# Food Production and Energy:

# How Will High Gas Prices Affect the North Carolina Food Supply?

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## ABSTRACT


KYUNG BOK CHO. Food Production and Energy: How Will High Gas Prices Affect the North Carolina Food Supply?
(Under the direction of Cathy Packer)

The modern food production industry depends heavily on fossil fuels at all steps of the process to make food cheap, abundant and available. But prices for oil, natural gas and coal have been edging upward for the past few years. The continuous increase in energy prices has raised production costs across the industry, and businesses have begun to pass on the costs to the consumer. Some experts say that the food industry's reliance on cheap fossil fuels could eventually cripple the system. This series of articles examines the effect of higher energy prices on farming, processing, distribution, restaurants, retail and the purchasing decisions of consumers. It finds that individual farmers are the hardest hit so far and that it may be too early to say with certainly what will happen to the average consumer. Meanwhile, efforts are being made to lessen the reliance on fossil fuels by developing alternative energy sources.

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Even from halfway across the world, my family has always built me up when I was down and deflated me when I was cocky. These past two years were an opportunity to think about what family means to me, and I will emerge from this experience with a newfound appreciation for it.

Coming to the University of North Carolina for graduate school was one of the best decisions I ever made. I would like to express my gratitude to the teachers and friends who made it such a fascinating ride.

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## A. Introduction

The average American is acutely aware of how much gas it takes to fill up the car. He knows much less about how much fuel goes into filling his stomach. In modern America, with its energy-intensive, high-yield food production system, it takes 400 gallons of fossil fuels a year to grow, process, distribute and prepare food for one person. (The average car in the country burns up about 600 gallons of gasoline annually.) “Eating oil” or “eating fossil fuels” is how several authors have described America’s dependence on fossil fuels for its abundant food supply.

The cost of fossil fuels has hit its highest point since the Oil Shocks of the 1970s. According to the federal Energy Information Agency, the average retail price of gasoline on March 20 was $2.50 per gallon, a 40-cent, 18.7-percent increase from the previous year. Even before hurricanes Katrina and Rita hit the Gulf Coast last summer, the price of crude oil had been edging upward; prices rose every week for the first nine months of 2005. Though crude has dropped from its post-Katrina high of $70 per barrel, it has remained at more than $60 since the beginning of the year. The agency announced in January that gas prices were likely to rise every month for the first half of 2006.

Food producers said that higher energy expenses stung them hard after the hurricanes, but that there had been mounting pressure from rising fuel costs long before that. Vegetable farmer Gary Wise of Mount Olive, N.C., will be halving his acreage of bell peppers and squash this year because of production costs. Such crops are grown on black plastic with liquid fertilizer, both fossil fuel-derived products, and prices for both have gone up 40 percent, he said. The price of diesel for running farm machinery has jumped to about $2.40 per gallon, a $1 increase during the year, said Bob Strayhorn, an Orange County, N.C., cattle farmer. Many farmers worried about the 30- to 40-percent increases in the cost of nitrogen fertilizer, which is made with natural gas, while some greenhouse growers actually opted not to grow anything during the coldest months because of heating costs.

The off-farm part of the food industry actually uses more energy than farming, studies show. Food processors use large amounts of electricity to run their machines, while food distributors operate vast fleets of diesel-powered trucks to move food from sea to shining sea. Restaurants have the highest energy consumption per square foot among commercial buildings, according to the industry, while retailers must deal with the electricity costs of lighting and refrigeration.

Cost increases at the production level usually take time to hit consumers' wallets, but the average American may begin to feel the pressure sometime in the near future. Wise has raised the price of some vegetables by 25 cents a pound at his stall at the State Farmers Market in Raleigh. "Americans are going to have to start paying more for food," he said. Energy prices trickled down the food chain to hit the That Coffee Place, a Chapel Hill, N.C., café, that earlier this year announced an 8-percent price hike because of the increased cost of coffee and "everything else that is transported by truck."

Scholars who have researched energy use in food production agree that it was fossil fuels such as oil and natural gas that enabled humans to produce enough food for a global population that ballooned from less than 2 billion to more than 6 billion during the last century. But predictions differ greatly on how food production will be affected once those fossil fuels become more expensive and scarcer. In 1983, economists Sandra S. Batie and Robert G. Healy were guardedly optimistic about the nation's ability to continue producing cheap and abundant food. But agricultural scientists David and Marcia Pimentel wrote in 1996 that the current system is unsustainable for its dependence on nonrenewable energy. They called for a more efficient food production system and the voluntary reduction of the world population to one-third its current level.

Several authors expect locally grown food to gain prominence as transportation costs climb, and some suggest a vegetable-oriented diet as a way to save on the energy expenses of making food. But the U.S. Department of Agriculture said in a February report that food prices would rise at a slower pace than the general inflation rate, and free-market economists expect higher energy prices to spur technological innovation in all fields to avert any crisis.

The purpose of this series of articles is to explore the impact of high energy prices on the food supply system of North Carolina, including:

1) Growing food on the farm, which includes costs for synthetic fertilizers made from natural gas and fuel-powered machinery and irrigation;
2) The postfarm part of food production, which includes processing, packaging and transportation and uses energy for machinery and heating; and
3) Retail sales and consumption, which affect the average consumer most directly through the pricing of food.

The objective of the project is to inform readers, who are presumably unfamiliar with the workings of the food supply chain, about:

1) The degree to which the food production system is dependent on fossil fuels;

2) The possible effects of permanently higher oil prices on the average consumer, such as higher food costs and a change in which food is available; and
3) The efforts being made both on and off the farm to lessen dependence on fossil fuels.

To establish the premise that energy costs will stay high for the foreseeable future, it is first necessary to discuss the reasons behind the current upward trend in oil prices.

## B. Expensive Energy: Here to stay?

Anthropologist L. A. White wrote that civilization evolved because humans learned to harness greater levels of energy (1969, ch. 13). Starting with fire and wood, humans went on to utilize coal and steam. Then came the oil bonanza; Richard Heinberg (2003) of the New College of California wrote that humans "utterly transformed our societies and our personal lives" (p. 44) – in other words, industrialized – to make use of this cheap and abundant energy.

Oil boasts several advantages compared to most energy sources, including its fossil-fuel cousins natural gas and coal, that make it difficult to replace. One asset is its energy density. One gallon of gasoline running a machine does the same amount of work as one human working 40 hours a week, for two-and-a-half weeks (Pimentel, 1980). Other strengths include its ease in transport and storage and its versatility, as it can be refined into fuels such as diesel and gasoline for use in transportation, heating and the production of plastics.

Oil was also cheap, at least until recently. Only eight years ago in 1998, the annual price hit a historic low at \$11.31 (\$14.05 in today's dollars, according to the Federal Reserve Bank of Minneapolis' online Consumer Price Index calculator). But since the beginning of this year, the price has hovered in the $60 range, hitting $68.75 on Jan. 20.

The current rise in oil costs is often compared to that of the 1970s, with the reassurance that today's rates pale before those prices. In December 1979, the average monthly price of a barrel of oil soared to an all-time high of $38, or $106 in today's dollars. At the beginning of the 1970s, it had been about $3. Higher oil prices led to 10-percent inflation rates in the United States and pulled the world into a recession that lasted until the mid-1980s (Kunstler, 2005). But the oil glut of the 1980s and 1990s soon followed, showing that the previous shortages had been artificial interruptions in oil delivery caused by politics, including Arab opposition to American pro-Israel policies and the Iran-Iraq War.

The forces behind the current upward curve in energy prices appear fundamentally different from those of the 1970s. The first factor is the upswing in demand from emerging economies such as China and India. The International Energy Agency estimated that the world will consume 120 million barrels a day in 2030, a 50 percent jump from current levels. The increase in demand will come mainly from emerging economies such as China and India. Charles Featherstone (2005), a journalist specializing in energy- and Middle East-related issues, saw 2004 as the year that China ousted America as the main influence on oil costs. It is now the world's second-greatest oil consumer and will require 100 percent of current world exports in 10 years.

While most agree that global demand is surging, two schools of thought exist on whether supply will be able to keep up. An imminent drop in production is the focus of the "Peak Oil" theory, which has garnered the support of many scientists since the 1950s. This view has gained the attention of the news media and world governments due to recent hikes in energy prices, according to the BBC. Still, more people remain unconvinced that supply will decrease, saying that scientific innovation will prevent shortages and attributing recent inflation to short-term factors such as the hurricanes. “It’s the geologists on one side and the economists on the other side,” a Washington energy analyst told *The New York Times*.

Both sides appear to agree on one thing: expensive energy is here to stay. Peak Oil theorists see increasingly higher prices to be the result of faltering supply. Meanwhile, critics of the theory expect high oil prices to provide the impetus for increasing production.

Peak Oil theorists say that oil itself may never run out but that its easy-to-access, easy-to-use liquid form will. Geologists Colin J. Campbell and Jean H. Laherrére, each with more than 40 years of oil-industry experience, called it “the end of cheap oil” in their 1998 *Scientific American* article. They concluded that the peak, or highest point, of world oil production would pass in 2010, leading to high energy prices and international tension.

Geologist M. King Hubbert is usually credited with raising the alarm about oil depletion. In a 1956 paper presented to the American Petroleum Institute, Hubbert drew up a bell curve of past and future oil production based on known reserves and the rate of discoveries. He predicted that the “peak” for U.S. oil production would come between 1966 and 1972. It actually hit in 1970 at 11.3 million barrels a day, a number that has now dropped below 5 million. Journalist John Gever and his three scientist co-authors described the Hubbert curve as “very accurate” (Gever, Kaufman, Skole, & Vörösmarty, 1986, p. 55) for successfully predicting both the date and size of the domestic peak.

Geologists who use Hubbert’s methods to analyze oil production on a global scale generally expect the world peak to come before 2010 or shortly afterward. These include Kenneth Deffeyes of Princeton University and Albert Bartlett of the University of Colorado. A non-scientist who warns of a shortage is Matthew Simmons, former energy advisor to the

Bush Administration and author of the book "Twilight in the Desert: The Coming Saudi Oil Shock and the World Economy." Even oil companies show signs of bracing themselves. In the mid-1980s, Gever et al. (1986) saw corporate mergers as "perhaps the most eloquent testimony" (p. 85) that the industry expected little outward expansion. Last year, Chevron ran a series of advertisements that read, "One thing is clear; the era of easy oil is over."

OPEC nations, including Saudi Arabia, may be nearing their peaks sooner than expected. Saudi Arabia has failed to deliver on its recent promises to keep oil prices down through increased production (Kunstler, 2005). The North Sea reserves, which were partly responsible for the 1980s oil glut, also pump forth 10 percent less every year (Sprott, 2005).

In the 1980s, University of Maryland business administration professor Julian Simon and other "cornucopians" had expected new discoveries to solve the problem. Gever et al. (1986) criticized such views, as the rate and quality of new discoveries has declined since the 1960s despite advances in surveying technology. More recently, energy economist and prominent Peak Oil critic Michael C. Lynch (2001) pointed out that major oil fields in Kazakhstan and Iran were found in 1999 and 2000. Yet even in 1999, the better year, the new discoveries were only 60 percent of yearly consumption (Heinberg, 2003). A February 2005 report commissioned by the Department of Energy called the lack of discoveries "one of a number of trends that suggest the world is fast approaching the inevitable peaking" of production (Hirsch, Bezdek, & Wendling, 2005).

Others such as political scientist Bjørn Lomborg (2001) backed nonconventional fuel sources such as shale oil as an alternative to liquid petroleum. Heinberg (2003) criticized this suggestion as uneconomical as the ore must be mined and heated to 900 degrees, leaving behind great volumes of waste. On average, exploiting shale oil requires nearly seven times the energy as the most uneconomical forms of petroleum in production today.

Optimists such as energy analyst Daniel Yergin, Pulitzer-winning author of a book on oil, trust that higher prices will encourage conservation, spur scientific innovation and create new economic incentives. For instance, the oil from the Caspian Sea and the shores of Brazil would not have been profitable otherwise. Yergin told *Parade* that the biggest threats to the oil supply were above, not below, ground; he was referring to the hurricanes of 2005 and political instability in the Middle East. But he also said that higher demand from developing countries was a permanent trend, as China's former cyclists were now drivers.

Therefore, in terms of energy prices, Peak Oil theorists consider inflation to be an inevitable and irrevocable trend, one that will accelerate after global production actually starts to drop. But should their critics' predictions come to pass and new fuel reserves are harnessed, prices may rise at a slower pace or even decrease to a degree. Yet even among optimists, nobody appears to expect oil prices to fall back to 1990s levels.

Natural gas, the other major fossil fuel, also faces the double pressures of growing demand and shrinking supply. Natural gas accounts for one-fourth of total U.S. energy consumption and is used extensively in home heating and as a raw material for fertilizers. Unlike oil, virtually all of the domestic supply originates in North America, due to the difficulty of transport. According to Energy Information Agency researcher Barbara Mariner-Volpe (2004), U.S. consumption has outstripped production since the mid-1980s, and the gap will continue to widen. The first hint about a gas problem came in 2000, when prices shot up by 400 percent. In 2003, prices jumped again from $3 per thousand cubic feet to $6. The American Gas Association claimed the volatility was because "natural gas production has struggled to keep pace with demand." This winter, the average home heating bill is expected to jump 24 percent from last year (EIA, 2006).

Permanently higher energy prices could have dire consequences for society. Virtually all services and industries in a modernized country heavily rely on fossil fuels to function. Food production is no exception. The dramatic output increases of the 20th century were made possible by the "technological trinity" (Socolow, 1999, p. 6007) of natural gas-derived fertilizers, fuel-powered irrigation and engineered seeds, which depended on the first two factors to deliver on their promises. Due to this high degree of dependence on nonrenewable energy, scholars predict that high energy prices or supply shortages will have an impact on the nation's food production. However, what the actual results could be appears to be a point of contention.

## C. LITERATURE REVIEW

Scholars agree that the "Oil Shocks" of the 1970s drew the attention of academics and the food industry alike to the issue of fossil-fuel dependence. During the energy shortages of the 1970s, food reserves declined sharply, and food costs rose around the world (Dvoskin & Heady, 1977). Farmers faced actual physical shortages of machinery, fertilizers and fuel, as well as higher production costs; for example, fertilizer prices shot up 62 percent in 1974 and 49 percent more the next year (Rawlins, 1980, p. 79). Yield predictions were based on how available these resources were, rather than the traditional factors of climate and acreage. Writing in 1980, N. Omri Rawlins of Middle Tennessee State University saw the energy issue as a new, major problem for agriculture and the economy as a whole: "Very few problems have the economic, social, and political impact as the energy shortage" (p. 13). Accordingly, economists and scientists produced a flurry of research in the late 1970s and early 1980s on energy use, laying the base for future inquiries. In a summary of existing research, John Hendrickson of the University of Wisconsin at Madison (1996) noted that much of the data on the subject dated from the 1970s and was in need of updating.

In contrast, a lack of interest in energy-related issues is noticeable in works dating from the mid- to late- 1990s, even those that are very comprehensive in other regards (such as Connor & Schiek's 1997 book on the food processing industry). Energy was not a major consideration in economist Tim Dyson's (1999) projections for the world food supply through 2025, perhaps because oil prices had been nearing historical lows during the 1990s. For example, Dyson said that grain prices were more volatile than before but saw the reasons as lower levels of cereal stocks and a "worrying" (p. 5932) rise of volatility in North American production due to climate change. However, with energy prices rising again at the turn of the century, another wave of interest in energy and food production appears to be building within the scholarly community, judging from the number of publications.

