Environmental, Health, and Safety Guidelines for Sugar Manufacturing

Introduction

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP)[1]. When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards. These industry sector EHS guidelines are designed to be used together with the **General EHS Guidelines** document, which provides guidance to users on common EHS issues potentially applicable to all industry sectors. For complex projects, use of multiple industry-sector guidelines may be necessary. A complete list of industry-sector guidelines can be found at: www.ifc.org/ifcext/enviro.nsf/Content/EnvironmentalGuidelines

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, with an appropriate timetable for achieving them.

The applicability of the EHS Guidelines should be tailored to the hazards and risks established for each project on the basis of the results of an environmental assessment in which site-specific variables, such as host country context, assimilative capacity of the environment, and other project factors, are taken into account. The applicability of specific technical recommendations should be based on the professional opinion of qualified and experienced persons.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

Applicability

The EHS Guidelines for Sugar Manufacturing include information relevant to sugar manufacturing facilities. Annex A contains a full description of industry activities for this sector. This document does not include agriculture and field activities, which are included in the EHS Guidelines for Plantation Crop Production.

This document is organized according to the following sections:

Section 1.0 — Industry-Specific Impacts and Management
Section 2.0 — Performance Indicators and Monitoring
Section 3.0 — References
Annex A — General Description of Industry Activities

[1] Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility.

1.0 Industry-Specific Impacts and Management

The following section provides a summary of EHS issues associated with sugar manufacturing that occur during the operational phase, along with recommendations for their management. Recommendations for the management of EHS issues common to most large industrial facilities during the construction and decommissioning phases are provided in the **General EHS Guidelines**.

1.1 Environment

Environmental issues in sugar manufacturing projects primarily include the following:

- Solid waste and by-products
- Wastewater
- Emissions to air

Solid Waste and By-Products

Sugar industry activities generate large quantities of organic solid waste and by-products (e.g. leaves from cane or beet, molasses from the final crystallization, press mud or cachaza, bagasse fiber from the cane, mud and soil arriving at the plant with the raw material, and lime solids from the juice clarification). Generated mainly from the primary treatment of raw materials, these waste materials may also present a risk from pesticide residues. The amount of waste generated depends on the quality of the raw materials themselves and on the initial cleaning in the field.

The generation of higher quality waste can provide opportunities for reprocessing of otherwise discarded raw materials into commercially viable by-products (e.g. paper making and particle board manufacturing)., Other solid wastes from the sugar manufacturing process include spent filter material (e.g. active carbon, resins from the ion exchange process, acids from chemical cleaning of equipment, vinasse or spent wash from the distillation of fermented molasses-sugar juice, and ashes from the steam boiler plant).

The recommended techniques for prevention and control of solid waste from sugar cane and beets include the following:

- Avoid burning cane leaves in the field before harvest. The trimmings from the sugar cane should be spread in the field to biodegrade;
- Use bagasse (waste fiber) from the cane as fuel for steam and power generation. Depending on production capacity and raw material input volumes, using bagasse as a fuel can meet the plant energy demand and may generate excess electrical energy for sale;
- Use molasses beneficially as a feedstock for:
    - Fermentation and organic chemical manufacturing
    - Production of citric acid and yeast
    - Distillation industries
    - Organic chemical manufacturing (e.g. ethanol)
- Use beet leaves and roots (which enter the facility as part of the raw material and accumulate during the washing process) as an energy-rich feed (e.g. for ruminants);
- Collect waste products, (e.g. beet tops from the washing process) for use in by-products or as animal feed;
- Convert beet pulp into feed (e.g. for cattle). During the processing season it can be sent as return loads on empty beet lorries;
- Separate stones from the beet during the washing process and reuse in other industrial applications (e.g. road building and construction industries);
- Remove soil and earth from the beet while in the field and before transport to reduce the risk of spreading pesticide residues;

- Use organic material in the wastewater and the spent wash from distillation to produce biogas;
- Use filter and dry lime from the juice clarification process to make a soil-conditioning product for agricultural land;
- Compost organic solids from press mud (cane laundry) to make high-quality organic manure for agricultural production.

