Renewable Energy for Development

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The EU emissions trading system: getting it right

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The European Emissions Trading System is a crucial component of Kyoto implementation for the EU. Phase I of the ETS will conclude next year, and Phase II will begin in 2008. The allocation process for emissions allowances requires Member States to submit National Allocation Plans to the Commission for each Phase. Recent research points towards a few core principles for the allocation process that can improve both the effectiveness and the efficiency of the Trading System (Editor's note).

The European Emissions Trading System (ETS) is the cornerstone of the EU strategy for reaching its Kyoto greenhouse gas (GHG) reduction targets, covering almost half of CO_2 emissions in the EU. The goal is to secure emission reductions at the lowest possible overall cost; trading allows companies/participants to seek emission reductions to meet the aggregate emissions cap wherever and however it is cheapest to do so. Schemes such as the ETS are sometimes referred to as cap & trade systems, since total emissions are capped, and then participants can trade allowances that they have received or obtained. The carbon price is determined by market forces, i.e. by the intersection of supply and demand.

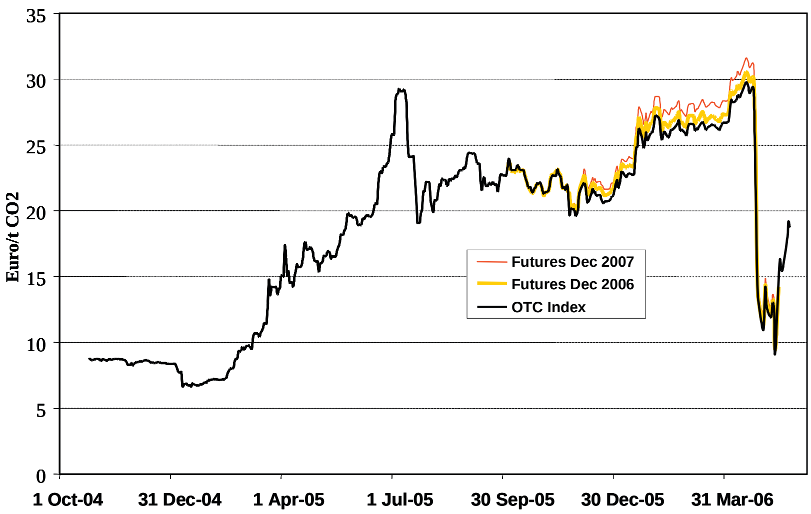

Figure 1: Historical price development of the value of emissions trading allowances in the EU ETS

ETS Phase I

All 25 member states of the European Union participate in the scheme, which commenced operation on 1 January 2005. In the first phase (2005-2007), the EU ETS includes some 12,000 installations, representing approximately 45% of EU CO_2 emissions. It covers energy and other combustion facilities, oil refineries, coke ovens, ferrous metals processing, cement, glass/ceramics, and pulp and paper sectors. Allowances[1] were generally given out to the installations at no cost.

The price of allowances[1] increased more or less steadily to its peak level in April 2006 of about €30 per tonne CO_2 (see Figure 1), but came crashing down in May 2006 to under €10/ton when it became clear that many countries had given their industries such generous emis-

[1] "Allowances" in this article refers to emissions trading allowances.

In this issue:

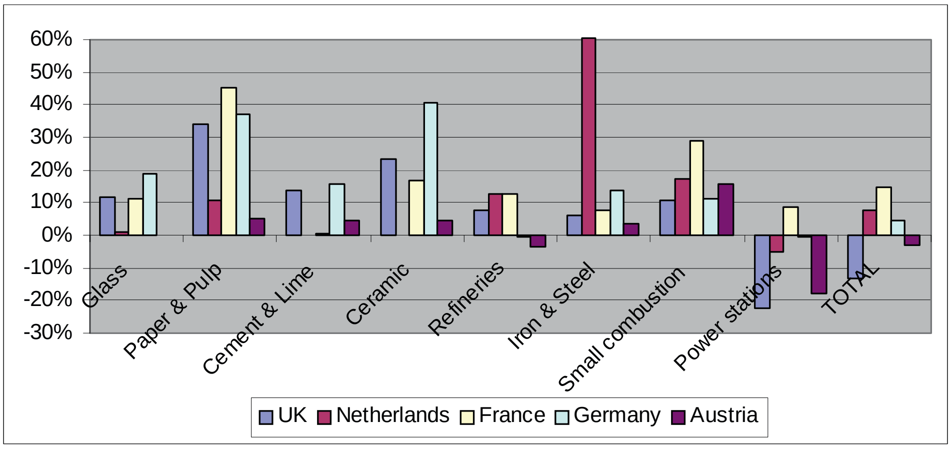

Figure 2: Verification data (Allowances / Emissions) for Phase 1 ETS. Source: ENTEC 2006

sion caps that there was no need for them to reduce emissions. Consequently, national governments have been accused of abusing the system under industry pressure; NGOs, researchers, policy analysts, and others have called for much stricter caps in the second phase (2008-2012).

One lesson from Phase I is that the allocation of allowances was quite generous in most sectors, with the exception of the power sector and refinery sectors in some countries. As shown in Figure 2, several large EU countries had significant surplus allowances in most of the industry sectors. Only the UK had an overall deficit, while the surplus for some sectors/countries was as high as 40 to 60%. The allocation across sectors in most countries continues to face intense industry lobbying.

