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D 4.4: Current process description Fruit & Vegetables Processing Plants (English)

Transfering
Energy Save
Laid on Agroindustry

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1. Introduction

The food industry is the leading manufacturing sector in Europe, in terms of economic turnover, value added, employment and number of companies. The economic sector turnover was around 950 billion Euros in 2010 and it employed nearly four million people. Of the 283.000 food companies in Europe, over 99% are SMEs (Small and Medium Enterprises). These SMEs generate almost half of the industry's food and drink turnover and employ over 61% of the workforce. The agro-food industry is composed by transformation companies, using agricultural products (primary production) to supply the food industry which produce food and beverages (transformation industry). Specifically, in Italy the food industry, with its 124 billion Euros (12%), it is the second manufacturing sector after the metal mechanic sector, showing the forth economic turnover in Europe behind Germany (18%), France (16.5) and United Kingdom (12.2%). More in detail, in Italy the agriculture sector, which represents only 2% of the GDP, supplies for 65% of its production the food processing industry, which then supplies with 41% of its products the food commercial industry system. The agro-food products account for more than 42% of the total selling of food in shops and small markets, and accounts for about 70% of the total retail market. As general figure, the Italian GDP of the agro-food system, in its wider meaning of agriculture and food industry, has reached a global annual value of 267 billion Euros, which corresponds to 17% of the GDP in 2010, when considering all the related components – primary sector, food industry, retail, services, and all linked activities – with annual growth rates of over 10% since the 1990s.

Nowadays, the global food market is fragmenting into specific consumer segments, and the trend is towards the growth of supermarket retailing with consumers more and more attracted by food products which respects their lifestyle as well as their needs of good health and well-being. Whilst in the past, most of the agro-food products was consumed by the family and commercialized by local markets, today the food products are provided by the supermarket chains, with the agro-food industry transformed from "supply push" to "demand pull". In Italy, the supermarket retailing industry holds more than of 50% of the agro-food products while it is 90% in France, 70% in Germany and UK.

This transformation, however, on one hand has increased the availability of food products but, on the other hand, it has raised concerns on the implications of the growing demand of energy use by the food industry systems in OECD countries. Nowadays, both the agro-food supply chains and the food industry at large need to look for solutions to face some of their major challenges: i) extreme fragmentation on the supply side; ii) serious imbalances in the distribution of value along the supply chain; iii) scarce propensity to innovate in technology; and iv) significant logistic critical points. Thus, within an increasingly globalised environment, EU food industry needs to improve energy efficiency and energy use and, at the same time, to implement best practices in supply chain management focusing on the new needs of consumers and in the development of production and processing based on the principles of environmental sustainability.

This report examines mainly the technical aspects associated with the energy consumption of the processing food industry of vegetable & fruit, seeking to identify the energy budget of each of the components in the food processing supply chain.

2. Sector characteristics

Most part of the Italian production of fruits & vegetables are processed and used in the sector of food industry (LG MTD, 2008). As general rule, they are classified as:

- first gamma – fruits and vegetables for direct market selling;
- second gamma - fruit and vegetables preserved by being sterilized by thermal processes, dried or processed with the use of a mix of techniques;
- third gamma – refrigerated products;
- fourth gamma – fresh products hygienically treated and ready to eat, to be maintained for a short time in controlled atmosphere;
- fifth gamma - products softly cooked and ready-to-eat, to be maintained for some weeks in controlled condition.

Food industry of vegetable paste includes all the products which have had a treatment to increase their conservation:

- thermal treatments for sterilization / pasteurization;
- treatments by low temperatures (refrigerated);
- dehydration (drying);
- mix of techniques (with additives, fermentation, etc.).

The quantity of fruits & vegetables included in the second and third gamma is evaluated in about 7.0 million of tonnes per year, of which 5 million tonnes are represented by the tomato fruit. In the Table 1 are illustrated the primary plant products (fruits & vegetables), reported the characteristics of the processed products, and the main treatments of stabilization used, according to a classification into three groups (vegetable, tomato and fruits). In addition, in each group the most important plant species are reported, together with the merchandise typology and the base process used for the preservation of the products. As general scheme, the production of fruits & vegetables after harvesting has to be transported as soon as possible to storage areas. At the reception there is a soft control and evaluation of the sanitary state which, however, it is usually done in internal labs by specific equipment in order to analyze different the plant products, e.g.: refractometric extract (tomato, fruit, etc.), specific weight (potatoes, peas, etc.), consistency, boiling tests, etc. After that, the plant product is washed with water containing detergents and other sanitizers in order to remove field soil, surface micro-organisms, fungicides, insecticides and other pesticides. Then, the products are sorted to remove non-standard fruits-vegetables and selected for quality grading (variety, dimensions, maturity, etc.). Finally, the plant products starts the various treatments which can be mechanical, chemical, physical, thermal, etc., in relation to the product characteristics, the organoleptic quality, the market where are delivered (Tab. 1 - 2).

