
# Biofuels trade and sustainable development:

# The case of Pakistan

**Shaheen Rafi Khan, Moeed Yusuf, Selina Adam Khan, Reza Abbasy**

**The Sustainable Development Policy Institute (SDPI)**

**Working document**
**December 2007**

**Acknowledgments**

The authors are grateful to the UK Department for International Development (DFID) and the Dutch Ministry of Foreign Affairs for funding this work.

# Contents

# Acronyms

| | |
|---|---|
| BOD | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| C++ | Calcium |
| CEO | Chief Executive Officer |
| CHG | Coherent Harmonic Generation |
| CIEP | Commission of Industrial Ethanol Producers |
| $CO_2$ | Carbon Dioxide |
| EC | European Community |
| ENA | Extra-Neutral Alcohol |
| EU | European Union |
| GATT | General Agreement on Tariffs and Trade |
| GoP | Government of Pakistan |
| GSP | General System of Preferences |
| Ha | Hectares |
| K+ | Potassium |
| MT | Metric Ton |
| MINFAL | Ministry of Food, Agriculture and Livestock |
| NWFP | North West Frontier Province |
| PO | Phosphorous |
| pH | Potential of Hydrogen - negative 10-base log (power) of the positive hydrogen ion concentration; measure of acidity |
| REN | Rectified Ethanol |
| TSS | Total Suspended Solids |
| UN | United Nations |
| USA | United States of America |
| USD | United States Dollar |
| WTO | World Trade Organization |

# 1 Introduction

The Climate Change 2007 Fourth Assessment Report has finally muted the sceptics. Climate change predictions regarding temperature and rainfall, the frequency and severity of extreme events and sea level rise are both dire and scientifically accurate. There is a corresponding urgency to address both the causes (mitigation) and the effects (adaptation). Renewable energy in general, and biofuels, in particular has begun to look like an increasingly viable mitigation option. For the north they offer prospects for meeting their emission reduction commitments. The south sees in them a way to both reduce energy import bills as well as earn precious foreign exchange. However, there are risks associated with going down this route. Global environmental benefits also generate adverse local environmental impacts, as forests are cut down to grow 'energy' crops. Similarly, multinationals offer price incentives to farmers to switch food to fuel, thereby threatening food security.

The rapid uptake of biofuels reflects, among other things, the ease with which it can replace or be blended with fossil fuels such as petrol and diesel. World biofuel production in 2006 amounted to 55 billion litres. The USA and Brazil are the largest producers of ethanol in the world (38 per cent and 33 per cent of the global ethanol production) followed by China (7.5 per cent). Blending compatibility also explains why many countries have picked up on biofuels as an easy way to reduce their oil import bill or to earn foreign exchange. Thailand is building over a dozen ethanol plants using sugar cane and rice husks as a fuel source. China has constructed the world's largest fuel ethanol facility at Jilin. It uses corn, but Chinese biofuel distillers are also experimenting with cassava, sweet potato and sugar cane. Beijing is reportedly planning to import Brazilian ethanol as well. Japan has already gone down that route; it signed its first 15 million litre deal with Brazil in May 2006 as a prelude to replacing up to three per cent of Japan's gasoline. This is predicted to generate a demand for 1.8 billion litres of fuel ethanol a year.

The USA is the main importer of bioethanol, accounting for 31 per cent of global imports. USA imports represent five per cent of domestic production and they mainly come from Brazil (54 per cent). The European Union (EU) imports a large proportion of the bioethanol it uses, mainly from Brazil and Pakistan. Its plans for the future entail replacing consumption of fossil fuels by 6 per cent by 2010. This will significantly boost the growing biofuels trade and would require a fivefold increase in the production of biofuel crops - a gap other countries hope to help fill[1]. Malaysia, is one country that is expanding oil palm plantations and setting up biodiesel plants expressly to serve the German market.

A global biofuel economy, with a division of labour favouring the most efficient producers, would be a key boon to developing countries. Year round growing seasons and cheap farm labour offer a valuable competitive advantage over cold, high cost northern countries. Super efficient Brazil now sells ethanol at the equivalent of US $25 a barrel, less than half the cost of crude. Because parts of the sugar cane plant are used both to fertilise the fields and to fire up the distilleries, Brazil uses much less fossil fuel to produce alcohol than Europe and America. In those countries, by contrast, ethanol costs about USD 70 and USD 50 and upwards, respectively because of shorter growing seasons, lower crop yields and higher wages.

[1] Karen Bendz. 2005. "EU's largest ethanol exporter, loses privileged status", GAIN Report.

Yet this emerging global market in biofuels is running into political trouble. Developed country farm lobbies provide a momentum to biofuels development, but they also demand protectionist barriers. "Everyone pretends [their enthusiasm] is for the environment, but it's all about agricultural subsidies," biofuels expert Delahouliere warns. To encourage biofuels, the EU pays farmers 45 euros for each hectare of "energy crops" they grow[2]. That provides them a powerful incentive to produce and keep cheap foreign ethanol from entering their market. When Pakistan got special access to EU markets in 2002 and began shipping ethanol, local farm lobbies persuaded Brussels to change its policye and re-establish tariffs. The United States of America also imposes an extra US 54-cent-a-gallon import duty. In addition, almost every country has its own biofuel standard with different specifications[3].

The preamble provides both a backdrop and a context for this study. Essentially a scoping exercise, its objectives are to: a) assess the production potential of energy crops in Pakistan; b) evaluate the foreign exchange savings potential from reduced fossil fuel imports and the foreign exchange earnings potential from biofuel exports; c) assess the sustainable development implications of increased biofuel production and trade and d) suggest economic and institutional policy options to promote the production, domestic use and exports of biofuels. The study also presents anticipatory policy measures and identifies research gaps where more work needs to be done to maximise sustainable development at minimum risk.

Section 2 provides a characterisation of Pakistan's biofuel sector. Section 3 describes the biofuel value chain. In section 4, we provide an overview of domestic and international policies governing ethanol production and trade. Section 5 focuses on the main sustainable development concerns related to biofuel production and use. Section 6 recaps the major arguments.

[2] http://www.msnbc.msn.com/id/8769619/site/newsweek/page/2/
[3] Ibid.

# 2 Characterisation of the biofuel sector

In the context of this study, the term 'biofuel sector' refers to the primary, secondary and tertiary stages of production. The process includes sugarcane production, sugar refining and conversion of molasses to biofuels. In Pakistan's case, the end product is ethanol.

## *2.1 Contribution of sugarcane and sugar production to the national economy*

The sugar industry in Pakistan is the second largest after textiles. Currently there are 76 sugar mills operational in the country[4]. Sugar production in Pakistan has shown an upward trend since the 1990s. From a production level of 2.89 million tons in 1991-92, production reached four million tons in 2003-04[5]. Notwithstanding, sugar production has been fluctuating over the years, primarily due to unpredictable sugarcane yields. An increase in sugarcane production is possible through yield increases, since yields are currently well below the global average. In contrast, the scope for area expansion is limited (NCS, 1992)[6].

**Table 1: Sugar production and yield in Pakistan**

| *Area'000 Hectares Year* | *Punjab* | *Sindh* | *NWFP* | *Baloch* | *Pakistan* |
|---|---|---|---|---|---|
| 5-Years Average | 669.5 | 253.7 | 105.8 | 0.7 | 1029.7 |
| 2000-01 | 615.5 | 238.8 | 105.9 | 0.6 | 960.8 |
| 2001-02 | 656.8 | 240.7 | 101.5 | 0.7 | 999.7 |
| 2002-03 | 735.3 | 258.6 | 104.9 | 0.8 | 1099.6 |
| 2003-04 | 709 | 259.9 | 104.8 | 0.8 | 1074.5 |
| 2004-05 | 644.7 | 214.9 | 106.4 | 0.4 | 966.4 |
| | | | | | |
| *Production'000 Tonnes* | | | | | |
| 5-Years Average | 28693 | 14837.8 | 4803.5 | 36.9 | 48371.2 |
| 2000-01 | 26740 | 12049.7 | 4784.4 | 32.2 | 43606.3 |
| 2001-02 | 31803.1 | 11416.3 | 4787.2 | 35 | 48041.6 |
| 2002-03 | 33168.6 | 13797.6 | 5049 | 40.6 | 52055.8 |
| 2003-04 | 34023 | 14611.8 | 4745.6 | 38.6 | 53419 |
| 2004-05 | 33048 | 9357.4 | 4816.2 | 22.5 | 47244.1 |
| | | | | | |

[4] Research and Economic Development Cell, 2006, "Sugar Sector in Pakistan – its Performance and Way Forward", Karachi Chamber of Commerce and Industry.
[5] Ibid.
[6] Government department experts refer to the possibility of converting waterlogged saline areas in southern Punjab and Sind to sugarcane production. However, independent experts argue that the area gains here will be offset by declining water availability in areas in the Northern Punjab and the NWFP, which are presently devoted to sugarcane production.

| *Yield per Hectare (Production/Area)* | | | | | |
|---|---|---|---|---|---|
| 5-Years Average | 42.86 | 58.49 | 45.40 | 52.71 | 46.98 |
| 2000-01 | 43.44 | 50.46 | 45.18 | 53.67 | 45.38 |
| 2001-02 | 48.42 | 47.43 | 47.16 | 50 | 48.06 |
| 2002-03 | 45.11 | 53.35 | 48.13 | 50.75 | 47.34 |
| 2003-04 | 47.99 | 56.22 | 45.28 | 48.25 | 49.72 |
| 2004-05 | 51.26 | 43.54 | 45.27 | 56.25 | 48.89 |

Source: Agriculture Statistics of Pakistan, 2005-06

In most years, Pakistan consumes all the sugar produced within the country, meeting excess demand through imports. Pakistan imported 0.27 million tons of sugar in 2004-05 and faced a domestic shortage again in 2005-06, which had to be met through imports. In the few years when the country produced surpluses, high production costs prevented exports. Despite sugar prices more than doubling since 1992, Pakistan continues to remain globally uncompetitive. In fact, the emerging markets in ethanol offer prospects of making sugarcane production economically viable[7].

### *2.2 Biofuel production potential*

Pakistan's bioethanol production has grown rapidly: by three per cent in 2000, seven per cent in 2001, nine per cent in 2002 and fourteen per cent in 2003. Bioethanol is produced entirely from molasses, a direct by-product of sugar production. While other indigenous raw materials, such as maize, rice, wood pulp and other forest residues are available in large quantities, they do not offer the same scope for additionality that sugarcane does. In other words, the opportunity cost of producing bioethanol is substantially lower than that for other available sources. The sustainable development implications are, therefore, positive. Bioethanol production will not displace food crops or cause deforestation due to land clearance. Basically, there is a large untapped potential to convert raw molasses to bioethanol, provided the right kind of policy incentives are in place.

