changed, that will not be done.

Three postponed their projects because of:

Personal reasons and too high initial costs of equipment (in future installation the heat recovery system will be implemented and the responsibility is not clear)

The other three companies are planning to realize the saving measures in 2013 and will do further investigation or already invite offers for equipment: the reason are on the one hand motivated people on the other the expected savings.

6 Summary – Conclusions

The kind of saving measure, the corresponding saving potential and the payback is dependent on the following facts:

- First of all it depends on what is already implemented in the company. This is especially true for heat recovery systems, but also e.g. CHP.
- Second, some saving measures are country-specific.
- CHP is dependent on the subsidies for the construction of the CHP and the feed-in tariff. Especially Spain and Germany seem to have quite good conditions². In other countries (like Austria) there is only a subsidy of 10% but no feed-in tariff for fossil CHPs.
- For solar thermal the solar radiation is crucial, therefore e.g. in Ireland no solar thermal plant was suggested, whereas in Bulgaria in half of the audits solar thermal was proposed. On the other hand, even for solar thermal proposal other circumstances are also relevant, e.g. in Spain in not a single case solar thermal was proposed.³

Therefore, no generally valid rules for saving measures in a country or an enterprise can be given. This is why such a tool as EINSTEIN, starting with a detailed analysis of energy consumption and considering the specific situation of a certain company is needed. Another advantage of EINSTEIN is that no specific energy saving measure is preferred, but all different solutions are evaluated. To sum it up:

- EINSTEIN provides the different audit-steps and the software.
- EINSTEIN has no focus on a single technology or sector.
- EINSTEIN facilitates the evaluation of all possible solutions and their combinations.
- EINSTEIN is appropriate for fast audits (in the sense that e.g. a result is a proposal for a heat exchanger, incl. proposed power, but not a detailed feasibility study for this single heat exchanger).

A conclusion on whole sectors and countries is not possible or difficult due to the small number of audits performed. The results highlight that the potential for energy reduction by heat recovery and process optimisation is far from being fully utilised. Therefore, a special weight has to be set on this topic. The economic feasibility of further measures depends strongly on the national and local frameworks and particularities. By the integration of renewable energy sources as solar thermal as well as CHP energetic, environmental and economic useful proposals can be offered to

² In most Spanish audits CHP has been proposed due to the existing feed-in tariff. Nevertheless, in 2012 feed-in tariffs have been eliminated within the packages of saving measures for mitigation of the financial crisis.

³ In almost all Spanish audits solar thermal has been considered as one of the possible alternatives. Nevertheless, these proposals remained a 2nd choice due to the economic criteria applied, which was a pay-back period of not more than 4 years.

industries and big buildings in order to secure the attractive location of the companies as well as to reach defined environmental targets.

Furthermore the target of the audit campaign to further develop and adapt the EINSTEIN tool to the needs of an audit in different sectors and buildings has been fulfilled. By this the suitability of EINSTEIN for all sectors and buildings is proven, as all proposals and ideas can be evaluated in an objective and independent manner. Therefore, the auditors are provided with a very useful tool.