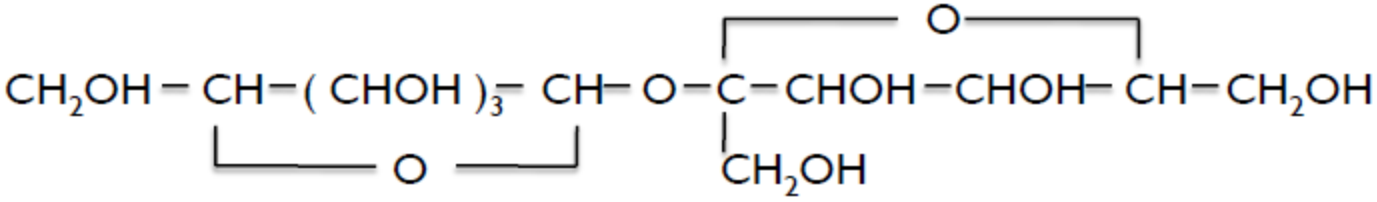
Carbohydrates

- Naturally occurring combinations of C, H and O
  - With H and O in 2:1 ratio (Hydrates of Carbon)
- The most common types
  - Sucrose (ordinary sugar)
  - Starch
  - Dextrose
  - Cellulose
- Fermentation Industries
  - Use carbohydrates as a substrate for production of various chemicals & biologicals.

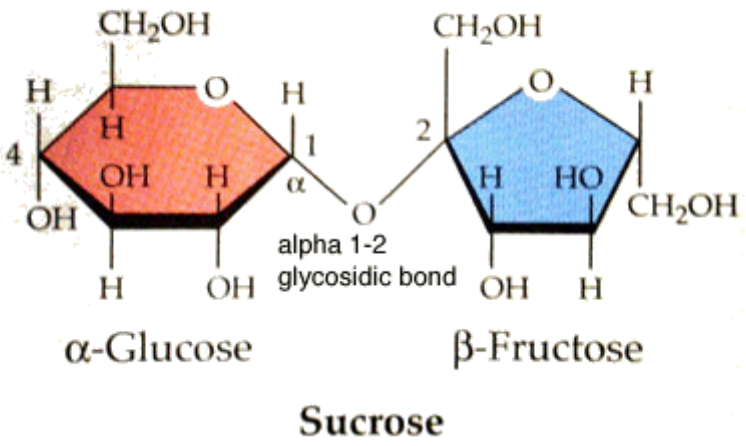
Sucrose

- Chemical formula : $C_{12}H_{22}O_{11}$ (disaccharide)
- Naturally in most fruits and vegetables. Sugar occurs in greatest quantities in sugarcane and sugar beets from which sugar is separated economically and commercially.

- Structural formula : (Glucose + Fructose)



- Molecular weight – 342
- Density = 1.58 kg/m^3
- Sucrose is soluble in water but slightly soluble in methyl alcohol and ethyl alcohol.



Sucrose

SUGAR INDUSTRY: NATIONAL ECONOMY

TABLE I

No. of Working Sugar Factories	453
Cane Price Per Tonne	US$ 20
Cane Price paid annually	US$ 3700 Million
No. of cane farmers	50 Million
Sugar Production	20.0 Million Tonnes (Raw Value)
Annual Tax contribution to exchequer	US $ 500 Million
Employment including ancillary activities	2 Million People
Fuel Ethanol of 5% blend (Value)	US $ 200 Million per annum
Current export of Co-generated power (Value)	US $ 100 Million per annum

The average cane crushing capacity in India, Brazil and Thailand is given below :

Country	Avg. Capacity (TCD)
Thailand	10300
Brazil	9200
India	3500

The Government of India licensed new units with an initial capacity of 1250 TCD upto 1980s which was subsequently increased to 2500 TCD. Government de-licensed the sugar sector in August 1998, thereby removing the restrictions on expansion of existing capacity as well as on establishment of new units, with the only stipulation that a minimum distance of 15 Kms would continue to be observed between an existing sugar mill and a new mill. The number of sugar mills and the growth in capacity over decennial period 1980-81 to 2000-01 and in the year 2001-02 to 2003-04 is given in Table No. II.

