SCOOPE Saving Cooperative Energy

D3.4 Extended Value Stream maps of NACE 10.1: Slaughterhouse and quartering

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About this document

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Table of contents

List of Figures

1. Introduction

This document, taking as a first starting point the Current Value Stream Mapping of the sector of MEAT AND POULTRY, particularly Slaughterhouses activities, contains the description of each industrial process including the associated equipment. According to this data, the most relevant ones from the energy point of view have been identified in order to serve as basis for the following stages of the project such as the setting up of benchmarking baselines in thermal and electricity consumption.

2. Current Value Stream Mapping

Below the current value stream mappings of the sector of MEAT AND POULTRY using the LEAN&GREEN symbology are showed.

Besides, the most relevant inputs and outputs regarding energy issues and also greenhouse effect gasses emissions and water consumption, raw materials have been identified in the flow diagram.

2.1. Slaughterhouses: Pigs, Cattle and Sheep

In the case of the pigs, cattle and sheep the slaughter processes are very similar, following a continuous line, without any auxiliary additional process. Thus, the current value stream mapping is showed in the Figure 1, highlighting the special parts of the process for each particular case: pigs, cattle and sheep.

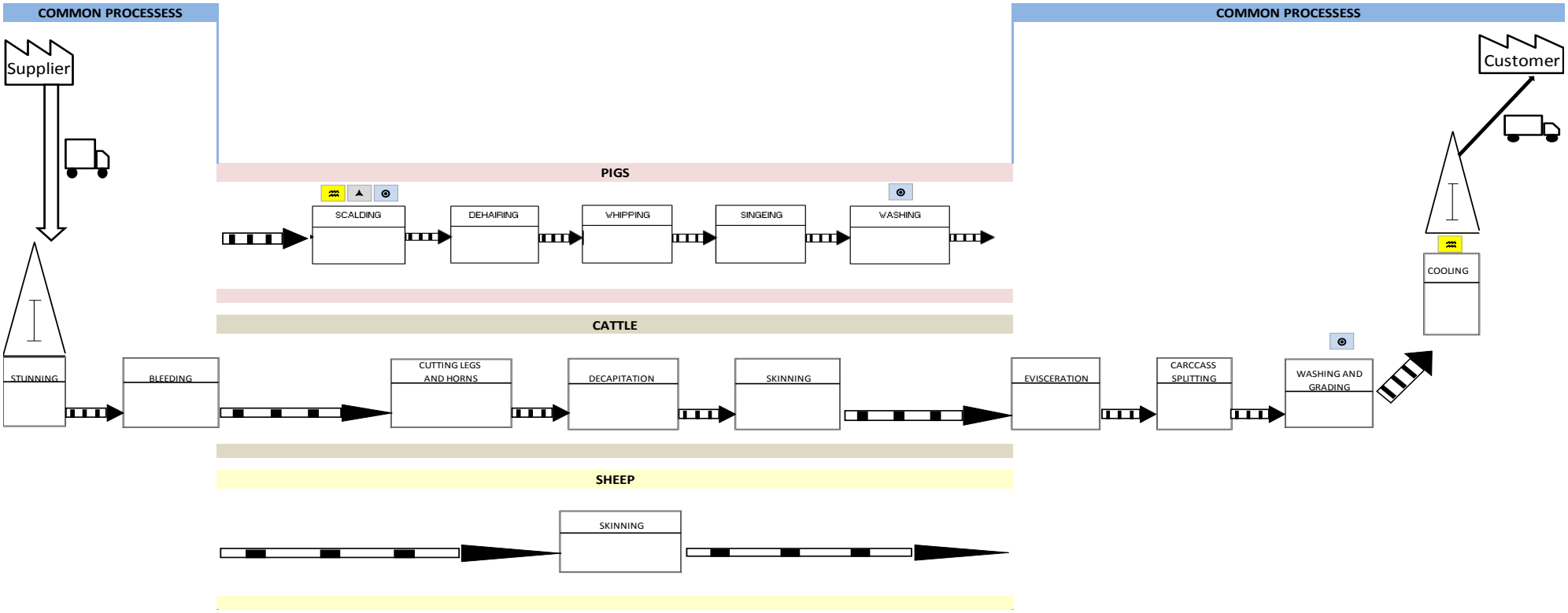


Figure 1: Current value stream mapping for pigs, cattle and sheep slaughterhouses.

2.2. Slaughterhouses: Poultry

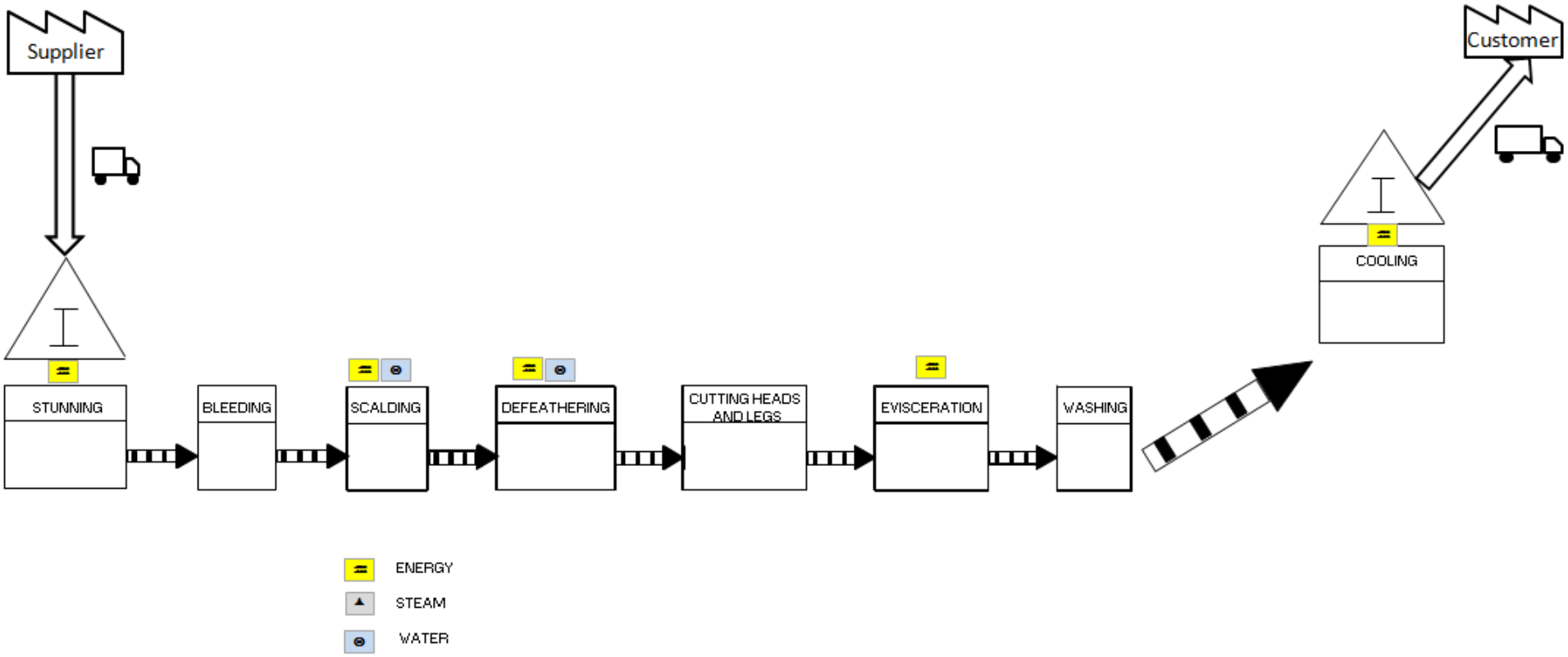


Figure 2: Current value stream mapping for poultry slaughterhouses.

