Chapter 4
Subsidies to Ethanol in the United States

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Abstract Ethanol, or ethyl alcohol used for motor fuel, has long been used as a transport fuel. In recent years, however, it has been promoted as a means to pursue a multitude of public policy goals: reduce petroleum imports; improve vehicle emissions and reduce emissions of greenhouse gases; and stimulate rural development. Annual production of ethanol for fuel in the United States has trebled since 1999 and is expected to reach almost 7 billion gallons in 2007. This growth in production has been accompanied by billions of dollars of investment in transport and distribution infrastructure. Market factors, such as rising prices for petroleum products and state bans on methyl tertiary butyl ether (MTBE), a blending agent for which ethanol is one of the few readily available substitutes, drove some of this increase. But the main driving factor has been government support, provided at every point in the supply chain and from the federal to the local level. This chapter reviews the major policy developments affecting the fuel-ethanol industry of the United States since the late 1970s, quantifies their value to the industry, and evaluates the efficacy of ethanol subsidization in achieving greenhouse gas reduction goals. We conclude that not only is total support for ethanol already substantial — \$5.8–7.0 billion in 2006 — and set to rise quickly, even under existing policy settings, but its cost effectiveness is low, especially as a means to reduce greenhouse gas emissions.

Keywords Agriculture · biofuel · corn · energy · ethanol · policy · renewable energy · subsidies · support · United States

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Acronyms & abbreviations

AFV:	alternative fuel vehicle
bgpy:	billion U.S. gallons per year
mgpy:	million U.S. gallons per year
CAFE:	corporate average fuel economy
CBERA:	Caribbean Basin Economic Recovery Act
CO_2:	carbon dioxide
CRS:	Congressional Research Service
E10:	a blended fuel comprised of 10% ethanol and 90% gasoline
E85:	a blended fuel comprised of 85% ethanol and 15% gasoline
EIA:	U.S. Energy Information Administration
EPA:	U.S. Environmental Protection Agency
EPACT05:	Energy Policy Act of 2005
FFV:	flexible-fuel vehicle
GHG:	greenhouse gas
GJ:	gigajoule (10^9 joules)
GSI:	Global Subsidies Initiative
IRS:	Internal Revenue Service
JCT:	Joint Committee on Taxation (of the U.S. Congress)
MPS:	market price support
MTBE:	methyl tertiary-butyl ether
NAFTA:	North American Free Trade Agreement
OECD:	Organisation for Economic Co-operation and Development
OTA:	Office of Technology Assessment
RFA:	Renewable Fuels Association
RFS:	Renewable Fuels Standard
USDA:	U.S. Department of Agriculture
VEETC:	Volumetric Ethanol Excise Tax Credit

4.1 Introduction

The modern U.S. ethanol industry was born subsidized. The Energy Tax Act of 1978 introduced the first major federal subsidy for ethanol, a 4 cents-per-gallon reduction in the federal excise tax on gasohol, or E10 (a blend of 10% ethanol and 90% gasoline). In that same year, the first commercial ethanol production capacity came online. Between 1980 and 1990, production capacity more than quintupled, ending the decade at around 900 million gallons per year (mgpy). Despite a slower period of growth from the late 1980s through the mid-1990s, production capacity has grown in recent years at a very fast pace over most of the last decade. According to the Renewable Fuels Association (RFA) the main ethanol trade group, production capacity increased from 1.7 billion gallons per year (bgpy) in 1999 to 7.3 bgpy at the end of 2007 (RFA, 2007a). An additional 6.2 bgpy of capacity were under construction, the vast majority of which will rely on corn (RFA, 2007b).[1] Meanwhile, the supply side of the ethanol market is evolving towards ever larger plants, with the largest having annual capacities approaching 300 mgpy (Planet Ark, 2006). This trend will have important effects both on feedstock supply and on the market power of different portions of the supply chain.

Conversion into ethanol serves as an increasingly important outlet for the industry's main feedstock, corn. Estimates of the share of U.S. corn production used for ethanol vary, but most place it above 20% in 2007, and likely to rise above 30% within the next few years.[2] Despite rapid growth in demand and diversion of corn into fuel, ethanol consumption for 2006 (5.4 bgpy) supplied less than 4% of the fuel used by gasoline-powered vehicles in that year (Fig. 4.1).[3]

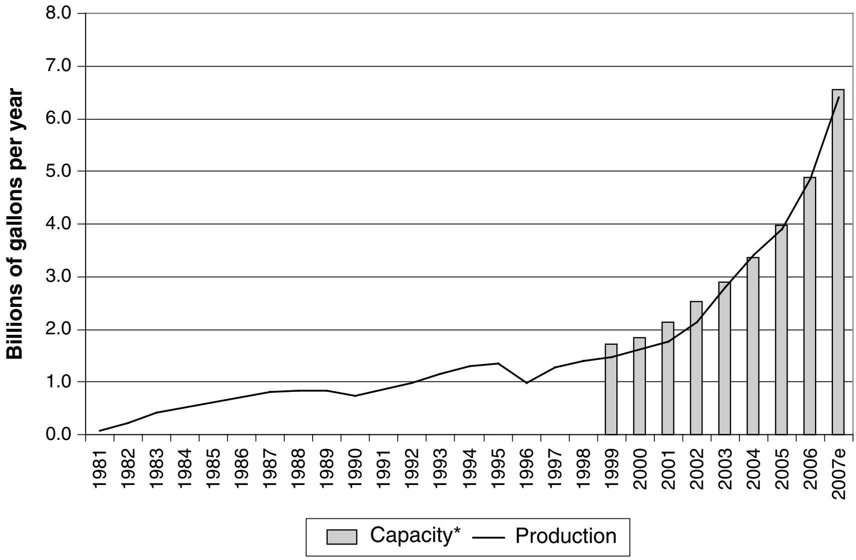

Fig. 4.1 Fuel-ethanol production capacity[1] and output[2] in the United States, 1981 through 2007
[1] Data for 2007 are authors' estimates. Capacity data prior to 1999 are not available.
[2] Capacity represents an estimated mid-year value, obtained by taking the geometric mean of the values reported at the beginning of the year shown and the value at beginning of the following year.
Sources: • **1981–2005:** Energy Information Administration, *Annual Energy Review 2006*, Report No. DOE/EIA-0384(2006), Table 10.3, "Ethanol and Biodiesel Overview, 1981–2006", Retrieved December 7, 2007 from; http://www.eia.doe.gov/emeu/aer/renew.html; • **2006:** Renewable Fuels Association; "Industry Statistics", Retrieved December 7, 2007, from http://ethanolrfa.org/ industry/statistics/.

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[1] Sugar from cane or beets, which is an important feedstock in ethanol production in regions such as Brazil and the European Union, has so far played a very small role within the United States. This is largely due to import quotas that make sugar too expensive as a feedstock.
[2] See FAPRI, (2007, February), p. 11; USDA (2007, February), p. 39.
[3] Ethanol consumption data from RFA (2007c); US gasoline consumption data from EIA (2007b).

Industry promotion of expanded purchase mandates and continued protection from imports demonstrate that producers are counting on the government to help keep production viable. Both policies were being considered by Congress in the autumn of 2007. Even more aggressive policy interventions have also been proposed, such as setting a floor price for oil in order to protect the domestic ethanol industry from low oil prices that would render ethanol uncompetitive (see, e.g., Lugar and Khosla, 2006). Clearly, in order to understand the industry, one has to understand the roll of government incentives.

This analysis draws heavily on two in-depth studies conducted for the Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (Koplow, 2006; 2007) which in turn form part of a multi-country effort by the GSI to more thoroughly characterize and quantify subsidies to biofuels production, distribution and consumption.[4]

This chapter first describes the evolution of government support for ethanol, focusing on the major federal programs. Thereafter follows a more detailed discussion of federal and state support policies, arranged by their point of initial economic incidence. Virtually every production stage of ethanol is subsidized somewhere in the country; in many locations, producers can tap into multiple subsidies at once.