Table 1 - Primary plant products (fruits & vegetables), characteristics of the processed product, main treatments of stabilization used in Italy

	Primary plant products	**Characteristics of the processed product**	**Preservation treatment**
Vegetables	Peas, beans, green beans, spinach, potatoes, asparagus, corn, chickpea, lentil, artichokes,	✓ Raw ✓ Water addition	Thermal treatment
	Olives, small artichokes, mushrooms, onions, peppers, carrots, cucumbers, capers, etc..	✓ In oil ✓ Pickled ✓ Brine ✓ Chemical treatments	
	Various	✓ Dry	Dehydration
	Various	✓ Frozen and cooled (3rd, 4th and 5th range)	Freezing, Cooling, Protective atmosphere
Tomato	Tomato	✓ Concentrate	Water removal and heat treatment
		✓ Peeled	Thermal treatment
		✓ Peeled ✓ Grinded ✓ Sliced	Thermal treatment
		✓ Juices ✓ Puree	Thermal treatment
		✓ Powder ✓ Flakes	Dehydration

	Primary plant products	Characteristics of the processed product	Preservation treatment
Fruits	Strawberries, mixed berries, pears, apples, peaches, apricots, prunes, pineapples, cherries, grapes, various	✓ With water addition ✓ Syrup	Thermal treatment and possible synergy with sugar/chemical stabilizers
	Peaches, prunes, apricots, cherries, strawberries, raspberries, figs	✓ Jams ✓ Jellies	Thermal treatment and possible addition of sugar/chemical stabilizers
	Citrus	✓ Marmalades ✓ Juices	Thermal treatment and possible addition of sugar/chemical stabilizers
	Pears, peaches, apples, grapes, apricots, tropical fruits, mixed berries	✓ Juices ✓ Nectars	Thermal treatment
	Various	✓ Candied fruits	Thermal treatment
	Various	✓ Dried fruits	Sugar
	Various	✓ Frozen fruits and available	Cooling

2.1. Sector characteristics: processes

Raw material is delivered at the receiving dock from a truck or other vehicle. An initial inspection of the fruit/vegetable is performed: traceability codes, batch size, product quality, vehicle condition, etc.., information usually registered in the cooperative database. Electric trucks carry out loading and unloading for a pre-cooling process and / or a processing line.

Figure 1. Tomato delivering before processing line

The storage of the products can be performed in freezers, and / or a specific area conditioned for this purpose, where the products are to be passed to processing lines for handling and packaging.

Figure 2. Storage for products

Palletting and / or dumping differ depending on product type and type of dump container used: ie, if the product is collected in plastic bins, the dumper will be adapted to these plastic boxes. More and more companies are using machinery for palletting.

Figure 3. Machine for palletting 1

Washing and drying steps are not fixed in the process of handling and packaging of fruits and vegetables, and depend on the morphology and characteristics of the product.

Figure 4. Tunnel used for drying 1

The sorting process is common to many products in the sector of fresh fruit and vegetables. Sorting can be made by color, size, or other physical properties. Companies currently market a large number of products: sorting machines must cover winter and summer campaigns, with equipment capable of classifying the widest range of possible products.

Figure 5. Equipment for sorting and grading

Figure 6. Machinery for control on products ready for marketing

Many other treatments can be used: degreening, drencher, stripping, waxing, etc. Finally, specific machinery is used for package and delivery. A suitable quality control, depending on the type of product, is performed in this last phase.

Figure 7. Area of packaging preparation

Figure 8. Area of grading and package preparation

3. General data of energy consumption in fruits & vegetables sector

As a general scheme, the food industry uses energy for food processing and preservation, for safe and convenient packaging, and for storage. Safe and convenient packaging is extremely important in food manufacturing and it is also energy intensive. The more recent packaging techniques require aseptic techniques and electro-chemical changes. Proper storage is also energy dependent. Freezing and drying are the most crucial methods for food storage.

Freezing operations require a large amount of electricity. Smil (2008) estimated that food storage involves between 1-3 MJ/kg of retail food product. Drying procedures usually depend on fossil fuels. Older dehydration systems were designed to operate with maximum throughput, disregarding energy efficiency. Approximately half of all energy end-use consumption is used to change raw materials into products (process use), which include heating and cooling, refrigeration, machine drive (mechanical energy), and electro-chemical processes. Less than 10 % of the energy consumed by manufacturing is for non-process uses, including facility heating, ventilation, refrigeration, lighting, facility support, onsite transportation, and conventional electricity generation. Boiler fuel can represent nearly one-third of end-use consumption.