Molasses are a direct by product of the sugar cane crushing process. Table 2 shows the production levels of molasses since 1990. The fluctuating trend tracks sugar production. In part, molasses production has also been held back somewhat by a slight improvement in the sugar recovery rate[8].

[7] Research and Economic Development Cell, 2006.

[8] In absolute terms, recovery is still low at 8-9 percent compared to other major sugar producing countries (Philippines, Cuba), where the recovery is over 10 percent.

**Table 2: Molasses production in Pakistan**
**(Million tonnes)**

| Year | Pakistan | Punjab | Sindh | NWFP |
|---|---|---|---|---|
| 1990-91 | 1.12 | 0.61 | 0.47 | 0.04 |
| 1991-92 | 1.17 | 0.54 | 0.58 | 0.04 |
| 1992-93 | 1.33 | 0.63 | 0.65 | 0.05 |
| 1993-94 | 1.69 | 0.97 | 0.68 | 0.05 |
| 1994-95 | 1.65 | 1.01 | 0.59 | 0.05 |
| 1995-96 | 1.36 | 0.82 | 0.50 | 0.04 |
| 1996-97 | 1.32 | 0.80 | 0.48 | 0.03 |
| 1997-98 | 1.98 | 1.24 | 0.68 | 0.06 |
| 1998-99 | 2.11 | 1.28 | 0.76 | 0.08 |
| 1999-00 | 1.40 | 0.80 | 0.53 | 0.06 |
| 2000-01 | 1.50 | 0.90 | 0.55 | 0.04 |
| 2001-02 | 1.82 | 1.22 | 0.52 | 0.08 |
| 2002-03 | 2.05 | 1.30 | 0.66 | |

Source: Pakistan Sugar Mills Association, Annual Report 2003

Despite the increase in sugar and molasses production, bioethanol production has remained very small in terms of its contribution to the national economy. As we indicate later, the unrealised potential reflects policy lapses, particularly the absence of an incentive framework. Until recently, the bulk of the raw molasses was exported, with only minor quantities converted to industrial alcohol for domestic use and export. An even smaller proportion was converted into ethanol for export. While recent policy impetus enhanced interest in the sector, unpredictable global demand, thanks largely to European import restrictions, dampened industry interest in producing ethanol.

### *2.3 Alcohol exports*

Export of molasses has remained between 0.70 million to 1.75 million tonnes over the years. However, over the past five years, a substantial proportion of these molasses was converted into three grades of alcohol i.e. fuel or anhydrous, neutral or extra-neutral (ENA) and industrial or rectified ethanol (REN).

**Table 3: Export of molasses**

| Year | Quantity ('000 tonnes) | Value (Million Rs.) |
|---|---|---|
| 1990-91 | 776.07 | 0.82 |
| 1991-92 | 947.00 | 1.35 |
| 1992-93 | 892.62 | 1.40 |
| 1993-94 | 703.45 | 0.99 |
| 1994-95 | 769.64 | 1.21 |
| 1995-96 | 806.40 | 1.85 |
| 1996-97 | 1,056.13 | 2.02 |
| 1997-98 | 1,359.33 | 2.54 |
| 1998-99 | 1,688.51 | 1.80 |
| 1999-00 | 1,748.00 | 2.20 |
| 2000-01 | 1,190.01 | 2.46 |
| 2001-02 | 1,607.38 | 3.90 |
| 2002-03 | 1,272.63 | 2.65 |

Source: Pakistan Sugar Mills Association, Annual Report 2003

Pakistan exports two forms of alcohol: undenture ethyl alcohol and ethyl alcohol spirit[9]. Presently around 21 distilleries in the country operate at roughly 60 per cent capacity, converting on average 1.8 million tons of molasses[10]. Fuel grade ethanol, which is blended in petroleum products, fetches the highest price in the world market. Requiring 99.8 per cent purity, pure alcohol can be converted into fuel ethanol through the simple molecular sieve process.

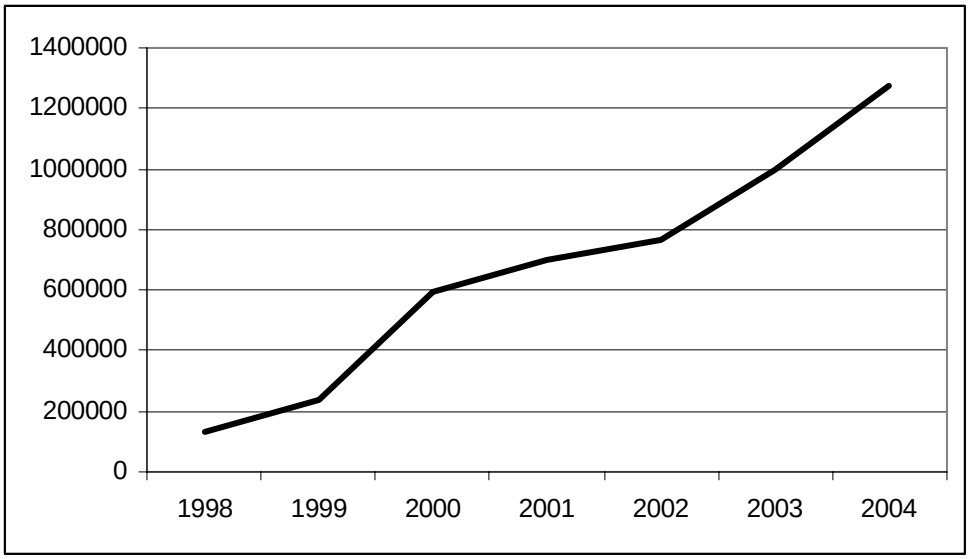
Alcohol exports have increased rapidly over the past five years, as indicated by the trend data below. The bulk of exports went to Japan and the EU, with Italy being the single largest recipient within EU. Notwithstanding, exports to the EU as a whole declined in the wake of Pakistan's removal from the GSP scheme. Pakistan exported around 167,610 tons of alcohol during 2006 and about 22,975 tons during first two months of 2007. The average export price for different grades of alcohol ranged from USD 560 to USD 680 per ton. Total earnings amounted to USD 100.6 million in 2006. The value-addition in molasses through its conversion into alcohol has enabled exporters to earn eight to ten times more foreign exchange[11].

[9] The different grades of alcohol are being produced from molasses with a ratio of 1:5, meaning of five tons of molasses are required to produce 1 ton of alcohol.

[10] Rana, P.I., "Alcohol worth USD100m exported in 2006". Dawn, 6 March 2007.

[11] Rana, "Alcohol worth $100m", 2007.

**Figure 1: Pakistan's industrial alcohol exports**

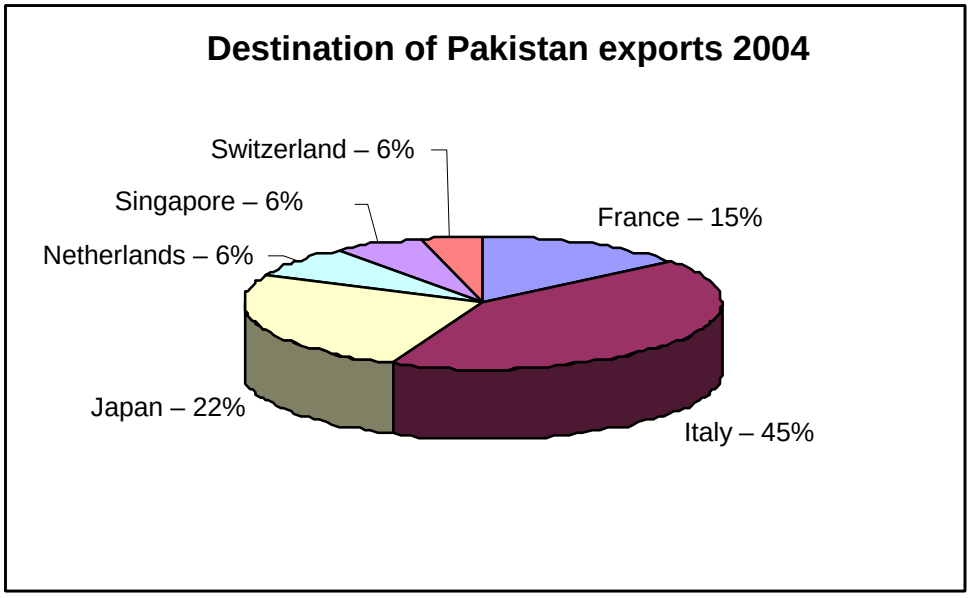



Source: Federal Bureau of Statistics (statistics from various years).
Note: Measurement in litres

The main destinations for Pakistani industrial alcohol exports in 2004 were Italy (thirty per cent, Japan (eighteen per cent), France (ten per cent) and Turkey (nine per cent)[12]. Including the Netherlands, more than 50 per cent of Pakistan's total industrial alcohol exports went to the EU prior to the imposition of the revised GSP (see section 4.2)[13].

[12] More recent figures are being compiled.
[13] Randy Schnepf, "European Union Biofuel Policy and Agriculture: An Overview", CRS Report for Congress

**Figure 2: Destination of exports**




Source: Federal Bureau of Statistics 2004-05

# 3 Biofuel chain

## *3.1 Sugarcane production*

Pakistan is the world's fifth largest sugarcane producer. However, in terms of per acre yield, it compares unfavourably with other major producers. The low yield is a consequence of poor agronomic practices. Land is poorly prepared with simple cultivators which do not plough the fields to the depth required for a deep-rooted crop like sugarcane. Seed qualities are also often poor and the seed rates used are low, the latter resulting in lower plant populations. Moreover, while fertilisers are applied heavily, their use is unbalanced for the most part. Another factor constraining sugarcane yield is poor management of the ratoon crop. A recent survey found that as many as 50 per cent of the farmers consider the ratoon crop a bonus and maintain the cane crop as ratoon[14]. However, average yields of the ratoon crop are low even by Pakistani standards. Furthermore, water availability is a serious problem. Sugarcane cultivation coincides with the summer months when water is scarce; competing crops limit the availability of water for the sugarcane crop. Finally, water logging and high salinity remain major concerns, since a number of areas under cane cultivation are affected by high salinity and thus sugarcane yields are lowered drastically as is the sugar content in the cane[15]. Moreover, despite being the fifth largest sugarcane producer, Pakistan ranks fifteenth in terms of global sugar production. The low sugarcane yields, stagnant acreage and low sugar recovery ratios are the major reasons for the high cost of production of sugar in Pakistan, compared to other major sugar producers world wide.

