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D 4.2: Current process description Animal Feed Factories

(English)

tesla

Transfering
Energy Save
Laid on Agroindustry

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About this report

This report has been develop in the framework of the TESLA project (Intelligent Energy in Europe) and has been founded by the European Commission.

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1. Introduction

The aim of the animal feed production is to mix, as homogenous as possible, various raw materials and components to provide a balanced nutrition to food producing animals with the best conversion performance. Complexity relates to the use of raw materials and components, to the different technological characteristics, and to various physical aspects.

Most of them require grinding and this need determines the plant types by the positioning of this operation in the process. Thus, there are two main types of process flow diagrams:

- Pregrinding process flow diagram (see Figure 1): In this case, the raw materials are firstly ground separately and stored before dosing (weighing). Pre-grinding has a reputation to provide good productivity performances of the mill, but it requires, for the same raw material, several bulk silos for the different millings.

- Predosing process flow diagram: In this case, all the raw materials are weighed, coarsely mixed before being ground together formula by formula. Predosing allows simplifying feed mills, with fewer raw material silos for multi-species feed mills and a good fit milling and formulation. The drawback will be the division of the grinding step batch by batch, more consumption of energy and the need of servocontrols to automate the processes.

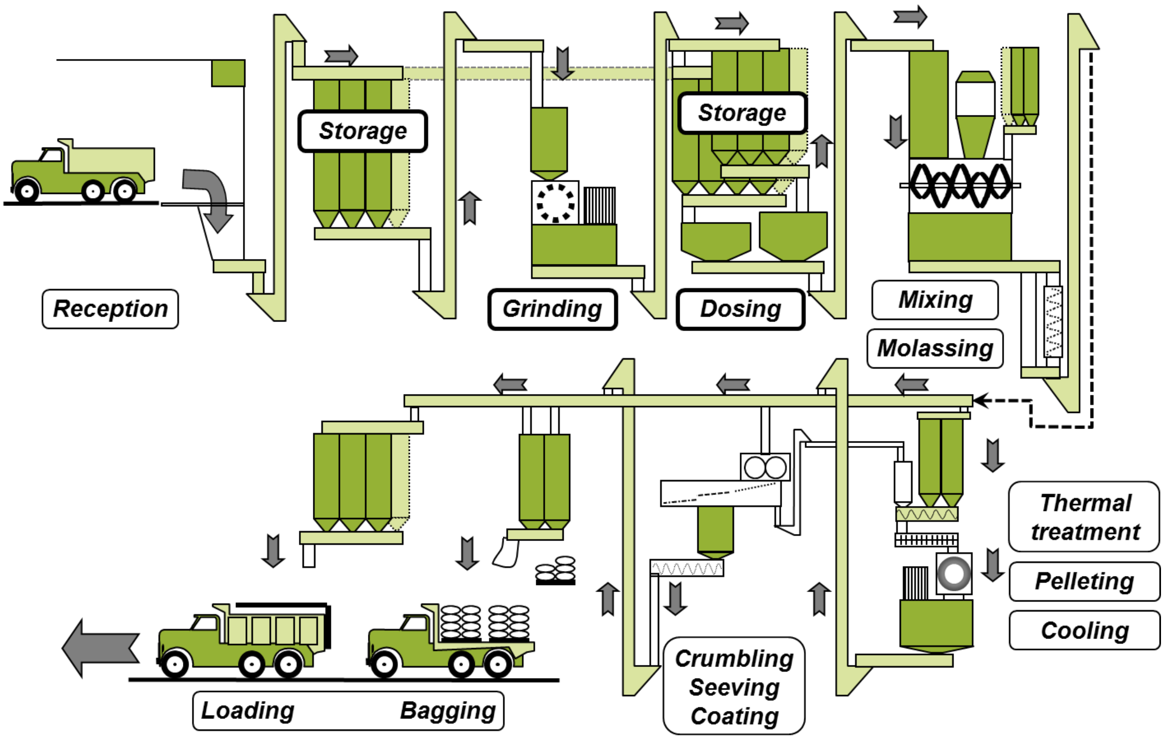

Figure 1: Pregrinding diagram (Tecaliman)

There are different final presentation types for animal feeds:

- Either the state: for instance, the feed called "meal"
- Either the form: compacted pellets or crumbles, heat treatment by steam injection and compression in dies.

The commercial conditioning also provides differentiation. Animal feed can be delivered in bags or in bulk.

Generally, in Europe, a feed mill has short time of raw materials storage (average 3 days after dosing). Production management is run on a just-in-time production system. The feed orders by breeders trigger the production orders with very short delivery time (2-3 days maximum).

Raw materials purchases, whose prices are volatile and often speculative, will depend on the feed formulation as well as on the estimated consumption. The traceability of supplies and deliveries is facilitated by efficient production software.

Management of feed quality plays an important role in the compound feed industry. It must meet the requirements of specific certification schemes based on good manufacturing practices. In France, specific authorizations are allocated by the government at feed mills according to their production type (use of additives, medicated feed manufacturing, animal feed production salmonella free).

In Europe, for 25 years, compound feed production has experienced three major phases. The first is a very significant increase in production volumes from 1988 to 1993, then a constant but much smaller increase from 1993 to 2008 and then a slight decrease in volumes produced since 2008. Figure 2 outlines this.

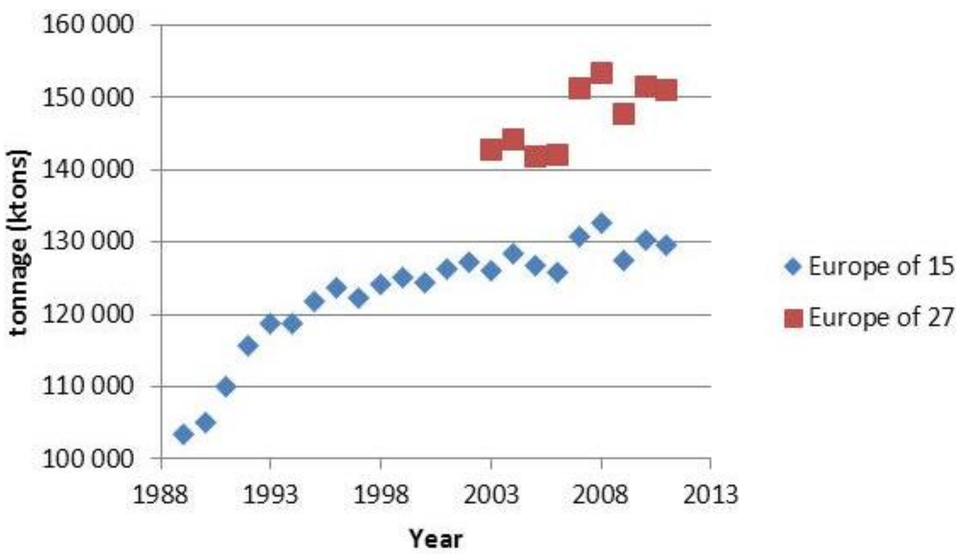

Figure 2: Compound feed production in Europe (Fefac data)

In 2011, the European compound feed production was 150.0 Mtons for Europe with 27 countries or 130.0 Mtons for Europe with 15 countries.
In the TESLA project, we focus only in four countries: France, Italy, Spain and Portugal. Figure 3 outlines the compound feed production of these countries.

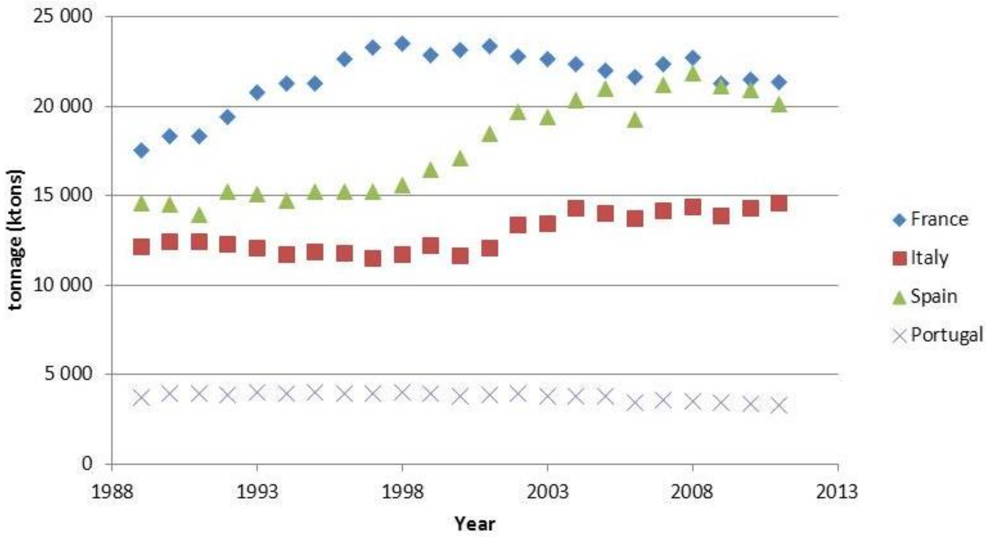

Figure 3: Compound feed production of France, Italy, Spain and Portugal (FEFAC data)

In 2011, French compound feed production was approximately 21.3 Mtons. For Spain, it's about 20.1 Mtons. Italy produced 14.5 Mtons and finally, Portugal made 3.3 Mtons.

2. Feed processing plant characteristics in France, in Spain, in Italy and in Portugal

2.1. Overview of production processes in animal feed plants

2.1.1 Reception

Various raw materials are received in a feed processing plant: grains, pellets, powdery, liquids,…

Feed ingredients can be classified in macroingredients (incorporated to the feed formula in a rate greater than 1 %) and microingredients (vitamins, minerals, and other materials usually required in feeds in small amounts as feed additives).All raw materials arrive by truck or, more rarely, by trains.

Grains and pellets are discharged into reception hoppers and transferred by mechanically to the storage units.

The micro-ingredients could be delivered in a mixture form called premix packed in bulk, big bags or bags.

Bulk powdery (phosphates, carbonates, urea, salt,...) are transferred, most of the time by a pneumatic system.

Macro-liquids are pumped into their external tanks and micro-liquids are often delivered cubitainers (IBC).

In the case that the feed mill produces medicated feed under veterinary prescription, it will receive medicated premixes, usually in bags, which will be stored in a specific area with limited access.