ETS Phase II

The second phase (2008-12) will cover not only CO_2, but all GHGs, and credits from the project-based Kyoto Mechanisms (CDM and JI) are expected to be introduced through the “Linking Directive.” National Allocation Plans (NAP) for Phase II were to be submitted to the Commission in June 2006; most Member States submitted their draft plans after the deadline and some had not submitted as of October 2006. The Phase II allocation process has been more complicated due to stronger industry lobbying, the context of differential national Kyoto allocations, and a stronger overall level of concern around competitiveness issues and longer term (post-2012) options.

Big money is at stake. In total, the allowances will be worth more than €200bn – total covered emissions are likely to exceed 10 billion tonnes of CO_2, trading at a market price that has peaked well over €20 a tonne. But struggles over the scale of allocations form only part of the story. As allocation plans finally start to emerge, it is important to develop a clear view on what might constitute a “good NAP”, in economic as well as environmental terms.

Three core principles

Identifying basic principles for NAPs and the processes underlying them is a complex undertaking. However, recent extensive research[1] points towards three core principles for NAPs that can deliver effective and economically efficient incentives to support the combined goals of European industrial competitiveness and GHG emission reduction.

(i) The *cutbacks in free allocation should be significant in relation to both the uncertainties in underlying emission projections, and the profit-making potential of the different sectors.* This is necessary not just to reduce emissions,

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[1] *Allocation and competitiveness in the European Emissions Trading Scheme,* the Carbon Trust, supported by research published in Climate Policy, all available from http://www.carbontrust.co.uk/climatechange/policy/allocation_competitiveness.htm

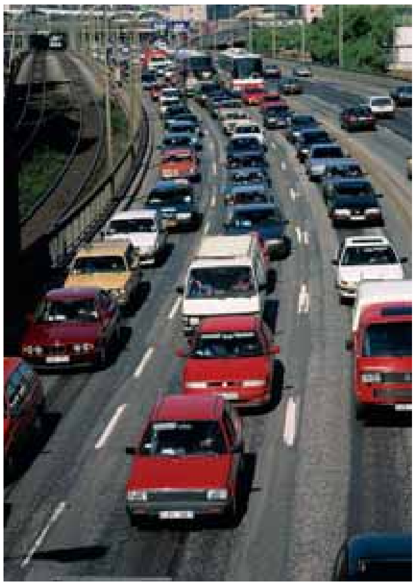

Photo: Bengt Ekeholt/Pix Gallery

The EU ETS does NOT cover mobile sources of GHGs

The Stockholm Environment Institute (SEI) is an international research institute focusing on sustainable development. The Institute works through an international network of centres, associates, and field staff around the world.

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but to broaden managerial attention, reduce the perverse incentives that come from free allocation, and to comply with the State Aid principles that govern European commerce.

(ii) *Phase II NAPs should explore diverse approaches to benchmarking allocations to incumbents, but should seek a common, undifferentiated benchmark for new entrants.* Benchmarks can reduce perverse "updating" incentives, but because a major purpose of free allocation is to compensate existing facilities ("incumbents") for sunk investments, benchmarks for incumbents are bound to be diverse and complex. The same constraints do not apply to new entrants, as the incentives are entirely different: differentiating new entrant benchmarks rewards carbon-intensive investment, which is counterproductive.

(iii) *Auctioning should be used to the maximum extent to re-inject supply, to reduce distributional disparities, to support low-carbon industrial investment and innovation, and to increase price stability.* The Regional Greenhouse Gas Initiative (RGGI) system for CO_2 cap-and-trade in power generation across the north-east US, due to start in January 2009, stipulates a *minimum* of 25% auctioning. Free allocation generates both perverse incentives and excess profits. Auctioning compensates for significant emissions cutbacks by re-injecting supply; it reduces windfall profits (particularly in competitive power markets) and it generates revenues that governments can use to reduce distributional disparities and support low carbon investment and innovation. Moreover, a common minimum price for auctions can increase stability and investor confidence, supporting a floor price for Phase II in the face of large uncertainties, and increasing the credibility of long-term price signals.

Germany and UK

Late in June 2006, countries began to clarify their plans. Industries lobbied strongly not to be treated more stringently

Photo: Nils-Johan Norenlind/Pix Gallery

Paper mill, Stora Enskär, Sweden

than others, and the focus of interest was on the two biggest emitters in Europe, Germany and the UK. The first out of the two was the proposed German NAP. Many people worked hard to make the German plan simpler than Phase I and to improve specific details. Yet, in its current form it violates all three of the core principles:

(1) The cutback to heavy industrial users of 1.25% is insignificant compared to projection uncertainties. Germany's Phase I NAP was supposed to be set on the basis of such projections, but excepting refineries, all other industrial sectors had surplus allocations in 2005 more than 10% above their actual emissions. A proposed cutback of 15% to power generators sounds impressive, but only relative to projected growth, which may be overstated: the sector would still profit at far bigger cutbacks (as was the case in UK Phase I). The overall allocation maintains current emissions levels across sectors that in aggregate have historically reduced them.

(2) The proposal to give new coal power stations twice as many allowances per kW as new gas stations in effect gives them a double subsidy: simulations conducted show that such new entrant allocations could result in the construction of new coal plants that would not have been economic without the EU ETS - raising both emissions and future power prices as carbon controls tighten.

(3) The German plan does not harness any of the potential benefits of auctioning. Moreover, the lack of fundamentals that seems to have informed the debate is worrying. Auctioning does not increase power prices: in competitive markets these are set by opportunity costs, which are wholly unaffected by auctioning.

