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Renewable energy for value added agro processing

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Abstract
Energy is essential and play vital role in agro processing industries. The energy consumption as well as employment and value added by the post harvest food (PHF) system is several times greater than the farm level activities. The total food system uses around 17-20 percent of total energy use in the economies. Limited access to energy is one of the challenges that must be overcome for small- and medium-sized agro processing enterprises to establish themselves in rural areas.
In the region, food losses are often caused by a lack of access to energy for adequate post-harvesting operations, such as drying, steaming, boiling, heating, blanching, storage and processing, as well as a lack of transportation and distribution in most of the agro processing industries. In addition, rising energy prices affect the competitiveness of existing Agri-food processing enterprises and highlight the need for the food-processing sector to reduce energy consumption.
This paper describes the importance and types of energy used in agro-food processing sector, commonly used energy intensive unit operations and their management. The scope and matrix of renewable energy technologies for agro-food processing industries were discussed.

Keywords: Agro-food processing, energy management, renewable energy

Introduction
A significant part of agricultural production goes through some degree of transformation between harvesting and consumption to make food edible and digestible. Energy is required to preserve food, reduce post-harvest losses and to extend the availability of food over a longer period. The energy consumption as well as employment and value added by the PHF system is several times greater than the farm level activities. The total food system uses around 17-20 percent of total energy use in the economies [3]. Of this, usually around one-fifth to one-quarter only is spent on production on the farm and the remainder goes into post-harvest operations [8, 12].

Limited access to energy is one of the challenges that must be overcome for small- and medium-sized enterprises to establish themselves in rural areas. In developing countries, most food losses occur during harvest and storage. For this reason, improving post-harvest activities in developing countries represents a priority area for increasing farmers' income [7, 9]. Food losses are often caused by a lack of access to energy for adequate post-harvesting operations, such as drying, steaming, boiling, heating, blanching, storage and processing, as well as a lack of transportation and distribution. Another factor that influences the development of the agro-food industry is the need to manage industrial by-products, residues and wastes in an environmentally sound way. One management option is to use industrial wastes to produce energy. In addition, rising energy prices affect the competitiveness of existing food processing enterprises and highlight the need for the food-processing sector to reduce energy consumption. Increasing energy efficiency and integrating renewable energies can do much to improve the sustainability and economic competitiveness of food processing industries. Profit is generally one of the most common and accepted criteria determining the success of an economic activity. Integrated Food-Energy Systems must be profitable in the long term for its practices to be adopted by small-scale farmers and other stakeholders.

Types of Energy used in PHT Operations
Energy one of the important parameter in various unit post harvesting along with top operating expenses as material, labour and water. Broadly two main types of energy are heat and work. However, other forms of energy uses are 1) electrical energy, 2) mechanical energy, 3) chemical energy and 4) heat energy. The energy available or used in agro industries are classified the basis of source of availability as direct and indirect energy [6, 7].

1. **Direct source of energy:** The direct sources, which release the energy directly, like human labor, bullocks, and mechanical or electric power units.
2. **Indirect sources of energy:** The indirect sources, which do not release energy directly but release it by conversion process like seeds, manures (farm yard and poultry), chemicals, fertilizers and machinery.

On basis of comparative economic value the energy may be classified as

1. **Non-commercial energy:** The energy sources, which are available cheaply like human labor, animal sources, fuel wood, twigs, leaves agro-wastes, solar energy, wind energy and animal dung, etc.
2. **Commercial energy:** The energy sources like petroleum products (diesel, petrol and kerosene oil), coal and electricity, which are capital intensive.

The direct/Indirect energy may be further classified as renewable and non-renewable sources of energy depending upon their replenishment.

Renewable sources of energy

The energies, which can be replenished in due course of time like human beings, animals, solar and wind energy, fuel wood, agricultural wastes, Biomass, process waste etc. Seed and manure can be termed as renewable indirect source of energy.

Non-Renewable sources of energy

The energy sources, which are not replenished like coal and fossil fuels (Diesel, petrol, kerosene, LPG, furnace oil, LDO etc. Chemicals, fertilizers and machinery manufacturing are the non-renewable indirect sources of energy (Fig.1).

