WORLD RESOURCES INSTITUTE

Technical Document for *Rattling Supply Chains:*

Methodology and Data Sources for the Base Case and Ecoflation Scenario

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**Andrew Aulisi, Amy Cassara, Crystal Davis,
Ruth Nogueron, Jeff Rodgers, and Amanda Sauer**

This document is a companion to *Rattling Supply Chains: The Effect of Environmental Trends on Input Costs for the Fast Moving Consumer Goods Industry*
Available at http://www.wri.org/publication/rattling-supply-chains

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1. Overview

To illustrate the financial relevance of environmental issues the World Resources Institute (WRI) and A.T. Kearney, Inc. collaborated to develop a future scenario for major environmental trends, including climate change policy, physical climate change and water scarcity, deforestation, and biofuel policy. This scenario, termed Ecoflation,[1] was then applied to assess the cost impacts on energy, agricultural, and timber commodities throughout the supply chains of companies in the Fast Moving Consumer Goods (FMCG) industry.

This report is a pilot analysis: the methodology can be regularly updated, and the approach can be expanded and adapted to include other environmental issues, industries, and value chains.

Industry focus:
Fast Moving Consumer Goods, including food and beverage, personal care, and household care. This industry was chosen because of data availability, in-house expertise, broad public interest, relevance to current events, and the interesting suite of issues affecting the industry

Scenarios:
1. Base Case: Future commodity prices as currently predicted by leading forecasting agencies.
2. Ecoflation: Ecoflation represents the view that in the future as natural resources become scarcer and sustainability issues become more pressing, environmental costs will increasingly be borne by those responsible, thus creating an "ecoinflation" that is not currently priced into economic transactions. In other words, our scenario envisions a world in which costs that are currently borne by society are internalized in firms.

   The following themes are included in the Ecoflation scenario:
   a. Climate Change Policy
   b. Climate Change Impacts/ Water Scarcity
   c. Deforestation
   d. Bioenergy Policy

Forecast periods:
1. 2013.
2. 2018.

Geographic scope:

Global. Scenario themes and commodities will limit geographic scope to relevant markets and production regions as outlined in this document.

Key commodities:
The following commodities were chosen due to their financial and/or environmental significance.
1. Energy (oil, coal, natural gas)
2. Cereals (corn, wheat)
3. Soy
4. Sugar
5. Palm Oil
6. Timber (pulpwood)

[1] Derived from "eco" and "inflation."

Major assumptions:

Base Case

- .
- All manufacturing facilities are located in the United States and Europe.
- The fuel mix of electricity generation remains constant.
- Wood pulp prices remain flat at 2006 levels (due to lack of publicly available price forecasts).
- Water is obtained at insignificantly low or no cost through subsidized rates for agricultural and industrial users.

Ecoflation

- Energy commodity prices do not change appreciably as a result of climate policy. Therefore oil and natural gas used for raw materials, rather than combusted for energy, remain the same as the Base Case prices.
- Demand for energy is inelastic.
- The downward effects on cereal, soy, sugar and palm oil prices from repealing bioenergy policy are negated by increased demand for ethanol and biodiesel from higher gas and diesel prices.
- Agricultural production regions remain constant and irrigation is increased where it already exists in order to meet water needs under changing climate conditions.
- The cost structure of irrigation agriculture in the U.S. is applied to all regions.
- The elasticity of demand for agricultural commodities remains constant.
- Agricultural users pay a 50-fold increase in water prices due to increased competition and a reduction in public water price subsidies.

Limitations:

The goal of this initiative was not to forecast prices but rather to determine the impact of environmental trends on readily available forecasts. Many factors impact costs, including consumer behavior, improvements in technology, geopolitics, demographic trends, natural resources, policy and regulation, markets. This analysis focuses on demographic trends, natural resources constraints/utilization, and policy/regulatory initiatives to inform commodity prices under both scenarios. Much more difficult to predict are changing consumer behaviors, technological advancement, and geopolitical unrest, all of which have been excluded from the analysis in order to simplify the model

Because our analysis is based on public available forecasts, we hesitate to deviate from the price points modeled by these groups without the ability to manipulate the models' inputs themselves. Therefore the commodity price changes from environmental issues reflect only first order impacts and not the dynamic interaction between supply and demand, substitution effects, infrastructure and other changes that would ultimately determine commodity prices. At best, we can strive to understand the inputs that the authors utilized and the assumptions that underpinned the values selected and strive for transparency in our approach. We believe that the reports selected are likely conservative in nature and provide a lower boundary for the threats that the FMCG industry faces in the near and extended term.

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2. Base Case

A Base Case was developed to provide a point of reference for the Ecoflation scenario. The Base Case applies existing price forecasts from the U.S. Department of Energy's Energy Information Administration (EIA) and the Food and Agricultural Policy Research Institute (FAPRI) for energy and agricultural commodities to the cost structure of the industry. In essence, the Base Case presents a vision of how leading forecasting agencies expect future commodity prices to trend.

Because the Base Case is based on existing readily available price forecasts, it shows major changes in macroeconomic and demographic drivers that will profoundly affect the FMCG industry, including increased consumer spending in the emerging middle classes of China and India. By design, however, these forecasts do not contain forward-looking assumptions for environmental trends, such as anticipated changes in weather patterns and public policy. Specifically, both FAPRI and EIA assume that existing public policies will remain unchanged and that average historic weather patterns will continue. In theory, at least, climatic patterns are expected to change and thus should be part of both the Base Case and the Ecoflation scenario. As we noted earlier, though, this is not currently the case for traditional price forecasts based on EIA and FAPRI data. As a result, physical climate change is included only in the Ecoflation scenario.

The Base Case is built upon a suite of price forecasts for the global commodities as described below:

A. Energy

1. Primary Fossil Fuels

Oil, coal, and natural gas price projections were obtained from the Energy Information Administration's *Annual Energy Outlook 2008(AEO 2008)*. The *AEO 2008* forecasts energy production and consumption trends by fuel and by sector through the year 2030 using the National Energy Modeling System (NEMS). NEMS is a modular system that models the interaction between supply, conversion, and demand for multiple fuels and sectors simultaneously.

The NEMS projects prices for the United States, along with international oil forecasts, under more than three dozen different cases. The High Price Case was used for the purposes of this analysis, which combines the EIA reference case baseline scenario with more pessimistic projections of the world's oil supply in the future.

Despite their near-exclusive focus on the United States, the EIA's energy projections are used here because they are the only available price forecasts that account for the drastic increase in oil prices observed over the past year. The International Energy Agency (IEA), considered the world's authoritative source for energy statistics and forecasts, had yet to publish their 2008 forecasts at the time this report was printed. Historical energy data are primarily based on well-established and institutionalized accounting methodologies, and are therefore considered reliable. However, any projection of energy prices has a high degree of uncertainty: EIA's oil price predictions for 2018 range from $74 to $145 depending on the scenario. Interannual variability and short-term spikes in prices are not reflected in these estimates.

The following oil, natural gas, and coal prices will be used for the reference case (Table 1):

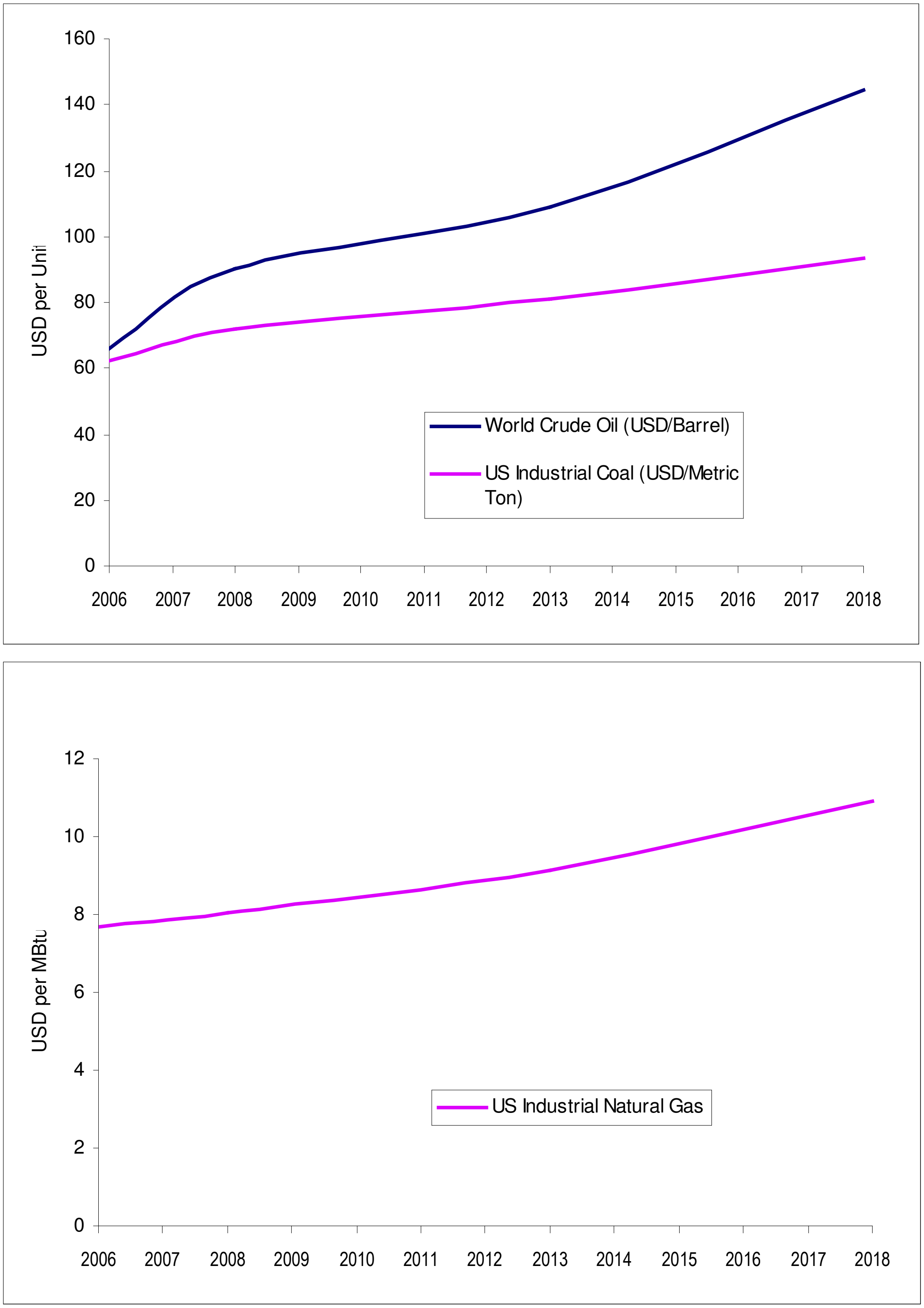
Table 1: Oil, Natural Gas, and Coal Reference Prices for 2013 and 2018

		unit	2006	2008	2013	2018	% increase 2006-2008	% increase 2006-2013	% increase 2006-2018	% increase 2008-2013	% increase 2008-2018
Crude Oil	Imported low-sulfur light crude	barrel	66	90	109	145	37%	65%	119%	21%	60%
Natural Gas	US Industrial Prices	Mbtu	7.7	8.0	9.1	10.9	5%	19%	43%	14%	36%
Steam Coal	US Industrial Prices	Mbtu	2.3	2.7	3.0	3.5	15%	30%	50%	13%	31%

Note: All prices are real using 3.2% inflation after 2013.