2.3. Slaughterhouses: Rabbit

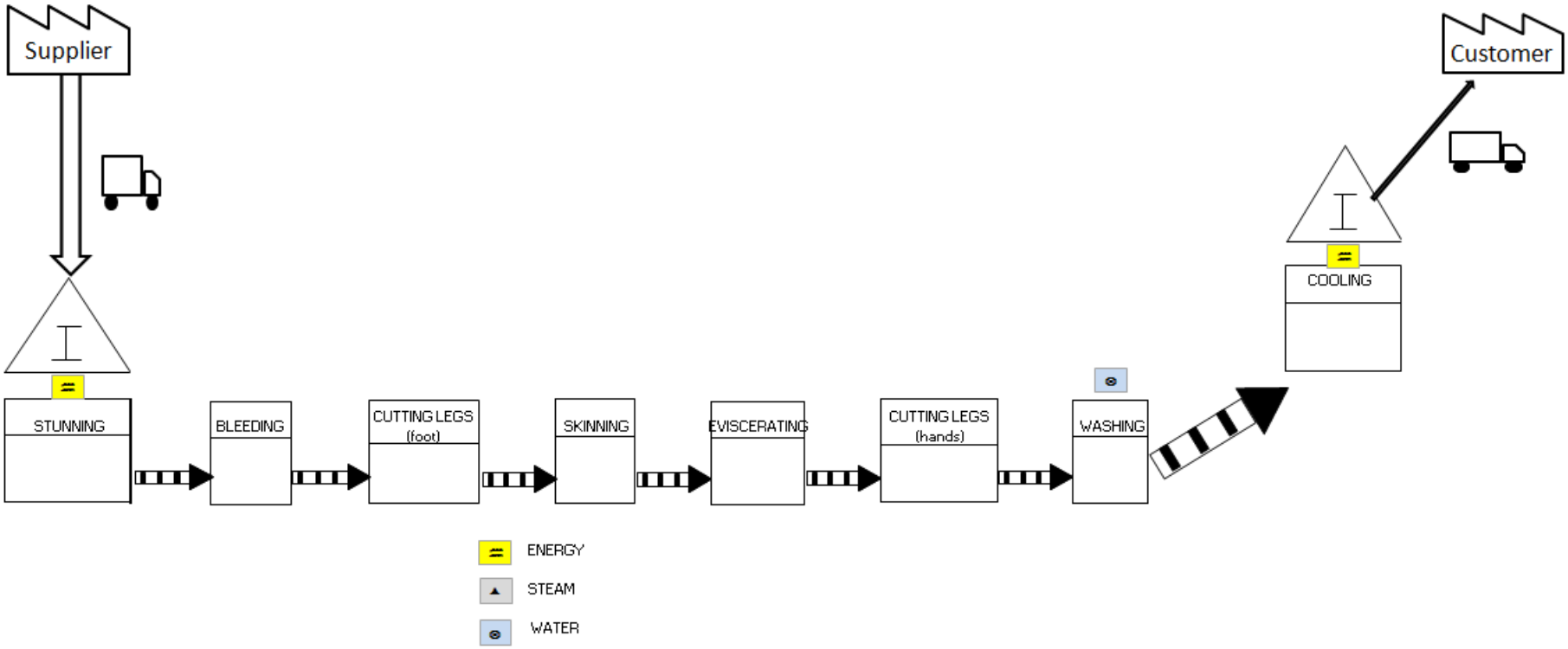


Figure 3: Current value stream mapping for rabbit slaughterhouses.

2.4. Meat processing

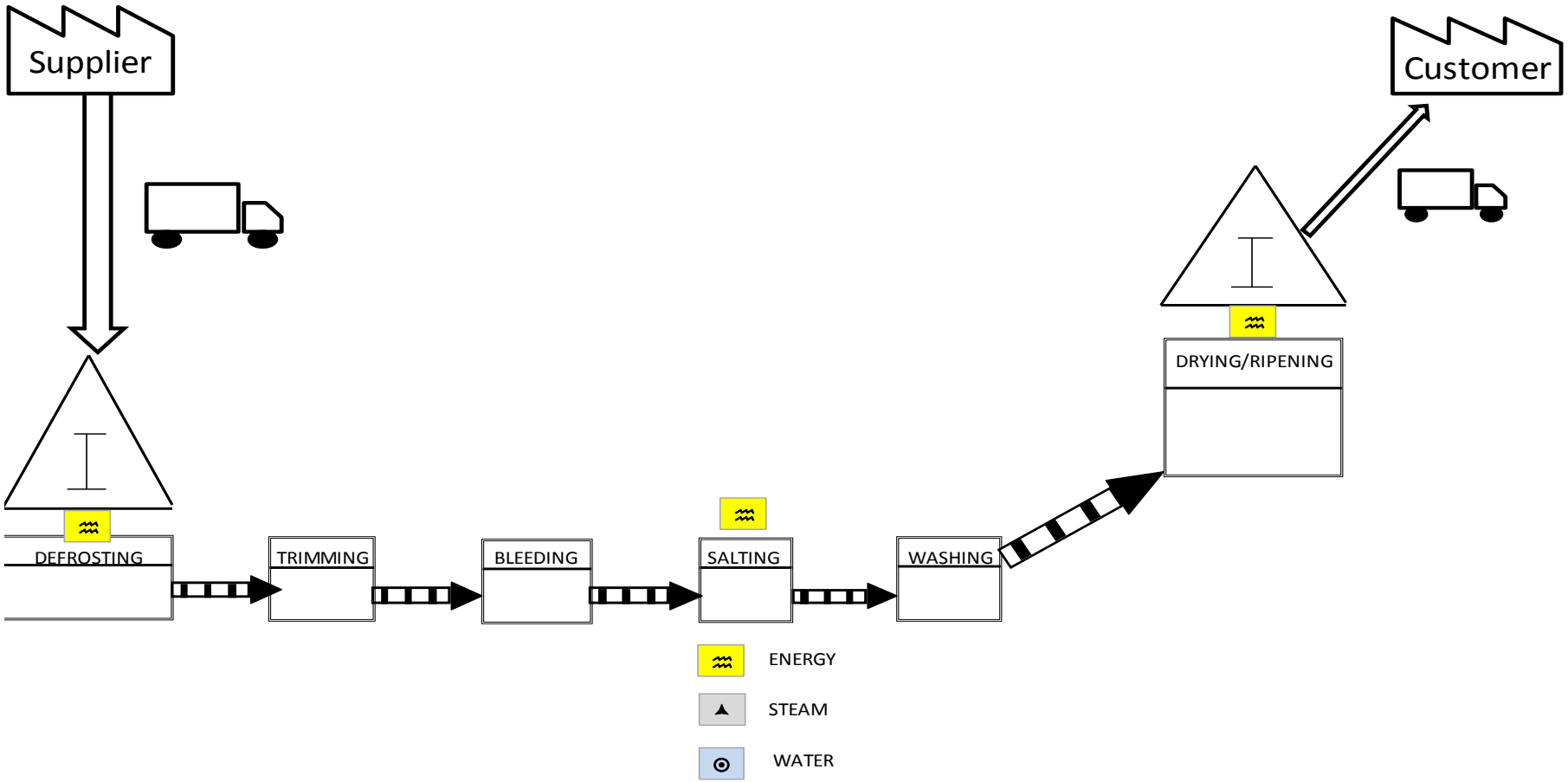


Figure 4: Current value stream mapping for meat processing.

3. Processes description and equipment

3.1. Slaughterhouses: Pigs, Cattle and Sheep, Poultry and Rabbit

3.1.1. Stunning

It is desirable to render an animal unconscious before it is slaughtered in order to eliminate pain, discomfort and stress from the procedure.

There are three main technologies used to effect stunning-Percussion, Electrical and Gas.

- Mechanical methods (Percussion stunning)

With percussive stunning, a device which hits the animal on the head, with or without penetration, is employed. Such devices, such as the captive bolt pistol, can be either pneumatic, or powder-actuated. Percussive stunning produces immediate unconsciousness through brain trauma. This method could be used for all the species.

- Electrical methods

These methods of stunning are well suited for pigs, sheep or goats, rabbits and poultry. Electrical stunning induces electroplectic shock or epileptic state in the brain. A low voltage alternating electric current is applied by means of two electrodes, which are placed on either side of the brain using tongs. There are two types depending on the species:

  - Head-only electrical stunning:

    Exposure of the brain to a current generating a generalised epileptic form on the ElectroEncephalogram (EEG).

  - Electrical waterbath

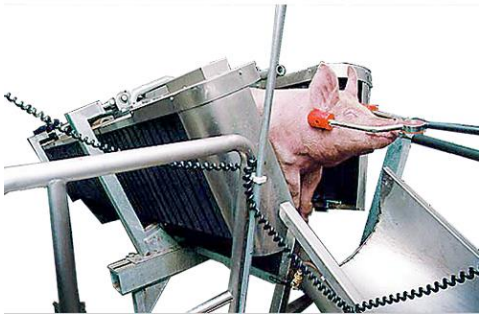
    Exposure of the entire body through a waterbath to a current generating a generalised epileptic form on the EEG (stunning) and possibly the fibrillation or the stopping of the heart (killing).