Sludge Treatment and Disposal

Recommended methods for the treatment of sludge from wastewater treatment include the following:

- Aerobic stabilization or anaerobic digestion. Anaerobic stabilization improves the sludge applicability to agriculture;
- Gravity thickening;
- Sludge dewatering on drying beds for small-scale facilities and dewatering using belt presses and decanter centrifuges for medium- and large-scale facilities;
- Using sludge from concentrated sugar juice prior to evaporation and crystallization (known as cane mud or cachaza) to produce organic manure and soil amendment for agricultural applications.

Wastewater

Industrial process Wastewater

Sugar processing wastewater has a high content of organic material and subsequently a high biochemical oxygen demand (BOD)[2], particularly because of the presence of sugars and organic material arriving with the beet or cane. Wastewater resulting from the washing of incoming raw materials may also contain crop pests, pesticide residues, and pathogens.

Recommended wastewater management includes the following prevention strategies:

- Segregate non-contaminated wastewater streams from contaminated streams;
- Reduce the organic load of wastewater by preventing the entry of solid wastes and concentrated liquids into the wastewater stream:
  - o Implement dry precleaning of raw material, equipment, and production areas before wet cleaning
  - o Allow beet to dry on field if possible, and reduce breakage during collection and transport through use of rubber mats and lined containers. Use dry techniques to unload beet
  - o Fit and use floor drains and collection channels with grids and screens or traps to reduce the amount of solids (e.g. beet parts) entering the wastewater
  - o Prevent direct runoff to watercourses, especially from tank overflows

Process Wastewater Treatment

Techniques for treating industrial process wastewater in this sector include preliminary filtration for separation of filterable solids; flow and load equalization; sedimentation for suspended solids reduction using clarifiers; biological treatment, typically anaerobic followed by aerobic treatment, for reduction of soluble organic matter (BOD); biological nutrient removal for reduction in nitrogen and phosphorus; chlorination of effluent when disinfection is required; dewatering and disposal of residuals; in some instances composting or land application of wastewater treatment residuals of acceptable quality may be possible. Additional engineering controls may be required to contain and neutralize nuisance odors.

Management of industrial wastewater and examples of treatment approaches are discussed in the **General EHS**

[2] Typical levels of biochemical oxygen demand (BOD_5) are 1,700-6,600 milligrams per liter (mg/L) in untreated effluent from cane processing and 4,000-7,000 mg/L for beet processing, while COD ranges are 2,300-8,000 mg/L from cane processing and up to 10,000 mg/L in beet processing.

Guidelines. Through use of these technologies and good practice techniques for wastewater management, facilities should meet the Guideline Values for wastewater discharge as indicated in the relevant table of Section 2 of this industry sector document.

Other Wastewater Streams & Water Consumption

Guidance on the management of non-contaminated wastewater from utility operations, non-contaminated stormwater, and sanitary sewage is provided in the **General EHS Guidelines**. Contaminated streams should be routed to the treatment system for industrial process wastewater.

Sugar manufacturing requires considerable quantities of high-quality water for raw material cleaning, sugar extraction, final sugar washing, and cooling and cleaning equipment. Steam is essential to the evaporation and heating of the various process steps in sugar processing. Beet and cane raw materials also contain high percentages of water, which can be recovered and reused during processing. General water conservation and management is covered in the **General EHS Guidelines.** Additional industry-specific measures applicable to sugar manufacturing include:

- Recycle process water and apply to the washing of incoming raw material;
- Use closed loops for intensive solid generating washings, (e.g. cane and beet wash) and flue gas scrubbers.