Liquid biofuels have been subsidized largely on the premise that they are domestic substitutes for imported oil; that they reduce greenhouse gas (GHG) emissions; and that they encourage rural development. Critics of subsidization have argued that the production process of these fuels is itself fossil-fuel-intensive, obviating many of the benefits of growing the energy resource; and that there are less expensive options for both GHG mitigation and rural development. Although the most recent work (Farrell et al., 2006a; Hill et al., 2006; U.S. EPA, 2007a) suggests some net fossil fuel displacement when biofuels replace petroleum products, the gains remain moderate, especially for corn-based ethanol. Others strongly contest these conclusions (e.g., Patzek, 2004; Pimentel and Patzek, 2005). Importantly, as additional analysis on modeling life-cycle impacts expands the parameters of assessment to include nitrous oxide emissions from fertilization and associated land-use changes from increased biofuel production, the net benefits of using ethanol produced from dedicated starch crops are looking less positive.

The second part of this chapter provides a variety of quantitative metrics on subsidy magnitude to illustrate how much support is being provided, not only per unit of biofuel produced, but also in terms of greenhouse gas (GHG) reductions. These values are intended to help in evaluating whether other options to diversify transport fuels or mitigate climate change might be more cost-effective.

4.2 Evolution of Federal Policies Supporting Liquid Biofuels

Subsidization of ethanol production at the federal level began with the Energy Tax Act of 1978. That Act granted a 4 cents-per-gallon reduction in the federal motor fuels excise tax for gasohol, a blend of 10% ethanol and 90% gasoline, also called

[4] A complete list of the GSI's studies can be found at http://www.globalsubsidies.org.

E10. This rate translates to 40 cents per gallon of pure ethanol at the time, and is equivalent to about $1.00 per gallon in 2007 dollars. The excise tax subsidy rate was adjusted frequently over the ensuing 25 years, until it was replaced by the Volumetric Ethanol Excise Tax Credit (VEETC) in 2004. VEETC is financed by general revenues, rather than through reduced collections for highway funding as occurred with the original exemption.

The US Congress introduced additional measures to support the ethanol industry in 1980. The Energy Security Act of 1980 initiated federally insured loans for ethanol producers, and from 1980–86 alcohol production facilities could access tax-exempt industrial development bonds (Gielecki et al., 2001). Also in 1980, Congress levied a supplemental import tariff of 50 cents per gallon on foreign-produced ethanol (RFA, 2005), which was increased to 60 cents in 1984 (Gielecki et al., 2001) and now stands at 54 cents.

Several states also started to subsidize ethanol around this time. Minnesota introduced a 40 cents per gallon ethanol blenders' credit in 1980 (phased out in 1997), as did North Dakota (Sullivan, 2006). A tally of state measures carried out by the Congressional Research Service two decades ago (CRS, 1986) identified incentives in place in 29 states. By 1986, state excise-tax exemptions alone were costing state treasuries over $450 million per year (in 2007 dollars) in foregone tax receipts.

In 1988, federal legislation began addressing the consumption side of the alternative fuels market. The Alternative Motor Fuels Act passed that year provided credits to automakers in meeting their Corporate Average Fuel Economy (CAFE) standards when they produced cars capable of being fueled by alternative fuels (Duffield and Collins, 2006).[5] Earning these credits did not require that the vehicles actually run on the alternative fuels, and because so few vehicles have (somewhat less than one percent of their mileage, according to a 2002 Report to Congress), the rule has been estimated to have increased domestic oil demand by 80,000 barrels a day (MacKenzie et al., 2005).

Environmental concerns have also helped improve the market position of biofuels. The Clean Air Act Amendments of 1990 mandated changes to the composition of gasoline in an effort to address two specific air-pollution problems. Reformulated gasoline was designed to help reduce ozone-forming hydrocarbons, as well as certain air toxins in motor-vehicle emissions, and was prescribed for areas of the country suffering the most-severe ozone problems. Oxygenated fuels were intended for use in the winter, in certain metropolitan and high-pollution areas, in order to reduce emissions of carbon monoxide. An oxygen-increasing additive, or oxygenate, was required to be added to these types of gasoline reformulations. However, the Amendments did not specify any particular oxygenate (of which there are several) for achieving these goals (Liban, 1997). Mandates to use ethanol for at least 30% of the oxygenates needed to meet these requirements were promulgated by the U.S. Environmental Protection Agency (EPA) in 1994 with the strong support of the

[5] The Energy Policy Act of 1992 (EPACT92) formally established E85 as an alternative transportation fuel. In addition, it established alternative-fueled-vehicle mandates for government and state motor fleets, policies that have indirectly encouraged demand for ethanol fuels over time (EIA, 2005a; Schnepf, 2007).

ethanol industry, but they were overturned in a court challenge a year later (Johnson and Libecap, 2001).

MTBE (methyl tertiary butyl ether), a petroleum-derived additive, emerged as the oxygenate of choice, primarily because the oil industry already had more than a decade of experience using it as an octane enhancer. Then, in 2004, concerns over the carcinogenicity of MTBE and contamination of groundwater from leaky storage tanks led several key states, starting with California, New York and Connecticut, to ban the additive (Yacobucci, 2006). By early 2006, nineteen other states had banned or limited the use of MTBE. The demise of MTBE was then accelerated by the Energy Policy Act of 2005 (EPACT05). In addition to not granting MTBE producers liability protection, Congress decided that the oxygenate mandates had yielded mediocre results, and so ended them. Effective 6 May 2006, non-oxygenated reformulated gasoline could be sold in most parts of the country (Yacobucci, 2006). With MTBE effectively no longer an option, ethanol remains as the main surviving competing fuel additive for increasing octane, a position that has helped further boost demand for the fuel.[6]

More significantly, EPACT05 also included the first federal purchase mandates for liquid biofuels. Referred to as the "Renewable Fuels Standard" (RFS), it fixed minimum consumption levels of particular specified fuels for each year, with the mandated level rising over time. Most of the mandated volumes under present law are expected to be fulfilled by ethanol from corn.

4.3 Current Policies Supporting Ethanol

Using a standard economic classification scheme for industry support, we provide an overview of the many types of incentives now in place to support the ethanol industry. As we were able to identify more than 200 support measures benefitting ethanol nationwide in 2006 (some of which also cover biodiesel, which is not discussed here), this section provides illustrations rather than a catalog.

4.3.1 Volume-Linked Support

Volume-linked support takes two main forms. The first, market price support, includes interventions such as import tariffs or purchase mandates that are linked to fuel volumes but operate by raising the price received by commodity producers above what it would be in the absence of such interventions. The second includes direct payments to producers that are linked to their levels of production. In the United States, output-related subsidies for ethanol are generally linked to gallons of fuel produced or blended.

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[6] Gallagher et al. (2001, p. 3) projected that the MTBE ban alone could double demand for ethanol within 10 years.

4.3.1.1 Market Price Support Associated with Tariffs and Mandates

Market price support (MPS) refers to financial transfers to producers from consumers arising from policy measures that support production by creating a gap between domestic market prices and border prices of the commodity (OECD, 2001). It can be considered the residual support element resulting from the interaction of any number of policies. Three policies play a significant role in supporting market prices for biofuels in the United States: tariffs, blending mandates, and tax credits and exemptions (de Gorter and Just, 2007). Ideally, MPS is measured by comparing actual prices obtained in a market with an appropriate reference price. Because the nature of the information on tax credits is much more concrete than that available on prices, for the purpose of this exercise we treat tax credits separately from the effects of tariffs and blending mandates. These latter two are described briefly below.

Tariffs — Imported fuel ethanol is currently subject to both the normal *ad valorem* tariff and a specific-rate tariff. The applied MFN (most-favored nation) tariff on imports of undenatured ethyl alcohol (80% volume alcohol or higher) is 2.5%, and on denatured ethyl alcohol it is 1.9%. The specific-rate tariff is 54 cents per gallon. Hartley (2006) notes that the supplemental tariff is punitive, since it is applied volumetrically to the full mixture (i.e., including the denaturant), and is actually higher than the domestic subsidy it supposedly offsets.

Not all ethanol imported to the United States is subject to these tariffs, however.[7] Canada and Mexico — the United States' partners in the North American Free Trade Agreement (NAFTA) — for example, can export ethanol to the United States duty-free. Countries that are covered by the Caribbean Basin Economic Recovery Act (CBERA) can export an unlimited amount of ethanol to the United States duty-free if it is made predominantly from local feedstocks, or a volume equivalent of up to seven percent of U.S. fuel-ethanol consumption if it is made mainly from feedstocks grown outside of the region (Etter and Millman, 2007).