- Gas methods (Carbon dioxide gas stunning)

The use of carbon dioxide (CO_2) gas is a relatively new method of stunning suitable for pigs and poultry. Basically, animals are stunned using various concentrations of CO_2 in air.

MECHANICAL METHODS

Percussive stunner	
Average capacity	
Installed power (kW)	



Restrainer with Manual Stunning Tongs	
Average capacity	
Installed power (kW)	2.2

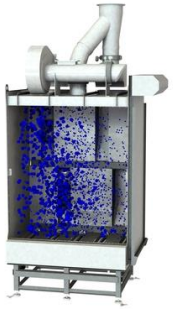
ELECTRICAL METHODS

Stunner (Electrical waterbath)	
Average capacity	4,000 birds/h
Installed power (kW)	0.34

Stunning pincers for rabbits	
Average capacity	
Installed power (kW)	0.2

GAS METHODS

CO2 Anaesthetising Plant (for pigs)	
Average capacity	60-600 pigs/h
Installed power (kW)	4-7

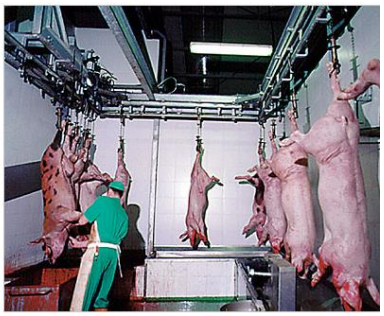


Multi stage stunning system (for poultry)	
Average capacity	
Installed power (kW)	

3.1.2. Bleeding

The objectives of bleeding are to kill the animal with minimal damage to the carcass and to remove quickly as much blood as possible as blood is an ideal medium for the growth of bacteria. Carcasses are bled over a trough or tank, to collect the blood. The blood trough is normally fitted with a double drain, one opening for the blood to be pumped to a tanker for disposal and the other for wash-water. Removable plugs seal the openings when they are not in use.

In the case of poultry, should a bird not be correctly cut, this could result in insufficient bleeding which in its turn can results in downgraded meat quality because of hemorrhages, shortened shelf life and there is even a big chance on loosing the bird for consumption totally. In this way, a previous killing process should be carried out. Single or dual killing machines allow precise positioning of the neck and the high shaft speed delivers an optimum clean cut without fraying of the neck skin. The neck of the bird is captured between guide bars and passed across a motorised circular knife or knives, incising either one or both sides of the neck.

PIG BLEEDING				**BLEEDING**		**POULTRY KILLING**	
							
Pre-Cleaning Whipper		**Powered Table for Horizontal Bleeding**		**Bleeding Tub**		**Killer**	
Average capacity	60-420 pigs/h	Average capacity	60-420 pigs/h	Average capacity		Average capacity	500–10,000 birds/h
Installed power (kW)	3-6	Installed power (kW)	0.75-1.5	Installed power (kW)		Installed power (kW)	0.55(engine for transport)+0.55 (engine for blade)

3.1.3. Pig and poultry scalding

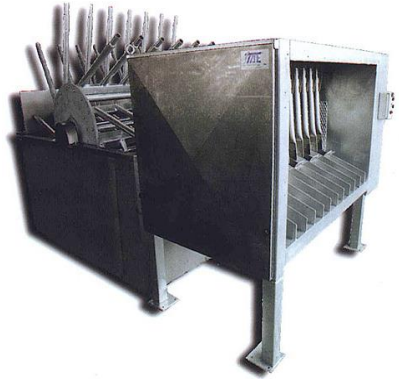
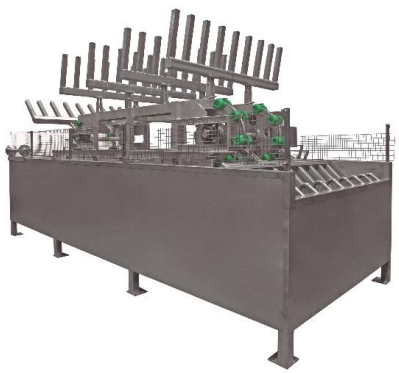
Scalding is a necessary pre-treatment for a proper dehairing of pigs. Pig carcasses are normally passed through a series of unit operations to remove the bristles. The blanching operation is performed only for pigs, because pork is marketed with skin included. When cattle or sheep is processed this operation is replaced by skinning.

Blanching operation allows removing the hair covering the surface of the animal, and for that water hot enough to ensure its fall is used.

Steam heating is normally used to maintain the temperature in the scalding tank and continuous make-up water is required to balance drag-out, which drips onto the floor and into the de-hairing machine. The scalding process produces some steam and odour.

For poultry, scalding is done to loosen feathers inserting in the follicles, as its elimination is not possible to implement dry, and thus facilitate subsequent plucking operation. Normally scalding is done by immersion, and two types are distinguished, the high and low scalding, depending on the binomial temperature-time used.

PIG SCALDING

			
Vertical Scalding Systems	**Scalding Basin**	**Powered Scalding Basin**	**Steam Scalding Tunnel**
Average capacity: 120-420 pigs/h	Average capacity:	Average capacity: 120-240 pigs/h	Average capacity: 120-420 pigs/h
Installed power (kW): 15-30	Installed power (kW):	Installed power (kW): 1.5	Installed power (kW): 16.5 - 44

POULTRY SCALDING

Jet stream scalder (immersion scalder)		Aero scalder	
Average capacity		Average capacity	
Installed power (kW)	3-12 kW (fan)	Installed power (kW)	

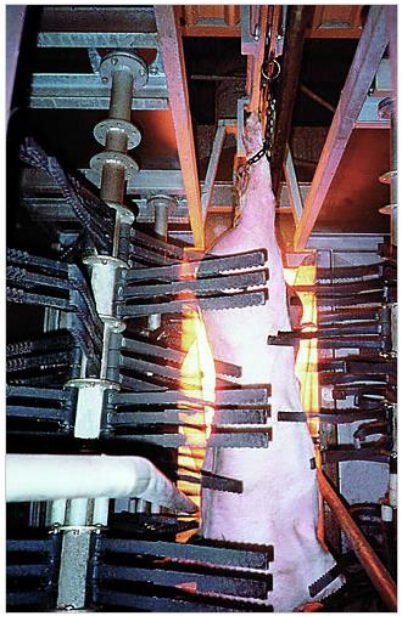
3.1.4. Pig Dehairing

Subsequently, a dehaired is performed allowing to remove almost all the bristles in the skin of pigs. An automatic de-hairing machine is used to remove bristles and toenails from pig carcasses. This comprises a number of rotating rubber flails, or similar, which brush or scrape the surface of the carcase. The best dehairing results are achieved in combination with a proper scalding process and are determined by factors such as the desired scalding time, temperature of the scalding water, breed of pig and seasonal influences.

DEHAIRING			
			
U-bar Dehairing System		**Dehairing System**	
Average capacity	180-420 pigs/h	Average capacity	240 pigs/h
Installed power (kW)	37	Installed power (kW)	5.5

3.1.5. Pig Whipping/Washing

The process of whipping is addressed to pig carcass washing and cleaning after bloodletting process. Depending on the capacity, the type of dressing hook, the species and the position in the machine line conveyor, the model with whip rolls in either vertical or horizontal direction could be selected.

WHIPPING	
	
Drying Whipper	
Average capacity	120-420 pigs/h
Installed power (kW)	3-6

3.1.6. Pig Singeing

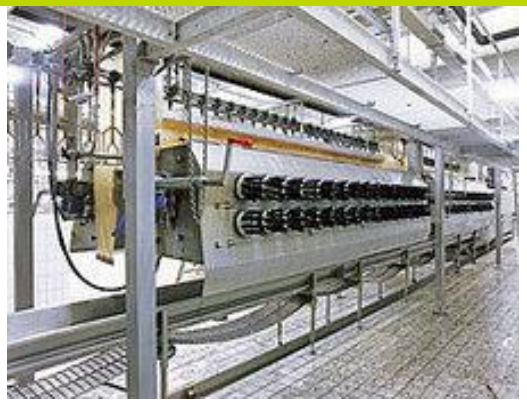
Once the pigs are depilated by dehairing and whipping they are subjected to a process of singeing with a torch to burn those bristles that have not been eliminated in the previous process, both for its hardness as inaccessibility, to provide a firmer skin texture and to eliminate micro-organisms.

