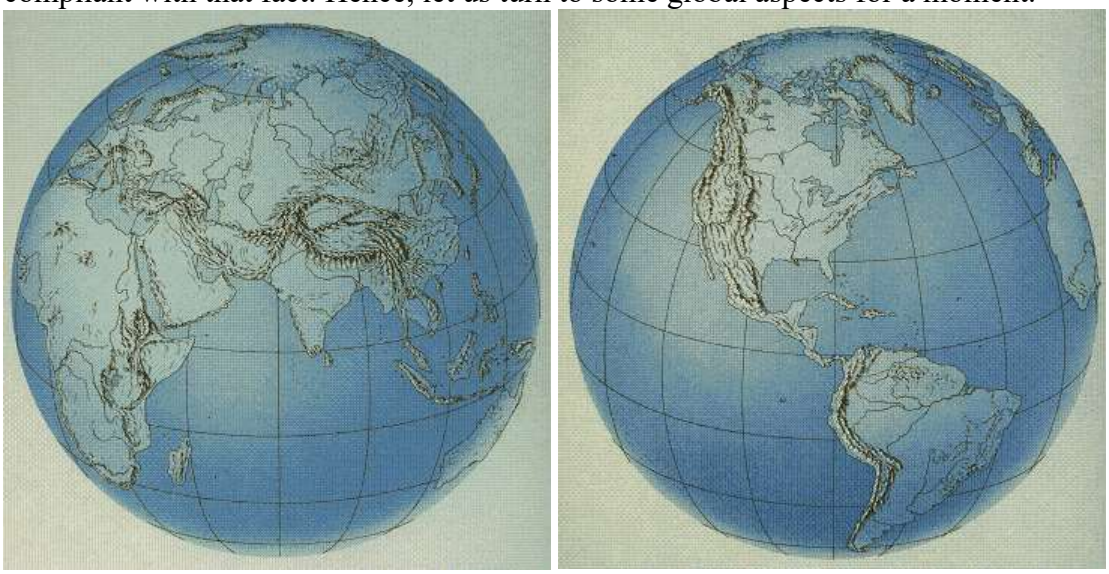
00-00: A little about biomass and the limitations…

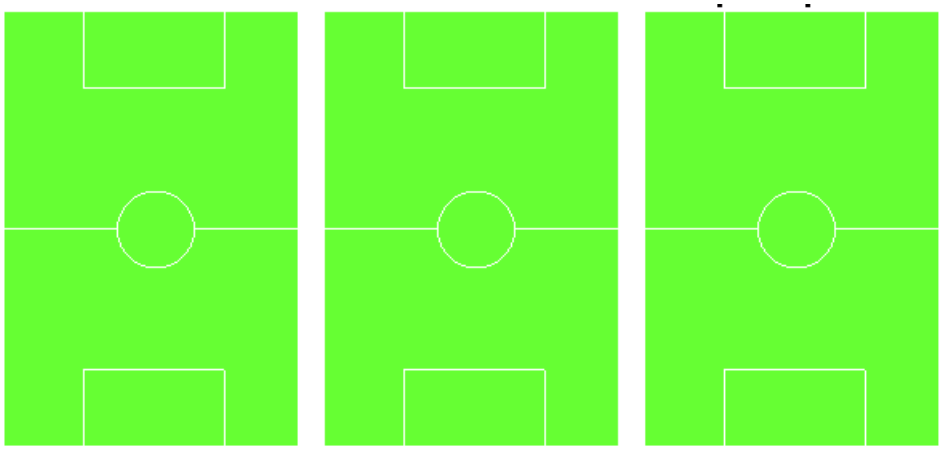
One very common misunderstanding when planning a biofuel-based energy system – even if it be a small scale and local system – is to forget the global aspect and concentrate only on local conditions. However, it must always be remembered that the local community – small as it may be – is a part of the world and that a sustainable energy system must always be compliant with that fact. Hence, let us turn to some global aspects for a moment.



The simplest starting point is to view our planet as a sphere with a circumference of 40000 km. From that assumption, it takes only the simplest math from secondary school to compute the total surface area – which becomes approximately 500 million square km. Now again return to school and remind yourself that approximately 70% of the earths' surface is covered with water – seas and major lakes. Hence the land area is approximately 150 million square km. Now divide this number by the number of people on this planet – a bit more than 7 000 million people, and you will find that the land area available to each of us is about 20 000 square meters which is just below 3 football fields. One football field is assumed as 100x70 m^2. So a bit less than three football fields is what every human being has as her "rightful share" of the land of this planet.

This is another world map than the one above

Splitting the world land area equal between us yields about three football fields per person



The next part of this exercise is more difficult, but if you go into encyclopaedias and databases, you'll be able to verify that the three football fields – still assuming that everybody has the "right" to an equal share – consist of about 0.85 football field of infertile land, about 0.85 football field of forested land, about 0.85 football field of dry grassland, about 0.3 football fields of rich grassland (good enough for grazing, that is) and, finally, about 0.15 football fields or arable land, arable without artificial irrigation. We will use "biomes" for these types of land: arable land, rich grassland, savannah, forest and infertile.