Renewable fuels standards — As noted above, federal RFS targets of 4 bgpy in 2006, rising to 7.5 bgpy by 2012, were introduced by EPACT. Post-2012 increases are meant to occur at the same growth rate as for gasoline demand. Higher credits (equal to 2.5 times those for sugar- or starch-based ethanol) are available for cellulosic ethanol until 2012, after which 250 mgpy of cellulosic ethanol usage becomes mandatory (Duffield and Collins, 2006). Biodiesel is included at a higher credit rate as well (1.5 times that of corn ethanol) because of its higher heat rate (EPA, 2006b).

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[7] Moreover, because of a loophole called the "manufacturer's duty drawback", even the amount of duty actually paid on ethanol imported from countries such as Brazil and China is uncertain. The World Bank (Kojima et al., 2007) points out that an oil marketer can import ethanol as a blending component of gasoline, and obtain a refund ("draw back") on the duty paid if it exports a like-commodity within two years of paying the initial duty. Since jet fuel is considered a like-commodity, and counts as an export when sold for use in aircraft that depart the United States for a foreign country, this has allowed some oil marketers to count such jet-fuel exports against ethanol imports and recover the duty paid on ethanol.

Several states have issued mandates of their own; they are often more stringent than the federal one. Minnesota had already established a renewable fuels mandate prior to the federal RFS; it requires that gasoline sold in the state must contain 20% ethanol by 2013. However, many other states have become active as well. In 2006, Iowa set a target to replace 25% of all petroleum used in the formulation of gasoline with biofuels (biodiesel or ethanol). Hawaii wants 10% of highway fuel use to be provided by alternative fuels by 2010; 15% by 2015; and 20% by 2020. A few other states have set more modest requirements, some of which (as for Montana and Louisiana) are contingent on production of ethanol within these states reaching certain minimum levels.

The combined effects of tariffs in the presence of renewable fuel standards — The main effect of a tariff is to protect domestic markets from competition from lower-priced imports, thus allowing domestic prices to rise higher than they would otherwise. When only a tariff is in place, competition from foreign suppliers of ethanol will be reduced, but domestic manufacturers must still compete with non-ethanol alternatives, notably gasoline.[8] Mandating a minimum market share for a good also normally drives up its price. The size of the impact will depend on a variety of factors, including how large the mandated purchases are relative to what consumption would have been otherwise; the degree to which output of the good increases as prices rise; and whether competition from imports is allowed. With a mandate but no tariff, the amount of ethanol sold domestically would possibly be higher than otherwise, but its price would be constrained by foreign sources. A mandate plus a tariff both raises the threshold price at which foreign-sourced ethanol becomes competitive, and protects domestic suppliers from being undercut by the price of gasoline.

A number of parties have tried to estimate how much the RFS mandates alone, or in combination with import tariffs, increase domestic prices of biofuels. Several (e.g., EPA, 2006b; Urbanchuk, 2003) reach the conclusion that increases in wholesale (also known as "rack") prices would be more than offset by government subsidies, resulting in declines in pump prices. The results of both of these studies are of course sensitive to the degree to which state and federal subsidies to ethanol would be passed on to consumers, rather than absorbed into operating margins and profits of ethanol market participants.[9]

Others have looked mainly at producer prices. Elobeid and Tokgoz (2006) (henceforth "E&T"), analyzed the impact of liberalizing ethanol trade between the United States and Brazil using a multi-market international ethanol model calibrated on 2005 market data and policies, taking the United States' renewable fuel standard

[8] The price ceiling for all ethanol would be set by the energy-equivalent price of gasoline, as adjusted by any additional value of ethanol as an additive (e.g., to raise octane levels). Foreign suppliers of ethanol in that case would also be price takers, and the main difference for lower-cost foreign supplies between the situation with and without the tariff would be the market share they could capture from domestic producers, especially in coastal-state markets.

[9] For a more detailed discussion of price formation and the economic incidence of subsidies in the ethanol market see Bullock (2007).

and Brazil's blending mandates as givens.[10] Were trade barriers alone to be removed (retaining the existing renewable fuel mandate of 7.5 billion gallons per year, as well as the VEETC), they estimate the average U.S. ethanol prices from 2006 to 2015 would fall by 13.6%, or $0.27 per gallon. These results provide a rough indication of the degree to which the import tariff, in the presence of the existing (EPACT05-established) renewable fuels standard, increases the cost of meeting that standard. Should the import tariff remain in place while a higher RFS is implemented (as are proposed in pending energy legislation), the MPS would be expected to rise significantly.[11]

Estimating market price support for a commodity ideally involves calculating the gap between the average annual unit value, or price, of the good (usually measured at the factory gate) with a reference price, usually either an average (pre-tariff) unit import price or the export price.[12] Since such data are not readily available for the U.S. market, we have used the E&T results to obtain a rough estimate of market price support exclusive of the effect of the VEETC, the subsidy value of which we treat separately.[13] Applying the E&T's price mark-up to domestically-produced ethanol generates an estimate of the contribution of the tariff to MPS of $1.3 billion in 2006, rising to more than $3 billion per year as domestic production grows.

4.3.1.2 Tax Credits and Exemptions

The federal Volumetric Ethanol Excise Tax Credit (VEETC), enacted in 2004 by the Jumpstart Our Business Strength (JOBS) Act, constitutes the single largest subsidy to ethanol. It provides a credit against income tax of 51 cents per gallon of ethanol blended into motor fuel. It is awarded without limit, and regardless of the price of gasoline, to every gallon of ethanol — domestic or imported — blended in the marketplace. Moreover, it is not subject to corporate income tax, which means its

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[10] Note that neither Elobeid and Tokgoz, nor any other researchers, have incorporated state-level renewable-fuel mandates into their models. Such state-level mandates, if they are both enforced and more stringent than the federal one, can cause additional price distortions.

[11] More recently, Westhoff (2007) simulated the effects on ethanol production and prices of expanding the mandated level of biofuel use in 2015 from 7.8 bgpy (the baseline) to 15 bgpy under a range of possible future petroleum prices scenarios. Current agricultural policies and the VEETC and ethanol tariff were assumed to remain unchanged. Compared with the baseline, he found that plant (i.e., producer) prices for ethanol in the 2015/16 marketing year would be on average 16 percent ($0.25 per gallon) higher. Considering the results of this study with the E&T results suggests that both the tariff and the RFS raise prices, and that the two effects are mutually supporting rather than additive.

[12] A complicating factor is that ethanol can be both a complement to gasoline when it is used as an additive, and a substitute for it when used as an extender. This makes estimating the appropriate reference price more difficult.

[13] Removal of both the import tariff and ethanol volumetric excise tax credit would generate even larger declines in domestic prices (between $0.29 and $0.36 per gallon, per Elobeid and Tokgoz (2006) and Kruse et al. (2007)). However, the tax credit subsidies are captured directly in our totals, while the MPS from the tariffs and RFS are not.

value to recipients is greater than if it were a simple grant, or a price benefit provided through an exception from an excise tax (Box 4.1).

Box 4.1 The benefit of tax exemption for the VEETC

Tax breaks allow larger than normal deductions from taxable income or reductions in taxes due. A side-effect of the reduced tax payments is that the remaining revenues of the enterprise rise. Although the tax burden will remain lower than before the tax break, a portion of the benefit is lost to the recipient because there is some tax due on the increase in earnings. For example, under standard rules if a firm gets a $1 production tax credit (PTC), their taxes paid go down by $1, but their bottom line — which is taxable — rises by that same $1 amount. If they pay taxes at a 30% rate, they would see their taxes rise by 30 cents, leaving them with only 70 cents of the original PTC. To generate $1 in *after-tax* value to a firm, a revenue-based subsidy would need to be higher than $1 — basically $1/(1-marginal tax rate), or $1.43 in this example. This higher value is referred to as the *outlay equivalent* value of tax breaks. It was routinely reported in US tax expenditure budgets until a couple of years ago.

The question of whether a tax subsidy is exempt from taxation matters quite a bit to evaluating the distortions in energy markets from government programs. Because the VEETC is an excise tax credit rather than a production tax credit it falls into a gray area of the tax code. This ambiguity illustrates how tiny changes in the interpretation of the tax code can increase the value of subsidies to the ethanol industry by billions of dollars per year.