Emissions to Air

Air emissions in sugar manufacturing are primarily related to particulate matter generated from bagasse-fired steam boilers, dust from unpaved access roads and areas, and sugar drying or packing activities. In addition, odor emissions are generated from beet processing activities and storage facilities. Beet factory juice clarification produces a sweet odor, which can be irritating. Inadequate cleaning of the raw material may result in fermented juice, which will also create a foul smell.

Particulate Matter and Dust

Recommended measures to prevent or control particulate matter include the following:

- Operate bagasse-fired steam boilers while targeting emissions guidelines applicable to the combustion of solid fuels presented in the **General EHS Guidelines**. Typical control methods include boiler modifications or add-on controls, (e.g. flue gas cyclones, fabric filters, or electrostatic precipitators, wet scrubbers and local recirculation systems) to capture the ash and recycle the water to prevent the emission of particulate;[3]
- Use wet scrubbers to remove dust from drying and cooling of sugar;
- Reduce fugitive dust from roads and areas by cleaning and maintaining a sufficient level of humidity;
- Install ventilation systems with filters on transport systems for dry sugar and on sugar packing equipment.

Exhaust gases

Exhaust gas emissions produced by the combustion of organic materials in boilers for power and heat generation can be the most significant source of air emissions in sugar processing activities. Air emission specifications should be considered during all equipment selection and procurement.

Guidance for the management of small combustion source emissions with a capacity of up to 50 megawatt hours thermal (MWth), including air emission standards for exhaust emissions, is provided in the **General EHS Guidelines**. For combustion

[3] The appropriate level of control for bagasse-fired boilers may need to be evaluated on a case-by-case basis as determined by model-predicted impacts on ambient quality.

source emissions with a capacity of greater than 50 MWth refer to the **EHS Guidelines for Thermal Power.**

Odor

Recommended measures to prevent or control odor in beet processing facilities include the following:

- Keep beet processing and storage facilities clean to avoid the accumulation and fermentation of juice;
- Use wet scrubbers to remove odors with a high affinity to water(e.g. the ammonia emitted from the drying of beet pulp);
- Consider use of bio-treatments;
- Ensure that vapor from the carbonation section is emitted from a stack of sufficient height.

Energy Consumption and Management

Sugar manufacturing facilities use energy to heat water and produce steam for process applications and cleaning purposes. Reducing energy consumption will have a positive effect on air emissions. General energy conservation and management is covered in the **General EHS Guidelines**. Additional industry-specific recommendations include:

- Install steam turbine-based combined heat and power technology, enabling the facility to generate its own process steam and electricity requirements and sell excess electricity;
- Use waste fiber or bagasse from the cane as fuel for steam and power generation. Ensure that the bagasse moisture level is below 50 percent before it is used as boiler fuel to improve its calorific value and overall efficiency for steam generation and avoid the need for supplemental fuels. ;
- Anaerobically digest high-strength organic wastes (e.g. vinasse or spent wash from distillery and organic chemical manufacturing) to produce biogas. Use biogas to fire distillery boilers or to operate combined heat and power systems generating electric energy and hot water / steam;
- Keep heating surfaces clean by adding chemicals to prevent incrustations. Incrustations are generated by mineral salts that are not removed during clarification and may be prevented or reduced by adding special polymers to the thin juice;
- Ensure even energy consumption by management of batch processes (e.g. centrifuges, vacuum pans) to schedule energy demand and equalize steam demand on the boilers;
- Reuse vapor from vacuum pans for heating juice or water;
- Use an evaporator with at least five effects;
- Combine drying of beet pulp with the main energy system in the facility.
- Select the operating conditions of the boiler and steam turbine system to match the heat-power ratio of the utility system to that of the facility. If, despite selection of a high pressure boiler, the facility needs to pass more steam through the turbine than it uses in the process to generate sufficient electricity, then it should condense rather than vent this steam.

