SUSTAINABLE SUGAR PRODUCTION

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Abstract

Sustainable production is becoming an increasingly important corporate issue. In the cane sugar industry, pressure for sustainable production has come largely from the end users of sugar and ethanol, although some of the major producers of sugar are aware of the advantages in the market place of sustainable manufacturing processes in terms of brand enhancement. This paper aims to introduce the main elements of sustainability and the major sustainability issues facing producers. The estimation of the carbon footprint in sugar production is described and the aspects of production affecting greenhouse gas emissions and ways of reducing them are identified. Attempts to certify production as sustainable have led to the need for formal certifiable sustainability standards in the sugar industry. The process of developing credible sustainability standards is described. Bonsucro (registered as the Better Sugar Cane Initiative) has received recognition from the EU as a qualifying voluntary standard. The Bonsucro certification processes now underway are described.

INTRODUCTION

Sustainability has been identified as a megatrend, which requires businesses to adapt and innovate or be swept aside (Lubin and Esty 2010). It is clear that there is a growing corporate move to address sustainable development and companies are beginning to appreciate that there are sound business reasons to adopt more sustainable production and processing practices. In addition, managing social and environmental risks is important for growers, processors, traders and food companies due to regulatory pressures as well as shareholder and consumer expectations. Increasingly environmental and social performance is affecting access to markets and to capital as well.

Brazil has been most active in embracing and reporting sustainability performance. This is largely due to the need to meet sustainable standards in producing biofuels for export to first world countries. Many corporations and some mills are reporting their results based on the Sustainability Reporting Guidelines proposed by the Global Reporting Initiative (GRI 2008). Some industry environmental leaders have also adopted procedures which enable them to be accredited to ISO 14001 for environmental management.

There are various ways in which sustainability can be defined. A generally accepted definition would be along the lines of sustainable development providing for human needs without compromising the ability of future generations to meet their needs. The American Institute of Chemical Engineers defines sustainability as “the path of continuous improvement, wherein the products and services required by society are delivered with progressively less impacts upon the earth” (Cobb et al. 2007).

Sustainability involves the “triple bottom line”, covering the three components of environmental responsibility, economic return (wealth creation), and social development. Environmental and social
concerns have been the main reason for the calls for the inclusion of sustainability criteria in the international trade of biofuels. The major issues addressed in sustainability studies include the efficient use of resources, particularly energy, water and raw materials, waste generation, protection of biodiversity and ecosystem services, and labour practices. Economic sustainability is sometimes overlooked but is equally important. Improving business and technical efficiencies inevitably also benefits the people and the environment, and needs to be an integral part of any sustainability exercise.

**SUSTAINABILITY ISSUES**

**General**
One of the fundamental requirements is to be legal in all activities, and conform to local, national and international laws.

Land use change, particularly following extensive expansion of cane growing areas, has been the focus of much attention. Concerns focus around food security i.e. whether cane is produced for ethanol production at the expense of other food crops, and also around the reduction in soil carbon stock following direct or even indirect expansion.

Biodiversity and High Conservation Value areas are also among the main concerns of many stakeholders. These are natural habitats where conservation or biodiversity values are considered to be of outstanding significance or critical importance, which may include land with a high carbon stock, as well as wetlands, forest, diverse grasslands and peat lands. This generally excludes what has historically been in use as croplands.

A concern expressed by producers is that a need to meet sustainability standards will impose reporting and measurement demands which will soak up manpower, time and money. For there to be buy-in by sugar producers, there must be some benefits in adopting standards. These are likely to include:

- A means of benchmarking against others.
- Some credits as a premium for producing sugar sustainably.
- For industries already meeting the conditions, a levelling of the playing fields in terms of meeting environmental and labour related issues.
- Management of risk and liability
- Enhancement of brand image and reputation

In the long run it is expected that conforming to such standards will save money, as inputs such as energy and raw material are used more efficiently, losses and wastage are minimized and manpower is used more productively.

**Social**
It is necessary to ensure that the ILO conventions on labour are complied with. These relate to minimum age of workers, absence of forced labour, absence of discrimination and the right to freedom of association, with or without unions. In addition, workplace health and safety is important, as is also fair employment conditions with formal contracts.

It is also necessary to establish that major suppliers to the operations, whether in the form of labour, services or products, are themselves fair and equitable employees, and that outsourcing is not used as a method of circumventing labour laws.
It is also becoming accepted practice in many industries to have formal stakeholder contact, grievance and dispute resolution process. This may involve employees as well as local residents, and anyone else affected by the operations.

**Environmental**

All emissions which can lead to global warming, ozone depletion, acidification and eutrophication need to be controlled and measured, as well as all residues and wastes. In particular the soil health, and related to it, the soil carbon stock, are vitally important. Eustice et al. (2011) have shown that cane burning reduces the organic carbon in the soil, while green cane harvesting can improve it. An environmental management plan is a pre-requisite, to control fertilizer use optimization, tillage practices, soil acidity and compaction, and prevent soil erosion. This should also help to minimize water and energy usage, and control the use of chemicals in a responsible manner.