These are hard facts and cannot be denied. The change of the global climate will affect the distribution and may increase – or decrease – the amount of each biome – but it will not change the size of the planet. Rather, the three football fields are rapidly shrinking because of the population growth.

You will realize that this view of the world is extremely simplified – but it serves it purpose to illustrate in a simple way what "sustainability" is about: The first step towards a sustainable development is to adopt our use of resources and our use of natural resources to what our planet really has to offer. This puts a strict upper limit to how much biofuel is available. But it also puts focus on the qualities of biofuel attainable – unless we prefer to compete with agriculture about the 0.15 football fields.

Viewing the biomes – bottom-up

Provided we want to avoid competition with the production of food and fibre, the biofuel fractions available are by-products from agriculture and from food and fibre processing, it's by-products from silviculture and from forest industry and it's by-products (i.e. organic waste fractions) from society.

The use of fertile, agricultural land solely for energy farming is obviously not sustainable in a world where the ration of such land per person is already only about 0.15 football fields and shrinking.

One should be careful not to regard the available fractions as "waste", because the word waste tends to suggest that these fractions are worthless – but they are not:

- Corn production yields straw as a by-product. This straw may be ploughed down as a green fertilizer, it may be dried and used as bedding or it may be dried and used as a fuel. Whichever use the straw finds – it is not worthless.
- Beef production yields manure as a by-product. The manure can be used directly as a fertilizer or it can first be used for biogas production and then the solid residue after the biogas process, the solid residue will still contain the nutrients, can be used as a fertilizer. Whichever use the manure finds – it is not worthless.
- Maize production yields stalks and leaves as a by-product. These are often left in the field and ploughed down as a green fertilizer but the leaves can also be removed and sold for basketry or similar. Or stalks and leaves can be dried and user for fuel. Whichever use the stalks and leaves may find – they are not worthless.
- Cotton production yields mainly stalks as a by-product. Again, these are often left in the field and ploughed down as a green fertilizer or they can be used for paper. But in this case, there is also a subsequent processing industry – the weaving industry – where cotton spills are produced as a by-product. Again, the stalks can be dried and used for fuel while

the cotton spills are already dry and make up an excellent fuel as they are. Whichever use the stalks and spills may find – they are not worthless.

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Over the millennia, farmers have found use for the by-products from agriculture for bedding, cattle food supplements, green fertilizer… and it must be understood that any alternate use of the by-products for energy purposes will initially be regarded with suspicion. So any use of agricultural by-products for fuel and energy purposes must be carefully prepared to avoid negative reactions and it must be understood and respected that the farming community rests upon a solid base of experience collected over more than a hundred generations. Hence, if the by-products find a new market, the farmer has to find a replacement and the price of the by-product to the energy company/fuel retailer will have to cover the cost for the replacement with the farmer. Finally, the farming community is proud, well aware that they are the ones producing the food we all eat and the clothes we all wear.

The rich grassland – comprising approximately 0.3 football fields per person – is mainly used for grazing as the global situation is today. The main by-product from grazing cattle is manure, which is an excellent basis for biogas production and which has already been mentioned. If competition with cattle breeding can be accepted, this land might lend itself well for miscanthus cultivation. The reason that the rich grassland is not arable may be lack of sunlight, lack of water or lack of nutrients.

The poor, in a global perspective dry grassland, amounts to approximately 0.85 football fields per person. In Europe, this is often used as a common for sheep grazing or for goats. This land is typically too dry for any cultivation and the by-products from animals living on this poor land are too meagre to represent any value from an energy point of view.

Forest land – boreal forest in northern Europe, temperate forest in Continental Europe – is the biome that has the greatest potential by far with respect to energy. At a forest felling site, typically 10-50 % of the stem mass is left in the form of brash, branches and treetops, depending on the species at hand. Also in subsequent processing – saw-mills, joineries – are by-products such as sawdust, cutter shavings and cut-offs produced. Sawn planks typically represent only about 50 % of the mass of the original stem wood – the remaining 50 % being found in sawdust and in shavings. To this comes then the brash that is commonly left at the felling site and that may be collected and used for energy. Also the forest represents one of the main biomes – 0.85 football fields per person.

Infertile land – the last one of the major biomes – is obviously useless for any type of biofuel production.

Organic fractions in societal waste consist of several different fractions, but disregarding household wastes one might identify trimmings from parks and from gardens as one major fraction easy to distinguish and scrapings from schools, restaurants and hospitals as the second one. The first of these fractions may be an excellent fuel as it is while the second fraction may be an excellent substrate for biogas production, possibly integrated with the municipal wastewater treatment plant.

To summarize, we have now found the following:
From the agricultural sector as a whole, there are three main types of energy materials:

1. Herbaceous crops or herbaceous parts of crops such as miscanthus, straw, cotton stalks, maize leaves and alike. These are all solid and dry, or can easily be dried in open air and may be used as a fuel.
2. Process industry residues and spills such as cotton spills, flax or other fibrous residues. Again this fraction is solid and dry.
3. Manure, chicken droppings and alike. This is extremely wet biomass that lends itself best for anaerobic digestion and for biogas production.

But the main resource by far is forest fuels and wood residuals.