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BESS - Benchmarking and Energy management Schemes in SMEs

Description of the Adjustment Factors used within the BESS Web based monitoring and benchmarking

Adjustment factors

The application has options for four different kinds of adjustment; boiler efficiency, climate, production utilization and production mix. The users of the international web benchmarking have the possibility to choose, whether or not to use adjustment factors or not. Below you find a description of the methodology for the different adjustments.

Climate

Though the influence of the climmate to the energy efficiency of many production sites is only modest a refinement can be made by adjusting the energy consumption with information on heating (and cooling) in different climatic zones, in order to get a more justifiable indicator. In order to manage the energy used in heating, it is needed to take account of the weather. Degree-days figures provide a simple and convenient way to do this by reducing the local weather to a single number representing how cold it was. *Table 1* indicate average heating degree-days (HDD) for most of the participating countries within the BESS-project.

Table 1*: Average heating degree-days (HDD) for some European counties. Source: Odyssee-Mure database.*

Country	HDD
Greece	1461
Spain	2152
Ireland	2343
Bulgaria	2798
Slovenia	2863
Belgium	3015
Austria	3132
Netherlands	3200
Sweden	3855
Lithunia	4114
Norway	4362
Finland	4818
EU	**2559**

There are various methods of calculating degree-day values, but all refer to a “base temperature”. For heating this is the outside air temperature at which no artificial heat is required to keep the building comfortable. The heating degree-days of a year are obtained by subtracting the average temperature of a day by the “base temperature” and accumulate this for all the days during the year. In this project we use 18°C as the “base temperature”.

$$\text{Heating degree-days, HDD} = 18 - T_{mean}$$

summed for all days in a year.

Cooling degree-days can be calculated in a similar way, but there is no officially designed base temperature and CDD are not implemented within the BESS-application.

The most accurate way of adjusting for climate is to use the heating degree days in the actual year of the localization of the plant. If this isn’t available, the heating degrees of the country may be used (preferable of the actual year). The climate of Brussels is used as the “normal climate”.

In production industries, only a part of the energy consumption is depending on the climate. This part differs from industry to industry, and is difficult to generalize. If you want to do adjustment for climate you have to report the average share of thermal energy that is depended of the climate in your company.

The climate dependent share of the thermal energy consumption will then be divided by the heating degree-days of the company/country and multiplied with the heating degree-days of Brussels.

Example 1:
Climate corrected thermal energy consumption = thermal energy * ((1-heating dependent share) + heating dependent share * heating degree-days (Brussels) / heating degree-days (Country A))

$$E\ (\text{thermal})_{c.c.} = 30\ 000\ \text{GJ/year} * ((1-0.2) + 0.2 * 3015/1500) = 36\ 060\ \text{GJ/year}$$

If this company were located in Brussels instead of in the south of Europe, the company would have used 20% more thermal energy due to the climate differences.

If you need more information how to calculate the degree days on the location of your production site over a specific period please contact an energy consulatnt or institute in your country.

Boiler efficiency

The energy reported from the companies is the actual use of energy, but in addition they are asked to report the annual boiler efficiency for all energy sources used in boilers. By doing this, it is possible to compare the net energy used in the production site, excluding differences in the energy production plant.

Example 2:

Net energy consumption = energy source A * boiler efficiency A + energy source B * boiler efficiency B….

$$E\ \text{net} = 10\ 000\ \text{GJ/year} * 1 + 30\ 000\ \text{GJ/year} * 80/100 = 34\ 000\ \text{GJ/year}$$

Capacity utilization

Specific energy consumption often increases when the production capacity isn't fully used because of basic energy use are being spread over less units of production than at full production rate. The objective to adjust for reduced production capacity utilization is to separate the effect of a production rate change from other variables and energy efficiency changes. Adjustment should only be used for external factors (beyond the influence of the company itself).

When adjusting for capacity utilization, the basic energy consumption is reduced in the case of lower production utilization to match the share of basic energy consumption at full capacity utilization. If e.g. the basic energy consumption at full capacity utilization is 30%, it might increase to 35% at the level of 80% production utilization. The basic energy consumption then represents a too large part of the total energy consumption that ought to be reduced to the same level as in the case of full production capacity utilization, see figure 1 and example 3.