**Table 4: Major sugarcane producers in the world**

| | Int ($ 1000) | MT |
|---|---|---|
| Brazil | 8,725,914 | 420,121,000 |
| India | 4,825,286 | 232,320,000 |
| China | 1,819,452 | 88,730,000 |
| Thailand | 1,029,610 | 49,572,000 |
| Pakistan | 981,260 | 47,244,100 |
| Mexico | 937,277 | 45,126,500 |
| Colombia | 827,669 | 39,849,240 |
| Australia | 794,369 | 38,246,000 |
| Philippines | 643,870 | 31,000,000 |
| USA | 535,948 | 25,803,960 |
| Indonesia | 529,635 | 25,500,000 |
| South Africa | 451,230 | 21,725,100 |
| Argentina | 400,861 | 19,300,000 |
| Guatemala | 373,860 | 18,000,000 |
| Egypt | 339,278 | 16,335,000 |

[14] "WWF - Pakistan Sustainable Sugar". 2004.
[15] Bilal Hassan, "Increasing Sugar Cane Yield", *Dawn*, February 19, 2007.

| | | |
|---|---|---|
| Viet Nam | 311,550 | 15,000,000 |
| Cuba | 259,625 | 12,500,000 |
| Venezuela, | 182,776 | 8,800,000 |
| Peru | 147,467 | 7,100,000 |
| Iran | 135,005 | 6,500,000 |

ource: "Major food and agricultural producers", Food and Agriculture Organisation

As indicated earlier, after cotton, sugarcane is the largest non-grain crop produced in the country[16]. Sugarcane is grown on nearly one million hectares, which represents four per cent of the total cropped area[17]. A large proportion of the farmers growing sugarcane own less than two hectares. Such farms cover a total of approximately 140,000 hectares. Underscoring the disparity, farms over four hectares cover the bulk of the cropped land area.

[16] "WWF - Pakistan Sustainable Sugar Initiative". National Project Planning Workshop February 2004.
[17] Government of Pakistan. 2005. "Agricultural Statistics of Pakistan 2004-2005". Ministry of Food, Agriculture and Livestock

**Table 5: Area under sugarcane by farm size**

| **Size of Farms (Hectares)** | **Total Farms** | **Farms reporting sugarcane** | | | |
|---|---|---|---|---|---|
| | | *No of farms* | *%age distribution* | *Area (hectares)* | *%age distribut-ion* |
| **All farms** | **6620224** | **838997** | | **884214** | |
| Under 0.5 ha. | 1290098 | 39830 | 4.75 | 10085 | 1.14 |
| 0.5 - 1.0 ha. | 1099330 | 76786 | 9.15 | 31647 | 3.58 |
| 1.0 - 2.0 ha. | 1425370 | 179563 | 21.40 | 99307 | 11.23 |
| 2.0 - 3.0 ha. | 966411 | 160269 | 19.10 | 116255 | 13.15 |
| 3.0 - 5.0 ha. | 890755 | 183963 | 21.93 | 181941 | 20.58 |
| | | | ***76.33*** | | ***49.68*** |
| 5.0 – 10.0 ha. | 580200 | 124965 | 14.89 | 165855 | 18.76 |
| 10.0 - 20.0 ha. | 260791 | 51837 | 6.18 | 126129 | 14.26 |
| 20.0 - 40.0 ha. | 77773 | 16318 | 1.94 | 83187 | 9.41 |
| 40.0 - 60.0 ha. | 15277 | 2718 | 0.32 | 22542 | 2.55 |
| 60.0 ha. and above | 14054 | 2720 | 0.32 | 46539 | 5.26 |
| | | | ***23.65*** | | ***50.24*** |

Source: Agriculture Census Report, 2000.

Sugarcane owners fall into one of three tenure classes: landowner, tenant/sharecropper, and lessee. A study of the socio-economic impact of sugarcane cultivation in Pakistan found the majority of growers in Punjab to be landowners, while most cultivation in the North West Frontier Province (NWFP) was undertaken by tenants[18]. No sugarcane cooperatives exist in the country. Growers continue to interact with their buyers in individual capacities.

About 80 to 85 per cent of the total sugarcane production goes towards the production of sugar[19]. The remaining 15 to 20 per cent is converted into *gur*, a local variant of sugar, which is largely produced and consumed in the North West Frontier Province (NWFP)[20].

The government establishes the support price of sugarcane annually based on various economic considerations[21]. While the aim is to protect small sugarcane growers from exploitation, policy loopholes mean that this aim is not achieved. The most important policy failure relates to zoning. Under the zoning laws, sugar mills can only purchase from designated areas; the purpose is to restrict the growth of sugar mills and hence prevent the creation of excess capacity. Lobbying by

[18] "WWF - Pakistan Sustainable Sugar". 2004.
[19] Asif Khan and Arshad Farooq, "The sugar dilemma". Dawn 25 April 2005.
[20] Gur is a consumer item which is not linked to the biofuel production chain but by the fact that gur production signifies a trade-off with sugar, and therefore molasses production. H.A. Naqvi, "Raising productivity in sugar industry". Dawn 22 August 2005.
[21] The key variables considered in the pricing policy include cost of production of sugarcane, market prices of the crop, nominal and real prices, economics of fertilizer use, domestic demand, supply, stocks, and prices of sugar, comparative economics of sugarcane and competing crops, prices of gur, average wholesale prices of sugar, international market dynamics, import and export parity prices, and efficiency of sugarcane production. Agricultural Prices Commission, 2005, "Price Policy for Sugarcane: 2005-06 Crop", Government of Pakistan.

the sugar mills has made such zoning selective. The government has succumbed to the wishes of large investors and instituted de-zoning arrangements, which allow sugar mills to purchase from anywhere. This creates pricing distortions which adversely affect small farmers, who then are compelled to sell at distress prices thanks to over supply. The middleman *(beopari)* and the premature crop contractor also exploit small and medium sugarcane farmers. Their financial dependence (for loans) on such intermediaries forces them to accept the price on offer. Finally during the harvesting season, sugar mills withhold immediate payments. The potential loss of weight through such orchestrated delays forces the farmers to sell at less than the official price. The Afghan refugee influx however provided a temporary reprieve to the NWFP farmers since *gur* is a preferred consumer item in Afghanistan. *Gur* making is a cottage industry and tax exempt. Therefore, given the higher profit margins of *gur* makers, producers are able to pay better prices to the sugarcane farmers in the NWFP.

### *3.2 Alcohol production*

The essential characteristics of the sugar industry were discussed in Section 2.1. Cane crushing produces sugar and molasses as a by-product. The molasses to bioethanol conversion process is conducted in distilleries. Currently, 21 distilleries exist in the country. The following table provides the installed capacities of the distilleries.

**Table 6: List of distilleries and installed capacities (2005-06)**

| Name | Ltr/Day | M.T./Day | M.T/Yr |
|---|---|---|---|
| Frontier-Takhat Bhai | 14,000 | 11 | 2,800 |
| Premier-Mardan | 46,000 | 37 | 9,200 |
| Khazana-Peshawar | 23,000 | 18 | 4,600 |
| Crescent-Faisalabad | 22,000 | 18 | 4,400 |
| Noon-Bhalwal | 80,000 | 64 | 16,000 |
| C.S.K.-Phalia | 125,000 | 100 | 25,000 |
| Shakarganj -I- Jhang | 160,000 | 128 | 32,000 |
| Shakarganj -II- Jhang | 100,000 | 80 | 20,000 |
| Crystaline-Sargodha | 100,000 | 80 | 20,000 |
| Chishtia | 100,000 | 80 | 20,000 |
| United Ethanol-Sadiqabad | 100,000 | 80 | 20,000 |
| Haseeb Waqas-Nankana | 125,000 | 100 | 25,000 |
| Tandianwala-Faisalabad | 125,000 | 100 | 25,000 |
| Habib-Nawab Shah | 143,500 | 115 | 28,700 |
| Al Abbas- Mirpur Khas | 170,000 | 136 | 34,000 |
| Shah Murad-Thatta | 125,000 | 100 | 25,000 |
| Dewan-Thatta | 125,000 | 100 | 25,000 |
| Uni Col-Mirpur Khas | 100,000 | 80 | 20,000 |

| | | | |
|---|---|---|---|
| Mitiari-Hyderabad | 100,000 | 80 | 20,000 |
| Pinnacle-Badin | 125,000 | 100 | 25,000 |
| Murree Brewery-Rwp | 9,000 | 7 | 1,800 |
| Total | 2,017,518 | 1,614 | 403,500 |