4. Industrial processes and energy consumption

Modern agro-food system consumes large amounts of fossil fuels for the production of food products of vegetal and animal origin to meet the global food demand. A number of studies have identified food as one of the main contributors to energy use. In fact, the energy used in the food sector commonly amounts to 20% of the total energy consumption in developed countries (Giampietro, 2002). The energy used for processing, transport and food preparation is usually around from three to four times the amount used for primary production (Smil, 2008). More in detail, the food industry requires thermal energy for heating, cooling and electricity in order to process the plant products. In addition, energy is embedded in the plastic or aluminum used for packaging. In the EU-27 the overall final energy consumption of the food industry has been rather stable since 1990, with a total amount of energy consumption around 30 MTOE during the period 1990-2006. In Europe, in terms of primary energy used in food industry, after a significant increase in natural gas consumption from 8.6 to 15 MTOE over the period 1990-2003, the use of natural gas in the food sector started to decline.

This is evident in Figure 9. In Italy, natural gas has played a crucial role in the food industry. Firstly the use of gas increased from 1 MTOE in 1990 to almost 1.9 MTOE in 2003. Then, the position of gas decreased rapidly, and the level of consumption fell to 1.3 MTOE in 2006. On the other hand, the

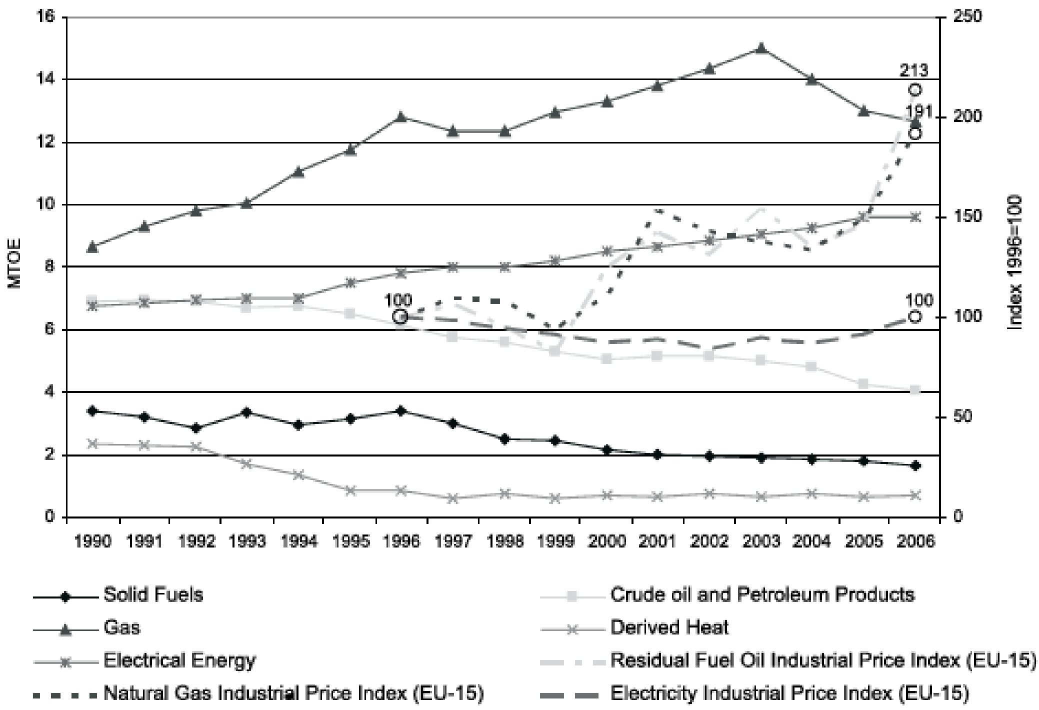

Figure 9. Final energy consumption in food, drink and tobacco industry EU-27, 1990-2006 (Eurostat)

consumption of the electrical energy increased, from 0.6 MTOE in 1990 to 0.9 MTOE in 2006.

Unlike other countries the consumption of crude oil and petroleum products increased and stabilized at the level of approx. 0.8 MTOE (Fig. 10).