Example 3:
A company produces 10 000 tons at full capacity using 10 GWh and the SEC is then 1 kWh/kg. At 80% capacity utilization it produces 8 000 tons using 8.6 GWh and the SEC is then 1.08 kWh/kg. 35% of this energy use goes to non-product depending uses (like space heating, washing, lighting etc). This amount could then be adjusted, since it becomes unfairly big when the capacity utilization goes down. The adjusted energy consumption then becomes:

$$8.6 * 0.35*0.8 + 8.6 * (1-0.35) = 8.0 \text{ GWh}$$

where the non-product dependent share of the energy use is adjusted by the production capacity utilization of 80%. The adjusted SEC then is 1.0 kWh/kg, i.e. the same as at full capacity. In this case it is only the production capacity utilization that has changed, other factors may influence the total energy consumption, but here they are not present, showing just how to handle different production rates.

Production capacity utilization may be defined as the production capacity the plant is designed for, at normal working hours. A practical way of calculating the production capacity utilization may be the actual raw material input divided by the designed input. For dairies this would then be treated raw milk, for bakeries consumption of flour and for the meat processing industry the received tons of meat.

A way of calculating the non-production dependent share is to plot the energy consumption against productions using data that have been collected at regular intervals (daily, weekly, monthly…). Most processes will exhibit a pattern through which a straight line (best fit line) can be drawn. This line indicates the relationship between energy consumption and its driver (in this case, production). The intercept with the y-axis shows the non-production dependent energy use in absolute figures, see figure 2.

To calculate the share of non-productive energy consumption at the actual production rate, the basic energy consumption is divided by the actual energy use at the actual production capacity utilization level. Of course this share shouldn't be too high, since the whole methodology depends on that the energy consumption is dependent on the production volumes. If not, another method has to be chosen (e.g. energy consumption per m² heated area).

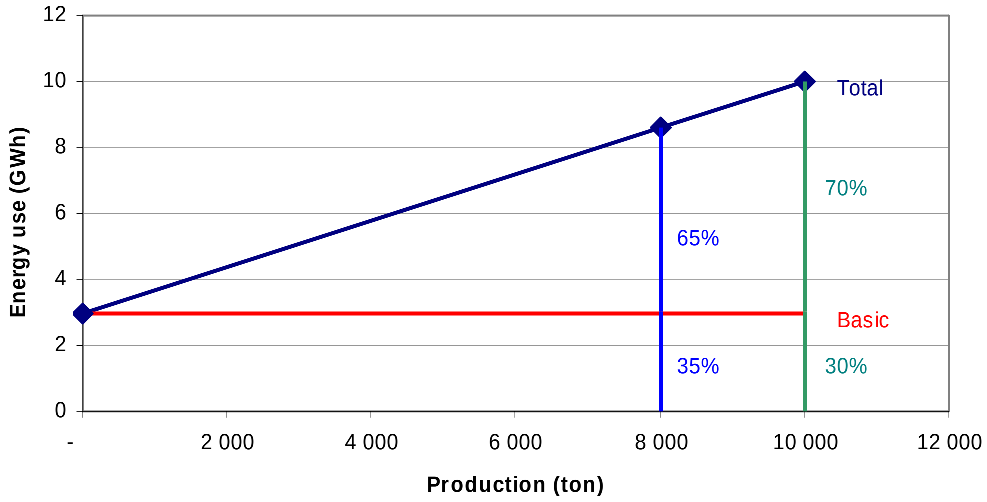

Figure 1: The share the basic energy consumption represents increases when the production utilization decreases