Commonly term Used in sugar industry

- Milling: Process for extraction Juice from sugarv cane
- Brix: Unit used to express concentration of sugar solution
- Bagasee: Left after extraction of Juice from sugar cane
- Press mud: Waste after clarification of Juice
- Defecation: Process used for producing raw sugar

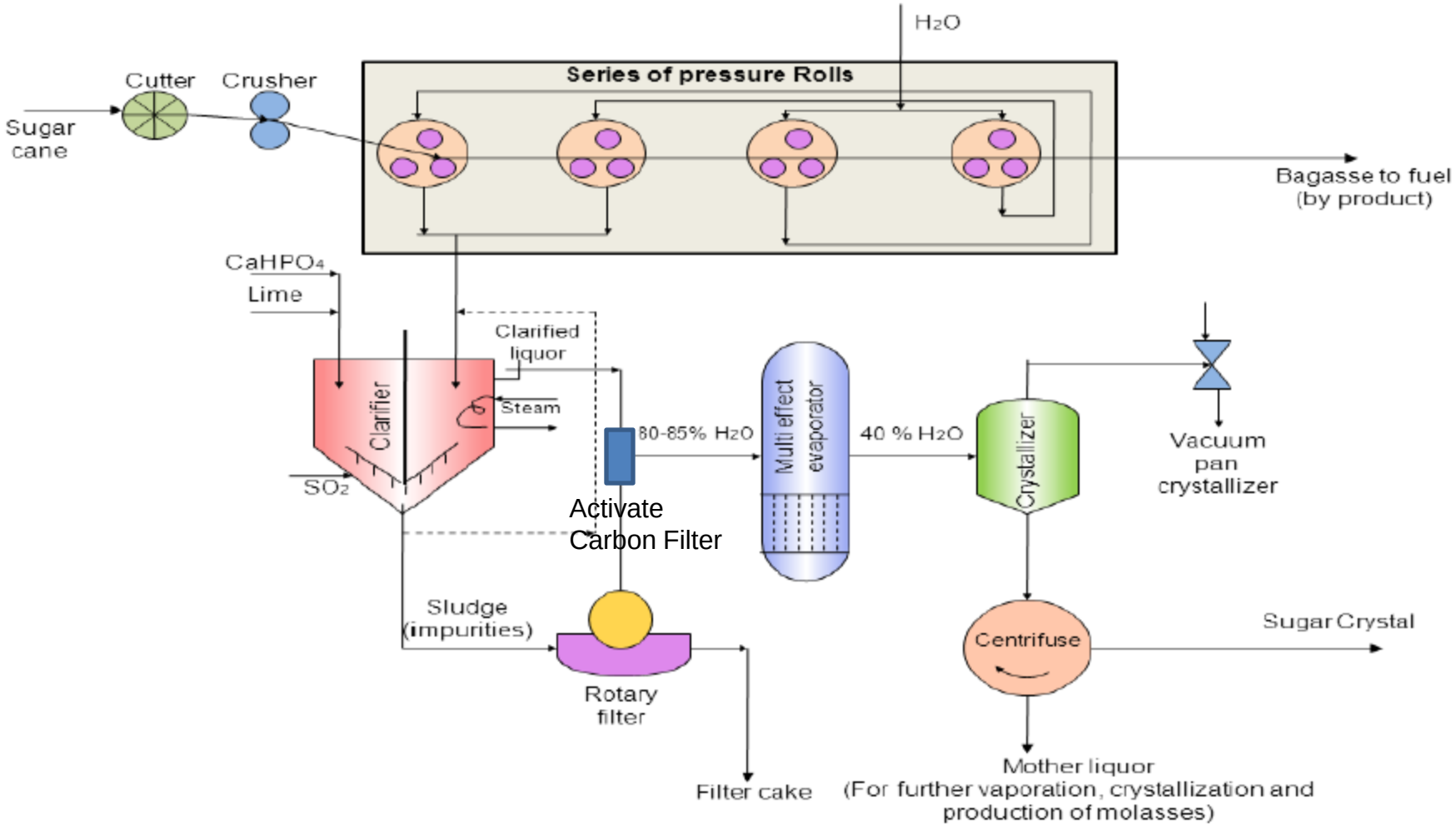
Commonly term Used in sugar industry

- Sulphidation: Purification using sulphur dioxide
- Carbonation: Purification using
- Massecuite: The mixture of sugar crystal and syrup produced by crystallisation
- Molasses: Syrup left after centrifuging and seperating sugar crystal
- Spent wash: Waste after separation of alcohol from fermenter

Production Process

- India is the homeland of sugarcane and sugar.
- Process : Extraction of sugarcane
  - Crystalline white sugar
  - Gur, a dark brown sugar concentrate
- Raw Material : Sugarcane
  - composition of sugarcane juice differences between varieties and location. It is a solution, containing soluble and insoluble impurities (i.e non sucrose species).
  - It's is also slightly acid with the pH between 4.5- 5.5, TSS 15-25 and sucrose 10 – 20 % w/w.