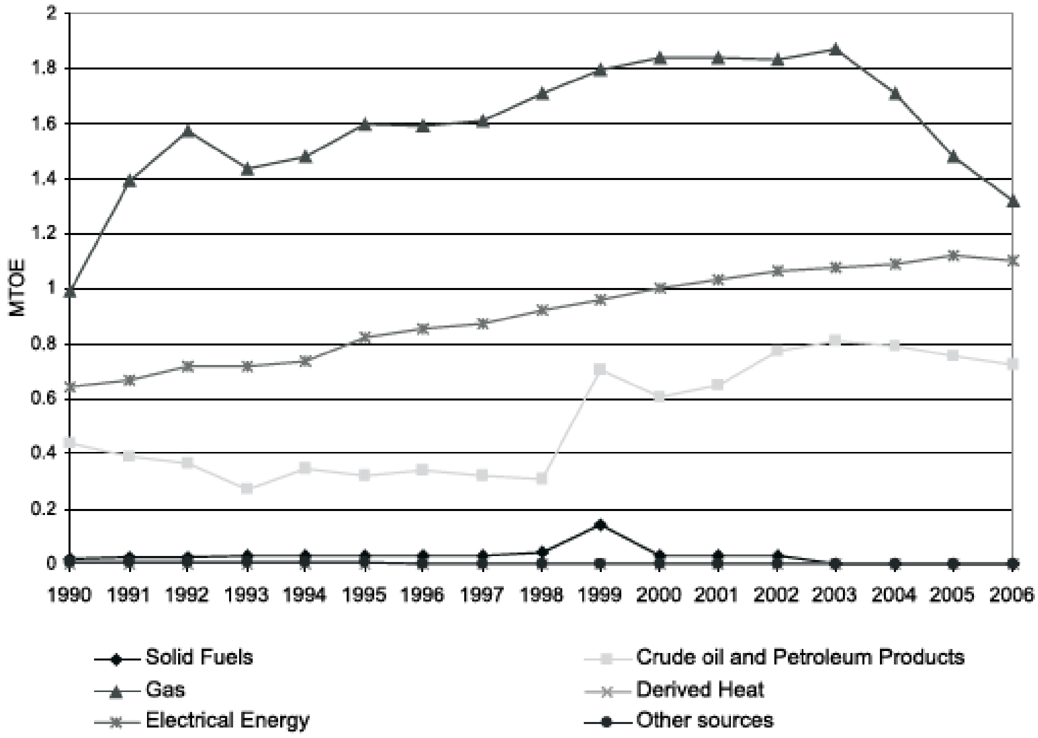

Figure 10 - Final energy consumption in food, drink and tobacco industry – Italy, 1990 - 2006 (Eurostat)

In 2010, the energy consumption of industry in Italy was 31.6 MTOE, with an energy intensity equal to 130.2 TOE/M€00. In particular, figure 11 which put in evidence the energy consumption performance of the different compartments of industry over the period 1990-2010. It can be seen as the food industry has had a trend of energy consumption ranging from 15.1 to 14.8 kTOE.