The UK plan involves a cutback of 8 million tonnes of carbon dioxide relative to projections, at the top end of the range the government had earlier announced for consultation; and it commits to auction 7% of the total allowances issued. It was widely seen as a deliberate strike to offer a counterpoint to the perceived weakness of the German plan, and reflect the strong commitment in the recent UK Energy Review to carbon pricing as a principal vehicle of policy. Yet, it does aim to impose all the cutbacks on the power sector, and none on others. Industrial competitiveness is perceived as being at stake.

Next steps

Many other countries have now submitted allocation plans. They are diverse and varied, and countries, industries, and NGOs are frantically trying to assess their relative standing. If the EU ETS is to have a meaningful future, this has to be but the beginning of a new phase in a Europe-wide debate on how to translate the theoretical efficiency of emissions trading into practical reality. In Brussels – and in capitals around Europe – it will be quite some time before the final outcomes are known.

For more information, see http://www.carbontrust.co.uk/climatechange

Mainstreaming adaptation to climate change into official development assistance: promoting synergies or diverting money?

by Richard J.T. Klein, Senior Research Fellow, SEI

The linkages between climate change and development have highlighted the need to consider vulnerability and adaptive capacity within the context of development objectives and development assistance. Mainstreaming climate change adaptation into development assistance programmes could potentially improve their efficiency and effectiveness, but has also raised concerns about the possible diversion of resources and difficulties in tracking the impacts on adaptive capacity. (Editor's note)

Links between climate change and development are becoming increasingly apparent. It is now virtually certain that climate change is happening and that it is largely caused by human-induced greenhouse-gas (GHG) emissions. These emissions are driven by socio-economic development patterns characterised by economic growth, technology, population and governance. At the same time these patterns influence people's vulnerability to the impacts of climate change, which will in turn influence socio-economic development and thereby future GHG emissions.

Adaptation and official development assistance

The links between GHG emissions, climate mitigation and development have been the subject of intense study (for an overview see Markandya and Halsnæs, 2002). More recently the links between development and adaptation to climate change have been brought to light. Adaptive capacity is often limited by a lack of resources, ineffective institutions and inadequate infrastructure; factors such as these are often the focus of development assistance (Smith *et al.*, 2003). People's vulnerability to climate change can therefore be reduced not only by mitigating GHG emissions or by adapting to the impacts of climate change, but also by development aimed at improving the living conditions and access to resources of those experiencing the impacts, as this will enhance their adaptive capacity.

Adaptation and development are also linked because climate change poses a challenge to meeting development objectives. As climate change intensifies, adaptation to climate change is likely to become increasingly important in official development assistance (ODA) and other activities aimed at eradicating poverty (Sperling, 2003). Adaptation would have to consider three distinct ways in which climate change can impinge on the success of development projects (Klein, 2001):

(1) The risk(s) imposed by climate change on the ODA project with respect to its expected outputs (such as water supply, food security, human health, natural resources management and protection against natural hazards);

(2) The vulnerability to climate change of the community and/or ecosystem that is intended to benefit from the ODA project;

(3) The possible impacts of the ODA project and its outputs on the vulnerability of communities or ecosystems to climate change.

Flooded road, Ecuador

Photo: Bo Jansson/Pix Gallery

Mainstreaming adaptation

As the links between climate change and development have become apparent, the term "mainstreaming" has emerged to describe the integration of climate policies and measures into development planning and ongoing sectoral decision-making. The benefit of mainstreaming would be to ensure the long-term sustainability of investments as well as to reduce the sensitivity of development activities to both today's and tomorrow's climate (Klein, 2002; Huq *et al.*, 2003; Agrawala *et al.*, 2005). By its very nature, energy-based mitigation measures (*e.g.* fuel switching, energy conservation) can be effective only when mainstreamed into energy policy. For adaptation, however, this link has not appeared as self-evident until recently.

Mainstreaming would entail making more efficient and effective use of financial and human resources as compared to designing, implementing and managing climate policy separately from ongoing activities. Prospective efficiency and effectiveness gains provide a rationale to development agencies for analysing the potential for mainstreaming adaptation to climate change in their development activities. Over the past five years, six de-

Table 1: Types of portfolio screenings and key challenges for mainstreaming of adaptation

Challenges	Review of policies and strategies (Norad)	Country case studies (OECD, DFID)	Programme and project review (World Bank, GTZ, SDC)
Range of adaption options considered	++	++	+
Link to political processes	+	+++	+
Identification of synergies and conflics/contradictions between poverty reduction and vulnerability reduction	++	+++	+
Identification of new challenges caused by climate change	+	+	+
Enabling proactive strategies	+	++	+
Attention to process of mainstreaming adaptation	+	+	+
Link to practical ODA activities	+	++	+++
Awareness rasing on climate-development links	++	++	+++

+++ = high level of attention; + = low/negligible level

velopment agencies have taken the initiative to screen their portfolios of development activities, generally with two goals in mind: (i) to ascertain the extent to which existing development projects already consider climate risks or address vulnerability to climate variability and change, and (ii) to identify opportunities for incorporating climate change explicitly into future projects.

A recent study by Klein *et al.* (2007) assessed the screening activities to date, focusing on both the results and the methods applied by the six agencies. They found that the agencies do consider climate change as a real albeit uncertain threat to future development, but that they have given less thought to how different development patterns might affect vulnerability to climate change. They also found that different approaches towards screening consider different types of challenges for the mainstreaming of adaptation to climate change (Table 1).

