Energy efficiency in the food and drink industry – the road to Benchmarks of Excellence

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Abstract

Although Norwegian food and drink industry in general has a good track record in implementing Best Practice energy efficiency measures, a new study on the energy efficiency situation in the sector identifies a 20% economic profitable energy saving potential. The food and drink association and the Norwegian Government's energy agency – ENOVA have now agreed to realise the most cost effective measures, taking the sector to Benchmarks of Excellence. Twelve sub-sectors of the food and drink industry have been analyzed with regard to their implementation of energy saving measures. A bottom-up approach with a web-based questionnaire was used to map the implementation of more than 200 different energy saving measures in 664 individual companies. The results quantify the accumulated energy saving potential corresponding to certain investment cost levels. Moreover, the questionnaire touched upon more managerial matters e.g. to what extent energy management has been successfully integrated in the general business operations. The replies clearly demonstrate that energy management contributes to the implementation of energy saving measures. Companies that have introduced energy management have to a larger extent implemented measures than those that have not. It is also evident that the smallest companies to a limited extent have introduced energy management. One conclusion is therefore that the SMEs accounts for a great, unrealised energy saving potential. Consequently, ENOVA and the industry from January 2009 have started a three year programme with four of the sub-sectors focusing on networking, energy management and benchmarking.

Introduction

The Norwegian Government's energy agency - Enova SF manages the national Energy Fund and provides financing to programmes and initiatives that support and underpin national objectives. The Energy Fund is primarily financed through a surcharge on the grid tariff for tapping power from the distribution grid. The grid tariff surcharge is 1 øre/kWh, which means that a household with annual consumption of 20 000 kWh pays NOK 200 (20 Euro) per year to the Energy Fund through its electricity bill. Starting in 2008, the Energy Fund also include the return on a basic capital of NOK 10 billion, growing to NOK 20 billion (2 billion Euro) from 2009.

Enova SF is owned by the Ministry of Petroleum and Energy and was established in 2002 for the purpose of initiating and promoting an environmentally friendly restructuring of energy consumption and energy generation in Norway. Enova has the freedom to choose its policy measures and the responsibility to establish incentives and funding schemes that will result in cost effective and environmentally sound investments. In 2007, Enova achieved contractual commitments for an energy result of about 2.4 TWh, while 10.1 TWh was contracted in the period 2001-2007 /1/.

In terms of energy efficiency achievements, the bigger companies can show better results than the small and medium companies (SME). This difference can to a certain extent be explained by the fact that the SMEs have not been given too much attention from the governmental energy efficiency programmes.

The Food and Drink sector is a typical SME sector with more than 2000 companies where as many as 45% have less than 5 employees. However the sector is important in terms of value added and employment and the sector accounts for as much as 19% of the total employment in the whole industry sector.

Apart from the energy intensive industry, the food and drink sector represents the largest share of the energy consumption in Norwegian industry. The food and drink industry uses 4.7 TWh/year at a cost of NOK 2.1 billion. A realisation of the energy saving potential within the food and drink sector would make a substantial contribution to improved economic performance in each company. In addition it would also mean a significant reduction of greenhouse gas emissions.

In 2007 Enova decided to put stronger emphasis on energy efficiency in the food and drink sector and a study focusing on the energy saving potential was worked out by New Energy Performance AS (NEPAS) in cooperation with the food and drink association. This study identifies a 20% economic profitable energy saving potential provided that the industry accepts investment measures with pay-back less than 2 years. The food and drink association and the Norwegian Government's energy agency - ENOVA have now agreed to realise the most cost effective measures, taking the sector to Benchmarks of Excellence.

The following five steps approach to benchmark of excellence based on the energy management loop will be tested on the food and drink sector in Norway:

1. Identify opportunities
2. Set targets
3. Energy action plan
4. Benchmark and monitor progress
5. Review

These steps will interactive be followed both on sector and company level. The first step on sector level is completed and this paper will focus on the methodology and results from this exercise.