At the arrival of delivery trucks, they are weighed and a first quality control is performed. It determines the allocation of specific storage in the factory. The entry points to raw materials in the plants are multiple. A circulation plan guides to truck drivers toward reception places. For some raw materials, access keys allow avoiding that the truck driver deliver the ingredient in the wrong reception place.

Figure 4: Reception (Tecaliman)

The raw materials are systematically sampled at reception for carrying out quality checks before proceeding to the delivery. Additional controls are performed a posteriori in laboratories.

The controls results can imply different actions contemplated in the reception quality control plan: lot rejection, specific treatment (decontamination, drying,...), payment of raw material below the negotiated price, focusing on the supplier, supplier audits, modification of databases (NIRS databases,...).

2.1.2 Grinding

The grinding aim is to transform all the particles making up a formula to a similar particle size, consuming as low energy as possible. The similar particle size favors thereafter obtaining homogeneous and stable mixtures. The grinding fineness promotes pellet cohesion and the electrical efficiency of the pellet mill.

Unless design constraints of the plant, only raw materials as grains or pellets higher than desired particle sizes are ground. All others powdery raw materials will be added at the mixing step.

The most grinding mill type used in animal feed is the hammer mill.

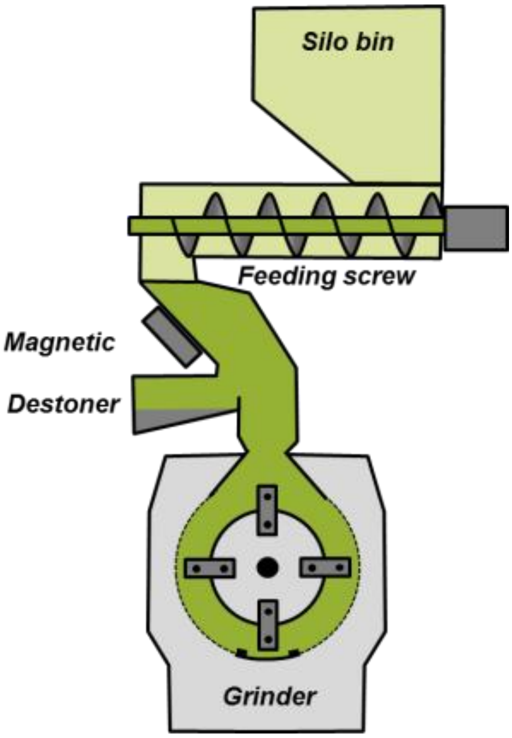

Figure 5: Hammer mill (Tecaliman)

Other grinding mill types (roller mill, disc mill,...) can be occasionally used in some feed mills but its use remains marginal. In each plant, one or more grinding mills are used depending on the desired rates for this operation. The supply device of each grinding mill includes a silo bin with, at its base, a screw conveyor which carries out the supply device of the grinding mill. Its rotational speed defines the grinding mill flowrate.

At the entrance of the grinding chamber, raw materials are purged of all foreign materials: the metal particles by a ferrous cleaner (a magnetic device) and the denser particles (stones) with a destoner operating with an airflow. The grinding chamber is delimited by a screen, calibrating the desired final particle size distribution. The particles are ground by reversible moving hammers hooked up on discs mounted on a rotor usually in rotation from 1500 to 3000 rpm.

Figure 6: Hammers in grinding mill (Tecaliman)

Between the disc and the hammer, fixed counter-hammers may be present.

High vacuum pressure generated by suction into the hopper beneath hammermill, provided by a large airflow also contributing to the operation of the destoner, extract the particles of the grinding chamber through the screen when they reached the right particle size.

The entrained air with the product is then separated from the meal most often by filtration in a sleeves battery installed on the ceiling of the hopper under hammermill. The cleaning sleeves are provided by a sequential injection system of compressed air at 6-8 bars.
In its lower part, the hopper under hammermill is provided with a transfer system (generally a screw conveyor) to ensure the ground products removal. This evacuation is completed by a rotating valve system, that prevents the air received, by the fan, comes to the downstream circuit of the hammermill.

2.1.3. Dosing

The dosing step is often assimilated with the single weighing operation of solid compounds in a "weighting" bin on which weighing sensors are positioned. In fact, to obtain an animal feed, weighing operations spread throughout the compound feed production process.

Thus, if the solid macro-ingredients are dosed at high flow rates and weighed over large hopper mounted on load cells, micro-ingredients and minerals (salt, carbonate, ...) can be measured and weighed on separate units micro-dosing or by hand in bag dumping step. In this case, the small quantities of products typically join the macro-ingredients flow in the mixing operation.

Liquid may be incorporated in the mixer, downstream of the mixer (molasses mixer) at the conditioner or release coating on the pellets.

On some compound feed industries, additives or medicated powders (medicated feed production) at low incorporation rates, even incorporated at the production end, just before loading with adding liquid.

Dosing should not be confused with the raw materials weighing. It aims to get the right quantities of each raw material needed to approach closer to the formula provided by the formulator. This dosing operation therefore involves two elements: dosing and weighing. Dosing is the process that manages the supply and distribution of products flow based on feedback from weighing sensors.

We deduce that the weighing element is a container or bin on weighing sensor which will be in accordance with the desired weight and the desired accuracy.

However, there may exist multiple dosing systems but the screws conveyors integrated into the bottom of the storage silo are usually used.

To stop the flow at the dosing end of fluidity product, we can see either fast reverse of the screw thread either a physical filling by shutter or trap at the end of the screw. Very frequently, the change in rotation speed of the screw will be used as a supplement to promote performance and accuracy.

Sometimes, down weighing on hopper can reconcile the two operations (dosing and weighing) in a single device.

The number of weighing bins may vary from one plant to another. The more important their number will be, the shorter dosing operation for simultaneous weighing it will be.

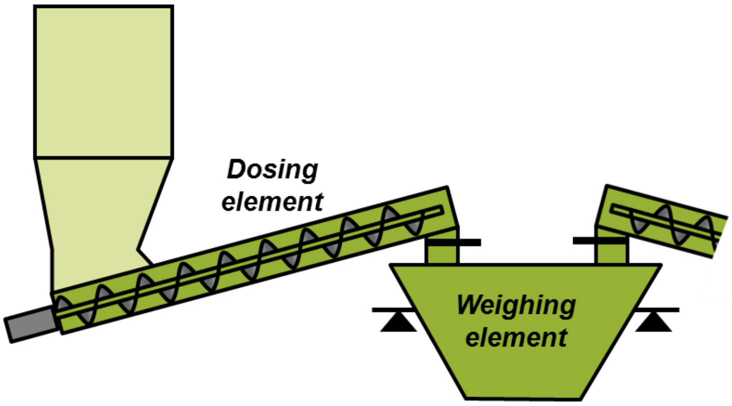

Figure 5: Screw conveyors and bin with weighing sensors (Tecaliman)

2.1.4. Mixing

The aim of mixing operation is to distribute, in a homogeneous manner, the elements of the dosed formula. This operation, compared to a similar operation in other industrial sectors, has particularities:

- Very small percentage of liquid added,
- Organic or mineral powders with very different physical characteristics,
- Very low incorporation rate of certain powders (100 g / t), but with a very high activity.

Among the various mixer types that you can meet in animal feed industry or in related industries (grains, minerals and medicated feeds, premixes):

- The most used mixer is the horizontal ribbon mixer with a ribbon agitator. A ribbon agitator consists of a set of inner and outer helical ribbons. The outer ribbon moves materials in one direction and the inner ribbon moves the materials in the opposite direction. The ribbons rotate and moves materials both radially and laterally for getting thorough blends in short cycle times. Plow mixers are usually dedicated to minerals or other microingredients. Plow mixers use wedge-like plows or specially angled paddles and a high-speed, solid shaft rotor within a horizontal, cylindrical tank.

- Paddle mixers and paddle ribbon mixer sallow carrying out the mixing in various directions. These double and triple action agitators insures rapid, homogeneous blending of the most difficult blending applications
- Twin shaft ribbon mixers or twin shaft paddle mixers. These mixers can improve the efficiency of the mixing processes.

In addition to micro and macro ingredients that are traditionally carried from the hoppers to the mixer, at least four types of liquids may be incorporated directly into the mixer:

- Fat (vegetable oils),
- Liquid by-products of sugar and fermentation industries, such as molasses.
- Amino acids
- Technical chemicals (different types of acids, ...).

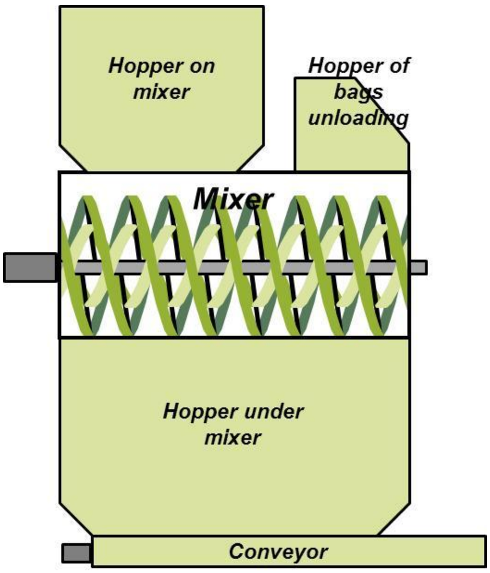

Figure 8: Mixing system (Tecaliman)

The two main parameters of the mixing operation are the mixing time and the filling rate. These two parameters have a direct impact on the production level of the plant, because it often has only one mixer.

The definition of maximum and minimum fill rate of a mixer depends on the mixer type and its manufacturer, usually between a30% and a 70% of the maximum height of the horizontal mixing device (ribbons, paddles, etc.).

The notion of mixing time takes into account the evolution of the mixture quality as a function of time. Cycle time of conventional mixing comprising filling and emptying will usually be below six minutes.

2.1.5. Pelletizing

The pelletizing aim is to convert the feed milled into pellets. This physical transformation of feed has many benefits, such as feed densification (about 40%) which generates an increase in storage capacity and a reduction of transport costs, a reduction of dust emissions or a better feed preservation.