SINGEING

Auto-Singeing Furnace	
Average capacity	120-420 pigs/h
Installed power (kW)	2.1

3.1.7. Poultry defeathering

The plucking operation is performed by machines possess a number of discs, drums or other devices provided with rubber fingers that birds passing in the opposite direction to its direction of rotation pluck the feathers follicles. It is also common to use hoses ending the operation. This performance is accompanied by a shower trailing feathers pulled off to a lower channel through which they are carried to a collection.

DEFEATHERING			
			
Attack Pluckers		**Plucker**	
Average capacity		Average capacity	
Installed power (kW)		Installed power (kW)	6

3.1.8. Cutting head and legs for poultry

The separation of the head is performed with automatic machines, provided with two guide bars passing between the heads. These bars pull the head and separated together with the esophagus and trachea. Thus the joints with the crop and the lung are removed, which facilitates automatic evisceration if it occurs after.

The legs are cut at the height of the tarsus, by an automatic machine. Birds fall after about a transport system (inclined plane or conveyor belt) that leads to the evisceration area if it is done later.

CUTTING HEAD AND LEGS	
	
Head puller	**Hock/feet cutter**
Average capacity	Average capacity
Installed power (kW)	Installed power (kW)

3.1.9. Cutting legs and horns for cattle and sheep / Decapitation

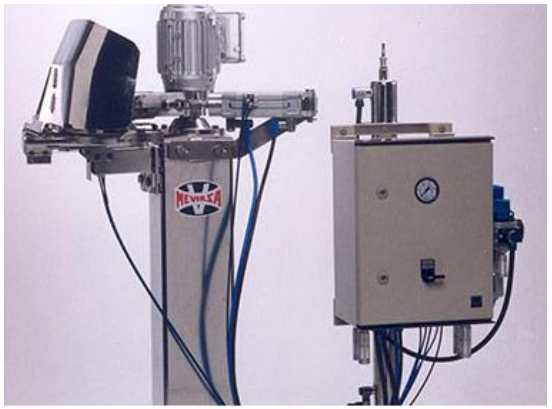
Cutting legs and horns and decapitation is carried out through shears.

In the case of the cattle and sheep, after the bleeding, the animals' forelegs, tail and udder/testicles are manually removed using knives. At some cattle slaughterhouses, the operator cuts a slit in the neck to allow further blood to escape, before cutting the head off. The tongue and cheeks may also be removed for human consumption.

Cattle and sheep heads are washed, inspected, then stained with the other Specified Risk Material and disposed of.

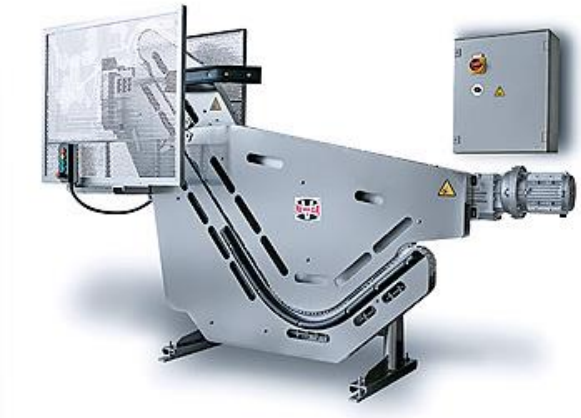
CUTTING LEGS AND HORNS		DECAPITATION	
			
Shears for bovine feets and horns		**Automatic shear for decapitation**	
Average capacity		Average capacity	
Installed power (kW)	2.2 - 4	Installed power (kW)	

3.1.10. Cutting legs for rabbits

CUTTING LEGS FOR RABBITS			
			
Foot-Cutter		**Hand cutter**	
Average capacity	2500 rabbits/h	Average capacity	2000 rabbits/h
Installed power (kW)	56	Installed power (kW)	37

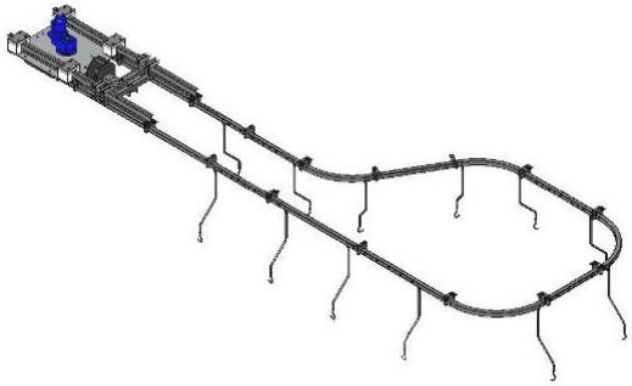
3.1.11. Skinning for cattle, sheep and rabbits

In the case of cattle sheep and rabbits after bleeding the remove of the skin is carried out. This operation could be done manually or mechanically by traction with the help of automatic machines.

CATTLE SKINNING		SHEEP SKINNING		RABBIT SKINNING	
					
Dehider		**Sheep skinner**		**Skin extractor machine**	
Average capacity	80 cattle/h	Average capacity	150 sheep/h	Average capacity	2.500 rabbits/h
Installed power (kW)	30	Installed power (kW)	2,2	Installed power (kW)	1

3.1.12. Evisceration

Evisceration is a very delicate operation from the point of view of hygiene. During this stage it is convenient to link the esophagus and rectum to avoid any contamination from the intestinal tract. Simultaneously with this operation inspection is carried out paying particular attention to lungs, liver, lymph nodes, spleen and heart.

PIG EVISCERATION	CATTLE EVISCERATION	SHEEP EVISCERATION
		
Organs Handling Conveyor	**Red viscera conveyor**	**Mechanized conveyor**
Average capacity	Average capacity	Average capacity
Installed power (kW)	Installed power (kW)	Installed power (kW)

In the case of poultry, in the evisceration line, chickens are hung from hooks on both thighs the back toward the operator. First and through cloaca guns working to vacuum the cloaca is suctioned and collapsed, a cut is made and deepened inward, breaking visceral inserts. It is usually also practice a wall abdominal cut to enlarge the opening.

The viscera must be conveniently removed so they can be inspected, and generally the called the edible offal (heart, gizzard and liver) are separated of those which are not.

Edible offal are classified, cooled and then packed in bags of plastic. Other offal, waste and feathers are removed as soon as possible avoiding contamination.

POULTRY EVISCERATION		
		
Vent cutter	**Opening machine**	**Eviscerator**
Average capacity	Average capacity	Average capacity up to 6,000 bph
Installed power (kW)	Installed power (kW)	Installed power (kW)

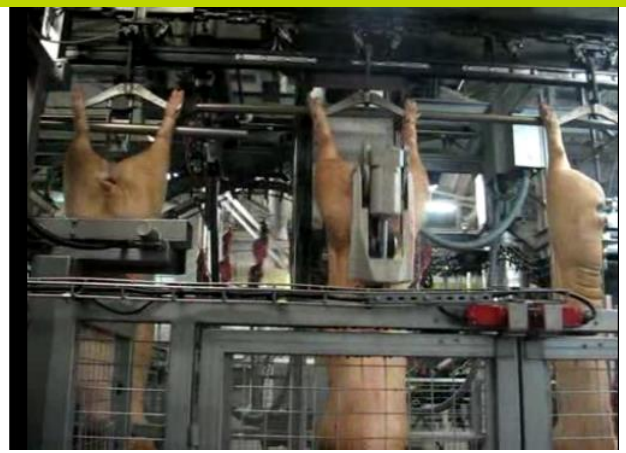
RABBIT EVISCERATION

Evisceration plant	
Average capacity	
Installed power (kW)	

3.1.13. Carcass splitting for pig, cattle and sheep

After evisceration, the cattle, sheep and pig carcasses are split along the spine using a saw.

In some slaughterhouses, the carcass is given a final rinse with low-pressure potable water before chilling or freezing. At every stage of production the meat is inspected visually to maintain quality standards.

AUTOMATIC CARCASS SPLITTING		MANUAL CARCARSS SPLITTING	
			
Auto splitter dynamic		**Splitting saw**	
Average capacity	550 pigs/h	Average capacity	
Installed power (kW)		Installed power (kW)	2.2

3.1.14. Washing

Washing of carcasses after evisceration operation is a compulsory requirement. The purpose of this operation is to clean both carcasses externally and internally, dragging with water part of the surface microorganisms.

After this stage, the carcasses pass to cooling facilities.