Approach and methodology

Estimation of the energy saving potential is based on a "bottom-up" approach within the sub-sectors of the food and drink sector. Division of sub-sectors is based on the official classification system used by Statistics Norway's Business register and in the Central Coordinating Register for Legal Entities. General framework conditions for the study are:

- System boundary is set around the factory fence
- Energy use = Purchased energy + Internal generated energy – Sold energy
- No changes in input (raw material) and output (end products)
- Measures are based on ordinary available technology

METHODOLOGY

The methodology used to estimate the remaining energy saving potential is based on twelve steps described in table 1. These steps are not very different from the steps that can be used in an energy audit on company level, but in this case the object for the study is the sub-sectors. The text below has reference to the different steps in this table.

Step 1: Sub-sectors

Division of sub-sectors is based on the official classification system used by Statistics Norway's Business register and in the Central Coordinating Register for Legal Entities. The food and drink sector was divided into the twelve sub-sectors as indicated in table 2. In 2007 the Standard Industrial Classification SIC2002 or NACE[1] was used, but from 1 January 2009 the classification system is updated to follow SIC2007[2]. In the table below is thus both SIC2002 and SIC2007 for the sub-sectors analyzed indicated. Because the fish industry is a major energy user in Norway the production of fish meal and oil (SIC 10.209) and operation of land based hatcheries (SIC 03.212) are treated as separate sub-sectors.

Step 2: Historical energy use

Historical energy use for the period 1998-2006 divided on energy sources was established based on national energy statistic. Figure 1 gives an example from the dairy-sector.

Step 3: Energy accounts

Energy use divided into different accounts within each sub-sector is based on available sector-studies, energy audits and specific knowledge about the sub-sector. Figure 2 illustrate the estimated energy use based on purpose within the dairy-sector (SIC 10.5).

Step 4 and 5: Measure lists

Measure lists linked to the different energy accounts was developed based on available sector-studies[3], energy audits[4], specific knowledge[5] and measure lists from other countries[6]. We also made use of horizontal and vertical measure lists worked out within the BESS-project /6/. One thing that we had to take into consideration when reading sector-studies and measure lists from other countries was that equipment and processes in Norway to a higher extent are based on electricity instead of natural gas.

The final list contains 34 general measures and from 4 to 20 sector-specific energy efficiency measures. An estimate on energy saving potential (%) and specific investment cost

1. NACE/SIC2002 (Nomenclature statistique des activités économiques dans la Communauté européenne) is the statistical classification of economic activities used in the European Community until 31.12.08.
2. Standard Industrial Classification 2007
3. Mainly reports submitted by the Norwegian Industrial Energy Efficiency Network Programme, IPPC (BREF-documents), US Energy Star Programme, UK Carbon Trust, Canadian Industry Program for Energy Conservation (CIPEC) and Danish Energy Agency
4. 172 audits from a national energy audit programme 1996-2002, separate audits supported by Enova 2002-2006, reported measures into the national web-based benchmarking system 1989-2006
5. Specific knowledge of consultants and supplier of equipment
6. Mainly measure lists from SenterNovem (http://www.kuiperinternetdiensten.nl/demo2/default.asp).

Table 1: Steps for estimation of energy saving potential

Step	Input	Process	Output
1	Statistics Norway's Business register	Divide industry inito more or less homogeneous sub-sectors	12 sub-sectors
2	National Energy statistic	Establish referenceline for energy use	Historical energy use 1998-2006 divided on energy sources
3	Available sector-studies, energy audits and specific knowledge	Estimate energy use based on purpose	Electric and thermal energy divided into general energy blocks (lighting, ventilation, compressed air, pumps, hydraulics, space heating, boilerhouse) and process related energy blocks (cooling, freezing, water heating, treatment plant etc.)
4	Available sectorstudies, energy audits, specific knowledge and measurelists from other countries	Develop measure lists	General measures (34) and process related measures (175)
5	Available energy audits, measurelists from other countries and specific information from different supplier-companies.	Add savingpotential and specific investment cost (NOK/kWh) to each measure	Measurelists with potential and investment cost
6	Knowledge about logical priority on measure implementation	Sort measurelist regard preferred order for implementation	Sorted measurelists with potential and investment cost
7	Available energy audits, measurelists from other countries and specific knowledge	Adjust specific potential for measures that have infuence on each other	Sorted measurelists with adjusted potential and investment cost
8	Web-based survey and list of e-mail adresses	Map implementation rate of each measure	Overview of implemetation rate of each measure within each sub-sector
9	Results from web-based survey	Estimate adjustment factor for remaining energy saving potential related to each measure in the sub-sectors	Adjustment factors for each measure in the sub-sectors
10	Adjustment factors for each measure in the sub-sectors, energy use in sub-sectors based on purpose	Estimate electric and thermal energy saving potential for each measure (n) within the sub-sector.	Electric and thermal energy saving potential for each measure in the sub-sectors
11	Electric and thermal energy saving potential for each measure in the sub-sectors	Sort the measure with estimated saving potential based on increasing specific investment cost. List accumulated energy saving potential.	Accumulated energy saving potential (electric, thermal and total) linked to increasing specific investment cost.
12	Accumulated energy saving potential (electric, thermal and total) linked to increasing specific investment cost.	Work out graphs that display accumulated energy saving potential linked to specific energy cost	Graphs that display accumulated energy saving potential (electric, thermal and total) linked to specific energy cost in each sub-sector.