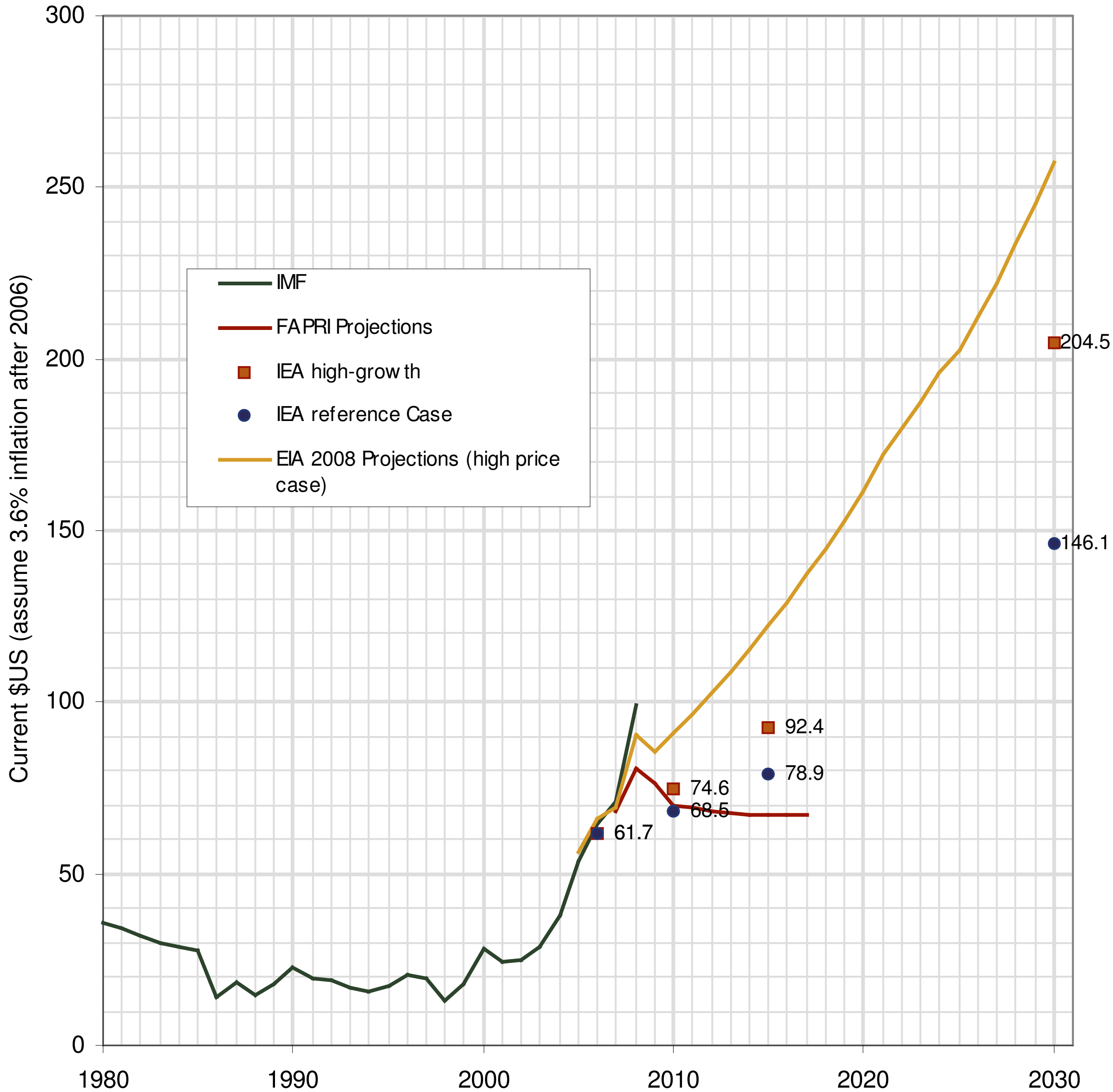
The AEO price predictions used in our Base Case are considerably different from past projections published by both the IEA and the EIA, which typically assume that oil supply will outpace demand in the coming decades. The forecasts used here project a crude set of supply curves based on models of international liquids supply and demand, energy investment trends, and long-term global resource economics predictions. See Figures 1 and 2.

Figure 1: EIA High Price Case Forecast Prices for Oil, Coal, and Natural Gas, 2006 - 2018



Note: All prices are real using 3.3% inflation from 2009 – 2012 and 3.2% after 2013.

Figure 2: Historical Oil Prices and Comparison of Projections, 1980-2030



2. Electricity

Given the regional nature of electricity markets, several assumptions were necessary to determine industrial electricity prices for the Base Case. In this analysis, electricity prices will be used as an input to manufacturing costs. We therefore made the simplifying assumption that all manufacturing facilities in the consumer packaged goods sector are located in the US and Europe.

Industrial electricity price projections are derived from the EIA's fuel price projections and the IEA's historical energy pricing and fuel mix data found in the *Energy Balances of OECD Countries* (Table 2). To calculate electricity prices, it was assumed that there is no change in cost of non-fossil fuel electricity generation and a change in price of coal and natural gas generation proportional to the change in price of the fossil fuel itself. In addition, it was assumed that fuel accounts for 35% of total delivered electricity costs to industrial users. For example, if coal prices increase 50% and a region received 20% of its energy from coal, the increase in price would be 20%*50% *35%= 3.5%. Prices reflect all taxes, fees, and surcharges for industrial consumers. These prices are low because they only incorporate changes in fuel prices, which represent just over a third of the average electricity cost.

The following fuel mixes of electricity generation were held constant:

Table 2: Fuel Mix of Electricity Generation for US and EU, 2005

	USA	OECD Europe
Coal	50.5%	28.4%
Oil	3.3%	3.9%
Natural Gas	18.3%	20.7%
Other	27.9%	47.1%

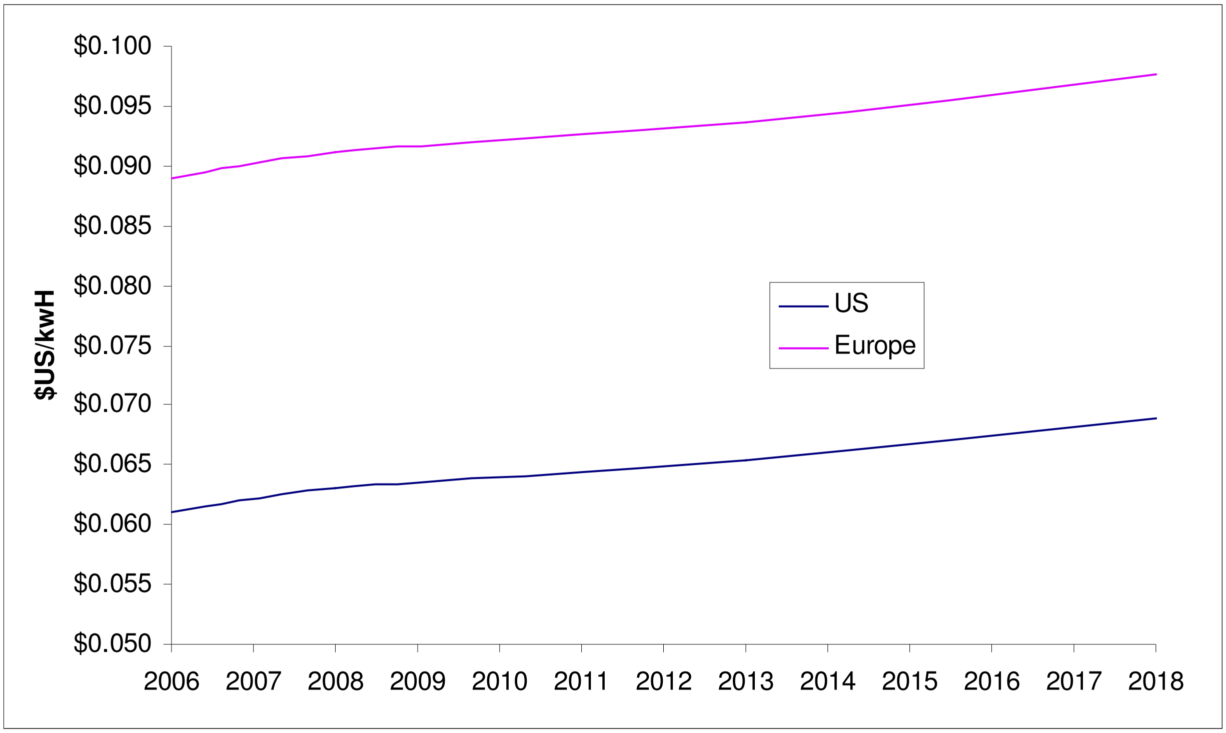
Source: International Energy Agency (IEA) Statistics Division. 2007. *Energy Balances of OECD Countries (2007edition)* and *Energy Balances of Non-OECD Countries (2007 edition)*. Paris: IEA. Available at http://data.iea.org/ieastore/default.asp.

The following electricity prices were used for the reference case:

Table 3: Electricity Prices for the US and Europe in $/KwH, 2013 and 2018

	2006	2008	2013	2018	% increase 2006-2008	% increase 2006-2013	% increase 2006-2018	% increase 2008-2013	% increase 2008-2018
US	0.061	0.063	0.065	0.069	3%	7%	13%	4%	9%
Europe	0.089	0.091	0.094	0.098	2%	5%	10%	3%	7%

Figure 3: Electricity Prices for the US and Europe, 2006 – 2018



The 2006 price for Europe is a weighted average, based on total electricity output in GwH and electricity prices for industry of the following 20 countries: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Norway, Poland, Portugal, Romania, Slovak Republic, Spain, Switzerland, Turkey, and the UK. For both the US and Europe, the 2008 price is interpolated from 2006 and 2010 natural gas and coal price projections, the 2013 from 2010 and 2015, and the 2018 from 2015 and 2030.

