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Energy Efficiency, a Step Towards Cleaner Production: An Integrative Case Study of the Meat Processing Industry in Hermosillo, Sonora

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Abstract

The efficient use of resources within industrial systems is a key aspect to consider in order to achieve sustainability, this perspective leads to the necessity to integrate production practices that incorporate economical, ecological and social perspectives limiting the negative impact of industries toward the environment (Blenginin and Shields, 2011). In matters of resource efficiency, energy to empower production processes is now a priority, correspondingly, there is a relevance on the reduction of the use of energy and its negative impacts towards the environment such as carbon emissions. Therefore the intersection of cleaner production and energy efficiency is reinforced as a more integrative approach to achieve sustainability (UNEP, 2004). This work shows the results of the application of energy efficiency audit with the objective to reduce the negative impacts to the environments due the operation of a meat processing industry. In order to increase efficiency and upgrade its competitiveness.

Keywords: *energy efficiency, cleaner production*

1. Introduction

To convert raw materials to final products, production processes involve the usage of energy, in quantities that can vary from production process to production process, resulting in fluctuating negative impacts derived of the depletion of the energy resources (Jorgenson et al, 2014). Therefore, since any production process involves usage of energy it is urgent to think on its impact from the societal, economic and environmental perspectives, making it a key element for the accomplishment of sustainable development (Stern, 2010).

Specifically, the food industry is one of the sectors with higher energy consumption contributing 33% to the total, and is in the category of meat processing where it has the greatest flow of energy used compared to other subcategories such as canned food, bottled drinks, etc. (USDA, 2010).

Within the food industry energy use in the supply chain is undeniable, whether in activities such as production, processing, packaging and distribution of food (USDA, 2010). In the case of the food industry in particular the meat processing industry due to the need to maintain low temperatures during the production process, storage temperatures, etc., results that this is one of the industries more energy intensive (Tang, et al, 2013). This dependence on energy consumption is the main cause of interest in the transition to a more energy-efficient industry, this mainly derived from the relationship between energy use and food prices as well as the environmental impacts of energy use as CO_2 emissions to the environment (United Nations Food and Agriculture FAO, 2014).

In order to exemplify the environmental implications of high energy consumption the metric equivalent of carbon dioxide is used, which represents an amount of a greenhouse gas whose atmospheric impact has been standardized to a unit mass of carbon dioxide based on the global warming potential of the gas (EPA, 2012). In other words, based on their consumption of electricity this metric describes how many emissions of greenhouse gases were released for the operation of an activity (Dalkia, 2014). If we examine the energy used through this equivalent of carbon metric we can recognize the ecological footprint of plants meat processing which have these have a great impact on the environment and in this situation, there is great potential opportunities for better use of energy in this type of facility (Sun and Lee, 2006). The reason that energy efficiency plays an important role is that it not only provides an increase in positive environmental performance of industry but also contributes to cleaner production, increased competitiveness, increase in the innovation capacity and allows companies to comply with government legislation (Schmidheiny, 1992).

2. Methods

A CP-EE methodology is described by UNEP (2004) and follows the systematic approach as the CP methodologies. This work adapts the first three CP-EE methodology steps: Planning and Organization, Pre-assessment and Assessment to compile information about the processes and specifically theirs energy consumption. Aiming to contribute to a cleaner production specifically towards the reduction to GHG emissions of the production processes derived from the energy use. Also, for a more detailed energy audit some tools from methodology described by AFNOR (2014) were taken into consideration to increase the opportunities for the efficient usage of energy. Making and integrative and adapted approach to energy efficiency in a meat processing plant. Due the nature of this work, the implementation steps and validation of the energy management systems are omitted since this work focus on the potential contribution for cleaner production through the reduction of GHG emissions derived from the usage of electricity.

3. Results

Company A is a food-processing and distributing company located in Sonora, Mexico. The system boundaries of this work are mainly focused on the food-processing and packing plant process of this plant. For the purpose of this work the energy input that will be assessed is electricity and its use on the main processes of production, cooling and lighting. The distribution of the finished product is left out of the energy boundaries but could be additionally researched as a new project, see Fig. 1.