From a technical perspective, Section 87 of the tax code specifically requires that tax credits for biofuels under Section 40 (the income tax credits) be included in taxable income, rendering their outlay equivalent value identical to the revenue loss. The language on the VEETC is not clear, however. Section 6426 of the Internal Revenue Code, which describes the VEETC, makes numerous cross-references to Section 40, mostly for definitional issues. There is no mention of Section 87.

In January of 2005, the Internal Revenue Service issued a guidance document on implementation issues related to the VEETC (IRS, 2005). Because this guidance was silent on the tax treatment of the credits, a consortium of industry groups filed comments requesting a clarification on the issue (Herman, 2005). The wording of their request indicates their inclination to treat the VEETC as not includible in taxable income until clearly instructed otherwise:

> One of the major questions facing our members is whether any part of the new excise tax credit for alcohol fuel mixtures is taxable, and whether there are any circumstances in which the excise tax credit or refund (payment) must be reported as part of gross income. (Herman, 2005)

Sources within both the Joint Committee on Taxation of the U.S. Congress (JCT) and the U.S. Department of Treasury have confirmed that, as of

September 2007 at least, there had been no technical corrections in how the excise tax credits are treated by the Internal Revenue Service (IRS), implying that the credits are still excludible from taxable income.

The incremental benefit of this exemption was roughly $1.2 billion for ethanol in 2006 on top of a direct revenue loss of $2.8 billion. The incremental subsidy from this tax loophole, supposedly a policy accident, has become the third-largest subsidy to ethanol. By 2015, even if there is no increase in the RFS, the VEETC will generate subsidies of $6.3 billion per year on a revenue loss basis and $8.9 billion per year on an outlay-equivalent basis.

In addition to the federal VEETC, several states provide reductions or exemptions for ethanol from motor fuel excise or sales taxes. The largest subsidies from these programs appear to be in Hawaii, Illinois, Indiana, and Iowa. With ethanol blends of 10% or less widely used in the country, reduced fuel taxes on E10 are becoming increasingly uncommon. Many still provide reduced rates for E85, however, and these can be fairly large per gallon. Based on the states we quantified, the average exemption for E85 was 11.5 cents per gallon; the median exemption was 7 cents per gallon. For now, the amount of ethanol consumed in E85 is small — less than 15 million gallons in 2006 according to the EIA. This is equivalent to roughly 17.4 million gallons of E85, assuming an 85% blend rate.[14] The largest revenue losses tend to come from states that exempt particular fuel blends from *sales* taxes on fuels. The standard reporting of fuel tax rates provides greater clarity on deviations in excise tax rates than for fuel sales taxes. This may be one explanation for the political preference to subsidize via the sales tax. State motor-fuel tax preferences, along with state-level mandates, seem to exert a big influence on where U.S.-produced ethanol ends up being sold.

4.3.2 Payments Based on Current Output

Production payments or tax credits to producers of ethanol have been on offer by the federal government and many states. These programs are normally structured to provide a pre-specified payment or tax credits for each unit (usually gallon) of output a plant produces. Supplier refunds also exist in a number of places, and operate in a similar manner.

At the federal level, the Small Producer Tax Credit, introduced in 1990, grants ethanol and biodiesel plants that produce less than 60 mgpy a 10-cents-per-gallon income-tax credit on the first 15 million gallons they produce (a maximum of $1.5 million per plant each year). Using industry data on plant nameplate capacity, we

[14] The actual blend rate is anyone's guess. States such as Minnesota allow winter blends as low as 60 percent ethanol to count as E85. Lower blend rates would drive up the overall subsidy costs of E85 within a state.

estimate the revenue loss from this provision to be over $100 million per year for ethanol. However, newer plants tend to be larger and we expect that by the end of 2009 less than 60% of the nation's ethanol plants will meet the 60 mgpy cutoff. Subsidies likely will not fall, however. When a similar situation occurred only five years ago (at which point less than 40% of the plants fell under the then 30 mgpy limit), Congress simply increased the limit.

Output-linked payments via the USDA's Bioenergy Program until recently paid an additional bounty per gallon of ethanol or biodiesel produced, with higher bounties for new production. These operated through grants rather than tax credits, but were otherwise fairly similar in structure and impact.

Several states also provide production payments or tax credits for producers. Some of the programs require eligible plants to pre-qualify with the government before they can claim a credit. Some cap the total payouts (or allowable tax credits) per year to all plants. This means that the early plants may absorb the entire available funds, or that the actual per-gallon subsidy received is well below the rate nominally noted in the statute.

4.3.3 Subsidies to Factors of Production

Value-adding factors in biofuel production include capital, labor, land and other natural resources. Surprisingly, even labor related to biofuels production does not escape subsidization. The state of Washington, for example, allows labor employed to build biofuels production capacity, or to make biodiesel or biodiesel feedstock, to pay a reduced rate on the state's business and occupation tax.[15]

4.3.3.1 Support for Capital Used in Manufacturing Biofuels

Scores of incentive programs have been targeted at reducing the capital cost of ethanol plants. Many of these are specific to ethanol (or ethanol and biodiesel), though others are open to a broader variety of alternative fuels. Government subsidies are often directed to encourage capital formation in a specific segment of the supply chain.

Generic Subsidies to Capital

The ethanol sector benefits from a number of important general subsidies to capital formation. Though available to a wide variety of sectors, these policies can nonetheless distort energy markets. All of them subsidize capital-intensive energy production more heavily than less capital-intensive methods. As a result, they tend to diminish the value of energy conservation relative to supply expansions. In addition,

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[15] Rates on manufacturing of ethanol and biodiesel fuel are the lowest of all categories, and less than one-third the normal rate on manufacturing activities. See WA DOR (2007).

the small print in how they are defined can generate differential subsidies by sector.

Depreciation governs the process by which investments into long-lived equipment can be deducted from taxable income. The theoretical goal of depreciation is to match the cost of an asset with the period over which it will produce income, generating an accurate picture of the economics of an industry. Politically, however, depreciation schedules have become another lever used by Congress to subsidize targeted groups. Federal legislation regularly reclassifies specific industries, or shortens the period over which capital investments can be deducted from taxable income for particular sectors. This generates more rapid tax deductions. Due to the time value of money, rapid tax reductions are more valuable than those occurring slowly over time.

Production equipment for ethanol (and biodiesel) is classified as waste reduction and resource recovery plant (Class 49.5) under the Modified Accelerated Cost Recovery System (MACRS).[16] This grouping includes "assets used in the conversion of refuse or other solid waste or biomass to heat or to a solid, liquid, or gaseous fuel," and allows full deduction of plant equipment in only seven years. An additional benefit comes in the form of the highly accelerated 200% declining balance method that can be used for Class 49.5, and that further front-loads deductions into the first years of plant operation.

With over $18 billion invested in ethanol production capacity since 2000 alone, this can constitute a fairly large subsidy. Note that our estimates incorporate only investments into plant capacity. For simplicity, we have not made similar calculations for investments in distribution infrastructure. These investments include terminals, retail facilities, tank trucks, rail cars and barges. During this same period, the ethanol industry's estimated additional spending on infrastructure assets was roughly $1 billion.[17]

Subsidies for Specific Production-Related Capital

In addition to general subsidies to capital that benefit multiple sectors of the economy, a number of subsidies target biofuel capital directly. Capital grants are used in many states and help finance production facilities, refueling or blending infrastructure, or the purchase of more expensive alternative fueled vehicles. Partial government funding of demonstration projects in the ethanol sector is common. The Energy Policy Act of 2005, for example, provided earmarked funds for a number of large biofuel-demonstration projects.

Credit subsidies, such as loans, guarantees, and access to tax-exempt debt, are common methods to subsidize the development of ethanol production and

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[16] Choosing the proper grouping is not always easy. This classification reflects input from Mark Laser at Dartmouth University, who noted that based on his reading of the IRS classifications, and "discussions with colleagues from NREL and Princeton," class 49.5 seemed the proper fit (Laser, 2006).

[17] Earth Track estimates based on data in EPA (2006a).

infrastructure. Title XVII of EPACT, for example, will guarantee up to 80% of the cost of selected new plants. Liquid biofuels comprised $2.5 billion of the initial round of requests for federal guarantees (DOE, 2007a), and the largest share (6 of 16) of projects chosen by the DOE to submit final funding proposals (DOE, 2007b). Program structures such as this leave little investment risk borne by investors and increase the chances of both poor project selection and of loan defaults. Many of the ethanol loan guarantees issued in the 1980s defaulted.