B. Agricultural Commodities (Cereals, Soy, Palm Oil, Sugar)

The Food and Agriculture Policy Research Institute's (FAPRI) at the Iowa State University and Global Insight produce annual price forecasts for major agricultural commodities. The 2008 forecast, released in April 2008, incorporates a higher oil price and demand for bioenergy inputs than previous forecasts. These price forecasts include recent increases in food commodity prices. For example, the price of wheat increased by 50% from 2007 to 2008. The prices of cereals, soy and sugar are expected to stabilize within +/-12% of 2008 prices, while palm oil prices are expected to continue to increase by 2013 and 2018, although at a lower rate than was experienced between 2006 and 2008. See Table 4 and Figure 4.

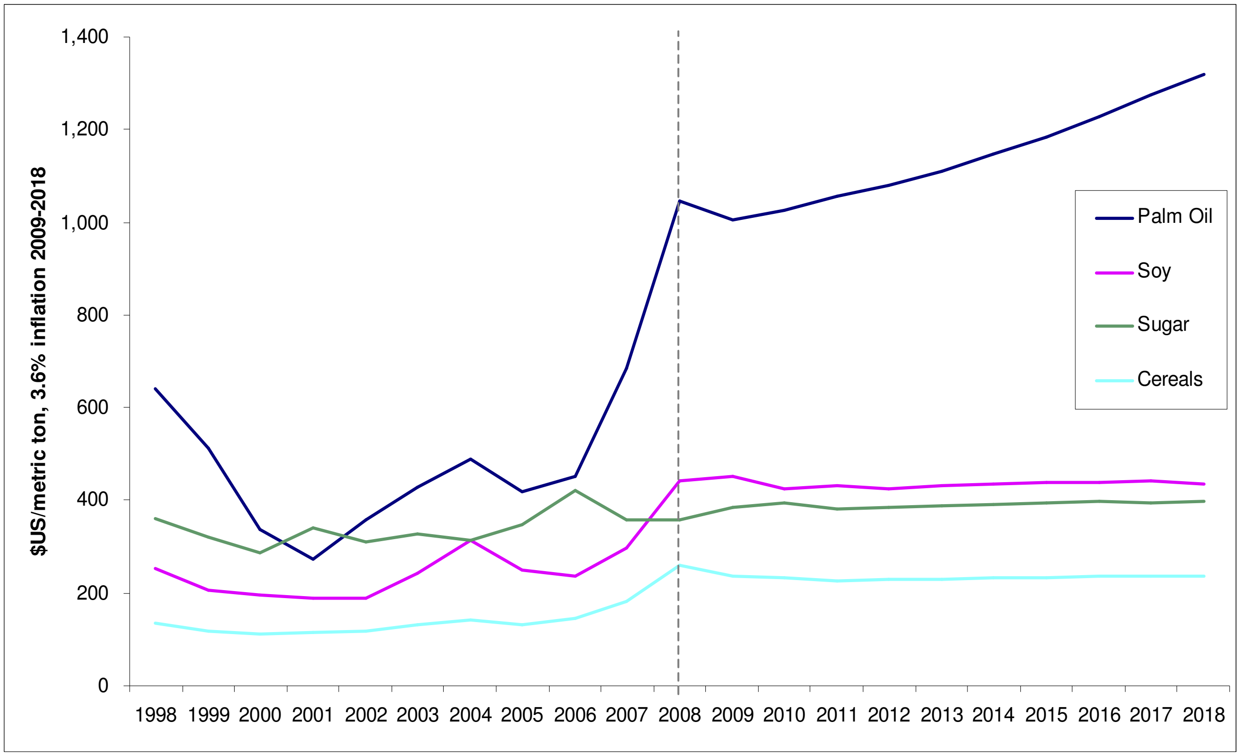
For most commodities, FAPRI reports forecast prices for several markets. Our Base Case prices are an average of the price points for each commodity. From the perspective of the cost structure analysis, cereals/grains is a more useful classification than the individual commodities because of their substitutability. While cereals and grains include many commodities, we used a weighted average of wheat and corn, the two dominate commodities, to calculate an aggregate price for cereals and grains.

Table 4: Base Case Agricultural Commodity Price Forecasts, in $US/metric tonne

	2006	2008	2013	2018	2006-2008	2006-2013	2006-2018	2008-2013	2008-2018
Cereal	144	260	230	236	81%	60%	64%	-12%	-9%
Soy	235	443	432	437	89%	84%	86%	-2%	-1%
Palm Oil	452	1046	1110	1319	131%	146%	192%	6%	26%
Sugar	423	358	390	399	-15%	-8%	-6%	9%	11%

Source: FARPI 2008 Agricultural Outlook. 2009-2018 prices include 3.3% inflation rate through 2012 and 3.2% thereafter.

Figure 4: Average Historical and Forecast Prices for Key Commodities, 1998 - 2018



The FAPRI forecasts are based on assumptions including average weather patterns, the extension of current agricultural, trade, and biofuels policy, medium population and economic growth, and oil prices around $68/barrel in 2013 and $67/barrel in 2018. See Table 5.

Table 5: 2008 FAPRI Agricultural Commodity Price Forecasts Assumptions

	FAPRI/Global Insight Baseline Assumption
Macroeconomic	- Annualized growth rates for about 40 countries with an average global GDP growth rate of 3.3% in 2013 and 3.2% in 2018. - Annualized oil prices increasing from $81/barrel in 2008 to $67/barrel in 2018 - World population growth rate of about 1%
US Policy	- 2002 Farm Bill is extend with provisions held constant through 2018 - 2007 Energy Independence and Security Act mandates for biofuel production. FAPRI assumes mandated levels of cellulosic ethanol are not met due to insufficient supplies and producers are offered a subsidy of $3.00 per gallon minus the wholesale price of gasoline, or $0.25 per gallon, whichever is greater. - Biofuel tax credits are extended when they would otherwise expire. - CRP contracts expire and CRP area falls due to strong crop prices
World Policy	- Continuing implementation of 2003 EU CAP reforms - 2003 EU Renewable Fuels Directive - Argentina's biodiesel mandate - Brazil's biodiesel fuel research program mandates - Canada's biofuels producers incentives - Uruguay Round Agreement on Agriculture are held fixed through 2018. Does not include Doha Round. - EU milk quota increased by 2% in 2008 to meet growing demand.

An important assumption underlying the FAPRI price forecasts is that all countries meet their current biofuels mandates in the future, with the exception of the European Union. These policies are important drivers for the price forecasts for maize, sugarcane, and palm oil. See Table 6.

Table 6: 2008 FAPRI Biofuel Production and Trade Forecasts

Maize

	Ethanol Production (million gallons)		Maize Use (thousand metric tonnes)		Percent of Domestic Maize Production	
	2007	2017	2007	2017	2007	2017
U.S.	8,722	17,963	79,781	132,867	24%	34%
China	429	576	3,100	4,289	2%	3%
Canada	147	671	1,054	4,820	9%	38%
EU	1,217	2,092	489	841	1%	1%

Sugarcane

	Ethanol Production (million gallons)		Sugarcane Use (thousand metric tonnes)		Percent of Domestic Sugarcane Production	
	2007	2017	2007	2017	2007	2017
Brazil	5,227	10,279	225,610	404,063	47%	58%

Palm Oil

	Biodiesel Production (million gallons) 2007	2017
Indonesia	101	110
Malaysia	36	38

Trade in Ethanol

	2008	2013	2017
	(million gallons)		
Net Exporters			
Brazil	1,006	1,847	3,591
China	118	22	23
Net Importers			
Canada	85	214	306
European Union	66	210	329
India	-68	103	214
Japan	211	271	309
South Korea	90	122	143
United States	427	725	2,223
Rest of World	326	380	422
World Net Trade	1,192	1,869	3,615
World Price* (U.S. Dollars per Gallon)	1.41	1.29	1.52

*World price assumed to be equivalent to the anhydrous ethanol price in Brazil

Trade in Biodiesel

	2008	2013	2017
	(million gallons)		
Net Exporters			
Argentina	153	199	251
Brazil	67	85	84
Indonesia	97	103	102
Malaysia	39	37	38
United States	200	108	127
Net Importers			
European Union	389	358	429
Japan	60	65	63
Rest of World	108	109	111
World Net Trade	557	532	602
World Price* (U.S. Dollars per Gallon)	4.82	5.22	6.00

*World price assumed to be equivalent to the Central Europe FOB Price
Source: FARPI 2008 Agricultural Outlook.

While there are distinctions between the assumptions underlying the AEO 2008 High Price Case for energy prices and the 2008 FAPRI/Global Insight Agricultural Outlook, the two forecasts both rely on Global Insight's macroeconomic model of the U.S. Economy. Gross Domestic Product, interest rates, employment, vehicle sales, and housing starts from the Global Insight model are used in the EIA's energy pricing projections. Both forecasts have been adjusted to reflect a 3.3% inflation rate through 2013 and 3.2% from 2013 to 2018.

The oil price assumptions used by FAPRI/Global Insight are $68/barrel in 2013 and $67/barrel in 2018. The EIA high price case oil prices are significantly higher, with $90/barrel in 2013 and $138/barrel in 2018.

Both the FAPRI/Global Insight forecasts and the EIA 2008 WEO take into account policies enacted through the end of 2007, most notably Energy Security and Independence Act that mandates large increases in U.S. biofuels production. Only the FAPRI model, however, accounts for policies enacted in 2008 (through April).

C. Timber

Most pulp used in for packaging in the FMCG industry is derived from softwood species originating in North America and Western Europe. There are many exceptions to this generalization as some hardwood pulp may be used, particularly from rapid growth eucalyptus plantations in Brazil. However for purposes of simplicity we focus on the North American and Western European softwood pulpwood markets.

WRI was not able to obtain price forecasts for pulpwood. The primary source of forest products related forecasts is RISI, a corporate data provider to the industry, however these forecasts are not publicly available. Therefore we hold an average of 2006 North American and European (Finland, Sweden, Germany, Austria) pulpwood prices constant for purposes of constructing a Base Case reference point. The 2006 pulpwood price is $28.25/cubic meter and was obtained from a publicly available RISI report.

We recognize that this approach is not optimal for the numerous reasons. This method does not incorporate expected changes in GDP and population that will drive changes in future demand for wood and fiber resources. Nor does it reflect expected changes in manufacturing capacity as new mills come on line, primarily in developing countries.

Furthermore, 2006 prices are considerably lower than 2008 prices. 2008 prices were high due to a supply demand imbalance that is expected to continue in the near term. Forces behind the supply constraints include: falling wood chip supply in North America due to US housing slowdown, Canadian foresters strike, delays in Indonesian expansions, Chinese capacity closures, Russian log export duties, and the Canadian mountain pine beetle epidemic.[2] However, in the near to medium term, wood and fiber is expected to become more scarce while in the long term supply is expected to increase at least in pace with demand, if not more.[3]

However, this approach still allows us to proceed with the scenario analysis because our results focus on the delta between the Base Case and the Ecoflation scenario. The primary caveat is that timber related commodity prices are the only commodities to just include inflation factors from the Ecoflation scenario and not the underlying Base Case trends discussed above.