Process Flowsheet



Juice extraction pressing →Purification of juice →Clarification → evaporation → Crystallization → Centrifugation → Drying and screening

Process Description

- ***Juice extraction pressing***
  - Two or three heavily grooved crusher rollers break the cane and extract a large part of the juice. Revolving knives cutting the stalks into chips are supplementary to the crushers.
  - As the cane is crushed, hot water (or a combination of hot water and recovered impure juice) is sprayed onto the crushed cane counter currently.
- ***Clarification***
  - The juice from the mills, a dark green color, is acid and turbid.
  - The clarification (or defecation) process is designed to remove both soluble and insoluble impurities (such as sand, soil, and ground rock)
  - The process employs lime and heat as the clarifying agents. Milk of lime neutralizes the natural acidity of the juice, forming insoluble lime salts.
  - Heating the lime juice to boiling coagulates the albumin and some of the fats, waxes, and gums, and the precipitate formed entraps suspended solids as well as the minute particles.
  - The muds separate from the clear juice through sedimentation. The non-sugar impurities are removed by continuous filtration. The final clarified juice contains about 85 percent water and has the same composition as the raw extracted juice except for the removed impurities.

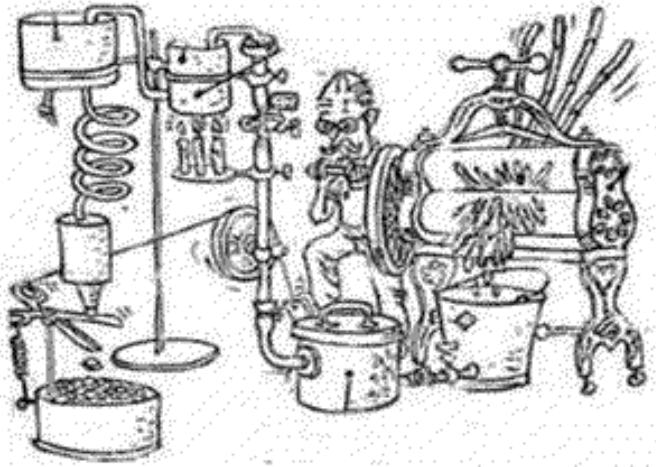
- ***Evaporation***
  - To concentrate this clarified juice, about two-thirds of the water is removed through vacuum evaporation.
  - Generally, four vacuum-boiling cells or bodies are arranged in series so that each succeeding body has a higher vacuum (and therefore boils at a lower temperature). The vapors from one body can thus boil the juice in the next one—the steam introduced into the first cell does what is called *multiple-effect evaporation.* The vapor from the last cell goes to a condenser. The syrup leaves the last body continuously with about 65 percent solids and 35 percent water.
- ***Crystallization***
  - Crystallization is the next step that takes place in a single-stage vacuum pan. The syrup is evaporated until saturated with sugar. As soon as the saturation point has been exceeded, small grains of sugar are added to the pan. These small grains, called *seed,* serve as nuclei for the formation of sugar crystals. Additional syrup is added and evaporated so that the original crystals that were formed are allowed to grow in size.
  - The growth of the crystals continues until the pan is full. When sucrose concentration reaches the desired level, the dense mixture of syrup and sugar crystals, called *massecuite,* is discharged into large containers known as crystallizers. Crystallization continues in the crystallizers as the massecuite is slowly stirred and cooled.

- ***Centrifugation***
  - Massecuite from the mixers is allowed to flow into centrifugals, where the thick syrup, or molasses, is separated from the raw sugar by centrifugal force.
  - The high-speed centrifugal action used to separate the massecuite into raw sugar crystals and molasses. A centrifugal machine has a cylindrical basket suspended on a spindle, with perforated sides lined with wire cloth, inside which are metal sheets containing 400 to 600 perforations per square inch.
  - The basket revolves at speeds from 1,000 to 1,800 RPM. The raw sugar is retained in the centrifuge basket because the perforated lining retains the sugar crystals. The mother liquor, or molasses, passes through the lining (due to the centrifugal force exerted). The final molasses *(blackstrap molasses)* containing sucrose, reducing sugars, organic non-sugars, ash, and water, is sent to large storage tanks.
- ***Drying and packaging***
  - Damp sugar crystals are dried by being tumbled through heated air in a granulator. The dry sugar crystals are then sorted by size through vibrating screens and placed into storage bins. Sugar is then sent to be packed in the familiar packaging we see in grocery stores, in bulk packaging, or in liquid form for industrial use.