1.2 Occupational Health and Safety

Occupational health and safety hazards for sugar manufacturing facilities are similar to those of other industrial facilities and recommendations for the management of these issues can be found in the **General EHS Guidelines**. In addition, occupational health and safety issues that may be specifically associated with sugar manufacturing operations include the following:

- Physical hazards
- Exposure to dust and biological hazards
- Exposure to chemicals (including gases and vapors)
- Exposure to heat and cold and radiation

- Exposure to noise and vibrations

Physical Hazards

The most common risks for accidents in sugar manufacturing facilities are trips and falls caused by slippery floors, stairs, and elevated platforms (e.g. due to water and molasses), the incorrect use of equipment (e.g. packaging and transport equipment), contact with sharp edges on process equipment (e.g. replacing worn beet slicing knives in the slicing machines), accidents involving conveyor belts, and explosions (e.g. sugar drying and storing, and from gas fuels storage, and boilers). Recommendations for the management of these issues can be found in the **General EHS Guidelines**.

Repetitive Work Injuries

Sugar manufacturing activities may include a variety of situations in which workers can be exposed to lifting, carrying, and repetitive work, and work posture injuries. Recommended management approaches to reduce these injuries are discussed in the **General EHS Guidelines**.

Dust and Biological Hazards

Workers are exposed to dust (including biological and microbiological agents) during the sugar drying and packing processes. Recommendations for the management of these issues can be found in the **General EHS Guidelines**.

Heat, Cold, and Radiation

Workers can be exposed to heat, cold, and radiation from changes in the internal climatic conditions caused by cold and warm areas or activities and exposure to heat (e.g. from boilers or hot equipment). Recommended measures to prevent and control exposure to heat, cold, and radiation are discussed in the **General EHS Guidelines**.

Noise and Vibrations

Noise and vibrations result from a variety of sources (e.g. internal and external transportation, flow in pipelines, lime milling, rotating machinery, ventilators, turbines, and compressors). Recommended measures to prevent and control exposure to noise are discussed in the **General EHS Guidelines**.

1.3 Community Health and Safety

Community health and safety impacts during the construction, operation, and decommissioning of sugar manufacturing plants are common to those of other industrial facilities, and are discussed in the **General EHS Guidelines.**

2.0 Performance Indicators and Monitoring

2.1 Environment

Emission and Effluent Guidelines

Table 1 presents effluent guidelines for this sector. Guideline values for process emissions and effluents in this sector are indicative of good international industry practice as reflected in relevant standards of countries with recognized regulatory frameworks. Effluent guidelines are applicable for direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in the use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification as described in the **General EHS Guidelines.** These levels should be achieved, without dilution, at least 95 percent of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. Deviation from these levels due to specific local project conditions should be justified in the environmental assessment.

Combustion source emissions guidelines associated with steam- and power-generation activities from sources with a capacity equal to or lower than 50 MWth are addressed in the **General EHS Guidelines** with larger power source emissions addressed in the **EHS Guidelines for Thermal Power**. Guidance on ambient considerations based on the total load of emissions is provided in the **General EHS Guidelines**.

Table 1. Effluent levels for sugar manufacturing

Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD_5	mg/l	50
COD	mg/l	250
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Biocides	mg/L	0.05
Temperature increase	°C	<3[b]
Total coliform bacteria	MPN[a] / 100 ml	400
Active Ingredients / Antibiotics	To be determined on a case specific basis	

Notes:
[a] MPN = Most Probable Number
[b] At the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use, potential receptors and assimilative capacity

Environmental Monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Additional guidance on applicable sampling and analytical methods for emissions and effluents is provided in the **General EHS Guidelines**.

Resource Use

Table 2 provides examples of resource consumption indicators in this sector. Industry benchmark values are provided for comparative purposes only and individual projects should target continual improvement in these areas.