Table 2: Sub-sectors analyzed

SIC 2007	Sub-sector	SIC2002/NACE
03.212	Operation of marine hatcheries	05.022
10.1	Processing and preserving of meat and production of meat products	15.10
10.2	Processing and preserving of fish, crustaceans and molluscs	15.20
10.209	Other processing and preserving of fish and fish products	15.209
10.3	Processing and preserving of fruit and vegetables	15.30
10.4	Manufacture of vegetable and animal oils and fats	15.40
10.5	Manufacture of dairy products	15.50
10.6	Manufacture of grain mill products, starches and starch products	15.60
10.7	Manufacture of bakery and farinaceous products	15.81+15.82
10.8	Manufacture of other food products	15.80

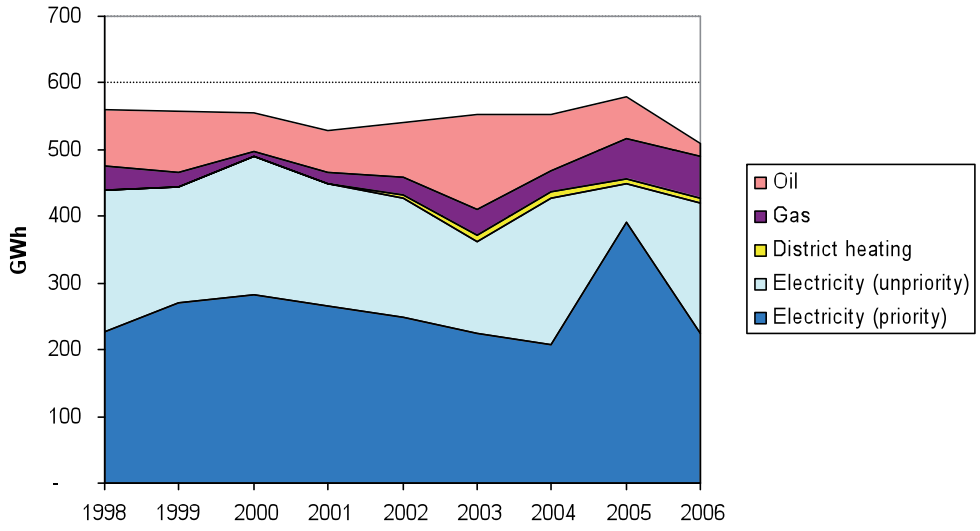

Figure 1. Historical energy use divided on energy sources within the dairy-sector (SIC 10.5).

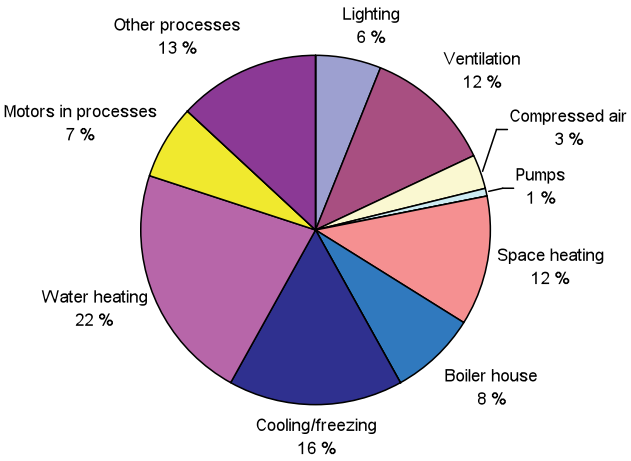

Figure 2. Energy accounts in the dairy-sector (SIC 10.5).