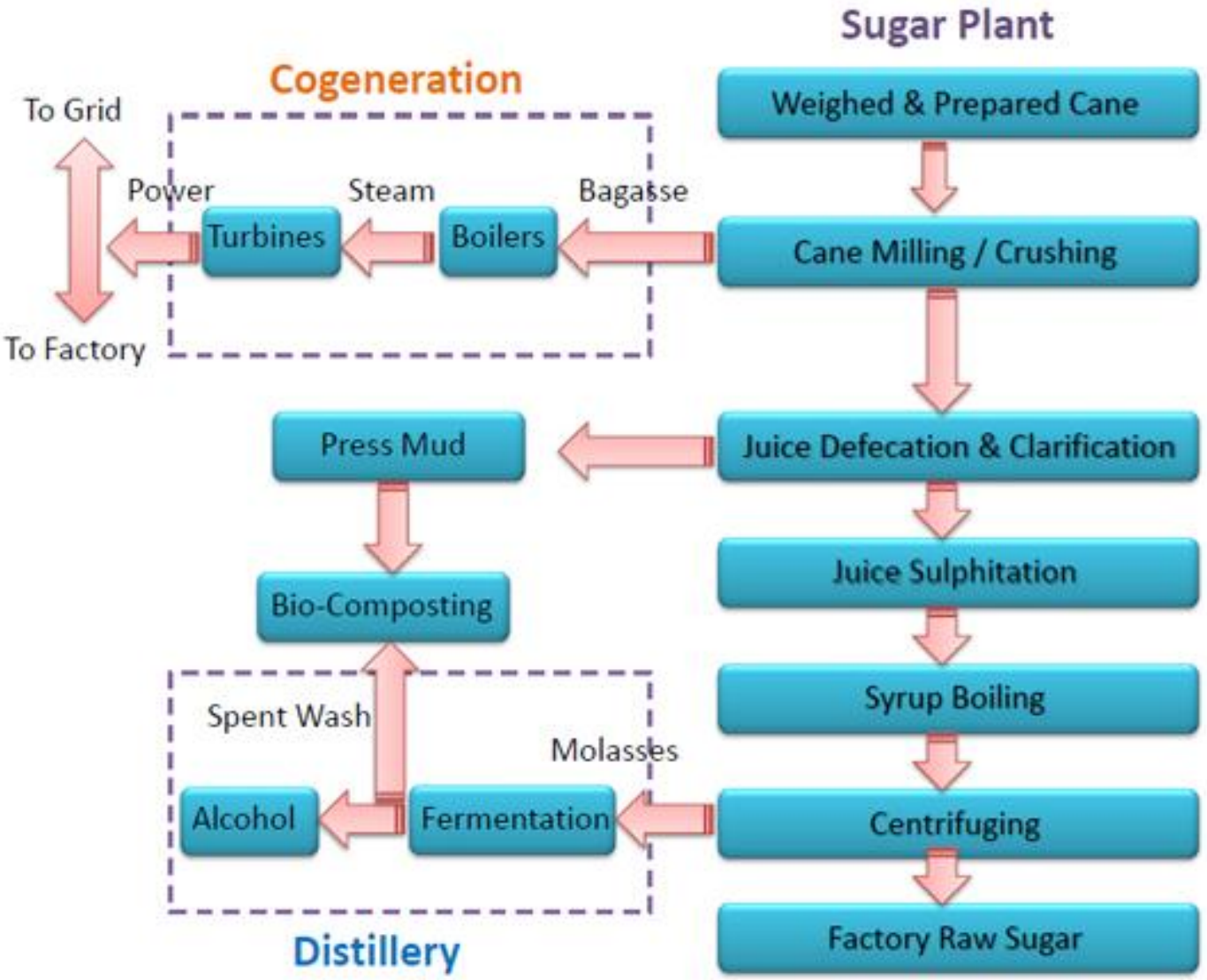
Chemical Systems Technologies
Chemical Systems
An ISO - 9001:2008 Certified Company

- Membrane based process for one-step refinery grade sugar production
- Low cost brine recovery system
- Unique system for filtrate clarification, without recycling to mixed juice
- Patents for sugar/alcohol manufacturing processes

They have strategic alliance with CIBA SPECIALITY CHEMICALS (BASF) and LANXESS (BAYER) for their special products for sugar manufacturing.



