

## Potential Annual Ethanol Energy Output Compared to Annual Petroleum Products

Annual Petroleum Products GJ x10 <sup>6</sup> /yr		Wheat 161x10 <sup>6</sup> GJ/yr	Wheat 47x10 <sup>6</sup> GJ	Sugar 57x10 <sup>6</sup> GJ/yr
		% petroleum product		% petroleum product
Gasoline	688	23%	7%	8%
Diesel	586	27%	8%	10%
Gasoline+diesel	1,274	12.5%	3.5%	4.5%
Crude oil	1,630	10%	3%	3.5%

### REFERENCES

ABARE 2005, *Australian Commodity Statistics*, Australian Bureau of Agricultural and Resource Economics 2005, Canberra, pages 205, 214 and 305.

BP 2005, *BP Statistical Review of World Energy*, June 2005.

Grant, T., Beer, Tom & Olaru, Doina 2005, *Life cycle assessment of greenhouse gas emissions from proposed Primary Energy Bio-refinery facility*, CSIRO Report JL 73A/1/F05-3 for Primary Energy Ltd, June 2005.

Patzek, Tad W, & Pimentel, David 2005, *Thermodynamics of Energy Production from Biomass*, invited manuscript 416 Patzek8-18-04 accepted by Critical Review in Plant Sciences, pp. 55 & 56.

Patzek, Tad, W. 2005, *Thermodynamics of the Corn-Ethanol Biofuel Cycle*, Critical Review in Plant Sciences **23**(6):519-567, 2004, p. 89 (petroleum) & 94 (corn) in website version.

### APPENDIX

#### UNITED STATES FOSSIL FUELS AND BIOMASS ENERGY

The United States is the most energy intensive consumer in the world. The data below compares the energy consumed from fossil fuels with the potential biomass energy arising from photosynthesis.

The annual fossil fuel consumption in the United States of America, if all burnt, would yield  $20 \times 10^{15}$  kcalories of energy. The energy content of the annual net addition to all biomass from photosynthesis is  $13.5 \times 10^{15}$  kcals (Pimentel & Pimentel 1996). The fossil energy potential is 40 per cent greater than that for all biomass. About 70 per cent of biomass energy is fixed on agricultural land. Oil comprises 40 per cent of US fossil fuel consumption, most of it as transport fuels.

#### Reference

Pimentel, David & Pimentel, Marcia 1996, *Food, Energy, and Society*, University Press of Colorado, p. 20.

**APPENDIX 5**  
**AUSTRALIAN LIQUID BIOFUELS**  
**NATIONAL PRODUCTION BOUNDARIES**

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This paper compares the energy content of ethanol derived from Australia's annual production of sugar and wheat with the energy content of annual consumption of auto gasoline, auto diesel and primary oil. It demonstrates the energy content of anhydrous ethanol from sugar and wheat would be a small fraction of the energy content of annual consumption of petroleum-based fuels. While anhydrous ethanol from biomass is technically viable as a transport fuel it cannot be produced on a scale that replaces current petroleum products. It is not remotely possible to divert much of these agricultural products to fuel production at the expense of food supply.

### **SUGAR**

Annual production of sweeteners (sugar and honey) is notionally 5 million tonnes with variations according to seasons and markets. Honey is a negligible component (ABARE 2005). One tonne of sugar yields 0.385 tonnes of anhydrous ethanol that has a high heating value (HHV) of 29.65 GJ/tonne (Patzek & Pimentel 2005). Thus potential annual anhydrous ethanol production from sugar is 1.925 million tonnes with an HHV of  $57 \times 10^6$  GJ.

### **WHEAT**

From 1991/92 to 2004/05 average annual wheat production was 18.6 million tonnes with a range from 8.97 million tonnes (1994/95) to 26.13 million tonnes (2003/04). Average production from 1999/01 to 2004/05 was 21.3 million tonnes (ABARE 2005). We will use a figure of 22 million tonnes. Domestic consumption of wheat is just over 5 million tonnes per year, leaving 17 million tonnes that could be converted to ethanol.

Proposals for production of anhydrous ethanol from wheat quote a yield of 0.4 litres per kilogram of wheat (Grant et al. 2005). Ethanol has a density of 0.787 kg/litre that translates this yield to 0.315kg ethanol/kg of wheat. This figure is consistent with the ethanol yield from corn in the US (Patzek 2005). Thus there is a potential annual production of 5.4 million tonnes of ethanol from wheat. At an HHV of 29.65 GJ/tonne this is 161 million GJ per year (Patzek 2005).

In the drought year of 2002/03 Australian wheat production was only 10.1 million tonnes, leaving 5 million tonnes for anhydrous ethanol production. This could yield 1.6 million tonnes of anhydrous ethanol, or 47 GJ.

### **PETROLEUM FUELS**

The HHV of gasoline is 46.7 GJ/tonne and its density ranges from 720 to 800 tonne/klitre – we will use a figure of 740 kg/klitre. The HHV therefore is 34.6 GJ/klitre (Patzek 2005). Annual consumption is 19,876 ML (14,708,600 tonnes) equivalent to 688 million GJ (ABARE 2005).

The HHV of diesel is 45.9 GJ/tonne and its density is 0.84 kg/litre. The HHV therefore is 38.6 GJ/litre (Patzek 2005). Annual consumption is 15,185 ML (12,755,000 tonnes) equal to 586 million GJ (ABARE 2005).

The HHV of crude oil is 42 GJ/tonne and its annual consumption is 38.8 million tonnes, or equivalent to 1,630 million GJ (BP 2005).

The Table below summarises the position. Depending on ethanol from grain must take into account domestic grain consumption for food and seed. There would be major supply crises in drought years.