This section will examine the existing academic literature on the dependence of modern food production on conventional fossil fuels, which many scholars consider excessive. There is less consensus on how energy price increases or energy shortages could affect the nation's food supply, as projections range from cautious optimism to warnings of widespread starvation. Scholars have also made suggestions for making food production less reliant on fossil fuels, such as organic farming or changes in diet.

**Fossil Fuels, On and Off the Farm**

"We must eat oil or we must starve," said petroleum chemist Maurice B. Green in his book *Eating Oil: Energy Use in Food Production* (1978, p. 81). Increases in food production based on cheap energy resources enabled the global population to grow from less than 2 billion to more than 6 billion in a single century (Heinberg, 2003). Gever et al. (1986) also observed that "much cropland today could not be farmed at all without the use of fossil energy" (pp. 201-202). Such statements emphasize the reliance of modern industrialized agriculture on fossil fuels to produce bountiful amounts of food.

Because the laws of physics dictate that new energy cannot be created from nothing, one must inject more energy into food production to harvest more nutritional calories (i.e., food) from the process. In the 20$^{th}$ century, this extra input came mostly from fossil fuels, in the form of fertilizers made from natural gas and fuel for running tractors and irrigation systems. Fossil fuels are now "as essential as land and water for agriculture," said agricultural scientist David Pimentel (1980, p. 9). Depending on how the food production system is defined, between 12 to 20 percent of total U.S. fossil fuel use goes into making food (Hendrickson, 1997). The results were dramatic. By the 1960s, Illinois corn farmers had boosted their yields per hectare (2.5 acres) by nearly three times their 1930s levels, according to Green (1978). Still, Heinberg (2003) criticized the current system as the least efficient form of food production ever practiced, when total energy inputs are compared to the dietary calories that are gained.

His views are supported by the research of David and Marcia Pimentel of Cornell University, whom Hendrickson (1997) recognized as "perhaps the most prolific analysts of food system energy use over the past twenty years" (p. 1). Pimentel and Pimentel, in their book *Food, Energy, and Society* (1996), found that U.S. farms expend 3 kilocalories of fossil fuel energy to produce 1 kilocalorie of food. (The kilocalorie is a unit of energy commonly known as the "calorie.") They compared this rate with different methods of corn farming practiced around the world, from those that require only human labor to those that use animals. Such traditional methods were two to four times more efficient than industrial farming. The results were similar when the exercise was repeated for wheat, rice and peanuts.

Another study that affirmed the low energy-efficiency of industrialized agriculture was a comparison of farming in 75 developed and developing countries by agricultural economist Piero Conforti and agricultural scientist Mario Giampietro. According to their results (Conforti & Giampietro, 1997), all OECD (Organisation for Economic Co-operation and Development) countries were grouped toward the lower end of efficiency. (The OECD consists mostly of developed countries that follow the principles of democracy and a free-market economy.) The United States was the 21st least efficient overall.

The extant literature agrees that the biggest increase in on-farm energy inputs came from the use of farm chemicals derived from fossil fuels, such as fertilizers, pesticides and herbicides. In particular, nitrogen fertilizer use increased nearly 16 times between 1945 and 1970 (Edwin, 1974). Researchers acknowledge the role of chemicals in increasing outputs but also tend to level more criticism at them than at farm machinery. The larger energy requirements of chemicals and environmental side effects such as soil depletion and disruption of the ecosystem appear to be the reasons (Pimentel & Pimentel, 1986; Allen, 2004). Gever et al. (1986) explained that fertilizers "actively promote degradation of existing organic matter" (p. 165) while being less effective on soil devoid of organic matter to begin with, so the more one uses, the more one needs.

The relevance of soil and cropland preservation to energy issues was clarified further by David and Susan Pimentel (1986). The authors explained that continuing losses of cropland to urbanization, highways and soil erosion were offset by increasing the yields from remaining land, mainly through fossil fuel input. For example, three times more fossil fuels must be applied to grow the same amount of corn on half the acreage. "With energy resources now at a premium, the U.S. cannot afford to lose valuable cropland and continue to make up the deficit with fossil fuel" (p. 270), they concluded, making land preservation their primary suggestion for reducing energy dependency. This opinion concurs with the results of work by Conforti and Giampietro (1997), who identified population pressure as the main force driving agricultural industrialization in most countries; in other words, lack of farmland rather than lack of human labor was the factor.

The exception to scholars calling for less chemical use was Green (1978), who said that during an energy shortage, crop protection through chemical means should be intensified to salvage as much food as possible. Pesticides and herbicides accounted for 1.6 percent of on-farm energy use in 1970, a cost that Green said was insignificant compared to their benefits. (It is worth mentioning that Green was an employee of Imperial Chemical Industries, a fertilizer and pesticide producer, at the time of writing. He disclosed this fact in the book's foreword adding that the views expressed were his and not the company's.)

Fuel-powered irrigation has enabled Western states such as Colorado, Arizona and California to overcome their arid climates. An irrigated acre of Great Plains land grows three to four times more food than a nonirrigated one (Gever et al., 1986). But Gever et al. objected to extensive irrigation for its role in accelerating soil damage. According to the authors, most irrigation water is high in sodium, which degrades the soil; therefore, more nitrogen fertilizer must be applied to offset these losses. Pimentel and Pimentel (1986) agreed that irrigation was an energy-intensive process that should be less relied on, as growing 1 hectare of corn in an arid region requires more than three times the fossil energy required to grow the same amount of food in a climate with optimal rainfall.

Meanwhile, the postfarm procedures of processing, packaging and transport consume more energy than the actual growing of food. Pimentel (1980) used the example of a can of sweet corn to show that only one-tenth of the total energy used in making it was expended on the farm. Heinberg (2003) said that four to several hundred times more energy may go into making a food item than is gained from eating it, depending on the degree of processing. Such an imbalance was possible only because fossil fuels have been cheap, he said.

Researchers tend to be more critical of the energy expenditures of the postfarm sector than on-farm usage (Green, 1978; Pimentel, 1980; Pimentel & Pimentel, 1996). Many are scientists who point out that processing and transportation do not enhance nutritional quality, often destroying nutrients and wasting food. Green (1978) observed that processing is done to add economic, rather than nutritional, value to a food product.

Food and beverage processing accounts for one-fourth to one-third of the total energy use of the entire food system (Hendrickson, 1997). But the energy needed to create various kinds of foods differs. Pimentel and Pimentel (1996) examined 18 processed food products and found that the energy needed to make one kilogram of each ranged from nearly 19,000 kilocalories for instant coffee and 15,600 kilocalories for breakfast cereals to 354 kilocalories for milk (p. 188).

Green (1978) asked whether packaging had not gone beyond reasonable bounds, finding that it had taken up 36 percent of energy use in food processing in 1970. He targeted canning as especially energy-demanding, as canned foods require 10 times more energy to make than can be gained by eating them. In his view, canned soft drinks were some of the most energy-profligate foods ever made, and there was “absolutely no justification” (p. 54) for canning pet food except that it was profitable for the pet food industry.

In Pimentel's example of the can of corn (1980), packaging costs were one-third of the product's total energy budget. Eighty percent of those packaging costs went into making the can. But Pimentel arrived at a different conclusion about canning, saying that it could become more advantageous in the face of rising energy costs as it was less energy-intensive than freezing and made food lighter and easier to transport.

The energy costs of packaging come from plastic, which is made from oil derivatives, and the oil that all containers require for their manufacture. Therefore, replacing plastic containers with other kinds is not necessarily energy-efficient, said Pimentel and Pimentel (1996). They analyzed the energy needed to produce 16 common types of food containers and found that a wooden berry basket required only 69 kilocalories, while a 12-ounce steel can needed 568 kilocalories, and a one-quart polyethylene bottle took about 2,500 kilocalories. The most energy-expensive container was a half-gallon glass milk jug that required about 4,500 kcal (p. 195). The authors pointed out that glass bottles, despite their relatively environment-friendly image, do not save energy unless reused four or five times.

Transportation accounts for another sizeable chunk of postfarm energy use. According to Hendrickson (1997), researchers have found transportation to take up 3 to 6 percent of the energy consumption of the entire food system, or up to 12 to 13 percent depending on their definitions of the term. Some studies focused on the actual delivery of food, while others included the costs of fuel production and vehicle maintenance. Green (1978) had an especially expansive view of transportation and included the use of personal cars for food-related business by industry representatives or government officials. He said that in 1970, such use accounted for 0.7 percent of the nation's total energy, compared to the

1.6 percent that went into food transport (p. 54). He also analyzed the transportation costs of consumers or restaurants for buying food and concluded that half as much fossil energy is used to shop for food as is needed to make it. Green held that such findings were significant, but such broad definitions of transportation were not found in other studies.

Compared to on-farm energy use, the postfarm sector appears to have been less explored by scholars. Some seem to consider it a relatively unimportant topic; in their book *Food Processing: An Industrial Powerhouse in Transition* (1997), which billed itself as "the most comprehensive review available of the United States food processing industry" on its back cover, agricultural economists John M. Connor and William A. Schiek barely took note of energy-related issues. For example, the authors mentioned that food processing became roughly twice as efficient between 1947 and 1987 largely because of energy conservation measures adopted after the 1973 Oil Shock, but gave no details on what those changes were.

**Possible Implications of Expensive Energy for Food Production**

Researchers agree that food production depends heavily on fossil fuels, but tend to differ in their estimates on what will happen once energy prices go up or actual shortages occur. In terms of prices, Rawlins (1980) wrote that consumer prices increased in earnest in 1973 but did not single out expensive energy as the only reason. Inflation pressure had been building since the beginning of the 1970s from growing global demand for food resources and adverse weather conditions that reduced harvests, he said.

Agricultural economists Dan Dvoskin and Earl O. Heady (1977) considered food exports to be a major factor in determining the rate of inflation. The more dollars the United States spends on imported oil, the more the value of the currency drops, spurring exports.

Such a situation can lead to more profits for some producers but also dramatic price hikes for domestic consumers, said the authors. Using a mathematical model, they analyzed five different scenarios including 100-percent increases in energy costs either with or without substantial gains in exports. Of these, the scenario with doubled energy prices but without major export growth was the only one the authors dubbed "very likely" (p. 57). In this case, corn and wheat prices rose 13 percent, and the average inflation rate for all 10 food commodities analyzed was 12 percent. But when exports rose significantly, sending more food overseas, prices for U.S. consumers jumped to more than twice their current levels.

The potential effects of expensive energy on the amount of production appear to have attracted more scholarly attention than consumer prices, and conclusions differ greatly from study to study. Princeton University professor Robert H. Socolow, a physicist, attributed the disagreements to the differences between disciplines:

> Economists and agronomists are locked in debate about likely future yields. In the energy world, economists and geologists are locked in virtually the same debate, this time about likely additions to reserves of fossil fuels. The reason for lack of resolution is the same. The historical record shows a run of successes (higher yields, new reserves) for many decades. Because the method of the economists is to predict future outcomes from past performance, economists expect success to continue. And because for the scientists future success depends on discoveries they will have to make and do not now know how to make, the scientists are doubtful. (Socolow, 1999, p. 6007)

The predictions of Green (1978) fell into the more dire category. He estimated that without fossil fuels to power food production, the carrying capacity of the United States would drop to about 120 million, its population in 1930. ("Carrying capacity," an ecological term, means the maximum population a habitat can sustain indefinitely.) Should the system continue in its present form, Green warned, "The United States, despite its wealth, is not immune from the hunger of the Third World – it is only a matter of time" (p. xiii).

On how many people the world can sustain without fossil fuels, Heinberg (2003) assumed a similar tone: “A safe estimate would be this: *as many people as were supported before agriculture was industrialized* – that is, the population at the beginning of the 20$^{th}$ century, or somewhat fewer than two billion people” (p. 177, emphasis in original). He expected energy shortages to come at a much more drastic pace than other researchers. Therefore, he did not allow much time for technological breakthroughs and their implementation. Anticipating criticism, the author put forth even more reasons to believe that industrialized nations are ill-prepared to handle an agricultural crisis, such as the vast losses of soil and cropland during the past century.

David and Marcia Pimentel have written since the 1980s that fossil fuel-dependent food production is unsustainable. And though such urgent statements from them are rare, the preface to *Food, Energy, and Society* (1996) implored the governments of the world to create a plan for reducing the world population to 2 billion because “[i]f humans do not control their numbers, nature will” (p. xvi). In a 1999 paper for *Agricultural Engineering International* co-authored with scientist Marianne Karpenstein-Machan, they wrote that natural forces had already begun to control population through disease and malnutrition. Since 1984, there has been less grain grown per person, they said (grains make up 80 percent of the world’s food supply).

Other scholars, mainly economists, show more confidence in the food system’s capacity to weather major changes in the energy market. Dyson (1999) wrote that he was “cautiously optimistic about our chances to better feed humanity in the next few decades” (p. 5929). He expected grain yields to increase from 4 tons per hectare in 1995-1997 to 5.5 tons by 2025, an amount sufficient to sustain the world population. To do so, consumption of nitrogen fertilizers would double by then, he said. (However, according to Pimentel et al. (1999), world fertilizer production fell by more than 23 percent between 1985 and 1998 due to the short supply and high price of natural gas.)

A study by agricultural economists Kenneth Hanson, Sherman Robinson and Gerald Schluter (1993) predicted only minor decreases in food production even with significantly higher energy prices. They analyzed a hypothetical scenario in which crude oil sold at $50 per barrel, compared to its 1993 base price of $19.30, and calculated that total food production would drop by 0.1 percent to 0.3 percent, depending on international trade levels. The researchers considered exports to be important for the same reasons as Dvoskin and Heady (1977), since profits from new exports would partially offset the impact of higher production costs. Therefore, the authors concluded that industries that lack significant overseas markets, such as dairy and sugar, would be the most vulnerable in an energy crisis.

Some researchers pointed out certain production methods or localities that would be hardest hit by high energy prices. In an article for *Scientific American*, economists Sandra S. Batie and Robert G. Healy (1983) expressed a "guarded optimism" (p. 45) about the nation's ability to continue producing cheap and abundant food. But they noted that "disproportionate increases in the price of certain agricultural inputs, particularly energy, will tend to reduce the profitability of many current agricultural practices" (p. 45). One of these was irrigation, due to the double pressures of rising energy costs and depletion of water resources. Therefore, the locations of farms could change: "Higher transportation costs may make it feasible to fatten cattle on feedlots in the South rather than shipping them to the Middle West" (p. 48).

Dvoskin and Heady (1977) also expected irrigation to suffer from high energy costs. Out of their five hypothetical scenarios, the one they considered most likely was that with doubled energy prices and no significant increase in food exports. In this case, irrigated acreage decreased by 22 percent. Another scenario postulated a 10-percent drop in energy supply, leading to the loss of 9 million irrigated acres. The authors predicted a reverse in the trend for shifting production of crops such as cotton to the arid Western states and concluded that irrigated farming could continue only with “high exports and abundant energy supplies” (p. 61).

The real-life case of the Hawaiian beef industry of the 1970s was analyzed by agricultural economists Roland K. Roberts and Gary R. Vieth (1984) with beef extension specialist James C. Nolan Jr. The authors concluded that the energy inflation of the 1970s had a significant impact on Hawaiian producers, precipitating a 22-percent drop in beef output and stymieing industry growth for the rest of the decade. They also observed changes in industry practices, as the pre-1974 trend of increasing grain-fed beef production was reversed and producers began to increase grass-fed beef instead. (According to Green, 1978, grass-fed cattle produce twice as many calories as are needed to raise them. In contrast, industrialized grain-fed beef requires high fossil fuel inputs and returns only one-tenth the energy used in production.) The authors acknowledged Hawaii as an extreme example, mainly because of its high transportation expenses, but held that energy considerations should also be included in the business decisions of other states’ beef industries.