Plant Economy



Major engineering problems

- Extraction of juice from cane
  - Optimization : design of rolls, temperature, time of operation
  - Use of ultrasonic vibration
- Choice of flocculation agents
  - High magnesia lime is old but best choice
  - CO_2 in carbonation step : reduce alkalinity ; improved filterability and decolorization
- Evaporation & Crystallization
  - Difficult crystallization, Calendria type evaporators are used
  - Crystallization : batch-wise in 4^{th} or last effect
  - Measurement of supersaturation : boiling point rise, vacuum measurement and control

- **Critical zone of supersaturation**
  - Transition region- pulverized sugar seeds are added and new nuclei are produced at highest point of saturation (graining)
  - Metastable region- degree of supersaturation is reduced by decreasing vacuum and crystal will grow
    - Simultaneous feed liquor addition and evaporation can raise the total quantity of crystal.
- **Separation of crystal from syrup**
  - Improved centrifugal machine design (high speed 1800-2400 rpm)
  - Control of viscosity and surface tension of syrup give clean and rapid separation

- **Inversion of sugar**
  - Acid hydrolysis of sugar in glucose and fructose

$$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$$

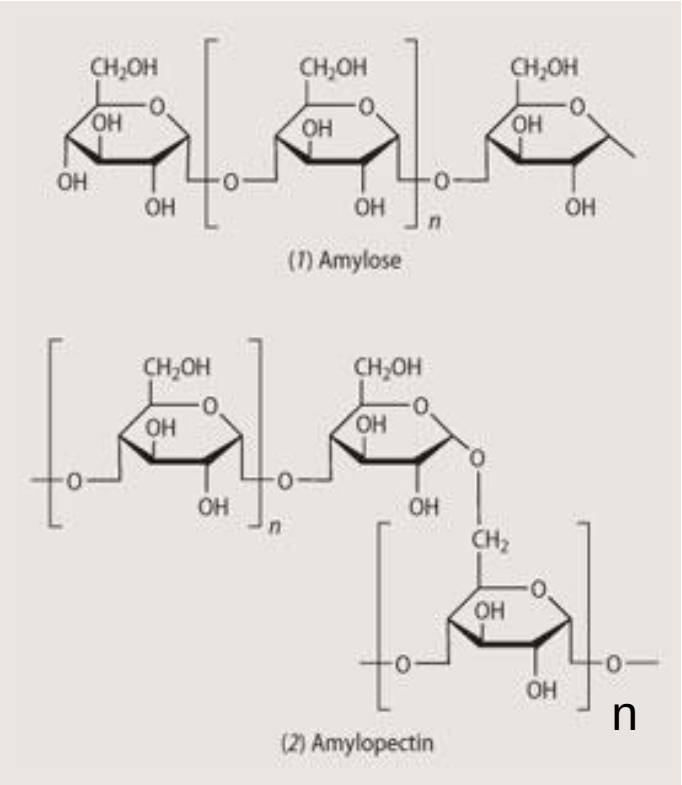
  - The extent of inversion is measured by polarimeter. The non inverted sugar has +97° polarization and completely inverted sugar has -20° polarization.
  - Minimized by : making quick delivery to the sugarcane presses less than 2 days
  - Low temperature – short time conditions : to reduce inversion

Extraction from sugarcane for Gur production

- Low cost product made by simple evaporation process.
- Cane juice extraction → Clarification
- Concentration
  - Occurs in open pan evaporators until (80-85% solidification).
  - The product run out of the bottom of pan.
  - The product is dark brown solidifies paste at room temperature and invert partially to mono-saccarides on storage.
  - It contains neutritionally desirable minerals, particularly iron.