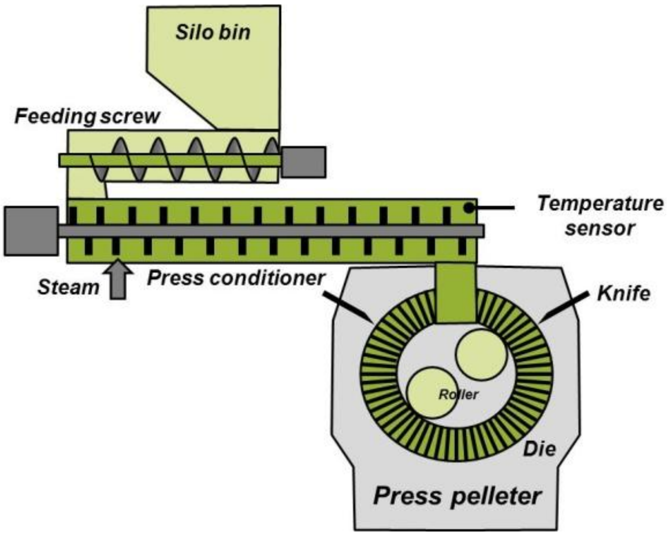

Figure 9:Pellet mill

However, it has some disadvantages, such as expensive investments (silos, pellet mill, boiler, cooler...), additional energy costs (electricity and steam), or the change in water content with "free" water incorporation.

The pelletizing is characterized by a line composed of different successive steps:

- Storage in the "small storage silo" in various numbers, but generally 2.
- A screw conveyor for each small storage silo which is also the supply screws controlling the pelletizing flowrate,
- A cylinder mixer, also called conditioner, in which the feed is mixed with steam,
- The pellet mill.

After pelletizing, the feed passes by gravity through a cooler and possibly a crumbler or crusher and a sifter. The smaller particles are separated from the feed and come back to the pellet mill. In the line periphery, a boiler and a steam system are installed.

Ingredients usually are supplied to the conditioner by using a screw controlled by a speed variation device. The supply flowrate of the conditioner and the pellet mill is adjusted to a setpoint value for the current speed of the pellet mill motor.

The conditioning of the ingredients is performed by continuous incorporation of dry steam.

The steam injection, close to the inlet, is regulated at the output by a temperature sensor, allowing the feed treatment between 40 and 95°C. The residence time distribution in the conditioner can vary from few seconds to several hundred seconds.

The passing of meal through previously prepared dies affects the palletizing process. Dies can be either disc dies either ring dies (more typically on pellet mill with vertical dies) or rotating dies.

In the pelletizing process, meal is brought, after passing a magnetic device, inside the ring, a metal ring perforated of circular channels. After being compressed by rollers, the meal is oriented towards the die using scraper knives. Then the meal is extruded through the die channels. The product comes out in the form of a cylinder. At the exit of the die channels, two knives slice the cylinder slicing setting up the pellet length.

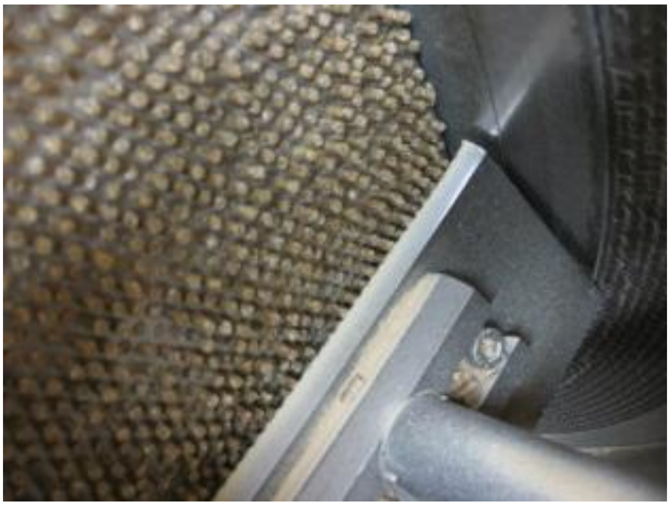

Figure 10:Knives of pellet mill (Tecaliman)

The steam amount injected into the conditioner affects the production flowrate and the energy consumption of the pellet mill. The pelletizing process is the first consumer of energy in a feed processing plant:

- 50 to 60% of electric energy consumption
- 80 to 90% of steam consumption

2.1.6. Heat treatment

Heat treatment is usually related to the need of feed hygienisation in order to eliminate preventively pathogenic microorganisms.

The feed in the meal form is subjected to heat treatments, including steam.

Heat treatments can be carried out continuously or by batches. The principle consists in treating the feed with a temperature of 85°C

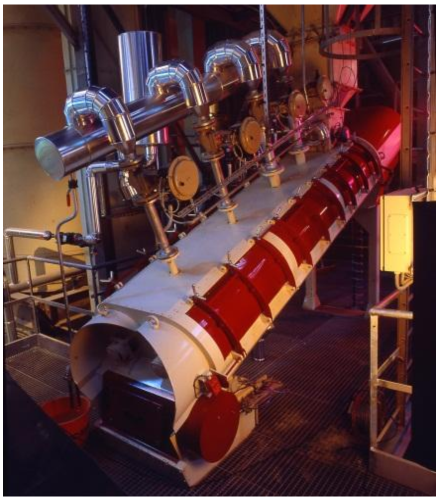

Figure 11: Example of heat treatment equipment (Tecaliman)

for several minutes under the steam action. Unlike conditioners of pellet mill, steam can be incorporated in several spots and treatment devices are systematically insulated.

In continuous systems, the residence time distribution of particles must be kept under control so that all particles undergo the expected treatment. These treatments result in a "wet pelletizing" by bonding fine particles of the largest particles under the steam action.

Other treatments are possible, such as extrusion, but they found few applications in the animal feed field, except for petfood plant and fishfood plant that use more likely this feed technology.

2.1.7.Cooling

Each pelletizing or heat treatment line has necessarily a cooler, because it is impossible to store a warm and moist product without risks of clumping and microbial degradation.

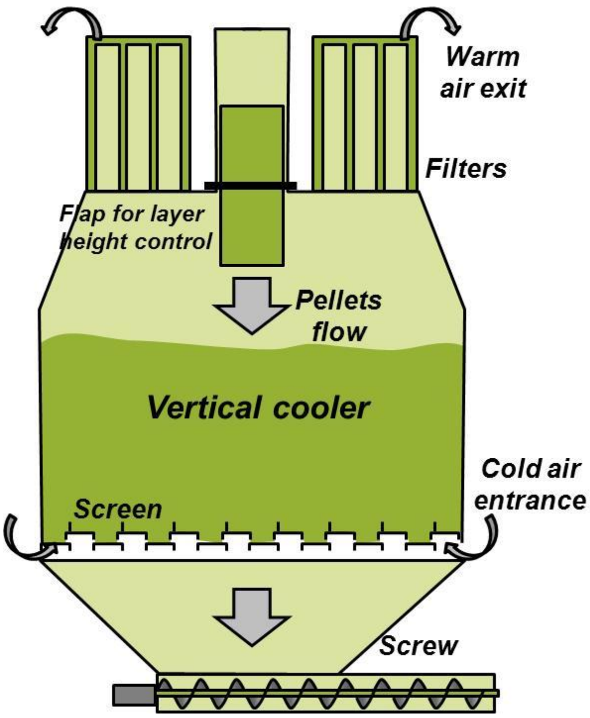

Figure 12: Cooler (Tecaliman)

The aim of this step is to cool and to dry pellets in a single device. In animal feed, the drying and cooling steps are combined.

These processes are carried out by creating an environment airflow within the feed mass. Drying is carried out by heat use carried by the product and cooling by adjusting the heat of the incoming air.

The cooling process is the result of coupled exchanges of heat (enthalpy) and substance (water) between the air and the product. The air is gradually warmed by heat exchange with the product as it passes through the cooler.

The heat exchange coupled depends, among other things, on:

- the energy contained in the pellets at the exit of the pellet mill,

- the air velocity in the cooler,
- the production flowrate of the pelletizing line,
- the pellet size,
- the ambient air characteristics, ...

In practice, the pellets change to a temperature between 50°C and 95°C and a moisture at around 14% to 17% at the die outlet (at the cooler inlet) at a temperature of a few degrees above the ambient temperature (between 5 and 10°C above). The moisture must be lower than the prescribed value (14%) at the cooler outlet. To ensure good feed preservation, it is also necessary to appreciate the free water content and the saturation vapor pressure.

This process is done in vertical counterflow coolers or horizontal and crossflow coolers. Air is drawn downstream from the cooler by a fan, so that it passes through the bed depth of product.

This air is charged in particles in contact with pellets or meal. Then, it must be filtered before being discharged outside the plant. The air velocity variation can be managed by a valve or a speed variation device. In order to not generate preferential flows in the bed depth of product, because of a variable thickness, a flap for layer height control is installed at the inlet of homogenizing the surface.

2.1.8. Crumbling/Sifting/Coating

The aim of crumbling is to breaking up pellets into smaller particles agglomerated for small animals (chicks, quails, etc) from the pellets manufactured. Usually the crumbler consists of two corrugated rolls situated below the cooler/drier exit. The pellets can then be diverted into the crumbler, if crumbles or granules are desired, or they can by-pass it. .The distance between the two rollers can be adjusted for getting the desired size for the crumbles produced.

One of the rollers rotates at a higher speed in order to perform a "slicing" of pellets rather than a crushing.

The crumbles production is expensive because, for obtaining crumbles of good quality, it is needed:

- To grind fine meal in order to increase pellets consistency.
- to produce pellets of very good quality (good pelletizing and good drying/cooling)
- recycle products too thin at the sifting and to pellet it again, which reduces the overall production rate.

The main issue is setting up the end of the batch cycle by stopping the recycling of fine particles. The operations manager can choose to incorporate the final fine particles to the batch or to eliminate them.

The separation of fine particles is typically performed by a sifting. The excessive presence of fine particles in the feed may be badly tolerated by some animals. For this reason, livestock farmers require their feed suppliers to avoid this excessive presence of fine particles. Two sieves can be used for generating three particle size distribution classes:

- A coarse sieve retaining agglomerates or any foreign matter with large sizes. The majority of the pellets pass through the sieve and the large particles are eliminated.
- A fine sieve retaining the pellets and allowing the selection of fine particles to be recycled on the pellet mill.

For avoiding their soiling, some sieves can be equipped with rubber balls in motion in their lower part.

After sifting, liquids (often fat and/or enzymes but also vitamins or organic acids) can be incorporated into the feed at a step called spray coating outside the pellets. This is the last step of dosing and the formula is definitely considered complete at this step.

Figure 13: Sieve (Tecaliman)

Most of the time, this incorporation is performed on a very simple device consisted of:

- a hopper with two levels
- a dosing system allowing flowrate management
- a spraying zone
- a mixtures screw
- a retention screen

The liquids to be sprayed are brought from their tanks to the incorporation place (with or without buffer tank) through piping systems and pumps.