Some states (e.g., Delaware's Green Energy Fund) provide direct credit subsidies that are open to ethanol production facilities. Others apply their limited allowances to issue tax-exempt bonds to ethanol projects. Hawaii has authorized $50 million of tax-exempt bonds to fund a bagasse-fed ethanol plant, for example. Nebraska has authorized public power districts to build ethanol plants, and to use tax-exempt municipal bonds to finance their construction.[18] New Jersey is another example, having approved $84 million in tax-exempt financing for a privately-owned ethanol plant.

Special tax exemptions for purchasing biofuels-related equipment are also common. Generally, the tax exemptions are not contingent on production levels. For example, Montana exempts all equipment and tools used to produce ethanol from grain from property taxes for a period of 10 years. In Oregon, ethanol plants pay a reduced rate (50% of statute) on the assessed value of their plant for a period of five years. These policies reduce the private cost to build a biofuels facility.

Subsidy Stacking

Subsidy stacking refers to a practice whereby a single plant will tap into multiple subsidy programs. This is common during the construction of a new plant, but unfortunately is often quite difficult to see when surveying subsidies. One $71-million, 20-million-gallon-per-year ethanol plant being built in Harrison County, Ohio, for example, has been able to line up government-intermediated credit or grants from seven different federal and state sources, covering 60% of the plant's capital.[19]

Regulatory Exemptions

The waiver of regulatory requirements normally applied to similar industrial developments, but from which ethanol has been exempted, also provide a benefit equivalent to a subsidy. These exemptions can sometimes be quite surprising given ethanol's claim to be an environmentally-friendly fuel. For example, Minnesota

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[18] The subsidies associated with this power may not always be direct. The Nebraska Public Power District, for example, can provide coal and operate coal-fired boilers for ethanol plant operators (Dostal, 2006).

[19] *Project Briefing: Harrison Ethanol On Site/Off Site Rail* (2006, January 10). Retrieved December 8, 2007, www.dot.state.oh.us/OHIORAIL/Project%20Briefings/January%202006/ 06-03%20Harrison%20Ethanol%20-%20briefing.htm. See also www.ethanolproducer.com/article.jsp?article_id=1910.

exempts ethanol plants (though not biodiesel) with a production capacity of less than 125 mgpy from conducting an environmental impact assessment so long as the plant will be located outside of the seven-county metropolitan area.[20]

Less stringent regulation of pollutants from the biofuels sector can also provide a benefit to the industry, by reducing its capital or operating costs. In April 2007, the EPA reclassified ethanol fuel plants from their former grouping as "chemical process plants" into a less-regulated grouping in which firms producing ethanol for human consumption had been operating. The Agency characterized the change as one of providing "equal treatment" for all corn milling facilities (EPA, 2007b). However, the change also increased the allowable air emissions from fuel ethanol facilities substantially — from 100 tons per year to 250 tons. In addition, fugitive emissions (i.e., not from the plant stack) no longer have to be tallied in the emissions total. Finally, the plants have less stringent air permitting requirements in that they no longer have to install the Best Available Control Technology (BACT). Even an industry trade magazine (Ebert, 2007) notes that

> [r]egardless of the legislative tributaries that many producers will have to navigate, barring litigation, most facilities will be able to take advantage of the new rule to expand and ramp up production, to build new plants with greater capacities or to potentially switch to a different power source, such as coal.

The majority of ethanol produced in the country is for fuel purposes, not human consumption.[21]

4.3.3.2 Policies Affecting the Cost of Intermediate Inputs: Subsidies for Feedstocks

Government policies in the United States support the use of key biofuel feedstocks indirectly, through farm subsidies. Because of the United States' dominance in the global markets for corn and soybeans, federal subsidies provided to those crops during the nine years following the passage of the 1996 Farm Bill kept their farm-gate prices artificially low — by an average of, respectively, 23% below and 15% below average farm production costs, according to Starmer and Wise (2007). Market prices were depressed by somewhat less than the unit value of the subsidies, though the specifics varied according to market conditions. Adding to the complexity, corn and soybean markets are linked at several points. For one, the crops are often grown on the same land, in rotation. Second, they both yield competing products, such as vegetable oils and protein feeds (in the case of corn, as a byproduct of producing ethanol). These interactions complicate the way in which subsidies operate across the biodiesel and ethanol sectors.

Corn has historically been one of the most heavily subsidized crops within the United States. The Environmental Working Group (EWG), which tracks farm

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[20] See MN Statutes 2007, section 116D.04, Subd.2a.

[21] Two inquiries to the EPA's manager for this rule seeking information on cost savings to industry from the change went unanswered.

subsidy payments, estimates that corn subsidies totaled nearly $42 billion between 1995 and 2004 from 12 federal programs,[22] reaching a high of $9.4 billion per year in 2005 (Environmental Working Group, 2006; Campbell, 2006). In 2006, corn did not qualify for first installments on counter-cyclical payments because the effective prices for corn exceeded its respective target price (USDA, 2006). Nonetheless, corn growers continued to receive fixed annual payments on their 2006 harvest.

Pro-rating these values to ethanol, based on the share of supply diverted to fuel production, generates an estimate of expenditure on corn subsidies associated with ethanol production of nearly $500 million for 2006, despite the sharp decline in counter-cyclical support. As ethanol production continues to consume a larger share of the domestic corn crop, its absolute (but not per-gallon) share of corn subsidies will rise accordingly.

The linkages between energy and agricultural policy are also having effects on the environment. Already, rapid growth in demand for biofuel feedstocks, particularly corn and soybeans, is changing cropping patterns in the Midwest, leading to more frequent planting of corn in crop rotations, an increase in corn acreage at the expense of wheat, and the ploughing up of grasslands (GAO, 2007). This trend is worrying, as a growing body of evidence suggests that greater carbon sequestration can be achieved through protecting natural ecosystems than by substituting biofuels for petroleum (Righelato and Spracklen, 2007).

US corn production remains chemical-intensive. Moreover, both corn and soybeans, like all row crops, typically experience higher rates of erosion than crops like wheat. Corn production is often water-intensive as well, a problem that is being exacerbated by current trends in corn-based ethanol plants. These are expanding westward, into areas more dependent on irrigation than corn produced in the Central Midwest. Some of that expansion is into counties served by the heavily overpumped[23] Ogallala Aquifer. In addition to corn production, the ethanol plants themselves also require significant volumes of water (Zeman, 2006; National Research Council, 2007).

4.3.4 Support for R&D on the Production Side

Federal spending on biofuels R&D hovered between $50 and $100 million a year between 1978 and 1998 (Gielecki et al., 2001). The U.S. Office of Technology Assessment reported that direct research on ethanol within the DOE was less than $15 million per year between 1978 and 1980 (OTA, 1979). It is notable that the federal government started the Bioenergy Feedstock Development Program at Oak

[22] These included production flexibility; loan deficiency; market loss assistance; direct payments; market gains farm; advance deficiency; deficiency; counter-cyclical payment; market gains warehouse; commodity certificates; farm storage; and warehouse storage. EWG data deduct negative payments or federal recaptured amounts from the total. See http://www.ewg.org/farm for more details.

[23] See USGS (2003).

Ridge National Laboratory nearly 30 years ago to focus on new crops and cropping systems for energy production (Schnepf, 2007). The program continues to operate in a similar form today.[24] Ethanol-related R&D is estimated to reach $400 million per year annually by 2009 (Koplow, 2007), mainly related to cellulosic ethanol.

4.3.5 Subsidies Related to Consumption

Numerous federal and state subsidies support investment in infrastructure used to transport, store, distribute and dispense ethanol. A separate set of policies underwrites the purchase or conversion of vehicles capable of using alternative fuels.

4.3.5.1 Subsidies to Capital Related to Fuel Distribution and Disbursement

Getting ethanol from the refinery to the fuel pump requires considerable infrastructure, separate from that used to distribute gasoline. Pure ethanol attracts moisture, which means that it cannot be transported through pipelines built to carry only petroleum products. High ethanol blends, like E85, also have to be segregated and stored in corrosion-resistant tanks, and pumped through equipment with appropriate seals and gaskets. All such investment is expensive.