(NOK/kWh) is added to each measure based on information sources mentioned above. General measures are sorted into the following eight groups (number of measures in parenthesis); lighting (4), ventilation (4), compressed air (4), pumps (3), hydraulics (3), space heating (4), boilerhouse (7) and good housekeeping/energy management (5). Examples of measures linked to compressed air are:

- Avoid leaks in the system (pipes, tubes, rapid coupling, gaskets and valves)
- Right operating pressure (delivered pressure is often higher than necessary)
- Right air quality (air treatment equipment to remove water, oil and pollution increase demand of energy)
- Compressed air on demand (manual or automatic on/off, speed control, etc)

Step 6 and 7: Sort measure list and adjusted potential

Some measures have a certain influence on other measures, and these are listed with the highest priority first. The main rule is that measures that are close to end use are given the highest priority. Additional insulation is for example listed before improvement of boiler efficiency. Energy saving potential for different measures that have influence on each other is then adjusted down.

Step 8 and 9: Map implementation rate

Implementation rate of the measures were mapped by a web-based market survey among 664 companies. About 30% of the companies gave reply on the questionnaire. The questionnaire had the following four steps;

1. General information about the company, size, employees etc.
2. Questions about the companies' perception of barriers to energy efficiency
3. Questions about implementation rate of general energy saving measures (34 different measures)
4. Questions about implementation rate of process specific energy saving measures (4-20 different sector specific measures)

The questionnaire asked about the implementation rate, more specifically if the various measures have been completed, partly completed, not completed or not relevant. If completed or not relevant, the remaining energy saving potential for that specific measure is zero. If partly completed the remaining energy saving potential is estimated to 50%, and if not completed the full energy saving potential remains for that specific measure. Average sector implementation rates for all specific measures can then be calculated.

The survey also included some questions with regard to energy management. Energy management was treated as one of the general measures. In order to make this measure more concrete and easy to answer, specific questions were asked about critical success factors regarding energy management. These questions are:

1. Has the company worked out energy related targets and action plans?
2. Has the company carried out actions for awareness and training?
3. Has the company implemented procedures for optimal operation and maintenance?
4. Has the company implemented procedures for energy optimal design and procurement?
5. Has the company implemented procedures for monitoring and measurement?

Step 10: Estimate energy saving potential

The energy saving potential for each specific measure is then calculated. The formula used to estimate electric and thermal energy saving potential for each measure (n) within the sub-sector is:

$$P_n = (E_{el,B1} * k_i * p_n + (E_{term,B1} * k_i * p_n)$$

Where,

P_n = Total energy saving potential (electric + thermal) for measure n
$E_{el,B1}$ = Electric energy used on energy block 1
$E_{term,B1}$ = Thermal energy used on energy block 1
k_i = adjustment factor on implementation
p_n = energy saving potential linked to measure n, where n is measure in measure list (see step 4 and 5)

Step 11 and 12: Work out graphs

Graphs showing the accumulated energy saving potential corresponding to investment costs have been displayed for each sub-sector. Figure 3 illustrates the accumulated energy saving potential corresponding to investment cost for the bakery sector. From the figure we can see that the total energy saving potential for this sector is 109 GWh/year. This potential represents 34% of total energy use in the bakery sub-sector. Electric