Table 2. Resource and energy consumption

Input per unit of product	Mass load unit	Industry benchmark
Energy (fuel and electricity) consumption in beet industry	kWh/ton beet MJ/ton beet	300[a] 819[b]
Additional fuel consumption in cane industry	L fuel/ton cane	0
Fresh water consumption per unit of production (raw materials)	m^3/ton cane m^3/ton beet	0.5 – 0.9 0.5[a]

[a] EC (2005)
[b] CEFS (2003)

2.2 Occupational Health and Safety

Occupational Health and Safety Guidelines

Occupational health and safety performance should be evaluated against internationally published exposure guidelines, of which examples include the Threshold Limit Value (TLV®) occupational exposure guidelines and Biological Exposure

Indices (BEIs®) published by American Conference of Governmental Industrial Hygienists (ACGIH),[4] the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),[5] Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),[6] Indicative Occupational Exposure Limit Values published by European Union member states,[7] or other similar sources.

Accident and Fatality Rates

Projects should try to reduce the number of accidents among project workers (whether directly employed or subcontracted) to a rate of zero, especially accidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g. US Bureau of Labor Statistics and UK Health and Safety Executive)[8].

Occupational Health and Safety Monitoring

The working environment should be monitored for occupational hazards relevant to the specific project. Monitoring should be designed and implemented by accredited professionals[9] as part of an occupational health and safety monitoring program. Facilities should also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents. Additional guidance on occupational health and safety monitoring programs is provided in the **General EHS Guidelines**.

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[4] Available at: http://www.acgih.org/TLV/ and http://www.acgih.org/store/
[5] Available at: http://www.cdc.gov/niosh/npg/
[6] Available at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9992
[7] Available at: http://europe.osha.eu.int/good_practice/risks/ds/oel/
[8] Available at: http://www.bls.gov/iif/ and http://www.hse.gov.uk/statistics/index.htm
[9] Accredited professionals may include Certified Industrial Hygienists, Registered Occupational Hygienists, or Certified Safety Professionals or their equivalent.

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Annex A: General Description of Industry Activities

Sugar manufacturing facilities process beet and cane into crystalline sugar and other by-products (e.g. ethanol and other organic chemicals). In excess of 70 percent of the world's sugar production is based on sugar cane, with the remainder based on sugar beet. Typical cane processing facilities may process between 500 to 10,000 tons of cane per day. Beet processing facilities may process between 2,000 tons beet/24 hrs to 15,000 tons beet/24 hrs.

The modern sugar mill may use bagasse (waste fiber) to provide for its own electrical energy needs while supplying excess power to the local grid Separate facilities process the beet and cane into other sucrose products (e.g. liquid sugar, organic sugar, and organic syrup) for distribution to other industry applications or to consumers.

Sugar cane contains 70 percent water, 14 percent fiber, 13.3 percent saccarose (about 10 to 15 percent sucrose), and 2.7 percent soluble impurities. Sugar beet has a water content of 75 percent, and the saccarose concentration is approximately 17 percent.

Production Process

Beet and cane sugar production processes are similar. Both involve reception, cleaning, extraction, juice clarification, evaporation, crystallization centrifugation, drying, storing, and packing stages as illustrated in figures A-1 and A-2. Beet and cane sugar manufacturing are typically located adjacent to the sources of raw materials to reduce costs and transportation time, and to ensure fresh raw material. Reception of Beet and Cane

Sugar beet and cane are unloaded from the transportation vehicles after a sample has been taken for assessment of sugar and dirt content. The beet production line runs continuously at full capacity, whereas the sugar cane production line usually has to stop every approximately 14 days to facilitate removal of encrustations on heating surfaces. Cane and beet processing facilities typically have substantial areas to stockpile enough raw materials to facilitate continuous production.

Washing and Extraction of Cane

Traditionally, cane has been burned in the field before transport to processing facilities to remove any leaves from the cane stalk. The current trend is to harvest green unburned cane, returning leaves to the field where the crop residue promotes soil conservation. Cane factories may have washing operations followed by disaggregation of the raw material using knives and hammer mills.