2.1.9. Conditioning/Loading/Delivery

A conditioning line is composed of storage hoppers, a sack filling station and a palletizing system.

The main elements of the sack filling station will be the dosing / weighing that must be sufficiently precise to assure that the conformity between the bagged quantity the quantity declared in the label. The second key element is the labeling or bags marking that must be made in accordance with the applicable legislation.

Figure 14: Bag conditioning (Tecaliman)

In most cases, the bags are delivered to dealers or distributors while the bulk is delivered directly to livestock farmers. Usually most of production is delivered in bulk. In the case of cooperatives, mostly there is a direct link between the feed production plant and the livestock farms consuming the produced feed.

At the plant, loading can be done in the truck in several ways:

- Either directly on a weigh-bridge.
- either by a weighing tool pre-installed between storage cells of finished products and loading.

Figure 15: Loading cells of a truck (Tecaliman)

The truck is divided into cells (typically seven to nine) in order to separate the different batches of deliveries.

Logistics, the loader and the delivery driver all contribute to the loading development according to the round schedule, and the compatibility between batches.

Upon arrival to the farm, unloading depends on the truck type:

- Pneumatic hoses are connected between the storage cell of the truck and the storage silo. A pneumatic conveyor system is used to transport the product from the truck to the storage silo.
- Mechanical: the conveyor system in the boxes (screw or chain conveyors) discharges the feed on the basis of a vertical screw. In the screw outlet, the feed is taken by the mobile transverse screw to be driven into the silo of the farm.

2.2. Plant characteristics by country

Each country has a specific feed production. For this energy efficiency project, it is important not to forget the type of compound feed production because, according to the target animal, the formula ingredients varies as well as the physical appearance of the final product. These differences have an impact on the energetic consumption to produce these animal feeds. Figures 16 to 19 outline all the production types for each country.

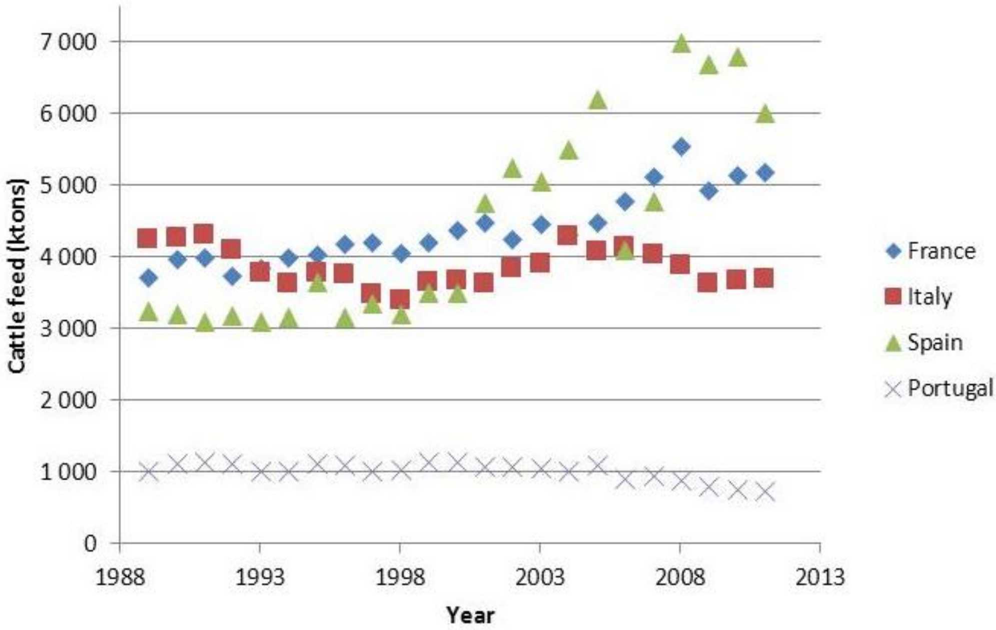

Figure 16: Cattle feed production (Fefac data)

Figure 16 shows the cattle feed production. In 2011, Spain produced 6.0 Mt, followed by France (5.2Mt), then Italy (3.7Mt) and Portugal (0.7Mt).

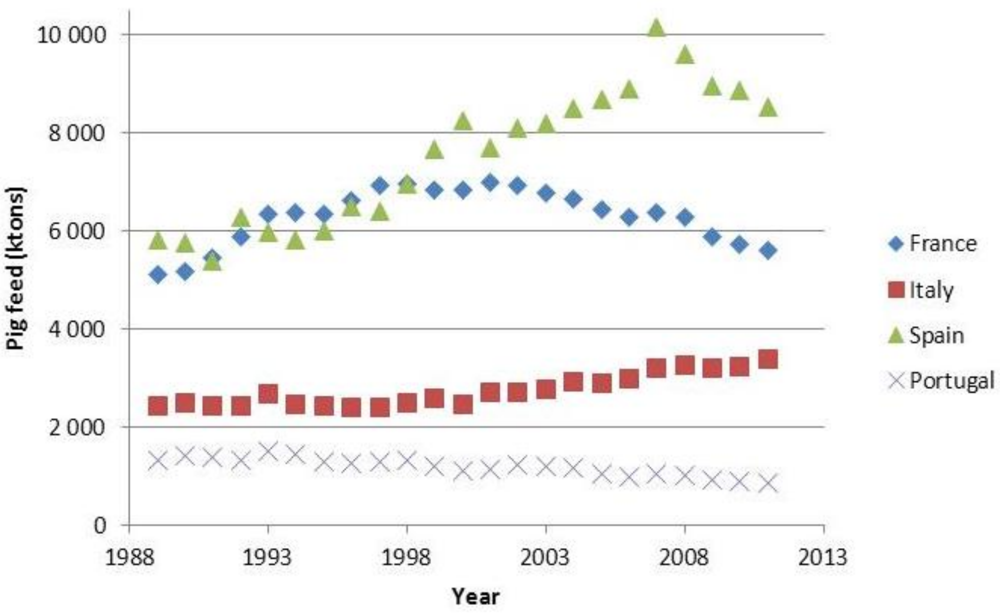

Figure 17: Pig feed production (Fefac data)

Figure 17shows the pig feed production. In 2011, Spain produced 8.9Mt, followed by France (5.6 Mt), then Italy (3.4Mt) and Portugal (0.9Mt).

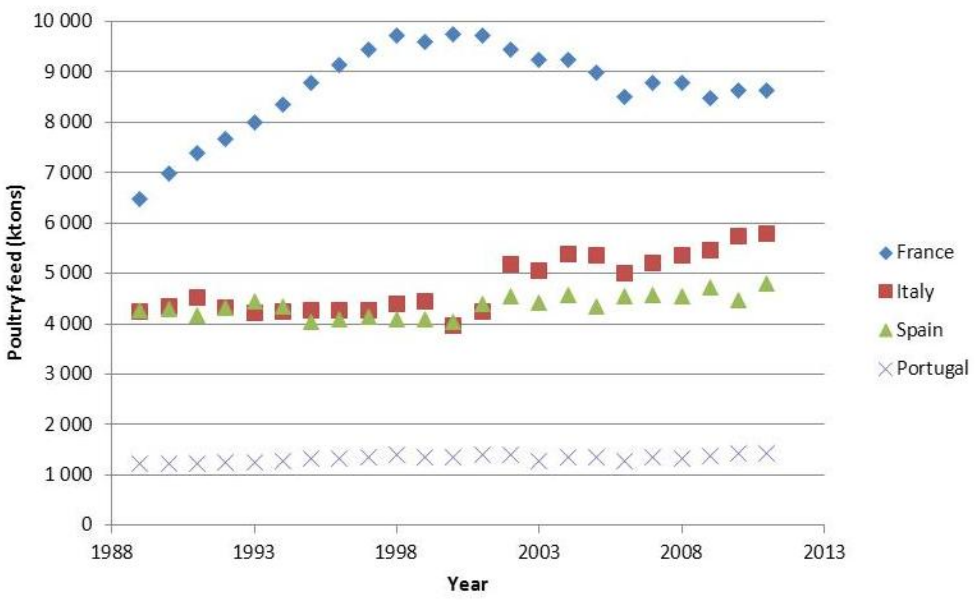

Figure 18: Poultry feed production (Fefac data)

Figure 18 shows the poultry feed production. In 2011, France produced 8.6 Mt, followed by Italy (5.8 Mt), then Spain (4.8 Mt) and Portugal (1.4 Mt).

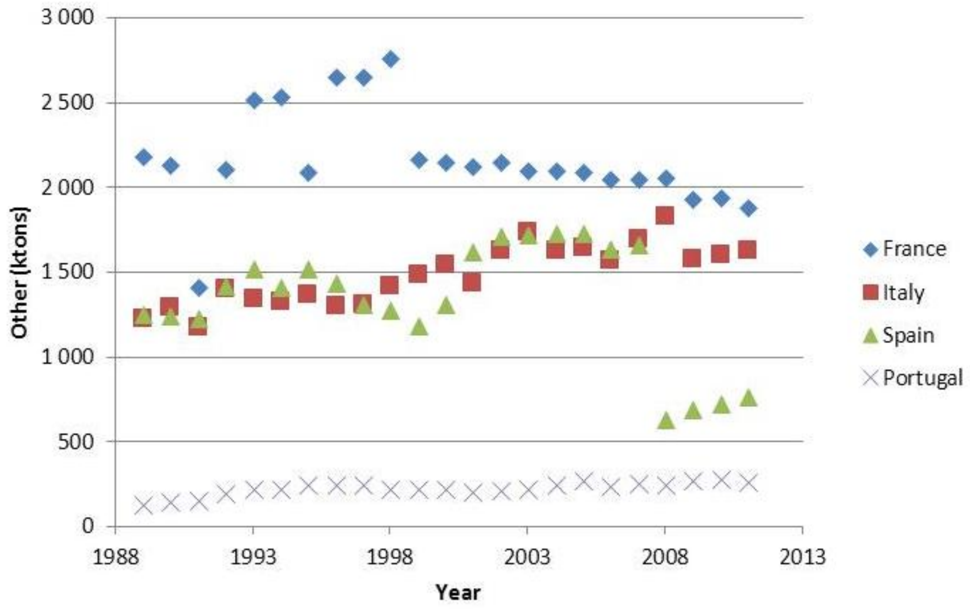

Figure 19: Other feed productions (Fefac data)

Figure 19 shows the other types of feed production. In 2011, France produced 1.9 Mt, followed by Italy (1.6 Mt), then Spain (0.8 Mt) and Portugal (0.3 Mt). Figure 19 shows that between 2007 and 2008, Spanish data for other feed production has a significant change. This change is too important to be only a national change in the animal feed production. For example, it could be due to a change in the animal species included in these categories when elaborating the national statistics.

