Renewable Energy

Seventh lecture Asst prof. Dr. Rudainah Ali

Photosynthesis is the making (synthesis) of organic structures and chemical energy stores by the action of solar radiation. It is by far the most important renewable energy process, because living organisms are made from material fixed by hotosynthesis, and our activities rely on photo synthetically produced oxygen with which the solar energy is mostly stored. Photosynthesis occurs in both land-based and marine plants, thereby influencing the concentration of CO2 in our Earth's atmosphere and consequently the greenhouse effect .

However, applications of bioenergy mainly involve terrestrial biomass. Photosynthesis on land stores energy at a rate of about 0.8 × 1014 W (i.e. about 10 kW per person; . As biomass decays or combusts, the stored energy is released from reactions with oxygen. This is the energy equivalent of the power output of about a million large nuclear power stations and is about four times the present total commercial energy use by mankind.

Virtually all terrestrial photosynthesis occurs in the leaves of living plants. Solar radiation causes electrons to be excited in a key part of these leaves (the chloroplast), which through a complex series of chemical processes outlined in to, leads to the production of oxygen and carbon-based structural material. These chemical processes are sensitive to the temperature of the leaf, so plants have evolved to ensure that some solar radiation is reflected or transmitted, rather than absorbed (which is why leaves are seldom black). The role of water transpiration in both the chemical reactions and the temperature control is an integrated aspect of the process.

The energy processes in photosynthesis depend on the photons (energy packets) of the solar radiation, each of energy $h\nu$, where h is Planck's constant and ν is the frequency of the radiation. The organic material produced is mainly carbohydrate (e.g. cellulose, which is long-chain polymer of glucose $C_6H_{12}O_6$). If this (dry) material is burnt in oxygen, the heat released is about 16 MJ/kg (4.8 eV per carbon atom, 460 kJ per mole of carbon). The fixation of one carbon atom from atmospheric CO_2 to carbohydrate proceeds by a series of stages in green plants, including algae:

1- Reactions in light: the solar photons excite and separate electrons and protons in hydrogen atoms of water, with O_2 as an important byproduct and with electrons excited in two stages to produce strong reducing chemicals.

2 -Reactions not requiring light (called 'dark' reactions, but occurring at any time): the reducing chemicals from (1) reduce CO_2 to carbohydrates, proteins and fats.

In the overall chemical equations (1) and (2), the oxygen atoms initially in CO2 and H2O are distinguished; the latter being shown with a dot over the O. Thus, combining both the light and dark reactions and

neglecting many intermediate steps:

$CO + 2H_2O \xrightarrow{\text{Light}} O_2 + [CH_2O] + H_2O$ ---------------[1]

where the products have about 4.8 eV per C atom more enthalpy (energy production potential) than the initial material because of the absorption of at least eight photons. Here [CH2O] represents a basic unit of carbohydrate, so the reaction for sucrose production is:

$12CO_2 + 24H_2O \longrightarrow 12\,O_2 + C_{12}H_{22}O_{11} + 13H_2O$

There is extensive variety in all aspects of photosynthesis, from the scale of plants down to molecular level. However, the end result is that energy from the Sun is stored in stable chemicals for later use – a principal goal of renewable energy technology, yet happening all around us