In April 2006 the OECD organised a ministerial-level meeting of its Development Assistance Committee (DAC) and Environment Policy Committee (EPOC). The meeting served to launch a process to work in partnership with developing countries to properly integrate environmental factors into national development policies and poverty reduction strategies. The meeting resulted in an agreed Framework for Common Action Around Shared Goals, as well as a Declaration on Integrating Climate Change Adaptation into Development Co-operation (OECD, 2006). These outcomes underlined the importance of mainstreaming adaptation into ODA activities and are expected to provide an impetus to all development agencies to consider climate change in their operations.

Concerns

The above discussion may give the impression that a broad consensus has emerged that mainstreaming adaptation into ODA is the most desirable way of reducing the vulnerability of people in developing countries to climate change. Although a consensus is starting to emerge amongst development agencies, concerns about mainstreaming have been voiced within developing countries and amongst academics. On the one hand there is concern that scarce funds for adaptation in developing countries could be diverted into more general development activities, thereby making it difficult to evaluate the benefits with respect to climate change (Yamin, 2005). On the other hand there is concern that funding for climate policy would divert money from ODA that is meant to address challenges seen as being more urgent than climate change, including water and food supply, sanitation, education and health care (Michaelowa and Michaelowa, 2005).

A concerted research effort is needed to answer questions concerning the efficiency and effectiveness of mainstreaming, barriers to and opportunities for mainstreaming, the accountability of industrialised countries with respect to their commitments under the United Nations Framework Convention on Climate Change and, ultimately, the practical desirability of mainstreaming adaptation into ODA.

Acknowledgements

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For the references cited in the text, see http://www.sei.se/red/red-vol19-no3-references.html

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Harnessing sweet sorghum for bioenergy in Zambia

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Agricultural biomass can be converted into bio-ethanol, which can be used as a transport fuel for blending with petrol or as a stand-alone fuel. The use of ethanol as a transport fuel reduces negative environmental impacts associated with combustion of fossil fuels at local, regional and global levels. Ethanol can be made directly from sugar-bearing crops such as sugarcane and sweet sorghum. Recent trials conducted with sweet sorghum in Zambia suggest that its potential is quite high.

There are a number of driving forces in favour of expanded production and use of bio-ethanol, including rural development, competitiveness of the sugar industry, uncertainty in global crude oil price movements, and environmental concerns ranging from local (e.g. leaded fuel) to global (climate change mitigation). Traditionally, bio-ethanol in tropical and subtropical regions is produced from sugarcane molasses, which has limited availability, being a by-product of sugar production. Under some scenarios for expanded use of bio-ethanol, reliance on molasses alone as a feedstock may constrain market growth.

Currently, Zambia's gasoline demand stands at about 190 million litres per annum. At the intended 10% ethanol blending to meet the regulative octane number of 91, domestic ethanol production from molasses would just be sufficient to meet the demand. However, it is projected that fuel demand will increase at a rate that exceeds the growth in the sugarcane industry, so that future molasses supply will not be sufficient to produce the anticipated future ethanol demand. It is also important to look at the future scarnios for the whole region of southern Africa.

Photo: Kalaluka Munyinda, UNZA

Figure 1: Growth of sweet sorghum (Praj 1) at UNZA (University of Zambia) farm

Market potential of bio-ethanol

Within the Southern Africa Development Community (SADC), the ethanol market will greatly be influenced by the following factors:

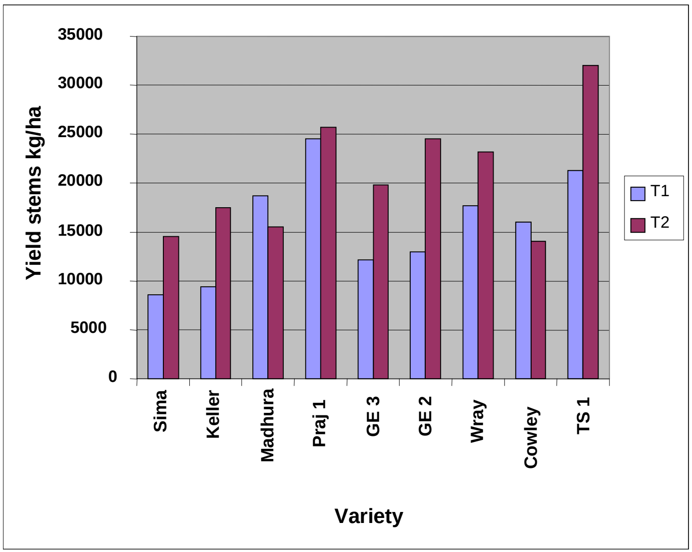
- High oil world prices
- The need to improve the balance of payment by saving on hard currency
- Sustainability and competitiveness of the sugar industry
- Need to substitute lead and MTBE as octane enhancers for gasoline fuels
- National and regional policy decision and legislation on the level of blending
- Poverty reduction and the need for more local employment

The feedstock requirement for the SADC region depends on the amount of gasoline consumed and the level of percentage blending required. At 10% ethanol blending (the minimum required for ethanol to replace lead), there is a current deficit of ethanol amounting to over 862 million litres in the SADC region. The expansion of sugarcane estates is limited by various factors, such as high capital costs and complicated land preparations. Alternative feedstocks such as sweet sorghum can be used to make bio-ethanol. It is estimated that 400,000 – 500,000 hectares (ha) of sweet sorghum would meet the deficit. Southern Africa has abundant land to accommodate this demand.

Sweet sorghum

An efficient low-cost feedstock needs to have the following characteristics: sugar-bearing, highly productive, remunerative for the farmers, low cultivation costs, and giving zero discharge of waste water. Taking into account the climate and soils in southern Africa, sweet sorghum has high potential. It is sugar bearing, with a short crop cycle of about three and half months. As such, depending on the climatic conditions and availability of water, it can be grown twice in a year, resulting in higher annual yield compared to sugarcane.