POULTRY WASHING		RABBIT WASHING	
			
Inside/outside bird washer		**Brushes**	
Average capacity		Average capacity	2,500 rabbits/h
Installed power (kW)		Installed power (kW)	0.5 kW

3.1.15. Cooling

One possibility to preserve the carcasses is cooling them. This operation is normally performed in two phases. In the first phase the carcasses are introduced into airing chambers at a temperature of between -3 ° and 0 ° C in order to reduce quickly the body heat of them at that time is around 40 ° C. After one or two hours, the carcasses are stored in chambers at a temperature of between 0 ° and 4 ° C (second stage) where they will remain until further transfer to cutting plants. Since there are a lot of particularities to take into account (such as size of the carcass, time of working, etc) to determine the necessities of cooling, below an example of a possible equipment for cooling in a pig slaughterhouse is presented:

COOLING EQUIPMENT	AVERAGE CAPACITY	INSTALLED POWER (KW)
Cold conservation chambers	250 pigs/day (5 h/day slaughterhouse working)	51,00
Airing chamber	250 pigs/day (5 h/day slaughterhouse working)	166,00
Waiting room	250 pigs/day (5 h/day slaughterhouse working)	3,00
White entrails chamber	250 pigs/day (5 h/day slaughterhouse working)	29,00
Red entrails chamber	250 pigs/day (5 h/day slaughterhouse working)	29,00
Slaughterhouses by-products chamber	250 pigs/day (5 h/day slaughterhouse working)	11,00
Room of expedition	250 pigs/day (5 h/day slaughterhouse working)	3,00

In the case of poultry, after evisceration process, the products are automatically transported to the refrigerator.

POULTRY REFRIGERATOR

Average capacity	1,400 kg/h (dressed weight)
Installed power (kW)	2-11 kW

3.2. Meat processing

3.2.1. Defrosting

Most of the times, the meat pieces received are frozen. These legs must be defrosting slowly. Thus, these pieces are defrosted firstly by refrigeration chambers and after it by hot air. This hot air is usually produced by a steam boiler.

3.2.2. Trimming and bleeding

Starting raw material from is usually fresh meat that has been given a commercial basis into the cutting room during the operation profiled and trimmed. Most industries ham working with fresh ingredients although some dryers are beginning to work with frozen raw material.
Prior to the operation of "salty" is usually done a exsanguination consisting of doing a massage to remove any blood that remains in the leg.

BLEEDING	
	
Bleeding-Massaging Machine	
Average capacity	600 pieces/h
Installed power (kW)	1.5

3.2.3. Salting

Its purpose is the incorporation of common salt and salty agents covered by European Regulations, to the muscle mass, promoting dehydration and conservation of the pieces, and contribute to the development typical colour and flavour cured products.

It will be held covering parts sea salt, once rubbed with salt, of those mentioned in the preceding paragraph. The ham will be covered with salt and placed in a chamber at a temperature between 0 and 4 ° C with a relative humidity between 75 and 95%.

The salting time depends on the weight, fat content and conformation of the ham and will be required to achieve the established salinity limit for the final product.

SALTING					
					
Nitrites machine drum		**On line nitrites applicator drum**		**Maceration vacuum drum machine**	
Average capacity	1,000 kg	Average capacity	600 pieces/h	Average capacity	1,850 kg
Installed power (kW)	3	Installed power (kW)	2	Installed power (kW)	5.14

3.2.4. Washing

After salting, the hams are put in washing machines that remove salt residues adhering to the surface of the ham.

WASHING					
					
Washer and brusher machine for hams		**Automatic recover salt of hams**		**Desalting and washing hams -low consumption of water**	
Average capacity	600 pieces/h	Average capacity	600 pieces/h	Average capacity	600 pieces/h
Installed power (kW)	5.88	Installed power (kW)	3.3	Installed power (kW)	9.25

3.2.5. Post-salting

This phase is getting aims homogeneous distribution of salt inside the piece, inhibiting undesirable microbial growth and channelling the biochemical processes of hydrolysis (lipolysis and proteolysis) that will produce the aroma and flavour.
In this phase, the hams remain at low temperatures maintained between 0 ° C and 6 ° C Temperature and relative humidity (RH) between 70 and 95%. The residence time of the pieces in this phase will comprise a minimum period of 40 days nor more than 60 days.

Moreover, due to the anatomical differences ham muscles, a conformation after salting stage is needed and is very important to match the batch and to acquire all the pieces the same thickness which facilitates uniform drying and a more homogeneous commercial presentation.

POST-SALTING	
	
Automatic press form	
Average capacity	600 pieces/h
Installed power (kW)	0,18

3.2.6. Drying/Ripening

During this phase the gradual dehydration of the product continues and takes place the natural fusion of some of the fat from the adipose tissue, at which it is estimated that the drying is sufficient.

The ham is placed for curing in a chamber with a temperature between 6 ° C to 16 ° C maximum and decreasing the relative humidity to reach values between 60 and 80% for at least 90 days.

Subsequently, the temperature will rise between 16 and 26 ° C and humidity relative be maintained between 55 and 85% for at least ninety days.

DRYING/RIPENING	
	
Ripening chamber	
Average capacity	20,000 pieces
Installed power (kW)	181

4. Overview list of the processes and equipment

4.1. Slaughterhouses: Pigs

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
STUNING	Automatic stunning system	Electric	Electricity
	CO2 Anaesthetising Plant	Electric	Electricity
SUSPENSION AND TRANSPORTATION	Bleeding zone	Electric	Electricity
	Slaugther zone	Electric	Electricity
	Evisceration zone	Electric	Electricity
BLEEDING	Pre-Cleaning Whipper	Electric	Electricity
	Powered Table for Horizontal Bleeding	Electric	Electricity
SCALDING	Vertical Scalding Systems	Thermal	Electricity+natural gas
	Steam Scalding Systems	Thermal	Electricity+natural gas
	Powered Scalding Basin	Thermal	Electricity+natural gas
DEHAIRING	Dehairing System (tunnel)	Thermal	Natural gas
WHIPPING	Drying Whipper	Electric	Electricity
SINGEING	Auto-Singeing	Thermal	Natural gas
WASHING	Pre-drying	Electric	Electricity
SPLITTING	Auto splitter dynamic	Electric	Electricity
WASHING	Red entrails washing	Electric	Electricity
	Intestine discharge	Electric	Electricity

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
CHILLING	Cold conservation chambers	Thermal	Electricity
	Airing chamber	Thermal	Electricity
	Waiting room	Thermal	Electricity
	White entrails chamber	Thermal	Electricity
	Red entrails chamber	Thermal	Electricity
	Slaughterhouses falls chamber	Thermal	Electricity
	Room of expedition	Thermal	Electricity

4.2. Slaughterhouses: Cattle

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
STUNING	Percussive stunner		
SUSPENSION AND TRANSPORTATION	Bleeding zone	Electric	Electricity
	Slaugther zone	Electric	Electricity
	Evisceration zone	Electric	Electricity
CUTTING LEGS AND HORNS	Shears	Electric	Electricity
DECAPITATION	Shears	Electric	Electricity
SKINNING	Dehider	Electric	Electricity
SPLITTING	Splitting saw	Electric	Electricity
CHILLING	Cold conservation chambers	Thermal	Electricity

4.3. Slaughterhouses: Sheep

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
STUNING	Restrainer	Electric	Electricity
	Electric stuning (tongs)	Electric	Electricity
SUSPENSION AND TRANSPORTATION	Bleeding zone	Electric	Electricity
	Slaugther zone	Electric	Electricity
	Evisceration zone	Electric	Electricity
SKINNING	Neumatic skinner	Electric	Electricity
SPLITTING	Splitting saw	Electric	Electricity
COOLING	Cold conservation chambers	Thermal	Electricity

4.4. Slaughterhouses: Poultry

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
STUNING	Multi stage stunning system (CO2)	Electric	Electricity
	Electrical waterbath	Electric	Electricity
SUSPENSION AND TRANSPORTATION	Slaugther zone: Engines, conveyors	Electric	Electricity
		Electric	Electricity
	Evisceration zone: conveyors	Electric	Electricity
BLEEDING	Killer	Electric	Electricity
SCALDING	Immersion scalder	Thermal	Electricity+natural gas
	Aero scalder	Thermal	Electricity+natural gas
DEFEATHERING	Plucker	Electric	Electricity
CUTTING HEAD AND LEGS	Head puller	Electric	Electricity
	Hock/feet cutter	Electric	Electricity
EVISCERATION	Vent cutter	Electric	Electricity
	Opening machine	Electric	Electricity
	Eviscerator	Electric	Electricity
WASHING	Inside/outside bird washer	Electric	Electricity
CHILLING	Poultry refrigerator	Thermal	Electricity