Interest is being shown in measuring the water footprint of sugar and ethanol (Gerbens-Leenes et al. 2009, Nähle and Kunz 2012). While there is still some uncertainty as to how it should be defined, it appears that the water footprint for sugar and ethanol is lower for beet than for sugarcane, but both are fairly low by comparison with other food products. In addition, the water footprint per unit of energy of bioelectricity is about a factor of 2 smaller than that for bioethanol.

Biodiversity is also a high priority. It is necessary to preserve mangrove swamps, forests, wetlands, pristine (biodiverse) grasslands, avoid High Conservation Value areas and keep green corridors. New estates should not be established in wetlands, peatlands, swamp areas, and cane burning should be kept to a minimum.

**Economic**

Many systems designed to promote sustainability neglect economic sustainability, which makes them inherently less useful. Key to sustainability is continuous improvement, and this must take economic issues into account.

Companies are reluctant to divulge costs and returns, which makes the development of metric indicators difficult. However the Global Reporting Initiative promotes the use of value added/t product, which is now quite widely reported by many companies. This represents revenue less direct costs, and is the value returned to employees in the form of wages, to government in the form of taxes, to shareholders in the form of dividends and funds retained for investment.

Economics are also affected by the quality of raw materials and products, operating efficiencies (yields and recoveries) and by water and energy use.

It is also important to establish that sufficient funds are allocated to R+D and extension, to achieve economic improvements over the longer term. Science and technology drive change and are critical elements of a sustainability strategy.

**GHG EMISSIONS**

The aspect of sustainability standards which perhaps attracts the most attention is the effect on climate change and in particular greenhouse gas (GHG) emissions. This is derived together with estimates of primary energy used and direct land use change effects.

**Current status**
A number of studies have been done to estimate net energy ratios and carbon emissions associated with bioethanol production. Different estimates of GHG emission savings relative to fossil fuels are obtained if different assumptions are made in the calculation procedure. Estimates in Brazil indicate emission savings in the range of 75% to 90% relative to gasoline, depending on the extent of cane burning and power export.

The EU has compiled a Renewable Energy Directive (RED) which sets out how the emissions should be calculated for the production of a biofuel from any particular feedstock. Some GHG emission saving default values are given, assuming no land use change, to be used in the absence of primary data required for its calculation. Ethanol produced from sugarcane has the best default value of 71% emission saving relative to fossil fuels; emission savings using corn, wheat or sugar beet are significantly lower, varying between 16 and 52% depending on the feedstock and the process used.

The carbon footprint of sugar has received less attention. Recently, both British Sugar Corporation and Tate & Lyle have published information on the carbon footprint of their sugar. A method of estimating net energy usage and greenhouse gas emissions in processing sugarcane has been developed, based initially on work done on biofuels (Rein 2010). The calculation routine was developed for use in the Bonsucro standards.

**Major issues**

Estimates are largely dependent on assumptions made in the calculations. The main issues to be considered in estimating the carbon footprint are as follows (Rein 2010):

- **System boundary.** It is essential to describe accurately the boundary of the system being examined, indicating clearly what is included and excluded.
- **Direct and indirect effects.** Direct inputs are mainly fuel and power inputs, expressed in terms of the primary energy value (taking into account e.g. the efficiency of conversion of fuel to power, and the energy in producing gasoline and diesel). Indirect inputs include, in addition, the energy required for the production of chemicals, fertilizers and other materials used.
- **Land use change.** The effect on the carbon stock of planting cane compared to its previous status needs to be accounted for. Only direct land use change is included at this stage.
- **Handling of co-products and multiple products.** The method of allocating emissions to products can affect the estimates.
- **Default and secondary data.** It is always necessary to make some assumptions in the absence of direct measurements. The value and source of the data used can have a substantial effect on computed emissions.
- **Energy embedded in capital goods.** Emissions associated with capital equipment are usually included in calculations in America and excluded in Europe.

**Carbon footprint of sugar**

Carbon dioxide (CO$_2$) from sugarcane emitted in combustion and in ethanol fermentation is considered zero CO$_2$ emission to the air, because this is the carbon taken in from the air during sugarcane growth. Methane (CH$_4$) and nitrous oxide (N$_2$O) have global warming potentials 25 and 298 times that of CO$_2$ respectively (IPCC 2007). The carbon equivalent value is calculated by multiplying the mass of each of these gases by its global warming potential. This is added to the CO$_2$ evolved and expressed as CO$_2$ equivalent (CO$_2$eq). Therefore even small amounts of CH$_4$ and N$_2$O need to be considered in arriving at GHG emission estimates.