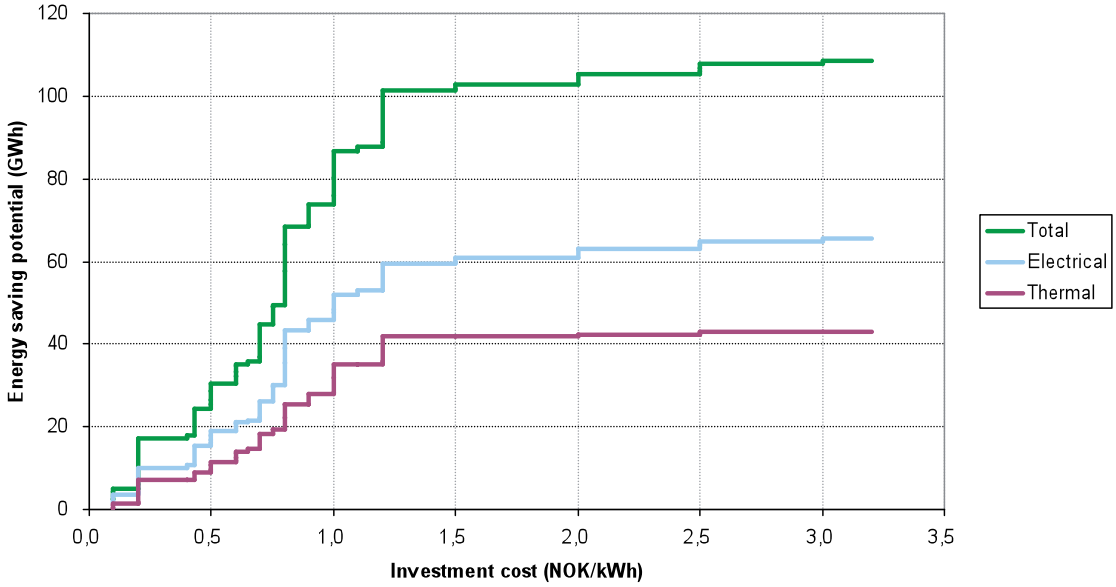

Figure 3. Accumulated energy saving potential corresponding to investment cost for the bakery sector.

and thermal energy saving potentials are 43 and 66 GWh/year respectively. 80% of the potential can be realised with a payback period of about 2 years (less than 1 NOK/kWh). Similar figures are found for all the 12 different sub-sectors within the food and drink sector. Most of the low-cost measures are related to the general measure list, and for the case of bakeries 50% of the energy saving potential is related to general measures. The average electricity price in the bakery sector is 0,48 NOK/kWh[7], and if we assume that the companies accept measures with payback less than two years there exist a 20% economic profitable energy saving potential within this sub-sector.

Results

The 187 responding companies represent almost 30% of the energy use in each sub-sector. However the bigger companies are overrepresented in the survey. Energy saving potential and other results from the market survey is presented as quantitative and qualitative results below.

QUANTITATIVE RESULTS

The total energy saving potential in the entire food and drink industry adds up to 1.3 TWh p.a. This corresponds to 30% of the total energy consumption in this sector. 49% of the potential relates to reduction in the electricity consumption. About 68% of the potential can be realised for less than 1 NOK/kWh as compared to average electricity price for the food and drink industry in Norway of 0.49 NOK/kWh[7] in year 2006, or with a down payment period of about 2 years. Figure 4 illustrates the energy saving potential separated in different subgroups /2/.

The total thermal energy saving potential for all sectors corresponds to the emission of 50,000 tons of CO_2, given that only CO_2 emissions from combustion of oil and gas are included. Furthermore given that the distribution between oil and gas consumption is equal to the share in the total food and drink industry in 2005.

The emission of greenhouse gases can be further reduced by converting oil and gas to CO_2-free or -neutral energy sources. If all the oil and gas consumed in the food industry in 2006 were replaced by biofuel or CO_2-free, renewable electricity, the emissions would have been reduced by additional 330,000 tons of CO_2.

QUALITATIVE RESULTS

The survey reveals the perception that the most significant obstacles for realisation of the energy saving potential relates to:

1. Uncertainty regarding profitability/economic savings
2. Lack of investment capital or capital needed for other priorities
3. Lack of competence regarding possibilities

These are primarily obstacles for the SMEs. Hence, energy saving measures have not been implemented to the same extent in this group compared to the larger companies. This can be seen from figure 5 where remaining energy saving potential is linked to the size (number of employees) of the company.

We find more or less the same results if the size of the company is based the energy use. Companies that consume more than 50 GWh p.a. claim that they have implemented 60-80% of the energy saving measures described in this study.