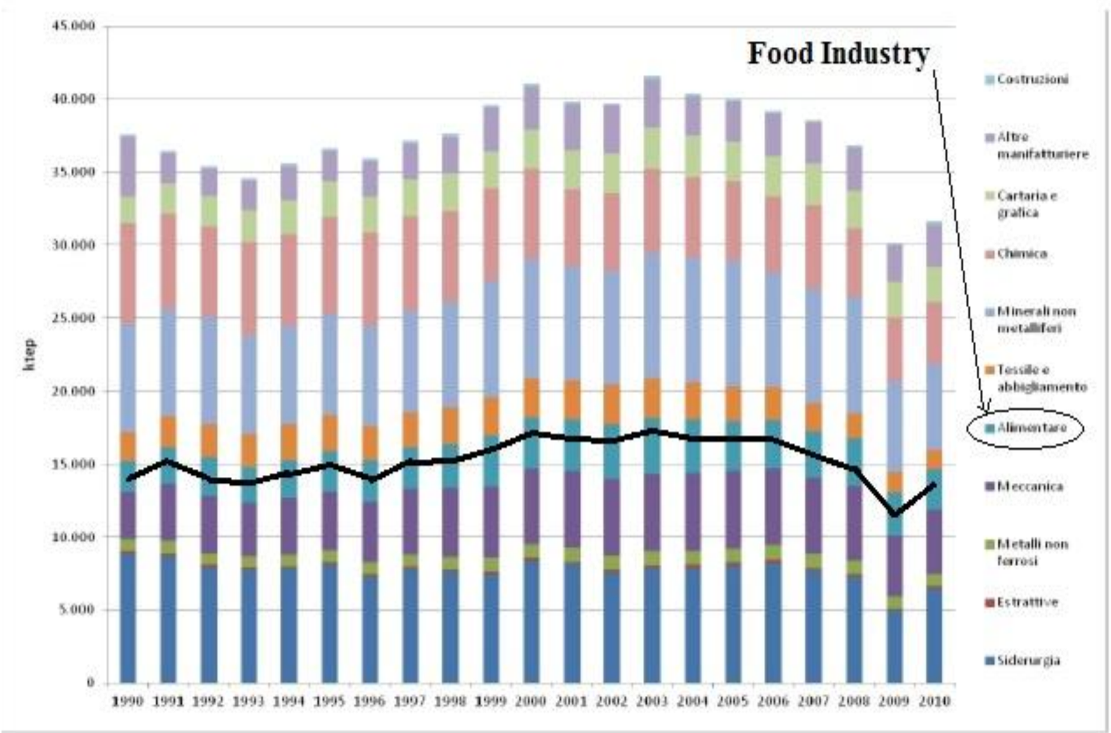

Figure 11. Energy consumption in the sector of food industry from 1990 to 2010 (RAAE, 2012)

With reference to Italy, a survey recently made by ENEA (Campiotti et al. 2012) on the energy demand of Italian agro-food system showed a final energy consumption of 16.43 MTOE (Tab. 6). The table put in evidence as the final energy consumption of the food industry (thermal, storage, drying and cool chain) represents about 2,90% of the total final energy consumption accounted by the all agro-food system (both the primary production and the food industry).

Table 3 - Energy demand of Italian agro-food system

Productive sectors	Consumption (Mtoe)
Direct consumption (irrigation, processing land, air heating, utilities)	3,03
Food Industry	2,90
Indirect consumption (phytosanitary, fertilizers, plastics), transport, preparation, storage, distribution, storage, sales	10,50
Total	**16,43**

4.1. Industrial processes and energy consumption

Tables 4, 5, 6 and 7 report the percentage of energy consumption requested by each of the processing operations which characterize the fruits & vegetables sector.

Table 4 - Percentage of energy consumption for processing of vegetable & fruits: industries based in thermal processes

Processing phase	**%**
Raw material reception	0,5
Washing, sorting and sizing	8,2
Cutting, grinding, calibration, peeling, etc.	12,2
Blanching/drying	32,7
Cooling and rinsing	1,1
After-treatment operations, checking and packaging	8,2
Heat treatment of stabilization	36,8
Cooling	0,2
Storage	0,2
TOTAL ENERGY	**100,0**

Table 5 - Percentage of energy consumption for processing of vegetable & fruits: industries based in cooling processes, from an analysis of ten fruit and vegetable processing plants (Cooperativas agroalimentarias, 2010).

Processing phase	**%**
Raw material reception, washing, sorting and sizing	19,5
Processing: cutting, grinding, calibration, peeling, etc. After-treatment operations, checking and packaging	12,2
Cooling / cold storage	46,4
Transport	2,0
Air conditioning	2,5
Lighting	7,8
Auxiliary processes	9,6
TOTAL ENERGY	**100,0**

On average, the energy consumption accounts mainly for electricity used by the process of cooling and refrigeration, heating for both treatments and for infrastructure buildings, and thermal energy for hygiene. The energy demand of the food industry can be classified as depending on six major energy sub-systems, namely: i) air; ii) steam; iii) motor and pumps; iv) compressed air, v) cooling and refrigeration, vi) heating and lighting of infrastructure and buildings, and the vii) energy input by the transportation. In Italy, the sector of fruit and vegetable processing uses 60% of the energy mainly for the electrical use due to cooling and operation of refrigeration plants, while 40% of the energy accounts as thermal energy used for thermal treatments for pasteurization and sterilization.

However, it should be outlined that because either the processing technologies or the primary raw materials (fruits & vegetables) treated can be quite different between the companies the data in the tables could not reflect the whole picture. Tables 6 and 7 reports data regarding the electrical and thermal energy consumption per ton which accounts for the processing of fruit and vegetables.

Table 6. Industrial processes and energy consumption for each process: industries based in thermal processes

Processing step	Electrical energy (kWh per ton of processed product)	Thermal energy (kWh per ton of processed product)	Electricity for water pumping (kWh per ton of processed product)
Raw material reception	3,4		
Washing, sorting and sizing	2,1	51	
Cutting, grinding, calibration, peeling, etc.	3,4	72	3
Blanching and drying	1,5	209	
Cooling and rinsing	3,9		3
After-treatment operations, checking and packaging	3	50	
Heat treatment for stabilization		229	8
Cooling	1,1		
Storage	1		
TOTAL ENERGY	**19,4**	**611**	**14**

Table 7. Industrial processes and energy consumption for each process: industries based in cooling processes, from an analysis of ten fruit and vegetable processing plants (Cooperativas agroalimentarias, 2010).