Finally, some scholars concerned themselves with the broader ramifications of high energy prices on the U.S. and global economies, rather than just consumer prices or output levels. Batie and Healy (1983) considered the “real uncertainty” (p. 53) in an expensive-energy situation to be whether the United States could maintain its level of food exports. Falling exports could have major implications for the entire American economy, they said, as exports had been “particularly valuable in cushioning the economy against external shocks” (p. 45). For example, agricultural exports had made up for more than 62 percent of the country’s expenditure for oil imports since 1973. (Gever et al., 1986, p. 148 quoted Richard Bell, assistant secretary of agriculture for the Ford administration, as saying, “Agridollars have gone a long way toward offsetting our petrodollar drain.”)

A drop in American food exports could also affect other countries, according to Gever et al. (1986), who noted that the United States has been holding down world crop prices through its significant surplus production. Without it, food could become less affordable for people in other, often poorer countries, even those who had not directly consumed American-grown food.

**Suggestions for a More Energy-Efficient Food System**

Researchers who highlight the food industry’s dependence on fossil fuels usually include several suggestions for creating a less energy-intensive system. Many agree with Pimentel and Pimentel (1986), who said, “Because food production uses energy, the food system and ultimately food consumption patterns in the United States may need to be changed – especially when fossil energy supplies become scarce” (p. 278). Some scholars emphasized the role of the consumer in pressuring the industry toward change while others focused on what steps producers could take both on and off the farm. Ways that the government could facilitate change were also proposed in several writings.

Green (1978) said consumer preferences would be the most influential factor in realizing a more energy-conscious food system: “In a free market system, it is the consumers’ ability and willingness to purchase which stimulates production and supply and determines its nature" (Green, 1978, p. 77). Gever et al. (1986) saw altered purchasing patterns as especially important in promoting change in agribusinesses. For example, a partial return to regional and seasonal diets would encourage the industry to cut back on transportation and refrigeration, they said. But in general, even those who stressed the role of the consumer had few specific ideas beyond dietary change.

David and Marcia Pimentel have repeatedly suggested reducing meat consumption as a practical way for consumers to save energy. They claimed that this would actually increase food supplies, as less food would be fed to livestock. The world's livestock eat an estimated 40 million tons of grain while producing only 1 calorie of food for every 20 calories they eat (Pimentel & Pimentel, 1996, p. 291). To demonstrate the efficiency of a vegetarian diet, Pimentel (1980) compared the fossil energy required to provide the daily food intake (3,300 kcal) of a non-vegetarian, a vegetarian who eats dairy and eggs, and a pure vegetarian. Each diet required 33,900, 18,900 and 9,900 kcal, respectively (p. 27). However, the scientists realized that "modifying human diets is a complex issue because it involves personal habits and choices" (Pimentel & Pimentel, 1986, p. 280). They suggested that nutritionists working in community settings could help people at least increase their intake of plant food.

On the likelihood that consumers would make such changes, Tufts University professor William Lockeretz (1986) observed that people sometimes make purchasing decisions based on values other than price, such as environmental concerns. But later in the chapter, he wondered whether consumers would be willing to accomodate an in-season, local food production system. Such a model is often described as energy-efficient, as it saves on transportation and heating costs (such as for greenhouses). Lockeretz questioned the desirability of such a diet, saying that it "at best could be called drab, at worst nutritionally deficient" (p. 307). Unlike Lockeretz, economists Batie and Healy (1983) saw rising food costs, rather than ideology, as the factor that would lead people to reduce meat consumption.

Scholars have more specific suggestions for producers to conserve energy and enhance efficiency. Some afford a high level of priority to the farm compared to the off-farm sector, such as Green (1978), who said that "primary agricultural production should be the last thing to suffer" (p. 88) in an energy shortage.

On the farm, Pimentel et al. (1999) suggested rotating alternating crops of corn and soybeans, a method sometimes called "green manure," to lessen fertilizer and pesticide use. (Legumes can fix atmospheric nitrogen into the soil.) According to the authors, fields that had done so boosted their yields by 8 percent while using 40 percent less fossil fuels.

More efficient use of existing resources was also suggested. Socolow (1999) noted that much fertilizer is wasted by "suboptimal application" (p. 6005). He explained the effects of applying 100-kilogram batches of synthetic fertilizer to a hectare of corn, saying that the plants absorb 39 percent of the first 100 kilograms but only 13 percent of the second. According to scientists David Pimentel, Paul Hepperly, James Hanson, David Douds and Rita Seidel (2005), U.S. farmers use about $2.5 billion more worth of fertilizer than plants can utilize.

Animal manure could also be used more wisely, said Pimentel and Pimentel (1986). By collecting manure promptly, storing it in tanks and turning it under the soil during application, the amount of nitrogen supplied to the soil could be doubled compared to when manure is left for long periods in barns and placed on the surface of the land, they said.

Many researchers consider organic farming to be energy-efficient. Reducing energy inputs is a "high priority" of this method, by either cutting down on energy use or replacing fossil fuels with other energy sources, said Lockeretz (1986, p. 292). “The deterioration in the energy situation that began about a decade ago has been regarded as an important incentive for adoption of alternative agricultural methods” (p. 300). Another of its goals is to reduce the food system’s reliance on the postfarm sector, such as transporters, processors, distributors and packagers, he said. Pimentel et al. (2005) agreed that organic farming aimed to decrease the use of fuel and agrochemicals and considered its future bright, based on increases in sales and production. Farmers would also benefit economically, said the authors, as the price premium for organic grains has ranged between 65 percent to 140 percent since the 1990s, making organic corn 25 percent more profitable on average than conventional.

To compare the energy efficiency of conventional and organic farming, Pimentel et al. (2005) analyzed the results of a 22-year experiment by the Rodale Institute, an organic-farming research institution. This experiment compared the production costs and yields of three different ways of growing corn: the “conventional” method using synthetic fertilizers and pesticides, an organic model that used animal manure, and another organic model that depended entirely on plants for soil enrichment. According to the results, the organic systems yielded nearly as much food as the conventional field within two to three years. In years of drought, the organic models produced almost 30 percent more than the conventional one, probably due to the buildup of organic matter in the soil. Meanwhile, both organic models used about 30 percent less fossil energy than conventional corn farming. (The authors did realize that the outputs of organic farming could be significantly lower in some instances. In one European experiment, organic corn yields were 30 to 50 percent less than conventional depending on how much nitrogen was supplied, they said.)

Lockeretz (1986), while not disagreeing with the value of organic farming, was more cautious about its merits. He emphasized the need to consider the effects of a single change on the overall process to correctly judge how much, or even if, energy was being saved. For example, substituting animal manure for chemical fertilizers incurs new energy costs for hauling and spreading; therefore, depending on the distance, manure use does not automatically save energy. But in the same book, Pimentel and Pimentel (1986) concluded that manure use would require only one-third the energy of fertilizer use. The caveat was that these results applied to when manure and cropland were 1.5 kilometers apart. The authors acknowledged that transport was the "major problem" (p. 275) in using manure, as animal feedlots are usually far from farmland.

An oft-mentioned way for farms to boost energy efficiency is to produce "biofuels," energy sources made from living organisms or their manure. Liquid biofuels such ethanol derived from corn or bio-oils refined from vegetable oils garnered the most attention from scholars as a possible petroleum substitute. But scientists Mario Giampietro, Sergio Ulgiati and David Pimentel (1997) wrote in *Bioscience* that "[l]arge-scale biofuel production is not an alternative to the current use of oil and is not even an advisable option to cover a significant fraction of it" (p. 587). The infrastructure for manufacturing and supplying biofuels to any significant degree were nonexistent and unlikely to be created, they said, and land for producing grain for alcohol would directly compete with land for producing food. Batie and Healy (1983) were also skeptical about bioalcohol, as 60 percent of the nation's corn would be needed to replace 10 percent of its gasoline. "The obvious repercussions on food prices are sobering" (p. 47), they said. Pimentel et al. (1999) opposed biofuels simply for being inefficient. The process for making ethanol burns up 65 percent more energy than is gained from the end product, they wrote. They doubted that even technological advances would bring that number down to less than 26 percent.

As for how much the nation's farms can cut their overall energy inputs, Batie and Healy (1983) said energy was too vital for farms to reduce its use significantly, in spite of rising prices. Their expectations are backed by the research of Dvoskin and Heady (1977), whose mathematical analysis found that even a doubling in energy prices would cause only a 5 percent reduction in on-farm energy usage (p. 57).

At any rate, said Lockeretz (1986), most alternative food systems call for higher labor inputs and more farmland for each region, so a large-scale transition toward localized organic farming is unlikely to be easy. "It is very difficult to bring back the people, cropland and support facilities necessary to revive agriculture" (p. 305), he said.

Some researchers saw more opportunities for energy savings in the off-farm process. Green (1978) agreed, but advised caution in making changes to this sector: "Most of the ways for saving energy in primary agricultural production … would have very little effect on the range of foodstuffs available, the eating habits of the nation, or the consumer's freedom and variety of choice. Many economies in energy use in food processing, distribution, and preparation would almost certainly affect one or all these things" (p. 117), he said.

Food scientists Felix Barron and Joel Burcham (2001) emphasized food safety as the primary consideration that "cannot be compromised" (para. 3) when making processing more energy-efficient. Heating would be a crucial part of the process as it destroys microbes and parasites that cause spoilage and disease. Regarding food safety, Pimentel and Pimentel (1985) identified sun-drying as an effective way to preserve food, whereas drying grains using fossil fuels is energy-intensive. In the United States, such methods use more than two times the energy needed for sun-drying, the authors said.

Not all scholars have agreed on whether canning is energy-efficient, but more appeared to consider it wasteful. Barron and Burcham (2001) were among those who saw the energy usage of canning as significant and called for improvements in efficiency. The research of Pimentel and Pimentel (1985) suggested that energy could be saved simply by changing the raw material for the can, as aluminum cans required about three times the energy of steel cans to make. Making an aluminum soft-drink can took up 11 times the energy that a person would gain from drinking the beverage (1,643 kilocalories versus 150 kilocalories).

Another part of the food system that shows heavy energy consumption is transportation. The nationwide scale of the U.S. food system also makes the food supply vulnerable to transportation disruptions, such as those resulting from an energy shortage, said Lockeretz (1986). In the face of the 1970s oil crises and the decline of local agriculture, such concerns prompted a flurry of state and local plans for increasing food self-sufficiency, according to the author. Patricia Allen (2004) of the University of California at Santa Cruz advocated the creation of a localized food system to reduce transportation costs and ensure a region's food security. She pointed out that such objectives tied in with those of alternative agriculture and saw the strengthening of that movement as the best way to achieve this.

Compared to consumers and producers, scholars typically assign the government a minor role in energy saving. Green (1978) said direct governmental intervention was unlikely, partly because of the difficulty of juggling the interests of various companies. The government is more likely to use financial techniques such as selective taxation and subsidies, he said. Heinberg (2005) suggested the government abolish subsidies to industrial agriculture and include population-regulation policies in the national food policy, such as economic incentives to have smaller families.

Should the country face an energy crisis, the government has already shown that it recognizes the importance of food production. According to Rawlins (1980), agriculture was given top priority in the federal Mandatory Petroleum Allocation Program of 1973, a policy developed to prepare for and deal with extreme energy shortages. The program, which included the printing of fuel rationing stamps, eventually was not needed.

But others were skeptical of the government's capability to effect change quickly enough. Allen (2004) wrote that major changes in federal food policies are rare because of the various "structures of power and privilege" (p. 187) holding them in place and that large-scale policy alterations usually occur only as a reaction to crisis. Therefore, the alternative agriculture movements scattered across the country must build coalitions amongst themselves to bring about change at the policy level, she said. Allen appeared optimistic about that possibility, claiming that food issues "clearly have the potential to catalyze broad social movements" (p. 212) because food is such a vital, fundamental commodity.

Batie and Healy (1983) criticized the federal government's "limited expenditures on research and development and on the extension programs that bring the results of such research to the farm" (p. 51), as they considered technological changes to be crucial in enhancing energy efficiency. The authors called for more research funding in order to curtail the possibility of higher food prices, diminished exports or the need to divert substantially more resources away from other industries in order to produce food.

Scholars agree that the current food supply system in this country is highly dependent on fossil fuels. But the effect of inflated energy costs on food producers and consumers is unclear, and researchers differ in their expectations. Many of the predictions appear to be either educated guesses based on empirical statistics or extrapolations based on rigid mathematical models, without input from the industry or consumers. Therefore, little research has been done on what a long-term increase in energy prices will do to the actual people involved in the production and consumption of food – in other words, everybody.

## D. Series Outline

This series of articles explores the possible effects of higher energy prices on the food supply system of North Carolina. For consumers, the main concerns will be inflation and possible changes in the amount and variety of available food. On the other hand, the on- and off-farm food industries will be concerned with production costs and which foods and production methods would be more profitable in an expensive-energy situation. These topics are addressed in the following four articles:

1. Fossil Fuels Feed the Food System. The first article informs the reader how and why fossil fuels are used in food production, and to what extent. As background, a brief discussion of trends in oil prices and the reasons for expecting prices to stay high for the time being are included.

2. The High Cost of Making Food. The second article highlights the effects of high energy prices on farmers and food manufacturers. More emphasis is placed on livestock than vegetables or grains because of its larger significance to the state's economy.

3. Energy Prices Trickle Down the Food Chain. The third article examines the effects of high energy prices on food consumers, including individuals, restaurants and retailers. Distribution has been included here as that process does not actually create food.

4. Kicking the Fossil-Fuel Habit. The last article focuses on ways to conserve and

replace fossil fuels in the food system. Existing and upcoming technologies for harnessing alternative energy sources are discussed, as well as ways of using less fossil fuels in food production and distribution.

## E. Medium

The articles were reported and written in a form considered suitable for publication in a Triangle-area newspaper such as *The News & Observer* of Raleigh. Repeated searches of this newspaper's online archives showed that other than a September 2005 Associated Press article on the effect of high energy prices on the nation's farmers in the wake of Hurricane Katrina, *The News & Observer* has not covered the topic of energy prices and food production.

As *The News & Observer*'s target audience is the general public, the reader was not assumed to have any prior knowledge on food production, its related industries, alternative energy technologies or energy-related issues in general.

## F. Newsgathering and Reporting

### Background

The subject of this thesis is a marriage of two recent interests: food and energy. The direct influence came from a course I took in Spring 2005, Professor Robert Daniels' "Anthropological Perspectives on the Energy Crisis." The course introduced me to Peak Oil theory and the slew of problems that would descend upon society should it be true. I found the subject fascinating and disturbing, partly because of my own country's heavy energy-dependence.

One of the readings for that class was Dale Allen Pfeiffer's apocalyptic article, "Eating Fossil Fuels." (It turns out that Pfeiffer has expanded the article into a book of the same name to be published this fall.) Though I have come to regard this author with some skepticism after reading one of his books, my interest was sufficiently piqued, and I considered the issue important enough to develop into a long-term project.

I also wanted to try my hand at economics reporting or at least something close to it. My work experience so far centers in local reporting and features. By this time I was feeling the need to try something new and, if lucky, perhaps discover some previously unused journalistic muscle that I didn't know I had. As I had practically no background in economics, Professor Chris Roush's Fall 2005 "Economics Reporting" class was essential in grasping what types of information would be relevant to a subject and where I could find them.

I did some of the work during the Fall 2005 semester for Professor Barbara Friedman's "Specialized Reporting" class. For that six-page project I focused exclusively on farmers, with Maple View Farm's Roger Nutter playing the role of key informant. Some but not all of the farmers interviewed for that assignment make repeat appearances in this thesis.