4.5. Slaughterhouses: Rabbits

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
STUNING	Stunning pincers	Electric	Electricity
SUSPENSION AND TRANSPORTATION	Slaugther zone: Engines, conveyors	Electric	Electricity
	Evisceration zone: conveyors	Electric	Electricity
BLEEDING	Blood pump	Electric	Electricity
CUTTING LEGS	Foot cutter	Electric	Electricity
	Hand cutter	Electric	Electricity
SKINNING	Skin extractor	Electric	Electricity
EVISCERATING	Evisceration plant	Electric	Electricity
WASHING	Brushes	Electric	Electricity
CHILLING	Airing tunnel	Thermal	Electricity
	Airing chamber	Thermal	Electricity
	Cooling chamber	Thermal	Electricity

4.6. Meat processing

PROCESS	EQUIPMENT	ELECTRIC AND/OR THERMAL	SOURCE OF ENERGY
DEFROSTING	Steam boiler	Thermal	Natural gas
TRIMMING BLEEDING	Bleeding-Massaging Machine	Electric	Electricity
SALTING	Nitrites machine	Electric	Electricity
WASHING	Washer	Electric	Electricity
	Desalting	Electric	Electricity
POST-SALTING	Press form	Electric	Electricity

5. Sankey diagram

Sankey diagrams are a specific type of flow diagram, in which the width of the arrows is shown proportionally to the flow quantity.

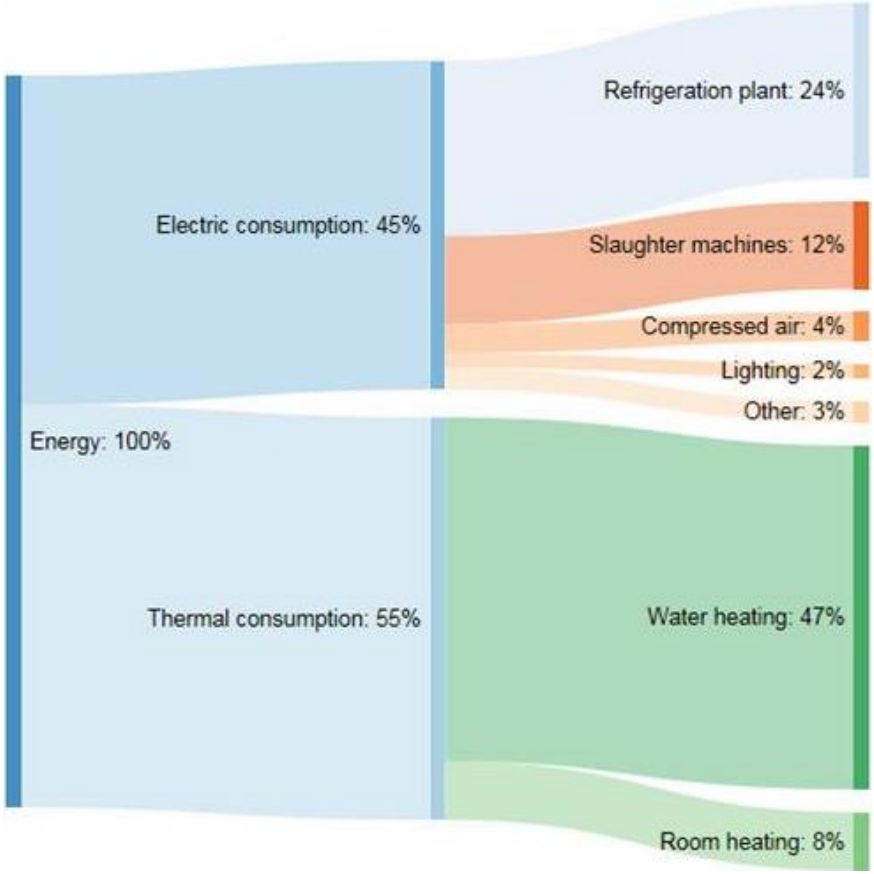
In this case, they will be used to visualize energy consumption in each process, putting a visual emphasis on the major energy flows within the whole process carried out in a slaughterhouse. They will be very useful in locating dominant contributions to the overall energy flow.

The following Sankey Diagrams have been elaborated with the data gathered from the BREF on Slaughterhouses, the article published by ELSEVIER about “How much energy to process one pound of meat?”, the Diagnosis of electric energy use in a poultry slaughterhouse, and the data from the Energy analysis of agro-food industries carried out by the Agencia Extremeña de la Energía.

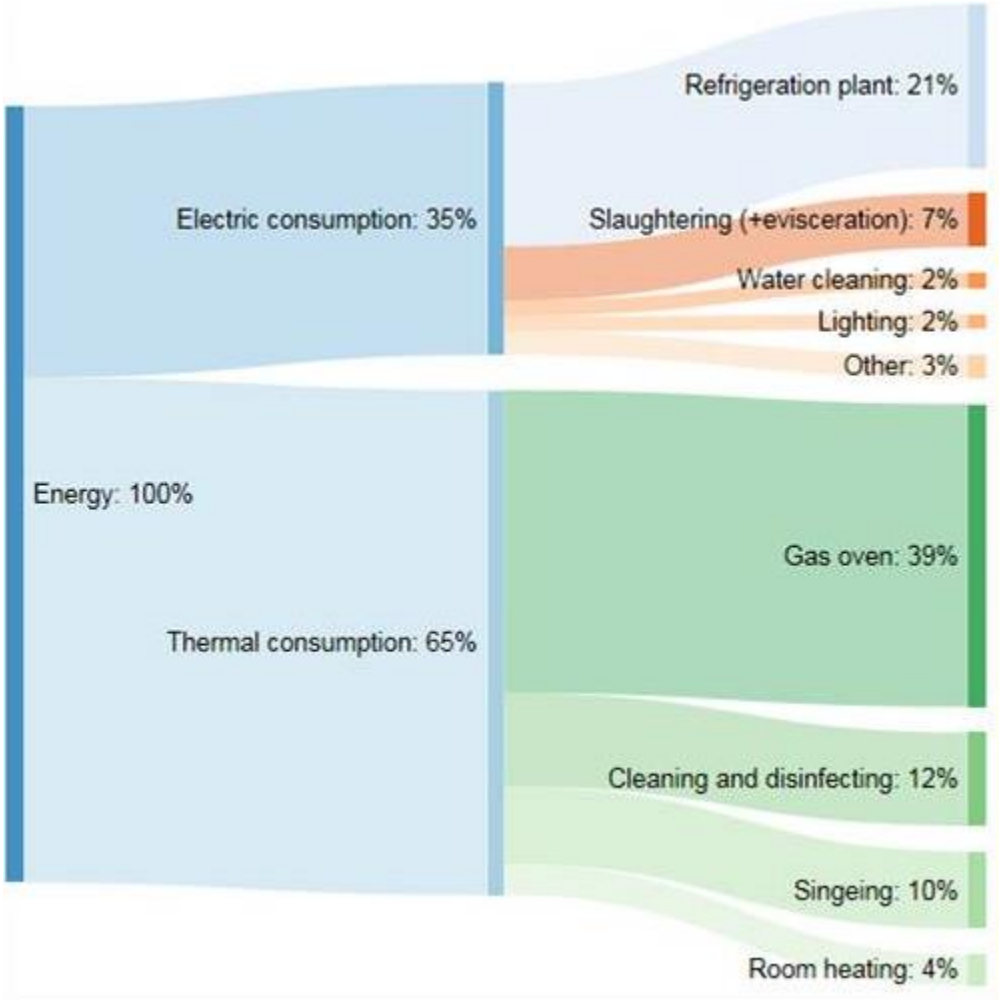
In the management of these data an homogenization of the terms and naming of the processes has been done, in order to facilitate the comparisons between processes.

Although particular data were found on the distribution of energy consumption in pig, cattle and poultry slaughterhouses (as showed here below) and although these data differs one from another, it was also edited a Sankey -as representative as possible- compiling data from all these slaughterhouses. The compiling Sankey -for the slaughterhouses in general- is the first one showed here below.