Processing step	Electrical energy (kWh per ton of processed product)	Thermal energy (kWh per ton of processed product)
Raw material reception, washing, sorting and sizing	4,0	7,8
Processing: cutting, grinding, calibration, peeling, etc. After-treatment operations, checking and packaging	7,4	
Cooling / cold storage	28,1	
Transport	0,6	0,6
Air conditioning	1,5	
Lighting	4,7	
Auxiliary processes	5,7	0,1
TOTAL ENERGY	**52,0**	**8,5**

More studies are available about specific facilities (Tables 8 and 9). In fruit and vegetable processing plants for the fresh market, facilities are usually based in cooling/freezing processes, so a high percentage of the energy consumption is electrical. In some cases, energy consumption is directly proportional to the cooling needs.

Table 8. Energy consumption of a typical fruit processing industry (10.000 tons of product/year), from an analysis of the University of Evora of a representative facility

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)
Reception	Electronic scale Washing machine (Drencher)	57	184	33.500		
Conservation	Cold storage		270	536.000		
Packaging	Calibrator Packaging machine	6	39	67.000		
Expedition	Chambers expedition	6	19	33.500		
Lighting and other electrical auxiliary equipment	Fluorescents		12	56.300		
Thermal auxiliary euipment						
Auxiliary equipment	Forklifts	14			10	14.560
TOTAL			**523**	**726.300**	**10**	**14.560**

Technology applied in the processes offers opportunities for energy savings in this sector. In some processes, automation devices are connected to a PC and information is stored. Analysis of the stored information can show aspects of the process that can be improved. Appropriate maintenance programs can also contribute to a better management of energy consumption.

Table 9. Technical conditions of a typical fruit processing industry, from an analysis of the University of Evora of a representative facility

PROCESS (sequential order)	TYPICAL TECHNOLOGY	Quality control	Automation control technology	Information storage devices (if exist)	Typical type of maintenance
Reception	Electronic scale Washing machine (Drencher)	Weight, appearance of the fruit	No	Manual information	Weekly cleaning, manual (with air, water and specific disinfectants)
Conservation	Refrigeration facilities	Appearance of the fruit	Specific automation controllers	Controllers connected to a PC	Weekly cleaning, manual (with air, water and specific disinfectants)
Packaging	Calibrator Packaging machine	Caliber	No	Manual information	Weekly cleaning, manual (with air, water and specific disinfectants)
Expedition	Chambers expedition	Weight	No	Manual information	Weekly cleaning, manual (with air, water and specific disinfectants)
Lighting and other electrical auxiliary equipment	Fluorescents	No	No	No	No
Thermal auxiliary equipment		No	No	No	No

5. Alternative technologies and new perspectives

Several improvements are available for increasing the energy efficiency of motors which are widely used in the food industry. Overall, estimation of the average energy savings indicate that a 20% reduction can be obtained from motors/pumps improvements. Steam systems and hot water are nowadays widely used in food industry. Their improvement in terms of energy efficiency can certainly raise positive results on energy saving and economy. It was estimated that the application of measures, improvements and interventions of energy efficiency in steam systems (boilers, heat distribution), compressed air systems (bottling, dehydration, conveying, spraying coatings, cleaning), cooling and refrigeration process, heating and lighting of buildings, can certainly contribute to achieve an average energy savings ranging from 15 to 25 percent (Kaminski and Leduc, 2010). A good knowledge of the entire system rather than taking a demand-side or a supply-side approach can be very effective to improve energy efficiency of the food processing.

For instance, it was reported that can be more convenient to minimize the amount of heat that needs to be removed in the processing phase, rather than to improve the energy efficiency of the cooling system (Cleland, 2010). One of the most important energy budget of industrial companies is due to the electric consumption of motors, which account 74% of the total electricity, whilst 4% is due to lighting and 22% to other energy users. Thus, the choice of very efficient motors can allows either to efficient working process or to save electrical energy (Fig. 4).