Since 2004, the federal government and many states have started to offer financial incentives to help defray some of those costs. Under EPACT, a refueling station can obtain a tax credit that covers 30% of eligible costs of depreciable property (i.e., excluding land) for installing tanks and equipment for E85. This is capped at $30,000 per taxable year per location, and is estimated to cost the U.S. Treasury $15–30 million per year.

At least 15 states also provide assistance to establish new E85 facilities at retail gasoline outlets, as well as to support other ethanol distribution infrastructure. The Illinois E85 Clean Energy Infrastructure Development Program, for example, provides grants worth up to 50% of the total cost for converting an existing facility (up to a maximum of $2,000 per site) to E85 operation, or for the construction of a new refueling facility (maximum grant of up to $40,000 per facility). Florida recently created a credit against the state sales and use tax, available for costs incurred between 1 July 2006 and 30 June 2010, covering 75% of all costs associated with retrofitting gasoline refueling station pumps to handle ethanol; equipment for blends as low as E10 can qualify.

4.3.5.2 Support for Vehicles Capable of Running on Ethanol

The emergence of ethanol FFVs on the market provided a means for federal and state agencies to meet federal requirements for alternative fuel vehicles (AFVs) established in the Energy Policy Act of 1992. These requirements stipulated that

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[24] http://bioenergy.ornl.gov/

certain government entities purchase AFVs for specified fractions (75% in the case of new light-duty vehicles) of their fleets when purchasing new vehicles. One result of this requirement was that, over time, the federal government acquired significant numbers of ethanol FFVs. Support for privately owned FFVs is also provided by several states in the form of rebates and tax credits for purchasing AFVs, or reductions on license fees and vehicle taxes, some of which apply to ethanol FFVs.

The individual states, and even some municipalities, have also provided regulatory incentives that favor AFVs. These include: the right to drive in high-occupancy vehicle (HOV) lanes, no matter how few the number of occupants in the vehicle (Arizona, California, Georgia, Utah and Virginia); the right to park in areas designated for carpool operators (Arizona); and exemptions from emissions testing (Missouri and Nevada) or certain motor-vehicle inspection programs (Ohio). Because every state develops its own definition of what exact vehicles types may participate in their AFV incentives, it is difficult to evaluate how many of these incentives apply to ethanol-powered vehicles.

4.4 Aggregate Support to Ethanol

To develop a better sense of how all of the individual subsidy programs affect the overall environment for ethanol, we have compiled a number of aggregate measures of support. The aggregate data provide important insights into a variety of policy questions, ranging from the financial cost of the support policies to taxpayers and consumers, to estimates of the costs of achieving particular policy goals. Among arguments put forth in support of biofuel subsidies are that they help the country to diversify from fossil fuels in general, and petroleum in particular; and that they have a better environmental profile than fossil fuels.

Quantification is often difficult either because the subsidy's course of action is indirect (e.g., mandated use of ethanol) or because data on the magnitude of support (especially at the state level, or with tax breaks or credit enhancements) are difficult to locate. As a result, there are inevitable gaps in our subsidy tallies.

Despite not counting everything, however, the subsidy picture is striking. We estimate that total support for ethanol was $5.8 billion to $7.0 billion in 2006 and, assuming no change in the RFS, will rise sharply to $11 billion by 2008 and $14 billion by 2014 (Table 4.1). The VEETC at present is the single largest ethanol subsidy and the difference between the high and low estimate is primarily associated with the incremental benefit blenders receive from the VEETC being excludible from income taxes (Box 4.1). We believe the high estimate is a more accurate representation of government support to ethanol than is the low estimate. Subsidies from the VTEEC were $3–4 billion in 2006, and are projected to total $34 to $48 billion over the 2006–12 period.

Total undiscounted subsidies to ethanol from 2006–2012 are estimated to fall within the range of $68 billion to $82 billion. Implementation of a higher RFS (e.g., 36 bgpy by 2022) would increase total subsidies by tens of billions of dollars per year above these levels.

Table 4.1 Estimated total support for ethanol

Element	2006	2007	2008	Total, 2006–12
Market Price Support	1,390	1,690	2,280	17,450
Output-linked Support[1]				
Volumetric Excise Tax Credit (low)	2,810	3,380	4,380	33,750
Volumetric Excise Tax Credit (high)	4,010	4,820	6,260	48,220
USDA Bioenergy Program	80	Ended in '06	–	80
Reductions in state motor fuel taxes	390	410	440	3,210
State production, blender, retailer incentives	120	NQ	NQ	120
Federal small producer tax credit	110	150	170	1,100
Factors of Production – Capital				
Excess of accelerated over cost depreciation	170	220	680	3,250
Federal grants, demonstration projects, R&D[2]	110	290	350	2,140
Credit subsidies	110	110	110	880
Deferral of gain on sale of farm refineries to coops	10	20	20	130
Factors of Production – Labour	NC	NC	NC	NC
Feedstock Production (biofuels fraction)	510	640	740	5,010
Consumption				
Credits for clean fuel refueling infrastructure	10	30	20	140
State vehicle purchase incentives	NQ	NQ	NQ	NQ
AFV CAFE loophole	NQ	NQ	NQ	NQ
Total support[3]				
Low estimate	5,820	6,940	9,200	67,260
High estimate	7,020	8,390	11,070	81,720

[1] Primary difference between high and low estimates is inclusion of outlay equivalent value for the volumetric excise tax credits. A gap in statutory language allows the credits to be excluded from taxable income, greatly increasing their value to recipients.
[2] Values shown reflect half of authorized spending levels where funds have not be appropriated. This reflects the reality that not all authorized spending is actually disbursed.
[3] Total values reflect gross outlays; they have not been converted to net present values. This follows the general costing approach used by the Joint Committee on Taxation.
[4] Totals may not add due to rounding.
[5] NC = Subsidies were quantified but not counted because provision was generally applicable across the economy. NQ = Subsidies exist that were not quantified.
Source: Koplow (2007).

Market price support, related to the combination of high barriers to imports and domestic purchase mandates, comprises the second largest subsidy to ethanol, at \$1.3 billion in 2006, rising to more than \$3 billion per year by 2010. Should the RFS be increased to 36 or 60 bgpy as is being considered, market price support would become the largest subsidy element, surpassing even the VEETC. Feedstock support also remains important, despite falling countercyclical payments, as direct payments remain high and ethanol is absorbing an ever-higher share of the total corn crop.

Based on 2004–2005 patterns of fuel consumption we estimate state sales and excise tax exemptions for biofuels to generate a subsidy to ethanol of approximately $400 million in 2006. Fuel taxes change regularly. In any given quarter, at least a few states will change their rates. Similarly, different sources for this information also disagree. While many states provide generous exemptions for E85, sales information are hard to come by, making revenue-loss calculations difficult. We have prorated national E85 sales data (also a few years old) by the state share of E85 refueling stations. This approach enables us to generate a rough estimate, despite the limitation of implicitly assuming that all pumps dispense the same amount of fuel per year. Rising demand; large new incentives, such as a full exemption from state taxes for E85 in New York; larger credits in Iowa; and rapidly growing sales of both ethanol blends and E85 suggest subsidies in 2007 and 2008 will be substantially higher.

State policies beyond reductions in motor-fuel taxation were quantified only for 2006, based on Koplow (2006). Had these many state supports been catalogued and quantified, the magnitude of state and county supports would be much larger than what is shown in the table.