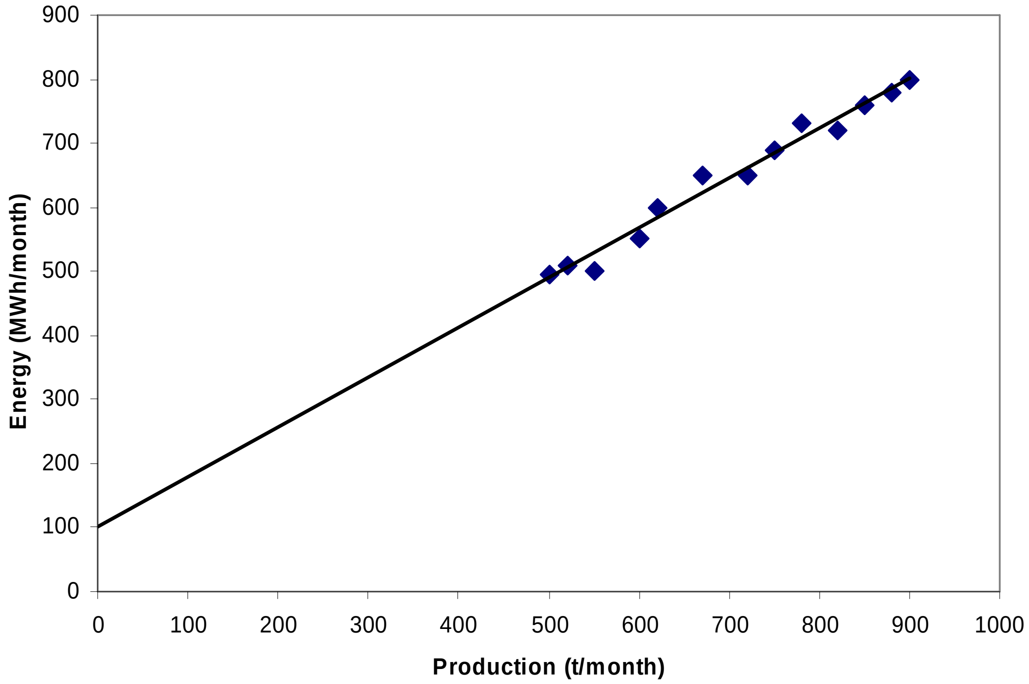

Figure 2: Monthly energy consumption vs. production volume. The intercept with the y-axis gives the basic energy consumption.

Production mix

In some industrial branches, the diversity for products is quite large and the energy consumption for each product may vary a lot. The best way to compare companies is to have homogenous groups with companies producing the same products, with the same type of equipment and with similar production volumes. But often this isn't possible to achieve, and then a sort of normalization of different products as regards the energy intensity of each product, is a way to adjust for different production mix. In the Norwegian scheme, such normalization factors exist for the dairy and meat industry sector. As a beginning, these factors will be used, if the user would like to compare companies with different production mix. In the future, new normalization factors may be calculated and will then replace the Norwegian factors.

In the ***bakery industry***, the quantity of flour is multiplied with 1.35 to get the production volume of bread. In the bakery industry there is no adjustment for different production mix.

Example 4:

Production volume in bakery industry = 1.35 * tons of flour

In the ***meat industry*** the production normalization factors presented in Table 2 is used, when adjustment for different production mix is chosen. When benchmarking without adjustments for different production mix is chosen, the quantities of all products are added (the frozen volume is not included).

Table 2 *Product normalization factors in meat industry*

Product	Normalization factor
Slaughtered bovine animals	1
Slaughtered swine	1
Slaughtered other animals	1
Produced cooked/fried meat	2.9
Produced cured meat	5.7
Other preparations of meat	1
Frozen volume	1.4

Example 5:

Normalized production in meat industry = 1 * tons slaughtered + 2.9 * tons of cooked/fried meat + 5.7 * tons of cured meat + 1 tons of "other meat" + 1.4 * tons of frozen volume

Unadjusted production = tons slaughtered + tons of cooked/fried meat + tons of cured meat + tons of "other meat"

In the ***dairy industry*** the production normalization factors presented in Table 3 is used, when adjustment for different production mix is chosen. When benchmarking without adjustments for different production mix is chosen, the quantities of all delivered milk and produced juice are added.

Table 3 *Product normalization factors in dairy industry*

Product	Normalization factor
Processed milk	0
Sweet milk products	0.209
Sour milk products	0.657
Cup products	0.966
Hard cheese	1.925
Brown cheese	3.663
Other cheeses	2.854
Casein	1.952
Dried products	3.812
Butter /butter oil	0.800
Preserves	0.787
Supplemental milk delivered	0.076
Juice	0.209

Example 6:

Normalized production in dairy industry = 0.209 * litres of sweet milk products + 0.657 * litres of sour milk products + 0.966 * litres of cup products + 1.925 * kg of hard cheese + 3.663 * kg of brown cheese + 2.854 * kg of other cheeses + 1.952 * kg of casein + 3.812 * kg of dried products + 0.800 * kg of butter /butter oil + 0.787 * kg of preserves + 0.076 * litres of supplemental milk delivered + 0.209 * litres of juice

Unadjusted production = litres of processed milk + litres of produced juice