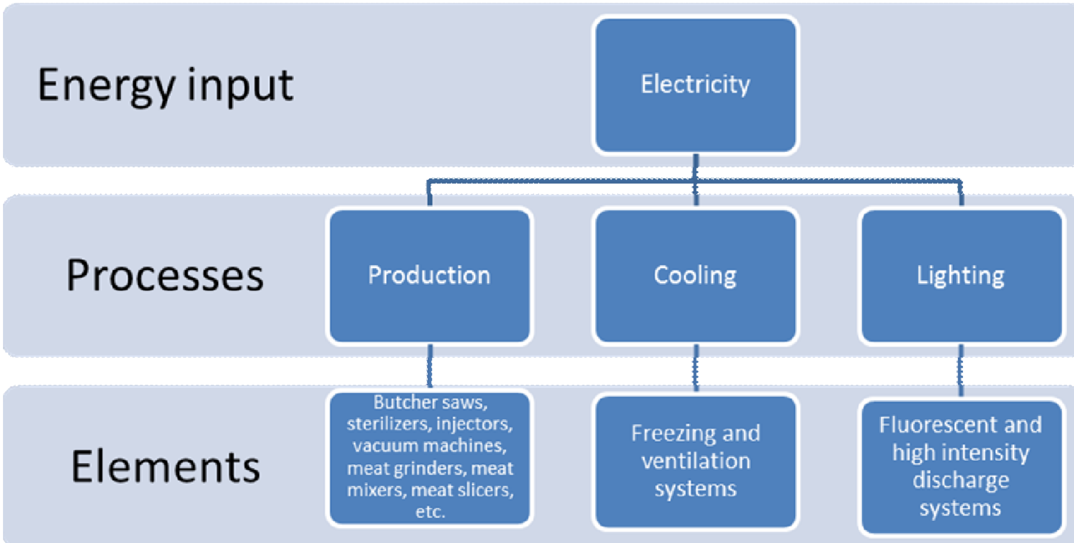
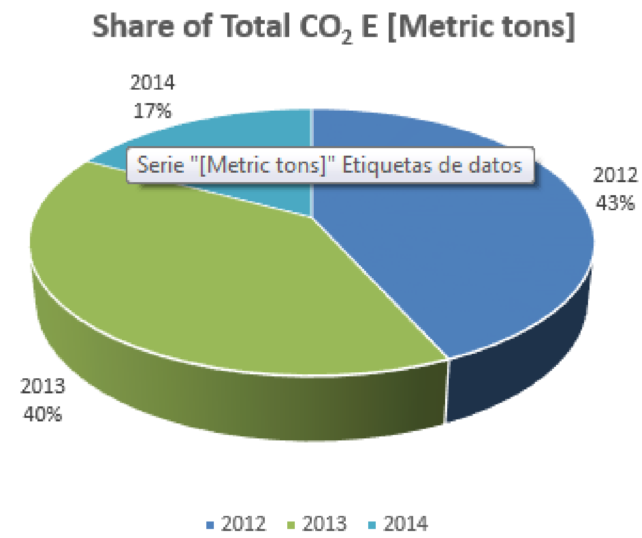


Fig. 1. System boundaries.

In this case study energy consumption was translated into their carbon dioxide equivalent. According to the glossary of climate change of the U.S Environmental Protection Agency this metric compares the emission from various greenhouse gases based on their global warming potential. Therefore the Carbon dioxide equivalent (CO_2 E), expressed on Metric tons, describes the potential climate warming capability of several gases on one standard unit. To represent the global warming potential derived from the consumption/generation of electricity standard ratios are used to convert in equivalents amounts of CO_2.

This ratios are mostly defined by the electricity mix of each country, the Mexico's electricity mix, primarily entails the use of oil and gas, so the standard of conversion from KWh to their carbon dioxide equivalents according to the *2014 Climate Registry Default Emission Factors* Mexico is defined with a 510.1 CO_2 E by consumed MWh. In Fig 2, we can find the annual description of the used energy sources at the company, and their detailed carbon equivalent in metric tons.