**Newsgathering**

The newsgathering process went smoothly, for the most part. The hardest task was simply trying to cover all the ground that made up the food chain. Whenever I began to research a new aspect of the food production system, it felt like I was starting from scratch, having to understand a whole new industry each time.

It helped to ask my interviewees to suggest other contacts, often from other sectors of the food industry. The importance and efficiency of this cannot be overstated. I am quite sure that this was the biggest reason I was able to talk to many of my sources.

More than one person was skeptical that I'd ever reach any farmers who grew their animals under contract with agribusinesses. One with personal ties to the hog industry filled me in on some background on industry-media relations that I had not been well aware of due to my short stay in North Carolina. Hog companies were extremely wary of the media because of previous reporting on topics such as manure pollution, he said.

I suspected that if a company did give me some names, those farmers would have been the ones wearing the most heavily tinted rose-colored shades anyway. Therefore, all the livestock growers quoted in the articles had been suggested to me as possible contacts by other interviewees. The people of North Carolina State University and the trade associations such as the North Carolina Poultry Federation and the North Carolina Pork Council were especially helpful in this regard.

Even though I was armed with the phrase, "So-and-so suggested I contact you to ask about this," I wasn't sure how willing or open a contract grower would be. So it was a nice surprise that many turned out to be friendly and helpful.

It was much the same story for the people in food companies. The only success I had through a company's public relations department was at Food Lion, the supermarket chain. Jeff Lowrance in public relations repeatedly sent me relevant press releases and set up an interview with the company's energy manager.

I thought that it must be because the company considered itself a leader in the energy-efficiency field. Only in Lowrance's reply to my thank-you note did I learn of another possible reason he might have helped me – he is an alumnus of the same master's program that I will be leaving shortly.

After about a week of fruitless attempts through corporate public relations offices, I abandoned that path and approached people in much the same way I did livestock farmers – by dropping the names of other people.

I noticed in some earlier interviews that people would start talking about issues such as greenhouse gas emissions and residual nitrogen in the ecosystem. These are important topics closely related to fossil-fuel use but are beyond the scope of this project. Therefore I started making clear that my inquiry was not environmental but economic in nature, especially when approaching those in the livestock industry. This was not a compromise on my part, as my interest in energy issues never came from the environmental side.

I was able to meet in person most of the people within the radius of a 60-minute drive. The farthest I went was Julian Barham's hog and tomato farm in Johnston County. The single most important place was Raleigh. North Carolina State University was absolutely crucial, with its broad and deep collection of agriculture-related resources, both human and otherwise. Also, nearly all the major trade associations are located in the state capital.

I attended two events: the annual conference of the Carolina Farm Stewardship Association in November and the Triangle Peak Oil Conference in March. Both were held in Durham. In March, I also toured Piedmont Biofuels' research facility in Moncure.

Of course, some people did not return any calls or e-mails despite repeated attempts, especially those in corporations. At least two potential sources agreed to help me then never responded to any further contact on my part. In other cases, I was able to talk to people once but could not pin them down a second time to ask some follow-up questions.

Business owners and employees were generally reluctant to say exactly how much they were spending on energy and especially about how it affected their profits. In the case of public companies, some information could be gleaned from the financial reports they filed with the Securities and Exchange Commission. However, these reports were often vague on the exact effect of energy prices on their business, and the larger the company, the harder it was to attribute any change in the company's fortunes to energy prices alone. I tried to point out these limitations in the writing.

That brings me to the other kind of source that was almost as essential as people – documents. Numbers were a crucial part of the research due to the nature of the topic. As most ordinary people do not carry around all the statistics in their heads, I had to slog through what was probably hundreds of pages from the Web sites of government agencies, corporations and nonprofit organizations.

Locating the information often took as long as analyzing it. Government Web sites are gold mines of information, often without easily recognizable maps. This means that though I found a great many fascinating documents (my favorite is probably the September 2005 report by the U.S. Army Corps of Engineers), there are probably just as many that I missed simply because I could not find it.

When it came to statistics, I assigned the most credibility to government information, which was also the most up-to-date in many cases. Still, I regarded some of the forward-looking statements with a grain of salt. If I could not find government data, I turned to the many reports produced by nonprofit organizations, keeping in mind that though these groups might not work for profit they do work for an agenda.

As for forward-looking statements, several people said that energy was a major issue in food production but it was too soon for the real effects to be known, especially for consumers. After doing all my research on this topic, I agree. This made me wary as a journalist of making predictions, regardless of the bold pictures painted by some pessimists and optimists. While I was writing the articles, I tried not to jump to conclusions and focused on presenting for the reader the facts of what has already happened.

Of course, that does not mean I don't have an opinion. By talking to food producers and experts and reviewing the existing literature and raw data, I was aiming to draw my own conclusions on the veracity of Peak Oil theory and the role of energy in food production. In short, I have decided that Peak Oil is valid, though I find I have more faith than some of the more pessimistic "peakists" in humanity's ability to make the transition to a post-fossil-fuel society in time.

It appears that even with a substantial rise in energy prices, the average American eater will be shielded from the effects for quite a few years to come. In North Carolina, livestock producers will feel a heavy burden from natural gas prices, while vegetable farmers will pay through nitrogen fertilizer costs. Farmers will feel the biggest pinch because the current system allows them almost no way to pass on their increased costs and because the types of energy sources they use are more susceptible to inflation. Larger corporations will fare better, as they have more ways to turn a profit and more money to begin with. I also think it likely that the price of food coming from afar will see an increase in prices due to transportation expenses. It is also clear that though more and more people will convert to alternative energy sources in the years to come, no decisive change in the general public's attitude will come until the price gap with conventional fuels is narrowed significantly.

It is the less-affluent parts of the world that will suffer more, as is pointed out in the last article. America, with its vast reserves of money and sizable food surplus, will probably maintain its food security longer than most other nations. As long as there is energy and food in the global market, America can afford to pay more for it than anybody else.

This leaves me concerned for my own country, which is heavily dependent on foreign energy resources. “A land without a drop of oil” is an oft-appearing expression in Korean energy-conservation campaigns. But there appears to be little awareness about Peak Oil. On the other hand, Koreans use less energy per capita than Americans. Korea has an excellent public transportation system, and I almost never drove a car in Seoul because I could get anywhere on foot or by subway.

The bigger problem, in my view, is what could happen to Korea’s neighbors, namely China and North Korea. The food situation in North Korea is dismal enough that the average person’s height actually shrunk over several years because of malnutrition. Such long-term deprivation could foment social unrest in the hermetic nation, which could in turn bring about the worst-case scenario for South Korea – a sudden collapse of the Kim Jong Il regime, with the chaos spilling over the DMZ. As for China, Western scholars are already worrying about how it will feed its massive population, and the sheer magnitude of any possible problem in that country could not help but have major consequences for Korea.

Finally, I have developed a great respect for the people who grow our food. The system certainly has its problems, such as environmental degradation and food safety issues that arise from intensive animal production and of course heavy fossil-fuel use. But I believe that people have a moral obligation to feed the mouths already brought forth into the world. Despite its problems, the current way of doing things will probably be our only choice for the time being for producing sufficient food cheaply enough to feed everyone.

My grandparents, originally from the countryside, grow a surprising amount of food on their little urban plot (a rare thing in crowded Seoul). Even though I lived next door to them for about 10 years, I had never been interested in learning any farm or garden work, content enough with simply eating the fruits of their labor. When I go back, I think I will ask them to teach me how to plant a seed and pluck a weed, how to wield at least a tiny bit of power over what goes into my food and my body.

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The human and main document sources for each article, not all of whom were quoted, are as follows. Those that figure in more than one article are listed according to their first appearance. All locations are within North Carolina unless otherwise noted.

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## G. Limitations

This project focuses on edible food. Therefore, some of the state’s major agricultural products such as tobacco were excluded from consideration. Within food, emphasis was placed on products that have a bigger share of the state’s economy, so discussion on products like beef were left out in favor of pork and poultry.

This project does not touch on environmental or ecological issues. The burning of fossil fuels inevitably releases greenhouse gases, and the use of synthetic fertilizers can lead to nitrogen pollution in streams and rivers, among other problems. Such a topic deserves its own thesis and a researcher who is more interested in the topic than I.

Possible personal biases include a tendency to view the practices of major businesses with more suspicion than those of small and independent producers, and a preference for organic produce. To prevent these biases from coloring the articles, I tried to strike a good balance of sources while focusing on those who better represent the overall N.C. food industry. I also tried to document the claims made by interviewees through other sources such as government statistics before including them in my articles. I believe that being aware of these biases helped me stay vigilant in maintaining the fairness of the presentation.

Another possible bias is that part of my background is in science, while I have almost no experience with economics. While reading for the literature review, I noticed that I tended agree with the scientists simply because their methods made more sense to me. Therefore I made a conscious attempt to speak with agricultural economists for the articles, and it turned out that scientists and economists agree on more issues than the literature led me to expect.

## Article One

## Fossil Fuels Feed the Food System

Last fall the hurricanes came to the Gulf Coast, gasoline hit $3 a gallon at the pump and the letters started coming to Julian Barham, a Johnston County, N.C., hog and tomato farmer.

We're sorry, read the notices from his suppliers, but we have to raise prices because our fuel costs us more now.

Barham found it "kind of disheartening" that he was expected to help cover other people's energy bills when he was worrying his own, but he had no choice. "All we can do is sit back and watch."

So Barham watched the price for tomato boxes go up three times, 7 percent each time. Roger Nutter of Maple View Farm, an Orange County, N.C., dairy producer, saw prices rise 15 percent for the 20,000 plastic bottle caps he needs every week. Gary Wise, a Mount Olive, N.C., vegetable farmer, faced liquid fertilizer prices 40 percent higher than the previous year.

Energy prices are at their highest point since the oil shortages of the 1970s. The average charge for regular gasoline on March 20 was $2.50 per gallon, according to the federal Energy Information Administration. Though prices have stabilized after shooting past $3 per gallon immediately after the hurricanes, this is still a 40-cent, 18.7-percent increase from the previous year. The agency announced in January that it expected gasoline prices to keep on climbing for the first half of 2006.

Like most other modern industries, the gears of the food production chain are greased with fossil fuels. Individual farmers are perhaps the most vulnerable of the bunch, but all participants of North Carolina's highest-grossing industry, including processors and distributors, are affected in myriad ways not obvious to the average consumer whose only encounter with a hog is with a fork and knife.

Fossil fuels are so essential to producing cheap and abundant food that it takes 400 gallons of fossil fuels to feed the average American for a year, according to a study by David Pimentel, professor of agriculture and life sciences at Cornell University. The average car in the United States burns 600 gallons of gasoline annually.

"The last time people were worried about energy was in the late 1970s," said Gary Bullen, an extension specialist in the Department of Agricultural and Resource Economics at North Carolina State University. "Until recently, the increases hadn't been enough to have a big effect."

Now people are worrying again, producers and experts said. The 1970s price shocks turned out to be short-term shortages, but the current rise in energy prices has been going on for several years already. And that means that eventually, with time, the effects will trickle down to consumers.

**Why is energy expensive?**

"The problem is not that oil is running out. There will probably still be oil left even 100, 200 years from now," said Gerald Cecil, professor of physics at the University of North Carolina at Chapel Hill. "The problem is that the rate of supply can't match the rate of demand, and that difference is what will drive the upward swing in price."

Cecil has developed and taught courses about an imminent drop in oil production and its possible impact on society, a theory also known as Peak Oil. Peak Oil theorists usually expect the world to pass its peak level of production shortly before or after 2010, leading to staggering jumps in the price of fuel and dire consequences for industrialized societies.

Since the 1950s, the theory was kept alive mostly by scientists, who engaged in heated debates with their critics (often economists) about the likelihood of an energy shortage. But it took Hurricane Katrina to bring one-fourth of the nation's crude oil production to a halt and hit Americans with $3-per-gallon gasoline for the theory to gain mainstream attention.

The media began writing about the debate surrounding Peak Oil and gave airtime to people like Matthew Simmons, a former Bush administration energy adviser who warns that Saudi Arabia is running dry. On Capitol Hill, Reps. Roscoe Bartlett, R-Md., and Tom Udall, D-N.M., formed the bipartisan Congressional Peak Oil Caucus in October.

The post-Katrina scare also coincided with the release of a report by the U.S. Army Corps of Engineers that concluded, "[T]he oil market will remain fairly stable, but with steadily increasing prices as world production peaks. … After the peak is reached, geopolitics and market economics will result in significant price increases above what we have seen to date."

Even Chevron, the second-largest U.S. oil company, ran its "Will You Join Us?" series of advertisements last year, saying, "One thing is clear; the era of easy oil is over."

Still, many remain unconvinced that the world will face an energy shortage and expect that higher energy prices will encourage companies to develop new energy sources such as an ore called "oil shale." High prices are also the incentive to drill oil from previously uneconomical locations such the Caspian Sea and the Brazilian shore, say the critics.

But if “peakists” and their critics disagree on the matter of energy supplies, they agree on the outlook for global demand; the oil thirst of the developing world, led by China and India, is a permanent trend. “World energy consumption is projected to increase by 57 percent from 2002 to 2025,” said a report released last year by the federal Energy Information Administration.

Cecil agreed that the demands of developing countries are a major inflation pressure but said it wasn’t the whole story.

“People put a lot of blame on China, but Americans just drive more and more each year,” he said. “We drive 11,000 to 13,000 miles per year per person. … We’re desperately trying to burn it up before the Chinese burn it up.”

With about 5 percent of the world’s population, the United States consumes about a quarter of its fossil fuels. “Americans are addicted to oil,” President Bush declared in this year’s State of the Union address. Bush’s Advanced Energy Initiative, as outlined in the speech, is a long-term plan for kicking the habit. Though driving less was a not a suggestion, he called for a 22-percent increase in research funding for “clean energy” such as solar and wind power and a 75-percent reduction of Middle Eastern oil imports by 2025.

**Fossil Fuels into Food**

But how much can food producers cut down on fossil fuel use when they need it to feed everybody? The miraculous yield increases of the 20th century would have been impossible without such a versatile, potent and (previously) cheap energy source.

Farming changed significantly during two decades starting in the 1950s with the widespread use of commercial fertilizers made with natural gas and of fuel-powered machinery, said Bullen of N.C. State.

"The efficiency increase in agriculture was exponential," he said. "Yield increases were significant, farm sizes got bigger, food prices came down. The government policy is cheap food."

One U.S. farmer could feed 2.5 people at the dawn of the $20^{th}$ century; by its end, one farmer was feeding 130 people, according to the National Academy of Engineering. Thriving on the abundance of food, the world population swelled from 2 billion to more than 6 billion during the past century alone.

Fossil fuels contribute to farming through chemicals or machines. Synthetic fertilizers can supply more than 60 times more nitrogen to the soil than the same amount of manure. Irrigation systems powered by electricity or diesel made much of the arid Western states arable and tripled crop yields in the Great Plains.

Farm machines such as tractors and combines have automated nearly the entire farming process from planting to harvest. A person can take a whole day to shuck 100 bushels of corn, while a modern combine does the job in five minutes and shells kernels to boot, according to the National Academy of Engineering.

But even more energy is spent on food after it leaves the farm for processing, packaging and transport. Pimentel of Cornell University, who has studied energy use in food production for more than two decades, has found that only 10 percent of the energy needed to make a can of corn was used on the farm. Packaging costs alone were one-third of the total energy budget, according to his research.