Source: Karachi Chamber of Commerce and Industry, 2005-06

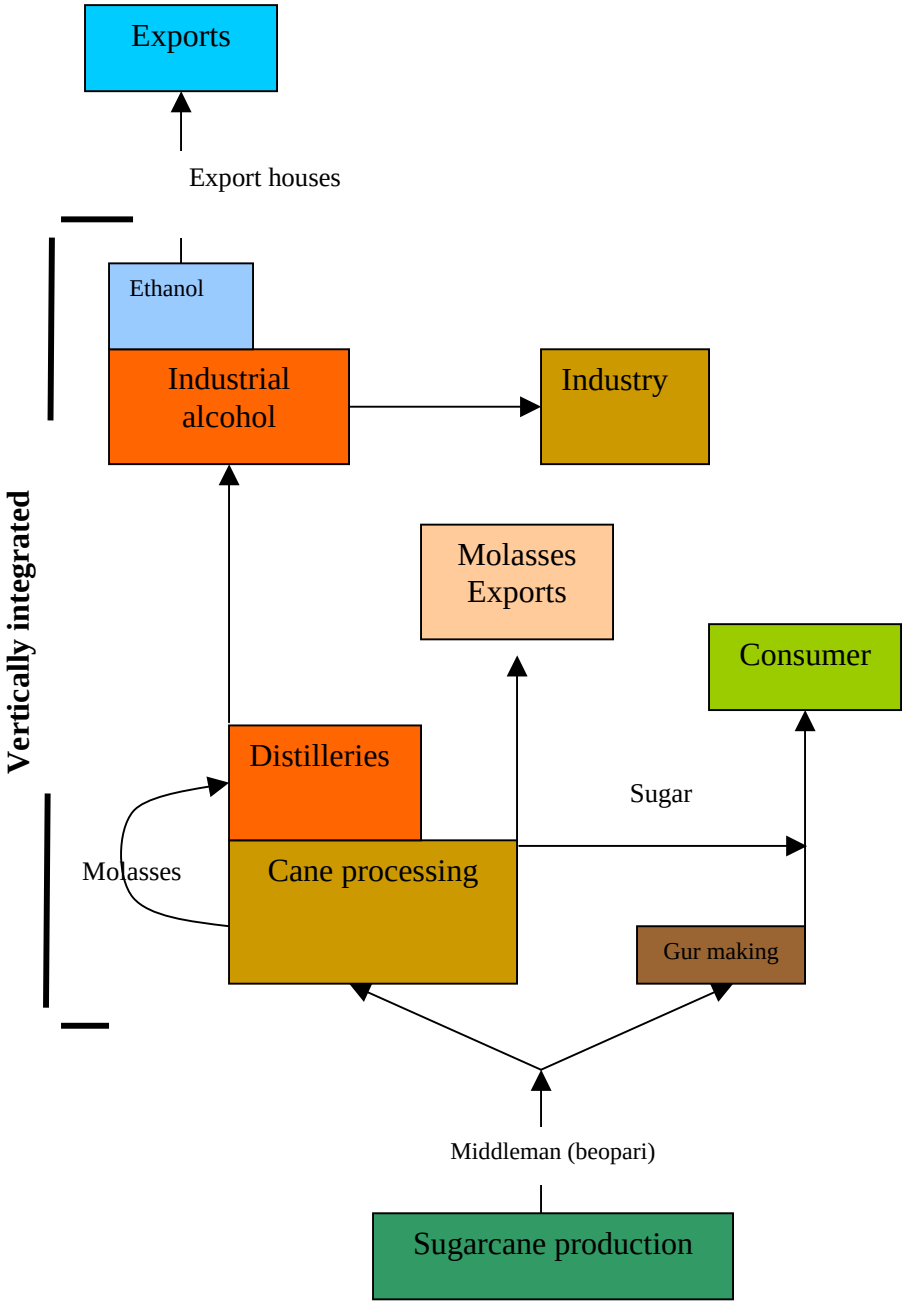
The majority of the distilleries are attached to sugar mills and are situated on-site. This makes integration of the bioethanol production chain relatively simple. The mill receives the cane, crushes for sugar, stores the molasses in storage tanks on-site, and then passes it on to the distillery for industrial alcohol production. Industrial alcohol can be converted into fuel alcohol in a simple process by using molecular sieve technology, which requires a capital expenditure of USD 1.5 million and can be completed in 5 to 6 months[22]. As many as eight distilleries have installed the sieve technology to process industrial ethanol into fuel ethanol. The fuel ethanol conversion plant is linked to the industrial alcohol plant. Notwithstanding the integrated production cycle, we found during our interviews that the distilleries are unable to satisfy their entire demand from internal molasses production. They purchase additional molasses from other sugar mills not having distillation facilities[23].

### *3.3 Alcohol distribution*

Distilleries in Pakistan have three major buyers for their products. Domestic industry purchases industrial alcohol for various purposes. Fuel ethanol is currently only being sold domestically in small quantities to Pakistan State Oil (PSO) as part of a pilot project. PSO blends the ethanol with gasoline in a ten per cent ratio. The third and predominant outlet is exports. Industrial and fuel ethanol are exported through international trade houses[24]. They are brought from distilleries throughout the country to the port of Karachi for onward shipping to different parts of the world. The bulk of the bioethanol exported is used in various industrial processes. The final consumers of exported biofuel are oil refineries where the biofuel is blended with gasoline in a 10:90 ratio. No Pakistani distilleries however deal directly with the end-users of bioethanol. Trade is conducted through trade houses which act as intermediaries.

[22] Government of Pakistan, "Production and Consumption of ethanol and Gasol in Pakistan", Formulation of a National Policy to Encourage the Local Production of ethanol/Gasol in Pakistan, 22 March, 2006.
[23] Interview with Mr. Ahsan Ahmed, Deputy Managing Director, Noon Sugar Mills and Distillery, 7 March 2007.
[24] Ibid.

**Figure 3: Biofuel sector flowchart**



# 4 Biofuel promotion policies

## *4.1 Domestic policies*

The correct mix of domestic policies can produce desirable economic and environmental outcomes. Such polices should focus on export and import substitution, which will generate both foreign exchange earnings and savings. To date, one of the main reasons for the retarded growth of the biofuel industry is the lack of enabling government policies that could motivate the private sector, supporting its demonstrated willingness to invest. Sustaining such investment requires the correct mix of policy incentives and political will.

### 4.1.1 Import substitution

Pakistan imported petroleum products worth USD 3.1 billion in fiscal year 2006, which accounted for 85 per cent of the total oil consumption in the country. This also constitutes a large chunk of the country's trade deficit. Clearly, a shift towards local fuel ethanol consumption would save the country considerable foreign exchange. Any decrease in foreign exchange earnings or government revenue due to reduced molasses exports or subsidies and tax breaks that may be necessary to incentivise the fuel ethanol industry would be more than offset by the forex gains due to a decrease in oil consumption. Below we produce four future scenarios for fuel ethanol use in the country and the estimated reduction in the oil import bill under each scenario (see Annex 1 for the background data used to calculate scenarios).

**Table 7: Foreign exchange saving in terms of oil import reductions**

| | **Scenario 1** | **Scenario 2** | **Scenario 3** | **Scenario 4** |
|---|---|---|---|---|
| *Assumptions* | The entire production of molasses is used to make fuel ethanol; there is no export of molasses | Entire production of molasses is used to make ethanol, such that 50% of molasses are used to make fuel ethanol and 50% are used to make industrial ethanol; there is no export of molasses | Current exports of molasses continue (0.450 million tons); The rest is converted to fuel ethanol | Current exports of molasses continue (0.450 million tons); 50% of the remaining is converted to fuel ethanol and 50% to industrial ethanol |
| *Estimated production of fuel ethanol* | 284,240 MT | 142,120 MT | 198,740 MT | 99,370 MT |
| *Potential foreign exchange savings through reduction in oil imports* | USD 125,065,600 | USD 62,532,800 | USD 87,445,600 | USD 43,722,800 |

Source: In-house calculation

Both the economics and production conditions for bioethanol are favourable. Fuel ethanol is highly price-competitive with gasoline. While a detailed comparative estimate has not been

attempted, the rough estimate is that the unit cost of production is approximately half that of gasoline, accounting for crude import and processing costs. The raw material, molasses, is abundantly available. Also, the potential for producing fuel ethanol from major crops, such as rice and maize, and wood pulp and forest products has not been tapped. Pakistan consumed 1.6 million tonnes of gasoline in the fiscal year 2006. A ten per cent blend represents a foreign exchange saving of USD 300 million, which doubles at a 20 per cent (feasible) blend. The private sector has swung its weight in favour of fuel ethanol production, stipulating the following conditions:

**The Pakistan Sugar Mills Association has made the following recommendations:**

1. 'A mandatory ten per cent blending with petrol be announced after consultation with the oil companies. To make it viable for the oil companies substantial tax breaks may be announced. Most obvious in the list of incentives for the Sugar Mills Association is the removal of General Sales Tax on the sale of industrial alcohol which is currently imposed. While this will only impact government revenues marginally, it may in fact prove consequential in incentivising domestic sales of ethanol if enough demand is generated. Throughout the world the blending program is introduced with full support of the Government and by offering major incentives to the industrial stakeholders. No change in car engines is required for a ten per cent blend.

2. A ten per cent blend can be increased, subsequently, with minimal changes in the engine.

3. All automobile companies must be given a target to produce a certain percentage of flexible fuel cars by a certain date. This percentage should then increase in the following years.

4. Other sources of raw material; maize, wheat, rice, potatoes, sorghum etc., should be explored by the Ministry of Food, Agriculture and Livestock (MINFAL)

5. As the programme moves ahead and the consumption of fuel ethanol increases, the sugar industry can make ethanol directly from cane juice, as is done in Brazil and many other countries.

6. For the programme to succeed it is imperative to set the price of fuel ethanol according to the price of molasses. A system of determining the price of molasses can be set up in consultation with all the stakeholders.

7. To ensure the availability of molasses, the Government might have to restrict the export of molasses, as is done in several countries. But this can be done only by taking all stakeholders into confidence.

Source: Ministry of Industries, Production and Special Initiatives, "Production & Consumption of Ethanol & Gasol in Pakistan. Formulation of a National Policy To Encourage the Local Production Of Ethanol /Gasol In Pakistan". http://www.moip.gov.pk/.

In July 2006, Pakistan State Oil (PSO) and the Hydro Carbon Institute of Pakistan (HDIP) announced a pilot project to introduce blended fuel within the country aimed at meeting the energy shortfall. In three PSO petrol pumps (Karachi, Lahore and Islamabad), fuel ethanol is being blended with gasoline in a 10:90 ratio (E10). However, there is a cosmetic aspect to this initiative. Essentially, despite fuel ethanol's potential and private sector backing, policy support is still nascent; further, the prognosis is not encouraging. While the government has directed the petroleum ministry to

develop a long term fuel ethanol conversion plan, it is almost self evident that the oil lobby will stall progress.

The private sector communicated certain policy proposals to the government, highlighting these repeatedly during our interviews. These included a ceiling on molasses exports and a subsidy on bioethanol production to compensate for the fluctuation in molasses prices. To date however, there has been no visible government response. In fact, the government's move to allow PSO, a state owned Oil Company to conduct a background study on the feasibility of bioethanol clearly illustrates the clout of the oil lobby within the official enclave. An equally obvious signal was the move to put the bioethanol promotion mandate within the Ministry of Petroleum and Natural Resources (MoP&NR) rather than the Ministry of Industries or the Ministry of Environment. The policy provenance clearly needs to shift if any pro-ethanol initiative is to succeed. As further evidence of the pro-oil bent, Pakistan has initiated an aggressive domestic policy to explore indigenous reserves. Foreign investors have been provided with highly attractive terms to invest in the oil and gas sector in the country. A number of concessions and exploration licenses have been accorded to various multinational entities during the past few years.

### 4.1.2 Export promotion

As long as current policy on fuel ethanol is dictated by the oil sector, import substitution will be a slow process. The immediate prospects lie in export promotion. As indicated, Pakistan presently exports over 160,000 tons of industrial alcohol and bioethanol, earning a little over USD 100 million in foreign exchange, which is well below potential earnings. While industrial alcohol and fuel ethanol have a higher value added component and fetch a substantially larger price, molasses continue to be exported in bulk, notwithstanding the recent pick up in fuel alcohol exports. As Table 8 indicates, a mismatch exists between the revenues and the quantum of exports; the same quantum converted to industrial alcohol or fuel ethanol would yield substantially higher foreign exchange earnings.