[2] DB Research, September 20, 2007. "Global supply shocks and pulp price impacts."
[3] IPCC Fourth Assessment Report, Working Group II, chap. 5.

D. Water

Although water is essential to the production of all the commodities outlined above, reference case water prices are nearly impossible to obtain because water prices exist at a highly regional level, if at all. In general there is not a market for water, with a few exceptions in water scarce regions such as Australia. In addition, water prices usually do not reflect the true value of water as an economic good because water usage is heavily subsidized by governments.

Water subsidies can be found in nearly every single market throughout the world and often are hidden in unexpected ways. Determining the full cost of water requires factoring in many aspects of water that are usually not considered. Most subsidies enable farmers to avoid paying even the energy costs of transporting water. Besides the energy costs, the maintenance of the infrastructure is subsidized; the capital investments to develop the infrastructure are subsidized; the opportunity costs and economic externalities are not effectively priced; and environmental externalities are not included.

Given these issues, the Base Case assumption is that water is obtained at subsidized rates for agricultural and industrial users that are at insignificantly low or no cost.

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3. Ecoflation Scenario

Building upon our proposed Base Case, Ecoflation imagines a future in five and ten years in which growing environmental concerns lead to a set of aggressive yet plausible policies at the international, national, and local levels to protect and sustain natural resources. Acknowledging the need to secure and sustain key resources, the public and private sectors readily embrace environmental policies, and consumers demand environmentally preferable goods and services. Ecoflation represents the view that in the future as natural resources become scarcer and sustainability issues become more pressing, environmental costs will increasingly be borne by those responsible, thus creating an "ecoinflation" that is not currently priced into economic transactions. In other words, our scenario envisions a world in which costs that are currently borne by society are internalized in firms.

Building on the expected macroeconomic and demographic changes predicted under the Base Case, the Ecoflation scenario introduces new public policies to protect natural resources that are likely to affect the supply chains of FMCG companies. In the near and medium terms, these policies initially will result in higher prices for primary commodities. But over the long term, technological innovation, efficiency improvements, changes in consumption patterns and production practices, and climate change adaptation strategies are likely to reduce or retract many of these costs. Furthermore, in the Ecoflation scenario we included changes in the physical climate that were not incorporated in the Base Case's data sources. Note that the price impacts related to changes in physical climate also apply to the Base Case and are likely to become more pronounced without appropriate mitigation policies.

WRI has identified key environmental issues and assumptions to create the Ecoflation scenario, including climate change policy, physical climate change and water scarcity, deforestation, and bioenergy policy. The application of this scenario will result in commodity price changes, or a delta between the Base Case and the Ecoflation scenario prices.

The environmental themes were chosen through consultation with WRI experts and a literature review. The subsequent price impacts on commodities from these themes were determined by a process that includes: (1) Referencing relevant economic and production forecasts from policy analysis and scientific studies where available; (2) extrapolating impacts from relevant historic events; and (3) surveying WRI and A.T. Kearney experts.

See Table 7 for a summary of major themes and price impacts included in the Ecoflation scenario.

Table 7: Summary of Themes and Price Impacts for the Ecoflation Scenario

Theme	Description	Price Impact over Base Case	2013	2018
CLIMATE POLICY	The U.S. implements comprehensive climate change policy, inviting international cooperation and participation on climate regulation, which results in a global price for greenhouse gas (GHG) emissions in most economies, resulting in a global price of carbon in most economies of $30/tonne in 2013 and $50/tonne in 2018. There is no price impact from oil and natural gas used as a raw material, rather than combusted for energy.	Oil	15%	22%
		Natural Gas*	25%	40%
		Coal*	198%	378%
		Electricity**	24%	45%
		* US price forecast **average of US and EU prices		
CLIMATE CHANGE & WATER SCARCITY	Climate changes increase water scarcity in major agricultural regions, leading to higher production costs and declining yields.	Cereals	6%	13%
		Soy	1%	3 %
		Palm Oil	0%	0%
		Sugar	0%	0%
	Extreme climate events occur with greater frequently, causing unpredictable disruptions and price spikes to agricultural commodities.	Not assessed due to the episodic nature of extreme weather events.		
DEFORESTATION	In response to public concerns about deforestation, consumer products companies in the United States and EU voluntarily agree to source all wood and fiber from sustainability-certified forests and to increase the use of recycled fiber for all paper packaging and products.	Wood and Paper Products	7%	13%
	International efforts to reduce deforestation in developing countries will be greatly strengthened, increasing competition for agricultural and forest lands as new incentives and programs limit expansion into tropical forests.	Not assessed due to lack of existing models/studies.		
BIO-ENERGY	By 2013, the major biofuel-consuming countries retreat from existing biofuel mandates and instead apply sustainability requirements to all relevant biofuel government policies.	Not assessed due to lack of existing models/studies.		

A. Climate Change Policy

The U.S. implements comprehensive climate change policy, inviting international cooperation and participation on climate regulation, which results in a global price for greenhouse gas (GHG) emissions in most economies.

> *The 2009 U.S. presidential administration proposes a comprehensive climate change policy framework similar to the 2008 Lieberman–Warner bill that should be approved in 2009 and go into effect by 2013.*[4] *The policy's aggressive targets are to set a substantial price on greenhouse gas emissions and to raise funds (though the auction/sale of allowances) to finance programs and funds for international adaptation to climate change, technology deployment, and forest protection. These important goodwill measures are meant to convince developing countries to take action while at the same time the European Union (EU) and other Organization for Economic Cooperation and Development (OECD) countries continue to establish tough, long-term climate change policy measures that align with or and, in many cases, exceed in stringency, those of the United States. In addition, some countries in the industrialized bubble (Mexico, South Korea) will institute national greenhouse gas reduction targets over the next five years that are comparable in stringency to those of the United States.*
>
> *Importantly, China also takes action to address climate change in this scenario. Although China does not set a cap on greenhouse gas emissions, it does take climate change seriously because of the projected negative physical impacts, and it has enacted strong renewable energy and energy efficiency targets and major technology investments, such as carbon capture and storage (CCS). China also taxes oil, coal, and natural gas, based primarily on energy security concerns, with climate as a complementary concern. This tax is comparable to that in the United States and the EU. Now that China is acting on climate change, some but not all developing countries have followed suit, but using taxes, not cap and trade. As a result, the world's major economies will converge around a global price on a carbon dioxide equivalent of $30/tonne in 2013 and $50/tonne in 2018.*

Although the Lieberman-Warner Bill (S. 2191) was recently rejected by the US Senate, there are reasons to believe it is the most feasible climate change policy to date in the U.S. and that it will be reintroduced under a new administration in 2009.

Several economic studies have modeled the effects of the Lieberman Warner proposal: An analysis from the U.S. Energy Information Administration[5] in response to a request from Congress and a 2007 analysis from the Joint Program of the Science and Policy of Global Change at the Massachusetts Institute of Technology.[6] Under the EIA's analysis, the Core Case represents an environment where key low-

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[4] Also known as the America's Climate Security Act of 2007 (S 2191), this bill would create a national cap-and-trade scheme for greenhouse gas emissions, in which most polluters would be allocated right-to-emit credits based on how much greenhouse gas they currently emit. The cap would tighten over time, until by 2050, emissions would be reduced to 63 percent below 2005 levels.

[5] Energy Information Administration (EIA), "Energy Market and Economic Impacts of S2191, the Lieberman–Warner Climate Security Act of 2007," April 2008.

[6] Sergey Paltsev et al., "Assessment of U.S. Cap-and-Trade Proposals, Appendix D: Analysis of the Cap and Trade Features of the Lieberman–Warner Climate Security Act (S.2191)," MIT Joint Program on the Science and Policy of Global Change, Report 146, 2007.

emissions technologies, including nuclear, fossil with carbon capture and sequestration (CCS), and various renewable energy technologies, are developed and deployed in a timeframe consistent with the emissions reduction requirements without encountering any major obstacles, even with rapidly growing use on a very large scale, and the use of offsets, both domestic and international, is not significantly limited by cost or regulation. Under this scenario, the EIA predicts a carbon price of $22/tonne in 2013 and $39/tonne in 2018. However, in the Limited International Offset scenario, the expected carbon price is $60/tonne in 2013 and $98/tonne in 2018.[7]

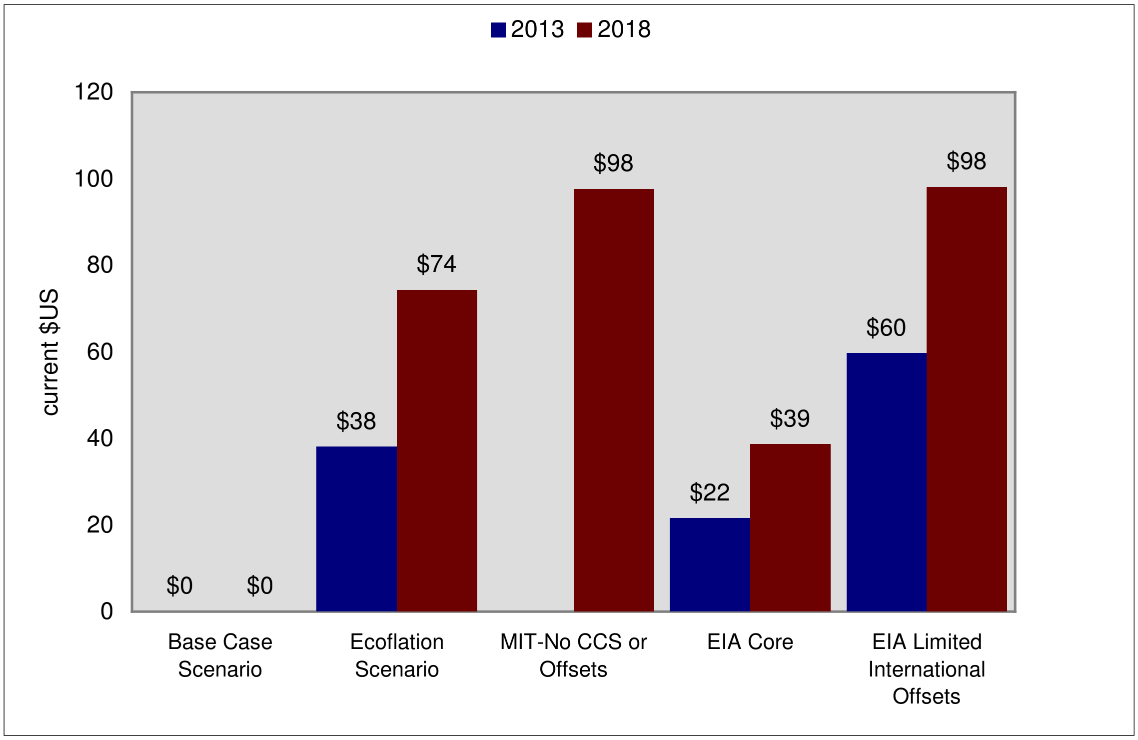
Overall, our Ecoflation scenario price of $30/tonne in 2013 and $50/tonne in 2018 is less than or equal to the carbon prices predicted by the four scenarios of the MIT study and falls between the U.S. Energy Information Administration's scenarios. These models make different assumptions about the role of offsets, among other variables. See Table 8 and Figure 5.