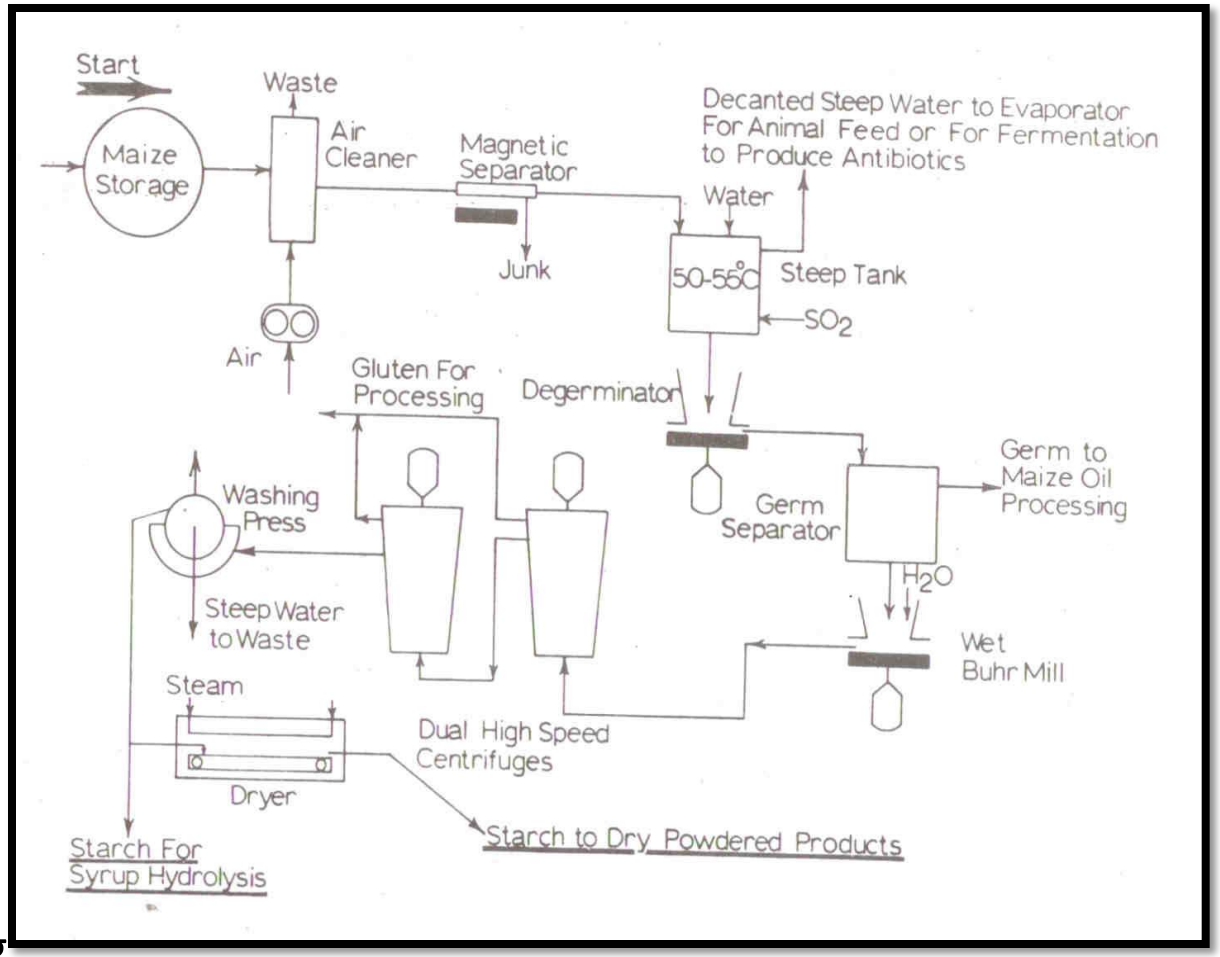
Starch

- High polymer carbohydrate
- Occur in grains and roots in form of granules (3-100 µ)
- Chemical formula : $C_6H_{10}O_5$
- n varies 200-500
- Major source : Maize kernel



Process Description

- Cleaning & screening
- Steeping
- Coarse grinding & degermination
- Fine grinding & extraction
- Gluten separation
- Starch refining
- Dehydration & drying



Manufacture of Ethanol from Molasses

- Ethanol is a volatile, flammable, clear, colorless liquid.
- A good solvent. It is also used as a germicide, beverage, antifreeze, fuel, depressant and chemical intermediate.
  - Molecular formula- C_2H_5OH
  - Molecular weight- 46.07
  - Density- 0.791 at 20˚C
  - Boiling Point- 78.3˚C
- It can be made by the fermentation process of material that contains sugar or from the compound which can be converted to sugar.