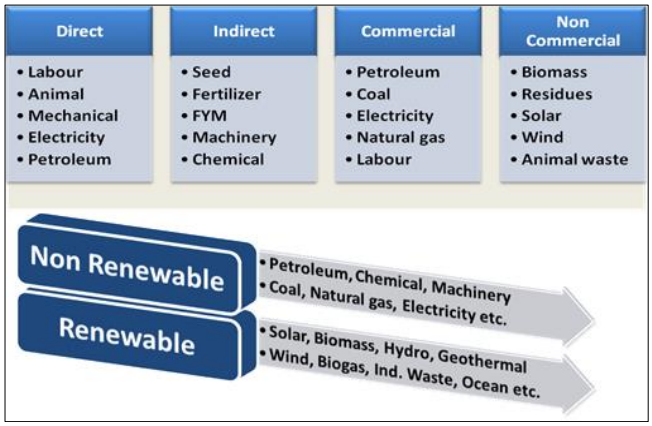

Fig 1: Classifications of energy in Agro-Food Industries

Energy management in post harvest operations

The fundamental goal of energy management in processing industry is to produce value added goods and provides services with the least cost and least environmental effect. It is defined as "The strategy of adjusting and optimizing energy, using systems and procedures so as to reduce energy requirements per unit of output while holding constant or reducing total costs of producing the output from these systems" The objective of Energy Management is to achieve and maintain optimum energy procurement and utilization, throughout the organization and:

1. To minimize energy costs / waste without affecting production and quality
2. To minimize environmental effects.

The objective of the efficient energy management in the processing industry could be achieved with two possible routes

1. Energy audit/Assessment of the processing unit to explore the conservation opportunities
2. Utilization of nature's free, eco-friendly renewable energy technologies.

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It is an effective tool to [3, 11, 12]:

- Explore relationship between energy and production
- Identify pattern, type, level and efficiency of energy use
- Provide base line information for energy consumption
- Help to identify energy conservation opportunity
- Help to identify measures for efficiency improvement
- Help to reduce disparities among similar process and provide ecological perspective.

It is the tool for estimation of energy requirement in any process prior to conservation in very effective way to alleviate energy constraints and utilization of alternative energy option through the renewable energy technologies, which is clean, reliable, cheap and easily available to meet the demand of these operations.

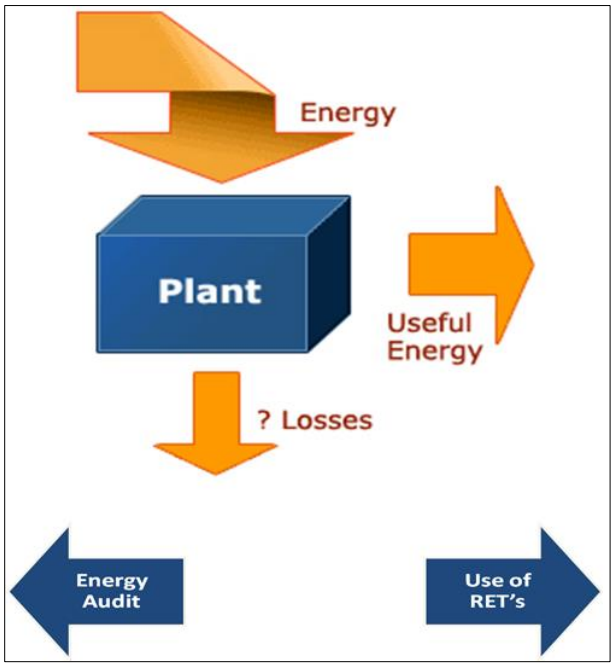

Fig 2: Energy Management in Agro-Industries

The commonly used unit operations performed, energy forms and in various agro-processing industries are summarized in Table 1.

Table 1: Unit operations and form of energy used in agro processing industries

SN	Processing Industries	Unit operations	Energy Used
1	Cashew Processing	Distillation Milling Cleaning Sorting Cutting Peeling Drying Boiling Steaming Sterilization Tampering Cooling Shelling Chopping Pasteurization Heating Blanching --and many more	Electricity
2	Juice/Candy production		Diesel
3	Rice Processing		Petrol
4	Edible Oil Expression		Furnace Oil
5	Gur Making		Gasoline
6	Tamarind Processing		Kerosine
7	Timber processing		LPG
8	Palm Karnel oil processing		LDO
9	Paper and Pulp Processing		Wood
10	Grain Mills		Shells
11	Dal Mills		Processes Waste
12	Poultry and Meat processing		Coal
13	Fish Processing		Charcoal
14	Kori-tooofu processing		Pit
15	Tea processing		Lignite
16	Cassaa processing		RDF
17	Kokum processing		Bruqietted fuel
18	Bakery processing		Agri. Residues
19	Milk Processing		Animal Waste
20	Canned food processing		Human Power
21	Vegetable processing		Animal Power
22	Jute processing		Wind Energy
23	Grain processing		Solar Energy
24	Sugar cane processing		Biogas
25	---- and many more		Landfill gas etc…