32% of the companies confirm that they have an energy policy. Small companies have to less extent an energy policy than bigger companies. Other critical success factors regarding energy management has also been analysed. Figure 6 illustrate remaining energy saving potential regard to what extent energy related targets and action plans are implemented. From the figure we can see that companies that to less extent have implemented energy related targets and action plans have more remaining energy potential than companies that have this

7. Statistics Norway. Final figures 2006: Energy prices by industry sub class and energy type

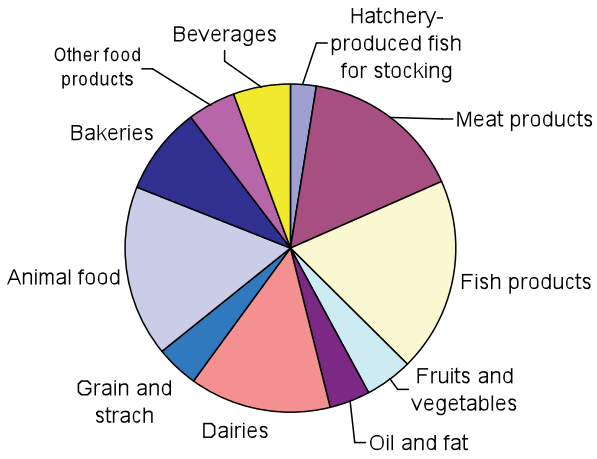

Figure 4. Energy saving potential separated in sub-sectors (% of total potential).

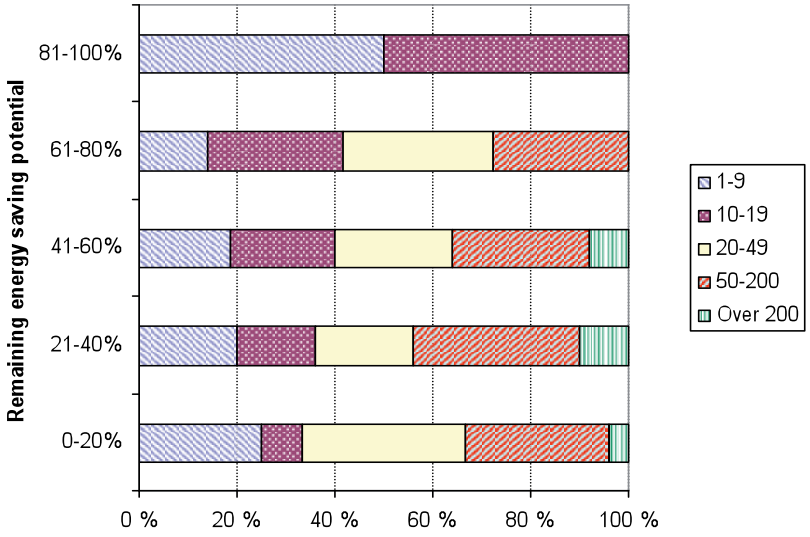

Figure 5. Remaining energy saving potential regard to size of company.

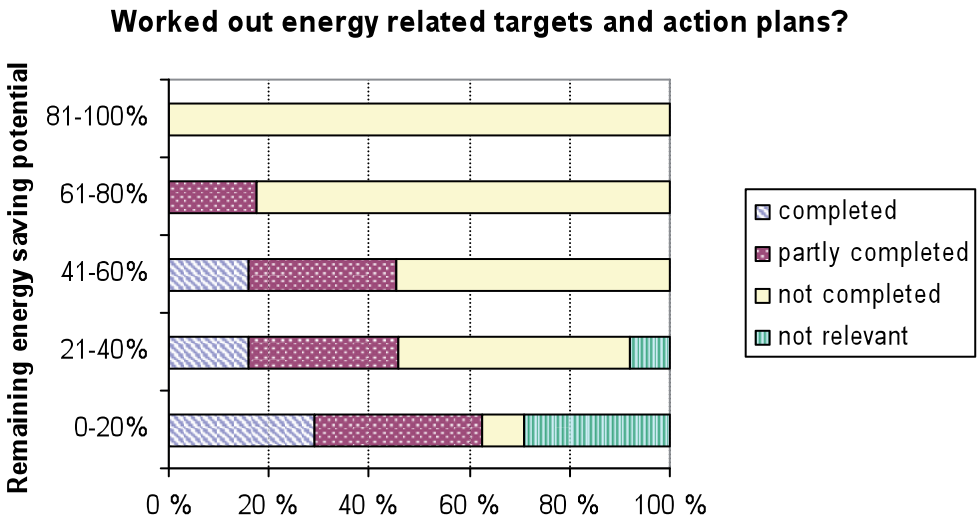

Figure 6. Remaining energy saving potential regard to what extent energy related targets and action plans are implemented.

partly or completed implemented. From the same figure we see that there are companies with not much remaining energy saving potential that find it not relevant to work out energy related targets and action plans. This can indicate that companies which have implemented most of the measures don't find it necessary to continue the work to set new targets and work out action plans.