Depending on circumstances, the carbon footprint of raw sugar is expected to be in the range of 200 to 500 kg CO$_2$eq/t sugar. Rein (2010) has shown that particular improvements can be achieved by focusing on the following, in roughly the following order of importance:
• Cogenerate and export power to the maximum extent possible
• Maximize cane yield and factory recovery
• Reduce the amount of fertilizer and chemical input, particularly N fertilizer
• Reduce the extent of cane burning
• Reduce the quantities of any supplementary fuels purchased
• Minimize irrigation power input
• Reduce cane transport distances
• Recycle water to reduce water intake

Export of power from a sugar cane mill can substantially reduce the carbon footprint. Levels of export of power above about 80 kWh/t cane can actually lead to a negative carbon footprint.

A critical issue is the effect of land use change. Changing land from most forms of natural vegetation to cane imposes a substantial increase in calculated emissions.

The GHG emissions in refining are almost entirely due to fuel used for steam and/or power generation. A refinery operating at a steam/melt ratio of 1.0 will require roughly 0.125 t coal to be burnt, resulting in an emission figure of 382 kg CO$_2$eq/t sugar melted. This is of the same order of magnitude as the carbon footprint of the raws being melted. The choice of raw sugar supplier of course also has a substantial influence on the carbon footprint of refined cane sugar.

If natural gas is used instead of coal, the situation is improved, since the GHG emissions associated with natural gas are about 60% of those when burning coal. This reduces the emissions level to about 230 kg CO$_2$eq/t sugar melted, but this is still high in relation to the raw sugar emissions. Other emissions in refining are not very significant (Rein 2011).

Emissions from transport of raws to a destination refinery depend on the mode of transport. Long distance road transport significantly increases the carbon footprint, whereas emissions from transport by sea in a bulk carrier are relatively small. Unfortunately there can be wide discrepancies in databases referring to emissions due to transport (Plassmann et al. 2010).

**Results of other studies**

**Sugar**

Reported values for raw sugar at the mill gate vary from 203 and 311 in Thailand and Japan (Hattori et al. 2008), to 551 in South Africa (Mashoko et al. 2010), to values in the range of 500 to 800 kg CO$_2$eq / t raw sugar in Australia (Renouf and Wegener 2007). Cane farming is the major contributor to GHG emissions, and a reduction in fertilizer use and the phasing out of cane burning significantly reduce GHG emissions. Assumptions about emissions from the use of N fertilizer are a major source of discrepancies between estimates.

Florida Crystals market “carbon-free” sugar, achieved through the cogeneration and sale of electric power. Their power generation facility can produce 80 MW from 103 bar steam, using the mill bagasse as well as 900 000 tons of wood waste/year diverted from landfill as the fuel sources.

Values for the carbon footprint of refined white sugar vary from 380 kg CO$_2$eq / t sugar in a 1 kg consumer pack (Tate & Lyle), to 528 kg CO$_2$eq/t refined sugar in Thailand (Hattori et al. 2008) and 570 kg CO$_2$eq/t sugar for cane sugar refined in the US (Taylor and Koo 2010).

The best case for refined cane sugar is an annexed refinery. Plassmann et al. (2010) report a figure of 400 kg CO$_2$eq/t white sugar produced in Mauritius and landed in Europe.
The comparison between beet and cane sugar largely revolves around how energy is produced and used. In the US it appears that beet sugar has a considerably larger carbon footprint than cane sugar, 1160 kg CO₂ eq/t sugar for beet sugar and 570 kg CO₂ eq/t for cane (Taylor and Koo 2010). In Europe Klenk et al. (2012) report that the carbon footprint for EU refined cane sugar (642 to 760 kg CO₂ eq/t sugar) is similar to that for EU beet sugar (242 to 771 kg CO₂ eq/t sugar), taking into account transport of raw sugar to the EU.

British Sugar used the procedure of PAS 2050 (BSI 2008) to arrive at a figure of 600 kg CO₂ eq/t beet sugar. This is the B2B figure, as provided to the industrial user. About 60% of the emissions are due to fuel use at the factory. Use of cogeneration and the manufacture of ethanol in combination with a gas-fired turbine can significantly improve energy and emission improvements relative to gasoline, which is put to good use in British Sugar’s operations.