Renewable Energy technologies for post harvest operations

The most commonly available renewable energy sources in and around the post harvest operations/industries are solar, wind, biomass and process bio-waste. The renewable energy sources, which are abundantly available in nature, has vast potential to provide the substitute for the commonly used mechanical, electrical, heating/cooling form of energy in agro processing industries.

The solar energy technologies can be used for direct conversion into electricity using photovoltaic and into heat (thermal) energy in the temperature range of 50 to 200 °C. Wind energy conversion technologies can be used for generation of electricity as well as mechanical power. Biomass energy technologies have vast potential to produce mechanical, electrical, process heat energy required in the industry. The biomass resources has potential to convert the solid biomass in to enriched solid fuel (Charcoal), gaseous fuel (Producer gas/biogas) and liquid fuels (Ethanol/biodiesel) [1, 2, 4, 5].

The utilization of renewable energy technologies for different operations commonly performed during the post harvest operations are summarized in the following matrices.

Table 2: Matrix of solar energy technologies for post harvest operations

SN	Solar Energy Technologies	Application Media	Temp. range	Applications/use
1.	Solar water heater	Hot water	(<80 °C	Blanching, washing, cleaning, Boiler feed water etc.
2.	Solar box cooker	Cooking	80-100 °C	Cooking, Boiling, brewing, baking, mashing, extraction etc
3.	Parabolic solar cooker	Process heat	100-250 °C	Cooking, frying, roasting, baking, etc
4.	Solar concentrating collector	-Process heat -Steam	>200 °C	Sterilization, pasteurization, bleaching, hydrogenation etc.
5.	Solar air heater	Hot air	50-80 °C	Heating, drying, dehydration
6.	Direct solar dryer	Hot air	50-80 °C	Drying of grain, agricultural commodity which are not thermal sensitive
7.	Indirect solar dryer	Hot air	50-80 °C	Drying of food commodity which are thermal sensitive
8.	Solar still	Evaporation	50-80 °C	Distill water, concentrated juice, essence etc.
9	Solar absorption cooling	Evaporation	<15 °C	Work space comfort and storage
10	Solar refrigeration & HVAC	Evaporation	<5 °C	Storage
11.	Solar Photovoltaic System	Electricity	10-45 °C	Indoor/outdoor lighting, Water pumping, Control systems etc.

Table 3: Matrix of biomass energy technologies in post harvest operations

SN	Biomass Technologies	Biomass Feedstock	Product	Uses in Industries
1	Direct Combustion	Wood, agro residue Process waste, MSW Shells, Briquetted fuel	--	Heat and power
2	Gasification		Producer gas	Heat and Electricity
3.	Carbonization		Charcoal	Heat Electricity
4	Pyrolysis		Crude oil	Lubrication, Transport
5	Anaerobic digestion	Animal manure, Agro- waste, Landfills, Waste Water, effluent, De-oiled cake	Biogas	Cooking, power generation, heat, boiling , lighting etc
6	Aerobic digestion	Sugar or starch crops, Wood waste, Pulp sludge, Grass straw	Ethanol	Transport fuel
7	Transesterification	Rapeseed, Soy beans Waste vegetable oil Animal fat, Non edible oil	Biodiesel	Mechanical power and electricity

Based on the availability of source of energy and the unit operation, one can utilize the renewable energy technologies for the different operations in the Agro-food processing Industries to reduce the burden of energy and became a self reliance with more profit.

Conclusion

The energy is the most ital and one of the profit-deciding components in the value addition process of agricultural commodities. The systematic approach for estimation of energy in industry helps to identify the energy intensive operation and type of energy used.

The wide utilization of commercially available renewable energy technologies for post harvest operations can provide the profitable solution for energy security and clean environment.

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