With all these figures, an observation can be made: these countries do not manufacture the same ratios of compound feed. These differences have impact on the energy consumption of each country because for each animal, the presentation of the finished feed will not be the same. For example, for cattle, the presentation form will be mainly pellets. For poultry, it can be pellets, crumbles or meal. The figures in this point show a clear difference between Spain and France: France manufactures more poultry feed than Spain and Spain produces more pig feed than France. This difference could cause differences in energy consumption. In the next points, a description of the compound sector is done for each country in order to compare them.

2.2.1. In France

As a reminder, in 2011, the compound feed amount (excluding pet food) was approximately 21.3 megatons. Figure 20 summarizes the French compound feed production.

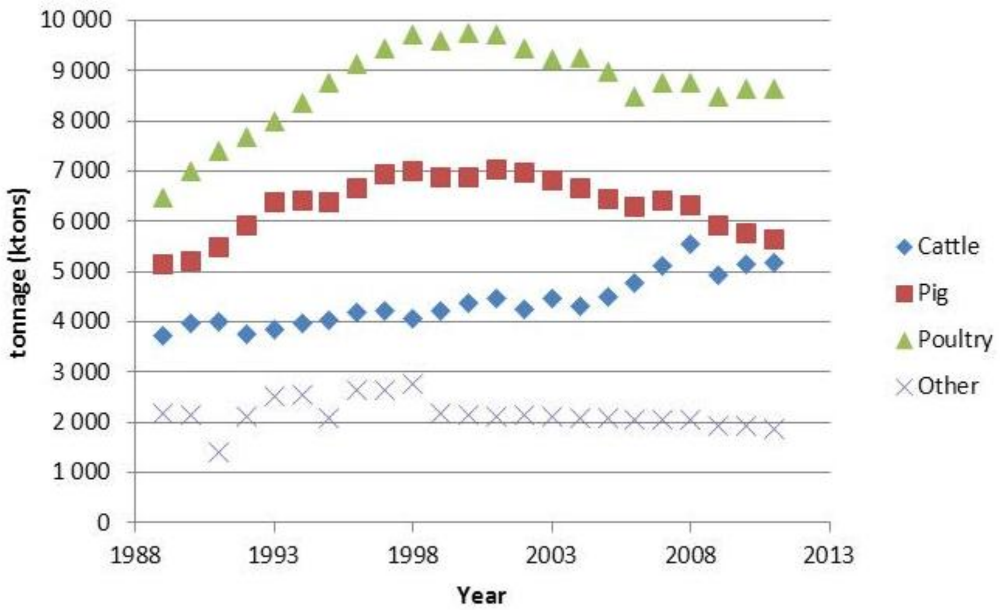

Figure 20: French compound feed production (Fefac data)

The animal feed production efficiency is an essential part of the transformation of vegetable products in animal products (meat, milk, egg). This transformation is based from composed formulations of many overall dry raw materials and liquid raw materials incorporated up to 10-12% of the final composition of animal feed. The cost of raw materials making up the animal feed must be optimized, because raw material costs represent at least 80% of feed price (SNIA, 2013). For the remaining 20%, if transport and distribution to livestock farms are removed, there are only 12 to 13% to cover the costs of animal feed production that include: investment, maintenance, personnel, and control energies.

This is a low margin business with high intensity of capital invested in equipments and materials, making the animal feed activity very sensitive to volume. It is because of the type and production methods of feed mills:

- High throughput (automation and little handling are important factors)
- Gravity is used for reducing energy costs transfer in plants (plant height)

French feed mill are predominantly agro-industry cooperatives and the feed production is mainly manufactured in the large western. Indeed, Bretagne, Pays de la Loire and Poitou-Charentes include 65% of the French metropolitan production.

- **Size ranges in France:**

French feed mills can be considered as:

- Big when its production is higher than 100.0 kilotons (kt) of feed/year,
- Medium when its production is from 50.0 to 100.0 kt of feed/year,
- Small when its production is lower than 50.0kt of feed/year.

Figure 21 outlines the number of feed mill by production level produced.

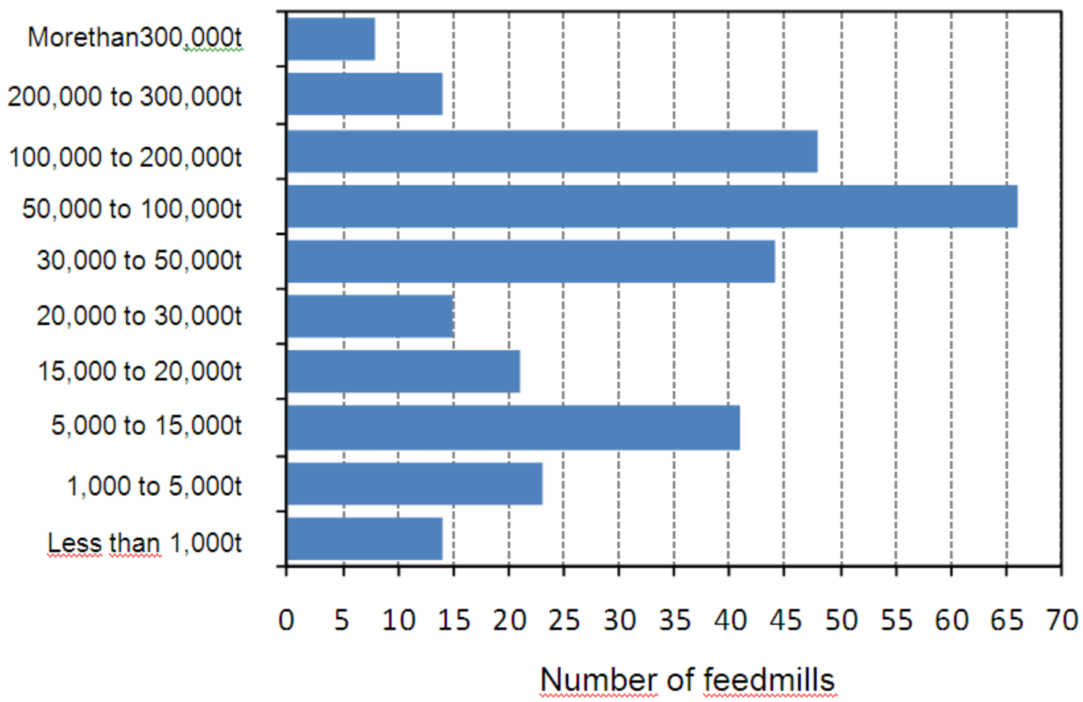

Figure 21: Number of feed mill by production level produced (SNIA-CoopdeFrance, 2009)

In the big size range, there are 68 feed mills. In the medium size range, there are 66 feed mills and in the small size range, it exists 158.

- **Number of feed mills:**

The number of feed mills has decreased continuously for the last 20 years but the average production level per feed mill have increased. Figures 22 outlines the changes in the number of feed mills and the average production level produced per site.

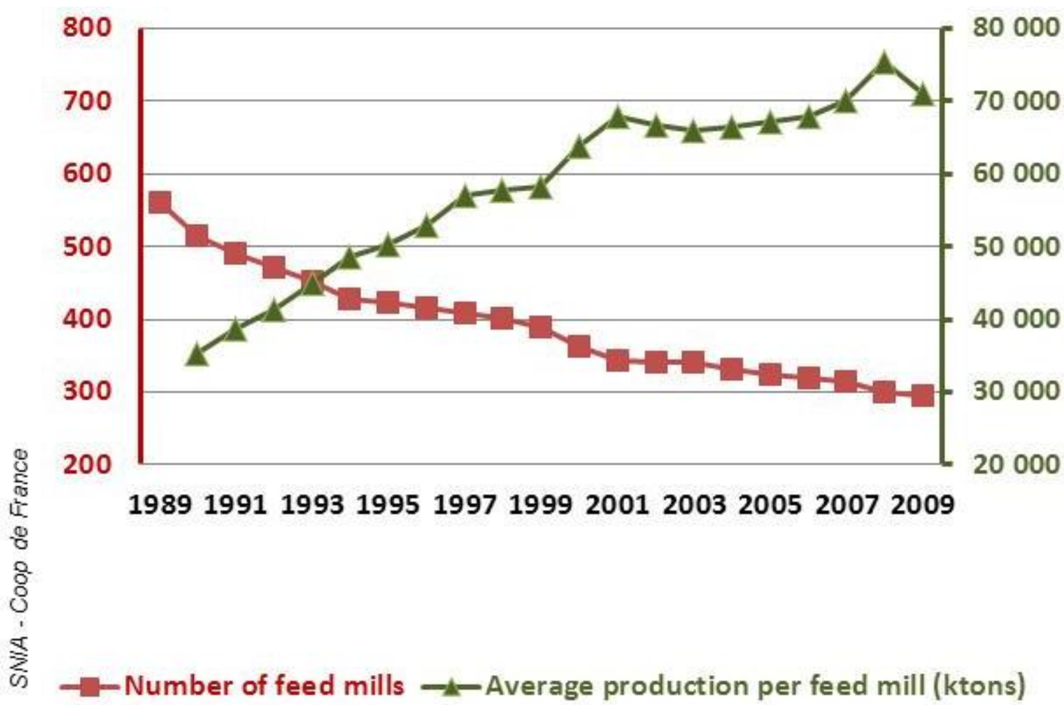

Figure 22: Changes in the number of feed mills and the average production level produced per site (SNIA-CoopdeFrance, 2009)

In 2008, the number of compound feed plants was 301 for an average annual production level per site of 75.3 kt but in 2010, this number of compound feed mills only was 292 and the average annual production level per site is 80.0 kt.

- **Production value of the sector:**

The compound feed profession accounts for about 12000 jobs in the French territory for a turnover of 7.14 billion euros (FEFAC, 2011).

2.2.2. In Italy

As a reminder, in 2011, the compound feed amount (excluding pet food) was approximately 14.6megatons. Figure 23 summarizes the Italian compound feed production and the table 1 indicates the repartition of Italian production.