Extraction of the sugar juice is achieved with roller mills which press out the juice. The remains of the cane stalk are called "bagasse," which contains cellulose fiber. This is mostly used in the process facility as fuel for energy supply. Where fuel is available from another source, the bagasse may be used for further processing in the cellulose industry. Cane juice extraction may also be achieved by a diffusion leaching process, which can result in higher rates of extraction with 50 percent less energy consumption than a mechanical mill.

Washing and Extraction of Beet

Washing of sugar beet is water intensive and wash water is typically recirculated. During washing, soil, stone and leaves are separated from the beet. Separated stone can be used, for example, as gravel for the construction industry. Disintegration of the beet is accomplished by cutting into slices (cossettes), The juice is extracted by a diffuser, where the slices are mixed with hot extraction water to form a sugar solution, known as 'diffusion juice'. The spent beet cossettes in the beet pulp are then pressed and dried to produce animal feed.

Clarification, Evaporation, and Crystallization

The juice resulting from the extraction process is clarified by mixing it with milk of lime, after which it is filtered to remove the mud. In beet-based sugar production, the lime is produced from limestone, which is combusted in a specially designed lime kiln. The main outputs are burnt limestone and carbon dioxide (CO_2). The burnt limestone is used to generate milk of lime and the CO_2 is also added to the liquid in a process called carbonation. Because large quantities of milk of lime and gas are needed, this is a continuous process. These substances are added to the juice and, in the process of carbonation, bind other components, such as protein, to the lime particles. The lime is then filtered, resulting in lime sludge, and dried for use as a soil conditioning agent in agriculture. The resultant clear solution of juice is called "thin juice."

Although the carbonation process gives good results, it is rarely used in the cane industry because of the investment required and a general lack of the main raw material, limestone. Cane processing facilities typically purchase ready-made burnt limestone powder and use this to generate milk of lime. After clarification, the thin juice has a sugar content of approximately 15 percent. Concentrations greater than 68 percent are needed to allow sugar crystallization, and this is achieved through evaporation. Water is removed from the thin juice in a series of evaporating vessels until a syrup with a dry matter content of 68–72 percent is obtained. This thick juice is further evaporated until sugar crystals form, and the crystals and the accompanying syrup are then centrifuged to separate the two components. The final syrup, which contains 50 percent sugar, is called molasses. Sugar crystals are then dried and stored (e.g. in silos).

Molasses is the most important by-product of the sugar production. Molasses can be used as cattle fodder or as raw material in the fermentation industry. To facilitate the use of the molasses, which is generated in relatively high volumes, sugar factories may be combined with distillation plants (see below). The basis for the distillery can be sugar juice, molasses, or a combination of these products.

