Table 1. Farm energy inputs into corn grain ethanol production. Application rates of nitrogen, phosphorus, potash, herbicides, and insecticides are 2003 averages of the 9 top corn producing states (IL, IN, IA, MI, MN, NE, OH, SD, WI) weighted by state production (1). Production energy requirements are average values of five studies representing recent independent estimates of corn grain ethanol NEB (2-6), with exceptions as noted.

	Application rate	Production energy requirement		Per hectare energy usage		Input energy in ethanol production *	
	kg/ha	*MJ/kg*		*MJ/ha*		*MJ/L*	
Hybrid seed	-	-		215 †	(2)	0.06	
Nitrogen	146.1	51.47 ‡	(2, 4, 5)	7,523		2.07	
Phosphorus	53.1	9.17	(3-5)	486		0.13	
Potash	65.6	5.96	(2-5)	391		0.11	
Lime	-	-		313 §	(2, 5, 6)	0.09	
Herbicide	2.23	319 ¶	(3-6)	713		0.20	
Insecticide	0.08	325	(3-6)	26		0.01	
Fossil fuel	-	-		8,484 ‖		2.34	
Farm capital	-	-		769	(Table 3)	0.21	
Household	-	-		-		1.18	(Table 4)
Total						6.39	

* The 2000-2004 average annual yield of the top nine corn producing states weighted by their total production is 9,296 kg/ha (7, 8). These nine states accounted for 79.1% of domestic corn production in 2004. The dry-mill conversion efficiency of ethanol from corn is 0.3908 L/kg, which is an average of three estimates (2-4). We exclude wet-milling conversion efficiencies (5). The dry-milling process currently accounts for 75% of the corn grain ethanol production market share and is expected to increase (9). We omit estimates based on older technologies (*e.g.*, 0.3726 L/kg) (6) that are dramatically lower than recently documented dry-mill plant efficiencies (*e.g.*, 0.3979 L/kg) (9, 10).

† Hybrid corn seed, which is planted to grow the corn used to generate ethanol, requires additional production steps when grown, processed, and distributed. Our estimate of the energy required to produce hybrid corn seed is derived from the only study that both uses current USDA data and provides the formula used to derive this estimate (2). We exclude studies that do not account for the energy to grow the hybrid seed (4), are based on research more than 25 years old (6), do not thoroughly explain how they derived their estimate (3), or are not well supported (5).

‡ Estimates of fertilizer production energy requirements from one study (6) are excluded because they are from sources that do not reflect current domestic production efficiencies (*e.g.*, the Food and Agriculture Organization, which is not specific to the US). Additionally, for nitrogen we exclude an estimate that includes transportation energy (3), and for phosphorus we exclude an estimate that is substantially lower than others (2).

§ Unlike fertilizer and pesticide use, lime use is not systematically reported by the USDA. Therefore, we rely on other studies for lime application rates as well as energy intensity. We exclude those studies that either exclude this input analysis (4) or have too low a value (3). We divide liming energy inputs equally between corn and soybean production.

[¶] We exclude the estimate that provides a combined pesticide input (2) because it is not parsed into insecticides and herbicides.

[‖] This category includes fossil fuels directly used in crop production (diesel, gasoline, electricity, natural gas, and LP gas), custom work, farm-related transportation, and personal commutes. We exclude an estimate of fossil fuel use that is substantially lower than those of the other studies (4). We prorate the energy for irrigation of one of the studies (6) to reflect that only 15% of corn acreage in the 9 states is irrigated. We exclude estimates for custom work that include worker sustenance energy (5, 6), which we account for separately as part of our expanded category of household energy usage. Our farm-related transportation estimate is from one study (2), and we specifically exclude another (6) because the assumption that machinery, fuels, and seeds were shipped an estimated 1,000 km is unrealistic. Our personnel commute energy estimate is based on the only study that includes this input (5), although we modify this estimate by using our corn yield rate and corn to ethanol conversion rate.