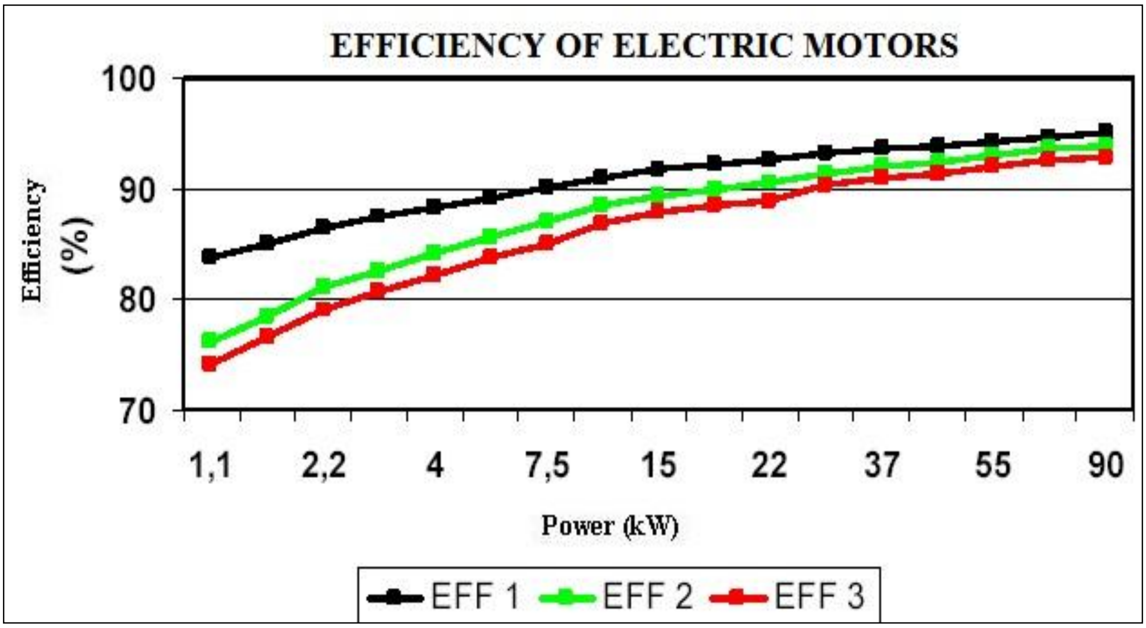

Fig. 4 – Energy efficiency of different electrical motors

Another significant field of operation for decreasing energy consumption in food industry is represented by necessity to improve energy saving through a better maintenance and design of plants, equipments and structures. For instance, it was reported that a tube with diameter of 108 mm and length of 100 m used to allow a steam flow at 8 atm. and 174 °C, if appropriately provided with an insulation of 30 mm of thickness. Thus, the insulation could allow an energy saving in respect of a non-insulated tube of about 89%.

Similarly, an oven for food industry with an outside surface of 800 m^2 could allows an energy saving of 84% if insulated with panels of glass wool of 40 mm of thickness, respect to a similar oven not insulated. Similar improvements can be done for refrigerators, freezers, pumps, motors, fans, and other equipments. Over 100 technologies have been identified for improving energy efficiency (Galitsky et al., 2003). Of interest is the application of standards of minimum energy performance (MEPS) in order to encourage the use of more efficient compressors and improved designs for heat exchangers, light, fans and controls.

Renewable energy represents an important field of application that should be considered from companies to reduce their energy costs. Production of heat from biomass available on-site or steam raising and co-generation from industrial plants for drying of fruit and vegetables with benefits as energy reduce and efficiency. Optimizing combustion efficiency, recovering the heat from exhaust gases and selecting the optimum size of high efficiency, electric motors, can yield energy savings of between 20 to 30 percent. Finally, other improvements can be reached in the food storage by better using the schemes of ventilation or by installing high efficiency variable speed fans provided with inverters. FAO reports that cost-effective reductions in energy use could be achievable at all the stages of the food supply chain in most countries by increasing the introduction of innovative technologies as well as by processing less-energy-demanding food products and less quantity of packaged food.

6. Further information

This section focuses on the possible proposals and actions that can be put in operation to save energy and/or improve energy efficiency of processing plant and services. In addition, it is also outlined the use renewable energy systems not only as an opportunity for energy saving but also as an essential component for improve the sustainability of the food industry sector (e.g.: solar energy and biomass as energy sources to be integrate into process of dry and cold storage). Of particular interest are also the incentives by the government to support energy efficiency actions by private investors. The Italian White Certificate scheme was created with the aim of promoting energy efficiency measures on final energy uses. The first draft was defined by a Ministerial order in July 2004. The White Certificates scheme provides a corresponding number of white certificates (each equal to one TOE) on the basis of yearly energy saving targets certified by the submission of projects. Almost every project involving an improved efficiency in the final consumption of energy can be admitted in the scheme, from boilers to lighting systems, from solar thermal to cogeneration, for solid biomass in place of fossil fuels, from electric motors to industrial processes. These savings can be achieved through energy efficiency actions among end-users and are assessed using tons of oil equivalent (TOE) as measurement unit. Cumulative targets for distribution system operators (DSOs), set at 200,000 toe in 2005, rose from 2.2 million toe in 2008 to 6.0 million TOE in 2012. Another components of the food industry that in the last decade rose much interest is the fresh-cut horticultural segment which supplies both the food service industry and the retail outlets. The most popularly used packaging format is propylene film for bags in either 250 and 500 gm packs (energy consumption for polyethylene is 92-111 MJ/kg, for polyvinyl is 85-107 MJ/kg, for polystyrene is 118-160 MJ/kg, for polyester is 170-222 MJ/kg). In Italy not less than 20 tons of plastic are annually used by this food chain, with an economic balance of about 1 billion Euros, which makes less sustainable the food industry sector. The following tables 10 and 11 show some of the proposals that could be carried out in order to improve the energy efficiency and to reduce the fossil energy use in the food industry.