In the United States' national-scale food system, transportation is a significant energy input. Studies have found that distribution accounts for up to 11 to 12 percent of the food industry's energy use. According to John Hendrickson of the University of Wisconsin at Madison, fresh produce travels 1,500 miles on average. Milk and eggs usually stay within 50 to 75 miles.

**Fossil fuels at work**

Maple View Farm is the food production process in a nutshell – or rather, a milk bottle. For more than nine years the Nutter family has raised its cows, processed and packaged its products and sent out its trucks on delivery.

The Nutters first came to the farm in 1963 but only branched out into processing and distribution in 1996. Roger Nutter, manager of the on-site bottling plant, said it was the family's only choice for breaking away from increasingly lopsided contracts with agribusinesses and remain in the farming business.

With 15 employees, the farm produces 7,500 gallons of milk every week for about 60 local restaurants and supermarkets. Bookkeeper Muffin Brosig said the farm was now 35 percent more labor-efficient than it was in the beginning because of technology.

Like most modern farms, little would get accomplished here without fossil fuels, as nearly every step of the process, including milking, bottling and storage, has been mechanized or automated.

"For this size, we use more energy than other dairy farms," Nutter said. "The dairy farm has the same energy use as others, but processing takes a little more energy, and the biggest is delivery."

On the dairy farm, about half of the 250 Holstein cows on the farm are milked three times a day by electric machines that suck up to eight gallons of milk out of each cow. Electricity is the cheapest form of conventional energy and has shown the most stable price.

What's left are the tractors that haul the cows' feed, the hay balers and the chopper for corn and barley. Trucks are sometimes used to haul silage, fermented grains used for fodder. Farm machines run on non-highway diesel, which is slightly pricier than gasoline even without a 30-cent road tax added to its cost. Nutter said he fills up two 1,000-gallon diesel tanks once every two weeks during the winter and more often during the spring and summer.

Nutter doesn't need chemical fertilizers for crops, which are a major concern for many other farmers. On average, fertilizers accounted for about 28 percent of a farm's energy use in 2002, according to a study by Iowa State University economist John Miranowski. Diesel fuel was second, at 27 percent.

Up to 90 percent of the cost of making nitrogen fertilizer is from natural gas. The Energy Information Administration's "Short Term Energy Outlook" report for March showed that the average price for natural gas this year was expected to be 17.4 percent higher than in 2004. Farmers said that some types of fertilizers cost up to 40 percent more.

But expensive energy spares nobody, Nutter said. New expenses for grain farmers could eventually cause Maple View to pay more to buy soybean meal and ground corn for its animals, though it is difficult to say exactly how much of that increase came from energy costs.

The next step in milk production is processing and packaging. Maple View Farm's 6,000-square-foot milk-bottling plant sits right next to the barns and processes the milk into a form acceptable to the modern consumer and state dairy laws.

Among the various machines, the pasteurizer burns the most fuel to maintain a temperature of 160 degrees for 30 minutes at a time, Nutter said. The procedure is vital for killing microorganisms and guaranteeing food safety.

Inside the homogenizer, high pressure forces the liquid through small nozzles to blend fat molecules, preventing the formation of a cream layer. The bottle washer and the 3,000-gallon milk tanks also require 160-degree water for cleansing. The boiler burns 30 gallons of diesel every day.

The bottling machines, refrigerators and freezers run on electricity. The plant requires $5,000 worth of energy every month, which bookkeeper Brosig said was 1 to 2 percent of total costs.

Once again, while direct energy expenses can be tallied, the indirect costs don't show up so neatly on paper. Some suppliers add a fuel surcharge to the price of goods when gas prices spike. Nutter's new extra charges for sugar, milk powder and even employee uniforms ranged from $5 to $15 per delivery, to say nothing of the 15-percent increase in plastic cap prices.

Milk is relatively energy-efficient when compared to more highly processed foods, according to Pimentel. For example, one kilogram each of instant coffee and breakfast cereal require 54 times and 44 times more energy to produce than the same amount of milk. The differences come from processes such as grinding, milling, drying and baking.

Distribution is where Nutter found it easiest to reduce energy costs immediately, by reducing the longest trips to stores in Cary and Raleigh from twice to once a week. That cut 10 percent off the company's fuel bill, Brosig said.

Otherwise, everything in the plant that can run on electricity already does, and not much economizing can be done on the dairy farm, Nutter said.

He had tried to pass on some costs but failed. “We were going to add a little surcharge for delivery to the grocery stores,” he said. “But the groceries wouldn’t allow it.”

Therefore the company must save energy and sell more product. Brosig said Maple View Farm has not raised prices even while competitors’ milk prices went up more than 20 percent during the past year. The new cost-competitiveness led to a 15 percent increase in sales volume, she said.

The new sales have helped the company handle the pressure of high energy prices so far. Brosig said that profit margins had slipped somewhat but not to the point that she is overly concerned.

**Implications for the N.C. food industry**

Food producers and experts said it was too early to gauge the exact effect of expensive energy on the industry as a whole. It may also be too soon for consumers to notice any major changes in the supermarkets. But many producers expected energy costs to become an increasingly difficult issue, one over which they have little power.

Food may well be as vital to the N.C. economy as energy is to food. Agriculture is the state’s largest industry; in 2002, the farming, manufacturing, wholesaling and retailing of food accounted for $45.3 billion, or more than 15 percent of the gross state product, according to a report by professor Mike Walden of N.C. State.

Therefore, many people are surprised to learn that the soils in the state are “naturally infertile,” said J. Paul Lilly, associate professor emeritus of soil science at N.C. State. “If you look at pictures that were taken of cropland and wasteland in North Carolina in the ’20s and ’30s, one thing will strike you – how little growth is on the land. The landscape right now is the most luscious it has ever been, ever.”

Crop production became sustainable only with the advent of synthetic fertilizers in the late 1800s, according to an article titled “N.C. Agricultural History” that Lilly wrote for the state agriculture department’s Web site. North Carolina farms reaped 11.5 bushels of corn per acre in 1883. But armed with agrochemicals, machinery and engineered seeds, the state’s farmers were able to increase their output to about 95 bushels per acre, according to the article.

Some worry that the recent hikes in energy costs could make some farmers unable to keep working such miracles. “Productive farmland in this state could be left untended next spring, the result of high diesel fuel costs and related farm input costs that are putting profit beyond reasonable possibility for some farmers,” said Larry Wooten, president of the nonprofit North Carolina Farm Bureau, in an online column written in December.

With farm costs trickling down to grain prices, the state’s livestock industries could also see a major jump in production costs. Poultry and hogs are the state’s most important food products. One reason these could successfully compete with meat from other states was cheap transportation; 60 percent of livestock feed comes from the Midwestern Corn Belt states, mostly by train.

More food producers could soon reach their limit for absorbing energy costs and begin raising prices. This year, the federal Department of Agriculture expects to see a food inflation rate of 2 to 3 percent “as retailers pass on higher energy and transportation costs to consumers in the form of slightly higher retail prices,” according to a January report.

However, the average rate of increase in food prices for the past decade was 2.6 percent, with each year's inflation pressures coming from factors such as weather, international trade, labor availability and outbreaks of plant and animal diseases.

On the other hand, the decline in the importance of farm prices to consumer retail prices and intense price competition among retailers were some of the reasons that kept inflation low, according to studies by the government and the Food Marketing Institute, a trade association of food wholesalers and retailers.

So although food inflation may be driven by a different factor this year, consumers may not be able to tell the difference in the checkout lane.

But prices will likely climb in the long run, said Simon Rich, former CEO of Oklahoma City, Okla.-based Louis Dreyfus Natural Gas. "The [energy] market's saying prices are going to stay up and probably go higher," he said.

Eventually, with farmers facing prices 30 to 40 percent higher for their fossil fuels, the higher costs would trickle down to the consumers, Rich said.

And as energy prices affect all steps of the food chain, higher farm expenses are not the only inflation pressure on food. The Associated Press reported in November that Kraft Foods raised prices on products such as Nabisco cookies and frozen pizza by an average of 3.9 percent because of mounting energy and packaging costs.

The federal government is turning greater attention to the dependence of food production on fossil energy. The Department of Agriculture announced in February that it would earmark $85 million for energy-related projects during the fiscal year beginning Oct. 1, a 27-percent increase from the previous year. At the same time, the total budget for the entire department dropped by nearly $3 billion to $93 billion. The funds will support research on efficient production technologies and renewable energy sources, the agency said.

Some producers are already exploring ways to distance themselves from the volatile fossil fuel market. Piedmont Biofuels of Pittsboro, N.C., is planning to build a 1 million-gallon-a-year biodiesel plant for refining used cooking oil into fuel, said Vice President Lyle Estill. The group is probably the largest biodiesel cooperative in the country with about 230 members, he said.

Earth Fare, an Asheville, N.C.-based organic- and health-food supermarket chain, has been packing its bakery and deli items in plastic containers derived from corn instead of petroleum since 2004. Making these containers requires only half the fossil energy of plastic packaging, according to a company statement.

**Hitting close to home**

When N.C. labor ceased to be cheap for businesses, manufacturers moved their factories to other countries in search of low wages, as many in the state know the hard way.

But manufacturers can't bring down energy costs by going abroad. Energy in other countries is not necessarily cheaper than in the United States, especially gasoline. Since expensive fuel drives up transportation costs, moving production farther away from consumers could backfire on producers.

In other words, the solution is likely to be found not in a faraway country but close to home. Experts such as Pimentel suggested that food production could become increasingly localized as transportation costs climb. Consumers will prefer local produce over lettuce from California should fuel prices cause the latter to lose its price advantage.

And when it comes to food, there is also the small matter of freshness and nutrients.

"We can import a lot of things like shirts and shorts," said Wise. "But you can't really import fresh strawberries from China."

Wise is one of the few farmers who can set their own prices. At his vegetable stall at the State Farmers' Market in Raleigh, he has raised the price for some products by about 25 cents per pound, "just enough to cover some expenses."

The former schoolteacher said that he expected to see more producers raising prices.

"Some of the farmers haven't, but I don't know how long they can keep doing that. We try to stay reasonable, but some things have to go up. … Americans will have to start paying more for food."

## Article Two

## The High Cost of Making Food

Rising energy prices are pushing the food industry toward a "tipping point" that could put farmers out of business and raise consumer prices, said food producers and industry experts.

Energy costs are dealing the last blow to some farmers who have struggled with mounting production costs for years. Food companies soon might agree that this is the time to raise prices for their products – and make them stick. Farmers' and processors' attitudes toward energy are changing as its price ceases to be either cheap or stable.

Energy prices will "reduce the number of farms, just like small companies are going to fold," said Jerry Hardesty, director of education and development for the nonprofit North Carolina Pork Council.

Large companies are faring better, cushioned by immense reserves of capital and multiple revenue sources. But agribusinesses have begun to pass on their costs to consumers to maintain profit levels, something they been loath to do in the face of competition.

Fossil fuels such as natural gas, oil and coal play a crucial role in creating food today. These nonrenewable resources provide heat for animals and greenhouses, create the agrochemicals used to enrich soils and run the powerful farm machines that perform in a matter of minutes the jobs that could take a human a whole day.

Fossil fuels also provide the energy that makes the processing plants go round, churning out a dizzying variety of packaged or pre-cooked foods that can be transported thousands of miles, stored for long periods without spoiling and conveniently prepared in a matter of minutes.

The prices of such important resources are edging upwards. According to the federal Department of Energy's latest "Short Term Energy Outlook," released in March, natural gas prices rose from $5.70 per thousand cubic feet during the first quarter of 2005 to $7.59 this year. The department expects to see an average price of $9.13 for the first quarter of 2007. In other words, natural gas prices will have jumped 60 percent within two years.

Diesel prices usually trace a similar trajectory to gasoline, including its sudden spike during the post-Hurricane Katrina scare of 2005. Diesel averaged $2.58 per gallon on March 20, a 34-cent, 15-percent increase from the previous year.

Electricity rates have remained relatively flat in comparison despite higher coal prices – so far. Last year, the state Utilities Commission approved a 7.5 percent increase in Progress Energy Carolinas' industrial rates, half of what the company said it needed to recoup its higher energy costs. In March, Duke Power requested a 13.4 percent rate hike, saying in its application that contract coal prices had jumped 70 percent within the past two to three years, including transport costs.

**Energy prices hit the farm**

Julian Barham, a hog and tomato farmer in Johnston County, N.C., said that energy prices would be the ruin of many farmers if prices kept on climbing like they had for the past couple of years.

He also didn't expect most farmers to get out of the business while they could. "On the farm, it's your job, it's your home, it's everything you've got," he said. "Farmers have a tendency to ride the whole thing down into the ground."

The corner of Barham's mouth tends to edge upward while saying the grimmest things, but his eyes remain devoid of humor.

Barham runs a large-scale hog operation under contract with Prestage Farms, a pork and poultry producer. His role in the hog business is to breed his 4,000 sows to produce the piglets sold when they are three weeks old to "finishing farms" for fattening.

Pigs and poultry need heating when young. Barham's hog houses burn 20,000 gallons of liquid propane gas annually. Those prices went from $1.09 per gallon to $1.49 this year, he said. Other costs for livestock are lighting and ventilation, both from electricity.

Dan Kerns, co-owner of a McLeansville, N.C., poultry hatchery that produces 6 million hatching eggs annually, estimated that energy now takes up 15 percent of his costs, up from 10 percent last year.

Barham built his first tomato greenhouse in 1999 to make use of his hog lagoon water as fertilizer. The tomatoes are sold either on-site at the farm or to grocery stores. The greenhouses require 75,000 gallons of propane a year. The irrigation system for his lagoons run on 30 to 40 gallons of diesel a day.

But he still needs $2,300 worth of fertilizers every month. "When we started it, fertilizers were nothing," he said, shaking his head. "Nothing."

Now fertilizers are certainly something, especially for vegetable growers like Gary Wise, who tills a 50-acre farm with his family in Mount Olive, N.C. Fertilizer prices have gone up 25 percent to 40 percent since last year depending on the type, Wise said.

This was largely due to the jump in prices for natural gas, which accounts for up to

90 percent of the cost of making nitrogen fertilizers. On average, fertilizers are the single largest energy input on U.S. farms, according to a study by Iowa State University economist John Miranowski.

Fertilizers are vital for farming the "naturally infertile" land of North Carolina, said J. Paul Lilly, associate professor emeritus of soil science at North Carolina State University.

Another important material for vegetable farmers is plastic, which is spread over the ground to keep moisture in and weeds out. Plastic is made from resin, a petroleum derivative, and Wise said its price has risen about as much as fertilizer.

Though energy is commanding more attention from producers as its costs rise, labor is still typically the bigger, if not the biggest, of farm expenses. Barham said he spends about four times more money on labor than on energy and that wages go up at a more or less predictable rate every year.

The lack of such predictability is what makes energy inflation the "scariest," Barham said. "This fuel, it climbs all of a sudden like that and it scares you. Labor in the last ten years has gone up as much as fuel did in two years."

Farmers feel pressured by energy inflation also because they have virtually no chance to pass on the new costs to others, said Robert Ford, executive director of the North Carolina Poultry Federation.

Few farmers can set their own prices. Most of the time, the businesses they sell to do it for them. In the case of livestock, the company writing the contract often sets a price that holds for four to five years.

Some said that the sense of powerlessness on the part of those paying the bills also breeds anxiety. "Energy costs are really something [producers] have no control over," said

Hardesty of the Pork Council.

Wise echoed that thought as he unloaded turnips, collards and sweet potatoes from his truck at the State Farmers' Market in Raleigh, N.C. "If labor goes up, you can finagle that a little bit. You can't cut back so much on your gas."

The "tipping" that Barham spoke of may already have begun on smaller farms. Barham said he knew several tomato growers who recently shut down their greenhouses in the face of heating costs nearly 50 percent higher than the previous year's.

