Biomass knowledge

What is it?

The vegetation that covers our planet is a natural storage of solar energy. The organic matter composing it is called biomass.
Biomass is produced through the photosynthesis process, when carbon dioxide from the atmosphere combines with underground water to produce sugars, starch, cellulose, lignin, protein substances, fats, etc. The same solar energy that activated the photosynthesis is contained in the chemical bonds of these substances. In this way 2×10^{11} tons of carbon are fixed each year, with a corresponding energy content of 70×10^{3} megatons of oil.
By burning biomass, atmospheric oxygen combines with the carbon contained in the biomass, freeing carbon dioxide and water, and producing heat. Carbon dioxide goes back into the atmosphere and is ready to be re-used in the photosynthesis process to produce new biomass. Therefore biomass is a renewable resource.
The term biomass indicates several types of products: agricultural and forest residues, waste of wood processing industry (wood shavings, sawdust, etc.), waste of the zoo-technical industry, agricultural and food residues (residues of crops for the production of human and animal food (straw), “energy cultures” aimed at the production of fuel, and organic biomass from other sources, such as the green fraction of solid urban waste and other types of heterogeneous industrial waste.

What is for?

In The main applications of biomass are: energy production (biopower), fuel synthesis (biofuel) and product synthesis (bioproduct).
In the energy field, wood and cellulose biomass (wood and by-products of grass, tree and forest cultivation) is mainly used as multi-purpose fuel: household heating, to produce electric energy and industrial uses.
Other sectors affected by the processing of this raw material are: the sectors of paper, cellulose, particle-board, compounds, animal food and chemical products.
“Energy culture”, i.e. the cultivation of vegetal species growing rapidly, are generally used in the production of bio-fuels. For example, the processing of organic matter of plants producing vegetal oil and sugars (sunflower, sugar sorghum and beetroot) are the raw material of bio-ethanol, which can be used as an additive for petrol and bio-diesel, that is a mixture similar to gas-oil.
Bio-fuels, as well as producing heat and/or electric power, can be used as a car propeller, both mixed with other fuels or pure.

Where is it?

Biomass is one of the most available renewable energy sources on our planet. In 2011 biomass satisfies around 10% of the primary energy use of the world (*International Energy Agency Key World Energy Statistics 2013*). Nevertheless, its use is not shared in a homogeneous way. In developing countries, biomass covers from 34 to 40% of the total energy need. On the other hand, in industrialised countries its contribution is very limited and biomass only amount to 3% of primary energy use. In particular, the United States obtain 3.2% of their energy from biomass, Europe obtains a total of 3.5% of its energy from biomass. In Sweden and Finland, the electric energy obtained by burning the waste of the forest industry satisfies respectively 17% and 15% of the domestic demand for electric energy. In Austria, biomass cover 13% of the domestic electric need. Instead, the contribution of biomass to the Italian national balance is limited to 2-3%. That distribution does not only take into account the attention and economic effort shown by certain countries in terms of search for and development of new technologies, but also the actual availability of land where “energy cultures” are to be implemented. Estimates show that, in developed countries, replacing fossil fuels with biomass would require over 950 mega-hectares (millions of hectares) of land available to be devoted to energy cultures. The countries in the northern-

central Europe are extremely developed as far as the use of biomass as energy source is concerned. They have installed large co-generation (joint production of electric energy and heat) and biomass-supplied district heating plants. France, that has the widest agricultural surface in Europe, invests a lot in the production of bio-diesel and ethanol, for which a de-taxation policy has been adopted. The UK, instead, has developed limited production of bio-fuels, which are currently considered as too expensive, and has dedicated to the development of a large and efficient system for the recovery of biogas from dumps, both for thermal and electric aims. Sweden and Austria, that boast a long tradition of firewood, have continued to increase the use of firewood for heating and district heating, encouraging the growth of copses (willow tree, poplars), that provide a yield that is 3-4 times higher than the average supply of these raw materials.