4.4.1 Subsidy per Unit Energy Output and as a Share of Retail Price

Estimates of total support provide only a first-level indication of the potential market distortion that the subsidies may cause. Large subsidies, spread across a very large market, can have less of an effect on market structure than much smaller aggregate subsidies focused on a small market segment. As shown in Table 4.2,

Table 4.2 Subsidy-intensity values for ethanol

	2006	2007	2008	Average 2006–12
Subsidy per gallon of pure ethanol	1.05–1.25	1.05–1.25	1.05–1.30	1.00–1.25
Subsidy per GGE of fuel[1]	1.45–1.75	1.40–1.70	1.45–1.75	1.40–1.70
Subsidy per MMBtu	12.55–15.15	12.45–15.05	12.70–15.30	12.15–14.75
Subsidy per GJ	11.90–14.35	11.80–14.25	12.05–14.50	11.50–13.95
Subsidy as share of retail price[2]	39–47%	46–56%	55–66%	50–66%
Estimated retail price ($/gallon of pure ethanol)	2.70	2.25	1.95	2.05

[1] GGE values adjust the differential heat rates in biofuels so they are comparable to a gallon of pure gasoline. This provides a normalized way to compare the subsidy values to the retail price of gasoline.
[2] Retail price projections are for E100 and B100 as estimated in Westhoff and Brown (2007) for 2006–12; and FAPRI (February 2007) for 2013–16.
Source: Koplow (2007).

subsidies on a volumetric basis are $1–$1.30 per gallon of ethanol, and roughly $1.40–$1.70 per gallon of gasoline equivalent (GGE). The average subsidy per gigajoule (GJ) of ethanol energy produced is between $11 and $14 during the 2006–12 period.

Subsidies per unit energy produced via ethanol subsidies top $11 per GJ in all years, reaching as high as $14.50 per GJ in 2008. For the 2006–12 period, subsidies to ethanol will be equal to half or more of its projected retail price. Actual price drops for ethanol during the summer of 2007 have brought prices well below the values shown in our calculations. As of October 2007, ethanol subsidies were equal to as much as 80% of the fuel's then spot-market price of roughly $1.60 per gallon (Kment, 2007; Shirek, 2007).

4.4.2 Subsidies per Unit Greenhouse Gas Displaced

A common claim by biofuels supporters is that ethanol will play an important role in facilitating the transition to a society with a low carbon footprint. To test how efficient existing policies are in getting us there, we examine the subsidy cost per metric ton of CO_2-equivalent displaced, and then compare this cost with the value of carbon offsets on the world's two major climate exchanges in Chicago (CCX) and Europe (ECX). The results are shown in Table 4.3.

The GHG displacement factors show a large variation across data sources. This is likely due to the complexity of the systems being modeled, but the variation forms a critical policy issue. As Kammen et al. (2007: 4) note:

> the indirect impacts of biofuel production, and in particular the destruction of natural habitats (e.g. rainforests, savannah, or in some cases the exploitation of 'marginal' lands which are in active use, even at reduced productivity, by a range of communities, often poorer households and individuals) to expand agricultural land, may have larger environmental impacts than the direct effects. The indirect GHG emissions of biofuels produced from productive land that could otherwise support food production may be larger than the emissions from an equal amount of fossil fuels.

For corn ethanol, researchers cannot even agree on the direction of impact. Thus, at one end of the displacement factors, GHG emissions rise rather than fall from its production. This would imply very large subsidies per metric ton of *extra* CO_2-equivalent emitted ($600 per metric ton in the case of corn ethanol).

The best possible case for corn-based ethanol uses the lower bound subsidy estimate and divides it by the most favorable studies showing GHG reductions over the ethanol fuel cycle. Even here, subsidies per metric ton displaced are around $300.[25] Based on historical prices for carbon offsets, this same investment could

[25] This value is lower than in our October 2006 study due to the use of a more favorable upper-end displacement value (a scenario with natural gas-fired plant capacity and avoided drying costs by direct use of wet distillers grain byproducts) based on new work by Wang et al. (2007). This scenario performs well above the average corn-ethanol plant of the future, also modeled in that same paper.

Table 4.3 Subsidy cost per unit of CO_2 equivalent displaced

	2006	2007	2008	Average 2006–12
Subsidy cost ($) per metric tonne CO_2 equivalent displaced				
Low estimate	305	300	310	295
High estimate[1]	(600)	(595)	(605)	(585)
Cellulosic hypothetical case – low	110	110	115	110
Cellulosic hypothetical case – high	200	200	205	195
GHG displacement factors				
Displacement factor – worst[1&2]	(24%)	(24%)	(24%)	(24%)
Displacement factor – best	39%	39%	39%	39%
Displacement factor – cellulosic worst	77%	77%	77%	77%
Displacement factor – cellulosic best[3]	114%	114%	114%	114%
Number of tonnes of carbon offsets subsidies could purchase				
European Climate Exchange[4]	12–24	11–22	11–23	11–21
ECX – cellulosic	5–8	4–7	4–8	4–7
Chicago Climate Exchange[4]	130–256	80–157	81–160	84–167
CCX – cellulosic	48–86	29–53	30–54	31–56
Cost of CO_2-equivalent futures contracts[5]				
ECX – Average prices paid for settlements during year noted	24.9	26.7	26.9	27.3
CCX – Historical average prices paid for settlements during year	2.3	3.8	3.8	3.6

[1] Negative values occur when the specific life cycle modeling scenarios estimate that GHG emissions from the biofuels production chain exceed those of the conventional gasoline or diesel they are replacing. This is fairly common with models that more centrally integrate the land use change impacts of the biofuels production system.
[2] Displacement factors represent the high and low values in the range from a variety of studies: Farrell et al. (2006b); Farrell et al. (2007); Hill et al. (2006); EPA (2007a); Wang et al. (2007) and Zah et al. (2007). The most favorable values included generally represent specific technologies rather than the average expected performance of either the current or future batch of plants.
[3] Values above 100% denote net sequestration benefits from the biofuel scenario (in this case, closed-loop poplar farming). It is not clear that the same high level of displacement would be maintained once the production base scaled up to meet the needs of the transportation sector.
[4] Although the subsidies pay for increased GHG emissions in the ethanol and biodiesel examples, subsidy reform would still free up public money that could be used to purchase low cost carbon offsets on the exchanges. The number of offsets is shown here.
[5] CO_2 futures contract data from European and Chicago exchanges, compiled as of October 2007. Prices represent historical averages of daily transactional data for contracts in the year in question. Markets are not interchangeable; higher prices in Europe reflect tighter constraints.

have purchased 80–130 times as much displacement on the CCX, the most appropriate benchmark for the U.S. carbon market. Even on the more expensive ECX, the subsidies could have purchased 11 metric tons of offsets.

We considered also a hypothetical case assuming the same levels of government support for ethanol, but a closed-loop production system based on short-rotation poplar (*Populus* sp.) as a cellulosic feedstock. Such a production system is believed to generate net sequestration (hence its 114% displacement value). Whether the impacts would really be so low once actual crops are produced on a large scale, move outside of their optimal range, and possibly require irrigation, is an open question. The hypothetical cellulosic-ethanol case provides better tradeoffs than for corn ethanol — \$110–204 per metric ton of CO_2-equivalent displaced — but the subsidies are still high: these funds could have purchased 4–8 times the offsets on the EXC or 30–85 times on the CCX.

4.4.3 Comparisons with Other Countries

The United States is by no means the only country that subsidizes ethanol production and consumption. Ethanol was heavily subsidized early in the development of Brazil's industry (from 1976 through 1998; see Boddey, 1993); although production is no longer directly subsidized, domestic consumption is still favored through

Table 4.4 Total support estimates (TSEs) and energy and CO_2 metrics for ethanol in selected OECD countries in 2006

OECD economy	TSE (10^9US\$)	US\$ per GJ	US\$ per litre of gasoline equivalent[1]	US\$ per metric ton of avoided CO_2-equivalent[2]
United States[3]	5.8–7.0	12–14	0.38–0.46	305–600
EU[4]	1.6	40	1.40	700–5500
Canada[5]	0.15	20	0.65	250–1700
Australia[6]	0.044	16	0.50	300–630
Switzerland[7]	>0.001	28	0.90	330–380

[1] Per litre of gasoline equivalent (LGE) values adjust the differential heat rates in biofuels so they are comparable to a litre of pure gasoline. This provides a normalized way to compare the subsidy values to the retail price of gasoline.
[2] Displacement factors represent the high and low values in the range from a variety of studies (e.g., Farrell et al. (2006); Farrell and Sperling, et al. (2007); Hill et al. (2006); EPA (2007a); Wang et al. (2007) and Zah et al. (2007) comparing the life-cycle emissions of greenhouse gases with that of unleaded gasoline. The most favorable values included generally represent specific technologies rather than the average expected performance of either the current or future batch of plants. The number in parentheses indicates that subsidies are actually generating extra GHGs.
[3] The primary difference between the high and low estimates in the first three columns relates to whether the volumetric excise-tax credits are counted in revenue-loss or outlay-equivalent terms. A gap in statutory language allows the credits to be excluded from taxable income, greatly increasing their value to recipients.
[4] The range in the final column reflects differences in displacement rates between ethanol produced from sugarbeets and ethanol produced from rye.
[5] The range in the final column reflects differences in displacement rates between ethanol produced from C-molasses and ethanol produced from grains.
[6] The range in the final column reflects differences in displacement rates between ethanol produced from waste wheat starch and ethanol produced from maize.
[7] The range in the final column reflects uncertainty in the displacement rates for ethanol produced as a by-product of cellulose production.
Sources: • **Australia:** Quirke et al. (2008); • **United States:** Koplow (2007); • **Other OECD economies:** Steenblik (2007).

much lower fuel-excise taxes than those applied to gasoline, and by rules preventing private ownership of diesel-powered cars. More recently, several OECD member economies have started offering reduced excise-tax rates on ethanol used as fuel, and in some cases financial assistance for ethanol-manufacturing plants.