Zambia has significant areas that are suitable for growing sweet sorghum. In comparison with sugarcane, it is easier to grow and handle, at about one third of typical cultivation costs, and



T1 - Boot stage; T2 - Soft dough stage

Figure 2: Harvest of sweet sorghum at different growth stages

also uses significantly less water. Additionally, traditional varieties of grain sorghum have been cultivated in Zambia and any new variety would not be alien. The post-process remains of sweet sorghum can be used as fodder for domestic animals, while the bagasse residue, which is similar to that of sugarcane, can be a source of heat and/or electricity energy.

Sweet sorghum trials in Zambia

The potential for sweet sorghum production in Zambia was evaluated by the University of Zambia in School of Agricultural Sciences and the School of Engineering (UNZA) during the 2004/05 growing season. Incidentally, this was a partial drought season, and in fact the trials confirmed the drought tolerance nature of sweet sorghum. The trials on sweet sorghum were conducted in eight localities in three agro-ecological regions of Zambia. The regions are categorised mainly on rainfall and to some extent soils.

The objective of the study was to evaluate the agronomic performance, sugar content and determine the optimum time of harvest of sweet sorghum varieties in three Agro-ecological regions and on different soil types. The study consisted of two factors with one factor being variety and the second being growth stage of the sweet sorghum. Eight exotic varieties were compared with a local variety called Sima in a randomised complete block design with four replications. Sima is a dual purpose sorghum developed for both grain and sweet stems which are used for silage. The study is still on-going.

Stem yields of sweet sorghum varieties for the UNZA site were compared at two growth stages: at booting and soft dough stage.[1] Specifically, accumulation of sugar for the UNZA site was evaluated at different days after planting. Stem yields and sugar content for the other sites including the UNZA site were compared only at one growth stage, namely the soft dough stage.

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[1]Boot stage = when head of grain starts coming out (i.e. on top of the growing stem)

Soft dough stage = texture of the grain as it moves through the process of drying up

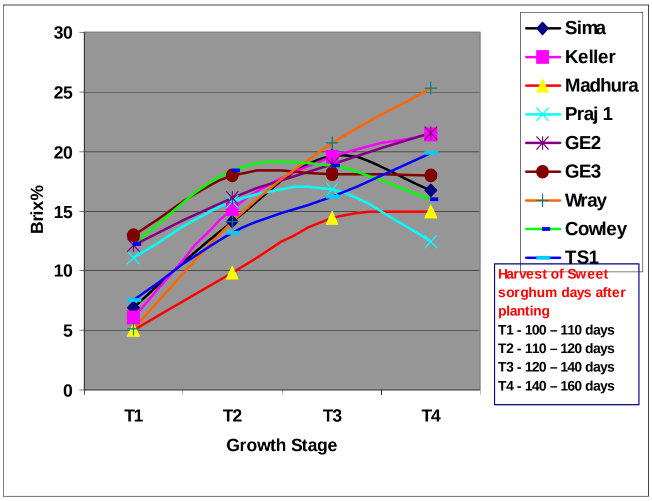


Figure 3: Accumulation of sugar in different varieties of sweet sorghum at UNZA Farm

Major findings of the trials

The highest stem yields were obtained for TS1, followed by Praj1, GE2 and Wray, as illustrated in Figure 2.

The increase of stem yields from booting to soft dough stage was only significant for Keller and GE2. Stem yields of 26663 kg/ha for TS1 were comparable to those obtained elsewhere especially considering that these were obtained under partial drought conditions in the 2004/2005 growing season.

The sweet sorghum yield varied with location, being very sensitive to the agro-ecological region. There was a two-fold reduction in stem yield in region III (the high rainfall region) compared to the other two regions. This is attributed to the acidic soil type of region III, and photoperiodic response. There was also an influence of soil type in region II, where the yield was generally lower on shallow and infertile soils. The stem and height also varied with locality, soil type and population density. In some cases, high population density resulted in thinner stems and therefore prone to lodging as had occurred with Madhura.

Sugar content (as measured by Brix%) varied with the variety and the stage of growth as well as the environment. Brix% was highest at Mpongwe and lowest at UNZA. Accumulation of sugar content at different stages of growth was only reported for the UNZA site (see Figure 3). As illustrated in the figure most varieties had reached the peak in sugar content by milk to dough stage, while Wray, GE2 and TS1 were still increasing; these were long season varieties whose growth was interrupted by the drought. The highest values of sugar content were obtained with Wray, Keller, GE2 and TS1, and lowest being Madhura. For most varieties, the sugar content was higher than the typical value of 11%, which improves the potential ethanol yield which is directly proportional to the sugar content.

Results on the agronomic performance so far obtained are very encouraging. The exotic varieties have proved to be competitive even compared to the local variety Sima. Although these re-

Photo: Kalaluka Munyinda, UNZA

Serious damage of stem borers at CFL

sults are only for the first season, they provide useful results to build on.

Pests and disease

A major concern in the cultivation of sweet sorghum is the impact of pests and disease. Among the troublesome pests for sweet sorghum are birds. The extent of loss differs among varieties. Pests of concern are stem borers and aphids. There are also various diseases, with varying degrees of damage. Major diseases include blight, gray leaf spot, sorghum rust, sooty stripe and the destructive sheath blight, which can cause up to 100% loss (see pictures).

