

LARGE BIO-ETHANOL PROJECT FROM SWEET SORGHUM IN CHINA AND ITALY (ECHIT): DESCRIPTION OF SITE, PROCESS SCHEMES AND MAIN PRODUCTS

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ABSTRACT: The ECHI-T project aims at elaborating a technical, economical and financial feasibility study on integrated bio-energy/bio-ethanol/DDG (Distillers' Dried Grains) production from Sweet Sorghum able to attract private capital investors for its positive economics. The main goal of the project is the definition of a possible plant configuration for each of the three selected sites (one in Italy and two in P.R.China). The analysis covers the complete biomass chain, from the production of the resource, to the reception of the biomass at the plant gate, to the supply of products and their potential market. The project intends to demonstrate that Sweet Sorghum is a very promising energy crop from both the economic as well as the environmental point of view, with high yields of grains, sugar and bagasse. In fact, it can be processed into various high value added commodities, such as bio-ethanol, DDG, electricity/heat, charcoal, hydrogen, activated coal, methanol, pulp for paper, with an overall positive economic performance and energy input/output ratio.

A selection of these possible processing steps has been made to draw a configuration in Basilicata region (Southern Italy), Dongying City (Shandong Province, China) and Huhhot City (Inner Mongolia, China). For each of the three configurations a preliminary technical, economical, environmental and financial feasibility study have been performed. This paper deals with the description of the three sites and with the main technical results of this project.

Keywords: bio-energy strategy, bio-ethanol, innovative concepts

1 INTRODUCTION

Bio-energy can offer a significant contribution to the future challenge of a more sustainable energy mix and in the medium-term also to the fulfillment of the Kyoto commitments that the EU is determined to implement. There is wide consensus that bio-energy has the possibility to provide a significant renewable and sustainable contribution to the EU energy scenarios, with its present estimated potential of ~200 MTOE/year (probably ~400 MTOE/year on the longer term). At present, the heat-market is the most developed one, but mainly in the Northern-Central Europe. Large possibilities exist for biomass resources (in particular energy crops) to penetrate the power generation and the transport markets: however, the demonstration of the economic viability of this new activity is essential for its large deployment. This project aims at demonstrating the feasibility of Sweet Sorghum cultivation for renewable and sustainable production of transport fuel (bio-ethanol, and - in case - hydrogen and methanol), energy (electricity and heat) and other products (as animal feed, pulp for paper, charcoal, activated coal) with commercially available technologies. In fact, integrated Sweet Sorghum complexes can contribute to the following EU policy needs and goals:

- Renewable energy production at competitive cost, both in the transport market (bio-ethanol from Sweet Sorghum sugar juice and grains) as well as in the electricity and heat market (from Sweet Sorghum bagasse), contributing to achieve the EU Kyoto goals for greenhouse gas emission reduction.

- Diversification of energy supply, with the non-fossil resource Sweet Sorghum produced at competitive cost, thereby reducing the dependency on non-EU (fossil) energy resources. Sweet Sorghum may be grown competitively within the EU.
- Vegetal protein production. Possibility of a significant co-production (approx. 1.5 t/ha) of vegetal proteins (DDGs), today of great interest for the EC due to the BSE problem.
- New permanent job creation in both the agricultural as well as in the industrial sectors.
- Innovation and development of advanced technologies. Processing of Sweet Sorghum can be done with existing, commercially available technologies, but the application of these technologies to Sweet Sorghum crop is very innovative. Furthermore, the integrated processing of an energy crop into several high added value products (as chemicals) has not been implemented yet. Should the Sweet Sorghum complexes be implemented, these would be the first of that kind.

The project contributes to the achievement of both European and Chinese policy measures that aim at increasing the share of (bio-)ethanol as fuel in the transport sector:

- The European Union [1] aims at replacing 20% of the fossil energy in the transport sector by 2020 with renewable fuels.
- The proposal for a Directive of the European Parliament and of the Council on the promotion of the use of biofuels for transport. The proposal,

currently under discussion, recommends that 2 % of the gasoline and diesel fuels used in the transport sector should be replaced with biofuels by 2005. This amount should increase with 0.75 % each year and reach 5.75 % in 2010.

- China has recently (May 2001) set up a national standard for (bio-)ethanol fuel, aiming at the widespread use of (bio-)ethanol in the transport sector in 3 provinces (Henan, Heilongjiang, Jilin) in a pilot-project phase. The final goal is to achieve a share of 25-30 % of ethanol cars in 2-3 years. The two Chinese oil companies involved in the project (Kenli Oil Company in Dongying and PetroChina in Huhhot) indicated that their interest in bio-ethanol from Sweet Sorghum stems from this Chinese national policy plan.