Not all farmers said they felt so much pressure. Kerns said energy was still a small part of his costs.

Kerns said his bigger energy-related concern was that government initiatives could direct more corn into the production of ethanol, an alternative fuel for vehicles.

"If there is a mandate that X percent of biofuel be put in our gas tanks, that could cause a shortage of chicken feed," he said. "And if there is a price increase in the cost of animal feed, not just chickens but beef and swine and anything, that would cause our price to be less competitive worldwide."

Less corn might be produced to begin with, said Geoff Benson, professor of agricultural and resource economics at N.C. State. He expected that corn farmers, who face the decision of whether to plant more corn or soybeans each spring, will favor the latter this year.

Corn soaks up 100 pounds of fertilizers per acre and is one of the crops that need the most chemicals. Legumes such as soybeans and peanuts require much less because they can fix their own nitrogen from the atmosphere.

Corn prices remain stable so far, but that could change in the future, said Professor

Kelly Zering of N.C. State. “Higher fertilizer costs will drive up the cost of all the grains.”

Another energy-related inflation pressure on grain prices would be transportation costs, as about 60 percent of the state’s livestock feed is brought from Midwestern states.

Such problems could prove to be major challenges for N.C. agriculture, especially as a livestock farmer’s largest cost is often feed. Poultry was North Carolina’s biggest farm commodity as of 2004, including broilers and turkeys. Hogs came in second, and greenhouse/nursery crops were a distant third, according to the state agriculture department.

**Coping with the costs**

Despite their concerns, farmers said there wasn’t much they could do in the short term to offset the energy expenses.

“I absorb it,” said Kerns. “It’s increasing my costs, and I’m not getting reimbursed for it.”

Like many other livestock farmers, Kerns grows his birds on contract. He said it was likely that the agribusinesses would eventually step in with financial support, but that it would “take a little while.”

Wise, the vegetable farmer, knows he has no influence on energy prices or the requirements for growing his crops. So he has decided to change what he can – acreage.

“I used to have 12 acres on plastic. I’m cutting down because of that to 6 or 7 acres,” he said. “If [production costs for vegetables] used to be $1,000 per acre before, it’s probably going to cost $1,600 an acre regardless of what [the crop] is. Squash, cucumbers, peppers, eggplants … I got to try to make a living, you know.”

Ford of the Poultry Federation also said it was hard for farmers to reduce their energy bills. “You just have to bite the bullet and buy it,” he said.

Ford suggested that producers could take small steps such as using better insulation for their animal houses, as “the little things add up.”

Farmers said it would help if agribusinesses would raise their buying prices but were generally pessimistic about the chances of that happening soon.

Instead, some companies are covering more of their growers’ costs. Tyson Foods, a leading meat and poultry producer, said in an October statement that it would give a total of $26 million in supplemental fuel payments to its 6,800 broiler growers across the country in November and February.

But none of those interviewed for this article said they knew of any agribusinesses that had stepped in so far to assist their growers.

Theoretically, farmers could shield themselves from fossil fuel prices by not using them. But it’s not as simple as it sounds, Barham said. He found that bermudagrass, a hay crop, didn’t burn strongly enough to heat the greenhouses. He is now thinking of using wood.

For the swine farm he considered using coal as a messier but cheaper substitute for propane gas. But the thought of plunking down money for new equipment made him balk.

Barham said he might revisit one of his earlier attempts at making energy – generating electricity from hog manure in a biogas digester. He started making his own electricity in 1996 but stopped two and a half years ago because the costs outstripped the savings. Now he hopes that reselling such electricity back to the utility companies will be profitable under state green energy laws.

The self-proclaimed “experienced optimist” said he expected to hold out longer than most other smaller farmers due to his size. But he was quick to say that he was barely keeping his head above water.

This year, it is likely that "overall net farm income will be reduced significantly," said Geoff Benson and Charles Safley of N.C. State, in a presentation on agricultural energy usage made for educational purposes.

The researchers suggested several ways that farmers could weather the impact, such as postponing non-essential investments, seeking income sources off the farm and reducing family living expenditures.

"None of these strategies are appealing but may be necessary," they said.

**Fossil power in processing**

Farms are the first and fundamental step of food production. But much of America's food no longer comes straight from the farm. Eighty percent of the nation's food is processed, a procedure that usually requires several times more energy than is needed to grow it, said David Pimentel, a Cornell University professor.

The main energy uses of processing are electricity for machines, lighting and refrigeration, and natural gas for heating and cleaning. Electricity is the more important energy source in factories, unlike on the farms, where natural gas and propane are consumed in much larger amounts.

Obviously, the more processing involved, the more energy involved. Ford of the Poultry Federation called pre-cooked food products such as Chicken McNuggets an example of "energy added" translating into "value added." Others such as Pimentel said that much processing is excessive, deploring it for wasting food and degrading nutrients while using up energy.

More food manufacturers are turning their attention to energy issues, according to a January article in *Food Processing*, a monthly trade journal. The magazine's annual Manufacturing Trends Survey found that 18 percent of 465 food makers across the nation considered energy to be their biggest manufacturing concern this year.

Energy was second only to food safety (30 percent). Last year, energy had been ranked fifth, with 16 percent of respondents saying it was their biggest concern.

Three out of four manufacturers said they had been "moderately impacted" by the rise in energy prices, and another 13 percent had been "severely impacted."

"There's a margin going down the drain," said Tommy Neese III, president of Greensboro-based Neese Country Sausage, describing how energy prices had affected his bottom line.

Neese's company processes about 6,000 pounds of pork every day into products such as sausages and liver pudding, and distributes directly to supermarkets in North Carolina, South Carolina and Virginia.

Neese said it was difficult to save on energy at the plant, especially where sanitation was involved. "If it takes 10 minutes to physically clean a piece of equipment [with hot water], you can't cut down on that," he said. He was also skeptical about whether alternative fuels would work for his machines.

Administrative offices offered more opportunities for cost cutting, in Neese's view. "You walk into an office and the lights are running full blast," he said. "It's just waste, and it's the hardest thing in the world to control."

Raising the prices for his products would be another way of making up for energy expenses. But not all manufacturers have price-raising power, said Neese.

“These companies that we deal with are pretty powerful,” he said. “They specifically said that if I choose to have a price increase on my product, I cannot use fuel as a reason.”

**The benefits of size**

Though the *Food Processing* survey showed that more manufacturers worry about energy than before, the numbers were lower than had been expected, wrote David Feder, managing editor of the magazine and author of the related article, in an e-mail. Only about one-fifth of respondents responded that energy was their biggest concern this year.

Manufacturers may feel less urgency because the energy costs of processing make up only a fraction of total food-making expenses. According to the federal Department of Agriculture, only 3.5 cents of every dollar spent by consumers on food in 2000 covered energy use in processing.

Meanwhile, 8.1 cents went into packaging and 4 cents into transportation. These figures include energy costs in the form of plastic packaging and running fleets of refrigerated trucks.

Therefore, energy may be crucial in production but is still only one of numerous factors that affect corporate profits. For example, even though heating costs are going up on chicken farms, consumers can expect to see depressed poultry prices for some time because of consumer wariness over avian flu, said Ford.

Large companies in particular have multiple operations that affect profits, so that losses in one aspect of business are often muted by gains in another. The first-quarter bottom line for Smithfield Foods, the world’s largest pork producer, was influenced by myriad factors ranging from high material costs for the company’s Polish operations to a “strong holiday ham season," according to its latest quarterly report to the Securities and Exchange Commission.

Higher energy costs for processing and transportation were said to have eaten into the company's profits from pork, but were not given special emphasis. The biggest factor that cut the company's quarterly profits to $145.1 million, a 20.8-percent plunge from last year, appeared to be a 21-percent drop in live hog prices.

In general, information on food manufacturing as a whole is more difficult to come by than for farming. No government agency tracks that particular sector like the agriculture department covers farms, nor do universities devote entire departments to its study. Industry analysis reports are available from private consultants, but for hefty fees. Corporations are reluctant to discuss the details of their operations.

But several major food companies have dropped hints about the impact of energy prices in their SEC filings. For example, Kraft Foods' latest annual report stated that the company sustained "significant impacts" from higher coffee, nuts, energy and packaging costs, which have "adversely affected earnings."

"The Company expects the higher costs environment to continue, particularly for energy and packaging," the report said.

While many companies that mentioned energy as a concern did not elaborate on the subject, the most recent quarterly report by Del Monte Foods was relatively detailed in its assessment.

In the report, Del Monte stated that inflated production costs were "reflective of the higher oil and natural gas prices which have a pervasive impact on our costs, including transportation, packaging and raw product."

The company has been able to cover much of those new costs by raising its prices, along with cost-saving efforts, according to the document. Higher prices boosted revenues for Del Monte's consumer products by 5.1 percent to reach $1.8 billion, even with losses in sales volume.

This increased the company's gross margin from 25.8 percent to 26 percent. The gain from higher sales was initially 3.2 percentage points, but was offset mostly by a 2.7-point loss "related to higher energy, logistics and other transportation-related costs, as well as higher steel and fish costs," the report said.

More and more food makers are claiming that energy costs are tipping them in the direction of raising prices, said Dave Fusaro, editor-in-chief of *Food Processing*.

Companies have been largely unsuccessful in raising prices and keeping them there, Fusaro said. A recent example was Kraft Foods' attempt in October, which the company attributed to higher energy and packaging costs. Fusaro said the company soon backed down after losing market share to cheaper store-brand products.

But a consensus among food manufacturers could make those new prices stick. "There appears to be building momentum [for industry-wide price increases]," Fusaro said. "They've been swallowing a lot of costs over the past couple years, and the energy thing was like the last straw."

Fusaro considered it significant that the heads of several food companies had openly announced at a conference of financial analysts in late February that their prices would have to go up. Previously, raising prices had been a "do-it-quietly-and-hope-nobody-notices" kind of affair, he said.

Many of those interviewed said it was too early to predict the exact influence of energy costs on prices or the availability of certain foods. Zering of N.C. State said that permanently high energy prices could lead to a reduction in the national supply of meat. Shorter supply could in turn cause meat prices to climb, encouraging producers to make more.

But it would take time for consumers to notice the changes, he said. "If a farmer makes a decision today, that decision won't show up at the meat counter until a year from now."

**Changing attitudes in a new world**

Most of the food producers and experts interviewed said there wasn't much that farmers and processors could do at this point to ease the burden of energy costs.

As for long-term ways of cutting energy expenses, producers were generally skeptical about alternative energy sources and hesitant about paying the up-front costs for the required equipment.

The expensive energy situation is "kind of a new world," said Gary Bullen, an extension specialist at N.C. State. The main difference with the short-term "Oil Shocks" of the 1970s is that this time around, it doesn't look like it will go away soon, he said.

But Bullen suggested that this new world may not be new enough. Even current energy prices, though high by the standards of merely one year ago, could be low enough to breed complacency, he said.

"[Gasoline] had to go to $3 a gallon for people to say, 'This is expensive.' I'm thinking that $2.20 isn't an issue for folks."

On the hog farm, Barham agreed that current price levels were sustaining the status quo. Should they fall, farmers could breathe easier; should they rise, the situation would get so bad that someone would have to take notice and do something about the prices, he said.

"I really don't want to see the fuel prices stay here," he said. "It's got to move, one way or another. Here, it's painful. … It's terrible to say, but somebody's got to cry uncle. If things get bad enough, things will change for the better."

The problems of the new world had their roots in the old, he said.

"When I was a kid, nobody thought about the price of gas. It was so cheap. Maybe that's the problem with this country."

## Article Three

## Energy Prices Trickle Down the Food Chain

Masako Satake noticed the price of canned soup in the supermarkets go up quickly last fall after Hurricane Katrina, "at the time that everyone was rushing to the gas stations" to fill up in case fuel ran out.

"I thought it was because of the gas prices," said Satake, a native of Hickory, N.C., and a returning student at the University of North Carolina at Chapel Hill. "It would have an influence on products that are heavier and transported by truck."

Satake's observations point out two truths – that transportation costs affect the price of everything and that supermarkets are where many consumers see the effect of energy prices on the food industry.

Getting food to the consumer is a crucial job in America's nation-wide food production system. Distributors supply the nation with a more or less uniform supply of good eats all year long using huge fleets of diesel-powered trucks. On any given day, a grocery basket can contain apples from Washington, Swanson frozen dinners made in an Arkansas factory and mangoes shipped in from Mexico.

Restaurants and supermarkets bring food directly to consumers, racking up heating bills for cooking and refrigeration costs to keep products fresh. They are nearly equally important to American consumers, who now split their food expenses almost evenly between restaurants and supermarkets, according to the Food Marketing Institute, a trade association of food retailers and wholesalers.

The effects of high energy prices on food begin stacking up at the farm, accumulate along the way and finally pool at the retail and restaurants level. These businesses then must decide whether to pass on the new costs to consumers.

They proceed with caution because price hikes can scare customers away. “Consumers, they have more options,” said Chip Stamey, owner of Greensboro-based Stamey’s Old Fashioned Barbecue. He said that consumers could easily go to another restaurant on the block, while businesses that deal with each other cannot make such changes as quickly.

Therefore, businesses usually absorb the added expenses for a while before attempting a price hike on the end user. “Eventually, we pass on to the customers, but not immediately like [the suppliers] do,” said Stamey, who recently raised his menu prices by 15 percent because higher energy prices were cutting into his profits.

Still, the U.S. Department of Agriculture does not expect to see a sudden jump in food prices. In a February report titled “USDA Agricultural Baseline Projections to 2015,” the agency said that food prices would rise at a slower pace than the general inflation rate. Highly processed foods such as cereals and bakery products would go up only slightly faster.

Those in the food industry may be uncertain about when and how to mark up their consumer prices. But they know one thing for sure; high energy prices are raising the cost of doing business.

**The travels of food**

The sight of huge trucks rolling down the nation’s highways is a familiar one. Many of these are part of the nation’s food distribution system, a “logistical achievement” that delivers billions of items a week to more than 100,000 retail food stores across the nation, according to the Food Marketing Institute.

Studies have found that fresh produce in the United States moves 1,500 miles on average from farm to plate. Mounting transportation costs for this long-distance travel could soon show up on price tags.

“Gas prices are expected to drive price increases across a multitude of product categories as a result of higher distribution costs,” said a report by Information Resources Inc, a sales and marketing research firm specializing in consumer goods.

For businesses, delivering food in North Carolina is less cost-efficient than in some other states because of its low population density, said Steve Hall, president of Hickory, N.C.-based Merchants Distributors Inc., the state’s largest food distributor.

“There’s 40 million people between Boston and New Jersey,” he said. “Here, there’s 10 million people spread over a much bigger expanse of real estate.” Therefore, longer distances must be covered to reach the same number of consumers.

Distributors said they were impacted by higher costs for diesel, which powers delivery vehicles and their refrigeration systems. Diesel prices follow those of gasoline closely while usually staying slightly higher. Prices averaged $2.58 per gallon on March 20, a 34-cent, 15-percent increase from the previous year.

Fuel prices are “absolutely” a concern, Hall said. Hall’s trucks burn about 70,000 to 75,000 gallons of diesel every week. On top of that, food manufacturers seem to charge more for their products at a faster rate of increase than before, he said.

To make up for the costs, Merchants Distributors uses a formula to compute its surcharges for grocery stores based on the price of fuel. “Nobody really wants to raise prices, but the costs get passed along to us, and it goes all the way downstream to the consumer,” Hall said.

Hall said he considered fuel a major expense. Transportation, including fuel, driver wages and the cost of new vehicles, makes up 20 percent of operating costs. Running the company’s 1-million-square-foot warehouse accounts for most of the remainder, he said.