Conversion to ethanol

Using a small-scale crusher, sweet sorghum juice was produced. The average juice extraction was 35%, with the remaining mass being 65% bagasse. It was encouraging to note that the minimum sugar content was 12.5%, while the maximum was 25.3%, the average being 18.2%. This result is interesting because the optimum sugar level for fermentation is around 15% to 20%. Yield results are summarised in Figure 4.

If a limited number of varieties will be considered for mass cultivation, the two with the highest potential are Wray and GE2, due to having not only high juice extraction ratio, but also high sugar levels. Wray had a juice extraction ratio of 35.1%, and 25.3 % brix , while GE2 had 37.0% and 21.7%, respectively. Although TS1 had sugar content of 20.0%, and juice extraction ratio of 32.1%, it had a high yield of 27 tonnes stem/ha, making it another variety to consider.

Concluding remarks

Among the main challenges facing most African countries are high poverty and unemployment. Ethanol production offers a sustainable development path by promoting a domestic renewable energy source and by creating jobs in agriculture, processing and marketing. At the

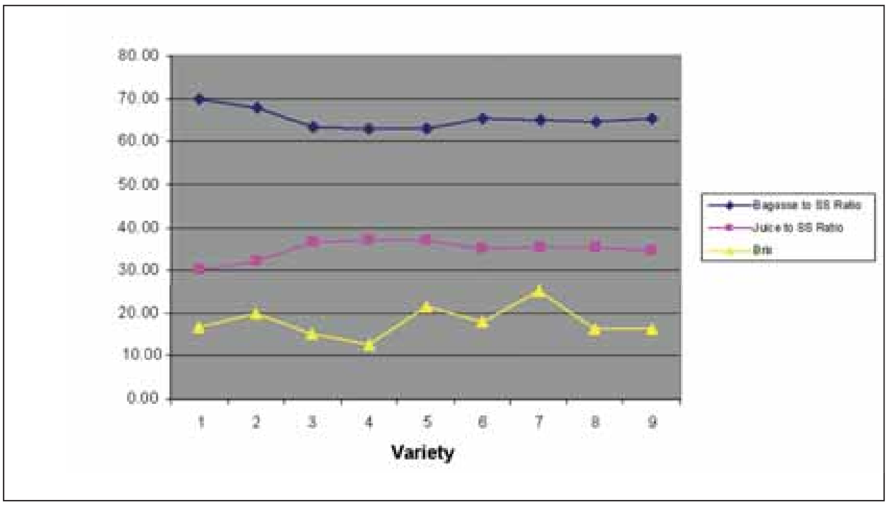
Photo: Kalaluka Munyinda, UNZA

Sorghum rust - losses up to 40%

SADC level, tariff and non-tariff barriers should be reviewed in order to encourage the flow of ethanol as a commodity, which would improve energy security.

Sweet sorghum appears to be a promising feedstock for expanding ethanol production, but national governments need to provide an enabling policy framework and other supportive structures. Key policy issues include standards for use of ethanol as an octane enhancer and an agricultural policy on outgrower schemes. To meet the increasing demand of ethanol and improve the livelihoods of the growers requires promotion of private sector participation in ethanol blending and fiscal incentives from the government. The high bagasse to juice ratio allows for direct combustion to produce heat and/or steam along with electricity for local use and possible sale.

The challenges faced in the cultivation of sweet sorghum can be overcome through good crop management, selection of favourable soil and climatic conditions, and crop improvement. Due to the great potential of the contribution of sweet sorghum to poverty reduction, investment should be made in R&D, and capacity building for outgrower farmers to improve yields and adopt best practices.



1 - Sima; 2 - TS1; 3 - Madhura; 4 - Praj1; 5 - GE2; 6 - GE3; 7 - Wray; 8 - Cowley; 9 - Keller

Figure 4: Sweet Sorghum juice extraction and bagasse production

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Bioenergy with carbon storage - strengthening Kyoto through complementary action to address the threat of abrupt climate change

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The complexity of the climate system means that climate change strategies must consider responses to the potential threat posed by Abrupt Climate Change as well as responses that are aimed at the gradual impacts of climate change. This article outlines a precautionary strategy based on large-scale bioenergy systems with carbon storage; the strategy provides a two-stage implementation process for responding to both dimensions of climate change - abrupt and gradual - based on the high productivity of tropical and sub-tropical biomass in combination with a comprehensive carbon management scheme (Editor's Note).

Harvesting of fast-growing eucalyptus trees in Brazil

In 1997, when the Kyoto Protocol was agreed, and for several years afterwards, climate change (or global warming as it was then usually called) was generally regarded as a long-term problem that would inflict damage on distant future generations. This gave rise to much debate on inter-generational equity as grounds for action that otherwise seemed unnecessary for several decades. Research and development with blue horizon technologies like photovoltaics and hydrogen would enable a low cost response later this century. There was a common belief that CO_2 levels could safely rise to twice the pre-industrial level, with possibly beneficial outcomes from a temperature increase of 1 or 2 degrees Celsius.

Abrupt climate change

This 1990's view was not shared by climate scientists, who strove to expose the risks from provoking the complex non-linear dynamic systems that determine the earth's climate. These fears found expression in the US National Academy of Sciences 2002 report on "Abrupt Climate Change – Inevitable Surprises". This appeared at a time when it was becoming apparent that Mother Nature might be getting impatient. Polar amplification of the average temperature trend was leading to symptoms of potential runaway processes such as the rapid retreat of Arctic sea ice cover, unexpected loss of land-based ice on Greenland and Antarctica, escapes of methane from thawing boreal tundra, and other phenomena.