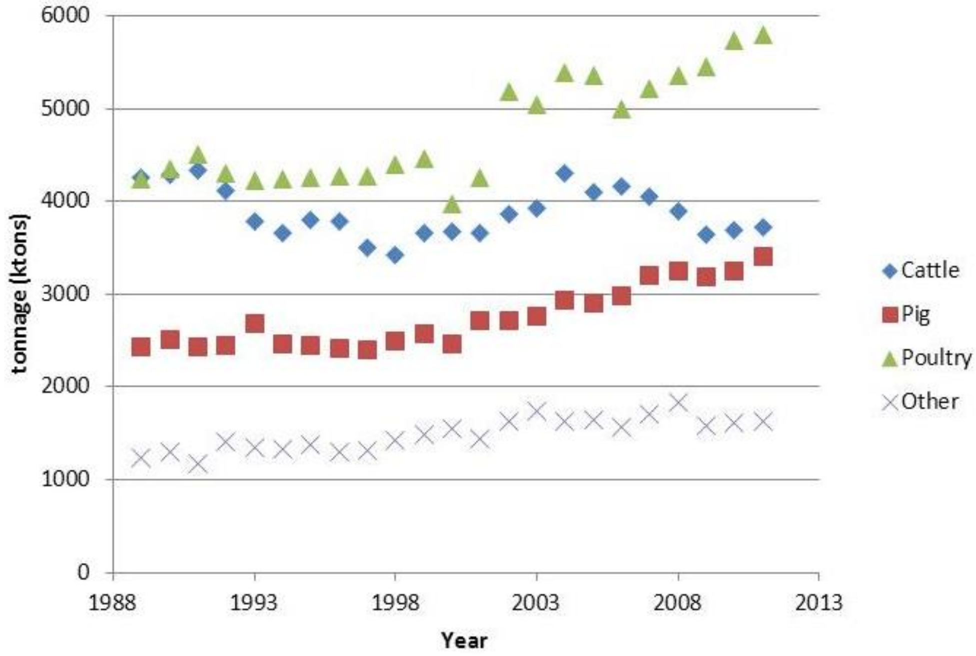

Figure 23: Italian compound feed production(Fefac data)

Table 1:Total production of the sector (2010)

Total production of the sector (2010)		
	Quantity (tons)	**% on the total**
Poultry	5,730,000	40.2
Cattle	3,683,000	25.8
Pigs	3,241,000	22.7
Rabbits	545,000	3.8
Sheeps	211,000	1.5
Horses	85,000	0.6
Fishes	105,000	0.7
Pet-food	617,000	4.3
Other animals	48,000	0.3
TOTAL	**14.265.000**	**100.0**

- **Size ranges in Italy:**5.000- 850.000 tons per year (Source: Istat –Assalzoo 2011)

- **Number of feed mills:**

A number of 600 companies are distributed in the Italian territory. They prepare feeding materials for the different animals (poultry, cattle, pigs, rabbits, sheep, horses, fishes, pet-food, etc.).

- **Production value of the sector:**

In 2011, the total economical turnover is 6,65billion euros. The number of direct operators is 8.500.

2.2.3. In Spain

As a reminder, in 2011, the compound feed amount (excluding pet food) was approximately 20.1megatons. Figure 24 summarizes the Spanish compound feed production.

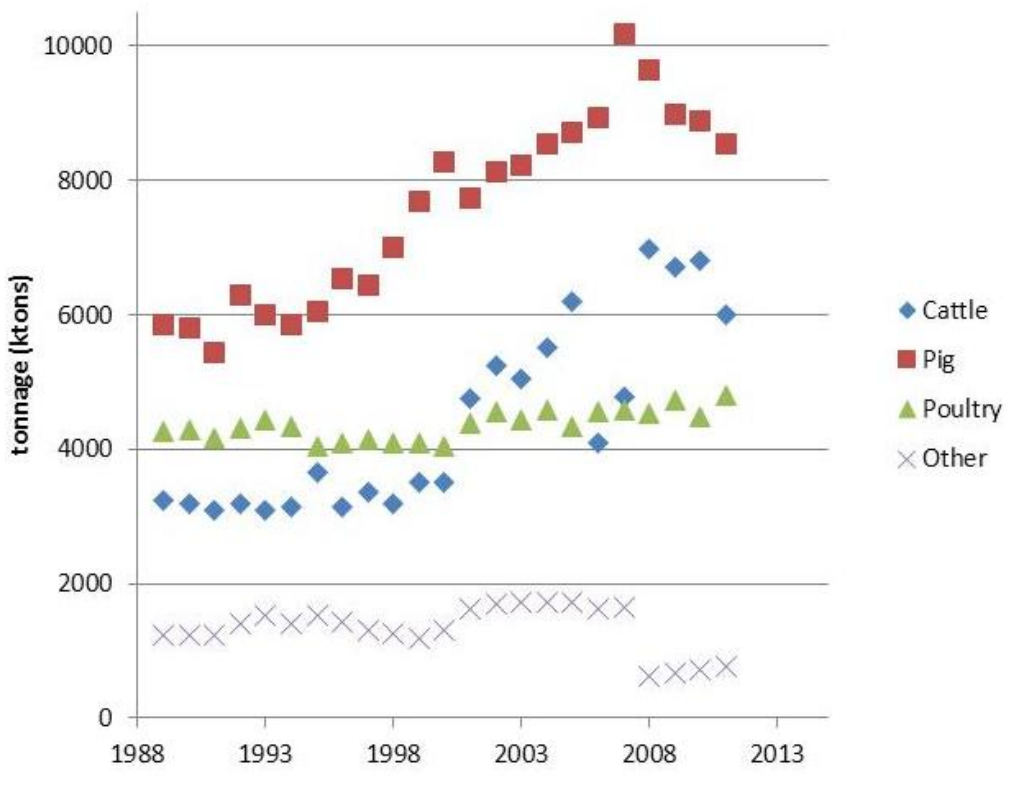

Figure 24: Spanish compound feed production(Fefac data)

- **Size ranges in Spain:**

Spanish feed mills can be considered as:

- Big when its production is higher than 30.0 kt of feed/year,
- Medium when its production is from 10.0 to 30.0 kt of feed/year,
- Small when its production is lower than 10.0 kt of feed/year.

- **Number of feed mills:**

The number of compound feed production units in Spain is about 854 in 2011 (FEFAC, 2011).

- **Production value of the sector:**

Current value of production of the sector in the country was about 5.75 billions de euros en 2010 (FEFAC, 2011).

2.2.4. In Portugal

As a reminder, in 2011, the compound feed amount (excluding pet food) was approximately 3.9Mt. Figure 25 summarizes the Portuguese compound feed production.

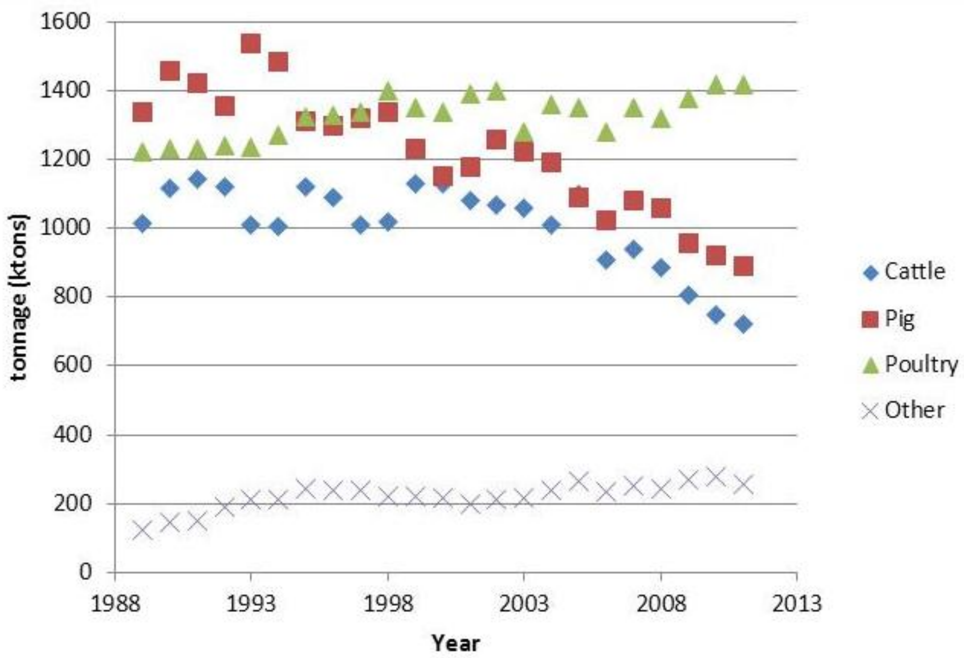

Figure 25: Portuguese compound feed production(Fefac data)

- **Size ranges in Portugal:**

Portuguese feed mills can be considered:

- Big when production is higher than 40.0 kt of feed/year
- Medium when production is between 20.0 to 40.0 kt of feed/year
- Small when production is lower than 20.0 kt of feed/year

- **Number of feed mills:**

The number of feed mills in Portugal is 124 (DGAV, 2013).

- **Production value of the sector:**

According with data from the Portuguese Institute of Statistics, in 2010, the production value of this sector was around 1.200 M €.(IACA, 2012).

3. General data of a typical plant by country

3.1. In France

According AGRESTE statistics of 2009 (French Ministry of Agriculture), the gross energy consumption of animal feed manufacturing totaled 420,404 toe (tons of oil equivalent)for total purchases of 149,721 k€.In this sector, primary energy sources used are electricity and fuels (natural gas, propane, butane, heavy fuel oil and domestic heating oil). Natural gas is the fuel most used for steam production.

On feed mills, electricity is always used for the motors of devices (it concerns approximately 90% of electricity consumption), for compressed air production and for lighting buildings. On some feed mills, electricity can be used for heating liquids contained in some storage silos for liquids and, with rare exceptions, for producing steam. Operation management decisions can cause empty operating periods or operating periods with a partial load in for different engines. These periods can more or less long.

Fuels are used for steam production and for heating water. For 15-25% of feed mills, domestic heating oil is consumed for the electricity production by generators operated via a specific contract (erasing of peak hours or modular).

Furthermore, it is noteworthy that, on average, 40% of the energy consumption (kWh) by a feed mill is used to produce steam.