Analysis on the other questions regarding energy management gives similar displays as figure 6. Out of this we see that strong energy management policies at company/corporate level contribute to the implementation of energy saving measures. Companies that have introduced energy management have implemented energy saving measures to a larger extent than others.

Discussion

This study is based on today's available technologies and implementation rate. The model used for calculation of the energy efficiency potential is quite simple and there are several factors that can alter the results.

The implementation rates that have been calculated for each sub-sector are based on answers that represent about 30% of the energy use in the sector. We have assumed that these answers can be used as model for the whole sector. Big companies are dominating in replying to the questionnaire. However, since small companies to a lower extent have implemented measures the potential might be even bigger.

The energy saving potential linked to each measure is of course also an important factor. This saving potential is based on audits from a national audit programme supplied with measure lists from the Dutch LTA-programme in the Netherlands and other available sector-studies. The measure lists has been reviewed by experts from the sub-sector to fit Norwegian conditions.

The results and findings from the study will now be followed up by establishing even stronger collaboration mechanisms between Enova and the food and drink industry. A three year programme with four of the sub-sectors (meat-processing, bakeries, breweries and grain mill and starches) focusing on networking, energy management and benchmarking has just started up in January 2009.

The objective of the programme is to realise the most cost-effective measures and by implementing energy management and to establish a culture for energy efficiency that helps the companies to improve their energy performance significantly, thus becoming "Benchmarks of Excellence".

The new European standard on Energy Management (EN 16001) will be an important benchmark for the quality of energy management /5/. However it is not realistic to expect that smaller companies can afford to be certified fully, and a simpler approach might be desirable.

The follow-up programme will e.g. make use of the models and tools from the EU LTA Uptake[8] and BESS-project[9]. BESS provides options for web-based international benchmarking that is already tested by three of the four sectors to focus on. This will give added value to the existing national web-based benchmarking scheme provided by Enova[10] as far as also other countries enter data into the database.

So far the BESS database contains benchmark-data from 140 companies within six different sectors (dairy, meat-processing, bakeries, breweries, laundries and textile industry) from 19 different European countries. The web-based benchmark application is very flexible with regard to expansion to new countries, sectors, indicators and future development. The application has options for adjustment regard external factors like climate (heating), capacity utilization, production mix and boiler efficiency. The application can easily be expanded by new countries and the appointed national administrator can manage and upload quality assured data and also translate the text in the application into national language. The participating companies either register their energy and production data directly into the web-application through a self-registration module, or blocks of national data from other sources can be imported into the database. Figure 7 is an output of anonymous benchmark results from the web-based application illustrating the comparison of specific energy consumption (SEC) within the bakery sector. The green column is a Norwegian bakery company only known by the company itself.

Figure 8 illustrate the historical change in SEC of the company compared to the average value in the bakery sector. The filter option buttons on the right side make it possible to decide which countries you will like to include in the comparison.

Conclusion

It has been estimated that a 20% economic profitable energy saving potential exist in the food and drink sector in Norway provided that the industry accepts investment measures with pay-back less than 2 years. The three most significant obstacles for realisation of the energy saving potential are by 187 companies reported to be:

4. Uncertainty regarding profitability/economic savings
5. Lack of investment capital or capital needed for other priorities
6. Lack of competence regarding possibilities

Replies from the survey clearly demonstrate that energy management contributes to the implementation of energy saving measures. Companies that have introduced energy management have to a larger extent implemented measures than those that have not. It is also evident that the smallest companies to a limited extent have introduced energy management. One conclusion is therefore that the smaller SMEs accounts for a great, unrealised energy saving potential.

Consequently, ENOVA and the industry from January 2009 have started a three year programme with four of the sub-sectors focusing on networking, energy management and benchmarking.