**Table 8: Export of molasses**

| Year | Quantity ('000 Tons) | Value US $ million |
|---|---|---|
| 2001-02 | 1742.7 | 70.30 |
| 2002-03 | 1272.6 | 44.21 |
| 2003-04 | 1457.3 | 44.98 |
| 2004-05 | 1151.4 | 71.62 |

Source: Agricultural Statistics of Pakistan, 2004-2005

A perverse domestic policy which contributes to this sub-optimal outcome is the high central excise duty and sales tax on alcohol. This needs to be removed to increase price competitiveness both abroad and domestically; the domestic comparison is between the bioethanol blend and gasoline price. Internationally, too, tariff restrictions apply, which we referred to earlier and discuss in more detail in the next section. However, negotiating tariff cuts is an extended process. In the interim, and especially in the light of the demonstrated positive environmental externality, Pakistan could follow India in imposing a ceiling on molasses exports.

The pricing issue, however, is a complex one and elicits different perspectives from stakeholders, such as sugar producers, energy consultants, academics and sugarcane farmers. The opposing views underscore the need for further research to arrive at an informed consensus. We have presented these alternative views in the text box below.

**Pricing bioethanol: a debate**

The petroleum sector view on setting optimal prices proposes to compare bioethanol against the fossil fuel alternatives, while working back from the retail price. Such an approach minimises the risk for policy makers of coming up against information asymmetries which a cost of production (COP) approach would entail. The current practice of the MoP&NR is to peg the prices of petroleum products at the base to international market prices. In other words, producer prices of petroleum products in Pakistan are based on international prices plus an allowance for transportation of products to Pakistan. The same pricing practice needs to be applied to bioethanol. Under this policy, the price of fuel grade ethanol offered to local consumers by the government would be linked to the international market price of ethanol, for instance, the last six months average of the world price of ethanol. The environment ministry concurred with this view, pointing out that in terms of energy equivalence, ethanol prices at Rs. 25/ MMBTU were comparatively higher than petrol. If it were possible to include the environmental aspect, such as carbon dioxide emission reductions, one might be able to get a more accurate measure of price competitiveness.

If this approach was to be adopted, then price subsidies would need to be offered for environmental or social reasons, with an additional mark up to incentivise industrialists to take a risk. Also, concurrently, other forms of renewable energy should also be explored, with the caveat that, with the exception of hydropower, other forms of renewable energy were not cheap. Further, with the "economic accessibility of energy" being positively correlated with the human development index, it is, therefore, key that energy be further subsidised to sustain threshold levels of consumption by the poor.

The sugar industry strongly contested what they saw as a flawed approach to pricing ethanol. In the first place, retail prices did not form an appropriate pricing benchmark, especially for comparative purposes, as fossil fuels immediately become non-competitive, with oil prices hitting USD 100 a barrel. Accordingly, a COP approach was more appropriate. The term "information asymmetries" was really meant to confuse. The bottom line was that the low cost of production is underpinned by an abundant availability of molasses. In effect, it was a combination of the government's discriminatory pricing policies (against ethanol) and external tariff and non-tariff restrictions that had jacked up ethanol prices, both domestically and abroad. The sugar industry only required that such policy biases be removed, and that they could produce ethanol competitively, without the need for 'environmental' and 'social' subsidies.

Sugar farmers raised an important point. If the government were to, in fact, remove domestic taxes on ethanol production, then a part of the windfall gains they would enjoy consequently should be passed on to farmers. The sugar industry, they argued, already received subsidies through various government interventions in order to ensure food security. These comprised a ten per cent import duty, a 35 per cent regulatory tax and interest rate subsidies. In addition, over the past two years, sugar produced in excess of the previous two years volume enjoyed excise duty exemptions. The Ministry of Agriculture concurred. From 40 kg of sugarcane, one could extract about 3.6 litres of molasses, which, converted to ethanol, could earn up to Rs.18 per litre. The estimated COP of ethanol was as low as 25 per cent of this revenue. As such, the conversion of molasses to ethanol represented a reduction in the COP of sugar, which accrued to the sugar industry. Unfortunately, this would not increase the incomes of sugarcane growers.

## *4.2 International policies*

### 4.2.1 Tariff preferences

Until recently, Pakistan was the second largest industrial alcohol exporter to the EU after Brazil, under the General System of Preferences (GSP). Initially, Pakistan and six other countries exported industrial alcohol to the EU under a no tax regime following a dispensation given in the EU anti-narcotics policy.

In May 2005, the Commission of Industrial Ethanol Producers of the EU (CIEP) accused Pakistan and Guatemala (the largest duty free exporters for the period 2002-2004) of dumping ethyl alcohol in the EU market, causing material harm to domestic producers. The Commission dropped proceedings a year later when full custom tariffs were restored on Pakistani imports. In particular, differentiated tariffs on bioethanol and feedstock (raw molasses in Pakistan's case) point to tariff escalation, which discriminates against the final product[25]. Reflecting these tariffs and closer monitoring of industrial alcohol exports to the EU, their prices went up.

Subsequently, following a complaint lodged by India, a World Trade Organisation (WTO) panel concluded that by granting tariff preferences to 12 countries under this special arrangement the EU was violating GATT/WTO preferential treatment obligations. The EU consequently removed Pakistan from the GSP. In the revised GSP regime, the anti-drug system has been replaced by GSP Plus for which Pakistan does not qualify. Eligibility requires countries to demonstrate that their economies are poorly diversified and consequently are dependent and vulnerable. Further, GSP covered imports from such countries must amount to less than one per cent of total EU imports under GSP. Pakistan's industrial alcohol exports are just above one per cent. Thus, the country does not qualify on either grounds. The industrial sector hold the view that the Ministry of Commerce should have hired legal help and filed an appeal with the EU to revise this decision. Industrialists even made an offer to share the costs of hiring strong defence lawyers, but the government took no action.

Currently there is no unique customs classification for bioethanol. Industrial alcohol is traded under the code 22 07 which covers both denaturated (HS 22 07 20) and undenaturated alcohol (HS 22 07 10)[26]. Both types of alcohol can be used for biofuel production[27]. Despite this lack of specific customs classification, there is already evidence indicating that the use of tariffs is common practice in countries keen to protect their domestic agricultural and biofuel industries from external competition. Moreover, the actual tariffs vary. For instance, the EU and the USA have trade agreements that grant different market access conditions to various countries. Table 9 shows present tariff levels in the EU and in other importing countries.

[25] The News 2005 "Increase in oil and gas prices."

[26] See the World Custom Organization Website at http://www.wcoomd.org/ie/en/Topics_Issues/HarmonizedSystem/DoucmentDB/0422E.pdf

[27] EC 2005

**Table 9: Tariffs on ethanol 2005**

| Country | Ethanol Import Tariff |
|---|---|
| USA | 2.5% |
| Brazil | 20% |
| Argentina | 20% |
| Thailand | 30% |
| India | 186% |
| Canada | 4.92 cents per liter = 19 cents per gallon |
| EU | 19.2 cents per liter = 87 cents per gallon |

Source: "Ethanol Facts: Trade", Renewable Fuels Association, 2005

The local distilleries have consequently begun to suffer losses and some have ceased operations. After 2002-03, the number of distilleries in the country had increased from six to twenty one[28]. However, given a rise in molasses exports post 2003-04, and the more stringent EU tariff measures, the distilleries were soon running idle capacities. Currently, at least two distilleries have shut down, with another five are contemplating that option[29].

### 4.2.2 Technical, environmental and social standards

Environmental and social standards are now part of the global trading regime. There is little dispute on whether such sustainable development issues should be linked to trade. The question now is how it should be done. While the north continues to insist upon the stringent implementation of such standards, the south is becoming increasingly wary of the use of standards as hidden trade barriers. Moreover, since standards do not tend to be uniform, it becomes virtually impossible for resource constrained producers in the south to develop variants of their products to conform with standards specific to a particular destination.

Bioethanol trade has been no exception in the debate over standards. The EU, a major market of Pakistani industrial alcohol exports till 2006, has imposed domestic, fuel quality limits on the use of bioethanol and biodiesel. A maximum of five per cent blending is allowed, thus limiting the biofuel market. Specifically for biodiesel, further directives necessitate the production of biodiesel predominantly from rapeseed oil and not from soya oil or palm oil. In addition, the EU's "Biomass Action Plan" is contemplating certification to ensure that biofuel imported is produced from crops grown in an environmentally sustainable manner. Individual EU members such as the Netherlands and UK are already developing certification schemes. A number of additional voluntary measures to ensure import of 'sustainable' biofuel are also underway. The varying standards requirements across the north present additional compliance problems for a technically and institutionally unprepared south[30].

Pakistan, in principal has supported standards in the global trading regime. But, concurrently, as a member of the southern block, it has repeatedly opposed any measures that may allow the north

[28] Not all of these distilleries produced fuel ethanol.
[29] Parvaiz Ishfaq Rana, "Ethanol export to EU comes to a halt". Dawn, 27 August 2005.
[30] IIED, 2006.

to use standards as 'protective' devices against free trade. Its stance on the EU agricultural support, which includes energy crops, echoes that of the G-20 block within the WTO. Pakistan seeks an end to EU subsidies to its farmers, especially 'Amber Box' subsidies. Negotiations on the EU's agricultural support however continue with no end in sight.

### 4.2.3 Institutional uncertainty

Biofuels and bioethanol continue to remain unresolved issues in the World Trade Organisation (WTO), complicating its trade facilitation. Experts claim that the WTO has never really probed energy issues because few energy producing countries have been members of the organisation; biofuels have warranted even less attention as it constitutes a small percentage of the world's energy supply[31]. The WTO classifies bioethanol as an agricultural product, making no distinction between its use as fuel and for other purposes; biodiesel is classified as an industrial product, thus 'having two competing fuels with different rules'[32].

Fuel ethanol as an environmental good is the subject of yet another debate. Weber Amaral, CEO of the Brazilian Biofuels Institute, predicts that the discussion around biofuels is likely to become more complicated as the range of products used to make biofuels expands. Amongst other things, classification could affect how fuels are treated during trade talks and whether governments will be allowed to pay biofuel producers export subsidies. Further, there has been a call for world standards on biofuel contents as well as rules and regulations on subsidies on biofuel crops in a report published by the International Food and Agricultural Trade Policy Council. 'If no decisive action is taken, Hebebrand said governments could end up "cross-subsidising" biofuel by-products like glycerol'[33].