In response to the danger of abrupt climate change, some researchers pointed to the importance of a near-term technology-based approach focused on bioenergy – growing new fuel rather than extracting fossil fuel (Read, 1994). The emergence in the late 1990s of carbon capture and sequestration (CCS) as a potential mitigation technology led to the idea of linking CCS to bioenergy to give BECS – bioenergy with CO_2 storage.

Paris workshop

The BECS concept offered the possibility of implementing negative emissions energy systems that would, in effect, draw CO_2 out of the atmosphere. Its potential led the UN Foundation to support an expert workshop to address the policy implications of potential abrupt climate change (ACC), which was convened in Paris in October 2004.[1]

What emerged from this workshop and related efforts was a holistic greenhouse gas management strategy that recognized the value of large-scale expansion of bioenergy, with particular attention to the highly productive biomass systems of tropical and sub-tropical regions. The workshop included papers on: Brazilian experience with large-scale sugar cane and forest-based bioenergy; a review of second-generation technologies that are within reach; the prospects for CO_2 storage in deep saline aquifers in ma-

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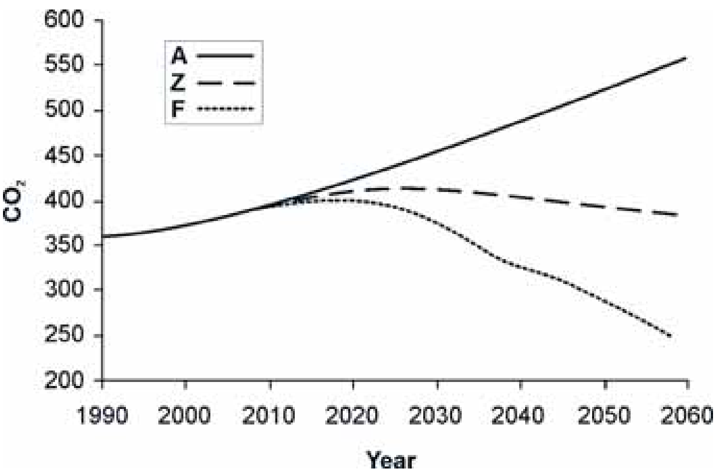
[1] Selected refereed papers from the Conference are collected in number 11/1 of *Mitigation and Adaptation Strategies for Global Change.*



Scenarios

A = SRES-A2

Z = SRES A2 with a transition to zero emissions technologies between 2011 and 2035

F = SRES-A2 with a transition to negative emissions technologies over the same period.

Figure 1: Comparison of zero emission systems and negative emissions systems in mitigating the level of CO_2 (in ppm) in the atmosphere. N.B. The comparison is extended to 2060 only. The usual timeframe for mitigation studies (2100 and beyond) is too far distant in relation to the threat of abrupt climate change.

jor biomass regions; proposed *terra preta* technology[2] for carbon storage; a review of bioenergy project experience; and analysis of a technology-based approach to ACC within Kyoto's cap and trade approach.

The workshop had as its starting point the notion of BECS as a two-stage process within a precautionary strategy. In the first step, large-scale sustainable bioenergy is implemented, including a world market in biofuels with South-to-North trade. The second step is to retrofit CCS – if – climate science suggests that ACC is imminent. This two-stage approach was adopted because large-scale bioenergy, though low-cost, must be based on large-scale land use improvements that require a few decades. Furthermore, with the two-stage approach, the high-cost second stage (which, with advance planning, can be implemented quickly) is at worst deferred, and at best – if the threat of imminent ACC does not materialize – is not needed.

Alternative futures

The effectiveness of the holistic strategy is illustrated in Figure 1. With the bullish IPCC SRES-A2 scenario as baseline (Line A) this provides a comparison with an ambitious – possibly implausibly ambitious – programme of emissions reductions *à la* Kyoto that sees global emissions reduced to zero from 2035 (Line Z).

Line F illustrates a programme of carbon stock management with large-scale deployment of bio-based negative emissions systems implemented over the same period. This would see a worldwide improvement in the way we use land. It would raise the sustainable productivity of the land through investments in tilling the soil (or minimum-tilling it) on a scale comparable with current global investments in drilling for oil. In that way, CO_2 is taken out of the atmosphere by increased photosynthesis. After taking carbon out of the atmosphere, it is then conserved carefully through residue handling and recycling, while consuming biofuels along with traditional products of the land. Finally, carbon-rich wastes are stocked somewhere safer than in the atmosphere.

Using the additional supply of biomass produced through increased land productivity to provide fuels gives only a zero emissions system on a flow basis. However, this is an important achievement, since production of – and trade in, liquid biofuels – address the otherwise intractable problem of transport emissions. But, from the perspective of stocking carbon somewhere safer, the growth of energy forest plantations to build a strategic stock of bioenergy raw material gets a large amount of pre-combustion carbon out of the atmosphere. On combustion, the resulting CO_2 can be compressed and stored underground (CCS – as is promoted in relation to "clean coal"). Or combustion can be partial, through pyrolysis, to co-produce liquid fuels along with long-lived carbon-rich biochar that is stocked in the soil for improved fertility, *terra preta* style. Or, with no combustion, carbon can be stored by building long-lived wooden houses and structures.

In relation to the threat of ACC, the comparison between lines Z and F demonstrates the importance of comple-

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[2] Portuguese expression for fertile dark earth found amongst the otherwise low fertility yellow clays of Amazonia. They are the remains of a lost pre-Columbian civilization that fertilized the soil with biochar that acts as a substrate for fungal and microbial activity essential to the rooting activity of plants.