8. EU LTA Uptake is an EU supported project focusing on the option by Long Term Agreement (http://www.ltauptake.eu)

9. BESS (Benchmarking and Energy Management in SMEs) is a toolbox for SME (http://www.bess-project.info)

10. National web-based benchmarking are offered 43 different sectors/benchmark-classes on www.enova.no/industrinettverk

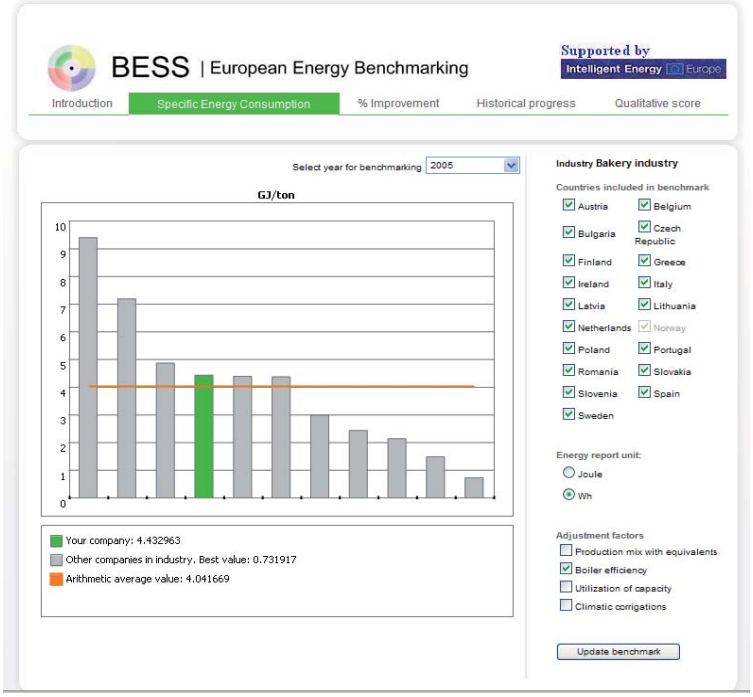

Figure 7. Example of BESS benchmark results – SEC of a bakery company compared to other bakeries.

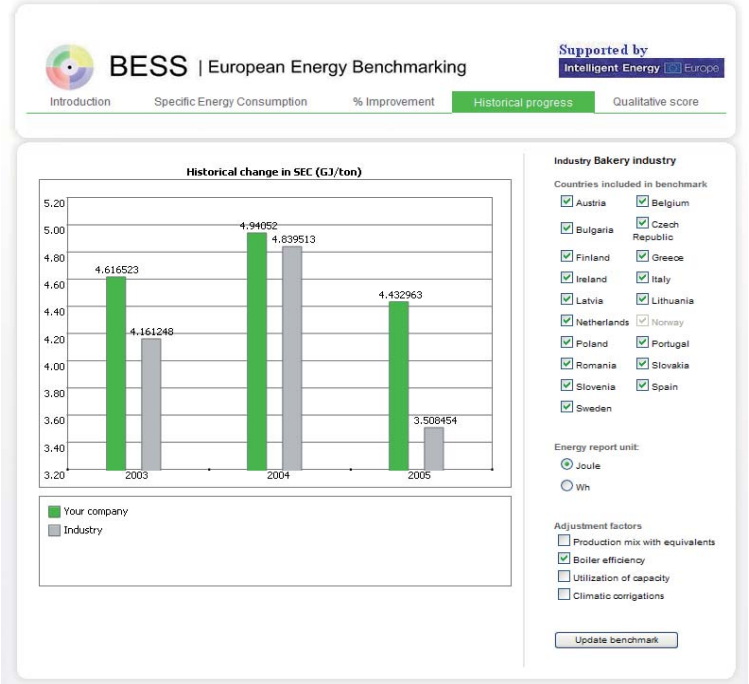

Figure 8. Example of BESS benchmark results – Historical change in SEC of a bakery company compared to the average value in sector.

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/5/ CEN/CLC BT/TF 189 Project team Energy Management Systems started to work out an European standard in January 2007. The standard (EN 16001) is planned to be published in 2009.

/6/ Benchmarking and Energy management Schemes in SMEs (BESS) – http://www.bess-project.info