Given the optimistic forecasts for biofuel growth prospects, 'the World Trade Organisation and others must act now to regulate rules and standards that are very muddled'. According to the International Food and Agricultural Trade Policy Council, which released the report on WTO rules on fuels like fuel ethanol, developing countries are 'wildly producing biofuels'. But with rules for things such as import standards varying from country to country 'the WTO, the World Customs Organisation and national governments must work together to make sure that the future biofuel trade runs smoothly'[34]. The report warns against government intervention, aimed at protecting the domestic fuel market, as threatening to stunt the growth in trade; intervention includes tax incentives and high tariffs and subsidies. Further it recommends a unified classification for biofuels.

Pakistan stands to gain from increased bioethanol trade. Within Pakistan, agricultural subsidies have been withdrawn for virtually all crops, largely due to lack of resources and IMF/World Bank led structural adjustment of the economy that has been undertaken since the 1990s. Overall agricultural production in Pakistan is taxed. Sugarcane production, which is the only crop relevant to the bioethanol industry is not subsidised. In fact, a major worry is the gradual shift of farmers away from sugarcane to more economically lucrative crops.

---

[31] "Long Ignored by the WTO, Biofuels Might Receive Attention", *Congress Daily*, 27 October 2006.
[32] Ibid
[33] "WTO must set rules for future biofuel trade-report", Reuters AlertNet, 27 October 2006.
[34] Ibid

# 5 Sustainable development impacts

This section attempts to identify the potential sustainable development impacts of increased bioethanol production. The economic aspects have already been assessed such as import substitution, export promotion, energy security, and predictability of production. This section focuses on potential social and environmental impacts.

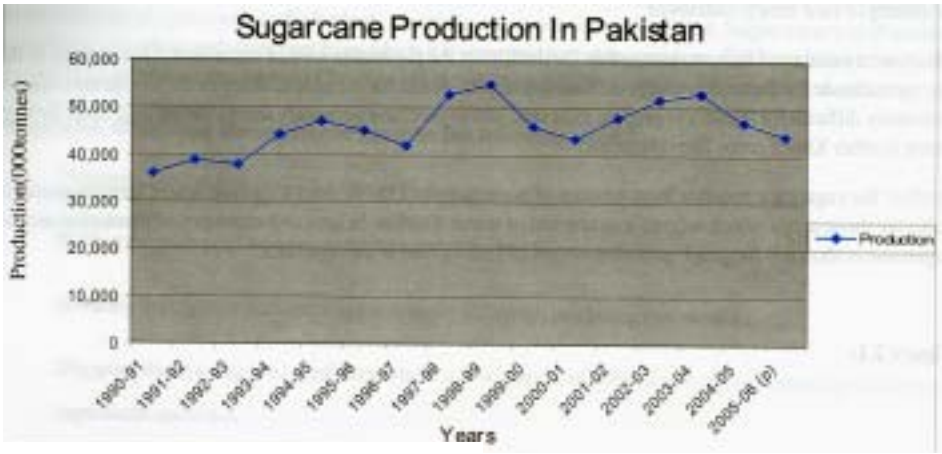
## *5.1 Sustaining sugarcane production*

Sugarcane production is driven by a national policy which emphasises self sufficiency in sugar. In the short to medium term, such a policy potentially generates derivative benefits in the shape of bioethanol production. Essentially, they would ensue from the alternative use of the abundant stocks of molasses, provided the correct policy and economic incentives are in place for such conversion. There are no backward linkages with sugarcane production *per se*. As indicated, it is the concern with food security that drives the government to seek ways to incentivise sugarcane growers, or to find alternatives such as sugar beet.

However, in the long term, the sustainable development concerns associated with the production of feedstock may materialise if biofuels production in Pakistan takes off. In view of the emerging scarcity of water and land, land use conversions (deforestation) and crop switching (undermining food security) would then become legitimate concerns.

On average, over the past five years, sugarcane production has averaged 50 million tons per annum as compared to the requirement of nearly 75 million tons to meet the installed sugar mill production capacity.

**Figure 4: Fluctuating sugar cane production in Pakistan**




Source: Economic Survey of Pakistan 2005-06

The lack of predictability is linked to variable water supply. Sugarcane is a water intensive crop requiring between 64 and 80 acre inches of water. While Pakistan has adequate surface and ground water, the difference between good and bad production years is contingent upon

rainwater. During drought years, sugarcane production drops substantially. In years of high rainfall, sugarcane production rises, on occasion producing gluts. For the future, sugarcane shortages have been forecast as the norm as discrete water supply runs up against increasing demand to meet agricultural, household, energy and industrial needs. Consequently, growers have begun to shift to crops such as maize and sunflower that require much less water, and mature over a much shorter period.

According to current estimates, approximately 75 million tons of sugarcane input is required to satisfy the 6.7 million ton domestic demand for sugar[35]. Over the last decade however, on average, mills have received just 35 million tons of sugarcane[36]. Clearly, in years when sugarcane production is low, not only does sugar production suffer but so does molasses output. The Ministry of Food, Agriculture and Livestock (MINFAL) is attempting to promote sugar beet as a viable alternative to sugarcane, both for sugar and bioethanol production. However, annual production currently stands at just 300,000 tons and the crop is grown mainly in the NWFP[37]. In 2002, Government of Pakistan started experimenting with various varieties of sugar beet in order to determine its feasibility in the Pakistani climate. Thus far, experiments in Punjab, Singh, and NWFP have produced encouraging results. Imported beet seeds from France and Germany have proved to be resilient enough to do well in Pakistani conditions, thus allaying concerns about beet's inability to mature under the high temperatures experienced in Pakistan[38]. The advantages of beet are higher yield (above 50 tons/hectare), significantly less water requirement, and a higher conversion ratio from beet molasses to bioethanol[39]. It can also be intercropped with sugarcane. Interview responses confirmed that the government would need to provide substantial subsidy to the mills to convert their production processes to beet as concerns about the high capital cost to process beet were raised.

Another way to address these concerns is to enhance sugarcane yield. The yield has increased only marginally over the past five years and is currently about 50.1 tons/hectare, which is much below the global average of 60 tons/hectare[40] (see section 3.1).

A possible long term equity issue relates to the conversion of sugarcane or beet production to 'cash crop' agriculture, with its attendant negative spin offs. One can envisage added impetus for corporate agricultural giants to take over and thus marginalise small producers in a bid to concentrate sugarcane or beet production. Moreover, agricultural encroachments into ecologically sensitive areas could also be an unwelcome consequence[41].

### *5.2 Social impacts*

[35] Ibid.
[36] Ibid.
[37] Ibid.
[38] Interview with Inayatullah Khan, Cane Commissioner of Pakistan, Ministry of Food, Agriculture and Livestock, 20 February 2007.
[39] Inayatullah Khan, unpublished ,"Feasibility of Sugar Beet Cultivation in Pakistan", Ministry of Food, Agriculture and Livestock.
[40] Khan, "Feasibility of Sugar Beet Cultivation", unpublished.
[41] See Ilan Kruglianskas, "Fuel ethanol: Climate Benefits with Responsible Production", Task 40 workshop on Sustainable Biomass Production for the World Market, World Wildlife Fund.

### 5.2.1 Pricing issues

The government price support policy aims to ensure fair prices for sugarcane growers while keeping consumer welfare in mind. Equity concerns emerge from market imperfections. Middlemen (see section 3) play a key role in sugarcane procurement and often end up exploiting small scale farmers forcing them to sell at distress prices. In collusion with mill owners, they orchestrate delays at the mill gate; the problem becomes exacerbated during surplus years[42]. The farmer has no option but to accept the price offered (lower than the support price) or face further delays. Large farmers are better placed as their crop represents a large proportion of the mill intake and they also have greater political clout[43]. Small farmers are indebted to middlemen for their consumption and input needs, which also leads to under pricing. Further, a report by the Agricultural Prices Commission of Pakistan indicates that the scales installed to weigh sugarcane do not provide correct readings[44]. However, given the high level of illiteracy among small scale growers, such practices go undetected. Moreover, mills are also known to make undue deductions contending that sugarcane quality is low and contains high trash content[45].

The effects of government intervention are also felt in the molasses and industrial alcohol markets. While the benchmark prices for these products/by products are determined in global markets, the government distorts relative prices by taxing locally produced alcohol (see section 4.1.2).

### 5.2.2 Labour issues

A life cycle analysis suggests little impact on employment either way. In the short to medium term, value added is likely to occur as a result of switching from molasses to bioethanol production, which has no back effects on either sugarcane or sugar production. In the long term, if Pakistan finds substantial markets abroad for bioethanol and this triggers land use changes, it may trigger discernible impacts both in growing sugarcane and processing.

Reverting to the short to medium term, the sugar sector in Pakistan employs nearly 75,000 people. The sector suffers from over capacity. While unions exist, sugar mills often threaten layoffs in order to right size the industry. Labour unions find it difficult to negotiate with employers as the sugar cartel exercises enormous influence over decision makers in the country[46].

Labour conditions in general are no different than in other industries that produce for domestic consumption. Pakistan, in general has made progress in meeting global labour standards in export oriented industries. However, the performance has remained dismal in cases where client pressure to conform has been absent. On average, industrial wages in sugar processing remain at par with industries in other sectors. However, the situation is markedly poor in the province of Sindh, where instances of employers not entertaining labour laws, withholding employee benefits

[42] "Price Policy for Sugarcane", 2005
[43] Research and Economic Development Cell, 2006.
[44] Ibid.
[45] Ibid.
[46] Muhammad Aslam Memon, "Sugar Industry in Pakistan", Pakistan and Gulf Economist, 23-29 September, 2002.

agreed upon in original contracts, and punishing them for involvement in union activities is commonplace[47].

Unlike the sugar industry, industrial alcohol production is highly capital intensive and requires a few skilled plant operators and engineers. Adding value in the form of ethanol is again a highly capital intensive process, requiring little or no additional labour. Taking realistic projections for Pakistan's bioethanol production in coming years, there is little possibility that the bioethanol sector would become a major employer. At the same time however, an analysis suggests that no labour displacement would occur as a result of an increase in fuel ethanol production. First, as fuel ethanol is produced from a byproduct of the sugar production process, there is no question of labour displacement within the sugar mills. The other potential concern could be with regard to labour displacement in the oil industry, as fuel ethanol will end up replacing oil consumption. Again, for the foreseeable future, one does not envisage an increase in the blending ratio beyond ten per cent. At this rate, oil refining processes are not likely to be discontinued (this is distinct from revenues for the oil companies, which may drop).