Year	Quantity [KWh]	CO^2 E [Metric tons]
2012	4192023	2891
2013	3832094	2642
2014	1660109	1145

Fig 2. CO_2 Share 2012-2014

To obtain even more detailed information on the main energy consumers within the company process a detailed energy balance was created. In this balance the company's operation was categorized into five categories that separate the energy consumers. Categories as production, heating, ventilation and air conditioning (VAC), Information technology (IT) and lighting, each category includes every appliance used to function and it is disaggregated in a daily basis. Identification of equipment problems can also be determined with the quantification of energy fluxes of the equipment, for this assessment of the consumption hours by each equipment has been made and then translated to its CO_2E.

Therefore, with this information a comprehensive approach to energy consumption and its impacts toward the environment can be assessed and can point to the main areas in which energy efficiency measures will have a major impact. To exemplify the categorization processes realized in this work chart 1 describes the breakdown of consumption of the appliances related to the production processes.

Chart 1. Quantification of energy usage on the production process.

Machine	Operation daily hours	Quantity	Daily total consumption (KW)	Cost	CO_2 E	Share of total CO_2 (%)
Machine 1	16	1	2.9	506.2	1.6	2
Machine 2	16	1	2.2	379.6	1.2	1
Machine 3	16	4	1	169.6	0.5	1
Machine 4	16	4	1.5	254.4	0.8	1
Machine 5	16	8	0.7	126.5	0.4	0
Machine 6	16	1	63	10687.9	34.6	34
Machine 7	16	1	1.1	186.6	0.6	1
Machine 8	16	1	0.8	147.5	0.4	0
Machine 9	16	2	8	1357.2	4.4	4
Machine 10	16	1	5.5	949.1	3.07	3
Machine 11	16	1	11	1866.1	6.05	6
Machine 12	16	1	0.7	127.2	0.4	0
Machine 13	16	1	1.8	316.3	1.02	1
Machine 14	16	1	1.1	189.8	0.6	1
Machine 15	16	1	2.6	442.9	1.4	1
Machine 16	16	1	1.4	253.1	0.8	1
Machine 17	16	1	5.5	949.1	3.07	3
Machine 18	16	1	2.2	379.6	1.2	1
Machine 19	16	1	2.2	379.6	1.2	1
Machine 20	16	2	0.4	67.8	0.2	0
Machine 21	16	1	1.5	254.4	0.8	1
Machine 22	16	1	2.2	379.6	1.2	1
Machine 23	16	1	9.4	1594.7	5.1	5
Machine 24	16	1	3.4	576.8	1.8	2
Machine 25	16	1	27	4580.5	14.8	15
Machine 26	16	1	0.7	127.2	0.4	0
Machine 27	16	1	8	1357.2	4.4	4
Machine 28	16	1	9	1526.8	4.9	5
Machine 29	16	1	1.4	240.4	0.7	1
Machine 30	16	1	2.2	379.6	1.2	1
Machine 31	16	1	4.1	695.5	2.2	2
Total			185.3	31450.46	101.9	100

The evaluation of consumption and categorization of every appliance used will provide with the information necessary to describe the daily KWh consumption per category and can later be translated into its environmental indicator. In Fig 3, the daily KWh consumption of each category is described in terms of environmental impacts of these categories expressed in CO_2 Equivalents.