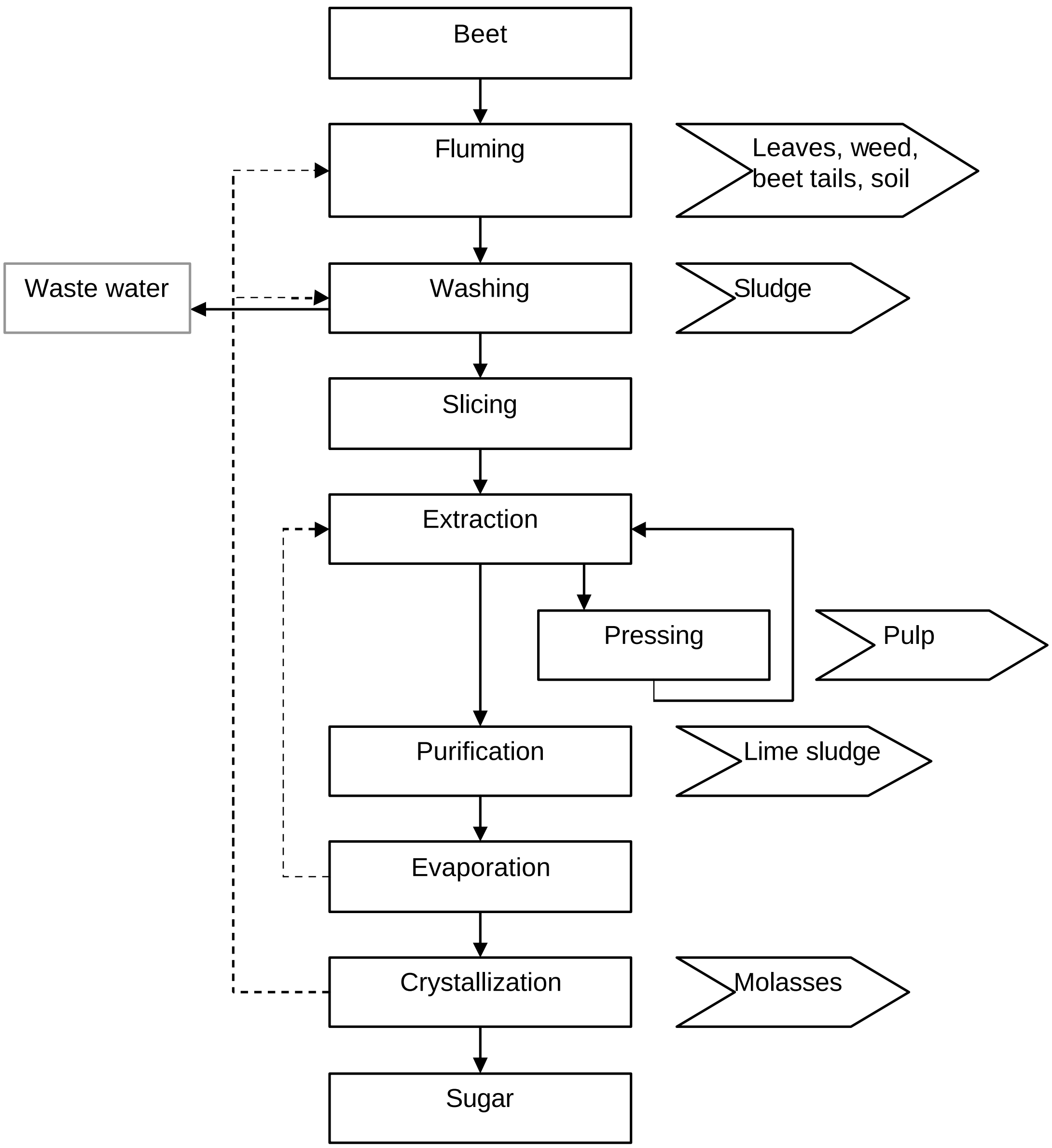
Sugar Refining

The refining of sugar involves affination (mingling and centrifugation), melting, clarification, decolorization, evaporation, crystallization, and finishing. Decolorization methods use granular activated carbon, powdered activated carbon, ion exchange resins, and other materials.