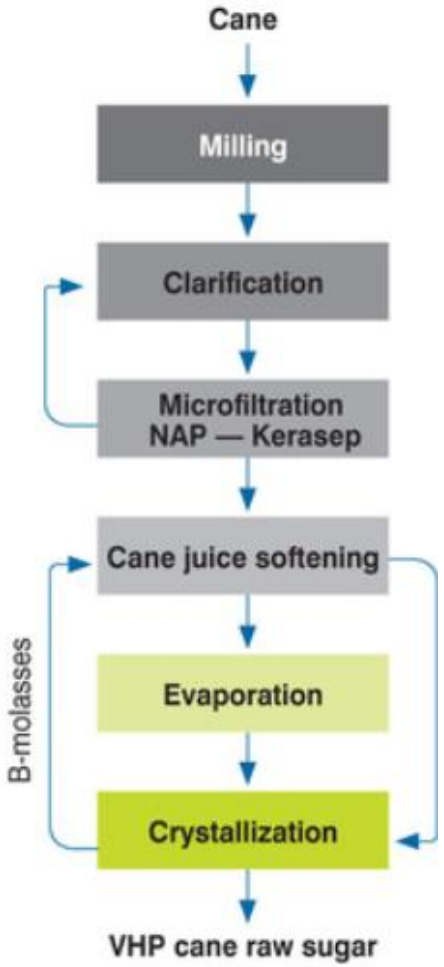
PRODUCE VHP SUGAR WITHOUT SULFITATION

Novasep has developed **NAP** microfiltration processes (**New Applexion® Processes**), which allows you to produce a higher quality sugar directly at your mill.

The NAP microfiltration of clarified cane juice, combined with both cane juice softening and **crystallization**, enables you to produce "**NAP sugar**" or VHP (Very High Polarization) cane raw sugar, without sulfitation:

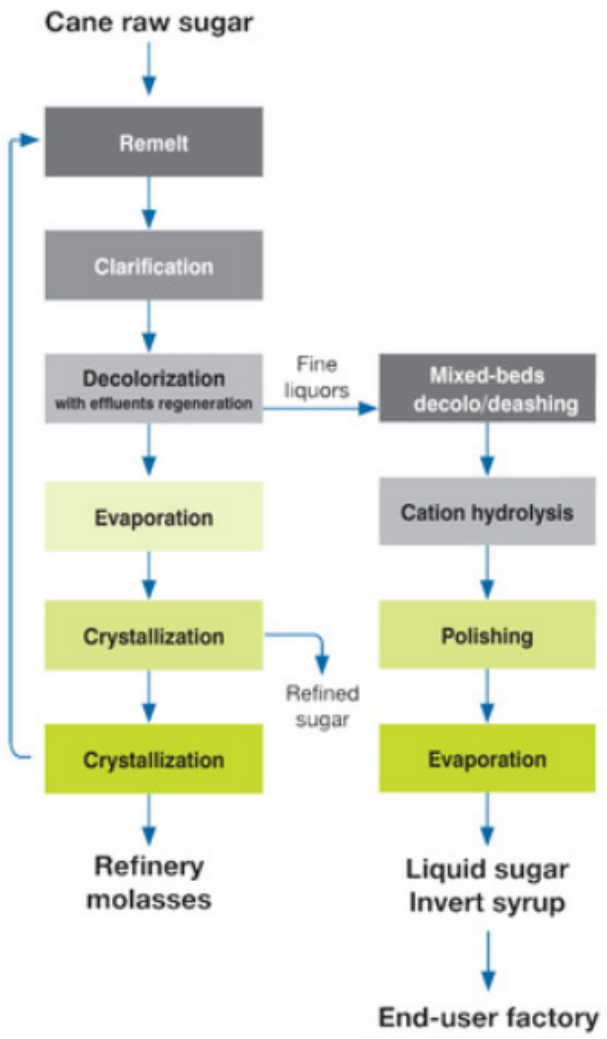
- **40% less color**
- **55% less ash**
- **20% higher crystallization speed**