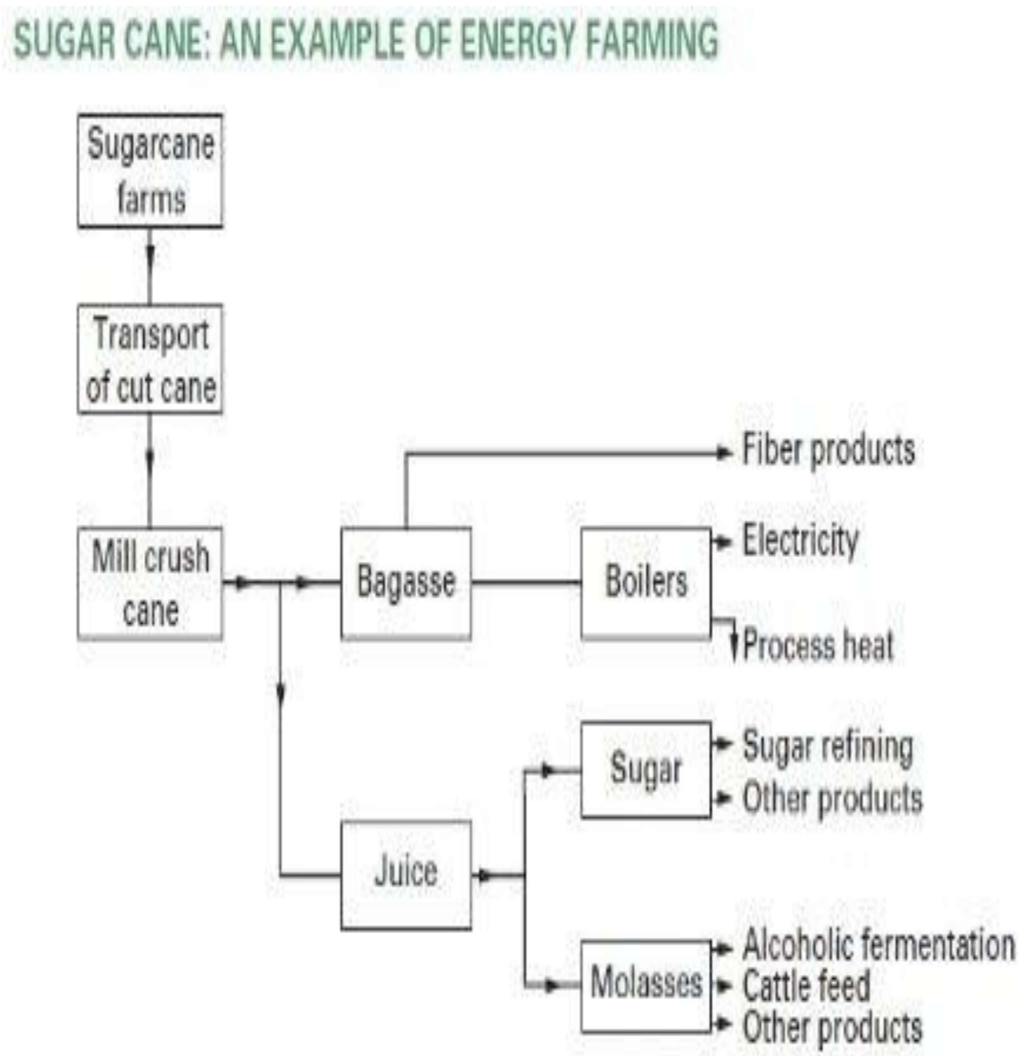
The flow-diagram shown in Fig. 9.1 indicates how a single crop (sugar cane) may be processed for both energy supplies and a wide range of products with no other inputs than just the locally grown cane. The cane stems, about 3 m long by 5 cm diameter, are harvested and then transported in bulk, either by lorries or on a light railway laid over the surrounding fields, to a central mill. Here, steam-powered rollers crush the cane to extract the juice as the main initial product. The juices pass principally for sugar extraction, with the residue (molasses): (a) used directly for cattle feed; (b) fermented on site to ethanol for spark-ignition vehicle biofuel, and (c)̓€used in pharmaceutical and other specialist chemicals. The cane's

fibrous residue from the rollers (bagasse) is burnt in boilers to raise steam to generate electricity and supplying heat for mill processes (notably boiling the juice to extract the solid sugar). Surplus bagasse is pressed with binder to make fiberboard for building construction. The boiler ash becomes a phosphaterich fertilizer. With modern efficient machinery there should be excess electricity generation for sale to̓€the utility distribution grid

Energy farming has advantages and disadvantages . A major disadvantage is that energy crops may substitute for human food production. For example, US grain farms grow about 40% of the world's maize (corn) crop and traditionally export about one-third of this for food, so that diverting maize corn to ethanol production as a US petroleum additive with no substitute action reduces a global food resource. second major disadvantage is that the totality of both intense food and biofuel production in intensive farming may lead to soil infertility and erosion. Strategies to avoid such disadvantages regarding energy crops include:

(a) use energy more efficiently; (b) grow plants that can supply both human foods (e.g. grain) and energy from the waste products (e.g. straw); (c) do not burn

(b) residue biomass in the field, and (d) decrease feeding human food crops to animals.



Geothermal energy

The inner core of the Earth reaches a maximum temperature of about 4000ºC, with the outward heat flow maintained predominantly by natural radioactive decay of certain dispersed elements (e.g. uranium, thorium and certain isotopes of otassium). Heat passes out through

There are three main uses of geothermal energy, as listed below in the order of decreasing thermodynamic quality, which happens also to be the order of their increasing geographical availability.

1- Electricity generation. At a few locations geothermal heat is Â.available at temperatures of more than 150ºC, as a natural flow of high-. pressure water and/or steam, so having the potential for electrical power Â.production from turbines. Several geothermal electric power
2- Hot water supply. In many more locations, geothermal heat is available at ~50 to 70°C
3- Heat pumps. Heat at ambient temperature from near-surface ground (to depths of usually about 3 m), or from rivers and lakes, is input to electrical-powered heat pumps, which provide heat to buildings at increased temperature. The systems are often called ‘geothermal’, although the input heat arises from soil heated by sunshine and ambient air. Note