Energy production

Biopower

The technologies used to obtain energy (biopower) from different types of biomass are different and the resulting energy products are different too.
Biopower technologies convert renewable fuels of biomass into heat and electricity by using equipment, which is similar to the one used for fossil fuels.
An advantageous characteristic of biomass is its availability, as it is able to keep its energy intact until it is used.
Briefly, thermo-chemical conversion processes of biomass are based on the action of heat that activates the chemical reactions needed to transform the matter into energy and can be used for those cellulose and wood residues whose C/N ratio is over 30 and the humidity content is lower than 30%.
The biomass that is more suitable to be subject to thermo-chemical conversion are wood and all its derivates (sawdust, wood shavings, etc), the most common wood-cellulose by-products (cereal straw, grapevine pruning residues, fruit trees pruning residues, etc) and some processing waste (husks, chaff, stones, etc).
Bio-chemical processes: bio-chemical conversion processes allow to obtain energy throughout a chemical reaction that takes place thanks to the contribution of enzymes, mushrooms and micro-organisms, that form in the biomass under particular conditions, and are used for that biomass whose carbon/nitrogen ratio is lower than 30 and humidity at collection is higher than 30%. The following products are appropriate for chemical conversion: aquatic breeding, some cultivation by-products (leaves, sugar-beet stems, vegetables, potatoes, etc.), liquid residues of zoo-technical industry and some processing waste (residues of alcohol processing made of grains, vegetation water, etc.), and some types of urban and industrial waste water.
The technologies that are currently used in the biopower sector are: cofiring, pyrolisis, gasification, combustion, “small modular” systems, aerobic digestion, anaerobic digestion, and carbonization.

Gasification

At present, in terms of biomass, “gasification”, which is a thermo-chemical process, is considered as one of the best and most promising technologies to produce electric energy: both as far as efficiency and environmental impact are concerned.
Each plant is subdivided into three sections, where three stages of the productive process are carried out: gasification, gas turbine and thermal cycle. During gasification, the wet biomass is conveyed into a drier making excess water evaporate. After being dried, biomass proceeds to the gasifier, where it is transformed in a synthetic gas composed of molecular nitrogen (N2), steam (H2O), carbon monoxide (CO), carbon dioxide (C2), molecular hydrogen (H2), methane (CH4) and a small fraction of heavier hydrocarbons.
Then the synthetic gas is cooled and filtered to eliminate dust, contaminants (cyanic acid, ammonia and hydrogen chloride) and organic compounds (phenols and fatty acids).
After being compressed, it is ready to operate the gas turbine where it will be burnt to heat the air to be conveyed to the thermal cycle. In the last section of the plant a boiler recovers the heat contained in the air coming from the gas turbine and produces steam for another turbine, which will operate the electric current generator.

Cofing

In order to optimise coal plants, it is possible to use biomass as complementary to coal. This is surely one of the cheapest solutions among the energy options offered by renewable sources. The cofiring is based on the replacement of a portion of coal with biomass to be used in the same boiler located in the already existing plant. This can be done by mixing biomass with coal before the fuel is introduced into the boiler or using separate feeding systems for coal and biomass. According to the type of boiler and the feeding system used, the biomass can replace up to 15% of coal in this

cofiring operation.

Pyrolysis

Pyrolysis is the thermo-chemical decomposition of organic materials that is obtained through heat application, at a temperature between 400 and 800°C, in complete absence of any oxidizing agents, or with a very reduced quantity of oxygen (in this case it can be described as a partial gasification). The products of pyrolysis can be gaseous, liquid, solid and their proportions depend on the pyrolysis method (fast, slow or conventional) and reaction parameters. One of the main problems linked to the production of energy through pyrolysis is the quality of the products, which has not reached an adequate level in its applications, neither with gas turbines nor diesel engines. For the future, the cycles with pyrolytic oil seem to be more promising, especially for large installations, while diesel engines, that use pyrolysis products, seem to be more suitable for small installations.
Direct combustion generally occurs inside equipment (boilers), where the heat is exchanged between combustion gases and process fluids (water, etc.).

Combustion

The combustion of products and agricultural residues has good results if substances rich in structured glucides (cellulose and lignin) and with a water content of less than 35% are used as fuels. The products that can be used are the following: wood in all its forms, cereal straws, residues of dry legumes, residues of oleaginous plants (castor-oil plant, etc.), residues of textile fibre plants (cotton, hemp, etc), wooden residues deriving from the pruning of fruit and forest plants, residues of the agro-food industry.

"Small-modular" systems

These systems could potentially satisfy the energy need of 2.5 billion people that have no electric energy. This capacity is due to the fact that most of these people live in areas where large quantities of biomass can be used as fuel. A small system with a capacity of 5 megawatts could be an excellent solution in villages. Small systems have a potential market also in industrialized countries, as they could be used as a complementary energy supply. Compared to fossil fuel systems, they are a more acceptable alternative also from the environmental point of view.

Carbonization

Carbonization is a thermo-chemical process that allows to transform structured molecules of wood and cellulose products into coal (wood coal or vegetal coal). Carbonization is obtained through the elimination of water and volatile substances from the vegetal matter, due to the action of heat in charcoal pile (cone-shaped wood piles, covered with earth, with a central outlet channel (chimney), where a slow wood combustion takes place, turning the wood into coal). Carbonization occurs outdoors, or in long and curved-neck containers, with a flask shape, that offer a higher coal yield.

Anaerobic digestion

It is a biochemical conversion process that occurs in the absence of oxygen and consists of the demolition, by micro-organisms, of complex organic substances (lipids, proteins, glucides) contained in vegetal and animal by-products, which produces a gas (biogas) made of methane (50-70%) and the rest is mainly CO2 and has an average calorific value of 23,000 kilojoules per cubic metre. The resulting biogas is collected, dried, compressed and stored, and can be used as a fuel to feed gas boilers and produce heat (also coupled with turbines for the production of electric energy), or to feed combined-cycle plants, or internal combustion motors (boat engines with a low number of turns are suitable for this). At the end of the effluent fermentation process the main nutritional elements that were already present in the raw material are kept intact (nitrogen, phosphorus, potassium), by favouring the mineralization of organic nitrogen. The effluent results to be an excellent fertilizer. Anaerobic digestion plants can be fed through residues with a high humidity content, like animal faeces, civil waste (waste water), food waste and the organic fraction of urban solid waste.
However, also in those dumps that are suitably equipped for the collection of biogas, only 40% of the gas produced can

be collected, while the remaining part is dispersed into the atmosphere. As the methane, that largely composes biogas, is a greenhouse gas with an effect that is twenty times as high as CO2 , emissions of biogas into the atmosphere are not desirable. When the decomposition of organic waste is obtained through anaerobic digestion of (closed) adequate plant digestors, almost all the gas is collected and used as a fuel.
The recovery of the biogas from dumps is a system that has been experimentally adopted in various countries (England has developed an efficient system of biogas recovery from dumps, both for thermal and electric aims).
In Sweden, there are biogas refuelling stations that supply methane vehicles.

Aerobic digestion

It is the metabolization of organic substances through micro-organisms, whose development depends on the presence of oxygen. These bacteria convert complex substances into simple ones, releasing CO2 and H2O and highly warming up the substrate, according to their methabolic activity. The resulting heat can then be trasferred outside, through fluid heat exchangers. In Europe the aerobic digestion system is used to treat waste waters. More recently, this technology has spread to Canada and the United States.