Table 8: Predicted carbon prices under the Warner Lieberman bill

	2006 $ per tonne		**Current Value $ per tonne** (3.3% inflation)	
	2013	2018	2013	2018
MIT – No Offsets or CCS	-	65	-	98
EIA – Core Case	18	27	22	39
EIA – Limited International Offsets	47	66	60	98
WRI/A.T. Kearney – Ecoflation Scenario	30	50	38	74

[7] These values are in current $US and assume 3.3% inflation until 2012 and 3.3% thereafter.

Figure 5: Predicted carbon prices under the Warner Lieberman bill (current $US/tonne)



Source: EIA, *Energy Market and Economic Impacts of S2191, The Lieberman-Warner Climate Security Act of 2007* and Sergey Paltsev et al. *Assessment of U.S. Cap-and-Trade Proposals, Appendix D: Analysis of the Cap and Trade Features of the Lieberman-Warner Climate Security Act (S.2191).*

In the Ecoflation scenario, we calculate energy prices by adding the carbon price directly to the price of oil, coal, and natural gas based on the carbon content of each fuel and assume no demand response. The Base Case price is applied for fossil fuel use as a raw material, as is consistent with the MIT findings but not the EIA. It is important to understand that these prices reflect only first order impacts to fuel prices and do not incorporate changes in demand, efficiency gains, infrastructure costs, substitution effects, and other variables that would ultimately determine the price of oil and electricity. This, combined with more recent energy price projections from the Energy Information Administration (June 2008), means that our oil prices are higher than those predicted by both the EIA and MIT and our electricity prices are lower than all but the EIA's "core" scenario. See Table 9 and Figures 6 and 7.

Table 9: Base Case and *Ecoflation* Scenario Energy Prices

	unit			Base Case		Ecoflation	
		2006	2008	2013	2018	2013	2018
Crude Oil	Barrel	66	90	109	145	125	176
Natural Gas - US Industrial Prices	Mbtu	8	8	9	11	11	15
Steam Coal -US Industrial Prices	Mbtu	2	3	3	4	7	11
Electricity – US	$US per KwH	0.061	0.063	0.065	0.069	0.085	0.107
Electricity-Europe	$US per KwH	0.089	0.091	0.094	0.098	0.111	0.131

Note: Prices assume emissions price added directly to fuel. Base Case prices hold where fossil fuels are used as raw materials and not combusted.

Figure 6: Predicted oil prices under the Warner Lieberman bill (current $US/tonne)

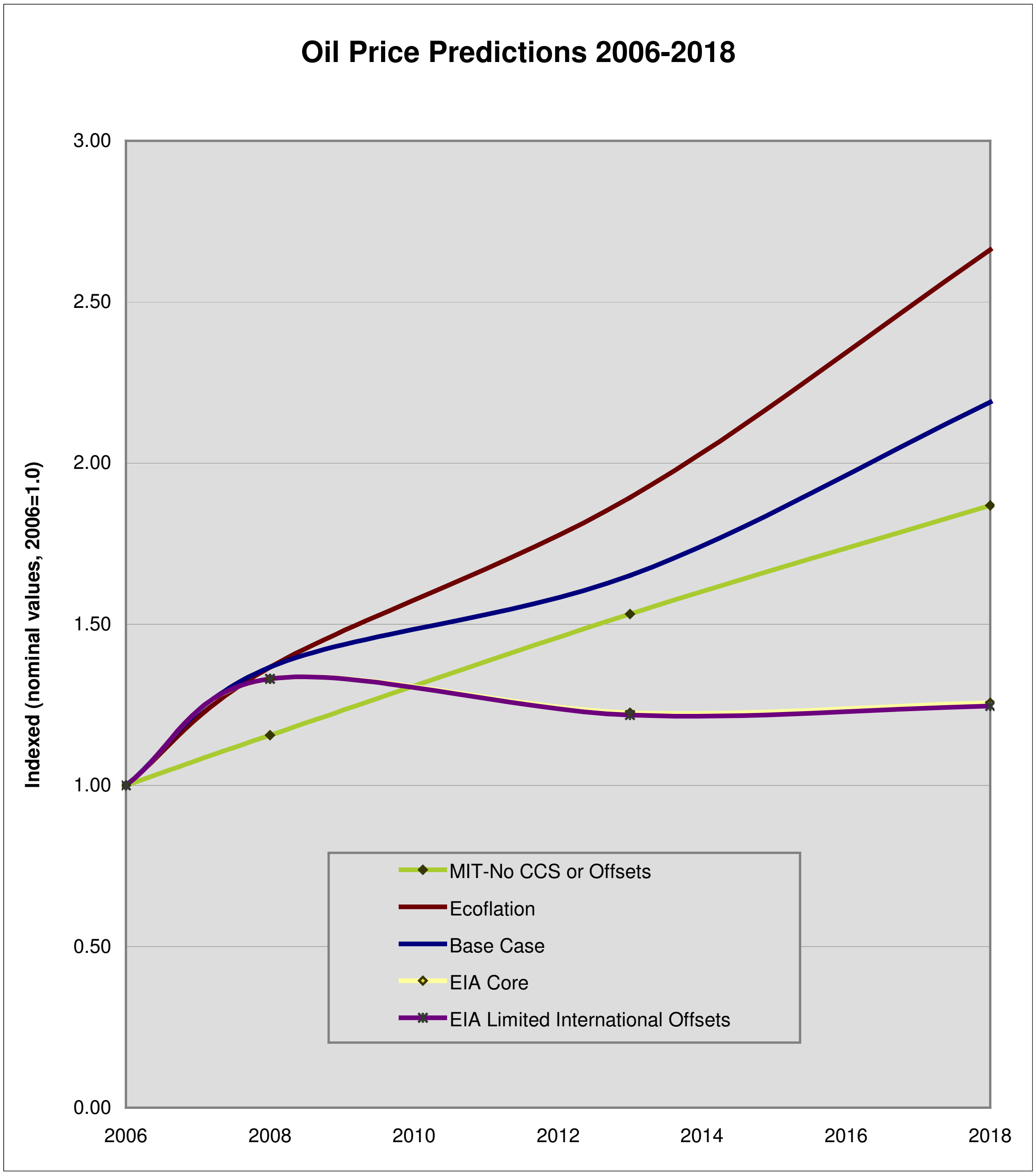
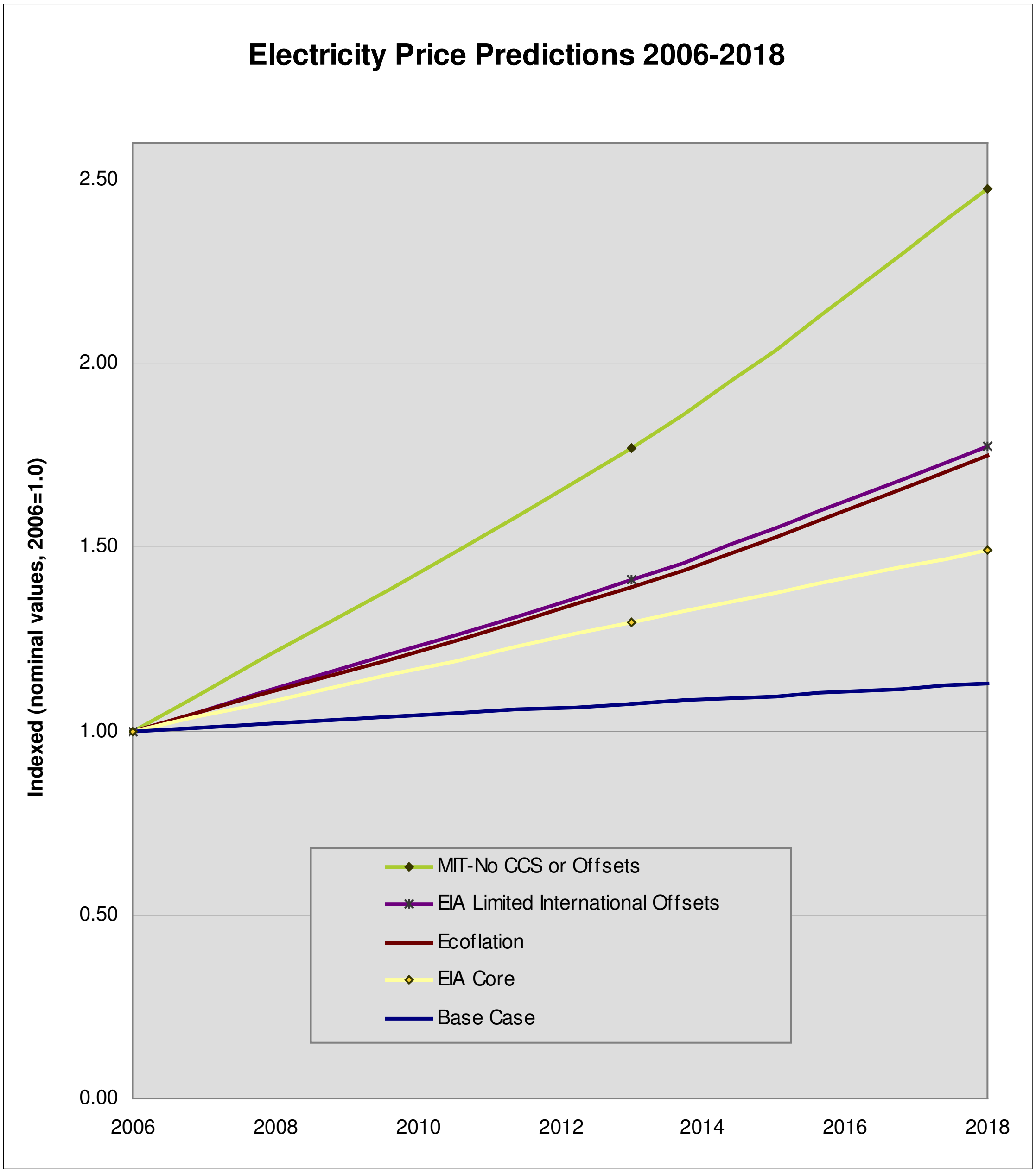


Figure 7: Predicted electricity prices under the Warner Lieberman bill (current $US/tonne)



B. Climate Change and Water Scarcity

Climate change increases water scarcity in key agricultural regions, leading to higher production costs and declining yields.