Distillery

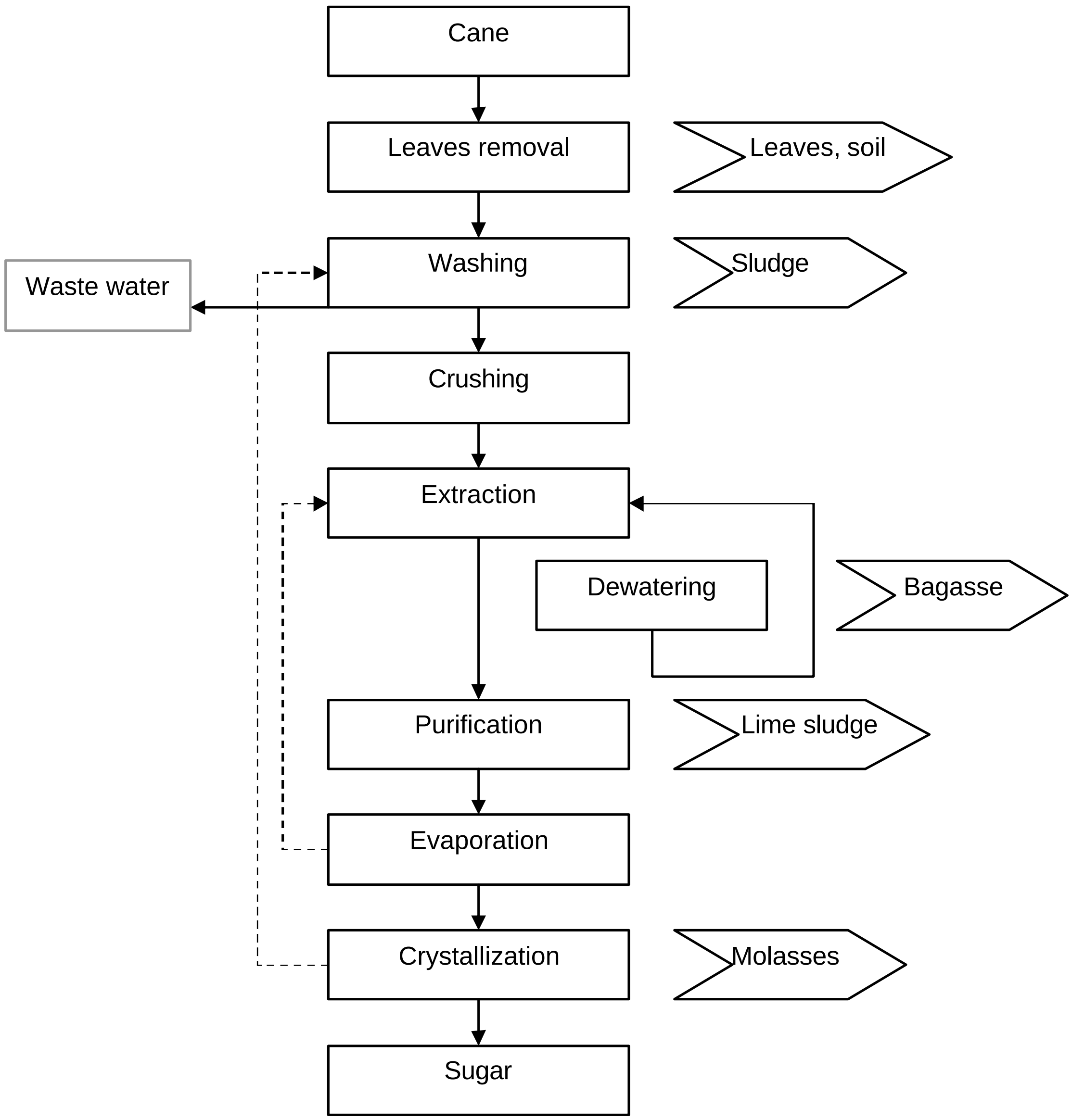
An associated distillery may employ batch or continuous fermentation, followed by distillation, to produce ethanol with a purity of 95 percent. This ethanol can be used in other industries or further processed and blended with gasoline. Waste from the distillation process is known as vinasse or spent wash. Anaerobic digestion of this waste is used to produce biogas, which can be utilized for the production of boiler fuel for the distillery or to fuel CHP engines. Remaining waste can be returned to agricultural fields and / or used in the composting of organic solids emanating from processing.

Figure A.1: Sugar Manufacture from Beet



Source : Adapted from the Comité Européen des Fabricants de Sucre (CEFS), 2003.

Figure A.2: Sugar Manufacture from Cane



Source: Adapted from the Comité Européen des Fabricants de Sucre (CEFS), 2003.