The specific energy consumption of a manufacturing unit is significantly influenced by the physical appearance of the feeds produced (meal, crumble or pellet), their expected quality related with feed parameters such as hardness or particle size and the target animal (pigs, poultry, cattle, young animals, pregnant animals, high producing animals, etc.). Indeed, compound feeds that are pelletized, represent around 75% of the national production of animal feed, of which 10% are produced in the crumble form (SNIA-Coop de France, 2012). In 2012, SNIA conducted an investigation about feed distribution via their physical aspect on 84 feed mills. It highlighted that:

- Cattle feeds are substantially all in pellet form
- Pig feeds are in around 50 % in pellets and around 40% in meal
- Poultry feed form depends on the poultry targeted i.e. egg production (layers), meat production (broilers) and for reproduction (breeding hen). The meal is mainly used for feeding layers and breeding hens. Pellets and crumbles are mainly for broilers
- Other animal feeds are essentially in pellet form

With respect to feed packaging, in France, approximately 95 % of feeds finished are delivered in bulk and the rest is delivered in bags.

Before giving French general data on energy consumption, it's important to point out that it does not exist national statistics of energy consumption per plant. Despite this lack of information, on the basis of a reference feed mill, it is possible to estimate some general data like:

- Feed mill size considered: 80.0ktof feed/year
- Typical ratio between electrical energy consumption/production: from 18 to 60 kWh per t of feed

- Typical ratio between electrical energy / thermal energy: 60 % / 40 %
- Typical ratio between thermal energy consumption/production: from 20 to 50 kWh per t of pelletized feed
- Typical electrical energy cost in the industry: from 60 to 110 euro/MWh
- Typical thermal energy cost in the industry: from 20 to 80 euro/MWh
- A little seasonality of the electrical energy consumption except cattle feeds
- A little seasonality of the thermal energy consumption except cattle feeds

3.2. In Italy

In addition, some general data of a reference feed mill are given (source: Company VALMORI SR):

- Feed mill size considered: 130.0 kt of feed/year
- Typical ratio between electrical energy consumption/production:20 kWh/tof feed
- Typical ratio between thermal energy consumption/production: 55 kWh/t of feed
- Typical electrical power installed: 450 kW
- Typical thermal power installed (boiler, etc.): 1.744kW, 813 kW (steam production, boiler)
- Typical electrical energy cost in the industry: around 144 euro/MWh (electricity)
- Typical thermal energy cost in the industry: around 37 euro/MWh (gas)
- No seasonality of the electrical energy consumption
- No seasonality of the thermal energy consumption

3.3. In Spain

In addition of these information, some general data of a reference feed mill (with mixer cart and pellet mill) can be given:

- Feed mill size considered: 21.5 kt of feed/year

- Typical ratio between electrical energy consumption/production: 20 kWh/t of feed
- Typical ratio between thermal energy consumption/production: 14 kWh/t of feed
- Typical electrical power installed: 900 kW
- Typical thermal power installed (boiler/vehicles/etc.): 700 kW boiler, 100 kW vehicles
- Typical electrical energy cost in the industry: 125 euro/MWh
- Typical thermal energy cost in the industry: 60 euro/MWh
- No seasonality of the electrical energy consumption
- No seasonality of the thermal energy consumption

3.4. In Portugal

In Portugal, analysing the data available from the National Statistics Institute and taking in account the previous definition for the dimension scale, 47 % of feed mills are small, 15 % medium and 38 % are big factories. The following information was recorded in a plant that manufactures 81.000 tons of feed stuff per year, being an example of a big feed mill. Some general data of a reference feed mill can be given:

- Feed mill size considered: 81.0 kt of feed/year
- Typical ratio between electrical energy consumption/production: 13.8 kWh/t of feed
- Typical ratio between electrical energy / thermal energy: 57 % / 43 %
- Typical ratio between thermal energy consumption/production: 10.4 kWh/tons of feed
- Typical electrical power installed: 430 kW
- Typical thermal power installed (boiler/vehicles/etc.): 220 kW boiler
- Typical electrical energy cost in the industry: 80 euros /MWh
- Typical thermal energy cost in the industry: 70 euros/MWh
- No Seasonality of the electrical energy consumption
- No Seasonality of the thermal energy consumption

4. Industrial processes in animal feed processing plants

4.1. In France

4.1.1. Typical plant data

For a feed mill of approximately 80.0 kt, it is possible to have different data according to the feed type. The Table 2 shows estimated data of three different feed mills (cattle, poultry and multispecies -cattle, poultry and pig-).

Table 2: Typical French plant data

	Feed mill specialized in cattle	Feed mill specialized in poultry	Feed mill multispecies (cattle, poultry and pig)
Annual opening time	5,500 h	6,000 h	5,600 h
Amount of feed	79.0kt	75.0kt	74.0kt
Amount of pellets	72.0kt	59.0kt	43.0kt
Amount of meal	7.0kt	16.0kt	31.0kt
Average production flowrate	$14 th^{-1}$	$13 t h^{-1}$	$13 t h^{-1}$
Annual electrical consumption	3.4 GWh	2.8 GWh	2.3 GWh
Annual thermal consumption	1.9 GWhlhv	2.4 GWhlhv	1.1 GWhlhv
Specific electrical power consumption (kWh per dosed ton)	43 kWh per dosed ton	37 kWh per dosed ton	31 kWh per dosed ton
Specific thermal power consumption (kWh lhv* per pelletized ton)	26	41	26

*lhv: lower heating value

In a feed mill, electrical power consumption mainly concerns three processes:

- Grinding from 10 to 30 % of global electrical power consumed,
- Pelletizing from 40 to 70 % of global electrical power consumed,
- Utility: Compressed air system from 5 to 12 % of global electrical power consumed.

For the example of a French feed mill specialized in cattle (table 2), the values of the typical technology used in the process are shown in the table 3.

Table 3: Technical conditions of French feed mill specialized in cattle

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**CAPACITY (t/hour)**	**Main electrical engine power (kW)**	**Estimated power of additional engine (fan, etc.) (kW)**	**Thermal power installed (kW)**
Grinding	Production line 1: Vertical hammer mill	From 10 to 12	90	From25 to 35	
	Production line 2: Horizontal hammer mill	From13 to 15	110	From25 to 45	
Pelletizing	Production line 1: Pellet mill	From10 to 12	200 kW	From70 to 90	
	Production line 2: Pellet mill	From6 to 8	132 kW	From50 to 70	
	Production line 3: Pellet mill	From6 to 8	132 kW	From50 to 70	
Auxiliary processes	Compressed air system:two air compressors	630 m³/hof compressed air	70 kW		
Auxiliary processes	Boiler	2.000 kg of steam per hour			1.400 kW

For the example of a French feed mill specialized in poultry (table 2), the values of the typical technology used in the process are shown in the table 4.

Table 4: Technical conditions of French feed mill specialized in poultry

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**CAPACITY (t/hour)**	**Main electrical engine power (kW)**	**Estimated power of additional engine (fan, etc.) (kW)**	**Thermal power installed (kW)**
Grinding	Production line 1:Horizontal hammer mill	From 12 to 14	132	From 40 to 50	
	Production line 2:Vertical hammer mill	From 10 to 12	90	From 25 to 35	
Pelletizing	Production line 1: Pellet mill	From 6 to 8	200	From 70 to 90	
	Production line 2: Pellet mill	From 3 to 5	132	From 50 to 70	
	Production line 3: Pellet mill	From 5 to 7	150	From 60 to 80	
Auxiliary processes	Compressed air system: two air compressors	360 m³/h of compressed air	42		
Auxiliary processes	Boiler	3.000 kg of steam per hour			2.050

For the example of a French feed mill multispecies -cattle, poultry and pig- (table2), the values of the typical technology used in the process are shown in the table 5.

Table 5: Technical conditions of French feed mill multispecies (cattle, poultry and pig)

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**CAPACITY (t/hour)**	**Main electrical engine power (kW)**	**Estimated power of additional engine (fan, etc.) (kW)**	**Thermal power installed (kW)**
Grinding	Production line 1: Vertical hammer mill with Variable speed drive	From 14 to 16	90	From 25 to 35	
	Production line 2: Vertical hammer mill with Variable speed drive	From 14 to 16	90	From 25 to 35	
Pelletizing	Production line 1: Pellet mill	5	160	From 60 to 90	
	Production line 2: Pellet mill	6	260	From 70 to 100	
Auxiliary processes	Compressed air system: two air compressors	478 m^3/h of compressed air	52		
Auxiliary processes	Boiler	2.000 of steam per hour			1.400

4.1.2. Technical conditions of typical plant

In France, a typical feed mill works 5.5 days per week, 24h per day. It is impossible to work only during daytime to save energy for lighting because production management is based on just-in-time principles. Each feed mill team is composed of approximately 3-6 persons and they work generally in 3 shifts of 8 hours or 2 shifts of 8 hours. This small number of persons is possible thanks to a high level of automation of the plant.

No waste is produced in animal feed. On the contrary, this sector used a lot of food by-products to manufacture feed. By-products are essential in animal feed production and they are important to complete the compound feed formulation. Raw materials are stored only 3 days maximum and compound feed only 1 day maximum.

One difference between pre-grinding plants and pre-dosing plants is the number of production lines and thus the device number for a same unit operation. In addition, if a feed mill has a feed specialization (cattle, poultry, pig, etc.), the equipment used can vary. Therefore, it is difficult to set up a type of feed mill as a single representative reference. But taking as reference a medium feed mill for multispecies of 80.0 kt per year, you can find:

- Reception: 1 or 2 reception pits
- Grinding: 1 or 2 hammer mills
- Dosing: 2 or more weighing bins
- Mixing: 1 mixer
- Pelletizing: 2 to 4 pellet mills
- Heat treatment: 0 or 1 heat treatment device
- Cooling: 1 cooler per pellet mill
- Crumbling/Sifting/Coating: 0 or 1 crumbler, 1 sifter per production line, 0 or 1 coater
- Conditioning: 0 or 1 backing station and 1 palletizing system
- Loading: 1 or 2 loading station
- Auxiliary processes:
    - A boiler to produce steam
    - Sometimes a generating set to produce electric energy
    - A compressed air system
    - A lighting system

For a typical French feed mill, additional information on the typical processes and technologies for quality and automation control is shown in Table 6:

Table 6: Potential technical conditions of a typical French plant

		FACTORS OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Quality control**	**Automation control technology**	**Information storage devices (if exist)**	**Typical type of maintenance**
Reception	Reception pit, chain type conveyor and bucket elevator, electrical engines	Moisture, cleanliness	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Grinding	Hopper with screw conveyor, hammermill feeder, Hammer mill with horizontal rotor [or vertical rotor], vacuum device, fan system and filtration system, hopper beneath hammermill with screw conveyor, electrical engines	Moisture, particle size distribution	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Dosing	Screw conveyor, weighting bin, electrical engines		Specific automation controllers	Data base	Preventive and/or corrective maintenance
Mixing	Ribbon mixer, automatic feeding for liquid, molasser, chain conveyor, electrical engines	Homogeneity test	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Pelletizing	Screw conveyor, horizontal conditioner, Pellet mill (2 or 3 rollers) with vertical ring die, electrical engines	Durability test, hardness	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Heat treatment	Screw conveyor, conditioner, electrical engines	Temperature	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Cooling	Vertical counter-flow cooler or horizontal cooler, electrical engines	Temperature Moisture	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Crumbling/ Sifting/ Coating	Crumbler with fan system and pneumatic system, sifter and coater, electrical engines	Particle size distribution (fine rate)	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Conditioning / Loading	Storage hoppers, a sacking-off station and a palletizing system, electrical engines		Specific automation controllers	Data base	Preventive and/or corrective maintenance
Auxiliary processes	Boiler Compressed airsystem Lighting, electrical engines		Specific automation controllers		Preventive and/or corrective maintenance

4.2. In Italy and in Spain

4.2.1. Typical plant data

For Italy and Spain, a usual type of plant is an animal feed mill with mixer cart and pellet mill. These feed plants manufacture from 5 to 150 kt of feed per year. The values of the typical technology used in the process are shown in the table 7.