Finally, the ECHI-T project also aims at establishing a more active co-operation between EU and P.R.China since it could be of mutual benefit:

- Sweet Sorghum is a well known Chinese crop in China, that has extensive experience in Sweet Sorghum development, cultivation and use. China's know-how could be successfully transferred to the EU for in-Europe cultivation, and seed supplied to EU during the start-up phase.
- Europe has suitable and valuable commercial technologies for Sweet Sorghum processing, potential financial resources (if the project is economically viable) and potential interest on the implementation of complexes based on Sweet Sorghum. EU technologies could be exported to the Chinese market.

The implementation of a large industrial bio-energy complex in China, as the one under assessment in the ECHI-T project, could be beneficial for Europe to verify the viability of these types of schemes in a different context. Moreover, the various mechanisms for carbon trading (as the Joint Implementation) could be implemented in a common EU-China project.

2 SHORT DESCRIPTION OF THE THREE SITES

2.1 Basilicata Region, Italy (Pisticci)

The Basilicata region, located in the Southern part of Italy, is mainly characterised by hilly areas (up to 2000 meters above the sea level), with two accesses to the sea (Ionio and Tirreno Seas).

The area (Bradano-Metaponto) which has been studied for the project consists of 5 separate zones situated in the valleys of two rivers. The total extension of the region is approximately 22,250 ha: the whole area is managed by the Consorzio di Bonifica di Bradano e Metaponto (CBBM). Within this land, 7000 ha were selected for the project, located near the Municipality of Pisticci, where the industrial complex could be located. These fields are mainly valley floor areas on alluvial soil, having a good or high degree of fertility and equipped with irrigation infrastructures (a pipeline for pressure irrigation system is available). The industrial area near Pisticci (Val Basento district), managed by the "Consorzio per lo Sviluppo Industriale della Provincia di Matera" (Syndicate for the industrial development of the province of Matera, CSIPM, also known as ASI, Area

Sviluppo Industriale – Industrial Development Area), extends for a total of 300 ha.

2.2 Shandong Province, P.R.China (Dongying City)

The Dongying City, in the Shandong Province, is located on the coast of Bohai Sea (118° 07'-110° 10' east longitude; 37°20'-38°10' north latitude) with 350 kilometers of coastal line: it is the bridge linking the northeastern and mid-China economic regions. It is 400 kilometers, 300 kilometers and 250 kilometers away from several large municipalities as Beijing, Tianjin, Qingdao and Jinan respectively. Dongying is well equipped with infrastructures, as highways, electric grids, power stations, etc.: Dongying covers an area of 790,000 hectare. The Delta of the Yellow River passes through the Shandong Province, flowing into the sea from Dongying, with a cross-section of approximately 128 kilometers.

Dongying is the production base of the second largest oil field in China with annual production of 30 million tons of crude oil and 23 billion m³ of natural gas per year. The Kenli Petrol Chemical Plant has been selected as the partner factory for large-scale production of bio-ethanol from Sweet Sorghum. The Kenli Petrol Chemical Plant is a large state-owned enterprise. The refinery plant covers an area of 60 hectares. Since 1999, Kenli has carried out the feasibility and planning study on the production of 30,000 tons of bio-ethanol and 10,000 tons of ethyl acetate, which has been listed as a Provincial-planned Project. At present, the Kenli target for bioethanol is 100,000 t/year. According to Kenli original plan, corn and dried sweet potato will be used as raw materials to produce ethanol: however, as the use of Sweet Sorghum is expected to be more convenient than conventional crops.

The land in Dongying - Shandong Province is suitable for Sweet Sorghum cultivation: today, a total area of 800 ha is already cultivated with this crop, mainly used as forage for cow and cattle. The potential plantation area reaches 60,000 ha. Several cultivars (as "M81-e", "Tianza No.2" and "Tianza No.3") have already been tested in Dongying, and results were very positive in terms of adaptability and productivity of these hybrids.

2.3 Inner Mongolia, P.R.China (Huhhot)

The Hueahote district (also called Huhhot) lies in the Inner Mongolia region (i.e. the P.R.China region close to the border of Mongolia), at approximately 40° North Latitude, W-NW from Beijing. It belongs to a middle-warm semi-dry zone: the average elevation is around 800-1,100 meters above the sea level.

Inner Mongolia Autonomous Region is the main animal husbandry zone in the P.R.China, with high demands for grass-feeds. However, specific regulations had to be issued in this region for environmental protection: the risk of desertification due to cattle breeding restricts the use of natural vegetation as feed or fuel. Therefore, a large market exists for animal feed products and domestic heating, that could be addressed by the ECHIT project.