> *Although climate change mitigation policies are expected to lessen the physical impacts of climate change over the medium and long terms, they will not affect current trends in the near term. Anticipated changes in temperature and precipitation patterns, and the consequential increase in weather variability and uncertainty, will intensify the impacts of water scarcity in some agricultural regions by 2018. As a result, irrigation will be increased to maintain yields, thereby raising the energy costs of production. At the same time, the growing competition for water resources will bring government rollbacks of current subsidies for water in order to encourage conservation and promote more equitable access to water resources.*

The physical effects of climate change will have large overall impacts for major commodities. While increased precipitation worldwide is expected, the rise in temperature will accelerate rates of evaporation and plant transpiration, requiring plants to receive irrigation water more frequently. All these impacts – positive or negative – are highly regional. Overall, climate change is expected to increase the variation of rainfall patterns in the form of both floods and droughts. Irrigation requirements are expected to increase as the atmosphere's water holding capacity also increases. As a result, the atmosphere will take longer periods of time to recharge with moisture, increasing droughts, and will release greater amounts of water when charged, creating more floods. The change in temperature will affect agricultural productivity through yield declines from harsher environmental conditions.

The costs of agricultural production will rise due to increased energy needs to produce water, greater water scarcity, and increased capital investments for irrigation systems. While our scenario focuses on climate change as the primary driver of water scarcity, many forces, as outlined in Table 10, will combine to influence water supply at the local level.

Table 10: Major Drivers Affecting Water Supply for Agriculture

Climate Change	- The variability of overall plant productivity will increase. - The variability of weather patterns will increase, resulting in more droughts and intense rainfall periods. - Irrigation requirements will increase as 55% of current production is rain fed.[8]
Population	- Population is expected to grow from 6.7 billion in 2008 to 7.5 billion in 2018, primarily in developing countries, where water scarcity factors are prevalent. - Population growth will create pressure for increased agricultural productivity, likely resulting in ever-greater rates of water withdrawals, as water use has historically increased twice as fast as population growth.[9] - Agriculture will compete with industry and individuals for water sources and will likely increase costs to users and create incentives to increase efficiency.
Consumption	- Economic growth in developing countries, especially China and India, will result in changes in consumer preferences for increased meat, fruits and vegetables. Especially with meat, these preferences will increase water demand due to the high virtual water content of these products.[10]
Groundwater Levels	- Increased weather variability and increased water withdrawals can lead to unsustainable consumption of ground and surface water. - The decline in rainfall (or its concentration in shorter periods of time, interspersed by droughts) may decrease the moisture content of the soil, requiring greater irrigation and further declines in water table levels. - As water tables drop, the cost of pumping will increase due to distance required to move water more vertical feet.

The approach relies on cost structure data for US agriculture that is applied globally.[11] While this assumption is clearly not accurate in many regions, it was necessary due to the lack of regional cost data for agriculture.

This cost structure was broken down first into surface water irrigation and groundwater irrigation. The two types of irrigation sources differ significantly in their respective prices structures, with groundwater irrigation consuming nearly twice as much energy as surface water irrigation due to vertical pumping. These price structures were then used for calculating the costs for each crop in each major country of production using data on the number of hectares currently under production.[12] Specifically, the country specific production data was multiplied by the percent of that crop that is irrigated,[13] the percent of all crops that are irrigated by surface or ground water,[14] the percent of irrigation that requires energy inputs,[15] and the corresponding irrigation price structure.

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[8] Comprehensive Assessment of Water Management in Agriculture, *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London: Earthscan, and Colombo: International Water Management Institute, 2007).

[9] Revenga, C., J. Brunner, et al. 2000. Pilot Analysis of Global Ecosystems (PAGE): Freshwater Systems. Washingtonne, DC: WRI. Available at www.wri.org/wr2000/freshwater_page.html

[10] JPMorgan (2008). Watching Water. *Global Equity Research.* April 2008.

[11] Gollehon, N. & Quinby, W. (2006) Irrigation Resources and Water Costs. Agricultural Resources and Environmental Indicators, Economic Research Service/USDA. EIB - 16

[12] FAOstat.

[13] Aquastat. If crop specific data could not be obtained, we assumed the crop is represented by general crop data.

[14] Aquastat. If that data could not be obtained for a specific country, we took an average of all countries and assumed that number was representative.

William Cline's research was used to calculate the increase in irrigation requirements as a result of increased temperature and precipitation changes by country. Cline's formula ($Z = 24.1 + 3.73T - .0455P$; adj. $R^2 = .21$) determines the expected quantity of water required for irrigation under climate change conditions by 2070. A straight-line regression was used to determine the results for 2018. This number was then multiplied by surface or ground water costs according to the USDA as well as the number of hectares under production in each country (as discussed above). This approach identified only the increased cost of irrigation as a result of climate change. This approach is somewhat conservative, as it does not include establishing irrigation where it currently does *not* exist.

We do, however, use a "water scarcity" variable to approximate the likely rise in water prices owing to the growing competition when the scarcity increases. Under this assumption, agricultural users are required to pay a value that is closer to the full economic costs of water, including a greater portion of operation and maintenance (O&M) costs, pumping costs, capital costs, opportunity costs, and environmental costs and externalities. Although this factor is highly variable, we used a value of 50-fold because it reflects the O&M costs in the lowest-cost scenario presented in a study demonstrating the overall costs of water. [16] Farmers seldom pay the full cost of O&M in many OECD countries, and irrigators even less often repay the capital costs associated with developing irrigation schemes.[17] Because of the low recovery rates of O&M and capital costs, a factor of 50 is somewhat conservative, therefore, especially when considered with opportunity costs and environmental costs, which make up a greater proportion of the cost of water than O&M and capital costs do.[18]

With water prices so low, even a 50-fold increase would not really be "dramatic" in terms of total delivered costs (TDC). So yes, prices will go up—partly because subsidies will go down—but the inflationary impact itself will be relatively minor. See Table 11.

Table 11: Base Case and Ecoflation Scenario Prices by Commodity, 2013 and 2018, in US$/metric tonne

			Base Case		Ecoflation Scenario		Ecoflation % change over Base Case	
	2006	2008	2013	2018	2013	2018	2013	2018
Cereal	144	260	230	236	242	264	6%	12.6 %
Soy	235	443	432	437	438	449	1.4%	2.8%
Palm Oil	452	1,046	1,110	1,319	1,112	1,324	0.1%	0.4%
Sugar	423	358	390	399	390	400	0.1%	0.4%

[15] Aquastat. If that data could not be obtained for a specific country, we took an average of all countries and assumed that number was representative.
[16] P. Rogers, A. Bhatia, and A. Huber, "Water as a Social and Economic Good: How to Put the Principle into Practice," (Stockholm: Global Water Partnership, 1996).
[17] OECD, "The Price of Water: Trends in OECD Countries" (Paris: OECD, 1999).
[18] Rogers et al., "Water as a Social and Economic Good."

C. Deforestation

In response to public concerns about deforestation, consumer products companies in the United States and EU voluntarily agree to source all wood and fiber from sustainability-certified forests and to increase the use of recycled fiber for all paper packaging and products.

> *The success of efforts such as the Lacey Act in the United States, as well as environmental nongovernmental organization (NGO) campaigns for forest protection, have led major consumer products manufacturers to agree voluntarily to increase the use of fiber certified to come from sustainably managed forests and postconsumer recycled content.*[19] *By 2018, all paper packaging in the FMCG sector will be either certified by a major certification scheme or contain at least 80 percent postconsumer content.*

The majority of timber utilized by the industry is softwood pulpwood for packaging and labels, with a small percent of solid wood used for shipping. Currently, pulp production is heavily concentrated in industrialized nations, with 70% of the global wood pulp production coming from temperate countries in North America and Western Europe.[20] Illegal logging is not a significant issue in fiber sourcing from North America and Europe, thereby limiting this aspect of sustainability issues in the short term.

By 2018, global demand for paper and paperboard is expected to surpass 450 million tonnes;[21] greater percentage of pulp production is expected to shift from the US and Europe to emerging countries, particularly Brazil, China and Russia:

- *Brazil:* Pulp plantations in Brazil cover 1,700,000 ha; the majority are eucalyptus plantations that, in some cases can be harvested in six to seven years thanks to development of silvicultural techniques, plant genetics and seed improvement. The Brazilian forest products industry plans to invest US$14 billions for pulp and paper processing that would increase capacity to process 14.5 million tons per year by 2012.[22,23] Despite some concerns about a possible deficit in wood availability to feed the pulp processing sector based on a slowdown in the rate of new plantings due to competition for land with the agricultural sector, it is considered that the potential of Brazil as a fiber base remains huge. [24]

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[19] In May 2008, an amendment to the Lacey Act was enacted by the U.S. Congress to require all goods imported into the United States that contained any plant content to declare the species and origin of the plant, in order to ensure its legality.
[20] Seneca Creek Associates, LLC, and Wood Resources International, LLC, “Wood for Paper: Fiber Sourcing in the Global Pulp and Paper Industry,” paper prepared for the American Forest and Paper Association, 2007, available at http://www.afandpa.org/temp/AFPAFiberSourcingPape12-07.pdf (8/22/08).
[21] Kuusisto, I. 2004. Trends and developments in the Chinese pulp and paper industry. Presentation at the International forum on investment and finance in China’s forestry sector. Jaakko Poyry Consultants. Available online at http://www.forest-trends.org/documents/meetings/Beijing_2004_sept/Ilkka%20Kuusisto%5B1%5D.ppt (7/22/08).
[22] Brazilian Pulp and Paper Association (Bracelpa), “Brazilian Pulp and Paper Industry: Industry Overview,” 2008, available at http://www.bracelpa.org.br/eng/estatisticas/pdf/booklet/Booklet%20Coletiva%20-%20Dezembro%202007%20Ingl%C3%AAs.pdf (7/22/08)
[23] PriceWaterhouseCoopers, “Risks and Rewards: Forest, Paper and Packaging in South America,” 2007, available at http://www.pwc.com/Extweb/onlineforms.nsf/docid/CA1F9C0804C4CA348525730D007BC094?opendocument
[24] Ibid.

- *China*: China's government is promoting the development of wood pulp industry fed by fast-growing plantations. Between 2007 and 2008 China is setting up capacity to process 11 million tons (little less than Finland's wood processing capacity) for paper and paper board, and it is targeting to establish 5.9 million hectares of pulpwood plantations by 2015.[25,26] There are some concerns, however, that pulp supply from plantations in some areas of China may not be competitive with Indonesian and Brazilian imports because of higher costs associated with limited availability of suitable lands.[27]
- *Russia*: pulp production increased by almost 20% between 2000 and 2005; substantial investments have been made in recent years mostly to bring effective capacity closer to design capacity. Government and the private sector have been promoting more investments to increase capacity and projects to invest in building a number of pulp mills have been announced; if these projects come to fruition, there will be a huge increase in current processing capacity.[28]

Other countries such as Indonesia and Chile may emerge as major pulp producers as well given money is currently being invested in processing capacity. Developing countries are emerging key players in the global pulp market and will attract the attention of U.S. and European consumers to illegal logging, particularly in Russia and China.