Table 7: Typical distribution of energy consumptions (Italy and Spain)

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Electrical power installed (kW)**	**Electrical energy consumption (kWh/year)**	**Thermal power installed (kW)**	**Thermal energy consumption (kWh/year)**
Raw material reception	Raw material hoppers, conveyors, electrical engines	55	13.000		
Milling	Horizontal hammer mill, electrical engines	230	146.000		
Mixing	Mixercart, horizontal mixer, electrical engines	240	82.000		
Addition of fat and molasses	Horizontal mixer, molasses mixer, electrical engines	35	9.000	80	20.000
Pelletizing	Pellet mill, steam boiler, cooler, electrical engines	260	108.000	420	170.000
Bagging	Electrical engines	40	21.000		
Lighting and other electrical auxiliary processes	Fluorescents	140	51.000		
Thermal auxiliary processes	Heating boiler, transport			300	110.000
TOTAL		1.000	430.000	800	300.000

For an animal feed plant with mixer cart and pellet mill, boiler uses diesel for producing steam and warm water and its energy efficiency is average 90 %. Diesel is used by vehicles and forklift trucks too. The product storage time is variable and it can be of days or months.

4.2.2. Technical conditions of typical plant

Technology applied in the processes offers opportunities of energy saving in this sector. In some processes, automation devices are connected to a data base and information is stored; analysis of the stored information can show aspects of the process that can be improved. A suitable maintenance can be related with a correct management of the energy consumption.

Table 8: Potential technical conditions of a typical Italian or Spanish plant

		FACTORS OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Quality control**	**Automation control technology**	**Information storage devices (if exist)**	**Typical type of maintenance**
Raw material reception	Raw material hoppers, conveyors, electrical engines	Moisture, cleanliness	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Milling	Horizontal hammer mill, electrical engines	Moisture, particle size distribution	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Mixing	Mixer cart, horizontal mixer, electrical engines	Homogeneity test	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Addition of fat and molasses	Horizontal mixer, molasses mixer, electrical engines		Specific automation controllers	Data base	Preventive and/or corrective maintenance
Granulation	Pellet mill, steam boiler, cooler, electrical engines	Durability test, hardness, temperature, moisture, particle size distribution	Specific automation controllers	Data base	Preventive and/or corrective maintenance
Bagging	Electrical engines		Specific automation controllers	Data base	Preventive and/or corrective maintenance
Lighting and other electrical auxiliary processes	Fluorescents				Corrective maintenance
Thermal auxiliary processes	Heating boiler, transport		Thermostats (heating boiler)		Corrective maintenance

4.3. In Portugal

4.3.1. Typical plant data

The following information was recorded in a plant that manufactures 81.000 tons of feed stuff per year, being an example of a big feed mill. The values of the typical technology used in the process are shown in the table 9.

Table 9: Typical Portuguese plant data

		VALUES OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS				
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**CAPACITY (t/hour)**	**Electrical power installed (kW)**	**Electrical energy consumption (kWh/year)**	**Thermal power installed (kW)**	**Thermal energy consumption (kWh/year)**
Raw material reception	Raw material hoppers, electrical engines	37.5	96	270.435		
Milling	Horizontal hammer mill, electrical engines	22.4	113	397.567		
Mixing	Mixercart, horizontal mixer, electrical engines	22.4	40	121.928		
Addition of fat and molasses	Horizontal mixer, molasses mixer, electrical engines		3	10.326		
Pelletizing	Pellet mill, boiler, cyclone coolers	5.6	180	276.668		
Bagging	Electrical engines	12	3	19.864		
Lighting and other electrical auxiliary processes	Fluorescents		5	16.637		
Thermal auxiliary processes	Heating boiler				220	794.640
Auxiliary equipments	Forklifts					49.659
Total			440	1.113.427		844.299

4.3.2. Technical conditions of a typical plant

This feed plant manufacture 81.000 tons per year, using hammer for milling. The cooling of the granules is by cyclone cooler. Gas is used as the energy source for the boiler. The forklifts use gas or diesel. Storage period of the feed product can vary between days or weeks depending on demand needs. The factory is currently producing 314 tons of feed per day, however the installed power allows this value to reach 540 tons. Table 10 presents the all production process with the typical technologies and respective electric and thermal energy consumption (kWh/year), quality control, automation and maintenance processes.

Table 10: Technical conditions of a typical Portuguese plant

		FACTORS OF THE TYPICAL TECHNOLOGY USED IN THE PROCESS			
PROCESS (sequential order)	**TYPICAL TECHNOLOGY**	**Quality control**	**Automation control technology**	**Information storage devices (if exist)**	**Typical type of maintenance**
Raw material reception	Raw material hoppers, electrical engines	Weight and samples for analysis of the raw material	Specific area with control panel	Manual	Manual
Milling	Horizontal hammer mill, electrical engines	No	Specific area with control panel	Manual	Self-cleaning, each month
Mixing	Mixercart, horizontal mixer, electrical engines	Weighing every day	Specific area with control panel	Manual	Manual, 15/15 days
Addition of fat and molasses	Horizontal mixer, molasses mixer, electrical engines	Weighing every day	Specific area with control panel	Manual	Manual, 15/15 days
Pelletizing	Pellet mill, boiler, cyclone coolers	No	Specific area with control panel	Manual	Manual, each day
Bagging	Electrical engines	Sample of final product for analysis	Specific area with control panel	Manual	Manual
Lighting and other electrical auxiliary processes	Fluorescents				
Thermal auxiliary processes	Heating boiler		Specific area with control panel		

5. Alternative technologies and new perspectives

The improvement solutions to save energy on production processes and utilities in animal feed processing mills are numerous. The interest of these solutions must be evaluated on a case by case basis for each feed mill. Each plant must be considered as a specific case, i.e., it is impossible to generalize one case for all feed mill. The return time can vary significantly depending on investment costs, operating time machine, the size of the machine, etc…

The list below details examples of improvement actions whose interest should be studied case by case:

- Process
    - Grinding

- Hammer mill
  - Use of a variable speed drive
  - Use of a high efficiency motor
- Ventilation
  - Use of a properly dimensioned fan
  - Use of a high efficiency motor
  - Use of a variable speed drive
  - Use of an adapted ventilation control and an adapted regulation system

- Pelletizing
  - Pellet Mill
    - Use of a high efficiency motor
  - Cooler Ventilation
    - Use of a properly dimensioned fan
    - Use of a high efficiency motor
    - Use of a variable speed drive
    - Use of inverter technology
    - Use of an adapted ventilation control and adapted regulation system
- Auxiliary processes
  - Steam generation and distribution
    - A properly dimensioned steam boiler
    - Selecting the most efficient burner technology
    - A combustion control of the burner
    - Use of an economiser for the preheating feed-water
    - Use of a condenser for the preheating feed-water
    - Minimising boiler blowdown
    - Recovering energy from boiler blowdown
    - Insulation of steam pipes, condensate return pipes, valves and fittings
    - Implementing a control and preventive maintenance program for steam boilers.
    - Implementing a control and preventive maintenance program for steam traps
    - Etc.
  - Alternative solution to produce steam

        - Heating biomass
        - Methanation
        - Gasification process
    - Compressed air systems
        - A properly dimensioned compressor
        - A variable speed drive
        - A high efficiency motor
        - Optimizing the pressure level
        - A heat recovery
        - Selection the most efficient air dryer technology
        - Reducing the leaks of compressed air systems
        - A storage of compressed air near to high-fluctuation uses
        - Etc.
    - Electric power supply
        - Energy efficiency management of transformers
        - Energy efficiency management of electrical motors
    - Lighting
        - Energy efficiency management of lighting: electronic ballasts, efficient lamps

6. Further information on the current process in animal feed production

Different solutions can be considered to improve energy efficiency. These solutions are not only technical but also solutions linked to management methods, such as product quality management, energy management, or production management could be considered.

Factors affecting product quality such as conditioning temperatures, steam flows, drying time, hardness and durability of pellets or particle size distribution of meal are strongly related with energy consumption. A better understanding of the needs and requirements of customers could allow improving energy efficiency without failing in satisfying customer needs and requirements.

Finally, between the managerial solutions, at least two types can be identified:

- The implementation of an active energy management system. This sector could make efforts in collecting, analyzing and reporting energy efficiency information in order to identify avoidable losses in energy

- The production scheduling:
  - Thanks to especially the timing diagram, it is possible to optimize the production time. In fact, if the number of no load run mode (without product) is as small as possible, the efficiency of each process is improved.
  - In optimizing the feed mill production rate, energy savings are done and more production can be achieved.

7. Conclusions

Each country has these typical production characteristics. Even if the current process is very similar in each country, the production capacity of a feed mill is very different from country to country. The energy saving measures could be different for each country depending on specific conditions such as energy price and energy regulation. Moreover, in a particular country, each feed mill should be considered like a unique case because the energy efficiency solutions proposed for a feed mill could not be the most suitable for another feed mill.

Energy efficiency improvement is a difficult and complex task in a feed mill. It is necessary to observe the practices and to have an important amount of data in order to evaluate as precisely as possible the different energy saving opportunities and their impact on the energy efficiency management of a feed mill.

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