**Other foods**
The implications of the magnitude of the numbers generated can be appreciated by comparison with other foodstuffs. The very low carbon footprint of sugar is illustrated by Nordic Sugar’s work (Anon. 2009), which yields the following results for emissions associated with foods:

<table>
<thead>
<tr>
<th>Food</th>
<th>CO₂ eq/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet sugar</td>
<td>675 kg CO₂ eq/t</td>
</tr>
<tr>
<td>Cheese</td>
<td>10 800 kg CO₂ eq/t</td>
</tr>
<tr>
<td>Beef</td>
<td>14 000 kg CO₂ eq/t</td>
</tr>
</tbody>
</table>

**DEVELOPMENT OF SUSTAINABILITY STANDARDS**

**Current Status**
Over the past few years, various initiatives have been developed to address the impacts associated with the production of biofuels. Some of them cover the entire supply chain while others deal with only parts of it. All countries have their own sets of regulations and laws governing environmental and social issues. Certification is still viewed with suspicion in some regions, being seen as a prescription by one country or customs union of the standards that a supplying country must meet as a condition for access to their markets.

**Requirements**
The International Social and Environmental Accreditation and Labelling (ISEAL) Alliance has developed a Code of Good Practice for Setting Social and Environmental Standards to evaluate and strengthen voluntary standards, and to demonstrate their credibility on the basis of how they are developed (www.isealalliance.org). Adhering to procedures that constitute good practices for setting standards ensures that the application of the standard results in measurable progress towards social and environmental objectives, without creating unnecessary hurdles to international trade.

The first step is the establishment of Principles, which are universal statements about sustainability and define the objectives. From the Principles flow the Criteria and Indicators. Criteria are the conditions to be met in order to adhere to a Principle. Indicators are measurable states that indicate whether or not associated criteria are being met.

The process of developing standards and indicators must be entirely transparent and inclusive, involving a multi-stakeholder process. This is vital if the standards developed are to have international credibility. Thus it is necessary to engage widely with the stakeholders in all spheres of operation and to encourage participation through comments, suggestions and input of any kind.
**Bonsucro**

Bonsucro is specifically focused on sugar and ethanol from sugarcane. It is a collaboration of sugar retailers, investors, traders, producers and NGOs who are committed to sustainable sugar and ethanol production. Bonsucro is funded by members, among whom are consumer companies (e.g. Coca Cola, Kraft), commodity traders (e.g. ED & F Man, Cargill), NGOs (e.g. WWF, Solidaridad), producers (e.g. Cosan, EID Parry), producer associations (e.g. UNICA, ASSOCANA) and oil companies (e.g. Shell, BP). The Bonsucro web site explains its activities in more detail (www.bonsucro.com).

Bonsucro has developed a Certification Protocol for members and auditors that lists the process and procedures for certification against the Bonsucro standards. This includes:

- rules and requirements for Certification Bodies to audit against the Bonsucro standards,
- certification requirements for economic operators to demonstrate compliance with the Bonsucro standards
- audit procedures for Certification Bodies to verify compliance with the Bonsucro standards.

Bonsucro has developed 2 standards:

- The *Production Standard* contains principles and criteria for achieving sustainable production of sugarcane and all sugarcane derived products in respect of economic, social and environmental elements.
- The *Mass Balance Chain of Custody Standard* contains a set of technical and administrative requirements for enabling the tracking of claims on Bonsucro sugarcane derived products along the entire supply chain after the mill.

For certification, third party certification is necessary. This requires verification by an assessor or inspector, certification as a result of the assessment, and accreditation based on the demonstrated competence of the certification body.

The Principles of the Production Standard accepted by Bonsucro members are:

1.) Obey the Law
2.) Respect human rights and labour standards
3.) Manage input, production and processing efficiencies to enhance sustainability
4.) Actively manage biodiversity and ecosystem services
5.) Continuously improve key areas of the business

In addition, conditions for chain of custody must be satisfied. If EU RED certification is required, a further commitment relating to the avoidance of using land with high biodiversity and high carbon stock must be satisfied.

The 5 principles above are broken down into 20 criteria and 48 indicators. The ISEAL Alliance comments as follows on standards: “A good standard is equally applicable anywhere within its geographic scope and focuses on achieving outcomes rather than prescribing methods for reaching these outcomes”. It is for this reason that Bonsucro has attempted to set indicators which measure outcomes, the impacts of their activities, rather than recording the existence of good practices. It is hoped that the values of the indicators will be universally applicable, with a minimum of regional variation required by local circumstances. The development of Bonsucro Standards is described elsewhere (Rein 2009).

An advantage of the use of metrics is that they can be used as a means of assessing ongoing improvement, by monitoring how the values of the metrics change over time. It also facilitates comparisons and benchmarking with other producers. Setting baseline values represents an ongoing challenge. It is not intended to be an “elitist” initiative intended to discriminate against certain
industries. The standards should not be “best achievable” but true reflections of what experts define as a minimum acceptable level that can realistically be achieved by responsible operators.

Bonsucro standards have received EU acceptance as a voluntary standard, and the first mill’s production was certified in June 2011. At the time of writing, 14 mills already have their production certified, involving 22.2 Mt sugarcane, giving 1.43 Mt certified sugar and 1.2 million m$^3$ certified ethanol.

REFERENCES


BBST 2012 Sustainability