# Electricity from sweet sorghum

Pieternel Claassen

Aim of the workshop: To estimate the number of Italian households that can obtain their electricity from sweet sorghum grown in Italy.

Background information:

The application of fuel cells is gaining an increasing interest in the world of energy production. The advantages of fuel cells are clear: the energy conversion is more efficient as compared to traditional energy conversion systems and emission is zero. However, when the feedstock for fuel cells, hydrogen, is derived from fossil fuels the process as such is not regarded as sustainable because of its contribution to the increase in carbon dioxide.

Biomass is one of the renewable resources that enable a sustainable hydrogen production. The focus of this study is on the biological conversion of biomass to hydrogen. The best-known, but often not recognized, site of biological hydrogen production is in the production of biogas [1]. Here bacteria convert organic matter to lower metabolites like organic acids, carbon dioxide and hydrogen. This hydrogen is immediately consumed by methanogenic bacteria, and methane is the final end-product which becomes available. By decoupling hydrogen production from methane production, a complete conversion of the organic matter to hydrogen can be realised. The first step in this process is the fermentation of organic matter to hydrogen and acetic acid. This is done using thermophilic bacteria which are highly efficient and prevent growth of methanogenic bacteria. The second step is the conversion of acetic acid in the effluent of the thermophilic reactor to hydrogen (Fig. 1) [2]. Because of unfavourable thermodynamics of this reaction, extra energy must be provided. By using photo-heterotrophic bacteria which obtain energy from light and organic matter, this drawback is overcome. The distinctive merit of the biological conversion is the efficient production of very pure hydrogen from wet biomass.

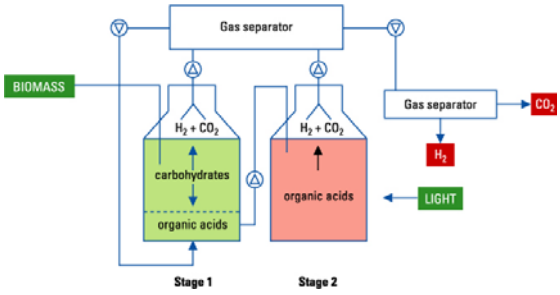


**Figure 1**: Two-stage bioprocess for hydrogen production from biomass

The raw material studied here is sweet sorghum which is under serious examination as a potential European energy crop. It is a $C_4$ crop, with a fibrous root system that branches profusely. Under favorable conditions, the above ground nodes may produce strong adventitious roots that may help to anchor the plant and reduce lodging; the roots can be extended to a distance of up to 1 m and a depth of 1.8 m. Sweet sorghum plants attain a height of up to 4 m. It is well adapted to the warm southern regions of Europe and moderately well adapted to several central European regions with mild climates. It is a cold-sensitive plant, so its adaptation in northern, cooler climates is poor. Historically, syrup production was the main use of sweet sorghum, but nowadays this crop is gaining attention as a potential alternative feedstock for energy and industry, because of its high yield in biomass and,

particularly, fermentable sugars. Sweet sorghum can be converted into energy carriers through either one of two pathways: biochemical and thermo-chemical. Through biochemical processes the crop sugars can be converted to biofuels (ethanol, hydrogen). Thermo-chemical processes such as combustion and gasification can be used for the conversion of the sweet sorghum bagasse (the residual cake from crop pressing) to heat and electricity [3]. Pulp for paper, compost, and composites materials are some other products that can also be derived from sweet sorghum bagasse.

[1] P.A.M. Claassen, J.B. van Lier, A.M. Lopez Contreras, E.W.J. van Niel, L. Sijtsma, A.J.M. Stams, S.S. de Vries and R.A. Weusthuis (1999) Utilisation of biomass for the supply of energy carriers. Applied Microbiology and Biotechnology 52: 741-755
[2] P.A.M. Claassen, J.W. van Groenestijn, A.J.H. Janssen, E.W.J. van Niel, R.H. Wijffels, Proceedings of the 1st World Conference on Biomass for Energy and Industry, Vol. II (2000) 1665.
[3] N. Bassam, Energy Plant Species (1998) p.235-242.

Approach: this workshop will be a calculation exercise for which you have to obtain specific information. You will work in teams to carry out the calculations and to search for data.

Use the Internet for the following data:

1) Estimate the productivity of sweet sorghum in Italy (tons/ha)
2) Estimate the amount of hectares available for growing sweet sorghum
3) Estimate the potential yield of hydrogen from sweet sorghum
4) Estimate the production in terms of electricity based on use of PEM fuel cells
5) Estimate the requirement of electricity of households in Italy

Discussion:

1) Would this be the best way to provide ‘green electricity’?
2) Which are the competitive technologies?
3) Could you provide a Strengths, Weaknesses, Opportunities and Threads analysis?