STEP 1.6 CASE STUDY

Detailed analysis of energy flows

A small-sized dairy company in Lebanon had already explored some improvement measures to save water and energy before it started the TEST project. What tipped the balance in the decision of the MED TEST II project management team to include the company was the unbounded enthusiasm and motivation of the owner to implement RECP measures in his company. This commitment is at the root of this success story.

Energy was found to be the second priority flow after raw materials due to its significant NPO costs and potential for increasing the company's energy efficiency: the specific energy consumption of the plant was 0.45 KWh/kg milk, whereas the international benchmark for best practice in dairy sector is 0.3 KWh/kg milk.

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At the beginning of the project, the company was convinced to install an information system: overall, 36 meters were installed in the company, mainly for monitoring energy and water use. Readings from the meters were recorded every day at the end of each shift together with the daily production quantities expressed as weight of milk processed and type of product made. The decision to install the information system at the project's start was crucial, as there was no history for the plant's energy use other than the electricity and fuel bills, and these were not enough to establish reliable baselines at the level of the chosen focus areas. This decision was adopted for several reasons: the most important being that "taking daily readings is like taking the pulse of the plant" said the plant manager. It also turned out to be a very effective way to engage both management and operators in improving resource efficiency (this phenomenon was observed not only in this company but also in other companies where monitoring systems were installed at the start of the TEST project).

The daily readings of critical operating parameters enabled the data analysis of specific energy consumers. From this, two significant energy consumers were identified: the steam and the chilled water systems. During step 1.5, the energy baselines had been calculated for monitoring the energy efficiency of these two focus areas.

The collected data also enabled a regression analysis to be carried out during step 1.5 at the level of the two focus areas, based on real data, which was used to set not only the baselines for the boilers and chillers but also to analyze their energy performance. For boilers, the regression between energy consumption and processed milk quantities resulted in a poor correlation coefficient (R^2=0.6). At the same time, single regression made between boiler energy consumption and ambient temperature also showed a poor correlation coefficient (R^2=0. 3). The consultants then conducted a multi-regression analysis, where energy consumption was thought to be affected by the ambient temperature besides the production level. The multi-regression showed improved correlation (R^2=0.77). The resulting regression equation was $Eb = 0.36*P - 425*T - 9141$ (where Eb is the energy consumed by the boiler in KWh, P is the quantity of milk processed in kg and T is ambient temperature in °C).

The regression analysis for the chillers showed better results. The correlation between chiller energy consumption and quantities of processed milk gave an R^2=0.75. The correlation coefficient increased to R^2=0.997 when ambient temperature was taken into consideration. The regression equation obtained was $Ec = 0.077*P - 138*T + 3870$ and it is used as baseline for the chilled water system (where Ec is the energy consumed by the chiller in KWh and the other symbols are as above).

The results of the regression analysis led to more investigations to understand the inefficiencies within each of these two energy users. The specific energy consumption of both the chilled water and the steam systems were analyzed thanks to the collected data (fuel consumption and steam output for boiler, electricity consumption and cooling effect for chillers). Boiler efficiency was around 70% while the chiller system's Coefficient of Performance was nearly 1.3, both values being indicative of low efficiency. Further investigations went on to determine the root causes of these inefficiencies, the core activity of Step 1.6.

The following deficiencies were identified:

- The boiler internals were not being cleaned periodically
- The boiler burner was out of tune leading to a less than optimal air-fuel mix ratio
- Two boilers were being used while one alone could do the job (poor load matching)
- The condenser fins of the chiller were clogged and bent
- The configuration of the refrigerant piping in the chiller ice bank tank was not conducive for good heat transfer
- In many places, insulation of the chiller and steam systems (pipes and equipment) was in poor condition.