Sysco, the world’s largest distributor to foodservices, cited fuel prices as one factor that drove down its profits in the latter half of 2005. In its latest quarterly report to the Securities and Exchange Commission, the company reported that its net earnings for this period dropped 10 percent from one year before.

Even though sales increased 7.5 percent from the previous year during this period, higher operating costs ate into the profit margin, the company stated.

Fuel cost the company about $27.6 million more than it did for the same period last year. But energy prices were not the biggest cost increase for the company. The extra fuel expenses were less than half of the news costs incurred by changes in accounting rules for employees’ stock compensation plans.

Though fossil fuel prices are higher than before, they are still cheaper to use in vehicles than other energy sources. Biodiesel is an alternative fuel that any diesel engine can use without modification but does not save money. One gallon of B20, the blend of 20 percent biodiesel and 80 percent regular diesel most often used in trucks, costs 20 cents more than a gallon of diesel.

Eastern Carolina Organics LLC, a Pittsboro-based distributor of organic produce, uses biodiesel to run its trucks. Sandi Kronick, marketing manager, said the business is run as a cooperative of organic farmers and that its main goal is to make organic food more accessible to consumers rather than turn a profit.

The costlier price could be an important deterrent for many other companies. Hall said that Merchant Distributors is "absolutely" interested in identifying long-term energy-saving strategies and is studying the feasibility of using biodiesel and other alternative fuels.

"But they're quite a bit more expensive," he said.

**Restaurants**

Don Fisher spent the past two decades waging an "uphill campaign" to get restaurateurs into an energy-saving state of mind.

He doesn't have to try as hard anymore. Fisher, president of Fisher-Nickel Inc., a California-based engineering consulting firm that specializes in promoting energy efficiency in restaurants, said that at least 10 times more restaurant owners were taking steps to save energy than two years ago, judging from heightened demand for his firm's services.

Many of those restaurant owners were jolted into action by last year's hurricanes, which sent energy prices soaring. In September, a survey by the National Restaurant Association found that one in four restaurant owners considered energy prices to be the biggest challenge facing his business. Fisher said he had never seen such a result before.

Restaurants are one of the most energy-intensive of businesses and can use more than six times more energy per square foot than the average commercial building, according to an article to be published in the bimonthly magazine of the North Carolina Restaurant Association.

An eatery's major energy use is electricity, followed by natural gas. These power an establishment's cooking, storage and cleanup activities, while keeping customers comfortable through lighting and temperature management.

Labor is the most significant cost for restaurants, and the recruitment and retention of employees were traditionally their major concerns. But Hong Kim, owner of Oishii, a Japanese restaurant in Chapel Hill, N.C., said energy costs had affected even his labor situation.

"I had an employee from Raleigh who quit recently because it cost so much to drive back and forth," he said.

Chapel Hill is about 30 miles away from the state capital. The employee had decided that paying extra for gasoline was the same as taking a salary cut, said Kim, who is still looking for a replacement.

The other impacts of costly energy were more predictable. Kim pays delivery surcharges for items such as fish, because it now costs more to run fishing boats. A typical addition would be $10 for a $300 delivery, he said.

But as energy costs are only 2 to 3 percent of Kim's costs, he said they did not affect his business too much. He was more worried about the effect of gasoline prices on customers, as fuel prices would discourage people from driving to a restaurant.

"Customers feel pressured by high gas prices," he said. "Our sales have slowed down, and the other restaurants around here say so, too." Kim said things were especially bad when gasoline surged past $3 per gallon, as he saw his revenues drop by more than 10 percent.

This makes him reluctant to raise prices, which he has not done so far. Customers already paid more just to get to a restaurant, and he didn't want to add to the burden, he said.

But diners may already be adjusting to the new reality. According to advance data on retail sales released by the U.S. Census Bureau, total restaurant revenues for the first two months of 2006 were 8.3 percent higher than those of the same period in 2005.

Stamey's Old Fashioned Barbecue of Greensboro, N.C., has recently started charging its customers 15 percent more than before. Owner Chip Stamey said increased sales had recovered enough of his profits so that energy had ceased to be a major concern.

Stamey's two restaurants often are recognized in the media for serving some of the best Western-style barbecue around. Energy-wise, they differ from most other eateries by using wood for cooking, but they use natural gas for other heating purposes.

The price increase was his first in two and a half years, Stamey said. The decision was made when the effect of higher energy costs reached a "critical mass." Along with steadily increasing utility rates, the suppliers who brought him his sugar, ketchup and paper goods had been tacking on delivery surcharges for a year even before the hurricanes, he said.

"Katrina was just the second wave of the fuel mess."

Stamey said he installed a more energy-efficient hot water heater in September as a long-term way of saving energy. But Kim does not think equipment replacement is an option for him. It is too soon for that because he only started his business in 2003, he said.

Such a situation is common among smaller restaurants, said Fisher of Fisher-Nickel Inc. Major national restaurant chains, on the other hand, have the buying power to encourage equipment makers to produce more efficient machines at lower prices.

"The major chains – your Applebee's, your Chili's, your Burger Kings and McDonald's – are adopting tighter rules for the equipment used in their restaurants."

The savings from using better equipment can be significant even if the up-front costs are higher, Fisher said. For example, the best fryers are three times more efficient than the most wasteful ones.

**Supermarkets**

Supermarkets are the other important venue in which consumers meet food. Like restaurants, food retailers face the challenge of saving energy without making the customer think the store is dimmer, colder or otherwise unfriendly in any way.

Again, labor is the major operating cost for this industry. In 2004, employee wages and benefits took up 14.6 percent of a supermarket's total sales, while 1.2 percent paid for utility costs such as energy and water, according to the Food Marketing Institute.

In terms of energy use, supermarkets differ from other retailers because of their high dependence on refrigeration, according to the federal Environmental Protection Agency.

"Fifty percent of the [energy] bill is refrigeration," said Gina Rye, energy manager at Food Lion, a Salisbury, N.C.-based supermarket chain. "Twenty percent is lighting and the rest is mostly deli and bakery use."

The electricity bill for food stores was 17 times as high as its natural gas bill, according to an Energy Information Administration survey from 1999, the latest year for which data is available. (The results of the most recent survey have yet to be released.)

Electricity prices have stayed more stable than those of gasoline, diesel and natural gas, according to the agency. The average commercial rate for electricity rose 4.4 percent from 2004 to 2005. During the same period, the annual averages for gasoline and natural gas jumped 22 percent and 23 percent, respectively.

Due to the high reliance on electricity, the energy costs of stores are somewhat more manageable than other sectors of the food industry. Food Lion said in an October statement that it has cut its overall energy expenses by 3 percent since 2000 even while opening more stores.

The company implemented its energy management plan in 2000, Rye said. Since then, it has taken steps such as replacing old light bulbs with more efficient models and sending out a team of specialists to help stores that fall behind the company's energy usage standards. "Our analysis shows that if we had done absolutely nothing, we would have double the energy cost that we have right now," she said.

Food Lion has been repeatedly recognized by the federal Energy Star program for its energy awareness. Out of more than 1,300 stores run by the company in the Southeast, about 400 have earned Energy Star recognition, meaning that the building falls within the top 25 percent in efficiency.

Another energy-conscious grocery chain is Lowes Foods, which operates more than 100 stores, nearly all in North Carolina. More than 20 are Energy Star-certified, according to the Energy Star Web site.

Gary Watson, vice president of business support for Lowes Foods, said his company reduced its energy usage through measures such as installing motion detection lights, beefing up roof insulation and hanging plastic strips in coolers to keep cold air inside.

Rye said her company's energy savings will give it a competitive edge. "It will reduce overall company expense, therefore keeping [consumer] prices low."

But Watson said the advantages "wouldn't be that pronounced" as more companies were now turning their attention to energy conservation.

"A lot of retailers are doing the same thing."

Meanwhile, there is the possibility that transportation costs could cow consumers into staying at home rather than coming out to shop. But a study by Information Resources Inc. suggested that grocery stores have less to worry about than restaurants. Food retail sales increased when gasoline was moderately expensive at $2 to $2.25 per gallon because consumers shied away from restaurants and chose to stock up at the grocery store instead, according to the report.

And according to the Census Bureau, food and beverage stores saw a 4.1 percent increase in sales during the first two months of 2006 compared to the same period last year.

**Consumers**

A store can do all it can to reduce its energy bills, but in the end, it must get consumers to open their wallets. Therefore the burning question for businesses is, what do consumers want and how will they behave?

Consumer preferences will have a bigger effect on businesses than energy inflation, said Jerry Hardesty, director of education and development for the nonprofit North Carolina Pork Council. “Most of the time, the consumer wants the cheapest source of food,” he said.

Present food inflation rates of 2 to 3 percent are “low to moderate,” said the Food Marketing Institute. Before that, food prices had gone up 4 to 6 percent annually during most of the 1980s. The study attributed the recent low inflation rates to factors such as technological advancement and “relentless competition” among retailers.

The Federal Reserve will also ensure that high energy prices do not spark major inflation by regulating the amount of money in the market, said agricultural economist Mike Walden of North Carolina State University in a column written for the newsletter of the

Carolinas Food Industry Council, an organization of food distributors and retailers in North and South Carolina.

Walden said the double-digit inflation following the "Oil Shocks" of the 1970s were the result of bad monetary policy. "In a move that some interpreted as trying to fool consumers into thinking they could afford the higher energy prices, the Fed rapidly expanded the money supply," he wrote.

The Department of Agriculture said in a February report that food prices would go up more slowly than the general inflation rate. A key assumption of the report was that crude oil prices would dip between 2007 to 2010 and that sufficient alternative energy sources would be developed to prevent energy shortages afterward.

But Simon Rich, former CEO of Louis Dreyfus Natural Gas and currently an organic beef farmer in Edenton, N.C., said such an assumption was a "folly" and "misleading."

Rich supports Peak Oil theory, which claims that global oil production will begin dropping in a few years, leading to irrevocable increases in fossil fuel prices. "In the long term … the increased price will just pass itself right along to the consumer," he said.

Even if food prices stay low, hefty gasoline prices could change consumers' purchasing habits. An October report by Information Resources Inc. found that retail food sales actually saw a year-on-year increase of 1.7 percent from February 2005 to July 2005, when gasoline averaged $2 to $2.25 per gallon.

"This sales boost was a result of consumers' reduced spending on entertainment and food outside the home," said the report.

Revenue growth slowed slightly to 1.4 percent from July 2005 to early September 2005, when gasoline sold at $2.25 to $2.70 per gallon. The report warned that sales growth would level off if gasoline surpassed $3 per gallon.

Among food products, frozen foods performed the best. Frozen dinner sales were especially strong, with annual increases of 9.7 percent and 7.3 percent for the two periods, respectively. Cold cereals were also winners, gaining 3.4 percent and 6 percent.

The report said the results supported this idea: “If a proportion of consumers has increased spending on food-at-home in lieu of going to restaurants, we would expect to see increases in sales of convenient meal solutions.”

Some consumers have become more vigilant about price tags at the store. Satake of Hickory, N.C., has been paying more attention to discounts and sales since she started feeling “upset” when the gas meter on her car goes down.

“I buy canned soup when it’s on sale at the local Harris Teeter,” said Satake, who shops only for herself. “Recently I bought three dozen. I would never have done that before.”

But new habits don’t always stick, said Soomee Lee, a skin care technician who lives in Chapel Hill, N.C. Lee said her farthest destinations for food shopping are Costco and the Oriental Supermarket in Durham, both about 13 miles away. After the hurricanes, Lee tried to reduce these trips to once every three weeks to cut gasoline costs.

“That didn’t last long,” she said.

Giving up restaurants has been somewhat easier. “Gas prices are a burden, so I bring my own lunch from home more often than eating out.”

Not everyone said they were impacted by gasoline costs. Lee Williamson, a Chapel Hill policeman, said they weren’t affecting his food-buying patterns.

“It’s the proximity,” he said. “In Chapel Hill, you’re not too far from anything.”

And if gasoline got much higher than current levels, as it did after Katrina?

As he gently held up a milk bottle over a baby carriage, its rubber tip squarely planted between the lips of a child inside, Williamson said gasoline still wouldn't change his way of doing things.

"For your family, food is important to get."

## Article Four

## Kicking the Fossil-Fuel Habit

In a crowded equipment shed in Moncure, N.C., Piedmont Biofuels churns out what it hopes will be the fuel of the future – biodiesel, which comes from used cooking fat and makes your car's exhaust fumes smell like fries.

"We can make fuel out of just about anything," said Evan Ashworth, a volunteer at the cooperative, as he led a group of visitors through the grounds of the research facility.

The faint but unmistakable smell of vegetable oil permeated the small building where fuel is made. Inside it was a 150-gallon former beer brewing vessel living a second life as a biodiesel reactor, two water tanks used for cleaning and various other devices all threaded together by pipes.

Together, these machines can convert almost any oil into biodiesel. A local grease hauler who collects discarded oils from restaurants donates the co-op's raw materials – a mystery mix of vegetable oil, pork lard and chicken fat with a few pieces of meat and french fries tossed in. (The solids sink to the bottom for two to three weeks and are composted for use as fertilizer after the liquids are drawn away.)

"[Vice President] Lyle [Estill] is always talking about making fuel out of squirrels," Ashworth said. "He wants to recycle the roadkill."

Sounds gruesome, but it could be a start in reducing North Carolina's 100 percent dependency on out-of-state fuel. State residents paid for that vulnerability after Hurricane

Katrina with the nation's third highest gasoline prices, said Larry Shirley, director of the North Carolina State Energy Office.

"In Katrina, we were caught completely off guard," Shirley said in his keynote address at a March 25 forum on the future of fossil fuel production.

Ninety percent of the state's oil comes through two pipelines stretching from the Gulf Coast, Shirley said. This is a higher level of dependence than most East Coast states, many of which have their own refineries or more ports for receiving imports.

North Carolina's no. 1 industry is not exempt from the effects of high energy prices. Modern food production depends heavily on fossil fuels such as oil, natural gas and coal to power the processes of farming, manufacturing, transport and retail.

Some people, such as Simon Rich, former CEO of Louis Dreyfus Natural Gas and an adjunct faculty member at Duke University, worry that energy prices could eventually reach prohibitive levels, crippling the industry's ability to produce enough food for everyone.

Fossil fuel-based technologies provided the basis for significant increases in food production during the past century. The past 35 years alone saw a 16-percent, 500-calorie increase in the amount of food available to the average American, according to the U.S. Department of Agriculture.

The fundamental solution would be to wean the food production system off nonrenewable fossil fuels, either by conservation or substitution. President Bush's recent Alternative Energy Initiative provides for a 22-percent increase in funding for alternative energy research by the Department of Energy. The Department of Agriculture also announced in February that it would increase its budget for energy-related projects 27 percent in the fiscal year beginning Oct. 1.

The good news: Many alternative energy sources are based on farm products, such as grains, oilseeds and manure. Use of these technologies would insulate food producers from the vicissitudes of the global energy market while strengthening farm incomes as well.

The bad news: Such technologies are a long way from widespread use, mostly because the monetary costs still outweigh the benefits. Few expect alternative fuels to be used to any significant degree without costly long-term changes to the existing infrastructure for energy supply and consumption, which was designed to run on fossil fuels.

"In the short term it's real hard to save energy, because currently there is the fuel distribution system in place," said Prince Dugba, senior environmental engineer at Smithfield Foods, the world's largest pork producer. "I don't see that distribution going anywhere in the near future."

**Fuels from food**

Liquid biofuels, energy sources derived from plant or animal matter, could possibly make this most car-dependent of nations go round in the future.