### 5.2.3 Food security concerns

Globally, a somewhat sensational representation is that the activities of the biofuels sector engender an unhealthy competition between 800 million motorists and 2 billion hungry people. This could be a legitimate long term concern for Pakistan although in the short to medium term, sugarcane and rice, two major production and export items, offer solid prospects for meeting domestic fuel demand at an E25 fuel blend[48]. Also, as it was mentioned above there exists considerable scope for sugarcane yield increases and for intercropping with sugarbeet[49]. However, should Pakistan decide to go for higher blends and/or substantially higher bioethanol exports in future, corporate intrusions displacing food with fuel could become a reality. Accordingly, there is a concurrent need to explore alternatives to biofuels as well, such as public transportation, increased vehicle efficiency and hybrid vehicles. With regard to biofuels production *per se*, and in a food security context, preferred long term policy would be to avoid distillation from food grains such as wheat and corn, which Pakistan also grows in abundance, as well as growing energy crops on marginal lands. The latter would also generate poverty alleviation benefits.

## *5.3 Environment*

[47] "Union Busting in Pakistan's Sugar Mills: Workers Face Dismissal and Illegal Detention" Asia and Pacific Regional Secretariat, International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations.

[48] The biofuel potential for rice husks and hulls has still not been explored in Pakistan.

[49] The Agricultural Prices Commission (API) and MinFAL favor policies that ensure self-sufficiency. These policies aim to increase yields per hectare, to encourage value addition, and to enhance profitability of sugar production and by-production. MinFAL aims to increase Pakistan's present yield (52 tons/ha) to the global average (68 tons/ha), and to improving sugar recovery rates, which were also below the global average. Policies designed to induce these changes included sugarcane support prices and import protection (a 15 percent duty on sugar imports).

Environmental impacts are evident at every step along the bioethanol value chain. Key stages include: (i) sugarcane production; (ii) production of molasses; (iii) distillation of molasses and; (iv) CHG emission reductions through the use of blended fuel.

Perhaps the most adverse environmental impacts occur at the sugarcane production stage. Such impacts derive from poor management practices. Environmental issues associated with cane production include impacts on soil, vegetation clearing, ground water use and contamination, pesticide pollution, and oxygen depletion in freshwater bodies. Sugarcane cultivation in Pakistan is known to cause soil erosion, soil alkalinity and a consequent reduction in the soil's nutrient holding capacity, as well as soil salinisation. Fertiliser and pesticide use is also often inefficient and ineffective, which apart from increasing costs of production also leads to poorer ground water quality and contamination of water bodies via pesticide residues. Moreover, oxygen depletion in water bodies is caused by inefficient harvesting practices that lead to water run off containing substantial quantities of cane juice. Finally, air pollution is caused due to the predominant practice of post-harvest burning of the sugarcane trash. While this is designed to achieve ratooning success and pest and disease prevention, it allows ash and smoke to escape into the atmosphere[50].

Production of molasses, the second leg in the fuel ethanol production cycle, also has environmental concerns associated with it. Since molasses is a byproduct of sugarcane processing in sugar mills, all environmental concerns related to the sugar industry apply to molasses production. While the sugar industry discharge includes solid, gaseous, and liquid waste, the latter two are harmful from an environmental perspective. The solid waste includes bagasse and press mud. The former is used as a fuel source within the industry and is thus recycled while the latter is mostly used by farmers in the vicinity of sugar mills as manure.

The level of gaseous discharge from the sugar industry is largely dependent on the source of fuel. Hydrogen sulphide, sulphur dioxide, oxides of nitrogen, carbon monoxide and trace metals are all discharged in varying degrees. Most literature on Pakistan suggests that these emissions remain well below the National Environmental Quality Standards (NEQS) limits. An exception is the smoke discharged from mills using fuel oil as a source of energy for the boilers, where the discharge is often found to be above NEQS. Finally, wastewater flowing out of sugar mills can potentially be highly polluting unless treated efficiently. Incidentally, the track record of the sugar industry and distilleries on this count has been exceptionally good (see below)[51].

The next step in the production chain is processing of molasses into industrial ethanol and further into fuel ethanol. This process takes place in the distilleries. Wastewater flowing out of distilleries is highly contaminated; it can pollute fertile land and harm aquatic life in water bodies, if left untreated. The rough proportion of waste in the out going effluent is provided in the following table:

**Table 10: Typical distillery wastewater composition**

[50] "WWF - Pakistan Sustainable Sugar". 2004; Research and Economic Development Cell, 2006.
[51] "Pakistan's Sugar Industry: Responding to the Environmental Challenge", undated, <http://www.cpp.org.pk/etpibrchr/brochure-sugar.pdf>;"WWF - Pakistan Sustainable Sugar". 2004.

| Parameters | Values |
|---|---|
| pH | 4.0 ~ 4.5 |
| $BOD_5$ | 40,000 ~ 45,000 |
| COD | 80,000 ~ 1,000,00 |
| TSS | 3000 ~ 5000 mg/lit |
| Sulphates | 4000 ~ 6000 mg/lit |
| Chlorides | 4000 ~ 6000 mg/lit |
| K+ | 4000 ~ 10000 mg/lit |
| PO 4 | 100 ~ 150 mg/lit |
| Ca++ | 500 ~ 700 mg/lit. |

Source: Talib, "Pollution Control in Sugar Industry", 2001.
Note: pH – hydrogen-ion concentration. 7 is normal. Above 7 indicates acidity, below 7 indicates alkalinity
BoD – Biological oxygen demand
CoD – Chemical oxygen demand
TSS - Total suspended solids
K – Sulphate
PO – Potassium
Ca - Calcium

While environmental legislation (Environmental Protection Act, 1997) exists to ensure industrial waste treatment in Pakistan, the implementation of these regulations is lax. The extensive technical and financial resources required for a robust monitoring and verification mechanism are not available[52]. Only industries that find a clear advantage in adhering to environmental stipulations tend to implement regulations seriously. The distillery industry falls in this category.

Notwithstanding the general lack of effluent treatment by industries in Pakistan, most of the distilleries in the country have installed treatment plants, albeit with varying efficiency. The major push factor for distilleries to be environmentally conscious is the cost saving associated with waste treatment. The distillery wastewater treatment is an anaerobic process through which the organic components of the wastewater are converted to biogas, with the excess sludge production being extremely small. The two major products of the treatment process are methane gas and carbon dioxide. Methane gas is recycled as an energy source in the distilleries, with as much as 70-90 per cent of the total energy requirement being met from methane[53]. In effect, distilleries have a 'closed carbon cycle'. The final discharge, when diluted with subsoil saline water has BOD and COD concentrations reduced by as much as 97 per cent and can be used for land irrigation[54]. The environmental gains from treatment are thus obvious. More important from the point of view of the distilleries however is the cost saving as a result of treatment.

**Table 11: Waste concentrations in treated distillery effluent**

[52] Nadia M. Akbar and Mahmood A. Khwaja, 2006, "Study on Effluents form Selected Sugar Mills in Pakistan: Potential Environmental, Health, and Economic Consequences of an Excessive Pollution Load", Sustainable Development Policy Institute.
[53] Akbar and Khwaja, "Study on Effluents from Selected Sugar Mills in Pakistan", 2006.
[54] K. Iqbal Talib, 2001, "Pollution Control in Sugar Industry", XXXVI Annual Convention 27 -28 August 2001, The Pakistan Society of Sugar Technologists.

| Parameters | Values | Performance |
|---|---|---|
| PH | 7.5~7.6 | Alkaline |
| $BOD_5$ | 4,000~4,500 mg/lit | 90% reduction |
| COD | 27,000~33,000 mg/lit | 65~67 reduction |

Source: Talib, "Pollution Control in Sugar Industry", 2001

Despite the reduction in contaminants, waste concentrations are still higher than the nationally set standards (National Environmental Quality Standards). However, this points to the unrealistically low levels of concentrations stipulated in official standards rather than any problems in the treatment process[55]. In fact, distillery plants maintain a reasonable level of technological sophistication in treatment, especially in the medium and large sized distilleries.

Regarding end use, the consumption of fuel ethanol in automobiles compared to fossil fuels leads to a substantial reduction in GHG emissions. The blended fuel provides a higher octane content without any presence of lead (traditionally used in gasoline as a booster), thus enhancing car performance and, at the same time, reducing disease causing emissions from car exhausts. Although no estimates specific to Pakistan are available, the general norm is that for blended gasoline carrying 22-24 per cent fuel ethanol, reduction of fossil carbon dioxide from the tailpipe could be as high as 80 per cent[56]. Moreover, the fact that fuel ethanol has a positive net energy fuel balance is also widely acknowledged. For instance, a recent study conducted at the Michigan State University found that on average a gallon of fuel ethanol contains 56 per cent more energy than the energy requirement to produce it[57]. While such estimates may not provide a good proxy for the potential benefits in Pakistan, given the varying production technology and practices, it nonetheless does point to some potential net environmental gain by using fuel ethanol compared to fossil fuels. However, there is a partial offset. Pre-harvest burning of sugarcane is a common practice in Pakistan and generates GHG emissions and air pollution in general. Moreover, despite the 'closed carbon cycle (CCC)' we observed in the plants we visited, replication on a larger scale would make the CCC a more difficult option. Hence, emissions during the industrial alcohol and ethanol production process would remain an enduring problem.

Ultimately, the sugar industry has the potential to generate projects under the Clean Development Mechanisms (CDM) to earn carbon credits. The E10 blend was an immediate possibility. With all the potential benefits, institutional and policy support was key.

[55] Ibid
[56] "Fuel ethanol FAQs", Saab BioPower
[57] Salameh, "Can Biofuels Pose a Serious Challenge?" 2005.

# 6 Conclusion

Given that the bioethanol industry in Pakistan is only starting to be developed, this paper can be considered as an anticipatory policy work and therefore it can set a concrete set of policy recommendations and research gaps about how to promote an industry that maximises sustainable development opportunities and minimises risks.

The promotion of bioethanol presents a win-win scenario for Pakistan. The country incurs an oil import bill of USD 3.1 billion every year. Substituting gasoline with bioethanol could result in considerable foreign exchange savings. Moreover, under current conditions there is no trade off between bioethanol and the food production cycle. Environmentally, beyond the traditional environmental risks associated with the agricultural phase, the bioethanol production process in distilleries exhibits a closed carbon cycle. Moreover, bioethanol substantially reduces GHG emissions from automobiles, at the same time allowing for better performance of vehicles.