Illegal logging is believed to suppress global timber prices, as it is obviously less expensive to produce than is sustainably managed timber.[29] Models suggest that a reduction in illegal logging would result in an increase of solid wood prices by 7 and 16 percent on a global average.[30] In the extreme case of Indonesia, where illegal logging supplies a large portion of the raw materials for pulp production, pulp prices increased by 25 percent from 2007 to 2008 as the government has cracked down on illegal logging.[31] Overall, pulp production in Indonesia is expected to be down by 75 percent for 2008.[32]

In response to illegal logging, in the Ecoflation scenario nearly all paper packaging in the FMCG sector becomes sustainably certified or contains at least 80 percent postconsumer fiber. The impacts on pulp prices from certification are likely to be small, as many materials certified by the Forest Stewardship Council (FSC) currently sell for the same price as non-FSC products. Although the costs of certification vary greatly by scale, region, and forest, one estimate for forests in North America is that FSC-certified softwoods cost 2 to 3 percent more to produce and that FSC-certified hardwoods are generally

[25] Kuusisto, I. 2004. Trends and developments in the Chinese pulp and paper industry. Presentation at the International forum on investment and finance in China's forestry sector. Jaakko Poyry Consultants. Available online at http://www.forest-trends.org/documents/meetings/Beijing_2004_sept/Ilkka%20Kuusisto%5B1%5D.ppt (7/22/08).

[26] C. Barr and C. Cossalter, "How Competitive is Wood Pulp Production in South China?" CIFOR, 2004, presentation at the meeting China and the Global Forest Products and Trade: Strengthening Production and Policy, available at http://www.forest-trends.org/resources/meetings.htm#B32006

[27] Ibid.

[28] PriceWaterhouseCoopers. 2006. Risks and rewards: forest, paper and packaging in Russia. PriceWaterHouseCoopers. Available online at http://www.pwc.com/Extweb/industry.nsf/docid/8044514ABA5FEDE78025712200647AB6 (7/22/08).

[29] Seneca Creek Associates, LLC, and Wood Resources International, LLC, "Wood for Paper: Fiber Sourcing in the Global Pulp and Paper Industry," paper prepared for the American Forest and Paper Association, 2007, available at http://www.afandpa.org/temp/AFPAFiberSourcingPape12-07.pdf (8/22/08).

[30] Ibid.

[31] Wood Resources International, "Wood Fiber Shortage Reduces Pulp Production in Indonesia in the 4Q," April 3, 2008.

[32] Ibid.

comparable in price to their noncertified counterparts.[33] But this cost is likely to increase in the future as demand drives new forests to become certified, many of which will likely be more expensive to certify if lower-cost options have already been certified. As a result, in our scenario we assume an increase from 2 to 5 percent in softwood pulpwood costs for certified packaging and labels.

Prices for packaging paper made from recovered fiber vary. The manufacturing costs using recovered fibers include several elements such as the availability of used paper; the costs of collecting, sorting, and transporting the paper; and the technical capacities of the manufacturing mills.[34] Although the price of recovered fibers has fallen sharply over the past decade, price premiums in North America, for example, vary from 7 to 10 percent for different paper grades.[35] The makers of corrugated boxes, at least in the United States, do not, however, charge a price premium for recycled content.[36] We therefore assume no price impact from greater recycled content.

Changes in energy prices, especially electricity, will have a significant impact on pulp and packaging prices. On average, electricity represents up to 20 percent of pulp production costs, but the energy consumption for recovered fiber is much higher, at 33 percent. The Ecoflation scenario determines the combined impact of a slight increase in pulp prices and electricity prices based on climate policy to bring a 7 percent increase in wood and paper product prices in 2013 and nearly 13 percent by 2018. See Table 12 for more details.

[33] M. Ohrenschall, “GREEN: Sustainably Managed Forest Products,” *Builder News Magazine*, April.
[34] Paper Task Force, “Recommendations for Purchasing and Using Environmentally Preferable Paper,” Environmental Defense Fund, 1995.
[35] Environmental Paper Network, Caledonian Shanks Centre for Waste Management, 2000.
[36] Paper Task Force, “Recommendations for Purchasing and Using Environmentally Preferable Paper,” Environmental Defense Fund, 1995.

Table 12: Major Assumptions Underlying Ecoflation Price Impacts for Timber Resources

Geographic	We assume 50% of pulp production is in the US and 50% in Europe to simplify the analysis.		
Cost Structure	**Cost Inputs**	**Timber/Fiber**	**Energy**
	Wood	60%	4%
	Recovered Fiber	Varies - not included in our analysis	33%
	Wood Pulp	50%	20%
Price Inflators	**Price Inflators**	**2013**	**2018**
	Wood	5%	5%
	Recovered Fiber	0%	0%
	Wood Pulp	5%	5%
	Electricity Prices	24%	45%
Timber Use Assumptions	Virgin Fiber		45%
	Recovered Fiber		50%
	Wood		5%
Final Price Impacts	**Price Impact**	**2013**	**2018**
	Solid Wood	4.0%	4.8%
	Recovered Fiber	7.9%	14.7%
	Virgin Pulp	7.3%	11.4%

Pulp manufacturing also requires large amounts of water and may be exposed to water supply and quality issues resulting from physical climate changes. But because this risk is specific to manufacturing location, we do not address it in the analysis.

4. Bioenergy Policy

By 2013, the major biofuel-consuming countries retreat from existing biofuel mandates and instead apply sustainability requirements to all relevant biofuel government policies.

> *Soaring food prices and environmental concerns have recently generated a backlash against biofuel policies, particularly in the United States and EU. The dialogue concerning the "sustainability" of global biofuel production thus will be strengthened and influence future policy conversations about renewable fuels. By 2013, these concerns will escalate and force a retreat from existing production and consumption mandates.*

For the first time in decades, agricultural commodity markets could experience a sustained increase in prices, driven in part by rapidly growing biofuels production. The magnitude of such price impacts will be determined by the quantity of biofuels produced and the types of feedstocks utilized, which are in turn dictated by government policies, fossil fuel prices, and available technologies.

Climate change and high crude oil prices are among several environmental, economic and geo-political factors that have recently inspired developed and developing countries alike to explore renewable alternatives to fossil fuels, particularly in the transport sector. Within the past decade, the US, EU, Canada, Brazil, India, China and others have adopted mandates for domestic biofuel consumption, either as an absolute quantity or fuel mix percentage. See Table 13 for an overview of these government supports.

Table 13: Biofuel Policies in the U.S., E.U., Brazil, Argentina, and Canada

U.S.	Energy Independence and Security Act of 2007	• *Conventional* (maize-based) ethanol target of 15 billion gallons by 2018 • *Advanced* (cellulosic, sugar-based, biodiesel) ethanol target of 11 billion gallons by 2018
	Tax Incentives & Tariffs	• *Ethanol Tax Credit* of \$0.51 per gallon • *Ethanol Specific Tariff* of \$0.54 per gallon
EU	Renewable Fuels Directive of 2003	Guideline of 5.75% share of biofuels in transport fuel use by 2010, 10% by 2020
Brazil	Biodiesel blending mandate	5% biodiesel blend mandate by 2010 and tax incentives for production
Argentina	Biodiesel blending mandate	5% biodiesel blend mandate by 2010
Canada	Renewable Fuels Strategy	Regulate a 5% renewable content in transport fuel by 2010
	ecoENERGY for Biofuels Program	\$1.5 billion over nine years to support biofuel production, including producer incentives.

Source: *FAPRI 2008 U.S. and World Agriculture Outlook*

Until recently, one of the EU's primary arguments for expanding the production of biofuels has been the mitigation of climate change. That is, when crops grow, they absorb carbon dioxide from the atmosphere, thus canceling out any greenhouse gas emissions that result from burning biofuels. However, planting, fertilizing, and harvesting the crop, as well as fermentation, distillation, and transportation, require machinery that uses fossil fuels. See Table 4 for a comparison of GHG emissions reductions over gasoline.

Table 14: Estimated GHG Emissions Reductions Relative to Gasoline

	% GHG Reductions
Maize ethanol	13-52%
Soybean biodiesel	41%
Brazilian sugarcane ethanol	100%
Oil palm biodiesel	~100%

Note: Excludes emissions from land use change
Source: Naylor, R.L., A.J. Liska, M.B. Burke, W.P.Falcon, J.C. Gaskell, S.D. Rozelle, and K.G. Cassman. 2007. "The Ripple Effect: Biofuels, Food Security, and the Environment." *Environment* Vol. 49(9): 30-43.

Importantly, recent research suggests that if emissions from land use change were included in the analysis, greenhouse gas emissions savings could be significantly lower or even negative, particularly for feedstocks grown in countries with a high risk of deforestation, such as palm oil in Indonesia and soybeans in Brazil.[37] Moreover, the potential land appetite of the world's 800 million car owners is vast: it would require roughly one-third of U.S. land to replace only 10 percent of U.S. transport fuel consumption with biofuels.[38]

There also is great concern about the impacts on food prices of diverting potential food and feed crops to biofuel production. Although the relative contribution of the greater demand for biofuels to current food price inflation is uncertain, the world's skyrocketing food prices—up almost 50 percent since last year—have triggered riots across the developing world. At an increased risk of malnutrition are the more than 800 million food-insecure people who live on less than $1 per day and an additional 2 billion to 2.5 billion people living on $1 to $2 per day.[39] On average, poor households spend between 60 to 80 percent of their income on food, compared with only 10 to 20 percent for people living in most of the industrialized countries.

At this point it is not clear what a "sustainable" biofuels policy would look like. The Roundtable on Sustainable Biofuels (RSB) is an international initiative bringing together farmers, companies, non-governmental organizations, experts, governments, and inter-governmental agencies concerned with ensuring the sustainability of biofuels production and processing. It has organized its commitment into a set of highly aspirational principles, criteria and indicators focusing on social, environmental and economic sustainability issues such as:

- Sustainable agriculture – promoting conservation of soil, air and water resources
- Climate change – ensuring consistent and significant reduction in greenhouse gas (GHG) emissions
- Social justice – encouraging active stakeholder engagement and rural and social development
- Food security – minimizing conflicts between biofuels production and nutritional needs

Second generation biofuels are considered to potentially be more sustainable than current ethanol and biodiesel options, at least from the social perspective because they are not derived from food feedstocks.