Table 10 - Proposals to check and improve energy efficiency of processing in food industry

PROPOSAL	ACTION
Analysis	Flow process sheet with energetically data (data on processing plants)
	Energy flows (processing and services)
	Energy critical steps
	Breakdown of energy consumptions between the different work components and equipment
	Examine of the value of products from an energy perspective(Life Cycle Evaluations that consider not only the initial capital costs but also on-going energy costs)
Control	By energetically payment to energy operator company

Table 11 - Proposal for improving energy efficiency and reducing energy use in food industry

PROPOSAL	ACTION
Improve work operation and plant and equipment performances	Re-use of waste thermal fluxes
	More rationale use of the processing and services plants (work curves, optimization of work's cycles, introduction of new equipment, etc.)
	Optimization of energy contracts with energy operator companies
	Optimization of plants and building structures by sustainable technologies and/or thermal conservation
	Minimum energy performance standards (MEPS) for machinery, such as electric motors, refrigerators, water boiler
Energy saving	Re-use of wet processing wastes, such as tomato rejects and skins, and pulp wastes from juice processing (e.g.: to be used as feedstocks in anaerobic digestion plants to produce biogas)
	Use of renewable energy sources were available to be used as substitute for fossil fuels to generate heat or electricity for use in building/plants/service
Energy responsible and government regulations	Energy Manager responsible to manage the demand for more energy-efficient behavior of operators and improve energy efficiency along-food processing plant system
	Economical incentives to sustain the improvement of energy efficiency (White Certificate system; "Conto Energia" to support electricity and thermal production, by renewable sources, and application of cogeneration systems)

7. Conclusions

In recent years, the food industry due to the increasing request by the market has become a sector of economic and political relevance and attracting the attention of policymakers. Studies on the processing component of food industry sector have shown that this phase of food transformation presents an increasing consumption of energy. This report, after a brief analysis of the food industry in Europe, develops a specific focus on the Italian food industry, by identifying and developing estimation on the energy consumption associated with the main processing phases of fruits & vegetables components. In Italy, energy consumption of processing of fruits & vegetable are around 0,41 MTOE, with a total for food industry of 2,9 MTOE, whilst all the agro-food industry sector is accounted for a total energy consumption of 16, 43 MTOE. The report founded that the electrical energy is mainly used for cooling and operation of refrigeration, while the thermal energy is used for thermal treatments as pasteurization and sterilization. However, several improvements are available either for increasing the energy efficiency or for reducing fossil energy use of motors and pumps, which are widely used in the food industry. In addition, the application of measures, improvements and interventions for improving energy efficiency in steam systems (boilers, heat distribution), compressed air systems (bottling, dehydration, conveying, spraying coatings, cleaning), cooling and refrigeration process, and heating and lighting of buildings can certainly contribute to achieve an average energy savings from 15 to 25%. As a result, there is being a growing interest for adopting measures of energy saving and energy efficiency and for the use of renewable technology in order to decrease energy costs and emissions along the different components of the food industry. A coordinated global energy efficiency strategy needs to be adopted in conjunction with consistent and stable policies to bring down the energy cost of the Italian agro-food system. The adoption of minimum energy performance standards for machinery (motors, refrigerators, and water boilers), and the use of renewable energy should be encouraged as solution to cut down the energy of heating and cooling, and reduce environmental impacts. For this purpose, it is of significant interest the Italian programme so-called "Conto Energia" to promote photovoltaic solar energy application in buildings, and the programme "White Certificates" on the incentives to support energy efficiency and substitution of fossil energy. Both programs are available for industrial and commercial buildings. Such policy can certainly contribute to raise awareness to companies in order to stimulate the introduction of technology innovation into market food products. The analysis of energy saving and efficiency options that could be applied in the Italian food industry, with specific attention to the component of fruits & vegetables shows a substantial potential that can be used as a basis for a broader study of the potential for energy efficiency improvements in the whole European Union. The final estimation of the total energy savings potential would require an in-depth analysis of applicability of the measures suggested for each of the fruits & vegetable processing components. In general, it can be concluded that there are many opportunities for improving energy efficiency and energy saving in the food industry through governmental energy policies and voluntary processes of technology innovation by companies. Investments in energy efficiency and renewable energy can be justified considering that such approach will certainly make the entire sector of food industry from primary production to transport and food processing more competitive and sustainable.

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