The two major liquid biofuels are ethanol derived from grains such as corn and biodiesel refined from plant and animal oils. About 3.5 billion gallons and 75 million gallons of each were produced in the country last year, according to the Department of Energy and the National Biodiesel Board, the trade association of the biodiesel industry. The federal government aims to increase their total use to 7.5 billion gallons by 2012.

Neither fuel is produced commercially within North Carolina as of yet. (Piedmont Biofuels' product has not been federally approved for sale to the general public and is only used by co-op members.) But consumption levels here are among the highest in the nation, according to an April 2005 report by the National Renewable Energy Laboratory.

The report noted the state government's efforts to replace its vehicles with those that can use ethanol and municipalities' promotions of biodiesel. For example, the city of Greensboro started using biodiesel in its fleet in 2002, and all government vehicles can fill up on biodiesel at two fueling sites within the city. The city used 850,000 gallons of biodiesel last year, said fleet manager Gary Smith.

Ethanol fuel is made from the sugars in plants. Brazil, the world's largest ethanol producer, makes it from sugarcane. The country has replaced about 40 percent of its vehicle fuel with ethanol. In the United States, corn serves as the main ethanol source because the climate is too cool to grow sugarcane.

But North Carolina's climate is less than ideal for corn farming. An acre of land in the Midwest bears up to 50 percent more corn than in North Carolina, said Kelly Zering, an agricultural economist at North Carolina State University.

The state's huge livestock industry buys 60 percent of its feed from the Midwest. Dan Kerns, a McLeansville, N.C., chicken farmer, said his major energy-related concern was that more corn would end up in ethanol plants rather than animal troughs, driving up the price of corn for feed.

Chris Hurt, an extension economist at Purdue University, wrote in a February article for a weekly agricultural economics newsletter that "While there remain many uncertainties, it is clear that the impact of corn ethanol is a 'big event' that could influence animal industries, perhaps for years to come."

If meat prices failed to offset the increases in corn prices, a "restructuring" of the locations of U.S. and world livestock production could occur, Hurt wrote. "This appears to be particularly true for the Eastern Corn Belt and the Southeastern U.S. where hog, poultry and dairy are more dominate [sic].”

David Pimentel of Cornell University, an authority on the subject of energy use in food production, did not consider ethanol a viable substitute for petroleum. He said that 14 percent of American corn now goes into producing less than 1 percent of the nation’s vehicle fuel. (The White House’s Web site gives the latter number as 2 percent.)

“That means 100 percent of corn becomes only 7 percent of the gas used in the country,” Pimentel said.

But corn is not the only crop that can be made into ethanol. Shirley said that other grains such as barley, which are better suited to the North Carolina climate, can yield more fuel than corn.

Also, a newer technology that converts the previously unusable fibers in corn husks and other grasses into fuel could prove “very profitable” for North Carolina, said Ashworth of Piedmont Biofuels.

“That will change the whole game.”

North Carolina’s major ethanol crop could be switchgrass, a hay crop that grows abundantly in the Southeast and has a high energy density, Ashworth said.

But switchgrass conversion is not yet economically viable. One goal of the federal Alternative Energy Initiative is to make the technology cost-competitive with corn conversion by 2012.

Piedmont Biofuels deals in the other kind of biofuel – biodiesel made from plant and animal greases. In August, the group plans to open the state’s first commercial biodiesel plant in Pittsboro, a facility with the capacity to produce 1 million gallons per year.

Biodiesel primarily comes from soybeans, but that's more because of the clout of the soybean industry than soybeans' worth as a biofuel source, Ashworth said. The co-op is researching the effectiveness of other oilseeds that grow well in North Carolina, and has found canola, sunflower and mustard particularly promising.

Stepping up biofuel production could mean that more of the $15 billion spent annually on petroleum stays within the state economy, said Vice President Estill.

Another advantage of biodiesel is that it can be used in farm machines, trucks and any other diesel engine without modification. It also has a higher energy density than ethanol.

Some of Whole Foods Markets' distribution trucks have been running on biodiesel since February. Ashworth said he goes to the supermarket chain's Morrisville, N.C., distribution center twice a week to supply the fuel. The trucks deliver food to the chain's stores in the Triangle area and Winston-Salem.

A weakness of biodiesel is its tendency to gel at cold temperatures, which is why the fuel is often blended with regular diesel. B20, a mix of 20 percent biodiesel and 80 percent conventional diesel, is the type most often used in trucks.

Another issue is price. A gallon of B20 always costs 20 cents more than ordinary diesel, Ashworth said. As for B100, the pure biodiesel that many co-op members prefer, its price has stayed constant at $3.50 per gallon no matter what the fossil fuel market looked like.

**The worth of waste**

An agricultural "product" that North Carolina makes in abundance but does not take enough advantage of is manure. An average hog produces 1.9 tons of manure a year, according to North Carolina State University's "2005 North Carolina Agricultural Chemicals

Manual." The state agriculture department tallied 9.8 million hogs in December.

Farmers could kill two birds with one stone with manure. It can serve as both a fertilizer and an energy source. "The best scenario is, you take all the energy out of [manure] and also all the fertilizer value in it," said Dugba of Smithfield Foods. "It's not either-or."

The nitrogen and minerals in manure would enrich the land, while the carbon content would produce energy, Dugba said.

But the high-flying science that makes such double use of manure is hampered by a more down-to-earth factor. "The technology's there," Dugba said. "The problem is the cost."

Still, the recent hikes in energy costs are likely to lead more farmers to consider reusing manure for at least one purpose, said Zering of N.C. State, who has studied manure use for a decade.

Rising fertilizer costs have already increased demand for hog manure in Iowa, the nation's leading hog producing state, where its value jumped 50 percent, the Associated Press reported in March.

Proper manure use could lessen farmers' reliance on synthetic fertilizers, which constitute their largest single energy use on average. "High natural gas prices … harm the competitiveness of U.S. farm products in global markets, as natural gas is a primary input for fertilizer," according to the White House's Web site in its section on the Advanced Energy Initiative.

But manure may not necessarily save money or energy, Zering said. The substance is bulky with a low nutrient density. To supply the same amount of nitrogen, a farmer needs to haul 16 to 100 times more manure than synthetic fertilizers.

Many farmers in the state use manure to grow bermudagrass, a hay crop with a voracious appetite for nitrogen, simply to get rid of large amounts of manure at a time, Zering said.

Some farmers try growing edible food with manure. Julian Barham, a hog and tomato farmer in Johnston County, N.C., started growing tomatoes in 1999 to make use of the waste from his 4,000 sows. He uses the water from his hog lagoons, supplemented with some synthetic fertilizers, for his pesticide-free greenhouse tomatoes.

Using animal waste to feed the soil harkens back to traditional methods of farming. Another of Barham's attempts owes more to scientific technology – using manure to make electricity.

Barham installed an anaerobic digester six years ago to break down the organic compounds in manure, producing biogas that can be burned to generate electricity. But he said he stopped using it two and a half years ago partly because the utility company attached a supplemental rider to his electricity bill, making the cost outweigh the benefits.

(Companies can make such charges to customers who generate their own power, said commissioner Sam J. Ervin IV of the North Carolina Utilities Commission. These rates are intended to reflect the company's costs of providing and maintaining the electrical grid.)

Smithfield Foods is using biogas produced from its wastewater to power its processing plants across the nation, according to the company's "2005 Corporate Social Responsibility Report." During fiscal year 2005, the company increased consumption of biogas by 48 percent, but biogas still accounts for only about 5.5 percent of energy use in the plants.

Dugba said he is working on a technology that rearranges the molecules of manure to create liquid fuel. "Energy is – whether you call it gasoline, diesel, propane – just carbon and hydrogen," he said. "These processes, all they do is rearrange the hydrocarbons into a specific energy type."

But hard economics might prevent the use of many promising technologies for the time being, according to a five-year study by North Carolina State University researchers, funded by Smithfield and Premium Standard Farms. The study, released in March, identified several "environmentally superior" waste management strategies, some which produced biogas but none of which were economically feasible.

**Forgoing fossil fuels**

Farming depends heavily on fertilizers, but fertilizers need not depend heavily on natural gas, said J. Paul Lilly, associate professor emeritus of soil science at N.C. State.

Lilly pointed out that natural gas does not provide the nutrition in fertilizer. The gas merely provides the hydrogen required to stabilize atmospheric nitrogen into ammonia, a form that plants can use.

"Any hydrogen source can be used to make ammonia," he said. "Natural gas has been used mainly because it's been cheap."

Others, such as those within the organic agriculture movement, advocate stopping the use of such materials altogether. "In the long run, [organic farming] is more energy-efficient than conventional agriculture," said Tony Kleese, executive director of the Carolina Farm Stewardship Association, a nonprofit that promotes sustainable farming in North and South Carolina.

Energy prices were now convincing farmers who had been pinched by years of mounting costs to consider organic farming methods, he said.

Organic farmers often use nitrogen-fixing crops such as legumes to boost the soil. A 25-year experiment in Pennsylvania showed that organic farming can produce nearly as much food as conventional farming while reducing fossil fuel use by one-third, according to research by Pimentel.

Reverting to more traditional farming methods can reduce energy use significantly. Rich, who raises organic cattle in Edenton, N.C. said he needs almost no fossil fuels to rear his herd except for a small amount for cutting and baling hay with a tractor.

Organic farmers also tend to be open to new energy-saving technologies. John Soehner, a vegetable grower with 4 acres of land in western Orange County, uses a 264-square-foot solar greenhouse to germinate all his seeds. During the day, large plastic containers full of water soak up the sun's energy and release it during the night, maintaining warmth without using natural gas.

Even with the door open on a nippy winter day, the interior of the small building was comfortably warm. "The lowest it ever gets in here is 42 degrees," Soehner said. He is thinking of building another one.

But despite its energy-efficiency, some doubted that organic farming will develop into a major movement, citing lower production and lower profits. Jerry Hardesty, director of education and development at the North Carolina Pork Council, said that raising hogs outdoors, as organic farmers often suggest, is less efficient because it takes longer and requires more feed and labor.

Barham said that many organic farmers are worse off than conventional farmers, as production amounts can be significantly lower. An organic farmer would have only 50 animals on the same space Barham keeps his 4,000, he said.

And going without fossil fuels doesn’t necessarily cost less, especially in the beginning. Kleese said it usually takes three years for a new organic field to produce as much as a conventional one, about the same amount of time required for a farmer to be certified organic and start commanding a premium in the market.

**Energy savings after the farm**

Organic food often squanders its energy advantage in distribution. As less than 1 percent of North Carolina farmers are certified organic, 85 percent of organic products consumed in the state come from outside, Kleese said.

Organic produce from California, grown without nitrogen fertilizers, still has to log 3,000 miles to reach North Carolina. Importing soybean oil from Iowa to make biodiesel doesn’t solve any problems, either, Kleese said.

Kleese suggested the creation of “a Southeastern regional food system” as a long-term way of cutting distribution costs. “The Southeast could be a closed loop if we set that as a goal,” said Kleese, meaning that most food demands can be met regionally.

Of course, the dependence on long-distance food is not a trait exclusive to organic produce. “The majority of food is grown thousands of miles away because we developed this desire for all sorts of out-of-season foods year-round,” Rich said.

Rich said he expected demand for locally grown food to increase as transportation costs climb.

Pimentel has long been a critic of heavy energy use in food production. To judge the energy efficiency of a food, he often compares the energy needed to produce a certain product to the nutritional calories gained by eating it.

Two heads of iceberg lettuce that have only 110 kilocalories (a measure of energy commonly called “calories”) of food value take about 750 kilocalories of energy to produce, Pimentel said. Shipping that lettuce across the continent from California in a refrigerated truck eats up another 4,000 kilocalories.

Pimentel said energy should also be saved in processing. “Eighty percent of our food is processed, which is a shocking number,” he said.

His research has found that a box of corn flakes packaged in a box and plastic liner requires 16,000 kilocalories to make. “Compare that to bread,” he said. “It would require only 700 kilocalories for processing and you could get the same nutrients.”

Reducing packaging would also help, Pimentel said, as plastics are a petroleum product and all containers require energy in their production. He cited the one-spoonful plastic containers of jam often provided in restaurants as an example of waste.

“Putting a glob of jelly on your plate wouldn’t be sophisticated but would save energy.”

**The role of government**

At a meeting of agricultural leaders in March, one of the topics discussed was the need for a position at the state government level to take charge of energy issues, Kleese said.

“I hate to use the word ‘energy czar,’ but we need someone who has the big picture, a vision to link the different pieces,” he said.

Meanwhile, the Midwestern states are setting an example for North Carolina, said Shirley of the State Energy Office.

“Midwestern farmers are building on-site biodiesel co-ops,” he said. “They are also getting royalties from wind turbines, $5,000 per turbine. So if a farmer builds 10 turbines on his land he can get $50,000 a year [from utility companies]."

The state provides grants to promote alternative energy. Greensboro smoothed out the price difference between regular diesel and biodiesel through a grant from state government, said city fleet manager Smith.

But the bulk of the money for farms comes from the federal Department of Agriculture, Shirley said. The 2002 Farm Bill created the Renewable Energy Systems and Energy Efficiency Improvements Program, which made $21.6 million available in grants this year.

But Rich said more should be done to promote alternative energy, such as requiring utility companies to buy a certain percentage of their electricity from renewable sources.

The state is considering such a step, one that 13 others have taken without major problems. "Wherever you have [the mandates], you see the growth of wind farms," Rich said. "They've raised electricity costs by a penny. Wind is actually cheaper than fossil fuels."

North Carolina has the potential to generate 7 billion kilowatt-hours a year, with most of its wind resources concentrated in the western mountains and eastern coast, according to the North Carolina Sustainable Energy Association, a nonprofit organization that promotes the use of renewable energy sources. This is equivalent to 5.6 percent of the state's total electricity generation in 2002, the most recent year for which statistics are available from the federal Department of Energy.

Shirley said the state government could eventually play a bigger role than the federal government in promoting alternative energy. Many politicians in federal government apparently consider the topic of a possible energy crisis to be "political suicide," he said.

But Shirley said the most important change would have to start elsewhere. “The action has got to come from the grassroots.”

**The bigger picture**

The federal government has recently been touting its energy policies, such as the Alternative Energy Initiative, and federal agencies are putting forth larger amounts of money for research and development.

The government is generally optimistic in its projections on how the current and future energy market will affect the food supply. In a February report, the U.S. Department of Agriculture forecast stable farm incomes and food prices for the next ten years, with a decrease in meat production and a slightly higher inflation rate for processed foods.

A key assumption of the report was that crude oil prices would drop between 2007 and 2010. Prices will rise after 2010, but by then alternative oil and energy sources will have been developed enough to mitigate the consequences of high fossil fuel costs, the report said.

But many disagree with the assumption and criticize the government for its perceived lack of urgency regarding future energy supplies. These include people such as Shirley; Rich, who has two decades of energy-industry experience; and scientists such as Gerald Cecil, professor of physics at the University of North Carolina at Chapel Hill.

“In the post-9/11 world, every piece of news that concerns the oil business is depressing,” Cecil said. “Most of the evidence confirms the pessimist’s perspective [that oil production will soon begin to fall].”

Rich said Americans should turn their attention to the rest of the world to fully appreciate what could happen if the transition away from fossil fuels comes too late.

The developing world would be hurt quickest and hardest, leading to massive social upheaval, he said. “Their ability to get something to eat every day is directly connected to reasonably priced nitrogen fertilizer.

“The more catastrophic thing is the developing world’s inability to feed themselves. It’s almost an afterthought that the cost of meat is going to go up for us.”

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