Photo: Francis X. Johnson, SEI

Harvested eucalyptus trees in Brazil being prepared for shipment

Meltwater of Muldrow Glacier, Alaska

menting the current emissions reductions rhetoric[3] with an additional focus on carbon stock management. We know that the thresholds for the runaway processes mentioned above are unknown; for instance, we do not yet know what is needed to prevent Greenland's ice cap from melting into the ocean, recently proposed by Sir David King as an example of a dangerous climate change induced event. There may well be other important unknowns whose existence or significance is not yet understood.

When the threat of ACC change comes to be better understood, it may turn out that a profile of CO_2 levels is required that is below line Z, in order to avoid Sir David's melt-down of the Greenland ice cap. In that case, emissions reductions cannot do the job and will need to be supplemented by large-scale carbon stock management. To be prepared for that, the first stage of the two-stage precautionary strategy mentioned above needs early implementation, i.e. build a large-scale sustainable global bio-energy market.

Complementarity to Kyoto

Clearly, any policy advance that reflects a concern to be prepared for urgent action in response to imminent ACC must not conflict with Kyoto. A number of publications forthcoming in 2007 put forward the holistic strategy as complementary to Kyoto, as well as addressing the threat of potential ACC and meeting sustainability and equity concerns expressed in the Millennium Development Goals. Thus far, there has been a failure of communication among disciplines, which has resulted in overlooking the holistic strategy. The holistic strategy also improves the negotiability for arrangements that deliver both energy security in the North and sustainable rural development in the South.

In order to implement a holistic strategy, policy instruments are needed for proportional obligations, such as renewable portfolio standards, in order to drive technological change. For example, an increasing obligation can be placed on energy suppliers to create a growing carbon stock in new plantation forests and to use biofuels in transportation. Such obligations can stimulate innovation and release entrepreneurial energies in expanding the market for sustainable technologies, enabling more ambitious Kyoto commitments and giving rise to a flow of sustainable biofuel projects to help meet such commitments. The first stage of the strategy – building a global biofuels market – is crucial and must be subject to conditionality that secures environ-mental and socio-economic sustainability.

At the same time, a new climate regime needs to address the dual inequity that exists, in the historic responsibility of the North for the current level of greenhouse gases, and the windfall profits to energy firms that comes from grandfathering emissions permits to precisely the sector that bears responsibility. A new regime would require, as a condition of permit issue, that an increasing proportion of the windfall gain be spent on sustainable biofuel projects in the South (where most of the land in need of investment and improved management exists), thereby providing supplies of biofuels to the global market and supporting sustainable export-led growth in the South.

A new international regime for facilitating the sustainable growth of a global bio-fuels market could develop from an initial set of bilateral bio-energy partnerships, possibly within the framework provided by the G8 Global Bioenergy Partnership (GBEP). Overall, the hope is for greater understanding of the potential of carbon stock management through land use improvements, and of the central role of bioenergy in that process. Such a regime would facilitate better preparedness to mitigate ACC, if it becomes imminent, as well as more ambitious Kyoto commitments after 2012.

Storage of carbon dioxide

For references, see http://www.sei.se/red/red-vol19-no3-references.html

For more information, contact pread2@attglobal.net

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[3] Of course the Kyoto Protocol does allow for afforestation and reforestation as offsets against emissions but these are treated as second best to the main business of emissions reductions.

ISD/ENB

COP 12/MOP 2 Closing plenary, Nairobi 6-17 November 2006

SMHI International Training Programme, in cooperation with SEI, financed by Sida (containing lectures, discussion and study visits)

CLIMATE CHANGE - MITIGATION AND ADAPTATION

Increasing greenhouse gas emissions and the potential impacts of climate change are a major concern to people around the world. There is an urgent need to enhance the capacity of individuals and organisations to respond to this challenge, especially in developing countries where vulnerability is greater. Successful strategies will have to include adaptation measures as well as efforts to mitigate the causes of climate change.

The overall objective of the International Training Programme (ITP) is to increase the knowledge about climate change and its consequences. The ITP covers methods for identification of vulnerable sectors in society, adaptation strategies and development of action plans to counteract climate change.

The training encompasses lectures, demonstrations, group discussions, exercises and study visits to relevant industries and institutions. An important part of the programme will be the development of the participant's individual projects.

Participation fee, as well as cost for accommodation and full board will be paid by Sida for participants from all invited countries, i.e. low, lower middle and upper middle income countries.

The 4-week ITP starts in the spring of 2007, and will be followed by a regional seminar in a location to be decided. The ITP is expected to be held again in 2008 and 2009. For more information, see SMHI webpage, **www.smhi.se**.

Advanced International Training Programme Opportunity

ECOLOGICAL SANITATION

The overall objective of the training programme is to disseminate knowledge and to develop skills for alternative sanitation options to support urban dwellers to reduce human health risks, to enhance people's nutritional status, to increase biomass production, and to protect water resources and other environmental assets.

Ecological sanitation (ecosan) is an eco-systems based approach to sanitation. It is multi-disciplinary in character and includes cultural and social desirability, human health, greywater treatment, safe processing of human excreta, protection surface and ground water, financing, technical performance, community involvement, social marketing, partnership-formation, policy development and related institutional issues, etc. Ecosan implies closing of water and nutrient cycles within the wider context of households, freshwater management and agriculture/biomass production.

For details re target group, target counties, content, conditions and schedule kindly refer to: **www.ecosanres.org or www.sei.se.**

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EcoSanRes