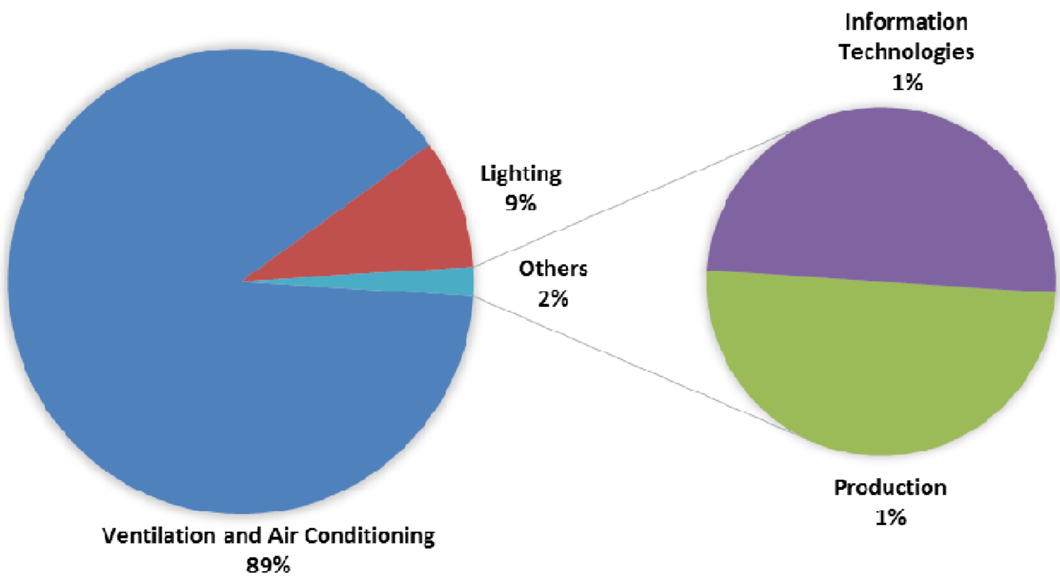


Fig 3. Energy usage environmental impact by categories

Energy efficiency potentials

The energy audit at the meat processing industry results with several measures that could be implemented to improve energy efficiency and reduce both energy cost and pollution to the environment: contributing to cleaner production of meat. The scope of the energy efficiency measures aim to reduce the energy consumption of the main processes that use energy in the production of meat. Measures include the installation of more energy efficient devices through the systems and reducing the air leaks that could exist. Furthermore, is also advised to prompt a reduction of energy use through the non-technical implementation but focusing on the social aspect of energy consumption. I.e. it's recommended to instruct employees with basic notions for energy efficiency aimed to specific targets such as turning off of lighting devices that are not being used.

With the identification of the main energy consumers a categorized list of the measures as presented in Chart 2. Result of a full review of the literature on energy efficiency and a selection of the viable options that can be implemented to achieve energy efficiency in the specific context of this case study.

Chart 2. Measures for energy efficiency

Scope	Measures to improve the energy efficiency
Illumination (Hesselbach, 2012)	- Installation of more energy-efficient lighting engineering
	- Reduction of the wattage of lights
	- Pale painted walls, ceilings and floors reflecting the light in a better way
	- Matching of the illuminance on the purpose of the workplace
	- Application of light sensors which adjust the illumination
	- Installation of motion detectors which are noticing if persons entering into an area or room and the light gets switched on
	- Intelligent time management and formation of zones depending on usage
	- With a control system can every employee control the illumination from his own computer
Pneumatic Systems (Thollander and Palm, 2013)	- Reduction of air leaks
	- Decrease of the air pressure
	- Converting into electric tools where possible
	- Usage of variable speed drive compressors
	- Consideration of the possibility to use the compressor's cooling output for space heating purposes
Electric drives (Müller et al., 2009)	- Usage of energy efficient motors (IEC standard 60034-2-1 or CEMEP efficiency category)
	- Regular maintenance of the drives
	- Minimization of ration radii, accelerations, displaced mass and velocities
	- Regeneration of braking energy
	- Utilization of variable speed drives (VSD)
	- Preferential usage of direct drives to reduce the friction losses
	- No oversizing of the electromagnetic drives
	- Switching on or off in a targeted manner of the drives
	- Selection of an energy efficient type of transmission
Pumping Systems (Thollander and Palm, 2013)	- Reduction of the flows through variable speed drives (VSD)
	- Improvement of gears and transmission
	- Reduction of the flows through effective time control
Ventilation and Air-conditioning Technology (Thollander and Palm, 2013)	- Reduction of the air flows through variable speed drives (VSD)
	- Reduction of the flows through effective time control
Space heating and cooling systems (Thollander and Palm, 2013)	- Heat recovering from hot exhaust air flows
	- Usage of ceiling fans
	- Shutdown of the heat circulation pumps in the summer
	- Usage of air curtains for shuttle doors
	- Reduction of the indoor temperature during heating season
	- Improvement of the roof and wall insulation
	- Supply of heat and cooling at the right temperature
	- Better insulation of pipes, heat exchangers etc.
	- If possible converting from steam into waterborne systems
	- Usage of heat pumps
	- Taking advantage of free cooling
Hot tap water systems (Thollander and Palm, 2013)	- Usage of more efficient shower heads and fittings
	- Better insulation of pipes, heat exchangers, etc.
Internal Transport (Thollander and Palm, 2013)	- Converting from diesel and gasoline vehicles into more energy-efficient ones (e.g., electrically powered)
	- Maintenance of adequate tire pressure
	- Improvement of the production planning to reduce transport distance
	- Optimization of the storage location to reduce the transport distance