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[37] T. Searchinger et al., "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-Use Change," *Science* 319(5867):1238–40.
[38] M. Von Lampe, *Agricultural Market Impacts of Future Growth in the Production of Biofuels* (Paris: Working Party on Agricultural Policies and Markets, AGR/CA/APM(2005)24/FINAL, Committee on Agriculture, OECD, 2006).
[39] Naylor et al., "The Ripple Effect,"30–43.

Yet there are many uncertainties around cellulosic and other second generation biofuel development. See Box A.

Box A: Cellulosic Biofuels Potential

So-called "second generation" biofuels from ligno-cellulosic biomass is made from a wide variety of plant materials, including wood wastes, crop residues and grasses, some of which can be grown on marginal lands not suitable for food production. The process for converting these to fuel is often more efficient because plant material rather than fossil fuels can be used to provide heat and power. As a result, cellulosic ethanol has an energy yield at least four to six times the energy expended during production and can reduce greenhouse gas emissions by 65-110 percent relative to gasoline. A 2005 study by the U.S. Departments of Energy and Agriculture estimated that cellulosic ethanol could displace 30 percent of the nation's transportation fuel needs without impacting food harvests.

However, generating cellulosic ethanol remains technically complex and commercially unprofitable. Bringing the price down to competitive levels will require significant investment and, in some cases, additional research and development; it remains unclear how long this will take. Even then, some cellulosic feedstocks may cause environmental problems, depending on how they are grown, processed, transported and used.

Most major economies currently have in place biofuel policies that are driving ethanol and biodiesel production, as well as contributing to higher prices for corn, soy, sugar, and palm oil feedstocks. Current soaring food prices have led to debate on this subject, resulting in a wide range of estimations of price impacts from biofuels on agricultural commodities. For example, the U.S. Department of Agriculture determined that biofuel production was responsible for only 2 to 3 percent of the increase in global food prices, but other agricultural research organizations put this figure closer to 30 percent for grain prices.[40]

In a scenario where the world gets tough on environmental issures, we envision that the principles developed by the Roundtable on Sustainable Biofuels are integrated into all relevant government policies, resulting in the clarification and/or revision of existing biofuels mandates. Impacts at the country or crop level will vary depending on the particular environmental and/or social issues of concern. Overall, we anticipate a net impact of reducing demand and production of biofuels relative to the reference scenario, which would drive down relevant agricultural commodity prices. See Table 15 for a list of major studies that predict the price impacts of biofuel policy on agricultural commodities.

[40] M. W. Rosengrant, *Biofuel and Grain Prices: Impacts and Policy Responses: Testimony before the U.S. Senate Committee on Homeland Security and Governmental Affairs*, May 7, 2008; available at http://www.ifpri.org/pubs/testimony/Rosegrant20080507.asp.

Table 15: Predictions of Price Changes under Various Biofuels-related Scenarios

Source	Scenario	Projected Price Increase
M.W. Rosegrant, S. Msangi, T.Sulser, and R.Vamonte-Santos, *Biofuels and the Global Food Balance* (Washingtonne, DC: International Food Policy Research Institute, 2006).	4% U.S. gasoline replacement by biofuels, 20% elsewhere, up to 58% in Brazil; no technology improvement, projected to 2020.	Corn: 41% Wheat: 30% Soy (oilseeds): 76% Sugar (sugarcane): 66%
	Same as above, but with cellulosic technology online by 2015, and crop productivity improvements	Corn: 23% Wheat: 16% Soy (oilseeds): 43% Sugar (sugarcane): 43%
M. Von Lampe, *Agricultural Market Impacts of Future Growth in the Production of Biofuels* (Paris: Working Party on Agricultural Policies and Markets, AGR/CA/APM(2005)24/FINAL, Committee on Agriculture, OECD, 2004).	Constant $60 per barrel price of oil, projected to 2014	Corn: 19% Wheat: 17% Soy (oilseeds): 19% Sugar: 20% Vegetable oil: 22.3%
	"Growth in line with publicly stated goals."	Corn: 2.5% Wheat: 4.4% Soy (oilseeds): 1.1% Sugar: 4% Vegetable oil: 12.9%
U.S. Department of Agriculture, Agricultural Baseline Projections: U.S. Crops, 2007-2016, http://www.ers.usda.gov/Briefing/Baseline/crops.htm	12 billion gallons of ethanol, 700 million gallons of biodiesel in the U.S., projected to 2016	Corn: 65% Wheat: 33% Soy: 19% Sugar: -8%
FAPRI, *Baseline Update for U.S. Agricultural Markets* (Columbia, MO: University of Missouri, FAPRI-UMC Report #12-06 2006).	6.6 billion gallons ethanol in Brazil, 0.8 billion gallons ethanol in EU, 8 billion gallons in U.S.; 4.9 mmt rapeseed oil in EU, projected to 2015-2016, relative to today	Corn: 30% Wheat: 11% Soy: 2% Sugar: 21% Palm oil: 17%

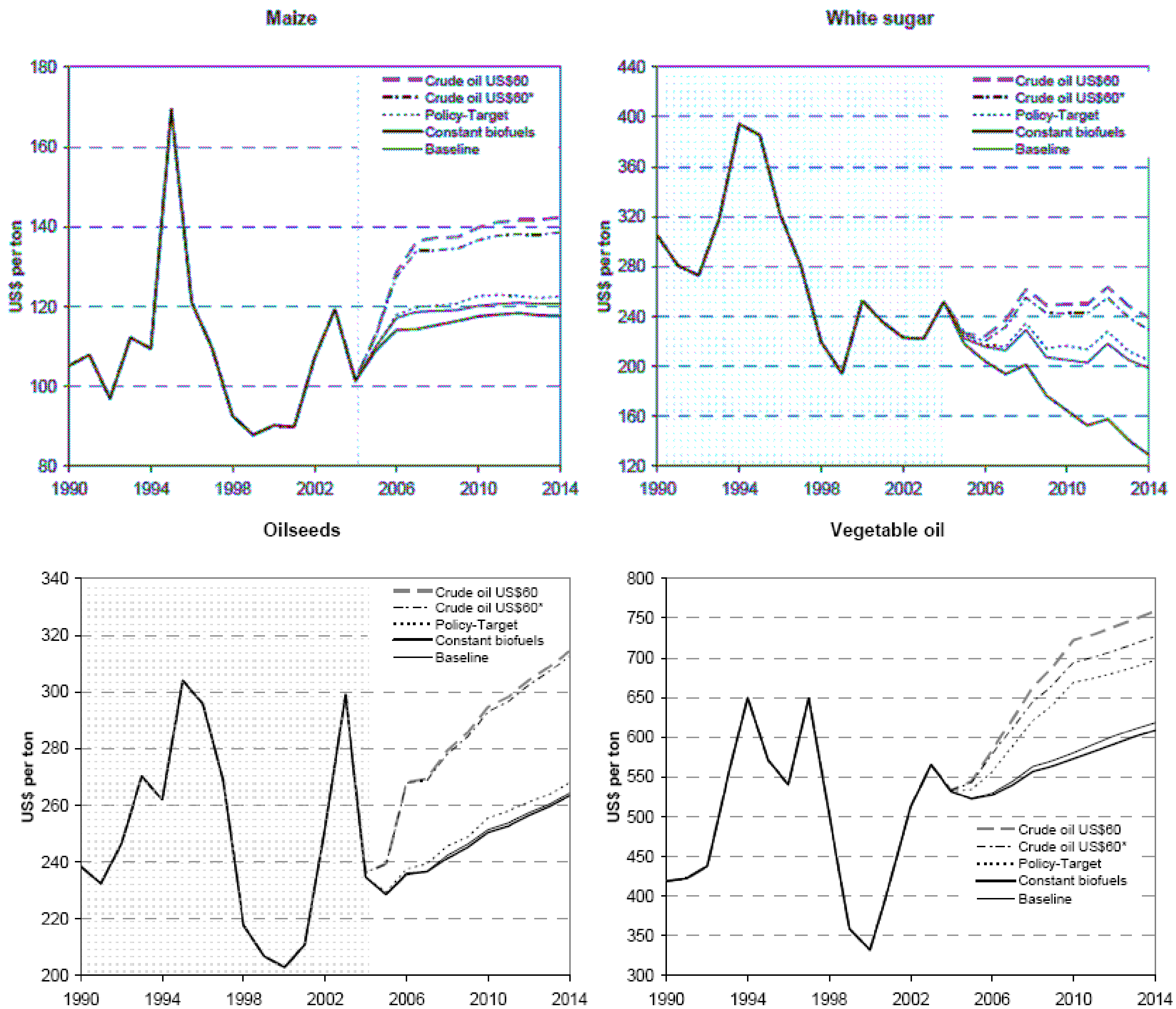
Historically, biofuel production has been driven by policy support; however, because ethanol and biodiesel offer substitutes for gasoline and diesel, higher oil prices may drive market demand. The relationship between oil prices and biofuel supply and demand is largely determined by indirect effects on the cost of biofuel production (via the energy input costs of agricultural production) and direct impacts on biofuel demand. In June 2008, a study was released showing that the impacts of higher oil prices on biofuel demand and subsequent commodity price changes in the United States were roughly equivalent to the price impacts of current biofuel policies.[41] But it is unlikely that high oil prices could increase biofuel production much beyond existing policy targets, owing to supply constraints on land availability and yield potential.[42]

A 2004 study by the OECD Working Party on Agricultural Policies and Markets forecast agricultural commodity prices between 2004 and 2014 using several scenarios, including a baseline oil price scenario of $35 per gallon and a high oil price scenario of $60 per gallon.[43] The resulting commodity price graphs

[41] Food and Agricultural Policy Research Institute (FAPRI), "Biofuels: Impact of Selected Farm Bill Provisions and Other Biofuel Policy Options," FAPRI-MU Report 06-08.
[42] Naylor et al., "The Ripple Effect," 30–43.
[43] M. Von Lampe, *Agricultural Market Impacts of Future Growth in the Production of Biofuels* (Paris: Working Party on Agricultural Policies and Markets, AGR/CA/APM(2005)24/FINAL, Committee on Agriculture, OECD, 2004).

below demonstrate that oil price impacts via biofuel demand are relatively insignificant at these low oil prices. See Figure 8.

Figure 8: Predictions of Price Changes under Various Biofuels-related Scenarios, OECD 2004



"Crude oil US$60*" denotes a scenario assuming higher crude oil prices, but unchanged petrol-based fuel prices – and hence unchanged biofuel prices – relative to the policy-target scenario.

We anticipate that a higher world oil price will increase demand for biofuels, more or less negating the reduction in demand that resulted from relaxing biofuel mandates. It is unlikely that oil prices could increase biofuel production much beyond existing policy targets due to short-term supply constraints. Therefore we assume the aggregate price impacts to be negligible as the removal of existing biofuels mandates will balance higher oil prices reflecting carbon emission prices.