A bit of history

Fire, unquestionably the most important discovery in the history of mankind, was discovered thanks to the accidental combustion of wood. Fire has illuminated, heated, protected and fed mankind for thousands of years. Briefly, fired fostered the birth of civilisation.

Wood, on the other hand, remained the most widely used raw material for many centuries, not only to burn fires, but also as building material. The invention of the steam engine allowed mankind to obtain mechanic energy from the combustion of wood, whereas up to the 18th century wind and water where the only mechanic energy sources available, thanks to wind and water mills.

During the Industrial Revolution wood started to become scarce owing to the massive deforestation carried out to produce energy. Mankind had to look for alternative energy sources and found them in coal and oil, which at the time were abundant albeit not renewable.

Only recently, energy need and the possible disappearance of fossil fuels and the pollution produced by the combustion led man to “re-discover” the usefulness of wood and biomass as energy sources.

Biochemical processes

Biochemical processes work thanks to the action of fungi and bacteria that grow in the biomass in specific conditions of temperature and humidity. These micro-organisms digest organic matter freeing molecules that are waste (for them) but precious for us. Not all biomasses are suitable for these processes: fungi and bacteria do not eat absolutely everything but necessitate organic matter rich in proteins and water. Seaweeds, rejects from the cultivation of potatoes and beets, food waste and animal faeces are very good.

The main products that can be obtained with these methods are biogas, bioethanol, fertilizers for agriculture and heat. Biogas is a mixture of gases, predominantly methane (50-70%) and carbon dioxide, which can be used for heating purposes or to make some particular plants allocated to the production of electrical energy work.

Bioethanol is an alcohol that can be used as car fuel. It is obtained from the fermentation of the sugars of beets and sugar cane. It is a fuel of great interest because it is clean and cheap. It has been calculated that 11 million tonnes of bioethanol are produced annually, especially in U.S.A. and Brazil.

Another interesting application of biomass is for heating animal farms and cultivations. The decomposition of waste products, like leaves or animal faeces, produce heat that can be used to warm up greenhouses and stables.

Thermochemical processes

It is well known that to light and feed a fire you need materials that burn and these, in technical terms, are known as fuel. Fuel alone is not enough for a fire to burn, another element is required: the combustive agent. The most common combustive agent is oxygen, which, in a combustion reaction, has the task of “oxidizing” the fuel, with the consequent release of energy in the form of heat and light. Fire therefore is simply the visible manifestation of a chemical reaction, combustion, that takes place between two different substances: the fuel and the combustive agent. There are numerous combustible substances and materials. Initially man burnt wood, then coal. Today the most common fuels are the fossil fuels: petroleum, methane gas and coal or fossilized carbon.

Combustion is the most ancient method to obtain energy from the biomass. Antique fireplaces, chimneys and stoves

have now been replaced by modern and efficient heaters that are able to exploit the hidden energy of wood and its derivatives. Fungi and bacteria prefer humid protein substances, but fire feeds best on dry materials that are rich in cellulose. Cellulose is a complex molecule. It is very resistant and consists of long glucose chains, the most simple of sugars. Plants are made of cellulose, so are wood, leaves, paper and cotton. There are various systems to obtain energy from wood, that are classified according to the combustion temperature and the type of physical and chemical transformation that is obtained. Firstly it must be pointed out that these systems use crushed wood. The chips of wood can be used just as they are, or compacted in small blocks or pellets. Wood pellets increase the efficiency of the heaters and leave them cleaner. Wood transformed in this way can be burnt at extremely high temperatures (about 1000°C), and it turns into a mixture of gases that can move turbines and produce electric power. When it is burnt at lower temperatures, (from 400 to 800°C) wood separates into gases, liquids and solids. The solid component, coal, can still be used as a fuel, and the liquid component, pyrolysis oil can be used as a fuel for engines or can be used as the base in the synthesis of other products.