Compared with these other countries, the United States still leads in terms of absolute support provided, though per gigajoule or litre of gasoline equivalent its subsidization rate is substantially lower than those of the EU and Switzerland, which apply much higher fuel taxes to gasoline (Table 4.4). Measured in terms of dollars per metric ton of avoided CO_2-equivalent emissions, however, the United States falls within the range of values measured for most other OECD member economies, which in all cases are orders of magnitude higher than the prices of CO_2-equivalent offsets on the major climate exchanges, as well as current estimates of the social cost of a metric ton of CO_2 emitted (see, e.g., IPCC, 2007).

4.5 Pending Legislation

Despite a growing awareness of both the fiscal and environmental concerns about biofuels, legislative support has not abated. As of October 2007, the most "aggressive" proposed reforms (both contained in the tax section of the 2007 Farm Bill) involve reducing the excise tax credit by 5 cents per gallon (less than 10%) once the existing mandate is reached. None of the major bills would phase out the tax credits under high oil prices (when biofuels are more competitive) or remove an existing loophole that allows claimants to exclude the tax credits from their taxable income, further increasing the cost of the provision.

Several major bills under consideration by Congress, including a large proposed Energy Bill and the 2007 Farm Bill, seek to increase levels of support for biofuels, particularly ethanol. By increasing the national mandatory consumption requirement (the Renewable Fuels Standard), for example, lawmakers hope to reduce risks to the industry of a sustained market downturn. The Energy Bill under debate in December 2007 (H.R. 6) would mandate 36 billion gallons per year by 2022. Senate Bill 23 includes a 60 billion gallon per year target by 2030. The costs of these rules are likely to be extremely large. The Energy Information Administration recently estimated that the incremental cost of a 25% renewable fuels mandate (on par with 60 billion gallons per year of biofuels) would $130 billion per year within the fuels sector alone. This translates to a cost per metric ton of CO_2-equivalent reduced of more than $115, or roughly 30 times the current cost of a carbon offset on the Chicago Climate Exchange. Costs of vehicle infrastructure and increased food prices would be extra.

While the specifics of the mandates vary, most do not take into account life-cycle environmental impacts of biofuel production chains. As a result, they may encourage expensive fuels that actually worsen GHG emissions. In addition, none provide a neutral framework within which alternative ways to wean the country from imported oil and reduce greenhouse emissions can compete on a level playing field. Such alternatives include improvements in vehicle efficiency, improved maintenance and tires, and hybrid and plug-in hybrid drive trains.

To further boost ethanol consumption, proposals are also being considered to increase the allowable limits for ethanol blends in gasoline for unmodified engines (currently 10%) and improve distribution infrastructure for E85.

Some proposals seek to diversify the current industry by creating specific incentives for ethanol derived from feedstocks other than corn starch, expanding support for cellulosic ethanol and widening the definition of "advanced biofuels" (a definition that in some bills put before Congress would include fossil-derived fuels, and in many includes fuels derived from sugar and sorghum). As such, the new legislation compounds the current distortions to crop markets with a host of new programs to underwrite production, harvesting, storage, and the transport of cellulosic feedstocks. Some legislation makes compliance with the Renewable Fuels Standard contingent on lowering the greenhouse gas profile of biofuels (difficult to verify given problems with existing life cycle models). However, none would similarly restrict access to the excise tax credits.

4.6 Conclusions

A rapidly-expanding production base, combined with a proliferation of policy incentives, has generated a growing level of public subsidization for the ethanol industry. Many of the existing subsidies scale linearly with production capacity or consumption levels, and the resulting rate of growth in the subsidy payments can be quite large. In addition, the subsidies do not decline as the price of gasoline rises, as is the case for some subsidies benefiting petroleum and natural gas, and for some ethanol-support programs elsewhere, such as Canada (Steenblik, 2007). Although the spiraling costs of the VEETC in particular have led to discussions and proposals for subsidy phase-outs when oil prices are high (Bantz, 2006), there are currently no constraints in place.

At some point, the expiration of existing incentives may temper the growth in subsidization, but that point is still quite a few years off. Strong political support has maintained the key subsidies to ethanol for nearly 30 years, and we anticipate that those forces will remain. In the near term, we expect subsidy levels to rise sharply. Of particular interest are higher renewable fuel mandates and the rate of growth of 85% ethanol blends (E85), for which there are a number of large state subsidies that currently apply to only a small base.

Our analysis illustrates not only that subsidies to ethanol are pervasive and large, but that they are not a particularly efficient means to achieve many of the policy objectives for which they have been justified. These subsidies are the result of many independent decisions at different levels of government, resulting in policies that are often poorly coordinated and targeted. Hundreds of government programs have been created to support virtually every stage of production and consumption relating to ethanol, from the growing of the crops that are used for feedstock to the vehicles that consume the biofuels. In many locations, producers have been able to tap into multiple sources of subsidies.

Because the bulk of subsidies are tied to output and output is increasing at double-digit rates of growth, the cost of these programs will continue to climb. Production is subsidized at the federal level even though consumption of it is mandated through the RFS. Ethanol production is supported on the grounds that it helps wean the United States from imported petroleum, but special loopholes in vehicle efficiency standards for flexible fuel vehicles (including those that run on high ethanol blends) result in higher oil imports (MacKenzie et al., 2005). The maintenance of a high tariff on imported ethanol (2.5% plus 54 cents per gallon), in particular, sits at odds with the professed policy of the U.S. government to encourage the substitution of gasoline by ethanol.

The absolute value of the subsidies is not the only, and perhaps not the main, indicator of the market-distorting potential of a set of support policies. Subsidies as a share of market price were above 40% as of mid-2006, for example, which is high in comparison with other fuels. Such high rates of subsidization might be considered reasonable if the industry was new, and ethanol was being made on a small-scale, experimental basis using advanced technologies. But that is not the case: the vast majority of subsidized production relies on mature technologies that, notwithstanding progressive improvements, have been around for decades.

Ethanol also has some greenhouse gas and local-pollution benefits. But the cost of obtaining a unit of CO_2-equivalent reduction through subsidies to the fuel is extremely high: we calculate that it comes to nearly $300 per metric ton of CO_2 removed for corn-based ethanol, even when assuming an efficient plant using low-carbon fuels for processing. Yet even under such best-case scenario assumptions for GHG reductions from corn-based ethanol, one could have achieved far more reductions for the same amount of money by simply purchasing the reductions in the marketplace. The cost per metric ton of reductions achieved through public support of corn-based ethanol already programmed over the next several years could purchase more than 10 times the offsets on the European Climate Exchange, or nearly 90 times the offsets on the Chicago Climate Exchange.

Most importantly, the U.S. government has neglected what should be its core role: to adopt a neutral strategy equally accessible to all potential options to reduce the country's reliance on imported oil. Such a strategy would not favor ethanol, but would encourage a range of potential solutions such as more efficient vehicles, better fleet maintenance, and alternative drive-trains such as plug-in hybrids. Similarly, the government has yet to indicate an exit strategy to wean the ethanol industry from protection and subsidies. Indeed, as is often the case with subsidies, current legislative proposals appear to entrench existing arrangements. These will ensure that the biofuel industry remains a significant drain on U.S. taxpayers for decades to come; and that improvements in transport-fuel options will be both slower and more expensive than would occur with a technology-neutral approach.

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