The PetroChina oil refinery, located 9 km from Huhhot City and covering an industrial area of 130 ha, has been selected for the ECHIT project in Inner Mongolia. Today the PetroChina refinery processes. The

target amount of ethanol for PetroChina Company is 100,000 t/y.

The low temperature typical of winter time offer unique on-field storage conditions for sweet sorghum stems stalks) in Inner Mongolia. In fact, since the temperature falls below zero at the harvesting season (end of October) cut stems will not deteriorate if left on the fields, and the stem-processing phase can therefore be completed by the subsequent April. Harvested stems can therefore be stored on the fields for a period of approximately 5 months. The quality and the fertility of the soil in this region are very good. Inner Mongolia has already developed Sweet Sorghum cultivation for food-ethanol (wine) production. The Sweet Sorghum wine is distilled and produced in Tuoketuo County, 70 km far from Huhhot.

3 SWEET SORGHUM CULTIVATION

The cultivation of Sweet Sorghum has been studied and planned for the different sites in Italy and China. 7,000 ha, 19,000 ha and 20,000 ha have been considered in Basilicata, Shandong Province and Inner Mongolia respectively. In the case of Inner Mongolia, a cluster scheme based on 10 similar unit of 2,000 ha each has been adopted. The existing rural structure and the logistic prerequisites in Huhhot did not seem suitable for a single large scale, centrally organised cultivation, plantation, and processing scheme. A decentralised structure based on 10 similar clusters has therefore been proposed for Inner Mongolia, more suitable for projects focused on the rural development issue.

Various cultivars have been selected for each site of the project. Irrigation demand and strategies have been elaborated by means of the [2] CROPWAT program by FAO and the associated CLIMWAT database.

With regards to the harvesting and processing time, different strategies have been elaborated for the Basilicata and Shandong regions (on one side) and the Inner Mongolia region (on the other side). In fact, the particular climate in Inner Mongolia allows a 5 months cane processing time (to squeeze the juice and produce the pellets), while in the other two regions this processing time is reduced to two months. However, in the case of Dongying, by mean of a careful selection of crop hybrids having different Growing Degree Days (GDDs) it is possible to obtain a 4 month harvesting time. Nevertheless, this approach requires irrigation, and a more detailed experimental work is necessary to assess the productivity, yields and elaborate a suitable price strategy for the farmers.

As far as regards the crop rotation, a two year rotation has been chosen, as its sustainability has already been demonstrated and is already carried out in China with wheat.

4 THE THREE INTEGRATED COMPLEXES: MAIN PRODUCTS

According to the scheme described in figure 1, various levels of integration are possible:

- 1st level: production of bio-ethanol/DDG/CO₂/bagasse pellets for sale
- 2nd level: production of bioethanol/DDG/CO₂/heat&power/bagasse pellets for sale
- 3rd level: production of bioethanol/DDG/CO₂/heat&power/pulp for paper
- 4th level: production of bioethanol/DDG/CO₂/heat&power/pulp for paper, activated coal
- 5th level: production bioethanol/DDG/CO₂/heat&power/pulp for paper, activated coal/hydrogen (syngas)/bio-methanol (or bio-Fischer-Trops gasoil)

The analysis of the possible schemes compared to local conditions and collected data, led to the conclusions that - at the present moment - the 2nd level of integration is the most suitable approach for the actual situation in the selected sites (with CO₂ recovery considered in Dongying only). Cogeneration from bagasse is not considered in Inner Mongolia.

The expected productions in each of the three sites are presented in figure 2. The scheme shows how Sweet Sorghum provides sufficient feedstock to produce the requested amount of bioethanol plus some high value additional products as bagasse pellets (animal feed) and electricity. In the case of Dongying, 12 MWel are produced all year round from bagasse for use in the refinery; moreover, given the amounts of CO₂ generated from juice and grain fermentation, in this site CO₂ recovery for various application (as beverages, etc.) can be considered.