4. Conclusions

Industrial processes need energy to function, implying several negative impacts to the environment. Therefore is imperative to improve the efficiency of such processes in order to achieve cleaner production and move to sustainable production. It is noted that the company in which this case study was developed has a remarking interest in minimize the damage that their processes have on the environment. As a summary, the main opportunities in this company can be described:

- Company A complies with all the regulatory framework of the meat processing industry, having an innocuous production processes.
- The implementation of some of the previously mentioned measures for energy efficient will have an impact on the overall efficiency of the studied company without affecting the regulatory compliance.
- Opportunities to further research on cleaner sources for energy should be noted and are also part of the company's transition to cleaner energy.
- Energy efficiency is one of the main topics that should be addressed in matters of cleaner production.
- The result of this first three steps on the CP-EE methodology serve as the basis to more energy efficient and cleaner production processes in Company A. Therefore a more depth analysis of materials flow is recommended.

5. References

UNEP, 2004. Guidelines for the Integration of Cleaner Production and Energy EfficiencyUnited Nations Environment Programme.

Blengini, G.A. y Shields, D.J., 2010. Green labels and sustainability reporting Overview of the building products supply chain in Italy. Management of Environmental Quality: An International Journal, 16(4), 21(4), pp.477-493.

Jorgenson, A.K., Alekseyko, k., Giedraitis, V. 2014. "Energy consumption, human well-being and economic development in central and eastern European nations: A cautionary tale of sustainability", Energy Policy, 66, pp. 419-427.

Stern, D. I. 2011. The role of energy in economic growth. Annals of the New York Academy of Sciences, 1219: 26–51. doi: 10.1111/j.1749-6632.2010.05921.x

Tang, P. & Mike Jones. 2013. ENERGY CONSUMPTION GUIDE FOR SMALL TO MEDIUM RED MEAT PROCCESSING FACILITIES. Australian Meat Processor Corporation LTD

Dalkia. 2014. Guide equivalences CO2 [ONLINE] Disponible en: http://www.dalkia.ie/ireland-energy/ressources/documents/1/20202,Guide-equivalences-CO2.pdf.

Sun, H & Lee, S. 2006. Case study of data centers' energy performance. Energy and Buildings, 38(5), pp.522–533. Disponible en: http://linkinghub.elsevier.com/retrieve/pii/S0378778805001738

Schmidheiny, S. with the Business Council on Sustainable Development. 1992. "Changing course: a global business perspective on development and the environment", ISBN: 978-0-262-69153-6,MIT Press.

FAOSTAT, 2013, "FAO Statistical Yearbook 2013: World Food and Agriculture", ISSN: 2225-7373, Food and Agriculture Organization of the United Nations, Rome, Italy.

Afnor Group. 2014. Guideline to efficient Energy management systems according to ISO 50001. [ONLINE] Disponible en: http://www.gut-cert.de/guide-enms.html