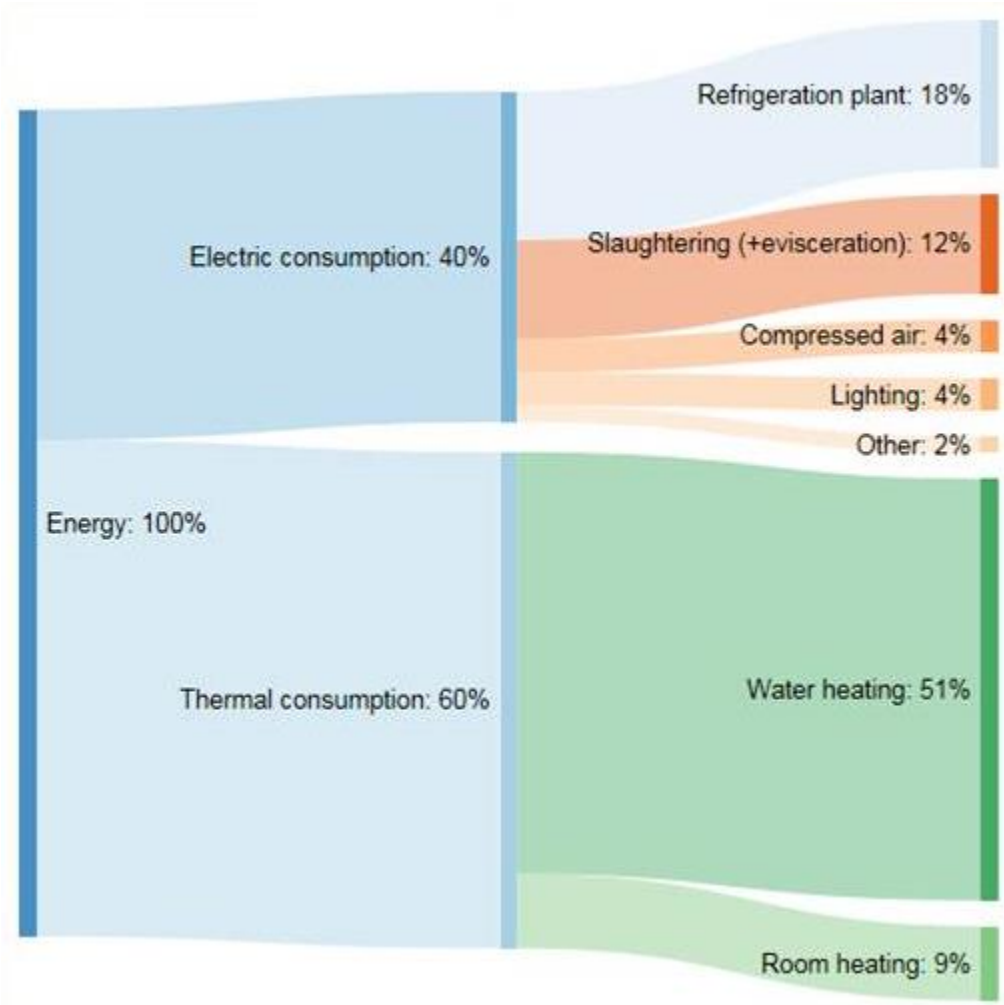
PIG-CATTLE-POULTRY



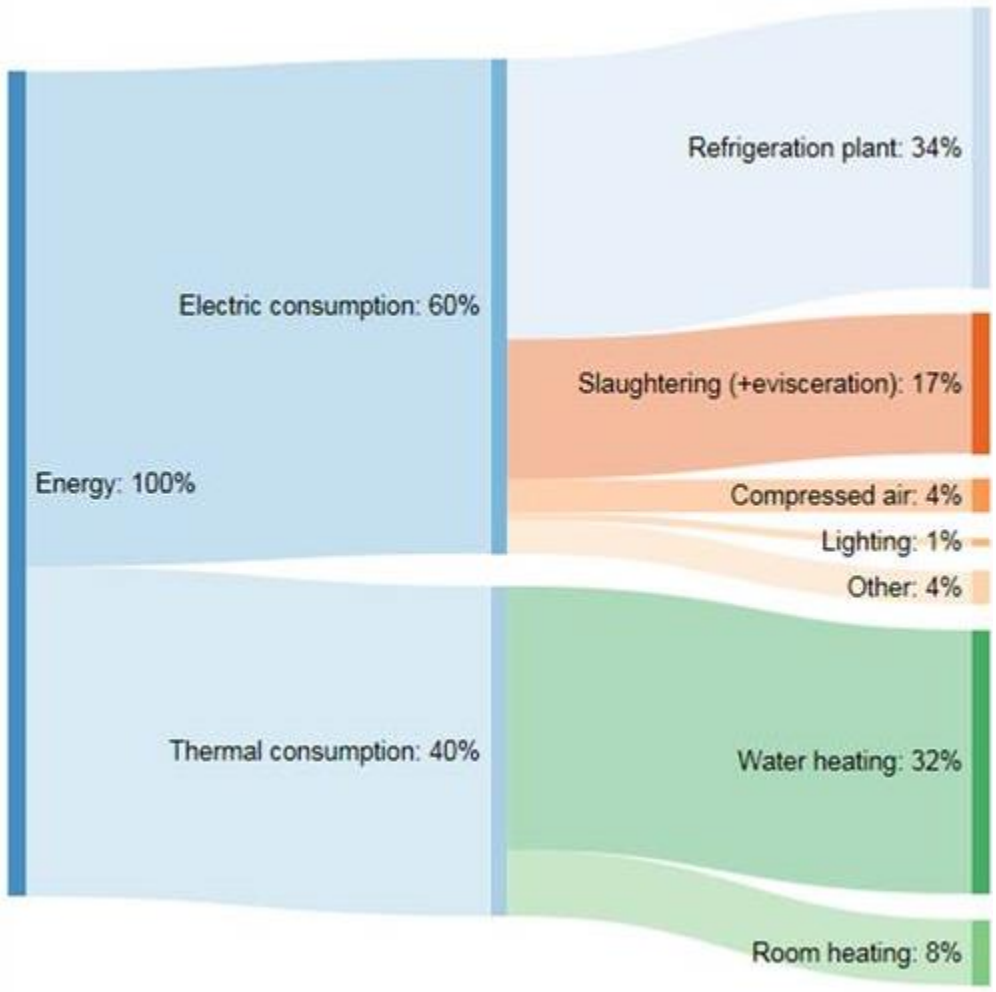
PIG


Refrigeration plant: 21%
Electric consumption: 35%
Slaughtering (+evisceration): 7%
Water cleaning: 2%
Lighting: 2%
Other: 3%
Energy: 100%
Gas oven: 39%
Thermal consumption: 65%
Cleaning and disinfecting: 12%
Singeing: 10%
Room heating: 4%

CATTLE

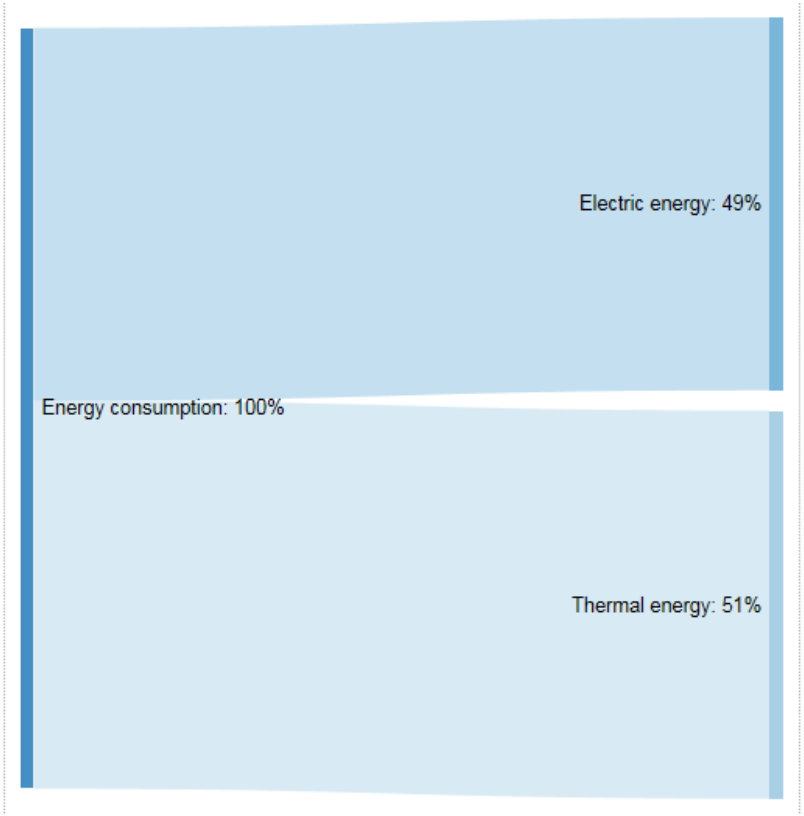

Refrigeration plant: 18%
Electric consumption: 40%
Slaughtering (+evisceration): 12%
Compressed air: 4%
Lighting: 4%
Other: 2%
Energy: 100%
Thermal consumption: 60%
Water heating: 51%
Room heating: 9%

POULTRY


Energy: 100%
Electric consumption: 60%
Thermal consumption: 40%
Refrigeration plant: 34%
Slaughtering (+evisceration): 17%
Compressed air: 4%
Lighting: 1%
Other: 4%
Water heating: 32%
Room heating: 8%

Finally, a different Sankey has been elaborated for the meat processing industries. In this project, the meat processing subsector is represented by the subsector of cured meat.