REFERENCES

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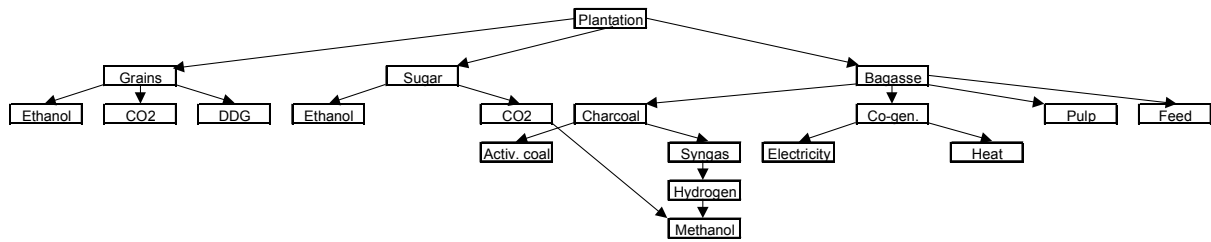


Figure 1: Sketch of the possible conversion paths in the Sweet Sorghum Integrated complex.

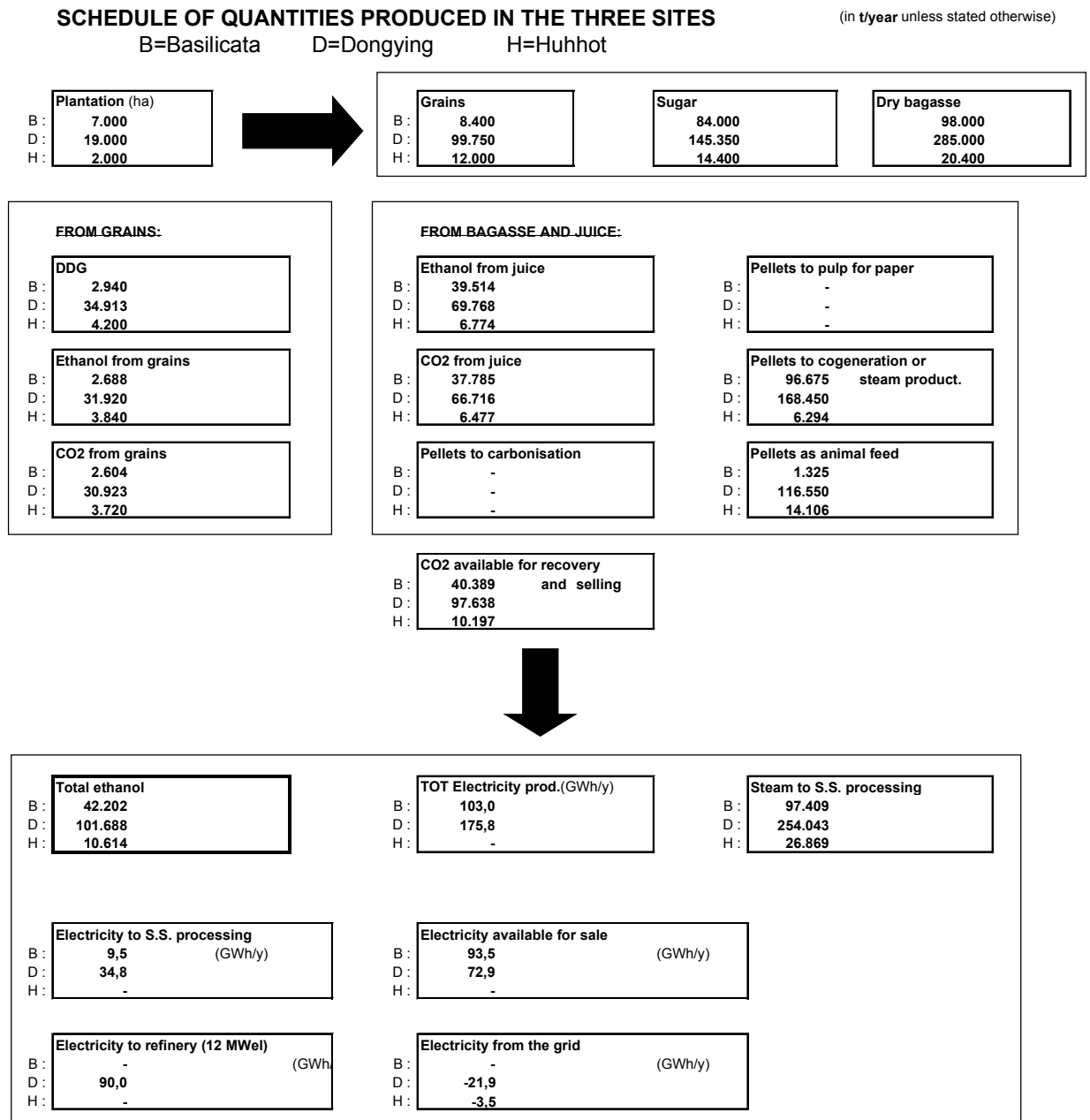


Figure 2: Expected productions in the three sites.