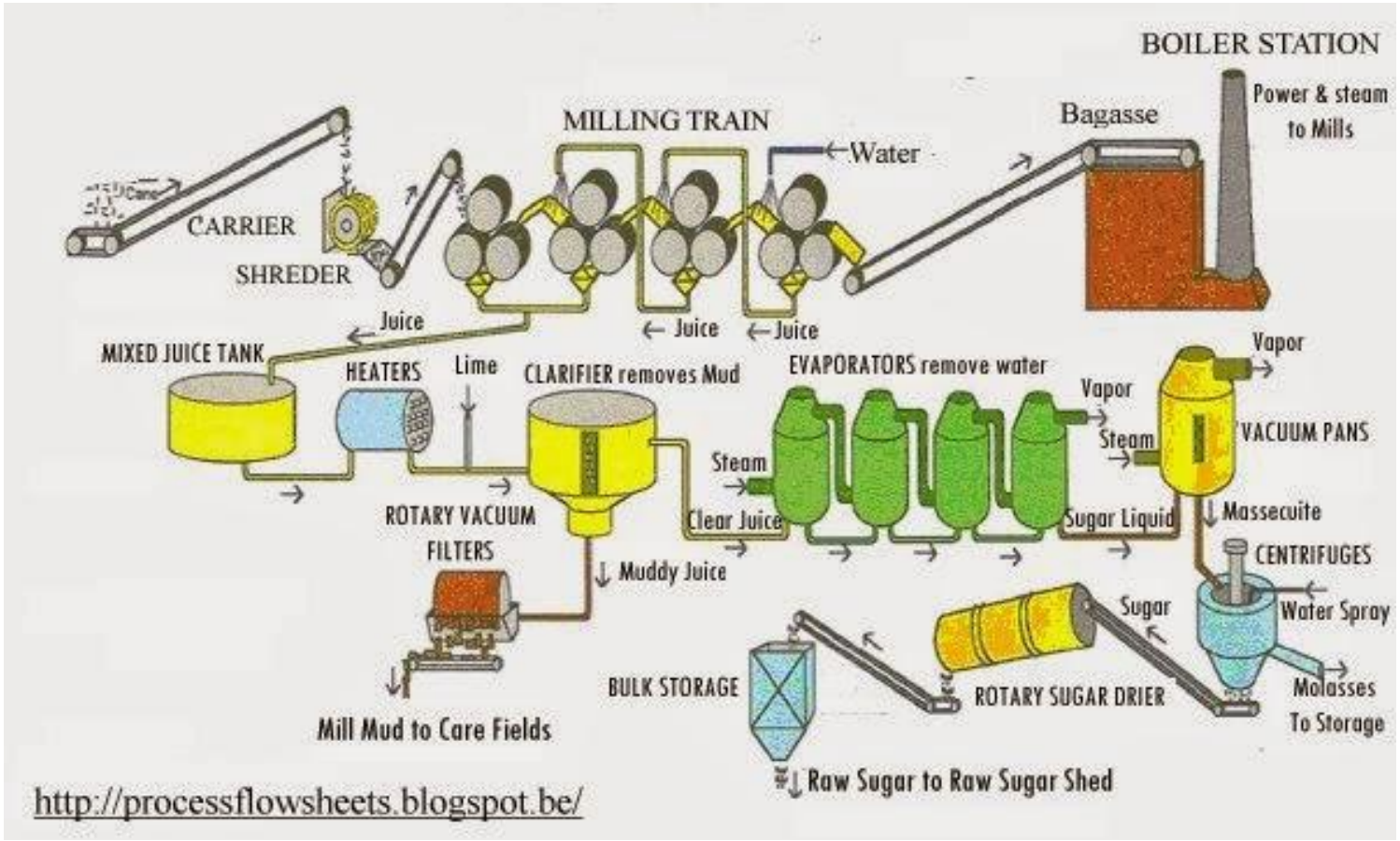
With microfiltered and softened cane juice, **evaporators** consume less energy and more bagasse is available for co-generation.



- Nanofiltration Brine Recovery System: **reduces by 30% the resin regeneration cost**
- Atmospheric Pre-Concentration System: uses low calories hot water which enables a **costs reduction of resin regeneration up to 50%**
- Brine Evaporator System: **reduces drastically NaCl consumption and regeneration effluents**

With no less than 40 000 tons of refined sugar produced every day using Novasep technology, trust




BOILER STATION
Power & steam to Mills
Bagasse
MILLING TRAIN
Water
CARRIER
SHREDER
Juice
Juice
Juice
MIXED JUICE TANK
HEATERS
Lime
CLARIFIER removes Mud
EVAPORATORS remove water
Vapor
Vapor
Steam
VACUUM PANS
Steam
Clear Juice
Sugar Liquid
Massecuite
ROTARY VACUUM FILTERS
Muddy Juice
CENTRIFUGES
Water Spray
Sugar
BULK STORAGE
ROTARY SUGAR DRIER
Molasses To Storage
Mill Mud to Care Fields
Raw Sugar to Raw Sugar Shed
http://processflowsheets.blogspot.be/