MEAT PROCESSING: CURED HAM



6. Identification of the key points for setting up the baselines in electric and thermal processes

The main activities consuming energy in this sector, accompanied with the type of power supply needed are showed in the following table:

PROCESS	TYPE ENERGY NEEDED	PRIMARY ENERGY SOURCE	EQUIPMENT NEEDED
SLAUTHERING+EVISCERA	ELECTRIC POWER	ELECTRIC POWER	ENGINES
MEAT PROCESSING	ELECTRIC POWER	ELECTRIC POWER	ENGINES
SCALDING	THERMAL (HEAT)	NATURAL GAS	BOILER
DEHAIRING	THERMAL (HEAT)	NATURAL GAS	BOILER
DEFEATHERING	THERMAL (HEAT)	NATURAL GAS	BOILER
SINGEING	THERMAL (HEAT)	NATURAL GAS	BURNER
COOLING	THERMAL (COLD)	ELECTRIC POWER	REFRIGERATION PLANTS
DRYING/RIPENING	THERMAL (HEAT+COLD)	ELECTRIC POWER+NATURAL GAS	REFRIGERATION PLANTS+BOILER

Taking into consideration the identification of the inputs and outputs of the main processes regarding energy issues, the most relevant key points for setting up the Key Performance Indicators are the followings:

- Thermal processes:

  Scalding: Due to the use of steam and water in this process, the energy and water consumption is very relevant so it should be recommendable setting up the correspondent Key Performance Indicator. There are some references regarding to the approximate specific consumption by pig (4 – 8 kg of steam/pig) that could be useful for this purpose such as the commented one by Ente Regional de la Energía de Castilla León (EREN) in the document “Plan de asistencia Energética en el sector cárnico” (page 22). Other references are the stated by the Agencia Extremeña de la energía in the document “Eficiencia Energética en empresas del sector agroalimentario (page 12) for the scalding and dehairing operations with an energy consumption of 29 kWh/t of treated meat because of the large quantity of steam supplied for cleaning the skin of the animals.

Singening: In the case of the pigs, it is also important to consider from the energy consumption point of view. Although the consumption is variable according to several factors, average fuel consumption could be estimated being 5,000 kcal/pig (page 22, “Plan de asistencia Energética en el sector cárnico”. Ente Regional de la Energía de Castilla León (EREN)).

- Electricity consumption:

  Cooling: The cool conservation of the meat is the main key point in the slaughterhouses processes, since the growth of microorganism should avoided in a very short of time. In this way, in this process the electrical energy consumption will be the dominant contribution to the general overview of the electricity consumption, thus a Key Performance Indicator will be desirable.

  Drying/Ripening: In the meat processing industries and, particularly, in the preparation of hams and shoulders, the drying phase and maturation represents the element with greater weight on overall energy consumption of the plant.
  The main process that occurs within the chamber is heat exchange between indoor air and cooling/heat coil , refrigeration equipment and a heat pump or boiler heat is used for it.

The power consumption of a slaughterhouse in Spain falls within the range 55-193 kWh/t carcase (average value of 155 kWh/ t carcase). These consumption values are similar to those cited in the document "BREF on BATs in the Slaughterhouses and Animal By-products Industries" for cattle and pig slaughterhouses in the United Kingdom that are in the range 36 to 154 kWh /t carcase. Another range of values in the BREF for pig slaughterhouses refers a total energy consumption of 280-380 kWh/t carcase, corresponding to about 1/3 to 2/3 electricity and thermal energy (page 63, Guía de Mejores Técnicas Disponibles en España del sector cárnico. MAGRAMA. 2005).

In poultry slaughterhouses, the highest thermal consumption is concentrated in scalding and cleaning equipment and facilities operations. Electricity consumption is primarily focused on the production of cold and equipment operation. There is great variability in energy consumption among facilities due to factors such as the type of energy management, energy efficiency of the equipment or its maintenance.

The consumption of thermal and electric energy in Spanish poultry slaughterhouses ranges from 125-220 kWh/t carcass. This consumption is lower than the referenced cited to poultry slaughterhouses in the BREF Best Available Technologies in Slaughterhouses In the range of 152-860 kwh/ t carcass (page 41, Guía de la producción limpia para el Sector de matadero y transformación de carne avícola de la Comunidad Valenciana, IMPIVA, 2009).

With regard to the meat processing there are some interesting references in the document “Plan de asistencia Energética en el sector cárnico”. In relation to the specific energy consumption in the case of cured sausages it can be established that the thermal energy is around 693 kWh/ton while the electric consumption is about 566 kWh/ton (page 23, “Plan de asistencia Energética en el sector cárnico”. Ente Regional de la Energía de Castilla León (EREN)).

In relation to the specific energy consumption in the case of cured hams it can be established that the thermal energy is around 500 kWh/ton while the electric consumtion is about 480 kWh/ton (page 28, “Plan de asistencia Energética en el sector cárnico”. Ente Regional de la Energía de Castilla León (EREN)).

This is only a preliminary approach to the identification of the Key Performance Indicators. The expert team responsible for the tasks related to setting up the Key Performance Indicators in thermal processes and electricity consumption will define the final ones according to their expertise.

7. Possible inefficiencies in the performance of the processes

One of the most usual inefficiencies detected in the meat and poultry sector in terms of energy is the not adequately dimensioned equipment or processing line. In this way, there could be idle periods while the equipment is working consuming energy. So, the production process should be deeply assessed in real conditions in order to match the estimated production for each period to the real capacity of the equipments.

The use of steam is usual in facilities of a certain size that incorporate in their production process the slaughter of animals. The steam is commonly used in the work linked to this stage of the process, such as washing, scalding and dehairing:

The most common defects in the use of steam generators, affecting low energy efficiency of the facility and an increase in the energy bill are:

- Poor monitoring combustion.
- Insufficient feed water treatment.
- Increased system purges.
- Insufficient and unscheduled cleanings.

In the cooling processes, there are some usual inefficiencies due to not sufficient maintenance or control of some parameters such as the energy consumption control regarding the power of the equipment.

8. References

- Reference Document on Best Available Techniques in the Slaughterhouses and Animal By-products Industries. 2005. http://eippcb.jrc.ec.europa.eu/reference/BREF/sa_bref_0505.pdf

- Guía de Mejores Técnicas Disponibles en España del sector cárnico. MAGRAMA. 2005 http://www.magrama.gob.es/es/alimentacion/temas/industria-agroalimentaria/Gu%C3%ADa_MTD_en_Espa%C3%B1a_Sector_C%C3%A1rnico_tcm7-8216.pdf

- Guía de Mejores Técnicas Disponibles en España del Sector Matadero y de los Transformados de Pollo y Gallina. MAGRAMA. 2006. http://www.magrama.gob.es/es/alimentacion/temas/industria-agroalimentaria/Gu%C3%ADa_MTD_en_Espa%C3%B1a_Transformado_pollo_y_gallina_tcm7-8219.pdf

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- Eficiencia energética en empresas del sector agroalimentario. Agencia Extremeña de la Energía. 2014. http://www.agenex.net/guias-altercexa/2_EF_ENERG_EN_EMPRESAS_DEL_SECTOR_AGROALIMENTARIO.pdf

- FAO (Environmental issues and description of slaughterhouse processes) http://www.fao.org/WAIRDOCS/LEAD/X6114E/x6114e04.htm#TopOfPage
- Mejores técnicas disponibles en la industria cárnica. AINIA. http://www.prtr-es.es/data/images/La%20industria%20c%C3%A1rnica-1954CFF26917CEF8.pdf