Despite the potential advantages of bioethanol use as fuel however, progress in promoting bioethanol use lacks impetus. The oil refining companies in collusion with the petroleum ministry have thus far managed to keep a lid on private sector involvement in popularising bioethanol use. The private sector, rather than being given incentives, faces domestic taxes on industrial alcohol sales. In addition to the domestic policy biases, major importing countries have also imposed restrictions on Pakistan, which has ended up compromising the country's export potential. The EU imposed tariffs under the revised GSP, that badly impacted the distillation industry. The loss of international markets has resulted in the closure of two distilleries. Another five are contemplating shutting down. Further, institutional uncertainties and unresolved issues especially pertaining to bioethanol classification may complicate the development and global growth of the industry. Initiatives such as the EU Biomass Action Plan may present further barriers in bioethanol exports from developing countries such as Pakistan.

Another major concern is with the sustainability of bioethanol production. In Pakistan, bioethanol is produced from molasses generated as a byproduct of sugarcane crushing. While sugarcane is a major crop, the stagnating area and lowering yields of the crop are likely to cause severe sugarcane shortages in the future. Bioethanol production is sure to suffer as a result. While sugar beet has the potential to make up for the shortage, it will only be able to supplement sugarcane over the long run. Other major crops also offer possibilities, as indicated in Table 12.

**Table 12: Crops grown in Pakistan that can be converted into ethanol**

| Crop | Production '000 tonnes | Area '000 hectares |
|---|---|---|
| Rice | 5024.8 | 2519.6 |
| Wheat | 21612.3 | 8358 |
| Maize | 2797 | 981.8 |
| Barley | 91.7 | 93.3 |
| Sugarcane | 47244.1 | 966.4 |
| Sugar beet | 121 | 2.8 |
| Rapeseed and Mustard seed | 215.8 | 257.2 |
| Potatoes | 2024.9 | 112 |

Source: Agricultural Statistics of Pakistan 2004-05

In essence, the domestic policy biases, export barriers, and concerns with regard to sustainability of sugarcane all lead to a poor prognosis for future development of bioethanol as a renewable fuel source in Pakistan. While the potential both for domestic use as well as exports remains high, key constraints fiscal, policy and external constraints will have to be addressed if positive outcomes are to accrue.

In light of the above, decision makers should consider the following steps along the fuel ethanol production chain:

- Removal of local taxes on the sale of industrial alcohol
- Impose a ceiling quota on the exports of molasses from the country
- Duty free import of the machinery required to convert industrial alcohol into biofuel
- Reduce collateral and/or institute revolving leases for investors willing to set up distilleries or import machinery
- Institute an aggressive marketing campaign within the public sector to apprise users about the availability and benefits of E10; in addition individual oil companies apart from PSO should be allowed to set up E10 stations and run their own marketing campaigns
- The number of pilot projects experimenting with E10 should be increased after a marketing campaign and PSO's monopoly on the experiment should be removed
- The government should allow the Ministry of Industries rather than the Ministry of Petroleum to take charge of biofuel development
- Until domestic demand rises, the Trade Development Authority of Pakistan (previously Export Promotion Bureau) must be mandated to seek new markets for the country's industrial and fuel ethanol, perhaps through a dedicated unit

- There is still a substantial gap in academic and technical research on the benefits of bioethanol usage in Pakistan. Both the public and private sectors should invest in research to determine the potential gains and major pitfalls in expanding the fuel ethanol industry

- The government must ensure that its price support policy for sugarcane is implemented and market imperfections due to the negative role of middlemen are removed. A viable option is to introduce a formal marketing mechanism by virtue of which designated agencies could act as middlemen between farmers and mills, ensuring that farmers get the officially stipulated price.

- There is a need for effective control over the sugar mill owners. The sugar mills behave in the form of a cartel which creates difficulties for sugarcane growers. Sugar hoarding is a common practice and though irrelevant to bioethanol production *per se*, it could suggest a possibility for molasses hoarding in the future if domestic demand for molasses increases multifold. The Monopoly Control Authority must take proactive initiatives in this regard.

- The merits of zoning and de-zoning for sugarcane marketing are debatable and the scheme ought to be revised to benefit the sugarcane growers.

- A multi-pronged approach is required to tackle low sugarcane yields. This would include discouraging farmers from using discarded or low yielding varieties and introducing new disease resistant varieties as alternatives. In addition, education programs to ensure better crop management practices have been repeatedly recommended.

- Environmental impacts in sugar cane and molasses production ought to be tackled. Application of Geographic Information Systems, better land preparation practices, integrated water management practices, and integrated pest management are already well known solutions and need to be stressed through better farmer education programmes. Wastewater treatment in sugar mills and distilleries is also widely practiced and must be emphasised further through the Environmental Protection Agencies to bring non-conforming units into the fold.

# Annex

Data used for scenario calculation (2004-05)

Blending ratio of gasoline: ten per cent fuel ethanol blended with 90 per cent gasoline

Molasses:

Total production: 1.496 Million tons
Exports: 0.450 Million tons
Domestic Consumption (including idle stock of 0.536 million tons at the end of the yr): 1.046 million tons
Molasses converted into ethanol: 0.510 million tons

Ethanol:

Total production: 82,000 MT
Exports: 80,000 MT
Domestic Consumption: 2,000 MT
Total Alcohol production capacity in Pakistan: 400,000 MT

Recovery ratio of ethanol from molasses: 1:5
Recovery ratio of fuel ethanol from industrial ethanol: 95:100

Oil:

Total import of crude oil: USD 2.60 billion
International price of 1 MT of oil: USD 440

Data was obtained from: Rana, “Ethanol export to EU”; Rana, “Alcohol worth $100m exported in 2006”; “Ethanol blending to boost petrol production”, 2005; “Increase in oil and gas prices”, 2005; Hydrocarbon Development Institute of Pakistan, “Pakistan Energy Yearbook 2005”;Interview with Ehsan Ahmed, General Manager, Noon Sugar Mills and Distillery, 7 March, 2007.

# References

"Anti-dumping: Protection against dumped Imports", Trade Issues. http://ec.europa.eu/trade/issues/respectrules/anti_dumping/index_en.htm, accessed on 20 February 2007.

Bendz, K., Pakistan, 2005. "EU's largest ethanol exporter, loses privileged status", Global Agriculture Information Network, GAIN.

"Fuel ethanol FAQs", Saab BioPower, http://www.saabbiopower.co.uk/faqs/, accessed on 13 March 2007.

"Fuel ethanol: Climate Benefits with Responsible Production". World Wildlife Fund, Workshop on Sustainable Biomass Production for the World Market, Brazil.

"Ethanol blending to boost petrol production", Dawn, 15 July 2005.

"Ethanol Facts: Trade", Renewable Fuels Association. http://www.ethanolrfa.org/resource/facts/trade/, accessed on 20 February 2007.

Government of Pakistan. 2005. "Agricultural Statistics of Pakistan 2004-2005". (Islamabad, Economic Wing, Ministry of Food, Agriculture and Livestock).

Government of Pakistan. "Exports and Re-Exports 2004-2005" (Islamabad, Statistics Division, Federal Bureau of Statistics).

Government of Pakistan. 2005. Hydrocarbon Development Institute of Pakistan. "Pakistan Energy Yearbook 2005" (Islamabad, Ministry of Petroleum and Natural Resources).

Government of Pakistan. 2005. Agricultural Prices Commission. "Price Policy for Sugarcane: 2005-06", Islamabad.

Government of Pakistan. 2006. Research and Economic Development Cell. "Sugar Sector in Pakistan – It's Performance and Way Forward" (Karachi, Chamber of Commerce and Industry).

Hassan, Bilal. "Increasing Sugar Cane Yield". Dawn, 19 February, 2007.

Inayatullah Khan. Unpublished. "Feasibility of Sugar Beet Cultivation in Pakistan". (Islamabad: Ministry of Food, Agriculture and Livestock).

"Increase in oil and gas prices", The News, 2 July 2005.

International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations. "Union Busting in Pakistan's Sugar Mills: Workers Face Dismissal and Illegal Detention" Asia and Pacific Regional Secretariat.

Javed Kayani, “Ethanol and flex-fuel vehicles”, Dawn, 16 January 2006.

Khan, H.K., 2005. “Trade Policy 2005-06”, (Islamabad, Ministry of Commerce).

Khan, S.R., et al. “Managing Conflict Through Trade: The Case of Pakistan and India” Sustainable Development Policy Institute, forthcoming.

“Long Ignored by WTO, Biofuels Might Receive Attention”, Congress Daily, 27 October 2006.

Memon, M.A. “Sugar Industry in Pakistan”, Pakistan and Gulf Economist. 23-29 September, 2002.

“Multilateral Disciplines to Phase Out Agriculture Dumping”, Trans Atlantic Consumer Dialogue. http://www.tacd.org/docs/?id=199, accessed on 23 February 2007.

Nadia M. Akbar and Mahmood A. Khwaja. 2006. “Study on Effluents form Selected Sugar Mills in Pakistan: Potential Environmental, Health, and Economic Consequences of an Excessive Pollution Load”, Sustainable Development Policy Institute.

“Pakistan’s Sugar Industry: Responding to the Environmental Challenge”. Undated. <http://www.cpp.org.pk/etpibrchr/brochure-sugar.pdf>.

Parvaiz Ishfaq Rana. “Ethanol export to EU comes to a halt”. Dawn, 27 August 2005.

Parvaiz Ishfaq Rana, “Alcohol worth USD100m exported in 2006”. Dawn, 6 March 2007.

“Production & Consumption of Ethanol & Gasol in Pakistan. FORMULATION OF A NATIONAL POLICY TO ENCOURAGE THE LOCAL PRODUCTION OF ETHANOL /GASOL IN PAKISTAN”, Ministry of Industries, Production & Special Initiatives. http://www.moip.gov.pk/ accessed on 15 February 2007.
“Quick Guide Biofuels”, BBC NEWS, 24 January 2007.

Salameh, M.G. 2005, “Can Biofuels Pose a Serious Challenge to Crude Oil?” Oil Market Consultancy Service. United Kingdom.

“Sugar Manufacturing In North West Frontier Province Problems and Proposed Solutions”. Pakistan Sugar Mills Association. North West Frontier Province.

“WWF - Pakistan Sustainable Sugar Initiative”. 2004. National Project Planning Workshop February 2004. Pakistan

“WTO must set rules for future biofuel trade-report”, Reuters AlertNet, 27 October 2006.

“WTO must set rules for future biofuel trade: report”, Daily Times, 28 October 2006.

“WTO Disciplines and Biofuels: Opportunities and Constraints in the Creation of a Global Marketplace”. 2006. International Food and Agricultural Trade Policy Council.

Zaidi, S.M.S., 2001. “Pollution Control in Sugar Industry”, XXXVI Annual Convention 27 -28 August 2001. The Pakistan Society of Sugar Technologists.